GROUND WATER RESOURCES

IOWA GEOLOGICAL SURVEY

Research and Service 1855-1858 1866-1869 1892- Water—Minerals—Environment

Boone County

Open File Report 82-8 WRD

Compiled by CAROL A. THOMPSON

GROUND-WATER RESOURCES OF BOONE COUNTY

Introduction

Approximately 80% of the residents of Boone County rely on ground water as the source of their drinking water. It is estimated that the use of ground water in the county currently approaches 1.1 billion gallons per year. For comparison, this amount would provide each new resident with 114 gallons of water a day during the year. Actually, few if any households use this much water, and the rather large annual per capita use reflects the greater water requirements of the county's industries, agribusinesses and municipalities.

The users of ground water in the county draw their supplies from several different geologic sources. Several factors must be considered in determining the availability of ground water and the adequacy of a supply source:

distribution - having water where it is needed,

accessibility - affects the costs for drilling wells and pumping water,

yield - relates to the magnitude of the supply that can be sustained,

quality - determines for what purposes the water can be used.

In terms of these factors, there are few locations in Boone County where the availability of ground water is not limited to some degree. The most common limitation is poor water quality, that is, highly mineralized ground water. Secondary limitations are generally related to poor distribution, small yields from some sources, and poor accessibility due to the great depths to adequate sources.

Occurrence of Ground Water in Boone County

The occurrence of ground water is influenced by geology -- the position and thickness of the rock units, their ability to store and transmit water, and their physical and chemical make-up. Geologic units that store and transmit water and yield appreciable amounts to wells are called aquifers. The best aquifers are usually composed of unconsolidated sand and gravel, porous sandstone, and porous or fractured limestone and dolostone. Other units composed of materials such as clay and silt, shale, siltstone, and mudstone yield little or no water to wells. These impermeable units are called aquicludes or aquitards and commonly separate one aquifer unit from another.

In Boone County there are two principal sources from which users obtain water supplies: the loose, unconsolidated materials near the land surface that comprise the surficial aquifer, and several deep rock aquifers. Between the surficial aquifer and the deep Cambro-Ordovician aquifer are two other major water-bearing units, the Mississippian and the Devonian aquifer systems. However, throughout Boone County the water contained in these aquifers is highly mineralized and often of too poor quality for human or livestock use.

Figure 1 shows the geologic relations of these beneath the county. Each aquifer has its own set of geologic, hydrologic, and water quality characteristics which determine the amount and potability (suitability for drinking) of water it will yield.

Surficial Aquifers

Unconsolidated deposits at the land surface are comprised of mixtures of clay, silt, sand, gravel, and assorted boulders. The water-yielding potential of these deposits is greater in units composed mostly of sand and/or gravel. Three sub-types of surficial aquifers used in the county are alluvial aquifers, drift aquifers, and buried channel aquifers.

Alluvial aquifers consist mainly of sand and gravel transported and deposited by modern streams and make up the floodplains and terraces in major valleys. Alluvial deposits are near surface, generally less than 50-60 feet, and because of their near surface position may be easily contaminated by the infiltration of surface water.

The drift aquifer is the thick layer of clay to boulder size material (till) deposited over the bedrock by glacial ice which invaded the county at least twice in the last two million years. The composition of the glacial drift varies considerably and in many places does not yield much water. There may, however, be lenses or beds of sand and gravel in the drift that are thick and widespread enough to store and furnish dependable water. These may be difficult to locate because of their irregular shape and because they are buried within other drift materials. Usually one or two sand layers can be found in most places that will yield enough water to meet domestic needs.

Buried channels are pre-glacial valleys filled with alluvial sand and gravel. These valleys were overridden by glaciers and are now buried under the glacial drift and may or may not coincide with present day alluvial valleys.

The distribution, yield, and water quality characteristics for the surficial aquifers are summarized in Figures 2 and 9 and Table 3. An indication of general thicknesses can be obtained by comparing the elevations of the top (the land surface) and the bottom (the bedrock surface) of the surficial deposits in Figure 4 and 5. The thickness of the glacial drift or the depth of buried channels can be determined by subtracting the elevation of the bedrock surface from the elevation of the land surface.

Rock Aquifers

Below the drift and other surficial materials is a thick sequence of layered rocks formed from deposits of rivers and shallow seas that alternately covered the state during the last 600 million years. The geologic map (Figure 3) shows the geologic units which form the surface of this rock sequence and Table 1 lists the geologic and hydrogeologic characteristics of the rock units underlying Boone County. Except for a small area on the eastern edge of the county, rocks at Pennsylvanian age lie directly below the glacial drift. These rocks in Boone County belong to the Cherokee Group and are primarily shales, siltstones, coal beds, sandstones and thin limestones. Because shales predominate, the Pennsylvanian sequence acts as an aquiclude and only locally

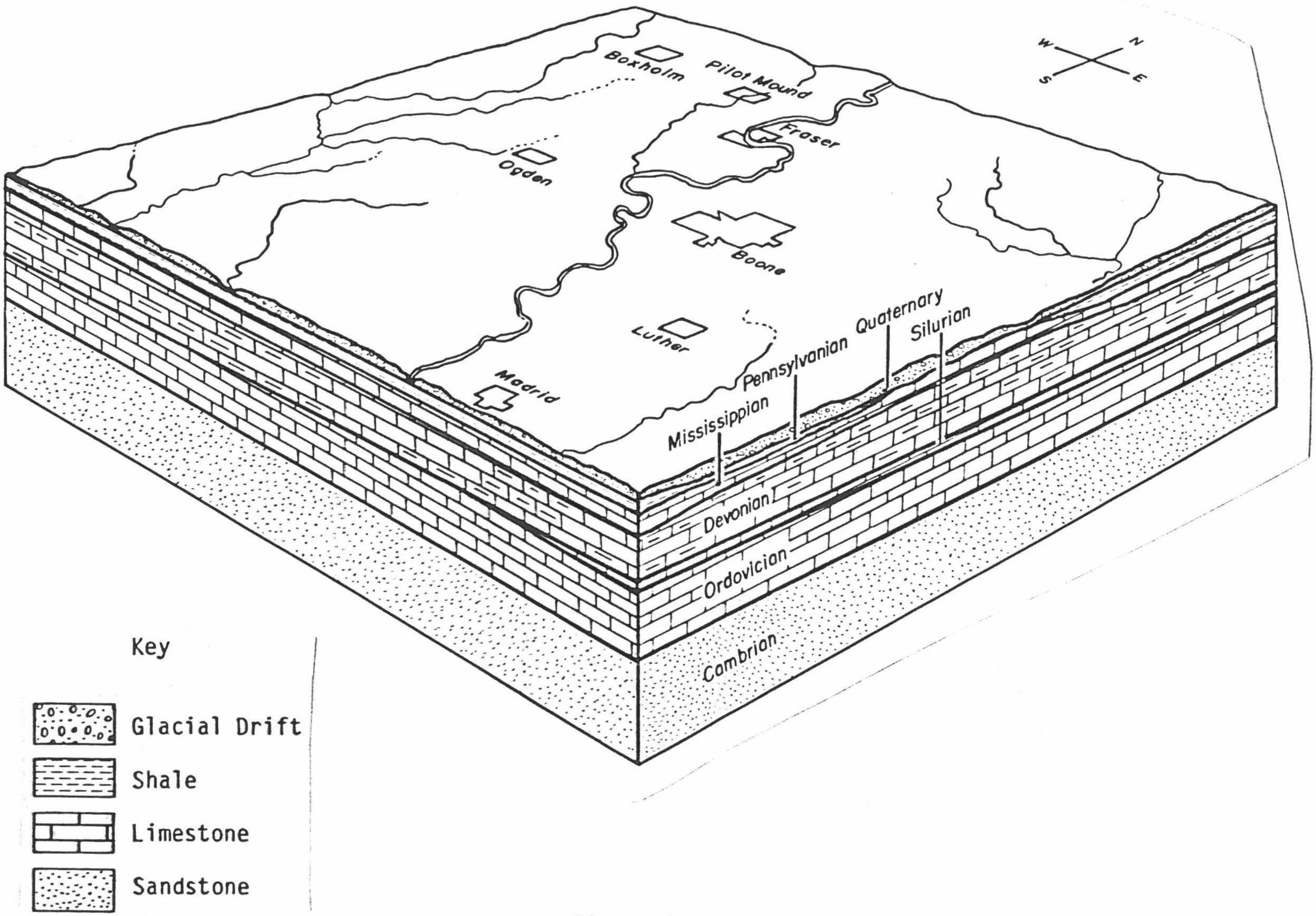


Figure 1

BLOCK DIAGRAM SHOWING THE GEOLOGY OF BOONE COUNTY can enough water be produced, usually from the sandstone beds. Water quality data extrapolated from neighboring counties indicate that in general the water is highly mineralized with high concentrations of dissolved solids, sulfate and sodium.

The Mississippian Aquifer is the most heavily used of the rock aquifers in Boone County and consists of a series of limestones and dolostones. The Devonian-Siurian aquifer is used by a few communities in Boone County and locally by rural residents. The main water producing units are limestones and dolomites. The Cambro-Ordovician aquifer produces the highest yields of the bedrock aquifers and includes the St. Peter sandstone, the Prairie du Chein dolomite and the Jordan sandstone, the latter being the major water producer. The maps in Figure 12 refer to the Jordan aquifer, which is composed of the lower two units of the Cambro-Ordovician aquifers. The St. Peter, being highly friable, is generally cased out in the deep wells.

The accessibility of ground water in rock aquifers depends on the depth to the aquifer. The deeper a well must be, the greater the cost for well construction and pumping. The depths to and thicknesses of units at specific sites will vary somewhat because of irregularities in the elevation of the land surface and in the elevation of the tops of the underlying rock units. Estimates of depths and thicknesses can be made by comparing Figure 4 with the maps of aquifer elevations in Figures 10, 11, and 12. The range in depth below land surface to the top of the county's principal bedrock aquifers is given for each township in Figure 6.

A second factor which affects ground water accessibility is the level to which the water will rise in a well (the static water level). Throughout the county water in the rock aquifers is under artesian pressure and rises in wells once the aquifer is penetrated. This can reduce the cost of pumping. Average static water levels for Polk County wells are shown in Figures 10, 11, and 12.

Average rates of yield and water quality characteristics for each of the aquifers are summarized in the maps in figures 10, 11, 12 and Table 4.

Table 1

GEOLOGIC AND HYDROGEOLOGIC UNITS IN BOONE COUNTY

Age	Rock Unit	Description	Thickness Range	Hydrogeologic Unit	Water-Bearing Characteristics
Quaternary	Alluvium	Sand, gravel, silt and clay	0-300 (feet)	Surficial aquifer	Fair to large yields (10 to 500 gpm)
	Glacial drift (undifferentiated)	Predominantly till containing scattered irregular bodies of sand and gravel			Low yields (less than 10 gpm)
	Buried channel	Sand, gravel, silt and clay			Small to large yields
Pennsylvanian	Marmaton Group	Alternating shale and limestone; thin coal and sandstone	100-375	Aquiclude	Low yields only from limestone and sandstone
	Cherokee Group	Shale, clay, siltstone, sandstone and coal beds, mostly thin			
Mississippian	Meramec Series	Sandy limestone	240-450	Mississippian aquifer	Fair to low yields
	Osage Series	Limestone and dolostone, cherty; shale			
	Kinderhook Series	Limestone, oolitic, and dolostone, cherty			
Devonian	Maple Mill Shale Sheffield Formation Lime Creek Formation	Shale, limestone in lower	0-50	Devonian aquiclude	Does not yield water
	Cedar Valley Limestone Wapsipinicon Formation	Limestone and dolostone, contains evaporites (gypsum) in southern half of Iowa	700-750	Devonian aquifer*	Fair to low yields
Silurian	Undifferentiated	Dolostone	0-50	Silurian aquifer	Low yields
Ordovician	Maquoketa Formation	Shale and dolostone	0-75	Maquoketa aquiclude	Does not yield water
	Galena Formation	Dolostone and chert		Minor aquiclude	Low yields
	Decorah Formation-Platteville Formation	Limestone, dolostone and thin shale, includes sandstone in SE Iowa		Aquiclude	Does not yield water
	St. Peter Sandstone	Sandstone		Cambro-Ordovician aquifer	Fair yields
	Prairie du Chien Formation	Dolostone, sandy and cherty			High yields (over 500 gpm)
Cambrian	Jordan Sandstone	Sandstone			
	St. Lawrence Formation	Dolostone		Aquitard	Low yields
	Franconia Sandstone	Sandstone and shale			
	Dresbach Group	Sandstone		Dresbach aquifer*	High to low yields
Precambrian	Undifferentiated	Coarse sandstone: crystalline rocks		Base of ground water reservoir	Not known to yield water

*not significant in Boone County owing to highly mineralized water contained.

Figure 2

SURFICIAL MATERIALS

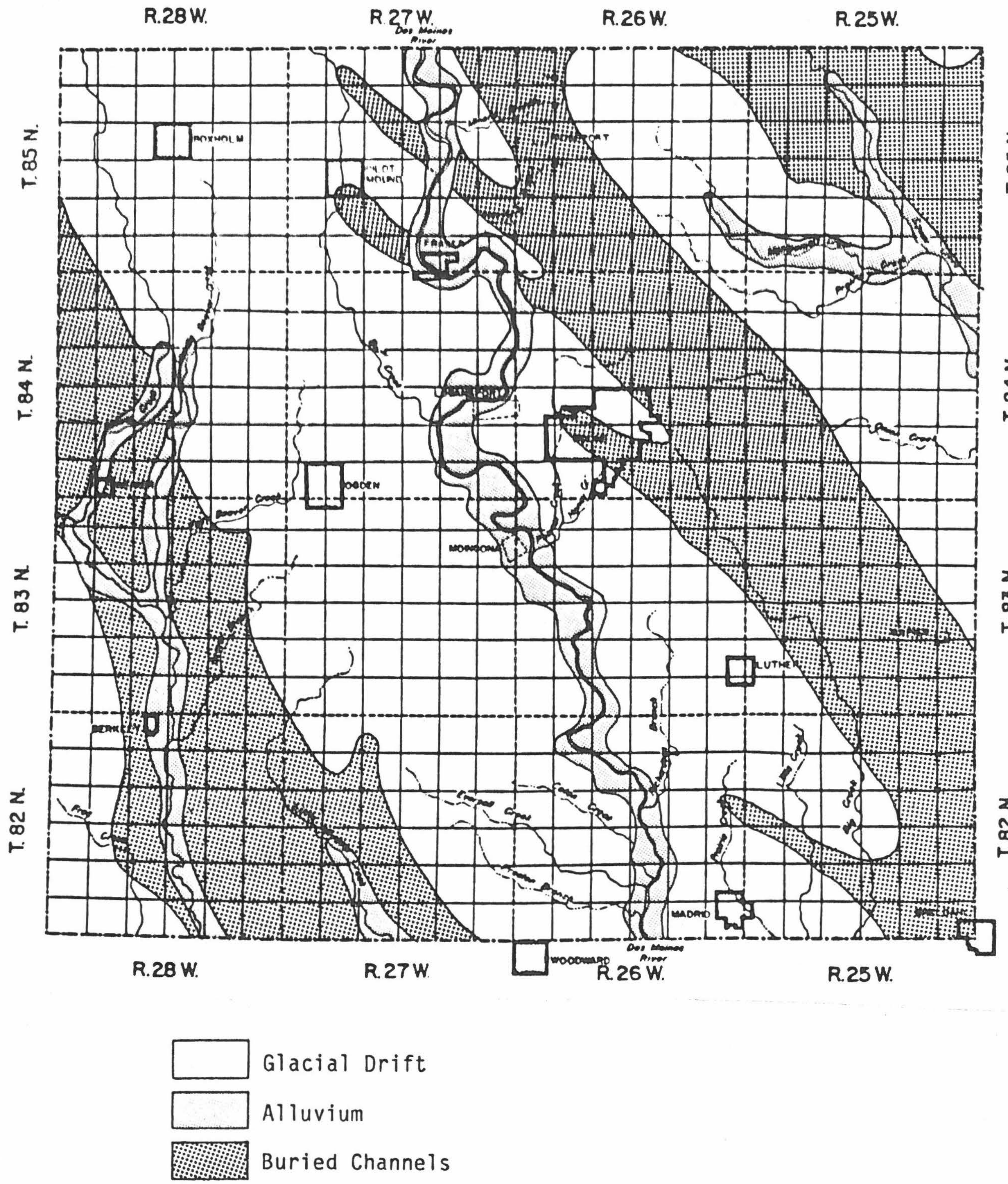
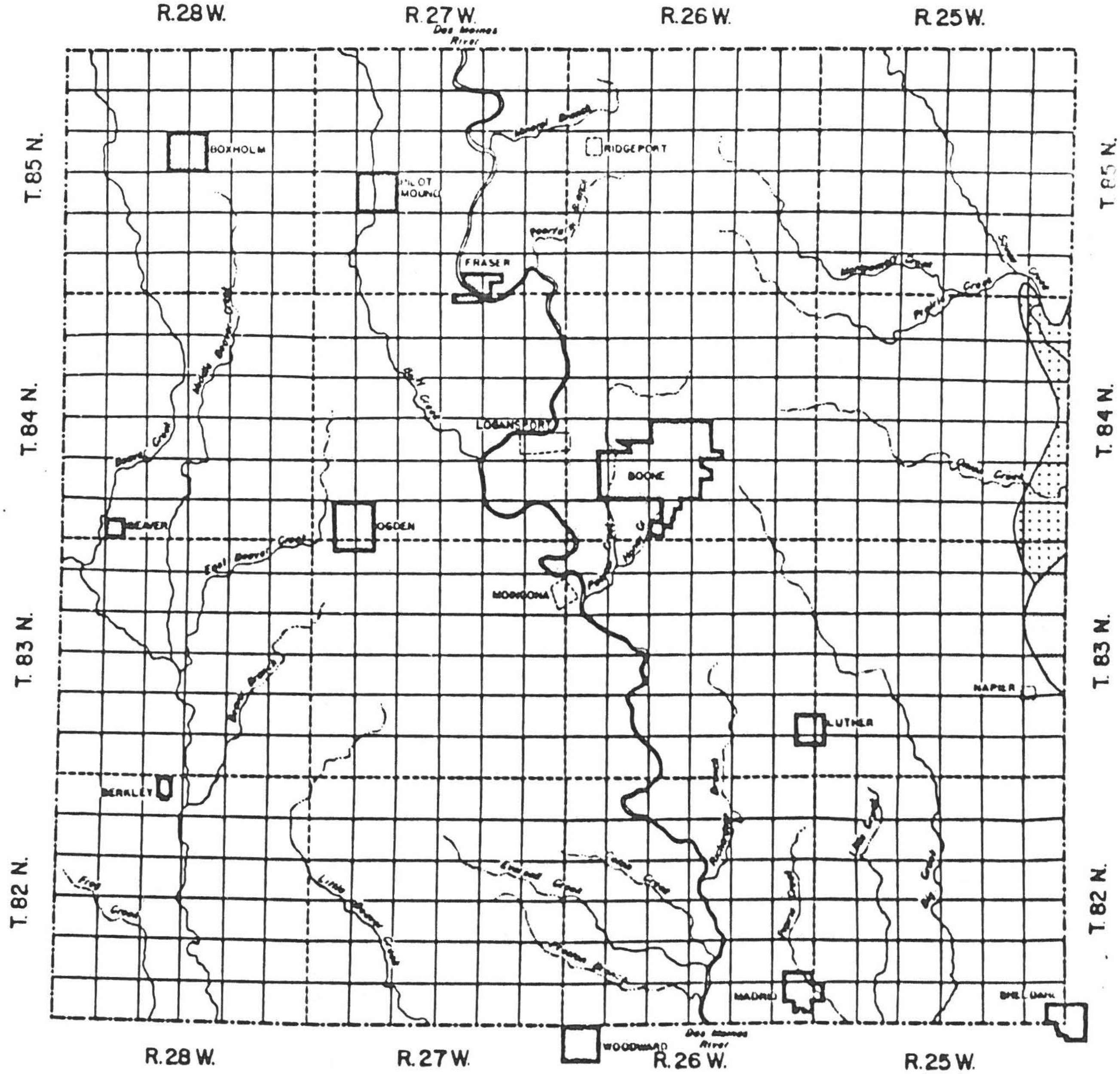


Figure 3

GEOLOGIC MAP



Pennsylvanian-Cherokee

Mississippian-Meramec

Mississippian-Osage

Figure 4

ELEVATION OF LAND SURFACE IN FEET ABOVE MEAN SEA LEVEL

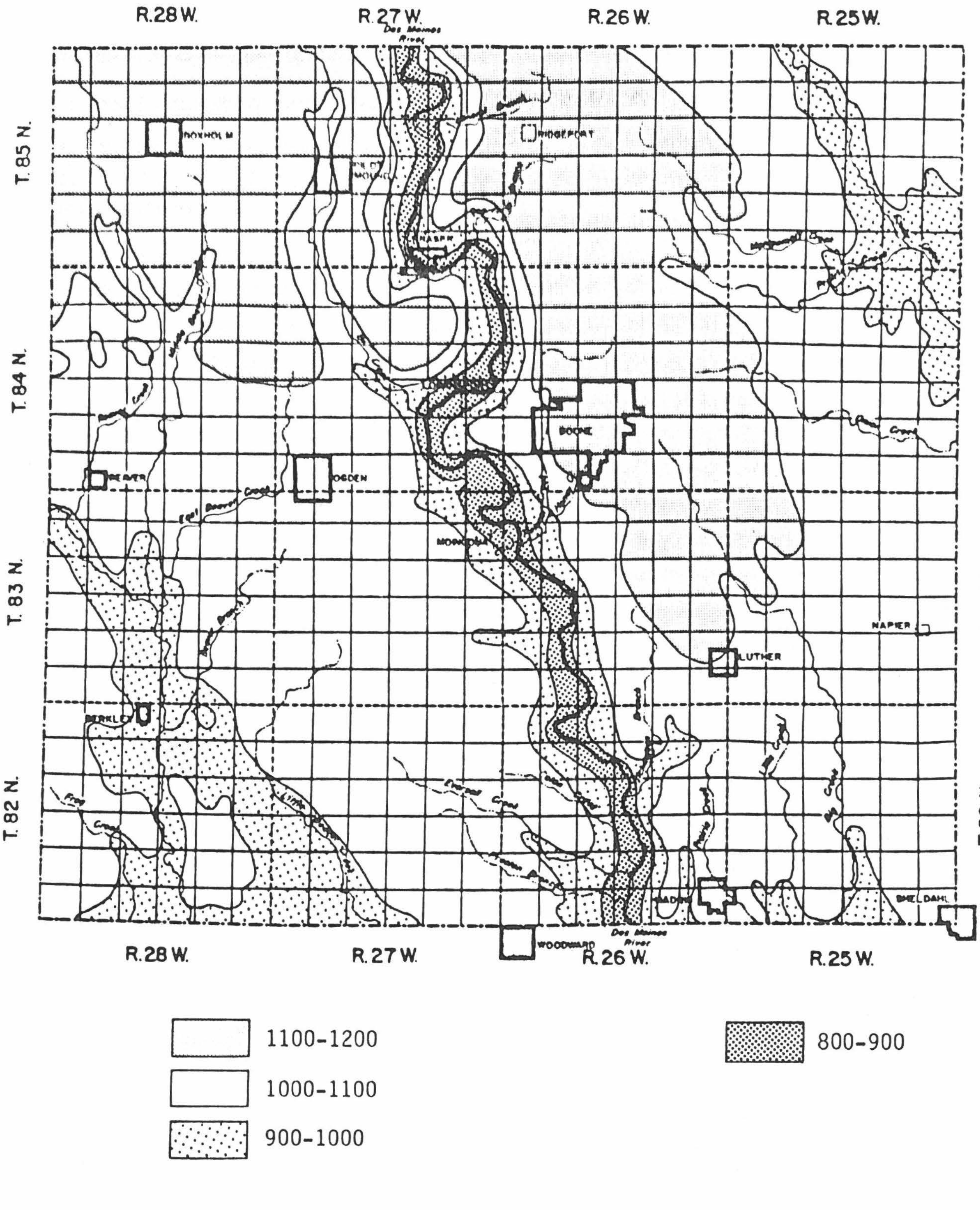


Figure 5

ELEVATION OF BEDROCK SURFACE IN FEET ABOVE MEAN SEA LEVEL

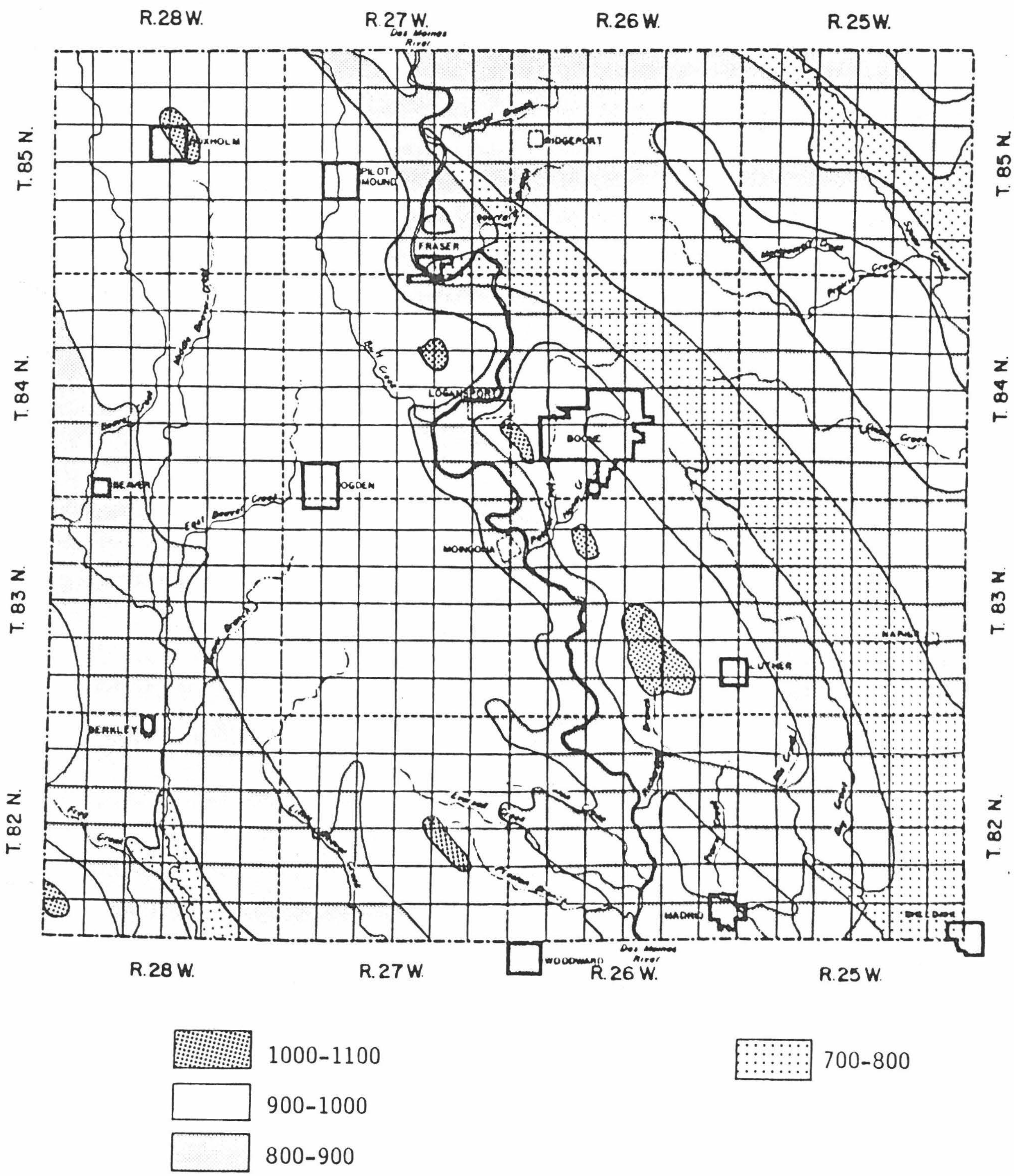


Figure 6

RANGE IN DEPTH TO BOONE COUNTY'S PRINCIPAL ROCK AQUIFERS

	R.28W.	R.27W.	R.26W.	R.25W.	
T.85N.	BEDROCK 100-300 MISSISSIPPIAN 200-600 DEVONIAN 675-850 CAMBRO-ORDOVICIAN 2050-2300	BEDROCK 0-200 MISSISSIPPIAN 200-500 DEVONIAN 400-800 CAMBRO-ORDOVICIAN 1850-2300	BEDROCK 0-200 MISSISSIPPIAN 200-500 DEVONIAN 500-800 CAMBRO-ORDOVICIAN 1850-2300	BEDROCK 0-200 MISSISSIPPIAN 200-400 DEVONIAN 450-650 CAMBRO-ORDOVICIAN 1975-2250	T.85N.
T.84N.	BEDROCK 0-200 MISSISSIPPIAN 100-500 DEVONIAN 550-825 CAMBRO-ORDOVICIAN 2050-2250	BEDROCK 0-200 MISSISSIPPIAN 200-500 DEVONIAN 375-775 CAMBRO-ORDOVICIAN 1850-2300	BEDROCK 0-200 MISSISSIPPIAN 200-600 DEVONIAN 325-725 CAMBRO-ORDOVICIAN 1850-2250	BEDROCK 0-200 MISSISSIPPIAN 100-600 DEVONIAN 400-700 CAMBRO-ORDOVICIAN 2100-2450	T.84N.
T.83N.	BEDROCK 0-300 MISSISSIPPIAN 100-400 DEVONIAN 475-750 CAMBRO-ORDOVICIAN 1950-2150	BEDROCK 0-300 MISSISSIPPIAN 200-500 DEVONIAN 450-650 CAMBRO-ORDOVICIAN 1850-2200	BEDROCK 0-300 MISSISSIPPIAN 150-500 DEVONIAN 425-825 CAMBRO-ORDOVICIAN 1850-2200	BEDROCK 100-200 MISSISSIPPIAN 200-500 DEVONIAN 550-800 CAMBRO-ORDOVICIAN 2200-2450	T.83N.
T.82N.	BEDROCK 0-300 MISSISSIPPIAN 200-400 DEVONIAN 475-750 CAMBRO-ORDOVICIAN 1950-2150	BEDROCK 0-300 MISSISSIPPIAN 200-400 DEVONIAN 450-725 CAMBRO-ORDOVICIAN 1950-2225	BEDROCK 0-200 MISSISSIPPIAN 200-400 DEVONIAN 425-725 CAMBRO-ORDOVICIAN 1950-2325	BEDROCK 0-200 MISSISSIPPIAN 200-500 DEVONIAN 550-750 CAMBRO-ORDOVICIAN 2100-2350	T.82N.
	R.28W.	R.27W.	R.26W.	R.25W.	

Figure 7

INDEX MAP FOR TYPICAL WELLS IN BOONE COUNTY

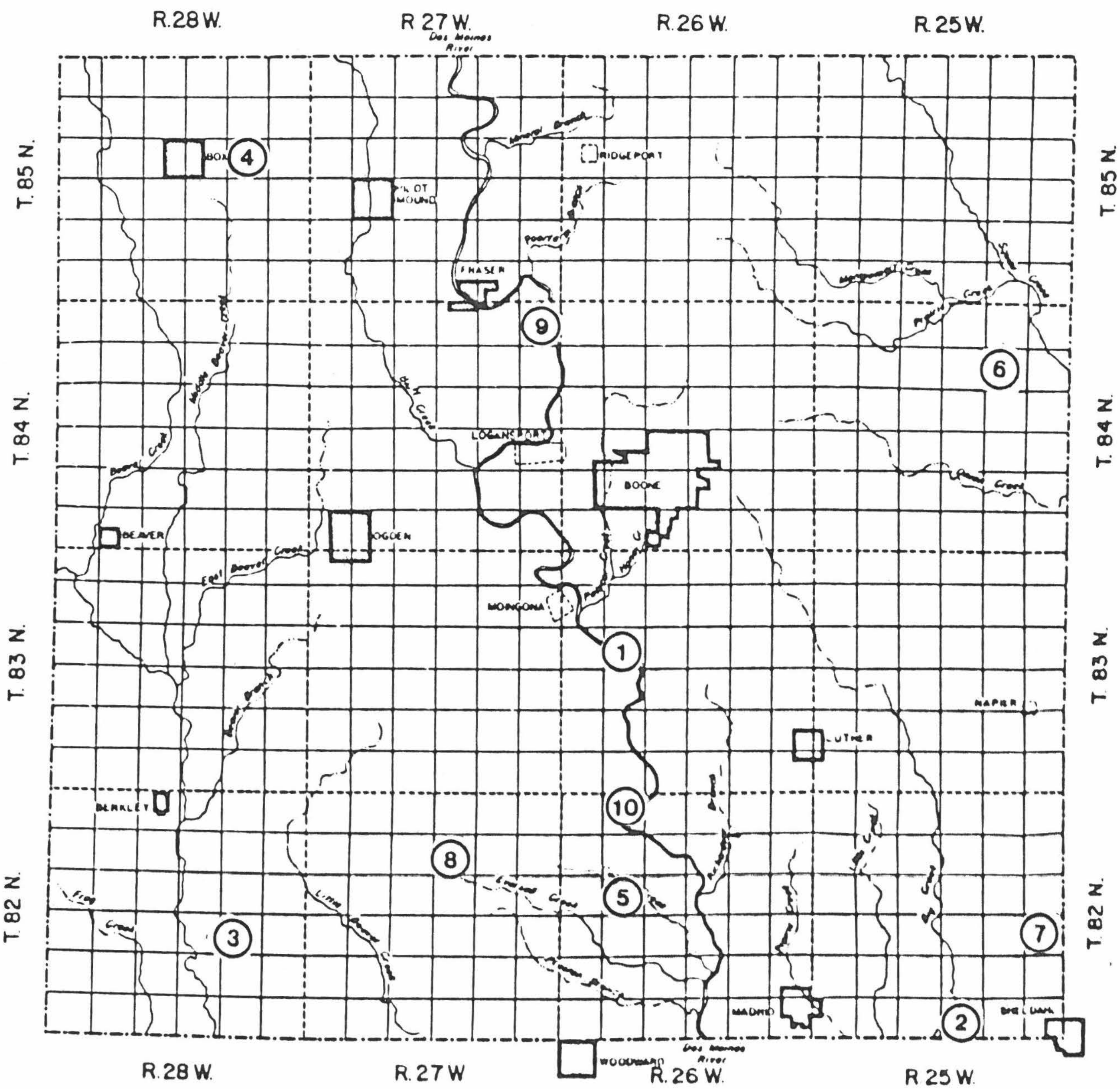


Figure 8

TYPICAL WELLS IN BOONE COUNTY

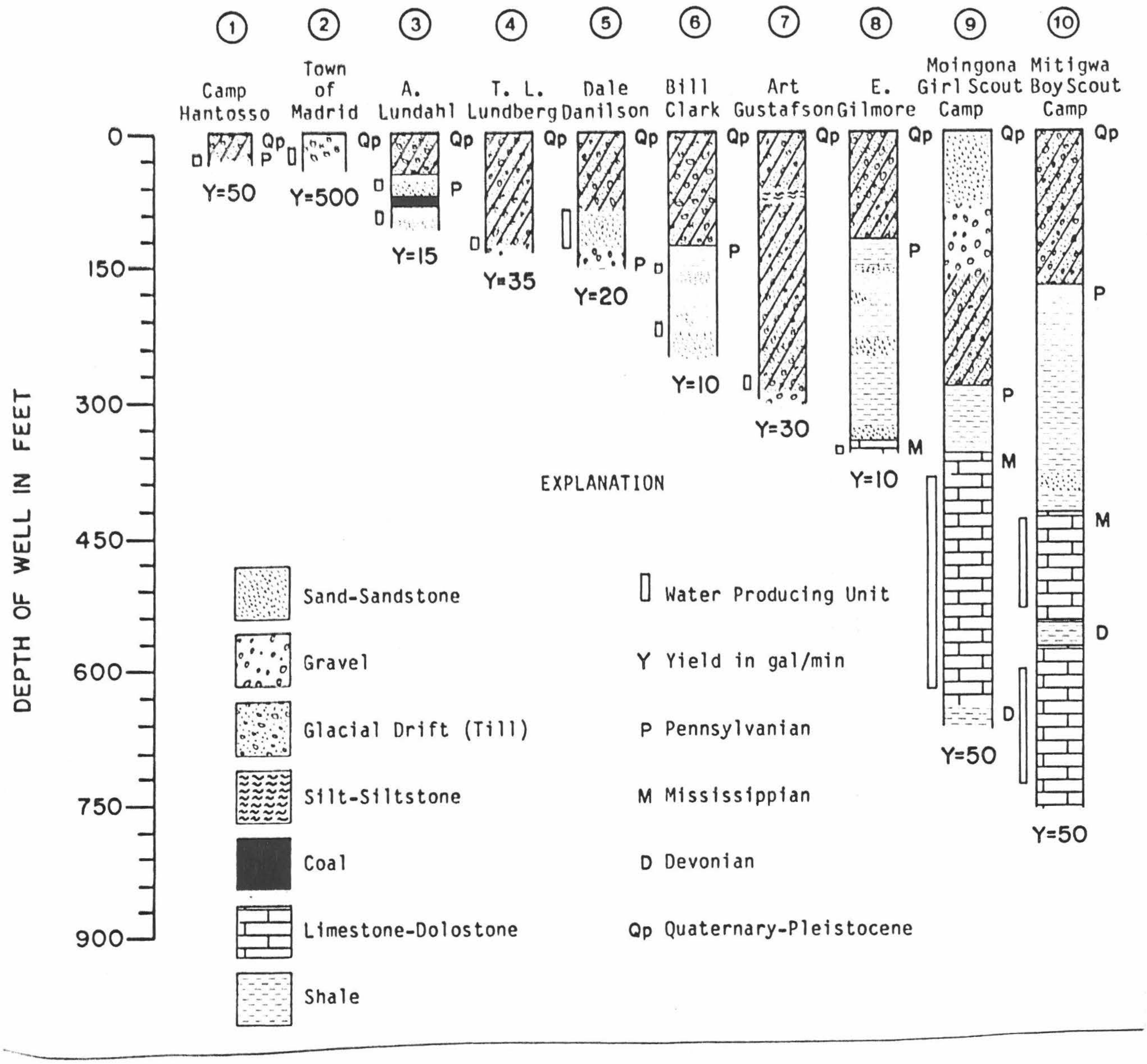


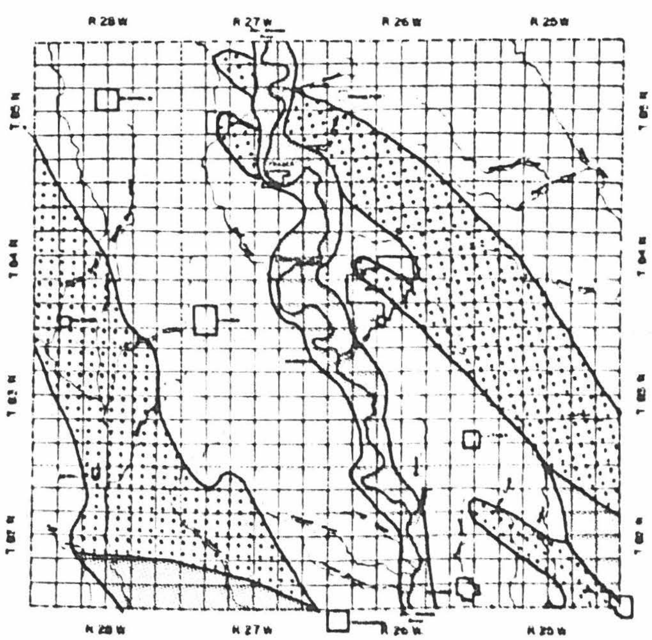
Figure 9

SURFICIAL AQUIFERS

Water Levels

Water levels in the surficial aquifers are difficult to analyze, because water rises to different levels in wells drilled into alluvial, buried-channel, and drift aquifers. The water table in the shallow drift aquifer generally slopes from high land areas toward the streams and, changes noticeably throughout the year in response to recharge from precipitation. Water levels in the alluvial aquifer fluctuate somewhat in the same way as those in the shallow drift aquifer; however, the main influence on the alluvial aquifer is the stage (level) of the associated streams. Water levels will be high during periods of high stream stage and low during the low-stage periods. The intermediate and deep drift and buried channel aquifers are under confined (artesian) conditions and are generally unaffected by local recharge-discharge relationships.

Water levels in the drift aquifers commonly are from 10 to 50 feet below the land surface, and those in the buried-channel aquifers have been reported to be as low as 150 feet below the land surface. The water levels in alluvial wells are from 4 to 20 feet below the flood plain surface and the depth to the water surface will be accordingly deeper in wells located on terrace surfaces.



Water yields to wells in gallons per minute

Below 20

20-100

100-500

Figure 10

MISSISSIPPIAN AQUIFER

Elevation of Mississippian Aquifer in feet above mean sea level.

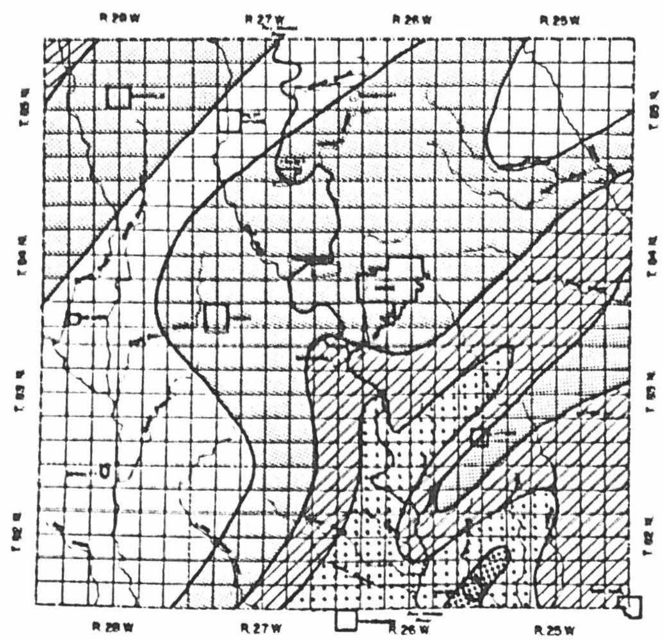
800-900

700-800

600-700

500-600

400-500



Water levels in wells in feet above mean sea level.

1000-1100

900-1000

800-900

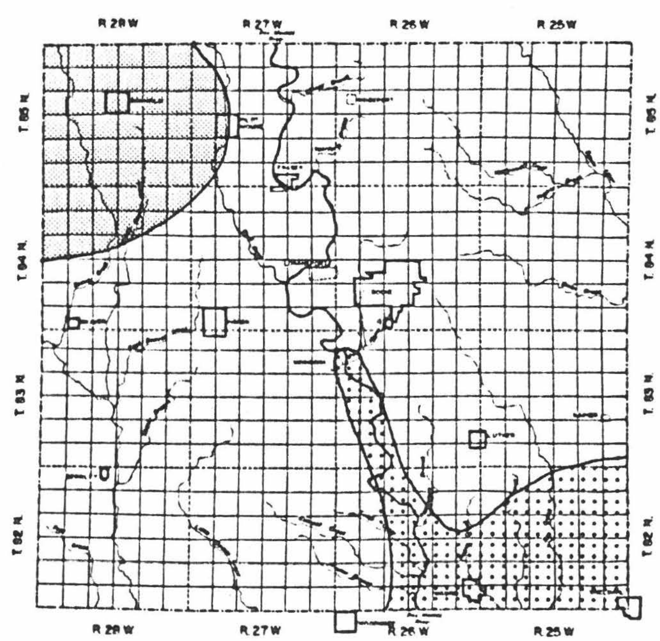


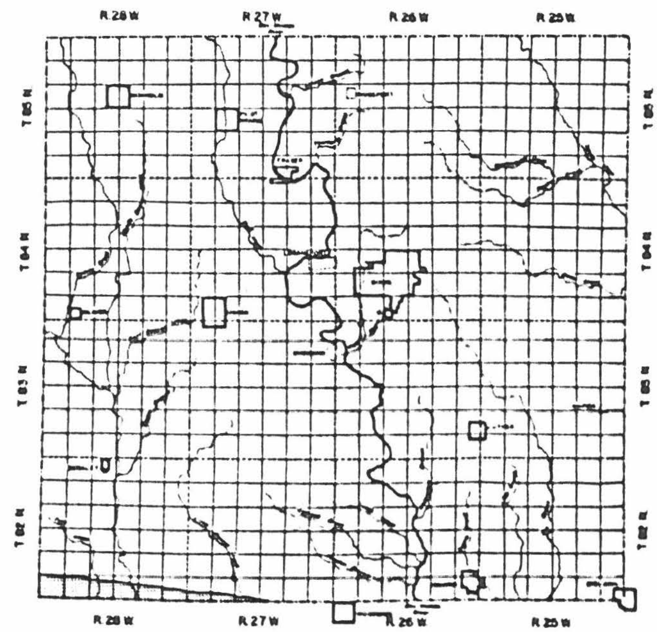
Figure 10 cont.

MISSISSIPPIAN AQUIFER

Water yields to wells in gallons per minute.

Below 20

20-50



Dissolved solids content in milligrams per liter (mg/l).

Below 1000

1000-1500

1500-2000

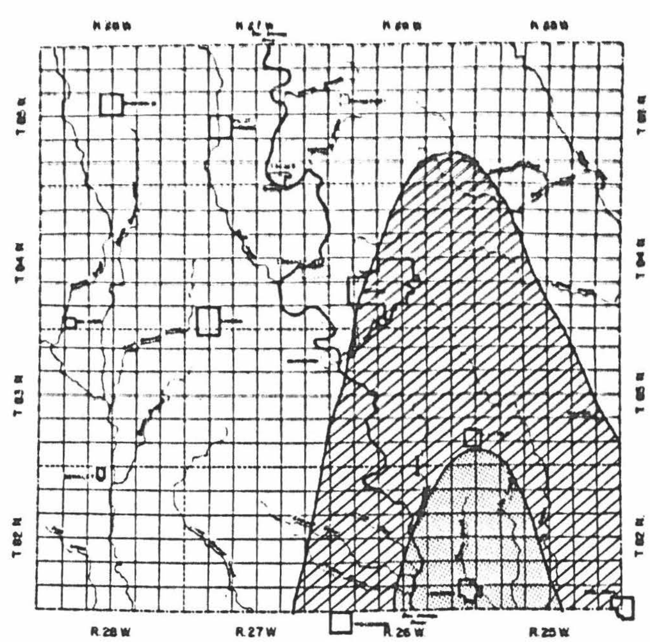
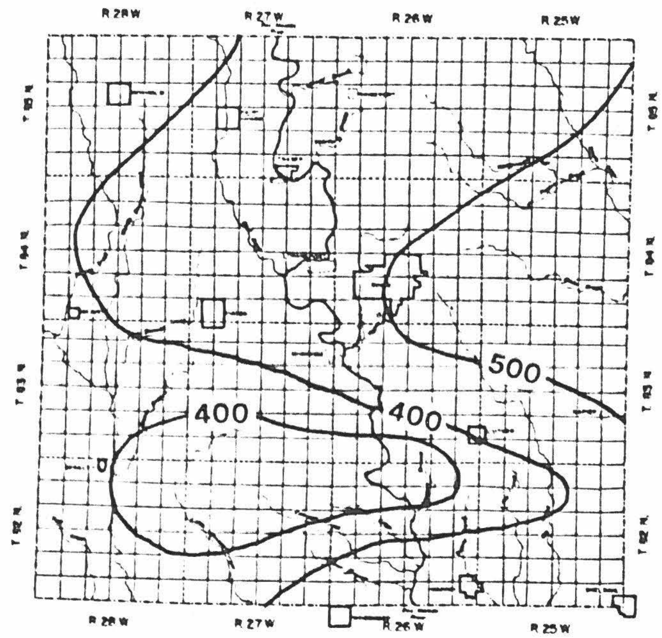


Figure 11

DEVONIAN AQUIFER

Elevation of Devonian Aquifer in feet above mean sea level.



Water levels in wells in feet above mean sea level.

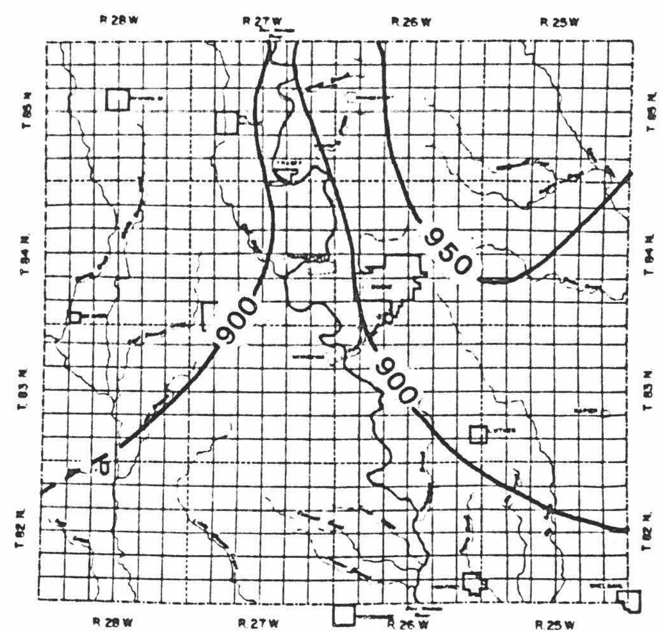


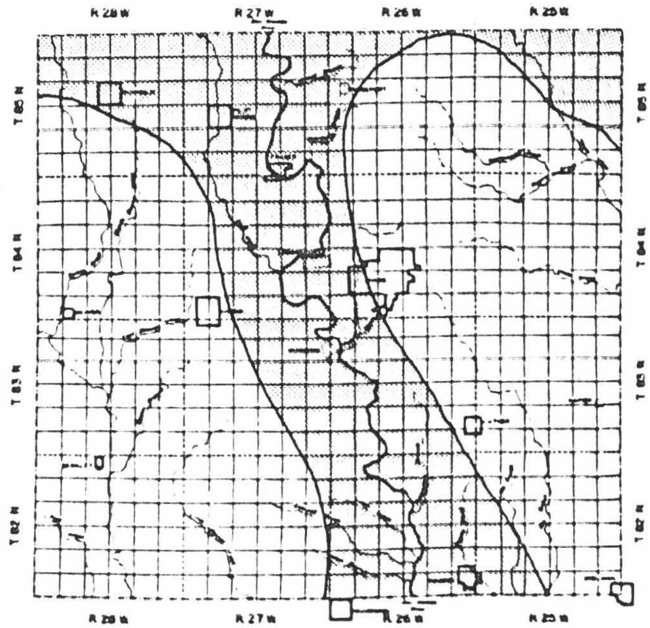
Figure 11 cont.

DEVONIAN AQUIFER

Water yields to wells in gallons per minute

Below 20

20-50



Dissolved solids content in milligrams per liter (mg/l).

1500-2000

Above 2000

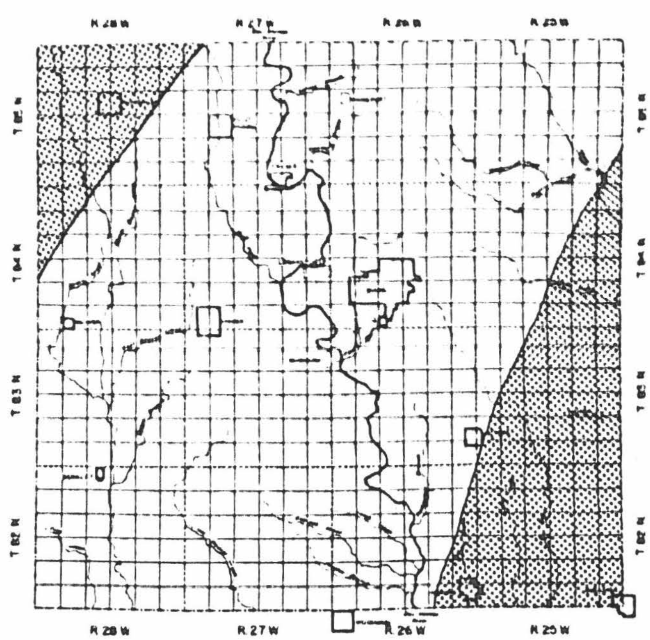
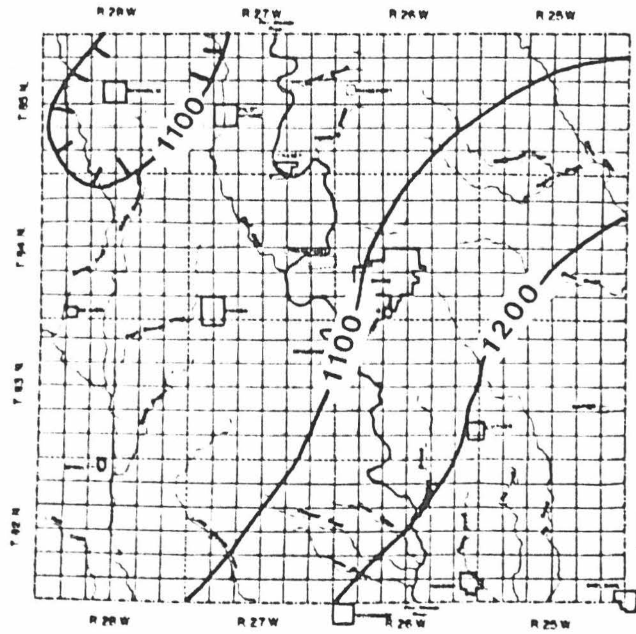


Figure 12

CAMBRO-ORDOVICIAN (JORDAN) AQUIFER

Elevation of Cambro-Ordovician (Jordan) Aquifer in feet below mean sea level.



Water levels in wells in feet above mean sea level.

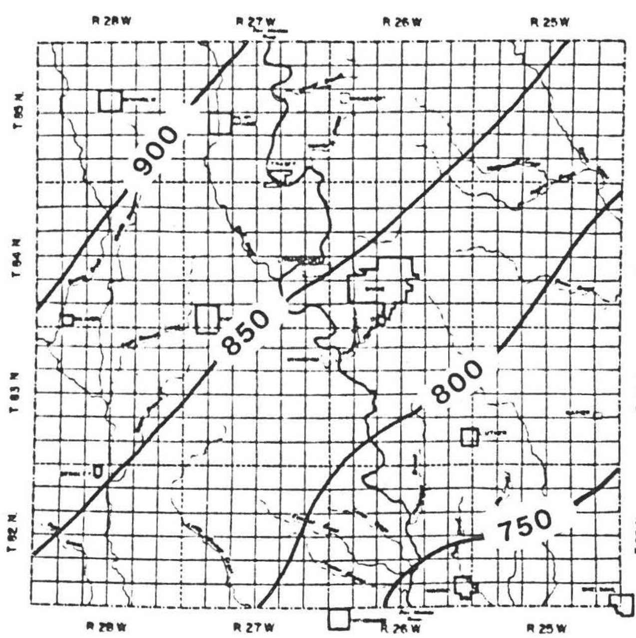
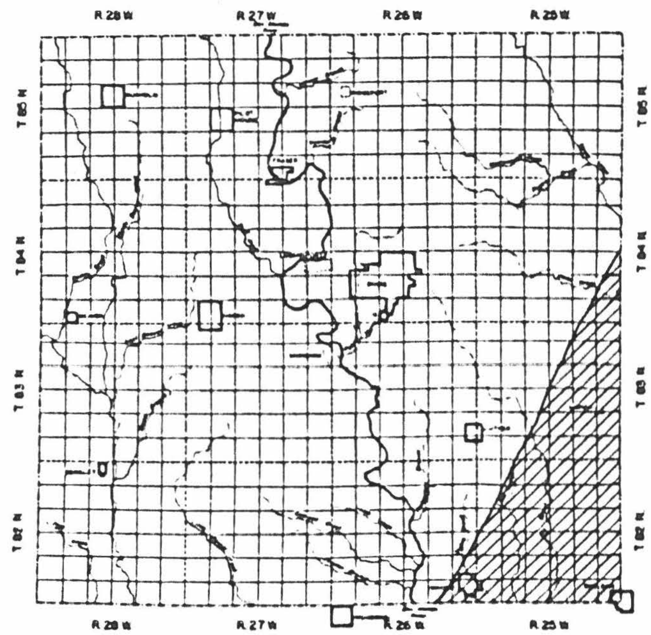


Figure 12 cont.

CAMBRO-ORDOVICIAN (JORDAN) AQUIFER

Water yields of wells in gallons per minute

(blank)	200-500
(hatched)	500-1000



Dissolved solids content in milligrams per liter (mg/l).

(blank)	1000-1250
(dotted)	1250-1500

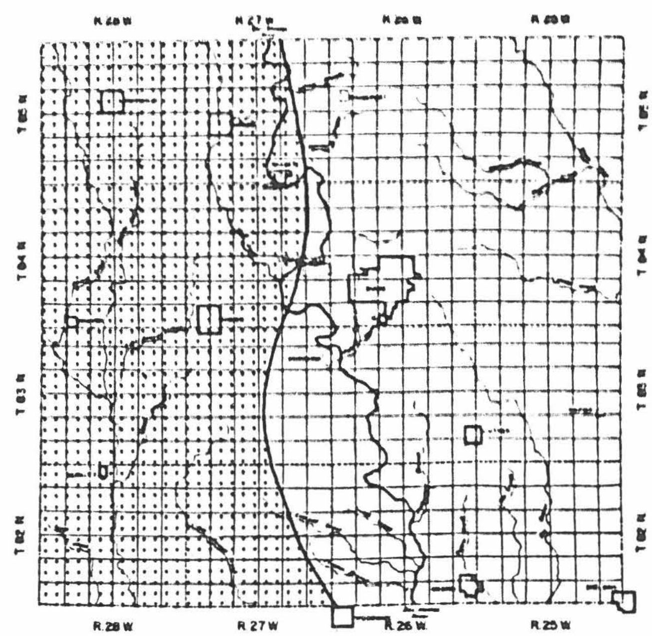


Table 2

SIGNIFICANCE OF MINERAL CONSTITUENTS AND PHYSICAL PROPERTIES OF WATER

Constituent or Property	Maximum Recommended Concentration	Significance
Iron (Fe)	0.3 mg/l	Objectionable as it causes red and brown staining of clothing and porcelain. High concentrations affect the color and taste of beverages. Iron is not listed in the following tables, as there are often major differences between reported and actual concentrations. It may be added to water from well casings, pumps, and pipes. The concentration also is affected by micro-organisms. Special sampling and analytical techniques are needed for accurate study.
Manganese (Mn)	0.05 mg/l	Objectional for the same reason as iron. When both iron and manganese are present, it is recommended that the total concentration not exceed 0.3 mg/l. Micro-organisms also affect the concentration. Special techniques are needed for an accurate study.
Calcium (Ca) and Magnesium (Mg)		Principal causes for hardness and scale-forming properties of water. They reduce the lathering ability of soap.
Sodium (Na) and Potassium (K)		Impart a salty or brackish taste when combined with chloride. Sodium salts cause foaming in boilers.
Sulfate (SO_4)	250 mg/l	Commonly has a laxitive effect when the concentration is 600 to 1,000 mg/l, particularly when combined with magnesium or sodium. The effect is much less when combined with calcium. This laxitive effect is commonly noted by newcomers, but they become acclimated to the water in a short time. The effect is noticeable in almost all persons when concentrations exceed 750 mg/l. Sulfate combined with calcium forms a hard scale in boilers and water heaters.
Chloride (Cl)	250 mg/l	Large amounts combined with sodium impart a salty taste.
Fluoride (F)	2.0 mg/l	Concentrations of 0.8 to 1.3 mg/l are considered to play a part in the reduction of tooth decay. However, concentrations over 2.0 mg/l will cause the mottling of the enamel of children's teeth.
Nitrate (NO_3)	45 mg/l	Waters with high nitrate content should not be used for infant feeding as it may cause methemoglobinemia or cyanosis. High concentrations suggest organic pollution from sewate, decayed organic matter, nitrate in the soil, or chemical fertilizer. High nitrates in the natural waters of central Iowa are limited to isolated occurrences, usually from shallow dug wells on farms. Since the high concentrations are characteristic of individual wells and not of any one aquifer, nitrate will not be discussed in this report.
Dissolved Solids	500 mg/l	This refers to all of the material in water that is in solution. If affects the chemical and physical properties of water for many uses. Amounts over 2,000 mg/l will have a laxitive effect on most persons. Amounts up to 1,000 mg/l are generally considered acceptable for drinking purposes if no other water is available.
Hardness (as $CaCO_3$)		This affects the lathering ability of soap. It is generally produced by calcium and magnesium. Hardness is expressed in parts per million equivalent to $CaCO_3$ as if all the hardness were caused by this compound. Water becomes objectionable for domestic use when the hardness is above 100 mg/l; however, it can be treated readily by softening.
Temperature		Affects the desirability and economy of water use, especially for industrial cooling and air conditioning. Most users want a water with a low and constant temperature.
Suspended Sediment		Causes water to have a cloudy or muddy appearance. It must be settled or filtered out before the water is used. It is the material that "silts-up" reservoirs, and it is the major cause of the reduction of reservoir life.

To the user, the quality of ground water is as important as the amount of water that an aquifer will yield. As ground water moves through soil and rock materials, it dissolves some of the minerals which, in turn, affect water quality. In addition to mineral content, bacterial and chemical contamination may be introduced through poorly constructed wells and seepage from other pollution sources.

Recommended standards for the common mineral constituents in water are described in the table above. These are accepted as guidelines for acceptable drinking water supplies. Limits for uses other than drinking often differ from these. For instance, water that is unacceptable for drinking and household use may be completely satisfactory for industrial cooling.

From past analyses of ground water, the averages (A) and ranges (R) of values in milligrams per liter (mg/l) for several constituents are summarized in Tables 3 and 4 for the surficial and bedrock aquifers in Boone County. Recommended concentrations for some constituents are often exceeded without obvious ill effects, although the water may be unpalatable. Water quality analyses for individual wells should be obtained to determine if concentrations of constituents that affect health are exceeded.

Table 3

CHEMICAL CHARACTER OF GROUND WATER

Surficial Aquifers

Average (A) and range (R)	Dissolved solids	Hardness (as $CaCO_3$)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Sodium (Na)	Iron (Fe)	Manganese (Mn)
					Alluvial aquifer				
A	508	385	103	22	.47	13	20.4	.05	.4
R	463-543	360-420	41-130	9-38	.3-1.2	<.1-37	5.2-54	<.01-.1	<.01-.79
					Drift aquifer				
A	531	391	87.6	13.7	.8	5.3	33.2	2.0	.2
R	417-721	236-498	5.6-290	.5-36	.2-6.3	<.1-27	5-150	<.02-6.4	0.2-1.2

The drift and alluvial aquifer yield the least mineralized water of all ground water sources in Boone County. The water in both aquifers is hard and the iron and manganese concentrations are above recommended standards. All other constituents, however, are well below the recommended limits.

Table 4

CHEMICAL CHARACTER OF GROUND WATER

Bedrock Aquifers

Average (A) and range (R)	Dissolved solids	Hardness (as $CaCO_3$)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Sodium (Na)	Iron (Fe)	Manganese (Mn)
				Mississippian aquifer					
A	727	239	277	16	2.4	.1	148	.61	.02
R	716-743	232-250	260-290	15-18	2.2-2.6		144-150	.5-.7	<.01-<.05
				Devonian aquifer					
A	2370	1505	1400	20	3.8	4.2	295	.96	.01
R	1640-3100	1060-1950	900-1900	18-23	2.6-51.	.1-8.1	80-510	.12-1.8	<0.1-.01
				Cambrian-Ordovician aquifer					
A	1836	933	993	41	2.8	3.0	178	.25	0.2
R	1660-1900	830-1030	870-1100	38-47	2.6-3.0	<.1-4.3	160-200	.1-.4	<.01-<.05

The bedrock aquifers are highly mineralized and are often of limited use for this reason. Only under extensive treatment is the water suitable for domestic and industrial uses, but without treatment it can be used for washing, cooling and fire-fighting.

The Mississippian aquifer has the best quality water of the bedrock aquifers. The iron and sulfate concentrations are above the recommended limits and the dissolved solids are slightly high. Water temperatures average 56°F (14°C) and range between 52°F to 61°F (11°C to 16°C).

Chemical quality data is liited from the Devonian aquifer as it is not heavily used due to its high mineral content. Dissolved solids average over 2000 mg/l and the sulfate concentration is well above the recommended limit. This is due in part to the occurrence of evaporite minerals (gypsum and anhydrite) in the aquifer.

Water from the Cambrian-Ordovician aquifer like that from the Devonian is very hard and has high dissolved solids and sulfate concentrations. The water temperatures range from 73°F to 76°F (23°C to 24°C).

RECOMMENDATIONS FOR PRIVATE WATER WELLS

Contracting for Well Construction

To protect your investment and guarantee satisfactory well completion, it is a good idea to have a written agreement with the well driller. The agreement should specify in detail:

size of well, casing specifications, and types of screen and well seal

methods of eliminating surface and subsurface contamination

disinfection procedures to be used

type of well development if necessary

test pumping procedure to be used

date for completion

itemized cost list including charges for drilling per foot, for materials per unit, and for other operations such as developing and test pumping

guarantee of materials, workmanship, and that all work will comply with current recommended methods

liability insurance for owner and driller

Well Location

A well should be located where it will be least subject to contamination from nearby sources of pollution. The Iowa State Department of Health recommends minimum distances between a new well and pollution sources, such as cesspools (150 ft.), septic tanks (50 ft.), and barnyards (50-100 ft. and downslope from well). Greater distances should be provided where possible.

The well location should not be subject to flooding or surface water contamination. Select a well-drained site, extend the well casing a few feet above the ground, and mound earth around it. Diversion terraces or ditches may be necessary on slopes above a well to divert surface runoff around the well site.

In the construction of all wells, care should be taken to seal or grout the area between the well bore and the well casing (the annulus), as appropriate, so that the surface water and other pollutants cannot seep into the well and contaminate the aquifer.

Locate a well where it will be accessible for maintenance, inspection, and repairs. If a pump house is located some distance from major buildings and wired separately for power, continued use of the water supply will not be jeopardized by fire in major buildings.

Water Treatment

Water taken from a private well should ideally be tested every six months. The University Hygienic Laboratory will do tests for coliform bacteria, nitrate, iron, hardness, and iron bacteria in drinking water for private individuals. Special bottles must be used for collecting and sending water samples to the laboratory. A sample kit can be obtained by writing to the University Hygienic Laboratory, University of Iowa, Oakdale Campus, Iowa City, Iowa 52242. Indicate whether your water has been treated with chlorine, iodine, or bromine; as different sample bottles must be used for treated and untreated water. The charge for the bacterial test is $4; for iron hardness and nitrate, it is $5; and the iron bacteria, $10. If your well is determined to be unsafe, advice for correcting the problem can be obtained from your county or state Department of Health. Several certified private laboratories also run water analyses.

Shock chlorination is recommended following the construction and installation of a well and distribution system and anytime these are opened for repairs or remodeling. A strong chlorine solution is placed in the well and complete distribution system to kill nuisance and disease-causing organisms. If the first shock chlorination does not rid the water supply of bacteria it should be repeated. If this does not solve the problem, the well should be abandoned or the water should be continuously disinfected with proper chlorination equipment.

Since most of the ground water in Boone County is mineralized, water softening and iron removal equipment may make water more palatable and pleasant to use. Softened water contains increased sodium; contact your physician before using a softener if you are on a sodium-restricted diet. Chlorination followed by filtration will remove most forms of iron and iron bacteria. Iron bacteria has no adverse effect on health but it will plug wells, water lines, and equipment and cause tastes and odors. Iron removal equipment can be used if problems persist.

Well Abandonment

Wells taken out of service provide easy access for pollution to enter aquifers supplying water to other wells in the vicinity. Unprotected wells may also cause personal injury. Proper abandonment procedures should be followed to restore the natural conditions that existed before well construction and prevent any future contamination. Permanent abandonment requires careful sealing. The well should be filled with concrete, cement grout, or sealing clays throughout its entire length. Before dug or bored wells are filled at least the top 10 feet of lining should be removed so surface waters will not penetrate the subsurface through a porous lining or follow cracks in or around the lining. The site should be completely filled and mounded with compacted earth.

ABANDONED WELLS SHOULD NEVER BE USED FOR DISPOSAL OR SEWAGE OR OTHER WASTES.

SOURCES OF ADDITIONAL INFORMATION

In planning the development of a ground water supply or contracting for the drilling of a new well, additional or more specific information is often required. This report section lists several sources and types of additional information.

State Agencies That May Be Consulted

Iowa Geological Survey[1]	123 North Capitol Iowa City 52242	(319) 338-1173
State Health Department[2,6]	Lucas Building Des Moines 50319	(515) 281-5787
Iowa Natural Resources Council[3]	Wallace Building Des Moines 50319	(515) 281-5914
Iowa Dept. of Environ. Quality[4]	Wallace Building Des Moines 50319	(515) 281-8854
University Hygienic Laboratory[5]	U. of IA, Oakdale Campus Iowa City 52242	(319) 353-5990
Cooperative Extension Service in[6] Agriculture and Home Economics	110 Curtis Hall, ISU Ames 50011	(515) 294-4569

Functions:

[1] Geologic and ground-water data repository, consultant on well problems, water development and related services

[2] Drinking water quality, public and private water supplies

[3] Water withdrawal regulation and Water Permits for wells withdrawing more than 5000 gpd

[4] Municipal supply regulation and well construction permits

[5] Water quality analysis

[6] Advice on water systems design and maintenance

Well Drillers and Contractors

The listing provided here was drawn from an Iowa Geological Survey mailing list and yellow pages of major towns in phone books. Those selected are within an approximate radius of 50 miles of Polk County. For a state-wide listing contact either the Iowa Water Well Driller's Association, 4350 Hopewell Avenue, Bettendorf, Iowa 51712, (319) 355-7528 or the Iowa Geological Survey, (319) 338-1173.

Bill Beemer
Beemer Well Co.
R.R. #2
Webster City, IA 50595

Bruinekool Well
Perry, IA 50220

Dewey Well Co.
Box 177
Slater, IA 50244

Lester Fouts & Son
340 1st
Rockwell City, IA 50574

Donald L. Hicks
Hicks Well Co.
Scranton, IA 51462

Huff Well Drilling Co.
R.R. #1
Winterset, IA 50273

Hughes Well Co.
4120 73rd
Des Moines, IA 50322

Max Larson
Larson Well Co.
Roland, IA 50236

Layne-Western Co., Inc.
705 S. Duff St.
Ames, IA 50010

Lee's Pump and Repair
Steam Boat Rock, IA 50672

Newton-Whalen Well Co.
1407 1st Avenue
Newton, IA 50208

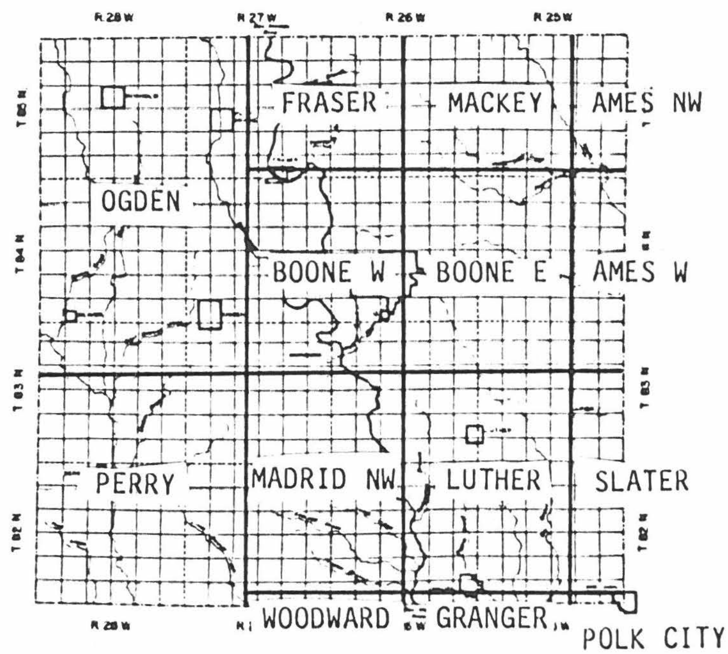
Harold M. Rasmussen
Callendar, IA 50523

Jerry Reiwertz
1133 9th Street
Nevada, IA 50201

Mr. Rosenquist
Rosenquist Well Co.
Burnside, IA 50521

Thorpe Well Co.
Ankeny, IA 50021

Topographic Maps (Available from the Iowa Geological Survey)



Map Title	Date (Published)	Scale	Contour Interval
Ames NW	1975	1:24,000	10'
Ames W	1975	1:24,000	10'
Boone E	1965	1:24,000	10'
Boone W	1965	1:24,000	10'
Fraser	1965	1:24,000	10'
Granger	1976	1:24,000	10'
Luther	1975	1:24,000	10'
Mackey	1965	1:24,000	10'
Madrid NW	1965	1:24,000	10'
Ogden	1951	1:62,500	10'
Perry	1950	1:62,500	10'
Polk City	1972	1:24,000	10'
Slater	1975	1:24,000	10'
Woodward	1976	1:24,000	10'

Useful Reference Materials

Horick, P. J., and Steinhilber, W. L., 1973, Mississippian aquifer of Iowa, Iowa Geological Survey, Misc. Map Series No. 3.

Horick, P. J., and Steinhilber, W. L., 1978, Jordan aquifer of Iowa, Iowa Geological Survey, Misc. Map Series No. 6.

Iowa State Department of Health, 1971 Sanitary standards for water wells, State Department of Health, Environmental Engineering Service.

Twenter, F. R., and Coble, R. W., 1965, The water story in central Iowa, Iowa Geological Survey Water Atlas No. 1.

Van Eck, O. J, 1971, Optimal well plugging procedures, Iowa Geological Survey, Public Information Circular No. 1.

Van Eck, O. J, 1978, Plugging procedures for domestic wells, Iowa Geological Survey, Public Information Circular No. 11.