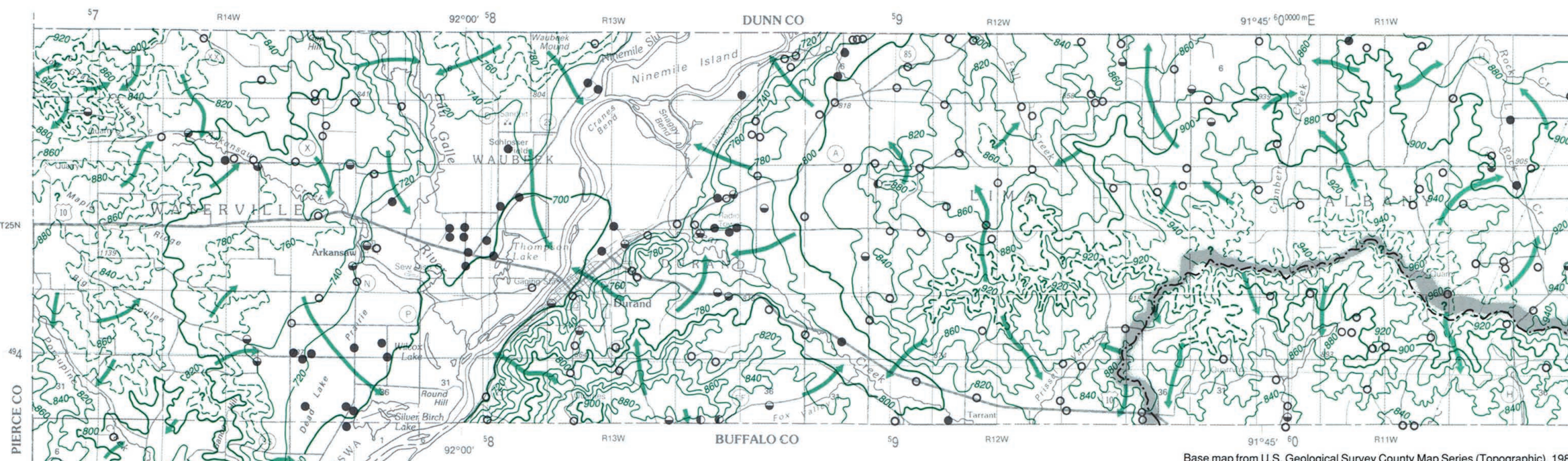
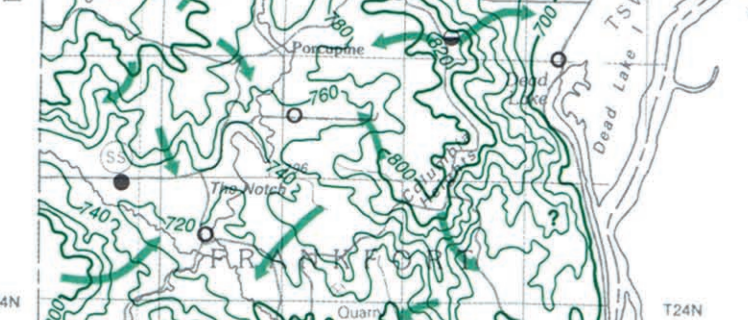
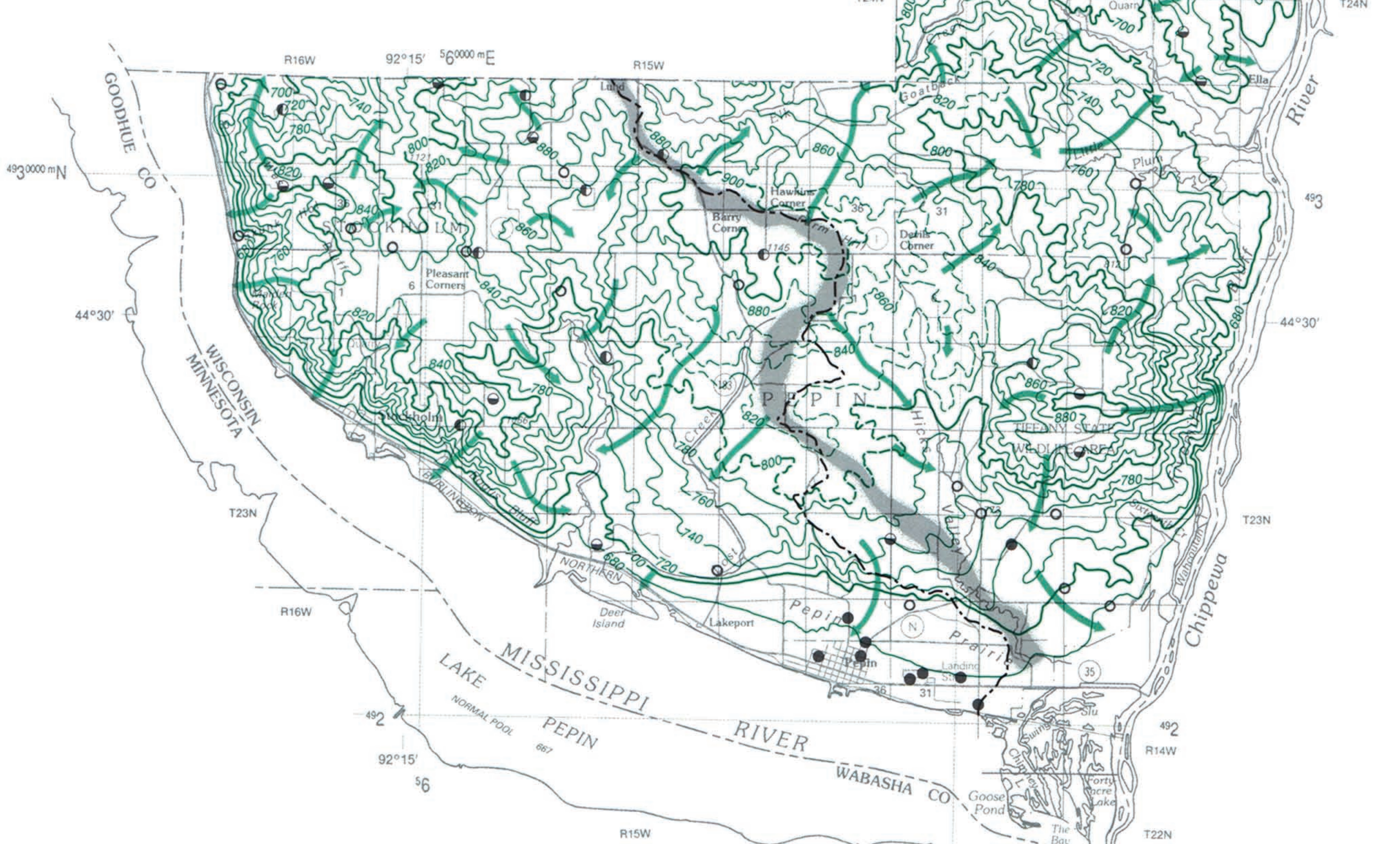
Generalized Water-Table Elevation Map of Pepin County, Wisconsin







Base map from U.S. Geological Survey County Map Series (Topographic), 1985.

UTM grid convergence (GN) and 1985 magnetic declination (MN) at center of map. Diagram is approximate.

Cartography by J.K. Erdahl, K. Campbell Roushar, and D.L. Patterson

Scale 1:100,000

KILOMETERS

MILES

M.A. Muldoon and D.M. Johnson, 1993

Miscellaneous Map 36

Sources of data

U.S. Geological Survey quadrangles (7.5-minute series, topographic; 1972-74), used to determine surface-water and well-water elevations.

Water-level observation wells from the Groundwater Level Monitoring Network operated and maintained by the U.S. Geological Survey and Wisconsin Geological and Natural History Survey.

Wisconsin Department of Natural Resources Well Constructor's Reports (1936-87).

Wisconsin Geological and Natural History Survey published and unpublished geologic logs (1896-1988).

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Explanation

840 — average elevation of water table in feet: 20-ft contour interval. Datum is mean sea level. Solid where considered accurate within ±0.3 mile on the land surface; dashed where considered accurate within ±0.7 mile on the land surface.

? — elevation of water table unknown; insufficient data

— · — surface-water divide

groundwater divide, approximately located

general direction of shallow groundwater flow

Geologic materials contributing water to well (All geologic information is taken from Department of Natural Resources Well Constructor's Reports on file at the Wisconsin Geological and Natural History Survey.)

- ○ sandstone
- ◐ limestone or limestone and sandstone
- ◒ shale or shale and sandstone
- ● sand and/or gravel

Data have not been field checked. Water-level elevation data were generalized from information collected over a period of approximately 50 years.

Introduction

This map is part of the Pepin County Groundwater Resource Investigation, a joint project of the Wisconsin Geological and Natural History Survey and the Pepin County Board. The purpose of this project was to compile and interpret hydrogeologic data for Pepin County. The resulting information can be used by those interested in soil- and water-resource and land-use planning.

The water cycle

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

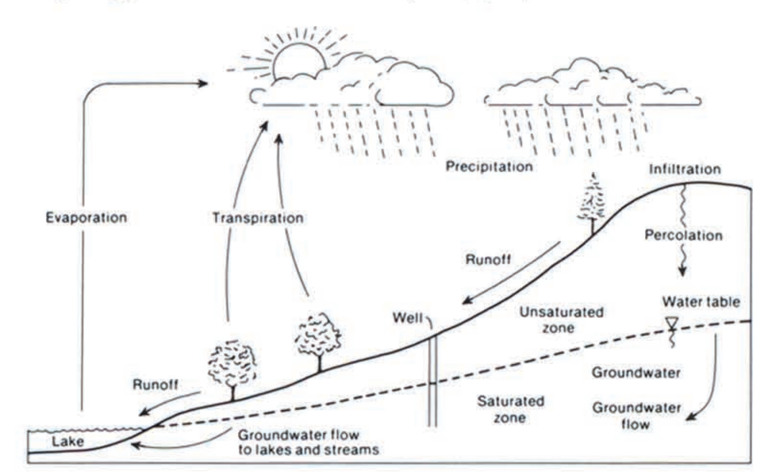

Figure 1. Schematic diagram of the water cycle.

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*.

Gravity moves groundwater through pore spaces; eventually, the groundwater discharges to the land surface, to a well, or to a water body where solar energy evaporates some of it into the atmosphere, thus 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.

Movement of groundwater and surface water

A saturated subsurface material that yields sufficient water to a well is called an *aquifer*. *Permeability* 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 inches per year in clay or in unfractured crystalline 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 crystalline granite commonly have few fractures that are poorly connected; as a result, they commonly have low permeability and transmit little water. However, 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. Wells are man-made groundwater-discharge points.

A *surface-water divide* is a line of separation, commonly a ridge or narrow tract of high ground that divides the surface waters that flow naturally into one basin from those that flow naturally into a different basin. There are two major surface-water divides in Pepin County. Most of the streams and rivers in Pepin County flow into the Chippewa River. However, in the westernmost part of the county, streams flow directly into the Mississippi River; in the southeastern part of the county, the surface waters flow southward into the Buffalo River.

A *groundwater divide* is similar to a surface-water divide, in that it is a ridge defined by contours of the water table. Shallow groundwater moves away from the divide in different (often opposite) directions. A groundwater divide does not necessarily coincide with a surface-water divide. However, the two groundwater divides in Pepin County approximately coincide with the surface-water divides. In much of central Pepin County, groundwater discharges to the Chippewa River and its tributaries. In the western part of the county, discharge areas include the Mississippi River as well as Bogus and Lost Creeks; these south-flowing streams are tributaries of the Mississippi River. In the southeastern corner of the county, Prissel Valley and other south-flowing tributaries of the Buffalo River are groundwater discharge areas.

Contamination of groundwater

Because groundwater originates from precipitation that percolates down from the land surface, any water-soluble material or liquid that is put on or in the ground has the potential to be transported to the saturated zone. The unsaturated zone can be a good natural filter and may remove many harmful materials from the recharging water by a variety of physical and biological processes. In general, fine-grained materials are better able to attenuate contaminants; as a result, areas with thin or sandy soils over a rock aquifer or thin or sandy soils with a shallow water table are especially susceptible to groundwater contamination. Once a contaminant reaches the saturated zone, it has the potential to move with the groundwater and discharge to wells or surface-water bodies. Concentration of contaminants in the saturated zone can be reduced by the processes of dilution, adsorption onto fine-grained particles, and chemical breakdown.

Contamination that occurs today may not become evident for several or even hundreds of years because groundwater can move as slowly as a few inches per year. Once contaminated, groundwater is difficult to purify and may take many years, decades, or centuries to be cleaned by dilution, attenuation, and chemical breakdown of contaminants.

Data compilation and interpretation

Data were compiled by Julie Gassen, Kim Cates, and D.M. Johnson at a scale of 1:24,000, using U.S. Geological Survey quadrangles (7.5-minute series, topographic) as base maps. 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 reports for a given area were compared with each other. Those judged to contain the most representative, reliable, and useful data available for each section were plotted. Data density across Pepin County ranges from the very few data points available in upland areas to at least one report per 1 to 2 square miles in the central and eastern parts of the county. A total of 252 well data points was used in constructing the water-table map.

Domestic wells are not ideal measuring points for determining water-table elevation. Most wells are open over long intervals and are completed far below the top of the saturated zone. Well Constructor's Reports for domestic wells provide good estimates of water-table elevation in areas where groundwater flow is more horizontal than vertical and poor estimates in areas where groundwater flow is more vertical than horizontal. To determine whether vertical groundwater flow was significant, we compared water levels for wells of different depths. In much of Pepin County, wells completed at different depths had similar water levels; however, in some areas (particularly upland recharge areas), vertical groundwater gradients seemed significant. In those areas, the well with the shallowest open interval was assumed to provide the closest estimate of the elevation of the water table, and data from the deeper wells were not used.

Well Constructor's Reports provide water-level measurements taken at different times of the year and in different years. Because of seasonal variations in water levels as well as changes in water levels with depth, a water level determined from a Well Constructor's Report was not used as an exact data point. Instead, the water level was considered to be part of a range of values. The elevations of springs, groundwater seepage areas (such as wetlands), lakes that intersect the water table, and rivers were used as data points in most areas.

Bedrock geology

The bedrock geology of Pepin County consists of Precambrian crystalline rock (commonly referred to as granite in Well Constructor's Reports) overlain by a thick sequence of Cambrian sandstone, shale, and Ordovician dolomite (Young and Hindall, 1972). Precambrian rock does not occur at the land surface in Pepin County; however, a few deep wells encounter it. Bedrock is within 10 feet of the land surface in much of Pepin County. The Cambrian sandstone and shale occur in much of central and eastern Pepin County. Upland areas in the western part of the county are capped by Ordovician dolomite (commonly referred to as limestone in Well Constructor's Reports) as are a few hills in the eastern part of the county.

During the most recent Ice Age (which began about 2 million years ago), glaciers flowed into Pepin County and then melted back several times. At some times, glaciers covered all but the southeastern corner of Pepin County. Glacial deposits (thin in most places) consist of till deposited prior to the most recent ice advance. These deposits have been eroded from much of the county and evidence of these early glaciations is sparse except in the northwestern part of Pepin County. The latest advance of the glaciers into Wisconsin (approximately 26,000 to 10,000 years ago) reached only as far as Chippewa County and did not reach Pepin County. However, water from the melting ice followed the Chippewa River drainage and deposited a thick sequence of sand and gravel. Silt-sized particles were also carried by the glacial meltwater. Some of these particles were deposited on river banks and bars and later picked up by the wind and deposited across the landscape. These deposits, called loess, cover much of Pepin County (Cates and Madison, 1990).

Although the geology is complex, the water table closely mimics topography. At the scale of this water-table map (1:100,000), the shallow groundwater system appears to be a single unconfined aquifer.

Many wells in Pepin County are completed in sandstone (60%) or a mixture of sandstone and shale (16%). The sand and gravel aquifer is used in places (20% of the wells), and some wells are completed in limestone or limestone and sandstone (4%).

Limitations of the map

This map depicts, in a general way, the direction of shallow groundwater flow, which is primarily perpendicular to lines of equal water-table elevation. "Shallow" refers to depth below the water table, and not to depth below the land surface. The accuracy of the interpreted contour lines varies throughout the study area, increasing with greater data density. The water-table elevation lines are solid where enough data are available to locate the lines with a reasonable degree of confidence (within ±0.3 mile on the map). The lines are dashed where data are less abundant or where hydrogeologic conditions are more complex and contour-line locations are considered to be accurate to within ±0.7 mile on the map. In the areas where a question mark appears on the map, such as the tops of hills, data are insufficient to interpret water-table elevation.

It was beyond the resources of this study to field-check the locations and water levels given on the Well Constructor's Reports that were used to construct this map. This map is a summary of available water-level data for Pepin County. It is intended for use at the published scale of 1:100,000 and should *not* be considered definitive for site-specific applications.

References

Cates, K.J., and Madison, F.M., 1990, Soil-attenuation-potential map of Pepin County, Wisconsin: Wisconsin Geological and Natural History Survey, Soil Map 10, scale 1:100,000.

Young, H.L., and Hindall, S.M., 1972, Water resources of Wisconsin: Chippewa River Basin: U.S. Geological Survey, Hydrologic Investigations, Atlas HA-386 (4 plates).