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Long-Term Ground-Water Level Monitoring Network and Aquifer Hydraulic Properties Database for DeWitt, Piatt, and Northern Macon Counties

by
Mark A. Anliker

Prepared for the
Mahomet Valley Water Authority

June 1999

Illinois State Water Survey
Ground-Water Section
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

LONG-TERM GROUND-WATER LEVEL MONITORING NETWORK AND AQUIFER HYDRAULIC PROPERTIES DATABASE FOR DEWITT, PIATT, AND NORTHERN MACON COUNTIES

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Abstract

Water-bearing sand-and-gravel deposits underlying large portions of DeWitt, Piatt, and northeastern Macon Counties comprise a substantial ground-water resource that supplies all of the area's drinking-water needs. Ground-water resources include the Mahomet aquifer, a saturated sand-and-gravel deposit associated with the deep, buried Mahomet Bedrock Valley. This aquifer traverses DeWitt, Piatt, and a portion of Macon Counties and extends across several other counties in central Illinois. Wells tapping this aquifer are generally 200 to 400 feet (ft) deep. Additional significant ground-water resources are associated with shallower, less continuous sand-and-gravel deposits, which are found beneath most areas within Piatt and DeWitt Counties. Wells tapping these shallower aquifers range in depth from about 50 to 200 ft and serve as a significant source of water for rural and municipal use. This report summarizes the existing ground-water level monitoring activities within the study area and provides a plan for further development of ground-water level monitoring activities via a proposed network of dedicated observation wells. Additionally, Illinois State Water Survey (ISWS) ground-water files were reviewed and compared to available computer-based records, and pertinent data were organized geographically to provide an overview of available aquifer hydraulic properties data for the region.

Introduction

Beneath central Illinois lies an ancient river valley-the Mahomet Bedrock Valley-which was carved into the underlying bedrock before the glaciers advanced and covered much of Illinois. The valley was filled with unconsolidated deposits of sand, gravel, silts, and clays left by the continental glaciers. Of major interest to planners; city, state, and local officials; agriculture; and industry are the highly productive sand-and-gravel aquifers that were deposited when meltwaters from the glaciers flowed within the Mahomet Bedrock Valley system.

Visocky and Schicht (1969) estimated that the quantity of renewable ground water which could be withdrawn from the sand-and-gravel aquifers within the Mahomet Bedrock Valley and its major tributaries in east-central Illinois, an area of about 3,700 square miles (sq mi), is about 445 million gallons per day (mgd). Kirk (1987) estimated that, in 1986, ground-water withdrawals from sand-and-gravel aquifers in those counties overlying major portions of the valley system were about 66 mgd, or only about 15 percent of the renewable resource.

During 1989, interest in the development of east-central Illinois ground-water resources within the Mahomet Bedrock Valley began increasing. The severe drought of 1988-1989 motivated many farmers throughout Illinois to invest in irrigation systems. In Piatt and DeWitt Counties, Cisco and Clinton added new supply wells to their water systems to meet increased demands caused by the drought and additional users. Also during this time period, Decatur began a ground-water exploration program to develop an emergency supplemental source of water for use during drought periods. This program culminated in the construction of a well field in southeastern DeWitt County designed to pump about 25 mgd.

This increased awareness of the Mahomet Bedrock Valley aquifer system and its potential for meeting regional water demands for individual, municipal, agricultural, and commercial uses led to a desire to learn more about the ground-water resource and to more effectively support future resource development plans by diverse interests in the region. In addition, the lack of information about cumulative interference drawdowns between existing and planned wells prompted the voters of Piatt and DeWitt Counties to form the Mahomet Valley Water Authority (MVWA). Voters in Decatur and northeast Macon County voted to form the Mahomet Aquifer Water Authority in 1989.

Purposes of the Study

The main purposes or goals of this study are two-fold. The first purpose of this study was to provide a plan for the development of a network of dedicated observation wells within and/or near the boundaries of the study area. The network of dedicated observation wells proposed herein represents a very significant opportunity to observe the temporal changes of water levels resulting from both potential increases in ground-water withdrawals and the potential effects of climatic changes (i.e., changes in precipitation, soil moisture, ground-water recharge, water demand, etc.).

The second purpose of this study was to gain insight into the available hydraulic properties data for the major aquifer systems within the study area. To enable ground-water resource evaluation and the production of a digital ground-water flow model (as envisioned in future projects), both the geometry and hydraulic characteristics of the sand-and-gravel aquifers and confining beds will be required. The review of available hydraulic properties data and the resulting analysis conducted herein is intended to provide guidance in future resource evaluation projects planned by the MVWA.

Previous Ground-Water Studies

A significant study of the ground-water resources in an area encompassing DeWitt and Piatt Counties was published in 1969 by the ISWS (Visocky and Schicht, 1969). The study area included portions of 20 counties in east-central Illinois, with DeWitt and Piatt Counties centrally located. The report described the geologic setting and hydrologic characteristics of the Mahomet Sand aquifer as well as the sands and gravels of the Illinoian deposits, called the middle aquifer. Water-level hydrographs for observation wells in the study area were presented, including the hydrograph for a shallow (water table) Piatt County well (well PIA 20N6E-31.6h[†]), for which measurements began in 1954. The emphasis in this 1969 study was on the Champaign-Urbana area because of the significant ground-water pumpage in that area. Estimated historical pumpage for several municipalities was documented according to use (i.e., public or industrial) and source (aquifer), and pumpage for rural supplies was estimated for 1965.

Sanderson (1971) summarized ground-water conditions in Piatt County, including pertinent geological factors, occurrence and movement, temperature and chemical quality, and well development. Municipal water-supply wells were described, and construction features for private rural domestic wells were tabulated by location to aid in appraising further ground-water resource development in the county.

A cooperative study (Kempton et al., 1982) conducted by the Illinois State Water Survey (ISWS) and Illinois State Geological Survey (ISGS) presented a preliminary mapping and stratigraphic delineation of the sand-and-gravel deposits in an approximately eight-county study area that included portions of DeWitt and Piatt Counties. In addition to documenting the distribution and water-yielding characteristics of the Mahomet Sand aquifer, the study presented characteristics and distribution of other previously undefined aquifers.

A more recent study concentrating on the geology of the Mahomet Bedrock Valley in east-central Illinois was conducted by Kempton et al. (1991). This study discussed the tributary bedrock valleys associated with the Mahomet Bedrock Valley and the stratigraphy of the fill within the valley. The report also summarized the hydrogeologic setting based on the geologic framework and available hydrologic data.

Anliker and Sanderson (1995) conducted a study in which about 550 existing wells were inventoried during 1993-1994, and a "mass measurement" of these wells was conducted during the fall of 1994. The data from this mass measurement of water levels resulted in maps of the potentiometric surfaces associated with the two predominant aquifer systems in DeWitt and Piatt Counties. Ground-water withdrawal data for both counties were extracted from the existing ISWS statewide water inventory program and tabulated for the period 1980-1994. Estimated and reported ground-water withdrawals for 1994 were segregated by township for the two counties to accompany the water-level data and for possible use in future ground-water modeling efforts.

Acknowledgments

Sponsorship of this project was provided by the Mahomet Valley Water Authority, Richard Helton, Chairman (1994-1997), and Robert Lieb, Chairman (1997-1999). The views expressed herein are those of the author and do not necessarily reflect the views of the sponsor or the Illinois State Water Survey.

Word processing to prepare this report was done by Pamela Lovett. Linda Hascall finalized the graphics. Eva Kingston and Agnes Dillon edited the report.

[†]The well numbering system used in this report is explained in appendix A.

Observation Wells - Existing and Proposed

The reconnaissance study, or "mass measurement", of ground-water levels sponsored by the MVWA and completed in 1994 (Anliker and Sanderson, 1995) used a "network" of mostly privately owned domestic wells. This "mass measurement" provided an important initial step toward documenting and evaluating the ground-water resources associated with the buried Mahomet Bedrock Valley. During the 1993-1994 reconnaissance study, almost 550 wells were documented and used for a one-time "mass measurement" of water levels. The resulting water-level maps developed from the collected water-level data provide benchmark information that will allow comparison of future ground-water levels as resource development occurs in the future. These water-level maps provide a one-time "snapshot" of water levels in the Mahomet aquifer (within the Banner Formation), as well as the aquifers in the overlying Glasford Formation across the Piatt, DeWitt, and northern Macon County region. Because these privately owned wells exist to provide potable water for use by the individual landowner or resident, they are not considered dedicated in the context of long-term water-level monitoring. Although it would be possible to again use most of these wells for additional future mass measurements, considerable lead time and effort will be required to reacquaint the individual well owners with the intent of another mass measurement and to again seek the owners' permission for the use of their well in another mass measurement. The proposed utilization of wells licensed (owned) by the MVWA for the sole purpose of collecting water-level data within and, perhaps, just outside the boundaries of the MVWA will be outlined here . Dedicated wells will provide the opportunity for the collection of water-level data to significantly supplement that collected from the existing, limited number of dedicated observation wells as well as that collected during past and, perhaps, future mass measurements. Additional benefits will be explained later in this report.

Existing Dedicated Observation Wells

The ISWS began systematic measurement of ground-water levels in the study area (figure 1) in 1954, when an automatic water-level recorder was installed in a shallow (Wedron Formation) water-table observation well in Piatt County (PIA 20N6E-31.6h). The ISWS staff began manual measurement of water levels in additional wells on a monthly basis in 1979 in response to drought conditions in the mid-1970s. Monthly water-level measurements in a deep (Banner Formation) well are currently taken at a well southeast of Cisco (PIA 18N4E-24.8a), and measurements from both a shallow (Wedron Formation) well and an intermediate-depth (Glasford Formation) well are obtained northeast of Cerro Gordo in wells PIA 17N4E-12.7hl and 2. These four privately owned wells, which are currently measured every month, are shown in figure 2.

In conjunction with the construction of its DeWitt County well field from 1989-1991, Decatur installed nine Mahomet aquifer water-level observation wells with continuous water-level recorders. One of these nine wells is located at the approximate center of the well field. The others are spaced approximately 1.5, 3, and 5 miles from the well field. These nine observation wells have been in operation since 1989. The locations of these wells also are shown in figure 2.

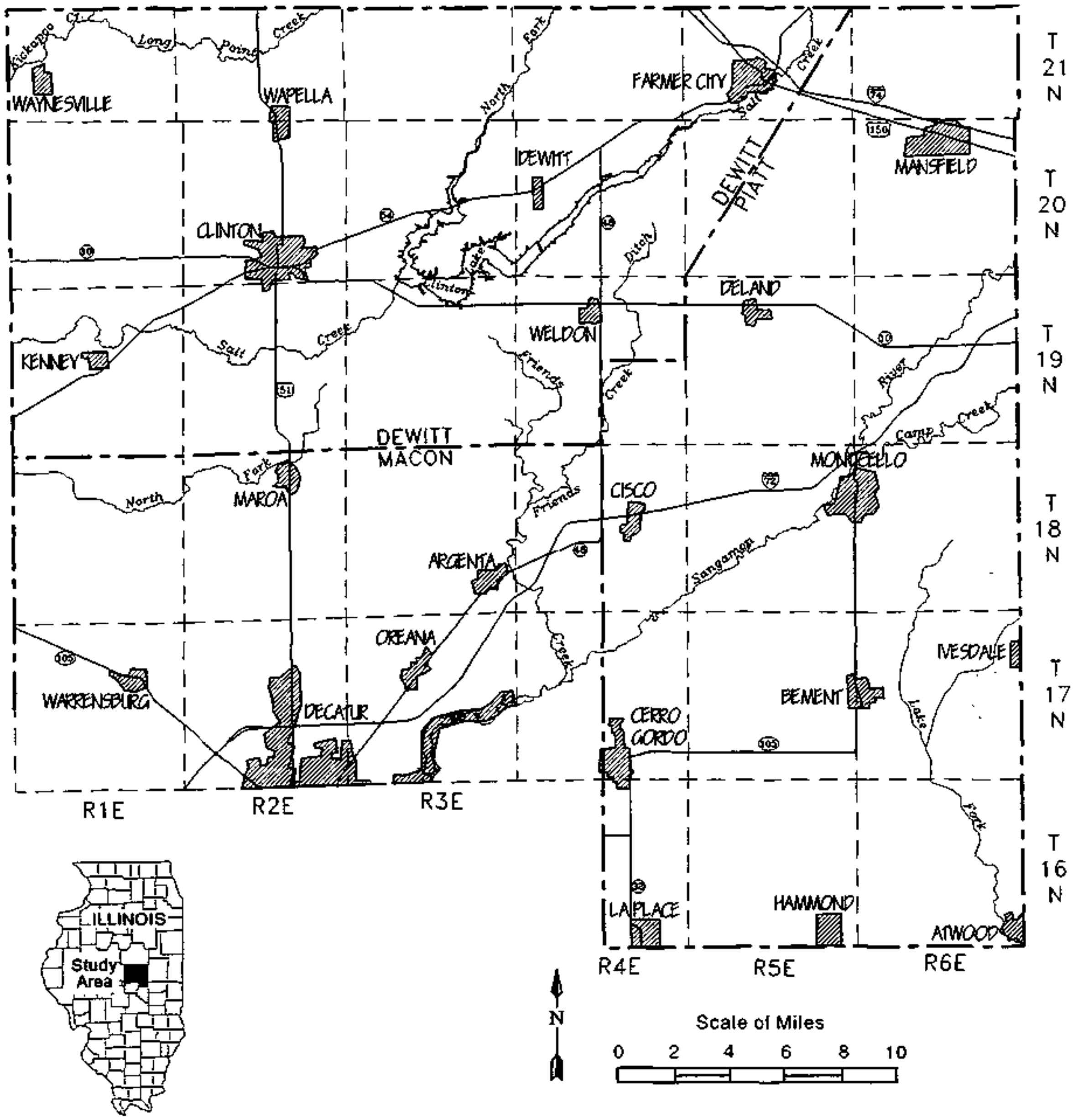

Figure 1. Location of study area

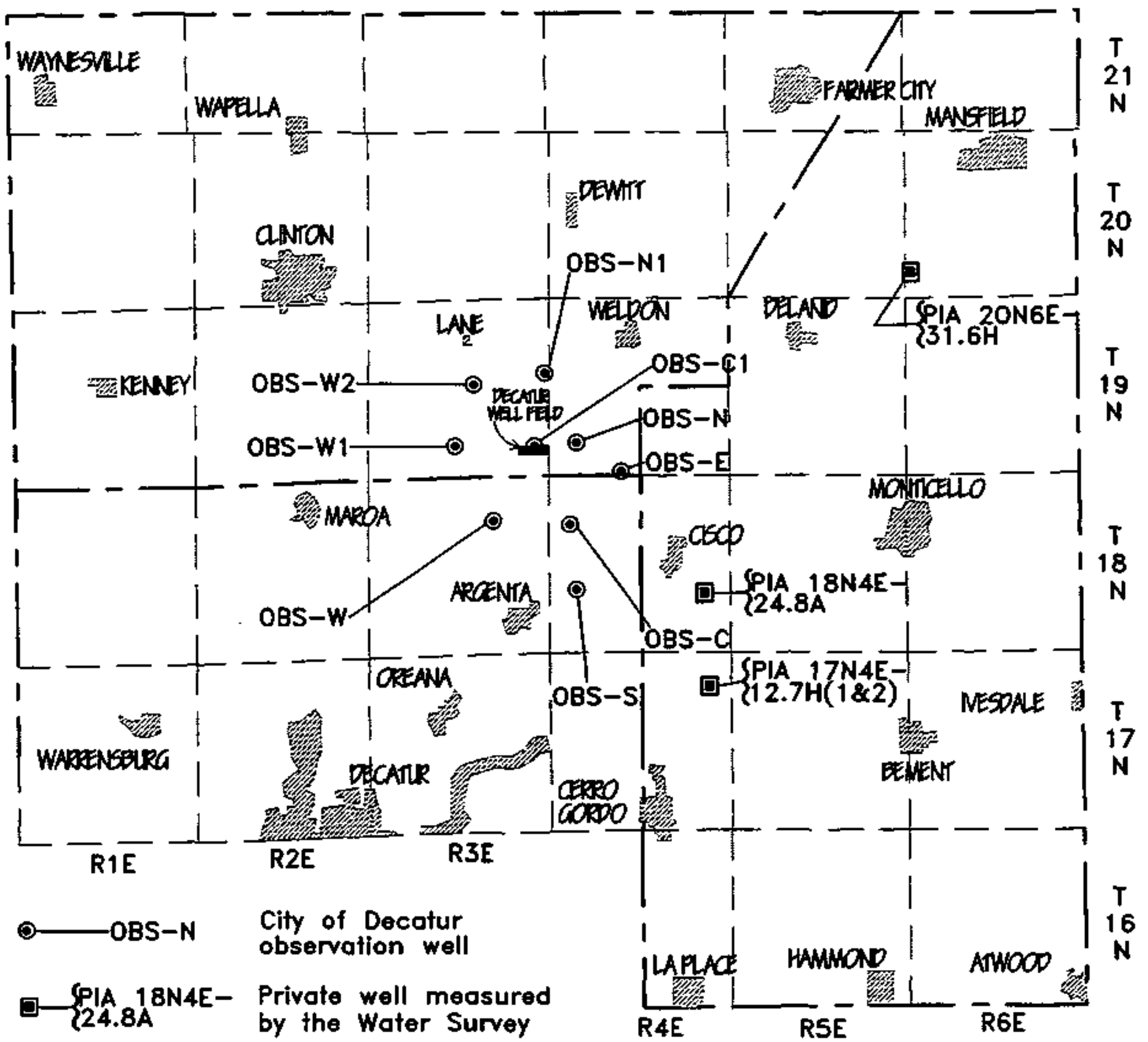

Figure 2. Location of observation wells

These 13 dedicated observation wells (4 measured by the ISWS and 9 measured by Decatur) represent the only wells that historically have been readily accessible for the collection of water-level data. However, the network of 550 privately owned wells used for the mass measurement of 1994 is a network for which permission must be sought prior to any future collection of water-level data.

The Benefits of Additional Dedicated Observation Wells

The 1993-1994 reconnaissance study suggested that a more extensive network of dedicated ground-water level observation wells is needed to collect water-level data on a more continuous basis and, hence, better understand the temporal changes in ground-water levels as influenced by precipitation and ground-water withdrawal patterns. Localized impacts of withdrawals from Decatur's emergency supply well field on ground-water levels in wells tapping the Mahomet aquifer are recorded by the existing network of Decatur's nine observation wells equipped with data-collection recorders. Significant water-level drawdowns are expected to occur beyond the boundaries of this existing network of nine observation wells if the well field is operated for extended periods of time. For this reason, it is suggested that a more extensive and far reaching network of dedicated observation wells be implemented with wells finished in the Mahomet aquifer.

The influence that ground-water withdrawals from the Mahomet aquifer may have on the shallower sand-and-gravel aquifer systems (upper Banner, Glasford, and Wedron) present above and outside (laterally) the Mahomet aquifer cannot be reliably predicted at this time. Past studies have indicated that withdrawals by the water utilities at Champaign-Urbana and Normal have distinct and direct influence on ground-water levels in overlying sand-and-gravel aquifers in those areas (Visocky and Schicht, 1969; Richards and Visocky, 1982; Wilson et al., 1998). Although overlying sand-and-gravel aquifers (Glasford) are reported to be absent within the immediate vicinity of Decatur's emergency supply well field, they are present within relatively short distances (about 3 miles) from the well field. This location relationship will influence the timing and extent of ground-water level impacts on wells finished in these overlying (shallower) sand-and-gravel aquifers. As discussed, water levels in the Glasford Formation are measured regularly (monthly by the ISWS) at only one location (Well PIA 17N4E-12.7h2) in the study area (figure 2).

Proposed Areas for Observation Wells

Areas at which dedicated observation wells are recommended to monitor long-term ground-water fluctuations in the Glasford and Banner Formations are shown in figures 3 and 4, respectively, and the rationale for an observation well in each area is explained below. The highlighted areas on figures 3 and 4 were determined from available geologic maps of the boundaries of the Mahomet aquifer and the Glasford Formation aquifers (Kempton and Herzog,

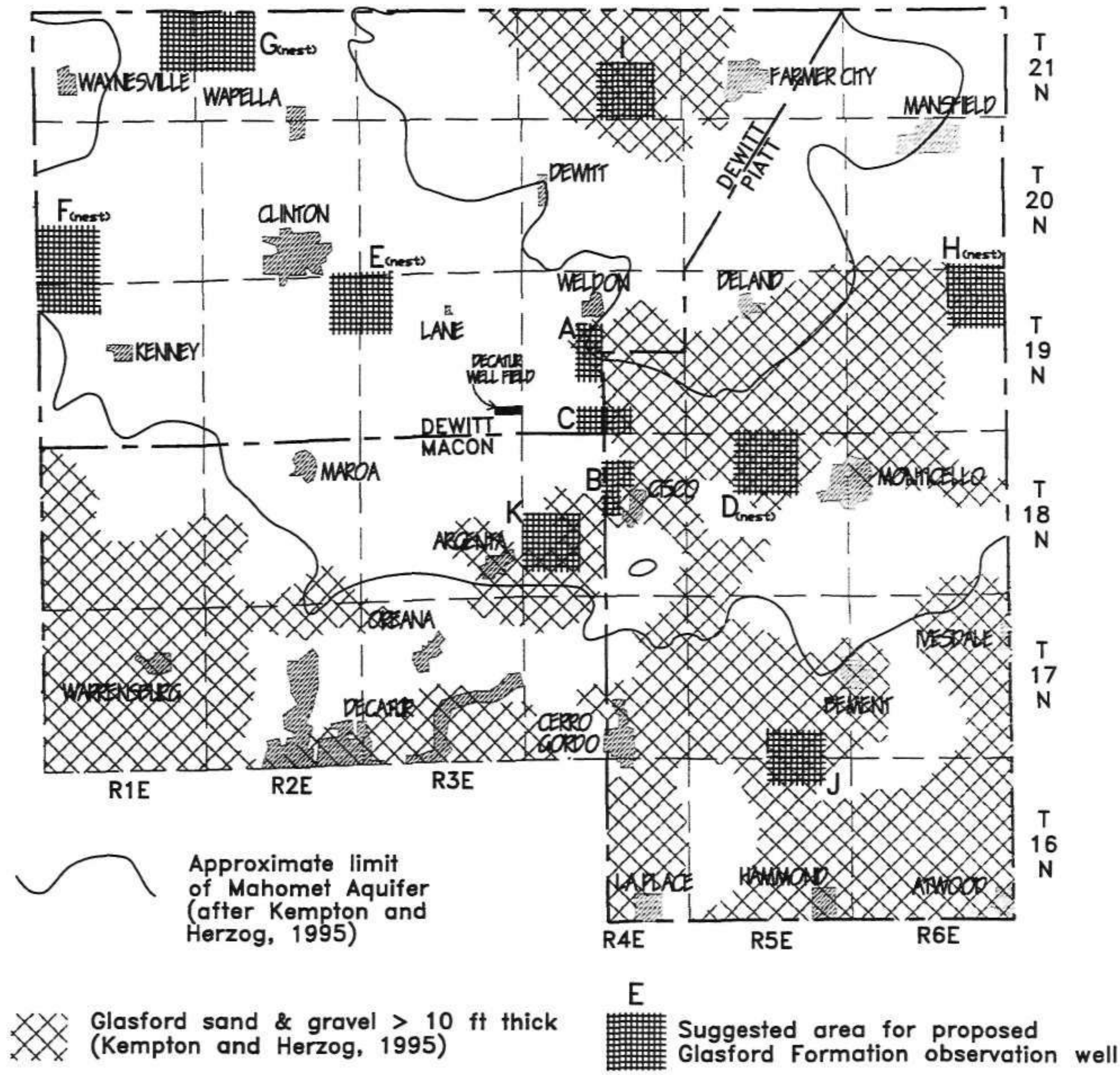

Figure 3. Proposed areas for Glasford Formation (Mahomet aquifer) observation wells

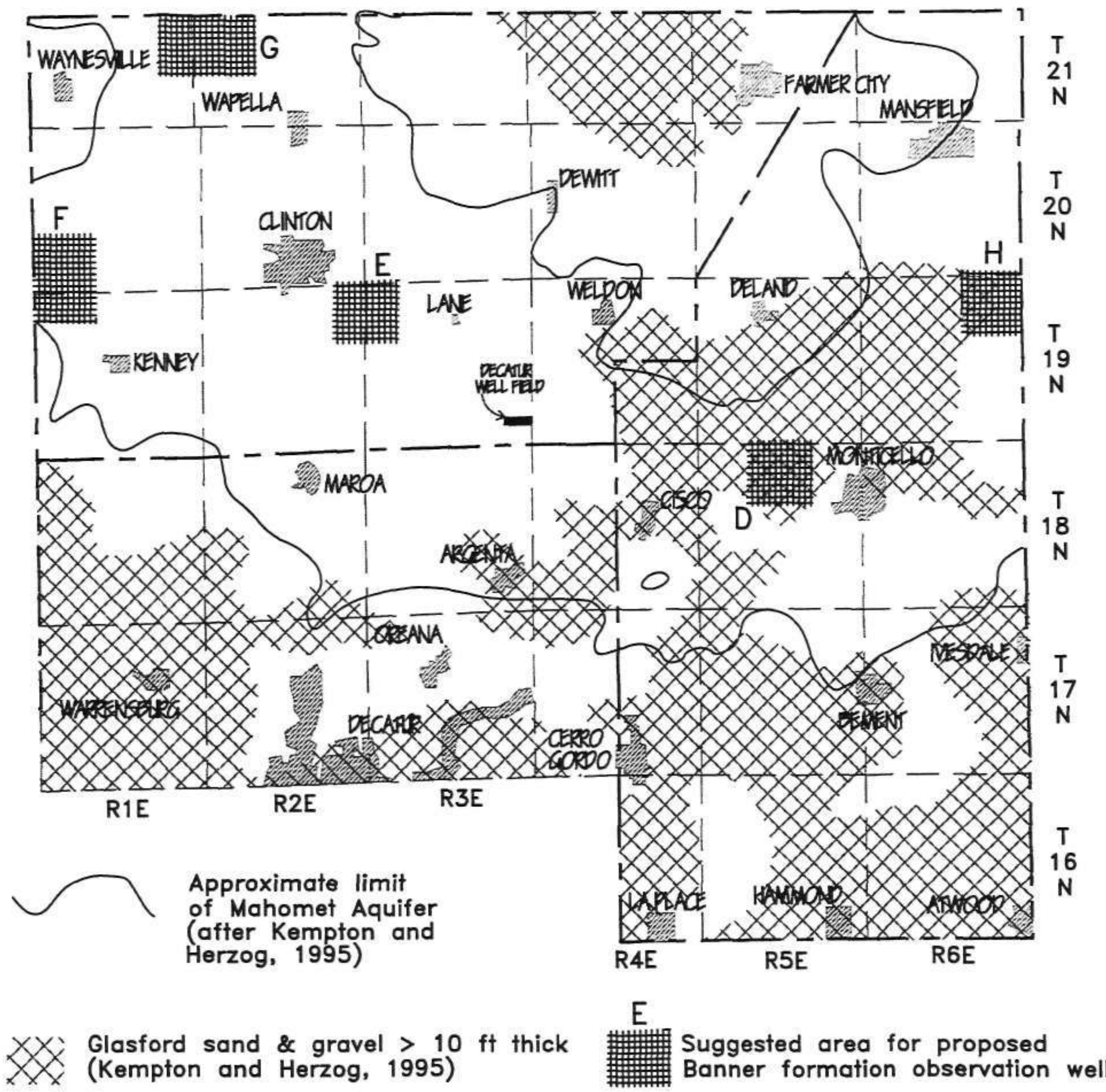

Figure 4. Proposed areas for Banner Formation (Mahomet aquifer) observation wells

1995), consideration of existing and potential ground-water withdrawals across the study area, and an examination of the locations of the existing dedicated observation wells.†

The size of these recommended areas, from 1.5 to 6 sq mi, was based on the purpose(s) for placing an observation well at each site. For example, to generally monitor regional water levels within the relatively wide boundaries of the Mahomet aquifer near the boundaries of Piatt and/or DeWitt County, one would have much latitude in choosing a particular site. Specifying the placement of an observation well anywhere within, for example, a 4 to 6 sq mi area is feasible and would serve the purpose. However, if the intended purpose is to collect ground-water level data to document water-level drawdowns in a particular aquifer near a particular public water supply, there would be less latitude in the placement of a dedicated observation well for that purpose; it would be necessary to specify a smaller area, such as 1 or 1 ½ sq mi. The rationale for the placement of dedicated observation wells (or well nests) in each of the areas highlighted in figures 3 and 4 is as follows:

Glasford Formation Observation Wells (Proposed)

Areas A and B. With respect to Decatur's DeWitt (County) well field, the public water supply wells for the villages of Weldon and Cisco are the nearest public water systems utilizing Glasford Formation deposits (aquifers). These aquifer deposits overlie the Mahomet Sand aquifer, which Decatur's DeWitt well field is designed to tap. The influence that ground-water withdrawals from the Mahomet aquifer may have on the sand-and-gravel aquifer systems (upper Banner, Glasford, and Wedron) present above and outside (laterally) the Mahomet Sand cannot be reliably predicted at this time. If the Glasford Formation observation wells could be installed in the vicinity of these two villages, potential water-level drawdowns in the Glasford Formation aquifers could be measured. Attempting to locate proposed observation wells at least ½ mile from the villages' supply wells is suggested to minimize the possibility of observing localized cyclical drawdowns resulting from the intermittent operation of these wells. Although the primary goal for installing observation wells in these areas would be to observe water levels in Glasford Formation aquifers, observation well nests also could be considered at these locations if the water authority's financial resources allowed.

Areas C and K. Placement of Glasford Formation observation wells in areas C and K would allow the measurement of water levels in the Glasford Formation aquifer system at locations farther from Cisco and Weldon than areas A and B, which are in the vicinity of public water supply systems utilizing Glasford Formation aquifers. Possible water-level declines in the Glasford Formation in areas C and K would be the result only of potentially significant water-level drawdowns in the underlying Banner Formation.

Well-log information for the Banner Formation observation well E (see figure 2), which was installed by Decatur and is within area C, indicates that Glasford sand and gravel overlies the

† For the areas discussed, a listing of property owners who have expressed interest in discussing possible cooperative involvement with the MVWA will be provided under separate cover to the MVWA.

Mahomet Sand at this location. This allows the possibility of an observation well nest at this location. Data from this observation well nest would allow the unique opportunity to analyze the hydraulic connection between the Mahomet Sand and the overlying aquifer(s) in the Glasford Formation at this location.

The well log for the Banner Formation observation well S (see figure 2), which was installed by Decatur, indicates "brown till" (sand?) at depths corresponding to the Glasford Formation. A functional Glasford Formation observation well could be installed at this location, which is within area K, resulting in another observation well nest.

Areas D and E (nests). Placement of Glasford (and Banner) Formation observation wells in areas D and E would allow the measurement of water levels in the Glasford Formation aquifer system at locations remote from any other significant withdrawals from this formation in the areas east and west of Decatur's DeWitt well field. Although Glasford Formation sand and gravel greater than 10 ft thick is not mapped in area E, the mass measurement work completed by the ISWS (Anliker and Sanderson, 1995) indicates that thinner Glasford Formation deposits exist in this area and throughout the majority of DeWitt and Piatt Counties.

Areas F and G (nests). Placement of Glasford (and Banner) Formation observation wells in areas F and G would allow the measurement of water levels in the Glasford Formation at locations at which the underlying Mahomet aquifer exits DeWitt County to the west and north, respectively. Although these areas are remote from existing centers of ground-water pumpage, initiating the collection of data at these locations would allow the analysis of ground-water flow across the MVWA boundaries if ground-water use conflicts arise in the future.

Area H(nest). Ground-water withdrawals from the Mahomet aquifer by the water utility at Champaign-Urbana have distinct and direct influence on ground-water levels in overlying Glasford sand-and-gravel aquifers (Visocky and Schicht, 1969). This influence on Glasford Formation aquifers was documented to extend within 6 miles (east) of the Piatt-Champaign County line. Placement of a Glasford Formation observation well in area H would allow monitoring of water levels in the Glasford Formation aquifer system at the easternmost boundaries of the MVWA, and would provide a way to monitor the effects of the significant pumpage east of Piatt County.

Areas I and J. Glasford Formation observation wells in areas I and J will allow the measurement of water levels in the Glasford Formation aquifer system at locations with significantly thick and laterally extensive sand-and-gravel deposits that do not overlie the Mahomet Sand. Observation wells at these locations would allow a comparison, or "independent check", to those wells that do overlie the Mahomet Sand.

Banner Formation (Mahomet Aquifer) Observation Wells

As indicated in the previous discussion regarding observation wells in the Glasford Formation, observation well nests constructed in the vicinity of areas D, E, F, G, and H will result in new observation wells in the Mahomet aquifer. These areas are shown in figure 4. From the perspective of the entire DeWitt-Piatt area, observation wells at these locations will provide a more even coverage for water-level data, as opposed to that currently available in the approximate vicinity of Decatur's DeWitt County well field. More specifically, observation wells in areas D and E will allow the collection of water-level data in the vicinities of Monticello and Clinton, which are the two larger public water supply systems in the study area using the Mahomet aquifer. Also, as was indicated earlier, observation wells in the vicinity of areas F, G, and H will allow the analysis of ground-water flow across the jurisdictional boundaries of the MVWA if ground-water use conflicts arise in the future.

Network Implementation

During this project a reconnaissance of the areas listed here was conducted to determine if any unused, privately owned wells were available and satisfactory for use as dedicated observation wells. Only one such well was found, and the property (well) owner was contacted. This well owner indicated only moderate interest in considering whether he would allow access to the well on an ongoing basis. Within the remaining ten areas at which dedicated observation wells are suggested, property owners were contacted and were generally agreeable to discussing the possibility of negotiating a suitable agreement with the MVWA for the construction of a dedicated observation well. As was mentioned, a listing of property owners who have expressed interest in discussing possible cooperative involvement with the MVWA will be provided under separate cover to the MVWA.

Contracting for the drilling of new observation wells at locations suggested here should be the responsibility of the MVWA. Scheduling of well drilling to attain completion of the monitoring network can occur as funds are available for this purpose. The ISWS, as part of this project and while project funds remain, will provide recommendations on the depth, diameter, and construction features of each new observation well that is contracted to be drilled.

Hydraulic Properties

Definitions

The principal hydraulic properties of an aquifer and any associated confining layer(s) that influence well yields and water-level declines are the hydraulic conductivity (K) or transmissivity (T), storage (s), and vertical permeability (P). The capacity of a formation (aquifer) to transmit ground water is expressed by the transmissivity, which is defined as the rate of flow of water, in gallons per day, through a vertical strip of the aquifer 1 ft wide and extending the full saturated thickness under a hydraulic gradient of 100 percent (1 ft per foot) at the prevailing temperature of the water. Transmissivity is the product of the saturated thickness of the aquifer, m, and the hydraulic conductivity, K (defined as the rate of flow of water in gallons per day through a cross-sectional area of 1 sq ft of the aquifer under a hydraulic gradient of 100 percent at the prevailing temperature of the water). The storage properties of an aquifer are expressed by the coefficient of storage, S, which is defined as the volume of water released from or taken into storage per unit surface area of the aquifer per unit change in head normal to that surface.

The rate of vertical leakage of ground water through a confining bed in response to a given vertical hydraulic gradient is dependent upon the vertical permeability of the confining bed, P'. When the confining bed is not well defined or is unknown, the ratio P'/m' (where m' is the thickness of the confining bed), termed the leakage coefficient by Hantush (1956), is used. The leakage coefficient is defined as the quantity of water, in gallons per day, that crosses a 1-sq-ft area of the interface between an aquifer and its confining bed per foot of head difference across the confining bed.

Aquifer Tests

The hydraulic properties of aquifers and confining beds may be determined by means of controlled aquifer tests, wherein the effect of pumping a well at a known constant rate is measured in the pumped well and in observation wells penetrating the aquifer at known distances from the pumped well. Ideally, it is desirable to conduct an aquifer test for extended periods of time (i.e., several days, perhaps up to a month) to observe the effects on water levels caused by aquifer boundaries (barrier or recharge) and/or leakage from overlying confining layers if present. Graphs of drawdown versus time after pumping started, and/or of drawdown versus distance from the pumped well, are used to solve formulas that express the relation between the hydraulic properties of an aquifer and its confining bed, if present, and the lowering of water levels in the vicinity of a pumped well. As the conduct of extensive, controlled aquifer tests using high-capacity test wells and water-level observation wells is difficult and costly, few such tests have been conducted throughout Piatt, DeWitt, and Macon Counties, as well as throughout the entire Mahomet Valley region. However, insights on the hydraulic characteristics may be gained by careful examination of shorter "production" tests, which often are conducted in connection with the construction of new municipal and industrial wells.

For the purposes of this report, the results of well-production tests are presented for those tests that allowed the calculation of hydraulic properties via a graphical analysis, such as the leaky artesian formula (Hantush and Jacob, 1955), the nonequilibrium formula (Theis, 1935), or the modified nonequilibrium formula (Cooper and Jacob, 1946). A description of each of these graphical analysis methodologies is beyond the scope of this report, and the interested reader is directed to any number of ground-water texts, or ISWS Bulletin 49, entitled *Selected Analytical Methods for Well and Aquifer Evaluation* (Walton, 1962).

Previously Available Data

Hydraulic properties data associated with the buried Mahomet Bedrock Valley are included in ISWS Report of Investigation 62 (Visocky and Schicht, 1969). This report lists the results of one aquifer test in DeWitt County and two aquifer tests in Piatt County conducted in the Mahomet aquifer. The duration of these tests ranged from 35 minutes to one day. For tests conducted in the overlying Illinoian deposits, the report lists data for two aquifer tests conducted in DeWitt County. No aquifer test data were listed for Piatt County.

Post-1969 Data

Numerous well production tests have been conducted since the Visocky and Schicht report (1969). The ISWS files containing production test information for DeWitt County, Piatt County, and the northern two tiers of townships in Macon County were examined with the goal of locating every production or aquifer test that has been conducted and subsequently analyzed graphically. The data collected during the tests were reviewed, the analysis of these tests were carefully examined, and the aquifer properties data were extracted and organized by geological formation.

Much of the data generated in past years and filed in the ISWS's well test files were generated from what more specifically could be called short-term specific capacity tests. During these relatively short-term tests, water-level measurements are taken both before and during a relatively short pumping episode. The specific capacity (pumping rate divided by drawdown) is then calculated and used as a general indication of the (short-term) capacity of the well. Water-level data collected during these specific capacity tests are greatly influenced by well design, the well condition or level of deterioration, and additional losses due to how much the individual well penetrates the aquifer (partial penetration effects). Therefore, aquifer hydraulic property data derived from an analysis of these specific capacity data are highly uncertain and are not presented in this report.

Tables 1 and 2 list 64 production tests of wells completed in the Banner or Glasford Formation aquifers within the study area and analyzed graphically. Of these 64 production tests, 34 involved only the pumped well and 30 utilized data from one or more observation wells. The average duration of all production tests was 4.5 hours, ranging from 0.4 to 48 hours. The average duration for those tests conducted in Banner Formation deposits was 5.9 hours. Excluding those tests conducted in the upper Banner Formation glacial deposits (see Kempton and Herzog, 1995) near Farmer City and outside the lateral limits of the Mahomet aquifer, the average duration for production tests was 8.4 hours. The average duration for tests conducted in the Glasford Formation deposits was 3.5 hours.

The locations of the production tests and the corresponding values of transmissivities, T, are shown in figures 5 and 6 for those conducted in the Banner and Glasford Formation deposits, respectively. Many of the production tests were conducted either on different dates in the same well or in different wells located in close proximity to each other. As one would expect, the aquifer test locations are "concentrated" at the towns and villages using the wells as their public water supply.

Analysis of Hydraulic Properties Data - Mahomet Aquifer

Within the approximate limits of the Mahomet Sand aquifer (figure 5), the values of transmissivity range from 7,800 to 281,000 gpd/ft. The average of all values within the same boundary is 155,000 gpd/ft, and the standard deviation is 92,000 gpd/ft. Kempton et al. (1991) described the Mahomet Sand (aquifer) as composed primarily of clear sand gravel with only minor amounts of fines. That, coupled with the regionally thick and continuous character of the

Table 1. Banner Formation Hydraulic Properties Data

WELL INFORMATION							TEST INFORMATION								
Location	Owner	Well no.	Well name	Year*	Bot. dia. (in.)	Screen length (ft)	Method of analysis	Test date**	Test depth (ft)	No. obs. wells used	Duration (hr)	Q (gpm)	Reported T (gpd/ft)	Reported storage coeff.	Reported leakage coeff.
03919N03E023H	IP-CLINTON STATION	2	CAMP J	1981	6	20	T	0381	340	0	3.0	80	162,000	--	--
03919N03E131H	WELDON	5	--	1978	8	28	T	0478	293	0	3.0	151	199,300	--	--
03919N03E361G	DECATUR	4	--	1989	16	76	TR	1189	334	3	48.0	2,500	275,000	7E-004	--
03920N01E284A	DEWITT COUNTY NURSING HOM	3	--	1990	5	16	T	0590	326	0	1.0	75	53,500	--	--
03920N02E342D	CLINTON	6	--	1948	12	40	TD	0360	345	2	23.9	500	88,000	9E-004	3.5E-002
03920N02E357F	CLINTON	10	E PARK WELL	1989	16	60	R	0989	360	1	6.0	1,032	200,300	--	--
03920N02E359F	CLINTON	11	W PARK WELL	1989	16	60	T	1089	360	2	3.0	1,180	181,000	--	--
03920N03E351C	IP-CLINTON STATION	1	MARINA	1980	4	40	T	0580	340	1	3.2	41	7,800	7E-004	--
03921N05E216G	FARMER CITY	10	LUCK (TH 2-79)	1980	8	20	R	0180	181	1	3.0	151	11,000	--	--
03921N05E217G	FARMER CITY	9	O'S GOLD	1979	8	18	T	1279	188	0	3.0	201	18,800	--	--
03921N05E282F	FARMER CITY	3	--	1951	6	14	T	0462	172	0	1.8	78	9,400	--	--
03921N05E282F	FARMER CITY	4	COUNTRY CLUB	1954	12	15	TR	0574	167	0	1.0	10	500	--	--
03921N05E282G	FARMER CITY	6	STENSEL	1955	12	20	TR	0574	172	0	1.0	200	2,800	--	--
03921N05E283E	FARMER CITY	2	SCARBROUGH	1945	12	15	T	0574	167	0	1.0	61	1,200	--	--
03921N05E285H	FARMER CITY	7	MCCONKEY	1967	8	15	T	0967	180	0	4.0	100	9,000	--	--
03921N05E285H	FARMER CITY	7	MCCONKEY	1967	8	15	R	0574	180	0	1.0	98	2,740	--	--
03921N05E338G	FARMER CITY	8	NEWBERRY	1972	8	16	TR	0574	153	0	1.0	34	1,050	--	--
03921N05E338G	FARMER CITY	8	NEWBERRY	1972	8	16	TR	0772	153	0	3.0	80	1,100	--	--
11518N02E028B	MAROA	2	SOUTH WELL	1939	8	22	T	1276	292	1	1.0	130	95,000	7E-004	--
11518N02E028B	MAROA	3	--	1948	8	20	T	1276	290	0	1.0	158	112,600	--	--
14718N04E148A	CISCO	4	--	1991	10	20	TR	0491	290	1	3.0	100	281,000	6E-004	--
14718N05E307A	DECATUR	2	N WEL - TH 5	1954	16	90	T	0754	252	2	7.2	2,550	270,000	1E-004	1.1E-003
14718N05E317G	DECATUR	1	S WELL	1954	16	90	T	0955	244	1	0.6	1,655	276,000	2E-004	--
14718N06E078A	VIOBIN CORP.	5	--	1973	12	42	TR	0173	228	0	3.0	350	165,000	--	--
14719N06E226C	WHITE HEATH WATERWORKS	1	--	1969	6	4	T	0869	233	0	24.0	75	70,800	--	--
14720N06E102G	MANSFIELD	4	--	1990	8	15	T	1290	217	0	3.0	245	34,960	--	--

Notes: * Year constructed.
** The first two digits indicate the month; the second two indicate the year.
Shaded data are for production tests conducted in upper Banner Formation deposits within the study area, but outside the boundaries of the Mahomet aquifer.
Method of analysis: T = time-drawdown, D = distance-drawdown, and R = recovery-time.
Q = pumping rate.
T = transmissivity.
-- indicates data not available.

Table 2. Glasford Formation Hydraulic Properties Data

WELL INFORMATION							TEST INFORMATION									
Location	Owner	Well no.	Well name	Year*	Bot. dia. (in.)	Screen length (ft)	Method of analysis	Test date**	Test depth (ft)	No. obs. wells used	Duration (hr)	Q (gpm)	Reported T (gpd/fl)	Reported storage coeff.	Reported leakage coeff.
03919N02E124E	WELDON SPRINGS STATE PARK	10	--	1995	5	8	T	0395	141	0	1.7	63	6,800	--	--
03919N02E127E	WELDON SPRINGS STATE PARK	9	MEADOW VIEW	1975	4	8	T	0993	140	0	1.0	10	838	--	--
03919N04E093D	WELDON	4	--	1972	8	6	T	1072	163	1	3.3	10	5,050	--	--
03919N04E093D	WELDON	TW1-71	--	1971	4	13	T	0371	166	0	3.0	36	3,500	--	--
03919N04E093E	WELDON	2	--	1948	8	10	T	0462	164	0	0.4	52	869	--	--
03919N04E094C	WELDON	3	--	1963	8	10	T	0863	167	0	6.0	100	3,500	--	--
03920N02E334H	WESTSIDE PARK MHP	1	WEST WELL	1973	4	4	T	0873	108	0	2.0	9	500	--	--
03920N02E336H	WESTSIDE PARK MHP	2	CENTER WELL	1974	6	3	T	0974	66	0	2.0	9	600	--	--
03920N03E322F	CLINTON LAKE RECREATION AF	5	WEST SIDE	1980	4	8	T	0880	80	0	2.0	10	1,200	--	--
03920N03E361D	CLINTON LAKE RECREATION AF	1	ST PK MAIN WELL	1981	8	10	R	0681	50	0	3.0	150	160,500	--	--
03920N04E092F	MID AMERICA COMMODITIES	2	FEED MFG	1980	6	12	R	0680	197	1	3.0	79	16,600	--	--
03920N04E212G	CLINTON LAKE RECREATION AF	8	WELDON ACCESS	1980	4	4	T	0880	68	0	2.0	10	5,500	--	--
03920N04E303H	DE WITT	TH2-77	--	1977	10	7	T	1077	169	0	6.0	25	300	--	--
03921N01E297B	WAYNESVILLE	8	LOCAL 8	1988	8	18	R	0388	149	1	3.0	53	6,400	--	--
03921N01E297B	WAYNESVILLE	OW1-8	OW 1 FOR #8	1957	8	20	T	0388	217	0	3.0	0	6,200	7E-004	--
03921N02E343B	WAPELLA	OW1-3	OW 1 FOR #3	1941	6	4	T	0884	78	0	3.0	0	61,900	5E-005	--
03921N02E343C	WAPELLA	3	--	1984	8	15	T	0884	80	1	3.0	200	92,600	--	--
11517N01E101A	WARRENSBURG	1	--	1935	--	7	T	0375	118	1	3.0	82	31,550	1E-004	--
11517N02E026H	FORSYTH	4	--	1982	12	20	TR	0582	154	2	4.0	620	70,000	3E-004	--
11517N02E026H	FORSYTH	5	--	1987	12	20	TR	1187	155	1	3.0	603	88,555	2E-004	--
11517N02E026H	FORSYTH	TW4	--	1981	8	23	TRD	0881	154	3	3.0	620	65,000	2E-004	--
11517N02E147H	FORSYTH	TH1-79	--	1979	8	15	TDR	0579	116	2	3.0	349	23,400	2E-004	--
11517N02E148H	FORSYTH	1	T1	1966	8	9	T	0466	104	0	6.3	113	9,960	--	--
11517N02E237E	LINCOLN LAB	2	--	1973	6	20	TR	0579	112	1	3.0	295	67,000	3E-004	--
11517N02E292E	BOB COOPER REALTY	1	--	1965	6	4	T	0965	77	1	1.7	36	15,750	1E-003	--
11517N03E092D	OREANA	2	--	1965	--	15	T	0477	132	2	3.0	128	26,000	1E-004	--
11517N03E092E	OREANA	1	--	1958	--	14	T	1958	132	0	1.0	102	10,800	--	--
11517N03E092E	OREANA	2	--	1965	--	15	T	0165	132	1	5.0	147	25,000	--	--
11517N03E108F	OREANA	TH9	TH9	--	--	20	T	0877	136	2	3.0	210	21,000	8E-005	--
11517N03E144H	OREANA	TH1	TH 1-90	--	--	30	TR	0890	150	2	24.0	250	64,000	2E-004	--
11517N03E276B	LONG CREEK TOWNSHIP	2	--	1981	10	20	TR	0481	86	0	3.0	200	52,800	--	--
11517N03E277B	LONG CREEK TOWNSHIP	1	--	1976	10	20	TR	0176	106	0	3.0	305	158,000	--	--
11517N03E278B	LONG CREEK TOWNSHIP	TW3	--	1967	5	20	T,D	1976	121	3	4.0	150	250,000	3E-004	--
14716N05E12	RUTH CORDTS	1	--	--	0	5	T	0580	59	0	1.3	10	6,300	--	--
14717N04E118D	CERRO GORDO	8	--	1975	0	16	T	0575	156	1	4.0	310	79,000	3E-004	--
14717N05E242H	BEMENT	TH1	TH1	--	0	15	TRD	0580	143	1	3.0	300	26,000	4E-005	--
14719N05E098B	DELAND	6	--	1982	0	7	TR	0682	79	1	3.0	46	1,600	4E-004	--
14719N05E098B	DELAND	7	--	1982	0	8	TR	0682	82	1	3.0	27	1,900	4E-004	--

Notes: * Year constructed.
** The first two digits indicate the month; the second two indicate the year.
Method of analysis: T = tlme-drawdown, D = distance-drawdown, and R = recovery-time.
Q = pumping rate.
T = transmissivity.
-- indicates data not available.

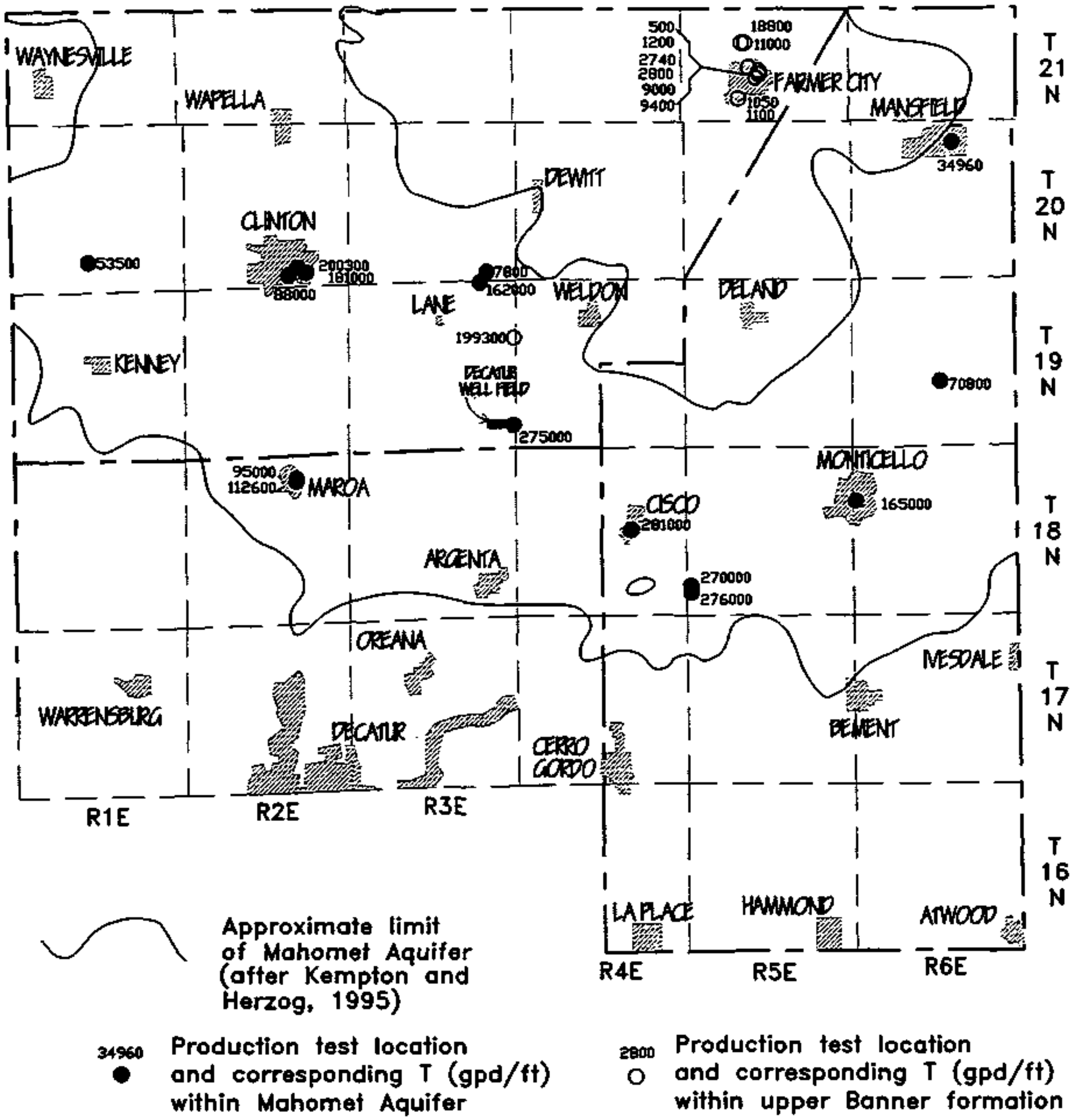

Figure 5. Locations of Banner Formation transmissivity data

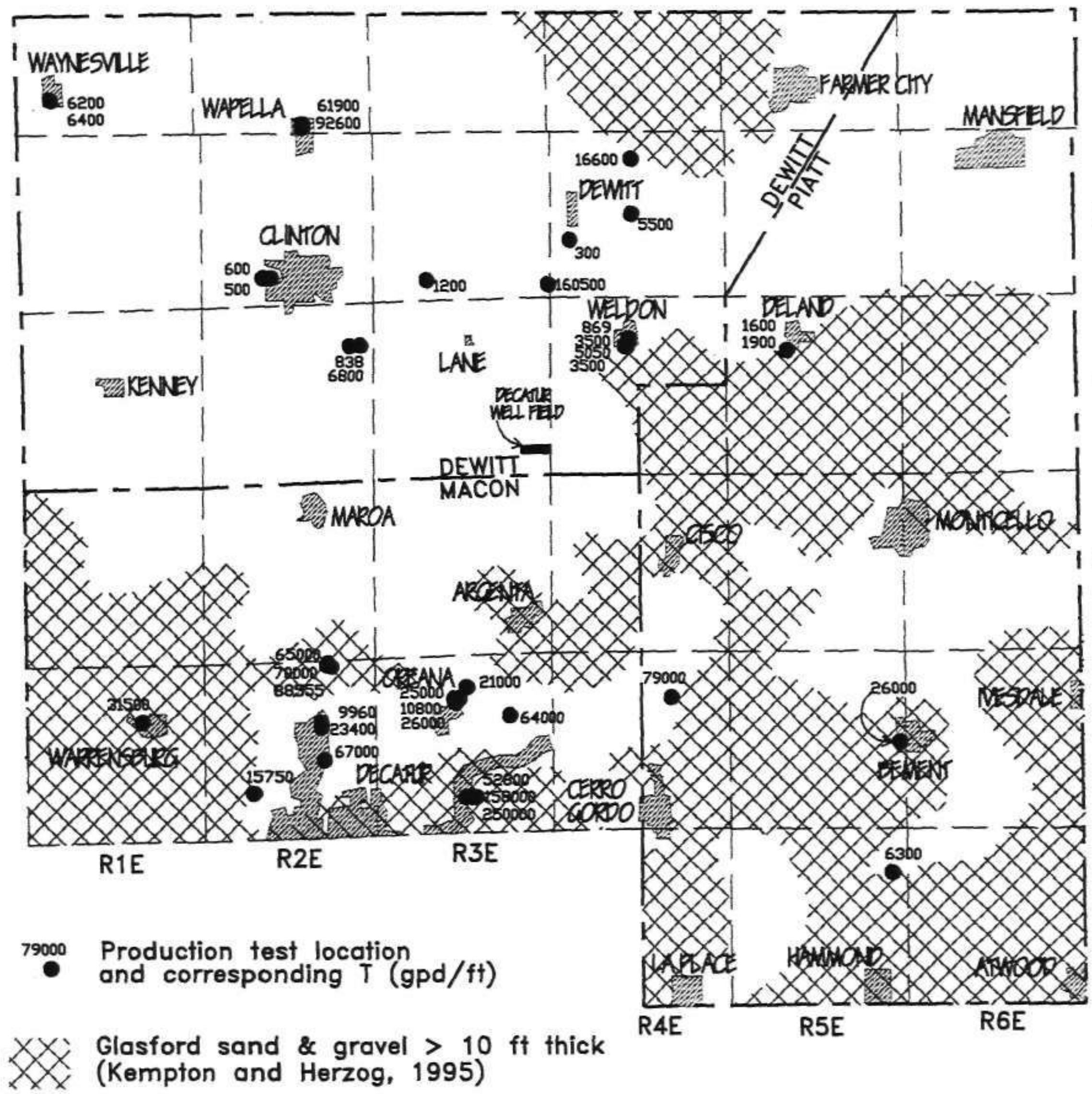

Figure 6. Locations of Glasford Formation transmissivity data

aquifer, lend to the generally narrow range of transmissivity values across the study area. Given that the Mahomet aquifer is locally as much as 200 ft thick and averages close to 100 ft thick (Kempton et al., 1991), keeping in mind that transmissivity is the product of hydraulic conductivity and aquifer saturated thickness, the order of magnitude for hydraulic conductivity values ranges from about 10^1 to 10^3 gpd/ft^2. This range fits well within the range (about 10^1 to 10^5) given for clean sand by Freeze and Cherry (1979).

Analysis of Hydraulic Properties Data - Glasford Formation Aquifers

Figure 6 geographically displays the transmissivity values that resulted from graphically analyzed data for production tests within the study area. A cursory review of the data points shows that a relatively large number of tests have been conducted and analyzed in DeWitt and (northern) Macon Counties compared to Piatt County. For the towns in DeWitt County that utilize wells finished in Glasford Formation deposits (i.e., Waynesville, Wapella, and Weldon), all have had production tests conducted and analyzed for transmissivity values. Numerous additional tests have been conducted and analyzed at facilities associated with Clinton Lake and Weldon Springs State Park. A few privately owned businesses with wells finished in Glasford Formation aquifers also have conducted production tests that contribute to available transmissivity data in DeWitt County.

For the towns in Piatt County that withdraw ground water from wells finished in Glasford Formation sand-and-gravel deposits (i.e., Deland, Bement, Cerro Gordo, and Hammond), all except Hammond have had production tests conducted that allowed graphical analysis for transmissivity.

Within the portion of Macon County included in this study, numerous production tests have been conducted in wells finished in Glasford Formation aquifers (figure 6). Noticeably, though, these tests have been conducted only in tier 17 north (T17N). This is most likely because the towns (Maroa and Argenta) in tier 18 north (T18N) are able to utilize wells finished in the underlying Mahomet aquifer.

A significant point in observing the locations of the transmissivity data points in figure 6 is that several production tests have been conducted in locations in which the sand-and-gravel deposits are less than 10 ft thick. This agrees with the observation by Anliker and Sanderson (1995) that Glasford Formation deposits are used extensively for smaller supplies (mostly private domestic wells) across the vast majority of the study area.

Another interesting observation is the apparent "concentration" of transmissivity data in the tier of townships T17N in Macon County. As was noted earlier, the option of finishing wells in the Mahomet aquifer mostly does not exist in Macon County, except in the tier of township T18N. South of T18N, the greater reliance upon Glasford Formation deposits has resulted in more production tests being conducted in that region. This has been the case for the water supply systems in Forsyth, Oreana, Warrensburg, and the Long Creek Township system near the northeast edge of Decatur.

For the entire study area, the values of transmissivity in the Glasford Formation deposits range from 300 to 250,000 gpd/ft. The average of all values is 38,600 gpd/ft, and the standard deviation is 54,200 gpd/ft.

Suggested Further Studies Addressing Hydraulic Properties Data

One may notice that hydraulic conductivity values are not presented for the Glasford and Banner Formation aquifer systems. Rather, transmissivity values determined from production tests are presented. The decision to present the data in this fashion was made in light of the current work being conducted by the ISGS to define the boundaries and thicknesses of these aquifers within the study area. Keeping in mind that hydraulic conductivity, K, is equal to transmissivity, T, divided by aquifer thickness, m, it is expected that a more meaningful analysis of regional hydraulic conductivities can be conducted at the conclusion of ongoing geological studies to more accurately define the regional geometry of the aquifers.

In looking at the "density" of available transmissivity data for the Mahomet aquifer (figure 5), a fairly evenly spaced "grid" of data points can be observed across the study area. If additional aquifer testing were to be conducted in the future to "fill-in" gaps in the available database of transmissivity (or hydaulic conductivity) values, consideration should be given to conducting tests in the vicinity of the villages of Wapella, Argenta, and, perhaps, Kenney.

In considering additional aquifer testing in Glasford Formation deposits, it is important to determine how additional data could be utilized. As the Glasford Formation deposits are currently used by relatively small public water supply systems and the rural population utilizing privately owned domestic wells, significantly large increases in ground-water withdrawals are not foreseen from these entities in the near future. Perhaps a greater effort should be concentrated on the degree of hydraulic connection between the Glasford Formation sand-and-gravel deposits and the underlying Mahomet aquifer. It is not known to what extent water-level declines in the Mahomet aquifer might impact water levels in the Glasford sands and gravels. At the time of this writing, Decatur is investigating this issue in the vicinity of its DeWitt County well field. Depending on the results of Decatur's study, perhaps additional aquifer testing should be conducted at locations more remote from the DeWitt County well field. Testing to better define the hydraulic connection (vertical permeability) between the two aquifer systems also will provide additional insight into the recharge characteristics of the Mahomet aquifer. As indicated earlier, dedicated observation well nests also would provide valuable insight into the hydraulic connection between these two aquifer systems.

An additional situation exists that should be considered by the MVWA regarding the conduct of additional studies within Piatt and DeWitt Counties. Representatives of several entities in central Illinois who have interests in the ground-water resources associated with the Mahomet aquifer are forming a consortium currently called the Mahomet Aquifer Consortium (MAC). The preliminary intention of this newly formed (forming) consortium is to determine the feasibility of assembling a group of ground-water users and scientists to further study the aquifer on a regional basis and eventually discuss the future management of the water resources associated with the Mahomet aquifer. Those currently involved in this consortium include individuals from the following agencies, municipalities, and companies: the ISWS; the ISGS; Northern Illinois Water Company (NIWC), Champaign; public works representatives from Bloomington, Normal, Decatur, Rantoul, Monticello; Consumers Illinois Water Corporation, Danville; and representatives of several water authorities from across central Illinois. It is the author's understanding that this consortium has the goal to study the resources associated with the Mahomet aquifer system on a regional basis and to develop a preliminary regional computer model that would be modified and refined as further hydrologic and hydrogeologic understanding develops through the assimilation and analysis of existing data and additional studies. The evolution of this computer model (a "living model") also could direct the conduct of additional studies in DeWitt and Piatt Counties.

Conclusions and Recommendations

This report presents suggested locations for the installation of a limited number of dedicated observation wells. Field reconnaissance efforts indicated that the chances are poor for locating existing, abandoned wells which could be used as dedicated observation wells at the suggested locations presented herein. In light of this, a listing of property owners who have indicated a willingness to discuss cooperative involvement with the MVWA has been provided (under separate cover) to the MVWA. Implementation of this network of dedicated observation wells can proceed at the discretion of the MVWA and as funds are available for the construction of individual observation wells.

This report includes the hydraulic properties (transmissivity) data generated by past production tests. The available data for the Mahomet aquifer represent a fairly evenly spaced "grid" of data points across the study area. These data could be used in the creation of a fairly coarse (preliminary) digital ground-water flow model, or as a decision tool as the MVWA considers the possibility of conducting additional aquifer tests within their jurisdiction.

The available transmissivity data for aquifers within the Glasford Formation are less evenly spaced throughout the entire study, as compared to data for the Mahomet aquifer. In light of the likely small growth or ground-water withdrawals from these (Glasford Formation) aquifers, additional testing in anticipation of additional significant development is not suggested. More so, future aquifer testing is recommended to better define the hydraulic connection (recharge characteristics) between Glasford Formation aquifers and the underlying Mahomet aquifer. This testing could proceed as the physical dimensions and geological characteristics of these aquifer systems are better defined.

Ideally, a phased program incorporating both the creation of a network of dedicated observation wells and additional controlled, long-term aquifer tests is suggested. A phased program of this nature would continue to build towards the information and database necessary to design and calibrate a representative digital ground-water flow model for the MVWA study area.

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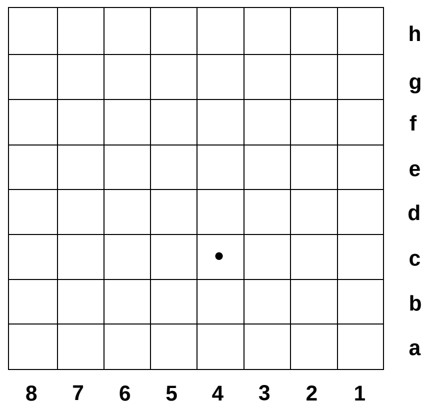
Appendix. Well Numbering System

The well numbering system used in this report is based on the location of the well and uses the township, range, and section for identification. The well number consists of five parts: county abbreviation, township, range, section, and coordinate within the section. Sections are divided into rows of 1/8-mile squares. Each 1/8-mile square contains 10 acres and corresponds to a quarter of a quarter of a quarter section. A normal section of one square mile contains eight rows of 1/8-mile squares; an odd-sized section contains more or fewer rows. Rows are numbered from east to west and lettered from south to north as shown in the diagram.

Piatt County
T18N,R5E
Section 23



The number of the well shown is PIA 18N5E-23.4c. When there is more than one well in a 10-acre square, the wells are identified by Arabic numerals after the lowercase letter in the well number. Any number assigned to a well by its owner is shown in parentheses after the location well number.

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