UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
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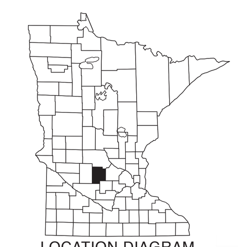
Prepared and Published with the Support of
THE MEEKER COUNTY BOARD OF COMMISSIONERS
AND THE MINNESOTA ENVIRONMENT AND NATURAL RESOURCES TRUST FUND
AS RECOMMENDED BY THE LEGISLATIVE-CITIZEN COMMISSION ON MINNESOTA RESOURCES

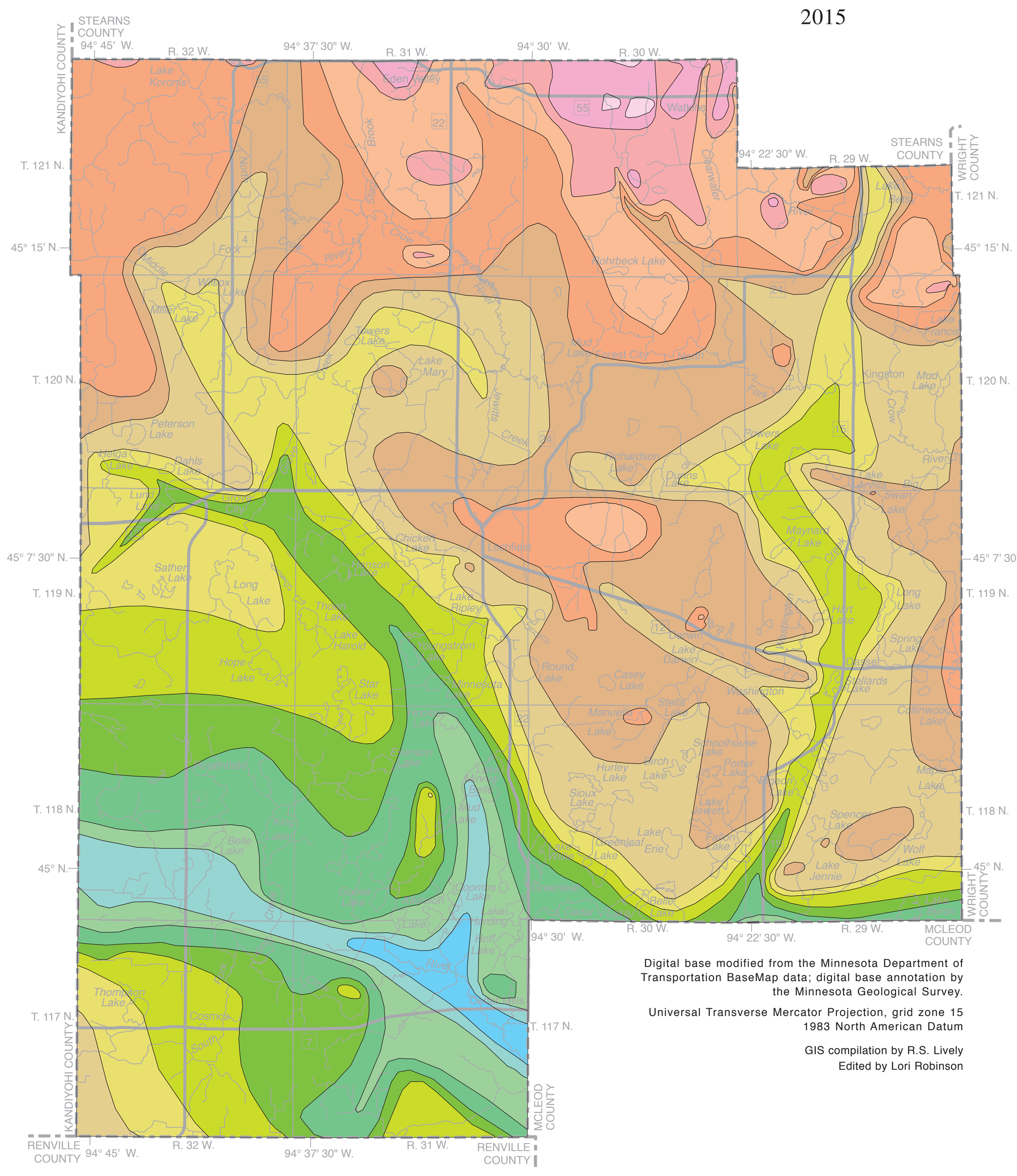

LOCATION DIAGRAM

BEDROCK TOPOGRAPHY

By

Julia R. Steenberg

2015



EXPLANATION

The configuration and elevation of the bedrock surface in Meeker County is represented by the colors assigned to 50-foot (15-meter) elevation intervals (example: 751-800 feet above sea level) on the Bedrock Topography map. The position of the contour intervals was determined from water-well construction records, scientific borings, seismic soundings, and geologic interpretation. The somewhat irregular distribution and density of data can be seen on the Data-Base Map (Plate 1), and this should be considered when assessing the reliability of the map at any particular location. Areas with a high density of bedrock control points are likely to have accurate interpretation of the bedrock elevation, whereas those areas with widely spaced control points may be less reliable and inappropriate for site-specific needs. Records of drill holes that intersect bedrock are concentrated in the eastern part of the county. The highest density of data points occurs near populated areas that rely on groundwater for their drinking water needs.

The bedrock surface in Meeker County varies from more than 1,100 feet (335 meters) above sea level near Eden Valley in the northeast to less than 500 feet (152 meters) above sea level within the deeply incised bedrock valley near Cedar Mills. The most prominent features of the bedrock topography are buried valleys that deepen to the south and east. Based on recent mapping in surrounding areas (Mossler, 2009; Mossler and Steenberg, 2012; Jirsa and others, 2011; Steenberg, 2013), the valley system deepens further to the southeast, crossing McLeod and Sibley Counties before connecting to the ancestral Mississippi River drainage near Belle Plaine. The present elevation of the bedrock surface is dependent on several factors, the most important of which appears to have been the resistance of bedrock to weathering and erosion. As a result, the bedrock topography exhibits some correlation with rock units. Rock types that are most resistant to erosion typically occupy higher parts of the topography, and less resistant rock types are associated with low areas. Slightly steeper valleys and more variable landforms exist over the less resistant Mesozoic rocks, and broader valleys are located on the more resistant Precambrian rocks.

Elevation of the bedrock surface in feet above mean sea level

1,101-1,150
1,051-1,100
1,001-1,050
951-1,000
901-950
851-900
801-850
751-800
701-750
651-700
601-650
551-600
501-550
451-500

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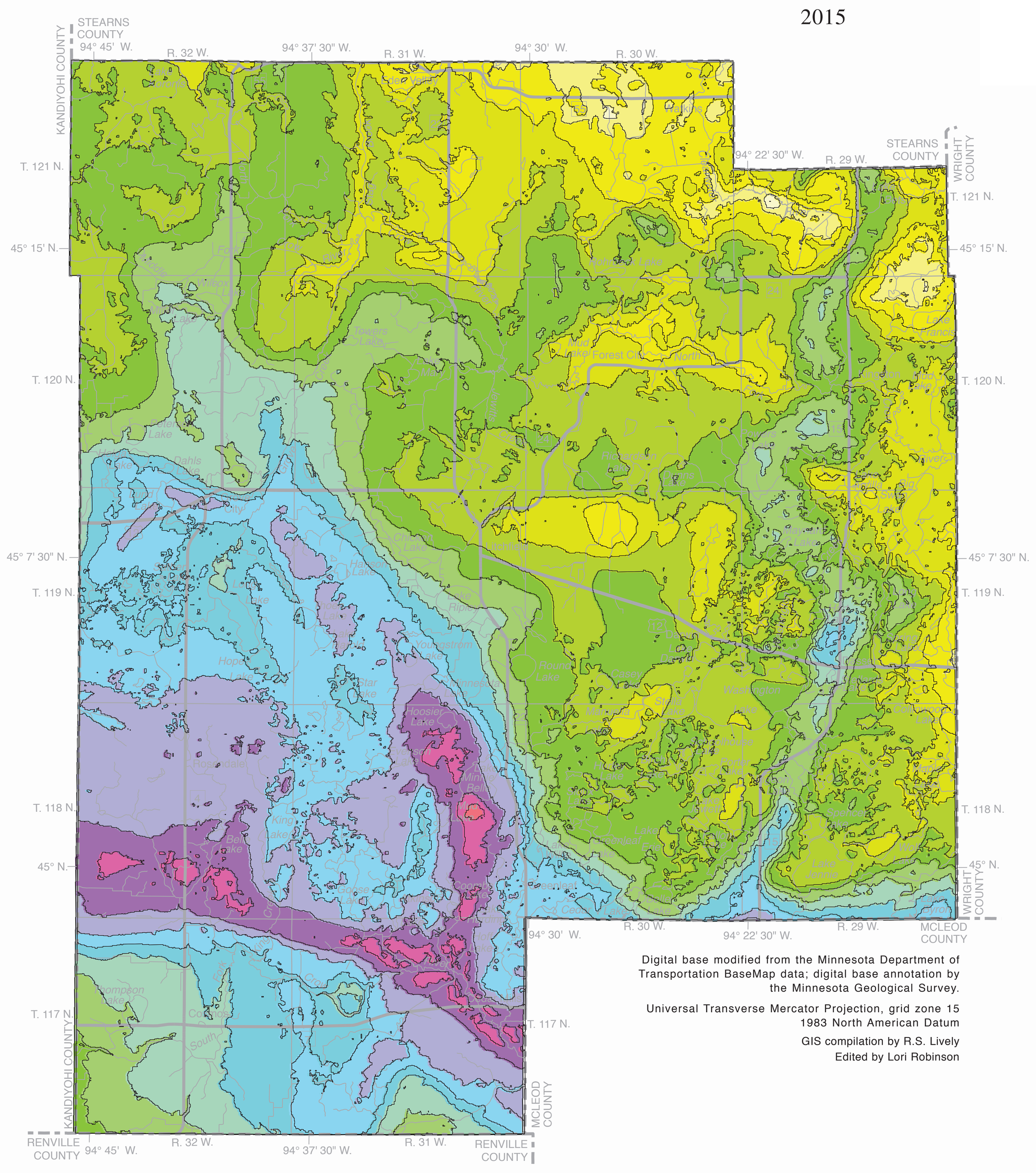
DEPTH TO BEDROCK

By

Julia R. Steenberg

2015



EXPLANATION

The depth to bedrock 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 is taken from the Bedrock Topography map, which was interpolated from the interpretation of water-well data and seismic soundings. The residual grid was then classified at a 50-foot (15-meter) interval to produce the color-coded Depth to Bedrock map. In places the thickness of the unconsolidated Quaternary sediments varies greatly across short distances, and mapping at this scale (1:200,000) may not properly resolve such prominent variations. For that reason it is best to consult site-specific data, such as water-well records and seismic soundings, wherever they are available.

The thickest sediments in Meeker County occur within the deep bedrock valleys near Cedar Mills, where there is nearly 700 feet (213 meters) of sediment overlying the bedrock. Areas where bedrock is at or within 50 feet (30 meters) of the land surface occur in the northeast near Eden Valley, where the Cretaceous bedrock is near the surface. The detailed appearance of the Depth to Bedrock map is related to surficial landforms because the land surface topography model is based on much more detail than the model of the bedrock surface.

Depth in feet from the land surface to the bedrock surface

0-50
51-100
101-150
151-200
201-250
251-300
301-350
351-400
401-450
451-500
501-550
551-600
601-650
651-700

SAND DISTRIBUTION MODEL

By

Gary N. Meyer and Jacqueline D. Hamilton

2015

INTRODUCTION

The Quaternary sand and gravel deposits of Minnesota are products of a 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 Meeker 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 three-dimensional models relate 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.

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 describes the vertical sequence of earth materials at one location. It falls to the geologist 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 to support accurate mapping of those features. In a similar manner, bodies of sand and gravel that occur at greater depths are typically not intersected by as 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 Meeker County vary greatly in character and thickness. These deposits are largely the result of many distinct glacial ice advances during the Pleistocene Epoch (Plate 4, Fig. 2), and most of the Quaternary aquifers within Meeker County consist of sand and gravel beds laid down by meltwater that flowed from these glaciers, forming deposits along rivers and in lakes. 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 (aquitards) that enclose the aquifers. The till layers left by each ice sheet tend to be more laterally persistent than the sand layers because ice typically spread across the entire county, whereas meltwater streams that deposited the sand and gravel were generally confined to drainages at the lower elevations of the evolving landscape. Sand and gravel may be deposited by both an advancing glacier and a retreating glacier of the same cycle, 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; Fig. 1). This differs from some previously published models in which the sand and gravel bodies were associated with the overlying till units. Unit designations, therefore, cannot be transferred from model to model without first taking into account their relative stratigraphic positions.

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 take the place of 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 Meeker County tend to be discontinuous. Over relatively short distances in most directions, the extent and thickness of any given aquifer is difficult to predict. In order to address this condition, 50 closely spaced (0.6 mile [1 kilometer]) cross section lines were generated in a west–east direction (see Plate 4, Fig. 1). Along these lines, water well records, records of scientific and engineering test holes, and descriptions of outcrops (mainly from within gravel pits and along the North Fork of the Crow River; Plate 1) were used by a geologist to identify contacts between units in the subsurface. The results from the cross section analysis were compiled digitally into grids of top and bottom surfaces and grid thicknesses for each interpreted unit of till and sand. Final interpretations along five of these cross sections are shown on Plate 4, *Quaternary Stratigraphy*.

Till is generally described as "clay" by well drillers. Although sand and gravel beds can occur within a till, they occur more commonly and tend to be thicker and more continuous 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 can sometimes be recognized by a change in the driller's description of the clay's texture (for example, clay/sandy clay/clay and gravel), 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 gridded elevation surface representing 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 grids representing the base of each unit were final, they were processed through GIS raster calculations to create top and bottom surfaces and a thickness for each geologic 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 9. 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 the extent and thickness, as well as factors such as sediment coarseness, degree of sorting, and consolidation. In many places two or more of these sand units form a single aquifer where they are juxtaposed with no intervening till layer (see cross sections on Plate 4).

Sand beds above and below till of the Hewitt Formation (units *hs* and *scs*; Figs. 4, 5), generally at depths of 50 to 150 feet (15 to 46 meters), are the most extensive aquifers within Meeker County, but are absent or thin in many areas. Younger, shallower aquifers are present in places (Figs. 2, 3), but in many areas older and deeper sands (Figs. 6, 7, 8, 9) must be utilized because they are the only practicable aquifers. Data from less extensive sand bodies, as well as from the till/fine-grained lake sediment bodies that were created in the geologic model, are not shown on this plate, but are provided with the digital files for this atlas.

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 underreport sand body thickness. As a result, some of the sands shown on the cross section (but not necessarily on the final sand distribution map) may be thicker and more widespread than they are portrayed. At increasing depths in the stratigraphic section, data availability diminishes and delineated sand bodies could be more or less continuous than shown. Note that the east–west linearity of some sand bodies may be the product of modelling along east–west cross-section lines.

In much of Meeker County water wells do not extend through the full thickness of the Quaternary deposits. The cross sections indicate that the characteristics of deeper deposits cannot be differentiated in many places (Fig. 10). However, where deep drill holes occur locally, thicker sands are commonly present. Additional sand bodies, or extensions of those mapped, are undoubtedly present in these undifferentiated parts of the Quaternary 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 Meeker County. However, given the limits of the data, as noted above, the model should be used as a guide and should not preclude site-specific investigations or inspection of individual well logs.

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CONTOURS FOR FIGURES 2 THROUGH 9

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

20
40
60
80
100
120 and greater

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

DEPTH FOR FIGURES 2 THROUGH 10

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 10).

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

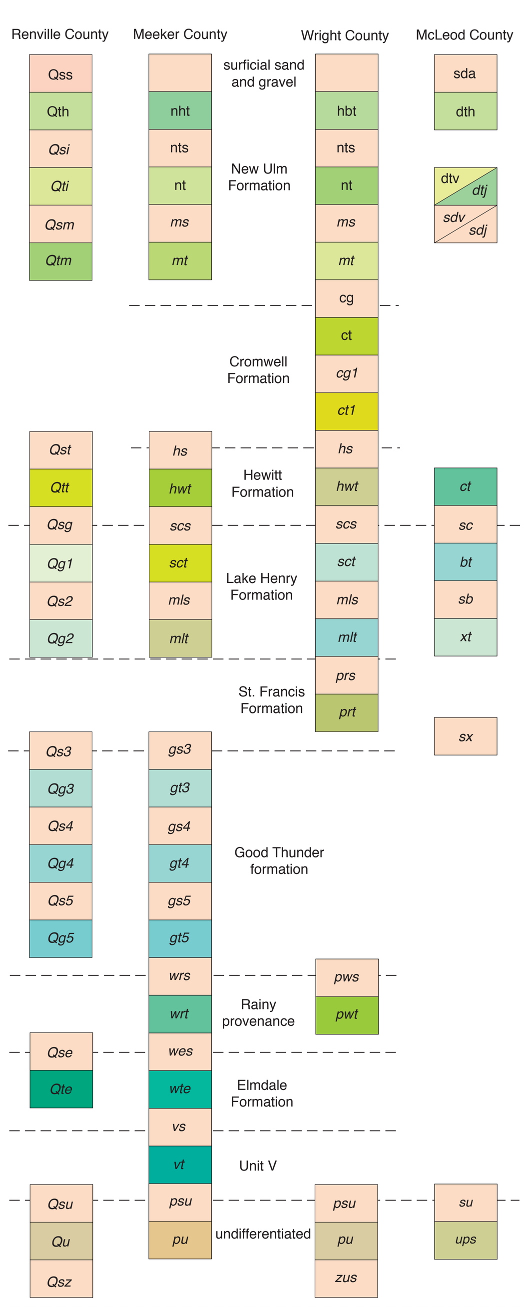

Figure 1. Stratigraphic position of sand and gravel bodies shown on the sand distribution diagrams (Figs. 2 through 9) compared with equivalent units mapped in surrounding counties (Lusardi and Lively, 2009; Knaeble and others, 2013a, b). Unit *pwt* in Wright County includes till of the Elmdale Formation (unit *wte* of Meeker County). Unit *ct* in McLeod County includes till of the Moland Member of the New Ulm Formation (unit *mt* of Meeker County), and unit *xt* in McLeod County likely includes till of the Good Thunder formation (units *gt3* and *gt4* of Meeker County).

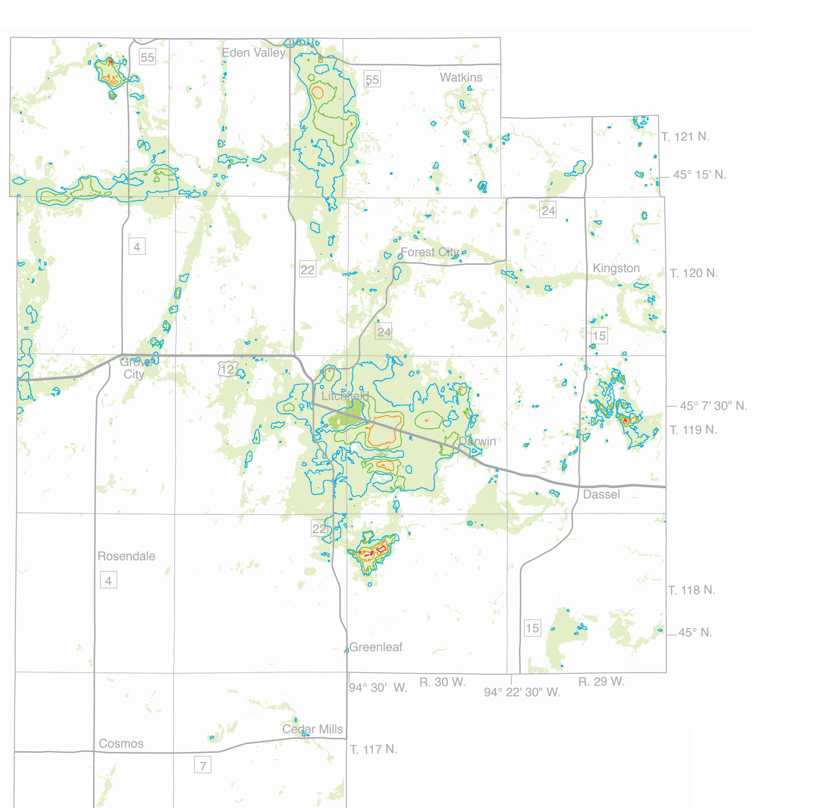

Figure 2. Surficial sand and gravel—Model-generated map showing the extent and thickness of sand and gravel bodies occurring at the land surface or below generally thin, fine-grained sediment in Meeker County. The sand and gravel bodies include units al, ls, eo, ng, ns, nlg, nd, ni, and hwi from Plate 3, *Surficial Geology*. The surficial aquifer of the county is the portion of these sand bodies that is below the water table (except for areas where the fine-grained sediment cover exceeds 10 feet [3 meters]).

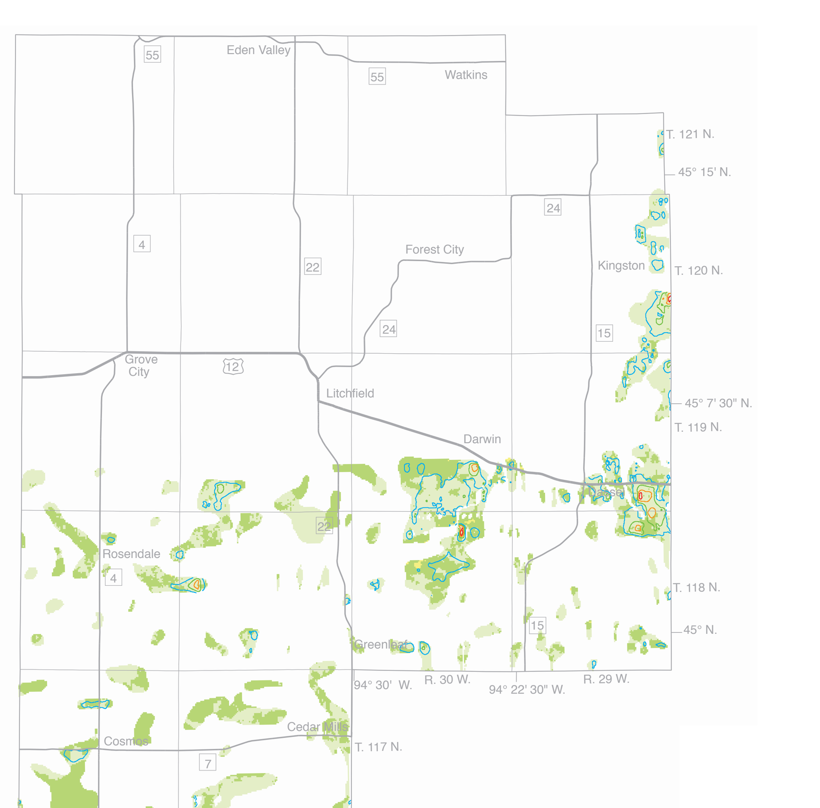

Figure 3. *ms* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies stratigraphically immediately above till unit *mt*. Mostly fluvial sediment, deposited by meltwater of the Des Moines lobe.

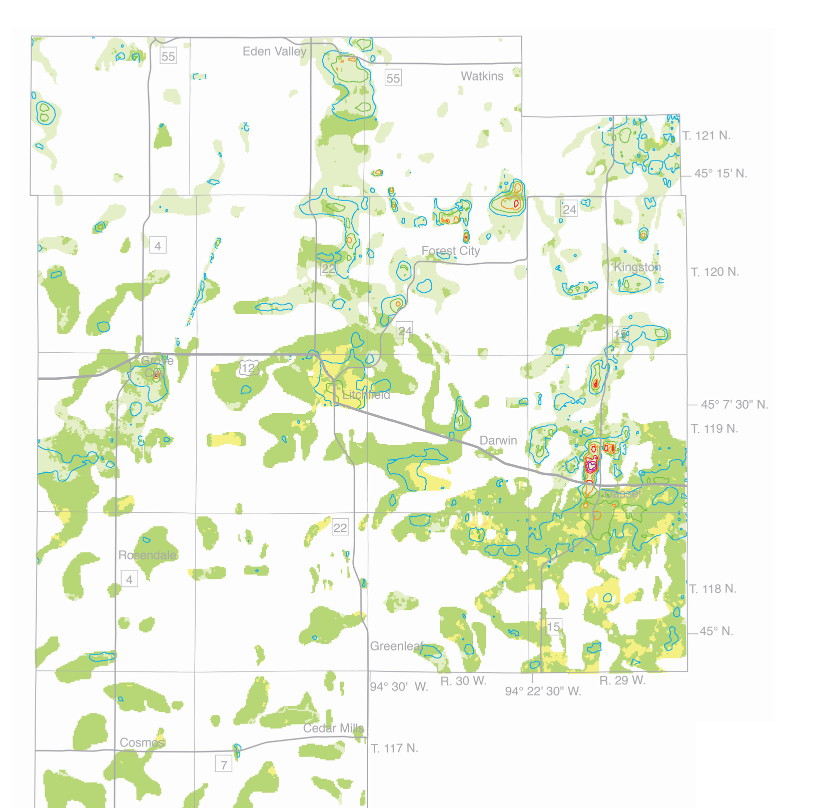

Figure 4. *hs* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies stratigraphically immediately above till unit *hwt*. Mostly fluvial sediment, deposited by meltwater of the Des Moines and/or Wadena lobes.

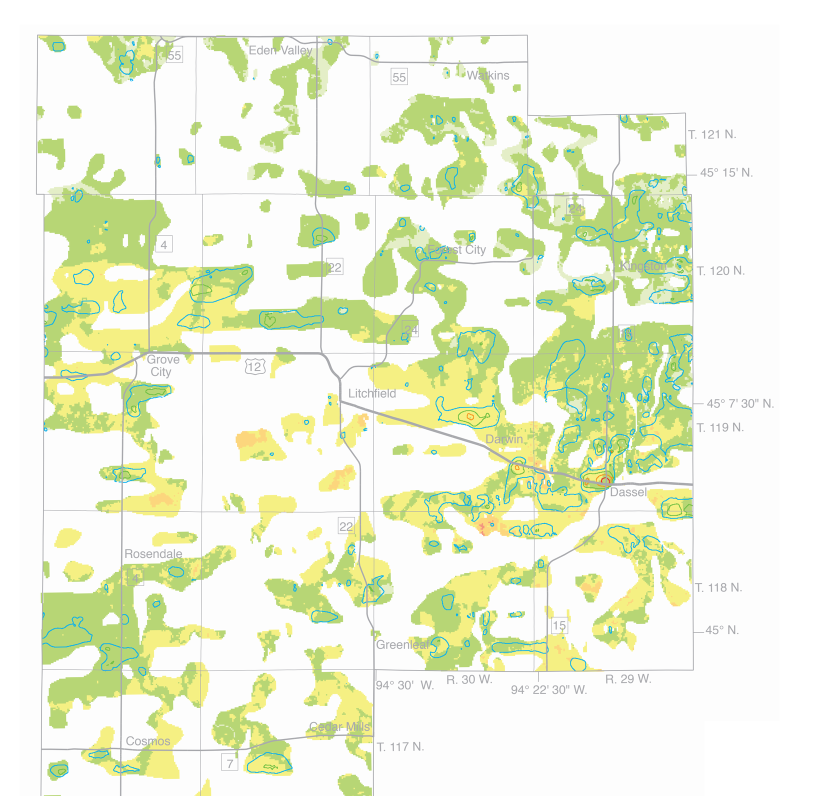

Figure 5. *scs* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies stratigraphically immediately above till unit *sct*. Mostly proglacial outwash of the Wadena lobe, but includes sediment of Winnipeg and possibly Superior provenance.

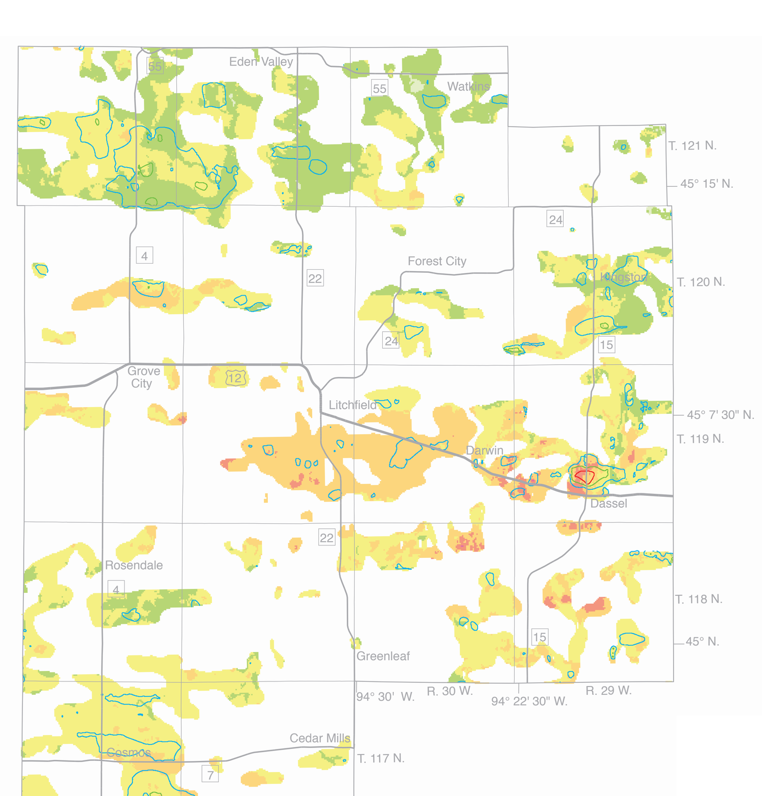

Figure 6. *mls* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies stratigraphically immediately above till unit *mlt*. Mostly Lake Henry Formation sediment, but includes some sediment of the St. Francis Formation.

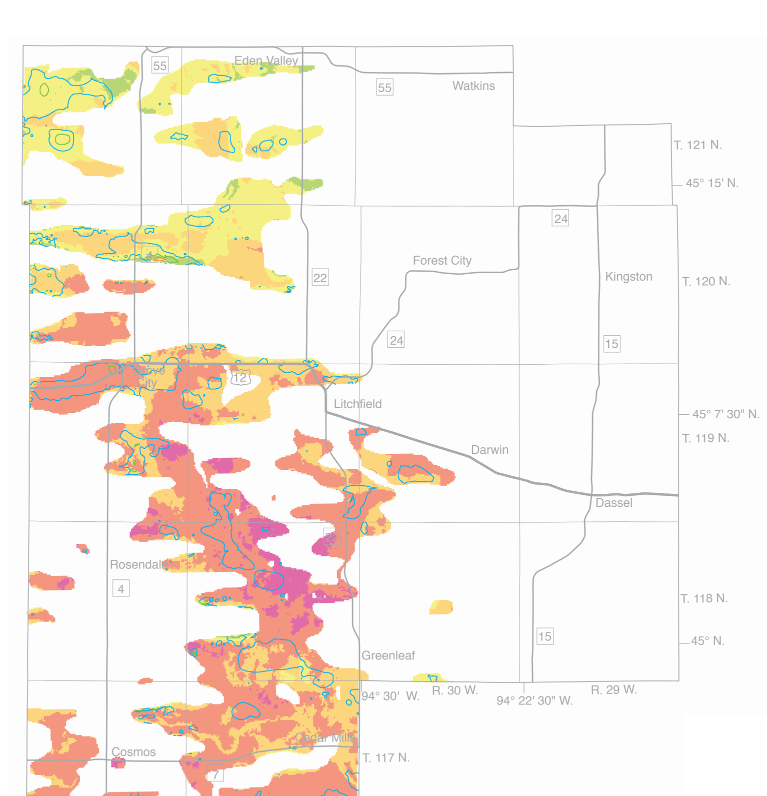

Figure 7. *gs4* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies stratigraphically immediately above till unit *gt4*. Mostly Winnipeg provenance sediment, but includes some Superior provenance sediment.

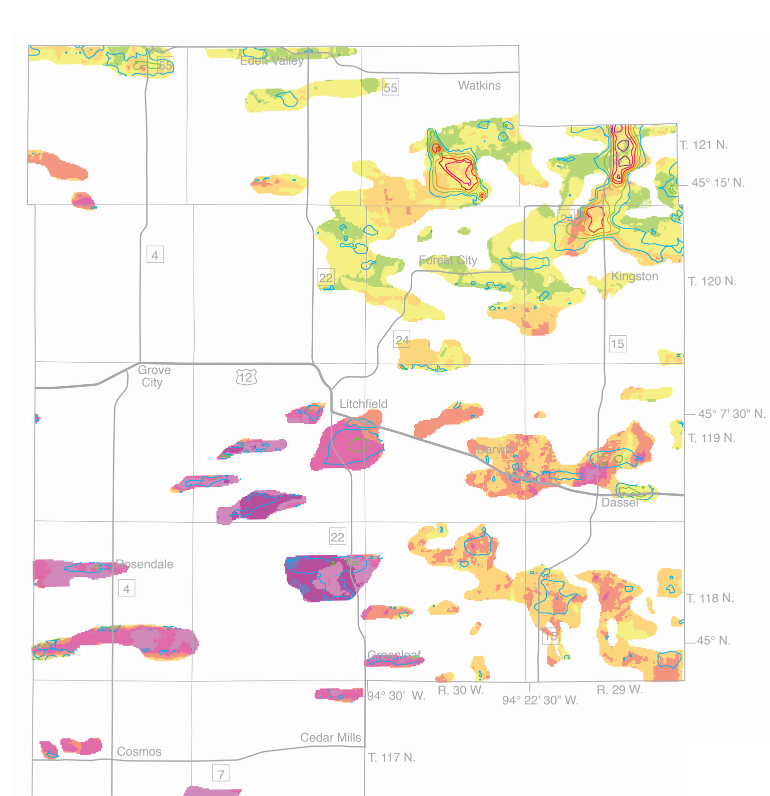

Figure 8. *wrs* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies stratigraphically immediately above till unit *wrt*. Includes Rainy, Winnipeg, and Superior provenance sediment.

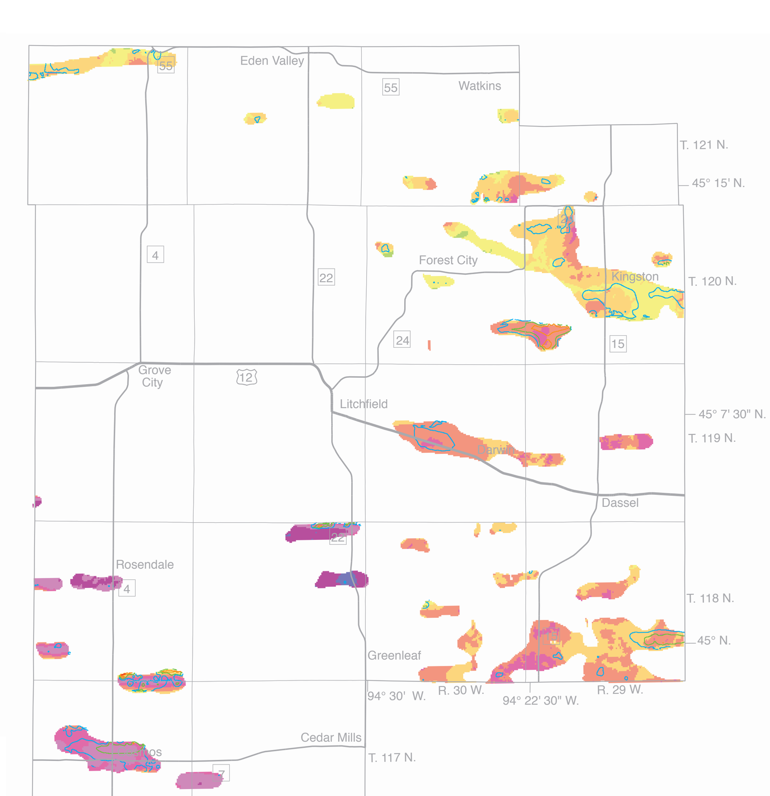

Figure 9. *wes* sand and gravel—Model-generated map of the extent, depth from the surface, and thickness of sand bodies stratigraphically immediately above till unit *wte*. Includes mostly Rainy and Winnipeg provenance sediment.

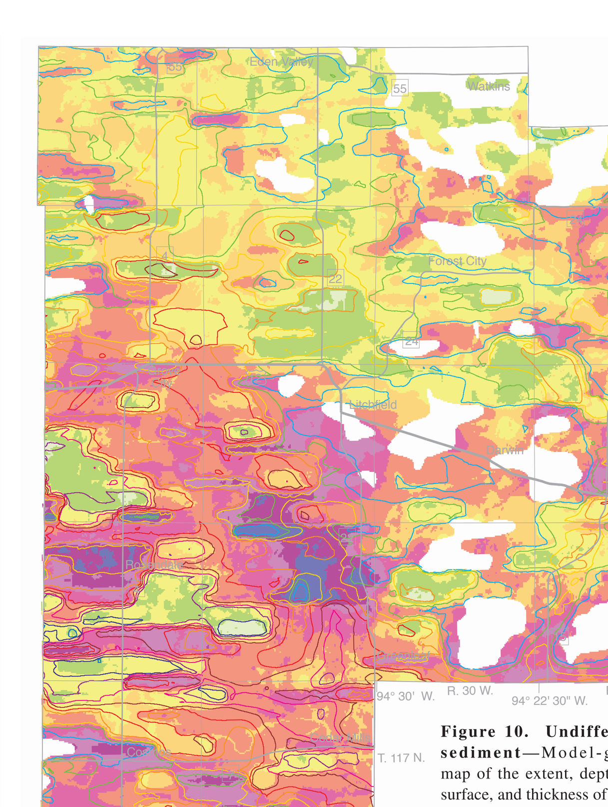

Figure 10. Undifferentiated sediment—Model-generated map of the extent, depth from the surface, and thickness of Quaternary sediment for which no descriptive data are available, contoured at 50-foot (15-meter) intervals.

CONTOURS FOR FIGURE 10

Thickness of undifferentiated sediment.

50
100
150
200
250
300
350
400
450
500