Research Report 124

Peoria-Pekin Regional Ground-Water Quality Assessment

by

Stephen L. Burch and Douglas J. Kelly

ILLINOIS STATE WATER SURVEY
DEPARTMENT OF ENERGY AND NATURAL RESOURCES

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Indexing Terms: ground-water quality, aquifer, Sankoty, regional study, Pleistocene, Illinois, methane, organic carbon, VOC, bedrock valley.

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PEORIA-PEKIN REGIONAL GROUND-WATER QUALITY ASSESSMENT

by Stephen L. Burch and Douglas J. Kelly

ABSTRACT

This study reports the results of ground-water sampling in central Illinois to define a baseline measure of ground-water quality for the Sankoty aquifer, the major aquifer serving the Peoria-Pekin region. The characterization was undertaken because the 540-square-mile area was targeted as having the potential for ground-water quality problems. Areas throughout the state were previously targeted because of the use of hazardous substances in proximity to ground-water users.

The initial assumption that potential problems might exist proved overly pessimistic. No significant, regional water-quality problems were observed in the Sankoty aquifer, which has a wide distribution and potentially large yields to wells. The overall quality of ground water from the Sankoty aquifer was found to be excellent, although very hard.

The study does recognize, however, that naturally occurring organic carbon occurs more frequently than was previously thought. This observation is likely to become important in areas where the ground water is chlorinated before use as drinking water. It is expected that the chlorination process may result in the formation of trihalomethanes and violate future drinking water standards. Therefore, it is recommended that future investigations of regional ground-water quality routinely include determinations for organic carbon.

An attempt was made to screen samples for hazardous substances by testing for volatile organic compounds (VOCs). Subsequent laboratory determinations made for those samples identified by the flagging technique proved inaccurate. Further testing was made for pesticides and organic compounds on those samples that triggered the VOC screen. It was determined that methane, a relatively harmless VOC, is dissolved in the ground water frequently tapped in the eastern portion of the study area. The methane caused sites to be erroneously identified as requiring further study. Therefore, the authors do not recommend the strategy of using VOCs as a screen for more deleterious organic compounds.

Regional flow within the aquifer is toward the Illinois River, which acts as a discharge boundary and receives ground water from both sides. Consequently, the ground-water system plays a role in maintaining baseflow in the Illinois River. Exceptions do occur, however. The most notable exception is in Peoria, where ground-water pumpage reverses the hydraulic gradient and induces recharge from the river. Water-table conditions (unconfined) were found to extend far beneath the bluff of the Illinois River valley. In fact, frequently where one would expect the Sankoty aquifer to be overlain by as much as 250 feet of clay till, it was unconfined.

INTRODUCTION

The concern for ground-water quality is based upon the potential for past and present human activities along the Illinois River valley to adversely impact the ground-water resource. Little is known of the resource's overall chemical character, and until recently our knowledge about organic contaminants has been limited. Compliance with regulatory statutes now requires testing for organic compounds and, consequently, is improving our knowledge of baseline water quality at specific public water supplies. However, in this study we sought to broaden the scope of water-sampling points.

A portion of the Peoria-Pekin area was targeted for special monitoring of ground-water quality by a research effort (Shafer, 1985) sponsored by the Illinois Department of Energy and Natural Resources (DENR). That statewide study identified the Peoria-Tazewell-Woodford County area, among others in Illinois, as having the potential for ground-water quality problems because of the use of hazardous substances in proximity to ground-water users. Although only a few wells in the Peoria-Pekin area were reported to contain contaminants, there were no definitive ground-water quality characterizations.

In its 1986 plan for protecting Illinois ground water, the Illinois Environmental Agency (IEPA) referred to the establishment of a "baseline groundwater quality." Although not explicitly stating what parameters might be included, the plan did state that a baseline consisted of sampling for inorganic and some organic substances. In its own monitoring network, the IEPA included testing for halogenated organic compounds: volatile organic compounds (VOCs) and volatile organic aromatics (VOAs).

This project seeks to establish the "baseline groundwater quality" of the Sankoty aquifer, the major aquifer supplying the Peoria-Pekin area. Because section 7 (b2) of the 1987 Illinois Groundwater Protection Act (IGPA) fails to elaborate on which parameters should be evaluated, the plan adopted for this study was borrowed from previous Water Survey assessments at Rockford (Wehrmann et al., 1988) and metropolitan East St. Louis (Rehfeldt et al., 1992). The strategy entailed sampling for a broad spectrum of constituents, including analyses for all major anions and cations, trace metals, and nonspecific tests for organic contaminants (i.e., purgeable organic carbon). If warranted, more detailed analyses were made.

Private wells located away from public water-supply wells were required to characterize regional ground-water quality. We soon learned that these wells were owned by small businesses or homeowners and tended to be grouped in districts or concentrated along major thoroughfares. The necessity for using these existing wells made it difficult to obtain a uniform distribution of sampling sites. Private wells were also much more common during previous Water Survey studies: few such wells remain today in the urban areas of Peoria and Pekin. This may be due to urban renewal efforts in the past two decades and the area's shift from an industry-based economy to a service-based one. The urban areas are also no longer confined to the riverfront and have expanded onto the uplands, making it more costly to drill a well and pump water.

Study Area Location

The Peoria-Pekin region (figure 1) is located southwest of Chicago in north-central Illinois. Like many of the older cities in the Midwest, Peoria and Pekin are old river towns that replaced military forts built along the Illinois River. The study area includes parts of three counties: Peoria, Tazewell, and Woodford.

The region lies between parallels 40° 30' and 40° 52' 30" N latitude and meridians 89° 22' 30" and 89° 45' W longitude and encompasses 540 square miles. The study area is rectangular, 27 miles long and 20 miles wide. Although Peoria and Pekin are the largest cities in the region, several smaller communities are also included on figure 2: East Peoria, Creve Coeur, North Pekin, Bartonville, Washington, and Morton.

Figure 1. Counties included in the study: Peoria, Woodford, and Tazewell

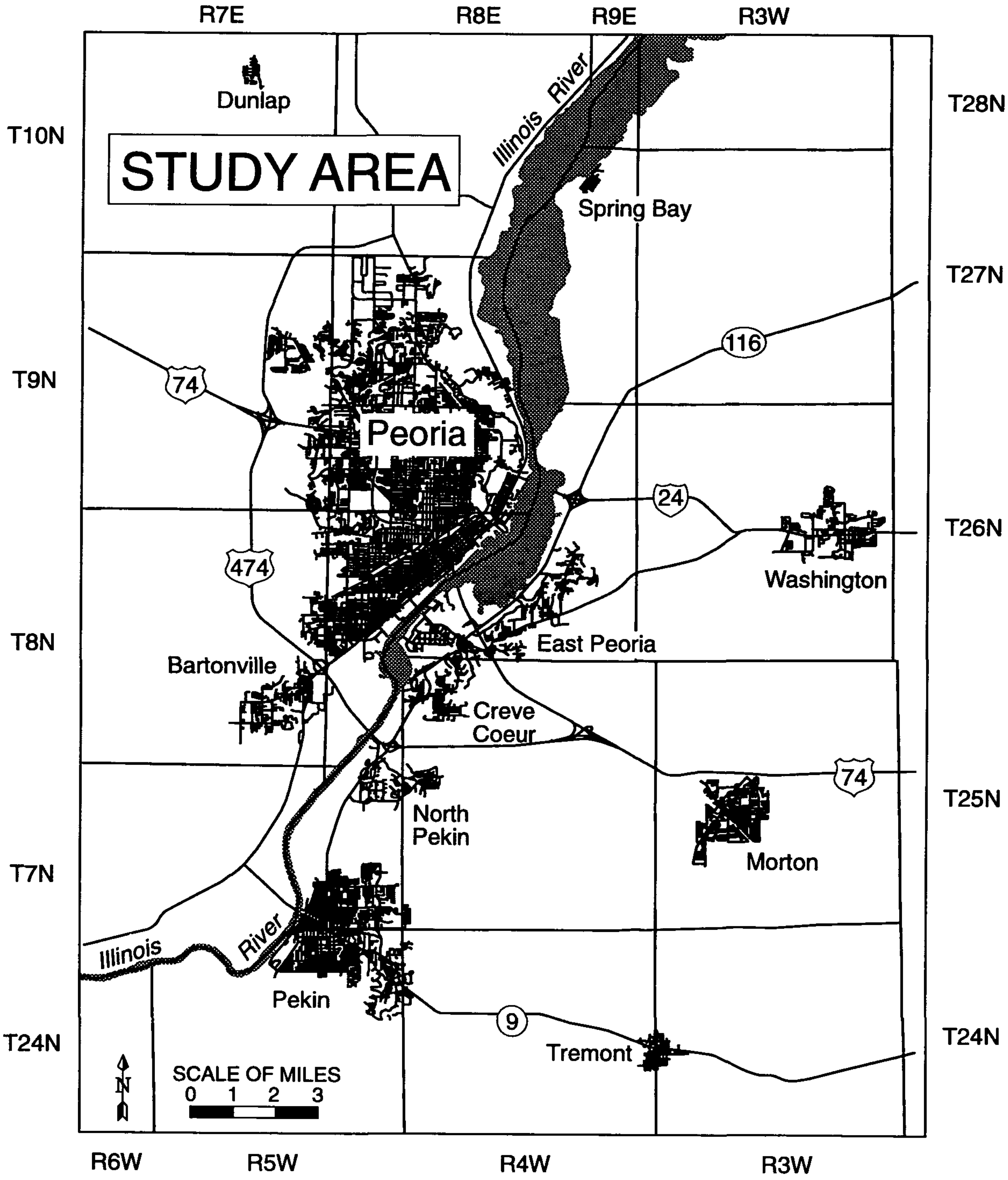

Figure 2. A map of the study area including townships, ranges, and communities

Previous Reports

The Illinois State Water Survey (ISWS) has a long history of studies in the Peoria-Pekin area (ISWS, 1940; Horberg et al., 1950; Marino and Schicht, 1969) and has routinely observed water levels in many observation wells. Precise study boundaries were not identified in those reports, but it was recognized that any study should describe areas that extend "beyond the immediate environs of Peoria in order that the regional extent of the glacial aquifers and buried or partly filled bedrock valleys may be portrayed" (Horberg et al., 1950). They described the study area as encompassing the communities of Peoria Heights, Peoria, and Bartonville in Peoria County; and East Peoria, Creve Coeur, and Pekin in Tazewell County. They referred to areas in terms of "well fields" and by way of illustration implied that the principal area of study lay along the Illinois River valley.

The maps used in the 1950 report include the southern half of township 10 north (T10N) in Peoria County and southward through the northern two-thirds of T24N in Tazewell County. Laterally the area extended from range 7 east (R7E) in Peoria County through R4W in Tazewell County.

Marino and Schicht (1969) stated that the Peoria-Pekin study area extended "from 6 miles north of Mossville to 5 miles south of Pekin." They widened the Peoria-Pekin study area eastward to include R3W, apparently to include the axis of the ancient Mississippi bedrock valley.

The only definitive work describing ground-water quality was done by Larson, at the Illinois State Water Survey, while the geologic and hydrologic studies were in progress during the 1940s (Horberg et al., 1950). He found that the character of samples from a particular source (well field) was generally constant, and that it was possible to differentiate each well field. Larson sought to find correlations between some inorganic constituents and the distances of wells from hydrogeologic influences, such as the Illinois River, bedrock topographic highs, Wisconsin-age till sheets, and valley walls. Today these factors are all known as "hydrogeochemical controls", but their significance was not appreciated by most researchers in the 1940s. Consequently, Larson analyzed primarily for hardness (calcium and magnesium carbonate), sulfate, and alkalinity.

Larson found that ground-water samples from wells along the Illinois River are invariably characterized by low sulfate content (< 10 milligrams per liter or mg/L) and by the presence of appreciable concentrations of ammonia and iron. He believed these samples to be representative of induced river water. By contrast, waters from other sand-and-gravel wells characteristically contained appreciable sulfate concentrations (>10 mg/L). A further distinction was the presence of elevated concentrations of hardness, alkalinity, and nitrate.

Topography and Drainage

Steep bluffs border much of the Illinois River through Peoria and Tazewell Counties. The steepness is due largely to the weathering character of loess. This wind-deposited strata has the ability, due to its physical properties, to stand in near-vertical cliffs before eventually slumping. The loess, commonly about 50 feet thick, overlies earlier deposits of till. Similar occurrences of loess exist at Council Bluffs, IA, along the Missouri River.

The drainage pattern that has been superimposed on the area results in narrow V-shaped ravines that seek the lower topographic position of the Illinois River. Significant among these are Tenmile Creek, Farm Creek, and Kickapoo Creek. Because the loess is so easily eroded, these streams frequently are laden with silt. Accordingly, there is an alluvial fan at the mouth of each of the creeks. Farm Creek forms the most conspicuous, symmetrical fan upon which the city of East Peoria is built (Udden, 1912). This alluvial fan was built so rapidly that it partly constricted the river, forming the Upper Peoria Lake on the north side and Lower Peoria Lake to the south.

Away from the Illinois River valley, the topography is much more subdued. The gently rolling land surface is noteworthy only because of the presence of the Bloomington Moraine. The elevation along the crest of the moraine is commonly more than 800 feet above mean sea level. Meanwhile the normal pool elevation of the Illinois River at Peoria is 440 feet above mean sea level.

Acknowledgments

We first acknowledge the people of the Peoria-Pekin area who opened their doors (or their faucets) to us. Most of the ground-water samples we collected were from privately owned wells.

We also sought to visit individuals who might be familiar with or exert control over the use of ground water in the Peoria-Pekin area. Consequently, we visited Mr. Bill Miller, City Engineer's office in Peoria, and briefly explained our interest and project goals to him and then to Mr. Mike Bietto, Peoria Park District. As a result of these visits, we obtained access to wells at two public golf courses managed by the Peoria Park District. We were also able to determine that most irrigation within Peoria uses "city water".

Telephone contacts with the Peoria Public School District revealed that the schools do not use wells for watering athletic fields. Manual High School does have an inactive high-capacity well, which we did not attempt to use. That well is near the public supply wells at Griswold Street Station, and it would not provide spatially significant information for our study.

Other contacts were made with private firms, key among them, the Peoria Division of the Illinois-American Water Company. That privately owned utility is the major provider of public drinking water to the Peoria region. We visited with Mr. Randy Pankiewicz (then the water quality superintendent) of their Peoria District to discuss ground-water quality, testing, and project goals. He agreed to make available to us results of their internal chemical testing of supply wells and seemed receptive to our broader effort to characterize the aquifer.

In East Peoria, Mssrs. Steve Karr and Dan Giebelhausen, Department of Public Works, gave us valuable insights to the water-supply system and access for the construction of an observation well at the wastewater treatment plant

Mr. Steve Funk, Pekin Park District, was of great help in showing us possible drilling sites on city-owned property. In North Pekin we received similar support from Mr. Frank Hardy, Department of Public Works.

Some of our colleagues at the Illinois State Water Survey should also be acknowledged. Most notable were Cecille Widolff and Joan Gosar, who assisted with field work; and Loretta Skowron, who provided inorganic chemical analysis of water samples and protocol guidance. Graphics were computer-generated by the senior author and enhanced by Dave Cox and Linda Hascall. Eva Kingston edited and formatted the final report and contributed to its readability.

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RELATIONSHIP OF GEOLOGY TO GROUND WATER

Geology is the study of the earth. It is based mainly on observations, which are logically explained by other sciences such as physics, chemistry, and biology. Geology encompasses a broad area and often lacks exactness because of the necessity to incorporate new ideas as they become available (Foster, 1971). This very practical science has contributed economically to our civilization. For example, geologic knowledge is used to locate mineral resources such as sand and gravel, petroleum, coal, and metals. One branch, hydrogeology, focuses on ground water with particular emphasis given to its chemistry, movement, and relation to the geologic environment

Types of Aquifers

Aquifers are geologic strata that can yield water in quantities sufficient to warrant economic development. This definition implies that what constitutes an aquifer, usually based on yield, might vary according to individual needs. Ground-water quality may also be a deciding factor.

Geologists, well drillers, and others working with ground water in the Midwest frequently think of two types of aquifers: glacial and bedrock. Glacial aquifers are generally composed of unconsolidated sand and gravel and were formed during the Ice Age. Only thousands of years old, these aquifers are much younger than the bedrock aquifers, which they overlie. Also because they are nearer the surface, glacial aquifers are more likely to be involved with surficial processes, such as recharge and discharge.

Bedrock aquifers are millions of years old and were originally deposited as unconsolidated sediments that have since hardened. The once soft clay deposits have been compacted and become shale; likewise, the sand grains have been cemented together forming sandstone; while lime precipitated in deeper seas has recrystallized the calcite-bearing mud into limestone. Ground water flows through crevices in the bedrock and between the grains of sandstone in these aquifers, but it is highly mineralized and is not generally desirable.

Conversely, the glacial aquifer in the study area yields water much more readily than do the bedrock aquifers. The water from this sand-and-gravel deposit is also less mineralized, thereby making it preferable. Consequently, this study focuses on the glacial aquifer due to its importance to the Peoria-Pekin region.

Bedrock Topography

Glacial deposits overlie the bedrock formations and fill in the irregularities of the bedrock surface. The outstanding irregularity on the bedrock surface of the study area is the ancient valley of the Mississippi River, which does not coincide with the present topography, but instead represents the topography prior to the Ice Age. This valley was formed by the ancestral Mississippi River, which flowed southeastward from above Rock Island, through Lee, Whiteside, and Bureau Counties, before turning south near Hennepin, IL. The Mississippi carved a valley more than 450 feet deep (Horberg et al., 1950) through the bedrock, bypassed the east side of Peoria, and then joined with another major bedrock valley, the Teays-Mahomet in southeastern Tazewell County, before flowing toward Havana and the present-day Illinois River valley (figure 3).

Minor tributary valleys slice through the bedrock uplands (figure 4). These valleys usually join the valley of the ancestral Mississippi in the Peoria-Pekin area with one significant exception, the Pekin-Sankoty bedrock channel. Instead of joining the river, this channel splits off, exits the ancient Mississippi valley above Peoria, and extends under the city and southwestward along the present Illinois River valley to a point past Pekin. The Pekin-Sankoty valley is narrower and not as entrenched as is the ancestral Mississippi channel.

Joining the Pekin-Sankoty valley is the Kickapoo Creek bedrock valley, which enters on the west side of Peoria and coincides roughly with the location of modern Kickapoo Creek, hence its name. Another tributary also joins the main bedrock valley about five miles to the north and appears to be connected to the Kickapoo valley (ibid.).

Effect of Geology on Ground-Water Quality

The earth's crust is composed almost entirely of only eight elements: oxygen (O), silicon (Si), aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), magnesium (Mg), and potassium (K). In nature, these elements combine to form minerals, which in turn group themselves into rocks. When ground water comes into contact with these rocks, it takes on their chemical character. Natural water is never pure, but rather an aqueous solution that results from the equilibrium solubilities and chemical kinetics (Hem, 1970). The chemistry or quality of the ground water is influenced by the lithologic composition of the aquifer through which it flows, the chemical and biological processes that occurred during its infiltration into the aquifer, and the length of time it has resided in that environment.

Most rocks in Illinois are sedimentary. The dominant lithologies include limestone ($CaC0_3$) and dolomite ($CaMg(C0_3)_2$). These carbonate rocks formed in warm, marine waters because of carbon's tendency to combine with oxygen. Shales are perhaps the most common lithology in central Illinois. They were formed by the weathering of aluminous silicates, typically the mineral feldspar, which was once part of the granitic Canadian Shield in most of eastern and central Canada. These silicates were deposited as mud on the continental shelf millions of years ago. Diagenesis, or the compaction

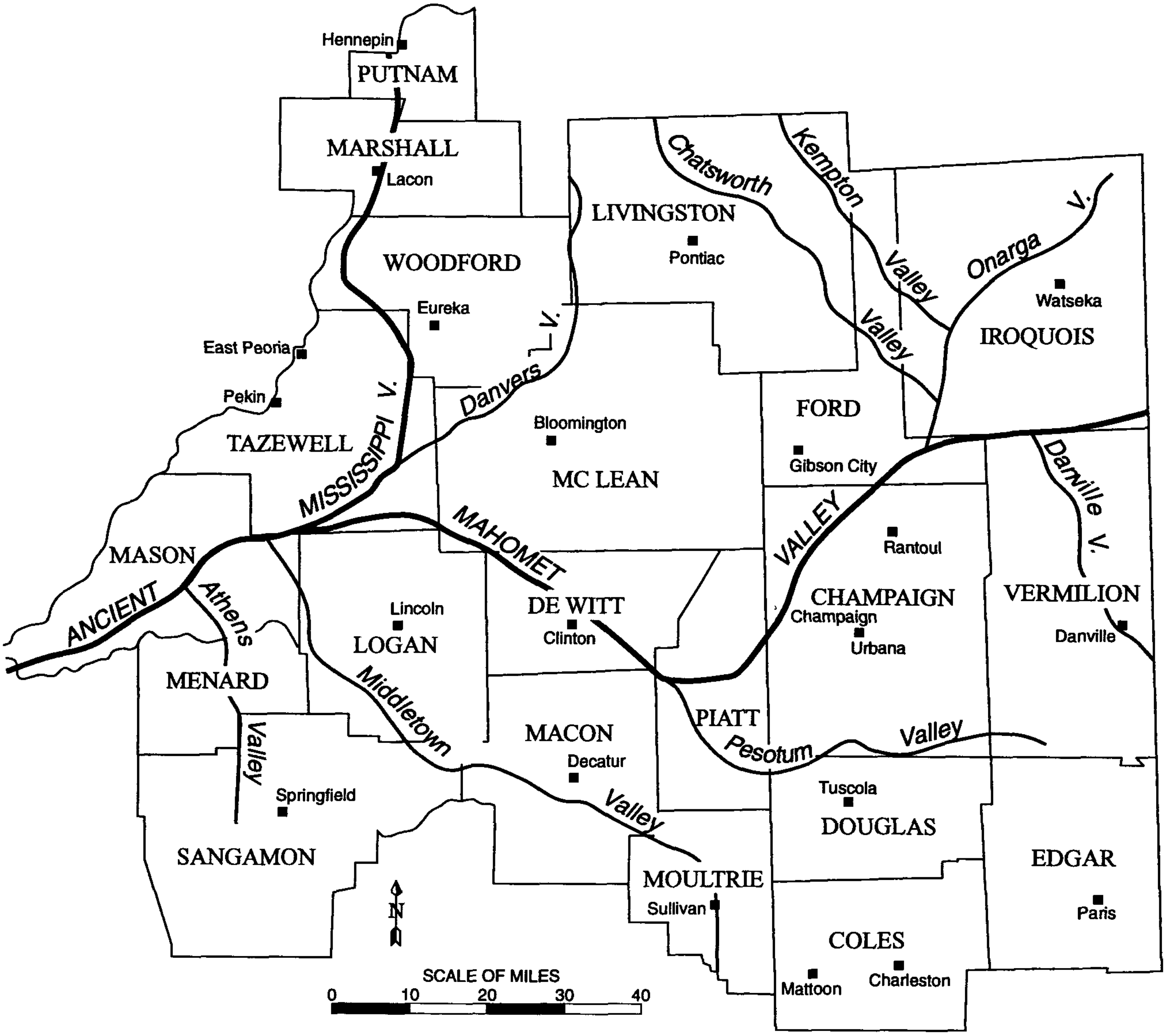


Figure 3. Major buried bedrock valleys in central Illinois

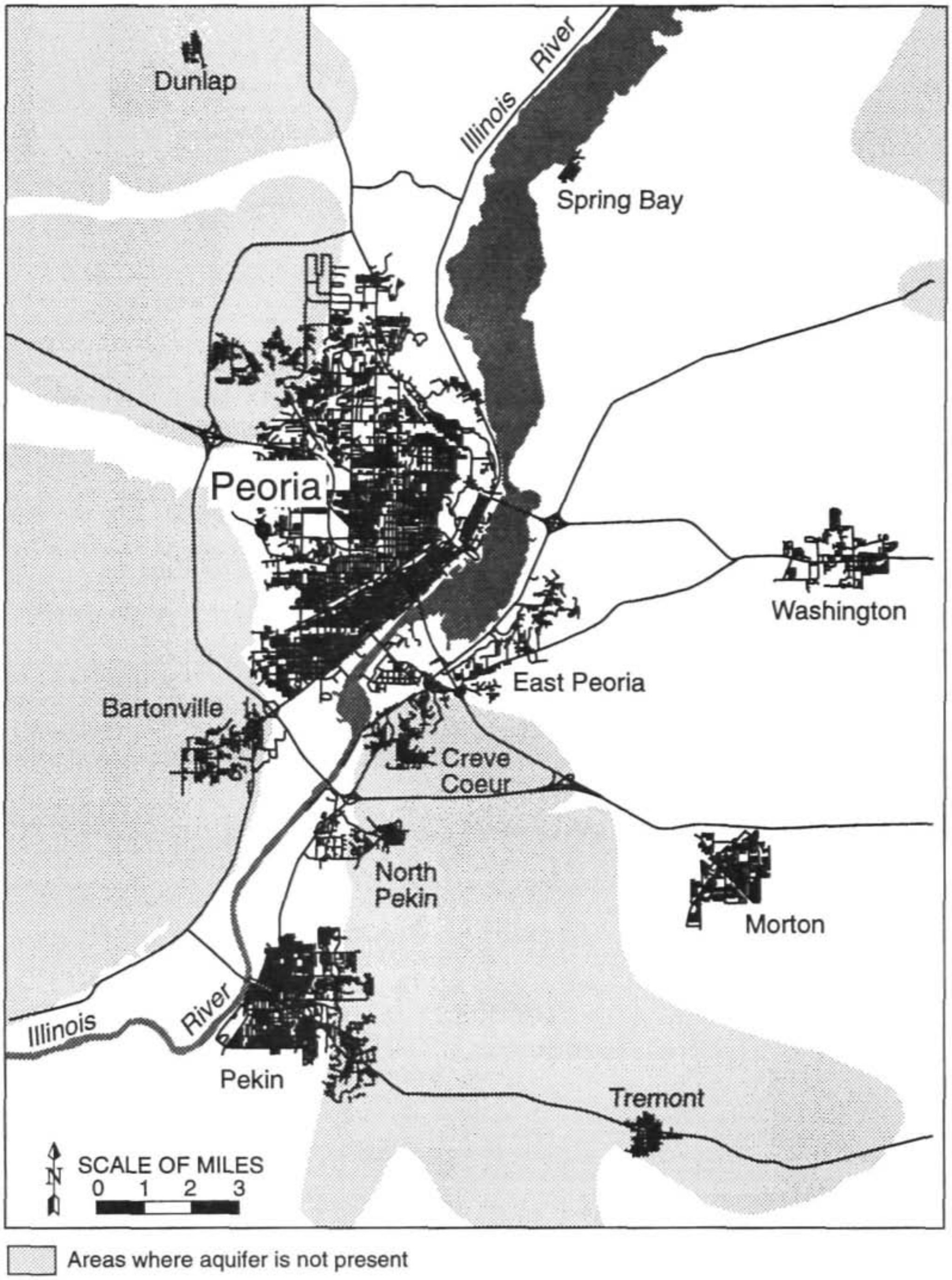


Figure 4. Approximate aquifer boundary and geographic relationship with Peoria, East Peoria, and Pekin

and chemical changes occurring to sediments during and after deposition, has resulted in an abundance of shale rich in the clay mineral illite.

Sandstone and coal also occur in the stratigraphic sequence of central Illinois, but to a lesser extent. Quartz ($Si0_2$) is the chief constituent of most sandstones, comprising 66 to 90 percent of the total (Pettijohn, 1975). Coal is comprised chiefly of carbon, hydrogen, and oxygen with nitrogen and sulfur as lesser constituents. Coal is frequently found in the Pennsylvanian-age bedrock that characterizes central Illinois.

Time too effects hydrochemistry. The quality of ground water tends to evolve towards that of seawater (Freeze and Cherry, 1979). In this process, known as the Chebotarev sequence, what begins as a bicarbonate ($HC0_3$) type of water eventually increases in sulfate content. The bicarbonate eventually yields to chloride that coexists with the sulfate. Finally, if the flow system is not interrupted, even the sulfate defers to chloride. The saline, chloride-rich water is usually very old and migrates to the center of sedimentary basins, such as the Illinois basin. From a hydrogeologic viewpoint, it is significant mat the composition of ground water changes as it moves deeper into the flow system.

Glacial Aquifers in the Buried Valleys

During the Pleistocene Epoch, great ice sheets covered much of the North American mid-continent. One of the earliest ice sheets covered the Peoria-Pekin area and its bedrock surface, before retreating to Canada. As a result, large volumes of water from the melting ice found meir way into the bedrock valleys. The swift meltwater streams carried vast amounts of debris away from the glaciers and left behind only the heaviest materials, the main reason for the prevalence of sand and gravel in the old river valleys. Old photographs from drill sites in me Peoria area document cobbles with 10- and 12-inch diameters, and even small boulders, on the bottoms of these valleys.

Ordinarily glacial deposits are composed dominantly of unstratified clays. But they sometimes do contain stratified sand-and-gravel deposits that serve as aquifers. The fine- to medium-grained aquifer material at Peoria, known as the Sankoty sand, is distinctive, readily recognizable in sample cuttings by its uniform quartz grains. Many of these grains, perhaps 25 percent, are pink, apparently from inclusions of hematite. The nonquartz fraction of the cuttings is composed of crystalline rocks and quartzite, indicating derivation from a northern Precambrian terrain (Horberg et al., 1950). The Sankoty sand is the most extensive aquifer in the area and certainly one of the largest aquifers in the state. Its thickness varies greatly from about 50 to 150 feet because the aquifer has been eroded in the Illinois River valley, and due to irregularities on the bedrock surface. The average thickness of the aquifer is about 100 feet.

Outside of the study region, the Sankoty sand has been described as far south as Mason City and north into Whiteside County. Horberg (ibid.) believed the sand was continuous along the bedrock valley of the ancient Mississippi drainage system and may have extended into Wisconsin and Minnesota.

REGIONAL HYDROLOGY OF THE SANKOTY AQUIFER

Ground-Water Flow Directions

Maps are one of the most important tools available to ground-water scientists. Much can be learned from the study of contour maps illustrating ground-water levels. First, the direction of ground-water movement can be determined. Second, by comparing maps of bedrock topography and water levels, one can infer a third map of saturated thickness (assuming the bottom of a water-table aquifer is represented by the bedrock). Saturated thickness maps can be very useful in determining the potential yield of a well and total storage available within an aquifer. Third, with some knowledge of aquifer boundaries, one may infer other factors such as changes in hydraulic conductivity.

Ground-water maps are constructed by plotting observed water levels at points on a map corresponding to individual well locations. The water levels are typically expressed relative to sea level, but may in fact be referenced to any datum. The elevation to which water rises in a well defines potentiometric surface and, strictly speaking, reflects the force potential causing ground water to flow.

A potentiometric map was constructed for this study by using water levels observed while sampling for ground-water quality (figure 5). It compares favorably with maps produced previously (Horberg et al., 1950; Marino and Schicht, 1969). The general pattern of ground-water movement continues to be toward the Illinois River, which represents a discharge boundary and receives ground water from both sides. Consequently, the ground-water system plays a role in maintaining baseflow in the Illinois River. Smaller flow systems exist, but the main impetus of flow-direction is toward the river.

Smaller flow domains are sometimes formed by pumpage at municipal well fields, which reverse the ground-water flow direction and frequently capture induced recharge from the river and the ground-water ordinarily moving toward it. These disruptions of regional flow result from areas of low hydrostatic pressure, or sinks into which ground water flows. Horberg and others (1950) referred to each sink by the well-field name (Sankoty, North, Central, or Pekin). Figure 6 shows the relative locations of these four well fields.

A comparison of water-level elevations within the Sankoty to the approximate top of the aquifer was made. The elevation for the top of the Sankoty sand typically varies from about 490 to 500 feet above mean sea level. Our analysis revealed that water-table conditions (unconfined) extend far beneath the bluff of the Illinois River valley. In fact, frequently where the Sankoty aquifer is overlain by up to 250 feet of clay hill and one would expect it to be confined, it was unconfined. Figure 7 illustrates the approximate boundary where the Sankoty switches to confined aquifer conditions (that is, where artesian pressure causes the water levels in wells reaching the aquifer to rise above the aquifer's top elevation).

Re-establishment of Former Observation Wells

The Water Survey directed the construction of approximately 25 observation wells in the Peoria area during the 1940s and early 1950s. Water levels in those wells were monitored for many years. In the late 1960s, Marino and Schicht (1969) attempted to correlate pumpage and ground-water levels. Since then, however, most of these wells have been ignored. During the current investigation, an effort was made to locate these old observation wells and measure their present water levels. A search revealed that most of the wells had been destroyed, but wells at three sites were recovered.

A metal detector was used at the Peoria Public Library, Lincoln Library branch, to find the old 4-inch well, which had been buried during library remodeling in 1968. The old observation well is still useful, unlike a nearby sister well clogged up by vandals.

Another observation well was found on the grounds of the Buehler Nursing Home. This well was important to investigators in the 1940s because it revealed a deep bedrock channel underlying the city of Peoria. The well had been used as a key water-level control point in the maps presented by Marino and Schicht (1969). But diagrams made for the 1969 study, showing the well's location, were inaccurate and contributed to its being "lost". Fortunately, our search revealed the original driller's log containing a note describing the well's true location.

A third site located just west of the Madison Park Golf Course turned up two more observation wells behind a firing range (Peoria Park Police) on the south edge of Horseshoe Bottom. These wells, which were found in a thicket of vines, brush, and trees, had once provided background water-level information about trends in the region because of their distance from the Central well field. We observed that the water level in the 6-inch well (old SWS well #7) was about 2 feet lower than values reported during 1967 and 1968. This decline is probably in response to increased pumpage of the Griswold Street wells located about 1/2-mile away.

Drilling of New Monitoring Wells

To supplement the nonuniform distribution of existing wells, new monitoring wells were constructed in Pekin, North Pekin, and East Peoria. These 2-inch diameter wells, ranging in depth from 24 to 105 feet, were used to provide water-level and water-quality information. They were constructed in 1990 over a three-week period using the Water Survey hollow-stem auger drill. A total of 1,181 feet were drilled to set 893 feet of well materials.

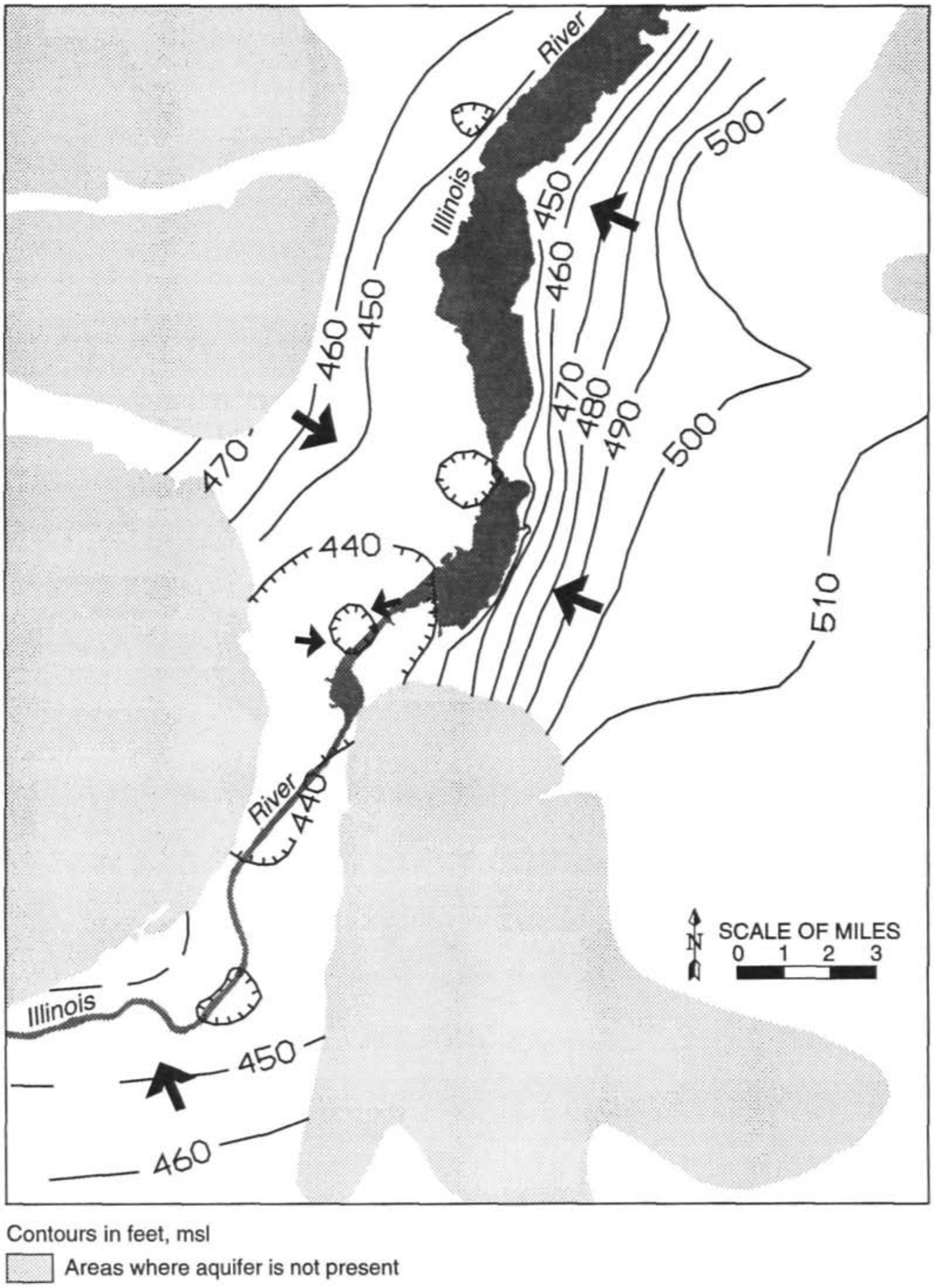


Figure 5. Elevation of potentiometric surface and direction of regional ground-water flow for the Peoria-Pekin region: 1990-1991 data

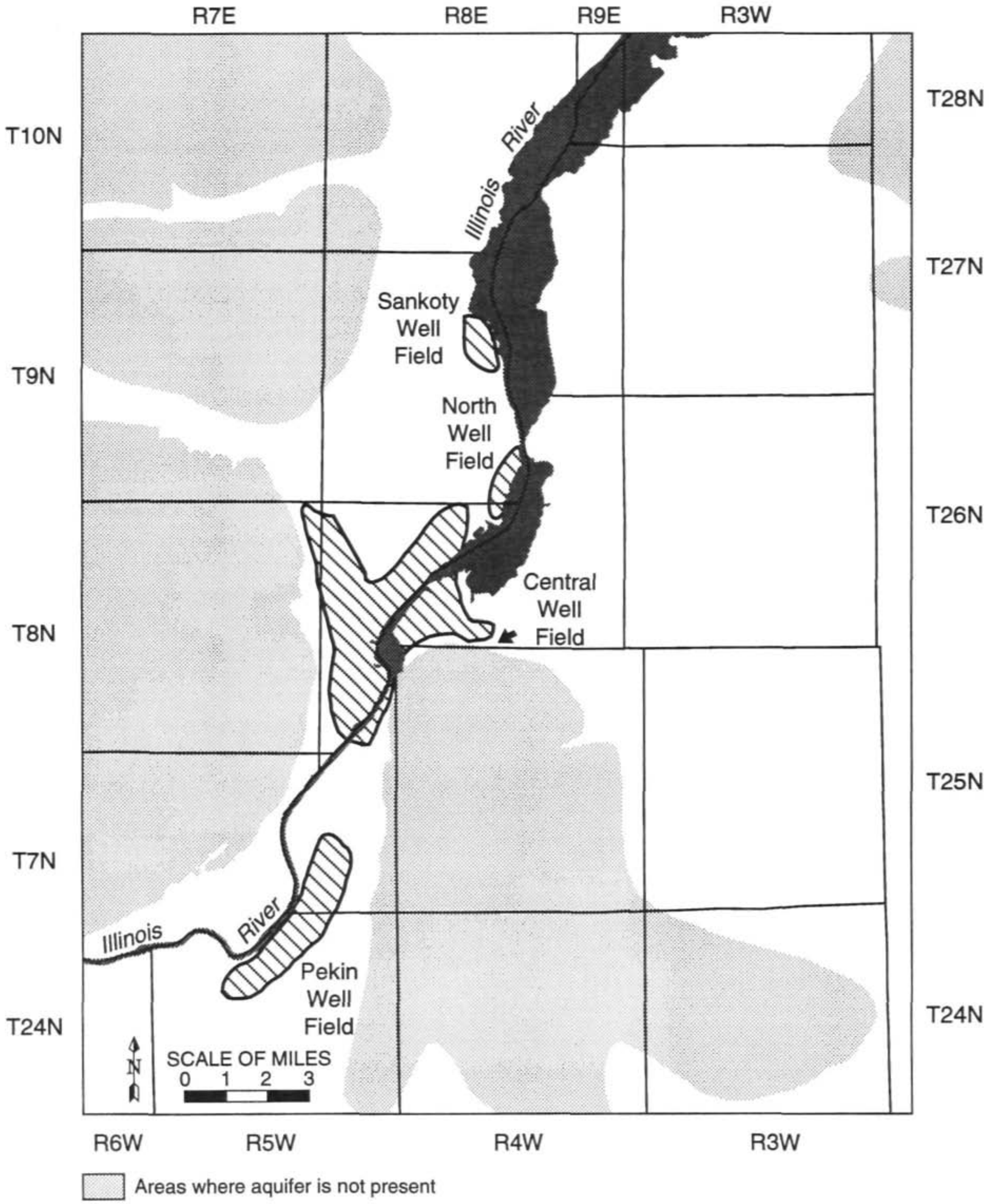


Figure 6. Locations of the Sankoty, North, Central, and Pekin municipal well fields

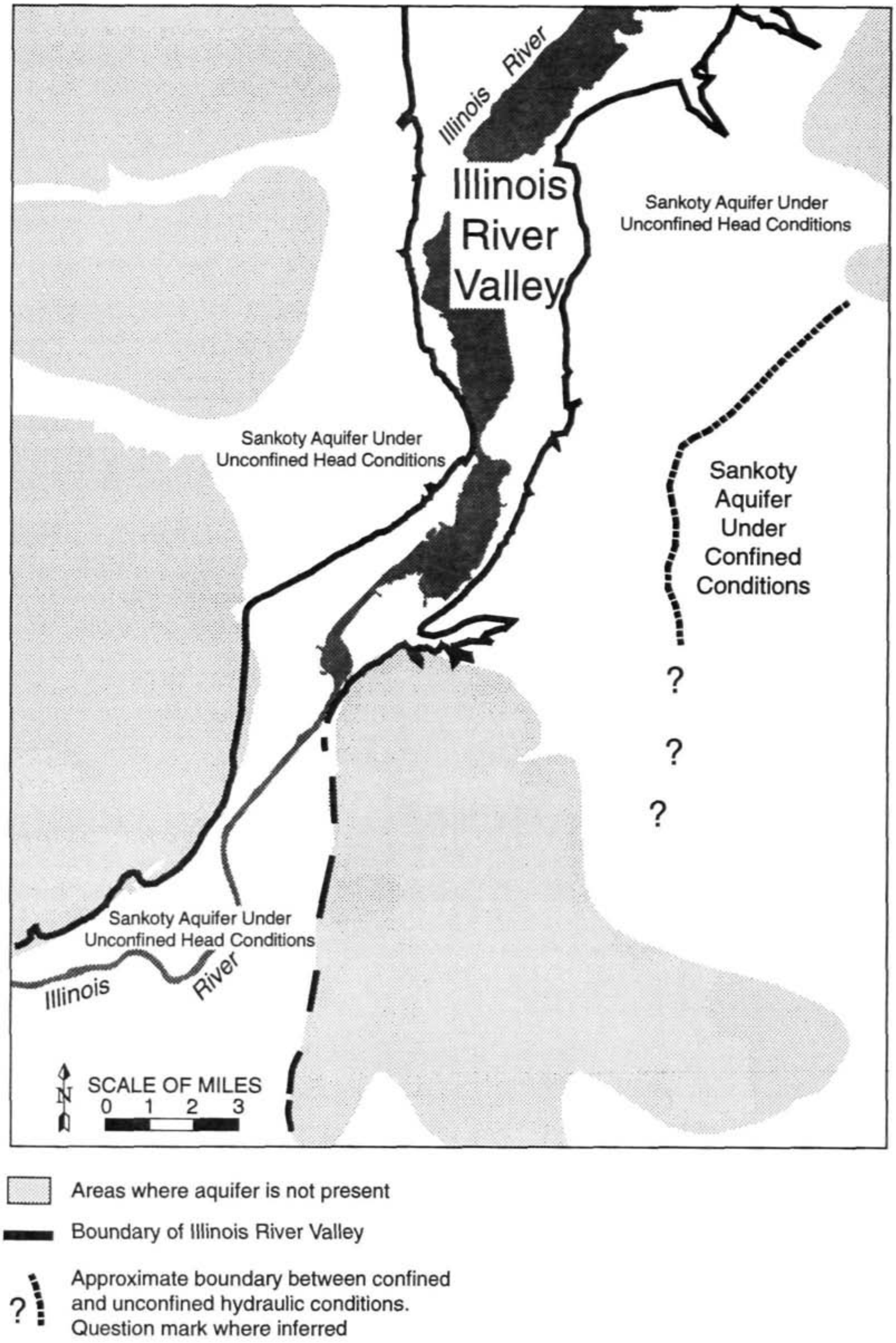


Figure 7. Areas of confined and unconfined aquifer conditions in the Illinois River valley

The elevations above mean sea level of the well-casing tops were determined using common surveying techniques. Depths to water were measured and subtracted from those measuring points to determine the elevation of the water-table's surface.

Holes were drilled at 16 sites, but only 13 were cased. Two of the new wells will serve as replacements for old Water Survey observation wells that were lost or destroyed. The others were sited in Pekin, North Pekin, and East Peoria to obtain information about these areas' water levels and water quality in these areas.

Well materials were a combination of stainless steel and polyvinyl chloride (PVC). Stainless steel screens were used in all of the monitoring wells. The first 10 feet of casing in most wells was also stainless steel. Above that point, however, PVC casing was used to minimize cost and weight. The 2-inch diameter wells project above ground about 18 to 24 inches.

Comparison to Old Water-Level Data

As was stated previously, observation wells were constructed in the 1940s for the Water Survey. Water levels in these wells were monitored for many years, usually with a float-type recorder (Horberg et al., 1950). The data were recorded continuously on paper charts at these sites because this method was considered to be more useful than periodic measurements made with a steel tape. The monthly charts obtained from these recorders were combined to form an annual hydrograph for many wells in the area. The period of record typically ranges from 1942 until 1958.

Records from four of these sites were found in the Water Survey archives. They included annual hydrographs from the Buehler Nursing Home well, the Lincoln Park well (now known as the Lincoln Library well), the Madison Park well, and the Bradley Park well, all of which were reported by Horberg et al. (ibid., pp.83-84).

Each hydrograph was digitized so that the historic water levels at the four Peoria sites could be compared with their 1965-1966 levels (Marino and Schicht, 1969) and the levels we observed in 1990-1991. The comparison revealed the same relative differences among the wells today as 50 years ago and that ground-water levels are generally higher today. The old and new measurements are shown as figures 8-11.

The best long-term record, from 1942 to the present, comes from the Bradley Park well (figure 8). It shows that the lowest water levels were observed in this well during the late 1950s, presumably because of the 1956-1958 drought. The highest water levels were observed during the 1980s.

The other hydrographs have shorter periods of record, generally from 1942 to 1962. They too document that the lowest ground-water levels at the Madison Park, Lincoln Park, and Buehler Nursing Home sites occurred during the 1956-1958 period. Modern measurements at these three sites show water levels are currently higher than at any time during the 1940s and 1950s. In fact, the Buehler Nursing Home well is almost 7 feet higher than when observed by Marino and Schicht in 1966-1967.

The authors measured water levels at 28 private wells not previously observed. These wells were broadly scattered over the entire study area, often beyond boundaries for municipalities and public-water supply systems. The measuring point elevation for each well was determined with surveying equipment, so that the water elevation above mean sea level could be determined.

Collectively, these ground-water levels plus those measured in the 16 new observation wells were used to make a new potentiometric map (figure 5). This map, as noted previously in this chapter, differs little from the maps made previously by Horberg et al. (1950) or Marino and Schicht (1969). We can thus conclude two major points: (1) the ground-water flow system continues to discharge to the Illinois River and maintains its baseflow, and (2) recharge enters the ground-water system at a rate sufficient to maintain this discharge plus the withdrawals made by wells.

Hydraulic Conductivity Calculations

Hydraulic conductivity is a measure of how much water moves through a medium in a unit of time. The general dimensions of this measure are length versus time (L/T), although the Water Survey traditionally uses rate versus area (gallons per day per square foot or gpd/ft^2). Hydraulic conductivity can be determined by several different methods, one of which is a slug test. All the methods share a common concept of stressing the aquifer (by abruptly adding a known volume or slug of water to a well) and monitoring its water-level response. The method is suited to slowly permeable deposits and fails to work in geologic materials such as those found in the Peoria-Pekin region.

Today we frequently stress the aquifer by applying compressed air to the well. This pneumatic version of the slug test method quickly lowers the water level from its equilibrium level. Water-level recovery occurs quickly once the pressure is released. The rate of recovery can be used to calculate the hydraulic conductivity of the geologic material in contact with the well screen.

Several pneumatic slug tests were performed in East Peoria (sections 29, 31, and 32). These tests confirmed what we already suspected: little high-quality aquifer material exists in East Peoria. Values of hydraulic conductivity in the tests were typically <150 gpd/ft^2. High-quality aquifer material would be expected to have hydraulic conductivity values >2,000 gpd/ft^2. Just across the river, in Peoria, however, aquifer tests had hydraulic conductivity values ranging from 5,000 to 28,000 gpd/ft^2 (Schicht, 1992). Apparently, good aquifer material was never deposited in East Peoria, or if it was, then it has subsequently eroded. As a result, the city of East Peoria has located its well field to the

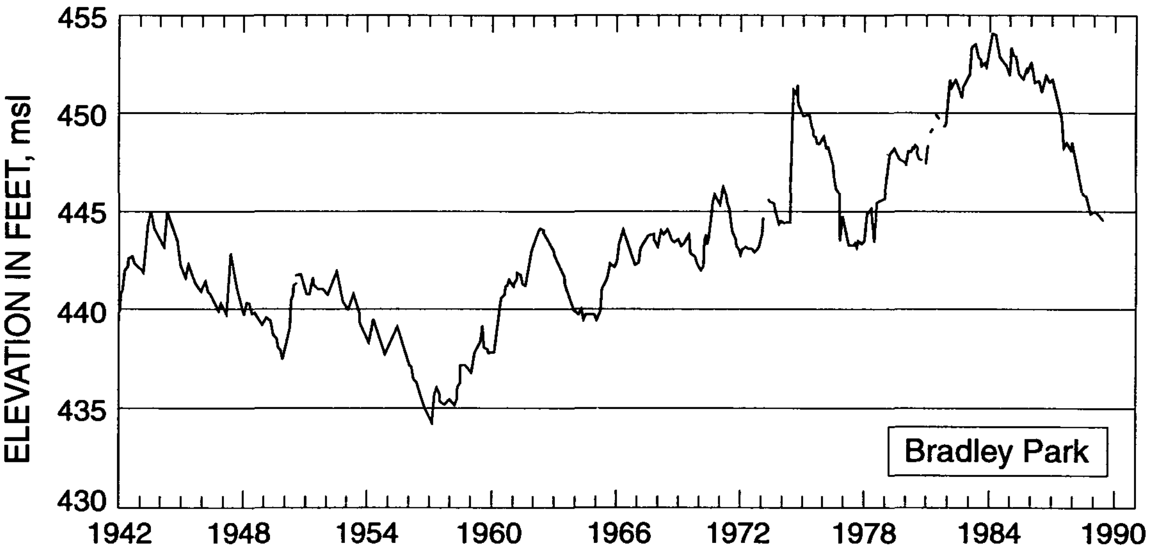


Figure 8. Hydrograph of observation well at the Bradley Park site: 1942 through 1990

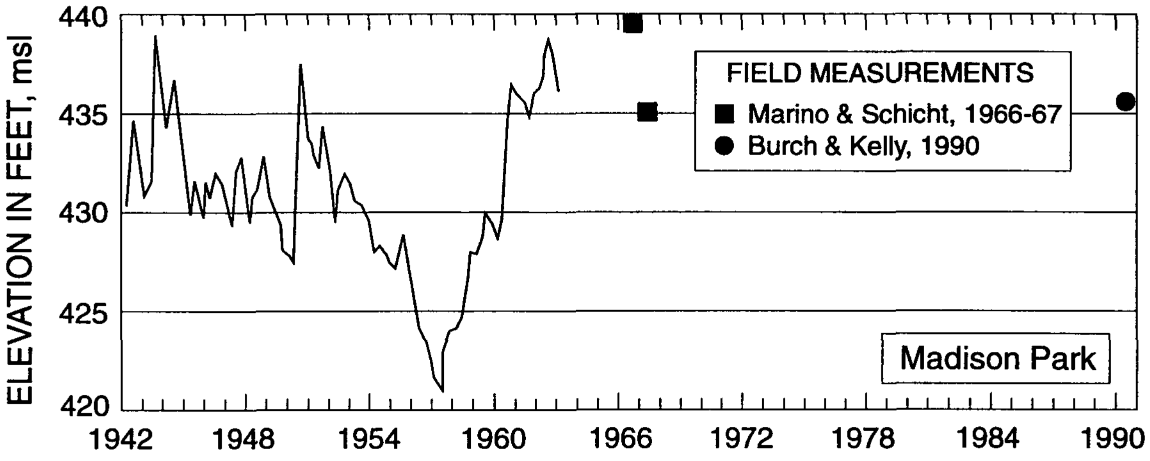


Figure 9. Hydrograph of observation well at the Madison Park site: historic water levels versus 1990-1991 observation

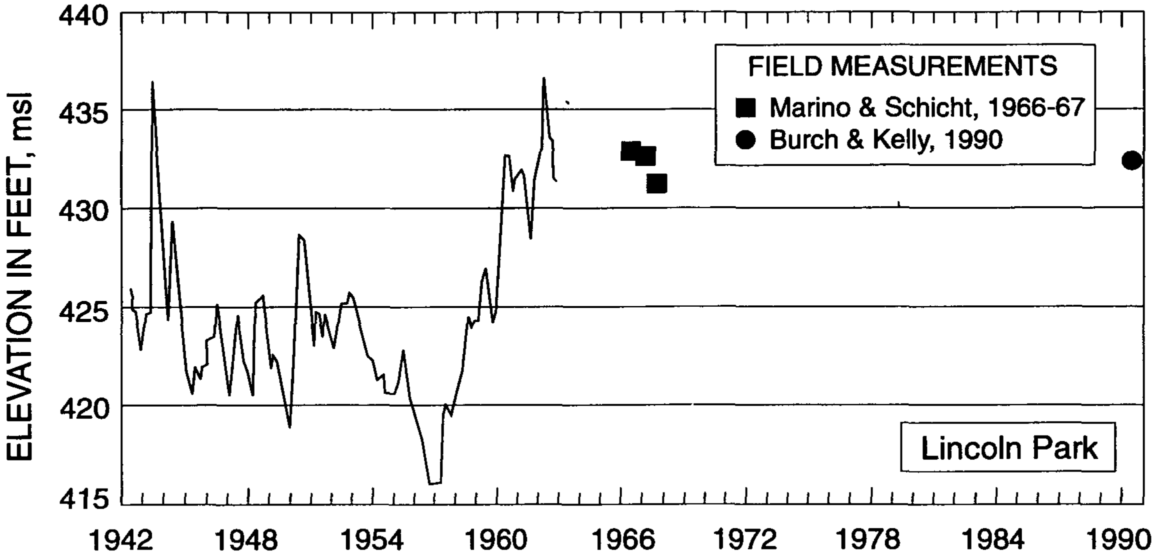


Figure 10. Hydrograph of observation well at the Lincoln Park site: historic water levels versus 1990-1991 observation

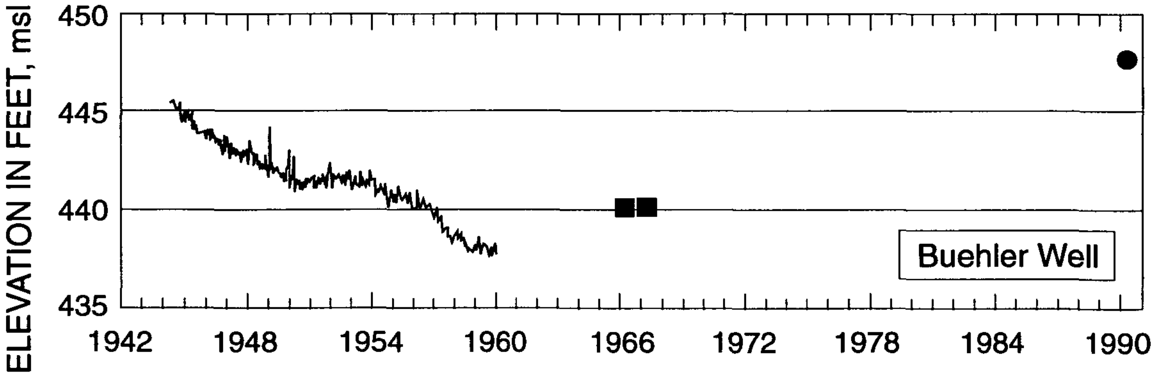


Figure 11. Hydrograph of observation well at the Buehler Nursing Home site: historic water levels versus 1990-1991 observation

east to take advantage of the more productive deposits lying in the bedrock valley.

The area of low hydraulic conductivity extends southwest from East Peoria on the Tazewell County side of the river in a narrow strip at Creve Coeur extending into part of North Pekin. Our drilling and slug testing of observation wells placed the boundary of this surficial deposit approximately at Lick Creek. South of the creek, the lithology of the surficial deposit changes to a well-sorted, fine-to-medium sand, and extends downward to the bedrock.

Hydraulic conductivities south of Lick Creek increase steadily to a range of 1,500 to 2,000 gpd/ft^2. The aquifer also widens as the uplands retreat from the river's edge. The determining factor becomes the bedrock surface elevation and its intersection with the regional potentiometric surface. This situation was apparent in our test hole drilled in Pekin's Mineral Springs Park where nearly 100 feet of sand initially seemed perfect for a well, but the sand was above the water table and therefore unsaturated, rendering the site unsuitable.

CHARACTERIZATION OF GROUND-WATER QUALITY

Natural waters attain their chemical composition through a variety of chemical reactions. The number of major dissolved constituents in ground water is quite limited (Davis and DeWeist, 1966). These constituents result from the interaction between the water and the minerals contained within the rock materials through which the ground water flows. Climatic and geologic factors have been at work and are responsible for the equilibrium composition that we are trying to define as "baseline" water quality. The ground-water system is dynamic and has been responding to seasonal changes since before humans inhabited the Peoria-Pekin area and began interacting with the natural environment. Nevertheless, generalizations can be made about the chemical character of the ground water, especially when describing its major constituents. These observations become less specific when characterizing trace minerals.

Sampling Plan and Procedure

The intent of this project was to characterize the ground-water quality of the Sankoty aquifer, the principal aquifer in the Peoria-Pekin region, by collecting representative ground-water samples for an accurate measure of hydrochemical parameters within the aquifer. This process required some knowledge and experience about what and where to sample, a properly designed and executed sampling plan, and reliable laboratory protocol. Therefore the strategy adopted was to initially sample for a broad spectrum of constituents, including determinations for all major anions and cations, trace metals, and nonspecific organic analyses. More detailed analyses were done at specific sites if warranted by the results. This philosophical approach was consistent with previous DENR assessments at Rockford (Wehrmann et al., 1988) and in the metropolitan area of East St. Louis (Rehfeldt et al., 1992).

The Water Survey issued a press release to the Peoria-Pekin area on May 24, 1990, asking well owners to allow the agency to test their water as part of a ground-water study. The press release stated that the researchers were having difficulty finding private and industrial users who did not rely on municipal supplies. Well owners wanting to participate in the testing were directed to contact the Water Survey for a free water analysis. Few people responded from outside the East Peoria area. Most respondents were from East Peoria and the area west of Washington, and frequently commented that they saw the article in the *Courier,* a local newspaper.

Sample collection for each well involved securing permission from the well owner/controller, purging the water system, field measurements of pH, temperature, and electrical conductivity, and finally sample collection. Site visits by a two-person team included 69 wellheads, most of which used submersible pumps. Most of the owner/controllers of the wells were not contacted ahead of time. On arrival at each site, the team briefly explained the project objective, and received full cooperation. Where possible, the depth to water was measured using a steel tape and the water level was recorded to the nearest 0.01 foot.

A total of 69 sites were sampled and numbered sequentially, but with the following exceptions: #63-#69 were not used, seven other sample numbers refer to sample blanks, and there were four duplicates for quality control. Not all samples from the sites were used in the analyses described in subsequent chapters of this report. In fact, three samples (#13, #14, and #76) deemed invalid were not reported because they were presumably softened prior to collection. Samples from five other sites (#28, #34, #46, #48, and #50) excluded from chemical interpretation were not representative of the Sankoty aquifer (due to well construction details). These wells were either too deep or shallow, and were subsequently determined to be tapping strata other than the Sankoty. Three final samples (#84-#86) grabbed at the end of the project were also not reported because the wells had not been pumped in decades and were deemed unreliable. The final result was that 60 highly representative samples were collected and used in the final interpretations. All sample locations, sampling dates, and related information, if known, are listed in appendix A. The distribution of the sites throughout the region is illustrated by figure 12.

When sampled correctly, each well was pumped until its temperature and pH stabilized. Usually this process involved several minutes during which sample bottles were labeled and cross referenced to an individual log sheet for each site. Additional information was also recorded on the log sheet, such as location (township, range, and section), owner/controller's name and address, date and time, and any notes describing the visit.

Samples from each site were collected in four containers. Two containers, usually with a 500-milliliter (mL) capacity, were filled with water that had passed through either a 0.2- or 0.4-micron filter (cellulose nitrate membrane). The other two samples were collected in different types of containers and did not require filtration. Details are described in the following three paragraphs.

The filtered samples were collected in two polyethylene bottles because their chemical constituents were determined by different laboratory methods. One of the bottles was used for the determination of total dissolved solids (TDS), sulfate, nitrate, chloride, and phosphate; while the other was analyzed for metals. In one or two cases, where it was not possible to filter in the field, samples were collected and subsequently filtered in the Water Survey laboratory.

The unfiltered samples were collected at each site for the determination of alkalinity and organic carbon. The alkalinity sample was collected in a 60-mL wide-mouthed polyethylene bottle. Attempts were made to fill the bottles with no air bubbles because the carbon dioxide contained in

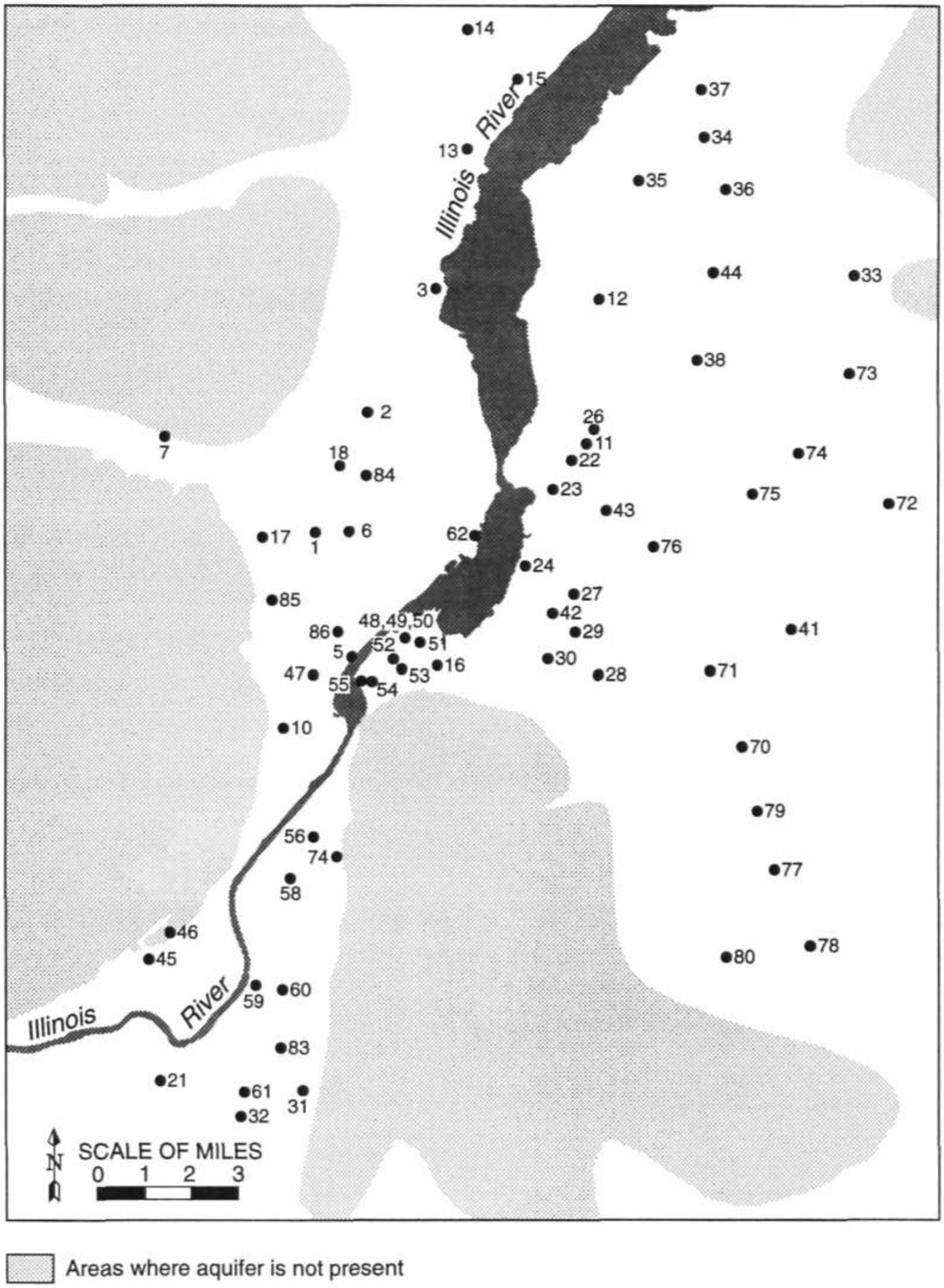


Figure 12. Distribution of ground-water sampling locations throughout the Peoria-Pekin region

air can alter alkalinity. After many tries, it became apparent that the bottles could not be filled without air (headspace). Because alkalinity is not critical to our study, it was decided that these alkalinity samples would be satisfactory for our characterization.

The other unfiltered sample was collected in an amber-glass bottle for the measurement of total organic carbon (TOC) and either purgeable organic carbon (POC) or non-volatile organic carbon (NVOC). Unlike the alkalinity bottle, the glass bottles were filled easily without headspace. Miscommunication with laboratory staff resulted in determinations of POC (also known as VOC) and TOC samples at only 53 sites. Four of these sites (#16, #17, #18, and #21) were sampled for POC in 40-mL amber-glass vials sealed with Teflon-lined septa held on by screw caps and analyzed by the Water Survey laboratory. During the second year of the project, the remaining 49 samples, collected in 125-mL amber-glass bottles with screw caps, were taken to a private laboratory (Daily Analytical Labs in Peoria) because of staffing changes at the Water Survey laboratory. Nonpurgeable organic carbon (NPOC) samples were collected at ten sites where no POC determinations were made. Those analyses were also done by the Water Survey.

None of the samples for organic analysis were filtered in the field. Field duplicates (#8, #19, #25, and #49) and blanks (#4, #9, #20, #39, #81, #82, and #87) were also submitted to the laboratories for quality control but are not reported in this report for the sake of brevity. All samples were kept on ice in a cooler during transport. Additional ice was used when multiday sample collection occurred. Care was taken to drain meltwater from the cooler and to store the samples in an upright position.

Laboratory Determinations

The inorganic laboratory determinations were performed at Water Survey facilities in Champaign, Illinois. The laboratory has been certified by the IEPA and follows strict quality control and quality assurance procedures. Most of the determinations were made using an inductively coupled plasma argon instrument (ICP). Ion chromatography were made for chloride, nitrate, phosphate, and sulfate. The organic determinations (TOC, POC, and NPOC) were done at the private lab in accordance with USEPA Methods 415.1 and 415.2.

The analyses in table 1 are indicative of ground-water quality at or near a particular well at the time of sample collection. The reader can be fairly certain of the validity of those parameters identified as major constituents in the table. A degree of caution should be exercised in interpreting the results for trace constituents, however. Locations for sample sites are listed in appendix A. The reader will note that not all sample numbers in the table are consecutive. As explained earlier in the text, some sample numbers (#63-#69) were not used. Also as explained previously, some samples are not reported in the interest of readability, but these data are on file at the Water Survey.

Results

Characterizations of water quality are usually expressed in milligrams per liter (mg/L). In the past, many results were expressed in terms of parts per million (ppm), but this weight-to-weight ratio led to misinterpretation, particularly for fluids with a specific gravity different than that of water. Thus, the following sections of this report use the more preferred weight-volume relationship denoted by mg/L or micrograms per liter (µg/L) when discussing very small amounts.

Major Constituents

The major constituents found in ground water are calcium (Ca), magnesium (Mg), sodium (Na), bicarbonate ($HC0_3$), sulfate (SO,), and chloride (Cl). Not surprisingly, some of these are among the most abundant elements in the earth's crust. Furthermore, the most abundant constituents in seawater are chloride, sodium, sulfate, magnesium, calcium, and bicarbonate. So it is not unexpected that we should see "earth products" as dissolved constituents in ground water.

An ionic balance is maintained between the positively charged and the negatively charged constituents. The positively charged ions are called cations, while the negatively charged ones are called anions. Calcium, magnesium, and sodium are the most significant cations in ground water. Sulfate, chloride, and bicarbonate are the dominant anions. Together, these constituents, which have been dissolved from rock, are frequently measured as total dissolved solids (TDS), a convenient, frequently used statistic to quickly characterize water quality.

The ground water of the Peoria-Pekin region is of a calcium-bicarbonate type in which nearly 48 percent of the cations are calcium while another 35 percent are magnesium. Not surprisingly, the water is very hard, with an average value of about 400 mg/L observed over the study area. The hardness of the water reflects the geochemical nature of the formations with which it has been in contact. In general, hard waters originate in areas with thick topsoil and limestone formations (Sawyer and McCarty, 1967).

Calcium was observed to average about 90 mg/L throughout the Peoria-Pekin region, although the laboratory determinations ranged from 31 to 178 mg/L. The average is within the normal range (10 to 100 mg/L) for calcium concentrations in ground-water supplies according to Davis and DeWeist (1966). Values in the main body of the Sankoty aquifer were observed to range from 60 to 80 mg/L. Figure 13 is a contour map of calcium concentrations in the study area. The most notable feature in the distribution pattern is that values in the "Sankoty-Pekin" channel, especially in the vicinity of Peoria and East Peoria, are higher than those obtained from wells tapping the main body of the aquifer.

Table 1. Results of Ground-Water Sampling

	Sample Number				
Parameter (mg/L)	*1*	2	3	5	6
Major Constituents					
Calcium	135.6	81.8	102.0	138.2	123.0
Magnesium	58.8	40.5	47.9	48.5	50.6
Sodium	13.1	8.7	18.4	46.1	34.9
Nitrate (as N)	2.0	<0.1	3.0	1.1	<0.1
Sulfate	153.	93.	78.	125.	114.
Chloride	31.3	4.1	40.2	75.	133.
Alkalinity	418.	305.	361.	441.	323.
TDS @180°C	677.	439.	522.	742.	666.
Secondary Constituents					
Iron	0.02	0.50	0.02	0.03	1.99
Manganese	0.066	0.369	0.006	0.012	0.470
Potassium	1.8	1.5	2.7	5.8	3.2
Fluoride	0.5	0.4	0.4	0.6	0.5
Ammonia	<0.02	0.81	<0.02	1.12	0.11
Boron	0.05	<0.02	<0.02	0.32	<0.02
Trace Constituents					
Aluminum	<0.025	< 0.025	< 0.025	< 0.025	< 0.025
Antimony	0.30	0.18	0.23	0.26	0.27
Arsenic	<0.03	<0.03	0.04	0.56	<0.03
Barium	0.10	0.37	0.08	0.07	0.20
Beryllium	<.002	<.002	<.002	<.002	<.002
Cadmium	<.009	<.009	<.009	<.009	<.009
Chromium	<.008	<.008	<.008	<.008	<.008
Copper	<0.009	< 0.009	< 0.009	< 0.009	< 0.009
Lead	<0.03	<0.03	<0.03	<0.03	<0.03
Mercury	<0.1	<0.1	<0.1	<0.1	<0.1
Molybdenum	<0.008	< 0.008	<0.008	< 0.008	< 0.008
Nickel	<0.018	<0.018	<0.018	<0.018	<0.018
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	<0.06	<0.06	<0.06	<0.06	<0.06
Selenium	0.1	0.1	0.1	0.1	0.1
Silicon	10.48	11.40	8.87	10.00	10.13
Silver	<0.016	<0.016	<0.016	<0.016	<0.016
Strontium	0.216	0.858	0.196	0.235	0.366
Sulfur	48.1	31.4	25.3	42.6	38.2
Thallium	0.23	0.19	0.27	0.32	0.25
Vanadium	0.006	0.006	0.006	< 0.006	0.007
Zinc	0.026	0.033	0.018	0.043	0.104
Organic Compounds					
TOC - 1st round					
POC - 1st round					
NPOC - 1st round	1.09	0.70	0.85	0.82	0.94
TOC - 2nd round					
POC - 2nd round					

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

	Sample Number				
Parameter (mg/L)	*7*	*10*	*11*	*12*	*15*
Major Constituents					
Calcium	82.7	111.2	140.9	68.1	88.0
Magnesium	36.5	43.4	51.5	32.0	36.8
Sodium	18.7	44.0	97.3	18.8	5.7
Nitrate (as N)	<0.1	<0.1	3.6	<0.1	8.2
Sulfate	<0.9	141.0	46.0	<0.9	63.0
Chloride	1.1	75.0	105.	2.7	11.4
Alkalinity	412.	316.	388.	357.	298.
TDS @180°C	407.	648.	859.	336.0	431.
Secondary Constituents					
Iron	1.61	1.82	0.04	3.00	0.03
Manganese	0.365	0.317	0.010	0.062	0.006
Potassium	1.6	1.8	7.9	1.9	2.2
Fluoride	0.5	0.5	0.8	0.3	0.3
Ammonia	0.86	0.06	<0.02	1.26	<0.02
Boron	<0.02	0.08	<0.02	<0.02	<0.02
Trace Constituents					
Aluminum	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Antimony	0.18	0.19	0.27	0.19	0.20
Arsenic	<0.03	0.37	<0.03	0.36	0.28
Barium	0.18	0.08	0.13	0.24	0.05
Beryllium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Cadmium	< 0.009	<0.009	< 0.009	< 0.009	< 0.009
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.009	< 0.009	0.023	< 0.009	0.014
Lead	<0.02	<0.03	<0.03	<0.03	<0.03
Mercury	<0.1	<0.1	<0.1	<0.1	<0.1
Molybdenum	0.014	< 0.008	< 0.008	< 0.008	< 0.008
Nickel	<0.018	<0.018	<0.018	<0.018	<0.018
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	0.10	<0.06	<0.06	0.20	<0.06
Selenium	0.1	0.1	0.1	0.1	0.1
Silicon	6.88	7.99	10.05	8.89	8.72
Silver	< 0.016	<0.016	< 0.016	<0.016	<0.016
Strontium	0.359	0.183	0.298	0.306	0.142
Sulfur	<0.22	50.4	14.6	<0.22	20.4
Thallium	0.13	0.24	0.22	0.20	0.20
Vanadium	0.007	< 0.006	0.007	0.009	0.007
Zinc	0.084	0.038	0.228	0.221	0.203
Organic Compounds					
TOC - 1st round					
POC - 1st round					
NPOC - 1st round	1.58	1.98	1.68	2.05	0.61
TOC - 2nd round					
POC - 2nd round					

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

Parameter (mg/L)	*Sample Number*				
	16	*17*	*18*	*21*	*22*
Major Constituents					
Calcium	153.9	121.3	111.0	86.4	76.5
Magnesium	59.6	43.4	47.9	38.3	34.2
Sodium	141.6	17.7	8.8	50.0	18.1
Nitrate (as N)	0.8	2.0	<0.1	4.2	<0.1
Sulfate	190.	137.	152.	127.	10.
Chloride	208.	25.5	26.6	69.	4.4
Alkalinity	486?	258.	317.	240.	373.
TDS @180°C	1100.	607.	587.	555.	378.
Secondary Constituents					
Iron	0.16	0.04	1.12	0.02	1.53
Manganese	0.278	0.010	0.171	0.013	0.106
Potassium	4.6	2.1	3.0	3.0	1.5
Fluoride	0.9	0.4	0.3	0.3	0.2
Ammonia	0.04	<0.02	<0.02	0.03	0.24
Boron	0.52	0.03	<0.02	0.04	0.06
Trace Constituents					
Aluminum	< 0.025	< 0.025	< 0.025	< 0.025	< 0.027
Antimony	0.37	0.35	0.31	0.26	<0.16
Arsenic	0.10	1.15	0.06	0.42	<0.05
Barium	0.11	0.09	0.05	0.08	0.12
Beryllium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.005
Cadmium	< 0.009	< 0.009	< 0.009	< 0.009	< 0.005
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	<0.010
Copper	0.032	0.022	0.019	0.016	0.010
Lead	<0.03	<0.03	<0.03	<0.03	< 0.033
Mercury	<0.1	<0.1	<0.1	<0.1	<0.05
Molybdenum	< 0.008	< 0.008	< 0.008	< 0.008	<0.014
Nickel	<0.018	<0.018	<0.018	<0.018	<0.017
Orthophosphate	<0.2	<0.2	<0.2	<0.2	<0.1
Phosphorous	<0.06	0.08	0.090	0.090	<0.17
Selenium	0.1	0.2	0.1	0.1	<0.60
Silicon	8.41	6.67	8.05	6.65	8.54
Silver	<0.016	<0.016	<0.016	<0.016	<0.010
Strontium	0.494	0.228	0.187	0.221	0.236
Sulfur	64.6	44.3	52.6	46.2	3.8
Thallium	0.36	0.44	0.33	0.32	0.15
Vanadium	< 0.006	< 0.006	0.006	0.009	<0.013
Zinc	0.390	0.183	0.082	0.020	0.130
Organic Compounds					
TOC - 1st round	1.6	1.1	0.9	1.1	1.8
POC - 1st round	0.18	0.16	0.15	0.12	<0.05
NPOC - 1st round	1.41	0.91	0.77	1.31	
TOC - 2nd round					
POC - 2nd round					

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

	Sample Number			
Parameter (mg/L)	*23*	*24*	*26*	*27*
Major Constituents				
Calcium	106.0	66.8	79.7	72.6
Magnesium	47.0	35.6	38.7	31.8
Sodium	14.1	44.7	36.7	39.2
Nitrate (as N)	0.8	<0.1	<0.1	<0.1
Sulfate	60.0	0.9	<0.9	<0.9
Chloride	40.1	11.3	26.8	9.8
Alkalinity	387.	426.	429.	405.
TDS @180°C	512.	425.	449.0	433.0
Secondary Constituents				
Iron	0.45	2.07	2.37	3.31
Manganese	0.170	0.065	0.123	0.112
Potassium	1.3	2.0	2.1	2.1
Fluoride	0.3	0.4	0.3	0.2
Ammonia	<0.02	1.88	1.20	0.16
Boron	0.07	0.32	0.11	0.24
Trace Constituents				
Aluminum	< 0.027	< 0.027	< 0.027	< 0.027
Antimony	<0.16	<0.16	<0.16	<0.16
Arsenic	<0.05	<0.05	<0.05	<0.05
Barium	0.14	0.32	0.39	0.05
Beryllium	< 0.005	< 0.005	< 0.005	< 0.005
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	<0.010	<0.010	<0.010	<0.010
Copper	< 0.009	0.011	< 0.009	< 0.009
Lead	<0.033	< 0.033	< 0.033	< 0.033
Mercury	<0.05	<0.05	<0.05	<0.05
Molybdenum	<0.014	< 0.014	<0.014	<0.014
Nickel	<0.017	<0.017	<0.017	<0.017
Orthophosphate	<0.1	<0.1	<0.1	<0.1
Phosphorous	<0.17	<0.17	<0.17	<0.17
Selenium	<0.6	<0.6	<0.6	<0.6
Silicon	7.30	7.37	9.64	7.98
Silver	<0.010	<0.010	<0.010	<0.010
Strontium	0.209	0.380	0.349	0.123
Sulfur	19.1	0.14	<0.11	<0.11
Thallium	<0.15	<0.15	0.16	<0.15
Vanadium	<0.013	<0.013	<0.013	<0.013
Zinc	0.093	0.243	0.488	0.080
Organic Compounds				
TOC - 1st round	0.7	4.7	3.6	3.5
POC - 1st round	<0.05	<0.05	<0.05	<0.05
NPOC - 1st round				
TOC - 2nd round				
POC - 2nd round				

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

	Sample Number				
Parameter (mg/L)	*28*	*29*	*30*	*31*	*32*
Major Constituents					
Calcium	121.	104.	85.2	85.5	78.8
Magnesium	51.3	47.5	37.5	40.6	36.3
Sodium	45.3	21.4	24.1	8.2	6.3
Nitrate (as N)	12.4	0.4	<0.1	5.4	5.9
Sulfate	82.	104.	94.	59.	72.
Chloride	87.2	37.0	57.8	19.6	15.4
Alkalinity	393.	365.	261.	311.	266.
TDS @180°C	661.	553.	464.	438.	412.
Secondary Constituents					
Iron	<0.02	0.08	2.54	<0.02	<0.02
Manganese	0.006	0.017	0.089	0.006	0.005
Potassium	4.8	2.5	2.2	<1.3	<1.3
Fluoride	0.4	0.3	0.2	0.2	0.2
Ammonia	<0.02	<0.02	<0.02	<0.02	<0.02
Boron	0.28	0.08	0.06	0.07	<0.05
Trace Constituents					
Aluminum	< 0.027	< 0.027	< 0.027	< 0.027	< 0.027
Antimony	<0.16	<0.16	<0.16	<0.16	<0.16
Arsenic	<0.05	<0.05	<0.05	<0.05	<0.05
Barium	0.13	0.06	0.23	0.09	0.04
Beryllium	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	<0.010	< 0.010	<0.010	<0.010	<0.010
Copper	0.009	< 0.009	< 0.009	0.037	< 0.009
Lead	< 0.002	< 0.033	<0.033	<0.033	< 0.033
Mercury	<0.05	< 0.005	<0.05	<0.05	<0.05
Molybdenum	<0.014	<0.014	<0.014	<0.014	<0.014
Nickel	<0.017	<0.017	<0.017	<0.017	<0.017
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	<0.17	<0.17	<0.17	<0.17	<0.17
Selenium	<0.6	<0.6	<0.6	<0.6	<0.6
Silicon	5.99	7.18	3.87	8.63	8.19
Silver	<0.010	<0.010	<0.010	<0.010	< 0.010
Strontium	0.214	0.165	0.138	0.115	0.107
Sulfur	26.6	32.6	30.9	19.9	24.1
Thallium	0.16	<0.15	<0.15	0.16	0.16
Vanadium	<0.013	<0.013	<0.013	<0.013	<0.013
Zinc	0.141	0.173	0.100	0.378	0.129
Organic Compounds					
TOC - 1st round	0.6	<0.5	0.6	<0.5	<0.5
POC - 1st round	<0.05	<0.05	<0.05	<0.05	<0.05
NPOC - 1st round					
TOC - 2nd round					12.0
POC - 2nd round					<0.05

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

	Sample Number				
Parameter (mg/L)	33	34	35	36	37
Major Constituents					
Calcium	64.3	104.	64.0	69.7	86.8
Magnesium	36.8	52.8	29.4	37.5	39.3
Sodium	83.8	15.6	13.9	49.0	7.19
Nitrate (as N)	<0.1	2.9	<0.1	<0.1	<0.1
Sulfate	<0.9	87.	<0.9	<0.9	<0.9
Chloride	22.3	45.8	1.7	6.2	4.1
Alkalinity	487.	358.	316.	436.	323.
TDS @180°C	510.	557.	298.	436.	427.
Secondary Constituents					
Iron	2.43	<0.02	1.85	1.72	3.42
Manganese	0.043	0.013	0.100	0.059	0.275
Potassium	2.1	<1.3	<1.3	1.8	<1.3
Fluoride	0.6	0.5	0.3	0.4	0.2
Ammonia	6.70	<0.02	1.00	2.88	<0.02
Boron	0.25	<0.05	0.08	0.23	<0.05
Trace Constituents					
Aluminum	< 0.027	< 0.027	< 0.027	< 0.027	< 0.027
Antimony	<0.16	0.17	<0.16	<0.16	<0.16
Arsenic	<0.05	<0.05	<0.05	<0.05	<0.05
Barium	0.35	0.07	0.29	0.27	0.11
Beryllium	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	<0.010	<0.010	<0.010	<0.010	<0.010
Copper	< 0.009	0.010	< 0.009	< 0.009	< 0.009
Lead	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	< 0.017	<0.017	<0.017	<0.017	<0.017
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	0.38	<0.17	<0.17	<0.17	<0.17
Selenium	<0.6	<0.6	<0.6	<0.6	<0.6
Silicon	7.95	7.13	7.42	8.44	8.43
Silver	<0.010	<0.010	<0.010	< 0.010	<0.010
Strontium	0.707	0.232	0.323	0.520	0.172
Sulfur	0.15	29.4	<0.11	<0.11	24.0
Thallium	0.18	0.20	0.16	0.17	0.19
Vanadium	<0.013	<0.013	<0.013	<0.013	<0.013
Zinc	0.192	0.162	0.123	0.082	0.107
Organic Compounds					
TOC - 1st round	9.7	1.4	2.4	6.5	1.3
POC - 1st round	<0.01	<0.01	<0.01	0.05	<0.01
NPOC - 1st round					
TOC - 2nd round				7.3	
POC - 2nd round				6.8	

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

	Sample Number			
Parameter (mg/L)	*38*	*40*	*41*	*42*
Major Constituents				
Calcium	62.8	31.0	83.	3.9
Magnesium	30.1	16.5	37.8	8.8
Sodium	13.5	84.9	59.2	220.
Nitrate (as N)	<0.1	<0.1	<0.1	<0.1
Sulfate	<0.9	<0.9	<0.9	89.
Chloride	1.6	1.1	26.9	39.6
Alkalinity	313.	331.	464.	372.
TDS @180°C	295.	354.	494.	594.
Secondary Constituents				
Iron	2.36	0.888	2.13	0.09
Manganese	0.065	0.009	0.102	0.019
Potassium	<1.3	<1.3	2.1	<1.3
Fluoride	0.2	0.7	0.3	0.4
Ammonia	0.80	0.28	0.78	<0.02
Boron	0.06	0.51	0.24	0.06
Trace Constituents				
Aluminum	< 0.027	< 0.027	< 0.027	< 0.027
Antimony	<0.16	<0.16	<0.16	
Arsenic	<0.05	<0.05	<0.05	<0.05
Barium	0.20	0.09	0.30	<0.01
Beryllium	< 0.005	< 0.005	< 0.005	< 0.005
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	< 0.010	<0.010	<0.010	<0.010
Copper	< 0.009	< 0.009	< 0.009	< 0.009
Lead	< 0.033	< 0.033	< 0.033	<0.033
Mercury	<0.05	<0.05	<0.05	<0.05
Molybdenum	<0.01	0.05	<0.01	<0.01
Nickel	<0.017	<0.017	<0.017	<0.017
Orthophosphate	<0.1	<0.1	<0.1	<0.1
Phosphorous	0.20	<0.17	<0.17	<0.17
Selenium	<0.6	<0.6	<0.6	<0.6
Silicon	7.99	5.83	8.34	7.29
Silver	<0.010	<0.010	<0.010	<0.010
Strontium	0.240	0.120	0.280	0.005
Sulfur	<0.11	0.16	<0.11	30.9
Thallium	<0.15	<0.15	<0.15	<0.15
Vanadium	<0.013	<0.013	<0.013	<0.013
Zinc	< 0.094	0.046	0.133	0.123
Organic Compounds				
TOC - 1st round	2.4	9.2	5.8	1.4
POC - 1st round	<0.01	<0.01	<0.03	<0.01
NPOC - 1st round				
TOC - 2nd round				
POC - 2nd round				

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

Parameter (mg/L)	*Sample Number* *43*	 *44*	 *45*	 *46*	 *47*
Calcium	71.0	66.6	69.6	137.	145.
Magnesium	32.4	29.8	22.4	57.8	61.1
Sodium	22.8	10.2	13.5	19.2	21.9
Nitrate (as N)	<0.1	<0.1	0.31	0.33	7.3
Sulfate	0.9	<0.9	141.	183.	213.
Chloride	1.8	1.6	2.4	14.0	43.6
Alkalinity	367.	310.	154.	445.	380.
TDS @180°C	364.	272.	359.	712.	797.
Secondary Constituents					
Iron	2.68	2.03	<0.02	0.06	<0.02
Manganese	0.047	0.074	0.005	0.162	0.007
Potassium	1.4	<1.3	3.7	3.7	3.1
Fluoride	0.2	0.2	0.4	0.4	0.5
Ammonia	0.74	0.48	<0.02	0.80	<0.02
Boron	0.11	<0.05	0.31	0.22	0.33
Trace Constituents					
Aluminum	< 0.027	< 0.027	< 0.027	< 0.027	< 0.027
Antimony	<0.16	<0.16	<0.16	0.20	0.20
Arsenic	<0.05	<0.05	<0.05	<0.05	<0.05
Barium	0.22	0.18	0.02	0.22	0.10
Beryllium	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	<0.010	<0.010	<0.010	< 0.010	<0.010
Copper	< 0.009	< 0.009	< 0.009	0.017	0.014
Lead	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	<0.017	<0.017	<0.017	< 0.017	<0.017
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	<0.17	0.19	<0.17	<0.17	<0.17
Selenium	<0.6	<0.6	<0.6	<0.6	<0.6
Silicon	7.34	8.36	4.26	6.96	8.79
Silver	<0.010	<0.010	<0.010	< 0.010	<0.010
Strontium	0.222	0.206	0.231	0.602	0.165
Sulfur	<0.11	<0.11	47.8	62.2	74.4
Thallium	0.18	0.18	<0.15	0.18	0.19
Vanadium	<0.013	<0.013	<0.013	<0.013	<0.013
Zinc	0.091	0.096	0.024	0.398	0.015
Organic Compounds					
TOC - 1st round	2.9	1.4	1.9	1.4	0.9
POC - 1st round	<0.01	<0.01	0.05	<0.01	<0.01
NPOC - 1st round					
TOC - 2nd round					
POC - 2nd round					

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

Parameter (mg/L)	*48*	*50*	*51*	*52*	*53*
	Sample Number				
Major Constituents					
Calcium	277.	54.5	178.	155.	77.8
Magnesium	60.1	21.0	81.6	73.8	36.4
Sodium	91.0	134.	129.	137.	20.9
Nitrate (as N)	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate	99.6	4.4	141.	145.	34.4
Chloride	419.	65.6	407.	310.	17.7
Alkalinity	646.	449.	522.	460.	384.
TDS @180°C	1460.	574.	1324.	1154.	419.
Secondary Constituents					
Iron	12.9	2.88	6.09	0.14	0.21
Manganese	2.63	0.362	0.180	0.735	0.167
Potassium	17.5	3.1	3.7	1.7	2.3
Fluoride	0.8	0.3	0.8	0.6	0.1
Ammonia	3.86	2.45	1.07	0.35	3.30
Boron	0.77	0.27	2.23	1.01	<0.04
Trace Constituents					
Aluminum	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Antimony	<0.15	<0.15	<0.15	<0.15	<0.15
Arsenic	<0.04	<0.04	<0.04	<0.04	<0.04
Barium	0.24	0.14	0.11	0.20	1.18
Beryllium	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Cadmium	< 0.004	<0.004	<0.004	< 0.004	<0.004
Chromium	< 0.008	<0.008	< 0.008	< 0.008	< 0.008
Copper	0.007	<0.006	0.009	< 0.006	< 0.006
Lead	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	< 0.008	0.528	< 0.008	< 0.008	< 0.008
Nickel	<0.015	0.016	<0.015	0.017	0.016
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	0.20	0.24	<0.15	<0.15	<0.15
Selenium	<0.5	<0.5	<0.5	<0.5	<0.5
Silicon	12.4	7.09	8.36	7.89	9.07
Silver	<0.010	<0.010	<0.010	<0.010	<0.010
Strontium	0.549	0.173	0.299	0.291	0.275
Sulfur	31.4	1.52	46.2	53.2	10.8
Thallium	<0.12	<0.12	<0.12	<0.12	<0.12
Vanadium	< 0.008	<0.008	< 0.008	< 0.008	< 0.008
Zinc	0.095	0.214	0.315	0.258	0.096
*Organic Compounds					
TOC - 1st round	9.9	4.3	5.1	2.5	3.3
POC - 1st round	<0.05	1.60	<0.05	<0.05	0.12
NPOC - 1st round					
TOC - 2nd round	<0.5	6.9	4.2	4.6	1.7
POC - 2nd round	<0.05	<0.05	<0.05	<0.05	<0.05

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

	Sample Number				
Parameter (mg/L)	*54*	*55*	*56*	*57*	*58*
Major Constituents					
Calcium	149.	63.5	89.0	83.7	59.4
Magnesium	69.4	22.7	38.6	36.6	41.0
Sodium	35.9	36.7	14.3	14.3	25.0
Nitrate (as N)	<0.1	<0.1	<0.1	2.62	<0.1
Sulfate	288.	<0.9	90.3	61.8	90.0
Chloride	70.7	59.8	38.2	26.9	55.5
Alkalinity	441.	290.	330.	319.	241.
TDS ©180°C	968.	351.	493.	460.	442.
Secondary Constituents					
Iron	<0.01	0.83	<0.01	<0.01	<0.01
Manganese	0.321	0.053	0.572	0.014	0.320
Potassium	3.8	4.7	2.2	1.2	4.1
Fluoride	0.4	0.2	0.1	0.3	0.1
Ammonia	0.43	3.85	0.05	0.02	0.08
Boron	0.22	<0.04	<0.04	<0.04	0.07
Trace Constituents					
Aluminum	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Antimony	<0.15	<0.15	<0.15	<0.15	<0.15
Arsenic	<0.04	<0.04	<0.04	<0.04	<0.04
Barium	0.06	0.16	0.07	0.05	0.04
Beryllium	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Cadmium	<0.004	< 0.004	<0.004	< 0.004	< 0.004
Chromium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Copper	< 0.006	<0.006	<0.006	0.016	<0.006
Lead	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	< 0.008	<0.008	0.022	< 0.008	<0.008
Nickel	<0.015	<0.015	<0.015	<0.015	<0.015
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	0.15	0.15	0.15	0.15	0.15
Selenium	<0.5	<0.5	<0.5	<0.5	<0.5
Silicon	7.03	3.11	5.12	8.35	4.38
Silver	<0.010	<0.010	<0.010	<0.010	<0.010
Strontium	0.212	0.144	0.110	0.097	0.129
Sulfur	90.2	0.13	28.1	19.3	29.1
Thallium	<0.12	<0.12	<0.12	<0.12	<0.12
Vanadium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Zinc	0.554	0.015	0.070	0.435	0.230
Organic Compounds					
TOC - 1st round	1.8	4.2	1.9	3.5	1.5
POC - 1st round	<0.05	1.00	<0.05	<0.05	<0.05
NPOC - 1st round					
TOC - 2nd round	1.5	4.0	1.5	1.5	1.9
POC - 2nd round	<0.05	0.31	<0.05	<0.05	<0.05

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

	Sample Number				
Parameter (mg/L)	*59*	*60*	*61*	*62*	*70*
Major Constituents					
Calcium	100.	127.	74.3	153.8	70.8
Magnesium	30.4	57.1	32.5	41.8	36.1
Sodium	32.6	28.4	5.12	128.3	32.5
Nitrate (as N)	3.98	4.62	15.0	2.82	<0.1
Sulfate	105.	119.	52.1	103.	<0.9
Chloride	68.7	127.	13.9	212.	6.6
Alkalinity	294.	337.	229.	452.	406.
TDS @180	595.	724.	397.	922.	406.
Secondary Constituents					
Iron	<0.01	<0.01	<0.01	<0.01	2.96
Manganese	0.032	0.019	0.004	0.072	0.025
Potassium	5.2	1.6	1.7	8.0	1.6
Fluoride	0.2	0.1	0.1	0.7	0.2
Ammonia	<0.02	<0.02	0.03	<0.02	0.96
Boron	0.11	0.17	<0.04	0.92	0.16
Trace Constituents					
Aluminum	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Antimony	<0.15	<0.15	<0.15	<0.15	<0.15
Arsenic	<0.04	<0.04	<0.04	<0.04	<0.04
Barium	0.06	0.05	0.03	0.09	0.21
Beryllium	< 0.003	<0.003	< 0.003	< 0.003	< 0.003
Cadmium	<0.004	< 0.004	<0.004	< 0.004	< 0.004
Chromium	< 0.008	< 0.008	< 0.008	<0.008	< 0.008
Copper	< 0.006	< 0.006	0.012	< 0.006	< 0.006
Lead	< 0.024	< 0.024	< 0.024	< 0.024	<0.024
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	< 0.008	<0.008	< 0.008	< 0.008	< 0.008
Nickel	<0.015	0.034	<0.015	<0.015	<0.015
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	<0.15	<0.15	<0.15	<0.15	<0.15
Selenium	<0.5	<0.5	<0.5	<0.5	<0.5
Silicon	6.39	9.86	6.72	7.89	7.47
Silver	<0.010	<0.010	<0.010	<0.010	<0.010
Strontium	0.161	0.141	0.076	0.276	0.350
Sulfur	33.5	40.3	16.5	35.5	<0.10
Thallium	<0.12	<0.12	<0.12	<0.12	<0.12
Vanadium	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Zinc	0.249	0.287	0.092	0.297	0.127
Organic Compounds					
TOC - 1st round	3.1	3.8	5.1	6.5	8.0
POC - 1st round	<0.05	<0.05	<0.05	<0.05	4.50
NPOC - 1st round					
TOC - 2nd round	1.8	2.5	1.6	3.1	4.5
POC - 2nd round	<0.05	<0.05	<0.05	<0.05	4.0

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Continued

	Sample Number				
Parameter (mg/L)	*71*	*72*	*73*	*74*	*75*
Major Constituents					
Calcium	71.4	67.1	68.3	62.5	66.0
Magnesium	33.5	30.6	35.0	29.9	32.2
Sodium	24.2	8.84	48.5	7.82	27.8
Nitrate (as N)	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate	<0.9	<0.9	<0.9	<0.9	<0.9
Chloride	4.1	1.2	7.0	1.1	4.4
Alkalinity	383.	321.	448.	305.	371.
TDS ®180°C	375.	310.	446.	289.	355.
Secondary Constituents					
Iron	0.01	1.27	2.55	0.70	0.35
Manganese	0.039	0.095	0.051	0.059	0.268
Potassium	1.2	1.0	1.8	0.88	0.99
Fluoride	0.2	0.1	0.2	0.1	0.2
Ammonia	0.54	0.11	1.26	0.17	1.13
Boron	0.13	<0.04	0.15	<0.04	0.07
Trace Constituents					
Aluminum	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Antimony	<0.15	<0.15	<0.15	<0.15	<0.15
Arsenic	<0.04	<0.04	<0.04	<0.04	<0.04
Barium	0.15	0.14	0.24	0.13	0.16
Beryllium	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Cadmium	<0.004	<0.004	< 0.004	< 0.004	< 0.004
Chromium	< 0.008	<0.008	< 0.008	<0.008	< 0.008
Copper	<0.006	< 0.006	< 0.006	<0.006	< 0.006
Lead	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	< 0.008	< 0.008	<0.008	< 0.008	< 0.008
Nickel	<0.015	<0.015	<0.015	<0.015	< 0.015
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	<0.15	0.18	0.24	<0.15	<0.15
Selenium	<0.5	<0.5	<0.5	<0.5	<0.5
Silicon	7.35	7.94	7.92	7.78	8.00
Silver	<0.010	<0.010	<0.010	<0.010	< 0.010
Strontium	0.270	0.183	0.465	0.195	0.373
Sulfur	<0.10	<0.10	<0.10	<0.10	<0.10
Thallium	0.12	0.12	0.12	0.12	0.12
Vanadium	< 0.008	< 0.008	< 0.008	< 0.008	<0.008
Zinc	0.022	0.096	0.065	0.070	0.126
Organic Compounds					
TOC - 1st round	3.8	2.3	9.7	1.9	6.4
POC - 1st round	0.61	1.20	6.30	0.44	3.70
NPOC - 1st round					
TOC - 2nd round	3.8	2.8	7.8	1.6	4.1
POC - 2nd round	0.81	1.0	6.2	0.06	3.6

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

Table 1. Concluded

Parameter (mg/L)	*77*	*78*	*79*	*80*	*83*
Major Constituents					
Calcium	67.8	73.2	69.6	47.6	48.0
Magnesium	34.7	34.2	35.2	35.1	18.1
Sodium	38.5	36.1	22.2	52.8	3.09
Nitrate (as N)	<0.1	<0.1	<0.1	<0.1	7.64
Sulfate	<0.9	<0.9	<0.9	<0.9	34.6
Chloride	9.4	4.3	3.2	2.2	8.3
Alkalinity	403.	418.	390.	398.	154.
TDS @180°C	395.	424.	367.	372.	249.
Secondary Constituents					
Iron	2.98	3.08	2.77	1.88	0.01
Manganese	0.023	0.023	0.031	0.013	< 0.002
Potassium	1.5	1.6	1.5	1.9	<0.46
Fluoride	0.2	0.2	0.4	0.4	0.1
Ammonia	0.89	0.92	1.46	2.68	<0.02
Boron	0.22	0.26	0.11	0.54	0.06
Trace Constituents					
Aluminum	< 0.024	< 0.024	< 0.024	< 0.024	0.009
Antimony	<0.15	<0.15	<0.15	<0.15	<0.15
Arsenic	<0.04	<0.04	<0.04	0.12	<0.08
Barium	0.16	0.17	0.22	0.14	0.018
Beryllium	< 0.003	< 0.003	< 0.003	< 0.003	<0.001
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.006
Chromium	< 0.008	< 0.008	< 0.008	<0.008	0.005
Copper	< 0.006	< 0.006	< 0.006	< 0.006	<0.001
Lead	< 0.024	< 0.024	< 0.024	< 0.024	< 0.027
Mercury	<0.05	<0.05	<0.05	<0.05	<0.03
Molybdenum	< 0.008	< 0.008	<0.008	0.019	<0.016
Nickel	<0.015	< 0.015	<0.015	<0.015	<0.018
Orthophosphate	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorous	<0.15	<0.15	<0.15	<0.15	<0.20
Selenium	<0.5	<0.5	<0.5	<0.5	<0.11
Silicon	7.06	7.93	7.46	5.73	6.51
Silver	<0.010	<0.010	<0.010	<0.010	< 0.003
Strontium	0.305	0.281	0.330	0.306	0.040
Sulfur	<0.10	<0.10	<0.10	0.16	11.4
Thallium	<0.12	<0.12	<0.12	<0.12	<0.17
Vanadium	< 0.008	< 0.008	< 0.008	< 0.008	<0.011
Zinc	0.171	0.036	0.223	0.045	0.006
Organic Compounds					
TOC - 1st round	8.8	6.3	6.7	8.8	
POC - 1st round	9.10	5.20	2.30	5.00	
NPOC - 1st round					
TOC - 2nd round	5.7	6.0	3.7	8.0	0.9
POC - 2nd round	6.5	3.0		4.6	<0.05

Sample Number (columns 77–83)

Notes: TDS = Total Dissolved Solids, TOC = Total Organic Compounds, POC = Purgeable Organic Compounds, and NPOC = Nonpurgeable Organic Compounds

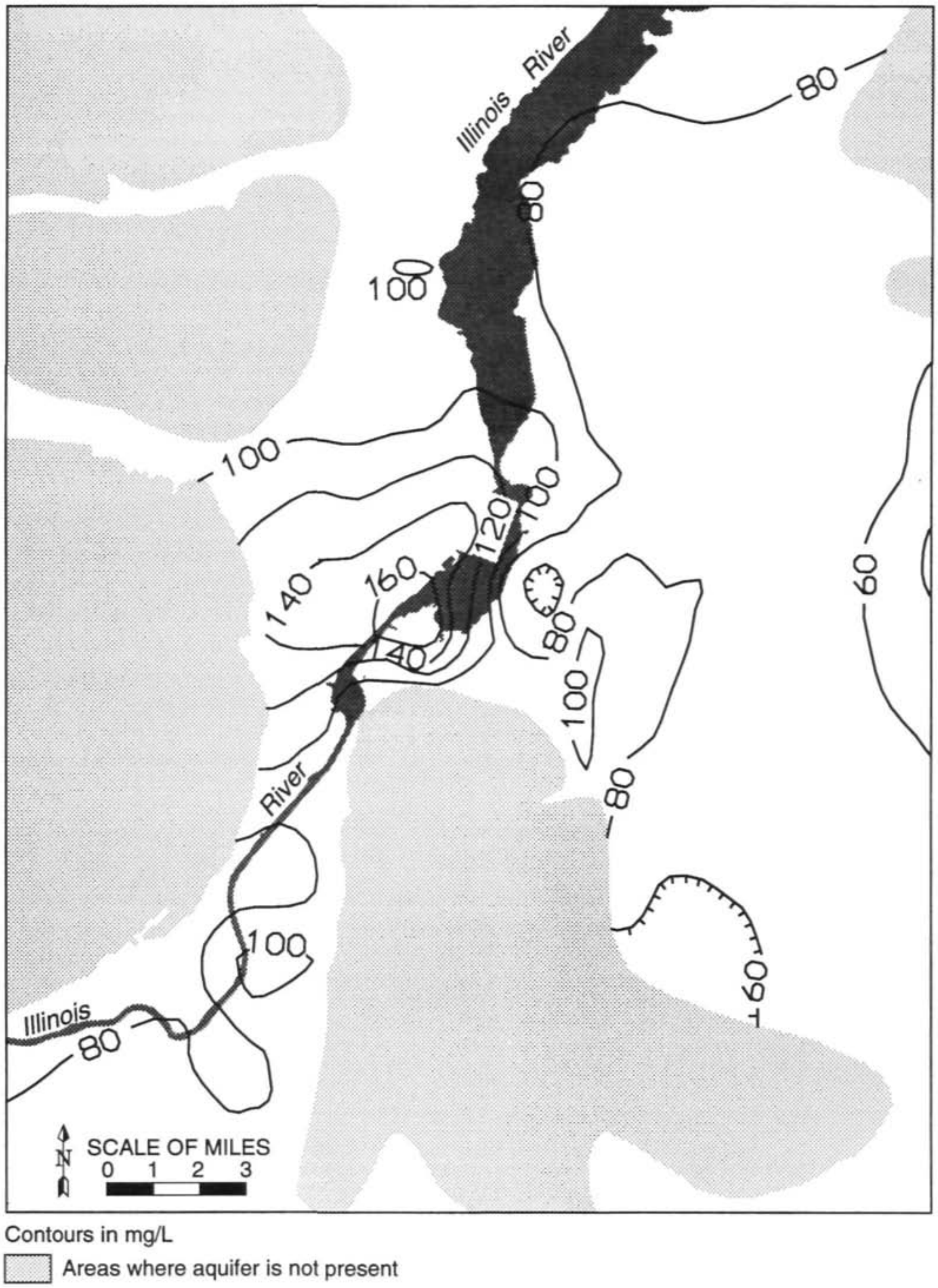


Figure 13. A contour map of calcium concentrations (in mg/L) in the study area

Magnesium values, more constant in value across the study area than calcium values, averaged about 40 mg/L and ranged from a low of 16 to a high of 82 mg/L. The location of the highest magnesium value coincides with high values for other constituents. A contour map of magnesium concentrations (figure 14) reveals anomalously high values in East Peoria. This suggests that factors other than which bedrock lithology subcrops the Sankoty are responsible for the variance.

Sodium is another important cation to observe when studying unconsolidated sand-and-gravel aquifer. Concentrations are usually much lower than for calcium. The difference is so pronounced that we usually use it to differentiate ground water into either a calcium type or a sodium type. For example, an analysis of a ground-water sample from the bedrock well at Mineral Springs Park (in Pekin) indicated a sodium concentration of 1,470 mg/L. Previous reports support the idea that values in the sand-and-gravel aquifer are typically an order or two lower in magnitude than those determined for samples from the bedrock (ISWS, 1940).

Average concentrations of sodium (about 36 mg/L) were observed in the Peoria-Pekin region in a range from 3 to 142 mg/L. As the contour map of sodium concentrations indicates, values in the Sankoty are elevated in the vicinity ofEast Peoria and downtown Peoria (figure 15). Possible comingling of the two types of ground water may be occurring in this area. In a small area of East Peoria, sodium values were elevated to about 140 mg/L. The historical records refer to the "Voris well", an old bedrock well in the vicinity. The corrosive nature of the ground water found in the bedrock aquifer may have compromised the physical integrity of that 700-foot well casing. Likewise, in Peoria another anomalous sodium value was found in the shallow sand-and-gravel deposit near a formerly flowing artesian bedrock well.

High values of chloride and a secondary constituent, boron, coincide with the locations of elevated sodium concentrations (figure 16). Both chloride and boron are common to the brackish water found in the bedrock ground-water system. Their presence reflects the oceanic heritage of the bedrock, especially that of the shale strata. It is thought (Hem, 1970; Drever, 1988) that seawater trapped in the shale at the time of deposition could be the source of the sodium and chloride. Boron, also commonly found in ocean water, would correspondingly be trapped in the shale interstices. Then when a well is drilled through this formation many millions of years later, the elements are accessible.

Nitrate (as nitrogen) was observed randomly within the study area (figure 17). It is not a widespread contaminant, but can be found occasionally. The authors observed one occurrence of nitrate in the northern part of the study area where the well may be downgradient of a septic tank system. Elevated values of nitrate were more commonly observed south of Peoria along the floodplain of the Illinois River. The authors speculated that some of these concentrations may be traced back to the huge piles of manure and distillery waste that floated down the Illinois River at the turn of the century (Talkington, 1991). Presumably diese piles were deposited on the inside of stream meanders and subsequently buried with alluvium. Granted, the idea may be far-fetched, but it may also explain some of the variability observed between North Pekin and Pekin. Only one site in the entire study area yielded a sample that exceeded the drinking water standard (10 mg/L) for nitrate. That sample, #61, was determined to be equal to 15 mg/L and was collected from one of our newly constructed monitoring wells. The well site is not surrounded by any residential properties, thus ruling out septic tank problems. Until recently, the area was irrigated and in full agricultural production. Because the depth to water was observed to exceed SO feet, it seems unlikely that leaching of fertilizers is the source of the high nitrate value.

Sulfate is also common in ground water because most sulfate compounds are readily soluble in water. Davis and DeWeist (1966) note that sulfate in ground water is generally <100 mg/L. The oxidation of pyrite, which is frequendy found in Illinois coals, contributes sulfate to the ground-water system. Higher values of sulfate were observed, not surprisingly, on the west side of Peoria where coal is frequently observed in bedrock outcrops. In samples collected in the Peoria-Pekin region, the sulfate value averaged 61 mg/L while observed values ranged from < 0.9 to 288 mg/L. The extremely low values seemed typical of sites in the eastern part of the study area and are attributed to the microbial activity of sulfate-reducing bacteria. Figure 18 illustrates the distribution of sulfate in the study area.

Alkalinity is one of the most common attributes of ground water. It is produced almost exclusively by bicarbonate ($HC0_3$) and carbonate ($C0_3$) ions that result from chemical reactions involving the carbonate system. Ground water commonly contains >50 mg/L but <400 mg/L of bicarbonate (ibid.). The laboratory determinations for samples from the Peoria-Pekin region averaged 356 mg/L. Figure 19 illustrates the distribution of alkalinity in the region and again suggests anomalously high values in the vicinity of Peoria and East Peoria. Below-average values were observed in the Pekin vicinity, presumably because the aquifer is not covered by clay till. The minimum and maximum values for alkalinity observed over the entire region ranged from 154 to 522 mg/L.

Perhaps the best overall, descriptive, water-quality statistic is TDS, a measure of how mineralized the ground water has become or the amount of residue that remains when a water sample evaporates. Natural waters range from <10 mg/L for TDS in rain and snow, to >300,000 mg/L for some brines. Water for most domestic and industrial uses should be <1,000 mg/L (ibid.).

A contour map of the TDS values that we observed in the Sankoty aquifer is presented as figure 20. It again illustrates anomalously high concentrations in the vicinity of East Peoria and downtown Peoria. The average TDS value for water samples from the Sankoty aquifer in the study area was 517 mg/L. This is certainly within acceptable limits and slightly above the statewide median value (Broten and Johnson, 1985).

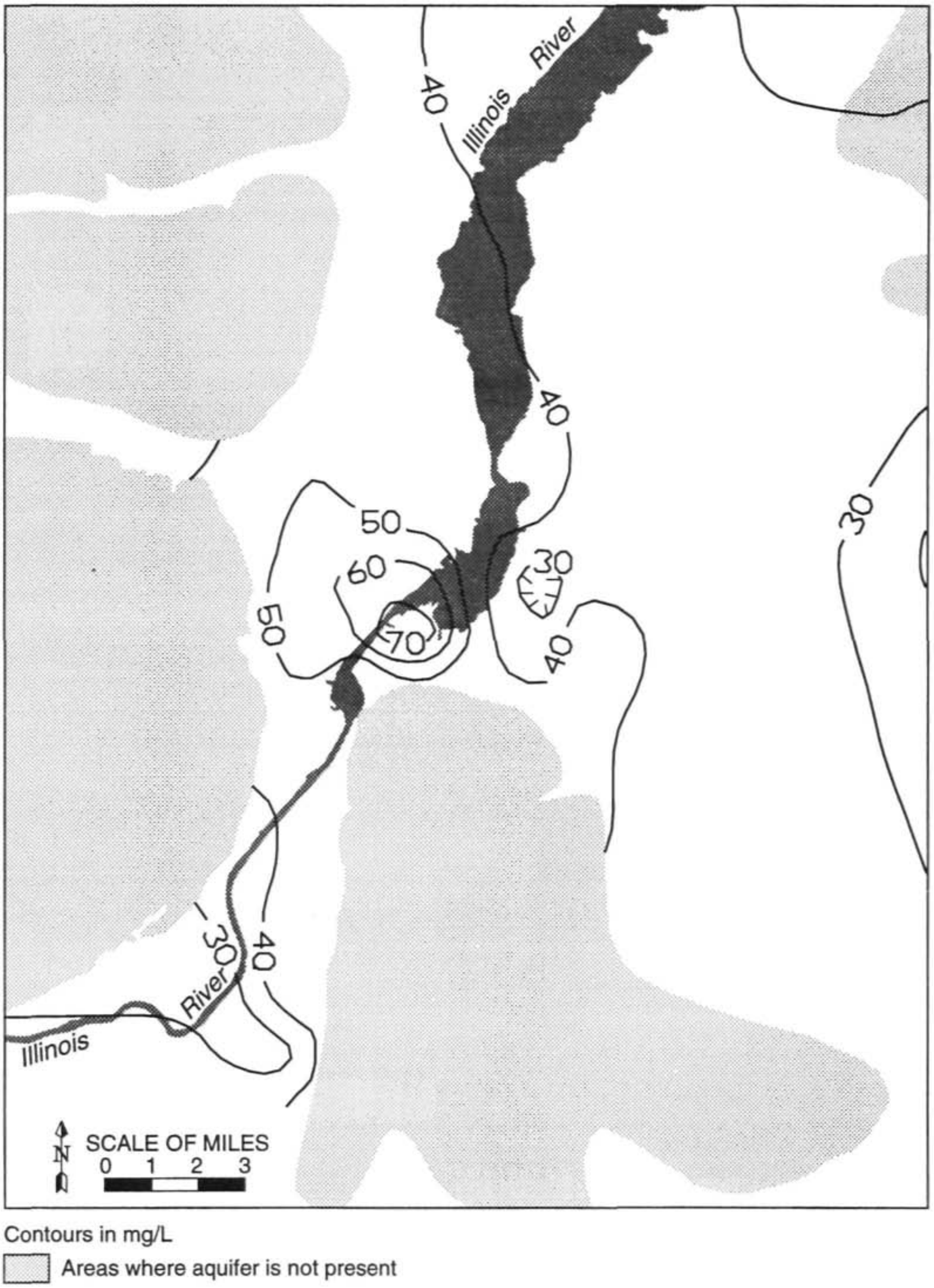
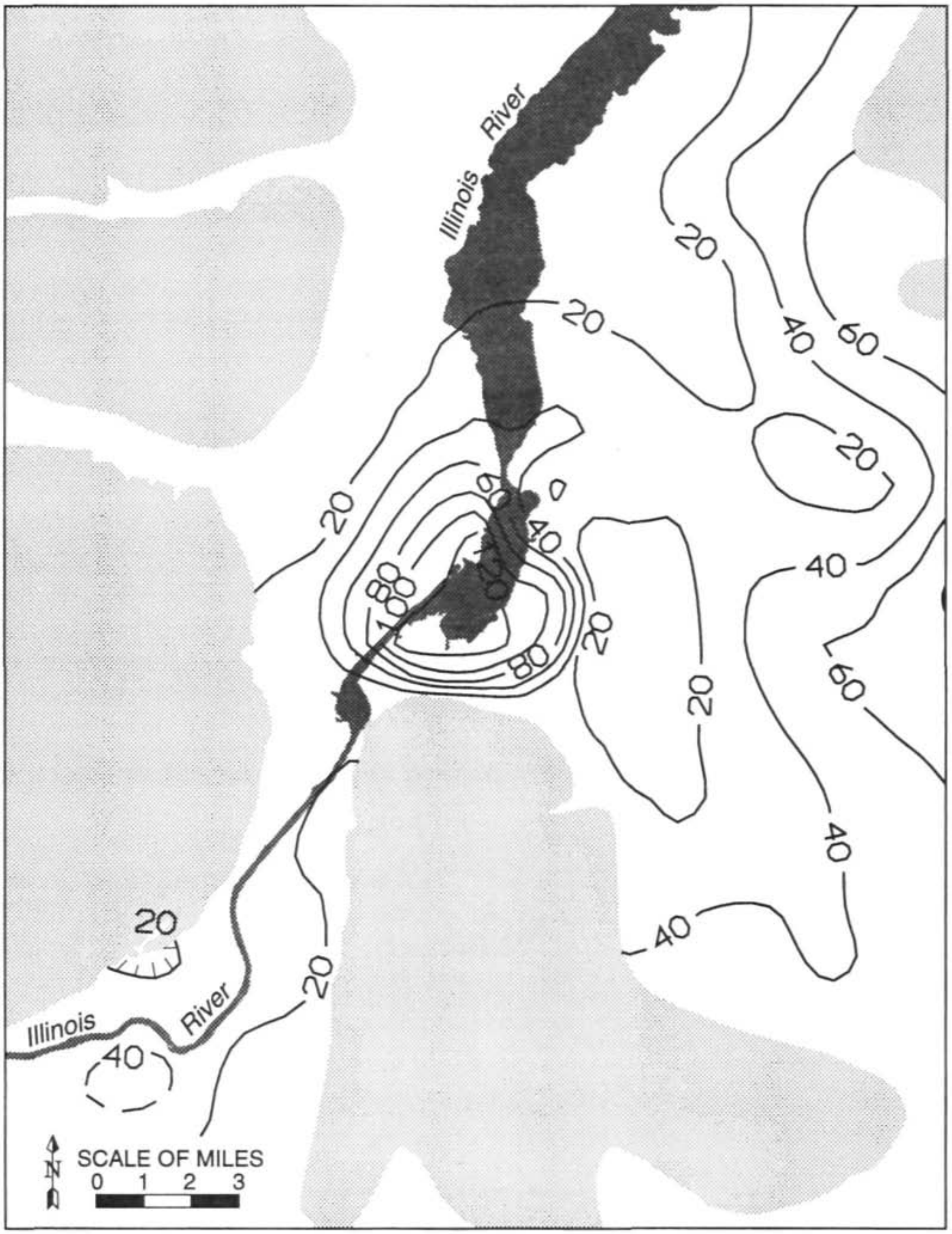


Figure 14. A contour map of magnesium concentrations (in mg/L) in the study area



Contours in mg/L

▨ Areas where aquifer is not present

Figure 15. A contour map of sodium concentrations (in mg/L) in the study area

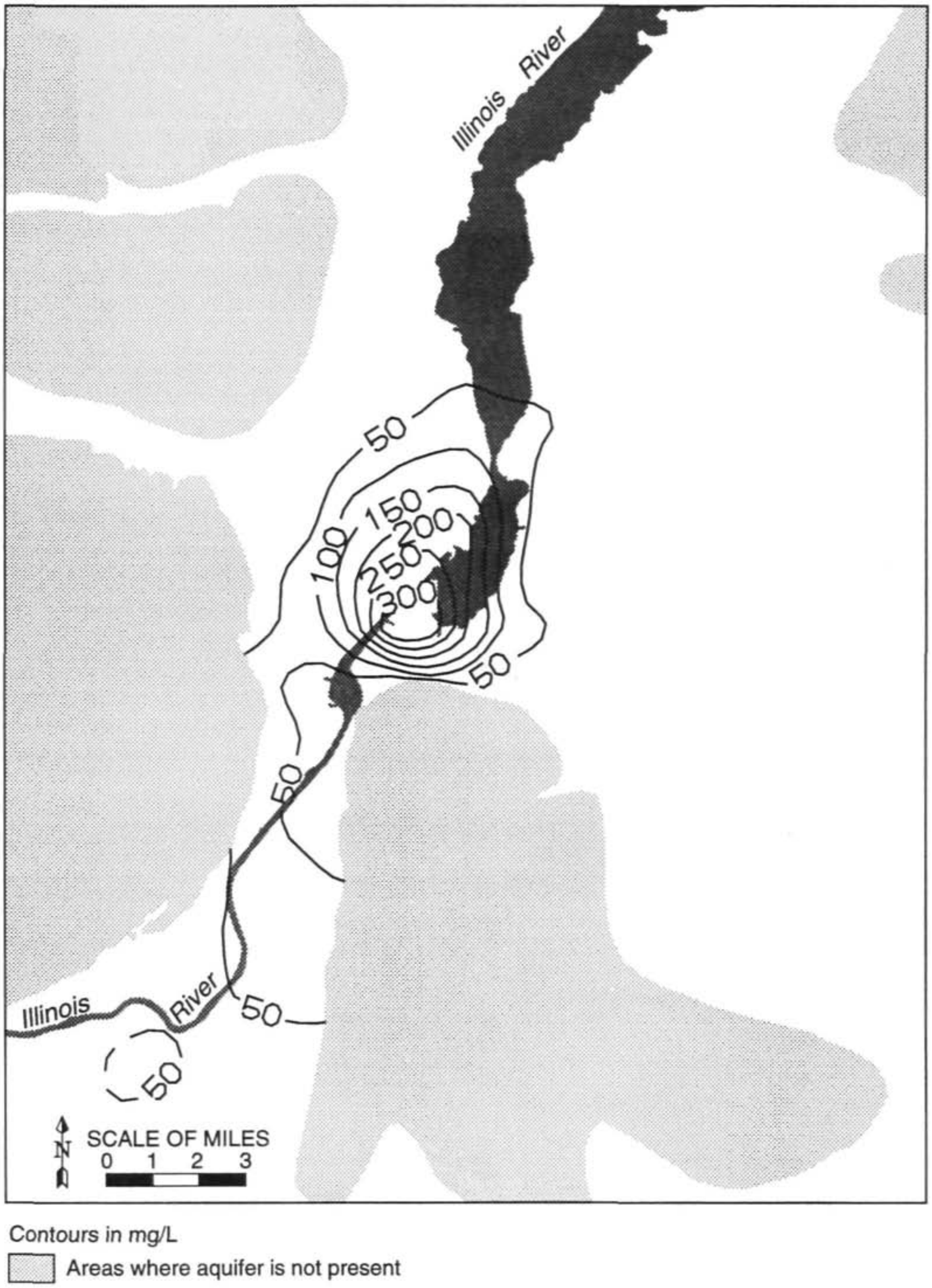


Figure 16. A contour map of chloride concentrations (in mg/L) in the study area

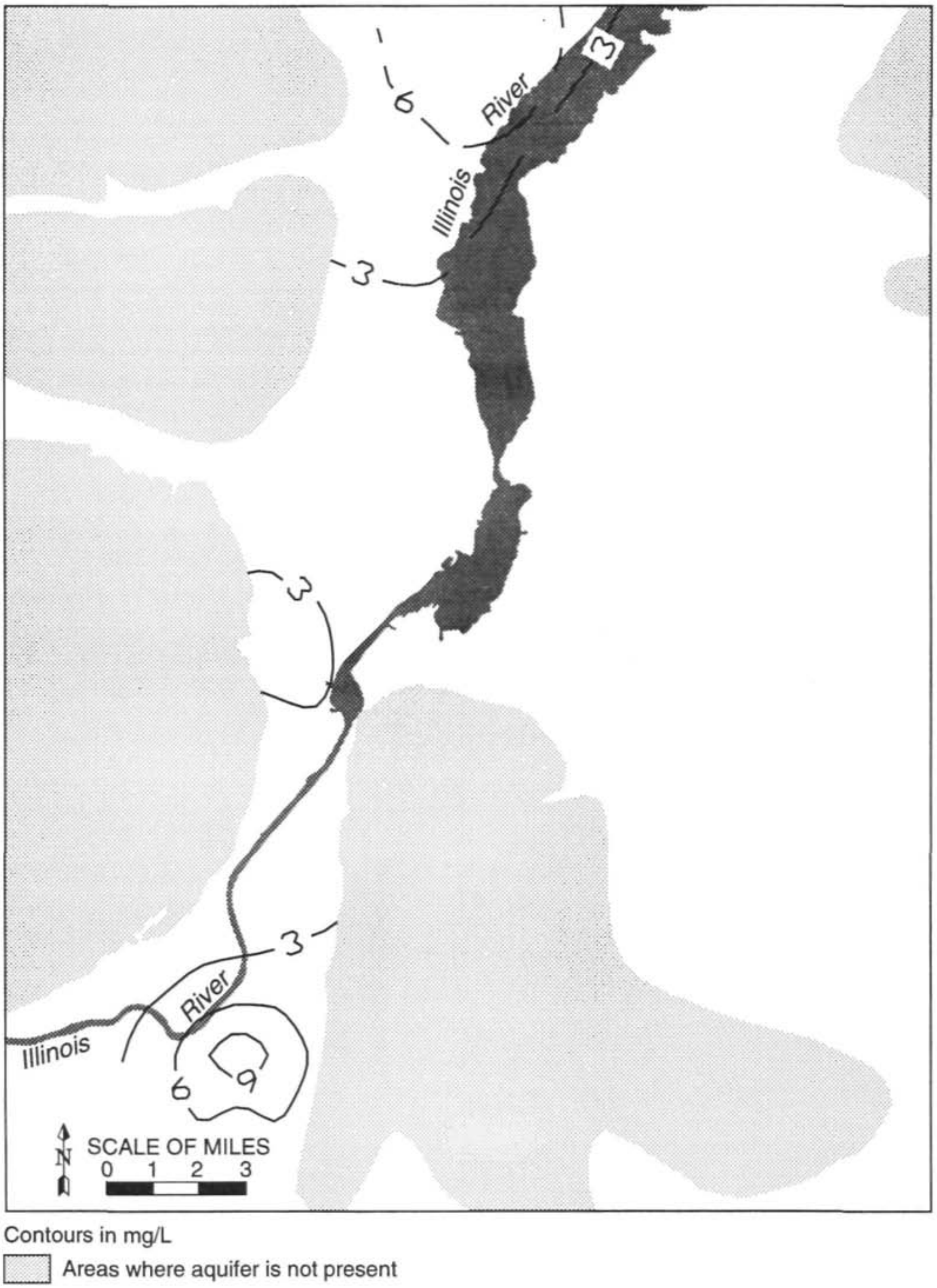


Figure 17. A contour map of nitrate (as nitrogen) concentrations (in mg/L) in the study area

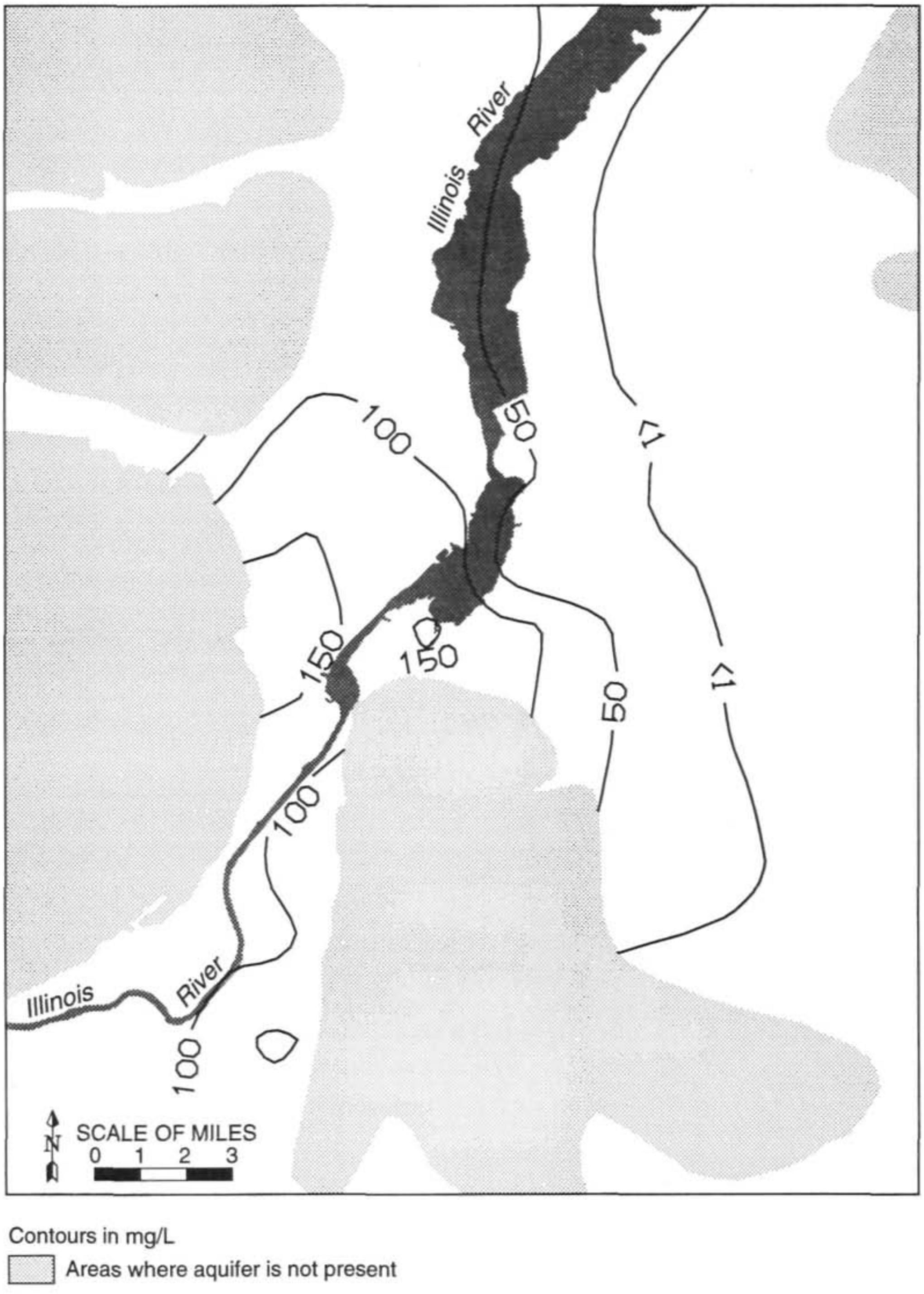


Figure 18. A contour map of sulfate concentrations (in mg/L) in the study area

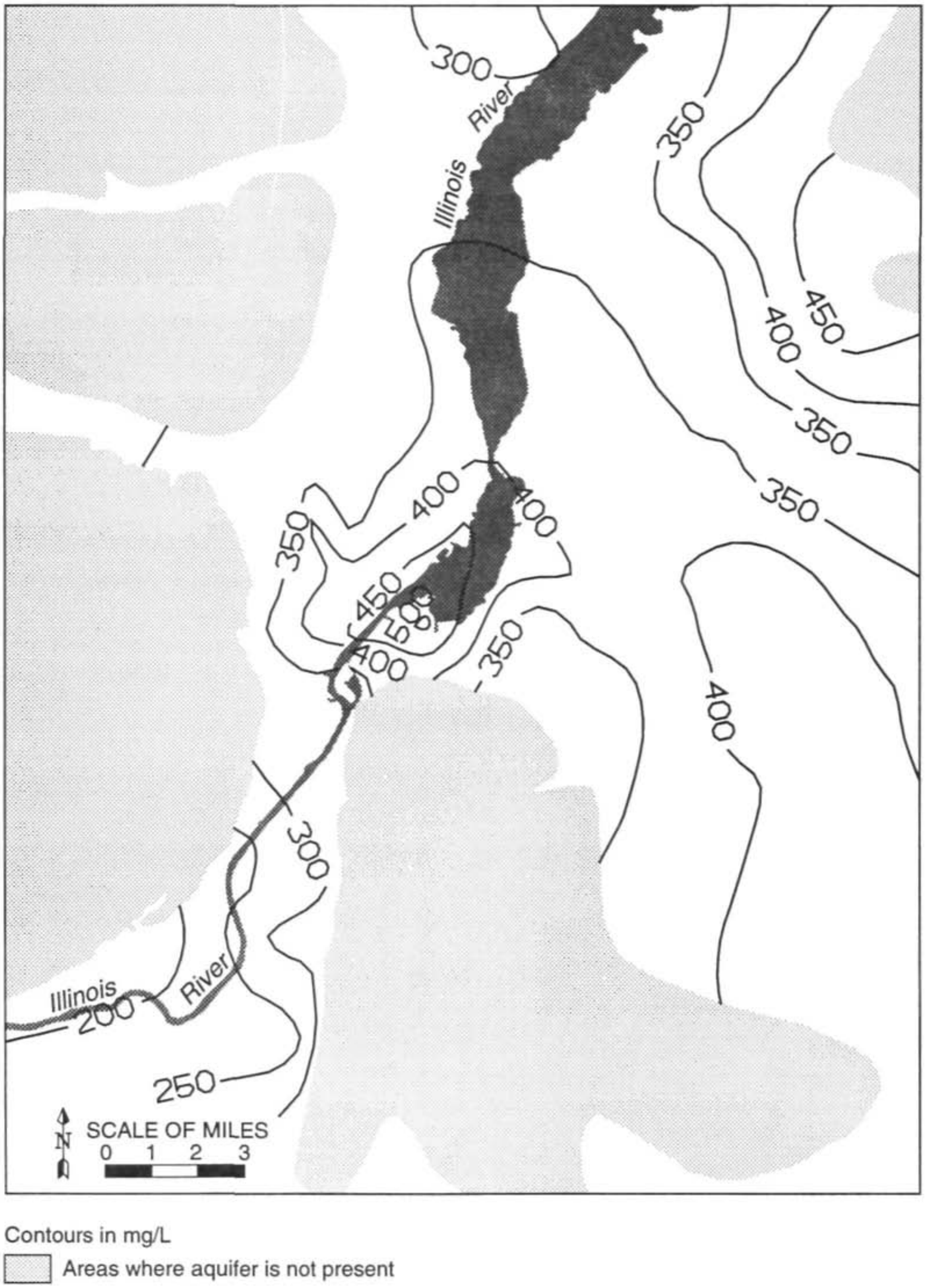


Figure 19. A contour map of alkalinity concentrations (in mg/L) in the study area

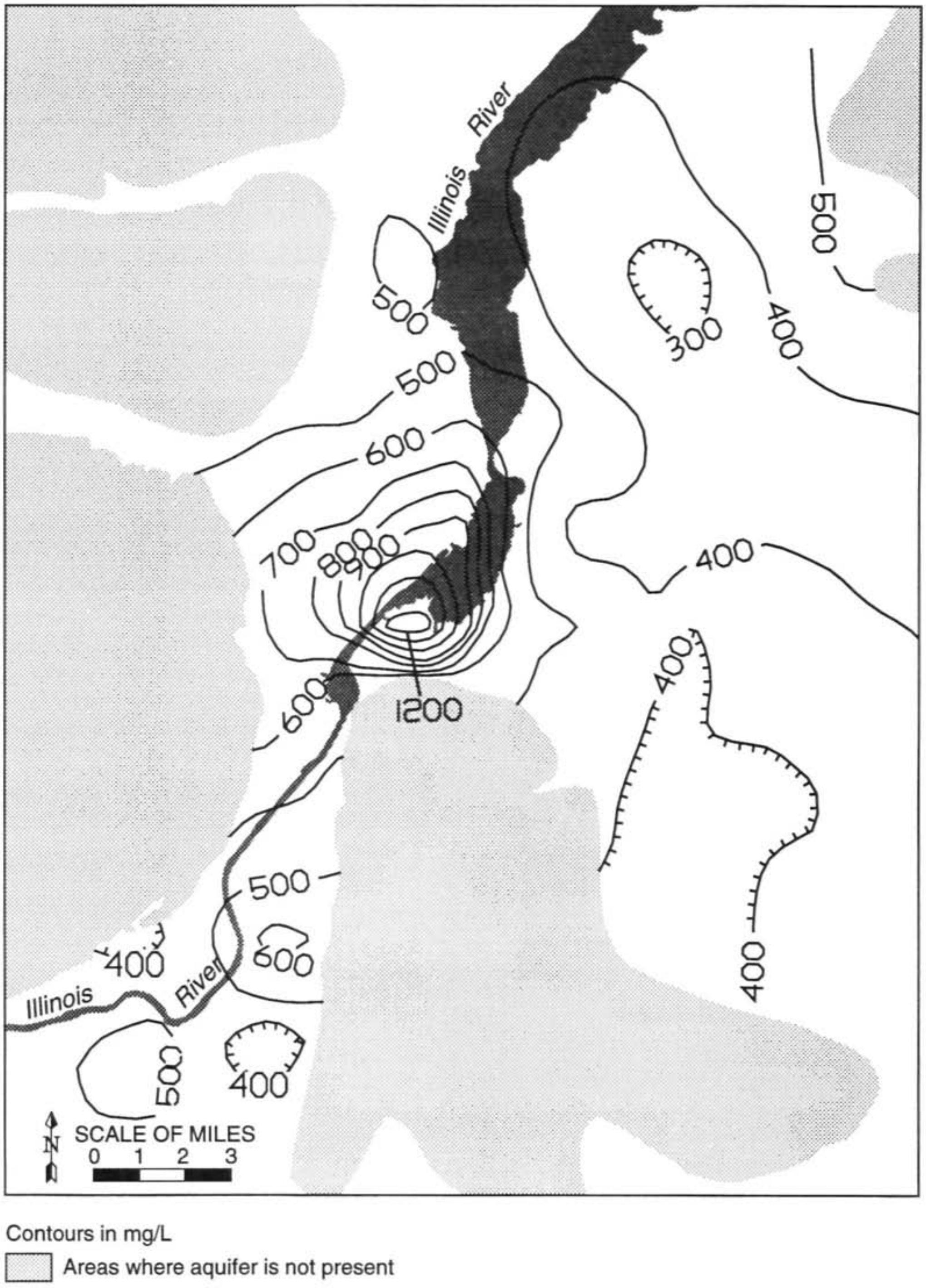


Figure 20. A contour map of total dissolved solids (TDS) concentrations (in mg/L) in the study area

Secondary Constituents

Ground water also contains elements that occur in concentrations much smaller than those of the major constituents. These secondary constituents are normally found in concentrations <10 mg/L. In this study, iron (Fe), manganese (Mn), potassium (K), fluoride (F), ammonia (NH_4), and boron (B) were defined as secondary. Iron and manganese are perhaps the best known, not because they represent a health hazard, but because they are nuisances to many private-well owners.

Iron is an abundant and widespread constituent of rocks and soil. Concentrations of only a few tenths of a milligram per liter can make water unsuitable for some uses. Although iron is an essential element for both plant and animal metabolisms (Hem, 1970), it frequently stains laundry and plumbing fixtures when present in water for domestic use. When exposed to oxygen, iron can cause water to become turbid and unacceptable from an aesthetic viewpoint. Iron also imparts a taste to water (Sawyer and McCarty, 1967).

Ground water routinely contains more iron than is aesthetically desired by most users. The traditional goal of public water suppliers has been <0.3 mg/L. Unfortunately, iron concentrations in determinations made for samples from around the Peoria-Pekin region confirm that the average is higher than what is desirable. In samples collected, the average iron value equaled 1.20 mg/L, with a range from near zero (<0.015 mg/L) to 6.09 mg/L. A contour map of the iron concentrations reveals that the lowest values of iron tend to occur within the "Sankoty-Pekin" bedrock valley, especially south Lick Creek (figure 21). The low values may be due to the well-sorted sand that comprises the aquifer and extends all the way up to the land surface. Precipitation (which is generally free of iron) can thus readily infiltrate the sand and recharge the aquifer. Conversely, the highest iron values are found around Morton and Washington where the Sankoty is covered by a thick clay till.

Manganese is a close companion of iron; usually when one element exists, so does the other. The standard is lower for manganese, but it too is commonly exceeded by groundwater samples. The traditional recommended limit for manganese is 0.05 mg/L, but the relatively new Illinois standard is 0.15 mg/L. The average value from the study area was 0.118 mg/L, although sample determinations ranged from <0.002 to 0.735 mg/L. A distribution map, without contours, of observed manganese concentrations is shown as figure 22.

Potassium, another secondary constituent in ground water, enters the flow system as a weathering product of certain clay minerals. All natural waters contain measurable amounts of potassium. Most ground-water supplies contain between 1.0 and 5.0 mg/L (Davis and DeWeist, 1966). In the Peoria-Pekin area, the authors observed values ranging from <0.46 mg/L to 8 mg/L, with an average of 2.4 mg/L. The high values seemed anomalous and may not be representative of the aquifer as a whole (figure 23). It is suspected that those values may be indicative of ground water from much deeper bedrock wells intermingling with the sand-and-gravel aquifer.

Fluoride too is a secondary constituent sometimes found in ground water. Most people are aware that fluoridation of public water supplies has become a firmly established public health measure. Drinking water standards for fluoride are set based upon annual average maximum air temperature. Consequently, the upper limit in the cooler parts of the United States is 1.7 mg/L, which decreases to 0.8 mg/L in the warmest areas. Samples from the Peoria-Pekin region ranged from 0.1 to 0.9 mg/L and averaged 0.3 mg/L. In other words, the natural concentrations of fluoride in the study area are below drinking water standards. Davis and DeWeist (1966) noted that waters high in calcium, such as those commonly found in the Sankoty, seldom contain more than about 1 mg/L of fluoride. A contour map of the fluoride concentrations identifies East Peoria and Peoria as the principal areas having elevated values (figure 24).

Ammonia is a chemically reduced form of nitrogen and is often a product of microbial decomposition where little oxygen is present. The process of ammonification is part of the nitrogen cycle. The cyclic transformation of nitrogen compounds begins with the decay of plant tissue buried within the aquifer. The highest values were frequently observed in the northeastern quarter of the study area (figure 25). The aquifer at this location exists under unconfined conditions and is overlain by a slowly permeable stratum. The highest observed value was 6.7 mg/L while about ten other values exceeded 1 mg/L. Another ten values were determined to have less ammonia than the detection limit (0.02 mg/L) of the analytical equipment. Average values were not reported because of the bias caused by not including those analyses that were below the detection limit.

Boron, as mentioned previously when discussing chloride, is a minor constituent in water (Hem, 1970). Small amounts of boron are essential to plant growth, but it can be harmful to some plants. Boron is not usually found in water analyses from glacial aquifers. Not surprisingly the average value for boron in the Peoria-Pekin region was quite small, 0.2 mg/L, and would have been lower were it not for sample # 48, #51, and #52 from three Water Survey observation wells constructed in East Peoria (figure 26). These three wells also contained anomalous values of chloride, which is indicative of contamination emanating from the bedrock.

Table 2 summarizes ground-water quality from the Sankoty aquifer in the Peoria-Pekin region.

Trace Constituents

Hem (1970) states that there is no precise definition of the term "trace" with reference to constituents in natural water. This category is difficult to establish because all elements are soluble in water at least to a small degree, and those concentrations may be difficult to measure. A working definition for this category might be all those substances that typically occur in concentrations <0.1 mg/L.

Drinking water standards exist for about half of these elements. Those standards are frequently below the detection limit of Water Survey equipment even though the

Table 2. Water Quality Assessment for the Sankoty Aquifer in the Peoria-Pekin Region

	Minimum	*Maximum*	*Average*
Major Constituents			
Calcium	31.0	178.0	90.1
Magnesium	163	82.0	39.9
Sodium	3.09	142.0	35.6
Nitrate (as N)	0.1	15.0	1.5
Sulfate	0.9	288.0	60.7
Chloride	1.1	407.0	45.7
Alkalinity	154.0	522.0	3563
TDS @ 180°C	249.0	1324.0	517.2
Iron	0.01	6.09	1.20
Manganese	0.002	0.735	0.118
Potassium	0.46	8.0	2.4
Fluoride	0.1	0.9	0.3
Boron	0.02	2.23	0.20

Note: The assessment does not include analyses from sites 13, 14, 28, 34, 42, 46, 48, 50, 76, and 84-86.

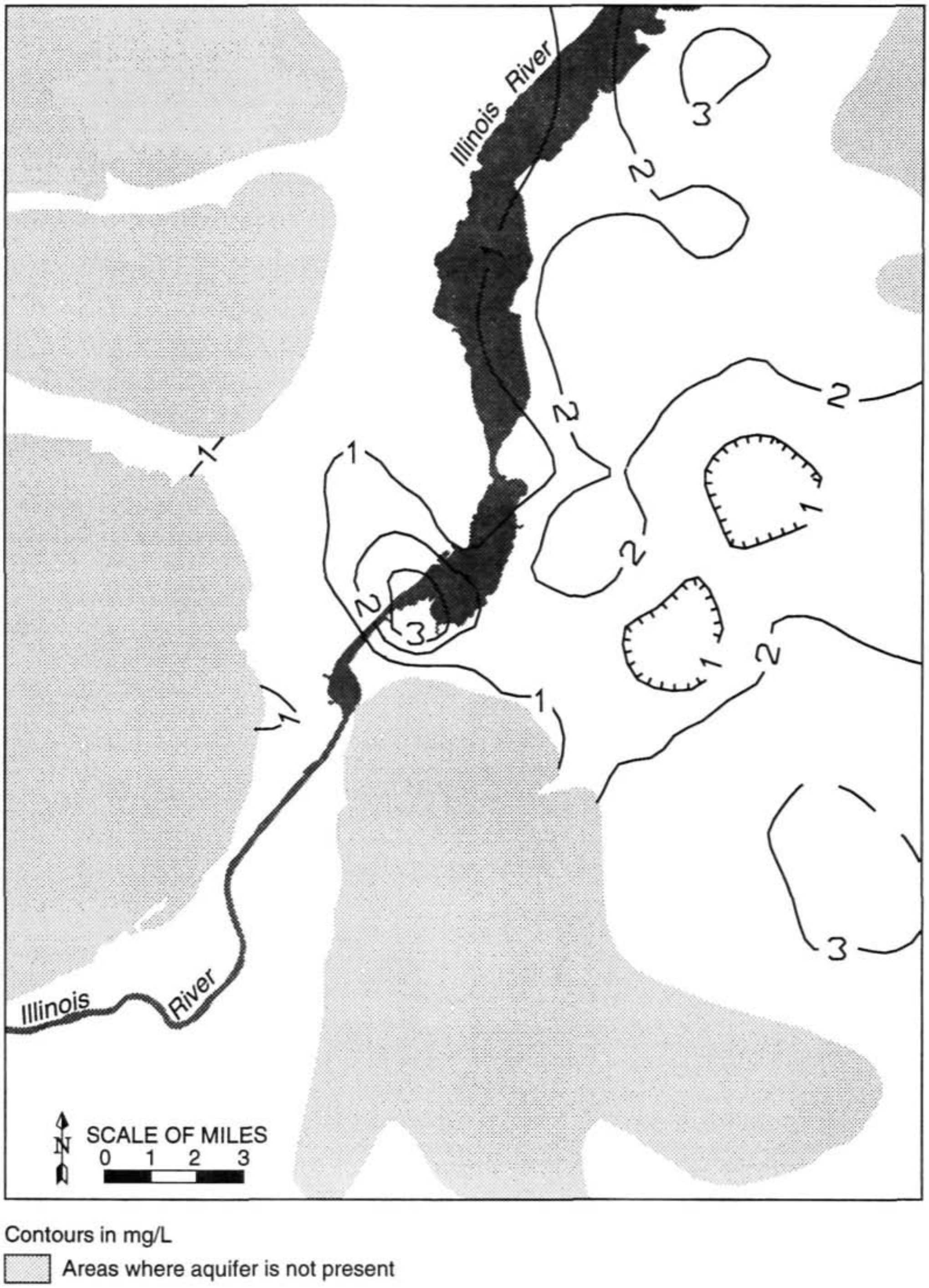
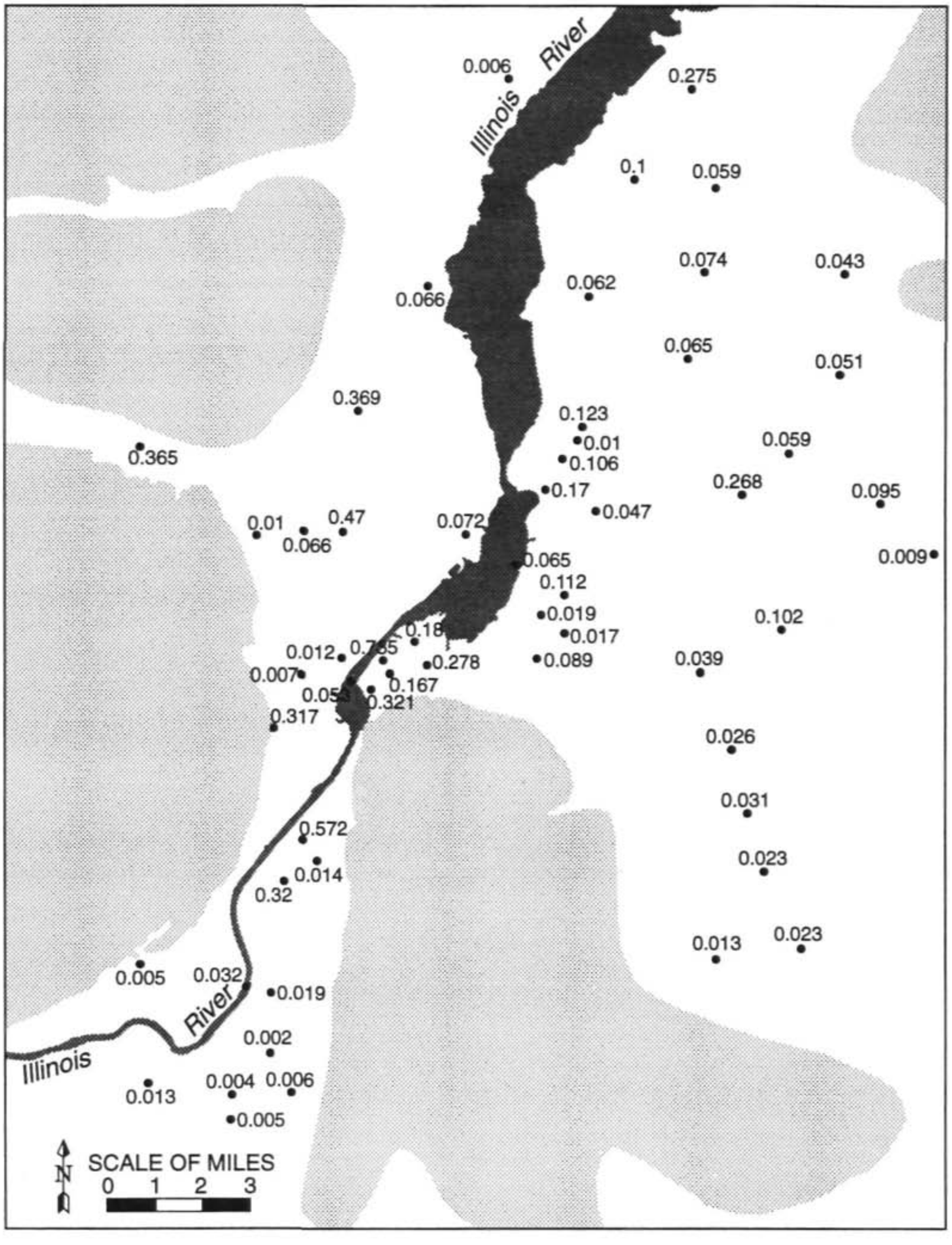


Figure 21. A contour map of iron concentrations (in mg/L) in the study area



▨ Areas where aquifer is not present

Figure 22. Manganese concentrations (in mg/L) in the study area

Figure 23. A contour map of potassium concentrations (in mg/L) in the study area

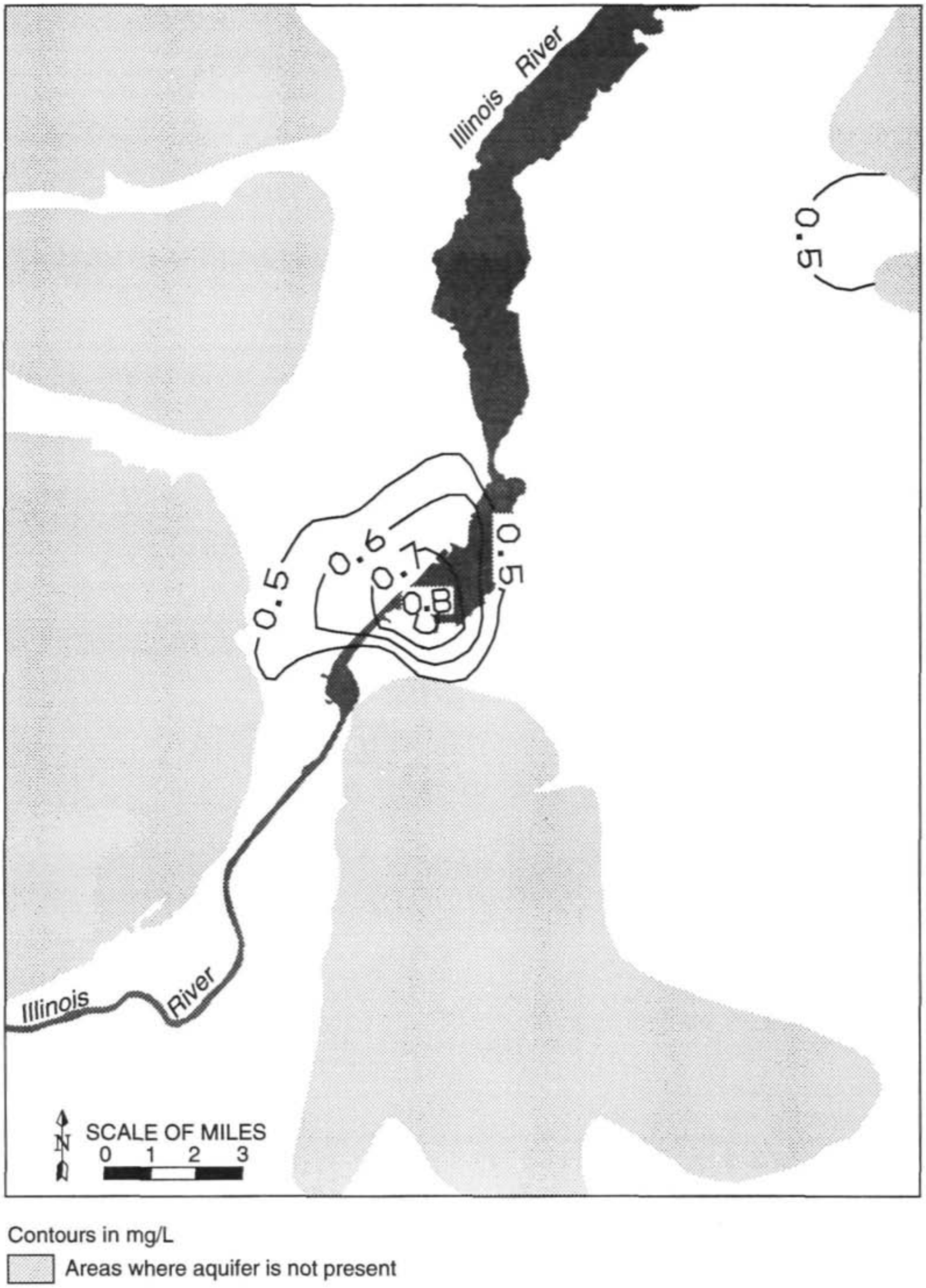


Figure 24. A contour map of fluoride concentrations (in mg/L) in the study area

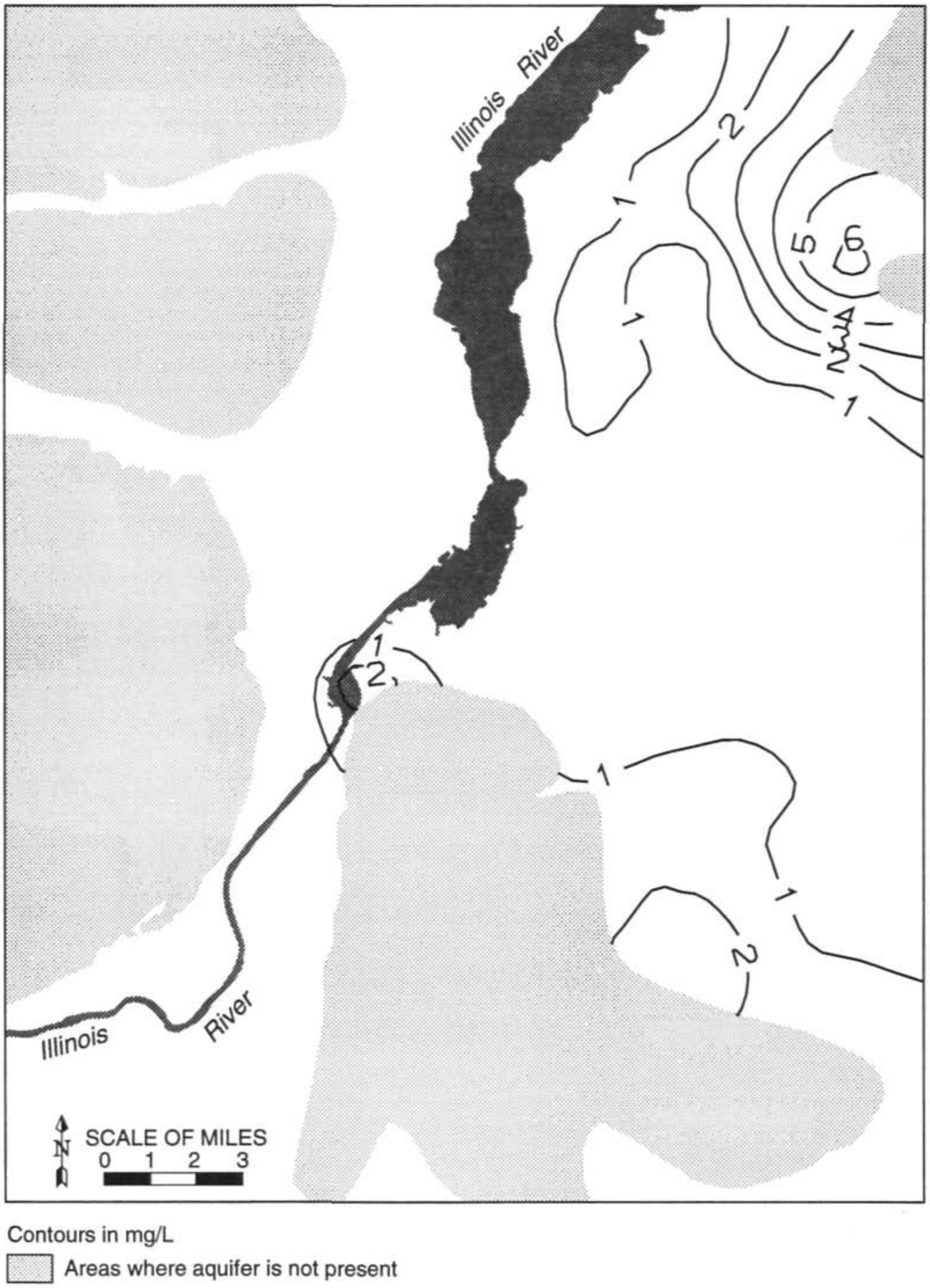


Figure 25. A contour map of ammonia concentrations (in mg/L) in the study area

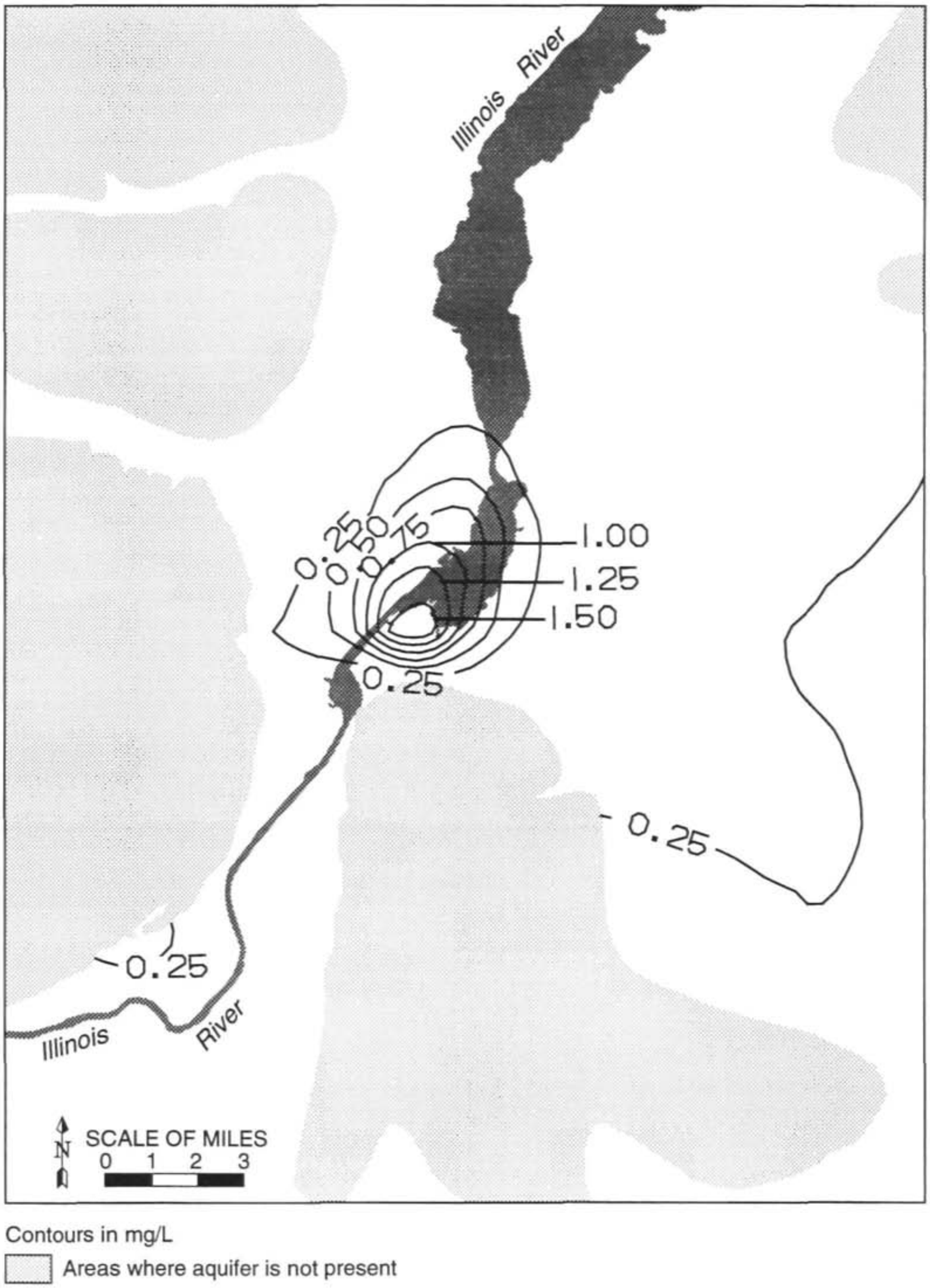


Figure 26. A contour map of boron concentrations (in mg/L) in the study area

laboratory has been certified by the DEPA. One sample from an observation well in East Peoria contained 1.18 mg/L of barium, which exceeds the 1.0 mg/L drinking water standard for barium. The average value for the region, 0.17 mg/L, was well below the standard, however.

The results from all of the samples were negative in terms of other trace metals, such as aluminum, beryllium, chromium, cadmium, copper, lead, mercury, molybdenum, nickel, silver, thallium, vanadium, and zinc. These elements usually exist at or below the detection limit of Water Survey equipment. They are not a widespread problem, nor are they common in the Peoria-Pekin region.

Some concentrations of arsenic and selenium were detected during the initial phase of this investigation. Laboratory reports thereafter indicated concentrations below the detection limit, however. It is difficult for chemists to accurately determine these concentrations with ICP methods. The authors cannot be certain of typical values for arsenic and selenium in the region, based on chemists' ICP analyses, but it is safe to say that both elements are present in minute quantities and could be studied further with atomic absorbtion techniques.

Most analyses for orthophospate and phosphorous were below the detection limit, butthree samples (#50, #73, and#33) showed phosphorous values of 0.24, 0.24, and 0.38 mg/L, respectively. No conclusions are offered, but these forms of phosphorous are not normally found in the region.

Customary analyses were made for sulfur and silica, but they are of little interest in ground-water characterizations. The average observed values were 21 and 7.5 mg/L, respectively. No drinking water standards exist for either constituent; they simply exist in ground water.

One final trace metal merits mention. Strontium, for which there is no drinking water standard, was detected in all samples from the region. Concentrations ranged from 0.01 to 0.85 mg/L, but averaged about 0.3 mg/L. Strontium is chemically similar to calcium and occurs in most ground-water samples in concentrations <1 mg/L (Davis and DeWeist, 1966).

Organic Constituents

All natural waters contain compounds of organic carbon. Many of the organic chemicals found in natural waters can be regarded as products of both biosynthesis and biodegradation. The transformation of carbon in the environment leads to humic substances, which are believed to represent a significant fraction of the bulk of dissolved organic carbon (Stumm and Morgan, 1981). Other organic compounds may also be present as particulate matter. Together they constitute one of the most straightforward chemical determinations in organic geochemistry: the analysis for total organic carbon (TOC). Dissolved organic carbon varies with the type of water from approximately 0.5 mg/L for ground water to >30 mg/L for colored water in swamps (Thurman, 1985). In the Peoria-Pekin region, TOC was observed to range from <0.5 to 9.9 mg/L, with an average of 3.7 mg/L.

Another laboratory procedure uses the "purge and trap" method to divide TOC into two fractions: those organic compounds that can be purged from a water sample (POC) and trapped on an adsorbent and nonpurgeable organic compound or NPOC. The detection of POC in ground water may be an indicator of either contamination or natural biodegradation. In this study, POC analyses were used as a screen for further organic testing. If POC concentrations >0.15 mg/L were detected, then more detailed determinations were made to identify the specific organic compound(s). Barcelona (1984) and Thurman (1985) have reported similar strategies because most natural waters contain only small amounts of POC.

The POC results ranged from <0.01 to 9.10 mg/L. Usually the POC concentration was below the detection limit (O.Olmg/L) and could not be determined. Based upon the experience of other Water Survey investigations at Rockford, we generally used a POC concentration >0.15 mg/L as our criterion for further study. Of our 53 samples, 16 exceeded our arbitrary standard. Twenty-five wells (15 of 16 plus 10 others) were resampled for POC to confirm the concentrations at these sites. Of the replicates, ten again exceeded our criterion. Additional testing at four new sites found two more wells with elevated POC concentrations.

The project effort then shifted to testing for specific organic compounds. Laboratory determinations for 42 VOCs and 23 pesticides were obtained. Lists of analytes are shown as tables 3 and 4. Samples were collected and tested for VOCs and pesticides at 16 and 9 sites, respectively. These sites were selected primarily because of the TOC concentrations (>3 mg/L) observed in an earlier round of sampling. Frequently these sites also had POCs higher than our arbitrary criterion. All the samples proved to be negative so neither VOCs or pesticides were responsible for the elevated TOC or POC values.

After consultation with the organic chemists, we decided to test for methane, which can be dissolved in water and could be responsible for the POC concentrations. Consequently, eight new samples were collected in partially filled 250-ml glass vials, sealed, and sent to a private laboratory for analysis. These sites were selected because their POC concentrations ranged from 1.00 to 9.10 mg/L. The analysis consisted of removing an aliquot of the vapor headspace with a syringe for direct injection into the analytical system per American Society for Testing Materials (ASTM) method D1946.

The results were positive, showing methane to be the source of the POC concentrations. Methane is a simple hydrocarbon (CH_4) sometimes found in ground water. It is naturally occurring and is sometimes called "drift gas" or "gas." A significant degree of correlation exists between the methane results and the POC concentrations (figure 27).

The occurrences of methane concentrations (figure 28) also correlate with a hydrogeologic control as illustrated by a visual comparison of where the methane concentrations occur, the potentiometric map (figure 5), and where the aquifer is confined. Conditions presumably exist in the

Table 3. List of Analytes: Volatile Organic Compounds

Compound	*Detection limit (µ/L)*
Chloromethane	<10
Vinyl chloride	<10
Bromomethane	<10
Chloroethane	<10
Trichlorofluoromethane	<5
Acrolein	<50
1,1-Dichloroethene	<5
Acetone	<10
Carbon disulfide	<5
Methylene chloride	<5
trans-1,2-Dichloroethene	<5
Acrylonitrile	<50
1,1-Dichloroethane	<5
Vinyl acetate	<10
2-Butanone	<10
cis-l,2-Dichloroethene	<5
Chloroform	<5
1,1,1-Trichloroethane	<5
Carbon tetrachloride	<5
Benzene	<5
1,2-Dichloroethane	<5
Trichloroethene	<5
1,2-Dichloropropane	<5
Bromodichloromethane	<5
4-Methyl-2-pentanone	<10
cis-l,3-Dichloropropene	<5
Toluene	<5
trans-1,3-Dichloropropene	<5
1,1,2-Trichloroethane	<5
2-Hexanone	<10
Tetrachloroethene	<5
Dibromochloromethane	<5
Chlorobenzene	<5
Ethylbenzene	<5
1,1,1,2-Tetrachloroethane	<5
Total xylenes	<15
Styrene	<5
Bromoform	<5
1,1,2,2-Tetrachloroethane	<5
1,3-Dichlorobenzene	<5
1,4-Dichlorobenzene	<5
1,2-Dichlorobenzene	<5

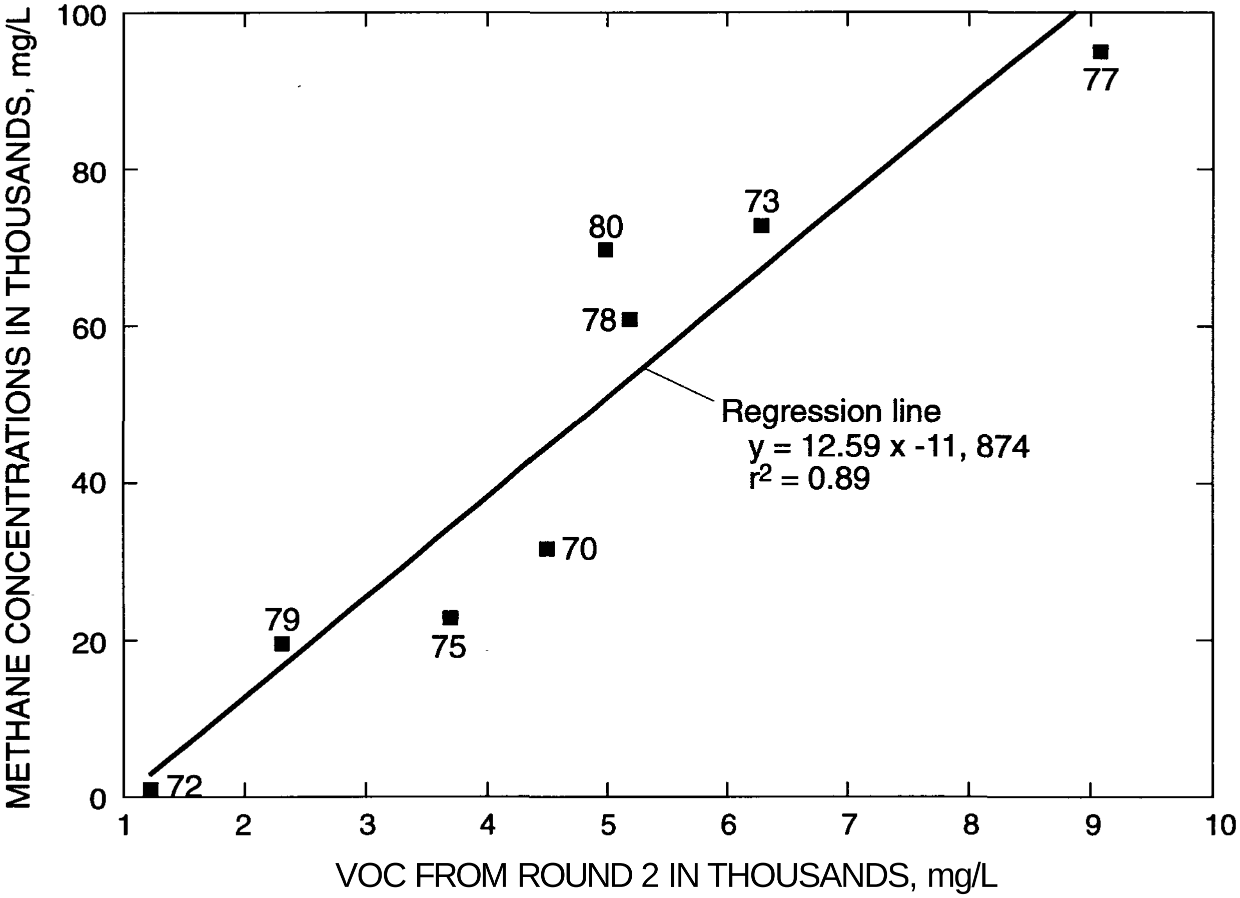
Table 4. List of Analytes: Pesticide Compounds

Compound	*Detection limit (µg/L)*
Acifluorfen	<5.0
Chlordane-alpha	<0.005
Chlordane-gamma	<0.005
Chlordane	<0.01
Chlorpyrifos	<0.10
Dieldrin	<0.01
Propachlor	<0.50
Trifluralin	<0.025
Alachlor	<0.25
Atrazine	<0.10
Butylate	<0.50
Carboxin	<2.0
Cyanazine	<0.10
Diazinon	<0.25
Dinoseb	<5.0
Ethalfluralin	<0.50
Ethaprop	<0.50
Fonofos	<0.10
Linuron	<0.50
Metolachlor	<0.50
Metribuzin	<0.10
Simazine	<0.05
Turbofos	<0.50

ground-water environment such that anaerobic degradation of organic (carbon-rich) matter occurs. The organic matter, presumably cellulose (wood growing along the ancestral Mississippi River) was deposited with the aquifer and has remained isolated from the atmosphere. The carbon sustains the bacterial activity, which produces methane in an area of low hydraulic gradient.

The noticeable absence of sulfate also supports the possibility of anaerobic, microbial activity. It is presumed that sulfate-reducing bacteria co-existed with methane bacteria and consumed the sulfate present when the aquifer was intially deposited.

Meents (1960) noted that the positions of the glacial moraines control the accumulation of drift gas (methane) in any one area. He also reported the frequent presence of methane in the Morton area of Tazewell County (T25N and 26N, R3W). This area coincides with the location of the Bloomington Moraine where the authors observed methane concentrations ranging from 800 to 95,000 mg/L. It is also suspected that the moraine may be associated with a ground-water divide and thereby influences regional flow within the aquifer.



Sample Number	VOC Round 1	VOC Round 2	**Methane Round 3**
70	4,000	4,500	**32,000**
72	1,000	1,200	**800**
73	6,200	6,300	**73,000**
75	3,600	3,700	**23,000**
77	6,500	9,100	**95,000**
78	3,000	5,200	**61,000**
79	2,300	2,300	**20,000**
80	4,600	5,000	**70,000**

Figure 27. The relationship between methane and VOC concentrations

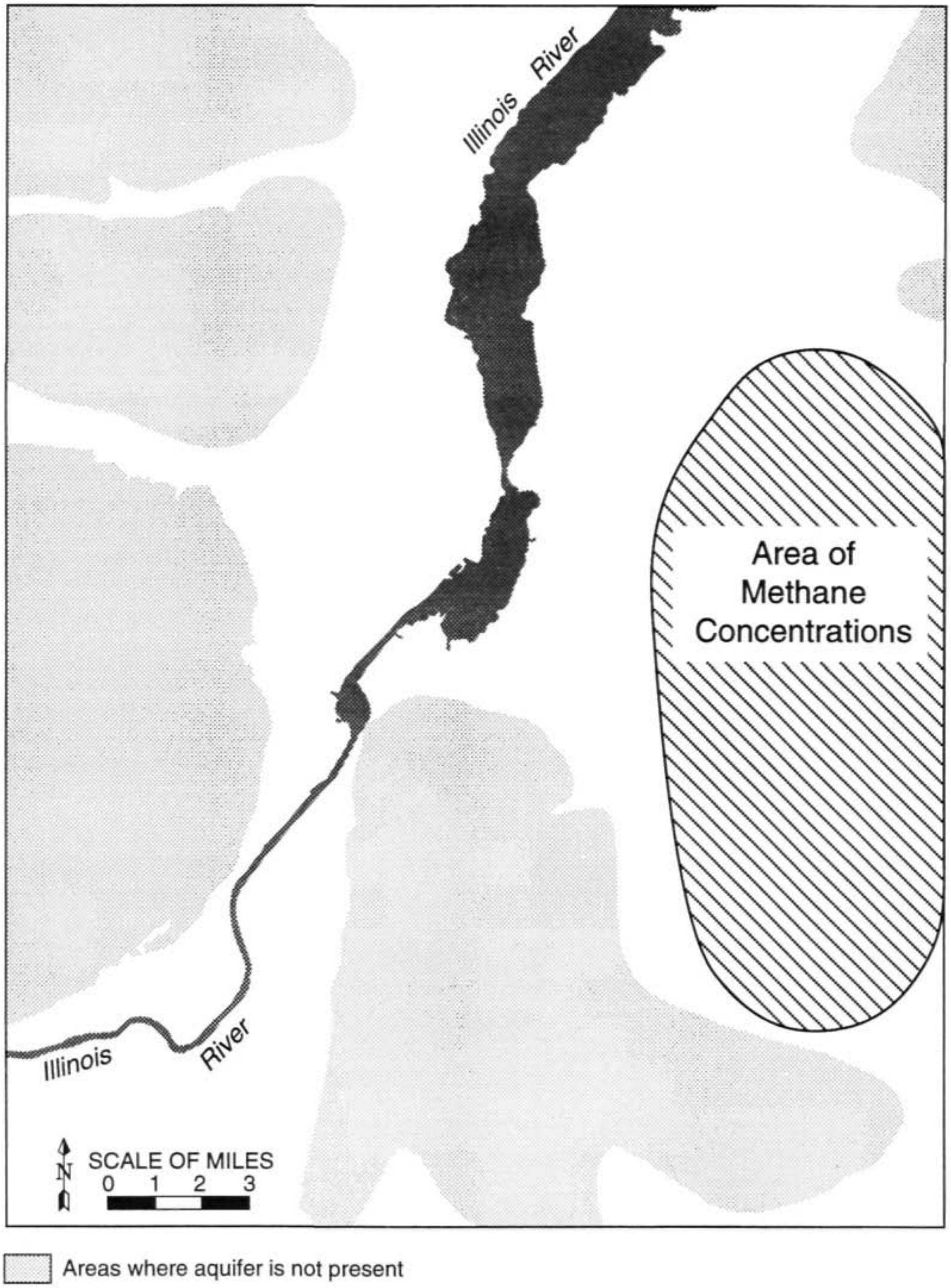


Figure 28. Methane concentrations in the study area

Location of Potential Contaminants

As stated in the introduction of this report, the concern about possible ground-water contamination was based upon the potential of human activities to introduce solutes into the hydrogeologic environment. The Peoria-Pekin area was targeted because of its use of hazardous substances in proximity to ground-water users. However, there are other potential sources of ground-water contaminants.

Bedrock Wells

As Horberg and others (1950) noted, the deep bedrock aquifers are capable of producing large quantities of water, which are of limited use because of their high mineral content. Water from these deep aquifers was reported to frequently have a strong sulfur taste and odor (ISWS, 1940). It was used primarily "for bathing pool purposes, but that is about all" presumably because it was warmer than water from the sand-and-gravel aquifers. The 1940 report goes on to say that the hydrostatic pressures within the bedrock aquifer(s) were "sufficient to cause a free flow at elevations 460 feet or less above sea level."

In terms of contamination, the report noted:

> Perhaps the most interesting data concern the effect of the various old sulfur wells on the mineral quality of the sand and gravel waters. These wells penetrate the Mississippian and Silurian formations and yield waters high in chloride and hydrogen sulfide content and relatively low in hardness. Since the static level of these sulfur wells is always higher than that of the more shallow wells, it is to be expected that there should be some penetration of this water into the sand and gravel strata. Casings, if there had been any, would in all probability be eaten away by such highly corrosive water and would no longer serve to prevent infiltration. The extent of penetration is surprising.
>
> The chloride content of these waters is about 1400 to 1500 parts per million and serves as an excellent "tracer" ion since most of the sand and gravel waters are of less than 25 parts per million chloride content.
>
> The greatest offender appears to be the old Sulfur Water Bath House well located near the heart of the Peoria business district or possibly a similar unknown well located near Adams and Fulton Streets, (p. 10)

Unwittingly, we found the same sodium-chloride situation more than 50 years later. Our first clue came with the collection of sample #16 in East Peoria. A search of the well logs on file at the Water Survey caused us to suspect the old "Voris" well located in the NWV¼, section 33, T26N, R¼W. We also found other records of deep bedrock wells and even a photograph of a flowing artesian well. Subsequent literature review found that the Water Survey reported their bedrock wells in the Peoria-Pekin region and chemical analyses for many of those wells in 1940. Most notable among these wells are the ones listed in table 5.

Although many of these wells were drilled in the late 1800s, not all of the subsequent salinity problems can be traced to these deep bedrock wells. The Water Survey undertook an informal study in 1968 to investigate the cyclic salinity problem in Peoria. Chloride contamination had plagued wells in the downtown, industrial area of Peoria for years. Because the contamination was first detected in the vicinity of the stockyards, the cause was assumed to be the deep artesian wells formerly used as a source of brine (Walker, 1970). The nearby industries generally accepted that it would be impossible to locate and seal these buried and abandoned wells after several unsuccessful attempts to do so.

However, Walker's investigation found that none of the data supported the hypothesis that abandoned salt wells in the stockyard area were causing the chloride contamination. Instead, he found that precipitation events coincided with the high chloride episodes. Eventually he traced the contamination to a brick-lined sewer and upstream to an abandoned packing plant where several tons of salt had been left in storage.

The impact of the chloride contamination has been minimized due to the relative proximity to the Illinois River. That is, the saline waters of the sand-and-gravel deposits tend to move laterally toward the river and discharge to it. The movement of these solutes is limited by two factors: (1) the pumping cones that capture them before they can reach the river, and (2) density differences between the fresh water and the contaminated waters tend to cause the more saline waters to "sink" to the bottom of the aquifer.

Landfills and Other Possible Contaminant Sources

The Peoria Disposal Company, Inc. landfill is located immediately west of the city of Peoria in the SW¼ of section 25 and W½ of section 36, T9N, R7E. The facility is located on a topographic high and overlies approximately 100 feet of till. The till unit overlies the unconfined Sankoty aquifer, which contains ground water that is moving to the southeast (Herzog et al., 1988).

The Tazewell County Landfill lies on the east side of the Illinois River. It too is located on a topographic high in the S¼ of section 25 and N¼ of section 36, T26N, R4W. Approximately 90 feet of till overlies the unconfined aquifer. Depth to water in the aquifer is nearly 120 feet below the land surface. The direction of ground-water flow in the aquifer is northwest toward the Illinois River.

For this report no attempt was made to obtain water quality data from monitoring wells at either landfill. Presumably the IEPA monitors each facility for any off-site migration of contaminants, should they occur.

An examination of the city directories for each decade between 1910 and 1971 reveals that the Peoria-Pekin region truly was an industrial center. Major alcohol, chemical, and paint manufacturers existed alongside distilleries and foundries. Gasoline and fuel oil dealers were common during the

Table 5. List of Bedrock Wells Possibly Discharging to the Sankoty Aquifer

Bedrock well	*Location*
Peoria	
Peoria's Central Park	(NE ¼, Section 3, T8N, R8E)
Glen Oak Park wells	(SE ¼, Section 34, T9N, R8E) and (NW ¼, NE ¼, Section 3, T8N. R8E)
Grant Street	(SW ¼, NW ¼, Section 2, T8N, R8E)
Logan Field	(NE ¼, SE ¼, Section 18, T8N, R8E)
Sulfur Water Bath House	(NE ¼, NE ¼, Section 9. T8N, R8E)
Peoria Mineral Company	(NE ¼, NE ¼, Section 23, T26N, R4W)
East Peoria	
Lumberyard	(SW ¼, NE ¼, NW ¼, Section 23, T26N, R4W)
Voris	(SW ¼, NW ¼, Section 33, T26N, R4W)
Pekin	
Pekin Mineral Springs Park	(NE ¼,NE ¼, Section 2, T24N, R5W)

first half of the century. Any contaminant that could have been produced, almost certainly was produced. And yet, we do not find widespread contamination of the ground-water environment.

Known sites of contamination do exist and have been widely reported in the news media. The oil-terminal facilities between North Pekin and Creve Coeur, for example, threatened the nearby public water-supply wells in 1990. As a result, the IEPA issued two ground-water contamination advisories because low levels of methyl tert butyl ether (MTBE), toluene, and xylene were detected in water samples. To alleviate the problem at this site, corrective actions were begun.

Other sites of petroleum or agriculturally related contamination probably exist along the riverfront. Spills at loading and unloading facilities, no matter how infrequent, are likely to occur. The major point is that their impact upon the ground-water system will not be regional in scope. This is because the dominant flow direction (that is, hydraulic gradient) is toward the Illinois River because it is a discharge boundary. During periods of high river stage, however the gradient can reverse. For example, high river stage in spring 1991 contributed to the capture of contaminants by North Pekin's well #1.

No attempt was made to inventory sites of potential contamination. Such an effort is beyond the scope of this study. The more important issue is the observation that the ground-water flow system is generally free from contamination largely because of hydrogeologic controls that operate on the system.

CONCLUSIONS

Ample supplies of excellent-quality ground water exist in the Peoria-Pekin region. The water is hard, but free from contaminants. Site-specific degradation has occurred usually near old artesian bedrock wells. Other contamination has been reported by the E P A in a small area near an oil-terminal facility along the Illinois River.

Regionally, no water-quality patterns exist. When studying calcium distribution, there is a possibility that values in the "Sankoty-Pekin" channel are slightly higher than those obtained from wells tapping the main body of the aquifer. In a small area of EastPeoria, values of sodium are elevated to about 140 mg/L, presumably because the physical integrity of a 700 foot well casing may have been compromised by the corrosive nature of the ground water found in the bedrock aquifer. Likewise, in Peoria another anomalous sodium value was found in the sand-and-gravel aquifer in the vicinity of a formerly flowing artesian bedrock well.

The overlying Sankoty aquifer is more important than any of the bedrock aquifers. The water in this unconsolidated deposit is of a calcium-bicarbonate type. Nearly 48 percent of the cations in the Sankoty are calcium, while another 35 percent are magnesium. Not surprisingly, the water is very hard, with an average hardness of about 400 mg/L being observed over the study area. Calcium was observed to average about 90 mg/L throughout the Peoria-Pekin region while magnesium values averaged about 40 mg/L. In our 60 reliable samples from the region, sulfate was determined to average 61 mg/L, while alkalinity was determined to average 356 mg/L. Together, all of the constituents unite to form the most descriptive water-quality statistic, total dissolved solids (TDS). In the Peoria-Pekin region, TDS typically averaged about 520 mg/L.

Closer inspection of the data shows that ground water also contains elements that occur in much smaller concentrations. These secondary constituents are normally found in concentrations <10 mg/L. In this study, iron determinations made for samples around the Peoria-Pekin region had an average value of 1.36 mg/L. Manganese, a close companion of iron, has a recommended limit of 0.05 mg/L, but in our study the average value was 0.16 mg/L. Fluoride too is a secondary constituent sometimes found in ground water, and values in samples from the Peoria-Pekin region ranged from 0.1 to 0.9 mg/L, with an average of 0.33 mg/L. In other words, the natural concentrations of fluoride in the Peoria-Pekin area are acceptable and below drinking water standards.

All natural waters contain organic compounds although ground water usually < 2 mg/L of dissolved organic carbon (DOC).. Many of the organic chemicals found in natural waters can be regarded as products of both biosynthesis and biodegradation. Until very recently, the Water Survey never even tested ground water for DOC levels. Even in this study, the authors focused on testing for purgeable organic carbon (POC). The authors observed total organic carbon (TOC) ranging from <0.5 to 9.9 mg/L, with an average of 3.7 mg/L in the Peoria-Pekin region. Meanwhile, POC results ranged from <0.01 to 9.10 mg/L and more often than not were below the detection limit (0.01 mg/L). So we can reasonably assume most of the carbon in the ground-water system is dissolved. Consequently, DOC determinations should be a higher priority than POC determinations.

Methane, a naturally occurring and rather simple hydrocarbon (CH_4) sometimes found in ground water, proved to be the source of the POC concentrations. Statistically, we determined a significant degree of correlation between the methane results and the POC concentrations. Consequently, we do not recommend the strategy of using POC as a screen for organic contamination because methane (a frequent component in ground water) can mislead investigations.

The methane concentrations also correlate with a hydrogeologic control where the aquifer is confined, rather than at atmospheric (unconfined) pressures and in an area of low hydraulic gradient.

It was observed that water-table conditions in the study area extend beneath the uplands for several miles. This unusual condition seems to result in a perched water table, that is, where an unsaturated zone separates the aquifer from a saturated zone occurring near the land surface.

The general pattern of ground-water movement is toward the Illinois River throughout the Sankoty sand under nonpumping conditions. Consequently, in a regional sense, the Illinois River represents a discharge boundary. Smaller flow systems may be established within the regional framework by pumpage. Use of the ground-water resource by municipal well fields does frequently reverse the ground-water flow direction, however.

RECOMMENDATIONS

Purgeable organic carbon (POC) determinations were used as a screen for further organic testing. When the POC concentrations were >0.15 mg/L, more detailed determinations were made in order to identify specific volatile organic compounds (VOCs) responsible for the elevated POC value. Laboratory determinations for these organic compounds were negative in all but one sample. Therefore, future water-quality characterizations should abandon the strategy of using POCs as screen for VOCs.

It is strongly recommended that future ground-water characterizations in Illinois include determinations for dissolved organic carbon (DOC), which is probably more widespread than previously recognized. These concentrations have a potential impact for water treatment facilities. That is, DOC, when chlorinated, forms trihalomethanes (THMs), which may exceed drinking water standards.

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APPENDIX A. LIST OF GROUND-WATER SAMPLE LOCATIONS

Well Locating System

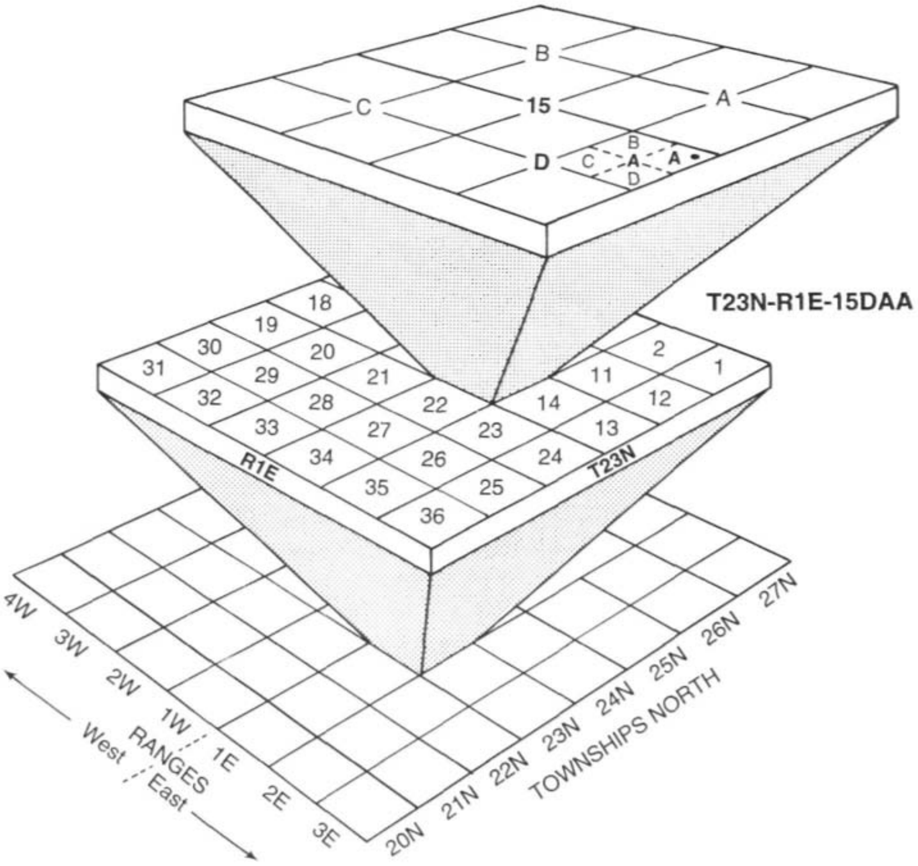
In 1785, the Continental Congress passed the first ordinance whereby the great land areas of the United States could be divided into reasonably small holdings. It was important that these parcels should have a useful shape, and be easily described and marked on the ground. Consequently, a system was established based on the principle that public lands should be divided into townships six miles square. It was further established that each township contain 36 sections, each one mile square.

The surveying system developed under the early laws was revised in 1796 and generally became known and referred to as "the system of rectangular surveys." The rectangular system was initiated in Ohio and was, in its early stages, somewhat experimental. Notable revisions of the rules were made as the surveys progressed westward. Revised Statute 43 (U.S. Codes 752 and 753) contains fundamental provisions for the subdivision of sections into quarter sections and quarter-quarter sections. The subdivisions are based upon establishing points midway between section and quarter-section corners and the center of the section.

The location of a particular site, in this report, is also based on an identification by township, range, and section (see figure below). But each section (square mile) is divided into quarters and labeled counter-clockwise either A, B, C, or D. When possible, the process was repeated three more times so that the location is accurately subdivided into 2½-acre subsections. The order of the letters is read from left to right: so the first letter refers to 160 acres, the second to 40, the third to 10, and the fourth to 2½ acres.

The numbering system used in this report to identify observation wells drilled by the Water Survey is based on using a three-letter county abbreviation, the last two digits of the year the well was drilled, and an uppercase letter. This information is presented in parentheses under "Usage type". The county abbreviation is separated from the year by a hyphen with no space between the year and the letter which identifies the well. For example, observation well TAZ-90C is located at T26N-R4W-29 DDBA.

No location, well depth, or topographic elevation data are listed for field blanks since it would be inappropriate to do so. Duplicate samples are listed as separate records and identified under "Usage type".



Sample number: 1 Location: T9N, R8E Sec. 31 DDCB
Lambert coordinates: X = 2965184 Y = 2796604
Well owner/controller: Newman Golf Course (Peoria Park District)
Date of sample collection: July 25,1989
Usage type: Irrigation
Well depth: unknown
Topographic elevation: 590 ft

Sample number: 2 Location: T9N, R8E Sec. 20 ADAC
Lambert coordinates: X = 2971406 Y = 2809883
Well owner/controller Notre Dame High School
Date of sample collection: July 25,1989
Usage type: Standby
Well depth: 300 ft
Topographic elevation: 720 ft

Sample number 3 Location: T9N, R8E Sec. 03 CABD
Lambert coordinates: X = 2978955 Y = 2823933
Well owner/controller: Detweillor Golf Course (Peoria Park District)
Date of sample collection: July 25,1989
Usage type: Irrigation
Well depth: Unknown
Topographic elevation: 476 ft

Sample number: 4
Well owner/controller: Illinois State Water Survey
Date of sample collection: July 25,1989
Usage type: **Field Blank**

Sample number: 5 Location: T8N, R8E Sec. 17 DBBD
Lambert coordinates: X = 2969333 Y = 2782403
Well owner/controller Peoria Union Livestock Company
Date of sample collection: July 26,1989
Usage type: Livestock watering
Well depth: 60 ft
Topographic elevation: 460 ft

Sample number: 6 Location: T9N, R8E Sec. 32 DCCB
Lambert coordinates: X = 2969026 Y = 2796502
Well owner/controller: Prairie Farms Dairy
Date of sample collection: July 26,1989
Usage type: Industrial
Well depth: 163 ft
Topographic elevation: 605 ft

Sample number: 7 Location: T9N, R7E Sec. 22 DCCA
Lambert coordinates: X = 2948195 Y = 2807245
Well owner/controller: Gary Reeves
Date of sample collection: July 26, 1989
Usage type: Domestic
Well depth: 120 ft
Topographic elevation: 541 ft

Sample number: 8 Location: T9N, R7E Sec. 32 DCCA
Lambert coordinates: X = 2948195 Y = 2807245
Well owner/controller: Gary Reeves
Date of sample collection: July 26,1989
Usage type: Sample Duplicate of #7 (for Quality Control)
Well depth: 120 ft
Topographic elevation: 541 ft

Sample number: 9
Well owner/controller: Illinois State Water Survey
Date of sample collection: July 26,1989
Usage type: Field Blank

Sample number 10 Location: T8N, R8E Sec. 30 BBA
Lambert coordinates: X = 2961757 Y = 2774616
Well owner/controller: Page II, Incorporated
Date of sample collection: July 27,1989
Usage type: Industrial
Well depth: Unknown
Topographic elevation: 445 ft

Sample number: 11 Location: T26N, R4W Sec. 01 CAB A
Lambert coordinates: X = 2995798 Y = 2806668
Well owner/controller: Germantown Electric Co.
Date of sample collection: July 27, 1989
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 490 ft

Sample number: 12 Location: T27N, R4W Sec. 24 ACDC
Lambert coordinates: X = 2997271 Y = 2822695
Well owner/controller Norman R. Miller
Date of sample collection: July 27, 1989
Usage type: Domestic
Well depth: 160 ft
Topographic elevation: 568 ft

Sample number: 13 Location: T10N, R8E Sec. 22 DDAA
Lambert coordinates: X = 2982482 Y = 2839571
Well owner/controller: Arnold & Judy Stoens (owned by State of Illinois)
Date of sample collection: July 28, 1989
Usage type: Domestic
Well depth: 58 ft
Topographic elevation: 490 ft

Sample number: 14 Location: T10N, R8E Sec. 10 ADAA
Lambert coordinates: X = 2982517 Y = 2852923
Well owner/controller: Verne Shaffner
Date of sample collection: July 28, 1989
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 520 ft

Sample number: 15 Location: T10N, R8E Sec. 13 BCBC
Lambert coordinates: X = 2988070 Y = 2847271
Well owner/controller: Bob Robinson
Date of sample collection: July 28, 1989
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 495 ft

Sample number: 16 Location: T26N, R4W Sec. 33 BCAD
Lambert coordinates: X = 2978924 Y = 2781509
Well owner/controller: Caterpillar, Inc.
Date of sample collection: August 25, 1989
Usage type: Drinking water
Well depth: 70 ft
Topographic elevation: 457 ft

Sample number: 17 Location: T8N, R7E Sec. 01 ABAA
Lambert coordinates: X = 2959438 Y = 2796002
Well owner/controller: Kingspark Mobile Estate
Date of sample collection: August 25, 1989
Usage type: Domestic (drinking water only at main office building)
Well depth: 84 ft
Topographic elevation: 487 ft

Sample number: 18 Location: T9N, R8E Sec. 29 BDCD
Lambert coordinates: X = 2968067 Y = 2804240
Well owner/controller: Salem Lutheran Church
Date of sample collection: August 25, 1989
Usage type: Domestic (lawn watering)
Well depth: Unknown
Topographic elevation: 630 ft

Sample number: 19 Location: T9N, R8E Sec. 29 BDCD
Lambert coordinates: X = 2968067 Y = 2804240
Well owner/controller: Salem Lutheran Church
Date of sample collection: August 25, 1989
Usage type: Sample Duplicate of #18 (for Quality Control)
Well depth: Unknown
Topographic elevation: 630 ft

Sample number: 20
Well owner/controller: Illinois State Water Survey
Date of sample collection: August 25, 1989
Usage type: Field Blank

Sample number: 21 Location: T24N, R5W Sec. 08 DBDD
Lambert coordinates: X = 2947622 Y = 2734938
Well owner/controller: Commonwealth Edison Co. (Well #50)
Date of sample collection: August 25, 1989
Usage type: Standby
Well depth: Unknown
Topographic elevation: 453 ft

Sample number 22 Location: T26N, R4W Sec. 01 CCCB
Lambert coordinates: X = 2994122, Y = 2804545
Well owner/controller: Robert Derrick
Date of sample collection: April 24, 1990
Usage type: Domestic
Well depth: 62 ft
Topographic elevation: 481 ft

Sample number: 23 Location: T26N, R4W Sec. 11 DBAB
Lambert coordinates: X = 2992065, Y = 2801190
Well owner/controller: Robert Hiatt (Hideaway Acres)
Date of sample collection: April 24, 1990
Usage type: Public
Well depth: Unknown
Topographic elevation: 463 ft

Sample number: 24 Location: T26N, R4W Sec. 23 BBCD
Lambert coordinates: X = 2989097, Y = 2792692
Well owner/controller: Gingher Piping, Inc.
Date of sample collection: April 24, 1990
Usage type: Irrigation
Well depth: Unknown
Topographic elevation: 458 ft

Sample number: 25 Location: T26N, R4W Sec. 23 BBCD
Lambert coordinates: X = 2989097, Y = 2792692
Well owner/controller: Gingher Piping, Inc.
Date of sample collection: April 24, 1990
Usage type: Sample Duplicate of #24 (for Quality Control)
Well depth: Unknown
Topographic elevation: 458 ft

Sample number: 26 Location: T26N, R4W Sec. 01 BDAA
Lambert coordinates: X = 2996458, Y = 2808038
Well owner/controller: Ascension Lutheran Church
Date of sample collection: April 25, 1990
Usage type: Noncommunity
Well depth: 137 ft
Topographic elevation: 533 ft

Sample number: 27 Location: T26N, R4W Sec. 24 CCBD
Lambert coordinates: X = 2994426, Y = 2789403
Well owner/controller: Edward Wanner
Date of sample collection: April 25, 1990
Usage type: Domestic
Well depth: 225 ft
Topographic elevation: 672 ft

Sample number: 28 Location: T26N, R4W Sec. 36 DBBA
Lambert coordinates: X = 2997061, Y = 2780264
Well owner/controller: Earl Smith
Date of sample collection: April 25, 1990
Usage type: Domestic
Well depth: 60 ft
Topographic elevation: 540 ft

Sample number 29 Location: T26N, R4W Sec. 25 CBBD
Lambert coordinates: X = 2994578, Y = 2785095
Well owner/controller: Jim & Rebecca Synder (R. Yelton)
Date of sample collection: April 25, 1990
Usage type: Domestic
Well depth: 214 ft
Topographic elevation: 660 ft

Sample number 30 Location: T26N, R4W Sec. 35 ABCB
Lambert coordinates: X = 2991401, Y = 2782297
Well owner/controller Pillsbury Company
Date of sample collection: April 26, 1990
Usage type: Domestic
Well depth: 103 ft
Topographic elevation: 495 ft

Sample number: 31 Location: T24N, R5W Sec. 11 DCDD
Lambert coordinates: X = 2963596, Y = 2733815
Well owner/controller: Mrs. Norlin A. Hardt
Date of sample collection: April 26, 1990
Usage type: Domestic
Well depth: 106 ft
Topographic elevation: 525 ft

Sample number: 32 Location: T24N, R5W Sec. 15 CAAA
Lambert coordinates: X = 2956737, Y = 2730813
Well owner/controller: James Franklin
Date of sample collection: April 26, 1990
Usage type: Domestic
Well depth: 91 ft
Topographic elevation: 493 ft

Sample number: 33 Location: T27N, R3W Sec. 24 BBBA
Lambert coordinates: X = 3025735, Y = 2825414
Well owner/controller: Izzack Walton League
Date of sample collection: June 14, 1990
Usage type: Noncommunity
Well depth: Unknown
Topographic elevation: 780 ft

Sample number 34 Location: T27N, R3W Sec. 05 AAAD
Lambert coordinates: X = 3009114, Y = 2840857
Well owner/controller: Jack Dickson
Date of sample collection: June 14, 1990
Usage type: Domestic
Well depth: 85 ft
Topographic elevation: 638 ft

Sample number: 35 Location: T27N, R3W Sec. 06 DCCD
Lambert coordinates: X = 3001564, Y = 2836039
Well owner/controller: Mike Eggleston
Date of sample collection: June 14, 1990
Usage type: Domestic
Well depth: >160 ft
Topographic elevation: 625 ft

Sample number 36 Location: T27N, R3W Sec. 09 BADB
Lambert coordinates: X = 3011336, Y = 2835018
Well owner/controller: Marvin Turl
Date of sample collection: June 15, 1990
Usage type: Domestic
Well depth: 240 ft
Topographic elevation: 685 ft

Sample number 37 Location: T28N, R3W Sec. 32 AABD
Lambert coordinates: X = 3008639, Y = 2846158
Well owner/controller Robert Fisher
Date of sample collection: June 15,1990
Usage type: Domestic
Well depth: 210 ft
Topographic elevation: 640 ft

Sample number 38 Location: T27N, R3W Sec. 29 DDBA
Lambert coordinates: X = 3008353, Y = 2815858
Well owner/controller: Mrs. Faye Halford
Date of sample collection: June 15, 1990
Usage type: Domestic
Well depth: 360 ft
Topographic elevation: 800 ft

Sample number 39
Well owner/controller: Illinois State Water Survey
Date of sample collection: June 15, 1990
Usage type: **Field Blank**

Sample number: 40 Location: T26N, R2W Sec. 18 DDD
Lambert coordinates: X = 3035575, Y = 2793937
Well owner/controller: Darrel Williams and Ron C. Schroeder
Date of sample collection: June 19, 1990
Usage type: Domestic (2 families)
Well depth: 173 ft
Topographic elevation: 770 ft

Sample number: 41 Location: T26N, R3W Sec. 27 DBAA
Lambert coordinates: X = 3018777, Y = 2785547
Well owner/controller: Joda Premo
Date of sample collection: June 19, 1990
Usage type: Domestic
Well depth: 250 ft
Topographic elevation: 770 ft

Sample number: 42 Location: T26N, R4W Sec. 26 ABDC
Lambert coordinates: X = 2992054, Y = 2787167
Well owner/controller: Tony Holcomb
Date of sample collection: June 21,1990
Usage type: Domestic
Well depth: 220 ft
Topographic elevation: 665 ft

Sample number: 43 Location: T26N, R4W Sec. 13 AABB
Lambert coordinates: X = 2998052, Y = 2798808
Well owner/controller: Ron Bemont
Date of sample collection: June 21, 1990
Usage type: Domestic
Well depth: 266 ft
Topographic elevation: 718 ft

Sample number 44 Location: T27N, R3W Sec. 16 CCDC
Lambert coordinates: X = 3010167, Y = 2825676
Well owner/controller: St. Mary's of Lourdes Church
Date of sample collection: June 28, 1990
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 747 ft

Sample number 45 Location: T7N, R7E Sec. 22 BBAA
Lambert coordinates: X = 2946278, Y = 2748701
Well owner/controller: Hollis Township Building
Date of sample collection: July 5,1990
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 468 ft

Sample number: 46 Location: T7N, R7E Sec. 15 ACDD
Lambert coordinates: X = 2948751, Y = 2751541
Well owner/controller: Mary Traenkenschuch
Date of sample collection: July 5, 1990
Usage type: Domestic
Well depth: 74 ft
Topographic elevation: 565 ft

Sample number: 47 Location: T8N, R8E Sec. 18 DDCD
Lambert coordinates: X = 2964837, Y = 2780324
Well owner/controller: South Side Worm Ranch (Tim Presley)
Date of sample collection: July 6, 1990
Usage type: Commercial
Well depth: 95 ft
Topographic elevation: 480 ft

Sample number: 48 Location: T26N, R4W Sec. 29 DCBB
Lambert coordinates: X = 2975420, Y = 2784515
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 29, 1990
Usage type: Observation (TAZ-90B)
Well depth: 24 ft
Topographic elevation: 448 ft

Sample number: 49 Location: T26N, R4W Sec. 29 DCBB
Lambert coordinates: X = 2975420, Y = 2784515
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 29, 1990
Usage type: Sample Duplicate of # 48 (Obs. Well TAZ-90B)
Well depth: 24 ft
Topographic elevation: 448 ft

Sample number: 50 Location: T26N, R4W Sec. 29 DCBB
Lambert coordinates: X = 2975420, Y = 2784515
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 29,1990
Usage type: Observation (TAZ-90A)
Well depth: 51 ft
Topographic elevation: 448 ft

Sample number 51 Location: T26N, R4W Sec. 29 DDBA
Lambert coordinates: X = 2977055, Y = 2784168
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 29, 1990
Usage type: Observation (TAZ-90C)
Well depth: 94 ft
Topographic elevation: 454 ft

Sample number 52 Location: T26N, R4W Sec. 32 BACC
Lambert coordinates: X = 2973989, Y = 2782016
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 30, 1990
Usage type: Observation (TAZ-90D)
Well depth: 64 ft
Topographic elevation: 439 ft

Sample number 53 Location: T26N, R4W Sec. 32 BDDD
Lambert coordinates: X = 2974800, Y = 2780491
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 30, 1990
Usage type: Observation (TAZ-90E)
Well depth: 52 ft
Topographic elevation: 441 ft

Sample number 54 Location: T26N, R4W Sec. 31 DACD
Lambert coordinates: X = 2971494, Y = 2779657
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 30, 1990
Usage type: Observation (TAZ-90F)
Well depth: 77 ft
Topographic elevation: 435 ft

Sample number: 55 Location: T26N, R4W Sec. 31 DBBC
Lambert coordinates: X = 2970337, Y = 2779788
Well owner/controller: City of East Peoria
Date of sample collection: October 30,1990
Usage type: Abandoned (Domestic)
Well depth: Unknown
Topographic elevation: 436 ft

Sample number: 56 Location: T25N, R5W Sec. 14 DAAD
Lambert coordinates: X = 2964963, Y = 2762232
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 30,1990
Usage type: Observation (TAZ-90G)
Well depth: 75 ft
Topographic elevation: 455 ft

Sample number 57 Location: T25N, R5W Sec. 24 ABBB
Lambert coordinates: X = 2967635, Y = 2759870
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 30, 1990
Usage type: Observation (TAZ-90H)
Well depth: 71 ft
Topographic elevation: 490 ft

Sample number 58 Location: T25N, R5W Sec. 23 ACCC
Lambert coordinates: X = 2962394, Y = 2757573
Well owner/controller Illinois State Water Survey
Date of sample collection: October 30, 1990
Usage type: Observation (TAZ-90I)
Well depth: 44 ft
Topographic elevation: 463 ft

Sample number 59 Location: T25N, R5W Sec. 34 DBDC
Lambert coordinates: X = 2958437, Y = 2745550
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 30, 1990
Usage type: Observation (TAZ-90J)
Well depth: 53 ft
Topographic elevation: 472 ft

Sample number 60 Location: T25N, R5W Sec. 35 CDBC
Lambert coordinates: X = 2961298, Y = 2745023
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 31, 1990
Usage type: Observation (TAZ-90K)
Well depth: 93 ft
Topographic elevation: 500 ft

Sample number 61 Location: T24N, R5W Sec. 10 CDDD
Lambert coordinates: X = 2956992, Y = 2733609
Well owner/controller: Illinois State Water Survey
Date of sample collection: October 31, 1990
Usage type: Observation (TAZ-90M)
Well depth: 83 ft
Topographic elevation: 506 ft

Sample number: 62 Location: T9N, R8E Sec. 35 CCDD
Lambert coordinates: X = 2983287, Y = 2796084
Well owner/controller: Komatsu Dresser
Date of sample collection: November 15, 1990
Usage type: Cooling
Well depth: 458 ft
Topographic elevation: 460 ft

Sample numbers 63-69 were not used (sequential order was broken intentionally)

Sample number: 70 Location: T25N, R3W Sec. 04 CDA
Lambert coordinates: X = 3013267, Y = 2772212
Well owner/controller: Oakwood Park (Morton Park District)
Date of sample collection: November 14, 1990
Usage type: Noncommunity
Well depth: Unknown
Topographic elevation: 720 ft

Sample number 71 Location: T26N, R3W Sec. 32 ADAD
Lambert coordinates: X = 3009694, Y = 2780760
Well owner/controller: Pine Lakes Country Club
Date of sample collection: November 14, 1990
Usage type: Noncommunity
Well depth: Unknown
Topographic elevation: 725 ft

Sample number. 72 Location: T26N, R3W Sec. 12 DDC
Lambert coordinates: X = 3029881, Y = 2799533
Well owner/controller: Martin Voorhees
Date of sample collection: November 14, 1990
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 778 ft

Sample number 73 Location: T27N, R3W Sec. 36 BBBB
Lambert coordinates: X = 3025354, Y = 2814258
Well owner/controller Mike Foster
Date of sample collection: November 14,1990
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 795 ft

Sample number 74 Location: T26N, R3W Sec. 03 DDDD
Lambert coordinates: X = 3019684, Y = 2805362
Well owner/controller Dorothy Smith
Date of sample collection: November 14,1990
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 792 ft

Sample number 75 Location: T26N, R3W Sec. 09 DDAA
Lambert coordinates: X = 3014396, Y = 2800628
Well owner/controller Bill Suits
Date of sample collection: November 14,1990
Usage type: Domestic
Well depth: 330 ft
Topographic elevation: 800 ft

Sample number: 76 Location: T26N, R3W Sec. 18 DDCB
Lambert coordinates: X = 3003313, Y = 2794673
Well owner/controller: John Yaunk
Date of sample collection: November 14, 1990
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 719 ft

Sample number: 77 Location: T25N, R3W Sec. 22 BCCD
Lambert coordinates: X = 3016845, Y = 2758532
Well owner/controller: Oliver King
Date of sample collection: November 14, 1990
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 703 ft

Sample number: 78 Location: T25N, R3W Sec. 34 AAAB
Lambert coordinates: X = 3020925, Y = 2749944
Well owner/controller: Mrs. Don Michel
Date of sample collection: November 14, 1990
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 685 ft

Sample number 79 Location: T25N, R3W, Sec. 16 ABDD
Lambert coordinates: X = 3014952, Y = 2765040
Well owner/controller: John Ackerman
Date of sample collection: November 15, 1990
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 718 ft

Sample number 80 Location: T25N, R3W Sec. 33 BCBD
Lambert coordinates: X = 3011505, Y = 2748702
Well owner/controller: Dave Anderson
Date of sample collection: Unknown
Usage type: Domestic
Well depth: Unknown
Topographic elevation: 682 ft

Sample number: 81
Well owner/controller: Illinois State Water Survey
Date of sample collection: May 1, 1991
Usage type: Field Blank

Sample number: 82
Well owner/controller: Illinois State Water Survey
Date of sample collection: May 2, 1991
Usage type: Field Blank

Sample number: 83 Location: T24N, R5W Sec. 11 BACB
Lambert coordinates: X = 2961279, Y = 2738276
Well owner/controller Illinois State Water Survey
Date of sample collection: May 8, 1991
Usage type: Observation (TAZ-90L)
Well depth: 105 ft
Topographic elevation: 538 ft

Sample number: 84 Location: T9N, R8E, Sec. 29 DADB
Lambert coordinates: X = 2971172, Y = 2803046
Well owner/controller: Illinois State Water Survey
Date of sample collection: May 8, 1991
Usage type: Observation (SWS #17 — Buehler Home)
Well depth: 313 ft
Topographic elevation: 665 ft

Sample number 85 Location: T8N, R8E, Sec. 07 CBCB
Lambert coordinates: X = 2960290, Y = 2788745
Well owner/controller: Illinois State Water Survey
Date of sample collection: June 17, 1991
Usage type: Observation (SWS #7 or #15 — Madison Park)
Well depth: 107 ft
Topographic elevation: 460 ft

Sample number: 86 Location: T8N, R8E, Sec. 17 BAAA
Lambert coordinates: X = 2967864, Y =2785191
Well owner/controller: Illinois State Water Survey
Date of sample collection: June 17, 1991
Usage type: Observation (SWS #9—Lincoln Library Grounds)
Well depth: 134 ft
Topographic elevation: 512 ft

Sample number: 87
Well owner/controller: Illinois State Water Survey
Date of sample collection: June 17, 1991
Usage type: **Field Blank**

APPENDIX B. DRILL LOGS

The following format is used to report drilling done for this study. The information listed at the head of each driller's log refers to when and where the hole was drilled, a formal name according to the parlance described in appendix A for the observation well if constructed at the site, a descriptive name of the site (in italics), and key personnel involved in drilling the test hole. The driller's logs are presented sequentially, by hole number (99-115) as they were drilled and in no way refer to the sample site numbers described in appendix A. If a water-quality sample was collected from an observation well, then it is identified under "usage type" in appendix A.

The rock term is given first in the driller's log and is followed by descriptive terms. The purpose of this form is to give emphasis to the material in each interval of depth (in feet) rather than to its particular color, texture, or other features, but the device is effective only where the term to be emphasized comes first in the line. Note that hyphens are used between words combined to form unit modifiers that immediately follow the principal term and that are not ordinarily hyphened. It is not proper to read back beyond a semicolon or a period because the matter that follows punctuation is not part of the first statement

Total depth (T.D.) of the hole, in feet, and well construction details are described at the bottom of log. Additional notes, such as depth to water, may also be listed at the bottom of the log.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90L

"Kiwanis Park South"	Location: T24N-R5W-11 BACB
SWS Hole #: R-99	County: Tazewell
Date Drilled: August 6,1990	
Driller: Buck	
Hydrogeologist: Burch	Casing Top Elevation: 540.06 feet

Located along tree line at southwest corner of the park.

Depth (feet)	*Description of materials*
0-3	Topsoil, black, sandy clay
3-8	Clay, brown, sandy, silty; unsaturated
8-30	Sand, brown, coarse with quartz granules; uniformly sorted over interval; damp, but not wet
30-80	Sand, brown, coarse; fairly well sorted, damp
80-85	Sand, brown, medium; silty
85-105	Sand and gravel; medium to coarse sand with 1/2- to 3/4-inch rounded gravel, lots of granules, appears more wet than previous intervals

T.D. = 105 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot and 2-inch diameter) at bottom and 102.5 feet of 2-inch diameter PVC, flush-joint casing to the surface. Set 4-inch-square well protector over top of well casing.

Note: Depth to water from top of casing = 96.53 feet (August 14, 1990).

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90M

"Pekin Industrial Park"
SWS Hole #: R-100
Date Drilled: August 7,1990

Location: T24N-R5W-10 CDDD
County: Tazewell

Driller: Buck
Hydrogeologist: Burch

Casing Top Elevation: 508.17 feet

Located on west side of Illinois Central Railroad right-of-way at center of south section line.

Depth (feet)	*Description of materials*
0 - 2	Topsoil, black
2 - 6	Clay, silty, sandy
6 - 10	Sand, brown, coarse to very coarse; with 1/4-inch gravel, feels damp
10 - 26	Sand, brown, medium to coarse; with granules moderately well sorted
26 - 38	Sand, dark brown, medium to very coarse; with granules. Darker color may be caused by more silt (?) or maybe more saturation. Still moderately well sorted.
38 - 47	Sand, very dark brown, medium to very coarse; wet and glistens in sunlight. Clayey enough to "glomp" into balls.
47 - 48	Gravel, fine, clayey
48 - 60	Sand, dark brown, medium to very coarse
60 - 83	Sand, brown, medium to very coarse; but less clay, looks like "Kiwanis Park South" sand (Hole #: R-99)

T.D. = 83 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot and 2-inch diameter), 10 feet of stainless steel casing (2-inch), and 66.5 feet of 2-inch diameter flush-joint PVC casing to the surface. Backfilled annulus with cuttings and sealed at surface with 25 pounds of bentonite powder and set 4-inch-square well protector over casing.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90K

"Pekin High School West Campus"
SWS Hole #: R-101
Date Drilled: August 7-8, 1990

Location: T25N-R5W-35 CDBC
County: Tazewell

Driller: Buck
Hydrogeologist: Burch

Topographic Elevation: 500 feet

Located on north side of the High School along abandoned railroad right-of way.

Depth (feet)	*Description of materials*
0 - 2	Fill; coal
2 - 8	Sand and fine gravel; brown, clayey, dry
8 - 12	Sand, brown, fine to very coarse; very wet
12 - 13	Sand, brown, fine to medium; very silty and wet
13 - 43	Sand, brown, fine to coarse; some fine gravel (1/4 inch), generally dry and moderately well sorted
43 - 53	Sand, brown, fine to medium; dry appearance with a fine "sugar-like" texture
53 - 93	Sand, medium dark brown, fine to coarse; with gravel (oblate shapes to 1/2 inch), sand is slightly clayey, appears dry

T.D. = 93 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot and 2-inch diameter), 10 feet of stainless steel casing (2 inch), and 80 feet of 2-inch diameter flush-joint PVC casing to the surface. Backfilled annulus with cuttings and sealed at surface with two bags of bentonite powder. Set 4-inch-square well protector over casing. Casing stickup is approximately 2.5 feet.

Note: Depth to water from top of casing = 59.62 feet (August 14,1990). Well damaged and bent over during 1991-1992.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90J

"Miller Park at RL 9 Bridge"
SWS Hole #: R-102
Date Drilled: August 9,1990

Location: T25N-R5W-34 DBDC
County: Tazewell

Driller: Buck
Hydrogeologist: Burch

Casing Top Elevation: 474.30 feet

Located on the south side and at the foot of the Route 9 bridge over the Illinois River. About 30 feet from corner of shuffleboard court on State right-of-way.

Depth (feet)	*Description of materials*
0 - 1	Fill
1 - 2	Topsoil, black, clayey
2 - 5	Clay, brownish-black, sandy
5 - 11	Sand, brown, medium to very coarse, dry
11 - 12	Gravel and sand, brown; gravel is up to 1 -inch elongated shapes while sand has medium to very coarse texture
12 - 19	Sand, brown, medium to very coarse with granules and fine gravel
19 - 36	Sand, brown, medium to coarse; "sugar-like" quality and moderately well sorted
36 - 38	Sand, dark chocolate brown, medium to coarse; organic rich?
38 - 53	Sand, brown, medium to coarse; "sugar-like" quality, wet and moderately well sorted

T.D. = 53 feet

Well construction details: Set 5 feet of Brainard-Kilman 2-inch diameter stainless steel screen (0.010-inch slot and 2-inch diameter), 10 feet of stainless casing (2 inch), and 40 feet of 2-inch flush joint PVC casing. Backfilled annulus with cuttings and sealed at surface with bentonite powder and set 4-inch-square well protector over casing. Casing stickup is approximately 2.4 feet.

SWS DRILLER'S LOG

"Mineral Springs Park"
SWS Hole #: R-103
Date Drilled: August 9, 1990

Location: T24N-R5W-01 BBBD
County: Tazewell

Driller: Buck
Hydrogeologist: Burch

Topographic Elevation: 540 feet

Located west of the 4-H Exhibition Barns near spruce tree north of roadway.

Depth (feet)	*Description of materials*
0 - 27	Sand, golden brown, very fine to medium; very-well sorted, slightly silty (aeolian?)
27 - 29	Sand, medium brownish-gray, very fine to medium, very well sorted; (organic-rich zone or weathered surface?)
29 - 37	Sand, golden brown, very fine to medium; very well sorted, slightly silty
37 - 44	Sand, golden to medium brown, very fine to medium; well sorted but wet and sticky (clayey?), can form 1-inch balls, same as 12- to 13-foot depth at high school (SWS Hole #101)?
44 - 73	Sand, brown, medium to very coarse
73 - 97	Sand, brown, medium to very coarse; with some well-rounded, fine gravel (1/4 inch), typical "Sand Ridge" type of material where gravel becomes coarse with depth and commonly has flattened, oblate shapes up to 1-½ inches
97 - 98	Sand; as above, harder drilling
98 - 100	Sand, light to medium brown, fine to coarse; may be from above, drill stem wobbling
100 -102	Shale?; very hard augering, down pressure about 600 psi
102-105	Unknown; easy drilling, sand cuttings with angular coal fragments, some gravel, probably not representative of this interval

T.D. = 105 feet

Note: Dropped weighted end of steel tape to bottom of hole. It came up dry. After pulling out all of the augers, an examination revealed the cutter head had dry, light-blue clay on it: presumably, bedrock. Did not case this hole.

SWS DRILLER'S LOG

"Dog Obedience Area"	Location: T25N-R5W-25 ABBB
SWS Hole #: R-104	County: Tazewell
Date Drilled: August 10,1990	
Driller: Buck	
Hydrogeologist: Burch	Topographic Elevation: 478 feet

Located east of Parkway Drive, just south of Lick Creek.

Depth (feet)	*Description of materials*
0 - 6	Clay, black
6 - 12	Clay, dark grayish-brown
12 - 15	Till, dark brown; silty, sandy, pebbly
15 - 20	Clay, yellow; with fine sand
20 - 27	Sand, brown, very clayey; soupy (wet)
27 - 35	Shale, black, very hard; jet black soup washes up the hole with few cuttings, finally received handfuls of angular black coal fragments with conchodial fractures

T.D. = 35 feet

Note: Did not case the hole. Nearby golf course was interested in irrigation potential at this location.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-901

"Junction of 29 & 98" Location: T25N-R5W-23 ACCC
SWS Hole #: R-105 County: Tazewell
Date Drilled: August 10, 1990

Driller: Buck
Hydrogeologist: Burch Casing Top Elevation: 464.50 feet

Located north of Illinois Route 98 and east of Route 29.

Depth (feet)	*Description of materials*
0 - 6	Sand, chocolate brown, clayey, with granules
6 - 8	Sand, medium brown, with coarse gravel (1-inch)
8 - 44	Sand, medium brown, medium to very coarse and with granules

T.D. = 44 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot size and 2-inch diameter), 10 feet of stainless steel casing, and 26.6 feet of 2-inch diameter, flush joint PVC casing to the surface. Backfilled annulus with cuttings and sealed at surface with one bag of bentonite. Set a 4-inch-square well protector over casing.

Note: Lost part of the hole while pulling auger; consequently, we only cased what was open.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90H

"Lincoln Blvd. in North Pekin"	Location: T25N-R5W-24 ABBB
SWS Hole #: R-106	County: Tazewell
Date drilled: August 13, 1990	
Driller: Buck	
Hydrogeologist: Burch	Casing Top Elevation: 490.30 feet

Located on the south side of Lincoln Blvd. in right-of-way.

Depth (feet)	*Description of materials*
0 - 3	Topsoil, black, clayey
3-15	Clay, very dark brown; slightly sandy
15 - 34	Sand, brown, medium to very fine; with granules and very fine gravel
34 - 37	Sand, brown, very fine to medium with 1 -inch gravel; well rounded gravel, cuttings appear dry
37 - 53	Sand, brown, very fine to medium
53 - 70	Sand, light golden brown, very fine to medium; has "sugar-like" appearance, very well sorted
70 - 71	Bedrock; resists auger drilling, bit pressure > 300 psi

T.D. = 71 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot size and 2-inch diameter), 10 feet of stainless steel casing, and 55 feet of flush-joint, 2-inch diameter PVC casing. Backfilled annulus with cuttings and sealed at surface with 1/2 bag of bentonite. Covered casing with 4-inch-square well protector.

Measured depth to water approximately 49.2 feet below the top of casing before leaving the site.

SWS DRILLER'S LOG

"Starke School area"
SWS Hole #: R-107
Date Drilled: August 14, 1990

Driller: Buck
Hydrogeologist: Burch

Location: T25N-R5W-25 CDBD
County: Tazewell

Topographic Elevation: 518 feet

Located at southwest corner of parking lot on north side of a creek. About 100 feet south of the intersection of Independence and Parish Streets in Pekin.

Depth (feet)	*Description of materials*
0 - 3	Topsoil, black, clayey
3 - 7	Clay, very dark brown
7-10	Clay, yellow brown with black mottling
10 - 60	Sand, brown, very fine to coarse; moderately well sorted, no gravel
60 - 73	Sand, brown, very fine to coarse with granules and fine gravel
73 - 75	Sand, light golden brown, very fine to medium; very well sorted and has "sugar-like" appearance
75 - 76	Bedrock; resists auger drilling

T.D. = 76 feet

Note: Did not case hole—dry.

SWS DRILLER'S LOG

"Cottonwood Site - North Pekin"
Location: T25N-R5W-24 BBBB
SWS Hole #: R-108
County: Tazewell
Date Drilled: August 14, 1990

Driller: Buck
Hydrogeologist: Burch
Topographic Elevation: 460 feet

Located along abandoned Gulf, Mobile, and Ohio Railroad right-of-way.

Depth (feet)	*Description of materials*
0-3	Fill; coal and sand mixture
3 - 6	Clay
6-10	Fill; slag, cinders
10 - 20	Clay, medium dark gray, sandy, silty
20 - 25	Clay, olive gray, very silty
25 - 63	Sand, brown, very fine with lots of clay; "soupy" cuttings have ketchup-like texture
63 - 80	Silty clay, light gray; poor recovery of cuttings!

T.D. = 80 feet

Note: This was the first of many more sites that did not contain the sand characteristic of Pekin and Mason County. Apparently this alluvial deposit covers the area from here upstream to East Peoria. Description of cuttings is almost impossible and should be based on split-spoon samples.

Did not case this "slimy" hole—observed till and clay on bottom auger flight.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90G

"Hicks Gas Site along Route 29" Location: T25N-R5W-14 DAAD
SWS Hole #: R-109 County: Tazewell
Date Drilled: August 15, 1990

Driller: Buck
Hydrogeologist: Burch Casing Top Elevation: 457.78 feet

Located along abandoned Gulf, Mobile, and Ohio Railroad right-of-way just south of what would have been the railroad's intersection with Route 29 in North Pekin.

Depth (feet)	*Description of materials*
0 - 1	Topsoil
1-9	Silt, brown; sticky and wet
9 - 25	Silt, grayish-brown, becoming yellow brown at 15 feet, slightly clayey; drier than interval above but still forms into 2-inch balls as cuttings come up the auger flight
25 - 33	Sand, brown, very silty; soupy thick slop again like previous site; sand grains are very fine to medium size
33 - 34	Till(?); harder drilling, no change in cuttings but bit pressure ranges from 300 to 600 psi
34 - 48	Silty sand, brown; soupy slop makes descriptions impossible
48 - 63	Silty sand, dark olive gray; pudding-like texture becoming more solid about 53 feet, gravel pebbles were recovered, suspect gravelly-till layer may be responsible
63 - 75	No cuttings returned to surface; easy drilling may indicate sand

T.D. = 75 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot size and 2-inch diameter), and 72.5 feet of flush-joint, 2-inch diameter, PVC casing. Purchased more than 1 ton of pea gravel and backfilled the annulus. Sealed at surface with bentonite and covered the casing with a 4-inch-square well protector.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90C

"IDOT Maintenance Yard, East Peoria"
SWS Hole #: R-110
Date Drilled: August 16-20, 1990

Location: T26N-R4W-29 DDBA
County: Tazewell

Driller: Buck
Hydrogeologist: Burch

Casing Top Elevation: 456.17 feet

Located inside Illinois Dept. of Transportation yard along the south fence.

Depth (feet)	*Description of materials*
0 - 4	Sand, brown, underlies a little black topsoil (fill)
4 - 10	Clay, black; and brick fragments (fill)
10 - 13	Clay, very dark brown; angular fragments of brick, rock and glass up to 2 inches in size, rocks at 13 feet
13 - 25	No cuttings but drilled the same as previous interval
25 - 30	No cuttings hard drilling
30 -31.5	Clay, medium gray; sandy in bottommost part of split-spoon sample
31 - 45	Clay, gray; drills easy, thick and soupy cuttings may be picking up color and sand content while coming up the augers
45 - 48	Silt, medium gray with faint greenish color. Contains wood splinters and occasional granules and concretions (loess?)
48 - 76	Silt, gray; cuttings are nondescript except to say it's "Peoria pudding"
76 - 80	Silt, gray; with hard spots between 76 and 78 feet (gravel?)
80 - 81	Sand, gray; blow-in filled bottom of hollow-stem augers. Washed out and attempted split-spoon sample. Recovered about 2 inches of fine gravel with some white clay.
81 - 93	No report; augered on with no change in drill speed. Washed 1/2- to 3/4-inch gravel from bottom of augers when setting casing. Presumably from this lower unit and may coincide with ancient Farm Creek bedrock valley.
93 - 94	Bedrock; refusal to further drilling. Light gray shale on bit when removed from hole.

T.D. = 94 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot size and 2-inch diameter), 10 feet of stainless steel casing, and 80 feet of flush-joint, 2-inch diameter PVC casing. Purchased 1-1/2 tons of pea gravel and backfilled around casing. Sealed at surface with bentonite powder and set 4-inch-square well protector over casing.

Note: Measured depth to water approximately 19.5 feet below the top of casing before leaving the site.

This well was intended to replace the Sword property wells previously drilled for the State Water Survey near this location in the 1940s and described in Bulletin 39.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90A

"Industrial Spur Exit onto Washington St."
SWS Hole #: R-111
Date Drilled: August 21, 1990

Location: T26N-R4W-29 DCBB
County: Tazewell

Driller: Buck
Hydrogeologist: Burch

Casing Top Elevation: 449.71 feet

Located inside loop formed by on-off ramp. At bottom of embankment.

Depth (feet)	*Description of materials*
0-13	Fill; clay, sand, brick fragments, generally dark brown color
13-19	No cuttings returned to the surface
19 - 22	Silt, medium dark gray with faint olive cast; some fine sand, saturated, "sloppy stuff
22 - 30	Clay (?); hard drilling with down pressures > 300 psi, no cuttings returned to the surface
30 - 33	Silt, olive brown; very soupy and wet, some grains of fine sand
33 - 46	Silt, brownish gray; clayey and some sand grains present, thicker consistency "Dairy Queen"
46 - 48.5	Shale, brownish-olive gray, hard; clay and some very fine sand, soupy but requires more than 800 psi down-pressure
48.5 - 50	Silt, brownish-gray; soft (subsequently wondered if this was a coal layer)
50 - 51	Shale, medium gray; split-spoon sample contained 4 inches of coal and 9 inches of medium gray shale

T.D. = 51 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot size and 2-inch diameter), 10 feet of stainless steel casing, and 32 feet of flush-joint, 2-inch diameter PVC casing. Backfilled annulus with cuttings (silty slop). Set 4-inch-square well protector over casing. Casing stickup equals about 2 feet.

Note: This is the westmost well of two at this site.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90B

"Industrial Spur Exit onto Washington St." Location: T26N-R4W-29 DCBB(2)
SWS Hole #: R-112 County: Tazewell
Date Drilled: August 21, 1990

Driller: Buck
Hydrogeologist: Burch Casing Top Elevation: 450.98 feet

Located inside loop formed by on-off ramp. At bottom of embankment.

Depth (feet)	*Description of materials*
0 - 24	See description for Hole # R-111

T.D. = 24feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot size and 2-inch diameter), 10 feet of stainless steel casing, and 10 feet of flush-joint, 2-inch diameter PVC casing. Purchased 300 pounds of washed play sand and backfilled annulus. Set 4-inch-square well protector over casing.

Note. This is the eastmost and shorter well of two at this site. The idea for the second well was to set the screen just above the clay layer observed in holes #R-110 and R-111.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90F

"East Peoria Sewage Plant" Location: T26N-R4W-31 DACD
SWS Hole #: R-113 County: Tazewell
Date Drilled: August 22,1990

Driller: Buck
Hydrogeologist: Burch/Kelly Casing Top Elevation: 435.79 feet

Located inside their fenced area and adjacent to Caterpillar property. Near intersection of Spencer and Cass Streets. This well was intended to replace the old recorder well previously drilled for the State Water Survey near this location in the 1940s and described in Bulletin 39.

Depth (feet)	*Description of materials*
0 - 4	Fill, black (sludge?); shiny
4 - 7	Clay, black; dull
7 - 13	Clay, black, dull; strong diesel fuel odor!
13 - 19	Clay, dark gray; diesel fuel odor continues, fewer cuttings
19 - 23	Clay, medium dark gray; cuttings form into shiny "silver ribbons" and stick to auger flights
23 - 24	Clay, medium gray, hard drilling. Also medium-gray silt cuttings probably from above. No diesel odor—but very sticky stuff.
24 - 29	Clay, medium gray, silty; sticky
29 - 38	No cuttings; soft easy drilling
38 - 57	No cuttings; probably sand according to natural gamma log
58 - 68	No cuttings; soft easy drilling, natural gamma log suggests silt
68 - 77	Gravel; cuttings, including medium sand, were washed up hollow-stem auger before well was set
77	Bedrock; auger refusal

T.D. = 77 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot size and 2-inch diameter), 10 feet of stainless steel casing, and 60 feet of flush-joint, 2-inch diameter PVC casing. Purchased "torpedo sand" from Faber-Muser Company in Peoria and backfilled annulus from 50 up to 40 feet. Then poured in 25 pounds of bentonite pellets; followed by another 200 pounds of sand and another 25 pounds of bentonite pellets. Filled remainder of annulus with "torpedo sand" and set 4-inch-square well protector over casing.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90D

"Intersection of Sanford & Richland Streets"
SWS Hole #: R-114
Date Drilled: August 23, 1990

Location: T26N-R4W-32 BACC
County: Tazewell

Driller: Buck
Hydrogeologist: Kelly/Burch

Casing Top Elevation: 440.43 feet

Located very near the Cedar Street overpass on Richland Street.

Depth (feet)	*Description of materials*
0 - 6	Fill, silty clay; very hard
6 - 8	Clay, brown, silty; soft
8-11	No cuttings; sand according to natural gamma log
11-13	No cuttings; probably silt
13-15	Silt, brown, sandy; very wet
15-23	No cuttings
23 - 27	Silt, brown, some fine sand; very wet and soupy
27 - 46	Silt, gray; very wet in layers; interbedded sand lenses?
46 - 53	No cuttings; drills easy (sand?)
53 - 60	Sand, gray, silty; after an initial flow of water the cuttings were similar to the 27- to 45-foot interval
60 - 64	Sand, gray, silty; thick yogurt-like texture, occasional gravel layer. A large chunk of gravel (3 to 4 inches in diameter) was found jammed into the bottom of augers when they were removed from hole.

T.D. = 64 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot size and 2-inch diameter), 10 feet of stainless steel casing, and 50 feet of flush-joint, 2-inch diameter PVC casing. Purchased pea gravel and backfilled annulus with 1000 pounds before placing 25 pounds of bentonite pellets in the annulus. Filled remainder to near the surface with another 1000 pounds of pea-gravel and sealed with bentonite powder. Set 4-inch-square well protector over casing. Casing stickup = 1.3 feet.

SWS DRILLER'S LOG

SWS Observation Well: TAZ-90E

"1-29 On ramp at Edmund St. in East Peoria" Location: T26N-R4W-32 BDDD
SWS Hole #: R-115 County: Tazewell
Date Drilled: August 24,1990

Driller: Buck
Hydrogeologist: Burch Casing Top Elevation: 442.68 feet

Located inside loop formed by Cedar Street (south) on ramp.

Depth (feet)	*Description of materials*
0 - 4	Topsoil, black
4-12	Clay, grayish-brown, silty
12-19	No cuttings; natural gamma log suggests silty sand
19 - 25	Silt, light brown; sticky wet "ooze"
25 - 32	Silt, gray, some very fine sand; soupy
32 - 35	Clay
35 - 50	Sand, gray, very fine, silty; very wet and soupy
50 - 52	Sand, gray, gravelly behavior when drilling, but no evidence in cuttings
52	Bedrock; auger refusal

T.D. = 52 feet

Well construction details: Set 5 feet of Brainard-Kilman stainless steel screen (0.010-inch slot size and 2-inch diameter), 10 feet of stainless steel casing, and 37 feet of flush-joint, 2-inch diameter PVC casing. Partially filled annulus with pea gravel, then added 25 pounds of bentonite pellets. Pushed silty cuttings into annulus and then filled to near the surface with more pea gravel. Sealed at surface with bentonite powder. Set 4-inch-square well-protector over casing. Casing stickup = 1.4 feet.

APPENDIX C. WATER-LEVEL MEASURMENTS

ID #	*Measuring point*	*Depth to water (ft)*	*Potentiometric elevation*
1	-	-	-
2	-	-	-
3	-	-	-
5	-	-	-
6	-	-	-
7	541.18	51.03	490.2
10	-	-	-
11	490.74	8.31	482.4
12	-	-	-
13	490.86	36.93	453.9
14	519.30	46.73	472.6
15	496.75	43.43	453.3
16	-	-	-
17	487.82	33.63	454.2
18	-	-	-
21	-	-	-
22	481.87	10.37	471.5
23	463.65	10.21	453.4
24	459.89	3.78	456.1
26	533.02	53.02	480.0
27	-	-	-
*28	540	22.71	517.3
29	660.58	164.41	496.2
30	495	12.26	482.7
31	-	-	-
32	494.59	35.27	459.3
33	780.56	279.79	500.8
*34	638	8.3	629.7
35	626.43	156.88	469.6
36	687.59	188.62	499.0
37	640.88	168.56	472.3
38	-	-	-
40	-	-	-
41	-	-	-
42	-	-	-
43	719.79	222.98	496.8
44	747.09	245.84	501.3
45	468.36	7.2	461.2
*46	-	-	-
47	-	-	-
*48	450.98	9.86	441.1
•50	449.71	12.93	436.8
51	456.17	19.17	437.0
52	440.43	4.23	436.2

APPENDIX C. CONCLUDED

ID #	*Measuring point*	*Depth to water (ft)*	*Potentiometric elevation*
53	442.68	7.43	435.3
54	435.79	0.24	435.6
55	436.73	2.64	434.1
56	457.78	14.87	442.9
57	490.30	47.20	443.1
58	464.50	20.68	443.8
59	474.30	31.97	442.3
60	-	-	-
61	508.17	54.46	453.7
62	460.31	17.74	442.6
70	720	208.53	511.5
71	-	-	-
72	778.74	262.99	515.8
73	795	294.59	500.4
74	-	-	-
75	-	-	-
76	719.9	219.66	500.2
77	703	189.53	513.5
78	-	-	-
79	-	-	-
80	-	-	-
83	540.06	92.31	447.8
84	666.02	218.51	4473
85	463.86	28.26	435.6
86	512.01	79.70	432.3

Note:
*Site not used in contouring water-levels and chemical data because of well construction.

[redacted]