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MINNESOTA GEOLOGICAL SURVEY
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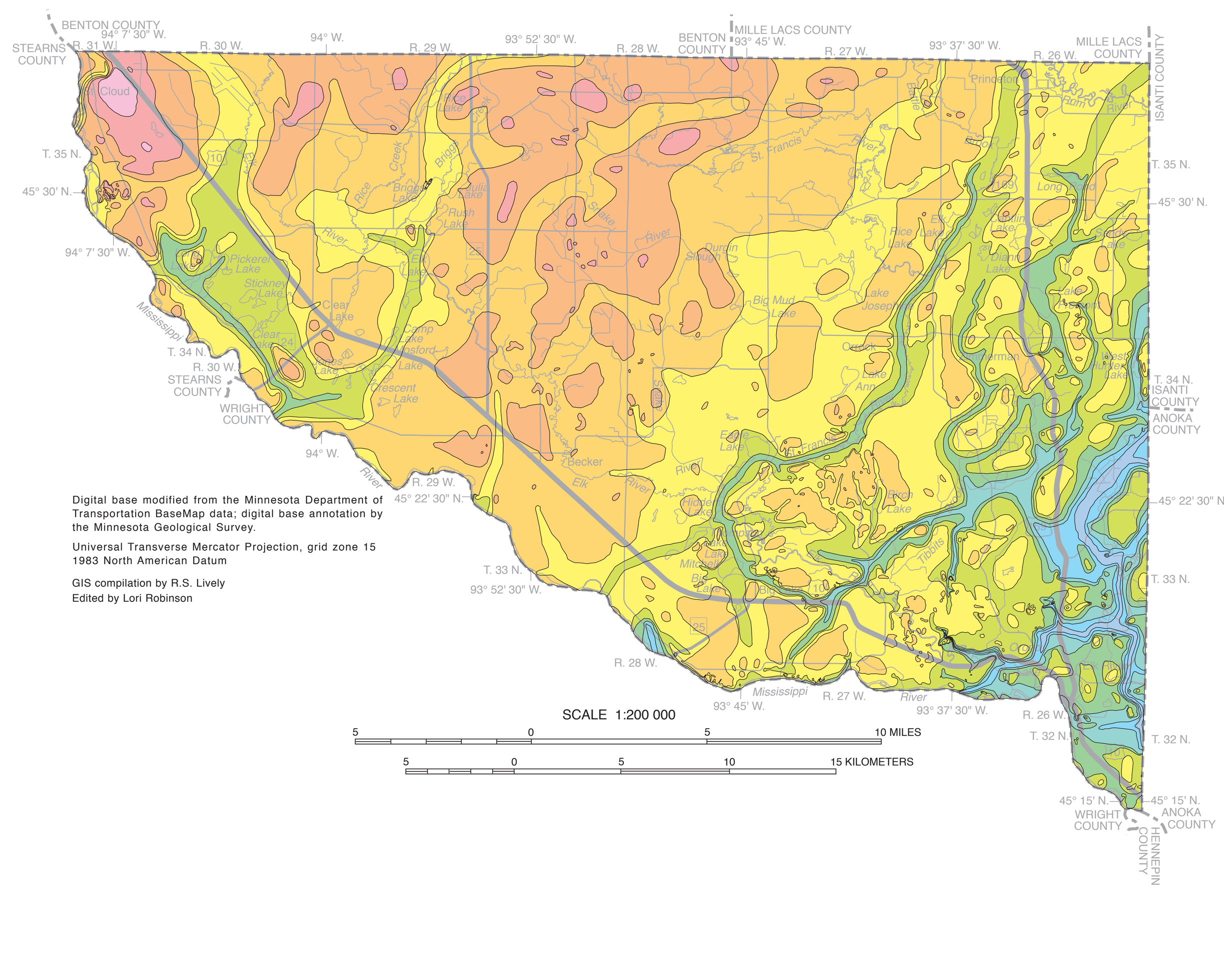
COUNTY ATLAS SERIES
ATLAS C-32, PART A
Sherburne County
Plate 5—Bedrock Topography,
Depth to Bedrock, *and*
Sand Distribution Model

BEDROCK TOPOGRAPHY

By

John H. Mossler

2013



EXPLANATION

The configuration of the bedrock surface is represented by colors assigned to 50-foot (15-meter) elevation intervals (example: 751 to 800 feet above sea level) on the Bedrock Topography map. The position of the contour intervals was determined mostly from records of water well construction and engineering test borings. Passive seismic soundings were also used to determine the elevation of the bedrock surface in some areas. The seismic data were collected by R.S. Lively and V.W. Chandler of the Minnesota Geological Survey. The irregular distribution of data can be seen on Plate 1, *Data-Base Map*, and should be considered when assessing the reliability of the map at a particular location.

The bedrock surface in Sherburne County varies from less than 550 feet (168 meters) to more than 1,000 feet (305 meters) above mean sea level. The most prominent features of the bedrock topography are buried bedrock valleys that cross parts of the county. The buried valleys deepen toward the south and east and intersect buried valley systems in Wright and Anoka Counties.

The interfluves of the buried valleys in the southeastern part of the county are generally underlain by the fine-grained sedimentary rocks of the Eau Claire Formation and Tunnel City Group. However, in central and western parts of the county the interfluves commonly are underlain by Precambrian igneous and metamorphic rocks. Deeper valleys in the southeastern and eastern parts of the county are underlain by the Mt. Simon Sandstone and Mesoproterozoic sedimentary rocks, mainly Hinckley Sandstone.

Elevation of the bedrock surface in feet above mean sea level

- 1,001-1,050
- 951-1,000
- 901-950
- 851-900
- 801-850
- 751-800
- 701-750
- 651-700
- 601-650
- 551-600

DEPTH TO BEDROCK

By

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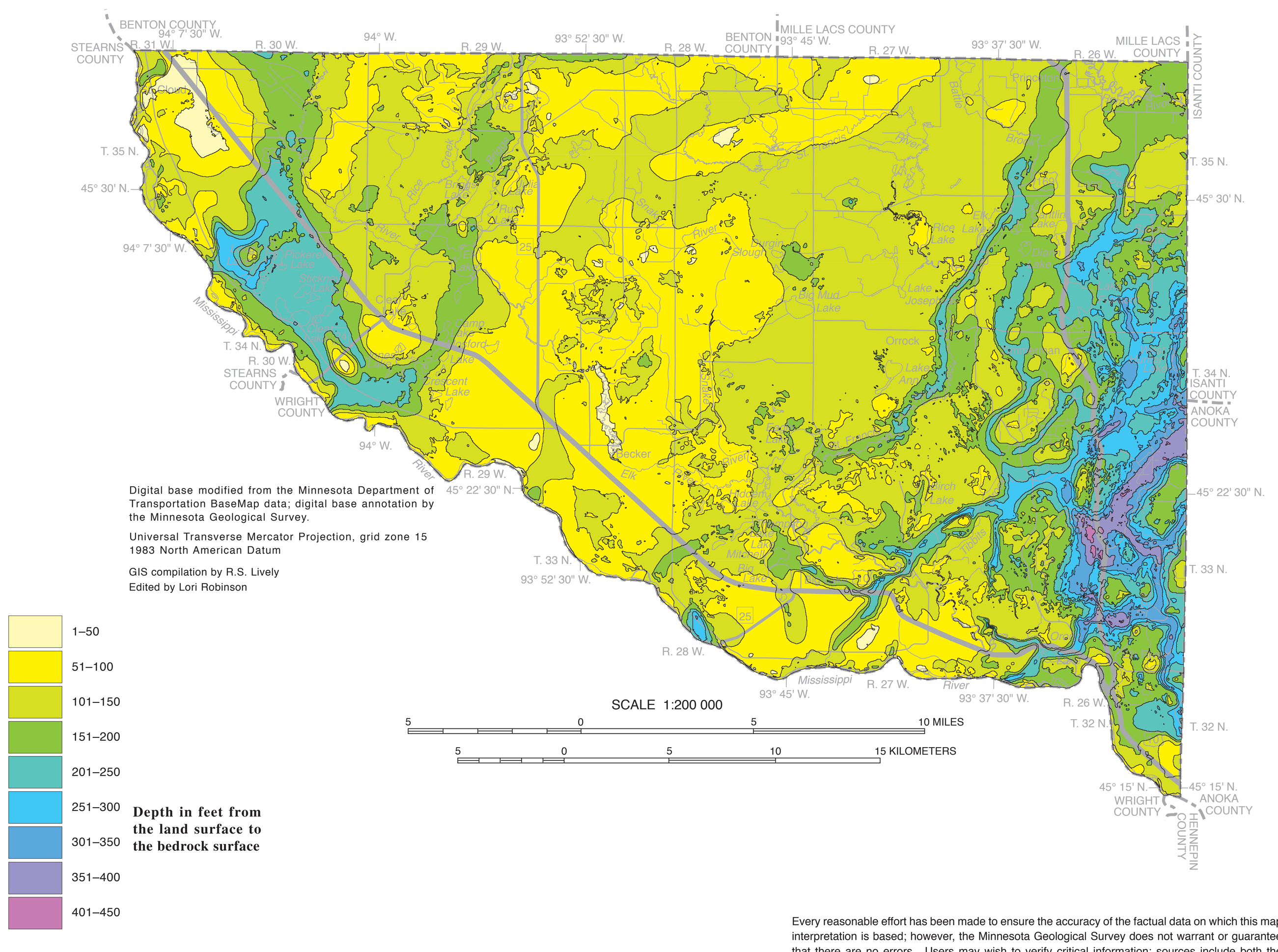
2013



EXPLANATION

The thickness of the glacial sediment is equal to the depth from the land surface to the bedrock surface. To calculate this thickness, a grid of bedrock-surface elevations was subtracted from a corresponding grid of land-surface elevations (30-meter cell size). The surface elevation grid was resampled from the national elevation 10-meter data set of the U.S. Geological Survey, whereas the bedrock elevation grid was interpolated from interpretations of water well, engineering test boring, and passive seismic data (see Bedrock Topography explanation). The residual grid was then classified at a 50-foot (15-meter) interval to produce the color-coded Depth to Bedrock map. Because the surface of a lake is regarded as the land surface elevation, the thickness of glacial sediment within lake boundaries includes the depth of lake water. To calculate the true thickness of sediment beneath a lake it is necessary to subtract the water depth at that location. In places the thickness of the glacial sediment varies greatly over short distances and mapping at this scale (1:200,000) may not properly resolve such variations. For that reason it is best to consult site-specific data, such as well records and seismic soundings, wherever they are available.

The thickest sediments in Sherburne County occur over deep, pre-glacial valleys in the bedrock surface. These occur throughout the county but are most prominent in the southeastern part of the county along the boundary with Anoka County. Sediment is more than 400 feet (122 meters) thick in some areas of the southeastern valleys but more commonly range from 200 to 400 feet (61 to 122 meters) in thickness. In contrast, bedrock is at the surface or within 50 feet (15 meters) of the land surface in the northwestern corner of the county and is less than 50 feet (15 meters) thick along stretches of the Mississippi River in western and central Sherburne County. Glacial sediment is less than 100 feet (30 meters) thick across much of the central part of Sherburne County. Most of the details in the Depth to Bedrock map are related to landforms because the model of the land surface is based on much more data than the bedrock surface topography model.

Depth in feet from the land surface to the bedrock surface

- 1–50
- 51–100
- 101–150
- 151–200
- 201–250
- 251–300
- 301–350
- 351–400
- 401–450

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SAND DISTRIBUTION MODEL

By

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2013

INTRODUCTION

The Quaternary sand and gravel deposits of Minnesota are products of a long and complex history of multiple glacial events that makes mapping of these potential aquifers difficult. However, establishing the location and characteristics of sand and gravel aquifers is an essential step toward their wise use and protection. In Sherburne County, this project employed a process that combined the understanding of a geologist with the data-handling ability of a geographic information system (GIS) to create three-dimensional models showing the distribution of Quaternary sand and gravel deposits that may be aquifers. The geologist interprets the three-dimensional models and relates aquifers to the glacial events that formed them. Although the models and interpretations are based on the best available data, they are unavoidably incomplete due to a lack of data in some areas (see Plate 4, *Quaternary Stratigraphy*).

Sand and gravel distribution at the land surface is mapped by a geologist from exposures, shallow drill holes, soil maps, and landforms. In contrast, interpreting sand distribution in the subsurface relies primarily on well records, scientific drill core, and drill cuttings. Each well record or drill log is an interpretation of the vertical sequence of earth materials at one location. It falls to the geologist to assess the accuracy of these interpretations and use them to predict what materials occur in the areas between wells or at depths not penetrated by the wells. That prediction is based on an assessment of the available data and an understanding of the glacial history and processes that created the glacial sediment. The distribution of data greatly affects the resolution and accuracy of our models. For example, if the wells are widely spaced, they will not intersect deposits of limited extent and cannot support accurate mapping of those features. In a similar manner, bodies of sand and gravel that occur deep in the subsurface are typically not intersected by many wells because shallower bodies of sand and gravel are adequate to supply water and there is no need to continue drilling.

The unconsolidated Quaternary sediments that overlie the bedrock in Sherburne County vary greatly in character and thickness. These deposits are largely the result of many distinct glacial ice advances during the Pleistocene Epoch (Plate 3, *Surficial Geology*). Most of the aquifers within Sherburne County consist of sand and gravel beds laid down by meltwater that flowed from these glaciers. Unsorted sediment deposited directly from the ice, termed "till," and fine-grained clay- and silt-rich bedded sediment deposited in ponded meltwater in front of the glaciers, form confining layers that may enclose the aquifers. The till layers left by each ice sheet tend to be more laterally persistent than the sand layers because they are more cohesive and were deposited by ice that typically spread across the entire county, whereas meltwater streams that deposited the sand and gravel were generally restricted to drainages at lower elevations of the evolving landscape and were easier to erode. To further confuse things, sand and gravel may be deposited by both the advance and retreat of glaciers, thus till from an ice advance may bury its own sand and gravel, as well as material deposited during a previous glacial event. By convention, the name designations of sand and gravel bodies depicted in this report are associated with their underlying till (except for those at the land surface and those that intersect the lowermost unknown units; Fig. 1).

Glacial ice and meltwater not only deposited sediments, but also eroded older, underlying sediments, creating a very disturbed "layer cake" stratigraphy. A new layer of sand or till could fill a void eroded into an older layer, or could completely displace an older layer, given sufficient erosion. The net effect of this depositional and erosional activity is that sand and gravel bodies that provide water to wells in Sherburne County tend to be discontinuous. Even over relatively short distances in most directions, the extent and thickness of any given aquifer is difficult to predict. In order to create a valid geologic model of the subsurface, 37 closely spaced (0.6 mile [1 kilometer]) cross-section lines were generated in a west–east direction (Plate 4, *Quaternary Stratigraphy*, Fig. 3). Along these lines, water well records and records of scientific and engineering test holes (Plate 1, *Date-Base Map*) were used by a geologist to identify contacts between till units in the subsurface. Final interpretations along seven of these cross sections are shown on the cross sections A–A' through G–G' on Plate 4.

Till is generally described as "clay" by well drillers. Although sand and gravel can occur within a till, more extensive deposits occur at the contact between two till sheets. Where two clay (till) layers related to different depositional events are not separated by a sand and gravel layer, their contact may be recognized by a change in the driller's description of the clay's texture, density, or color. Using the available data, contact lines were drawn along each cross section, with each line representing the base of a unit of sand and gravel or till. GIS software was used to extract elevation values from vertices along each unit line, and convert those into a raster elevation surface showing the distribution of the unit over the county. The till and sand surfaces were iteratively modified until the geologist was confident that they adequately represented the stratigraphic interpretation for the majority of water well data. When the till and sand surface rasters representing the base of each unit were final, they were processed through GIS raster calculations to create top and bottom surfaces for each geologic unit and a thickness for each sand unit. The result is a three-dimensional geologic model of tills and sands for the county. The more extensive sands portrayed by the geologic model are shown in Figures 2 through 13. Note that contours showing thickness of sand and gravel units may not close within the outline of each unit. This is an artifact of the GIS processing of raster surfaces. The figures show sand units ranging from the youngest sands at the land surface to buried, progressively older sands (Fig. 1).

Where saturated, these sand bodies are aquifers. Their capacities for water yield depend on their extent and thickness, as well as factors such as sediment coarseness, degree of sorting, consolidation, and potential for recharge. In many places two or more of these sand units form a single aquifer where they are juxtaposed with no intervening till layer.

The geologic model should be considered a probability map for the occurrence and approximate thickness of major sand bodies. The model does not guarantee sand and gravel will be found at all places shown, nor does it preclude them from being found in areas where they are not shown. Sands that were too thin or did not extend to neighboring cross sections commonly did not survive the processing that created the multiple surfaces. Because wells typically do not penetrate the complete thickness of sand layers, drillers' logs commonly under-report sand-body thickness. As a result, some of the sands shown on the cross sections (Plate 4; but not necessarily on the final sand distribution map) may be thicker and more widespread than portrayed. At increasing depths in the stratigraphic section, data availability diminishes and delineated sand bodies could be more or less discontinuous than shown. In many parts of Sherburne County water wells do not extend through the full thickness of the Quaternary deposits. The cross sections indicate that the characteristics of deeper Pleistocene deposits cannot be differentiated in many places. However, where deep drill holes occur, thicker sands are commonly present. Additional sand bodies, or extensions of those mapped, are undoubtedly present in these undifferentiated parts of the Pleistocene section. In spite of these limitations, the geologic model provides a realistic interpretation of where and what kind of geologic units would be encountered in the subsurface of Sherburne County. However, given the limits of the data, as noted above, the model should be used as a guide and should not preclude further site-specific investigations or inspection of individual well logs.

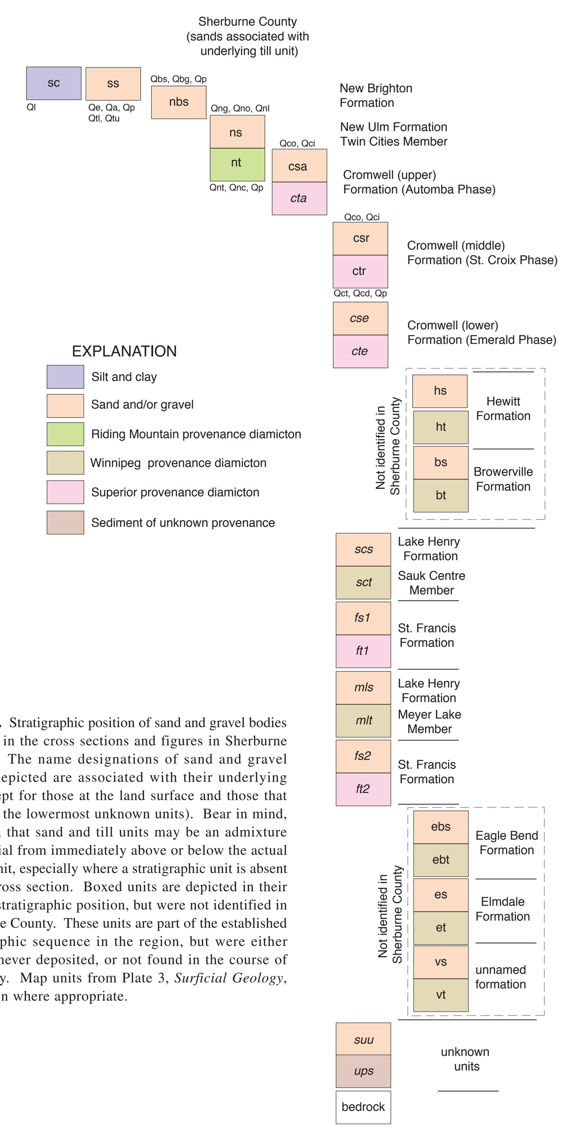

Figure 1. Stratigraphic position of sand and gravel bodies depicted in the cross sections and figures in Sherburne County. The name designations of sand and gravel bodies depicted are associated with their underlying till (except for those at the land surface and those that intersect the lowermost unknown units). Bear in mind, however, that sand and till units may be an admixture of material from immediately above or below the actual named unit, especially where a stratigraphic unit is absent on the cross section. Boxed units are depicted in their relative stratigraphic position, but were not identified in Sherburne County. These units are part of the established stratigraphic sequence in the region, but were either eroded, never deposited, or not found in the course of this study. Map units from Plate 3, *Surficial Geology*, are shown where appropriate.

CONTOURS FOR FIGURES 2 THROUGH 12

Thickness of a sand and gravel unit contoured at 20 foot (6 meter) intervals.

- 20
- 40
- 60
- 80
- 100
- 120
- 140

Note: Contour lines may not close at the edges of mapped areas. This is an artifact of the digital processing.

DEPTH FOR FIGURES 3 THROUGH 13

Depth in feet from the land surface to the top of a sand and gravel unit (depth from the land surface to the top of undifferentiated sediment is shown on Figure 13).

- 0–50
- 51–100
- 101–150
- 151–200
- 201–250
- 251–300
- 301–350
- 351–400

SCALE 1:300 000

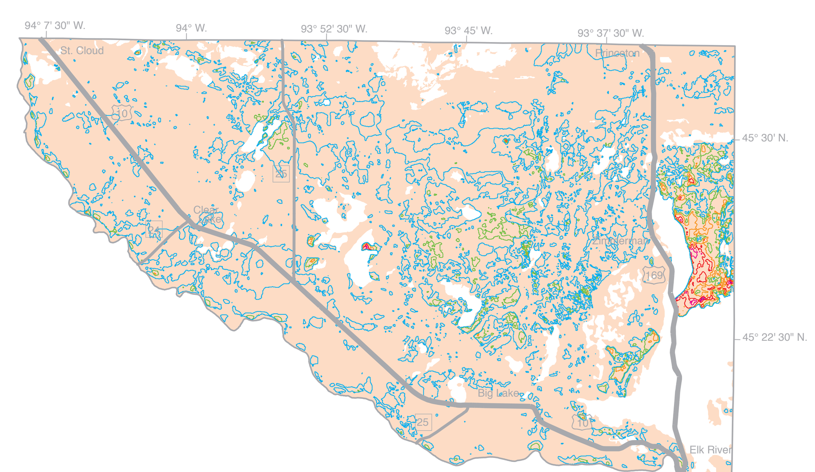

Figure 2. **Surficial sand (unit ss)**—Model-generated map of the extent and thickness of sand and gravel bodies occurring at the land surface in Sherburne County. Includes units Qe, Qa, Qtl, Qtu, Qp, and portions of Qbs, Qbg, Qng, Qno, Qnl, Qco, and Qci (from Plate 3, *Surficial Geology*). The surficial sand and gravel is overlain in places by peat and other fine-grained sediment (units Qp and Ql).

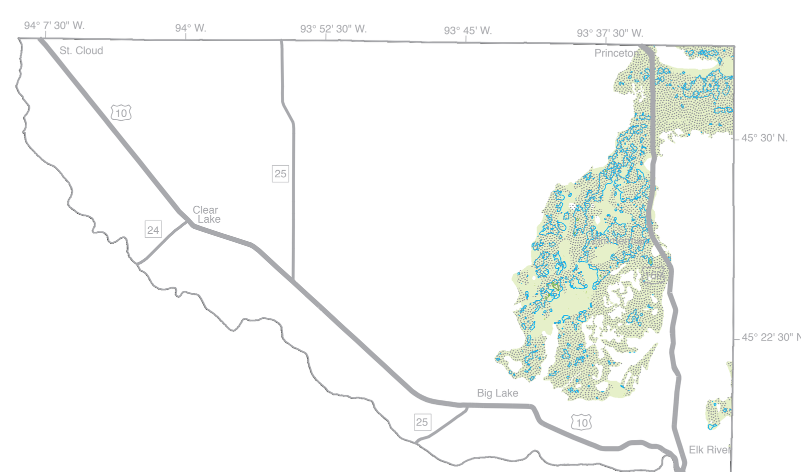

Figure 3. nbs sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies that commonly lie stratigraphically above till unit nt, but in places may overlie older units. Portions of unit nbs occur at the surface and are shown by a pattern overlay. These areas are included in the surficial sand model (unit ss, Fig. 2). Includes mapped units Qbs, Qbg, and Qp (from Plate 3, *Surficial Geology*). Consists of very fine-grained sand to gravel deposited in glacial Lake Anoka, which formed as the Grantsburg sublobe melted (Plate 3, Fig. 7).

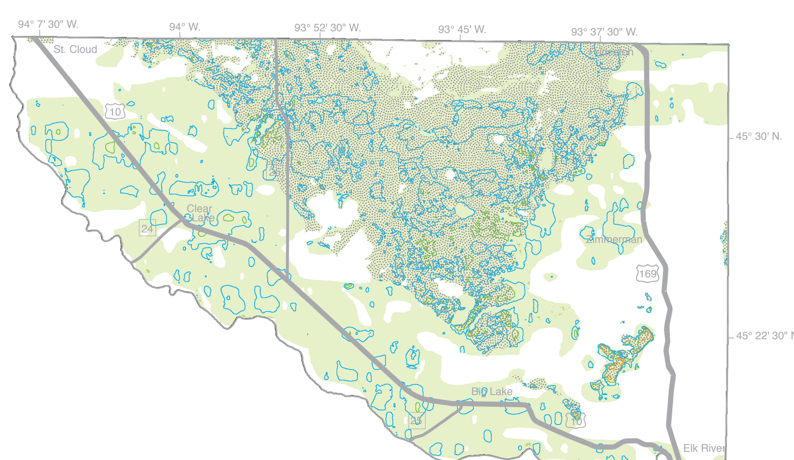

Figure 4. *ns* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies that commonly lie stratigraphically immediately above till unit nt, but in places may overlie older units. Portions of this unit occur at the surface and are shown by a pattern overlay. These areas are included in the surficial sand model (unit ss, Fig. 2). Includes mapped units Qng, Qno, Qnl, and Qp (from Plate 3, *Surficial geology*). Consists of silt to sand and gravel laid down by meltwater of the retreating Grantsburg sublobe. The outwash forms a uniform sheet deposit over much of the county. Thick sequences were deposited in ice-walled lakes within stagnant, melting ice.

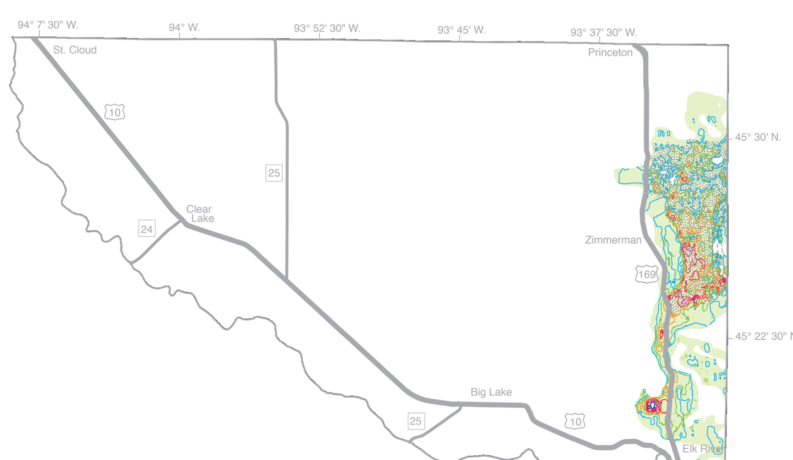

Figure 5. *csa* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies that commonly lie stratigraphically immediately above till unit cta, but in places may overlie older units. Portions of this unit occur at the surface and are shown by a pattern overlay. These areas are included in the surficial sand model (unit ss, Fig. 2). Consists of mostly proglacial sediment deposited by meltwater at the margin of the advancing Automba phase of the Superior lobe.

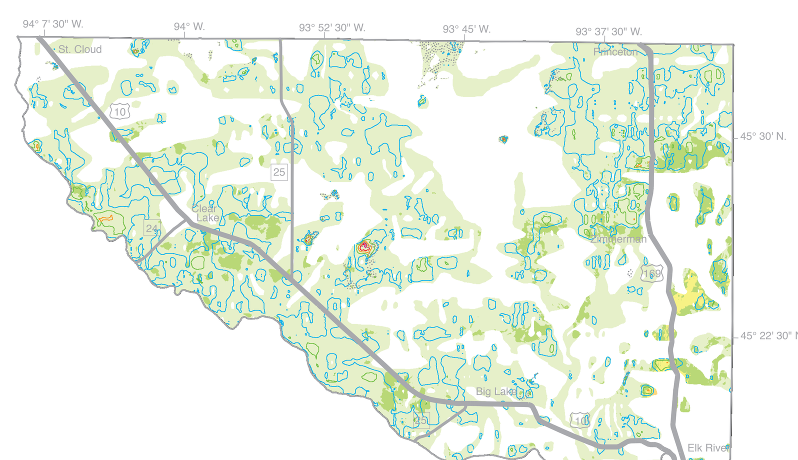

Figure 6. *csr* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies that commonly lie stratigraphically immediately above till unit ctr, but in places may overlie older units. Portions of this unit occur at the surface and are included in the surficial sand unit (ss; Fig. 2). Deposited by meltwater from the receding St. Croix phase and advancing Automba phase of the Superior lobe.

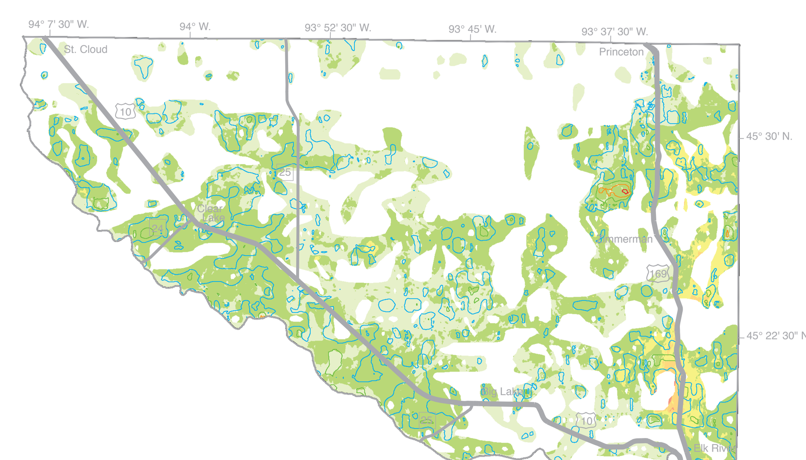

Figure 7. *cse* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies that commonly lie stratigraphically immediately above till unit cte, but in places may overlie older units. Deposited by meltwater of the receding Emerald phase and advancing St. Croix phase of the Superior lobe.

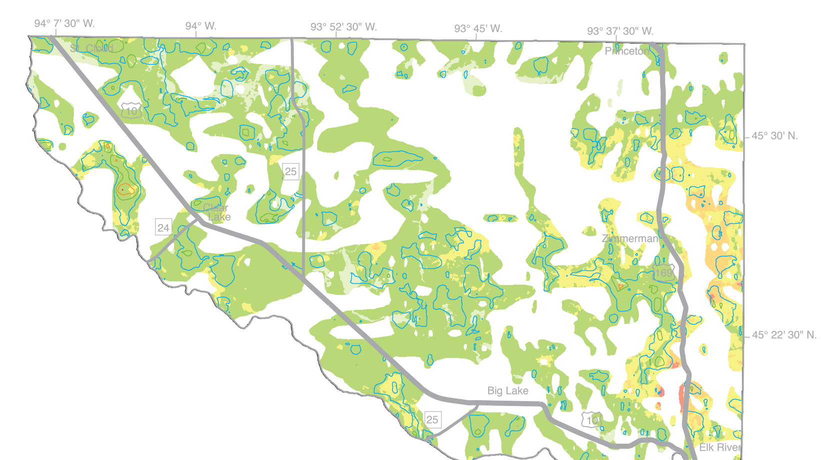

Figure 8. *scs* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies that commonly lie stratigraphically immediately above till unit sct, but in places may overlie older units. Deposited by meltwater of the receding Winnipeg provenance ice and advancing Emerald phase of the Superior lobe. May include older deposits.

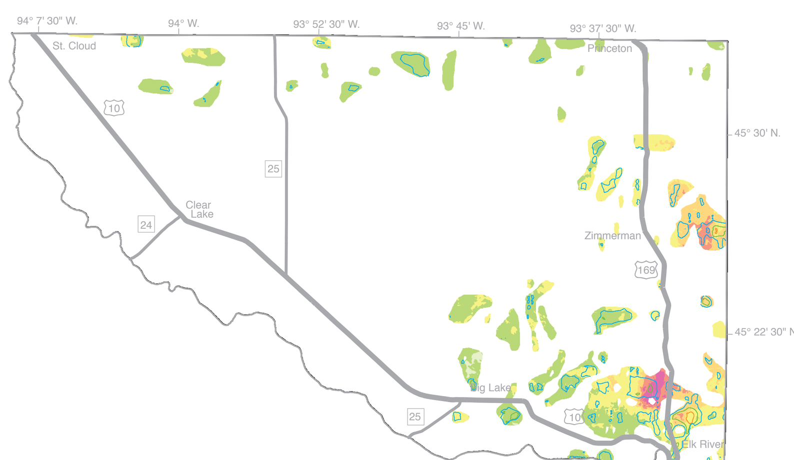

Figure 9. *fs1* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies that commonly lie stratigraphically immediately above till unit *ft1*, but in places may overlie older units. Deposited by meltwater of the receding Superior provenance ice, older deposits, and advancing Winnipeg provenance ice.

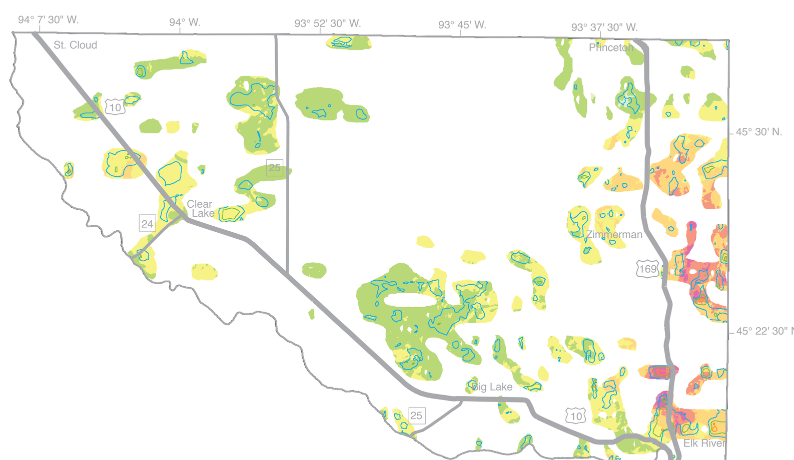

Figure 10. *mls* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies that commonly lie stratigraphically immediately above till unit *mlt*, but in places may overlie older units. Deposited by meltwater of the receding Winnipeg provenance ice, older deposits, and advancing Superior provenance ice.

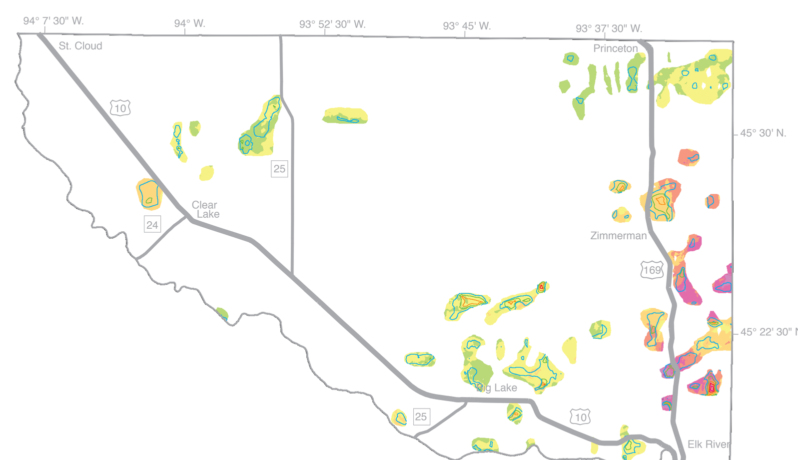

Figure 11. *fs2* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies that commonly lie stratigraphically immediately above till unit *ft2*, but in places may overlie older units. Deposited by meltwater of the receding Superior provenance ice, older deposits, and advancing Winnipeg provenance ice.

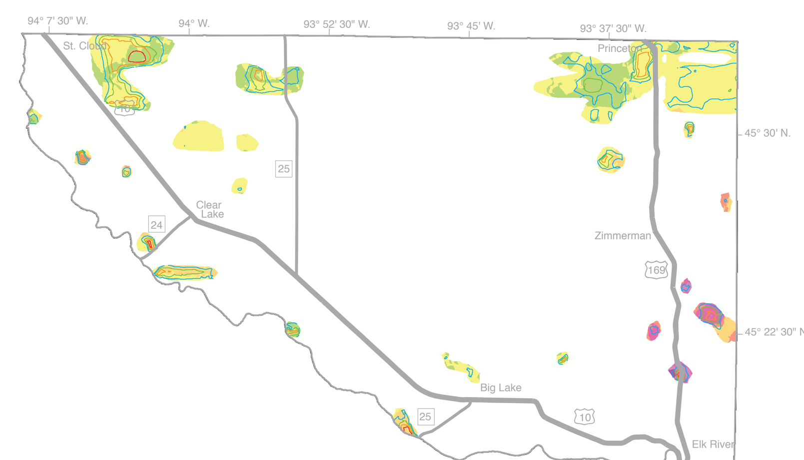

Figure 12. *suu* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies stratigraphically at the top of unit *ups*.

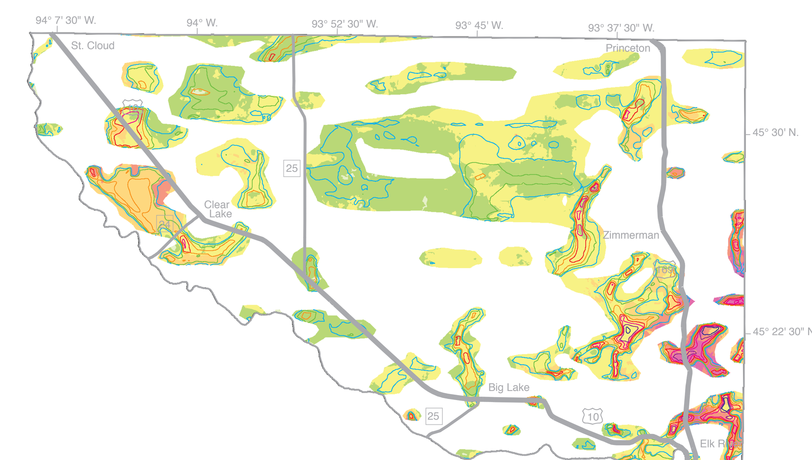

Figure 13. Undifferentiated Pleistocene sediment—Model-generated map of the extent, depth from the surface, and thickness of Pleistocene sediment for which no descriptive data are available, contoured at 50-foot (15-meter) intervals.

CONTOURS FOR FIGURE 13

Thickness of undifferentiated sediment.

- 50
- 100
- 150
- 200
- 250

Note: Contour lines may not close at the edges of mapped areas. This is an artifact of the digital processing.