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Water-table map of Dane County

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WOFR 95-01

INTRODUCTION

These maps are the results of cooperative funding provided to the Wisconsin Geological and Natural History Survey and United States Geological Survey from the Dane County Regional Planning Commission, City of Middleton, and Madison Metropolitan Sewer District. These maps were created as part of the Dane County Hydrologic Study, a study designed to compile and interpret hydrogeologic data for Dane County in order to better assess water resources issues. These water table maps are a small part of the total hydrologic study. The water table maps can be used as baseline information for future groundwater studies, and by local planners, environmental consultants and developers.

SOURCES OF DATA

These maps were constructed using existing water-well elevations available from

- Wisconsin Department of Natural Resources well constructor's reports (1936-1991),
- Wisconsin Geological and Natural History Survey published and unpublished geologic logs (1874-1991),
- Wisconsin Geological and Natural History Survey Open File Report WOFR 92-1, Water Table Map of the Upper Black Earth Creek Watershed,
- Wisconsin Department of Natural Resources monitoring-well data,
- Selected surface-water elevations from United States Geological Survey quadrangles 97.5-minute series, topographic; 1969-82).

THE WATER CYCLE

Gravity and solar energy play active roles in a continuous water recycling process called the *water cycle* (fig. 1)

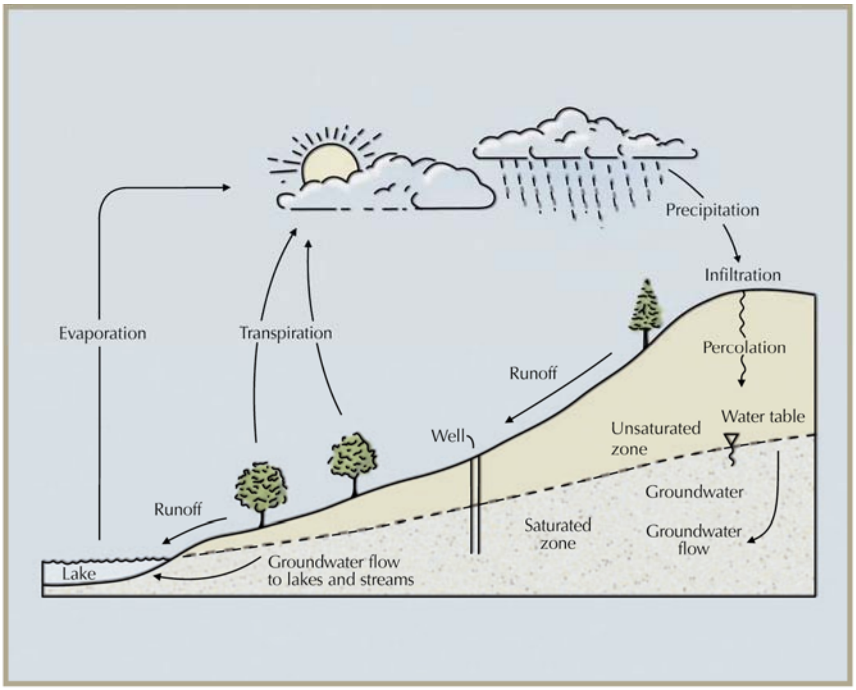


Figure 1. The water cycle.

Water falling on the land surface can flow downhill as overland runoff, evaporate, transpire through plants, or infiltrate into the ground. As this infiltrating water seeps downward through rock or soil, it travels through pore spaces and open cracks or fractures in the subsurface material. When these pores and cracks are completely filled with water, the material is said to be *saturated*.

The *water table* marks the top of this saturated zone, where hydraulic pressure in the pores is equal to atmospheric pressure. *Groundwater* is the water contained in the saturated zone below the water table. The amount of infiltrating precipitation partly determines the position, or elevation, of the water table, which fluctuates seasonally, and from one year to another. Above the water table, pores and cracks are partly or completely filled with air and partly filled with water, and the material is said to be *unsaturated*.

Groundwater, under the influence of gravity, moves slowly through pore spaces, eventually discharging to the land surface, to a well, or to a water body. Solar energy causes some water to evaporate, thus returning it to the atmosphere and continuing the water cycle.

In Wisconsin, the water cycle generally operates with 30 to 32 inches of precipitation during an average year, from which about 75 percent (22 to 26 inches) returns to the atmosphere by evapotranspiration. The remainder either flows over the land surface and collects in surface-water bodies or infiltrates into the ground as *recharge* to the groundwater system. The ratio of overland runoff to groundwater recharge varies considerably around the state, depending upon factors such as topography, soil type, vegetative cover, rainfall intensity, and individual farming and general land-use practices.

<u>Movement of Groundwater</u>

A saturated subsurface material that yields sufficient water to a well is called an *aquifer*. *Hydraulic conductivity* is a measure of the relative ease with which water can flow through an aquifer; it is dependent on the nature of the material through which the water is flowing. Large pores or fractures can hold more water than small ones, but in order for water to flow effectively, these pores or fractures must be interconnected.

Groundwater can move as rapidly as several feet per day in porous sand and sandstone, or as slowly as a few inches per year in clay or in unfractured shaley rock. For example, sandy soil and sandstone frequently have relatively large pore spaces that are well connected with each other, allowing water to move more easily than it can in clayey soil that has small, poorly connected pores. Rocks such as shale have low permeability except where they are fractured. If the fractures are well-connected these rocks can transmit water easily; however, if there are just a few poorly-connected fractures, these rocks transmit little water.

No matter how rapidly or slowly the groundwater flows, its natural direction of movement is in response to gravity, from upland recharge areas (where water infiltrates into the subsurface) to lowland discharge areas (lakes, rivers, springs, and seeps). Many surface-water bodies are groundwater discharge areas, so groundwater quality has a significant impact on the water quality of lakes, streams, and wetlands. Pumping wells are man-made groundwater-discharge points.

A groundwater divide is a ridge defined by contours of the water table. Shallow groundwater moves radially away from the divide. The location of groundwater divides is uncertain because they are defined with less precise data. The groundwater divide between the Upper Black Earth Creek/Wisconsin River Basin and the Yahara Lakes Basin was primarily determined from shallow piezometer data obtained from DNR monitoring records (HydroSearch, 1991) and two additional piezometers installed by WGNHS. The remaining groundwater divides separating the Black Earth Creek Basin from the Sugar River Basin, and the Koshkonong River Basin from the Yahara Lakes, were determined using water levels in domestic wells.

DATA COMPILATION

<u>Locations</u>
Data were compiled at a scale of 1:24,000, using U.S. Geological Survey quadrangles (7.5-minute series, topographic) as base maps. Quadrangle locations are shown in Figure 2 (at end of report). All available Wisconsin Geological and Natural History Survey geologic logs were plotted onto these base maps. The Wisconsin Department of Natural Resources well constructor's reports were examined and checked against historical plat books, U.S. Geological Survey ortho-photographs (1987), and maps of subdivision plots in order to determine locations. For some areas, particularly newer subdivisions, the locations of the wells were field checked before they were plotted onto the base maps. Over 4000 well construction reports and geologic logs were plotted. Data density varies across the county, with fewer data points in the rural portions of the county and more data points in urban areas. Map accuracy increases in areas of higher data density.

<u>Elevations</u>
Elevations of the wells were determined from U.S. Geological Survey quadrangle maps and the depth to water reported on the constructor's report or geologic log was used to calculate a water-level elevation. The topographic contour interval on the base map's 10 ft; therefore, elevations determined from the maps are assumed to be accurate to within ± ½ the contour interval. In some cases, the "map elevations" did not seem to provide realistic water-level elevations. For those wells, the elevations were field-measured using an altimeter. Altimeter measurements are accurate to within ± 3 feet. The elevations of approximately 150 wells were measured with the altimeter.

<u>Database</u>
After plotting the data, the locations were digitized and the information from the well constructor's report, or geologic log, was entered into a database.

DATA INTERPRETATION

Using existing file data, such as surface-water elevations and water elevations in domestic wells, to construct water-table maps requires certain assumptions.

<u>Surface-Water Elevations</u>
Using surface-water elevations as data points for a water-table map assumes that the surface-water bodies are accurate representations of the water table. Without detailed field

investigations, it is difficult to test this assumption. Over most of the map area, this assumption seemed valid; there were a few areas where water levels in several wells were lower than nearby surface-water elevations. In those areas, the surface-water elevations were not used as data points and the water-table contours do not correspond to the surface-water elevations.

<u>Water Levels in Wells</u>
In order to use water elevations in domestic wells as data points for a water-table map, one must assume that vertical hydraulic gradients are negligible. This assumption is necessary because most domestic wells are open over long intervals and are completed far below the top of the saturated zone. In order to evaluate whether vertical gradients were significant, the elevation of the open interval for each well was determined. Over much of the area, wells completed at very different depths had similar water levels; however, in some areas, vertical gradients seemed significant. In those areas, the wells with shallow open intervals were assumed to provide the closest estimate of the elevation of the water-table and data from the deeper wells were not used.

The areas of significant downward hydraulic gradients are typically the recharge areas of groundwater flow systems and the areas where groundwater divides occur. As noted above, domestic wells are not ideal measuring points for determining the elevation of the water table in these areas; as a result, the final maps represent an interpretation of the existing data, not exact maps of the water-table surface.

LIMITATIONS OF THE MAPS

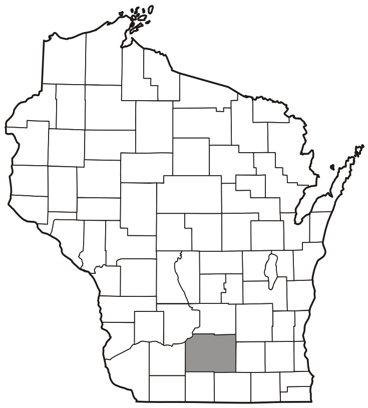
These maps depict, in a general way, the direction of shallow groundwater flow, which is assumed to be perpendicular to lines of equal potentiometric-surface elevation. The accuracy of the interpretation varies throughout the study are, increasing with greater data density. The contour lines are solid where enough data are available to locate the lines with a reasonable degree of confidence (within ± 0.25 mile on the maps). The lines are dashed where data are less abundant or where hydrogeologic conditions are more complex and their locations are considered to be accurate to within ± 0.5 mile on the maps.

It was beyond the resources of this study to field-check the locations and water levels given on all of the Department of Natural Resources well constructor’s reports that were used to construct these maps. These maps are a summary of available water-level data for Dane County. The maps are intended for use at the scale of 1:24,000 and should *not* be considered definitive for site-specific applications.

REFERENCES

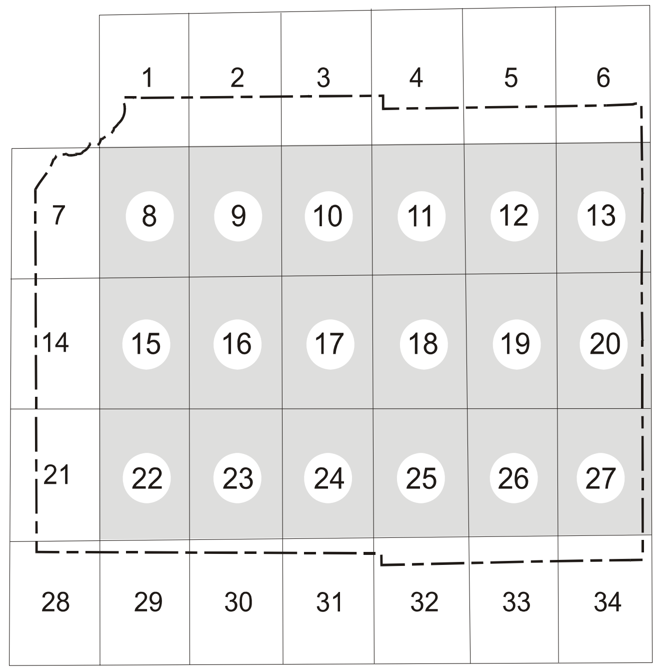
Bradbury, K.R. and McGrath, R.W., 1992. *Field Study of Atrazine Contamination of Groundwater in Dane County, Wisconsin*: Final Administrative Report to Wisconsin Department of Agriculture, Trade and Consumer Protection and Wisconsin Department of Natural Resources in fulfillment of contract No. 133-P531. Wisconsin Geological and Natural history Survey, 71 p.

HydroSearch, 1991. *Ground-water Monitoring Study at the Refuse Hideaway Landfill, Middleton, Wisconsin, Volumes I & II.* Submitted to the Wisconsin Department of Natural Resources, 6/24/91.



Location of Dane County

Index to 1:24 000 scale maps



1 Sauk City–1975
2 Lodi–1975
3 Arlington–1984
4 Morrisonville–1984
5 North Bristol–1980
6 Columbus–1980
7 Mazomanie–1962
8 Black Earth–1962 (82 PR)
9 Springfield Corners–1962 (69 PR)
10 Waunakee–1983
11 De Forest–1983
12 Sun Prairie–1962 (82 PR)
13 Marshall–1962 (71 PR)
14 Blue Mounds–1962
15 Cross Plains–1962 (82 PR)
16 Middleton–1983
17 Madison West–1983
18 Madison East–1983
19 Cottage Grove–1962 (82 PR)
20 Deerfield—1962 (71 PR)
21 Daleyville–1962
22 Mt. Vernon–1962
23 Verona–1962 (82 PR)
24 Oregon–1961 (82 PR)
25 Rutland–1961 (82 PR)
26 Stoughton–1961 (82 PR)
27 Rockdale–1961 (71 PR)
28 Blanchardville–1962
29 New Glarus–1962
30 Belleville–1962 (71 PR)
31 Attica–1961 (71 PR)
32 Evansville–1961 (71 PR)
33 Cooksville–1961 (71 PR)
34 Edgerton–1961 (71 PR)

PR Photorevised

Quadrangles included in this report

Figure 2. Index map of topographic quadrangles in Dane County.