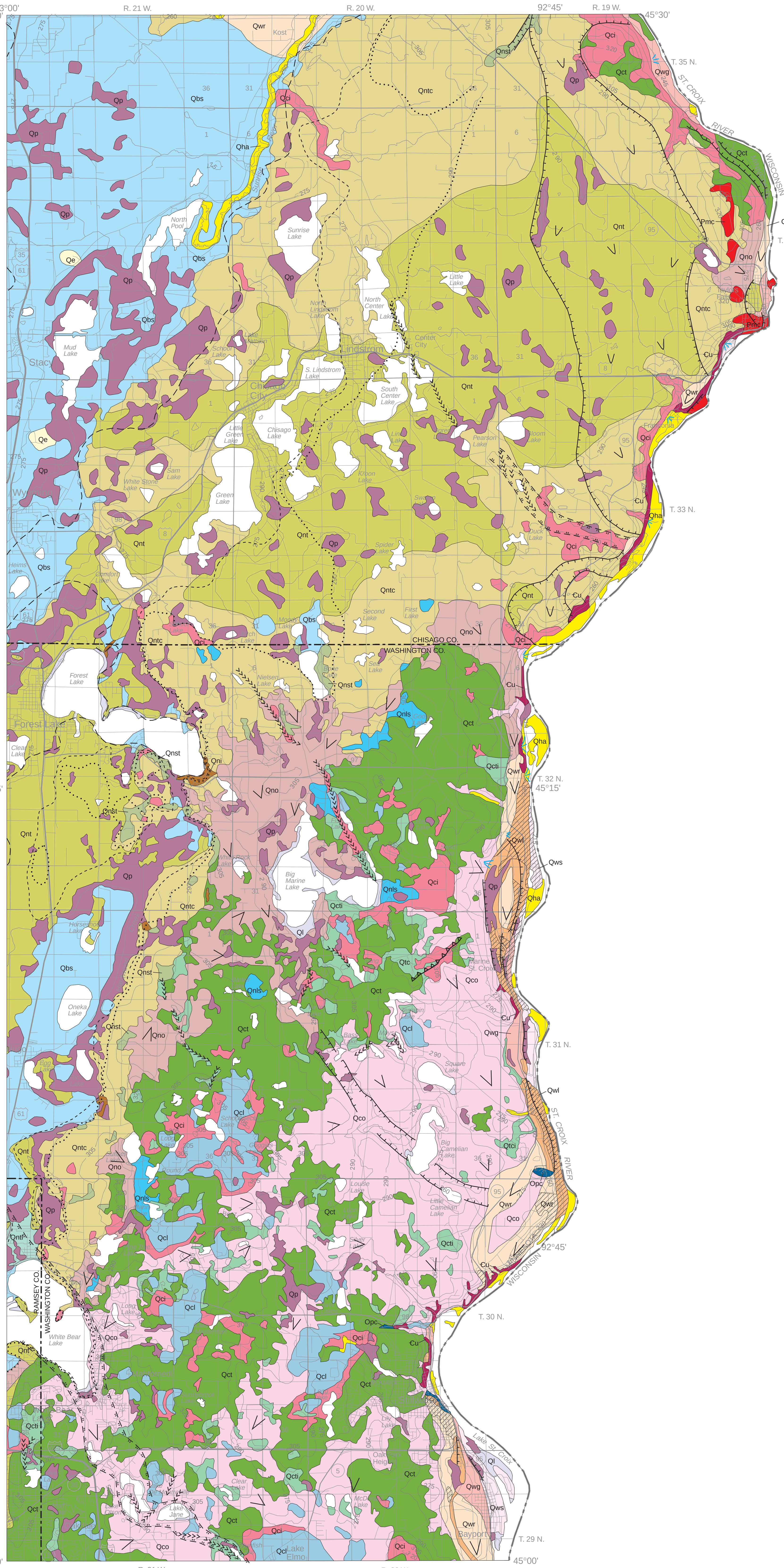
UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
D.L. Southwick, Director

PREPARED WITH THE SUPPORT OF THE U.S. GEOLOGICAL SURVEY AS PART OF THE 1998 STATE GEOLOGIC MAPPING PROGRAM ELEMENT (STATEMAP) OF THE NATIONAL GEOLOGIC MAPPING PROGRAM

MISCELLANEOUS MAP SERIES
MAP M-95
Stillwater Quadrangle



Digital base modified from 1990 Census TIGER/Line Files of the U.S. Bureau of the Census (source scale, 1:100,000); base annotation by Minnesota Geological Survey

Universal Transverse Mercator grid, zone 15
1927 North American Datum

Contours derived using USGS 90-meter grid cell digital elevation data.

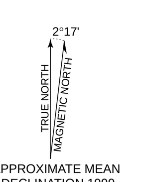
GIS compilation and cartography by Joyce Meints

SCALE 1:100 000

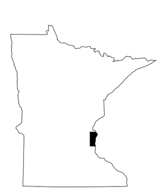
1 0 1 2 3 4 5 MILES

1 0 1 2 3 4 5 6 7 8 KILOMETERS

CONTOUR INTERVAL 15 METERS



APPROXIMATE MEAN DECLINATION 1999



CORRELATION OF MAP UNITS

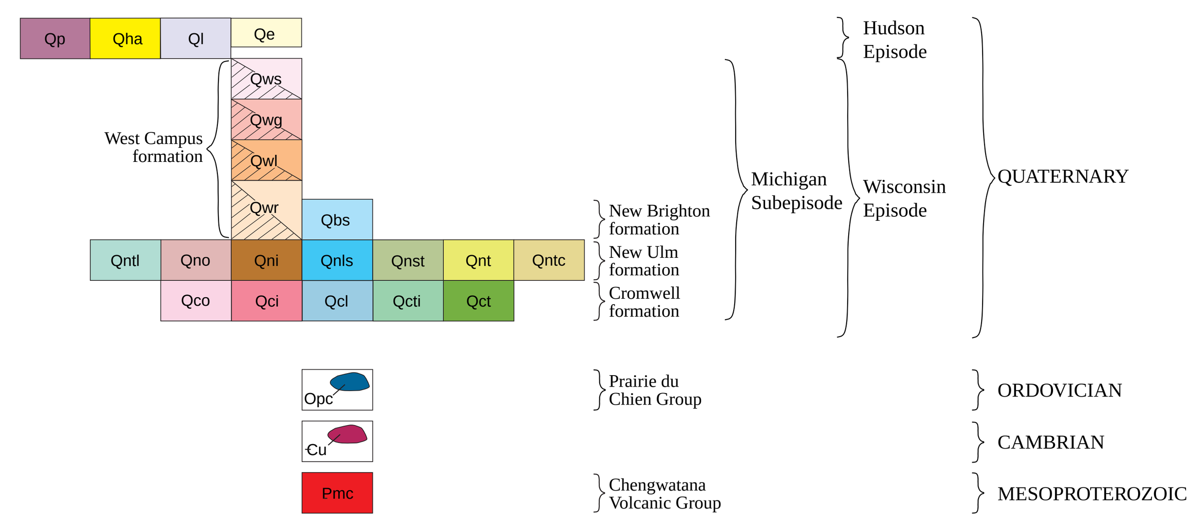


TABLE 1. GENERAL CHARACTERISTICS OF MAPPED GLACIAL DEPOSITS.

Provenance	Riding Mountain (northwest)	Superior (northeast)
Till texture	loamy	sandy
Color		
oxidized	yellow-brown to olive-brown	red-brown
unoxidized	gray	gray and red-gray
Pebble type		
white to buff carbonate	common	rare to uncommon
dark-gray to gray-green rocks	uncommon to common	common to abundant
red felsite and sandstone	rare to uncommon	common
gray shale	uncommon to abundant	absent

DESCRIPTION OF MAP UNITS

This map is a compilation of maps completed from 1990 to 1993 by several different authors. Unlike the maps from which it is derived, most of the deposits on this map have been placed in lithostratigraphic units that have been modified from units previously defined by Stone (1966), Matsch (1962 and 1972), and Wright and others (1970). The Correlation of Map Units incorporates a new scheme developed by Johnson and others (1997) for the division of the late Quaternary into episodes, emphasizing the diachronic nature of the map units. The Michigan Subepisode of the Wisconsin Episode replaces the late Wisconsinan glaciation of earlier publications, and the Hudson Episode is a new name for the current interglaciation or postglacial time—the time since Michigan deglaciation in various regions.

QUATERNARY

Qe **Eolian sand**—Very fine to medium-grained sand; more than 3 feet (1 m) thick; windblown; forms low-lying dunes.

Ql **Lacustrine deposits**—Sand and loamy sand with local, organic-rich layers; includes artificial beaches. Covered by thick fill in developed areas. Many deposits along the edges of lakes and bogs are too narrow to be shown.

Qp **Peat**—Partially decomposed plant matter deposited in marshes. Includes fine-grained organic matter laid down in ponded water, and marl (calcareous clay) at depth in places. Also includes deposits of alluvium along streams, narrow beach deposits, and small bodies of open water. In developed areas, many of these deposits have been buried under artificial fill; the organic sediment is commonly removed prior to filling in areas where major structures are built.

Qha **Floodplain alluvium**—Chiefly sand along the St. Croix and Sunrise Rivers; commonly overlain by about 5 feet (1.5 m) of sandy loam to loamy sand, with interbeds of organic-rich layers; gravelly in some places. Alluvium of smaller streams is finer grained. Some depressions on floodplains have been filled with thick silty to clayey sediment. Covered by thick artificial fill in developed areas. Within the St. Croix Valley, includes alluvial fan sediment that rises above the floodplain at the mouths of tributary valleys. Contacts with other map units are commonly scarps.

West Campus formation (Meyer and Patterson, 1997)—Sand and gravelly sand of mixed Riding Mountain and Superior provenance (Table 1). Coarsens to cobbly gravel in places. Laid down during early, higher stages of the St. Croix River, and preserved in terraces above the modern floodplain. The original West Campus Sand of Stone (1966), which encompasses fluvial sediment in terraces of the Mississippi Valley, is expanded here to include fluvial sediment deposited within the St. Croix Valley above the modern floodplain. The West Campus formation is mapped at four major terrace levels. A pattern indicates areas where bedrock is generally within 10 feet (3 m) of the surface.

Qws **St. Mary's terrace** (named after the community of St. Mary's Point in southern Washington County)—Clasts are mostly of Superior provenance. Surface about 10 to 30 feet (3 to 9 m) above floodplain level, at an elevation of about 700 feet (213 m). It does not extend above the dam at Taylors Falls. Most contacts with other map units (except peat) are scarps.

Qwg **Grey Cloud terrace** (Matsch, 1962)—Clasts are mostly of Superior provenance. Surface about 55 to 80 feet (14 to 24 m) above floodplain level (below the dam at Taylors Falls), ranging in elevation from about 760 feet (232 m) at the south edge of the map to about 790 feet (241 m) at the north edge. Most contacts with other map units (except peat) are scarps.

Qwl **Langdon terrace** (Matsch, 1962)—Clasts are mostly of Superior provenance; rare shale. This terrace has two distinct surfaces separated by a scarp. The upper surface corresponds to the main Langdon level along the Mississippi River, while the lower Langdon surface along the St. Croix is correlated with prominent channels cut into the Langdon terrace of the Mississippi River. The lower surface is about 90 to 110 feet (27 to 34 m) above floodplain level, rising in elevation from about 780 feet (238 m) at Oak Park Heights to about 800 feet (244 m) at Marine on St. Croix. The upper surface is about 120 to 150 feet (37 to 46 m) above floodplain level, ranging in elevation from about 815 to 840 feet (248 to 256 m). A scarp symbol separates the two surfaces. Most contacts with other map units (except peat) are also scarps.

Qwr **Richfield terrace** (Meyer and Jirsa, 1982)—Clasts of mixed provenance; shale is increasingly rare down river—essentially absent south of Stillwater. This terrace has two distinct surfaces. Most of the Richfield terrace south of Stillwater—at an elevation of about 860 feet (262 m), along with the area at Kost to the north (within the Glacial Lake Anoka basin)—at an elevation of about 880 feet (268 m), is interpreted to have formed following drainage of Glacial Lake Anoka (Meyer, 1998). All the other areas mapped as Richfield terrace north of Stillwater formed prior to drainage of the lake, when the St. Croix River served as the outlet stream of Glacial Lake Anoka (and possibly even earlier, by the drainage of Glacial Lake Grantsburg). This upper surface rises in elevation from about 875 feet (267 m) at Stillwater to 920 feet (280 m) above Taylors Falls, about 190 to 220 feet (58 to 67 m) above the modern floodplain. Most contacts with other map units are scarps.

New Brighton formation (Meyer and Patterson, 1997)—Mostly fine-grained sand laid down in Glacial Lake Anoka.

Qbs **Sand facies**—Very fine to medium-grained sand; loamy in places; widely scattered beds of silt to fine gravel at depth. Gravelly sand occurs locally where adjacent to glacial or fluvial sediment. The upper few feet (meter) of sand has commonly been reworked by wind action.

New Ulm formation (Meyer and Patterson, 1997)—Glacial, fluvial, and lacustrine sediment of Riding Mountain provenance (Table 1) deposited by ice and meltwater of the Grantsburg sublobe of the Des Moines lobe.

Qnls **Lake sand**—Very fine- to fine-grained sand and loamy sand; minor interbeds of silt and medium-grained sand. Capped in places by sandy silt. Coarse, gravelly sand occurs locally along boundaries and at or near the base. Deposited in ponded water in depressions between the margin of the Grantsburg sublobe and the stagnant ice-cored St. Croix moraine, and in small ice-walled lakes.

Qno **Outwash**—Sand, gravelly sand, and gravel. Deposited by meltwater issuing from the ice margin at or near its maximum extent. Includes abundant Superior provenance clasts eroded from older sediment; shale is absent to common. Commonly capped by a mantle of wind-blown silt (loess) less than 4 feet (1.3 m) thick.

Qni **Ice-contact stratified deposits**—Sand, gravelly sand, and cobbly gravel. Commonly includes interbeds of, and in places is capped by, sandy to loamy diamicton (mudflow sediment) and silt (lake sediment). Boulders are present in some deposits.

Qnt **Loamy till**—Chiefly loam-textured, unsorted sediment (diamicton); scattered pebbles, cobbles, and boulders. Lenses of stratified sediment are uncommon in most areas. Generally more than 20 feet (6 m) thick over the Cromwell formation. Overlain in some small, low-lying areas by 3 feet (1 m) or more of loamy to clayey, organic-bearing colluvium. Commonly water-washed and overlain in places by a few feet (meter) of lacustrine, fluvial, or eolian sand within the Glacial Lake Anoka basin and within areas bounded by scarps.

Qntl ***Loamy till beneath sandy lake sediment***—Till beneath as much as 20 feet (6 m) of fine-grained sand. Mapped only in Ramsey County.

Qnst **Sandy till**—Loam- to sandy loam-textured, unsorted sediment (diamicton), with pebbles, cobbles, and boulders; commonly capped by, or interbedded with, thin deposits of silty to gravelly stratified sediment. Includes complex deposits of thick sand and gravel too small to distinguish on the map from adjacent till deposits. Commonly less than 20 feet (6 m) thick over Cromwell formation deposits, with an intervening layer of the Twin Cities member.

Qntc **Twin Cities member** (Meyer and Patterson, 1997)—Complexly intermixed yellowish-brown to gray and reddish-brown to reddish-gray, loam- to sandy loam-textured unsorted sediment (diamicton), with pebbles, cobbles, and boulders. This mixture of both Riding Mountain and Superior provenance sediment formed by the erosion and incorporation of Cromwell formation material by the overriding ice of the Grantsburg sublobe. Small lenses of stratified sediment are common in many areas. Covered in places by as much as 20 feet (6 m) of the loamy till facies of the New Ulm formation. Where topography is steeply rolling or gullied, Cromwell formation deposits are locally at or very near the surface. Commonly water-washed and overlain in places by a few feet (meter) of lacustrine, fluvial, or eolian sand in the vicinity of sand deposits, within the Glacial Lake Anoka basin, and within areas bounded by scarps.

Cromwell formation—Glacial, fluvial, and lacustrine sediment of Superior provenance (Table 1) deposited by the Superior lobe and its meltwater. The Cromwell Formation of Wright and others (1970) is herein modified to include related lake sediment. Where mapped within or in the vicinity of New Ulm formation deposits, Cromwell formation deposits are commonly reworked at the top (by the overriding Grantsburg sublobe) and mantled in places by generally less than 10 feet (3 m) of younger deposits.

Qcl **Lake sand and silt**—Silt to medium-grained sand; interbeds and lenses of silty clay to gravelly sand, including sandy diamicton (mudflow sediment), and scattered dropstones. Rhythmically layered in places. Coarse sand and gravel occurs locally along boundaries. Thick silty to clayey sediments generally are concentrated toward the middle of the larger deposits. Primarily deposited in ice-walled lakes following ice stagnation. Silty sediment in depressions commonly consists, at least in part, of redeposited lacustrine and eolian sediment.

Qco **Outwash**—Sand, gravelly sand, and gravel; cobbly in places, especially near till and ice-contact deposits. Commonly overlain by 2 to 5 feet (0.6 to 1.5 m) of loess. Laid down by meltwater issuing from the receding ice margin. The surface of the outwash is highly irregular in most places due to the melting of underlying buried ice-blocks following deposition of the sand and gravel.

Qci **Ice-contact stratified deposits**—Sand, gravelly sand, and cobbly gravel; commonly includes interbeds of, and in places is capped by, sandy to loamy diamicton (mudflow sediment) and silt (lake sediment). Some deposits contain boulders. Many of the ice-contact deposits were laid down as deltas by meltwater entering ice-walled lakes. Other deposits were laid down along the courses (eskers) or at the mouths (kames) of subglacial streams.

Qct **Till**—Chiefly sandy loam-textured, unsorted sediment (diamicton) with pebbles, cobbles, and boulders; silty sand to cobbly gravel lenses are commonly present. Where beyond the margin of the Grantsburg sublobe, commonly overlain by 2 to 5 feet (0.6 to 1.5 m) of loess. Commonly water-washed and overlain in places by a few feet (meter) of fluvial or lacustrine sand in the vicinity of sand deposits and within the St. Croix Valley. Includes small areas of thick, loamy to sandy colluvium.

Qcti **Till, sand and gravel complex**—Sandy till capped by, and/or interbedded with, sand and gravel. Locally, patchy till over thick deposits of sand and gravel. Includes areas too small to distinguish till from ice-contact deposits, and small areas of thick, loamy to sandy colluvium.

ORDOVICIAN

Opc **Prairie du Chien Group**—Dolostone, commonly massive to thick bedded; sandy transitional zone at the base. Discontinuously exposed; sandy to rocky mantle generally less than 5 feet (1.5 m) thick.

CAMBRIAN

Cu **Cambrian rocks, undivided**—Quartzose sandstone, feldspathic to glauconitic sandstone and siltstone, and dolomitic siltstone {Jordan Sandstone, St. Lawrence and Franconia Formations, includes Ironton and Galesville Sandstones and Eau Claire Formation between Franconia and Taylors Falls (Cavaleri and others, 1987)}. Discontinuously exposed; sandy to rocky mantle generally less than 5 feet (1.5 m) thick.

MESOPROTEROZOIC

Pmc **Chengwatana Volcanic Group**—Basalt and associated rocks; discontinuously exposed; sandy to rocky mantle generally less than 5 feet (1.5 m) thick.

MAP SYMBOLS

Geologic contact—Approximately located.

Alluvial fan—Fan-shaped deposit at the mouth of tributary streams of the St. Croix River, rising above the surrounding surface.

General flow direction of braided streams—Arrows point downstream in the direction glacial meltwater once flowed.

Stream-cut scarp—Hachures on downslope side; shown where scarps cut across map units or where peat forms a terrace boundary. Boundaries of terrace units and alluvium are commonly at scarps, so are not shown by a scarp symbol. Where paired, scarps bound stream-scoured areas. Till deposits downslope of scarps are fluvially scoured and mantled in places by sand and gravel too thin and patchy to map separately.

Approximate shorelines of Glacial Lake Anoka—The maximum extent of the lake is difficult to determine, as it was likely ponded against buried stagnant ice. The ice-cored landscape was lowered when this ice melted. Till of the New Ulm formation within the mapped shorelines of Glacial Lake Anoka has been wave-washed and covered in places with thin beds of silt, sand, or gravel. The till in some of these areas has subsequently collapsed due to melt-out of underlying ice. Some of the collapsed till areas now lower in elevation than adjacent areas of New Brighton formation likely were once actually islands or peninsulas in Glacial Lake Anoka.

Fridley level—About 915 feet (279 m) above mean sea level.

Hugo level—About 940 feet (287 m) above mean sea level.

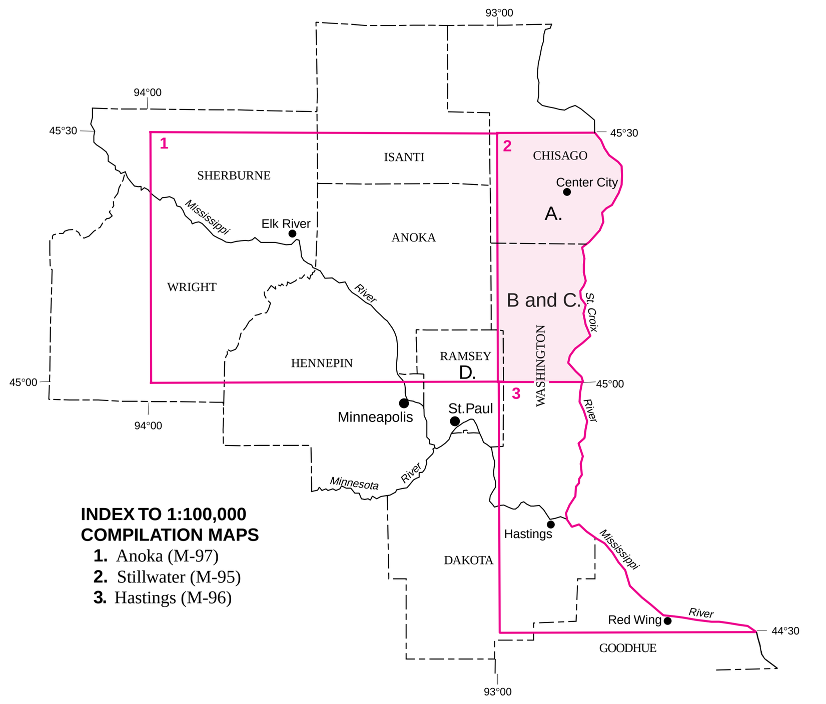
Maximum extent—About 960 feet (293 m) above mean sea level.

Esker—Sinuous ridge of sand and gravel, interpreted to have been deposited in an ice-walled channel of a glacial meltwater stream flowing at the base of the Superior lobe. The fluvial sediment may be covered by 10 feet (3 m) or more of till, especially in areas where the New Ulm formation is the surficial unit. Arrows show inferred flow direction.

Ice-marginal ridge of Superior lobe ice—Teeth on up-ice side.

Sides of a buried tunnel valley—Drainage channel interpreted to have formed below Superior lobe ice before partial burial by subsequent glacial events.

CHISAGO CO. **County boundary.**



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1. Anoka (M-97)
2. Stillwater (M-95)
3. Hastings (M-96)

SOURCES OF GEOLOGIC DATA USED TO COMPILE THE MAP

The map above shows the location of the Stillwater quadrangle (shaded) relative to surrounding counties and to the recently completed Anoka quadrangle (Meyer and Patterson, 1997). Citations A through D were used to compile the geology of the Stillwater quadrangle.

A. Meyer, G.N., 1993, Quaternary geologic map of Chisago County, Minnesota: Minnesota Geological Survey Miscellaneous Map Series M-78, scale 1:100,000, W93°08'31"-92°38'45"/N45°43'51"-45°17'45" [single printed sheet].

B. Meyer, G.N., Baker, R.W., and Patterson, C.J., 1990, Surficial geology, plate 3 *in* Swanson, L., and Meyer, G.N., eds., Geologic atlas of Washington County, Minnesota: Minnesota Geological Survey County Atlas Series C-5, scale 1:100,000, W93°01'22"-92°44'25"/N45°17'49"-44°44'45"[single printed sheet].

C. Mossler, J.H., and Bloomgren, B.A., 1990, Bedrock geology, plate 2 *in* Swanson, L., and Meyer, G.N., eds., Geologic atlas of Washington County, Minnesota: Minnesota Geological Survey County Atlas Series C-5, scale 1:100,000, W93°01'22"-92°44'25"/N45°17'49"-44°44'45"[single printed sheet].

D. Patterson, C.J., 1992, Surficial geology, plate 3 *in* Meyer, G.N., and Swanson, L., eds., Geologic atlas of Ramsey County, Minnesota: Minnesota Geological Survey County Atlas Series C-7, scale 1:48,000, W93°13'40"-92°59'01"/N45°07'28"-44°53'17" [single printed sheet].

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Hobbs, H.C., and Goebel, J.E., 1982, Geologic map of Minnesota, Quaternary geology: Minnesota Geological Survey State Map Series S-1, scale 1:500,000, W97°14'24"–89°28'45"/N49°23'23"–43°30' [single printed sheet].

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SURFICIAL GEOLOGY OF THE STILLWATER 30 x 60 MINUTE QUADRANGLE, MINNESOTA

Compiled by
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1999