Generalized Water-Table Elevation Map of St. Croix County, Wisconsin

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Introduction

This map is part of the St. Croix County Groundwater Resource Investigation, a joint project of the Wisconsin Geological and Natural History Survey and the St. Croix County Board. The intent of this project was to compile and interpret hydrogeologic data for St. Croix County. The resulting information can be used by St. Croix 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).

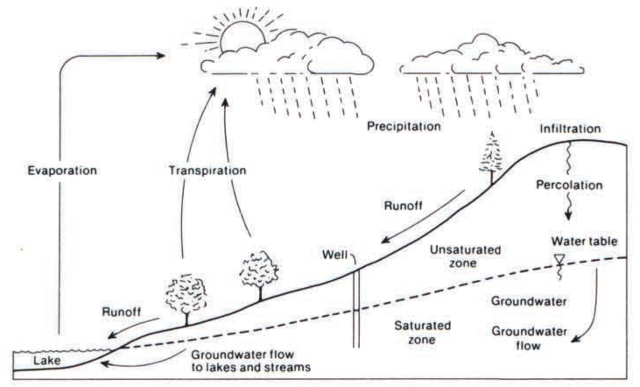

Figure 1. Schematic diagram of the water cycle.

Water falling on land flows downhill as runoff, evaporates, transpires through plants, or infiltrates into the ground. As this infiltrating water percolates 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* is the surface of this saturated zone, where hydraulic pressure 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 the material is said to be *unsaturated*. If a zone of saturated material is separated from an underlying main body of saturated material by an unsaturated zone, then the upper groundwater system is said to be *perched*. The upper water table is referred to as a *perched water table*.

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 surface 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

If a saturated subsurface material yields a sufficient quantity of water to a well, the material 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, these pores or fractures must be interconnected.

Groundwater can move as quickly as several feet per day in porous sand, or as slowly as less than 1 inch per year in clay or in dense crystalline rock. For example, sandy soils may have relatively large pore spaces that are well connected with each other, allowing water to seep more easily than it can in clayey soils that have small, poorly connected pores. Rocks such as limestone and dolomite are usually highly fractured; if these fractures are open and interconnected, water can flow quickly. Caves and sinkholes develop in areas where these fractures are enlarged by solution, and groundwater flow may become complex. Other rocks, such as crystalline granite, commonly have fewer, less well connected fractures than limestone and dolomite, and they commonly have a lower permeability and transmit less 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 (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.

A *groundwater mound* is a local mound-shaped elevation in a water table that builds up as a result of a zone or zones of material such as clay or shale that has much lower permeability than surrounding materials. The groundwater cannot drain as quickly from these materials; consequently, the water table is *mounded* at a higher elevation than in surrounding, more permeable materials.

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 in one direction from those that flow naturally in a different (often opposite) direction. It is a line across which no surface water flows. West of the surface-water divide in St. Croix County, most of the streams and rivers flow directly into the St. Croix River. The Rush River flows south to the Mississippi River. East of the surface-water divide, flow is into the Eau Galle River or into tributaries of the Red Cedar River. The Eau Galle and Red Cedar Rivers flow into the Chippewa River to the southeast.

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. Because data are especially scarce in the area of St. Croix County where the groundwater divide occurs, it can only be approximately located. The groundwater divide does not appear to coincide with the surface-water divide in much of St. Croix County. West of the groundwater divide in St. Croix County, groundwater flow is predominantly west into the St. Croix River. East of the groundwater divide, discharge points include the Eau Galle River and tributaries of the Red Cedar River, which flow into the Chippewa River to the southeast.

Contamination of groundwater

Because groundwater comes from water 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 groundwater. Soil is usually a good natural filter, removing many harmful materials from the recharging water as it moves downward. Areas of 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. Thin or sandy soils do not effectively remove many potential contaminants contained in liquid or solid waste products, or in other materials — such as road salt, manure, chemical fertilizers, pesticides, and herbicides — that are applied to the land surface. Once a contaminant reaches the water table, very little attenuation takes place; dilution will reduce the concentration of contaminants but will not remove them.

Because groundwater can move as slowly as a few inches per year, contamination that occurs today may not become evident for several or even hundreds of years. Once contaminated, groundwater is difficult to purify and may take many years, decades, or centuries to clean itself by the dilution process.

Data compilation and interpretation

Data were compiled at a scale of 1:24,000, using United States 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. For some areas, there were no reports, and for others, only a few; however, for most areas in western St. Croix County at least one report per 2 square miles was available. Data were scarcer in parts of the eastern two-thirds of the county; in some areas only one report was available per 6 square miles.

Because well constructor's reports provide measurements taken at different times of the year and in different years, a water level determined from a well constructor's report was not usually 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. In areas where the elevations of surface-water features differ greatly from the elevations of water levels in most nearby wells, the surface-water features may be perched or mounded, or may be higher because of strong downward hydraulic gradients. Wells in these areas often have water levels more than 100 feet below surface-water elevations. In these cases the surface-water features were not used, and the water table was based on the well data. Data are too sparse to delineate these areas, which may be local in their extent. Site-specific investigations beyond the scope of this study are necessary to determine which condition — perching, mounding, or strong downward hydraulic gradients — causes the difference between the surface-water elevations and the water levels in nearby wells.

A *potentiometric surface* is a surface that represents the elevations of water levels in tightly cased wells that penetrate a given aquifer. A water table is a special type of potentiometric surface where hydraulic pressure is equal to atmospheric pressure. By using water levels in wells as water-table elevations, it is assumed that the aquifer is *unconfined* (that is, the upper boundary of the aquifer is the water table, not a confining layer of relatively impermeable material such as clay or shale) and that vertical hydraulic gradients are negligible. Because these assumptions may not be valid in some areas of St. Croix County, parts of this map that are based solely on data from deep wells may more specifically represent a potentiometric-surface map rather than a true water-table map, but this difference should not affect the utility of this map for planning and management purposes.

On the basis of well constructor's reports on file at the Wisconsin Geological and Natural History Survey, approximately 57 percent of the wells in St. Croix County obtain their water from the highly fractured Prairie du Chien dolomite. Less than 17 percent of the wells obtain their water from Pleistocene deposits, mainly sand, gravel, and sandy till. Approximately 13 percent of the wells are completed in the St. Peter sandstone, which overlies the Prairie du Chien dolomite unconformably, and approximately 12 percent are completed in deeper sandstone units such as the Jordan, Tunnel City, or Galesville which underlie the Prairie du Chien dolomite. Less than 1 percent of the wells obtain their water from other aquifers, such as the Platteville dolomite, which overlies the St. Peter sandstone in a small area of southwestern St. Croix County.

Limitations of the map

Because shallow groundwater flow is primarily perpendicular to lines of equal water-table elevation, this map shows a generalized picture of the direction of shallow groundwater flow. "Shallow" refers to depth below the water table, and not to depth below the land surface. As stated previously, this map does not address the problem of local perched or mounded groundwater flow systems or of areas with steep vertical gradients. 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 enable the lines to be located with a reasonable degree of confidence to within ± 0.5 mile on the map. The lines are dashed where data are less abundant or where hydrologic conditions are more complex and their location is considered to be accurate to within ± 1.0 mile on the map. In areas where question marks appear 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 St. Croix County. It is intended for use at the published scale of 1:100,000 but should *not* be considered definitive for site-specific applications.

Sources of data

United States Geological Survey quadrangles (7.5-minute series, topographic; 1967-80)

Water-level observation wells from the Groundwater Level Monitoring Network operated and maintained by the United States 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 (1896-1989)

Explanation

Symbol	Meaning
1080 (solid line)	average elevation of water table in feet, solid where considered accurate within ± 0.5 mile on the land surface;
1020 (dashed line)	dashed where considered accurate within ± 1.0 mile on the land surface; 20 foot contour interval. Datum is mean sea level.
?	elevation of water table unknown; insufficient data
dash-dot line	surface-water divide
grey band	groundwater divide, approximately located
arrow	general direction of shallow groundwater flow
●	bedrock well, based on Department of Natural Resources Well Constructor's Report on file at the Wisconsin Geological and Natural History Survey
○	sand and/or gravel well, based on Department of Natural Resources Well Constructor's Report on file at the Wisconsin Geological and Natural History Survey

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

Published by and available from

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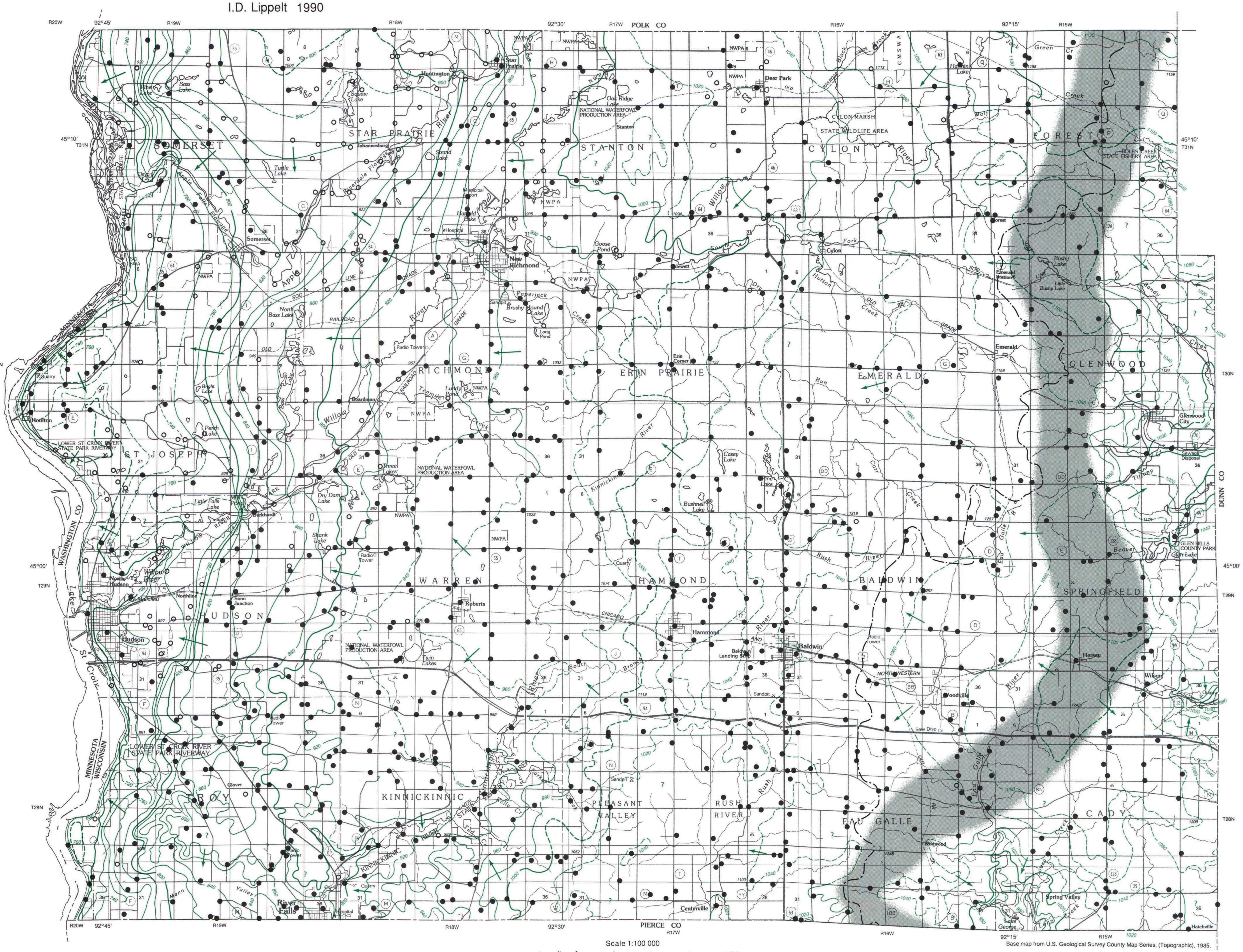
UWEX University of Wisconsin-Extension



Scale 1:100 000

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

Cartography by M.S. Humke

Miscellaneous Map 32