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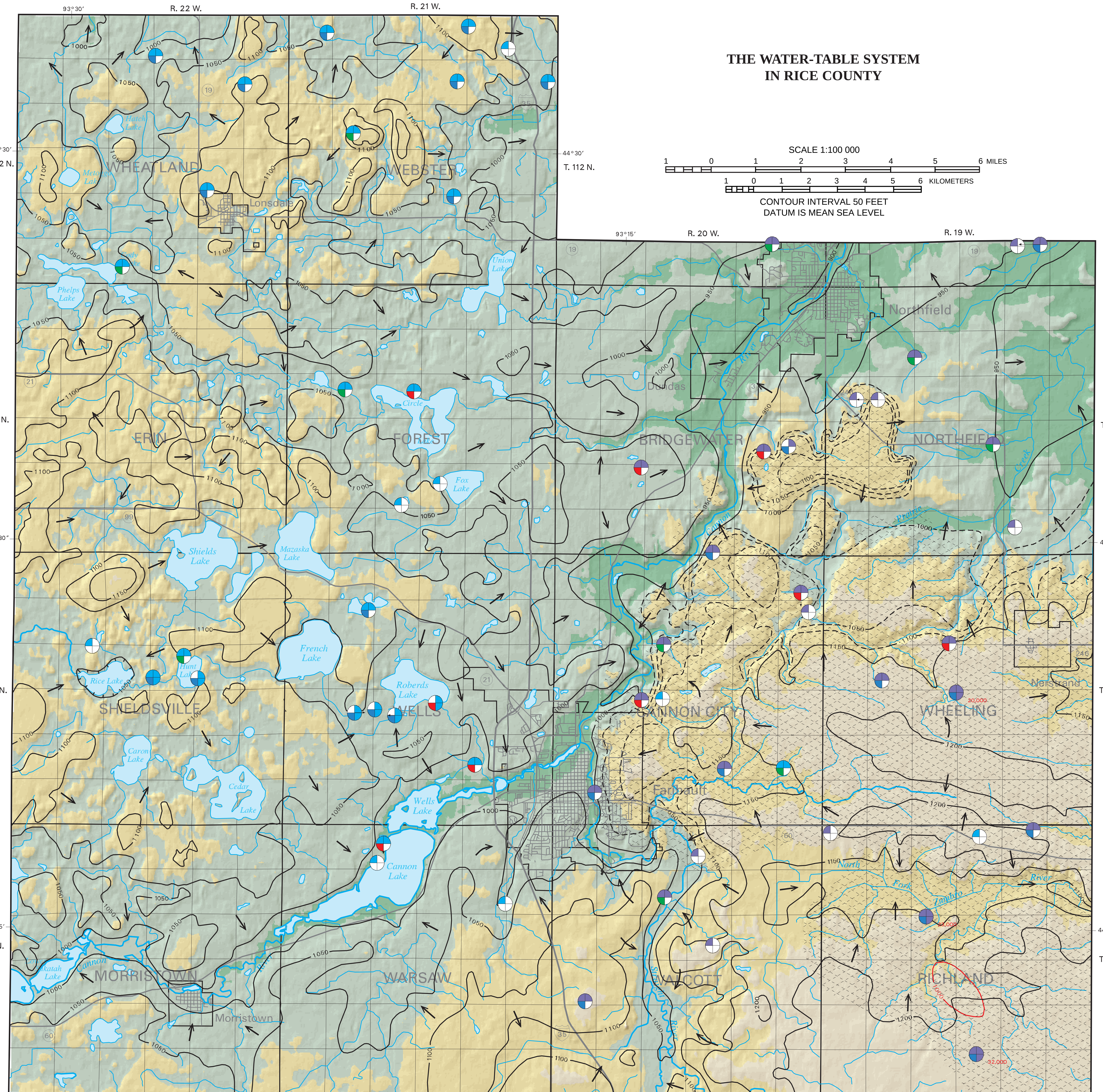
THE WATER-TABLE SYSTEM IN RICE COUNTY



MAP EXPLANATION

Water-table contour (feet above sea level)—Dashed where uncertain.

1000 *Water table*

1000 *Buried water table in bedrock*

General direction of ground-water movement in the water table

Perched ground water

~ 900 feet — ~ 1275 feet

Background color shows relative topographic elevation to illustrate physiographic features.

Key to Data Collection Symbols

Well measured for water level

Well sampled for general chemistry

Well sampled for tritium—Color indicates age as shown below

Well sampled for ^{2}H, ^{18}O, or ^{14}C—^{14}C age in years before present shown if analyzed (1,300)

Data collection symbol moved to avoid overlap—Arrow points to correct location

Aquifers [1]	*Tritium age of water samples* [2]
Quaternary	**Recent**
St. Peter-Prairie du Chien-Jordan	**Mixed**
	Vintage

[1] *No color indicates no data*

[2] *See Figure 1, Plate 8 for definition*

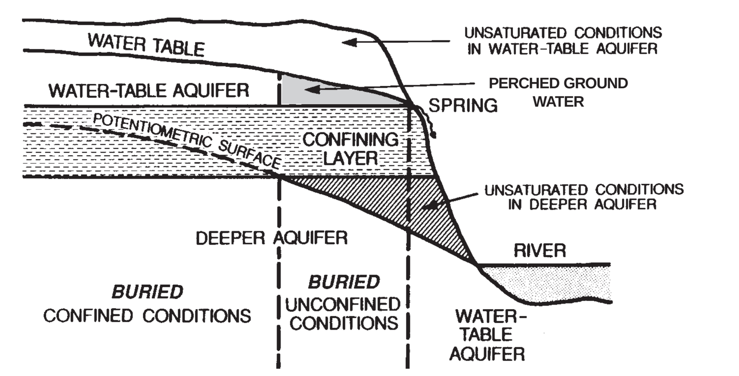


FIGURE 1. *Schematic diagram showing the relationship between buried confined and buried unconfined conditions in a deeper aquifer. Modified from Palen (1990).*

WATER-TABLE HYDROGEOLOGY

By
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[1]Intern, 1994
1997

INTRODUCTION

The Water-Table Hydrogeology map portrays the water-table surface throughout Rice County, whether in glacial deposits or in bedrock. The water table occurs in thick glacial deposits in most of Rice County. However, in the northeastern part of the county, where glacial sediments are thin or absent, the water table is in bedrock. The black contours indicate the uppermost water-table surface. Perched conditions occur in southeastern Rice County where a buried unconfined system occurs in bedrock. The elevation contour of the buried unconfined system in bedrock is shown in red. Plate 8 provides a more detailed description of the bedrock system. The topography of the county is shown as a shaded-relief map digitally derived from the U.S. Geological Survey (USGS) 1:24,000-scale Digital Elevation Model. The circular symbols on the map mark locations where water levels were measured and/or water samples were obtained. The smaller-scale (1:200,000) map shows the distribution of potential Quaternary aquifers in the county.

Very few wells in the County Well Index (CWI) data base are completed in Quaternary deposits. Only 22 are interpreted to be water-table wells. Several reasons account for the limited number of Quaternary wells: (1) most of the county is underlain by extensive, laterally continuous bedrock aquifers which yield large quantities of high-quality ground water; (2) surficial deposits of sand and gravel extensive enough to produce adequate quantities of water are primarily associated with the Cannon and Straight Rivers and Prairie Creek and are therefore geographically limited; and (3) the presence of buried sand and gravel deposits within the till is unpredictable and the size of these bodies is unknown, therefore the yield over time is less certain than that of the underlying bedrock aquifer. Because so few wells are completed at the water-table surface, other sources of data were used to estimate the elevation of the water table.

Development of the Water-Table Hydrogeology map relied heavily on the National Wetlands Inventory (NWI), which identifies the abundant wetlands as well as the perennial streams in the county. Using the NWI maps, the locations of perennial streams and wetland types 3, 4, and 5 were identified throughout the county (Minnesota Department of Natural Resources, 1996) and the corresponding elevations from USGS 1:24,000-scale topographic maps were regarded as water-table elevations. These surface-water bodies contain standing water year-round and were considered along with the lakes in the county as water-table features. Logs of water-table monitoring wells installed at potential contamination sites and results of seismic refraction surveys were also sources of water-table elevation data.

WATER TABLE AND BURIED UNCONFINED SYSTEMS

The water table is a surface below which the pores in sediment are fully saturated with ground water and above which those spaces are not fully saturated. The pressure of the water at this surface is equal to that of the atmosphere and it is not under confining pressure. Hence, the water-table surface is also referred to as an unconfined surface.

In western Rice County the hummocky topography and kettle lakes are characteristic of stagnant-ice deposits. In this area, the water table in the glacial sediments is continuous with the surface-water bodies. The abundant lakes and wetlands and the slow, immature drainage network are expressions of the water-table system.

In southeastern Rice County, relatively thick and laterally continuous deposits of pre-Wisconsinan till (see Plates 3 and 5, Part A) overlie the Decorah-Platteville-Glenwood confining unit. In this area, unconfined conditions exist in both the surficial deposits of pre-Wisconsinan till as well as the underlying St. Peter Sandstone (see area of perched conditions). The map displays the elevation contour of the buried unconfined surface in red in the southeastern portion of the county. Two vertically superimposed unconfined surfaces occur here. The relationship between these surfaces is schematically shown in Figure 1 (modified from Palen, 1990). The upper surface will be referred to as the perched water table and the lower as the buried unconfined surface. Cross section E-E’ on Plate 8 shows the vertical relationship between the perched water table and the buried unconfined surface in southeastern Rice County. The water table in surficial material is approximately 200 feet higher than the buried unconfined surface in bedrock.

Because of the relative absence of glacial deposits in northeastern Rice County, water-table conditions occur in bedrock. Here, the water table is in the St. Peter Sandstone (see Plates 2 and 5, Part A). This water-table surface is the lateral extension of the buried unconfined system in southeastern Rice County (see cross section E-E’ on Plate 8).

GROUND-WATER FLOW IN THE WATER-TABLE SYSTEM

The water-table flow pattern in the Quaternary sediments differs from that of the unconfined surface in bedrock. The topographic irregularity of the landscape gives rise to a highly variable and complex water-table surface. Ground-water flow in the Quaternary sediments consists of many local systems with relatively short flow paths. Furthermore, buried sand and gravel deposits contribute to the complexity of the ground-water flow system. Ground-water flow in this system is influenced by topography and surface-water features, resulting in variable ground-water flow directions in the Quaternary sediments. The unconfined surface in the bedrock exhibits a smoother, more consistent regional pattern, in both the buried unconfined and water-table systems. The regional flow within the bedrock is generally northward as illustrated in the unconfined portion of the Bedrock Hydrogeology Map and cross sections A-A’ and E-E’ on Plate 8.

Distinct physiographic differences between the Des Moines lobe stagnation moraine deposits in western Rice County and the well-dissected rolling topography of the pre-Wisconsinan till in eastern Rice County are clearly visible. The contrast between these physiographic regions results in different flow patterns in the water-table system.

In western Rice County, the supraglacial deposits of the most recent advance of the pre-late Wisconsinan Des Moines lobe have many small hills and depressions. These depressions contain lakes and wetlands of varying sizes. Although the land surface shows a complicated pattern of small hummocks and basins, there is limited overall vertical relief in this part of the county. Most of the water-table contours are 1050 or 1100 feet above sea level. The combination of the hummocky terrain, the abundant lakes and wetlands, and low relief result in very slow drainage. These lakes and wetlands drain into an immature stream system that eventually discharges into the Cannon River. Ground water in this area probably both recharges to and discharges from this poorly integrated drainage system. The area from Lake Sakatah eastward through Cannon and Wells Lakes (see Plate 5, Part A) serves as a ground-water discharge divide for the water table, hydrologically separating water-table flow between the northwestern and southwestern parts of the county. The extensive surficial sand and gravel deposits underlying this area also facilitate downward seepage from the water-table system, which recharges directly into the underlying bedrock system.

The area covered by the pre-Wisconsinan tills east of the Cannon and Straight Rivers has a much smoother appearance. During the last glacial advance this area was a high point in the landscape and the eastward-advancing glacier was diverted to the south. Because this area has been exposed to erosion for a longer period of time, streams have been eroding and dissecting the landscape longer than in western Rice County, creating a smoother, more mature landscape. Unlike western Rice County, there are few lakes and wetlands. There is greater vertical relief in the water-table surface in eastern Rice County—250 feet, compared to less than 100 feet in the west. Recharge occurs over the entire land surface and the water-table system discharges to the dendritic stream network.

INTERACTIONS BETWEEN GROUND WATER AND SURFACE WATER

There are three general types of interaction between ground water and surface water in Rice County and they correlate to three areas in the county. These types of ground water–surface water interaction are (1) many poorly integrated surface-water features of western Rice County that slowly both recharge and discharge ground water through the heterogeneous supraglacial deposits; (2) alluvial deposits of the Cannon and Straight Rivers that provide a discharge region for the water table throughout the county as well as recharge to the bedrock aquifer in the southeastern stretches of these streams; and (3) recharge by precipitation infiltrating from the land surface and discharge at local streams in eastern Rice County.

In western Rice County, leakage into and out of lakes and wetlands provides both discharge and recharge to the local surficial water-table system. Some of this ground water moves downward and contributes recharge to the buried Quaternary aquifers. The scale of this study is too regional in nature to provide a detailed description of the relationship between ground water and specific surface-water bodies in western Rice County.

The Cannon and Straight Rivers are the major drainages for the water-table system in the county. These streams flow within valleys created when the melting glaciers were providing a considerably greater volume of water and sediment load to these valleys than is occurring today. The alluvial deposits in the valleys directly overlie the regional St. Peter-Prairie du Chien-Jordan bedrock aquifer. The water-table and potentiometric contours indicate that ground water is discharging to the river through the alluvial deposits or directly from the bedrock into the Cannon and Straight Rivers. In this area the water-table system in the drift merges with the water-table system in the bedrock.

East and south of the hummocky terrain of the stagnation moraine in western Rice County, and in eastern Rice County where the pre-Wisconsinan till is at or near the surface, the land surface is characterized by rolling hills dissected by a well-developed dendritic stream network with very few lakes or wetlands. In these areas there is little water stored in surface-water bodies compared to western Rice County. Shallow ground water discharges to streams that flow into the Straight and North Fork Zumbro Rivers and Prairie Creek. In the area of perched conditions, most ground water in the water-table system does not penetrate the Decorah-Platteville-Glenwood confining layer. Ground water flows laterally north and west on top of the confining unit, and discharges over the eroded edge of this confining unit, directly recharging the underlying St. Peter-Prairie du Chien-Jordan aquifer.

SURFICIAL AND BURIED CONFINED QUATERNARY AQUIFERS

The small map (1:200,000 scale) on this plate displays the distribution of significant sand and gravel deposits identified in Rice County. The surficial sand and gravel map units are displayed at 1:100,000 scale on Plate 3, Part A. These deposits are primarily alluvium associated with the current stream system throughout the county. However, there are two significant bodies of surficial glacial outwash in Webster and Forest Townships that are not associated with the larger present-day streams.

Five generalized areas of buried sand and gravel deposits have been identified in western Rice County. These areas are defined by groups of Quaternary wells in a geographically limited area that have been completed within the same range of elevation and have similar static water elevations. The small map shows the elevation of completion, static water level, and average depth for this group of wells. These sand and gravel deposits are probably not laterally continuous at the elevation indicated. The cross sections shown on Plate 4, Part A, indicate that identified sand and gravel units are small and not widespread. The lack of information on the actual distribution of these sand and gravel units necessitates a generalized depiction of these areas. The sand and gravel deposits within each of these areas appear to represent a small, isolated aquifer, which is typical in glacial moraine deposits.

There is no obvious hydrologic connection between these five areas of buried sand and gravel. No similarity exists in regards to depth, static water elevation, or the distance above the bedrock surface. These buried Quaternary aquifers appear to be independent and isolated from one another and the sands and gravels of these aquifers may have been deposited at very different times. The static water elevations in wells in the buried Quaternary aquifers are below the water-table elevation and slightly above the elevation of the bedrock potentiometric surface (see Figure 2, Plate 9). These water-level relationships indicate a regional downward gradient in western Rice County.

WATER CHEMISTRY

Water samples were collected for chemical analysis from 23 Quaternary wells. Field parameters were measured at each site to assess well stabilization and general characteristics. All samples were analyzed for cations, anions, and tritium; a summary is given in Table 1. The water from these wells can be classified as calcium bicarbonate water (Fetter, 1988). Only nine of the samples had tritium concentrations greater than 0.8 tritium units. See Plate 9 for further discussion of tritium results.

Taken as a whole, the results of chemical analyses of water samples from the Quaternary wells in Rice County indicate limited human impact on ground-water resources. The concentration of nitrate was less than 1 milligram per liter (mg/L) in all samples. Chloride concentrations were variable, ranging from 0.071 to 25.9 mg/L, with a median concentration of 1.61 mg/L. Background chloride concentrations are less than one mg/L. Samples with significantly greater concentrations of chloride are considered to have been affected by human activity.

Samples from five Quaternary wells were analyzed for stable isotopes of hydrogen (^{2}H) and oxygen (^{18}O) to qualitatively examine the contribution of lake water to the shallow ground water. These samples were collected near Hunt and Roberds Lakes. The Minnesota Pollution Control Agency (MPCA) had previously collected stable isotope samples as part of the French/Roberds Lake Clean Water Partnership Project (J. Magner and C. Regan, 1993, personal communication.) Both the MPCA study and this study conclude that the lakes in western Rice County contribute surface water to the ground-water system. However, the data from this study indicate that the lakes are not the dominant source of recharge to the shallow ground-water system.

REFERENCES CITED

Fetter, C.W., 1988, Applied hydrogeology, 2nd ed.: Columbus, Ohio, Merrill, 592 p.

Minnesota Department of Natural Resources, 1996, Wetland types and definitions: St. Paul, Division of Waters, brochure.

Palen, B. M., 1990, Quaternary hydrogeology, plate 5 in Balaban, N.H. and Hobbs, Howard C., eds., Geologic atlas of Dakota County, Minnesota: Minnesota Geological Survey County Atlas Series C-6, scale 1:125,000.

ACKNOWLEDGMENTS

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TABLE 1. Characteristics of natural waters by aquifer in Rice County[1].
[Samples collected from 1992 to 1993 by Minnesota Department of Natural Resources staff; µS/cm, microsiemens per centimeter; °C, degrees Celsius; mV, millivolts; mg/L, milligrams per liter; TU, tritium units; n.a., not applicable]

Aquifer	Conductivity µS/cm	Temperature °C	pH pH units	Eh mV	Dissolved oxygen mg/L	Alkalinity as $CaCO_3$ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Fe mg/L	SO_4 mg/L	Cl mg/L	Nitrate as N mg/L	Tritium TU
Quaternary															
Mean	538	9.7	7.34	24	0.04	369	91.4	34.3	20.1	3.51	3.62	44.0	4.99	0.04	5.8
Median	541	9.5	7.29	-60	<0.01	390	91.0	34.5	12.8	3.36	1.91	23.5	1.61	<0.01	<0.8
Minimum	308	9.1	7.01	-175	<0.01	179	54.4	15.7	1.59	1.22	0.37	0.08	0.071	<0.01	<0.8
Maximum	812	11.5	7.75	318	0.28	471	150	50.7	89.4	7.50	20.4	341	25.9	0.86	53.5
Standard deviation	125	0.61	0.19	169	0.07	81.6	23.2	9.90	22.2	1.45	5.16	70.4	7.06	0.18	12.6
Number of samples	23	23	23	22	21	23	22	22	22	22	22	23	23	23	23
St. Peter-Prairie du Chien-Jordan															
Mean	507	9.4	7.22	92	0.07	317	86	30.6	13.0	2.74	6.37	47	4	0.13	4
Median	477	9.3	7.23	8	0.03	302	87.5	30.1	6.87	2.24	1.09	17.2	0.87	<0.1	<0.8
Minimum	295	6.4	6.2	-175	<0.01	100	33.6	18.5	1.18	0.91	0.01	0.10	0.31	<0.01	<0.8
Maximum	915	15.8	7.91	426	3.09	470	164	52.9	96.9	7.35	96.6	555	79.4	2.59	55
Standard deviation	144	1.1	0.26	176	0.6	82.3	23.7	7.35	16.0	1.5	20.8	104	11.6	0.4	11.2
Number of samples	54	54	54	53	51	53	54	54	54	54	54	54	54	54	53
St. Lawrence-Franconia															
Mean	604	9.6	7.29	-18	0.15	379	94.2	36.3	46.0	3.05	7.47	65.0	0.92	n.a.	n.a.
Median	580	9.7	7.38	-33	0.04	398	98.2	36.9	43.8	2.73	2.10	83.1	0.88	n.a.	n.a.
Minimum	533	9.1	6.98	-105	<0.01	303	73.9	33.3	14.2	2.41	0.28	10.7	0.52	<0.01	<0.8
Maximum	720	10.3	7.51	104	0.64	419	103	38.1	73.6	4.87	27.4	113	1.26	<0.1	<0.8
Standard deviation	72	0.5	0.21	76	0.27	48.4	11.6	1.95	23.6	1.03	11.5	49.7	0.30	n.a.	n.a.
Number of samples	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

[1] Includes both water-table and confined system samples, except one Galena aquifer sample, not shown.

Digital base composite of modified 1990 Census TIGER/Line files of the U.S. Bureau of the Census (source scale 1:100,000), U.S. Geological Survey (USGS) Digital Line Graphs (source scale 1:100,000), and Minnesota Department of Natural Resources (DNR)-developed Public Land Survey data (source scale 1:24,000); digital base annotation by Minnesota Geological Survey and the DNR. Project data compiled 1996 at the scale of 1:63,360. Topographic relief derived from USGS 1:24,000 scale Digital Elevation Model data.

Universal Transverse Mercator Projection, grid zone 15, 1983 North American Datum. Vertical datum is mean sea level.

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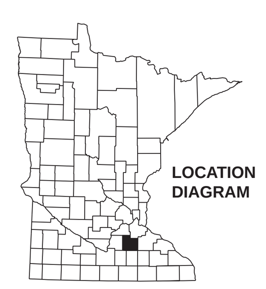

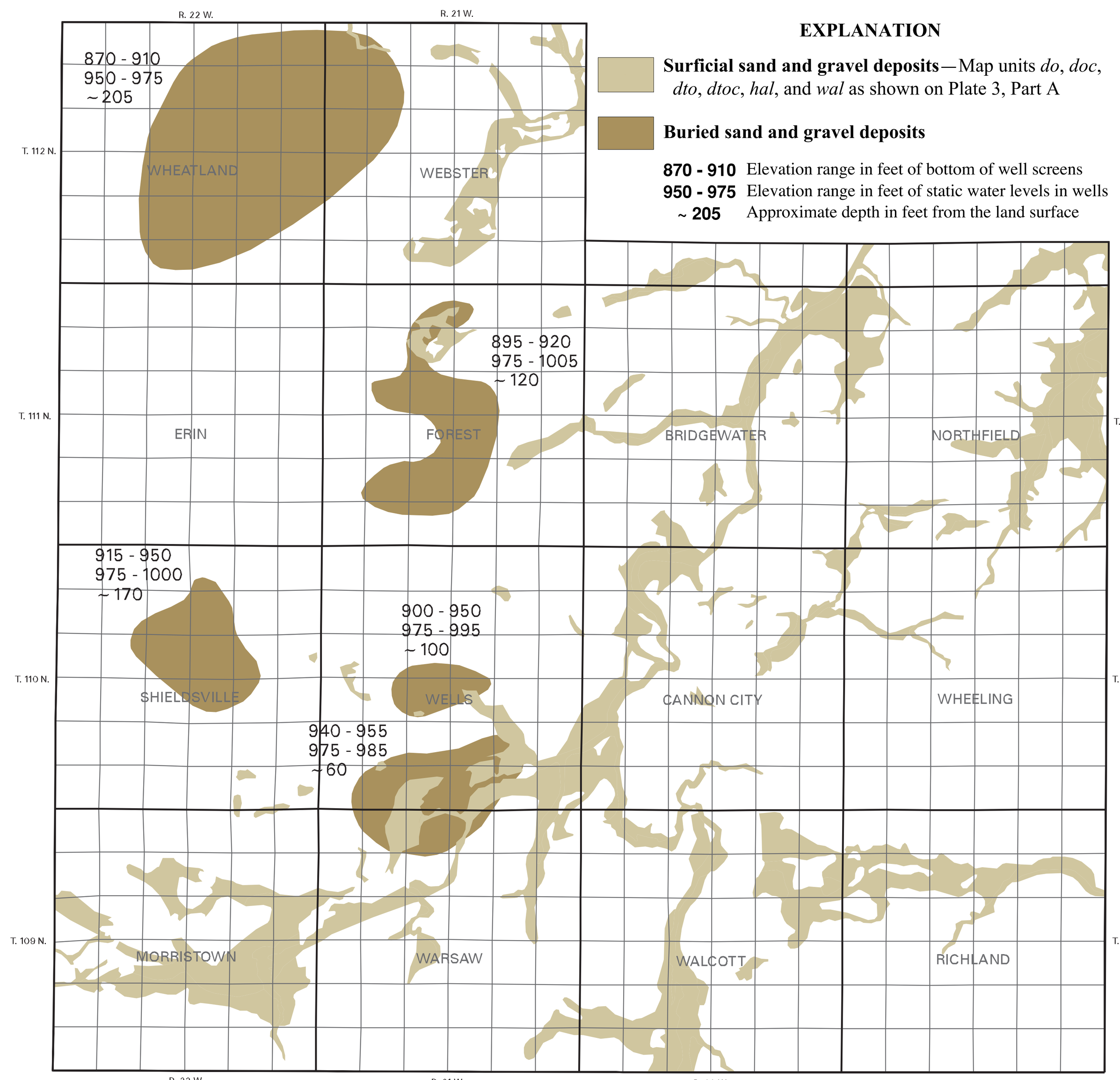

EXPLANATION

Surficial sand and gravel deposits—Map units *do*, *doc*, *dto*, *dtoc*, *hal*, and *wal* as shown on Plate 3, Part A

Buried sand and gravel deposits

870 - 910 Elevation range in feet of bottom of well screens
950 - 975 Elevation range in feet of static water levels in wells
~ 205 Approximate depth in feet from the land surface

POTENTIAL QUATERNARY AQUIFERS IN RICE COUNTY

Scale 1:200 000
Surficial aquifers compiled by the Minnesota Geological Survey (Plate 3, Part A)
Buried sand and gravel deposits compilation scale 1:200 000

The DNR Information Center
Twin Cities: (612) 296-6157
MN Toll Free: 1-800-766-6000
Telecommunications Device for the Deaf:
(612) 296-5484
MN Toll Free: 1-800-657-3929

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