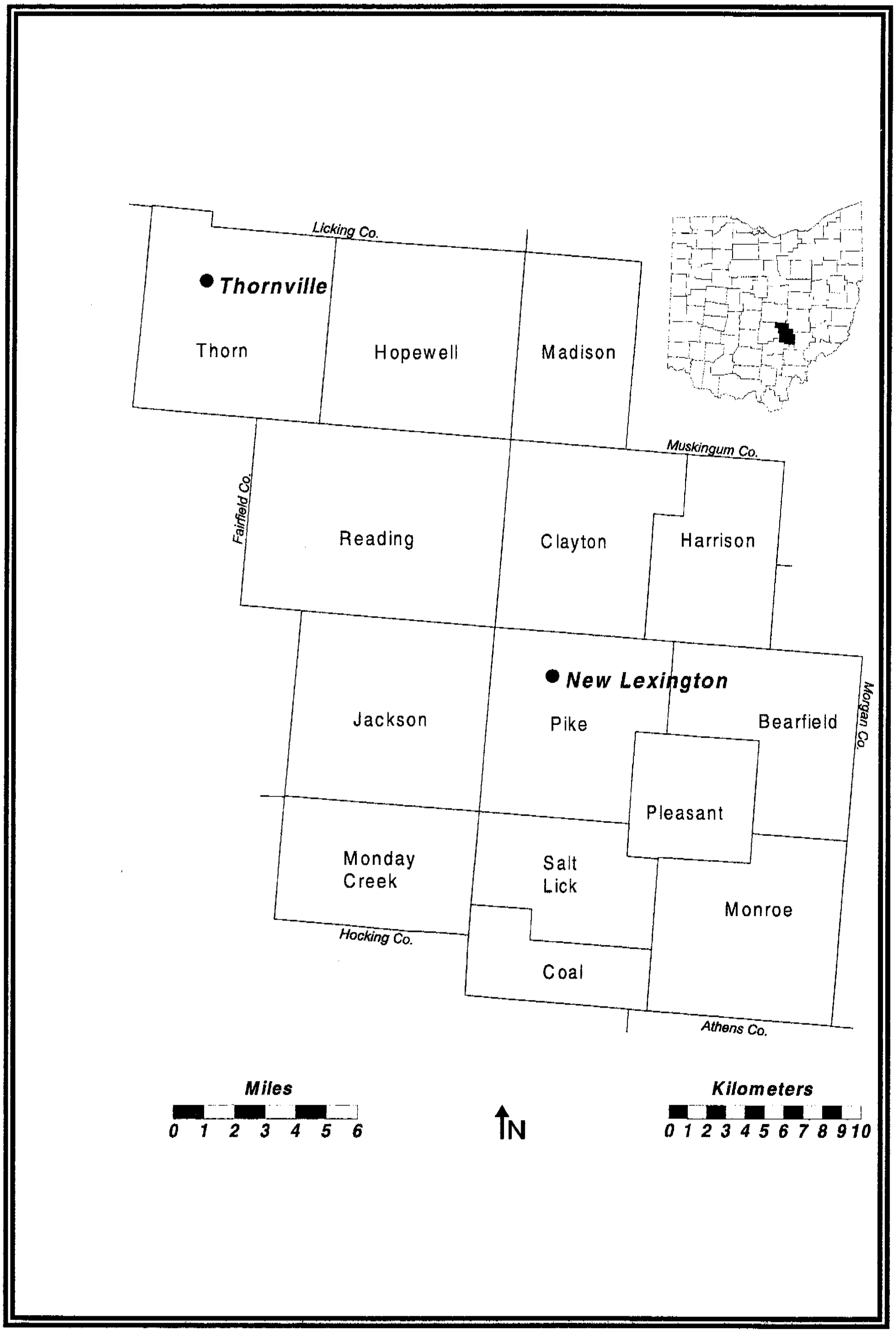
The Water Resources of Perry County Ohio



The Water Resources of Perry County, Ohio

by

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Acknowledgments

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Introduction

This report presents a portion of the results and findings of Project 94(h) EPA-15 "Assessment of Ground Water Quantity, Quality and Vulnerability to Nonpoint Source Contamination in Perry County, Ohio". Information gathered during this project can be used to support the use, protection, and restoration of the ground water resources of Perry County, Ohio. In addition, the data can serve as a basis for identifying priority ground water protection needs.

The objectives of the project were to: (1) field locate water wells, (2) update the computerized well log system at the ODNR, Division of Water, (3) evaluate the ground water resources of Perry County, (4) assess the vulnerability of ground water within the county to nonpoint source contamination, (5) digitize delineations of soil types, (6) map the bedrock geology, (7) estimate regional ground water flow directions, (8) sample and evaluate ground water quality, and (9) submit a final report documenting the results of the project. All data collected during this project can be obtained at ODNR. Brief descriptions of the work products for this investigation and their availability are listed in Table 1.

Purpose and Scope

The purpose of this report is to describe the hydrogeology and quality of the water resources of Perry County, Ohio. This purpose is achieved by detailed discussions of the geographic and geologic framework of the county and by examining hydrogeologic data pertaining to water availability and quality. The scope of this report is limited to existing data from water-well log and drilling reports and analyses of water samples taken in Perry County.

Study Area

Perry County occupies approximately 410 square miles in southeast-central Ohio. The county is divided into 14 townships. Perry County is bounded to the north by Licking and Muskingum Counties, to the northeast by Muskingum County, to the east by Morgan County, to the south by Athens County, to the southwest by Hocking County, and to the west by Fairfield County (Figure 1). The county seat is New Lexington.

Previous Studies

Stout et al. (1943) examined the water resources of Ohio. Flint (1951) mentions the availability of ground water in Perry County. Norris and Mayer (1982) studied the water resources of the Black Hand Sandstone in southeastern Ohio. Razem and Sedam (1985) examined the water quality of the Allegheny and Monongahela formations in southeastern Ohio. Vogel (1985) examined surface mining and water quality in Rush Creek Basin. The United States Geological Survey (1991)

Objective	Work Products
1	Approximately 2000 well log and drilling reports were field located throughout the county. Locations of the well logs were then mapped. Copies of the well logs and location maps are available at the ODNR, Division of Water.
2	A computerized well log system for Ohio is currently being created at the ODNR Division of Water. All well logs within Perry County have been entered into the computerized well log system and are on file at ODNR, Division of Water.
3	A map titled "Ground Water Resources of Perry County Ohio" (Spahr, 1996) provides a generalized evaluation of the ground water resources of the county. This color-coded map shows the expected yield, in gallons per minute (GPM), from the aquifers of the county. The map is available at the ODNR, Division of Water.
4	The assessment of vulnerability of ground water to nonpoint source contamination can be found in the "Ground Water Pollution Potential of Perry County, Ohio" (Spahr, 1997). The map and accompanying report are based on the report "DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings" (Aller et. al., 1987). The report and accompanying map are available at the ODNR, Division of Water.
5	Data from the "Soil Survey of Perry County, Ohio (Rubel and Jenny, 1988), were recompiled and the soil types were digitized. Digitized delineations of soil types as well as land use/cover maps are available at the ODNR, Division of Real Estate and Land Management, Resource Analysis Section.
6	Bedrock geology, bedrock topography, and structure contours of selected bedrock units of Perry County were mapped during this project (Brockman 1995a-I, Brockman and Pavey 1995, Brockman and Vorbau 1995a-e, Shrake 1995a-mm). Digital data files and open file maps of the bedrock geology, bedrock topography, and structure contours of selected bedrock units can be obtained from the ODNR, Division of Geological Survey.
7	Regional ground water flow directions of the major aquifer systems are estimated in this report.
8	Ground water quality is evaluated in this report.
9	This report documents the results of the project which describe the ground water resources of Perry County.

Table 1. List of work products and their availability for project 94(h) EPA-15.

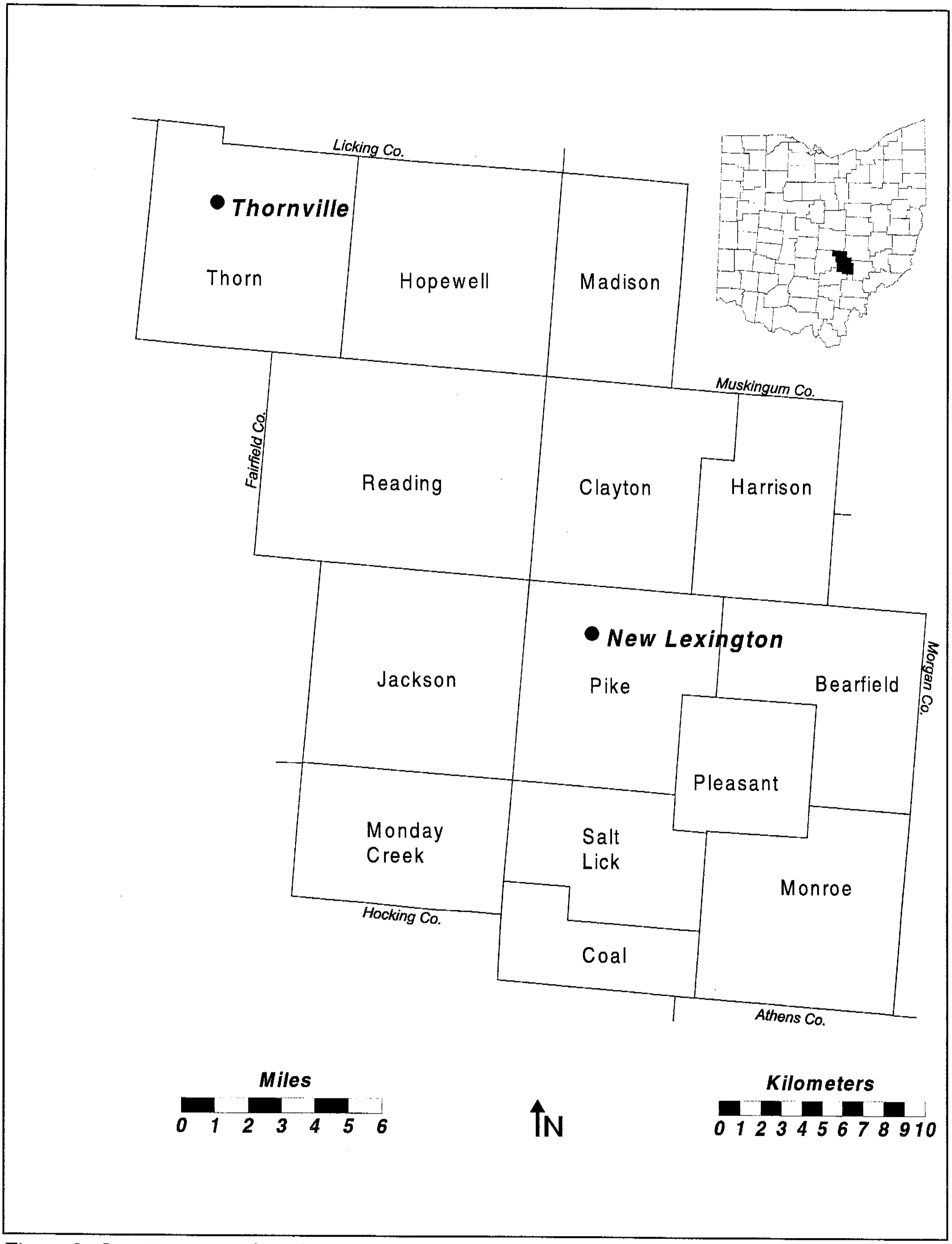

Figure 1. Location map of study area.

examined the geologic setting and water quality of selected basins in coal mining areas of Ohio that included portions of Perry County.

Geographic Setting

The population of Perry County was estimated to be 33,834 in 1996 (Ohio Department of Development, 1997). Population growth is primarily in the northern third of the county.

Land cover in Perry County is predominately forest and agriculture. LANDSAT data from 1994 indicate that approximately 57.85 percent of the county is classified as forest. Approximately 38.43 percent of the county is classified as agricultural. The remaining land is a mixture of residential, urban, industrial, active strip mines, quarries, and other miscellaneous uses. (Personal Communication, Gary Schaal, ODNR, Division of Real Estate and Land Management, 1997).

Although active strip mining, quarrying, and gravel pits account for a small percentage of land use, abandoned and reclaimed coal strip mines and underground mines are more widespread. Much of the 1994 LANDSAT data classified as forest include land that was once mined for coal. Soil maps indicate that soils whose parent material originates from strip mining account for 10.2 percent of the county soils. In addition, underground mines underlie approximately 9.1 percent of the county. (Personal Communication, Terry Wells, ODNR, Division of Real Estate and Land Management, 1997).

Perry County has a moderate climate. The average annual temperature from 1931-1980 was approximately 52 degrees Fahrenheit (Harstine, 1991). Precipitation for this same period averaged from 38 to 40 inches per year (Figure 2).

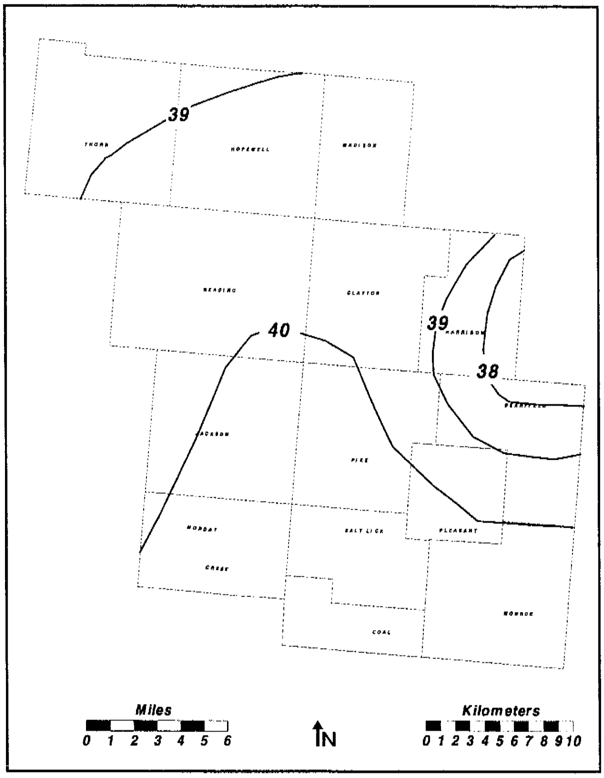

Figure 2. Average annual precipitation (in inches per year) for Perry County (modified from Harstine, 1991)

Perry County lies within the Glaciated Allegheny Plateau and Allegheny Plateau Sections of the Appalachian Plateau Physiographic Province (Brockman, 1997). The Glaciated Allegheny Plateau is divided into the Killbuck Plateau and the Illinoian Glaciated Allegheny Plateau (Figure 3).

The Killbuck Plateau, located in northwestern Perry County, covers most of Thorn Township. The Killbuck Plateau is characterized by glaciated ridges and flat uplands that are dissected by valleys. The valleys are interconnected by rock gorges and are partially filled with glacial deposits. Topographic relief is moderate and averages approximately 200 feet. The geology is characterized by thin to thick deposits of Wisconsinin-age till overlying Mississippian age sedimentary rocks.

The Illinoian Glaciated Allegheny Plateau is characterized by moderate relief (200 feet) consisting of dissected rugged hills that are capped by loess and weathered Illinoian till. This region is bounded by the Wisconsinan glacial margin of the Killbuck Plateau to the northwest and by the Allegheny Plateau to the southeast.

The Allegheny Plateau section of the Allegheny Plateau Province is characterized by dissected, moderately high relief (300 feet). This section occupies the approximate southeastern half of Perry County.

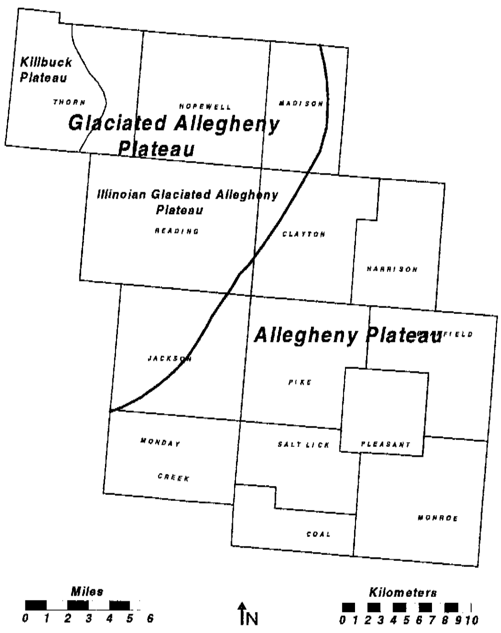

Figure 3. Physiographic regions of Perry County (modified from Brockman, 1997)

All streams of Perry County are part of the Ohio River watershed. The county is divided into the Muskingum, Hocking, and Scioto River Basins (Ohio Department of Natural Resources, 1985). These basins are further subdivided into the Licking River, Walnut Creek, Jonathan Creek, Rush Creek, Moxahala Creek, Sunday Creek, and Monday Creek sub-basins (Figure 4).

The highest point in the county is a ridge between Somerset and Junction City with an approximate elevation of 1200 feet above mean sea level (M.S.L.). The lowest elevation is approximately 700 feet M.S.L. along Sunday Creek, south of Corning. Areas of significant local relief are primarily found in the southern and eastern portions of the county.

Glacial Geology

During the Pleistocene Epoch, 2 million to 10,000 years before present, several episodes of glaciation occurred in central Ohio. The surficial deposits of Perry County consist of Early to Middle Pleistocene (Pre-Illinoian) water-deposited units, Illinoian ice- and water-deposited units, and Late Wisconsinan ice- and water-deposited units (Figure 5). Specific names for glacial deposits have not been adopted for Perry County. Therefore, the generalized glacial stratigraphy nomenclature for Licking County (Forsyth 1966; Szabo et al., 1993; and Angle, 1995) is used in this study (Table 2).

Glaciation had the net effect of leveling or smoothing the bedrock ridges of northwestern Perry County and filling valleys with thick sequences of glacial till, lacustrine, and outwash deposits.

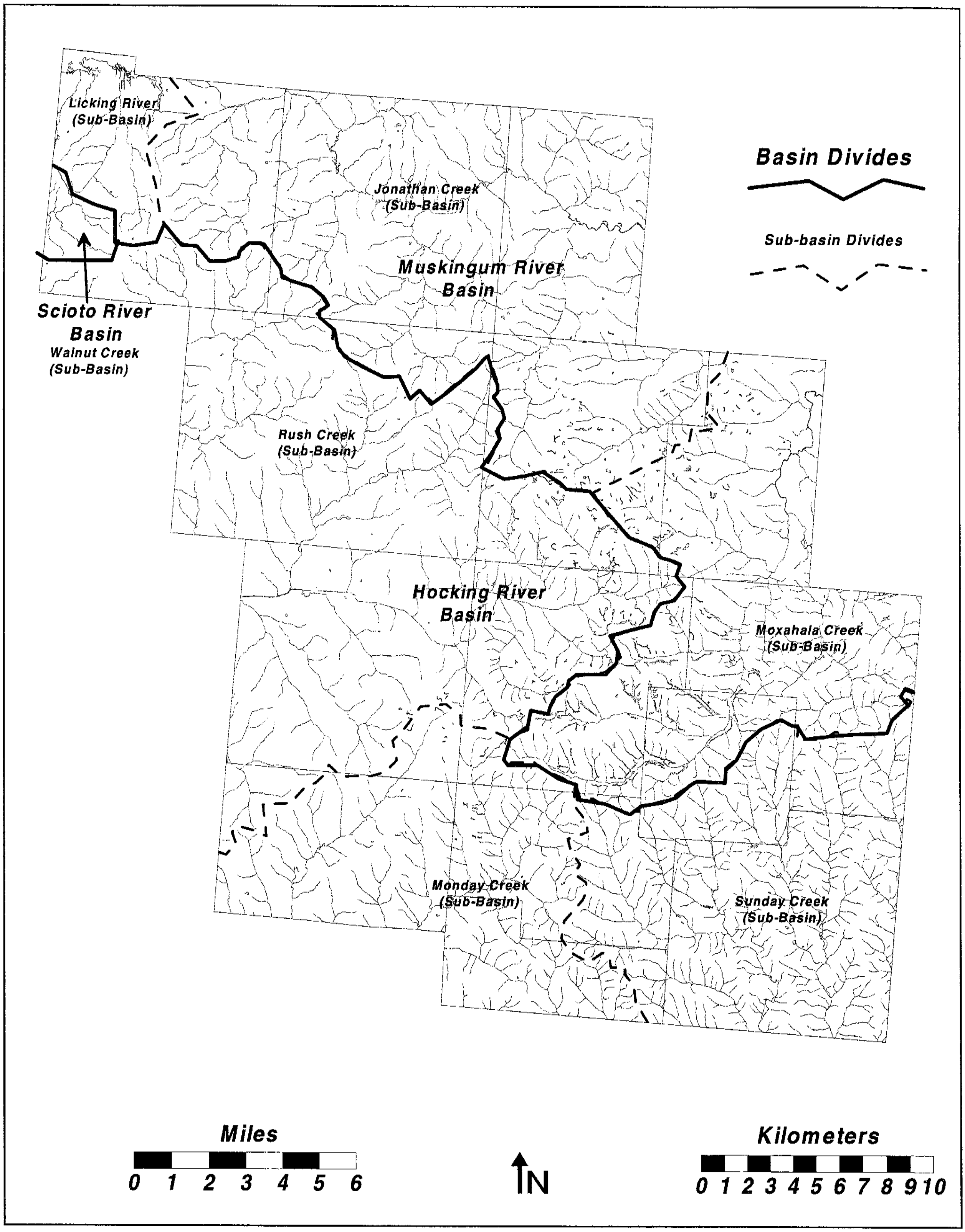

Figure 4. Major drainage basins of Perry County (modified from Ohio Department of Natural Resources, 1985)

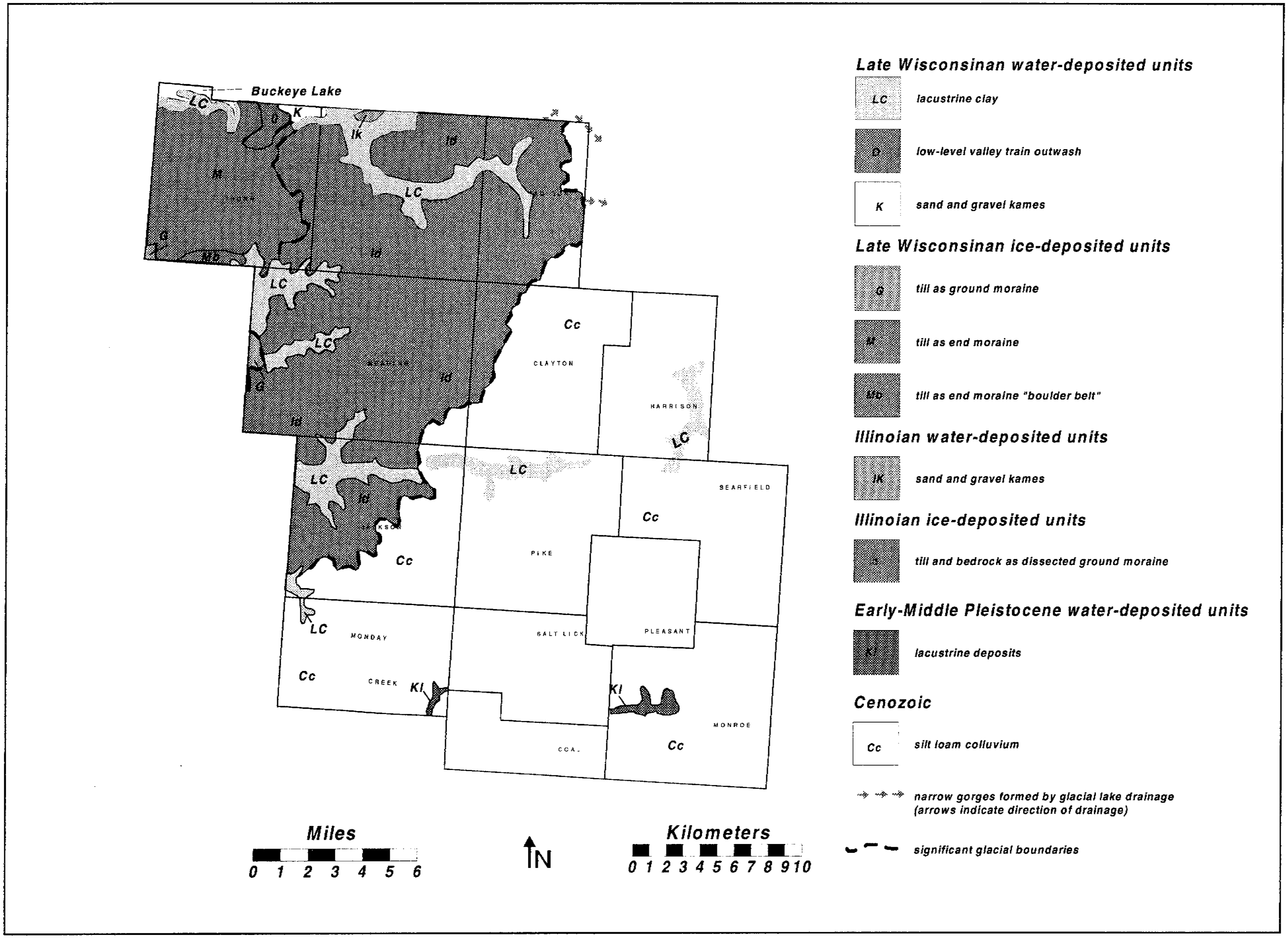

Figure 5. Glacial Geology of Perry County (modified from Goldthwait and Van Horn, 1993)

AGE (years ago)	EPOCH	STAGE		SUBSTAGE	UNIT OR INTERVAL
25, 000	PLEISTOCENE	WISCONSINAN	LATE	Wood-fordian	Centerberg Till (2) Mt. Liberty Till (2) Navarre Till (3)
40,000			MIDDLE	Farmdalian (1)	Paleosol, Loess ?
70,000			EARLY	Altonian (1)	Knox Lake Till (2) Millbrook Till (3,4)
120,000		SANGAMONIAN			Paleosol, Loess ?, Unknown
730,000		ILLINOIAN			Millbrook Till (3,4) Gahanna Till (3)
2,000,000		PRE-ILLINOIAN			

(1) Usage of these terms is being reveiwed.
(2) After Forsyth, 1966.
(3) After Szabo et. al., 1993.
(4) Age duration of the Millbrook Till is currently unknown.

Table 2. Generalized glacial stratigraphy of Perry County (after Forsyth, 1996; Szabo et al,. 1993; and Angle, 1995)

The thickest glacial deposits are found in a buried valley underlying Buckeye Lake in Thorn Township. These deposits are greater than 400 feet thick.

The advancing ice sheets and the infilling of previously existing valleys with glacial sediments blocked some stream drainage. A detailed study of drainage changes due to the glaciation is lacking for the county; however, two notable drainage changes or reversals have been observed.

The Jonathan Creek region provides a textbook example of drainage reversal. Prior to glaciation, Jonathan Creek flowed westward. Advancing ice and Wisconsinan kames likely blocked the ancestral stream causing the river to pond and flood the valley. This created a large lake that extended east of its present location of Glenford. This lake eventually overflowed through a new outlet. The new drainage cut down rapidly and created a new easterly-flowing drainage system (Flint, 1951).

Rush Creek and Little Rush Creek also experienced major drainage reversals. Little Rush Creek flowed west into Fairfield County until advancing ice blocked and ponded the stream. The waters rose and eventually breached the highlands to the south. The new drainage cut the steep, narrow gorge near Rushville. The new tributary merged with Rush Creek near Bremen (Flint, 1951).

Ancestral Rush Creek, referred to as Bremen Creek by Stout et al. (1943), also flowed westward. The advancing ice blocked and ponded the stream creating a sizeable lake. Eventually, a new outlet to the south was created. This new channel deepened and widened considerably over time (Flint, 1951). The sequence of events between the blockage and establishment of new outlets for Little Rush Creek and Rush Creek has not been determined.

Goldthwait and Van Horn (1993) show small areas of surficial lacustrine deposits in southern Perry County that they believed to be Early to Middle Pleistocene in age, marking the initial stream blockage at the onset of glaciation. More research is necessary to verify the age of these weathered lacustrine deposits. These units consist of remnant laminated lacustrine clay and silts that formed in ice dammed lakes and are often covered by recent alluvium. These deposits are located in Monday Creek and Monroe Townships in the southern portion of the county.

The Illinoian ice- and water-deposited units are located between the non-glaciated and Wisconsinan boundaries. The Illinoian ice-deposited units consist of dissected ground moraine composed of till mixed with loess and weathered bedrock. The landform in this area is referred to as dissected ground moraine due to the high amount of erosion (i.e. stream dissection) and to the overall thin veneer of till covering the bedrock surface. The Illinoian till is typically less than 10 feet thick and is generally highly weathered. Thicker deposits of Illinoian till presumably exist in the subsurface of some of the deeper buried valleys. Topography in these areas of the county reflect the underlying bedrock.

The Illinoian water-deposited units are limited to an isolated kame in northern Hopewell Township. The kame is composed of poorly-sorted sand and gravel with minor till. Kames are deposited in depressions, holes, crevasses, or tunnels in the melting ice sheet. As the surrounding ice melts, a mound of sediment remains behind.

The youngest surficial glacial deposits of Perry County are Late Wisconsinan ice- and water-deposited units. The Wisconsinan-glaciated portion of Perry County is dominated by ice-deposited end moraine. The Thornville Moraine (Flint, 1951) covers almost all of Thorn Township. There are only small patches of Wisconsinan ground moraine present in the county (Flint, 1951; Goldthwait, et al., 1961; and Goldthwait and Van Horn, 1993). In southern Thorn Township, a small portion of the end moraine is identified as a "boulder belt" because of the concentration of boulders found at the surface.

The surficial Late Wisconsinan water-deposited units consist of lacustrine clay, low-level valley train outwash, and kames. Lacustrine deposits tend to be composed of fairly uniform, dense silt and clay with minor fine sand. These deposits may display very thin bedding referred to as laminations. These sediments infer deposition in low-energy environments with little or no current or water flow. Surficial Wisconsinan lacustrine deposits are found in low areas along the margins of Little Rush Creek, Rush Creek, Buckeye Lake, Moxahala Creek, and Jonathan Creek.

Outwash deposits are created by active deposition of sediments by meltwater streams. These deposits are generally bedded (stratified) and sorted. Outwash deposits in Perry County are predominantly limited to stream valleys associated with meltwater from the melting ice sheets. Outwash deposits limited to stream valleys are commonly referred to as valley trains. Many of these valleys are now occupied by modern streams. Sorting (size distribution of grains) and coarseness of the deposits depend upon the nature and proximity of the melting ice sheet. Water-deposited sand and gravel kames and low-level valley train outwash are located adjacent to the Licking and Perry County boundary. The kames in northern Thorn Township are believed to be Wisconsinan, and the kame in northern Hopewell Township is believed to be Illinoian (Goldthwait and Van Horn, 1993). The Wisconsinan kames may have helped to block the former western drainage of Jonathan Creek.

Colluvium is present in much of the unglaciated upland areas of Perry County. Colluvium consists of material that has slumped and is commonly found at the toe or flanks of slopes. Colluvium deposits are composed of residuum, weathered material, and deposits from landslides.

Post-glacial deposits of alluvium and alluvial terraces were deposited within the past 10,000 years by water in present and former floodplains. These deposits are highly variable and heterogeneous, ranging in composition from silty clay to gravel.

Bedrock Geology

The bedrock of Perry County that crops out at the surface consists of sedimentary rocks from the Mississippian and Pennsylvanian System (Table 3). They are separated by an unconformity and erosional surface. The bedrock units vary in thickness and dip to the southeast at approximately 25 to 30 feet per mile (Flint, 1951). Figure 6 depicts the generalized bedrock geology of Perry County.

AGE	SYSTEM	GROUP	SIGNIFICANT FORMATIONS	DESCRIPTIONS
325 to 280 Millon Years Ago	Pennsylvanian	Conemaugh	Ames Limestone Brush Creek Limestone	Interbedded dirty sandstones, shales, mudstones, coals, and thin limestones. Very poor aquifer
		Allegheny	Upper Freeport Coal Middle Kittaning Coal Lower Kittaning Coal	Interbedded sandstones, shales, coals, and thin limestones. Moderate to poor aquifer.
		Pottsville	Lower Mercer Limestone Massillon Sandstone	Interbedded sandstones, shales, coals, and thin limestones. Moderate to poor aquifer.
355 to 325 Million Years Ago	Mississippian		Maxville Limestone	Thin to relatively massive limestone. Discontinuous due to erosion. Moderate to poor aquifer.
			Rushville Shale	Thin, soft, clayey organic shale. Poor aquifer.
			Logan Formation Cuyahoga Formation	Thin to massive interbedded sandstones, shales, and siltstones. Moderate to good aquifer.

Table 3. Generalized bedrock stratigraphy of Perry County (Shrake, written communication, 1996).

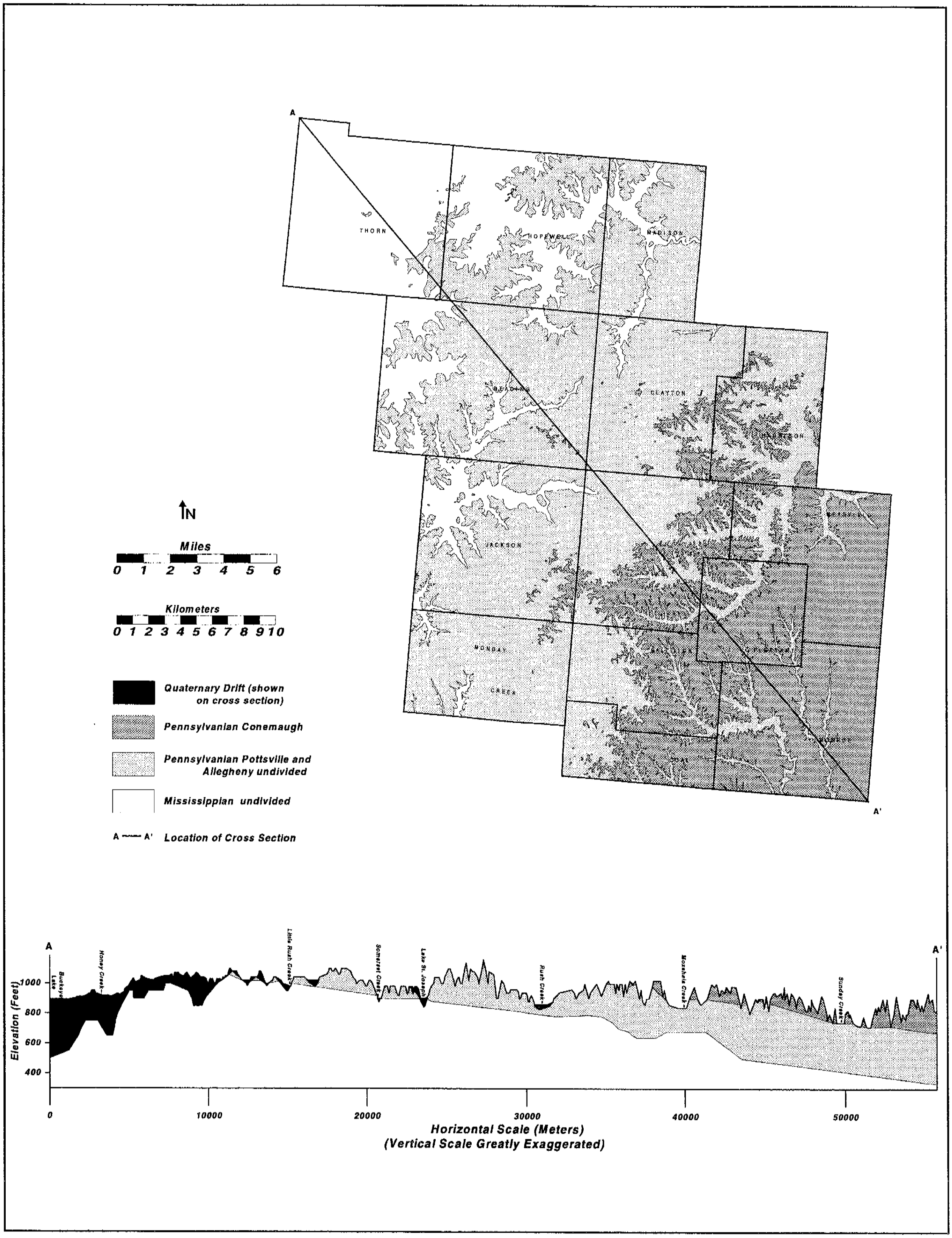

Figure 6. Bedrock geology of Perry County (modified from Shrake, 1995a-o).

Mississippian-age rocks are exposed primarily in valley walls in western and northern Perry County. The top of the Mississippian is a remnant erosional surface an ranges in elevation from 1140 feet in the northwest portion of the county to 340 feet in the southeastern corner of the county (Figure 7).

The oldest exposed units are the interbedded shales, siltstones, and fine-grained sandstones of the Vinton Member, the uppermost unit of the Logan Formation. Underlying these rocks are various other units of the Logan Formation and Cuyahoga Formation. These units are mapped from water well log and oil and gas well log records. Some reports refer to coarser, sandstone facies within the Cuyahoga Formation as the Black Hand Sandstone or Toboso Province (Hyde, 1915; Dove, 1960; and Wolfe et. al., 1962). Drillers informally refer to this unit as the "Big Injun" or "Engine Sand."

Overlying the Vinton Member in limited areas of Reading Township is the Rushville Shale (Flint, 1951). This unit, where exposed, consists of thin, interbedded clayey shales and soft limestones. The uppermost exposed Mississippian unit is the Maxville Limestone (Flint, 1951 and Lamborn, 1951). This unit is laterally discontinuous because of the erosional surface (unconformity) between the Mississippian and Pennsylvanian System of rocks. The Maxville is described as ranging from a sandy, fossiliferous limestone to a dense, fine-grained limestone. Exposures of this unit are found in quarries in Monday Creek Township near the town of Maxville, which is the type section locality for this formation.

The geology of the Pennsylvanian is highly complex and variable. The Pennsylvanian System in Perry County is divided into the Pottsville, Allegheny, and Conemaugh Groups. The Pottsville and Allegheny have been mapped together as a single unit (Shrake, 1995a-o). Widespread strip mining and underground mining of coal occurs within the Pottsville-Allegheny Group of rocks.

Units of the Pottsville Group comprise the lower-most rocks of the Pennsylvanian System. These rocks consist of interbedded sandstones, shales, siltstones, underclays, coals, and thin limestones. The Massillon Sandstone and the Lower Mercer Limestone are two units which have some utility as marker beds.

Overlying the Pottsville Group are rocks of the Allegheny Group. These units consist of interbedded shales, sandstones, coals, underclays, and limestones. Some of the more important marker beds in the Allegheny Group include the Lower Kittaning Coal, Middle Kittaning Coal, and the Upper Freeport Coal. Elevations for the top of the Allegheny range from 1180 feet in the west to 680 feet in the southeast (Figure 8).

Overlying the Allegheny Group are rocks of the Conemaugh Group. These rocks consist of interbedded shales, mudstones, dirty sandstones, thin coals, and thin limestones. Important marker beds in the Conemaugh include the Brush Creek Limestone and the Ames Limestone. Although these thin limestones are useful markers, they are too thin to be of economic importance.

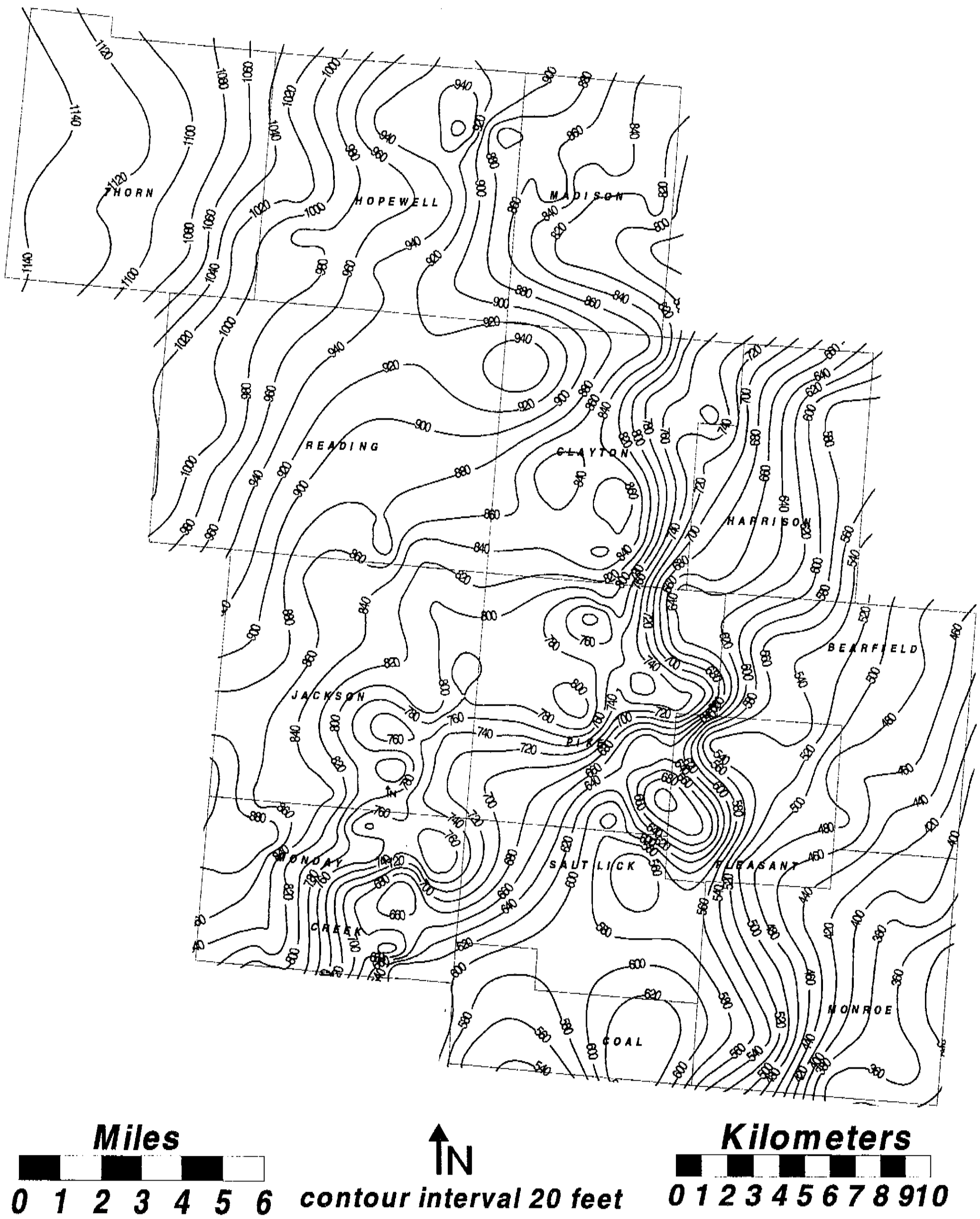

Figure 7. Structure contour map of the top of the Mississippian System in Perry County(modified from Shrake, 1995p-dd).

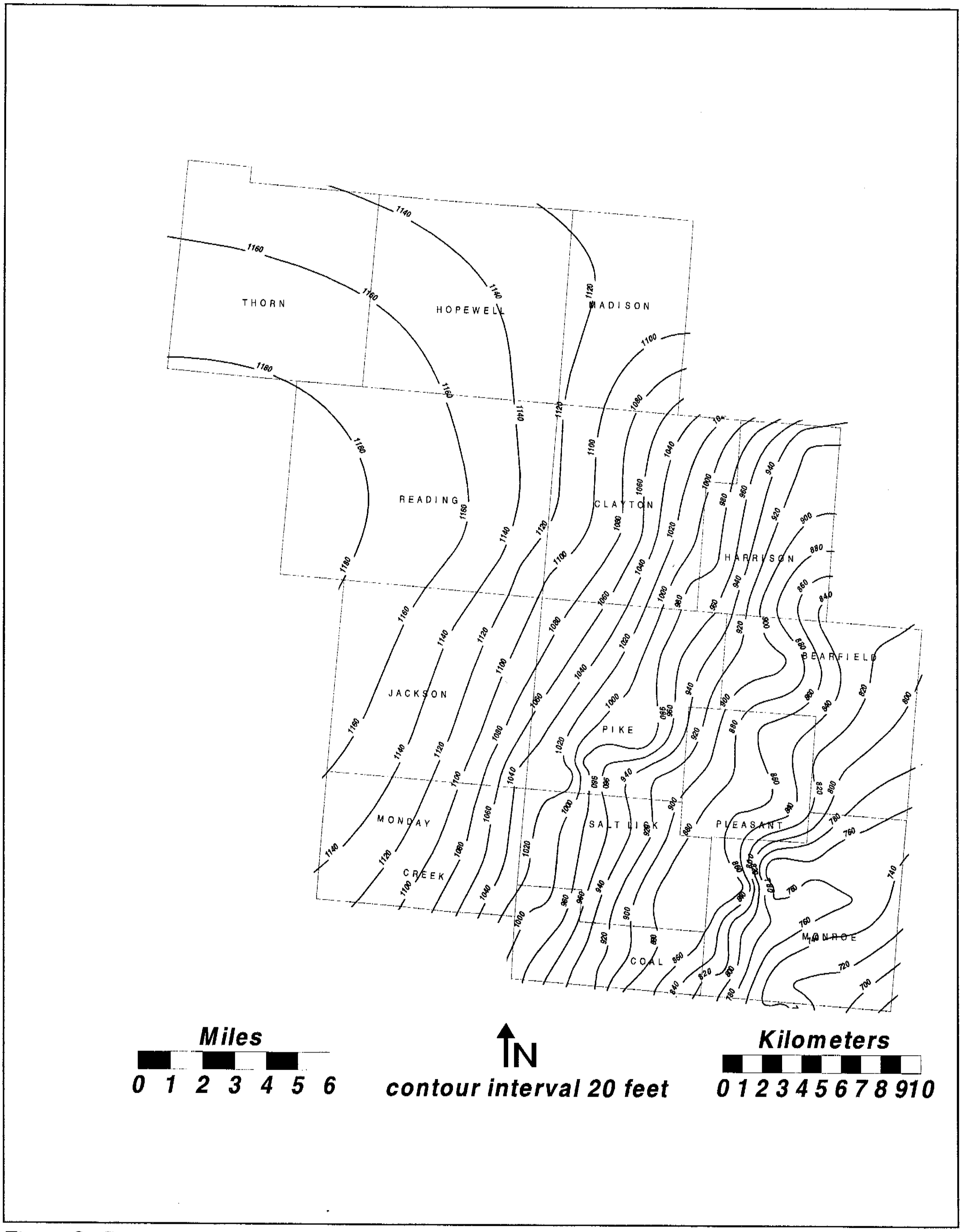

Figure 8. Structure contour map of the top of the Pottsville-Allegheny Groups of Perry County (modified from Shrake, 1995ee-mm).

Hydrogeology

Ground water in Perry County is obtained from both bedrock and glacial deposits. Wells developed in the bedrock obtain ground water from fractures and bedding planes in the upper, weathered sections and from the primary porosity of the rock. Wells developed in the glacial deposits obtain ground water from the interconnected pore spaces between grains of sand and gravel.

For the purposes of this investigation, aquifers were grouped into hydrostratigraphic units. A hydrostratigraphic unit is a formation, part of a formation, or a group of formations in which there are similar hydrogeologic characteristics allowing for grouping into aquifers or confining layers (Fetter, 1980).

Three primary bedrock hydrostratigraphic units are the main focus of this investigation (Figure 9). These units are the Mississippian undivided, Pennsylvanian Pottsville-Allegheny undivided, and Pennsylvanian Conemaugh. The Mississippian undivided hydrostratigraphic unit

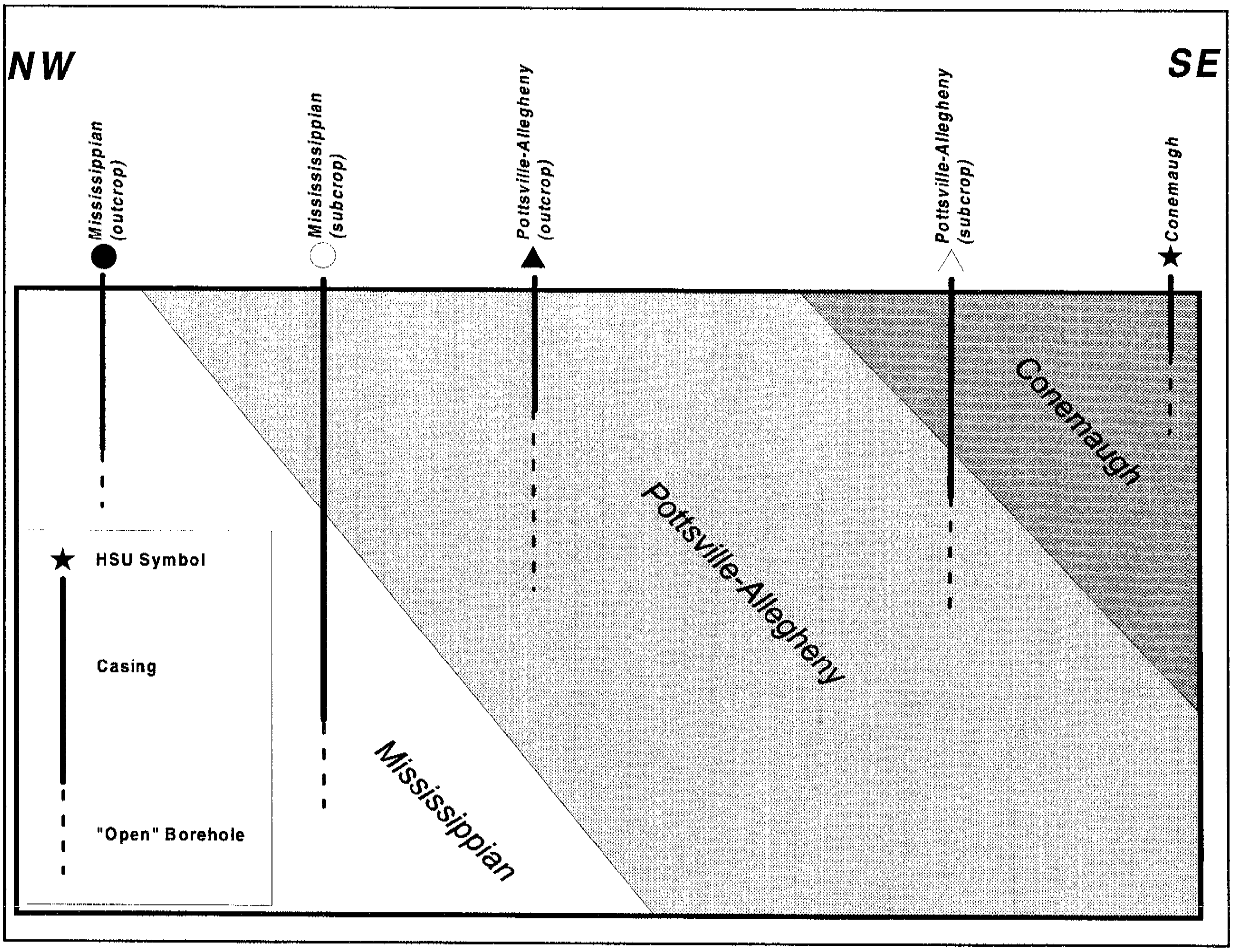

Figure 9. Conceptual cross section of the bedrock hydrostratigraphic units of Perry County and the configuration of the "open" portion of the borehole with respect to the units.

consists of interbedded sandstones and shales of the Logan and Cuyahoga Formations and the Maxville Limestone (where present). The Pottsville-Allegheny undivided hydrostratigraphic unit consists of the entire sequence of interbedded limestones, shales, sandstones, coals, and underclays found within these systems of rocks. This includes the Massillon Sandstone, the Lower Mercer Limestone, the Lower and Middle Kittaning Coals, and the Upper Freeport Coal. The Conemaugh hydrostratigraphic unit consists of the entire sequence of interbedded shales, mudstones, dirty sandstones, thin coals, and thin limestones of the Conemaugh Group in Perry County. Delineations of the bedrock hydrostratigraphic units follow the bedrock geology (Figure 6) and structure contour maps (Figures 7 and 8) of Shrake (1995 a-mm).

The glacial aquifers of Perry County are within the buried valleys. The drift in the glaciated uplands is too thin and lacks sand and gravel lenses and therefore was not considered an aquifer in this study. For this report, the buried valley aquifers have been named the Jonathan Creek-Buckeye Lake Buried Valley Aquifer, Moxahala Creek Buried Valley Aquifer, Little Rush Creek Buried Valley Aquifer, and the Rush Creek Buried Valley Aquifer (Figure 10). Delineations of the sand and gravel aquifers follow those mapped by Spahr (1996).

The Jonathan Creek-Buckeye Lake Buried Valley Aquifer is located in northern Perry County. This aquifer system consists of sand and gravel of varying thicknesses found at various depths. Sand and gravel units within the Jonathan Creek-Buckeye Lake Buried Valley Aquifer are often separated by till and lacustrine deposits. The lateral and vertical extent of this aquifer system is limited by bedrock walls which bound the buried valley. Drift, consisting of sand and gravel separated by till and lacustrine deposits, has a maximum thickness of 400 feet under the Buckeye Lake area.

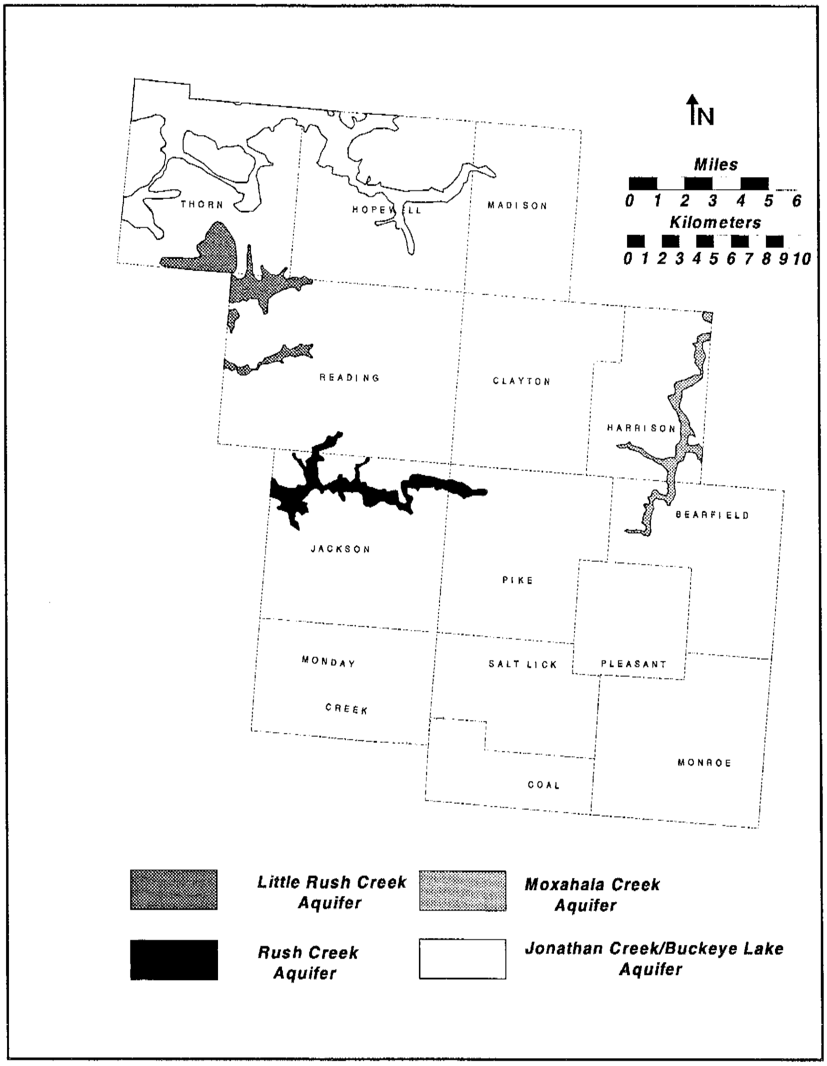

Figure 10. Delineations of the buried valley (sand and gravel) aquifers of Perry County (modified from Spahr, 1996).

The Jonathan Creek-Buckeye Lake Buried Valley Aquifer thins and narrows to the west.

The Moxahala Creek Buried Valley Aquifer is located in eastern Perry County beneath the northern reaches of Moxahala Creek. The highest yielding portion of this aquifer system is near Roseville where the drift is approximately 70 feet thick. The drift is composed of silt and clay with a small amount of sand and gravel in the deepest portions of the buried valley. The drift becomes finer and thinner to the south.

The Rush Creek Buried Valley Aquifer bisects the northern third of Jackson Township in an east-west orientation. The thickest portion of this aquifer system is near the western county line where the drift is approximately 60 feet. Water well logs report that this aquifer system consists of variable thicknesses of sand, silt, and clay that are beneath an upper silt and clay layer of approximately 20 to 30 feet in thickness. The drift thins eastward towards New Lexington.

The Little Rush Creek Buried Valley Aquifer is located in southern Thorn Township and northeastern Reading Township. Much of the aquifer system underlies the present day Little Rush Creek. The aquifer consists of sand and gravel lenses that are separated by variable thickness of till. The drift reaches a maximum thickness of approximately 200 feet.

The availability of ground water resources was interpreted from water well log and drilling reports on file at the ODNR, Division of Water. Approximately 2000 well logs were field located and examined for data. Table 4 lists the minimum, maximum, and average values for depth, yield, and specific capacity.

The availability of ground water resources is often expressed by the transmissivity of the

Hydrostratigraphic Unit	Well Depth (feet)				Well Yield (GPM)				Specific Capacity (GPM/ft)			
	min	max	avg	n(1)	min	max	avg	n(1)	min	max	avg	n(1)
Mississippian (undivided)	27	525	151	629	0.2	285	16	479	.0019	37.33	1.31	415
Pottsville-Allegheny (undivided)	16	423	85	641	.05	60	9	411	.0006	15	.68	387
Conemaugh	30	152	78	71	3	30	5	43	.0033	3	.28	43
Jonathon Creek/ Buckeye Lake	22	243	87	106	2	193	18.5	80	.13	10	1.56	68
Moxahala Creek	15	62	35	5	2	152	53	3	.29	10.5	3.7	3
Little Rush Creek	40	185	93	17	5	50	20	14	0.24	4	1.38	11
Rush Creek	37	78	45	9	5	99	23.75	8	0.14	4.95	1.47	6

(1) n = number of well log records

Table 4. General well statistics for depth, yield, and specific capacity for the groundwater-producing units of Perry County.

aquifer. Transmissivity is a measure of the amount of water that can be transmitted horizontally by the full saturated thickness of the aquifer (Fetter, 1980). Transmissivity equals hydraulic conductivity multiplied by the saturated thickness of the unit. Hydraulic conductivity describes the rate at which water can move through a porous medium.

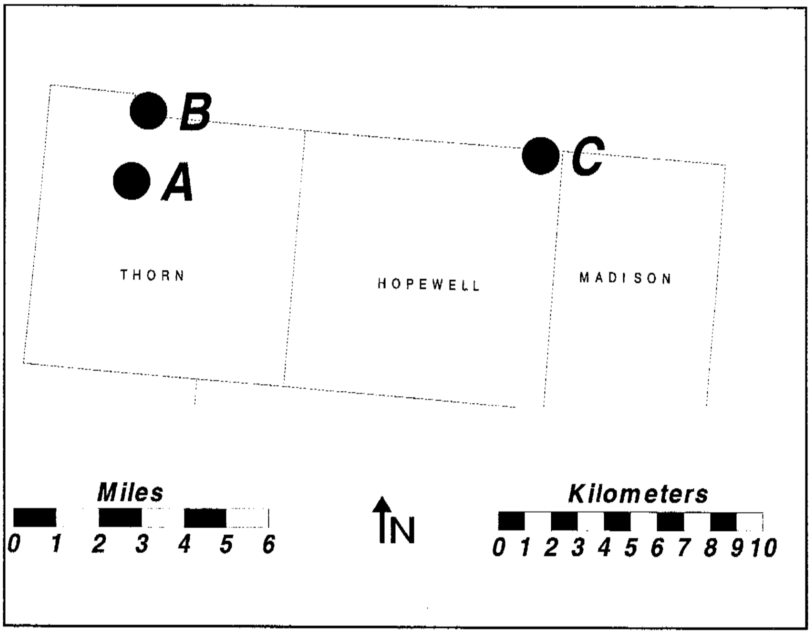

Figure 11. Locations of pumping tests conducted in Perry County.

Limited data on transmissivity and hydraulic conductivity exist for the aquifers of Perry County. Table 5 lists transmissivity and hydraulic conductivity values derived from pumping tests for some of the ground water-producing units of the county. The locations of the tests are shown on Figure 11.

Location	Unit (as defined in this study)	Transmissivity (gal./day/foot)	Hydraulic Conductivity (gal/day/foot^2)	Source of Data
A	Mississippian (undivided)	11,620	270	URS Consultants (1994)
B	Jonathon Creek-Buckeye Lake Buried Valley	4000	not available	BBC&M Engineering (1995)
C	Pottsville-Allegheny	not available	10.3	Eagon and Associates (1995)
C	Pottsville-Allegheny	not available	1864	Eagon and Associates (1995)
C	Mississippian (undivided)	not available	85.9	Eagon and Associates (1995)

Table 5. Transmissivity and hydraulic conductivity values derived from pumping tests conducted within Perry County.

Specific capacity was used to estimate aquifer properties because other data such as transmissivity and hydraulic conductivity were limited. Specific capacity is defined as an expression of the productivity of a well. It is obtained by dividing the pumping rate by the drawdown of the water level in the well (Fetter, 1980). Units for specific capacity are expressed in gallons per minute per foot of drawdown (GPM/ft). High specific capacity usually indicates high transmissivity and low specific capacity indicates low transmissivity (Walton, 1970). Specific capacity is theoretically related to transmissivity by the Theis et al. (1963) nonequilibrium equation:

$$\frac{Q}{s} = \frac{T}{264\log(Tt/1.87r_w^2S) - 65.5}$$

where,

$\frac{Q}{s}$ = specific capacity (GPM/ft)

T = transmissivity (GPM per foot of aquifer thickness)

t = duration of pumping (minutes)

S = storativity (dimensionless)

r_w = effective well radius (feet)

For this investigation, specific capacity data are not used to determine transmissivity. The Theis et al. (1963) equation assumes that the well fully penetrates a homogenous, isotropic, porous aquifer, well loss is negligible, and that the effective radius is equal to the radius of the pumped well. These assumptions are often violated or can not be fully determined from the available data. Also, estimations of transmissivity from specific capacity data using the Theis equation do not agree well with measured values of transmissivity from fractured rock aquifers (Huntley et al. 1992). However, in this study specific capacity values are used to compare the regional water transmitting properties of the hydrostratigraphic units. Comparisons were made regardless of well radius or duration of pumping.

Hydrostratigraphic Unit Comparisons

Box and whisker plots are used for statistical comparisons of specific capacity to well potential for each hydrostratigraphic unit. Polygons depicting the maximum, minimum, quartiles, median, and mean values of specific capacity are plotted in Figure 12. The first and third quartiles are represented as the ends of a rectangular box. The first quartile represents the value at which 25

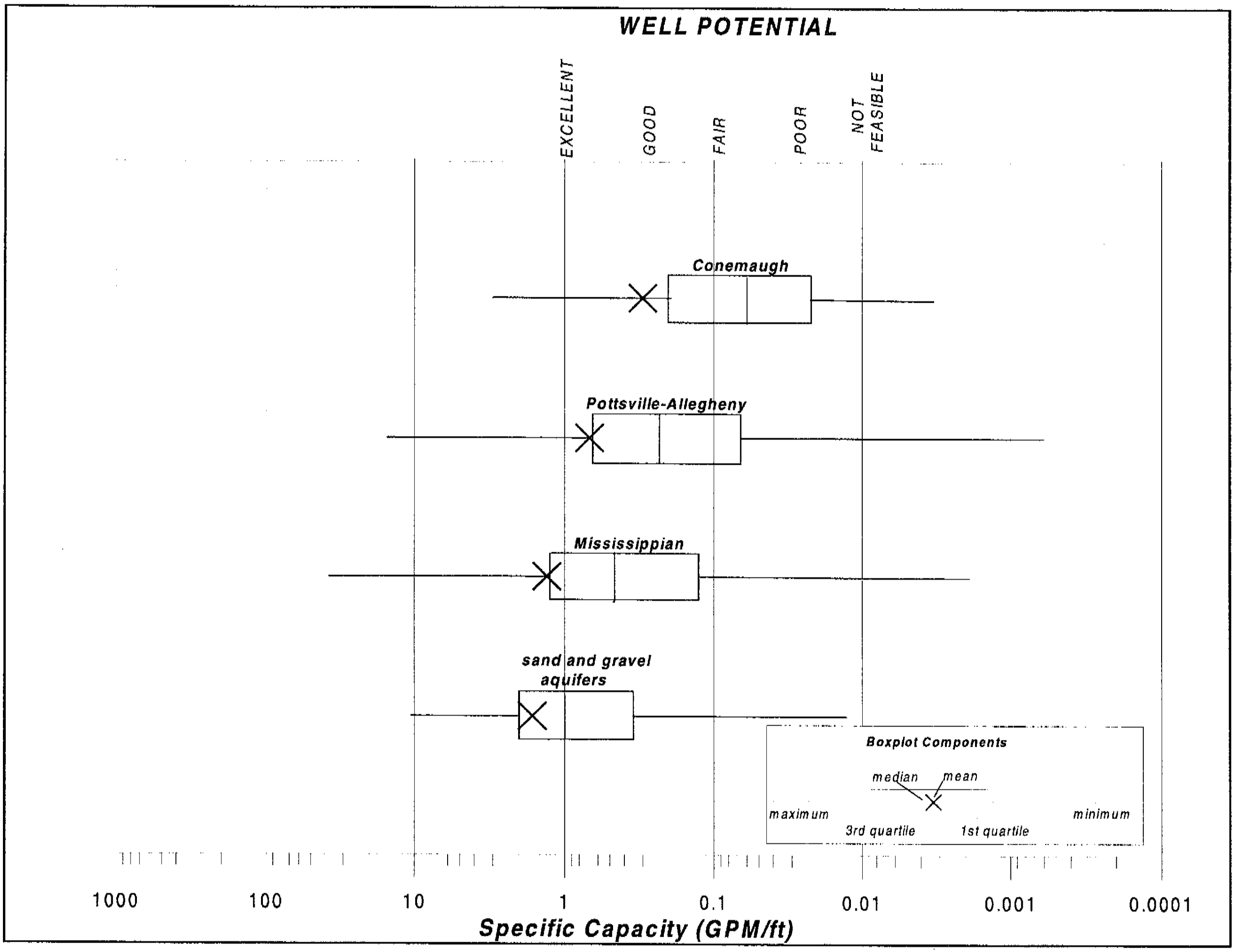

Figure 12. Comparison of domestic well potential and specific capacity for the hydrostratigraphic units of Perry County (well potential modified from U.S. Department of Interior, 1981).

percent of the values are less than the quartile value and 75 percent exceed the value. The third quartile represent the point at which 25 percent of the samples are greater than the quartile value and 75 percent are less than the value. The endpoints of lines extending from the rectangular box illustrate the maximum and minimum values. The median is displayed as a vertical line within the box and the mean is depicted as an "X". The upper scale represents well potential and the lower scale represents specific capacity.

Well potential is a relative classification scheme in which the practical use or relative productivity of a well is based on its specific capacity value. For this report, the values corresponding to well potential have been slightly modified from the U.S. Department of the Interior (1981) and customized for domestic well use for the county. Well potentials are classified as not feasible, poor, fair, good, and excellent. A specific capacity value of less than 0.01 GPM/ft is considered not feasible for a domestic well. These wells produce water primarily from borehole storage and are extremely slow to recover. An alternate water source, such as a spring, cistern, or public supply is usually recommended. A well with specific capacity between 0.01 to 0.1 GPM/ft is considered a poor to fair domestic well. These wells are also slow to recover and produce most of their water from borehole storage. These wells are slightly better than not feasible. A fair to excellent domestic well potential has a specific capacity value between 0.1 to 1 GPM/ft. These wells are usually sufficient to meet domestic needs. An excellent domestic well potential has a specific capacity value greater than 1 GPM/ft. These wells meet or exceed most domestic demands.

Probability plots are used to illustrate and compare the specific capacity values for the water-producing units of Perry County. Probability plots are graphs of ranked variable values plotted against their cumulative percentiles. Probability plots represent the percentage of wells which equal or exceed a particular value of specific capacity. This can be considered as the "likelihood" of obtaining a particular value based on the available data for the county. Probability plots were constructed by sorting data values into descending order. The order number was assigned to the value. Frequencies were then computed using the following equation:

$$F_s = \frac{m_0}{n_w + 1} 100$$

where,

F_s = percentage of wells whose values are equal to or greater than m_0

m_0 = order number of well record

n_w = total number of well records

Figure 13 shows a probability plot of specific capacity for each of the bedrock hydrostratigraphic units and for the sand and gravel aquifers. The following example describes how a probability plot can be used. To find the percentage of wells that equal or exceed a specific capacity of 1 GPM/ft ("excellent" well potential) for the Mississippian undivided hydrostratigraphic unit, first find the value of 1 GPM/ft on the vertical axis labeled "specific capacity." Follow the horizontal grid line representing 1 GPM/ft to the right until it intercepts the plot for the Mississippian undivided. Then, follow the vertical grid line until it reaches the bottom axis. The user should observe that 30 percent of the wells completed in the Mississippian undivided have a specific capacity equal to or greater than 1 GPM/ft. This implies that 70 percent of the wells have a specific capacity less than 1 GPM/ft.

As shown on Figure 13, a clear and distinct separation exist between the hydrostratigraphic units. A single-factor non-parametric analysis of variance (ANOVA) for unequal sample sizes was performed on the specific capacity data for the hydrostratigraphic units (Devore, 1995). This analysis indicated that the specific capacity populations of the Conemaugh, Pottsville-Allegheny, and

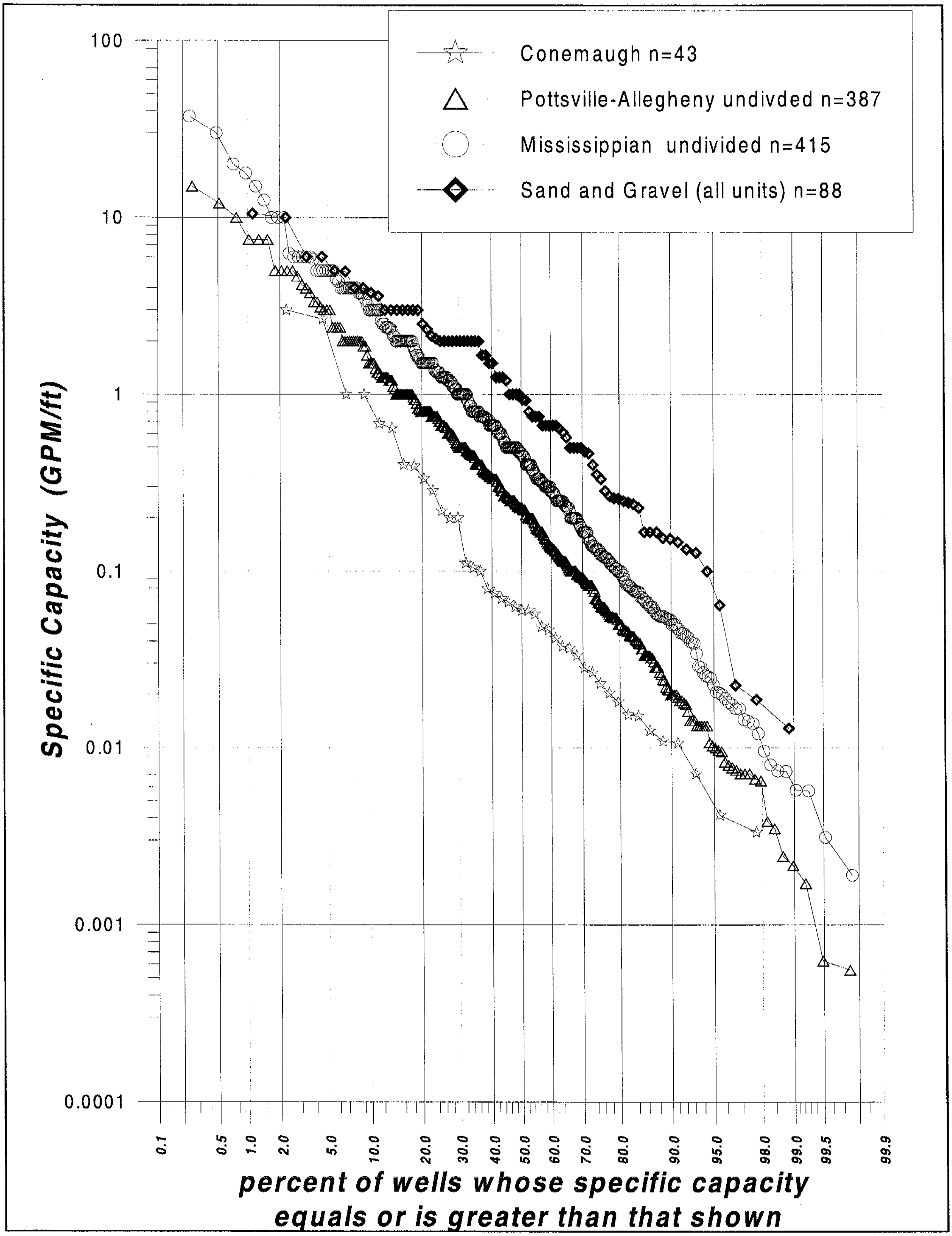

Figure 13. Probability plot of specific capacity for the hydrostratigraphic units of Perry County.

Mississippian are statistically different from one another. This distinction supports the separation of the ground water-producing bedrock formations into hydrostratigraphic units.

Bedrock Hydrostratigraphic Units

The specific capacity data for the bedrock hydrostratigraphic units were evaluated using probability plots and contour maps.. The contour maps were constructed from the database using GEO-EAS (Englund and Sparks, 1991) and SURFER (Golden Software, 1995) and illustrate the spatial variability of the data. The contours are based on the results of a variogram analysis and an interpolation using kriging. A detailed description of variogram modeling and kriging is beyond the scope of this paper. Isaaks and Srivastava (1989), Englund and Sparks (1991), and Deutsch and Journel (1992) describe these processes and techniques in greater detail.

Mississippian undivided

A probability plot of specific capacity was prepared for outcrop and subcrop well data for the Mississippian undivided (Figure 14a). Outcrop wells were considered to be wells in which the "open" portion of the borehole does not have an overlying hydrostratigraphic unit. Subcrop wells have a hydrostratigraphic unit overlying the borehole (Figure 9). Of the 415 wells that were evaluated, 235 are outcrop wells and 180 are subcrop wells. There is a distinct separation in the probability plots of specific capacity for outcrop and subcrop wells for the Mississippian undivided. A higher percentage of outcrop wells are more productive than the subcrop wells. This is probably due to a decrease in permeability with depth. The subcrop wells are drilled and cased to a deeper depth and therefore may not contain significant secondary porosity (i.e. fractures) which are present at the top of the rock surface.

A map depicting estimations in the spatial variability of the specific capacity values for the Mississipian undivided is depicted in Figure 14b. The values of specific capacity generally decrease to the south and east in the county. The highest range of values, greater than 10 GPM/ft, are found in Thorn Township, near the Village of Thornville. This corresponds to a greater than "excellent" well potential. The lowest range of values, 0.01 to 0.1 GPM/ft, are found in Monday Creek Township, near the southern county border. This range falls within the "not feasible to fair" well potential.

Pottsville-Allegheny

Figure 15a depicts a graph of probability versus specific capacity for outcrop and subcrop wells in the Pottsville-Allegheny hydrostratigraphic unit. Only 29 of the 387 wells are subcrop wells. The remaining 358 are outcrop wells. The distinction between outcrop and subcrop wells for the Pottsville-Allegheny hydrostratigraphic unit is not as clearly defined as the Mississippian undivided. This could be attributed to the small number of data points for the Pottsville-Allegheny subcrop wells or to the relative low permeability of the lithology of the unit.

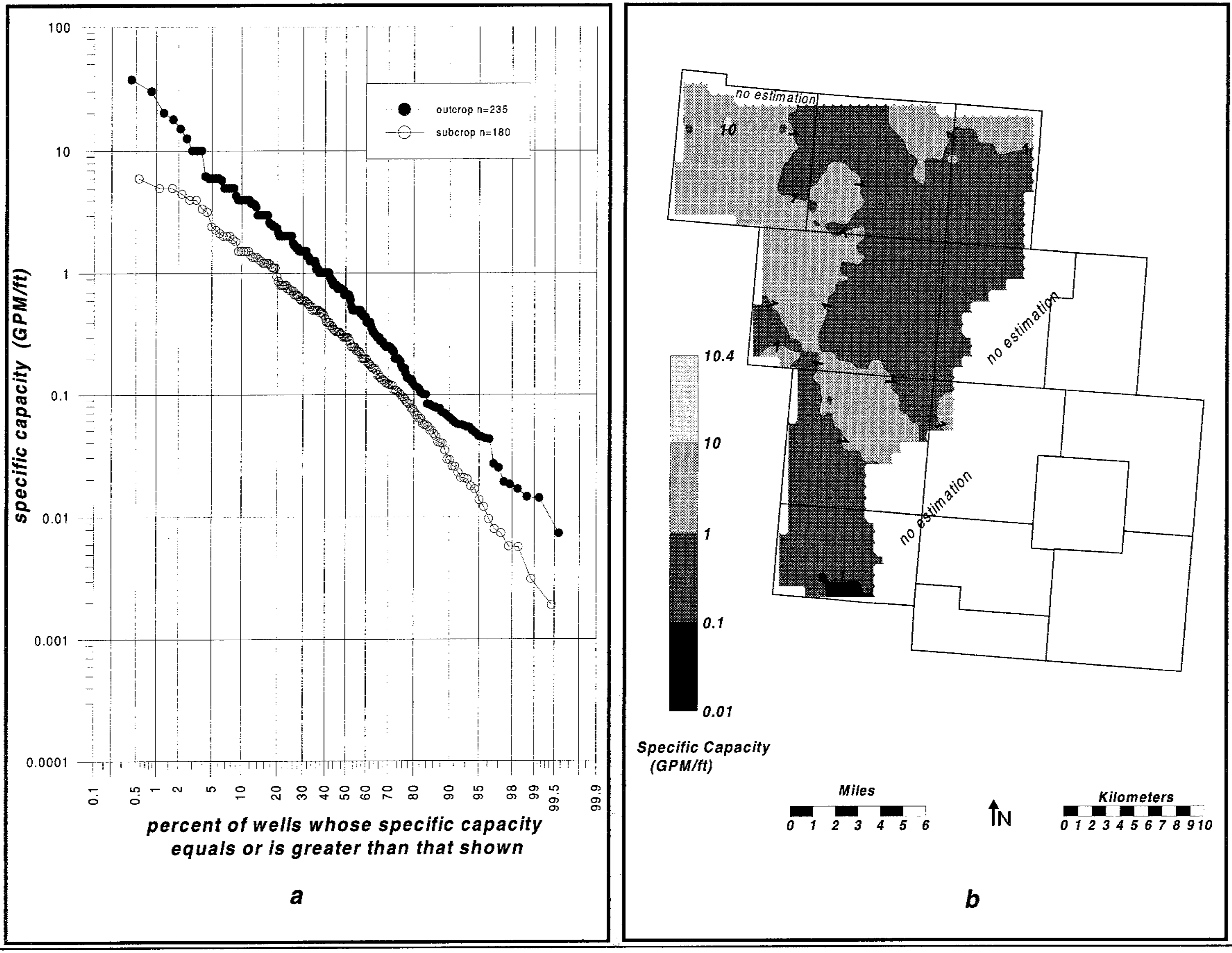

Figure 14. Mississippian undivided hydrostratigraphic unit of Perry County. (a) probability plot of specific capacity (b) spatial estimations of specific capacity.

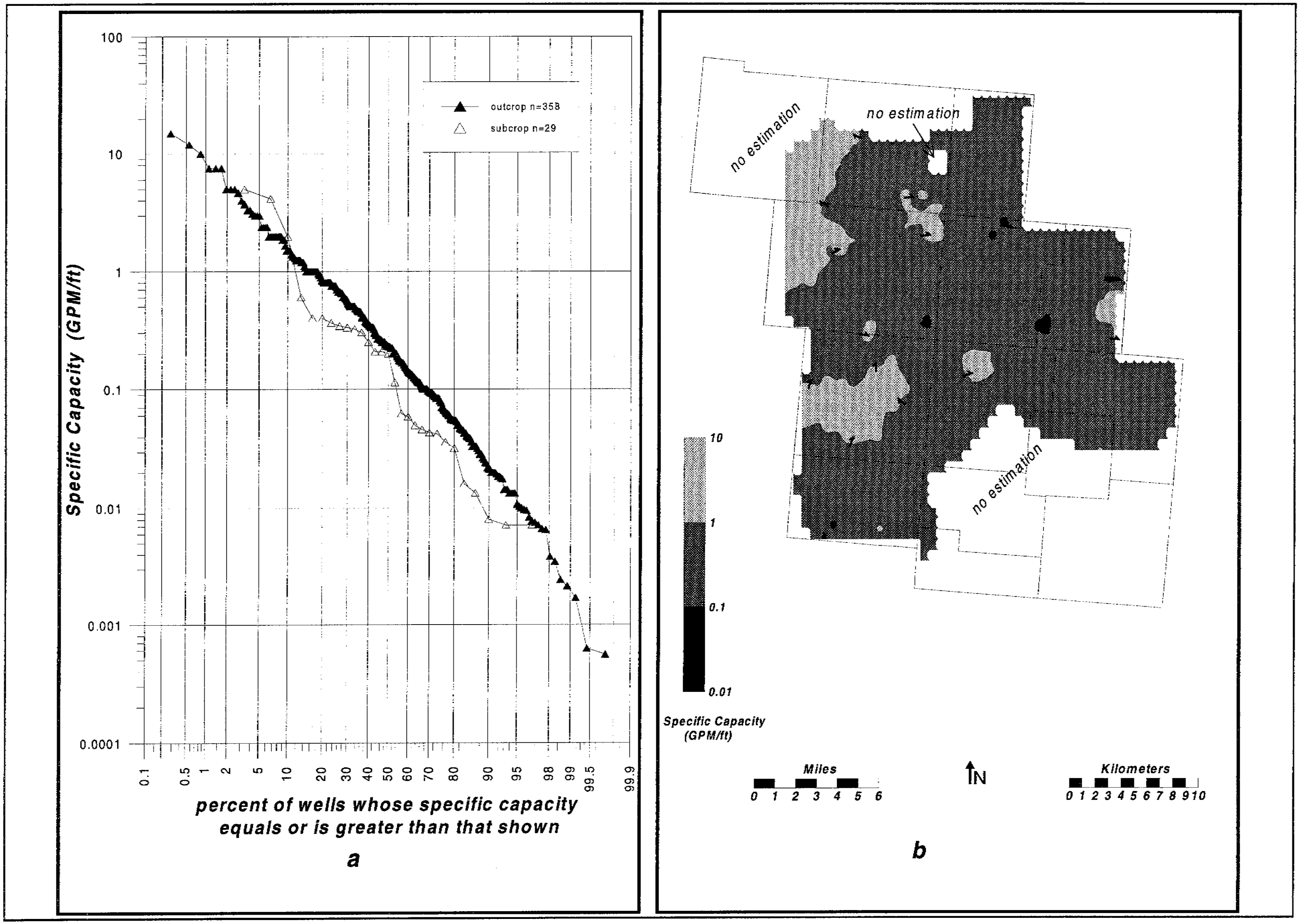

Figure 15. Pottsville-Allegheny hydrostratigraphic unit of Perry County. (a) probability plot of specific capacity (b) spatial estimations of specific capacity.

As shown in Figure 15b, the most productive regions for the Pottsville-Allegheny hydrostratigraphic unit are estimated to be in the western portion of the county. Here specific capacity values range from 1 to 10 GPM/ft. This corresponds to an excellent well potential. The least productive areas are small, isolated zones that range from 0.01 to 0.1 GPM/ft in Reading, Clayton, Harrison, and Monday Creek Townships. These regions are considered to have a not feasible to fair well potential.

Conemaugh

Figure 16a depicts the probability versus specific capacity for the Conemaugh hydrostratigraphic unit. No bedrock hydrostratigraphic unit overlies the Conemaugh in Perry County. Therefore, all records are from outcrop wells.

The most productive region for the Conemaugh is in the northwest portion of Pike Township where specific capacity values are estimated to be greater than 1 GPM/ft (Figure 16b). Domestic well potential is good for this area. The least productive region is a small strip in Salt Lick and Coal Townships where specific capacity values range from 0.001 to 0.01 GPM/ft. This region is not feasible for domestic well potential. No clearly defined spatial trends exist for the Conemaugh.

Sand and Gravel Aquifers

Probability plots and post maps were used to examine the specific capacity data for sand and gravel units. Post maps display symbols which depict ranges of specific capacity and the location of the data.

Jonathan Creek-Buckeye Lake Buried Valley Aquifer

A plot of probability versus specific capacity for the Jonathan Creek-Buckeye Lake Buried Valley Aquifer is shown in Figure 17a. Figure 17b is a post map of this unit. Data for this unit are grouped by well depth. Wells less than 65 feet are considered shallow and wells greater than 65 feet are considered deep. Thirty-nine wells are classified as shallow and 29 are considered deep. As shown in Figure 17a, there is a greater overall probability of obtaining a higher specific capacity from a shallow well than a deep well. Well potential for this aquifer system ranges from poor to excellent.

Moxahala Creek Buried Valley Aquifer

Only six wells completed in this aquifer were field located. Three of the water-well logs report specific capacity. Figure 18 shows the location and values of specific capacity. All of these wells are located in Harrison Township. Numerous other wells are drilled through the drift in the buried valley and into the underlying Pottsville-Allegheny hydrostratigraphic unit.

The most productive well for the Moxahala Creek Buried Valley Aquifer is located in Roseville where drift is approximately 70 feet thick. This well is 62 feet deep and penetrates 50 feet of clay

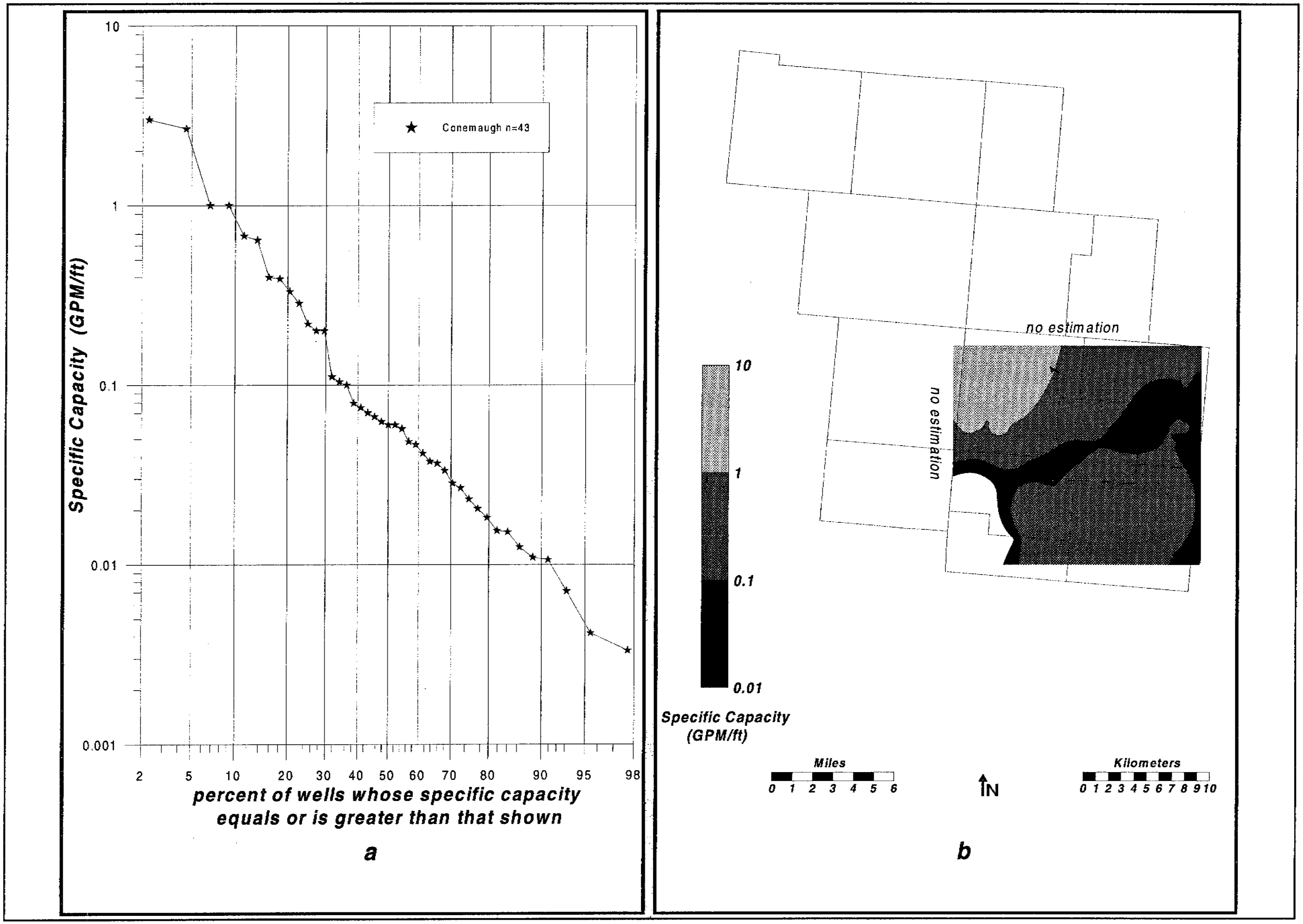

Figure 16. Conemaugh hydrostratigraphic unit of Perry County. (a) probability plot of specific capacity (b) spatial estimations of specific capacity.

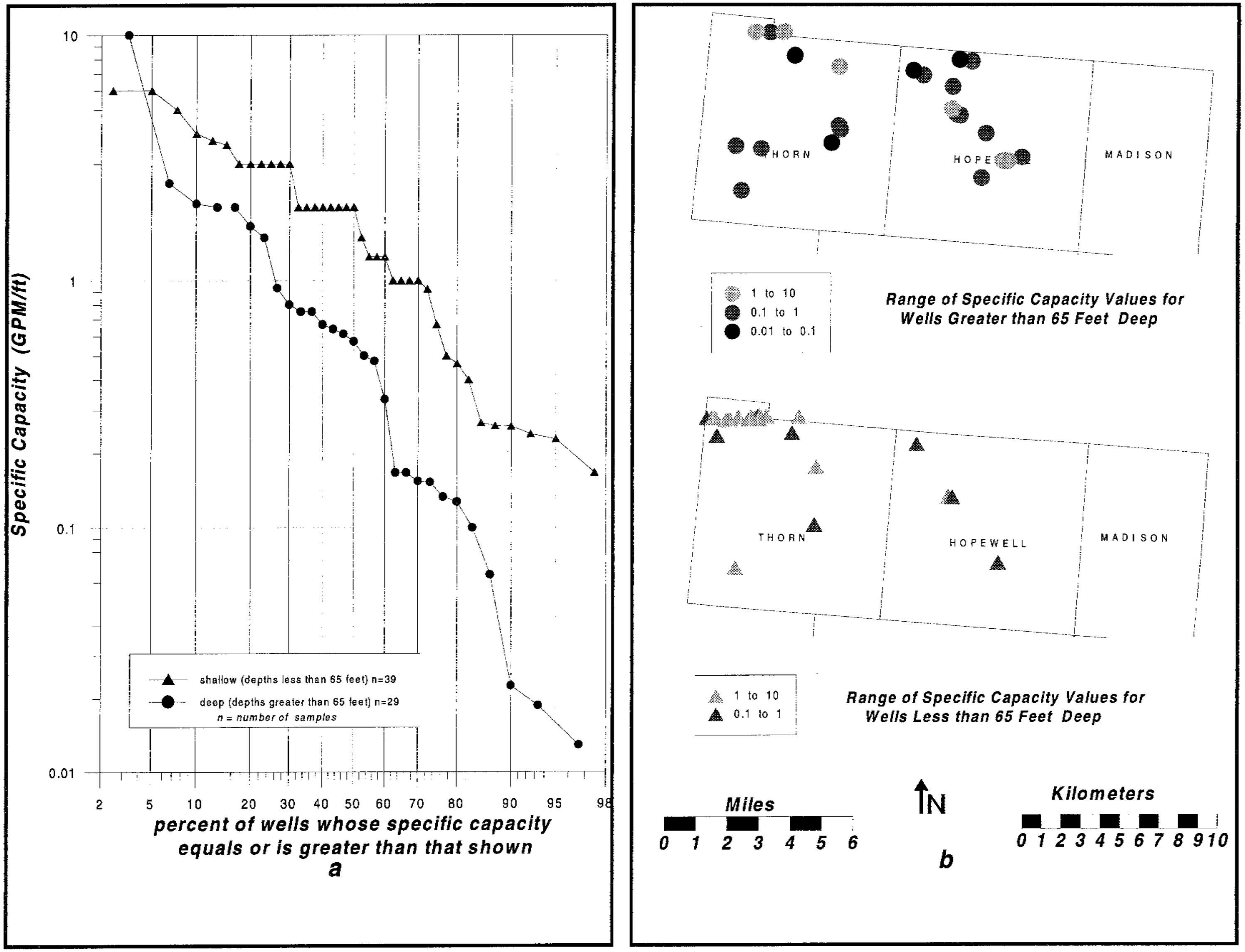

Figure 17. Jonathan Creek-Buckeye Lake Buried Valley Aquifer of Perry County. (a) probability of specific capacity (b) post map of specific capacity ranges.

before reaching the sand and gravel aquifer. The well is screened in 12 feet of sand and gravel. The well log reports that the well was pumped for 24 hours at a rate of 152 GPM with 14.5 feet of drawdown. This equates to a specific capacity of 10.5 GPM/ft.

The remaining wells are located to the south of Roseville where the drift is thinner. These wells are drilled to depths of 30 and 15 feet and have reported yields of 5 and 2 GPM, respectively. Specific capacity for these wells are 0.29 and 0.33 GPM/ft, respectively. These values correspond to a fair to good domestic well potential.

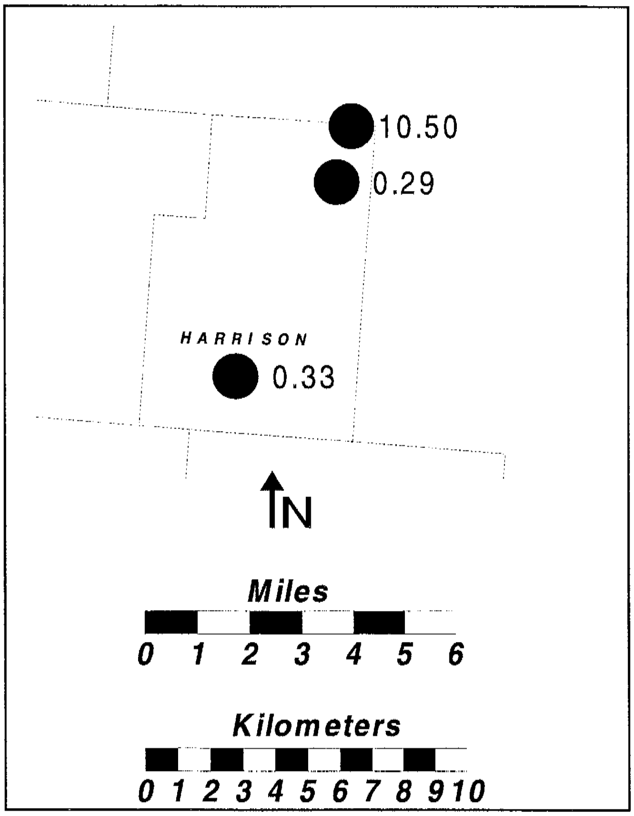

Figure 18. Locations and values of specific capacity (in GPM/ft)for the Moxahala Creek Buried Valley Aquifer of Perry County.

Rush Creek Buried Valley Aquifer

Only six well logs contain specific capacity data for the Rush Creek Buried Valley Aquifer. Figure 19 is a probability plot of the specific capacity values. All wells are located in Jackson Township. The values correspond to a fair to excellent domestic well potential.

Little Rush Creek Buried Valley Aquifer

A total of 11 records contain specific capacity data from the Little Rush Creek Buried Valley Aquifer system. These values correspond to a fair to excellent domestic well potential. A probability plot of specific capacity is shown in Figure 20. These wells are located in Thorn and Reading Townships.

Ground Water Flow Directions and Water Levels

The shallow or local ground water flow system for the hydrostratigrpahic units in Perry County is controlled by the basin morphology and surficial topography. The Conemaugh and large portions of the Pottsville-Allegheny and Mississippian hydrostratigraphic units are dissected by modern drainage and are not laterally extensive. As show in Figure 21, these flow systems are local and can be perched. Many of the perched aquifers can be seasonal or dependent on significant precipitation events. Precipitation that infiltrates the ground moves downward until it reaches a clay or shale layer of low permeability (Figure 21). Some of the water then moves laterally until it intersects the ground surface and discharges as a spring. Water that does not flow laterally is available

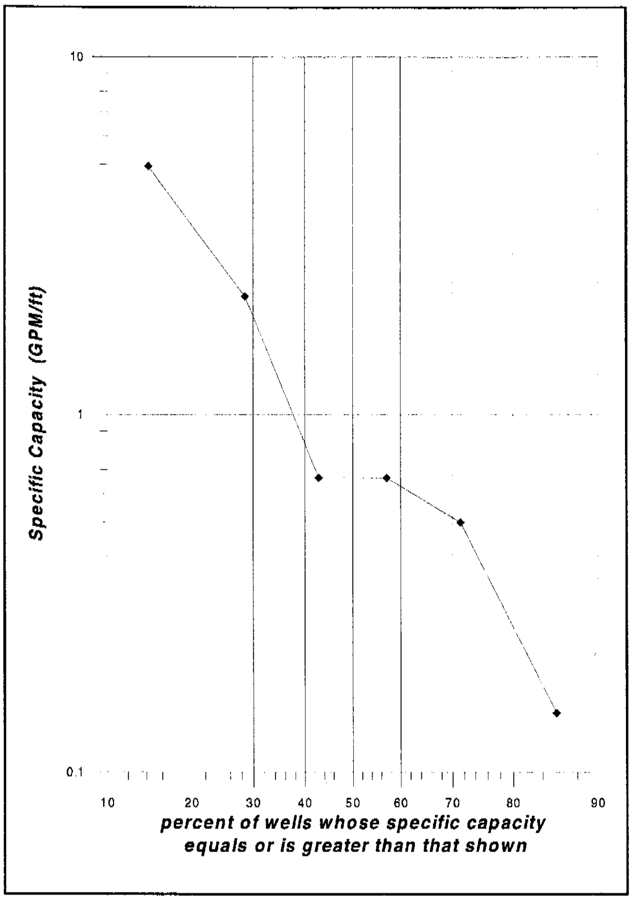

Figure 19. Probability plot of specific capacity for the Rush Creek Buried Valley Aquifer of Perry County.

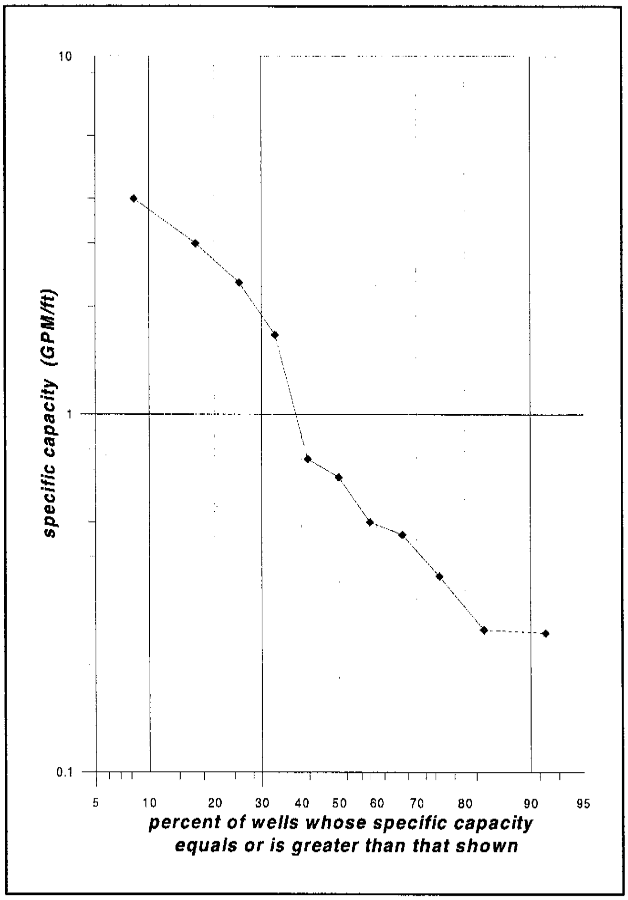

Figure 20. Probability plot of specific capacity for the Little Rush Creek Buried Valley Aquifer of Perry County.

to move vertically downward. This "stair step" pattern continues until the remaining water either becomes part of the regional flow system or discharges into a stream or tributary.

The Mississippian undivided is the most regionally extensive hydrostratigraphic unit in the county. Static water level-data from well log and drilling reports were used to construct a "historical" regional flow map (Figure 22). The usefulness of this map is limited due to the source of the data. Ideally, regional flow maps are constructed by data gathered at the same time. The data used to preparer this map were gathered by different individuals, using various methods of data collection, over a multi-seasonal period of time. Therefore, this map is provided to represent a generalized view of regional flow.

Static ground water elevations for the Mississippian undivided ranged in elevation from 1128 feet in Thorn Township to 671 feet in Madison Township. Ground water flows radially from higher elevations in Thorn and Reading Townships to lower elevations in the east and south. The water

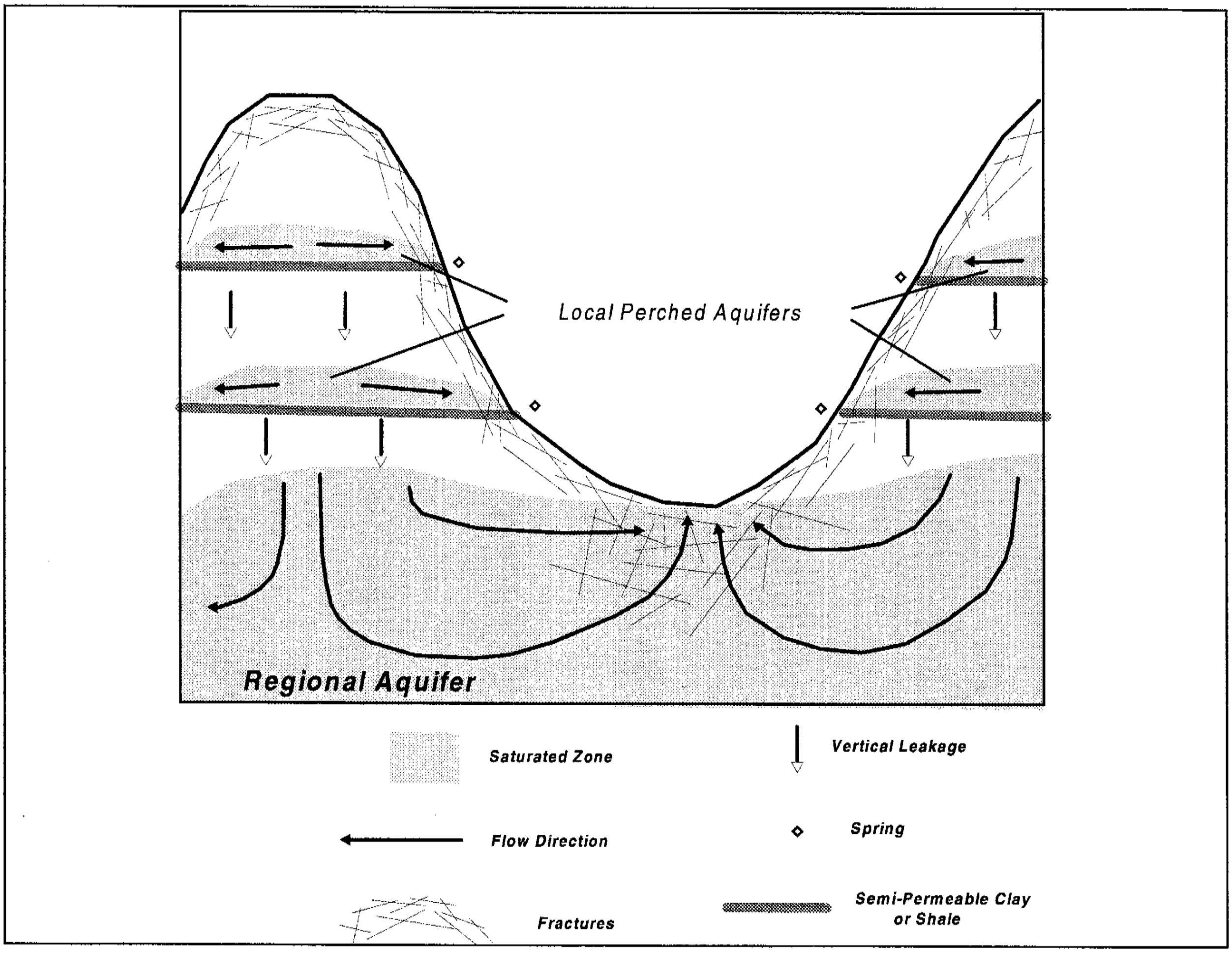

Figure 21. Conceptual ground water flow model (modified from Razem and Sedam, 1985).

discharges into Jonathon Creek, Moxahala Creek, Rush Creek, Monday Creek or becomes part of the regional flow to the southeast.

Recharge

Recharge to the hydrostratigraphic units and aquifers of Perry County is primarily supplied by precipitation. The steep slopes of much of the Allegheny Plateau and the Illinoian Glaciated Plateau regions of the county causes much of the precipitation to become runoff. Some of the precipitation that does not become runoff infiltrates into the ground and then moves laterally and discharges as springs, while the remainder continues infiltrating slowly downward. These factors limit the amount of recharge to the regional aquifers. The average effective recharge rate during a year of normal precipitation for bedrock aquifers that contain thin layers of sandstone, shale, and limestone is 3.77 inches per year or 179,000 gallons per day per square mile (GPD/mi ^{2}) (Pettyjohn and Henning, 1979). Flatter regions of the county that are adjacent to modern streams and have aquifers overlain by alluvium, outwash, or till receive more recharge than upland areas. An estimate

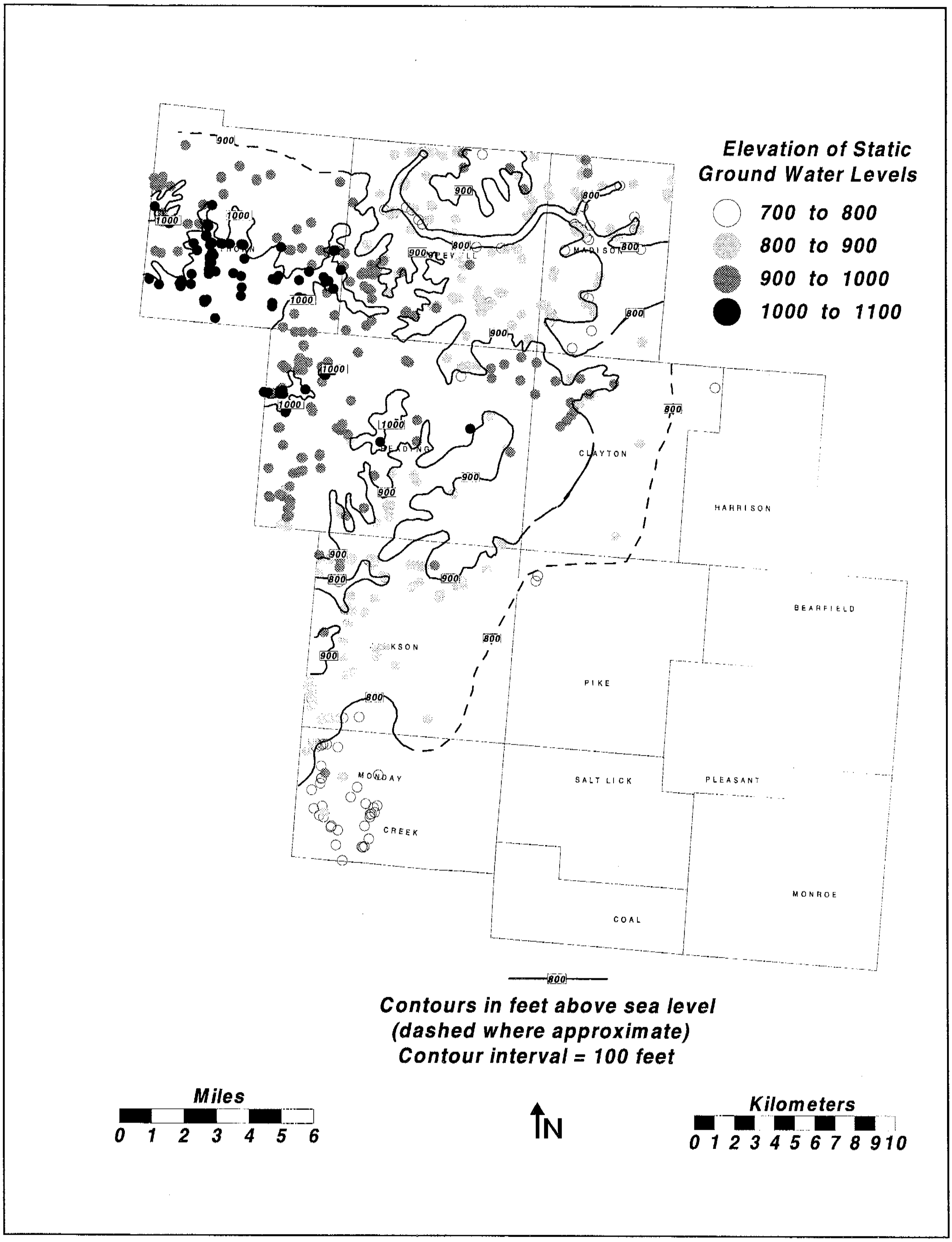

Figure 22. Regional flow map of the Mississippian undivided of Perry County.

of the average effective recharge rate during a year of normal precipitation for these aquifers is 6.58 inches per year or 312,000 GPD/mi ^{2} (Pettyjohn and Henning, 1979).

Water Quality

For this investigation, hydrostratigraphic and temporal variations in water quality were evaluated by analyzing the following parameters: major cations (calcium, magnesium, sodium, potassium, iron), major anions (bicarbonate, carbonate, sulfate, chloride), pH, specific conductance, total dissolved solids (TDS), hardness, pesticides, and fecal coliform bacteria. Groundwater samples from each hydrostratigraphic unit were collected and analyzed for the above parameters. Tables 6, 7, and 8 summarize the minimum, maximum, median, and average values of the chemical parameters for each of the hydrostratigraphic units. Appendix A contains sample location information and Appendix B contains a table of results from the analyses. The sample locations are depicted on plate 1.

Piper diagrams were used to graphically display the percent milliequivalents per liter (meq/L) of samples for each of the hydrostratigraphic units. Piper diagrams require that the results of the analyses be converted from milligrams per liter (mg/L) to meq/L. This is accomplished by dividing the ion concentration (in mg/L) by the equivalent weight of the ion which equals the molecular weight divided by its valence (electrical charge). Percent meq/L for cations and anions were plotted on trilinear diagrams. The points were then projected to a central graph. The hydro-chemical facies (water type) are then classified on the dominant cation and anion for the sample (Fetter, 1980).

Maps depicting the relative hardness of the samples were generated. Gray scaled symbols are used to display water classified as soft (0 to 60 mg/L), moderately hard (61 to 120 mg/L), hard (121 to 180 mg/L), and extremely hard (greater than 180 mg/L).

Maps depicting the location and concentration of samples (in mg/L) relative to the U.S. EPA recommended maximum limits for TDS, sulfate, iron, and chloride were plotted for each unit. Symbols were used to display samples which either exceed or do not exceed the recommended maximum levels.

Water samples were collected from January 1995 to April 1997 by the Perry County Health Department and the ODNR, Division of Mines and Reclamation. The Perry County Health Department collected and analyzed samples for fecal coliform bacteria from domestic wells in 1995. The Division of Mines and Reclamation collected ground and surface water samples from January 1996 to April 1997.

Ground water samples were collected from selected domestic wells, and surface water samples were collected from springs and streams. All samples adhered to the Division of Mines and Reclamation's normal field and laboratory protocol for quality assurance and quality control. To ensure that representative ground water samples were obtained, three volumes of water from each well were purged. Prior to purging, pH, specific conductance, and temperature were measured. These parameters were also measured during purging and when their values stabilized, a sample was

Hydrostatigraphic Unit	Number of Samples	Calcium (mg/l)				Magnesium (mg/l)				Sodium (mg/l)				Potassium (mg/l)			
		min	max	med	avg	min	max	med	avg	min	max	med	avg	min	max	med	avg
Mississippian (undivided)	53	.02	147	45	49	.03	53	14	16	4	1550	50	147	.2	20	2.6	3.3
Pottsville-Allegheny (undivided)	145	.01	459	57	69	.04	302	16	25	2	1360	17	49	.2	16	2.4	3.1
Conemaugh	27	10	406	48	64	3	68	18	19	5	270	23	46	1	5	2	2
Jonathon Creek/ Buckeye Lake Buried Valley	13	.07	121	74	71	.04	42	25	23	5.7	132	18	34	1.1	11	1.8	2.7
Moxahala Creek Buried Valley Aquifer	5	28	133	56	72	9.1	41	18	23	9	64	30	33	1	7.9	3.2	3.6
Little Rush Creek Buried Valley Aquifer	5	41	179	88	91	13	72	24	32	15	50	20	27	.9	2.8	2.4	2.1
Surface Water	68	1.1	172	41	56	1.8	126	14	31	1.2	68	11	18	.67	17	3	3.5

Table 6. General statistics for analytical results for calcium, magnesium, sodium, and potassium from ground water and surface water samples collected in Perry County.

Hydrostatigraphic Unit	Iron (mg/l)				Bicarbonate (mg/l)				Sulfate (mg/l)				Chloride (mg/l)			
	min	max	med	avg	min	max	med	avg	min	max	med	avg	min	max	med	avg
Mississippian (undivided)	.01	22	.43	1.7	43	464	275	275	5	375	35	62	5	2340	29	129
Pottsville-Allegheny (undivided)	.01	439	.61	8.9	0	724	156	156	5	2885	75	171	5	2000	15	49
Conemaugh	.01	84	.46	5.9	29	500	200	200	23	381	56	81	5	146	15	24
Jonathon Creek/ Buckeye Lake	.01	79	1.3	8.2	39	394	277	279	5	185	38	53	5	82	13	18
Moxahala Creek	.04	22	8	8.9	0	170	140	110	57	376	98	185	5	113	60	58
Little Rush Creek	.18	12.8	4.9	5	162	467	337	334	5	322	27	93	5	13	11	10
Surface Water	.01	49	.57	4.6	0	177	22	40	9	1045	78	249	5	92	17	20

Table 7. General statistics for analytical results for iron, bicarbonate, sulfate, and chloride from ground water and surface water samples collected in Perry County.

Hydrostatigraphic Unit	pH				Specific Conductance				Total Dissolved Solids (mg/l)				Hardness (mg/l)			
	min	max	med	avg	min	max	med	avg	min	max	med	avg	min	max	med	avg
Mississippian (undivided)	5.8	8.8	7.2	7.3	195	7220	745	1025	96	3948	428	601	23	645	240	243
Pottsville-Allegheny (undivided)	3.3	9.1	6.7	6.6	104	6870	585	756	22	3876	400	556	3	3936	268	384
Conemaugh	6.2	7.9	7	7	140	1217	560	594	112	868	316	382	17	494	224	243
Jonathon Creek/ Buckeye Lake	6.1	7.7	7.4	7.2	291	964	625	651	208	644	364	407	46	460	329	304
Moxahala Creek	4.3	7	6.5	6	390	1251	487	737	272	840	332	498	144	584	216	330
Little Rush Creek	7.1	7.8	7.3	7.3	398	1350	740	761	248	1088	444	506	155	739	356	376
Surface Water	2.9	8.3	6.2	5.8	53	2160	422	663	8	2148	262	502	24	1200	208	319

Table 8. General statistics for analytical results of pH, specific conductance, TDS, and hardness for ground water and surface water samples collected in Perry County.

collected (written communication, Kirk Beach, Division of Mines and Reclamation, 1997). Surface water samples were collected by filling sample containers at representative reaches of streams, lakes, and springs. The samples were sent to Coshocton Environmental Testing Inc. and analyzed for the target parameters.

Calcium and magnesium are very common in the surface and groundwater of Perry County. Sources of these cations include limestone and other sedimentary rocks as well as glacial till. These elements are the major source of hardness in water. Although high concentrations of these elements are not considered to be a health risk, they can cause scaling on the interior portions of pipes and inhibit the ability of a soap to lather.

Sodium is present in much of the surface and groundwater of Perry County. Sources of sodium in water could be the cement of sedimentary rocks that were deposited under saline conditions. Human activities such as the de-icing of roadways and exploration of oil and gas can also contribute to the concentration of sodium in water. Sodium is only considered a health risk for those on a sodium-restricted diet. High concentrations of sodium in combination with chloride result in water having a salty taste.

Low concentrations of potassium are present in the waters of the county. Sources of potassium include clay minerals that are present in sedimentary rocks. High concentrations of potassium are not considered to be a health risk.

Iron is common in the waters of Perry County. Minerals, such as pyrite, found in sedimentary rocks, are a major source of iron in water. Elevated concentrations of iron are common in waters from areas that have undergone coal strip mining. High concentrations of iron in water induce the growth of iron bacteria and can cause staining in laundry and plumbing fixtures. A high concentration of iron can also cause water to have a "metallic" taste. The U.S. Environmental Protection Agency (U.S. EPA) recommends that waters for public use should not exceed 0.3 mg/L iron. These standards are secondary and are for the aesthetic quality of the water and are not considered to be a potential health risk.

Bicarbonate and carbonate are present in much of the water of Perry County. Carbonate waters are usually associated with a high pH. High values of these constituents are generally not considered a health risk.

Sulfate is present in many of the waters of the county. Sulfur occurs in minerals such as pyrite which are found in sedimentary rocks. High concentrations of sulfates are usually found in waters from areas that have undergone extensive strip mining. High concentrations of sulfates can cause water to have a "bitter" taste and can also induce a laxative effect on the user. The U.S. EPA secondary standards recommend that waters for public use should not exceed 250 mg/L.

Chloride is similar to sodium in its origin in water. Waters rich in chloride can come from sedimentary rocks, de-icing salts, or oil and gas well brines. As previously stated, high concentrations of sodium in combination with chloride results in water having a salty taste. The U.S. EPA secondary standards recommend that water for public use does not exceed 250 mg/L.

pH is a measure of the acidity or alkalinity of a water. Water with a pH below 7 is considered to be acidic and water with a pH above 7 is considered alkaline. Low pH is associated with waters that have been affected by acid mine drainage from coal strip mined areas. Although there is no limit or standard for pH, a low pH may cause a water to taste sour. A low pH is also corrosive on plumbing and pipes.

Specific conductance is a measure of the ability of a water to conduct an electrical current. Waters with a high concentration of ions will usually have a high specific conductance. Specific conductance is usually proportional to total dissolved solids.

Total dissolved solids (TDS) is a measure of the total quantity of dissolved ionic matter in a water. The amount of TDS in water affects the way it tastes. The U.S. EPA secondary standards recommend that concentrations of TDS for water intended for public use does not exceed 500 mg/L.

Hardness is primarily a measure of the calcium and magnesium in a water sample. A hard water will cause scaling in pipes and water boilers. Hardness affects the ability of a soap to lather. Water can be classified as soft, moderately hard, hard, or extremely hard depending on the amount of calcium and magnesium present. Water with a hardness of 0 to 60 mg/L is considered soft. Water with a hardness of 61 to 120 mg/L is considered moderately hard. Water with a hardness of 120 to 180 mg/L is considered hard. Water exceeding 180 mg/L is considered very hard (Hem, 1985). The U.S. EPA does not recommend a limit for hardness.

Pesticides are chemicals used in agriculture. For this investigation, waters were sampled for atrizine using a pesticide immunoassay screen calibrated for triazine. Atrizine is the herbicide most commonly found in private water supplies (Heidelberg College Water Quality Laboratory, written communication, 1996). The U.S. EPA has set a safe drinking water standard of 3.0 micrograms per liter (parts per billion) for atrizine.

Fecal coliform bacteria are microbiological organisms that are present in water which has been in contact with sewage from human or animal waste. Positive results indicate that the water is unsafe for human use. The Ohio Department of Health sets standards for fecal coliform bacteria in private water systems in Ohio and the Ohio Environmental Protection Agency sets bacterial standards for public water supply systems.

Bedrock Hydrostratigraphic Units

Mississippian undivided

Ground water samples were collected from 53 wells completed in the Mississippian undivided and analyzed for major cations and anions. Figure 23 is a piper diagram of the results. Seven water types can be identified from this figure. Calcium bicarbonate is the most common water type.

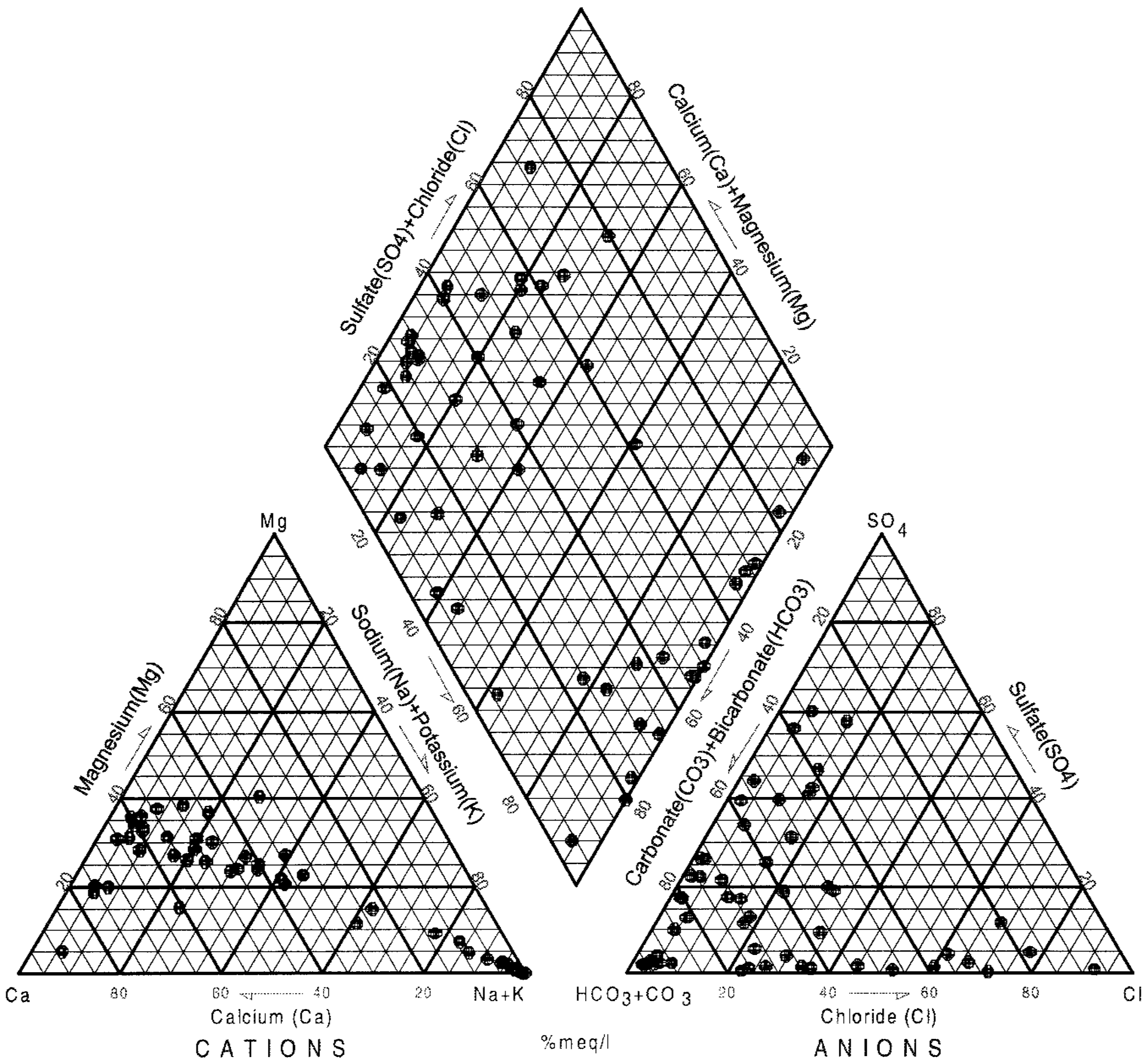

Figure 23. Piper diagram of major cations and anions in ground water samples collected from the Mississippian undivided hydrostratigraphic unit of Perry County.

Twenty five (47 percent) of the samples in the Mississippian undivided are calcium bicarbonate-type water. Fifteen (28 percent) samples are sodium bicarbonate-type water. Seven of the samples (13 percent) are sodium chloride-type water. Three of the samples (6 percent) are calcium sulfate-type water. The remaining 3 samples (each representing two percent of the total population) are classified as calcium chloride, magnesium sulfate, and sodium sulfate-type waters.

Water types for the Mississippian undivided in the northwestern region of the county predominately have a calcium bicarbonate-type water. Ground water changes in composition from calcium bicarbonate in the northwest to sodium chloride in the northeast. This trend appears to correspond to the regional potentiometric map for the Mississippian undivided (Figure 22).

Waters from the Mississipian undivided are typically extremely hard (Figure 24a). Sixty-six percent of the samples fall into this category of hardness. Thirteen percent of the samples are hard. Thirteen percent are moderately hard, and only 4 percent are considered soft.

Many of the samples from the Mississippian undivided exceed the U.S. EPA recommended secondary standards for maximum concentration levels of sulfate, iron, chloride, and TDS. Three samples (6 percent) exceed the recommended level of 250 mg/L for sulfate (Figure 24b). Thirty samples (57 percent) exceed the recommended level of 0.3 mg/L for iron (Figure 24c). Seven samples (13 percent) exceed the recommended level of 250 mg/L for chloride (Figure 24d). Twenty two samples (42 percent) exceed the recommended level of 500 mg/L for TDS (Figure 24e).

Pottsville-Allegheny

Ground water samples were collected from 145 wells completed in the Pottsville-Allegheny hydrostratigraphic unit and analyzed for major cations and anions. Figure 25 is a piper diagram of the results. This unit has the most diverse water chemistry of all the hydrostratigraphic units in the county. A total of 10 water types can be identified. Calcium bicarbonate is the most common water type. Fifty six of the samples (39 percent) in the Pottsville-Allegheny undivided are calcium bicarbonate-type water. Forty one samples (28 percent) are calcium sulfate-type water. Fourteen of the samples (10 percent) are sodium bicarbonate-type water. Thirteen samples (9 percent) are calcium chloride-type water. Eleven samples (8 percent) are magnesium sulfate-type water. The remaining eleven samples (6 percent) are sodium sulfate (5 occurrences), iron sulfate (2 occurrences), magnesium chloride (1 occurrence), magnesium bicarbonate (1 occurrence), and sodium chloride (1 occurrence) type waters.

The northwestern samples appear to be calcium bicarbonate- and calcium sulfate-type waters. No apparent trends in water types are evident for the other regions of the Pottsville-Allegheny hydrostratigraphic unit. The variety of water types reflects the diverse lithology of the unit and the impact of coal strip mining activities in the area.

Ground water from the Pottsville-Allegheny hydrostratigraphic unit is extremely hard (Figure 26a). Analyses indicated that 72 percent of the samples are considered extremely hard. Thirteen percent of the samples are hard. Ten percent are moderately hard, and only 5 percent are soft.

Figure 24. Spatial variability in the Mississippian undivided hydrostratigraphic unit of Perry County for (A) hardness (B) sulfate (C) iron (D) chloride (E) total dissolved solids.

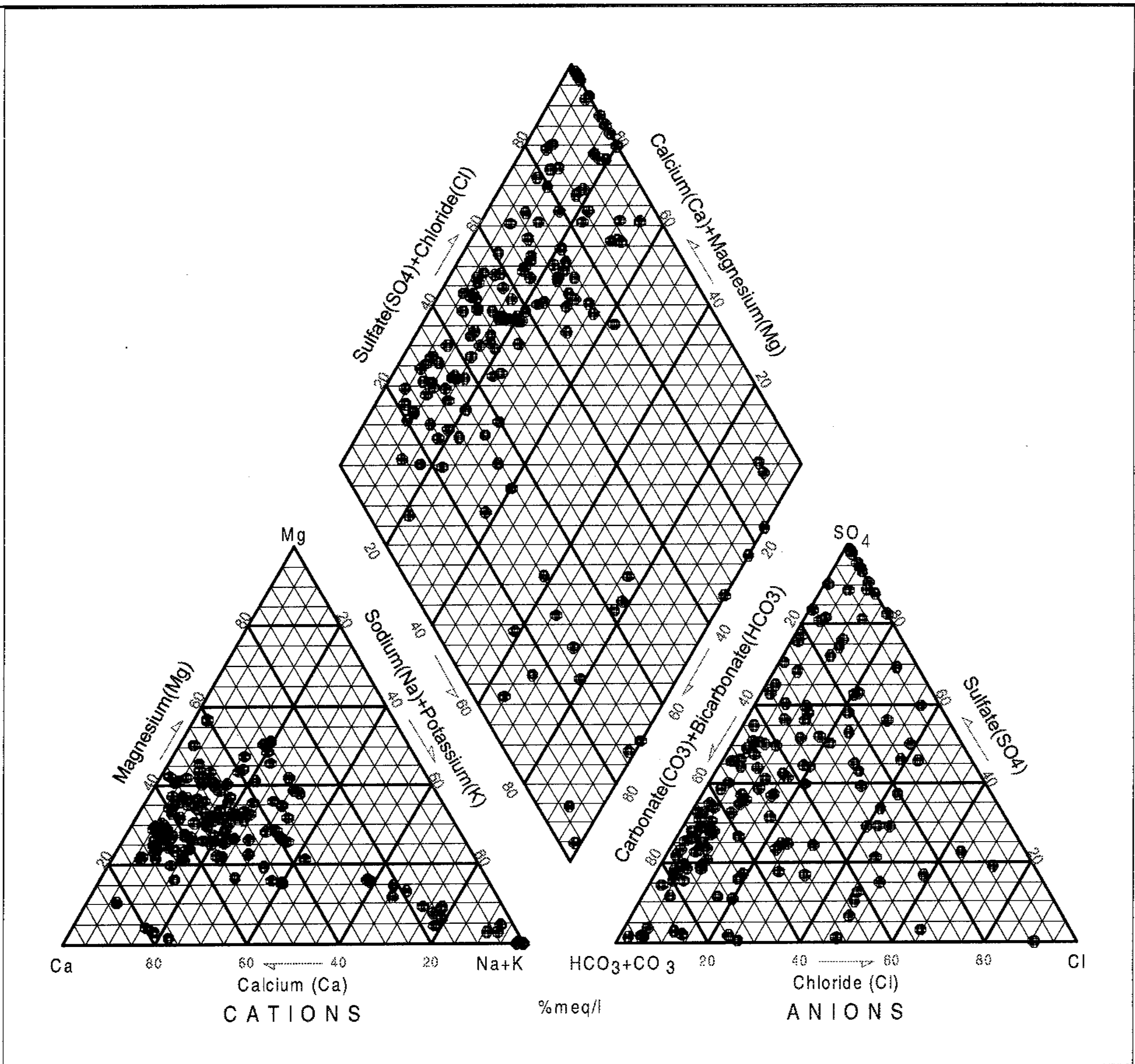

Figure 25. Piper diagram of major cations and anions in ground water samples collected from the Pottsville-Allegheny hydrostratigraphic unit of Perry County.

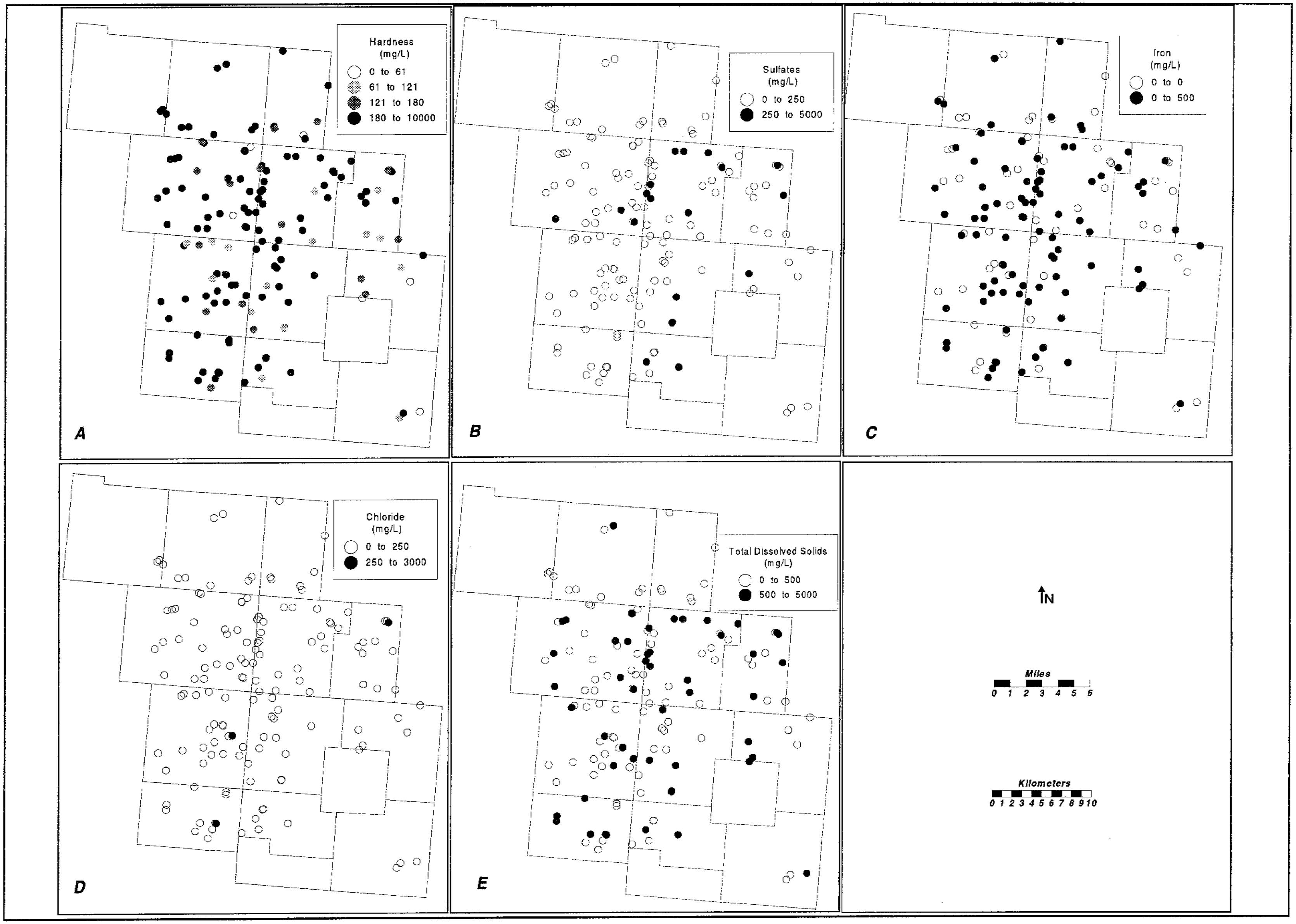

Figure 26. Spatial variability in Pottsville-Allegheny hydrostratigraphic unit of Perry County for (A) hardness (B) sulfate (C) iron (D) chloride (E) total dissolved solids.

Many of the samples from the Pottsville-Allegheny hydrostratigraphic unit exceed the U.S. EPA recommended maximum concentration levels for sulfate, iron, chloride, and TDS. Nineteen (13 percent) exceed the recommended level of 250 mg/L for sulfate (Figure 26b). Eighty nine samples (61 percent) exceed the recommended level of 0.3 mg/L for iron (Figure 26c). Three samples (2 percent) exceed the recommended level of 250 mg/L for chloride (Figure 26d). Fifty samples (35 percent) exceed the recommended level of 500 mg/L for TDS (Figure 26e).

Conemaugh

Ground water samples were collected from 27 wells completed in the Conemaugh hydrostratigraphic unit and analyzed for major cations and anions. Figure 27 is a piper diagram of the samples. A total of 7 water types can be identified. Calcium bicarbonate is the most common water type. Fourteen (52 percent) of the samples are calcium bicarbonate-type water. Five (19 percent) samples are calcium sulfate-type water. Four of the samples (15 percent) are sodium bicarbonate-type water. The remaining four samples (14 percent) are iron bicarbonate (1 occurrence), magnesium chloride (1 occurrence), magnesium bicarbonate (1 occurrence), and magnesium sulfate (1 occurrence) type waters.

Ground water from the Conemaugh hydrostratigraphic unit is extremely hard (Figure 28a). Analyses indicate that 74 percent of the samples are considered extremely hard. Eleven percent of the samples are hard. Eleven percent are moderately hard. Only 4 percent are considered soft.

Some of the samples from the Conemaugh hydrostratigraphic unit exceed the U.S. EPA recommended maximum concentration levels for sulfate, iron, and TDS. None of the samples exceed the recommended maximum concentration level of 250 mg/L for chloride. Only 1 sample (4 percent) exceeds the recommended level of 250 mg/L for sulfate (Figure 28b). Fifteen samples (56 percent) exceed the recommended level of 0.3 mg/L for iron (Figure 28c). Six samples (22 percent) exceed the recommended level of 500 mg/L for TDS (Figure 28d).

Sand and Gravel Aquifers

Figure 29 is a piper diagram for the Jonathan Creek-Buckeye Lake, Moxahala Creek, and Little Rush Creek Buried Valley Aquifers. No samples were obtained from the Rush Creek Buried Valley Aquifer.

Jonathan Creek-Buckeye Lake Aquifer

Thirteen ground water samples collected from the Jonathan Creek-Buckeye Lake Buried Valley Aquifer indicate that water of this unit is predominately of a calcium bicarbonate type. Ten of the 13 samples (72 percent) are calcium bicarbonate-type waters. Two samples are sodium bicarbonate-type water, and one is a calcium sulfate-type water.

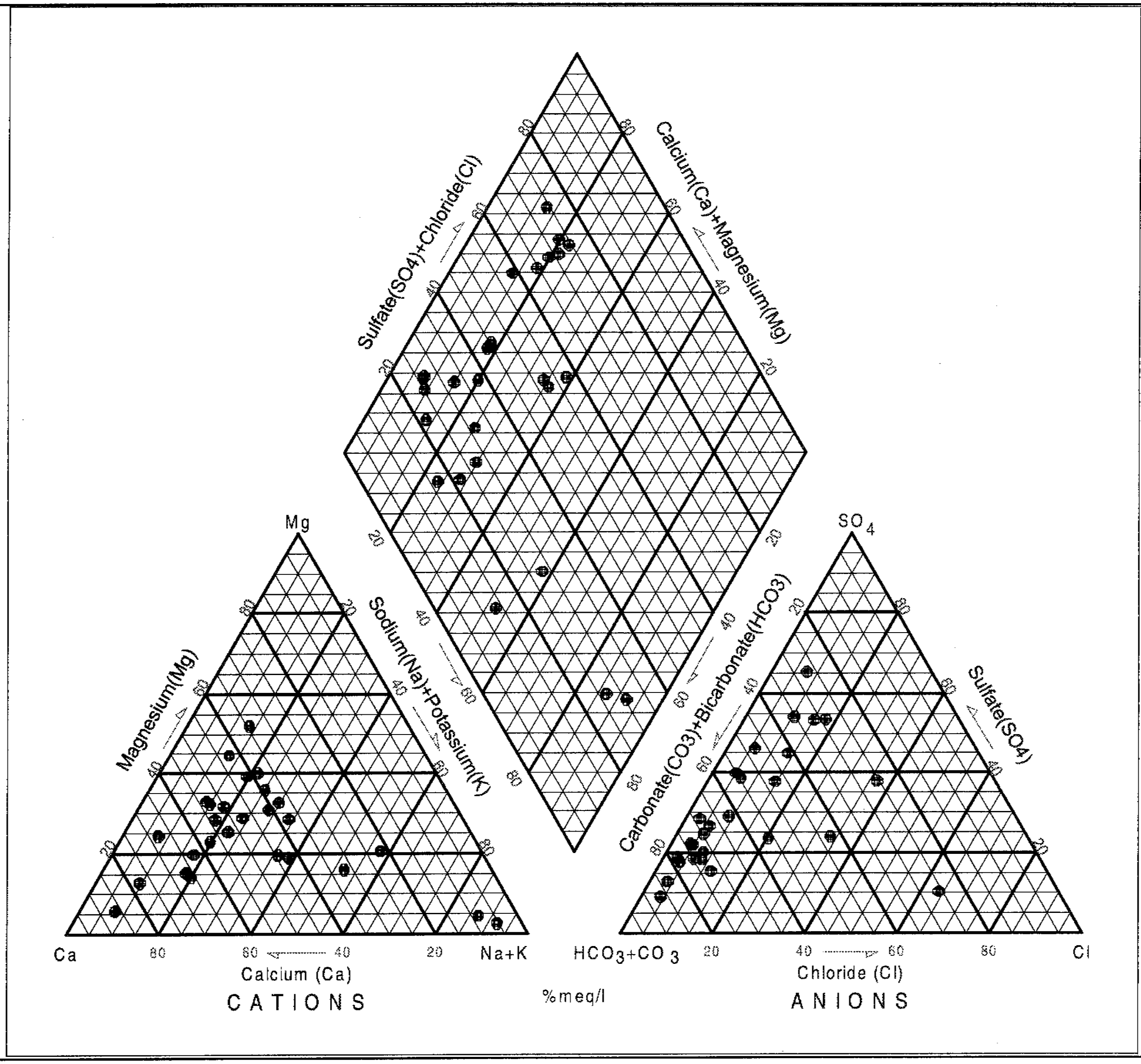

Figure 27. Piper diagram of major cations and anions from ground water samples collected from the Conemaugh hydrostratigraphic unit of Perry County.

Figure 28. Spatial variability in the Conemaugh hydrostratigraphic unit of Perry County for (A) hardness (B) sulfate (C) iron and (D) total dissolved solids.

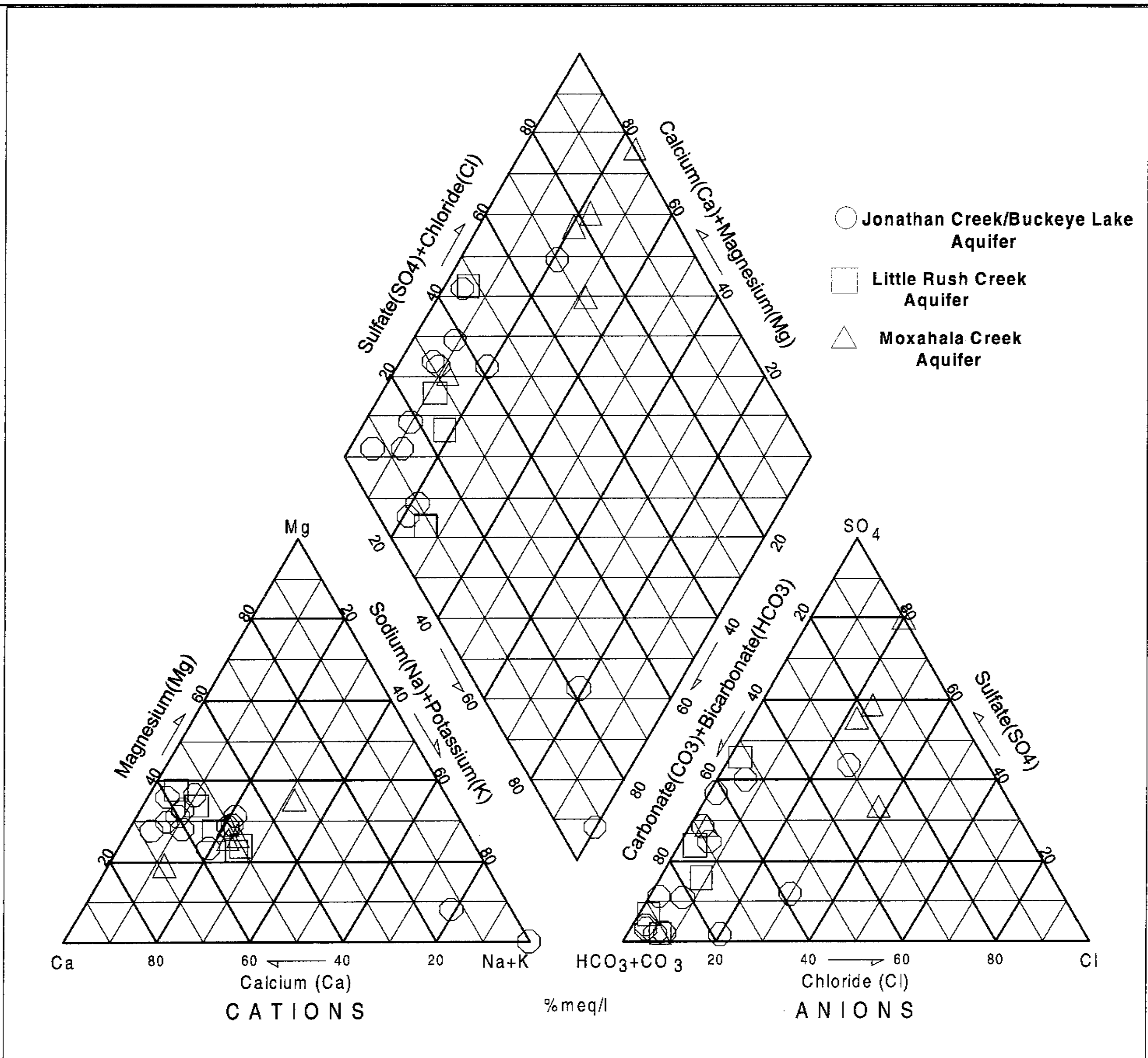

Figure 29. Piper diagram of major cations and anions in ground water samples collected from the buried valley (sand and gravel) aquifers.

Most of the samples from the Jonathan Creek-Buckeye Lake Buried Valley Aquifer contain hard water. Ten of the thirteen are classified as extremely hard. Two are considered hard, and only one is soft (Figure 30a).

Some of the thirteen samples from the Jonathan Creek-Buckeye Lake Buried Valley Aquifer exceed the U.S. EPA recommended maximum concentration levels for iron and TDS. None of the samples exceed the recommended maximum concentration level of 250 mg/L for chloride or sulfate. Ten samples exceed the recommended maximum concentration level of 0.3 mg/L for iron (Figure 30c). Four samples exceed the recommended maximum concentration level of 500 mg/L for TDS (Figure 30d).

Moxahala Creek Aquifer

Five ground water samples were obtained from wells penetrating the Moxahala Creek Buried Valley Aquifer. Three of the samples are calcium sulfate-type water. One is a magnesium chloride-type water, and one is a calcium bicarbonate-type water.

Figure 30a depicts the hardness of water for the Moxahala Creek Buried Valley Aquifer. Ground water samples from this aquifer system indicate that three samples are extremely hard and two are hard.

Some of the five samples from the Moxahala Creek Buried Valley Aquifer exceed the U.S. EPA recommended maximum concentration levels for sulfate, iron, and TDS. None of the samples exceed the recommended maximum concentration level of 250 mg/L for chloride. Two samples exceed the recommended maximum concentration level of 250 mg/L for sulfate (Figure 30b). Four samples exceed the recommended level of 0.3 mg/L for iron, (Figure 30c). Two samples exceed the recommended level of 500 mg/L for TDS (Figure 30d).

Little Rush Creek

Five ground water samples were obtained from wells completed in the Little Rush Creek Buried Valley Aquifer. All of the samples are calcium bicarbonate-type waters.

Ground water sampling results from this aquifer system indicate that four samples are extremely hard and one is hard (Figure 30a). Some of the five samples from the Little Rush Creek Buried Valley Aquifer exceed the U.S. EPA recommended maximum concentration levels for sulfate, iron, and TDS. None of the samples exceed the recommended maximum concentration level of 250 mg/L for chloride. Only one exceeds the recommended maximum concentration level of 250 mg/L for sulfate (Figure 30b). Four samples exceed the recommended maximum concentration level of 0.3 mg/L for iron (Figure 30c). One sample exceeds the recommended maximum concentration level of 500 mg/L for TDS (Figure 30d).

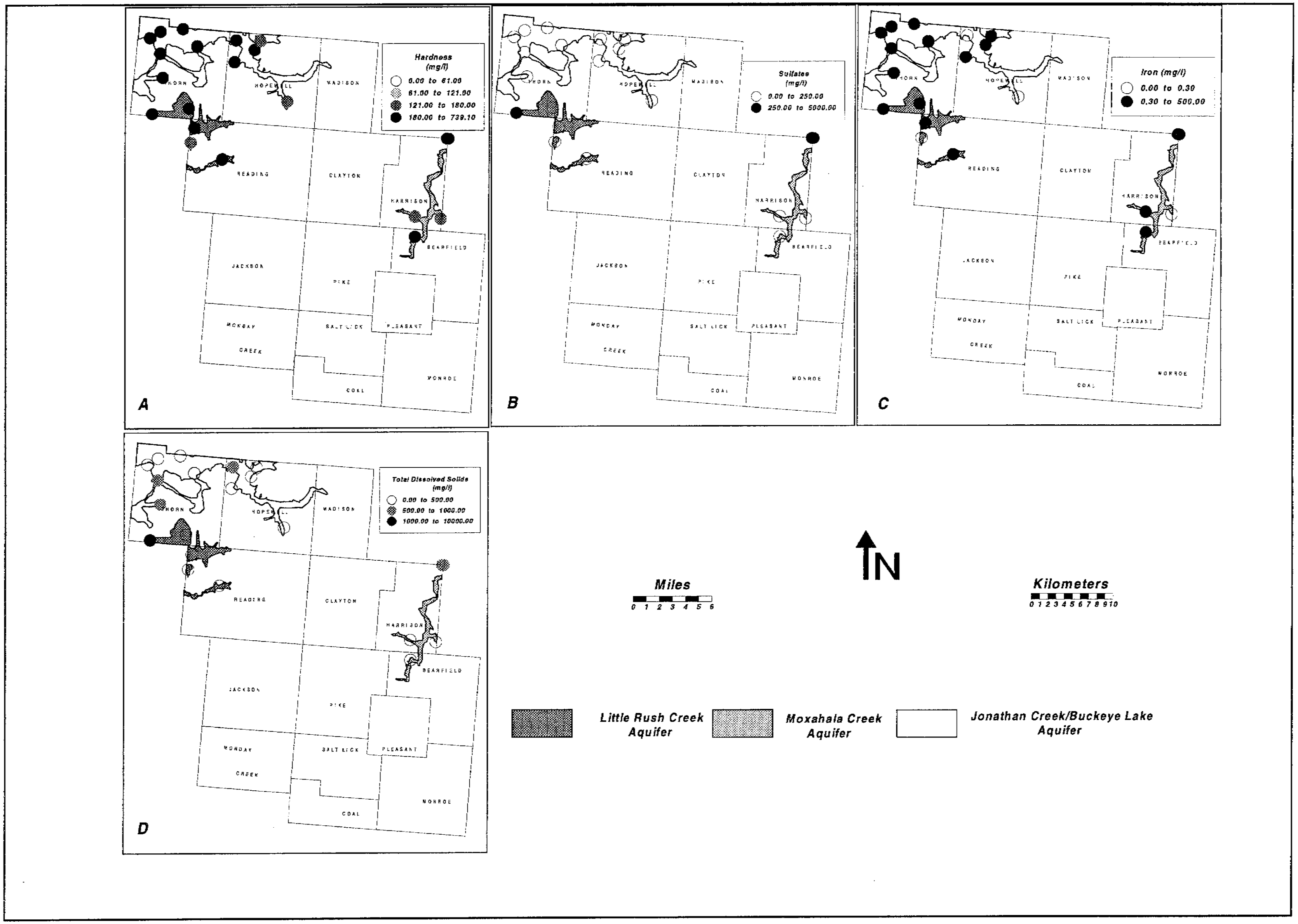

Figure 30. Spatial variability in the buried valley (sand and gravel) aquifers for (A) hardness (B) sulfate (C) iron and (D) total dissolved solids.

Surface Water

Sixty-eight surface water samples from springs, lakes, and streams were collected and analyzed for major cations and anions. Figure 31 is a piper diagram of the results. A total of 6 water types can be identified. Calcium sulfate-type waters account for 24 (35 percent) of the samples. Twenty-three samples (34 percent) are magnesium sulfate-type waters. Seventeen samples (25 percent) are calcium bicarbonate-type waters. The remaining five samples (7 percent) are sodium sulfate-, sodium chloride-, or calcium chloride-type waters.

Waters from the Jonathon Creek Basin are predominately calcium bicarbonate-type waters. Waters from Moxahala Creek are predominately magnesium sulfate-type waters. Waters from Sunday Creek are predominately calcium sulfate-type waters, except for two samples near the county border. These waters are sodium sulfate-type waters.

Surface water from the springs, lakes, and streams is extremely hard (Figure 32a). Analyses indicate that 58 percent of the samples are considered extremely hard. Thirteen percent of the samples are hard. Twenty-five percent are moderately hard. Only 4 percent are considered soft.

Some of the samples from surface waters exceed the U.S. EPA maximum concentration levels for sulfate, iron, and TDS. None of the samples exceed the maximum concentration level of 250 mg/L for chloride. Forty-seven samples (70 percent) exceed the recommended level of 250 mg/L for sulfate (Figure 32b). Forty-four samples (65 percent) exceed the recommended level of 0.3 mg/L for iron (Figure 32c). Twenty samples (29 percent) exceed the recommended level of 500 mg/L for TDS (Figure 32d).

Temporal Variations

Ground water and surface-water samples were collected two or three separate times at 22 locations to evaluate temporal changes in water quality. Pesticides as well as the major cations, major anions, hardness, TDS, and specific conductance were analyzed. The data were plotted on graphs that show the concentration of the constituents versus time (the date of analysis). Data are included in Appendix A.

Ground Water

Ground water samples were collected at 15 wells (Figure 33a). Six of the wells (T3, T4, T5, T7, T9, and T18) are completed in the Mississippian undivided hydrostratigraphic unit. Six wells (T8, T11, T13, T15, T16, and T19) are completed in the Pottsville-Allegheny hydrostratigraphic unit. Two wells (T17 and T21) are completed in the Conemaugh hydrostratigraphic unit. One well (T2) is completed in the Jonathan Creek/ Buckeye Lake buried valley aquifer.

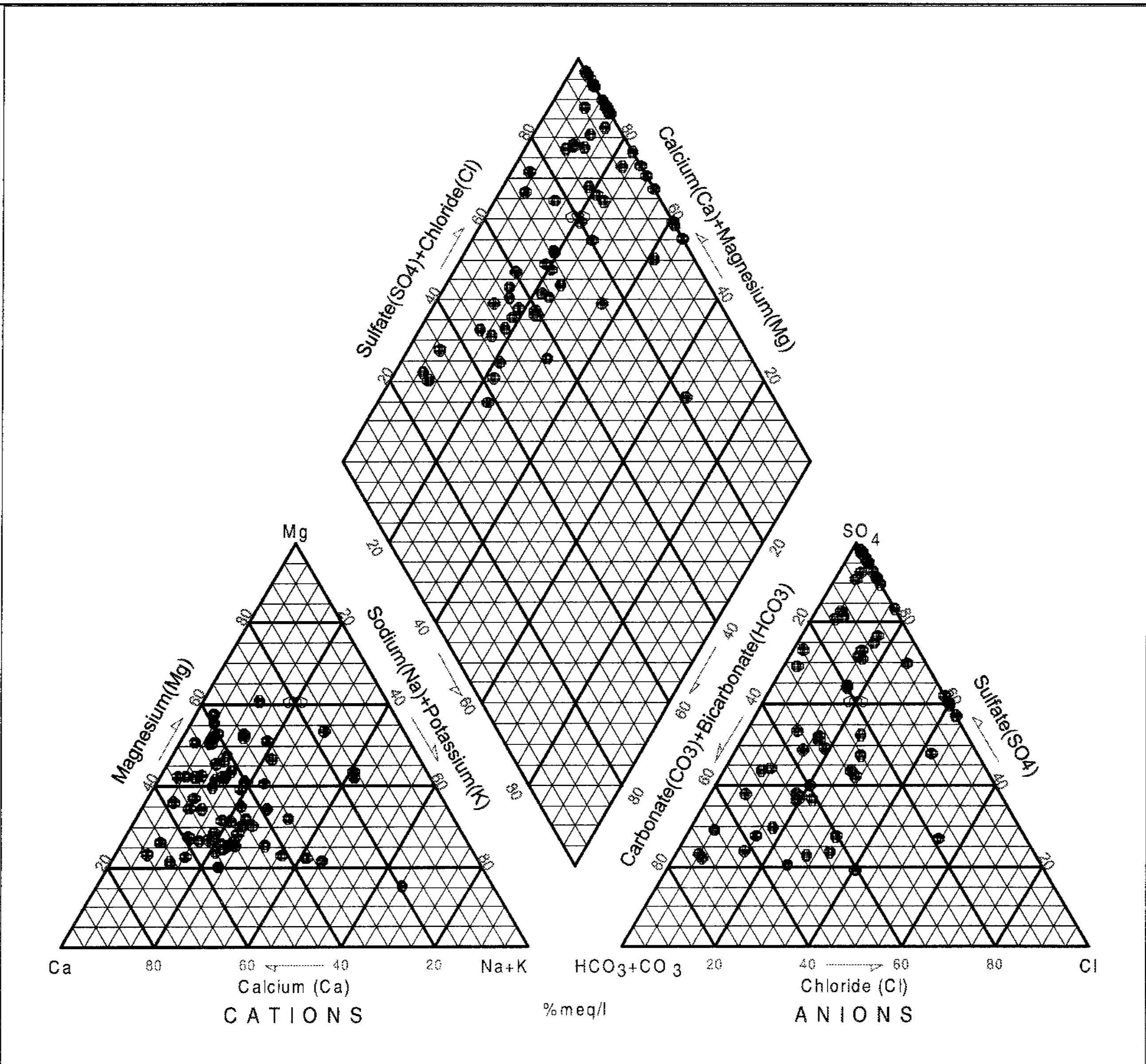

Figure 31. Piper diagram of major cations and anions from samples collected from surface water of Perry County.

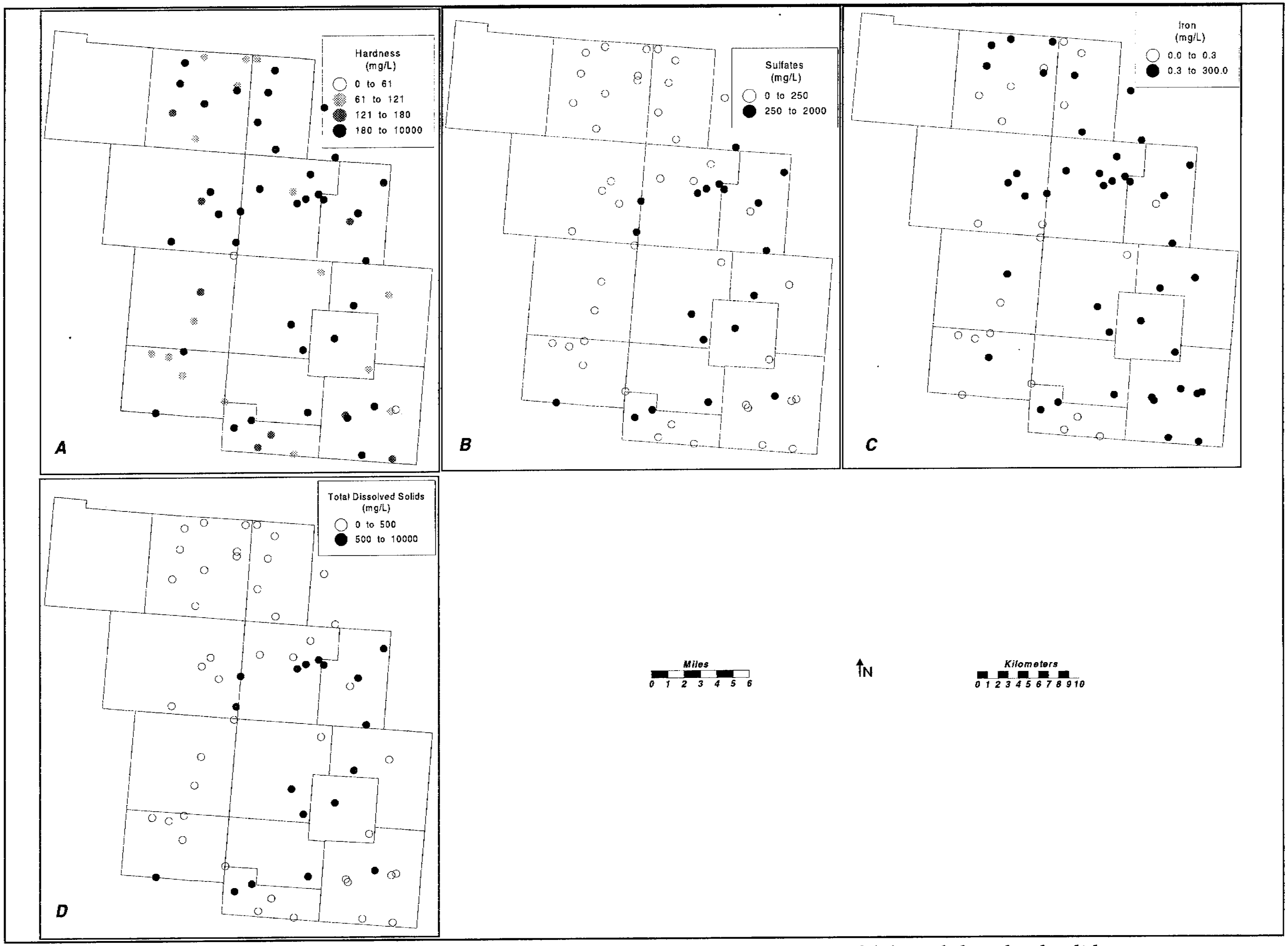

Figure 32. Spatial variability in surface waters for (A) hardness (B) sulfate (C) iron, and (D) total dissolved solids.

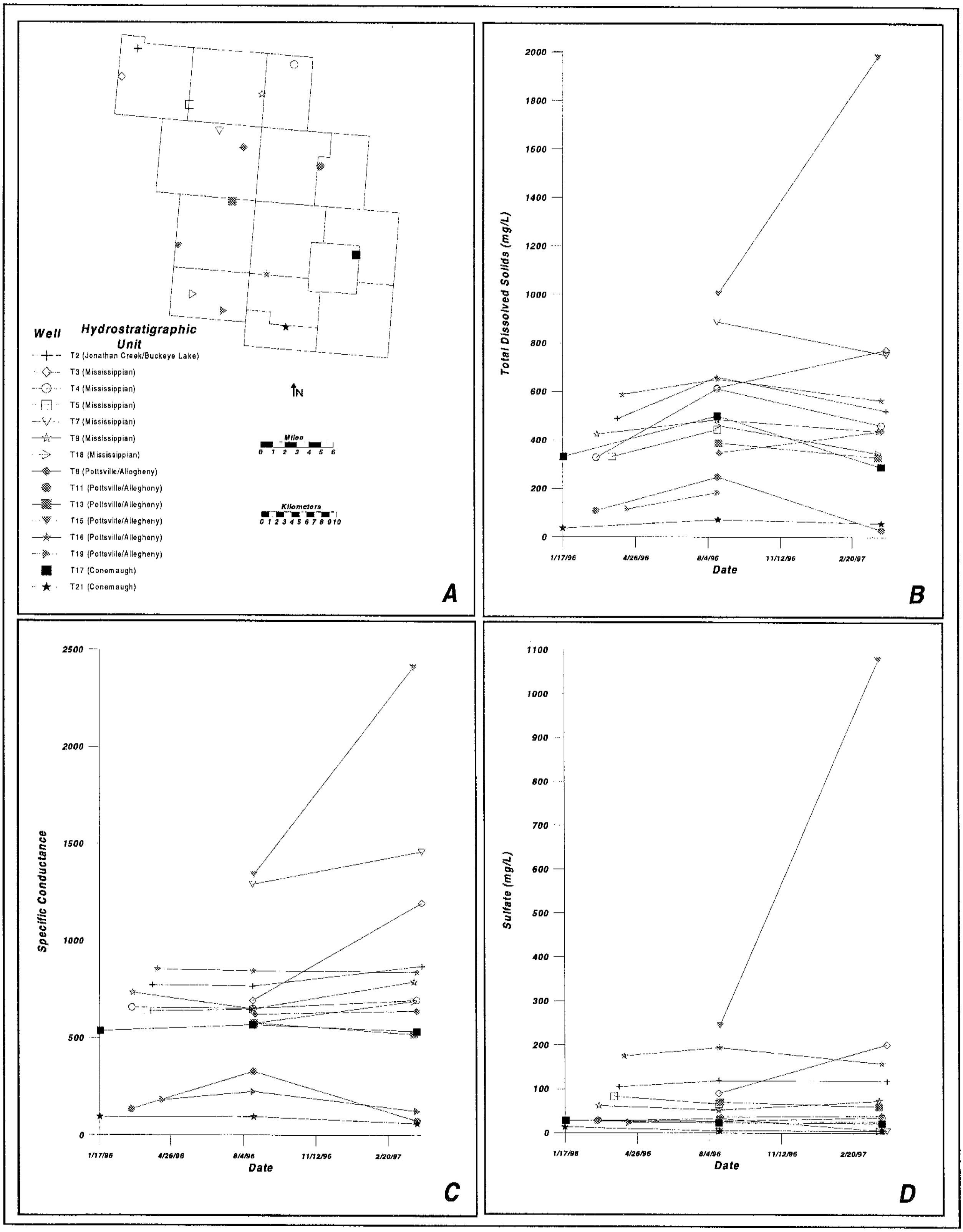

Figure 33. Temporal variations in ground water quality of Perry County: (A) location map of samples, (B) total dissolved solids, (C) specific conductance, and (D) sulfate.

Figures 33b shows the concentration of TDS (in mg/L) versus time. Most wells show very little variation except for well T15. Well T15 increased approximately 1000 mg/L from August 1996 to March 1997. Well T15 is shallow (44 feet deep) and completed in the Pottsville-Allegheny hydrostratigraphic unit. Well T8, which is also shallow (56 feet deep) and completed in the Pottsville-Allegheny hydrostratigraphic unit, shows a moderate increase for the same period. Well T3 also shows a moderate increase for the same period. Well T3 is completed in the Mississipian undivided and is 150 feet deep. Wells T17 and T11 show decreases in TDS for the same period. These wells are completed in the Conemaugh and the Pottsville Allegheny, respectively. Well T17 is 93 feet deep and Well T11 is 57 feet deep.

Figures 33c shows specific conductance versus time. Wells T15 and T3 show the greatest increase. Well T11 shows the greatest decrease. Specific conductance of the other wells remained fairly constant over time.

Figure 33d depicts the concentration of sulfate (in mg/L) versus time. Once again, Well T15 and T3 show the greatest increase while the other wells show very little variation in sulfate over time.

Figures 34a, 34b, and 34c show the concentrations of magnesium, calcium, and hardness versus time, respectively. Wells T15 and T3 show the greatest variations in each of these parameters over time. Well T11 exhibits considerable variation in calcium. Magnesium, calcium, and hardness in most of the wells remained fairly constant over time.

Figure 34d depicts the concentration of bicarbonate versus time. Many wells show variations in bicarbonate with time. The most notable variation is in Well T8. Well T8 decreased from 295 mg/L in August 1996 to 2.67 mg/L in March 1997.

Figure 35a shows the concentration of iron (in mg/L) versus time. Note that the concentration of iron in this figure has a logarithmic scale. Many wells showed variations in iron concentrations with time. Well T4 has the most variation. Well T4 is completed in the Mississippian undivided hydrostratigraphic unit and is 130 feet deep. From March 1996 to August 1996, the concentration of iron in Well T4 decreased form 2.54 to 0.02 mg/L. From August 1996 to March 1997, Well T4 increased from 0.02 to 0.04 mg/L.

Figure 35b depicts the concentration of potassium versus time. Many wells show a variation in potassium between sampling events. The greatest variation is in Wells T15 and T11.

Figure 35c shows the concentration of sodium versus time. Most wells show little variation. Well T13 shows the most variation between sampling events.

Figure 35d shows the concentration of chloride versus time. Wells T3, T4, T9, T15, T17, and T18 show the greatest variations between sampling events, while the other wells show very little variation in chloride over time.

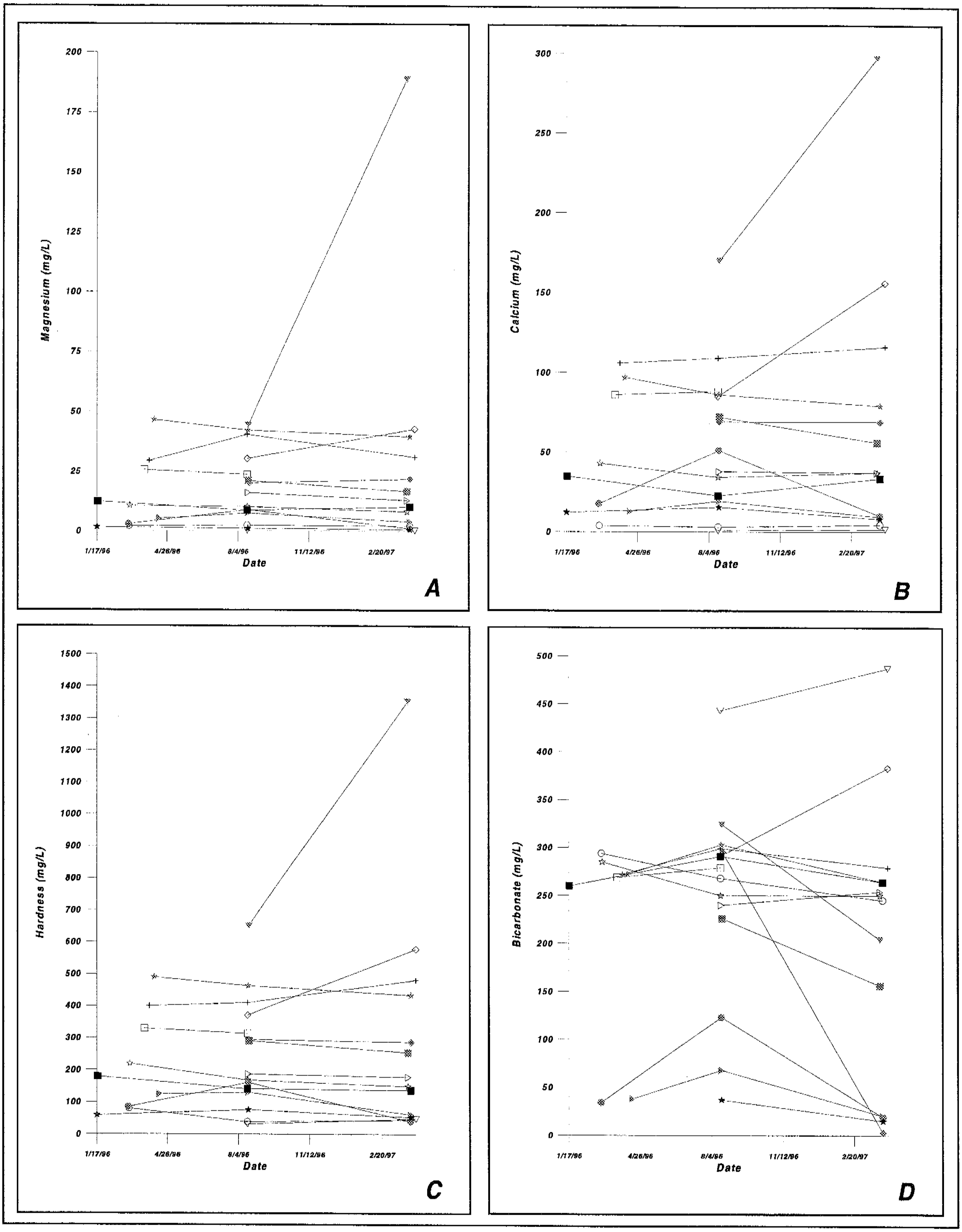

Figure 34. Temporal variations in ground water quality of Perry County: (A) magnesium, (B) calcium, (C) hardness, and (D) bicarbonate (Legend and locations are depicted on Figure 33a).

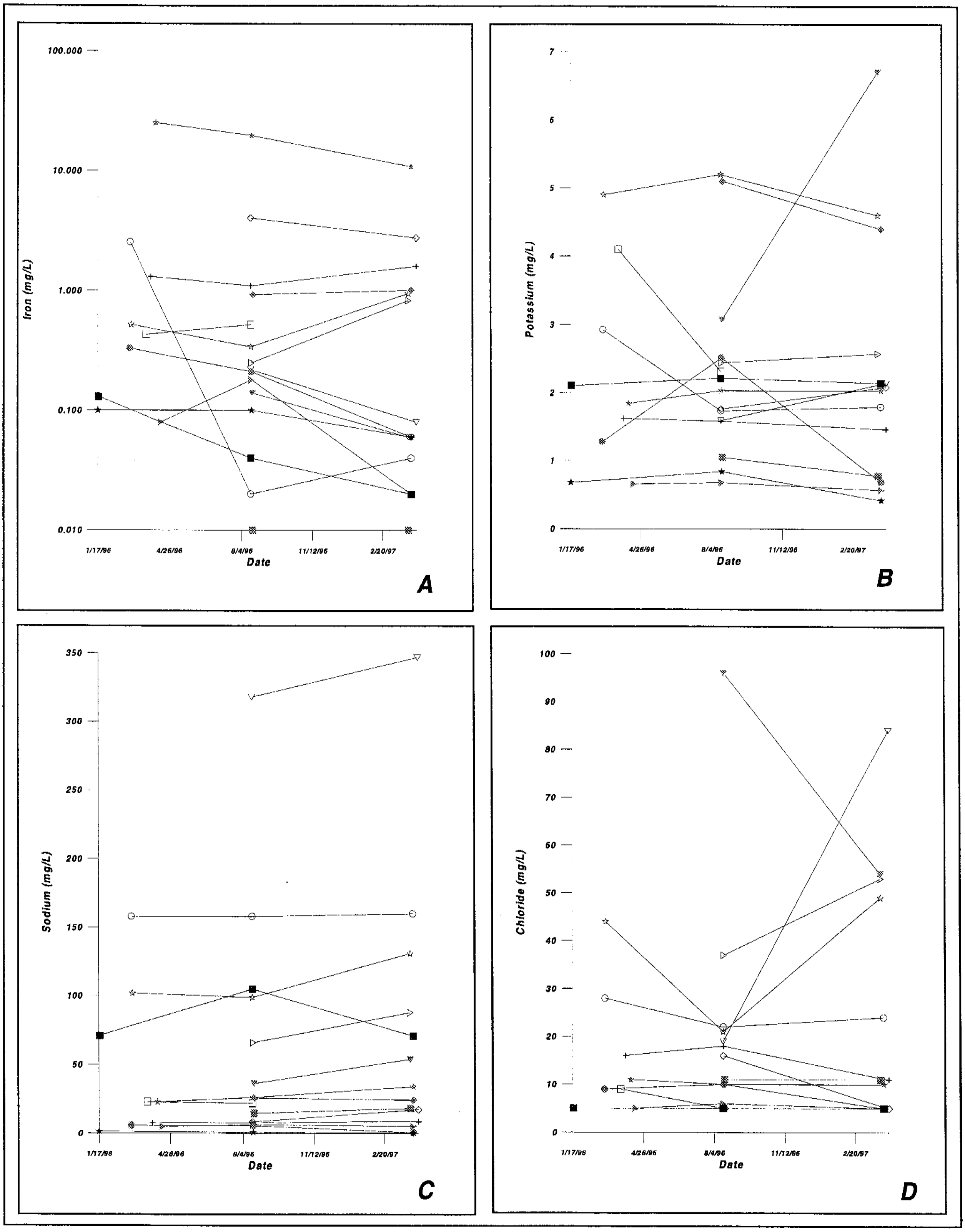

Figure 35. Temporal variations in ground water quality of Perry County: (A) iron, (B) potassium, (C) sodium, and (D) chloride (Legend and locations depicted on Figure 33a.).

Pesticides were found in very low concentrations in only a few samples. Most of the samples have levels below the detection limit of 0.05 parts per billion (μg/L) for triazine. None of the samples exceed the U.S. EPA recommended maximum contaminant level of 3 μg/L for triazine.

Surface Water

Seven surface-water sites were sampled to evaluate the temporal variations in water quality (Figure 36a). One sample (T1) is from Buckeye Lake. Four samples (T6, T10, T12, and T20) are from springs. Two samples (T14 and T22) are from streams.

Figures 36b, 36c, and 36d shows the concentration of TDS, specific conductance, and sulfate, respectively, versus time. The samples taken from streams, T14 and T22, show the greatest variability between sampling events. The other samples showed minimal variations of these parameters over time.

Figures 37a, 37b, and 37c show the concentrations of magnesium, calcium, and hardness versus time, respectively. T14 and T22 show the greatest variations between sampling events. The sample taken from Buckeye Lake (T1) is the only sample that shows an increase in concentrations of theses parameters from August 1996 to March 1997.

Figure 37d depicts the concentration of bicarbonate versus time. Most of the samples show a similar amount of variation between sampling events. T14 shows no variation in concentration between sampling events. This is probably due to the low pH of the samples from T14.

Figure 38a shows the concentration of iron (in mg/L) against time. T1 shows the greatest variation between sampling events. Most samples show minimal variation of iron between sampling events.

Figure 38b depicts the concentration of potassium versus time. The samples taken from streams, T14 and T22, show the greatest variability between sampling events. The other samples showed minimal variations.

Figure 38c shows the concentration of sodium versus time. T14 and T20 show the greatest variation of sodium between sampling events. The other samples show minimal variation between sampling events.

Figure 38d shows the concentration of chloride versus time. No sample shows a notable variation between sampling events. All samples show a decrease in concentration from the August 1996 sample to the March 1997 sample.

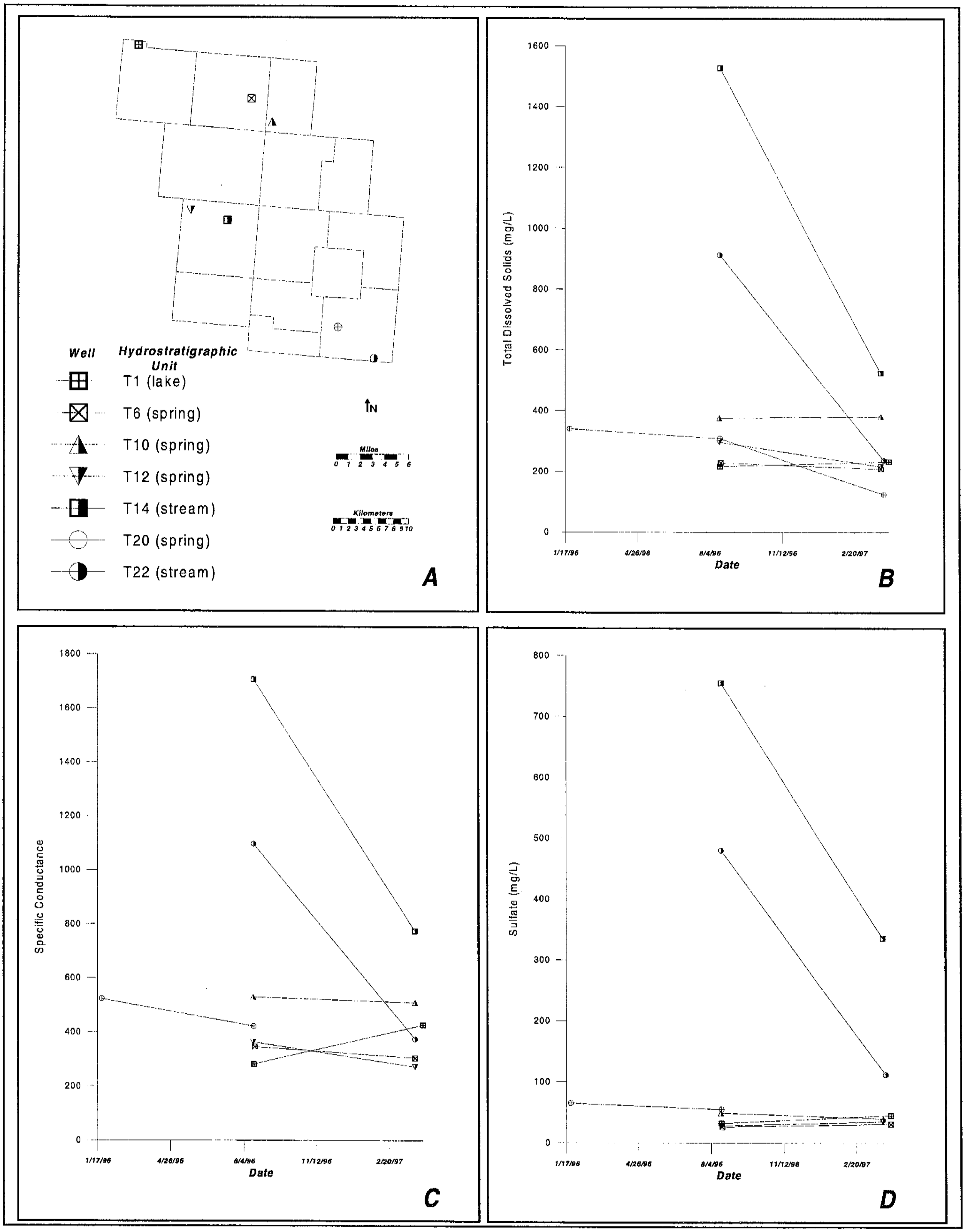

Figure 36. Temporal variations in surface-water quality of Perry County: (A) location map of samples (B) total dissolved solids, (C) specific conductance, and (D) sulfate.

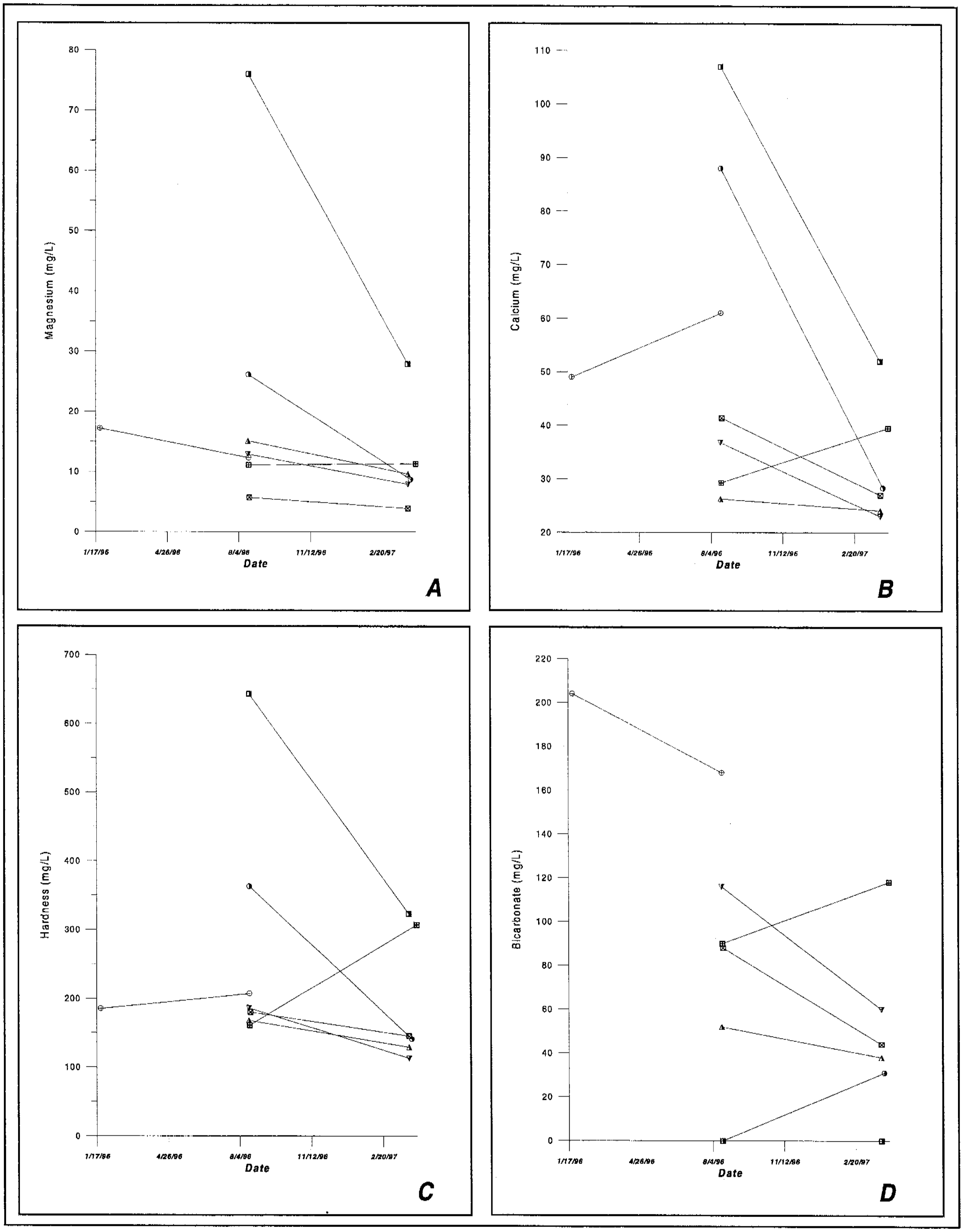

Figure 37. Temporal variations in surface-water quality of Perry County: (A) magnesium, (B) calcium, (C) hardness, and (D) bicarbonate (Legend and locations are depicted on Figure 36a).

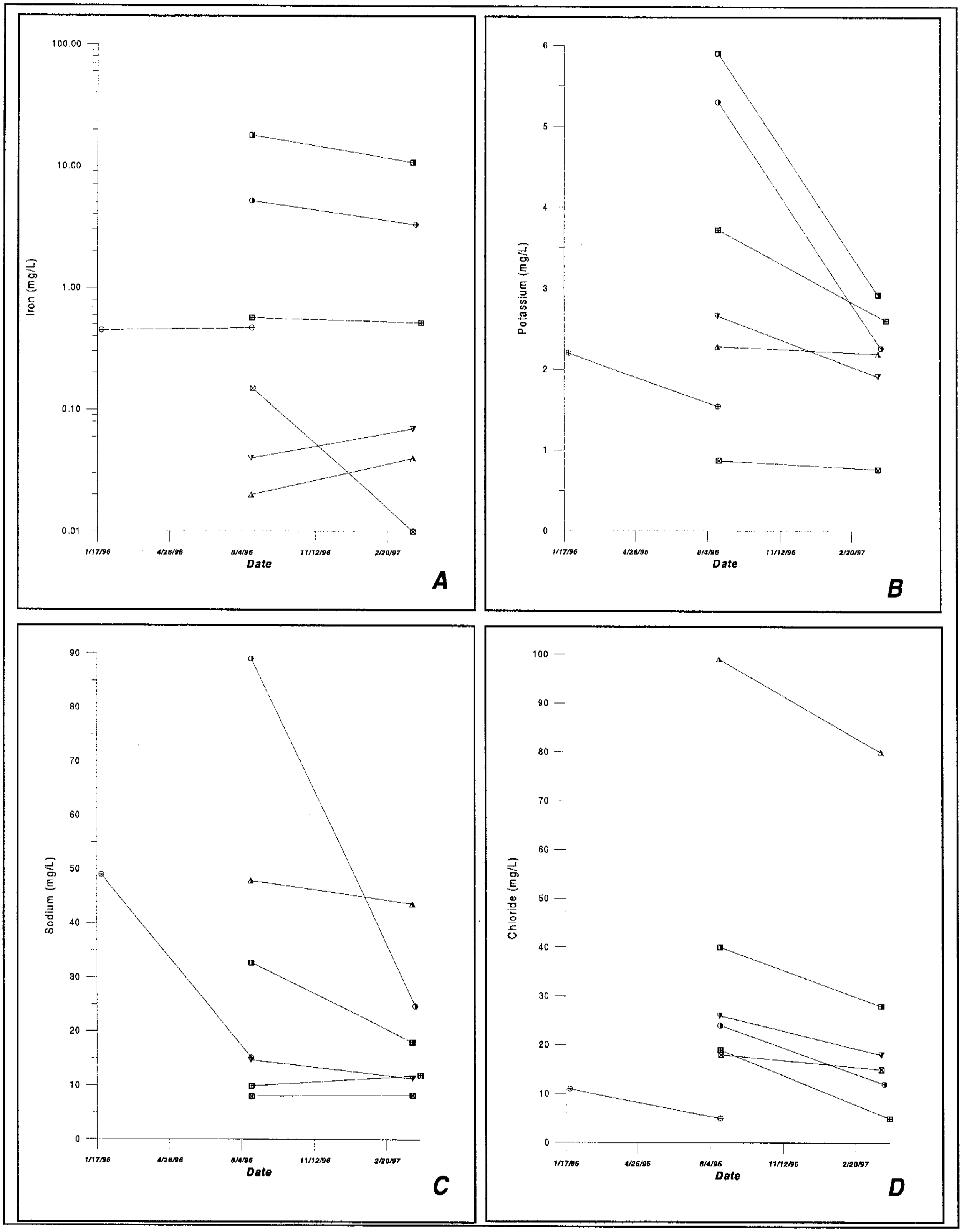

Figure 38. Temporal variations in surface-water quality of Perry County: (A) iron, (B) potassium, (C) sodium, and (D) chloride (Legend and locations are depicted on Figure 36a).

Only one surface-water sample (T1) exceeded the maximum concentration level of 3 µg/L for triazine. T1 had a level of 4.08 µg/L in August 1996. This level decreased to 0.52 µg/L in March 1997. The remaining samples have pesticides in very low concentrations. Most of the samples have levels below the detection limit of 0.05 parts per billion for triazine.

Fecal Coliform

The Perry County Health Department sampled 180 wells in 1995 to check for the potential presence of fecal coliform bacteria. Forty-six samples (25 percent) contained fecal coliform bacteria. The presence of fecal coliform and its spatial distribution in ground water can be attributed to several sources. Factors influencing the presence of fecal coliform include the proximity of wells to private septic systems and livestock farming. Improper well construction can allow bacteria to enter the well from the surface. Shallow wells and wells developed in highly permeable formations are generally more susceptible to contamination by fecal bacteria.

Summary

This report describes the hydrogeology and quality of the water resources of Perry County, Ohio. The hydrogeology was primarily evaluated by an interpretation of well log and drilling reports on file at the ODNR, Division of Water. Water quality was assessed by reviewing the analytical results from ground water and surface water samples obtained for this project. The ground water-producing formations of the county were divided into hydrostratigraphic units for regional comparison. The units studied in this report are the Mississippian undivided, Pottsville-Allegheny undivided, Conemaugh, Jonathan Creek-Buckeye Lake Buried Valley Aquifer, Moxahala Creek Buried Valley Aquifer, Little Rush Creek Buried Valley Aquifer, and Rush Creek Buried Valley Aquifer.

The Mississippian undivided hydrostratigraphic unit consists primarily of interbedded sandstones and shales. The Maxville Limestone is present in Hopewell and Sunday Creek Townships. The average well is 152 feet deep and has a specific capacity of 1.31 GPM/ft. Most of the wells in this unit are able to meet private water supply needs. Outcrop wells are usually more productive than subcrop wells. The most productive region appears to be near the Village of Thornville. Calcium bicarbonate is the most dominant ground water type. Most ground water from this unit is extremely hard.

The Pottsville-Allegheny hydrostratigraphic unit consists of interbedded sandstones, shales, coals, limestones, and clays. Secondary porosity (fractures) is the main source of water to wells developed in this unit. Well log records indicate that the average well in this unit is 85 feet deep and has a specific capacity of 0.68 GPM/ft. This corresponds to a good well potential. The most productive region appears to be in the vicinity of the northeast portion of Reading Township and east-central Jackson Township. This unit has a wide variety of ground water types. Calcium bicarbonate and calcium sulfate are most prevalent. Most ground water from this unit is extremely hard and likely exceed the U.S. EPA recommended level of 0.3 mg/L for iron.

The Conemaugh hydrostratigraphic unit consists of interbedded sandstones, shales, limestones, and clays. The average depth of wells completed in the Conemaugh is 78 feet. Specific capacity averages 0.28 GPM/ft. This is the lowest value for all hydrostratigraphic units in the county and corresponds to a fair domestic well potential. Calcium bicarbonate is the most dominant ground water type. Most of the ground water samples from this unit are extremely hard and exceed the U.S. EPA recommended maximum level for iron of 0.3 mg/L.

The Jonathan Creek-Buckeye Lake Buried Valley Aquifer consists of sand and gravel aquifers that are interbedded with clay and silts. The average well is 87 feet deep and has a specific capacity of 1.56 GPM/ft. Domestic well potential for this unit is excellent. Shallow wells (less than 65 feet deep) tend to be more productive than deeper wells. Calcium bicarbonate is the most dominant ground water type. All ground water samples from this unit were extremely hard and most exceed the U.S. EPA recommended maximum level for iron of 0.3 mg/L.

The Moxahala Creek Buried Valley Aquifer consists of sand and gravel. Three well logs indicate that the average depth of wells completed in this unit is 35 feet. The average specific capacity from these wells is 3.7 GPM/ft. The extent of this aquifer is extremely limited. Wells that do not encounter the sand and gravel of this unit are drilled deeper and completed in the underlying Pottsville-Allegheny hydrostratigraphic unit. The most productive area is near Roseville. Of the five samples from this unit, three are calcium sulfate-type ground water. Most of the ground water samples from this unit are hard and exceed the U.S. EPA recommended maximum level for iron of 0.3 mg/L.

The Little Rush Creek Buried Valley Aquifer is composed of sand and gravel interbedded with silt and clay. The average depth for wells completed in this unit is 93 feet, and the average specific capacity is 1.38 GPM/ft. All samples from the Little Rush Creek Buried Valley Aquifer (five) are calcium bicarbonate-type water. Most of the samples are hard and exceed the U.S. EPA recommended maximum level for iron of 0.3 mg/L.

The Rush Creek Buried Valley Aquifer is composed of sand and gravel interbedded with silt and clay. The average depth for six wells completed in this unit is 45 feet. and the average specific capacity is 1.47 GPM/ft. No ground water samples were collected from this unit for this investigation.

Surface-water samples were taken from springs, streams, and lakes. Surface water samples from the Jonathon Creek Basin are predominately calcium bicarbonate-type waters. Surface-water samples from Moxahala Creek Basin are predominately magnesium sulfate-type water. Surface-water samples from the Sunday Creek Basin are predominately calcium sulfate-type water. Most of the surface water samples are extremely hard and exceed the recommended limit of 0.3 mg/L of iron. Surface-water samples collected from the coal-mining region of the county contain high concentrations of sulfates and TDS.

Samples were collected to evaluate temporal changes in ground and surface waters. The most prominent changes in the ground- water quality over time were observed in a shallow well developed in the Pottsville-Allegheny hydrostratigraphic unit. Most variations in surface waters were observed in the samples collected from streams.

The Perry County Health Department sampled 180 wells in 1995 to check for the potential presence of fecal coliform bacteria. Forty-six samples (25 percent of the samples) contained fecal coliform bacteria.

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Appendix A: Water Sample Location Data

Sample ID refers to the project identification number of the sample. The ID consists of a identification prefix and a location number. The identification prefix refers to the hydrostratigraphic unit, surface water, or temporal sample from which the sample was collected. Locations are depicted on Plate 1. The prefix codes are as follows:

c	Conemaugh
m	Mississippian undivided
p	Pottsville-Allegheny undivided
jd	Jonathan Creek/Buckeye Lake Buried Valley Aquifer (deep)
js	Jonathan Creek/Buckeye Lake Buried Valley Aquifer (shallow)
lr	Little Rush Creek Buried Valley Aquifer
x	Moxahala Creek Buried Valley Aquifer
s	surface water
t	temporal sample (locations depicted on figures 33a and 36a)

Sample ID	Name	Address
c1	Hooper	5181 Marietta Rd SE
c2	McGiler	5825 Marietta Rd. SE
c3	Tacket	5985 Marietta Rd. SE
c4	Dearing	7460 Marietta Rd.
c5	Latta	1588 TR 195 NE
c6	Holcombs	1151 TR 197
c7	Weed	2675 SR 555 NE
c8	Pettet	1171 CR 66
c9	Trussell	1204 CR 66
c10	Hayes	720 CR 66
c11	Welsh	13815 SR 37 E
c12	Schooley	171 CR 22 NE
c13	Cuplar	2649 TR 197
c14	Chandler	3636 TR 423
c15	Samson	CR 16 RT 2
c16	Burill	CR 16 RT 2
c17	Taylor	3622 CR 16 RT 2
c18	Gary	3533 SR 555
c19	Ogen Corp	3624 CR 16 RT 2
c20	Bdyard	2880 TR 312
c21	Perami	11739 CR 12
c22	Bloomfield	11090 CR 12
c23	Lucas	6067 Bohemian Rd. RT 2
c24	Thomas	7397 TR 215A SE RT 2
c25	Ross	7899 TR 390 RT 2
c26	Morgan	PO Box 484 TR 392
c27	Brown	TR 298 RT 2
jd1	Flagg	10502 Honey Creek Rd.
jd2	Kasper	15188 SR 13
jd3	site #119	TR 88
jd4	Flas	8030 Blackbird
jd5	Kochensparger	CR 32
jd6	Lynn	11518 Ridenour Rd.
js1	Swisher	11643 Zartman Rd.
js2	West	10492 SR 204 NW

Sample ID	Name	Address
js3	Mechlying	5663 SR 204 NW
js4	Copperider	14794 George Ice Rd.
js5	Ellis	5502 TR 22
js6	Gower	10932 Gower Rd.
js7	Dawson	10575 Honey Creek Rd.
lr1	Reitler	9420 Ridenour Rd.
lr2	Bashore	9899 SR 13 NW
lr3	Rush Creek Golf Crs	TR 2 A
lr4	Wilson	7646 Rush Creek Rd.
lr5	Large	6625 Zion Rd.
m1	McVickers	12050 SR 204 NW
m2	Wyeth	11929 TR 82
m3	Boster	10839 High Point Rd.
m4	Toney	11001 TR 88
m5	Kromer	12435 Ridenour Rd.
m6	Daniels	11500 Ridenour Rd.
m7	Emmert	9430 High Point Rd.
m8	Lyons	13850 Zion Rd.
m9	Dobs	8885 SR 204
m10	Holland	8915 SR 204
m11	Duff	7345 TR 391
m12	Koob	7750 High Point Rd.
m13	Helser	7312 TR 87 NW
m14	Bendure	4938 High Point Rd.
m15	West	4928 CR 29
m16	Fischer	11245 Black Horse Rd.
m17	Orr	13294 CR 32
m18	Kafferberger	13833 Geo Ice Rd.
m19	Hanshaw	1347 TR 64
m20	Brumage	1910 Hopewell Indian Rd.
m21	Central Silica	Glassrock
m22	Rustlin Oaks	2150 Copperider Rd.
m23	Gower	10932 Gower Rd.
m24	Ours	10662 SR 668 N
m25	Corp	12289 SR 668 N

Sample ID	Name	Address
m26	Miller	3650 SR 204
m27	Milton	14916 Mt. Perry Rd.
m28	Kroft	Mt. Perry
m29	Savage	Kroft Rd.
m30	Toppls	13920 TR 58
m31	Smith	SR 204 4890
m32	Thompson	5325 Mt. Perry
m33	Darr	6540 Cimarron Rd.
m34	Byler	4587 CR 51
m35	Thompson	10435 Amish Ridge Rd.
m36	Graham	10420 Amish Ridge Rd.
m37	Owens	9660 TR 57
m38	Lyons	TR 45
m39	Mcglaughlin	6322 Rush Creek Rd.
m40	Meyers	8720 TR 36 NW
m41	Wilford	6333 Zoin Rd.
m42	Miller	6046 Zion Rd.
m43	Emmert	6015 Toll Gate Rd.
m44	Luning	3200 Green Branch Rd.
m45	O'Nail	2805 Old Somerset Rd.
m46	Owen	4750 Tile Plant Rd.
m47	Living World Church	3860 SR 37 W
m48	Gerren	2048 Flag Dale Rd.
m49	Coleman	3815 Marietta Rd.
m50	Herron	4181 Van Horn Rd.
m51	Garren	5875 TR 430
m52	Gregory	4266 TR 386 SW
m53	Helber	7644 SR 312
p1	Hershberger	13876 TR 64
p2	Rogers	13899 TR 64 NW
p3	Maxwell	15171 TR 30
p4	Rockwell	Cimarron Rd.
p5	Osborn	6349 Highpoint Rd.
p6	Leckrone	6192 Highpoint Rd.
p7	DuBall	10446 Zion Rd. NW

Sample ID	Name	Address
p8	Poorman	6929 Stone Quarry Rd.
p9	Massuros	9929 CR 27
p10	Fisher	3285 TR 70 NW
p11	Brown	8935 SR 757
p12	Waibel	9495 TR 68
p13	Lyle	3381 TR 40 NE
p14	Busse	3640TR 40
p15	Graham	10420 Amish Ridge Rd.
p16	Perry County Lumber	SR 22
p17	Hammer	7511 US 22 NE
p18	Cornwell	9910 TR 56 NE
p19	Catchell	9729 TR 56
p20	Kaisley	5470 Rush Creek Rd.
p21	Sagen	5207 CR 26
p22	Henderson	4955 Rush Creek Rd.
p23	Henderson	3098 SR 22
p24	Henderson	3098 SR 22
p25	Gibson	3392 SR 22
p26	Johnson	3738 Winegardner Rd.W
p27	Kemerer	5245 CR 62
p28	Martin	5589 SR 22
p29	Drettoe	4775 Stage Coach Rd.
p30	Miller	5755 TR 143
p31	Masterson	6852 SR 383 NE
p32	Masterson	6852 SR 383 NE
p33	Johnson	6552 SR 383 NE
p34	Dibari	6840 SR 13 NE
p35	Cannon	7805 Buckeye Valley Rd.
p36	Ruddle	7645 Buckeye Valley Rd.
p37	Kullman	744 Buckeye Valley Rd.
p38	Kessler	6815 Buckeye Valley Rd. S
p39	Williams	6256 Buckeye Valley Rd.
p40	Noll	3636 TR 121 NE
p41	Williams	6143 Buckeye Valley Rd.
p42	Embery	5570 Buckey Valley Rd. NE

Sample ID	Name	Address
p43	Severance	5565 TR 117
p44	Miller	5739 TR 45 NE
p45	Sheline	6390 Butcher Knife Rd.
p46	Harper	7850 Butcher Knife Rd.
p47	Goodall	8530 TR 441
p48	Cannon	7883 TR 114 NE
p49	Cannon	7728 TR 114 NE
p50	Hinkle	RT 2 SR 669
p51	Maynard	6618 A TR 154
p52	Nelson	8375 Main St. NE
p53	King	6170 SR 345 NE
p54	Smith	12222 CR 3
p55	Potts	12312 CR 3
p56	Jerry's Auto	12437 CR 3
p57	Desarro	Box 94 RT 2
p58	Thomas	11710 TR 167 NE
p59	Knight	TR 442
p60	Love	10990 TR 161 NE
p61	Wilson	12864 TR 325 NE
p62	Shearer	3680 Palomino Rd.
p63	Caudill	3132 TR 138
p64	Casto	3614 SR 668
p65	Severance Auto	4280 SR 668
p66	Miller	1710 TR 145
p67	Nutt	4660 TR 122 NW
p68	Wilson	5015 Old Summit Rd.
p69	Green	4760 Old Somerset Rd.
p70	Miller	4850 SR 13
p71	Foster	3663 TR 124 NE
p72	Foster	3663 TR 124 NE
p73	Garey	3767 CR 60
p74	Baker	3046 TR 126 NE
p75	Patterson	3255 Holden Dr.
p76	Woolfe	4550 Palmer Rd.
p77	Div ision of Forestry	SR 345

Sample ID	Name	Address
p78	Anderson	3982 SR 345
p79	Jorgenson	7832 CR 48
p80	Wooley	11210 CR 48
p81	Hailes	12037 Tunnel Hill Rd.
p82	Hammer	13241 SR 669
p83	Helwig	4350 Penn Rd.
p84	Keister	2591 Toll Gate Rd.
p85	Elekes	3225 Penn Rd.
p86	Lanier	1451 Garey Rd.
p87	Beach	2675 Garey Rd.
p88	Vanhorn	4390 SR 37 W
p89	Reed	2725 Old Somerset Rd.
p90	Cherry Auto Sales	SR 13
p91	Skilman	5740 Mainsville Rd.
p92	Kilekibager	5760 Mainsville Rd.
p93	Watto	5256 Marietta Rd.
p94	Leach	4036 TR 240
p95	Clark	3820 Marietta Rd.
p96	St. Patrick Church	1170 SR 668 S
p97	Householder	2622 Mainesville Rd.
p98	Mitchell	2569 Mainesville Rd.
p99	Fain	1506 TR 184
p100	Paxton	2955 TR 189
p101	Lee	R#1 TR 189
p102	Robinson	3365 SR668 S
p103	Morgan	SR 668 S
p104	Caton	2668 TR 184 SW
p105	Simpson	3171 SR 668 S
p106	Kunkler	2663 Marietta Rd.
p107	Perrin	2430 TR 131 SE
p108	Starner	2398 TR 131
p109	Shriner	3611 Marietta Rd. SE
p110	Reed	Marietta Rd.
p111	Lighthizer	2510 TR 128
p112	Hazlett	1982 TR 421

Sample ID	Name	Address
p113	Edwards	1600 Dutch Ridge Rd. SE
p114	Breece	2580 TR 213 SE
p115	Cinguepalmi	696 TR 217
p116	White	1089 SR 37
p117	Pickel	1751 SR 13
p118	Harris	2043 SR 13
p119	Miller	2029 CR 22
p120	Hinkle	1400 CR 22
p121	Heigley	8444 N SR 55 NW
p122	Brown	1147 TR 333
p123	Jones	5344 Dutch Ridge Rd. RT 1
p124	Jones	5502 Dutch Ridge RD. RT 1
p125	Heavener	TR 226
p126	Brainard	4171 TR 223
p127	Brainard	4171 TR 223
p128	Walker	6408 TR 235 SW
p129	Layne	4465 Griggs Rd.
p130	Caron	1493 TR 242
p131	Rogers	7984 TR 241
p132	Mohler	2605 TR 190
p133	Vincent	1473 TR 190
p134	Perdue	7786 TR 305
p135	Spring Box	TR 350
p136	Hoffecker	4340 TR 190
p137	Spring Box	Old Town Rd.
p138	Miller	TR 191B
p139	Miller	TR 191B
p140	Reed	6176 SR 93 RT 1
p141	McClain	6229 SR 93
p142	Jadwin	6918 Iron Point Rd.
p143	Dobson	TR 289 RT 2
p144	Buckeye Pipe Line	SR 13
p145	Brown	9125 Irish Ridge Rd.
s1	Gall	15008 Timber Rd.
s2	streams sample	CR 32

Sample ID	Name	Address
s3	stream sample	SR 240
s4	stream sample	SR 668
s5	stream sample	SR 668
s6	Caw	15001 TR 61
s7	Birchfield	15035 Mt. Perry Rd.
s8	Purkey	Gratiot Rd.
s9	stream sample	CR 34
s10	Heartwell	4444 TR 383
s11	Melinos	CR 51
s12	stream sample	TR 68
s13	Stream Sample	CR 60
s14	Somerset Reservoir	Big Tackle Rd. CR 45
s15	Stream Sample	SR 383 S
s16	Plasited	11150 Amish Ridge Rd.
s17	stream sample	jonathon creek
s18	stream sample	TR 49
s19	Stream Sample	TR 441
s20	Butcher Knife Creek	
s21	Turkey Run Creek	Sr 669
s22	Koehler	5685 Buckeye Valley Rd.
s23	Saxton	7480 SR 669
s24	Saxton	7480 SR 669
s25	Buckeye Creek	TR 154
s26	Buckeye Creek	TR 154
s27	Stream Sample	SR 669 & SR 345
s28	Hillside	TR 169
s29	Moxahala Creek	Roseville-Athens Rd.
s30	Moxahala Creek	Roseville-Athens Rd.
s31	stream sample	TR 161
s32	Goebel	36 N Buckeye
s33	Sawtelle	3661 Green Branch Rd.
s34	Metzger	2924 Green Branch Rd.
s35	Peters	1445 SR 668 S
s36	Manthenal	SR 93 RT 1
s37	Henry	

Sample ID	Name	Address
s38	Lockhart	4515 TR 430
s39	Syfert	1459 TR 333
s40	Syfert	1459 TR 333
s41	Harden	SR 668 S
s42	Harden	SR 668 S
s43	Ramond	1309 Bell Bottom Rd.
s44	Brown	3295 SR 668
s45	Humphrey	9425 210 TR NE
s46	Howard Williams Lake	TR 218
s47	stream sample	TR 215
s48	stream sample	SR 13
s49	Moxahala Creek	SR 93 NW
s50	stream sample	TR 323
s51	stream sample	TR 323
s52	Crooksville Reservoir	CR 22
s53	Strea,m Sample	SR 13
s54	monday creek	SR 668
s55	Stream Sample	Sulpher Spring Rd. & SR 155
s56	Stream Sample	CR 41
s57	Stream Sample	TR 427
s58	Stream Sample	TR 136 NW
s59	Strea,m Sample	TR 18
s60	Strea,m Sample	TR 18
s61	Stream Sample	SR 93
s62	Stream Sample	SR 155
s63	Stream Sample	Scenic Rd. CR 68
s64	Stream Sample	Cornstill Rd.
s65	Stream Sample	SR 13
s66	Strea,m Sample	CR 70
s67	Stream Sample	CR 70
s68	Stream Sample	CR 21& SR 13
t01	lake sample	10950 TR 500
t02	Dawson	10575 Honey Creek Rd.
t03	McCartney	11662 TR 390
t04	Strong	6538 Kroft Rd.

Sample ID	Name	Address
t05	Titten	10576 TR 26
t06	Carpenter	1179 TR 93
t07	Emmert	8455 SR 757 NW
t08	Wilson	2660 Wilson Rd.
t09	Smith	11973 TR 474
t10	Rhoades	4745 SR 22
t11	Freriks	9380 TR 169 NE
t12	Schrener	2209 Flagdale Rd.
t13	Gilligan	2245 Garey Rd.
t14	rush creek	SR 668
t15	Johnson	326 CR 15
t16	Blosser	4891 SR 93 SE A
t17	Weiner	12970 Porti -Flamingo Rd.
t18	Owings	4355 TR 386 SW
t19	Stephen	8111 TR 305 RT 1
t20	Arter	11473 SR 155 RT 1
t21	Williams	9181 Salem Hollow Rd.
t22	Stream Sample	CR 21
x1	Village of Roseville #2	451.5 Gardend St.
x2	Village of Roseville #3	451.5 Gardend St.
x3	Tolley TV Service	11445 Tunnel Hill Rd.
x4	Marlow	13207 SR 669
x5	Marolt	2463 SR 93 NE

Appendix B: Water Quality Data

Sample ID refers to the project identification number of the sample. The ID consists of a identification prefix and a location number. The identification prefix refers to the hydrostratigraphic unit, surface water, or temporal sample from which the sample was collected. Locations are depicted on Plate 1. The prefix codes are as follows:

c	Conemaugh
m	Mississippian undivided
p	Pottsville-Allegheny undivided
jd	Jonathan Creek/Buckeye Lake Buried Valley Aquifer (deep)
js	Jonathan Creek/Buckeye Lake Buried Valley Aquifer (shallow)
lr	Little Rush Creek Buried Valley Aquifer
x	Moxahala Creek Buried Valley Aquifer
s	surface water
t	temporal sample (locations depicted on figures 33a and 36a)

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
c1	4/18/96	7.04	236	0	524	316	45	5	40.8	37.4	17.4	1.67	0	287	Mg(HCO3)2	48.8	
c2	8/21/96	7.17	200	0	1080	848	381	33	118	68	62	3.75	1.13	494	CaSO4	60	20
c3	8/21/96	7.89	56	0	217	120	35	10	19.9	5.3	17.3	2.01	0	92	Ca(HCO3)2	96	32
c4	9/17/96	6.31	115	0	377	228	38	24	48	9.2	15	1.02	0	182	Ca(HCO3)2	90	45
c5	9/9/96	6.58	71	0	495	300	95	20	45	10.8	17	1.19	10.3	197	CaSO4	36	
c6	9/10/96	7.32	177	0	625	416	65	15	75	9.8	22.8	5.3	2.57	275	Ca(HCO3)2	32	
c7	9/10/96	7.22	193	0	536	296	60	10	57	21.1	17.9	1.14	0.16	252	Ca(HCO3)2	35	35
c8	9/10/96	7.28	221	0	560	272	37	21	41.9	21.9	37	1.34	0	224	Ca(HCO3)2	96	98
c9	9/10/96	7.31	209	0	524	304	41	14	406	16.7	40.5	1.11	0.12	224	Ca(HCO3)2	50	52
c10	9/10/96	7.35	189	0	385	228	23	5	37.7	13.9	21.2	0.86	1.77	182	Ca(HCO3)2	79	29
c11	9/11/96	6.45	70	0	257	160	39	5	22.5	7.2	7.3	2.28	0.46	129	Ca(HCO3)2		
c12	9/10/96	7.3	230	0	367	216	45	12	52	5.2	6.4	1.48	50	182	Fe(HCO3)2	43	
c13	9/17/96	7.75	238	0	584	368	56	9	10.2	3.3	118	1.81	0	17	NaHCO3	50	21
c14	9/17/96	7.79	500	0	1217	784	139	24	13.8	4.2	270	3.5	0.21	91	NaHCO3	75	
c15	1/18/96	7.21	468	0	909	548	39	13	66	20	123	1.9	1.01	365	NaHCO3		
c16	1/17/96	6.89	280	0	847	868	160	15	87	33.2	35.1	2.31	0.94	450	Ca(HCO3)2	54	55
c17	1/17/96	6.95	264	0	613	344	47	8	52	23.7	40.4	1.82	0	285	Ca(HCO3)2	88	100
c18	1/17/96	7	260	0	1035	668	115	119	97	26.2	100	2.1	84	445	Ca(HCO3)2	80	80
c19	1/17/96	7	196	0	559	308	64	5	43.7	24.3	31.3	1.4	0.26	255	Ca(HCO3)2	52.2	50

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
c20	9/18/96	6.3	30	0	317	240	35	25	26	7.6	10.7	3.5	0.36	127	CaSO4	47	
c21	9/18/96	6.2	29	0	140	112	35	5	21	2.9	5.1	2.7	0.5	77	CaSO4	24	24
c22	9/18/96	6.95	246	0	569	384	58	8	84	18.2	9.6	2.4	2.37	323	Ca(HCO3)2	24	24
c23	1/18/96	6.7	192	0	718	468	165	37	81	30.3	23	1.9	0.58	360	CaSO4	75	22
c24	1/17/96	6.59	48	0	275	188	70	17	18.9	11.9	10.7	2.27	2.09	125	MgSO4	93	
c25	1/18/96	6.83	276	0	866	508	210	20	74	33.8	75	2.8	0.91	385	Ca(HCO3)2	65	
c26	1/17/96	6.92	296	0	740	368	65	19	33.3	19.1	100	3.03	0.21	215	NaHCO3	100	
c27	1/24/96	7.14	101	0	698	460	32	146	62	39.5	20.3	2	0.1	310	Mg(Cl)2	41	
m1	8/28/96	7.3	332	0	1222	856	208	39	0	0.1	273	0.54	0.17	23	NaHCO3	120	109
m2	8/27/96	7.5	385	0	770	460	66	5	96	28.3	32.1	2.22	1.75	360	Ca(HCO3)2	169	167
m3	8/27/96	7.2	240	0	607	500	5	12	85	3.03	5.9	1.19	0.13	352	Ca(HCO3)2	59	41
m4	8/27/96	7.2	195	0	510	420	47	13	69	19.8	4.29	0.8	0.82	268	Ca(HCO3)2	65	57
m5	8/28/96	7.2	373	0	863	652	108	7	115	41.5	7.9	1.92	1.76	490	Ca(HCO3)2	82	77
m6	8/28/96	7.2	445	0	951	692	128	5	127	43.5	12.1	2.49	0.1	532	Ca(HCO3)2	175	170
m7	8/27/96	7.4	402	0	851	564	93	5	107	37.1	14.6	2.33	0.45	432	Ca(HCO3)2	110	90
m8	8/28/96	7.5	312	0	649	424	53	5	0	0	153	0.17	0.12	23	NaHCO3	150	141
m9	4/10/96	7.17	313	0	1559	784	10	284	84	21.4	212	3.39	1.97	315	NaCl		
m10	4/8/96	7.07	322	0	602	304	5	5	82	22.7	13.4	2.19	3.96	310	Ca(HCO3)2	84	
m11	3/13/96	7.1	258	0	499	276	5	7	50	19.5	27.1	1.95	0	265	Ca(HCO3)2	110	

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
m12	6/19/96	7.32	275	0	679	408	17	50	76	25.4	10.6	2.28	0.51	370	Ca(HCO3)2	54	
m13	5/14/96	7.06	298	0	806	560	133	18	106	31.9	9.9	3.3	0	480	Ca(HCO3)2	108	80
m14	4/8/96	8.39	356	55	787	428	8	6	6.2	2.56	187	2.26	0	80	NaHCO3		
m15	4/8/96	6.91	202	0	481	264	25	8	72	11.8	4.46	1.43	0	280	Ca(HCO3)2	106	
m16	4/8/96	7.03	265	0	673	352	375	29	70	53	55	20.3	21.5	290	MgSO4	64	
m17	3/14/96	6.99	187	0	1520	256	44	5	55	20.8	5.6	1.62	1.3	245	Ca(HCO3)2	51	
m18	3/18/96	7.55	318	0	914	276	5	105	17.1	5.7	192	4.44	5.4	185	NaHCO3	190	
m19	3/13/96	6.5	99	0	867	640	45	193	69	26.7	58	2.12	0	315	Ca(Cl)2	455	
m20	3/19/96	7.12	197	0	364	232	7	5	45.3	15.6	11.3	2.59	7	210	Ca(HCO3)2	295	
m21	3/18/96	7.22	239	0	477	516	5	8	33.4	14.1	50	4.5	2.29	235	NaHCO3	56	
m22	4/4/96	7.7	364	0	880	504	5	66	24.3	10.4	162	3.21	0.58	160	NaHCO3	189	
m23	3/18/96	7.24	252	0	492	296	5	5	35.3	17.2	45	2.65	1.73	210	NaHCO3	76	76
m24	3/18/96	7.91	464	0	1534	848	12	225	3.3	1.02	390	2.89	0.1	130	NaHCO3		
m25	3/13/96	6.4	70	0	413	300	114	21	39	16.6	5	3.15	1.22	350	CaSO4		
m26	4/8/96	7.01	166	0	374	180	15	5	33.8	10.4	23.6	2.61	0.49	160	Ca(HCO3)2	56	
m27	3/11/96	5.83	74	0	288	194	35	14	27.3	13.2	7.4	1.75	0.54	205	Ca(HCO3)2	47	30
m28	3/11/96	6.76	277	0	743	420	182	9	0.67	0.17	209	0.67	0.53	55	NaHCO3	250	100
m29	3/12/96	7.8	445	0	2720	1368	5	648	5.2	1.7	590	6.4	0.1	65	NaCl	310	
m30	3/5/96	7.71	277	0	2790	1640	60	697	8.2	3.7	600	3.92	0.47	135	NaCl	400	80

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
m31	3/6/96	6.55	198	0	760	476	60	73	92	14	39.4	4.47	0	410	Ca(HCO3)2	316	
m32	3/12/96	7.8	254	0	654	364	38	38	4.7	2.4	156	3.56	1.35	120	NaHCO3	186	180
m33	3/12/96	7.85	390	0	1480	772	5	251	4.2	1.3	278	3.95	0.1	130	NaCl	228	
m34	3/6/96	7.49	319	0	1682	912	33	330	5.7	2.5	363	3.32	0.11	85	NaCl	360	165
m35	3/5/96	7.91	327	0	1933	1080	21	404	4.84	2.7	403	3.41	0.1	85	NaCl	400	200
m36	3/5/96	7.49	312	0	7220	3948	35	2340	32.6	16.4	1550	8.6	0.12	260	NaCl	400	230
m37	3/6/96	7	317	0	1296	864	298	68	106	35.6	133	7.9	0.48	520	Na2(SO4)	121	27
m38	3/12/96	6.9	287	0	1248	916	325	20	147	45.6	75	8.7	0.18	645	CaSO4	109.2	
m39	9/4/96	7.92	402	0	1345	1304	53	137	14.7	5.1	262	3.12	0.39	84	NaHCO3	107	
m40	5/9/96	7.23	185	0	536	320	100	5	82	12.3	5.9	1.42	2.71	295	Ca(HCO3)2	63	31
m41	5/14/96	7.17	206	0	508	276	40	19	75	12.6	8.1	1.74	0.1	245	Ca(HCO3)2	60	28
m42	9/4/96	8.79	439	156	1567	984	5	128	2.68	0.99	336	2.3	0.1	34	NaHCO3	335	95
m43	5/16/96	6.86	160	0	546	272	50	55	41.1	15.6	39.7	1.79	21.9	185	Ca(HCO3)2	149	29
m44	6/12/96	6.71	43	0	195	96	34	9	11.9	6	4.8	1.78	3.27	160	CaSO4	97	100
m45	8/13/96	8	438	0	1380	832	21	113	2.07	0.48	294	4.05	0	264	Ca(HCO3)2	320	125
m46	9/9/96	7.29	242	0	745	352	60	51	55	19.6	53	2.4	0.81	264	Ca(HCO3)2	84	70
m47	6/21/96	7.33	292	0	742	392	5	63	14.6	7	147	4.36	0.24	103	NaHCO3	166	56
m48	9/23/96	6.8	256	0	761	480	86	37	83	31.4	36.3	2.46	0.41	348	Ca(HCO3)2	35	19
m49	9/23/96	6.3	176	0	689	472	131	36	80	27.2	33.8	4.77	1.12	305	Ca(HCO3)2	175	100

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
m50	9/24/96	6.75	211	0	539	288	27	30	53	17.3	40.6	2.69	0.1	220	Ca(HCO3)2	257	80
m51	5/14/96	7.31	188	0	444	232	37	22	47.1	13.9	18.7	2.69	0.43	205	Ca(HCO3)2	190	26
m52	4/24/96	7.22	263	0	725	328	5	80	54	19.2	66	2.78	0.23	240	NaHCO3	400	125
m53	4/18/96	7.65	250	0	439	288	6	5	21.8	8.6	67	2.35	0.39	146	NaHCO3	172	172
p1	3/13/96	6.6	118	0	490	284	72	22	40	20.3	10.8	4.3	1.69	285	Ca(HCO3)2	91	
p2	3/18/96	6.79	239	0	802	504	125	26	119	26.3	12.3	4.17	0.1	435	Ca(HCO3)2	82	
p3	3/11/96	6.64	224	0	602	420	165	10	100	20.6	12.1	3.6	0.65	370	Ca(HCO3)2	127	25
p4	3/12/96	6.7	110	0	392	160	41	29	39.1	15.2	15.7	2.65	0.1	255	Ca(HCO3)2	50	
p5	5/9/96	7	193	0	491	276	45	15	63	14.3	10.8	1.63	4.32	230	Ca(HCO3)2	60	43
p6	5/9/96	7	152	0	402	256	45	5	55	10.3	7.9	1.29	0.13	210	Ca(HCO3)2	53	35
p7	5/14/96	7.09	278	0	722	400	94	15	72	17.9	56	7	3.93	260	Ca(HCO3)2	93	59
p8	4/4/96	6.96	313	0	679	408	70	5	89	40.8	7.3	1.95	0.19	365	Ca(HCO3)2	111	
p9	4/3/96	7.19	254	0	783	468	178	7	122	33.6	9.9	2.21	0	475	Ca(HCO3)2	88	
p10	3/19/96	7.01	140	0	357	22	76	13	36.2	19.1	9.6	2.31	0.29	165	Ca(HCO3)2	60.9	60
p11	3/19/96	7.03	204	0	500	320	59	11	70	24.3	7.1	1.84	3.82	345	Ca(HCO3)2	75.6	
p12	4/8/96	6.19	110	0	432	256	90	5	38.8	12.9	11.5	3.58	0.98	208	CaSO4	72	
p13	3/18/96	6.72	186	0	446	300	34	5	75	5.7	6.2	0.88	0	280	Ca(HCO3)2	110	
p14	3/18/96	6.19	37	0	323	204	49	26	22.1	11.7	12.6	3.33	0.1	200	CaSO4	107.2	
p15	3/5/96	7	243	0	656	464	91	12	75	28.4	21	4.18	0.44	405	Ca(HCO3)2	49	20

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
p16	3/5/96	7.33	251	0	541	420	5	23	21.9	9.1	87	5.2	0.1	125	NaHCO3	61	27
p17	3/11/96	6.17	29	0	288	196	40	19	20.1	6.8	12.4	1.92	0.12	130	CaSO4		
p18	3/5/96	6.9	87	0	619	400	125	10	0.1	0.1	120	0.54	0.72	13	Na2(SO4)	44.5	
p19	3/6/96	4.53	0	0	561	416	225	23	39	19.5	13	2.19	1.59	305	CaSO4		
p20	9/4/96	6.99	193	0	560	464	83	8	69	19.2	9.9	0.82	0.1	298	Ca(HCO3)2	47	35
p21	9/4/96	7.19	223	0	814	824	137	30	111	28.9	12.4	3.37	0.16	398	Ca(HCO3)2	90	80
p22	5/16/96	7.23	267	0	1048	708	245	20	114	47.7	53	6.2	2.38	520	CaSO4	100	50
p23	3/13/96	6.6	202	0	761	496	181	11	114	27	12.2	2.35	3.53	565	CaSO4	86.4	
p24	3/13/96	6.6	276	0	761	684	203	29	131	43.8	15.6	3.66	10.8	565	Ca(HCO3)2	46	
p25	3/13/96	7.4	283	0	721	412	35	47	0.21	0.1	184	1.57	0.26	4	NaHCO3	33.5	29
p26	5/14/96	6.54	99	0	360	256	51	10	32.7	11.4	9.7	1.75	1.62	150	Ca(HCO3)2	70	41
p27	9/4/96	6.91	264	0	841	176	183	6	94	39.4	34.9	4.77	4.48	360	Ca(HCO3)2	55	40
p28	9/5/96	6.6	127	0	737	596	42	104	72	16.6	35.1	0.75	0.1	256	Ca(Cl)2	35	24
p29	9/5/96	7.18	230	0	548	360	36	12	71	16.7	9.7	3.23	0.22	298	Ca(HCO3)2	90	90
p30	9/9/96	6.81	191	0	524	288	65	7	77	13.7	6.3	2.08	1.03	272	Ca(HCO3)2	38	
p31	5/23/96	6.62	53	0	791	552	188	107	53	28.7	55	2.86	0	268	CaSO4	27	
p32	5/23/96	6.51	297	0	1032	780	238	92	139	34.9	16.3	3.88	2.48	520	CaSO4	60	60
p33	9/4/96	7.6	283	0	559	440	5	8	23.3	9.7	79	4.83	0.12	149	NaHCO3	100	
p34	9/5/96	7.39	254	0	749	772	145	11	87	33.2	21.3	1.94	0.1	379	Ca(HCO3)2	140	

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
p35	3/12/96	6.5	33	0	741	592	56	158	56	22.8	44	3.49	0.1	300	Ca(Cl)2	116	115
p36	6/6/96	7.2	258	0	600	376	35	5	31.2	11.6	79	5.4	0.81	160	NaHCO3	115.5	39
p37	3/12/96	6.6	13	0	477	324	140	16	55	1.78	11.4	2.21	0	290	CaSO4	60	34
p38	3/12/96	6.9	269	0	670	412	75	5	80	24.6	30.2	4.1	2.47	395	Ca(HCO3)2	122.1	
p39	3/13/96	6.3	129	0	1093	836	419	44	132	54	21.8	3.33	20.3	805	CaSO4	184.5	
p40	5/30/96	6.98	196	0	458	228	37	32	59	15.6	7.9	2.12	3.69	212	Ca(HCO3)2	75	43
p41	8/20/96	7.51	360	0	867	588	93	19	131	34.8	11.2	1.73	3.6	1526	Ca(HCO3)2	90	40
p42	8/21/96	6.98	139	0	987	820	393	5	136	49.4	16.9	1.96	22.9	536	CaSO4	98	98
p43	8/21/96	5.59	0	0	1471	1268	725	55	159	82	46.2	4.23	52	769	CaSO4	97	33
p44	3/11/96	5.12	0	0	3900	3876	2885	44	459	302	29.7	10	439	2505	MgSO4	78.2	60
p45	3/11/96	5.47	0	0	1942	1556	1225	14	267	119	18.9	5.4	78	1350	CaSO4	134	55
p46	3/11/96	6.33	167	0	835	556	260	6	96	56	14	2.4	0.12	530	CaSO4	79.2	
p47	3/6/96	6.86	118	0	666	504	239	13	70	29.7	18.5	2.04	10.4	415	CaSO4	60	
p48	3/11/96	6.41	148	0	548	360	122	10	72	19.9	23.4	3.28	0.15	300	CaSO4	150	
p49	3/11/96	6.26	228	0	1885	1532	955	5	311	122	30.5	2.09	0	1380	CaSO4	86	
p50	3/6/96	7.09	185	0	396	236	5	14	51	14.3	10.5	3.2	0.53	240	Ca(HCO3)2	45	20
p51	3/5/96	7.29	262	0	630	340	5	48	19.2	5	115	5.5	0.49	110	NaHCO3	67.6	
p52	3/5/96	7.19	224	0	671	432	140	43	89	17.9	23.3	3.4	4.38	360	Ca(HCO3)2	30	
p53	9/26/96	6.6	185	0	564	404	82	5	74	10.7	18.9	2.21	0.16	267	Ca(HCO3)2	15	

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
p54	9/25/96	7.01	152	0	351	184	27	5	36.3	8.7	15.9	1.6	7.5	179	Ca(HCO3)2	62	18
p55	9/23/96	6.55	217	0	1114	1444	428	5	134	69	25.5	2.02	0	608	CaSO4	71	73
p56	9/23/96	7.31	349	0	6870	3676	5	2000	53	23.1	1360	10.8	0.24	242	NaCl	65	49
p57	9/23/96	6.7	221	0	768	516	153	32	131	24.1	11.3	2.8	0.35	411	Ca(HCO3)2	16	16
p58	9/23/96	5.45	35	0	285	192	36	32	19.2	7.9	17.8	1.65	0.1	110	Ca(Cl)2	74	25
p59	9/23/96	6.49	158	0	414	232	51	10	41.1	17.6	19.5	1.92	0.93	212	Ca(HCO3)2	115	36
p60	9/23/96	5.9	37	0	400	352	153	5	35.2	20	8.1	1.19	0.52	195	CaSO4	24	24
p61	9/25/96	6.9	250	0	901	912	253	8	116	44.5	22.1	1.95	0	525	CaSO4	25	25
p62	6/4/96	6.3	118	0	1208	888	550	22	145	71	16.9	2.89	21.9	570	CaSO4	24.3	20
p63	6/12/96	6.74	104	0	623	372	83	89	57	19.1	26.3	1.57	2.42	275	Ca(Cl)2		42
p64	6/4/96	6.79	169	0	599	384	44	63	74	18.4	12.4	1.83	11	310	Ca(HCO3)2	40	38
p65	9/5/96	6.12	74	0	464	364	106	18	55	12.3	10.4	2.97	1.04	214	CaSO4	103	37
p66	5/30/96	6.4	158	0	585	364	125	32	71	19.3	15.3	4.01	4.26	268	CaSO4	144	108
p67	6/4/96	6.22	124	0	1519	892	385	95	0	0.1	311	0.23	0.13	3	Na2(SO4)	61	40
p68	6/4/96	6.02	59	0	534	352	130	35	61	14.5	14.6	5.9	2.62	240	CaSO4	110	52
p69	5/30/96	6.67	146	0	609	336	35	95	57	24.2	12.6	1.46	2.05	264	Ca(Cl)2	55	55
p70	6/4/96	7.03	215	0	551	336	85	5	62	20.4	15.8	1.73	0.57	320	Ca(HCO3)2	100	37
p71	5/30/96	5.85	25	0	299	188	60	37	23.1	9.1	6.5	4.54	6.4	130	CaSO4	90	23
p72	5/30/96	5.03	0	0	1624	1476	925	40	122	67	19.9	4.13	162	580	FeSO4	85.5	

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
p73	8/28/96	7.19	275	0	633	368	53	13	79	21.9	21.1	2.05	0	310	Ca(HCO3)2	110	25
p74	9/4/96	6.88	234	0	569	460	43	8	67	22	11.8	1.24	0.53	275	Ca(HCO3)2	95	40
p75	8/28/96	6.7	191	0	382	212	21	8	41.4	15.1	14.7	1.98	0	187	Ca(HCO3)2	102.5	107
p76	9/4/96	3.32	0	0	447	352	143	5	9.1	8.6	5.9	1.4	8.9	138	MgSO4	80.7	26
p77	8/14/96	6.8	111	0	2440	2680	1430	70	297	114	117	9.8	0.24	3936	CaSO4	180	121
p78	9/5/96	3.52	0	0	519	564	148	23	23.6	16.3	10.6	2.15	2.94	191	MgSO4	13.3	14
p79	9/26/96	5.3	10	0	166	140	47	5	7.3	7.2	4.2	1.19	1.01	76	MgSO4	26	26
p80	9/24/96	7.35	314	0	930	612	137	27	26.3	10.8	175	3.5	0.11	106	NaHCO3	73	42
p81	9/24/96	5.5	43	0	266	204	59	15	23.5	7.6	12.6	0.66	0.1	106	CaSO4	45	43
p82	9/24/96	7.02	158	0	318	192	5	5	35	10.5	15.1	1.85	1.58	148	Ca(HCO3)2	56	30
p83	8/5/96	6.25	147	0	987	1652	77	200	95	35.3	45.1	1.72	0.82	389	Ca(Cl)2	45	43
p84	6/21/96	6.22	16	0	186	148	46	11	9.4	8.1	6.7	1.19	0.1	84	MgSO4	101	
p85	8/5/96	6.09	69	0	368	308	67	22	28.6	15.9	9.7	2.98	0.31	161	CaSO4	84	48
p86	8/5/96	5.94	42	0	216	164	40	12	16.9	7.8	8.9	1.9	0	85	CaSO4	100	
p87	8/5/96	5.16	4	0	104	92	47	21	5.4	5.7	2.72	2.32	10.6	88	FeSO4	97	30
p88	8/15/96	6.65	40	0	216	212	31	9	13.9	9.2	5.1	2.44	0.1	241	Mg(HCO3)2	80	
p89	8/15/96	6.52	201	0	508	540	40	15	54	26.6	11.7	1.29	0.63	422	Ca(HCO3)2		76
p90	8/20/96	7.37	187	0	466	276	54	5	50	14.6	16.5	13.5	8.2	1266	Ca(HCO3)2	110	47
p91	8/21/96	7.62	215	0	538	348	79	5	80	23.2	8.3	1.81	2.46	314	Ca(HCO3)2	105	25

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
p92	8/21/96	7.37	238	0	536	352	125	8	65	17.4	16.8	3.26	45	318	Ca(HCO3)2	78	78
p93	7/31/96	6.51	196	0	512	352	53	13	68	14	16.9	3.37	0.12	356	Ca(HCO3)2	75	76
p94	7/31/96	6.6	129	0	560	416	125	18	57	19.7	24.9	3.63	12.1	568	CaSO4		32
p95	6/20/96	6.6	154	0	449	240	52	10	32.9	19.8	27.5	2.16	0.21	230	Ca(HCO3)2	100	25
p96	8/27/96	7.2	258	0	858	724	125	52	99	37.7	35.1	1.66	0.1	410	Ca(HCO3)2	60	24
p97	8/27/96	6.4	66	0	349	280	83	9	28.8	14.3	11.6	2.4	1.13	172	CaSO4	100	40
p98	8/27/96	7	189	0	437	312	47	9	57	21.8	7.3	2.31	0.89	214	Ca(HCO3)2	80	60
p99	9/23/96	5.1	14	0	226	168	47	19	10.8	8.3	11.9	0.95	0.13	81	MgSO4	28	28
p100	6/20/96	7.03	177	0	402	200	27	6	55	12.2	8	0.72	0.11	225	Ca(HCO3)2	77	77
p101	9/9/96	6.2	180	0	2370	2004	230	480	230	64	78	8.3	97	1024	Ca(Cl)2	60	35
p102	9/9/96	6.19	90	0	552	312	66	67	41.4	11.6	26.9	2.93	13.4	246	Ca(Cl)2	56	24
p103	5/16/96	7.76	261	0	910	496	5	139	27.8	8.2	151	5.1	0.62	125	NaHCO3	82	43
p104	5/16/96	7.08	186	0	492	304	62	6	51	14.1	11.4	2.76	20	215	Ca(HCO3)2	85	
p105	7/31/96	6.19	115	0	446	344	93	9	43.3	14.6	13.9	2.09	7.2	882	CaSO4	47	31
p106	9/24/96	6.9	289	0	916	656	199	16	136	35.9	23.8	3.34	0.61	496	Ca(HCO3)2	67	20
p107	9/24/96	5.9	68	0	1109	764	210	144	85	36.8	77	2.87	1.8	394	CaSO4	58	31
p108	9/24/96	5.95	70	0	514	356	80	50	42	19.3	25.9	1.99	0	195	CaSO4	150	
p109	4/18/96	5.78	33	0	300	192	60	20	20.4	7.1	25.5	1.74	0.39	137	Na2(SO4)	81.8	31
p110	4/18/96	6.22	26	0	185	152	42	6	9.6	8.1	9.5	1.28	1.39	78	MgSO4		18

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
p111	8/20/96	7	156	0	707	508	219	5	99	23.2	25.5	4.27	4.05	1670	CaSO4	200	34
p112	8/21/96	5.85	21	0	137	88	25	5	7.1	5.5	8.4	0.91	0.1	73	MgSO4	80	80
p113	8/15/96	6.5	83	0	352	420	77	8	23.7	15.7	14.5	1.36	1.35	400	MgSO4	46	16
p114	8/15/96	5.5	15	0	1640	2120	850	70	197	79	23.8	10.4	93	1820	CaSO4	138	140
p115	8/19/96	7.34	120	0	427	276	41	30	41.8	13.2	13	15.9	2.19	818	Ca(HCO3)2	95	
p116	9/11/96	8.01	111	0	2260	1516	878	6	26.9	7.5	429	4.73	0.39	136	Na2(SO4)	45	23
p117	9/11/96	7.75	319	0	1020	584	79	88	31.5	5.2	165	1.93	5.4	163	NaHCO3	70	31
p118	9/18/96	9.1	246	78	641	552	6	13	3.5	3.8	141	2.81	2.34	31	NaHCO3	60	60
p119	9/11/96	5.79	30	0	227	128	42	13	12.3	7.4	11.7	0.69	0.23	91	CaSO4	30	30
p120	9/11/96	8.2	363	29	739	432	5	5	1.7	0.34	185	2.43	0.1	45	NaHCO3	50	32
p121	9/10/96	6.81	191	0	591	336	40	33	77	13.8	17.5	0.84	0.3	272	Ca(HCO3)2	22	22
p122	4/18/96	7.31	335	0	887	544	70	24	41.5	12.9	134	6	0.11	190	NaHCO3	228	
p123	4/22/96	6.79	129	0	583	388	24	81	57	15.6	21.8	2.56	1.61	300	Ca(Cl)2	73	73
p124	4/22/96	6.95	99	0	424	324	11	59	35.7	8.7	16.5	1.96	0.16	215	Ca(Cl)2	86.3	86
p125	4/17/96	7.23	132	0	323	204	27	5	29.1	13.6	12.1	1.33	0.24	160	Ca(HCO3)2	99	
p126	9/17/96	6.86	131	0	973	608	344	5	0	0	211	0.63	0.1	8	Na2(SO4)	46	46
p127	9/17/96	7.5	281	0	665	408	35	37	24.8	8.1	119	4.1	1.64	106	NaHCO3	43	37
p128	4/18/96	6.71	195	0	794	596	75	56	85	34.5	11.9	1.95	2.77	473	Ca(HCO3)2	51.6	
p129	4/18/96	7.02	156	0	968	768	12	181	117	24	31.1	1.78	0.74	454	Ca(Cl)2	70	

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
p130	4/22/96	7.19	374	0	883	628	146	5	86	17.6	85	5.3	0.14	335	Ca(HCO3)2	123	
p131	4/22/96	7.25	265	0	649	480	65	5	65	13.3	57	4.77	0.11	240	Ca(HCO3)2	134	33
p132	4/23/96	6.66	318	0	1738	1180	160	254	134	105	62	5.8	1.52	875	Mg(Cl)2	80	40
p133	4/23/96	6.52	170	0	1377	1072	247	207	71	36.7	15.5	2.21	1.82	763	Ca(Cl)2	100	40
p134	4/23/96	7.19	253	0	656	384	80	5	34.3	12.8	86	3.29	0.31	250	NaHCO3	67	
p135	4/24/96	5.98	20	0	124	72	31	5	8.4	3.49	4.09	1.6	1.12	138	CaSO4		
p136	1/30/96	6.52	181	0	530	320	63	23	59	10.8	34.8	2.4	0.34	195	Ca(HCO3)2	62.2	20
p137	4/17/96	5.62	18	0	291	228	73	8	22.2	9.3	9.6	4.27	0	115	CaSO4		
p138	1/31/96	4.3	0	0	1043	832	620	5	83	71	4.63	3.03	0.3	495	MgSO4	36	
p139	1/30/96	4.4	0	0	1041	844	527	5	84	71	5.2	3.03	0.31	500	MgSO4	36	
p140	1/29/96	6.18	40	0	334	208	35	40	22.4	9	21.3	4.5	0.18	130	Ca(Cl)2		40
p141	4/17/96	5.19	6	0	302	224	72	20	19.6	7.9	16.5	5.5	0.52	200	CaSO4	18	
p142	1/22/96	3.69	0	0	1036	784	365	19	106	49	1.7	4	3.73	460	CaSO4	88	
p143	1/22/96	6.51	61	0	237	180	30	6	27.4	0.38	8.1	1.7	0.1	105	Ca(HCO3)2		
p144	1/22/96	6.31	165	0	721	476	70	65	82	2.01	20	3	5.7	320	Ca(HCO3)2	23	20
p145	1/22/96	8.09	724	0	1852	1052	5	150	5.5	0.16	421	2.4	0.13	27	NaHCO3	340	340
jd6	8/27/96	7.4	394	0	964	612	185	5	121	41.5	20.1	2.47	79	322	Ca(HCO3)2	164	164
lr1	9/4/96	7.11	467	0	1350	1088	322	11	179	72	17.2	2.43	4.97	739	Ca(HCO3)2	78	78
lr2	9/4/96	7.28	414	0	762	460	25	5	90	23.8	50	2.77	5.4	356	Ca(HCO3)2	142	147

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
lr3	5/14/96	7.75	289	0	553	292	5	13	58	16.8	33.7	1.62	1.78	250	Ca(HCO3)2	45	50
lr4	5/16/96	7.1	162	0	398	248	27	11	41.1	12.7	15.3	0.91	0.18	155	Ca(HCO3)2	109	44
jd1	8/28/96	7.7	361	0	684	420	10	7	73	25.1	33.5	2.04	4.39	329	Ca(HCO3)2	125	125
jd2	8/28/96	7.6	291	0	602	332	31	15	67	27.6	13	1.72	3.72	321	Ca(HCO3)2	135	137
jd3	3/18/96	7.31	272	0	549	260	5	10	0.1	0	132	2.51	0	46	NaHCO3	99	
jd4	4/10/96	7.11	302	0	625	352	11	5	87	21.7	6.6	1.11	3.23	345	Ca(HCO3)2	142	
jd5	3/14/96	7.08	214	0	538	316	70	5	74	23.3	11.5	1.58	8.6	335	Ca(HCO3)2	89	
js1	8/28/96	7.4	369	0	692	424	38	5	90	25.3	18.1	1.75	0.61	360	Ca(HCO3)2	56	56
js2	8/28/96	7.5	316	0	731	536	89	16	98	28.2	11.6	1.77	3.49	417	Ca(HCO3)2	32	32
js3	3/14/96	7.02	277	0	877	504	45	82	108	26.5	40.8	1.61	0.12	460	Ca(HCO3)2	28	
js4	3/14/96	7.43	272	0	613	364	5	40	17.6	6.8	123	2.34	1.3	165	NaHCO3	119	
js5	3/18/96	6.98	261	0	531	320	5	13	56	20.1	25.9	3.28	0.83	290	Ca(HCO3)2	50	
js6	3/18/96	6.09	39	0	291	208	45	20	24.1	9.6	5.7	11	0	150	CaSO4	23	
js7	8/26/96	7.5	264	0	768	644	155	17	112	40.9	8	1.57	0.98	417	Ca(HCO3)2	36	
x1	9/25/96	6.45	164	0	1132	840	320	95	116	40.9	53	2.49	22.1	546	CaSO4	63	50
x2	9/25/96	6.5	140	0	1251	764	376	113	133	39.5	64	3.24	2.42	584	CaSO4	63	50
x3	9/24/96	5.75	78	0	487	332	72	60	27.5	17.9	29.8	0.99	11.5	161	Mg(Cl)2	22	
x4	9/24/96	4.25	0	0	390	284	98	18	28.2	9.1	11.1	7.9	0	144	CaSO4	36	36
x5	9/11/96	6.98	170	0	424	272	57	5	56	9.5	9.2	3.28	8.2	216	Ca(HCO3)2	19.6	20

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
lr5	5/16/96	7.34	337	0	740	444	87	9	88	32.9	19.8	2.61	12.8	380	Ca(HCO3)2		75
s36	1/31/96	6.6	74	0	309	164	51	18	27.4	10.6	11	1.31	0.16	140	Ca(HCO3)2		
s37	3/11/96	6.3	70	0	396	248	85	24	39.1	15.5	17.3	3.3	0.1	210	CaSO4		
s58	1/29/96	6.07	8	0	108	92	33	5	5.4	5.5	3.2	0.94	0.1	75	MgSO4		
s44	9/23/96	6.2	62	0	213	160	34	5	20.8	8.2	5.3	0.95	0	89	Ca(HCO3)2		
s01	3/19/96	6.52	26	0	187	168	30	15	14.1	8.7	3.7	7	0.78	105	MgSO4		
s02	3/14/96	7.18	65	0	318	200	35	30	33	9.2	14.6	2.27	0.61	180	Ca(HCO3)2		
s03	3/18/96	6.81	96	0	365	252	35	32	40	11.8	12.2	4.9	0.49	200	Ca(HCO3)2		
s04	4/8/96	7.09	44	0	226	132	31	14	20.9	6.2	8.1	4.35	0.13	104	Ca(HCO3)2		
s05	4/8/96	7.21	99	0	421	216	64	25	48.1	10.6	11.6	3.29	0.36	185	Ca(HCO3)2		
s06	3/19/96	6.69	29	0	257	208	33	49	9.3	4.4	32.5	5.7	1.48	100	NaCl		
s07	3/11/96	5.79	17	0	105	396	22	5	9.8	3	1.91	6.1	0	85	CaSO4		
s08	3/12/96	6.9	149	0	401	264	52	7	61	12.3	5.6	2.09	0	245	Ca(HCO3)2		
s09	3/13/96	7.1	101	0	412	300	69	27	49	13.7	11.8	2.58	0.83	215	Ca(HCO3)2		
s10	4/8/96	6.89	121	0	332	176	29	6	40.9	9.9	4.48	2.3	0	145	Ca(HCO3)2		
s11	4/4/96	7.09	177	0	426	260	45	7	57	21.5	6.2	1.01	0	235	Ca(HCO3)2		
s12	4/8/96	7.71	88	0	308	160	39	17	33.3	9.4	9.6	2.04	0.1	115	Ca(HCO3)2		
s13	9/9/96	7.61	115	0	547	356	43	67	60	13	25.6	5.3	0.67	232	Ca(Cl)2		
s14	9/9/96	7.5	74	0	268	164	22	20	26.3	7.8	10	3.61	0.33	130	Ca(HCO3)2		

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
s15	9/9/96	8.08	115	0	502	356	49	50	40.8	14.4	29.7	5.7	0.93	193	Ca(HCO3)2		
s16	3/11/96	4.88	0	0	637	176	147	72	36.1	19.8	30	14	0	340	CaSO4		
s17	3/13/96	7.1	88	0	396	256	70	26	49	13.9	11.2	2.51	0.71	220	CaSO4		
s18	3/13/96	6.52	17	0	424	256	147	23	36	19.6	9.7	2.15	0.68	250	CaSO4		
s19	3/14/96	4.38	0	0	840	392	340	13	70	50	10.2	3	1.99	445	MgSO4		
s20	3/14/96	5.73	16	0	519	212	245	9	51	26	7.3	2.51	0.39	260	CaSO4		
s21	3/18/96	4.87	0	0	531	356	205	30	38.4	27.2	11.2	2.56	0.92	340	MgSO4		
s22	6/6/96	6	64	0	810	580	290	13	79	42	15.4	1.33	0.37	420	CaSO4		
s23	3/6/96	6.6	6	0	101	136	23	15	5.3	4.9	1.2	1.73	1.07	90	MgSO4		
s24	3/6/96	6.61	11	0	91	68	20	7	5.2	4.7	1.19	1.72	1.08	105	MgSO4		
s25	3/14/96	3.47	0	0	1520	1264	670	12	119	108	11.3	4.14	6.7	840	MgSO4		
s26	3/14/96	3.36	0	0	1243	992	590	23	85	65	13.5	3.51	8.3	630	MgSO4		
s27	3/14/96	3.48	0	0	1270	656	525	16	95	76	17.1	3.65	5.4	610	MgSO4		
s28	3/6/96	3.1	0	0	1901	1564	1045	15	172	115	12	3.05	28.2	1200	MgSO4		
s29	9/23/96	3.1	0	0	1754	836	878	22	159	92	54	4.8	8.5	965	CaSO4		
s30	9/23/96	3.1	0	0	1760	1472	830	22	161	93	52	5	8.4	769	CaSO4		
s31	9/23/96	2.98	0	0	1575	1580	784	10	121	90	18.1	4.9	5.9	725	MgSO4		
s32	9/24/96	6.88	84	0	333	260	60	8	44.6	8.7	8.3	2.56	0.15	161	Ca(HCO3)2		
s33	6/12/96	5.5	0	0	760	552	325	23	67	39.4	14.7	16.7	0	325	CaSO4		

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
s34	8/5/96	4.93	0	0	57	372	11	5	1.41	2.68	2.13	1.13	0.1	24	MgSO4		
s35	9/9/96	7.28	82	0	261	144	25	11	20.2	6.3	10.1	1.22	0.34	140	Ca(HCO3)2		
s38	5/16/96	5.89	22	0	158	80	26	12	9.7	5.5	4.38	1.08	0.14	75	CaSO4		
s39	4/18/96	6.41	85	0	532	424	165	5	48.4	23.9	4.91	1.54	0.1	278	CaSO4		
s40	4/18/96	6.25	96	0	585	448	225	5	63	30.1	4.37	1.32	0.1	332	CaSO4		
s41	4/24/96	5.79	0	0	56	8	9	5	1.12	1.76	2.9	0.67	0	50	MgSO4		
s42	4/24/96	5.7	0	0	53	16	10	5	1.13	1.9	2.97	0.67	0	85	MgSO4		
s43	4/22/96	6.59	22	0	97	128	23	5	5.3	4.74	2.86	2.25	3.29	120	MgSO4		
s45	9/18/96	5.8	37	0	211	168	46	11	12.7	7.9	5	3.02	0	100	MgSO4		
s46	9/17/96	2.87	0	0	2160	2092	1019	28	171	123	29	5.2	24.5	1090	MgSO4		
s47	9/17/96	3.04	0	0	2070	2148	868	27	148	126	18.4	4.5	9.8	1043	MgSO4		
s48	9/18/96	6.05	21	0	1232	1308	540	20	107	68	40	4.4	1.19	607	MgSO4		
s49	9/10/96	3.1	0	0	2020	1284	909	18	163	102	39.6	7.3	13.8	906	MgSO4		
s50	9/11/96	2.99	0	0	2150	1772	927	20	160	81	43.3	7.3	40.2	890	CaSO4		
s51	9/11/96	3.01	0	0	2160	1716	1042	19	157	104	45.2	7.5	43.1	965	MgSO4		
s52	9/11/96	8.32	66	0	203	120	25	10	21.6	6.3	8.2	3.55	0.5	95	Ca(HCO3)2		
s53	1/30/96	6.18	27	0	233	140	70	13	16	6.7	10	1.3	1.34	100	CaSO4		
s54	8/27/96	7.7	139	0	1066	852	352	66	116	56	60	5.6	0.11	468	CaSO4		
s55	1/31/96	3.8	0	0	1333	1036	531	19	89	47.6	68	4.32	48.5	440	CaSO4		

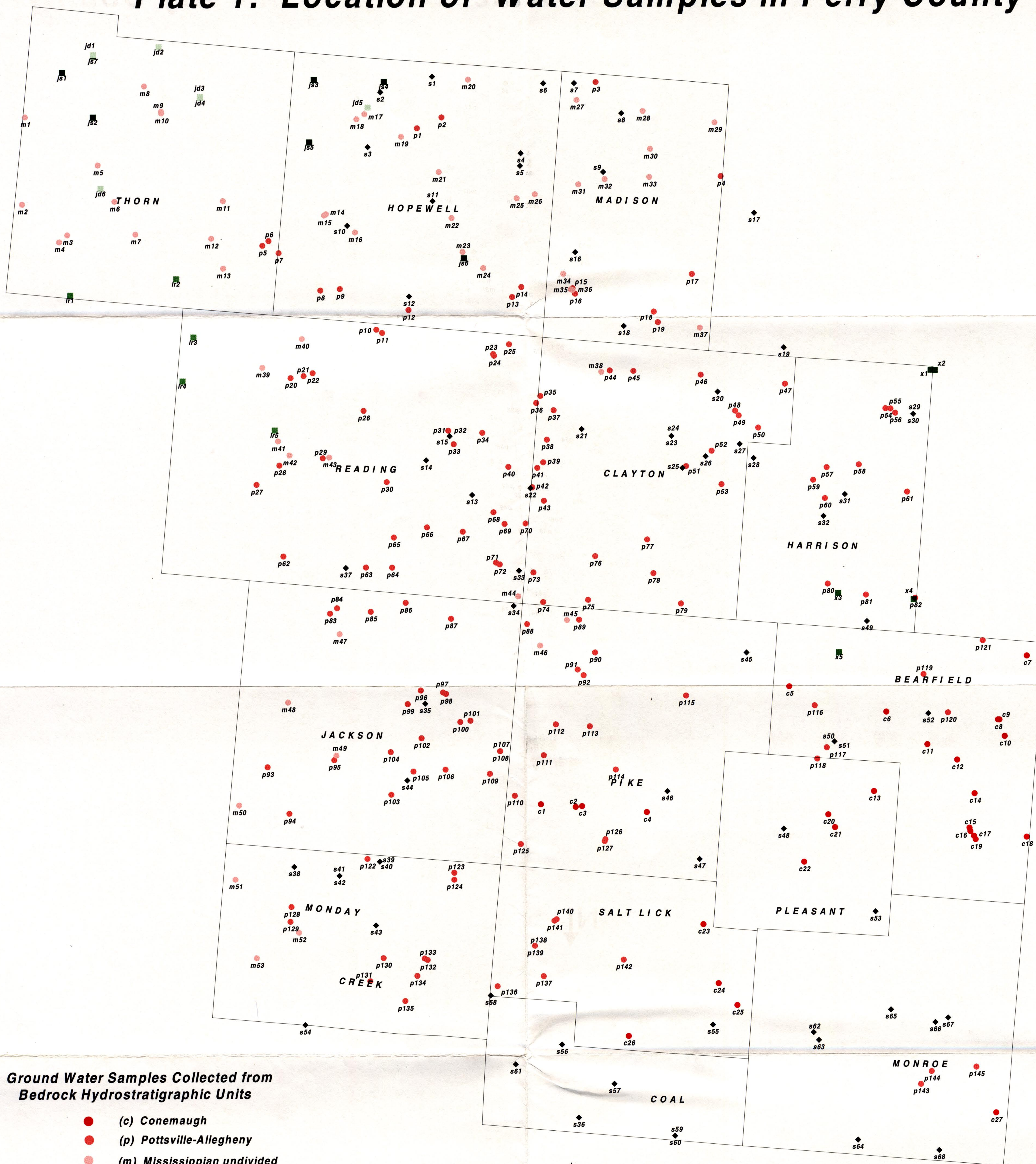
Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
s56	1/30/96	6.54	25	0	970	688	335	92	69	47	48	4	0.49	375	MgSO4		
s57	1/30/96	7.17	74	0	308	204	56	9	29	9.5	10.8	1.3	0.14	130	Ca(HCO3)2		
s59	1/31/96	6.7	19	0	293	184	102	6	26.7	10.1	4.81	1.39	0.26	125	CaSO4		
s60	1/31/96	6.6	19	0	300	172	105	5	26.7	11.3	4.88	1.4	0.26	105	CaSO4		
s61	1/31/96	4.5	0	0	896	664	445	25	45.4	61	20.6	3.92	0.97	420	MgSO4		
s62	1/31/96	6.4	34	0	471	304	145	24	53	13.9	21.2	3.48	1.4	175	CaSO4		
s63	1/31/96	6.6	36	0	471	288	169	25	40.3	15.9	21.2	3.51	1.61	205	CaSO4		
s64	1/31/96	6.1	0	0	669	468	235	20	47	20.5	26.7	3.06	8.6	225	CaSO4		
s65	1/30/96	5.61	0	0	719	504	304	22	41.9	16.4	63	2.9	16.6	210	Na2(SO4)		
s66	1/30/96	6.9	34	0	176	128	40	6	14	5	7.3	1	0.48	70	CaSO4		
s67	1/30/96	7.04	27	0	190	132	40	17	13.6	4.6	12.9	1.1	0.53	55	CaSO4		
s68	1/30/96	6.29	19	0	423	272	130	21	27.3	10.1	34.4	1.8	5.8	125	Na2(SO4)		
t01	4/7/97	8.28	118	0	427	232	45	5	39.5	11.3	11.9	2.6	0.52	307	Ca(HCO3)2		
t01	8/27/96	7.5	90	0	282	216	32	19	29.3	11.1	9.9	3.72	0.57	161	Ca(HCO3)2		
t02	4/10/96	7.01	272	0	773	488	105	16	106	29.4	7.6	1.62	1.31	400	Ca(HCO3)2	36	
t02	8/26/96	7.4	299	0	766	660	119	18	109	40.4	7.8	1.58	1.1	410	Ca(HCO3)2	36	
t02	4/7/97	7.07	279	0	870	520	118	11	116	31	8.7	1.46	1.6	481	Ca(HCO3)2	36	
t03	4/7/97	7.08	383	0	1195	772	201	5	156	42.8	17.3	2.08	2.76	578	Ca(HCO3)2	159	152
t03	8/26/96	7.5	291	0	693	616	90	16	85	30.3	8.3	1.76	4.05	371	Ca(HCO3)2	159	152

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
t04	3/31/97	8.05	245	20	695	460	35	24	4.3	2.19	160	1.79	0	44	Na(HCO3)2	130	
t04	3/12/96	7.9	294	0	657	328	28	28	3.9	2.1	158	2.92	2.54	80	NaHCO3	130	
t04	8/26/96	7.9	268	25	652	612	27	22	3	2.46	158	1.73	0	38	NaHCO3	130	
t05	8/26/96	7.5	279	0	646	444	66	5	88	23.7	21.9	2.31	0.52	314	Ca(HCO3)2	200	200
t05	4/3/96	7.18	269	0	639	332	83	9	86	25.6	22.8	4.1	0.43	330	Ca(HCO3)2	200	200
t06	3/27/97	6.3	44	0	305	208	31	15	27	3.9	8.2	0.76	0	145	Ca(HCO3)2		
t06	8/28/96	6.7	88	0	346	228	26	18	41.4	5.7	8	0.87	0.15	180	Ca(HCO3)2		
t07	8/26/96	8.8	443	180	1291	888	5	19	0.73	0.34	318	1.59	0.22	31	NaHCO3 (SOFT)	377	335
t07	4/7/97	8.83	487	100	1460	752	5	84	1.51	0.36	347	2.14	0.1	48	Na(HCO3)2	377	335
t08	8/29/96	7.32	295	0	622	348	36	5	69	20.1	25.7	5.1	0.93	295	Ca(HCO3)2	56	56
t08	3/31/97	6.98	2.67	0	640	436	39	5	69	21.8	24.2	4.4	1.01	287	Ca(HCO3)2	56	56
t09	3/13/96	6.9	285	0	734	424	62	44	43	10.7	102	4.9	0.52	220	NaHCO3	370	
t09	8/26/96	7.1	250	0	650	484	52	21	34.3	10.2	99	5.2	0.34	168	NaHCO3	370	
t09	3/27/97	6.77	250	0	790	436	73	49	37	8.2	131	4.6	0.95	149	Na(HCO3)2	370	
t10	8/26/96	6.7	52	0	530	376	49	99	26.3	15.1	47.9	2.28	0	168	NaCl		
t10	3/27/97	5.77	38	0	510	380	40	80	24.1	9.6	43.6	2.19	0	129	NaCl		
t11	3/31/97	6.88	19	0	74	28	5	5	9.9	1.17	0.51	0.69	0.1	40	Ca(HCO3)2	57.2	
t11	8/27/96	7.1	123	0	328	248	33	10	51	8.9	5.5	2.51	0.21	161	Ca(HCO3)2	57.2	

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
t11	3/11/96	6.94	34	0	134	108	27	9	17.6	3	5.6	1.28	0.33	85	CaSO4	57.2	
t12	3/27/97	6.22	60	0	272	216	35	18	23	7.9	11.3	1.91	0.1	113	Ca(HCO3)2		
t12	8/26/96	7.1	116	0	364	296	28	26	36.8	12.9	14.7	2.66	0	186	Ca(HCO3)2		
t13	3/27/97	6.7	156	0	520	328	60	11	56	16.7	18.2	0.78	0	255	Ca(HCO3)2	75	75
t13	8/28/96	7.1	226	0	577	388	70	11	72	21.1	14.6	1.05	0	291	Ca(HCO3)2	75	75
t14	8/27/96	2.8	0	0	1707	1528	755	40	107	76	32.7	5.9	18	643	MgSO4		
t14	3/27/97	3.49	0	0	775	524	336	28	52	27.9	18	2.92	10.8	323	CaSO4		
t15	8/28/96	7.04	324	0	1342	1004	245	96	170	44.3	36.2	3.07	0.14	651	Ca(HCO3)2	44	24
t15	3/27/97	6.52	204	0	2410	1980	1078	54	297	189	54	6.7	0.1	1353	MgSO4	44	24
t16	4/17/96	6.74	272	0	854	588	175	11	97	46.5	22.7	1.84	25.2	490	Ca(HCO3)2	70	20
t16	8/27/96	7.2	303	0	845	652	194	10	86	42.1	26.1	2.03	19.8	463	Ca(HCO3)2	70	20
t16	3/31/97	6.81	264	0	840	564	158	10	79	39.6	34	2.03	10.9	434	Ca(HCO3)2	70	20
t17	8/26/96	7.6	291	0	567	500	23	5	22.7	8.7	105	2.21	0	141	NaHCO3	93	
t17	3/31/97	6.99	264	0	535	288	22	5	33.4	10.2	71	2.14	0	137	Na(HCO3)2	93	
t17	1/18/96	7.28	260	0	536	332	28	5	34.9	12.4	71	2.1	0.13	180	NaHCO3	93	
t18	3/27/97	7.37	254	0	690	344	5	53	37	13	88	2.57	0.83	178	Na(HCO3)2	388	113
t18	8/27/96	7.8	240	8	574	460	5	37	37.8	16.1	66	2.44	0.25	187	NaHCO3	388	113
t19	4/24/96	6.49	38	0	181	116	24	5	12.9	5.3	4.86	0.66	0.1	125	Ca(HCO3)2	56	56
t19	3/31/97	5.51	20	0	125	124	26	5	9.3	4	5.1	0.57	0	61	CaSO4	56	56

Sample ID	Sampling Date	pH	HCO_3 (mg/L)	CO_3 (mg/L)	Specific Conductance	T.D.S. (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Hardness (mg/L)	Water Type	Well Depth (ft)	Casing Lenght (ft)
t19	8/27/96	6.7	68	0	224	184	26	6	19.3	7.5	6.2	0.68	0.18	130	Ca(HCO3)2	56.6	56
t20	8/27/96	7	168	0	422	308	55	5	61	12.3	15.1	1.54	0.47	207	Ca(HCO3)2		
t20	1/23/96	7.28	204	0	523	340	65	11	49	17.2	49	2.2	0.45	185	Ca(HCO3)2	60	
t21	1/17/96	6.4	26	0	95	36	13	5	12.2	1.68	1.25	0.68	0.1	59	Ca(HCO3)2	8	8
t21	8/27/96	6.6	37	0	95	72	5	5	15.4	1.16	0.88	0.84	0.1	76	Ca(HCO3)2	8	8
t21	3/31/97	6.31	15	0	61	56	5	5	8	0.78	0.28	0.42	0.1	53	Ca(HCO3)2	8	8
t22	3/31/97	6.64	31	0	375	236	112	12	28.3	8.7	24.7	2.26	3.32	141	CaSO4		
t22	8/27/96	3.3	0	0	1097	912	480	24	88	26.1	89	5.3	5.2	363	CaSO4		

Plate 1: Location of Water Samples in Perry County



Ground Water Samples Collected from Bedrock Hydrostratigraphic Units

- (c) Conemaugh
- (p) Pottsville-Allegheny
- (m) Mississippian undivided

Ground Water Collected from Sand and Gravel Aquifers

- (js) Jonathan Creek/Buckeye Lake Buried Valley Aquifer (shallow)
- (x) Moxahala Creek Buried Valley Aquifer
- (lr) Little Rush Creek Buried Valley Aquifer
- (jd) Jonathan Creek/Buckeye Lake Buried Valley Aquifer (deep)

Surface Water Samples Collected from Streams, Lakes, and Springs

- (s) Surface Water

Description of Map Symbols

Identification Symbol

c22 Sample Identification Number

Identification Prefix Letter

Location information on sampling sites are contained in Appendix A
Water Quality Data are contained in Appendix B

Miles

0 1 2 3 4 5 6

Kilometers

0 1 2 3 4 5 6 7 8 9 10

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