Generalized Water-Table Elevation Map of Buffalo County, Wisconsin

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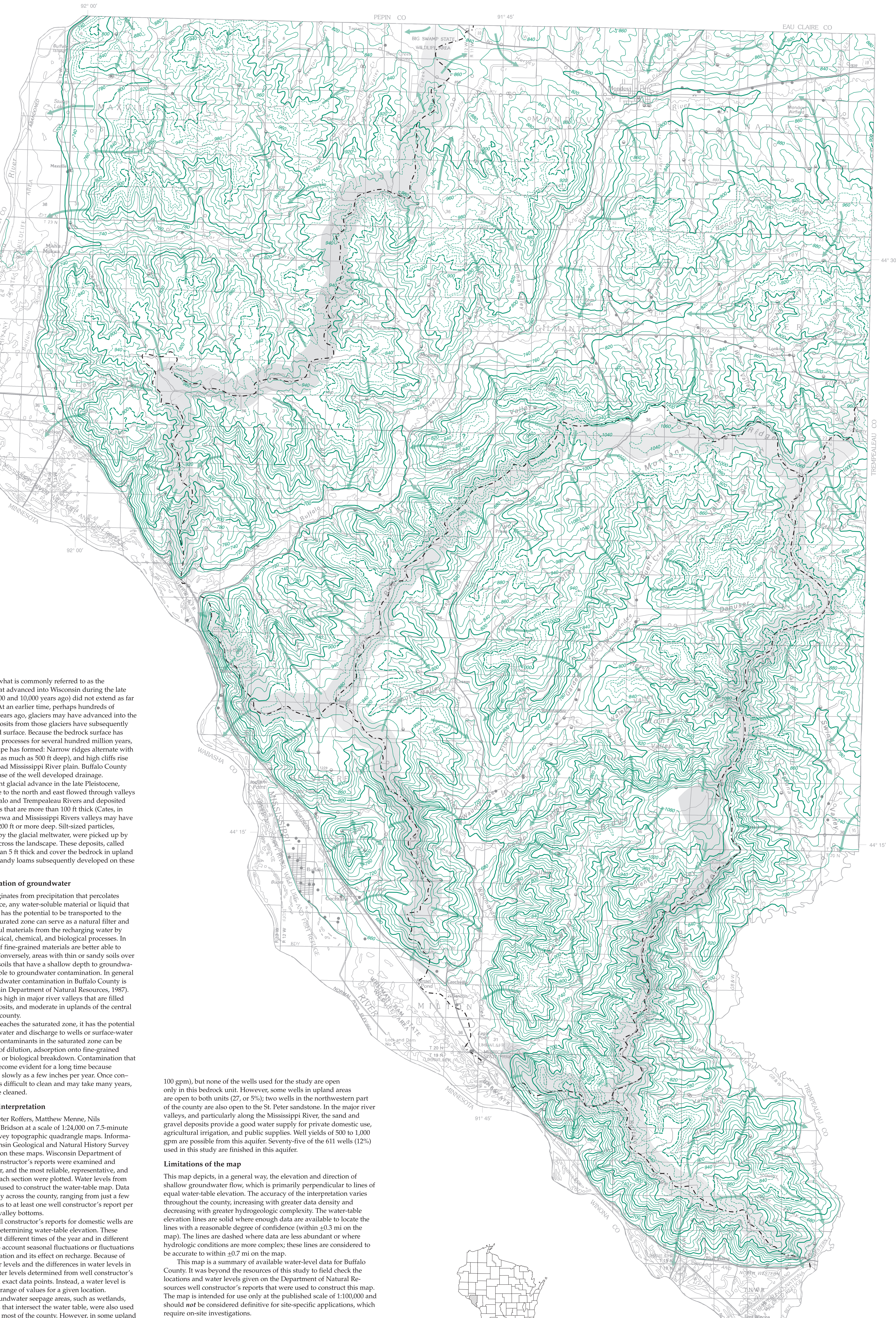
2000
Miscellaneous Map 50



Explanation

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

Geologic materials contributing water to well (All geologic information is taken from Wisconsin Department of Natural Resources well constructor's reports on file at the Wisconsin Geological and Natural History Survey. Materials contributing water to the well are those units that are saturated and penetrated by the open or screened part of the well.)

- sand and/or sand and gravel
- dolomite
- sandstone
- sandstone with shale and/or dolomite

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

The water cycle

When rain falls on the land surface, some of the water runs overland into streams and lakes, some is taken up by plants, some evaporates, and the remainder infiltrates into the ground. This is a continuous water recycling process, driven by gravity and solar energy, called the *water cycle* (fig. 1). The water that infiltrates into the ground ultimately discharges into lakes and wetlands, and provides much of the flow in streams. Because groundwater in Wisconsin has a relatively warm, uniform temperature (46°F–52°F), streams continue to flow even during winter.

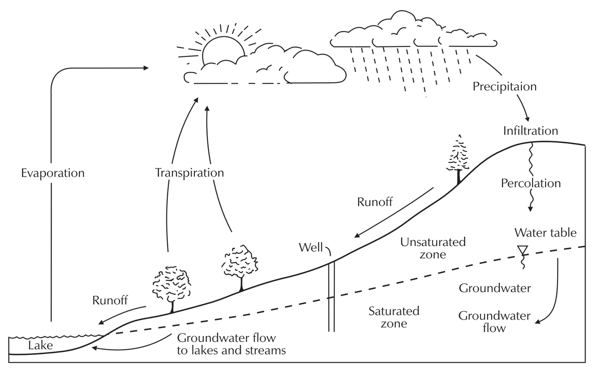


Figure 1. The water cycle (modified from Dunne and Leopold, 1978).

As infiltrating water seeps downward through soil or rock, it travels through pore spaces and open cracks or fractures in the subsurface materials. 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. 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*. The amount of infiltrating precipitation is one factor that determines the position, or elevation, of the water table, which typically fluctuates seasonally and from one year to another. The water table generally resembles a flattened form of the land surface.

Buffalo County receives about 30 inches of precipitation during an average year. Approximately 78 percent (23.5 inches) of this total returns to the atmosphere by evaporation or transpiration by plants (Young and Hindall, 1972; Young and Borman, 1973). The remaining 22 percent flows over the land surface as runoff into surface-water bodies or infiltrates into the ground as recharge to the groundwater system. The ratio of overland runoff to groundwater recharge varies considerably throughout the county, depending upon factors such as topography, the permeability of soil materials in the unsaturated zone, vegetative cover, rainfall intensity, and individual farming and general land-use practices.

Groundwater movement

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 for water to flow effectively, these pores or fractures must be connected.

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 granite. 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 and fine-grained sandstone, which have small, poorly connected pores. Rocks such as dolomite or granite 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 such as rivers, lakes, springs, and seeps where groundwater emerges again. Many surface-water bodies are groundwater discharge areas, so groundwater quality has a significant impact on the water quality of streams, lakes, and wetlands. Wells are manmade groundwater-discharge points.

A *surface-water divide* is a line of separation most commonly typified by a ridge or narrow tract of high ground that separates the surface-water and overland flow in one basin from surface-water flow in an adjacent basin. All streams in Buffalo County ultimately flow into the Mississippi River. However, three minor surface-water divides separate surface drainage into several stream basins within Buffalo County.

A surface-water divide separates the Buffalo River and the Waumandee Creek basins. These two basins drain much of the county.

Another divide separates the Buffalo River basin from small basins of several creeks draining directly into the Chippewa and Mississippi Rivers in the northwestern part of the county.

A divide separates the Waumandee Creek and Trempealeau River basins in the southeastern part of the county.

A *groundwater divide* is similar to a surface-water divide in that it is a ridge defined by contours of the water table. Groundwater moves away from the divide in different (often opposite) directions. Groundwater divides do not necessarily coincide with surface-water divides; however, the groundwater divides in Buffalo County do approximately coincide with the surface-water divides. Throughout much of the county, groundwater flows along short paths from upland groundwater recharge areas to local discharge areas, such as the Buffalo and Trempealeau Rivers, Waumandee Creek, and their smaller tributaries.

On the basis of well constructor's reports available for Buffalo County, the depth to groundwater ranges from just above the land surface in several wells to about 450 ft below the surface. The water table is close to the land surface in stream valleys, but it is deeper beneath hills and ridges. Stream valleys at low elevations (less than 950 ft above mean sea level) have water levels that are relatively shallow (within 40 ft of the surface). Valleys at higher elevations (greater than 950 ft above mean sea level) have water levels at depths less than 100 ft below the surface. The deepest water levels (190 ft or more below the surface) are beneath ridges that have elevations above 1,150 ft (approximately 10% of recorded wells). In most of the county (more than 80% of recorded wells), water can be found at depths between 10 and 100 ft.

Geology of Buffalo County

All Buffalo County is underlain at depth by Precambrian crystalline rock (commonly called granite by well drillers). This rock is overlain by a younger, thick, layered sequence of Cambrian sandstone, shale, and dolomite. The Cambrian rock is covered by younger Ordovician dolomite, which forms most of the ridge tops. Small amounts of a still younger bedrock formation, the Ordovician St. Peter sandstone, cap the ridges in the western part of the county (Brown, 1988). These Cambrian and Ordovician rocks dip gently toward the southwest at 10 to 15 ft per mile and gradually thicken in that direction (Young and Hindall, 1972). Bedrock is within 10 ft of the land surface over much of Buffalo County (Cates, in press).

Buffalo County is in what is commonly referred to as the Driftless Area. Glaciers that advanced into Wisconsin during the late Pleistocene (between 25,000 and 10,000 years ago) did not extend as far south as Buffalo County. At an earlier time, perhaps hundreds of thousands to millions of years ago, glaciers may have advanced into the county; however, any deposits from those glaciers have subsequently been eroded from the land surface. Because the bedrock surface has been exposed to erosional processes for several hundred million years, a highly dissected landscape has formed: Narrow ridges alternate with steep-sided valleys (some as much as 500 ft deep), and high cliffs rise 300 to 400 ft above the broad Mississippi River plain. Buffalo County has no natural lakes because of the well developed drainage.

During the most recent glacial advance in the late Pleistocene, water from the melting ice to the north and east flowed through valleys now occupied by the Buffalo and Trempealeau Rivers and deposited sand and gravel sequences that are more than 100 ft thick (Cates, in press). Parts of the Chippewa and Mississippi Rivers valleys may have alluvial deposits that are 200 ft or more deep. Silt-sized particles, deposited on floodplains by the glacial meltwater, were picked up by the wind and deposited across the landscape. These deposits, called loess, are generally less than 5 ft thick and cover the bedrock in upland areas of Buffalo County. Sandy loams subsequently developed on these loess deposits.

Potential for 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 serve as a natural filter and may remove many harmful materials from the recharging water by means of a variety of physical, chemical, and biological processes. In general, thick sequences of fine-grained materials are better able to attenuate contaminants. Conversely, areas with thin or sandy soils over bedrock or thin or sandy soils that have a shallow depth to groundwater are especially susceptible to groundwater contamination. In general terms, potential for groundwater contamination in Buffalo County is moderately high (Wisconsin Department of Natural Resources, 1987). Contamination potential is high in major river valleys that are filled with sand and gravel deposits, and moderate in uplands of the central and southern parts of the county.

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 by chemical or biological breakdown. Contamination that happens today may not become evident for a long time because groundwater can move as slowly as a few inches per year. Once contaminated, groundwater is difficult to clean and may take many years, decades, or centuries to be cleaned.

Data compilation and interpretation

Data were compiled by Peter Roffers, Matthew Menne, Nils Richardson, and Michelle Bridson at a scale of 1:24,000 on 7.5-minute series U.S. Geological Survey topographic quadrangle maps. Information from available Wisconsin Geological and Natural History Survey geologic logs was plotted on these maps. Wisconsin Department of Natural Resources well constructor's reports were examined and checked against each other, and the most reliable, representative, and useful data available for each section were plotted. Water levels from 611 well data points were used to construct the water-table map. Data density varies considerably across the county, ranging from just a few data points in upland areas to at least one well constructor's report per 1 to 2 square miles in the valley bottoms.

Water levels from well constructor's reports for domestic wells are not ideal data points for determining water-table elevation. These measurements are taken at different times of the year and in different years and do not take into account seasonal fluctuations or fluctuations caused by annual precipitation and its effect on recharge. Because of these fluctuations in water levels and the differences in water levels in relation to well depth, water levels determined from well constructor's reports are not considered exact data points. Instead, a water level is considered to be part of a range of values for a given location.

The elevations of groundwater seepage areas, such as wetlands, springs, creeks, and rivers that intersect the water table, were also used as data points throughout most of the county. However, in some upland areas, the elevations of springs and streams are as much as 100 ft higher than the water levels in nearby wells. These springs or streams may be perched or mounded above the regional water table because the immediately underlying bedrock has a low permeability that restricts the vertical flow of groundwater or creates a strong downward hydraulic gradient. Delineating the areal extent and thickness of this low-permeability bedrock requires collecting detailed subsurface data, which was beyond the scope of this study.

In upland areas where springs or streams appear to be perched, only water levels in wells were used as data points. The wells in these areas are drilled to depths more than 300 to 500 ft below land surface and the casing in these deep wells extends through the shallow low-permeability bedrock. The water-level elevations in these wells actually represent what is called the *potentiometric surface* of the deep aquifer that is *confined* by the overlying low-permeability bedrock unit. In contrast, the water table discussed earlier is a type of potentiometric surface that is represented by the water levels in typically shallow wells that do not penetrate a confining unit; the water table therefore represents the potentiometric surface of an *unconfined* aquifer. This distinction between water levels in unconfined and confined aquifers, although important to note, is not significant in Buffalo County. The possible use of a few potentiometric-surface water-level data in compiling the water-table elevation map has not altered the general shape of the water table or the general direction of groundwater flow and should not affect the overall utility of this map for planning and management purposes.

The Cambrian sandstone aquifer is the principal source of water in the county; properly constructed wells drilled into it yield up to 1,000 gallons per minute (gpm). Many of the 611 wells (509, or 83%) used for this study take water from this aquifer. Adequate amounts of water for domestic supplies can be obtained from the Ordovician dolomite (up to 100 gpm), but none of the wells used for the study are open only in this bedrock unit. However, some wells in upland areas are open to both units (27, or 5%); two wells in the northwestern part of the county are also open to the St. Peter sandstone. In the major river valleys, and particularly along the Mississippi River, the sand and gravel deposits provide a good water supply for private domestic use, agricultural irrigation, and public supplies. Well yields of 500 to 1,000 gpm are possible from this aquifer. Seventy-five of the 611 wells (12%) used in this study are finished in this aquifer.

Limitations of the map

This map depicts, in a general way, the elevation and direction of shallow groundwater flow, which is primarily perpendicular to lines of equal water-table elevation. The accuracy of the interpretation varies throughout the county, 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 mi on the map). The lines are dashed where data are less abundant or where hydrologic conditions are more complex; these lines are considered to be accurate to within ±0.7 mi on the map.

This map is a summary of available water-level data for Buffalo County. 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. The map is intended for use only at the published scale of 1:100,000 and should ***not*** be considered definitive for site-specific applications, which require on-site investigations.

NORTH

Sources of data

U.S. Geological Survey quadrangles (7.5-minute series, topographic; 1969–84) 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 Geological and Natural History Survey published and unpublished geologic logs (1938–85).

Wisconsin Department of Natural Resources well constructor's reports (1938–87).

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This map is an interpretation of the data available at the time of preparation. Every reasonable effort has been made to ensure that this interpretation conforms to sound scientific and cartographic principles; however, the map should not be used to guide site-specific decisions without verification. Proper use of the map is the sole responsibility of the user.

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Scale 1:100,000
KILOMETERS
MILES

Data capture by N.D. Jesperson, D.W. Hankley, and M.L. Czechanski
Digital cartography and editing by K.C. Roushar

Base map constructed from U.S. Geological Survey Digital Line Graph files (1990, scale 1:100,000), modified by Wisconsin Department of Natural Resources (1992) and Wisconsin Geological and Natural History Survey (2000).

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