GROUND WATER
RESOURCES

Washington County

Open File Report 80-92 WRD

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GROUND-WATER RESOURCES OF WASHINGTON COUNTY

Introduction

One-hundred percent of the residents of Washington 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 1.2 billion gallons per year. For comparison, this amount would provide each resident with 174 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 gound water and the adequacy of a supply source:

<u>distribution</u> - having water where it is needed,

<u>accessibility</u> - affects the costs for drilling wells and pumping water,

<u>yield</u> - relates to the magnitude of the supply that can be sustained,

<u>quality</u> - determines for what purposes the water can be used.

In terms of these factors, there are few locations in Washington 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 Washington 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 with 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 Washington County there are four principal aquifers from which users obtain water supplies. The loose, unconsolidated materials near the land surface comprise the surficial aquifer. Below this there are three major rock aquifers -- the Mississippian, the Devonian, and the Cambro-Ordovician aquifers. Figure 1 shows the geologic relations of these beneath the county. Each of the aquifers 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. Water-yielding potential of the surficial deposits is greatest in units composed mostly of sand and/or gravel. Three types of surficial aquifers are used: the alluvial aquifer, the drift aquifer, and the buried channel aquifer.

The alluvial aquifer consists mainly of the sand and gravel transported and deposited by modern streams and makes up the floodplains and terraces in major valleys. Alluvial deposits are shallow, generally less than 50-60 feet and thus may be easily contaminated by the infiltration of surface water.

The drift aquifer is the thick layer of clay to boulder size material 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 are, however, lenses or beds of sand and gravel within the drift which are thick and widespread enough to serve as dependable water sources. These lenses are difficult to locate because they are irregular in shape and buried within the drift deposits. Usually one or two sand layers can be found in most places that will yield minimum water supplies for domestic wells.

The buried channel aquifer consists of stream alluvium of partially filled valleys that existed before the glacial period. The valleys were overridden by the glaciers and are now buried under glacial and recent alluvial deposits.

The distribution, yields, and water quality characteristics for the surficial aquifers are summarized in Figures 2, 9, and 13. An indication of accessibility can be obtained by comparing the elevations of the top (the land surface) and the bottom (the bedrock surface) of the surficial deposits from Figures 4 and 5. The thickness of the glacial drift and the depth of the buried channels are determined by subtracting the elevations at selected locations.

Rock Aquifers

Below the surficial materials is a thick sequence of layered rocks formed from deposits of rivers and shallow seas that have covered the state within the last 600 million years. The geologic map (Figure 3) shows the geologic units which form the top of this rock sequence. These rocks are Pennsylvanian in age and are mainly shales. Although the Pennsylvanian rocks usually act as an aquiclude, there are locally sandstone layers (in Washington very scarce, but some near Ainsworth and Crawfordsville in the southeastern corner and Brighton in the southwestern corner) which could supply small yields to domestic wells. The Pennsylvanian rocks are very patchy throughout the county and are thickest (about 50-75') in the southwestern edge, but dwindle to 0' in most places except in the southeastern corner near Crawfordsville and Ainsworth and east-central near Haskins.

Underlying the Pennsylvanian aquiclude is a sequence of older rocks, portions of which form the three major rock aquifers in Washington County. This sequence and its water-bearing characteristics are shown in Table 1.

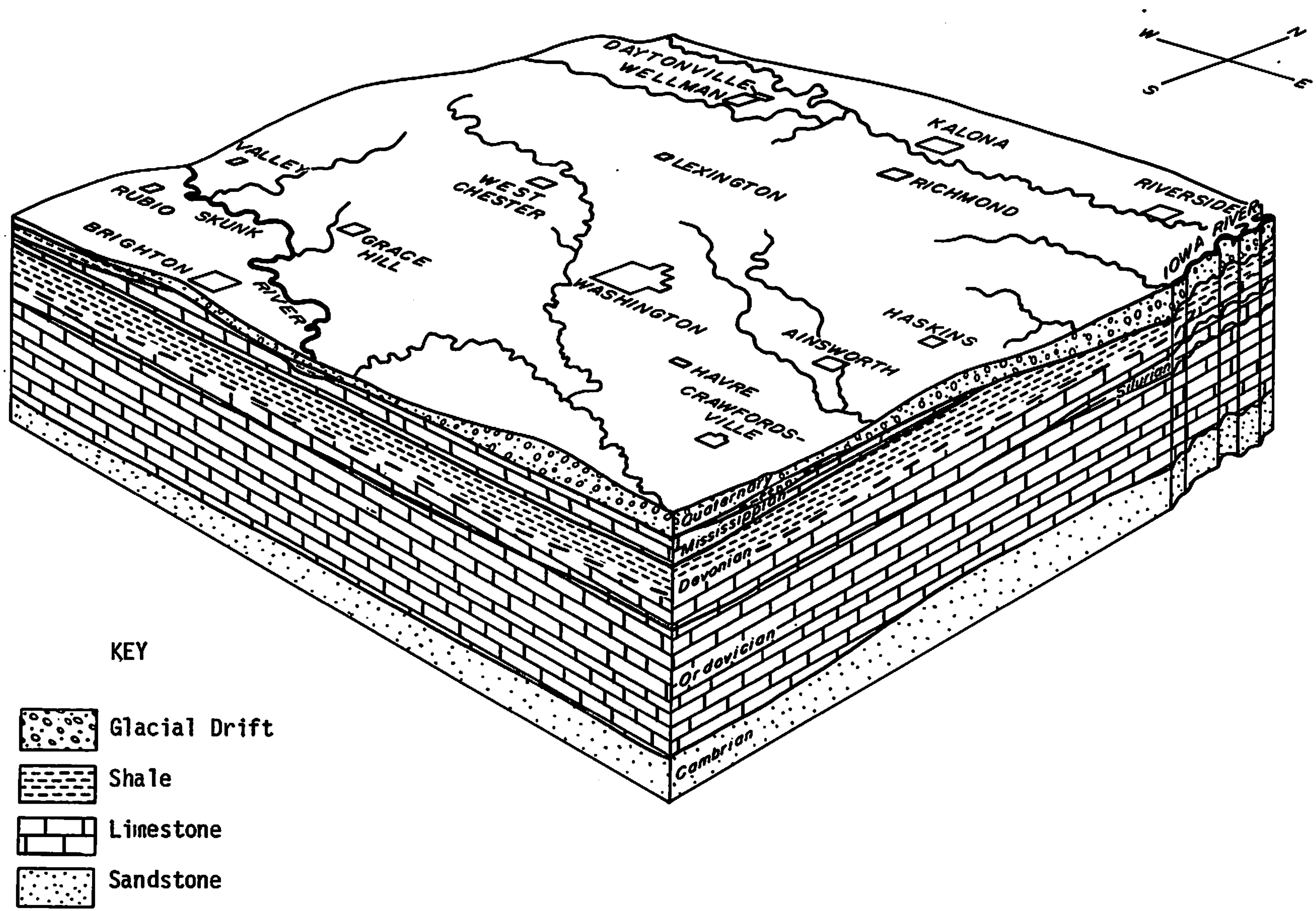


Figure 1

BLOCK DIAGRAM SHOWING THE GEOLOGY OF WASHINGTON COUNTY

Examples of the rock units encountered in several wells at various locations in Washington County are indexed and illustrated in Figures 7 and 8. The geologic unit that supplies ground water and the rate of yield are shown for each well.

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 the well once the aquifer is penetrated. This can reduce the cost of pumping. Average static water levels for Washington 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, 13, 14 and 15.

Table 1

GEOLOGIC AND HYDROGEOLOGIC UNITS IN WASHINGTON COUNTY

Age	Rock Unit	Description	Thickness Range	Hydrogeologic Unit	Water-Bearing Characteristics
Quaternary	Alluvium	Sand, gravel, silt and clay	0-320 (feet)	Surficial aquifer	Fair to large yields (25 to 100 gpm)
	Glacial Drift (undifferentiated)	Predominantly till containing scattered irregular bodies of sand and gravel			Low yields (less than 10 gpm)
	Buried channel deposits	Sand, gravel, silt and clay			Small to large yields
Pennsylvanian	Des Moines Series	Shale, sandstones, and limestones; mostly thin	0-60	Aquiclude	Low yields only from limestone and sandstone
Mississippian	Meramec Series	Sandy limestone	0-250	Mississippian aquifer	Fair to low yields
	Osage Series	Limestone and dolostone cherty; shale			
	Kinderhook Series	Limestone, oolitic and dolostone, cherty, also siltstone			
Devonian	Maple Mill Shale Sheffield Formation, Lime Creek Formation	Mostly shale, with siltstone in the upper part and limestone in the lower part	150-350	Devonian aquiclude	Does not yield water
	Cedar Valley Limestone Wapsipinicon Formation	Limestone and dolostone contains evaporites (gypsum), in southern half of Iowa	100-250	Devonian aquifer	Fair to low yields
Silurian	Undifferentiated	Dolostone	0-140	Silurian aquifer	Fair to large yields (25 to 200 gpm)
Ordovician	Maquoketa Formation	Shale and dolostone	375-550	Maquoketa aquiclude	Does not yield water
	Galena Formation	Dolostone and chert		Minor aquifer	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	550-850 which includes 90-150	Cambrian-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 sandstones: crystalline rocks		Base of groundwater reservoir	Not known to yield water

Figure 2

SURFICIAL MATERIALS

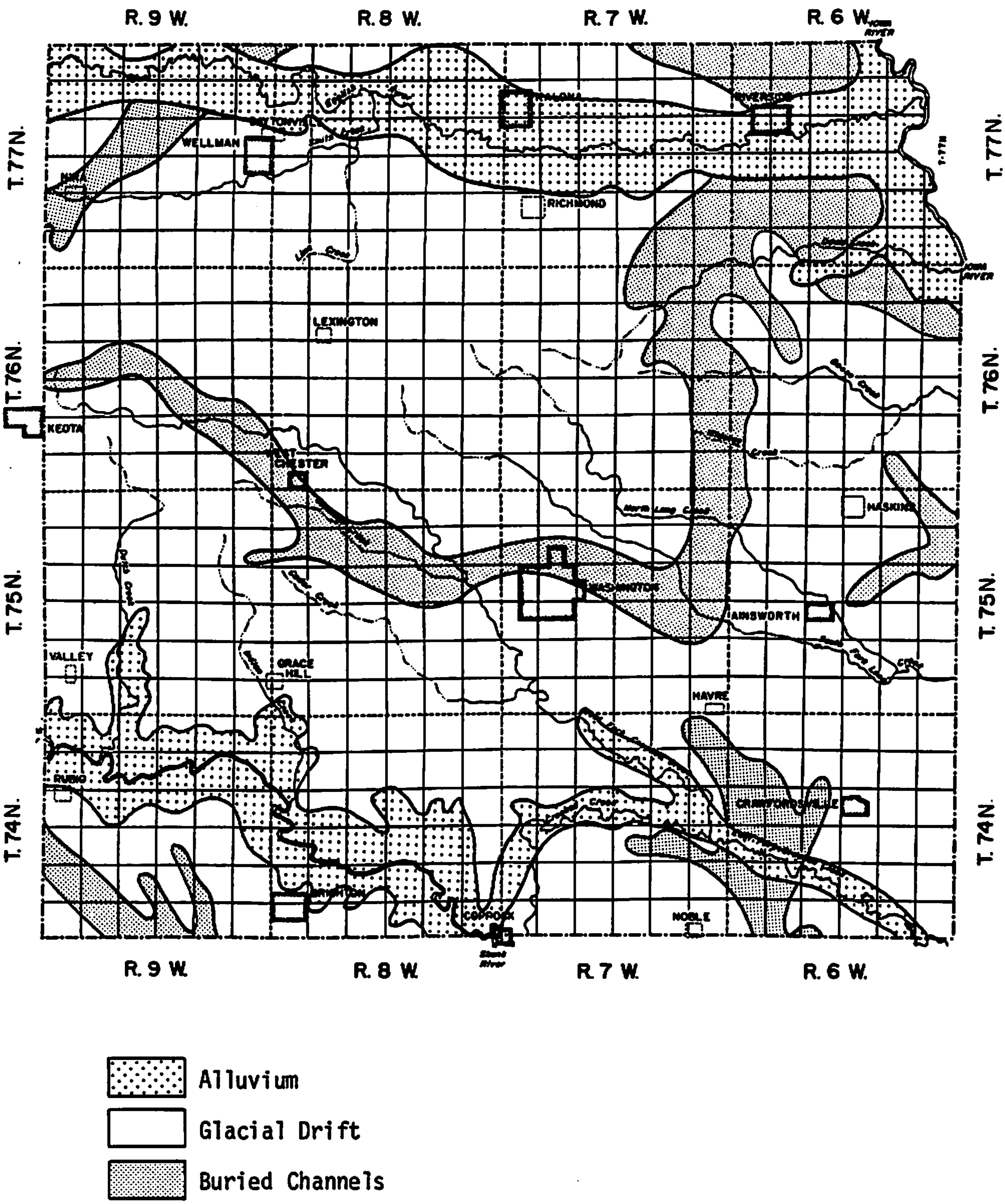


Figure 3

GEOLOGIC MAP

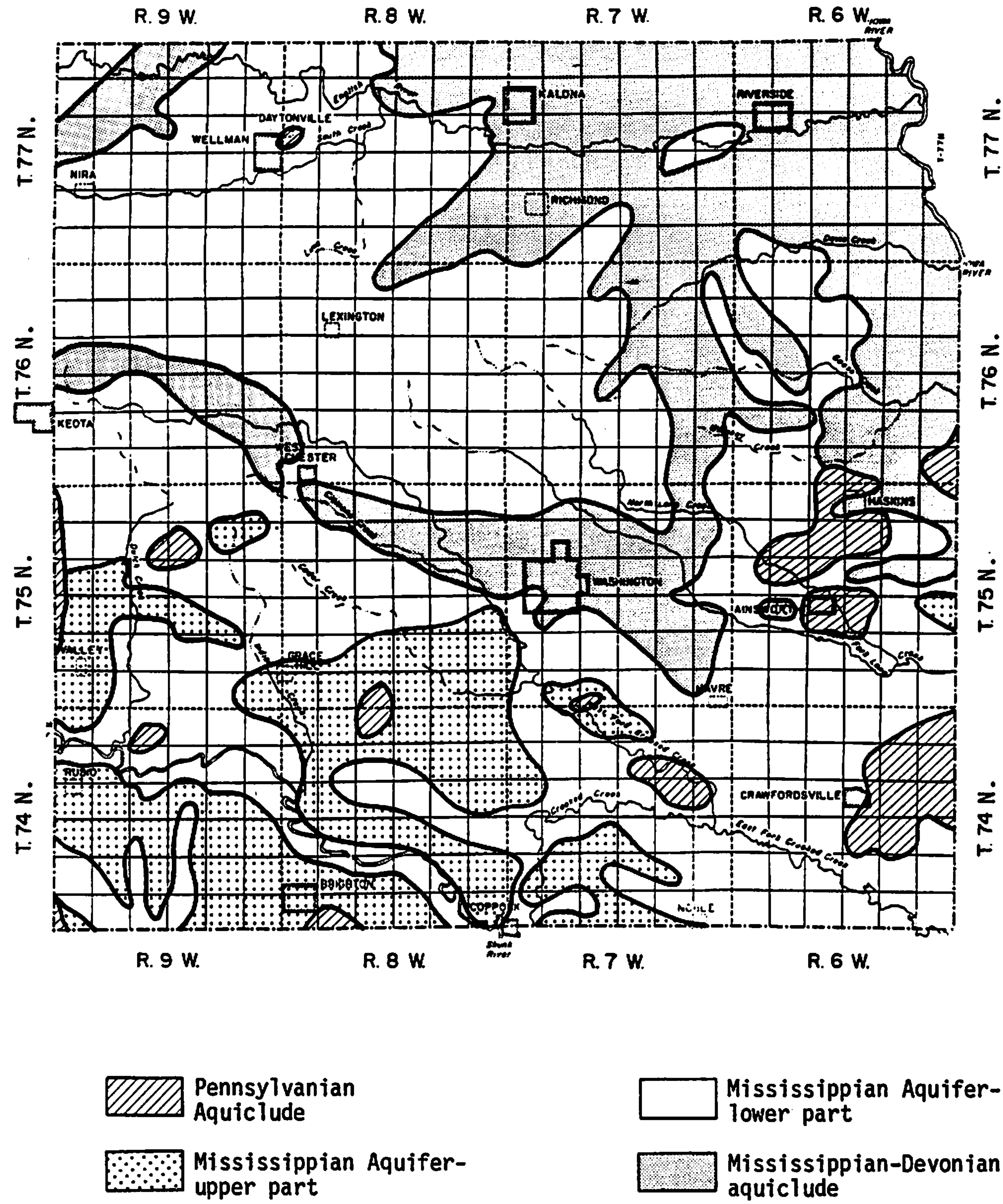


Figure 4

ELEVATION OF LAND SURFACE IN FEET ABOVE MEAN SEA LEVEL

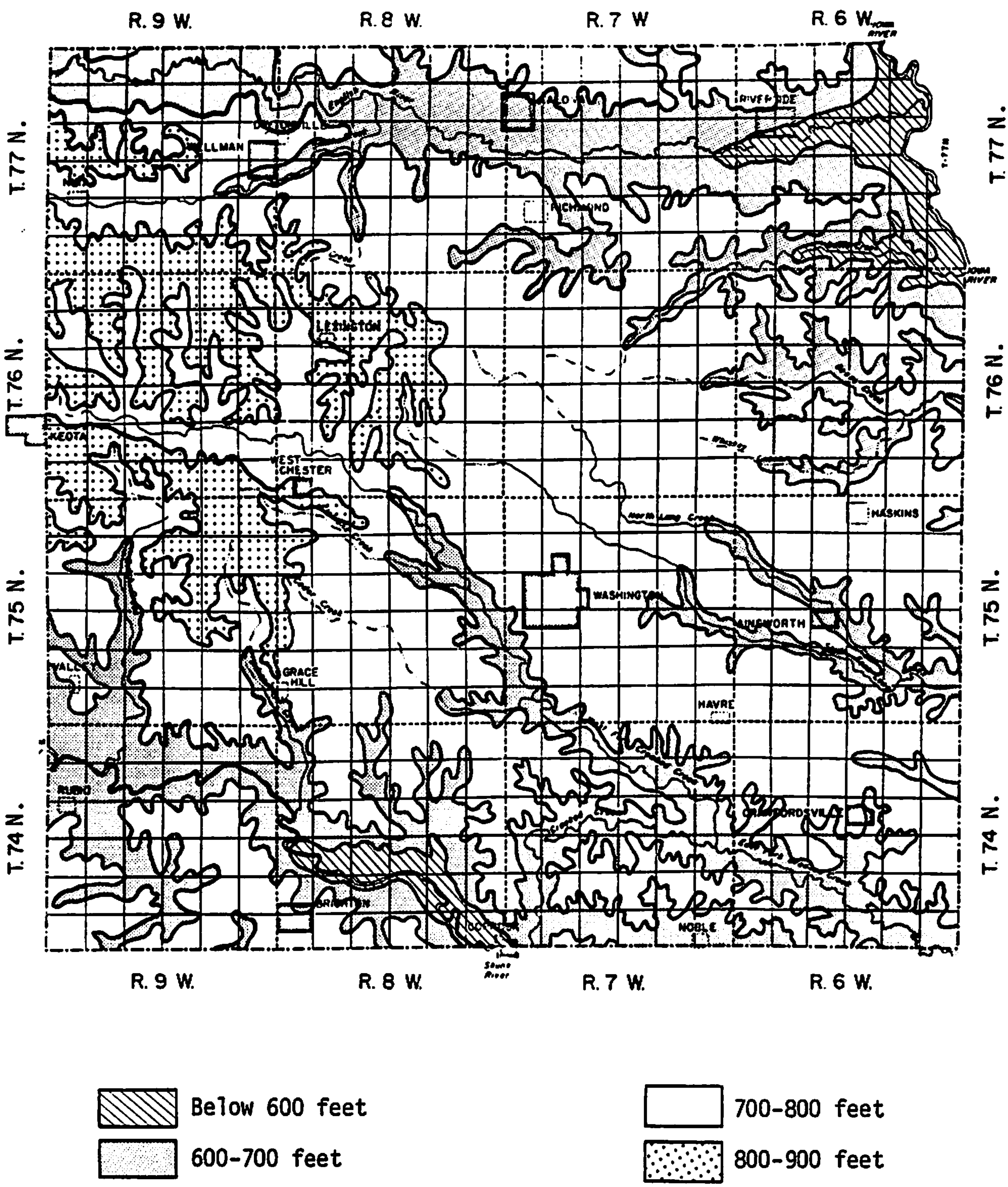
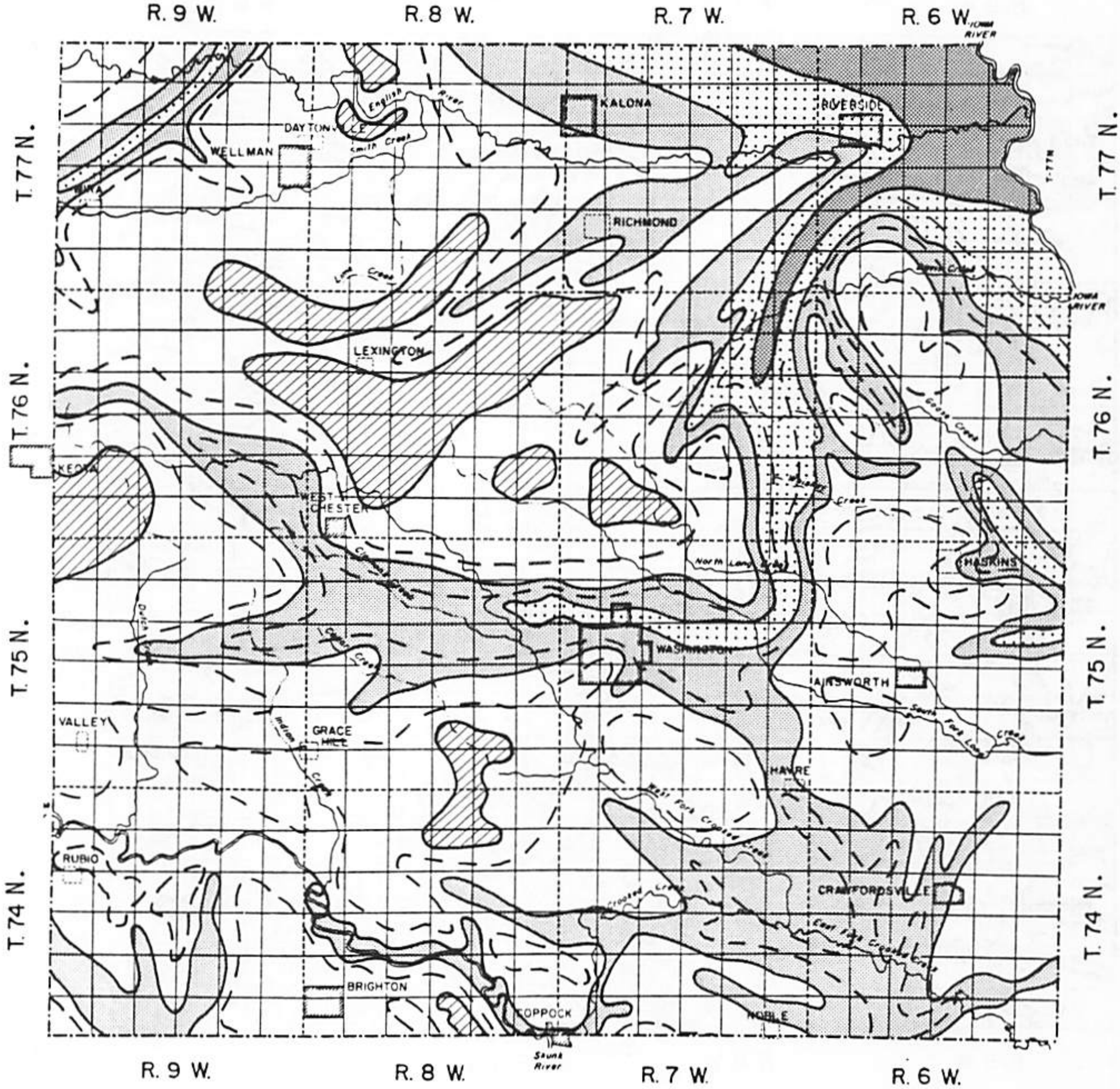


Figure 5

ELEVATION OF BEDROCK SURFACE IN FEET ABOVE MEAN SEA LEVEL



Less than 400 feet	600-700 feet
400-500 feet	Over 700 feet
500-600	— — — 50 foot contour

Figure 6

RANGE IN DEPTH TO WASHINGTON COUNTY'S PRINCIPAL ROCK AQUIFERS

	R-9W	R-8W	R-7W	R-6W
T-77N	BEDROCK 0-200 MISSISSIPPIAN 0-200 DEVONIAN 400-600 CAMBRO-ORDOVICIAN 1100-1300	BEDROCK 0-200 MISSISSIPPIAN 0-200 DEVONIAN 350-600 CAMBRO-ORDOVICIAN 1000-1200	BEDROCK 0-300* MISSISSIPPIAN 0-100 DEVONIAN 300-500 CAMBRO-ORDOVICIAN 1000-1100	BEDROCK 0-350* MISSISSIPPIAN 0-100 DEVONIAN 200-450 CAMBRO-ORDOVICIAN 900-1100
T-76N	BEDROCK 0-200 MISSISSIPPIAN 0-200 DEVONIAN 400-600 CAMBRO-ORDOVICIAN 1100-1300	BEDROCK 0-200 MISSISSIPPIAN 0-200 DEVONIAN 400-700 CAMBRO-ORDOVICIAN 1000-1225	BEDROCK 0-300* MISSISSIPPIAN 50-200 DEVONIAN 350-500 CAMBRO-ORDOVICIAN 1000-1100	BEDROCK 0-300* MISSISSIPPIAN 0-200 DEVONIAN 200-550 CAMBRO-ORDOVICIAN 900-1100
T-75N	BEDROCK 0-200 MISSISSIPPIAN 50-200 DEVONIAN 400-700 CAMBRO-ORDOVICIAN 1100-1300	BEDROCK 0-300* MISSISSIPPIAN 0-200 DEVONIAN 400-600 CAMBRO-ORDOVICIAN 1100-1250	BEDROCK 0-300 MISSISSIPPIAN 0-300 DEVONIAN 400-600 CAMBRO-ORDOVICIAN 1000-1100	BEDROCK 0-200 MISSISSIPPIAN 50-200 DEVONIAN 300-600 CAMBRO-ORDOVICIAN 1000-1100
T-74N	BEDROCK 0-200 MISSISSIPPIAN 0-200 DEVONIAN 500-600 CAMBRO-ORDOVICIAN 1100-1200	BEDROCK 0-200 MISSISSIPPIAN 0-200 DEVONIAN 400-700 CAMBRO-ORDOVICIAN 1000-1300	BEDROCK 0-200 MISSISSIPPIAN 0-200 DEVONIAN 500-600 CAMBRO-ORDOVICIAN 1000-1250	BEDROCK 0-200 MISSISSIPPIAN 50-200 DEVONIAN 500-600 CAMBRO-ORDOVICIAN 1000-1200

* Greater depth to bedrock in township, owing to the absence of the Mississippian Aquifer in various parts of that township.

Figure 7

INDEX MAP FOR TYPICAL WELLS IN WASHINGTON COUNTY

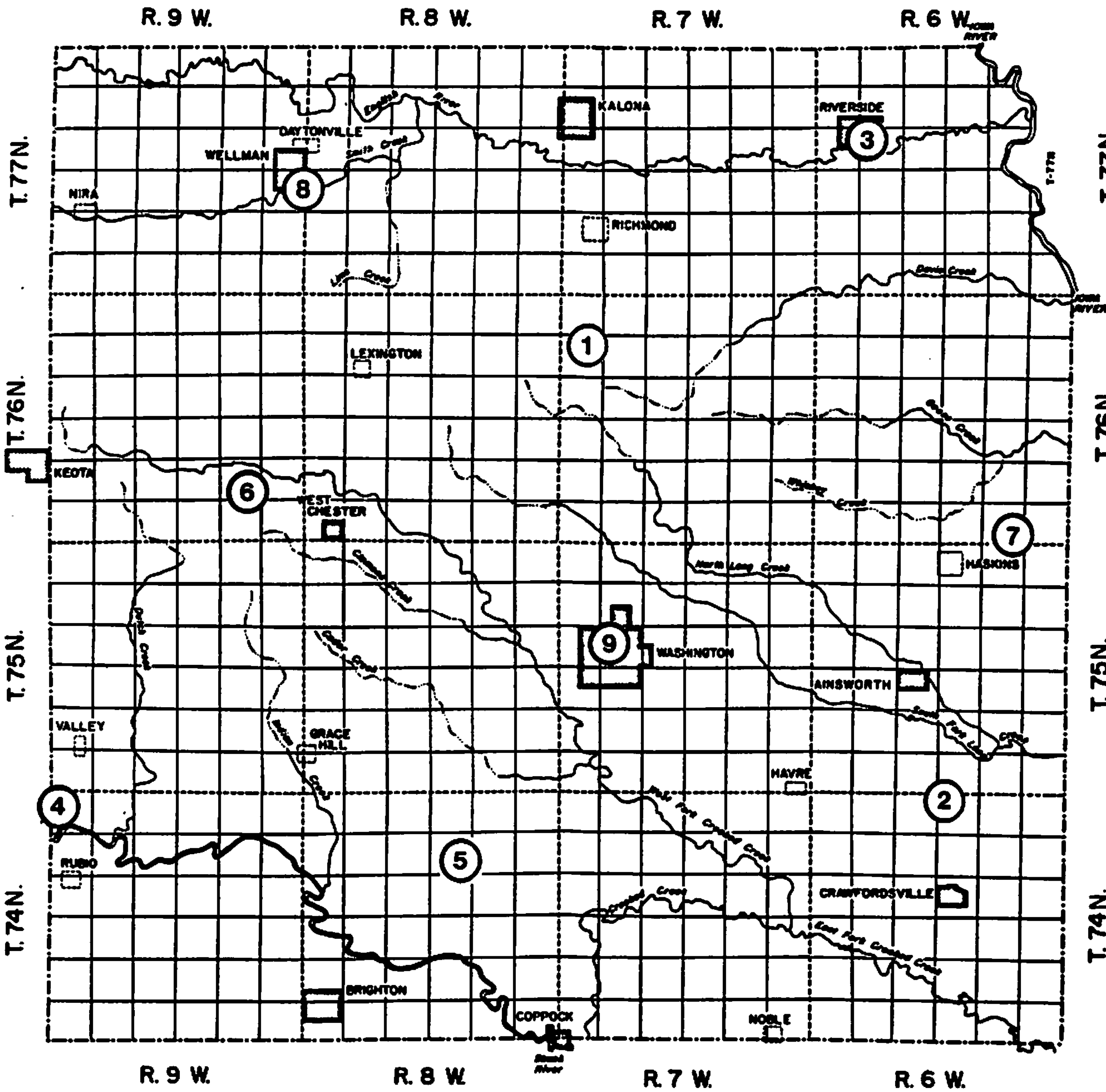


Figure 8

TYPICAL WELLS IN WASHINGTON COUNTY

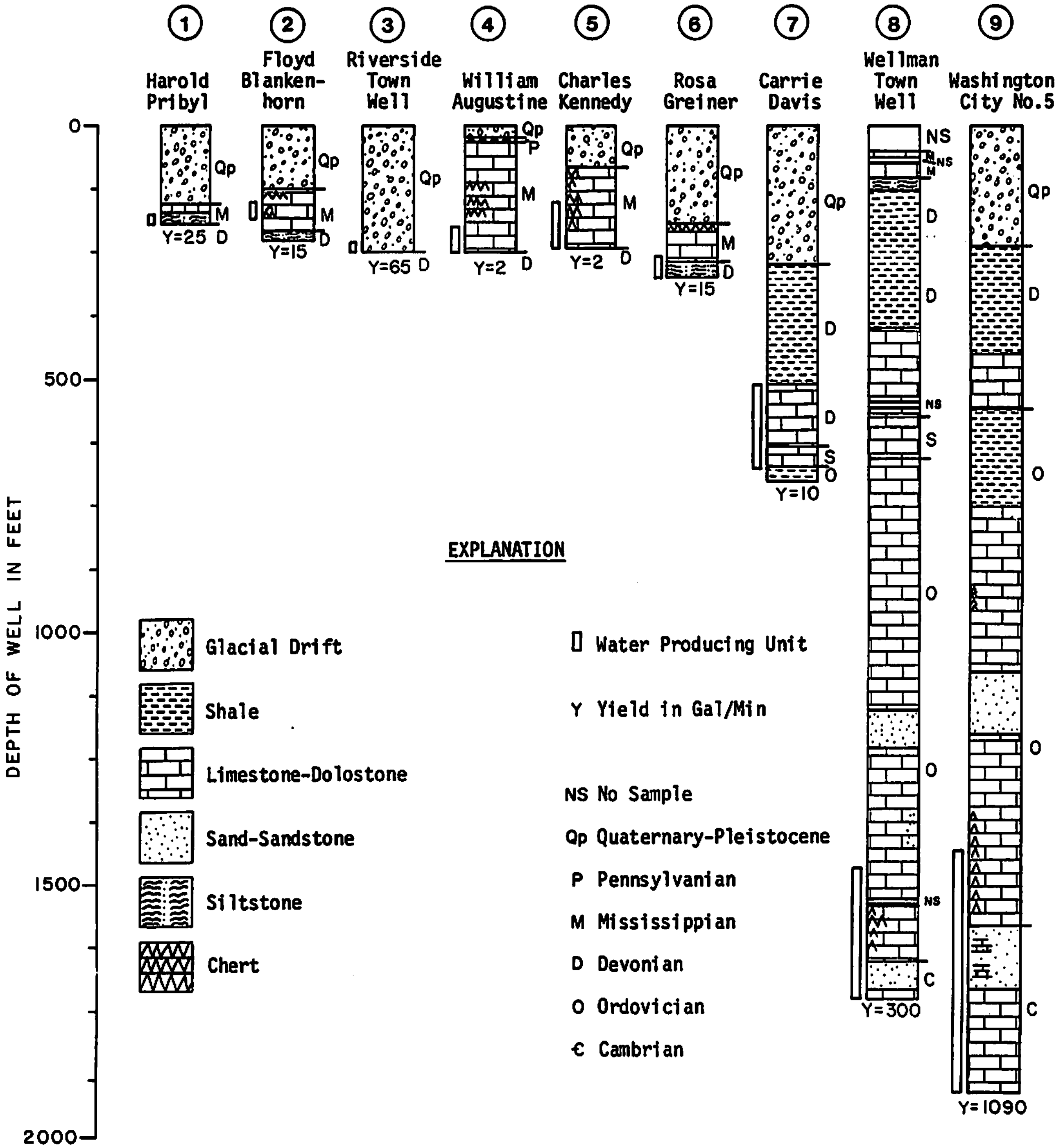
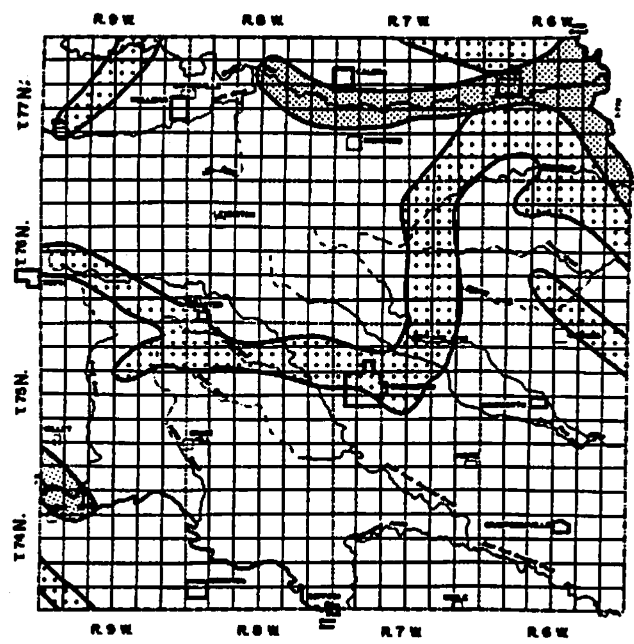


Figure 9
SURFICIAL AQUIFERS

Water Levels

Water levels in the surficial aquifers are difficult to analyze, water rises to different levels in wells drilled into alluvial, buried-channel, and drift aquifers. The water table in the drift aquifer generally slopes from high land areas toward the streams and, changes noticeably throughout the year. Levels in drift and buried-channel aquifers respond rapidly to recharge from precipitation. Water levels in the alluvial aquifer fluctuates somewhat in the same way as those in the drift and buried-channel aquifers; 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.

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 175 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

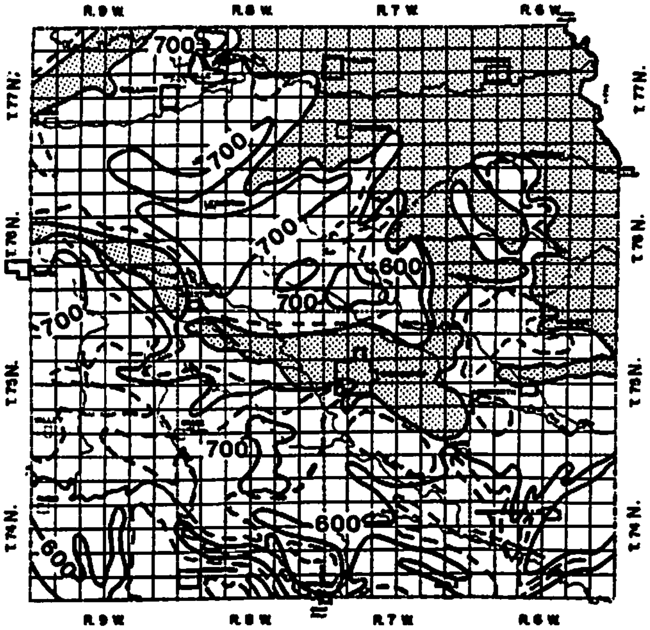
Below 20

20-100

100-500

Figure 10

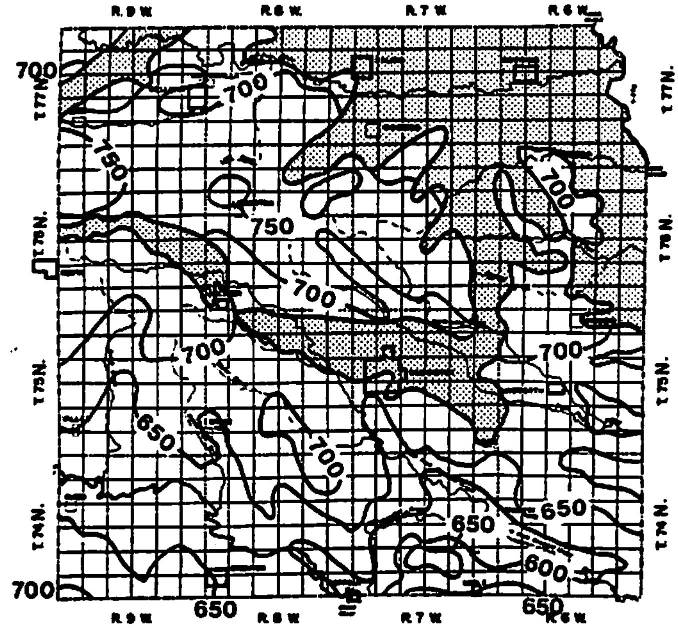
MISSISSIPPIAN AQUIFER



Elevation of top of the Mississippian aquifer, in feet above mean sea level

Mississippian aquifer absent

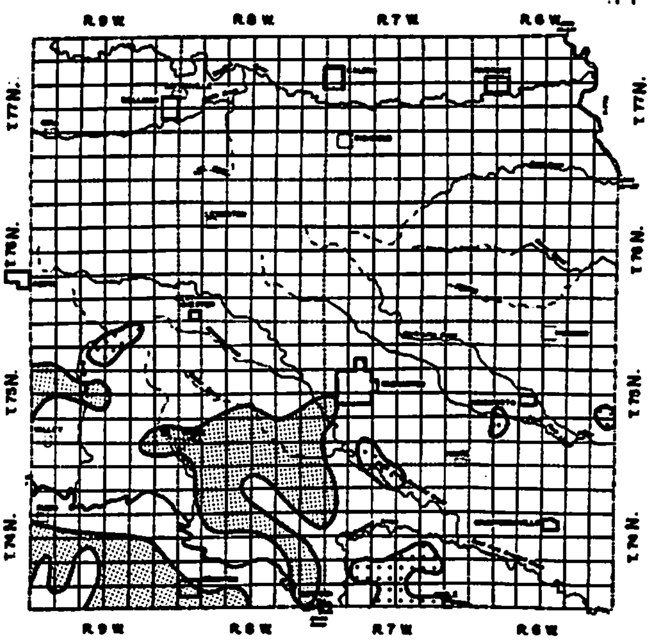
----- 50 foot contour



Water levels in wells in feet above mean sea level

Aquifer not present

Upper Part

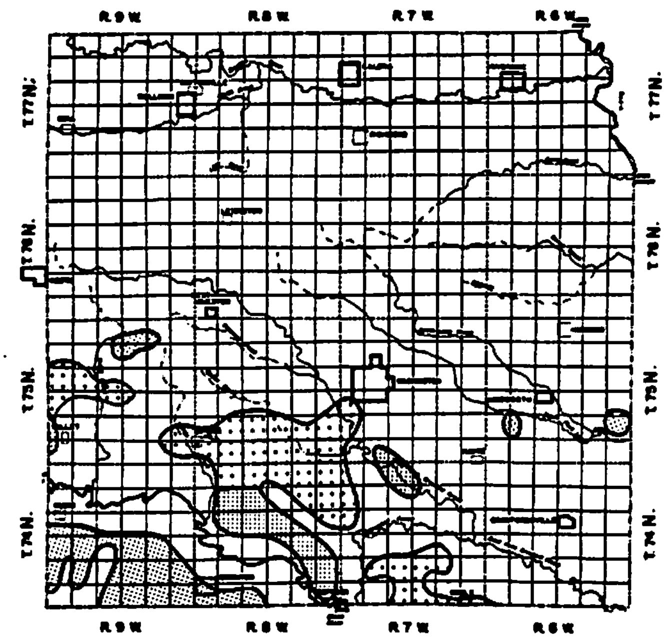


Water yields to wells in gallons per minute

Below 20

20-50

Aquifer not present



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

Less than 500

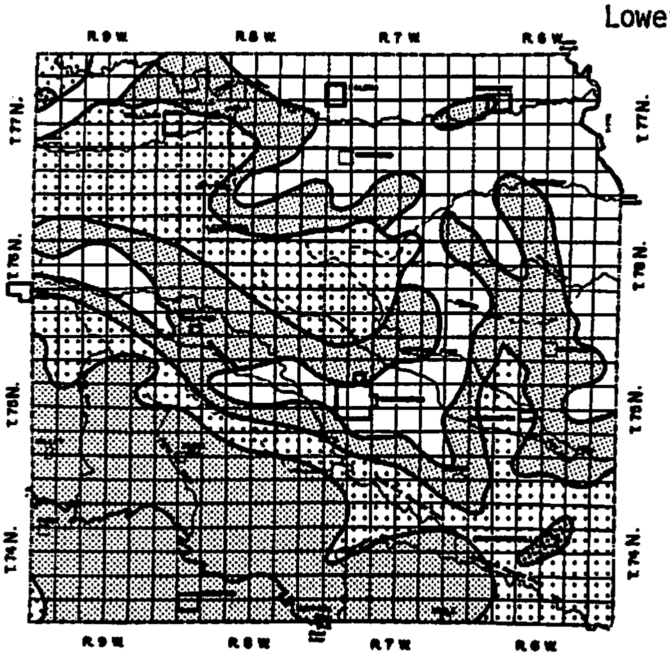
500-1000

Aquifer not present

*Other water quality data in Figure 13

MISSISSIPPIAN AQUIFER

Lower Part



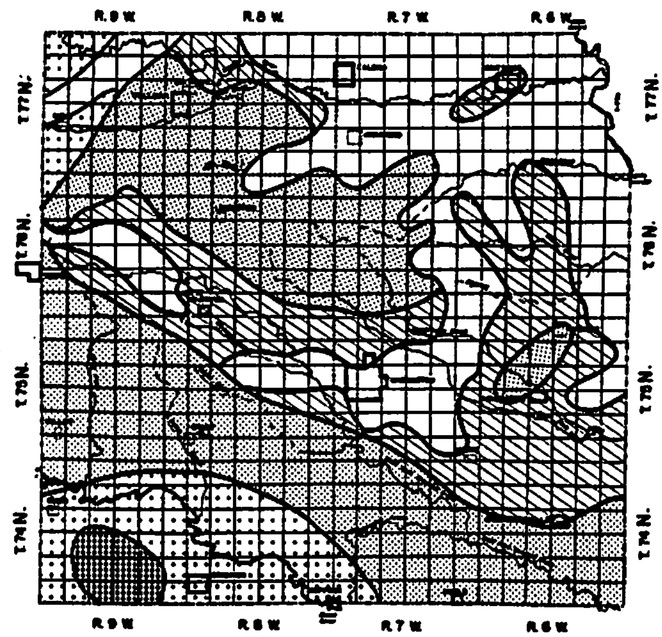
Water yields to individual wells, in gallons per minute.

Less than 20

20-50

More than 50

Aquifer not present



Dissolved-solids content of water, in milligrams per liter (mg/l)*

Less than 500

500-1000

1000-2500

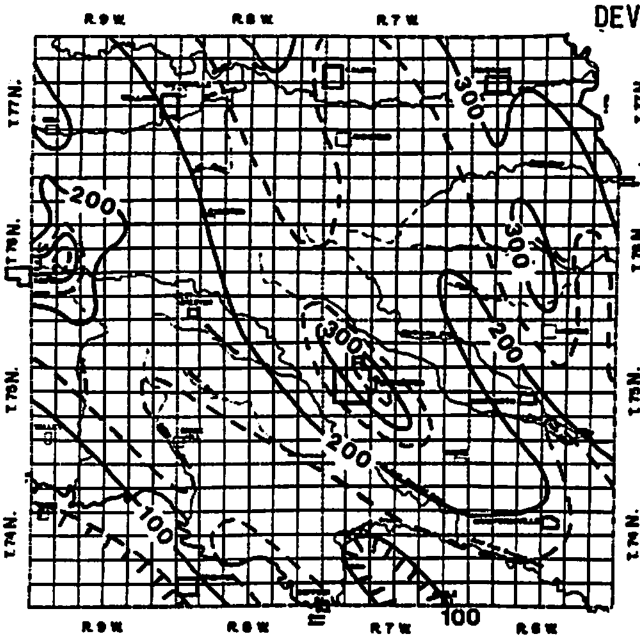
2500-5000

Aquifer not present

*Other water quality data in Figure 14

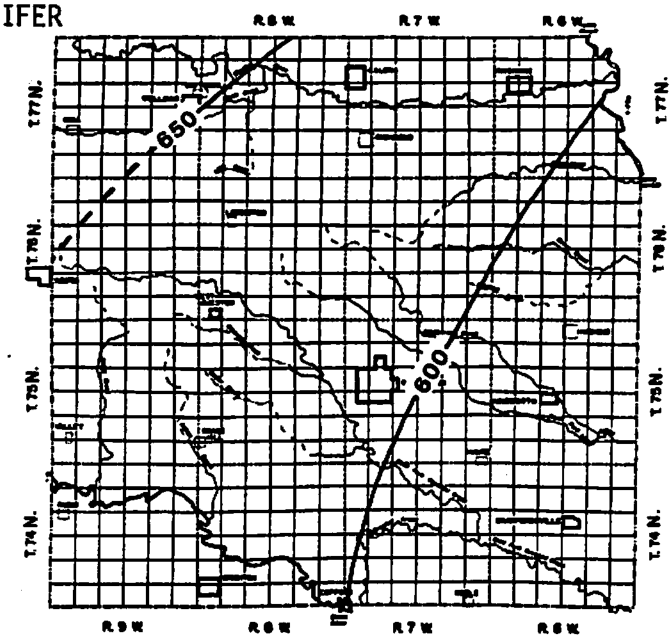
Figure 11

DEVONIAN AQUIFER



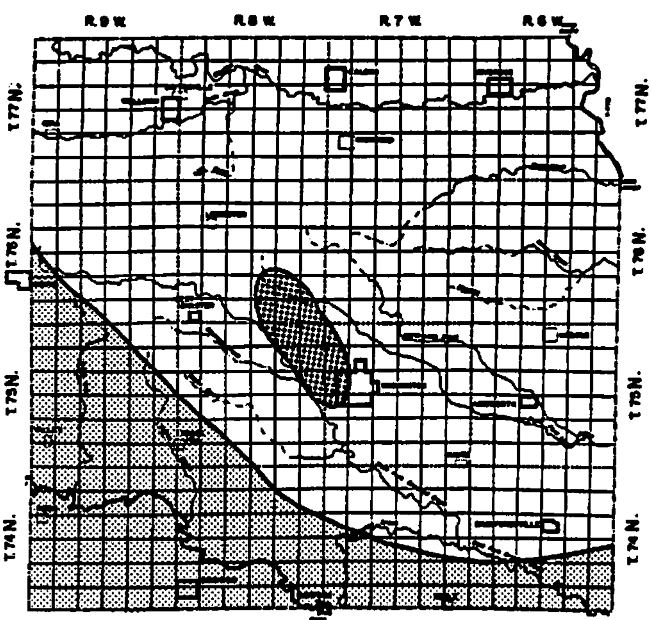
Elevation of Devonian Aquifer in feet above mean sea level

--- 50 foot contour



Water levels in wells in feet above mean sea level

--- Inferred 50 foot contour

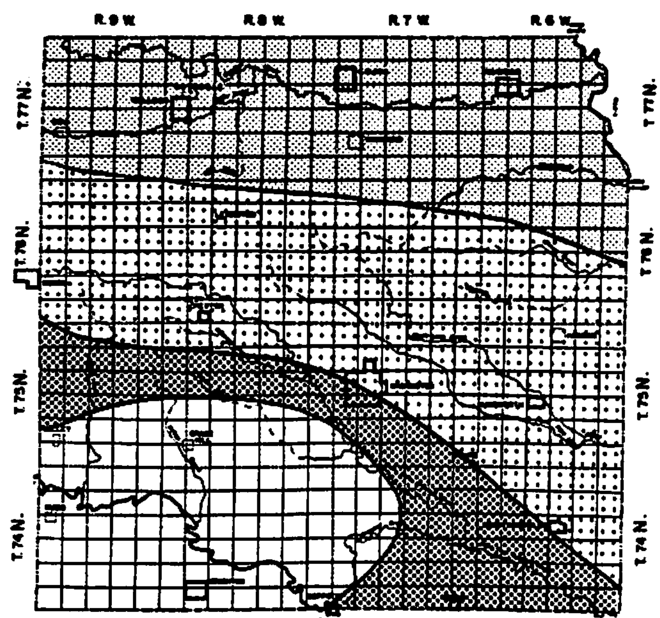


Water yields to wells in gallons per minute

Below 20

More than 50

20-50



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

2500-5000

7500-10,000

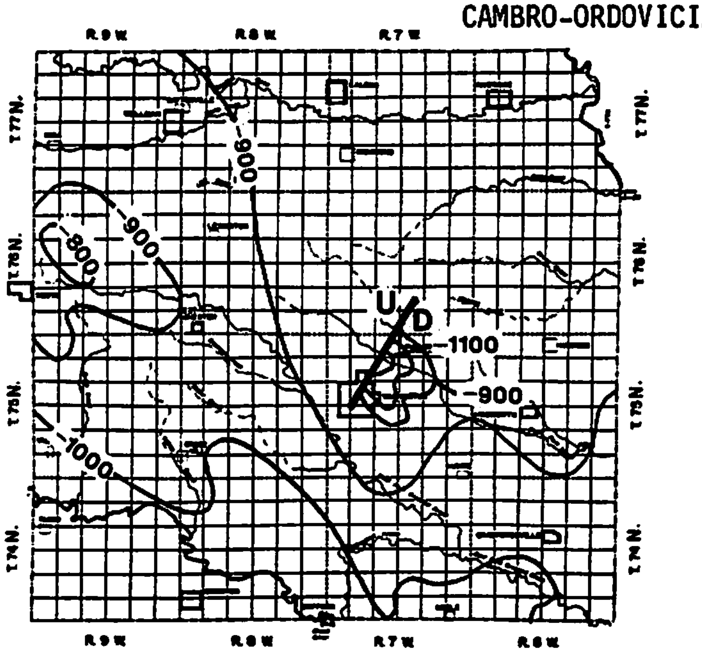
5000-7500

More than 10,000

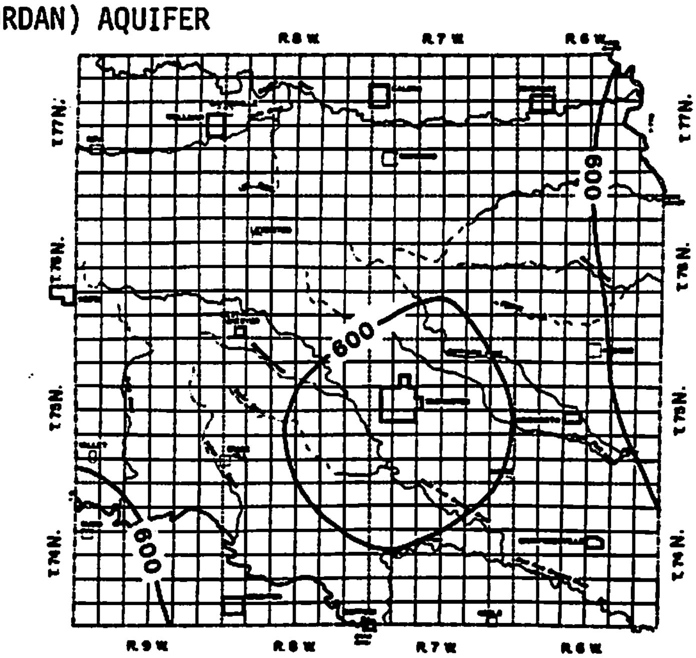
*Other water quality data in Figure 15.

Figure 12

CAMBRO-ORDOVICIAN (JORDAN) AQUIFER



Elevation of the Jordan aquifer in feet above sea level

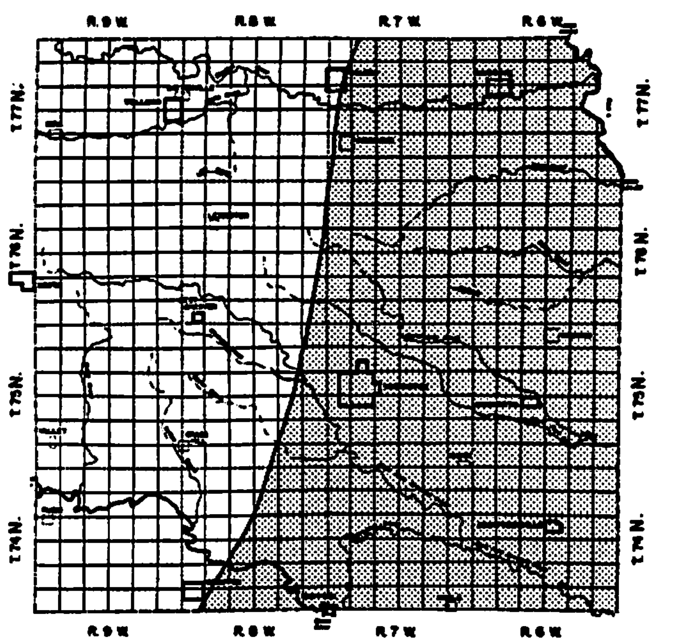


Water levels in wells in feet above mean sea level

U upthrown side

U/D fault

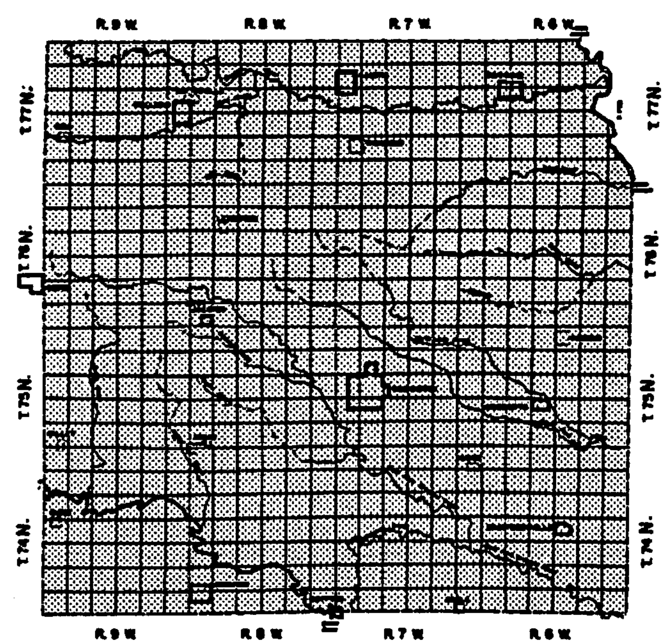
D downthrown side



Water yields to wells in gallons per minute

500-1000

More than 1000



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

1000-1500

*Other water quality data in Figure 15

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.

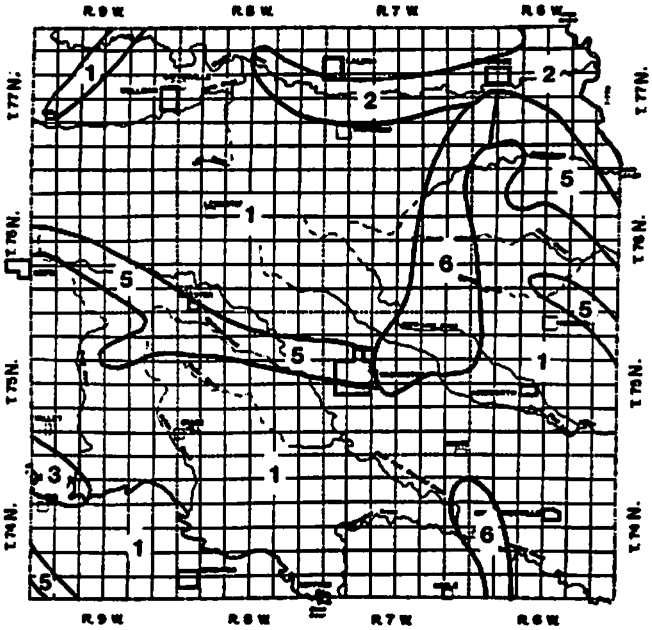
Recommended standards for common water constituents are described in the table above. These are rationally accepted as guidelines for acceptable drinking water supplies. Limits for uses other than drinking often differ from these. For instance, water that is unacceptable for drinking and household use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

From analyses of ground water averages (A) and ranges (R) of values in milligrams per liter (mg/l) for several mineral constituents are summarized in Figures 13, 14 and 15 for the 4 major aquifers in Washington 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.

Figure 13

CHEMICAL CHARACTER OF GROUND WATER

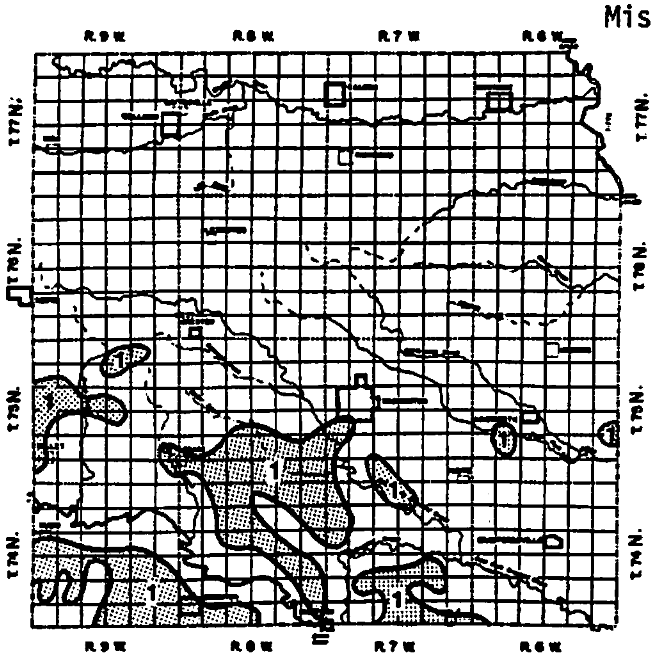
Surficial Aquifers



Area	Average and Range	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved Solids	Hardness (as $CaCO_3$)
Drift Aquifer										
1	A	[illegible]	[illegible]	43	[illegible]	74	2.7	0.4	[illegible]	[illegible]
	R	[illegible]	[illegible]	13-66	[illegible]	[illegible]	0.5-7.5	0.2-0.7	[illegible]	[illegible]
Alluvial Aquifer										
2	A	76	33	17	[illegible]	49	11	.4	431	[illegible]
	R	[illegible]	[illegible]	13-64	[illegible]	0.0-130	1.0-30	0-1.0	[illegible]	[illegible]
3	A	70	23	16	[illegible]	90	14	.3	415	290
	R	[illegible]	11-33	7.6-37	[illegible]	[illegible]	[illegible]	.2-.4	[illegible]	[illegible]
Buried Channel Aquifer										
4	A	[illegible]	[illegible]	171	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	A	90	32	45	400	49	7.8	.2	501	374
	R	55-135	17-40	3.5-133	305-673	.1-143	.5-36	0-.6	321-676	[illegible]
6	A	53	20	153	579	68	12	.4	[illegible]	215
	R	20-88	3.1-39	87-244	[illegible]	.2-170	2.5-20	0-1.0	[illegible]	[illegible]

Surficial aquifers yield the least mineralized water and of best quality of all ground water sources in Washington County. Water from the alluvial and drift aquifers are of good quality and found in large amounts. The dissolved solids content tends to be a bit high, but is acceptable for drinking purposes if no other water is available. The water from the buried-channel aquifer is often more mineralized than water from the other surficial aquifers, because they are next to the bedrock, through which they have cut their channels. Their dissolved solids content remains the same as these other surficial aquifers. Water temperatures average 54°F (12.0°C) and the range of temperatures is from 48°F to 58°F. (9.0°C to 14.5°C).

Mississippian Aquifer
Upper Part



Area	Average and Range	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved Solids	Hardness (as $CaCO_3$)
Upper Part of the Mississippian Aquifer										
1	A	104	32	43	472	91	4.5	0.4	537	399
	R	66-156	19-50	8.8-118	322-802	5.8-240	0.5-24	0-1.8	345-737	318-545

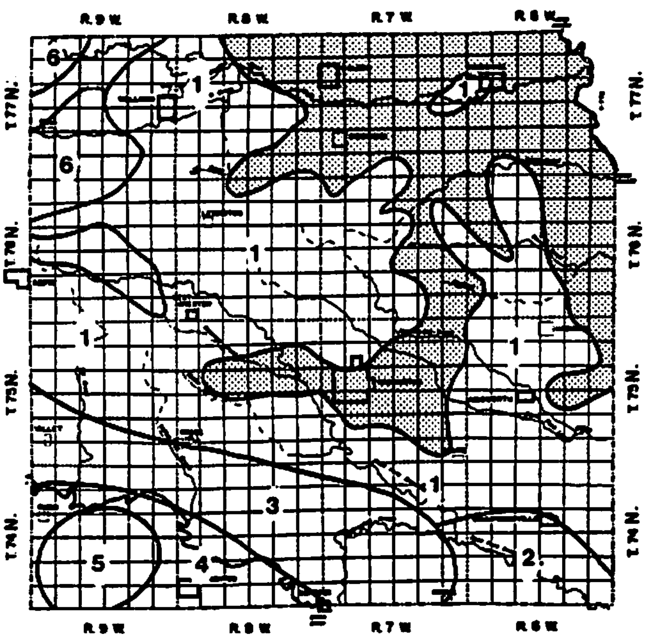
Good to fair water quality is available in the upper part of the Mississippian in area 1. The water is more highly mineralized than that typically found in the surficial aquifers and usually hard. The dissolved solids content is just slightly over recommended levels. Average water temperature is 55°F (13°C) and the range of temperatures is from 51°F to 60°F(10.5°C to 15.5°C).

Aquifer not present

Figure 14

Mississippian Aquifer

Lower Part



Aquifer not present

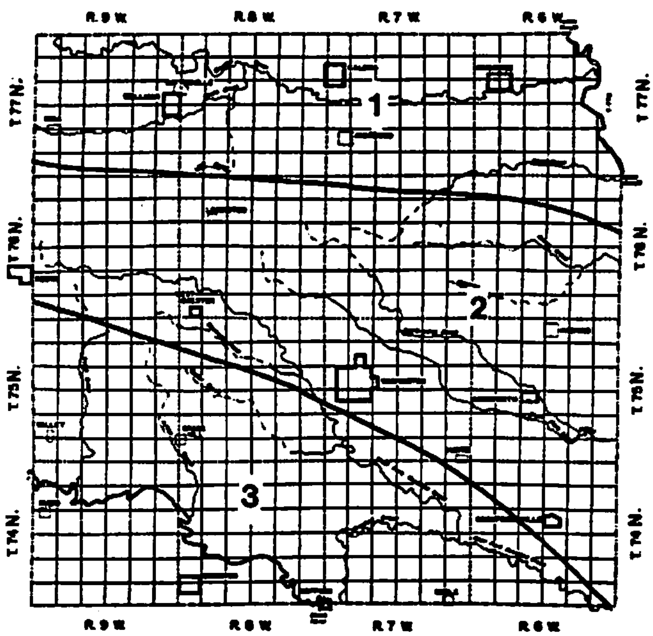
Area		Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved Solids	Hardness (as $CaCO_3$)
	Lower Part of the Mississippian Aquifer									
1	A	[illegible]	37	42	504	46	6	0.4	490	[illegible]
	R	[illegible]	13-41	9-127	[illegible]	1-135	0-63	0-1.7	[illegible]	[illegible]
2	A	[illegible]	[illegible]	117	613	57	16	.8	677	130
	R	[illegible]	[illegible]	[illegible]	[illegible]	1-190	.9-57	0.9-1.5	[illegible]	[illegible]
3	A	[illegible]	63	61	[illegible]	[illegible]	6	6	790	[illegible]
	R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.5-7	.6-.7	[illegible]	[illegible]
4	A	[illegible]	[illegible]	276	[illegible]	354	57	1.6	1110	355
	R	[illegible]	19-60	[illegible]	[illegible]	[illegible]	.5-110	.9-2.0	[illegible]	[illegible]
5	A	152	41	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
	R	[illegible]	30-47	[illegible]	[illegible]	[illegible]	600-1130		[illegible]	[illegible]
6	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.8	[illegible]	[illegible]
	R	[illegible]	33-136	[illegible]	[illegible]	400-1200	2.5-54	.4-1	[illegible]	[illegible]

Water in the lower part of the Mississippian Aquifer is generally of poorer quality than found in the upper part. Throughout the county the water is exceptionally hard. Areas 3,4 and 5, in the southwestern corner have high concentrations of dissolved solids and sulfates as area 6 in the northwestern corner. Area 5 also has an extremely high chloride content. Areas 1 and 2 seem to have the best quality water of the lower Mississippian aquifer. Average water temperature is 55°F (13°C), and the range of temperature from 51°F to 60°F (10.5°C to 15.5°C).

Figure 15

CHEMICAL CHARACTER OF GROUND WATER

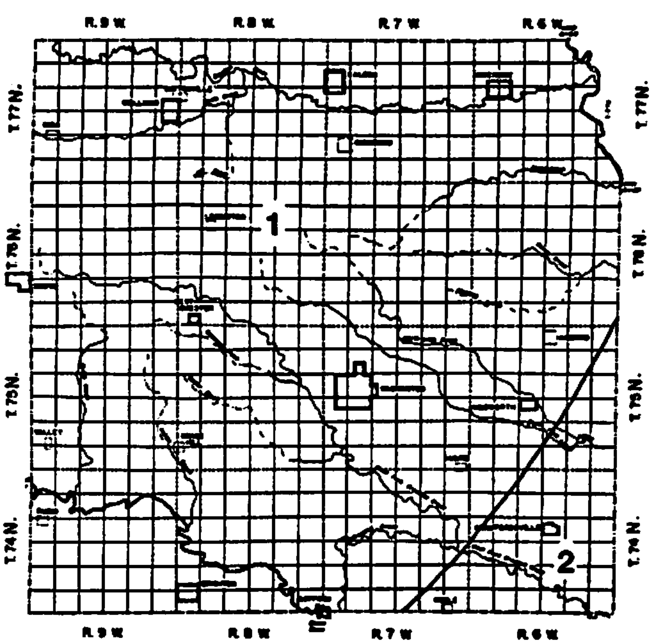
Devonian Aquifer



Area	Average and Range	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved Solids	Hardness (as $CaCO_3$)
1	A	316	88	993	322	2540	230	1.8	4643	1150
	R	201-431	83-94	855-1130	281-364	2480-2600	180-280	1.6-2.0	4490-4840	842-1460
2	A	359	115	1500	342	3450	515	2.4	6365	1380
	R	180-532	79-157	1330-1530	303-338	2200-4000	400-813	1.7-4.2	5050-6900	760-1870
3	A	492	130	2220	293	4580	1100	2.8	9570	1800
	R	441-617	97-135	1850-2700	183-378	4030-5000	550-1740	1.9-5.0	8240-11,100	1560-2180

The Devonian aquifer in this county posesses very highly mineralized water and is found to be of very poor quality. The water is highly mineralized with sulfate, sodium, iron and manganese and a dissolved solids content ranging from 4500 to 10,000 mg/l. Water temperatures are higher than that from the Mississippian aquifers sources averaging 60°F (15.5°C) and with a temperature range of 54°F to 64°F (12.0°C to 18.0°C).

Cambro-Ordovician Aquifer



Area	Average and Range	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved Solids	Hardness (as $CaCO_3$)
1	A	106	50	202	304	552	52	1.2	1180	470
	R	93-116	46-54	192-211	283-337	520-600	33-60	1.0-1.5	1120-1240	452-510
2	A	93	42	232	295	520	79	1.4	1130	406
	R	86-105	37-47	223-249	288-305	489-543	69-85	1.2-1.8	1110-1150	372-455

This deep aquifer yields water of relatively good quality compared to the other rock aquifers. The water is noticeably hard and exceeds recommended standards for sulfates and dissolved solids, but it is not as highly mineralized as that from parts of the Mississippian and Devonian Aquifers. Water temperatures are higher than other rock aquifer sources averaging 72°F (22°C) and with a temperature range from 68°F to 76°F (20.0°C to 24.5°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 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 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; for different sample bottles must be used for treated and untreated water. The charge for the bacterial test is $3.00; for iron hardness and nitrate, it is $3.00; and for iron bacteria, $5.00. 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 waters in Washington County are 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 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. These selected are within an approximate radius of 50 miles of Washington County. For a statewide listing contact either the Iowa Water Well Drillers Association, 4350 Hopewell Ave., Bettendorf, Iowa, 51712, (319) 355-7528 or the Iowa Geological Survey (319) 338-1173.

Mr. John Ahrens
Ahrens; Well Drilling
RR #2
Montezuma, Iowa 50171

Bailey Well Co.
203 E. Main
New London, Iowa 52645

Dwayne Bruinekool
Bruinekool Well Co.
Oskaloosa, Iowa 52577

Detrick Well Co.
RR #1
New London, Iowa 52645

Gingerich Well Co.
Kalona, Iowa 52247

Jack Kramer
Mt. Pleasant, Iowa 52641

Latta and Sons Well Company
Riverside, Iowa 52327

Duane Latta
Latta Well and Pump
Rural Route
Wilton, Iowa 52778

Neal Lyon Well Co.
Salem, Iowa 52649

McBurney Well Co.
Toodville, Iowa 52341

Miller and Son Well Co.
Kalona, Iowa 52247

Novotny Well Co.
Shueyville, Iowa 52338

Robert B. Novotny Well Drilling
Indian Creek Road, RR 2
Marion, Iowa 52302

Ralston Well Drilling Co.
1915 Bever Ave., S.E.
Cedar Rapids, Iowa 52403

Schlicher Brothers Well Co.
HWY 34 West
Fairfield, Iowa 52556

Schlicher Well Co.
P.O. Box 207
Donnelson, Iowa 52625

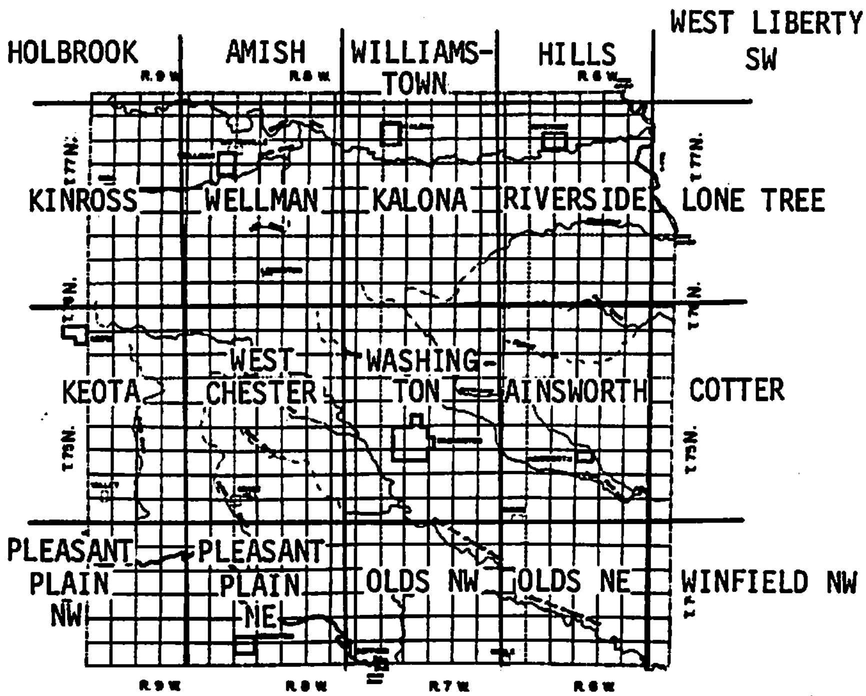
Schmeiser Well Co.
1111 Hageman St.
Burlington, Iowa 52601

Wayne Smith
Box 195
West Liberty, Iowa 52776

George Wilcox
Hiawatha, Iowa 52233

Wilson Well Co.
RR #3
Burlington, Iowa 52601

<u>Topographic Maps</u> (Available from the Iowa Geological Survey)



<u>Map Title</u>	<u>Date</u> (Published)	<u>Scale</u>	<u>Contour Interval</u>
Holbrook	1973	1:24,000	10'
Amish	1973	1:24,000	10'
Williamstown	1965	1:24,000	10'
Hills	1965	1:24,000	10'
West Liberty	1965	1:24,000	10'
Kinross	1973	1:24,000	10'
Wellman	1973	1:24,000	10'
Kalona	1969	1:24,000	10'
Riverside	1969	1:24,000	10'
Lone Tree	1969	1:24,000	10'
Keota	1973	1:24,000	10'
West Chester	1973	1:24,000	10'
Washington	1969	1:24,000	10'
Ainsworth	1970	1:24,000	10'
Cotter	1970	1:24,000	10'
	(Preliminary)		
Pleasant Plain NW		1:24,000	10'
Pleasant Plain NE		1:24,000	10'
Olds NW		1:24,000	10'
Olds NE		1:24,000	10'
Winfield NW		1:24,000	10'

Useful Reference Materials

Coble, R.W., and Roberts, J.V., 1971, The water resources of Southeast Iowa, Iowa Geological Survey, Water Atlas No. 4.

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, Jordon 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.

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.