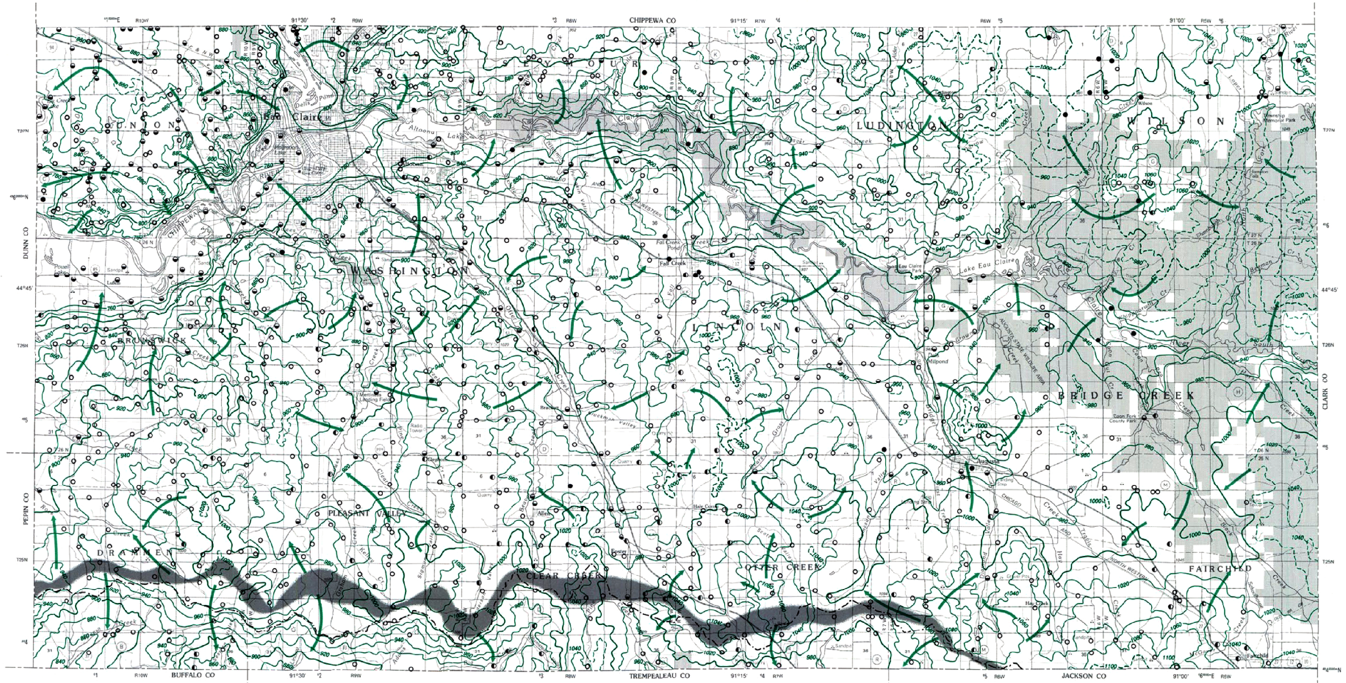
Generalized Water-Table Elevation Map of Eau Claire County, Wisconsin



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

Scale 1:100,000

1 0 1 2 3 4 5 6 7 8 9 10 KILOMETERS

1 0 1 2 3 4 5 MILES

M.A. Muldoon
1992

Introduction

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

The water cycle

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

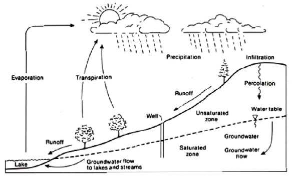


Figure 1. *The water cycle.*

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.*

Gravity moves groundwater slowly through pore spaces; eventually, the groundwater discharges to a well, the land surface, or 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 materials through which the water is flowing. Large pores or fractures in the subsurface 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 sands and sandstones, or as slowly as less than 1 inch per year in clay or in unfractured crystalline rock. For example, sandy soils and sandstones frequently have relatively large pore spaces that are well connected with each other, allowing water to move more easily than it can in clayey soils that have 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). Discharge areas are often associated with surface-water bodies, so groundwater has a significant role in the development and environmental health of lakes, streams, and wetlands. Wells also function as 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. It is a line across which no surface water flows. There is one major surface-water divide in Eau Claire County. North of the surface-water divide (which is located in southern Eau Claire County), the streams and rivers flow into the Eau Claire or Chippewa Rivers. These rivers come together near the city of Eau Claire and eventually flow into the Mississippi River. South of the surface-water divide, most streams flow into the Buffalo River, which is also a tributary of the Mississippi 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. The one major groundwater divide in Eau Claire County approximately coincides with the surface-water divide. Over much of central and southern Eau Claire County, discharge areas include north-flowing creeks that serve as tributaries to the Eau Claire River. In the northern part of the county, discharge areas include Fivemile, Sevenmile, Ninemile, Hay, and Muskrat Creeks and the North Fork of the Wolf River; these south-flowing streams are tributaries for the Eau Claire River. In the northwest corner of the county the Chippewa River and Dells Pond serve as groundwater discharge areas.

Contamination of groundwater

Because groundwater comes 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 from land-use activities. 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, Lucy Buchan, Xiangxue Cheng, and David 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 checked against each other, and the most representative, reliable, and useful data available for each section were plotted. Data density varies considerably across Eau Claire County; the density ranges from few data points on county-owned lands (eastern part of the county and along the Eau Claire River) to at least one report per 1 to 2 square miles in inhabited parts of the county. A total of 1,028 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. 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, water levels were compared for wells of different depths. Over much of Eau Claire County, wells completed at different depths had similar water levels; however, in some areas, vertical groundwater gradients seemed significant. In those areas, the wells with the shallower 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.

Well constructor's reports provide measurements taken at different times of the year and in different years. Because of the 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.

The bedrock geology of Eau Claire County consists of Precambrian crystalline rock (commonly referred to as granite) overlain by a thick sequence of Cambrian sandstones with minor amounts of shale (Brown, 1988). Pleistocene deposits (thin in most places) consist of till deposited prior to the late Wisconsin; these deposits have been eroded from much of the county. Evidence of these early glaciations is sparse except in the northeast part of Eau Claire County (Cates and Madison, 1989). The latest advance of the glaciers terminated north and northeast of Eau Claire County; however, water from the melting ice followed the Chippewa River drainage and deposited thick sand and gravel sequences. Although the geology is complex, the water table closely mimics topography, suggesting good hydraulic connections between the Cambrian sandstone and the surficial deposits. The shallow groundwater system appears to be a single unconfined aquifer at the scale of this water-table map (1:100,000).

Many wells in Eau Claire County are completed in sandstone (71%) or a mixture of sandstone and shale (9%). The sand and gravel aquifer is used in places (17% of the wells), and a few wells are completed in granite or sandstone and granite (3%).

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 interpretation varies throughout the study area, increasing with greater data density and decreasing with greater hydrogeologic complexity. 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 hydrologic conditions are more complex and their 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 Department of Natural Resources well constructor's reports that were used to construct this map. This map is a summary of available water-level data for Eau Claire County. It is intended for use at the published scale of 1:100,000 but should *not* be considered definitive for site-specific applications.

References

Brown, B.A., 1988, Bedrock geology of Wisconsin, west-central sheet: Wisconsin Geological and Natural History Survey Regional Map Series (Map 88-7), scale 1:250,000.

Cates, K.J., and Madison, F.M., 1989, Soils of Eau Claire County, Wisconsin, and their ability to attenuate contaminants: Wisconsin Geological and Natural History Survey, Soil Map 9 (Map 89-6), scale 1:100,000.

Explanation

- 1020 — average elevation of water table in feet, solid where considered accurate within ±0.3 mile on the land surface; dashed where considered accurate within ±0.7 mile on the land surface; 20-ft contour interval. Datum is mean sea level.
- ? — elevation of water table unknown; insufficient data
- surface-water divide
- groundwater divide, approximately located
- general direction of shallow groundwater flow
- county-owned land and Wisconsin Department of Natural Resources Wildlife Refuge

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
- sandstone and shale
- sand and/or gravel
- granite or granite and sandstone

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

Sources of data

U.S. Geological Survey quadrangles (7.5-minute series, topographic; 1972-84) were 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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