WATER FACT SHEET

U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

PREPARATION AND COMPARISON OF MAPS SHOWING THE DEPTH TO THE WATER TABLE, DAKOTA COUNTY, MINNESOTA

INTRODUCTION

Two techniques were used in the preparation of maps showing the depth to the water table in Dakota County, Minn. (fig. 1). One map was prepared using a traditional technique that requires hydrologic data interpretation. A second map was prepared using computer technique for interpolating water-level data obtained from well logs and hydrography. A third map was prepared to compare the depth-to-water-table maps prepared by the first two techniques.

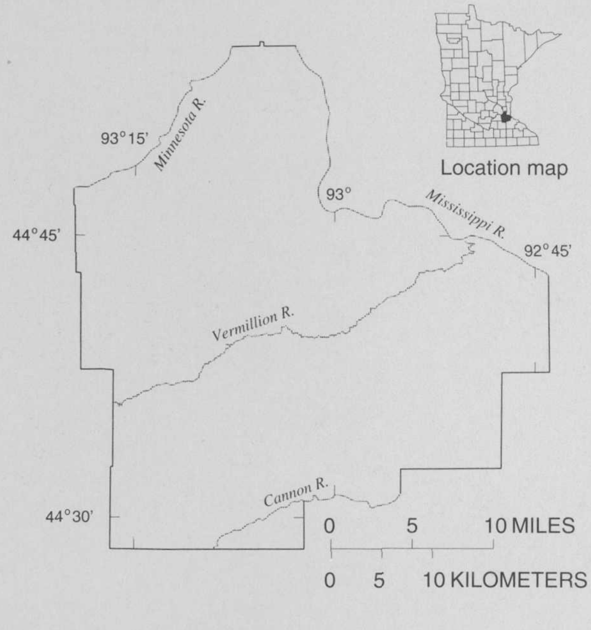

Figure 1.--*Location and hydrography of Dakota County*

GENERAL PREPARATION OF MAPS

In general, the preparation of maps showing depth to the water table is a multistep process. An initial step is the preparation of data to represent the elevation of the water-table surface. The water-table surface data are subtracted from land-surface elevation data to compute the depth to water table. Lines of equal depth to water are generated from the depth-to-water-table data and are used to prepare a map.

A geographic information system (GIS) can be used to automate map preparation and display, and to perform spatial-analysis operations. Spatial analysis involves integrating or comparing data from the same location. These data can include point data, such as wells; line data, such as rivers; discrete-area data, such as land use; or continuous area data, such as elevations. The spatial-analysis operations used in this study include generating a surface, overlaying elevation data onto a surface, and generating lines of equal depth from a surface.

The source of the land-surface elevation data is the 1-degree (1:250,000 scale) digital-elevation-model (DEM) data produced by the U.S. Army's Defense Mapping Agency using cartographic and photographic sources. The DEM data represent the land-surface elevation at a grid spacing of 3 arc-seconds, which, for Dakota County, is a spacing of about 305 feet in a north-south direction and 215 feet in an east-west direction.

The accuracy of a DEM is dependent on its source and spatial resolution of the data points. The source determines the degree of accuracy of the data with respect to the actual land surface and level of content that can be extracted. The source of the DEM is a 1:250,000-scale topographic map. The term "spatial resolution" refers to the distance between data points. The DEM produces a land surface that is smoother than the actual land surface because topographic features smaller than the spatial resolution are not reflected in the data.

The accuracy of the DEM is described by horizontal and vertical components. Horizontal accuracy refers to the error in the distance from a data point at the stated elevation to a point that is actually at that elevation. Vertical accuracy refers to the error in the elevation at that data point. Both components are dependent on the quality of the source and the processing procedures used in converting topographic data to the DEM format.

The stated accuracy of the 1:250,000-scale DEM data is a horizontal accuracy of 426 feet (circular error at 90 percent probability) and a vertical accuracy of ± 98 feet (linear accuracy at 90 percent probability). The vertical accuracy of the DEM data was checked against the topographic data portrayed on the 1:24,000-scale Cannon Falls topographic map. One hundred thirteen points on topographic contours were digitized and tested against the DEM data. The vertical accuracy was determined to be ± 39 feet. There was an 11-foot bias between the DEM data and the selected data.

The DEM data were used as the land surface for both map-preparation techniques. The depths to the water table for two of the maps presented in this report (figs. 2 and 3) were obtained by subtracting the elevation of the water-table surface from the elevation of the DEM-generated land surface.

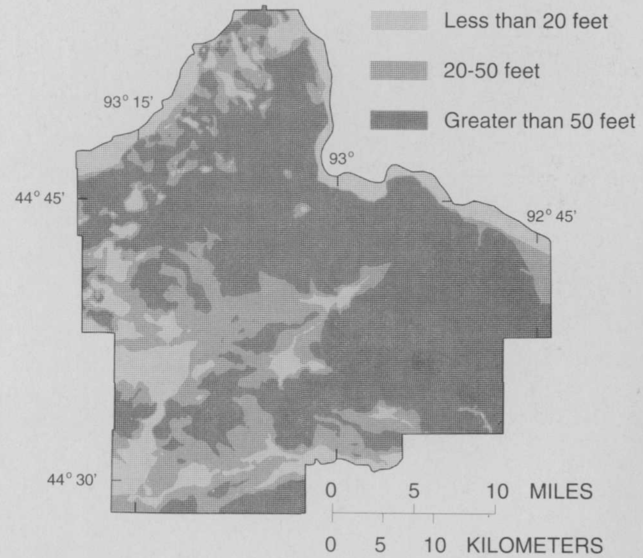

Figure 2.--*Depth to water table based on hydrologic interpretation (traditional technique) and digital elevation model data*

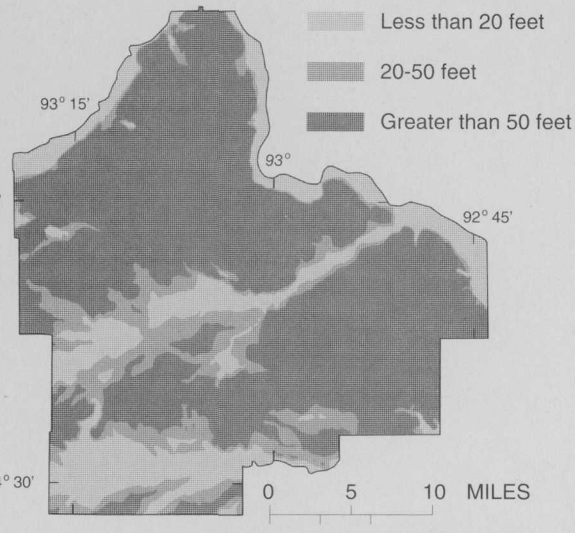

Figure 3.--*Depth to water table based on well log data and hydrography (computer technique) and digital elevation model data*

HYDROLOGIC INTERPRETATION (TRADITIONAL TECHNIQUE)

A water-table map of Dakota County was prepared by Palen (1990). The map was prepared using water-level data obtained from 67 well records, 55 soil borings (located mostly in the northern part of the county), and 9 observation wells. Water levels in lakes also were used where the elevation of the water level in a lake was not substantially different from the elevation of the water table in nearby wells. The static water levels in the wells and soil borings and the selected lake levels were used as control points by B. M. Palen (1990) of the Minnesota Geological Survey when she drew the water-table contours. Palen also adjusted the water-table elevation based on land-surface features.

Water-table elevations were digitally recorded from the water-table contours on the map prepared by Palen. The map scale is 1:126,720. The recorded contour interval is 25 feet below an elevation of 900 feet and 50 feet above an elevation of 900 feet. Data points along the water-table contours were selected digitally every 1,640 feet to construct a water-table surface with the GIS. The depth-to-water-table map shown in figure 2 is the result of subtracting water-table elevations from land-surface elevation (DEM data).

WELL-LOG DATA AND HYDROGRAPHY (COMPUTER TECHNIQUE)

The Minnesota Geological Survey maintains a data base called WELLS that contains well information for the State. The WELLS data base contains 23,879 records of wells in Dakota and adjacent counties as of October 1, 1989. A subset of 7,906 well records which included information that clearly indicated that the wells were completed in glacial drift and for which valid depth-to-water and land-surface elevations were available, were used. From this subset, a final subset of 1,042 wells in and near Dakota County were selected to define the depth to the water table.

The locations of wells in the WELLS data base are based on the U.S. Bureau of Land Management's system of land subdivision (township, range and section). A conversion program computes the location only to the center of a 40-acre area. There were many instances where well locations were the same. The water-table elevation data for these wells were aggregated and the average water-table elevation was used. The mean of the ranges of water-table elevations at the locations where the data was aggregated was 34 feet. The aggregation procedure resulted in 513 data points from the final subset of 1,042 wells.

The original intent was to not use water-level data for unusually wet or dry years. The range of water levels within an individual year, however, was generally similar to the range of water-level data at the locations where water levels were aggregated. Therefore, no attempt was made to remove water-level data for wet or dry years from the data base.

To include additional hydrologic information with the data from the WELLS data base, the streams shown on a 1:2,000,000-scale digital base map were overlaid onto the 1:250,000 scale DEM data and water-surface elevations were determined at 3,280-foot intervals along the stream. The addition of the stream data to the aggregated well data resulted in a final data set containing 717 data points. These data points were used to construct a water-table surface for analysis using the (GIS). The map shown in figure 3 is the result of subtracting the water-table elevations from land-surface elevation (DEM) data to define the depth to the water table.

COMPARISON OF MAPS

The absolute value of the differences between the two depth-to-water-table maps is shown in figure 4. The actual differences range from +193 feet to -201 feet. The area of greatest spatial variability between the maps is the northern part of the county, where the terrain is hilly and layers of till can separate lakes and streams from the uppermost outwash aquifers. The region of least spatial variability is the southern part of the county where the terrain is almost flat and the water table is close to the land surface.

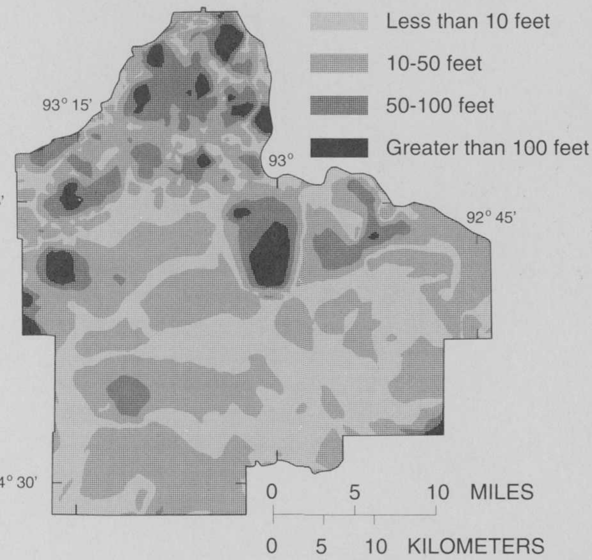

Figure 4.--*Difference in depth to water between figure 2 and figure 3*

Along part of the Vermillion River, in eastern Dakota County, the river is about 100 feet above the water table. The area is shown by the 50-100 feet area along the river in figure 4 and demonstrates one of the problems with the assumptions of the computer-generated water-table surface--major rivers do not always define the surface of the water table.

The water level in several wells was measured during winter 1989-90. The depth to water in these wells was compared with the depth to water for the same location for each of the maps. The measured depth to water averaged 25 feet less than that indicated by figure 2 and 31 feet less than that indicated by figure 3. Measurements of the depth to water ranged from 75 feet less to 145 feet more than the mapped depths to water.

CONCLUSIONS

The time needed to prepare a depth-to-water-table map from existing data using the computer technique is much less than that needed to prepare a depth-to-water-table map using hydrologic interpretation (traditional technique). However, the map prepared using the computer technique is not as accurate as that prepared by the traditional technique. The accuracy of the depth-to-water-table map prepared using the traditional technique is about the same as that of the land-surface (DEM) data. The spatial variability in the water-table surface has a large affect on the agreement between the results from the computer technique and the traditional technique.

SELECTED REFERENCES

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U.S. Geological Survey, 1987, Digital elevation models data users guide 5, Reston, Va. 38 p.

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