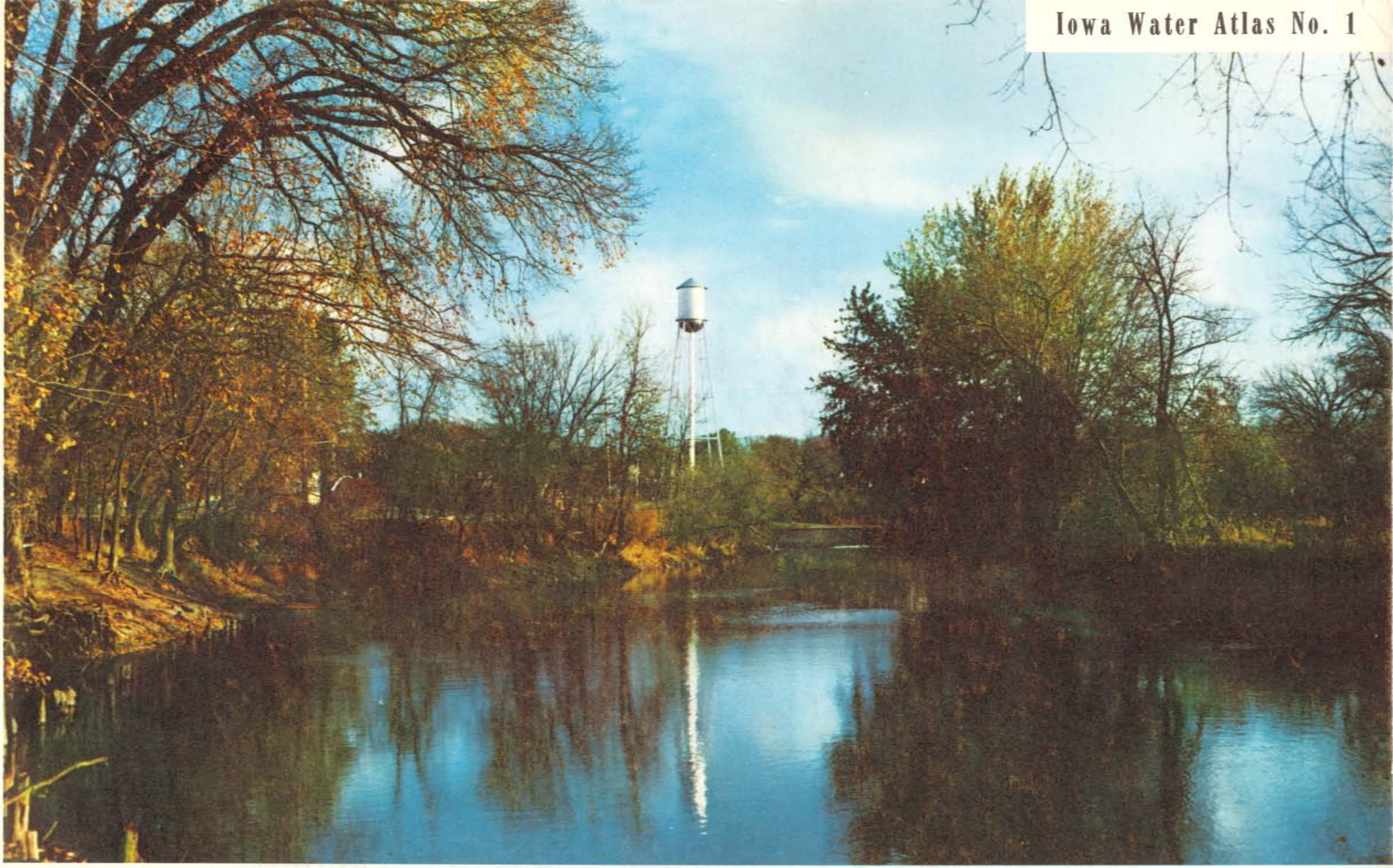
Iowa Water Atlas No. 1



THE WATER STORY IN CENTRAL IOWA

Iowa Geological Survey Water Atlas Number 1

THE WATER STORY IN CENTRAL IOWA

by

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This atlas presents information on the utilization, occurrence, quality, availability, and future demands of water in central Iowa

Prepared by the U. S. Geological
Survey in cooperation with the
Iowa Geological Survey

Published by the
STATE OF IOWA
1965

FOREWORD

In this age of ever-increasing demands on our water resources, we are often beset by numerous problems that arise whenever we attempt to develop or manage this resource. Solutions to water problems can be obtained only by a knowledge of basic water facts. Where is the water? How much is available? How good is it? How much are we presently using? What are our near-future requirements? This report provides answers to these questions, and also provides the means for a well-informed citizenry to keep abreast of the complex water situation.

"The Water Story in Central Iowa" is the first in a series of atlases describing the availability, quality, and utilization of water in Iowa on a regional basis. Reports on other regions in the state are forthcoming.

The basic information in this atlas has been collected over many years, first by the Iowa Geological Survey and later in cooperation with the U. S. Geological Survey. Other federal and state agencies, institutions, groups, and individuals provided aid and encouragement. In particular, we are indebted to the drilling contractors and well owners who have provided much of the information for our program.

H. GARLAND HERSHEY
State Geologist

Iowa City, Iowa
January 1965

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GLOSSARY

Abbreviations

- bgy - billion gallons per year.
- cfs - cubic feet per second; 1 cfs equals 449 gallons per minute or about 0.65 million gallons per day.
- gpd - gallons per day.
- gpm - gallons per minute.
- mgd - million gallons per day.
- mgy - million gallons per year.
- ppm - parts per million.

Alluvium - Clay, sand, gravel, boulders, and other matter transported and laid down by streams upon land not submerged beneath the waters of lakes or seas.

Altitude - The vertical distance between a point and a datum plane such as mean sea level.

Anticline - Rocks that have been folded so that they dip (slope) in opposite directions from a common ridge or axis.

Aquiclude - Rocks that will not transmit water fast enough to furnish an appreciable supply for a well or spring.

Aquifer - Rocks that contain and transmit water and thus are a source for water supplies.

Artesian water - Ground water that is under sufficient pressure to rise above the level at which it is encountered by a well--does not necessarily rise to or above the surface of the ground.

Average streamflow - The arithmetic average of the streamflow or discharge of all the complete water-years of record, whether consecutive or not. It represents the long-term total amount of water that a stream produces and thus is the limit on the amount of water available for use.

Basement complex - In most places, a complex of igneous and metamorphic rocks that lie beneath the dominantly sedimentary rocks.

Cement - Chemically precipitated material, commonly silica and calcium carbonate, occurring in the pores between the grains of some sedimentary rocks.

Contour interval - The difference in altitude between two adjacent contour lines.

Contour line - A line used to connect points of equal value, whether they be points of equal altitude on the land surface, on the bedrock surface, on the surface of a particular rock layer, or on the ground-water table. They are used to connect points of equal thickness of rock layers, and they are also used to connect points of equal amounts of precipitation.

Cryptovolcanic area - A small, nearly circular area of highly disturbed rocks that appear to have a volcanic origin but in which there is no trace of volcanic materials to confirm such an origin. Hence the name "crypto," meaning hidden.

Dissolved solids - the total concentration of the material in water that is in solution.

Dome - A roughly symmetrical upfold of layered rocks; the layers dip (slope) in all directions, more or less equally, from a point.

Drawdown - The lowering of the water table or artesian water level caused by pumping.

Drift - A mixture of rocks, such as boulders, gravel, sand, or clay transported by glaciers and deposited by or from the ice.

Evapotranspiration - A term embracing that portion of the precipitation returned as vapor to the air through direct evaporation or by transpiration of vegetation, no attempt being made to distinguish between the two.

Fault - A rock fracture or fracture zone along which there has been displacement of the two sides relative to one another. This displacement may vary from a few inches to many miles.

Igneous rocks - Rocks formed by solidification of hot, mobile rock matter or magma.

Infiltration - The movement of water through the soil surface into the ground.

Mean streamflow - The arithmetic average of a stream's discharge for a definite period of time, such as a day, month, or year.

Metamorphic rocks - Rocks that have formed in the solid state by recrystallization and reactions between rock matter in response to pronounced changes of temperature, pressure, and chemical environment.

Percolation - Movement under hydrostatic pressure, of water through the interstices of rock or soil.

Permeable rocks - Rocks having a texture that permits water to move through them perceptibly under the head differences ordinarily found in ground water.

Piezometric surface - The surface that everywhere coincides with the level to which the water from a given artesian aquifer will rise in wells.

Recharge - The processes by which water is absorbed and added to the zone of saturation.

Runoff - Water discharged through surface streams.

Sedimentary rocks - Rocks formed in a stratified fashion, layer upon layer, by the accumulation of sediment in water or on land after having been transported by water or wind.

Suspended sediment - Fragmental material such as clay or mud particles, silt, sand, and small rocks that is transported by being held in suspension by moving water.

Water stage - Elevation of a water surface above any chosen datum plane, often above an established low-water plane.

Water table - The upper surface of the zone of saturation except where that surface is formed by an impermeable body.

Zone of saturation - The zone in which all pores in the rocks are saturated with water.

The nomenclature and classification of rock units used in this report are those of the Iowa Geological Survey and do not necessarily coincide with those accepted by the United States Geological Survey.

ACKNOWLEDGMENTS

The authors are grateful for the information and assistance supplied by the people of central Iowa and by federal, state, county, and local agencies. The authors are especially indebted to H. G. Hershey, Director of the Iowa Geological Survey, and his staff who through the past years have examined and analyzed many rock samples. Their work has been the basis on which the various rock units described in this report were defined. Without this help, the report would not have been possible.

Special thanks are due the well drillers in the area. Because of their conscientious efforts in the collection of water data and rock samples through the years, the authors were able to obtain a much clearer picture of the water resources of central Iowa. The cooperation of the well owners also is gratefully acknowledged.

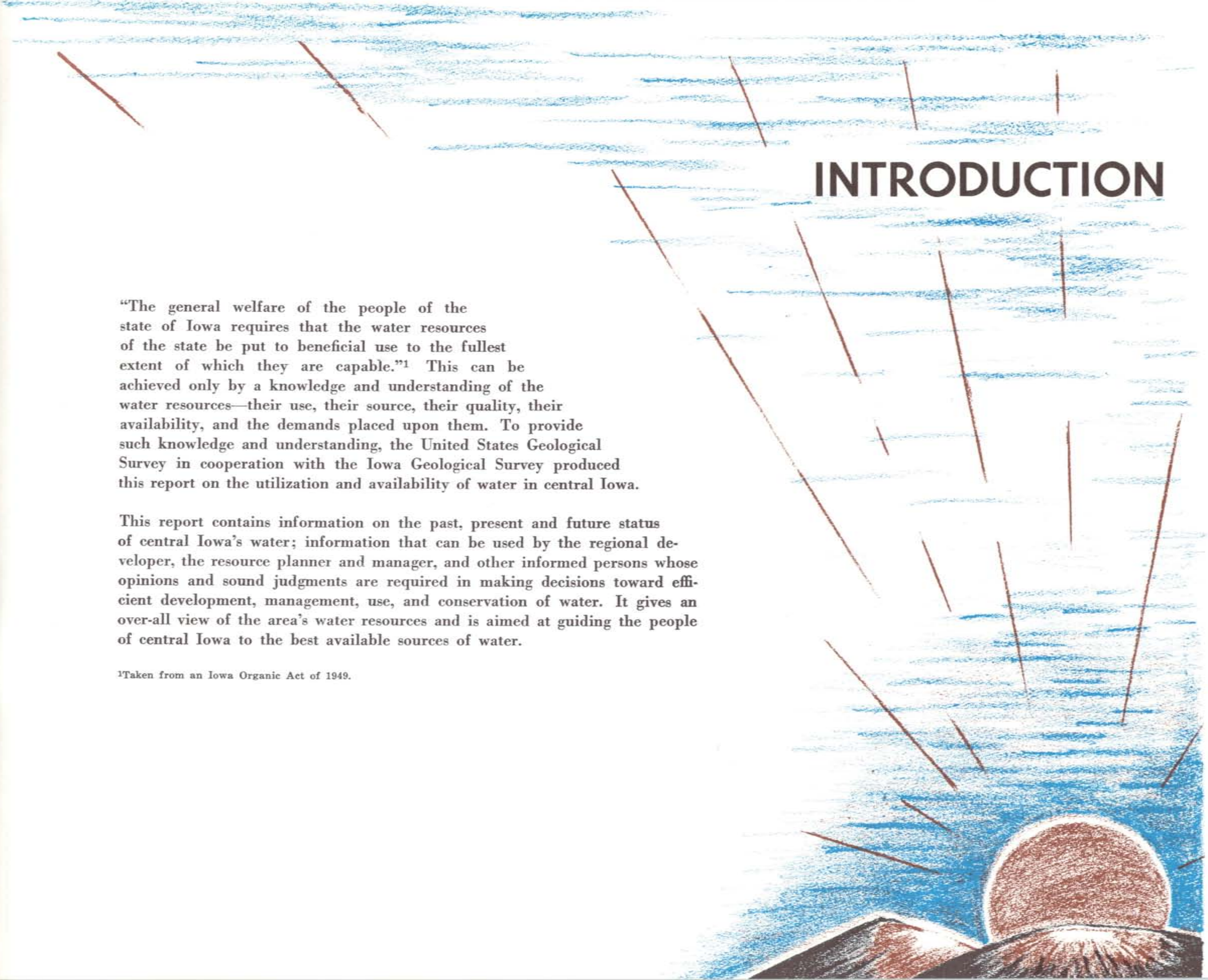
Grateful appreciation is expressed to all water superintendents and to all personnel of the local water departments who made available information and data on water pumpage, water use, and the water systems in their respective cities and communities.

The authors are especially grateful to Olatha Tweedy for typing the manuscript for this report and for her assistance in compiling part of the data used to construct some of the maps. Thanks also are due Don Riddle who did the final artwork on the introductory illustrations for each of the major sections and Bob Taylor who drafted some of the other illustrations.

INTRODUCTION

"The general welfare of the people of the state of Iowa requires that the water resources of the state be put to beneficial use to the fullest extent of which they are capable."[1] This can be achieved only by a knowledge and understanding of the water resources—their use, their source, their quality, their availability, and the demands placed upon them. To provide such knowledge and understanding, the United States Geological Survey in cooperation with the Iowa Geological Survey produced this report on the utilization and availability of water in central Iowa.

This report contains information on the past, present and future status of central Iowa's water; information that can be used by the regional developer, the resource planner and manager, and other informed persons whose opinions and sound judgments are required in making decisions toward efficient development, management, use, and conservation of water. It gives an over-all view of the area's water resources and is aimed at guiding the people of central Iowa to the best available sources of water.



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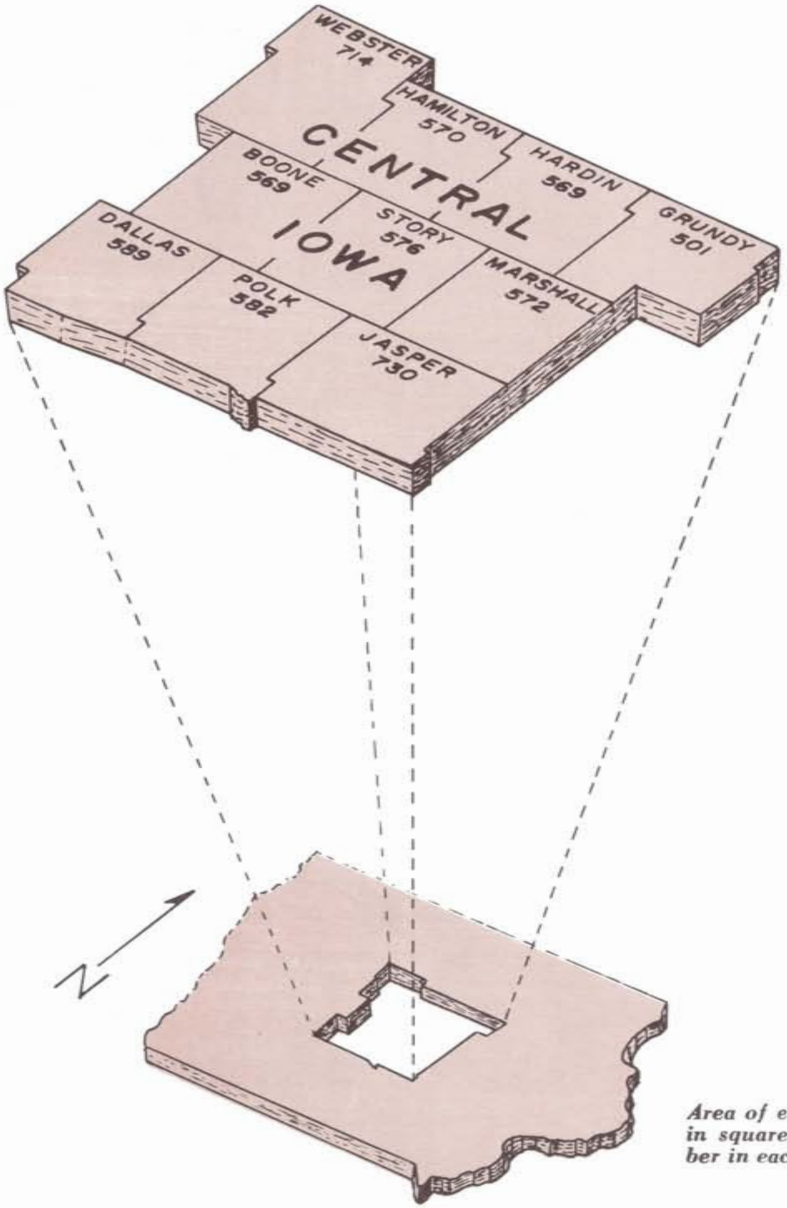
[1] Taken from an Iowa Organic Act of 1949.

Central Iowa—the setting

Central Iowa—a block of 10 counties near the center of the state. These counties encompass 5,972 square miles or 10.6 percent of the area of the state.

Central Iowa lies astride four large drainage basins—the Des Moines, Iowa, Skunk, and Cedar. The rivers in these basins flow southeastward and carry, on the average, about 3 billion gallons of water per day from central Iowa toward the Mississippi River.



Area of each county is shown in square miles by the number in each county block.


Minnesota
South Dakota
Big Sioux River
Wisconsin
River
Mississippi
DES MOINES
CEDAR
SKUNK
IOWA
Illinois
Nebraska
Missouri River
Missouri

The land surface

Central Iowa exemplifies the great expanse of plainslike country characteristic of Iowa. The horizon generally appears level; and the land, although dissected by many small streams, is flat to gently rolling. The major streams drain to the southeast; consequently, the lowest altitudes[2] of the land surface, about 775 feet, are in the south and it is in this area also that the land surface is rolling. The highest altitudes, about 1,250 feet, are in the north and here the land surface is predominantly flat. In general, the slopes of the land are gradual; steep or vertical cliffs occur only along parts of the Des Moines, Boone, and Iowa rivers.

The dissected land in the south and southeast parts of central Iowa offers many potential sites for water storage in artificial lakes. In the northern part of the area where the land is flat, water is stored in natural lakes that have been formed as a result of incomplete drainage. Man has drained several of these lakes in order to uncover the rich land on the bottom.

The altitude of the land surface is important in determining the depth to water-bearing rocks. A well started at a higher altitude will penetrate more rock before reaching a specific water-bearing zone than a well started at a lower altitude. For example, notice that the land surface at Waukee is more than 100 feet higher than the land surface along the Raccoon River. If a well were drilled at each place and both penetrated the same water-bearing zone, the well at Waukee probably would be more than 100 feet deeper than the well along the river. Similarly on a small tract of land, such as a farm, the difference in surface relief will make a difference in the well depth; a well on top of a hill generally will be deeper than one in a valley.

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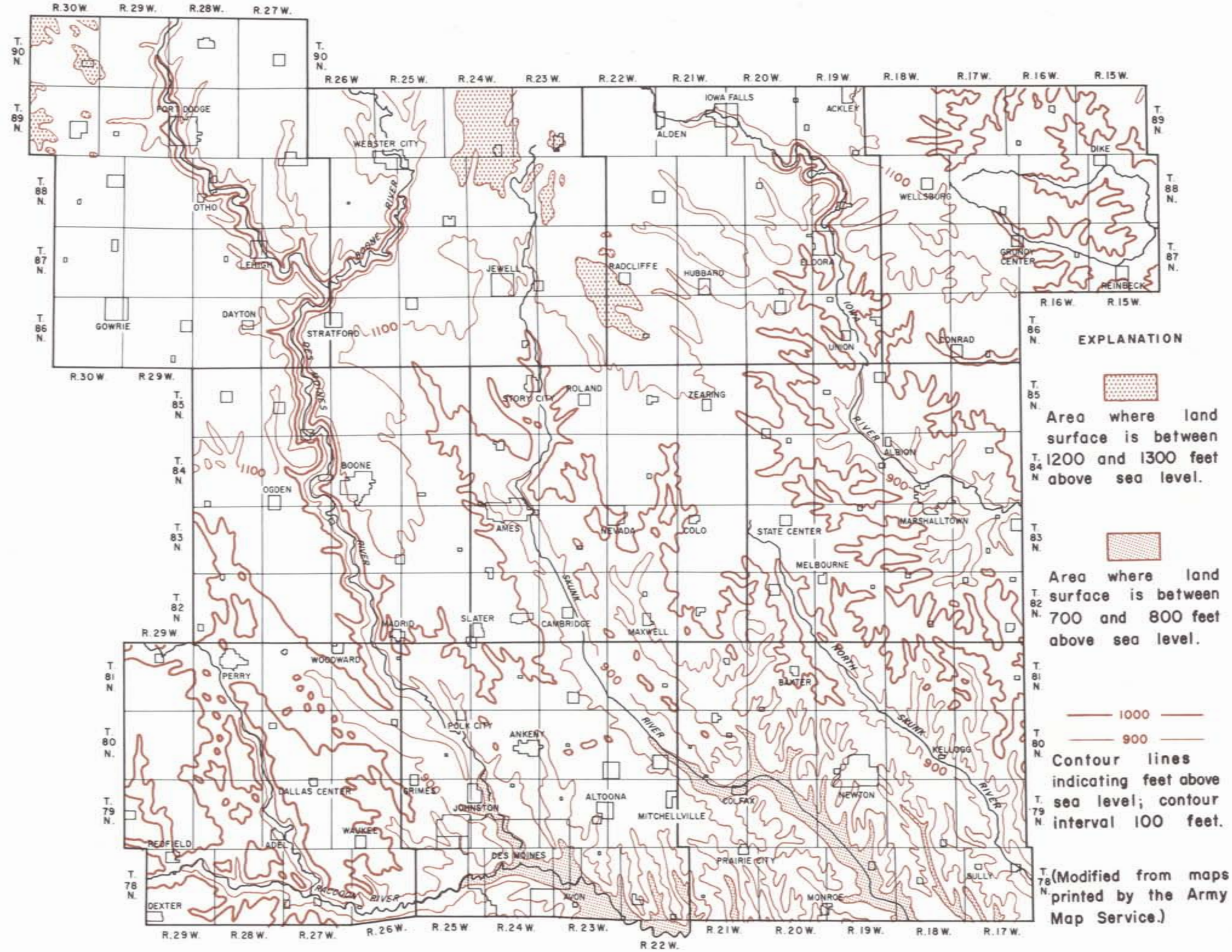
[2] Altitudes are shown by means of contour lines.

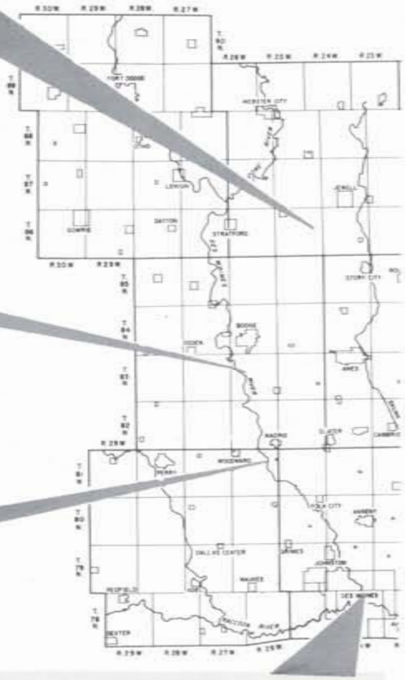


(Modified from maps printed by the Army Map Service.)

Scenes of Central Iowa

Flat land surface typical of northwestern parts of central Iowa.

Sandstone cliffs of Pennsylvanian age in Ledges State Park.



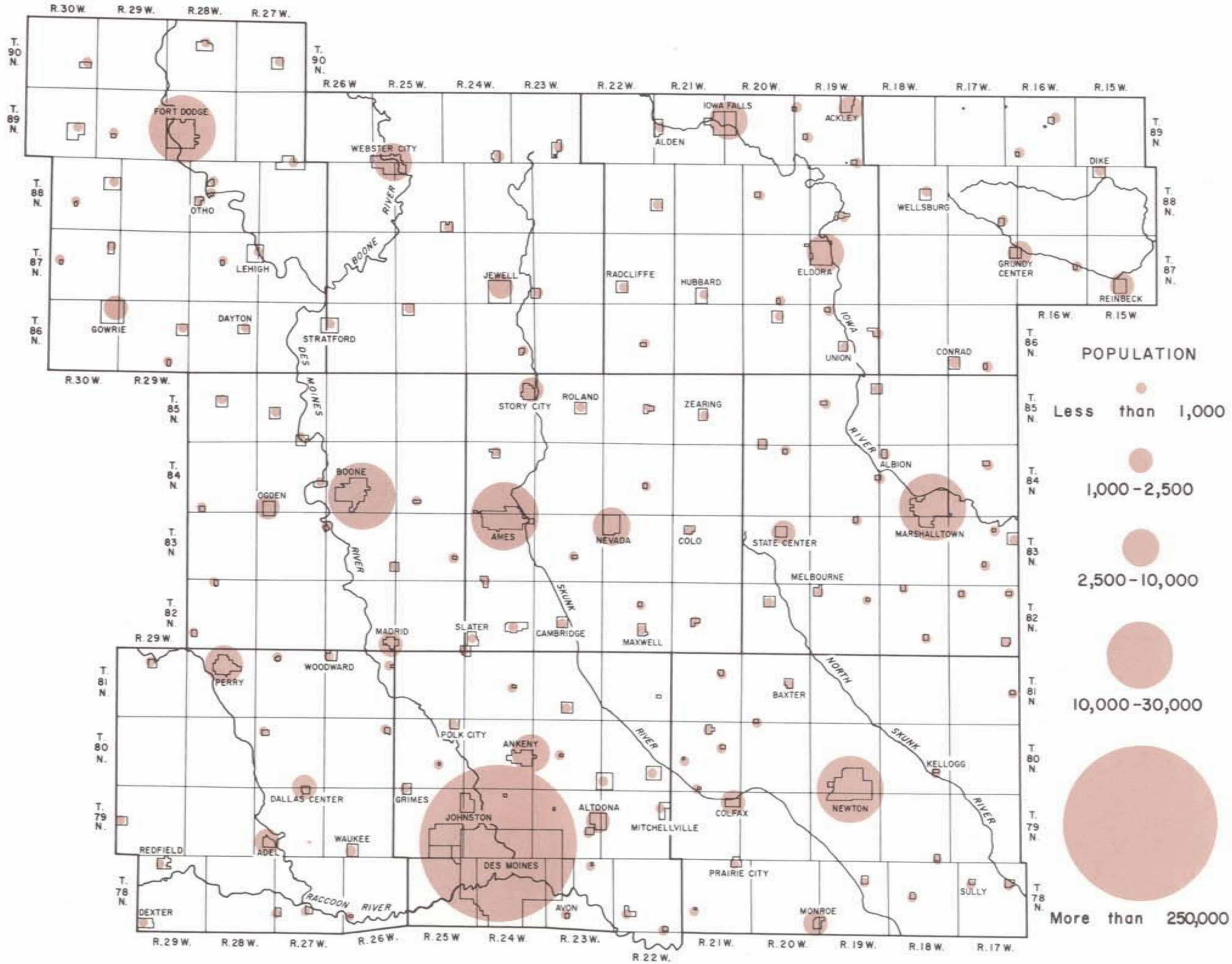
Des Moines River near Madrid on July 24, 1963. Streamflow was about 4,500 cfs or nearly double the average.

State Capitol in Des Moines, rocks of Pennsylvanian age in foreground.

The Iowa River and an outcropping of the upper bedrock aquifer at Iowa Falls.

Marshalltown well field.

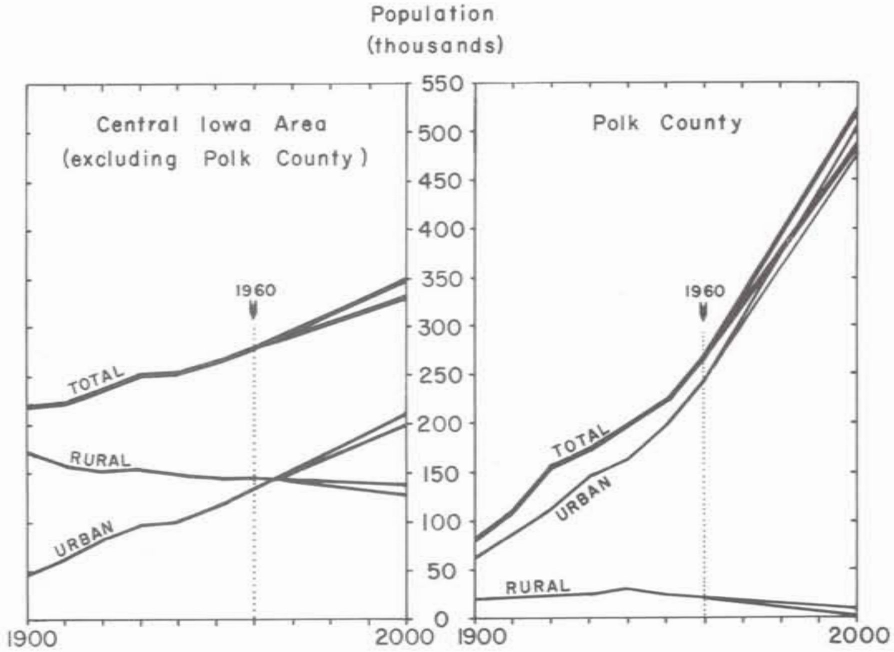
Rolling land surface typical of southeastern parts of central Iowa.



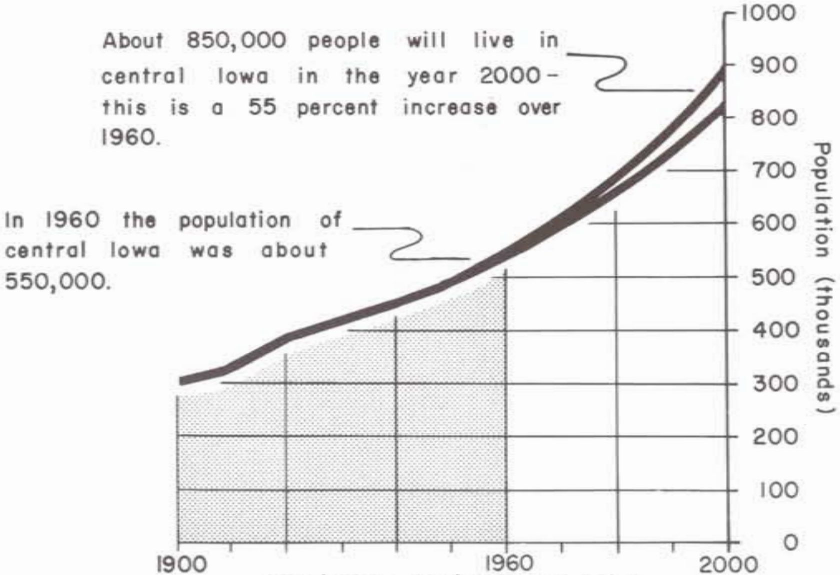
Urban population in 1960.

Population—past, present, and future

About 20 percent of the population of Iowa, or 545,575 persons, were living in central Iowa in 1960. More than 450,000 of these persons lived in urban areas.[3] Des Moines, the state capital and largest city, had a population of 208,982. The Des Moines urban area, which includes Des Moines, Urbandale, Windsor Heights, and several surrounding communities, had a population of 250,994. Five cities outside the Des Moines area had populations of over 10,000; the largest of these, Fort Dodge, had 28,399.



Population increase in Polk County overshadows all other population trends in central Iowa.



About 850,000 people will live in central Iowa in the year 2000—this is a 55 percent increase over 1960.

In 1960 the population of central Iowa was about 550,000.

Population continues to grow.

Population trends in central Iowa are similar to national trends. Total population has increased at a moderate rate and it is estimated, on the basis of past data, that it will continue to do so in the future.[4] Urban areas will be the focal points of population increase because industrial expansion in these areas will continue to create many new jobs. In rural areas the population will decrease as more efficient farming practices and other factors reduce the number of farms and farm operators and limit job opportunities. Hence, water problems in the future will be concentrated in the urban areas.

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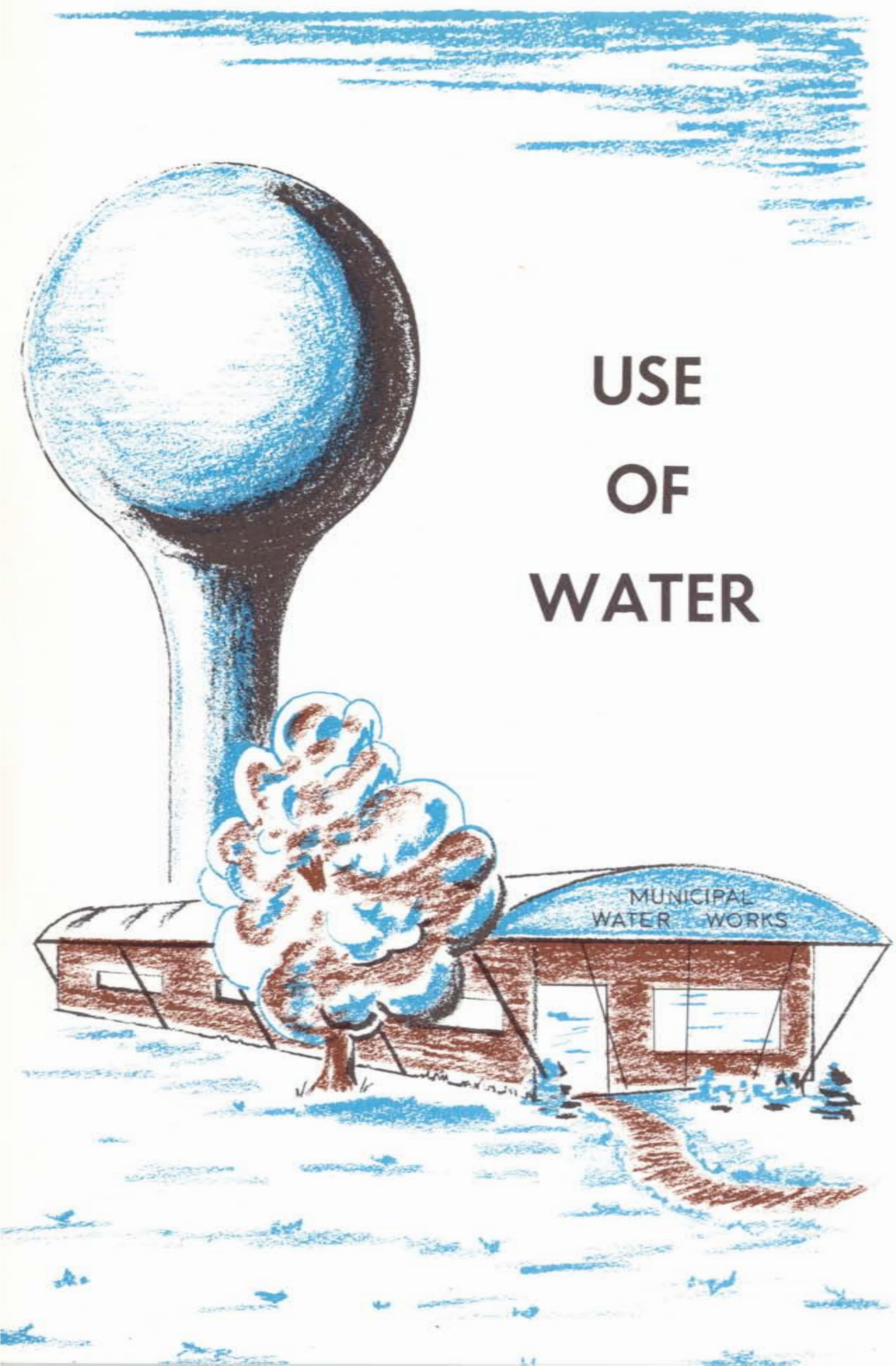
[3] Data from 1900 through 1960 for illustrations on these two pages are based on the U. S. Bureau of Census figures; accordingly, all places having a population of more than 2,500 are classified as urban.

[4] Population projections were made by graphical methods. (Fair and Geyer, 1954, p. 123). The upper curve of each projection represents the maximum expected population increase, the lower curve represents the minimum.



USE OF WATER

Most of us probably never give much thought to the question, "How is water used?" Yet we all use water for many purposes, sometimes in large quantities.

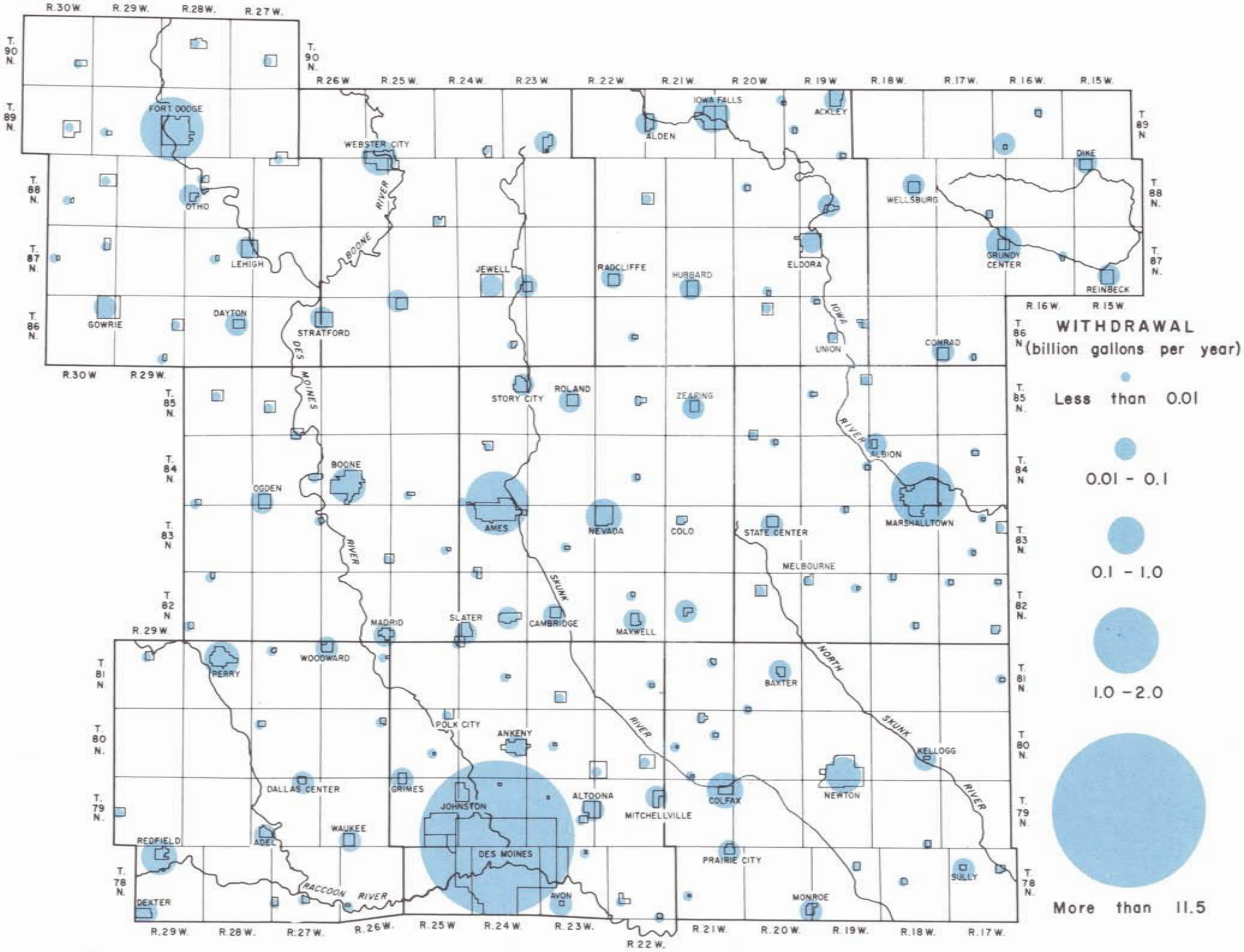
Let us consider how water is used, directly and indirectly, in our home during a typical day. As the sun rises, an electric alarm sounds and a new day begins. A switch is flipped and a light goes on. Soon coffee is brewing in the electric percolator. In a generating plant at some distant place water is being used to make steam or cool condensers in the production of the electric current for the alarm clock, the light, and the percolator. Water was used in brewing the coffee. As we prepare for the day, we use water to cleanse our face and hands or to take a shower. We flush a toilet and use water. As we dress we realize that water was used to produce the materials from which our clothes were made. At breakfast, we eat bacon and use some of the water required to raise and butcher the hog from which the bacon was derived. Water was used to grow and process the cereal we eat. Fruit juice and milk contain water. We pick up the newspaper and find that the news is printed on paper which required large quantities of water for its manufacture. When breakfast is finished, we use water to wash the dishes. Water is used to manufacture our soaps and detergents. The day has just begun and already the use of water is surprising.

We will use water in many other ways before the day is over. We may use it to wash clothes, to water the lawn, to cook meals, and to wash the car. We will drink water—alone—or in coffee, tea, or some other refreshing beverage. We may use it for recreational purposes such as boating, swimming, and fishing. Water will be used indirectly every time we use electricity. As can be seen, it would be impractical to list all the uses of water in our household during a typical day. However, in the evening when using another 20-30 gallons of water to take a bath we may well ponder a while on the importance of water in our lives.

Many of the products we use require water for their manufacture or production. Each industry uses water for different purposes during the processing of its product. Much of this water is used for cleaning, for cooling, for generating steam, for waste disposal, and for other purposes—seldom does it become incorporated in the finished product. Although the uses of water by industry are innumerable, several common products or processes and the quantities of water needed are shown below.

Product or process	Water needed
Vegetable canning	30-150 gallons per case
Steel making	1,000-1,500 gallons per ton of ore
Soft drinks	10-25 gallons per case
Meat packing	
hogs	500-800 gallons per head
cattle	250 ± gallons per head
turkeys	30 ± gallons per bird
Paper	10,000-85,000 gallons per ton of paper
Milk processing	1-5 gallons per gallon raw milk
Die casting	9,000-13,000 gallons per ton of aluminum and zinc

There are other uses for water. The animals and plants we raise for food use water. The fish we eat live in water. The trees from which we obtain lumber need water. We use water to treat and dilute our wastes. And on and on; the uses are many.



Water withdrawal in urban areas during a 12-month period in 1960-61.

How much water is used?

About 119 billion gallons of water were withdrawn from streams and ground-water reservoirs in central Iowa in a 12-month period during 1960-61. Of the total withdrawn, water for the generation of steam-electric power was greatest; more than 92 billion gallons were used for this purpose. Water withdrawn for domestic, agricultural, and industrial purposes was about 27 billion gallons.

More than 75 percent of this 27 billion gallons of water was used in urban areas—the Des Moines urban area alone used about 44 percent of the water.

Principal use of water in central Iowa during a 12-month period in 1960-61[1]

County	Population[2]	Water withdrawn, in billion gallons per year					
		Urban domestic[3]	Industrial & commercial	Rural domestic[4]	Livestock[5]	Unclassified[6]	All water
Boone	28,037	0.40	0.01	0.20	0.41	0.09	1.11
Dallas	24,123	.33	.22	.17	.37	.13	1.22
Grundy	14,132	.17	.06	.13	.52	.02	0.90
Hamilton	20,032	.25	.27	.14	.46	----	1.12
Hardin	22,533	.35	.48	.14	.53	.02	1.52
Jasper	35,282	.66	.32	.22	.67	----	1.87
Marshall	37,984	.68	.41	.19	.52	.19	1.99
Polk	266,315	6.14	3.94	.10	.26	1.96	12.40
Story	49,327	1.39	.21	.19	.37	.02	2.18
Webster	47,810	1.03	.88	.24	.37	.07	2.59
Total	545,575	11.40	6.80	1.72	4.48	2.50	26.90

[1] Water for generation of steam-electric power, the quarrying industry, and irrigation not included.

[2] Based on 1960 census.

[3] Includes all cities and communities having a population of 20 or more.

[4] Computed on the basis of a per capita consumption of 50 gallons per day.

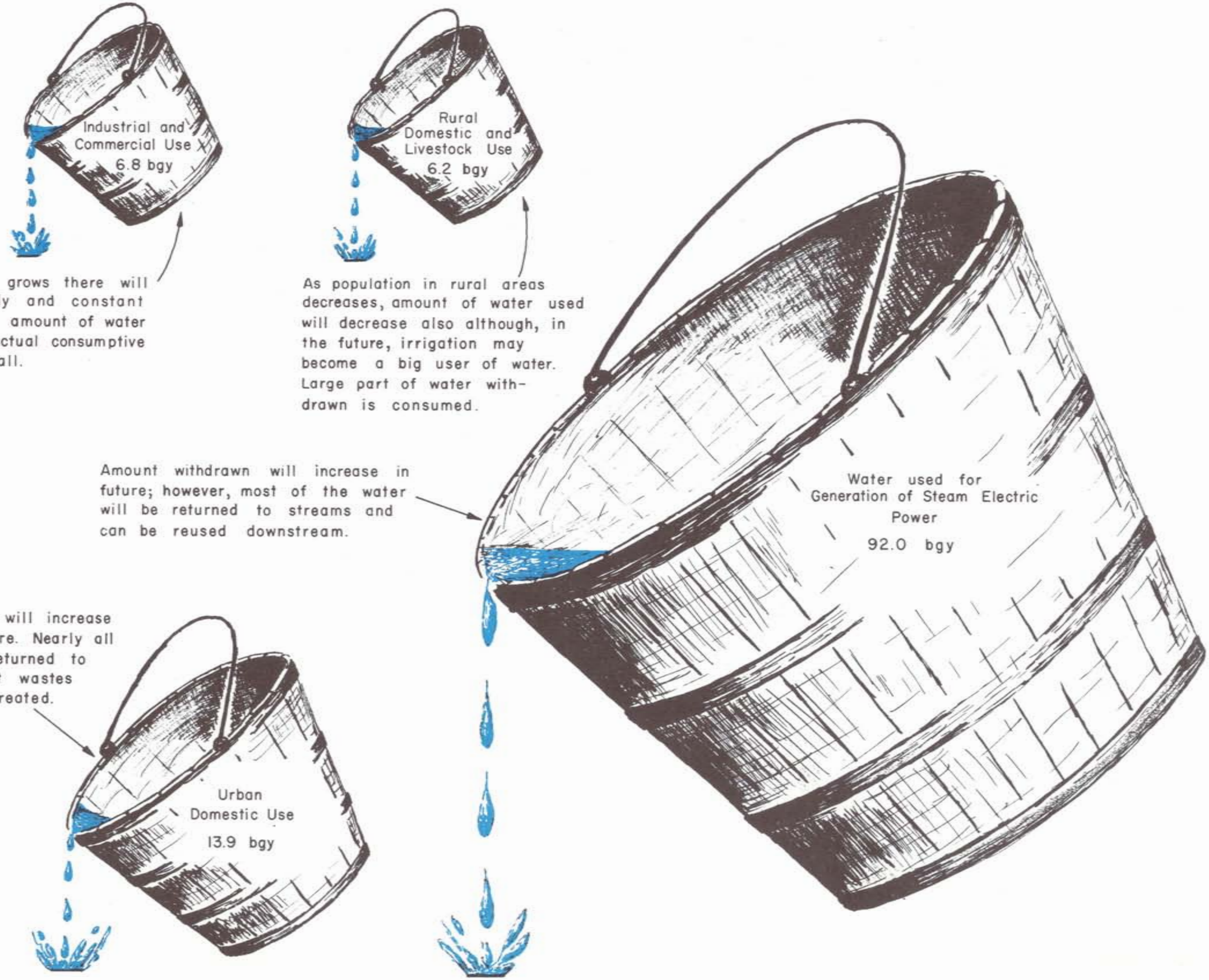
[5] Computed on the following rates, in gallons, per head per day: milk cows--20; cattle--10; hogs--3; sheep--2; turkeys--.06; chickens--.04.

[6] Includes water lost through leakage, water used to operate municipal offices and parks, and water used in water treatment and sewage disposal plants.

In addition, water is used in large quantities by the quarrying industry, but the actual amount is unknown. Permits[5] issued by the Iowa Water Commissioner's office to this industry allow a maximum use of about 12 billion gallons of water yearly, about 75 percent from quarry pits and 25 percent from streams.

Per capita use of water in central Iowa for domestic purposes only is about 65 gpd. In the larger cities, domestic use per person ranges from 65 to 85 gpd; whereas, in communities of less than 500 domestic use is about 48 gpd. These are direct-use figures that were calculated from water bills. However, the actual per capita use of water in the area is much greater. Based on all water withdrawn in central Iowa, except that for steam-electric power, the per capita use increases to 135 gpd. When water for steam-electric power is considered, the per capita use jumps to 610 gpd.

[5] In 1949 the State of Iowa, as quoted from an Iowa Organic Act of 1949, "created and established an Iowa natural resources council." This council, along with a water commisisoner chosen by the council, has "* * * jurisdiction over the public and private waters in the state and the lands adjacent thereto necessary for the * * * further development, protection, utilization, and preservation of the water resources of the state." Thus, the authority to regulate the use of water in the state is vested in the Iowa water commissioner's office. Without a permit from this office, water cannot be taken "* * * from any watercourse, underground basin or watercourse, drainage ditch or settling basin within the state of Iowa for any purpose other than a nonregulated use * * *."



As industry grows there will be a steady and constant increase in amount of water withdrawn; actual consumptive use is small.

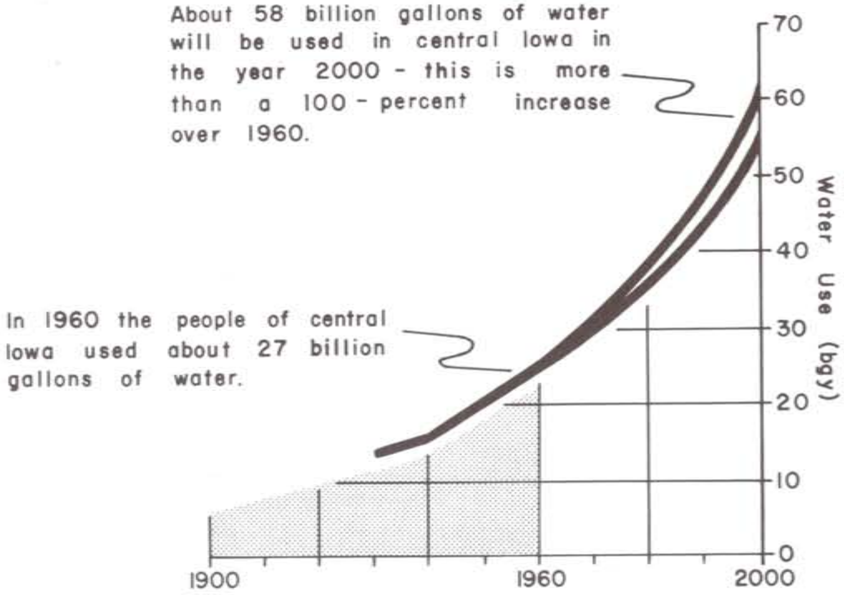
As population in rural areas decreases, amount of water used will decrease also although, in the future, irrigation may become a big user of water. Large part of water withdrawn is consumed.

Amount withdrawn will increase in future; however, most of the water will be returned to streams and can be reused downstream.

Water use will increase in the future. Nearly all water is returned to streams, but wastes must be treated.

The quantity of water used will increase rapidly, even faster than population. Projections[6] indicate that in A. D. 2000, the quantity of water used will have increased 130 percent from 1960; whereas, population will have increased only 55 percent. The increase in the use of water will be due primarily to industrial expansion and modernization but will be augmented by additional domestic use. New industrial plants, complicated industrial processes, increased air conditioning, and more modern sanitary measures will require large additional supplies of water. Automatic laundry equipment, dishwashers, garbage disposal units, and modern conveniences that are yet unknown will require larger supplies in the home.

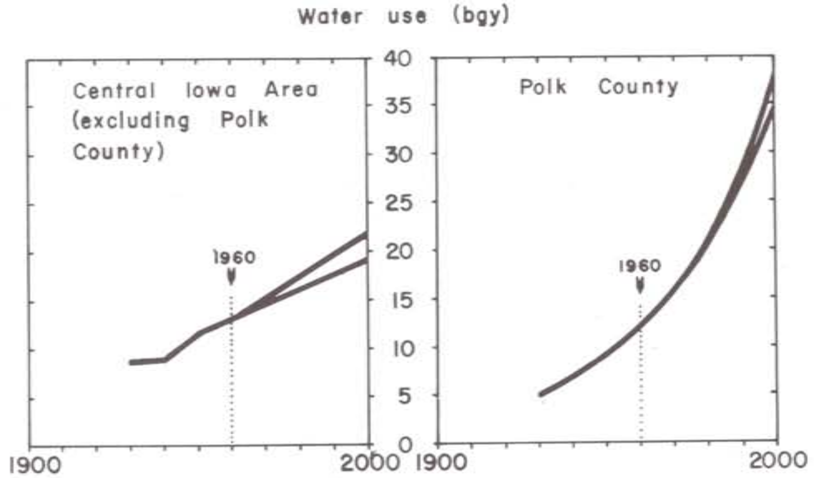
Use of water for irrigation may become an important factor in the future. At present, permits have been issued to withdraw about 2.2 billion gallons of water yearly, about 1.5 billion gallons from streams and 0.7 billion gallons from wells, for irrigation in central Iowa—considerably less is actually used. However, in the future, drought conditions may necessitate crop irrigation or economic conditions may be such that increased monetary returns will be realized from the higher yields afforded by irrigation.



About 58 billion gallons of water will be used in central Iowa in the year 2000 - this is more than a 100 - percent increase over 1960.

In 1960 the people of central Iowa used about 27 billion gallons of water.

Water is being used at an increasing rate.



Nearly twice as much water will be used in Polk County in the year 2000 as will be used in the remainder of central Iowa.

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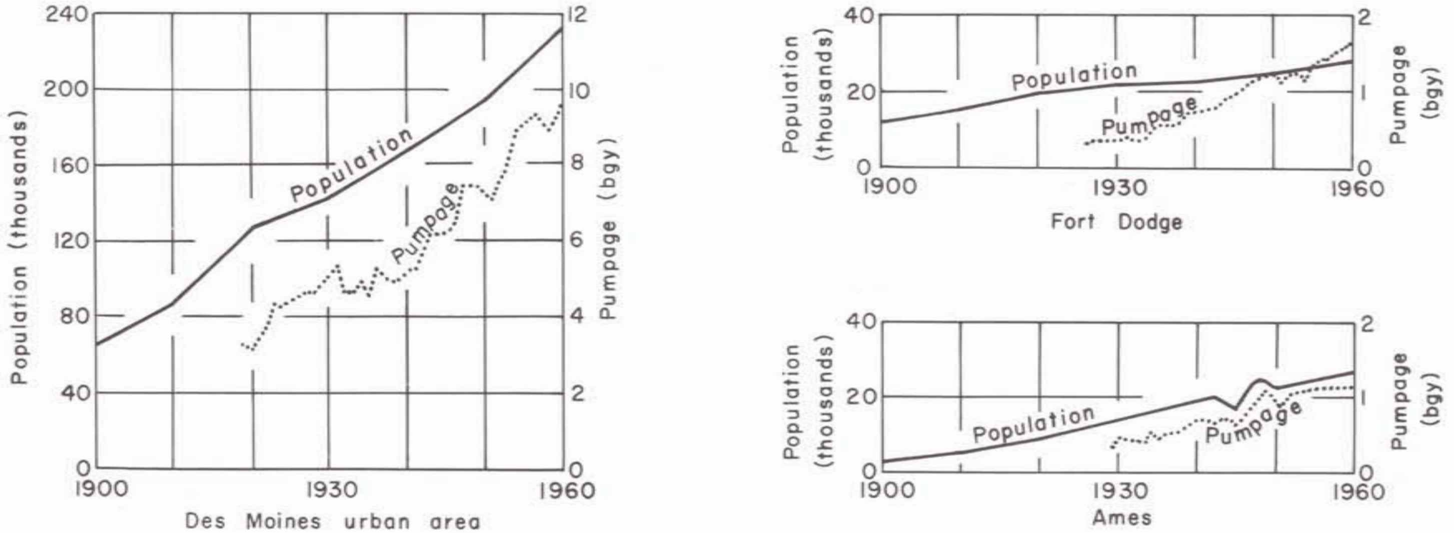
[6] The projections on this page, showing quantity of water used, were made by graphical methods (Fair and Geyer, 1954, p. 123). The upper curve of each projection represents the maximum expected increase in quantity of water used, the lower curve represents the minimum.

Factors that influence the amount of water used

Population, industry, and climate—these are the important factors influencing water use at present; there are others. In the future irrigation may become an important influencing factor.

Population and industry are closely related; as industry expands population grows and with growth comes new industry. The ultimate effect is that the demand for water increases. Through the years, the Des Moines urban area has been a big user of water. Here, as the city grew and became more industrialized, the rate of water use has increased faster than the population. A somewhat similar relationship has been experienced at Fort Dodge, where industry is one of the principal water users. Here, the per capita use has increased at an even more rapid rate than in the Des Moines area. However, in Ames, a university city, water usage tends closely to parallel population. This relationship is especially evident during the World War II period when the demand for water was directly correlative with the rapid fluctuation in student population.



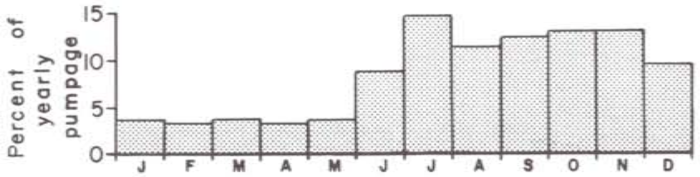
Des Moines urban area

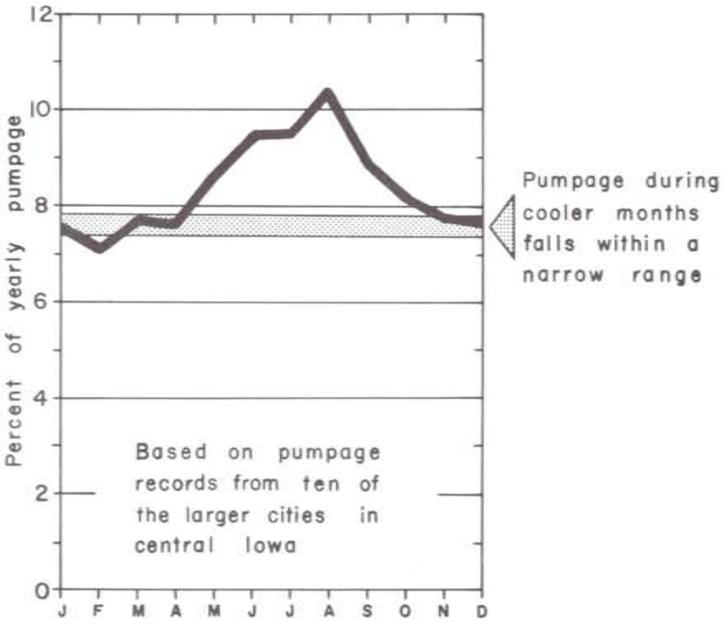
Fort Dodge

Ames

Pumpage varies with population and industry.

The influence of industry on a municipal water supply is shown dramatically in Ellsworth. This city has a population of about 500 and an industry that processes more than a million turkeys each year. In 1961, nearly 84 percent of the water was used during the 7 months when turkey processing was at a maximum. During turkey season, the city pumped about 6.2 million gallons of water per month; whereas, during the off season monthly pumpage dropped to less than 1.8 million gallons.



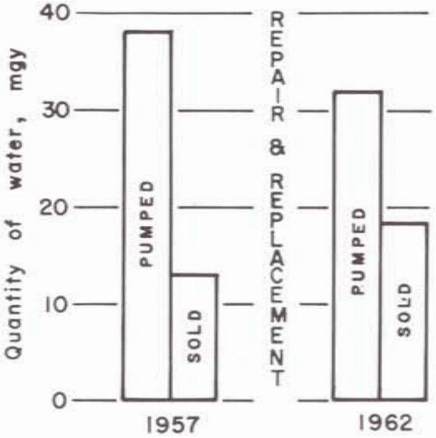


Seasonal changes, especially temperature changes, play an important part in water usage. When it's hot, the demands for water increase rapidly—offices use more water for cooling, water is used for watering lawns and gardens, swimming pools must be kept full, and we drink more water. Monthly pumpage during the warmer months ranges between 8.5 and 10.3 percent of the yearly pumpage. When temperatures fall there is corresponding decline in the demand for water. The monthly pumpage during the cooler months ranges between 7.5 and 7.7 percent. (February pumpage appears low because the month has fewer days.)

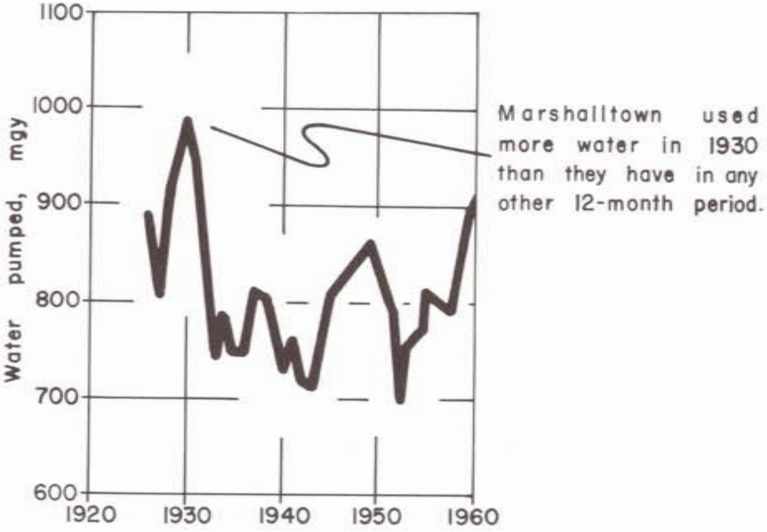
The cost of water will influence the quantity used. If water is expensive, it will be used conservatively. Conversely, when water is inexpensive it will be used freely. Thus, cities without a metering system will inevitably have a higher per capita use than cities with meters. For example, in central Iowa, Colfax (1960 population: 2,331) has an unmetered water system. The per capita domestic use in this city is 152 gpd—this is more than double the average per capita domestic use of 65 gpd in central Iowa.

Conserving water by efficient management

Illustrated here are two examples of ways by which water can be conserved. There are others. However, all would show one important feature—that water is not conserved for conservation's sake. Rather, water conserved is money saved. We will have managed our water efficiently when each drop taken from a stream or the ground is put to its most beneficial use. At the same time we will have used the pumping and distribution system to maximum advantage. When this is done, the water and the equipment will give more profitable production; and the money spent will yield larger returns.



Repairing and replacing leaky mains enabled the city of Hubbard to reduce the amount of water pumped although the quantity of water sold increased. Of the total water pumped, 35 percent was sold in 1957; whereas, after repairs, 58 percent was sold in 1962.

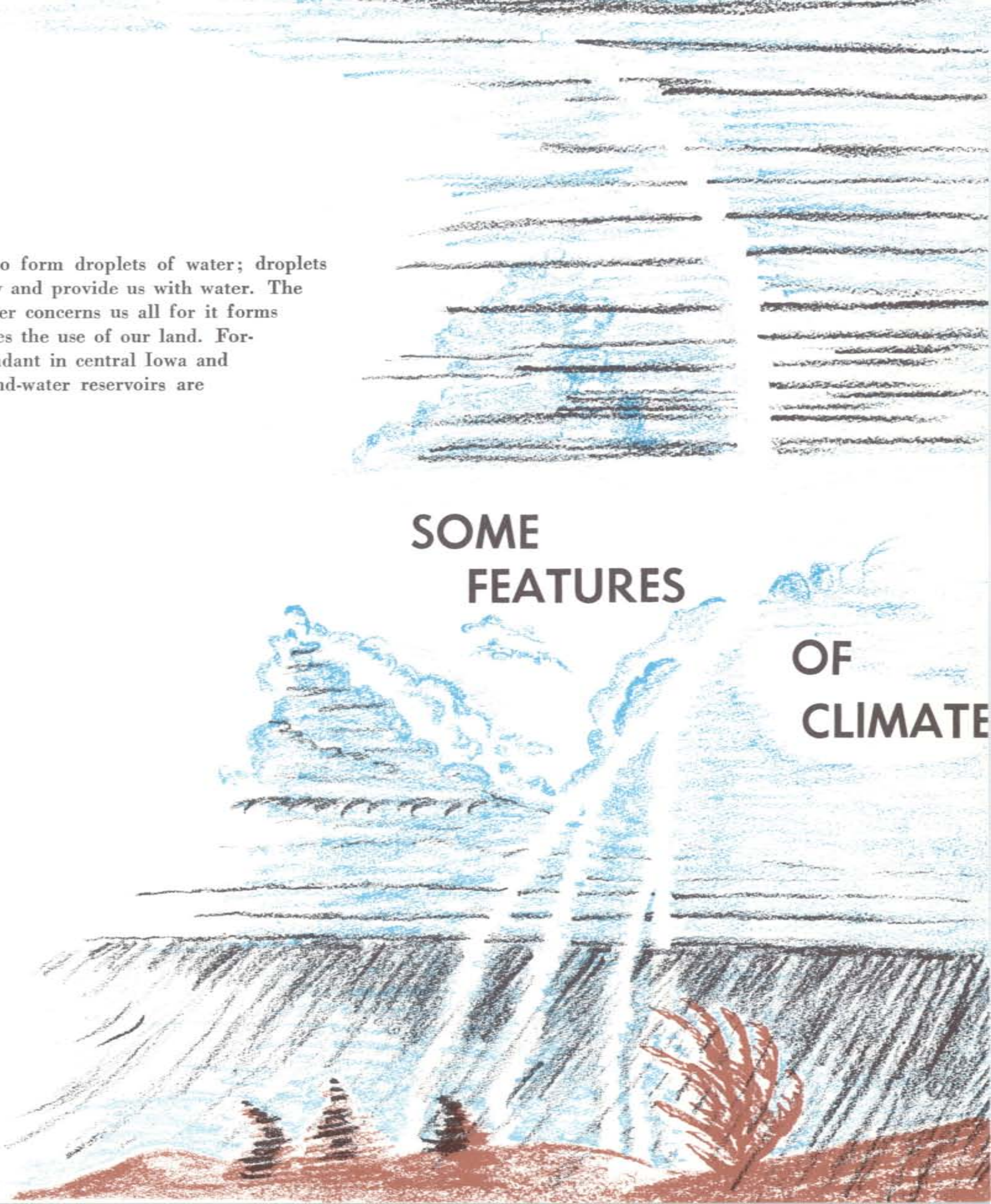


Marshalltown used more water in 1930 than they have in any other 12-month period.

Keeping accurate records is an important part of operating an efficient water plant. Records of water withdrawal in Marshalltown indicated an unusually high per capita water use about 1930. An examination of the water system revealed that 100 to 150 million gallons of water were being pumped annually to a lagoon in the city park. Pumpage to the lagoon was stopped and by 1932 the per capita use had been reduced by 40 gpd.

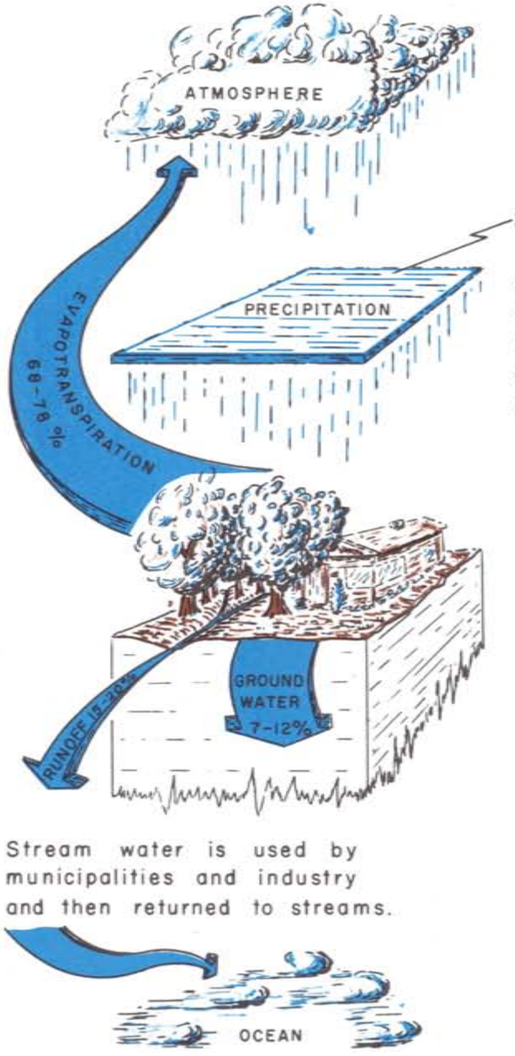
SOME FEATURES OF CLIMATE

Water vapor in the sky condenses to form droplets of water; droplets that fall on the earth as rain or snow and provide us with water. The quantity and distribution of this water concerns us all for it forms the core of our supply and determines the use of our land. Fortunately, this water is relatively abundant in central Iowa and because it is, our streams and ground-water reservoirs are replenished often.



The water cycle

From atmosphere to earth and from earth to atmosphere—this is water's cycle; a cycle that is never-ending. The movement of water on this journey is devious and varied. Water moves in our atmosphere as vapor. When the vapor condenses to very fine particles of water high above the earth's surface, clouds are formed. These moisture-laden clouds, sometimes white and wispy and at other times dark and threatening, are always on the move. As they move, increased condensation of the fine water particles may form droplets of water. These droplets move downward through the atmosphere—this is precipitation. During periods when the air temperature is warm, precipitation principally is in the form of rain; whereas when the air temperature is below freezing, precipitation generally occurs as snow.



200,000 gallons
or
enough water to
supply 10 people
for a year fall on
each 100-foot square
plot of land.

Stream water is used by municipalities and industry and then returned to streams.

A large quantity of water falls on central Iowa each year but not all is available for controlled use by man.

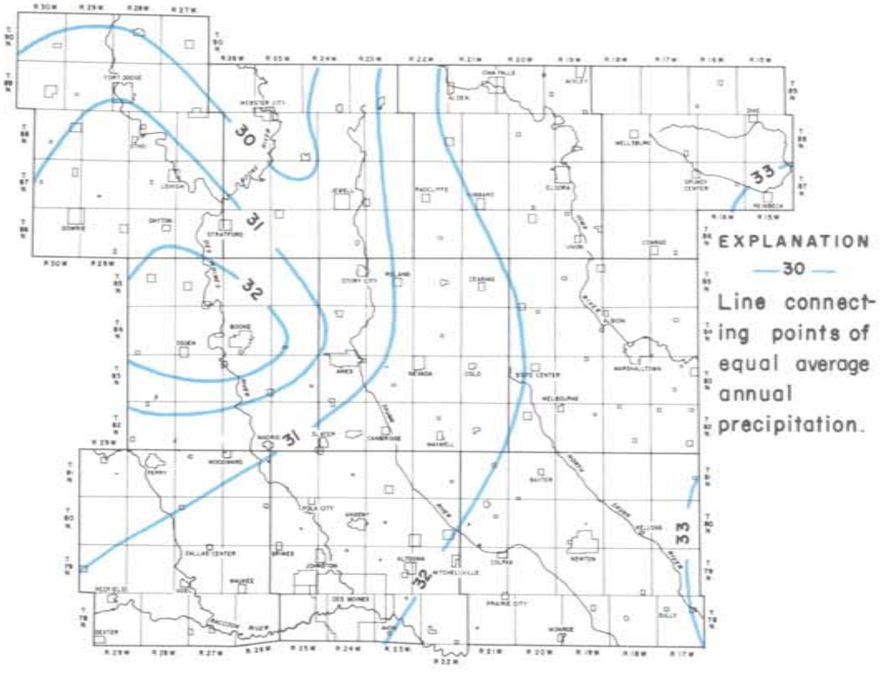
In central Iowa the average precipitation is about 32 inches per year. On a 100-foot square plot of land, for example, this is 200,000 gallons of water or enough water to supply each of 10 people with 55 gallons of water per day for a year.

Once water as precipitation hits the land surface it moves in many directions. It evaporates from the ground, from the roofs of houses, from streets, from lakes, from vegetation, and from everything else on which it has fallen. It is taken from the soil and transpired in large quantities by growing plants. In central Iowa these two processes, evaporation and transpiration, return 68-78 percent of the water from precipitation back to the atmosphere. This water is no longer available for use by man, although it must be noted that this is the water that supports and nurtures our forests and fields.

Water's most dramatic route of travel after reaching land surface is as runoff. Here, we see it as a bubbling brook or a roaring flood. It may be a passive pool or a tumbling waterfall. It is a rill, a creek, or a river. Eventually it becomes part of the ocean. Yet, water as runoff in central Iowa is but a small part, probably no more than 20 percent, of precipitation.

Probably about 7-12 percent of the water from precipitation infiltrates the soil and moves down into the underlying rocks until it reaches a zone where the rocks are saturated with water. The water in this saturated zone, called ground water, moves through openings, such as pores or cracks, in the rocks. Its movement may be very slow in some rocks, maybe less than a foot per year; whereas, its movement in other rocks may be several feet per day. Some of the water may remain stored underground; however, some will move through the rocks and eventually flow back to the surface in the form of springs and seeps. During dry seasons, ground-water seeps maintain the flow of perennial streams.

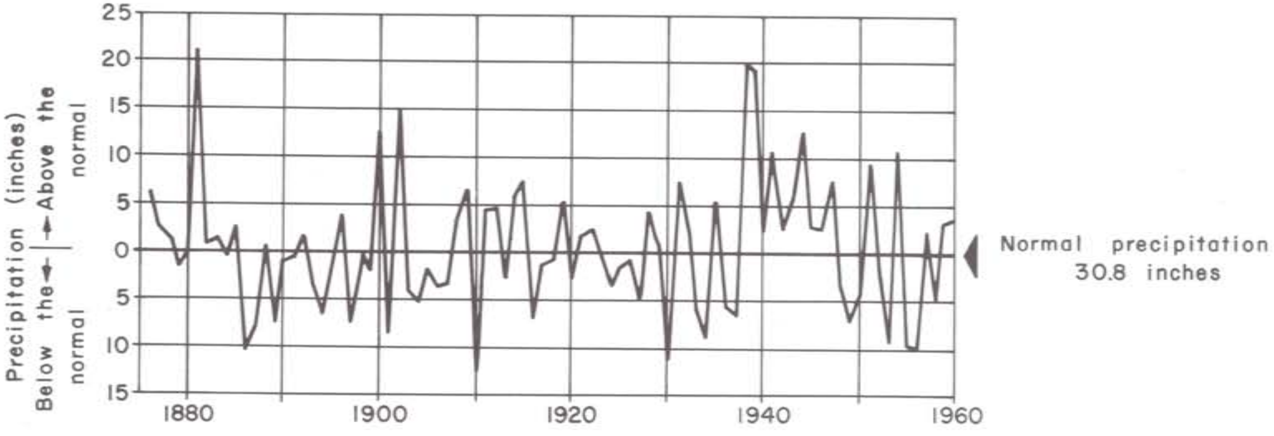
Ultimately, the water in our streams and oceans and even the water in the ground will repeat the "water cycle."



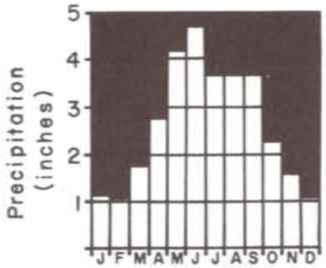
Precipitation replenishes streams and ground-water reservoirs

Precipitation, directly or indirectly, is the source of all water in central Iowa. It is this water that supplies our crops during growing season and feeds our streams and ground-water reservoirs. Without this water, streams would cease to flow and shallow ground-water reserves would diminish rapidly.

Normal annual precipitation in central Iowa ranges from about 30 to 33 inches—it seldom deviates more than 10 inches from the normal. For example, in 84 years at the Ames station there were only 3 years when precipitation was more than 10 inches below the normal and only 8 years when it was more than 10 inches above.

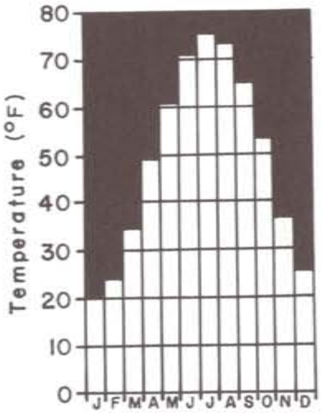


Precipitation at Ames Climatological Station.



The spring and summer months are generally the wettest.

Nature seems to provide Iowa with water when it is most needed. Precipitation is least during the winter months; a period when temperatures are low and less water is needed. But during the summer months when temperatures are high and large quantities of water are needed nature obliges us with increased precipitation.



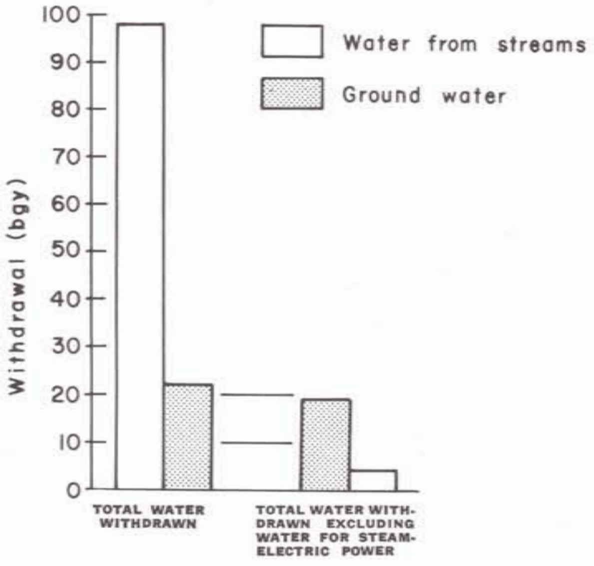
Average monthly temperatures range from 20 degrees in January to more than 70 degrees in June, July, and August.

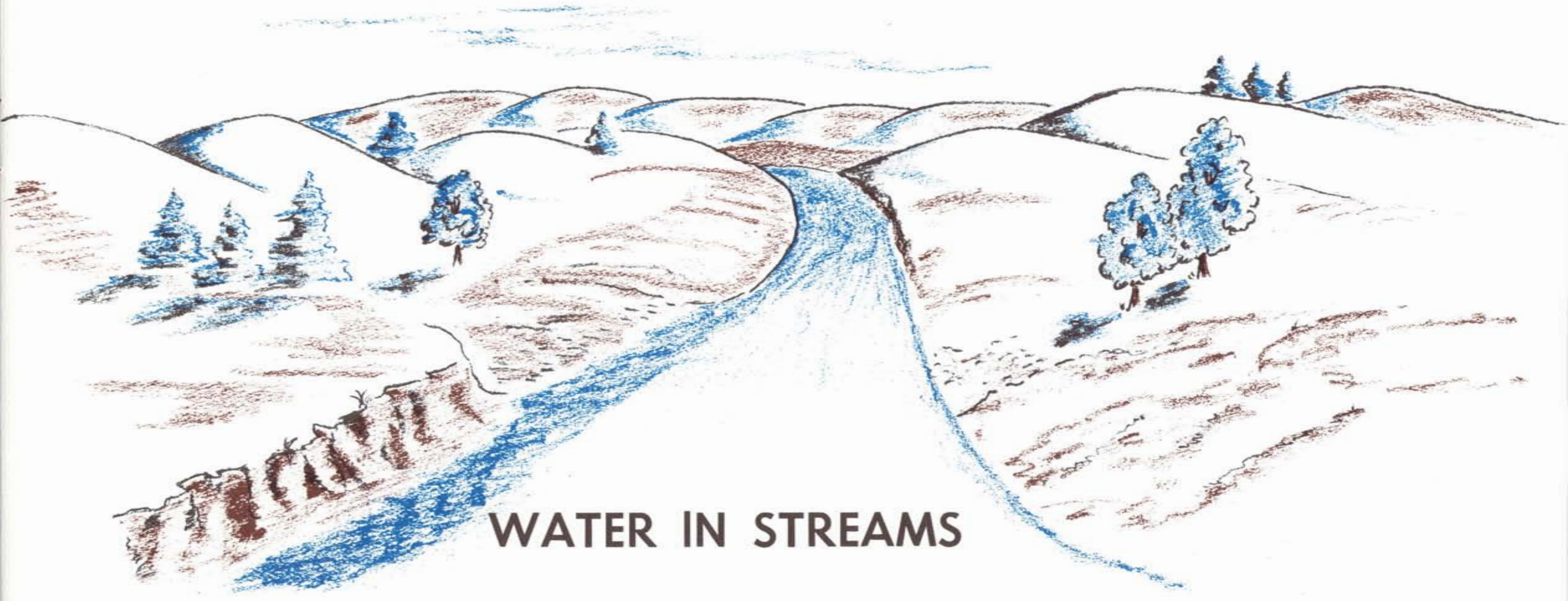
SOURCE OF WATER SUPPLIES

Wherever we live and whatever our needs for water, it is important that we know the sources from which water supplies are derived. For by knowing this, we may be able to determine if we, too, can obtain our supply from a similar source.

The water that we use comes from several sources. Small water supplies for household use can be obtained by storing water from precipitation in water barrels or cisterns; however, as we all know, this is not a completely dependable and satisfactory supply. Most water supplies for domestic, industrial, or livestock use generally are derived from two sources—from streams and from the ground.

In a 12-month period during 1960-61, a total of about 119 billion gallons of water were withdrawn from stream and ground-water sources. Of this total, more than 95 billion gallons were taken from streams; much of this was used in the generation of steam-electric power. Excluding water for power generation, most water in central Iowa was withdrawn from the ground-water reservoirs.



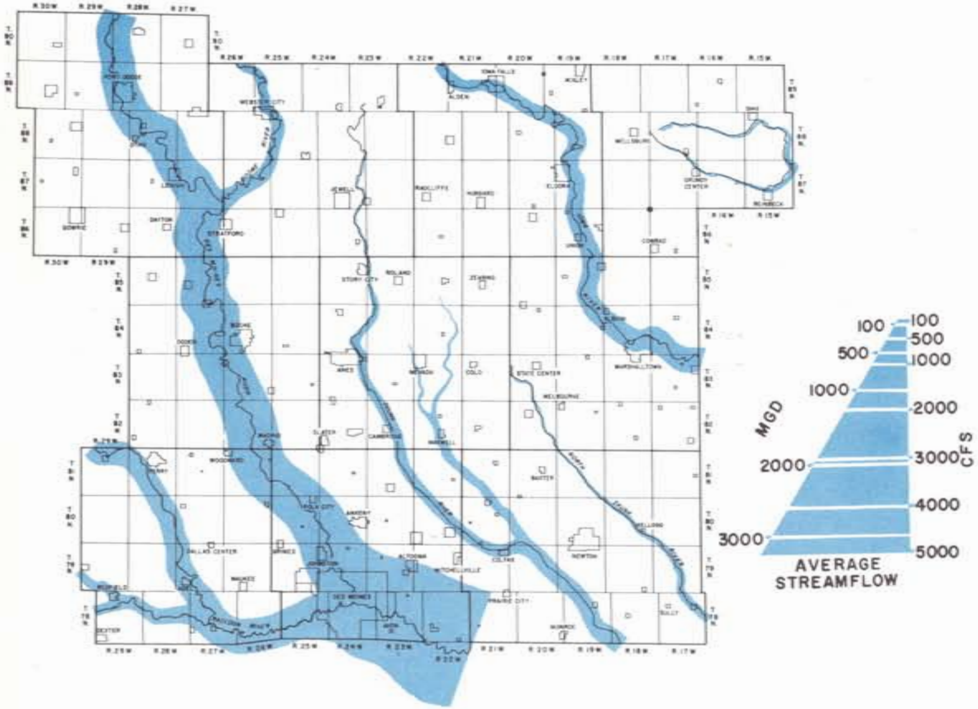


WATER IN STREAMS

Water in streams is used by man in many ways, but only a small quantity is consumed. Nearly all the water taken from streams to produce electric power is returned, as is much of the water diverted for municipal supplies. Recreational use of streams for boating and swimming is nonconsumptive as is man's use of streams as disposal media for waste. Irrigation consumes large quantities of water; however, the amount of water diverted for this purpose in central Iowa, is relatively small, when compared to water diverted for other uses.

Although little of the water in streams is consumed, all of man's uses may cause deterioration of its quality. If improperly managed, stream water may rapidly reach a point where the quality is so poor that it will no longer serve man advantageously. By keeping the streams clean, man assures himself of large quantities of usable water.

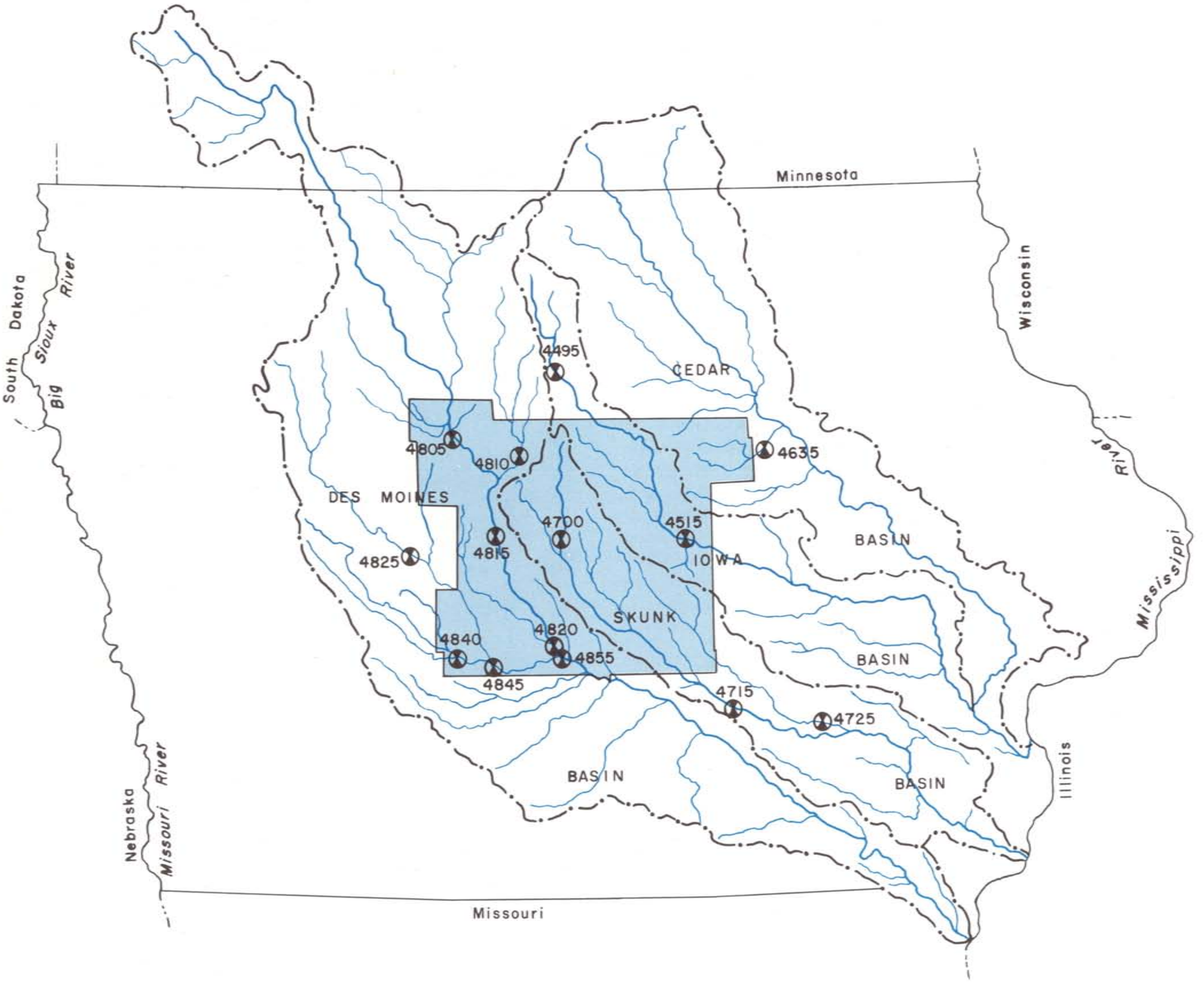
Streams, as a source for municipal water supplies in central Iowa, are relatively untapped. Only two cities, Adel and Des Moines, obtain water directly from streams. Yet three large rivers, the Des Moines, Iowa, and Skunk, carry a daily average of about 3 billion gallons of water from central Iowa toward the Mississippi River. Some water is drained from central Iowa by tributary streams to the Cedar River.



Average streamflow ranges from less than 100 to about 4,000 cfs.

Average streamflow in streams varies with the size of the upstream drainage area. From this area, numerous tributary streams deliver water to the major rivers. As one goes downstream, the drainage area is larger and the additional flow from the tributaries produces a corresponding increase in the flow of the rivers. As an example, the average flow in the Des Moines River just upstream from Des Moines is about 2,000 cfs; after receiving the water of the Raccoon River, flow in the Des Moines increases to 3,800 cfs. Similarly, the flow in other streams in central Iowa, whether creek or river, increases downstream.

The U. S. Geological Survey maintains stream-gaging stations on many of the larger streams in Iowa. The location of some of these stations is shown on the opposite page. Personnel of the Survey measure the flow of water past each station regularly and automatic recording devices at many stations keep a continuous record of water stage.


Minnesota
South Dakota
Big Sioux River
Wisconsin
Mississippi River
Nebraska
Missouri River
Missouri
Illinois
DES MOINES
CEDAR
IOWA
SKUNK
BASIN
BASIN
BASIN
BASIN
4495
4635
4805
4810
4515
4700
4815
4825
4840
4820
4855
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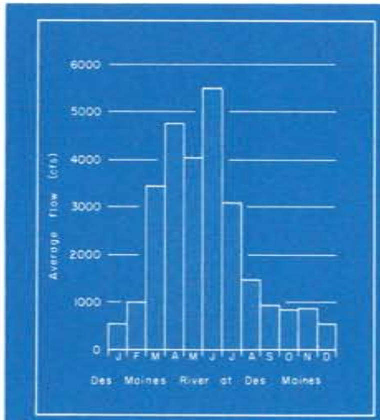
4725

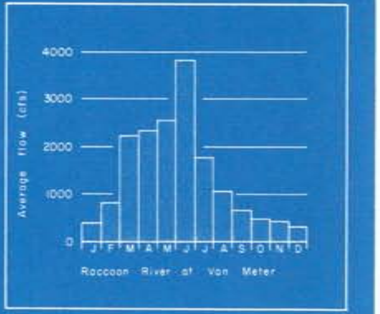
Streamflow—sometimes high, sometimes low

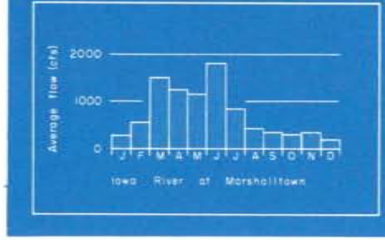
From rill to creek to river, the water in streams always is subject to variations in flow. There are times when rills and creeks contain no water and rivers flow but little. At other times, streams are torrents of water that wear away the land and destroy property. During much of the time, however, flow in streams is neither exceptionally low or high.

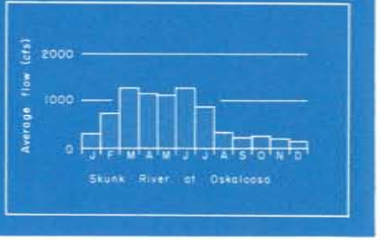
Fluctuations in streamflow are controlled by many factors, especially changes in temperature and precipitation. During the winter, precipitation, generally as snow, is less than during other seasons. Because air temperatures seldom rise above freezing at night and often remain below freezing during the day, the snow either accumulates on the ground or dissipates slowly. Small amounts of water from precipitation and low temperatures yield little runoff; thus, streamflow during this season of the year is low. In early spring, however, as temperatures rise above freezing, the snow and ice that have accumulated during the winter months melt. Because the soil just below land surface is either saturated with water or frozen, most of the water from the melting snow and ice runs directly to the streams with a resultant increase in streamflow. Increased precipitation and low evapotranspiration during this time further increases streamflow. In late spring, evapotranspiration losses become significant; however, they are offset by precipitation that is at a maximum at this time of year. In the summer precipitation is still relatively high, but streamflow decreases sharply because of evapotranspiration.

Changes in temperature and precipitation, as discussed above, cause the flow in any one stream to fluctuate; not only from season to season, but with each hour, day, month, and year.









Peak flows represent the maximum streamflow during any unusually high discharge, such as the crest of a flood. These flows are momentary—as soon as the crest passes, the water begins to recede. For example, the highest flow ever recorded at any one moment on the Raccoon River at Van Meter was 41,200 cfs; whereas, the mean flow for that same day was 33,000 cfs. The peak was 25 percent more than the day's mean flow.

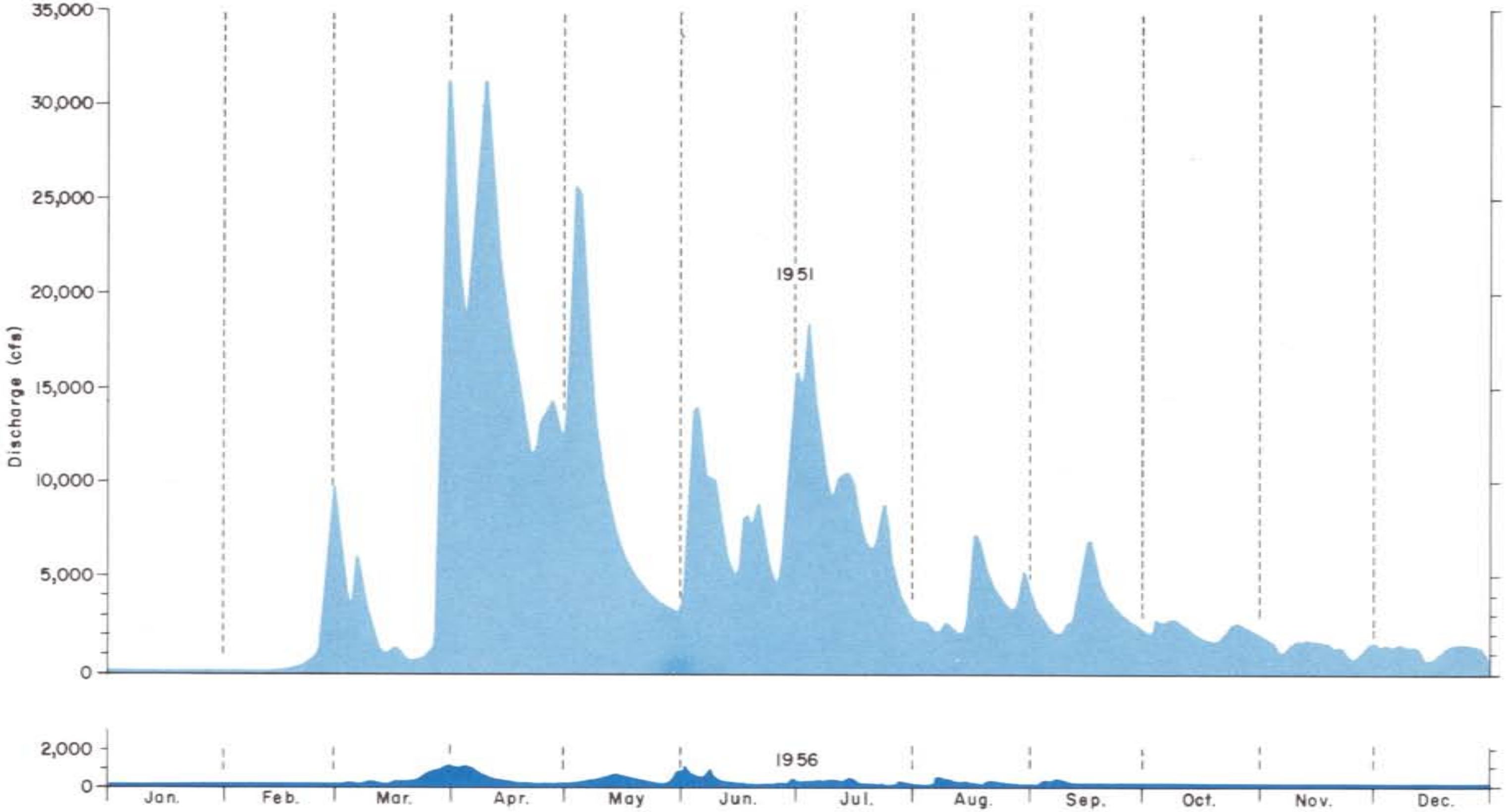
Daily mean flows vary considerably. For instance, at Marshalltown the highest daily mean flow of 39,400 cfs is more than 4,000 times greater than the lowest recorded daily mean flow of 9 cfs and more than 55 times greater than the average flow of 711 cfs.

Monthly streamflow is highest from March through June, and lowest from August or September through January. As an example, the extremes for these two periods are shown by the monthly flows of the Des Moines River at gaging station No. 4855 in Des Moines; the highest was 31,660 cfs in June, 1947, and the lowest was about 90 cfs for December, 1955.

The flow in streams of central Iowa

Gaging[1] station number	Stream	Lowest daily mean (cfs)	Lowest monthly mean (cfs)	Highest daily mean (cfs)	Highest monthly mean (cfs)	Maximum peak discharge (cfs)	Average[2] discharge (cfs)	Drainage area (sq. mi.)	Period[3] of record (years)
	Cedar River Basin								
4635	Blackhawk Creek at Hudson	1.9	2.34	7,500	1,026	9,000	106	303	8
	Iowa River Basin								
4495	Iowa River near Rowan	2.9	3.54	7,640	1,828	8,460	165	429	20
4515	Iowa River at Marshalltown	9.0	13.70	39,400	7,370	42,000	711	1,564	42
	Skunk River Basin								
4700	Skunk River near Ames	0.0	0.05	5,760	1,900	8,630	127	315	35
4715	Skunk River near Oskaloosa	1.8	5.30	14,500	4,610	20,000	755	1,635	15
4725	North Skunk River near Sigourney	0.1	0.13	23,200	4,145	27,500	379	730	15
	Des Moines River Basin								
4805	Des Moines River at Fort Dodge	14.0	32.80	34,000	12,950	35,400	1,272	4,190	28
4810	Boone River near Webster City	1.6	3.60	19,500	3,485	20,300	329	844	20
4815	Des Moines River near Boone	17.0	13.80	55,900	13,150	57,400	1,557	5,511	40
4820	Des Moines River at Des Moines	24.0	34.90	59,100	19,190	60,200	1,979	6,245	45
4825	North Raccoon River near Jefferson	0.6	5.04	23,200	5,341	29,100	625	1,619	20
4840	South Raccoon River at Redfield	19.0	30.10	15,400	5,017	35,000	414	988	20
4845	Raccoon River at Van Meter	10.0	17.20	33,000	13,970	41,200	1,174	3,441	45
4855	Des Moines River below Raccoon River at Des Moines	55.0	90.50	65,800	31,660	77,000	3,755	9,879	20

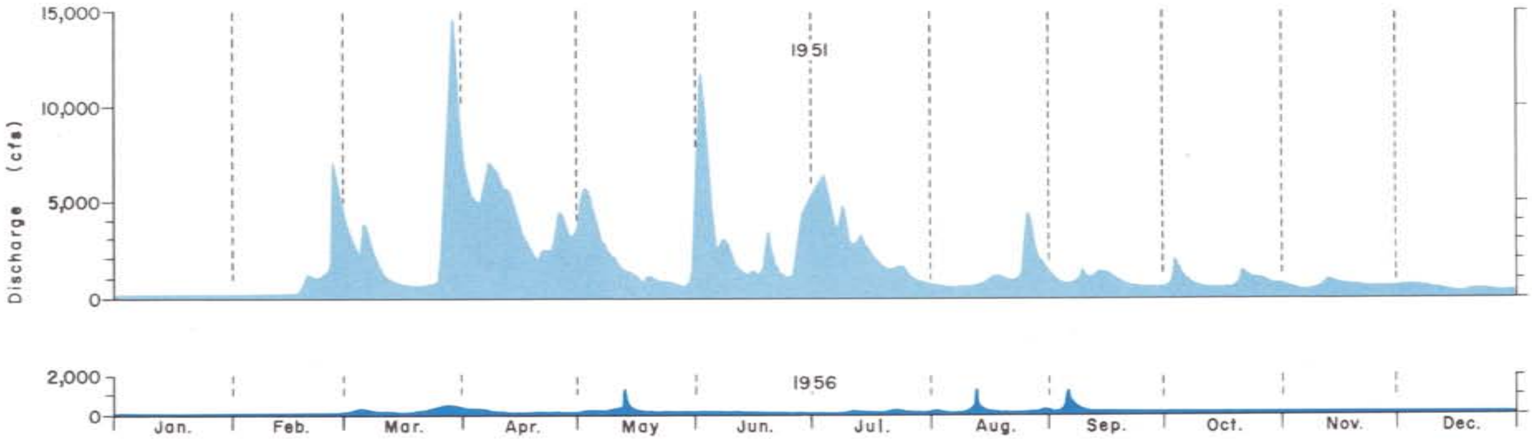
[1] Station number assigned by U. S. Geological Survey. See map on page 27.
[2] Mean of yearly discharges for number of years indicated.
[3] As of 1960, not necessarily continuous.



Streamflow in the Des Moines River at Des Moines
was high during 1951 but reached new lows in 1956.

Streamflow fluctuates from year to year. To illustrate these fluctuations, the streamflow records for a high-flow and a low-flow year—1951 and 1956—have been selected. The records for two streams are given to show how all streams in an area respond to similar climatic conditions.

In the year 1951, average streamflow was one of the highest on record and was more than twice the long-term average on both the Des Moines and Iowa rivers. This high flow was attributed to several factors—a large accumulation of snow during the winter, an above normal precipitation, and temperatures that were below normal. March 1951 was the coldest since 1912 and by the end of the month there was a heavy cover of snow on the ground. Warm rains near the close of the month produced very high stream flows, as much as 30,000 cfs on the Des Moines River, and caused extensive flooding along some streams.



The 1951-high and 1956-low streamflow in the Iowa River at Marshalltown.

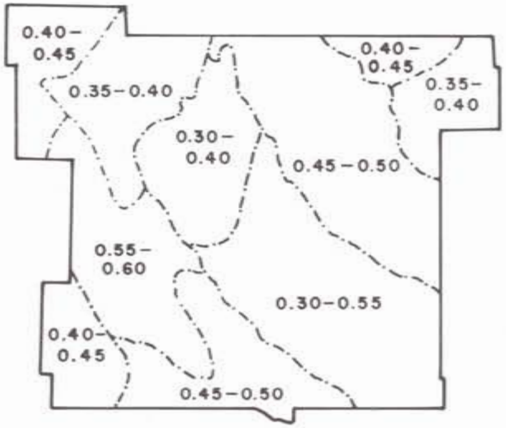
	Des Moines River	Iowa River
1951 average streamflow (cfs)	5,306	1,577
Long-term average streamflow (cfs)	1,979	711
1956 average streamflow (cfs)	211	113

Streamflow in 1956 was among the lowest ever recorded. Seldom was the flow on the Des Moines or Iowa rivers more than 1,000 cfs and the average for the year was less than one-sixth of the long-term average. Central Iowa was gripped by the most intensive drought on record. By June, nearly all of the area had recorded deficient rainfall for 14 consecutive months and by the year's end Des Moines had had one of its driest years. Annual precipitation during 1955 and 1956 was about 10 inches below normal at the Ames station. Not only precipitation and streamflow but also water levels in shallow wells were near an all-time low.

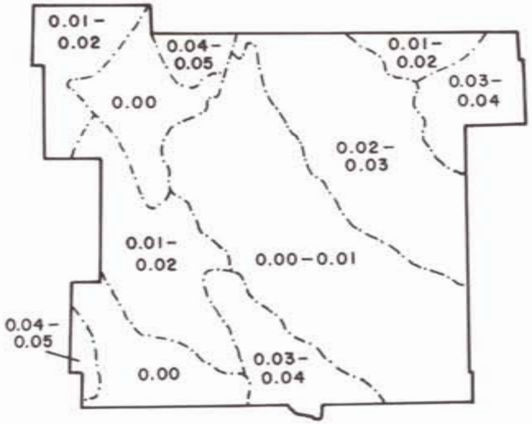
How much runoff?

Most tributary streams will not yield an adequate amount of water throughout the year to supply the demands of a municipal water system or to dilute and carry away municipal wastes. Some provision usually must be made so that in times of excess runoff, water can be stored for use during periods of low runoff.

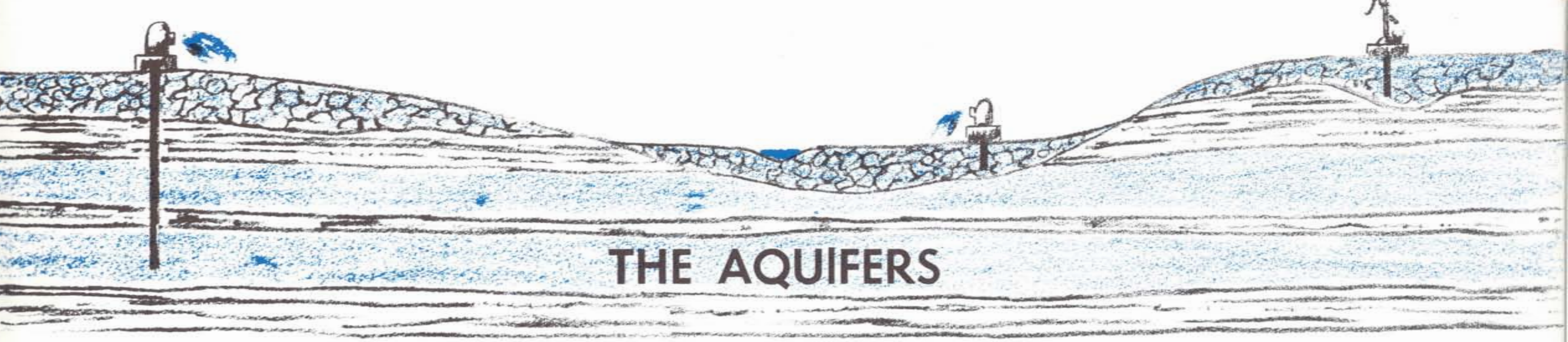
The average runoff in the smaller drainage basins in central Iowa is about 0.45 cfs, or about 290,000 gallons per day per square mile. If this "average" amount of water was available from our streams each day of the year, water shortages would not occur. However, in this case "average" refers to the average of all runoff. Plenty of water is available during periods of normal streamflow or periods of flooding.



Water may become scarce, however, during periods when runoff is low. The average low-flow runoff during September 24-30, 1956, was less than 0.02 cfs per square mile or 13,000 gallons per day per square mile. During this time, there was no runoff or no streamflow in some of the smaller drainage basins in central Iowa.



Runoff differs between the smaller drainage basins in central Iowa. The average runoff may be as high as 0.60 cfs per square mile in one of the smaller basins and as low as 0.35 in another not many miles away. These differences may be a direct result of variation in precipitation. Mostly, however, they result indirectly from variation in infiltration capacities and runoff characteristics which can be attributed to differences in rocks, soils, and topography. Furthermore, the headwater regions of some drainage basins contain lakes and swamps which capture and store runoff. This stored water is exposed to the sun and wind; hence evaporation is greater and the overall runoff in the basin is reduced.



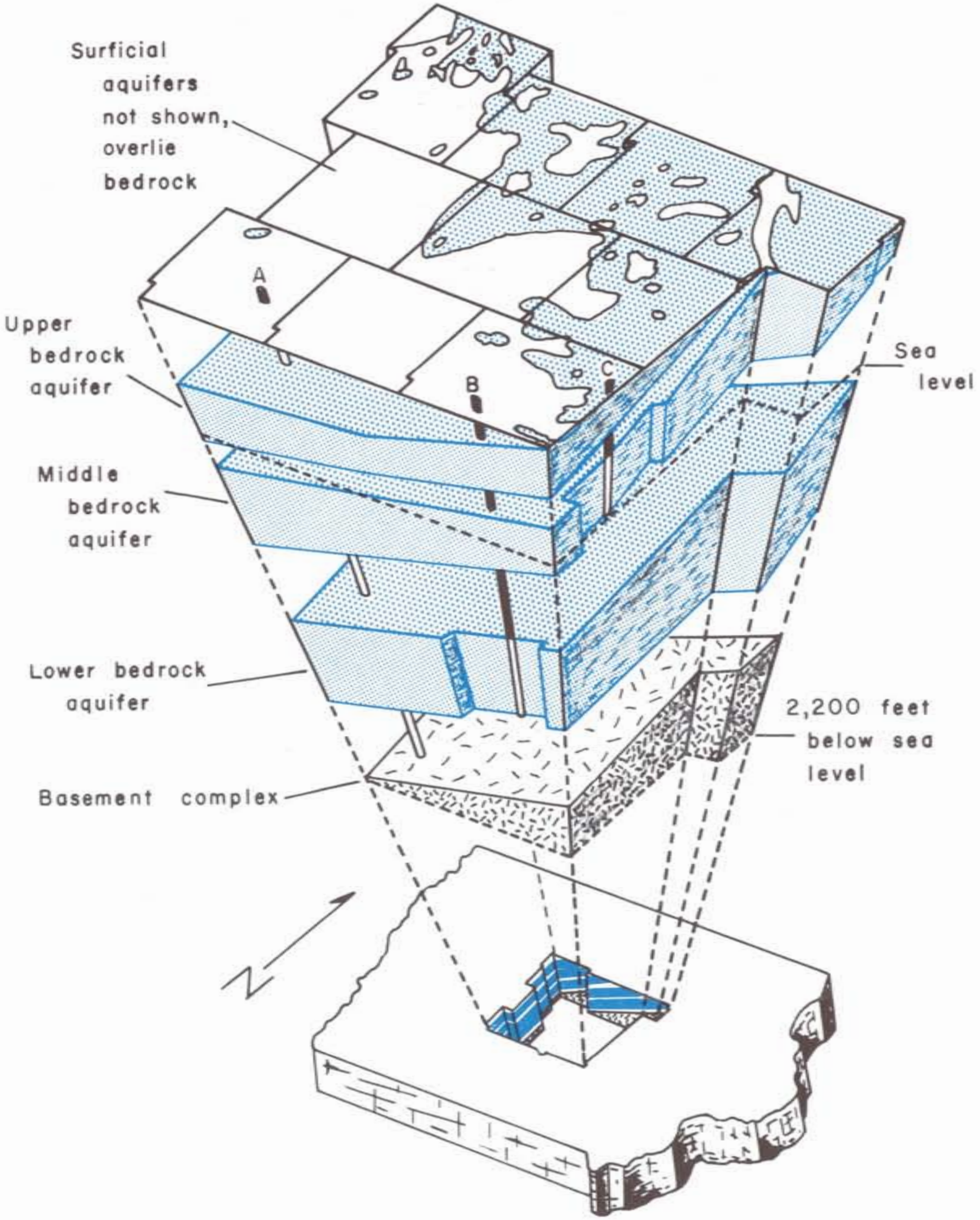
THE AQUIFERS

Aquifers are rocks that store, transmit, and yield water to wells and springs. In this report, each aquifer is a group of rock units that have similar physical features and, broadly speaking, have similar water-bearing characteristics. The aquifers generally are separated from each other by aquicludes, that is, rocks that yield little or no water.

All of central Iowa is underlain by several aquifers. The aquifers at or near land surface throughout most of the area are composed of irregular layers of unconsolidated rocks and are referred to herein as the surficial aquifers. Because of differences in areal distribution and water-bearing characteristics, these aquifers are discussed as three separate subunits—the alluvial aquifer, the buried-channel aquifer, and the drift aquifer.

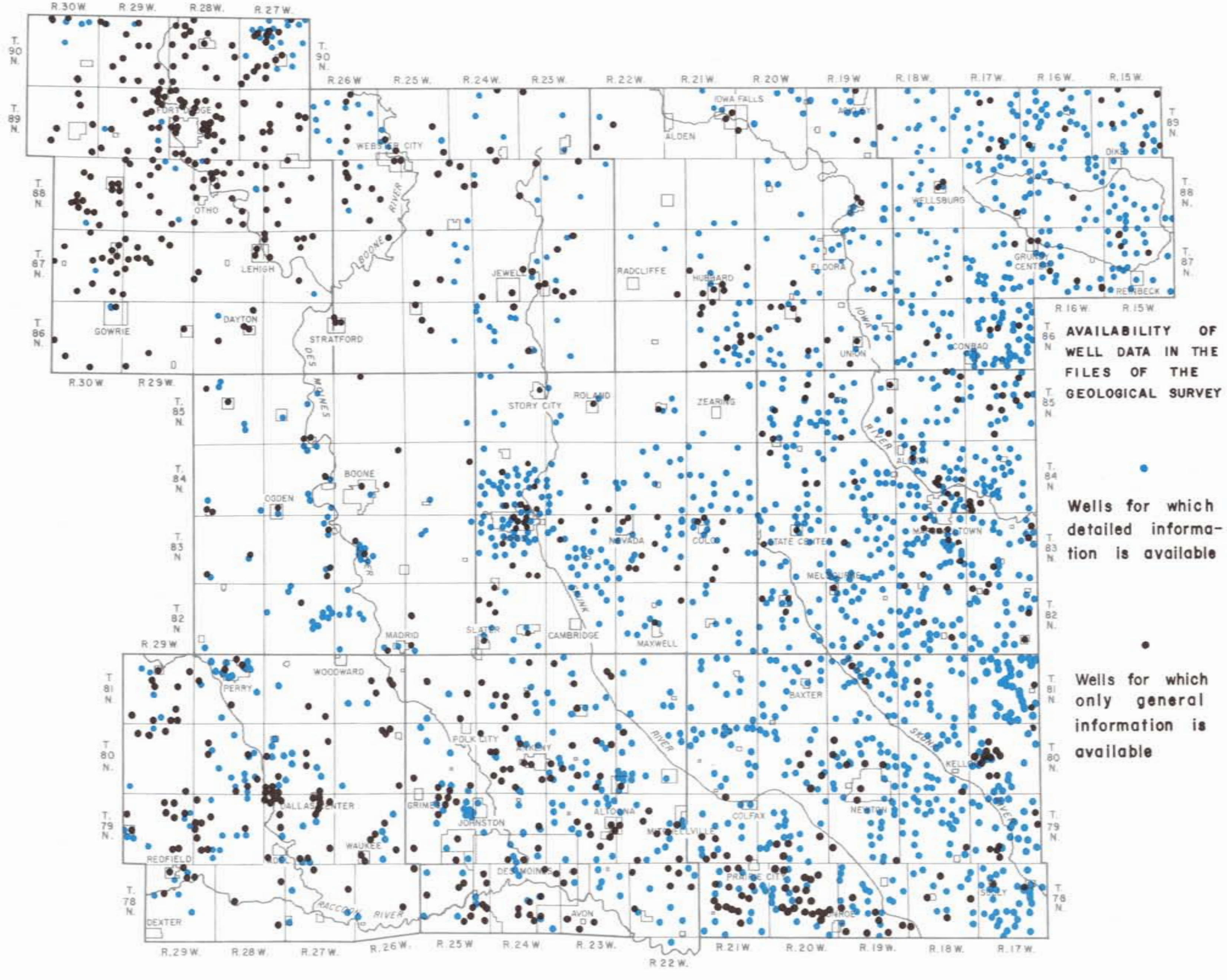
Underlying the surficial aquifers are a series of consolidated sedimentary rock units commonly referred to as "bedrock." These rocks are in layers, stacked one on top of the other, that generally dip (slope) to the southwest. Because some of the layers have water-bearing characteristics that are related, they have been grouped into three larger units referred to in this report as the upper, middle, and lower bedrock aquifers.

Underlying the sedimentary rocks are igneous and metamorphic rocks that often are referred to as "basement complex." In central Iowa these rocks seldom contain water.



The aquifers and how they occur.

Water can be taken from any one aquifer or combination of aquifers by the selective placement of well casing as is shown by wells A, B, and C on the accompanying illustration (cased part of well is black, uncased part is white). Well A penetrates all rocks from land surface to basement rock and because it is uncased, except for a short length near the top, it receives water from all aquifers. If any one of the aquifers contains water of poor quality, the entire water supply from well A would be of poor quality. Well B, however, extends no deeper than the lower bedrock aquifer and the water in all rocks above this aquifer is cased out. Therefore, all water pumped from well B is from the lower bedrock aquifer; if the water in this aquifer is of good quality then the total water supply will be of good quality. Similarly, as is shown by well C, other aquifers can be tapped and the water from the overlying aquifers excluded by the selective placement of the well casing.



AVAILABILITY OF WELL DATA IN THE FILES OF THE GEOLOGICAL SURVEY

● Wells for which detailed information is available

● Wells for which only general information is available

Wells provide information on ground water and its container

Wells were the primary source of ground-water information in the compilation of this report. Because the geologist cannot always see and measure rock layers, he must rely on information provided by rock samples collected during the drilling of wells and test holes.

The data from more than 2,300 wells were analyzed and the resulting interpretations are presented on the pages that follow. The location of these wells and the type of information for each is shown so that the reader may decide for himself as to the reliability and conclusiveness of the interpretations. In general, the more reliable interpretations of subsurface features are in areas where wells are heavily concentrated.

The aquifers and rocks in central Iowa

Aquifers	General thickness (feet)	Age of rocks	Name of rock units	General description of rock units
Surficial Alluvial Buried-channel Drift	0-380	Quaternary (0-1 million years old)	Undifferentiated	Primarily alluvium and drift composed of gravel, sand, silt, and clay
	0-900	Cretaceous (63-135 million years old)	Undifferentiated	Shale, limestone, and sandstone; in Webster County only
	0-550	Permian(?) (230-280 million years old)	Fort Dodge beds	Gypsum and shales; in Webster County only
		Pennsylvanian (280-310 million years old)	Undifferentiated	Shale, sandstone, thin limestones, and coal
Upper bedrock	0-475	Mississippian (310-345 million years old)	Ste. Genevieve St. Louis Warsaw Keokuk Burlington Gilmore City Hampton	Shale and limestone Limestone, sandy Shale and dolomite Dolomite and limestone Dolomite and limestone Limestone Limestone and dolomite
	5-200		McCraney English River Maple Mill Aplington Sheffield	Limestone Siltstone Shale Dolomite Shale
Middle bedrock	400-750	Devonian (345-405 million years old)	Lime Creek Cedar Valley Wapsipinicon	Dolomite and shale Limestone and dolomite Limestone, dolomite, and shale
	330-700	Silurian (405-425 million years old)	Undifferentiated	Dolomite and sandy dolomite
		Ordovician (425-500 million years old)	Maquoketa Galena Decorah Platteville	Dolomite and shale Dolomite and chert Limestone and shale Limestone, shale, and sandstone
Lower bedrock	375-560		St. Peter Prairie du Chien	Sandstone Dolomite and sandstone
		Cambrian (500-600 million years old)	Jordan St. Lawrence	Sandstone Dolomite
	350-550		Franconia Galesville Eau Claire Mt. Simon	Sandstone, siltstone, and shale Sandstone Sandstone, shale, and dolomite Sandstone
	-----	Precambrian (600 million to more than 2 billion years old)		Igneous and metamorphic rocks, locally overlain by sedimentary rocks that are chiefly sandstone

The rocks that are aquifers

The rocks that underlie central Iowa are listed in the table on the opposite page. Because the various layers of bedrock differ in composition and appearance, geologists have named each of the layers to facilitate discussion; these are shown in the table under the column headed "Name of rock units." In this report, however, rock units have been grouped on the basis of water-bearing features; rocks that are aquifers have been separated from rocks that are aquicludes. The four main aquifers are shown in the table. Water occurs in some of the other rocks in varying amounts but, because production is localized, discussion of these rocks is limited.

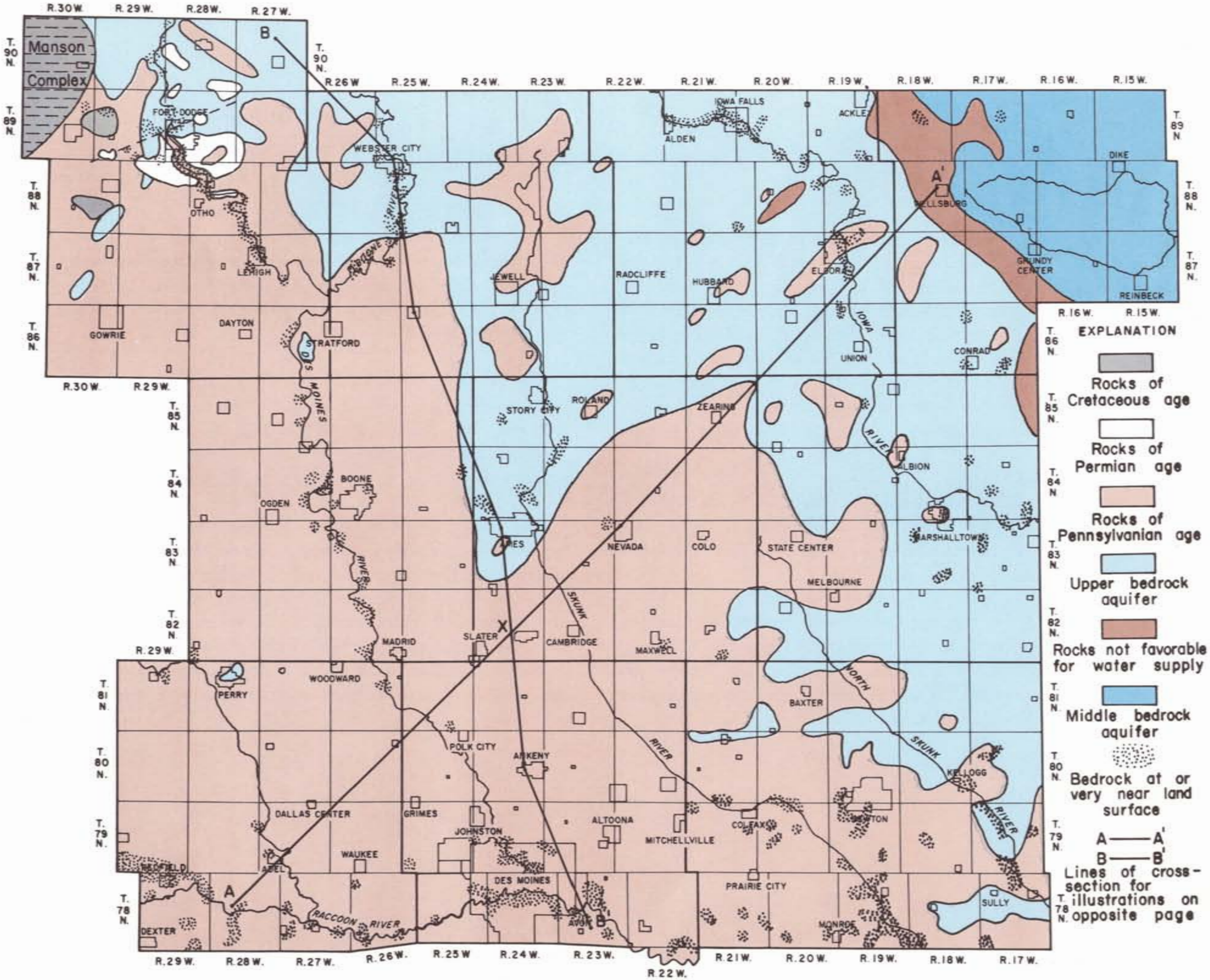
The surficial aquifers lie nearest land surface throughout most of central Iowa. These aquifers are composed of unconsolidated rocks containing various amounts of clay, silt, sand, and gravel, of which the latter two are the important water-bearing components.

The upper bedrock aquifer is the uppermost water-producing zone in the bedrock. It either lies directly under the surficial aquifer or is separated from it by an aquiclude. The rocks comprising this aquifer are primarily dolomite and limestone. Water is stored and transmitted in these rocks in solution cavities and fissures.

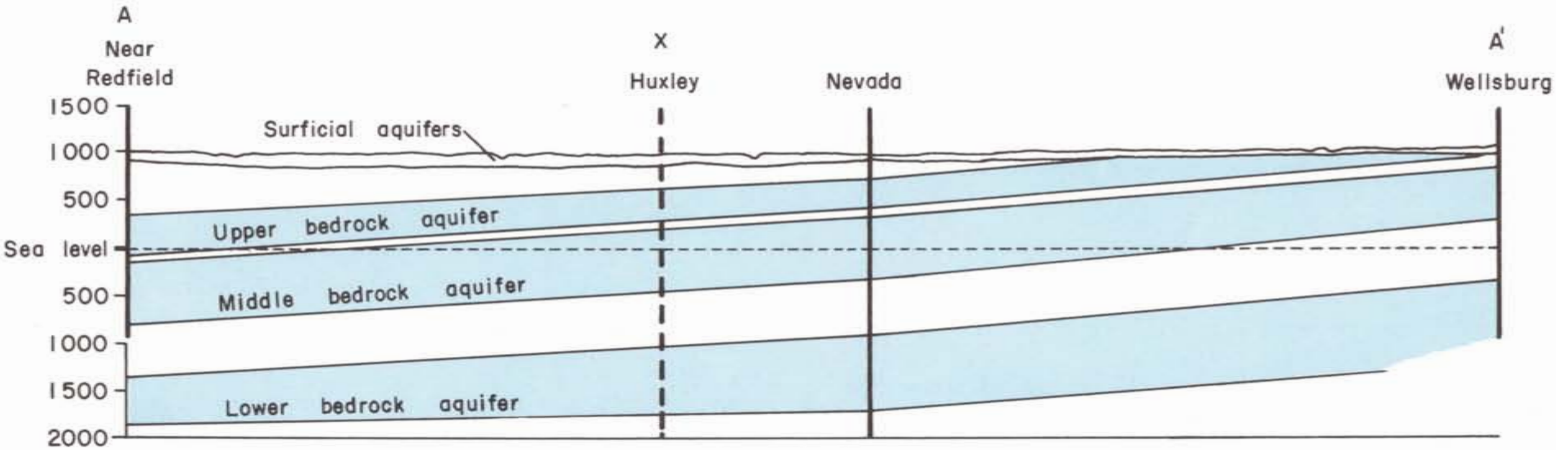
The middle bedrock aquifer is composed of dolomite and limestone also. However, it is separated from the upper bedrock aquifer by rocks that are relatively impermeable. Thus, each is a separate unit and, although they have many water-bearing characteristics that are similar, the water from each is different.

The lower bedrock aquifer is similar in some respects to the other bedrock aquifers in that it contains limestone and dolomite. However, it has one very important distinguishing feature—it contains sandstone. And, mainly because of one sandstone unit, known as the Jordan Sandstone, this aquifer generally can be depended upon for a water supply.

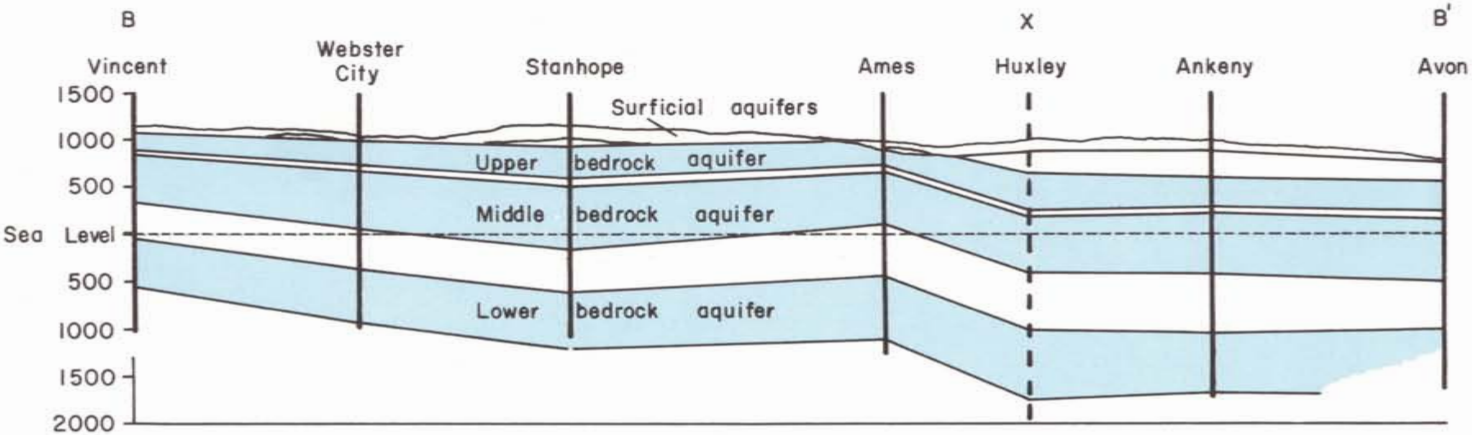
The illustrations on the following two pages depict the relationship between the aquifers. The map shows the areal distribution and spatial relations of the upper and middle bedrock aquifers as they would appear if the surficial aquifers could be stripped away. The cross-sections show the attitude of all the aquifers. In the cross-section from near Redfield to Wellsburg, the regional dip of the aquifers to the southwest is well illustrated. A buckle in the aquifers near Ames, commonly called the Ames anticline, is shown in the cross section from Vincent to Avon.



The areal distribution and spatial relations of the upper and middle bedrock aquifers.



The bedrock aquifers dip to the southwest.

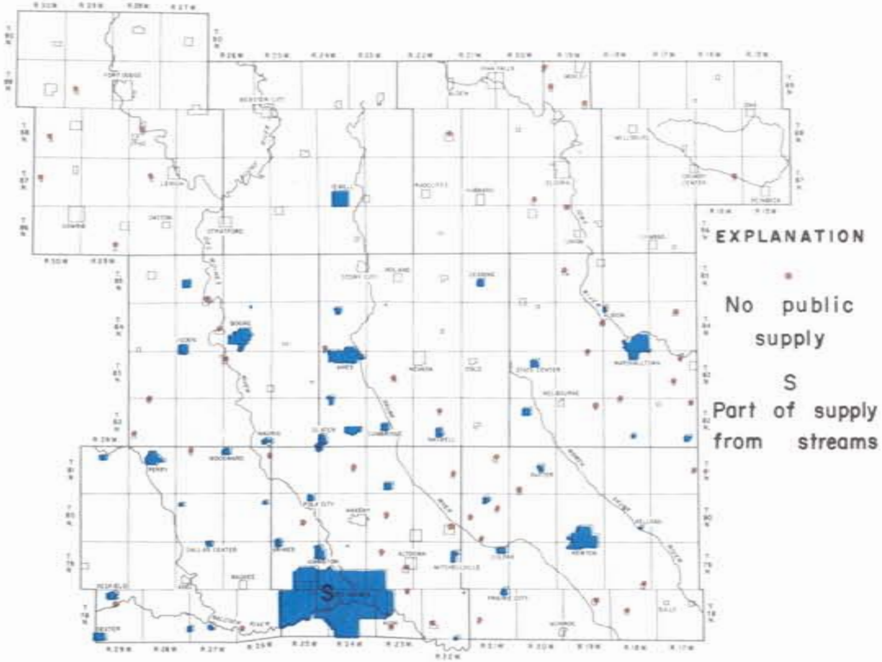


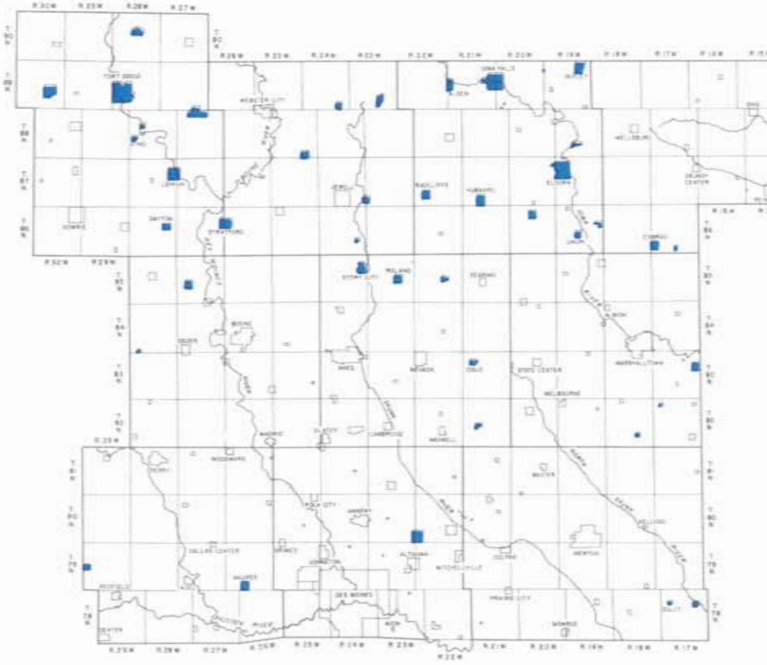
A buckle in the bedrock aquifers near Ames.

The aquifers that supply water for cities and communities

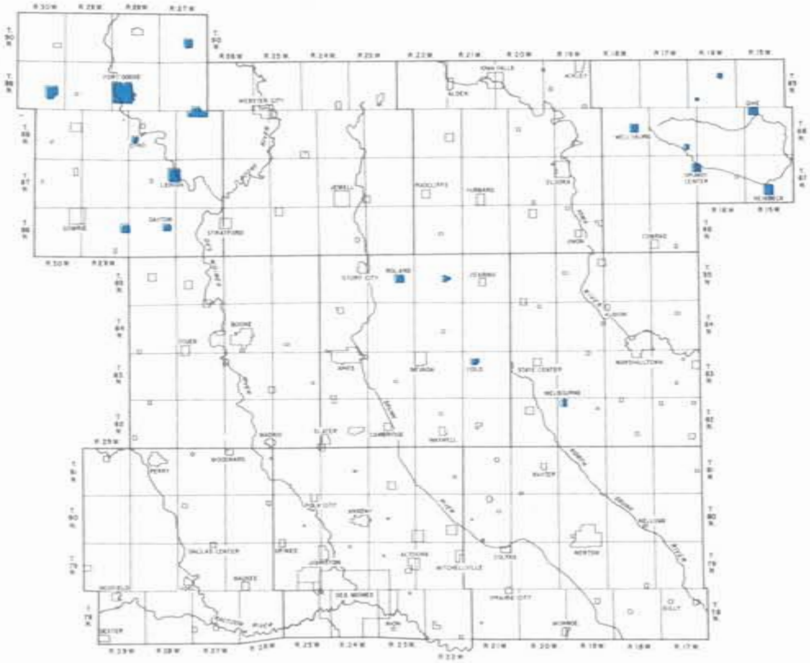
Various reasons determine why a city or community will choose one aquifer over the other as a source of water for their municipal supply. In general, however, the aquifer selected will be one that will provide the largest quantity of good water at the lowest cost.

The surficial aquifers are the source of water for municipal supplies in nearly 100 cities and communities in central Iowa. Also, they are the source of water for individual supplies in many of the small communities that have no municipal supply.



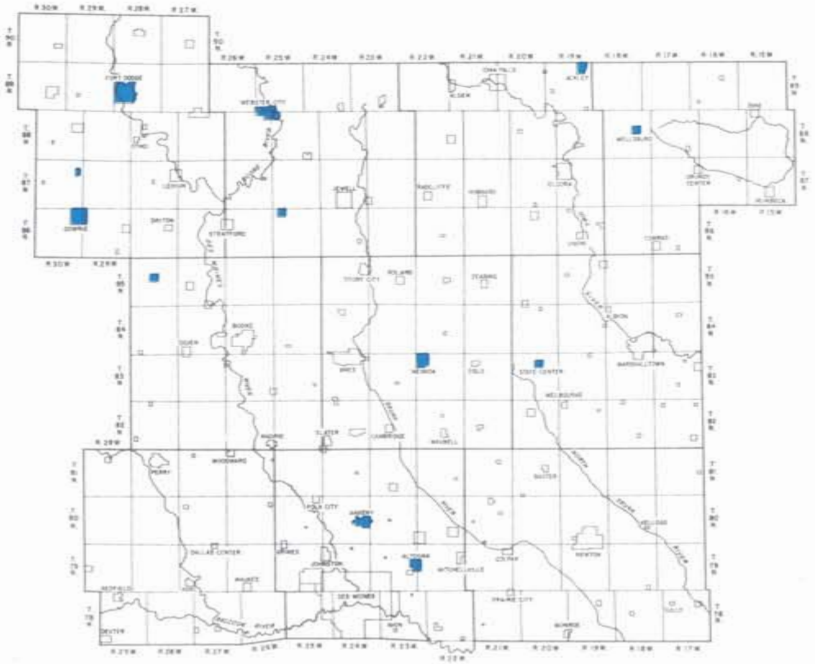


More than 40 cities and communities take all or most of their water from the upper bedrock aquifer.

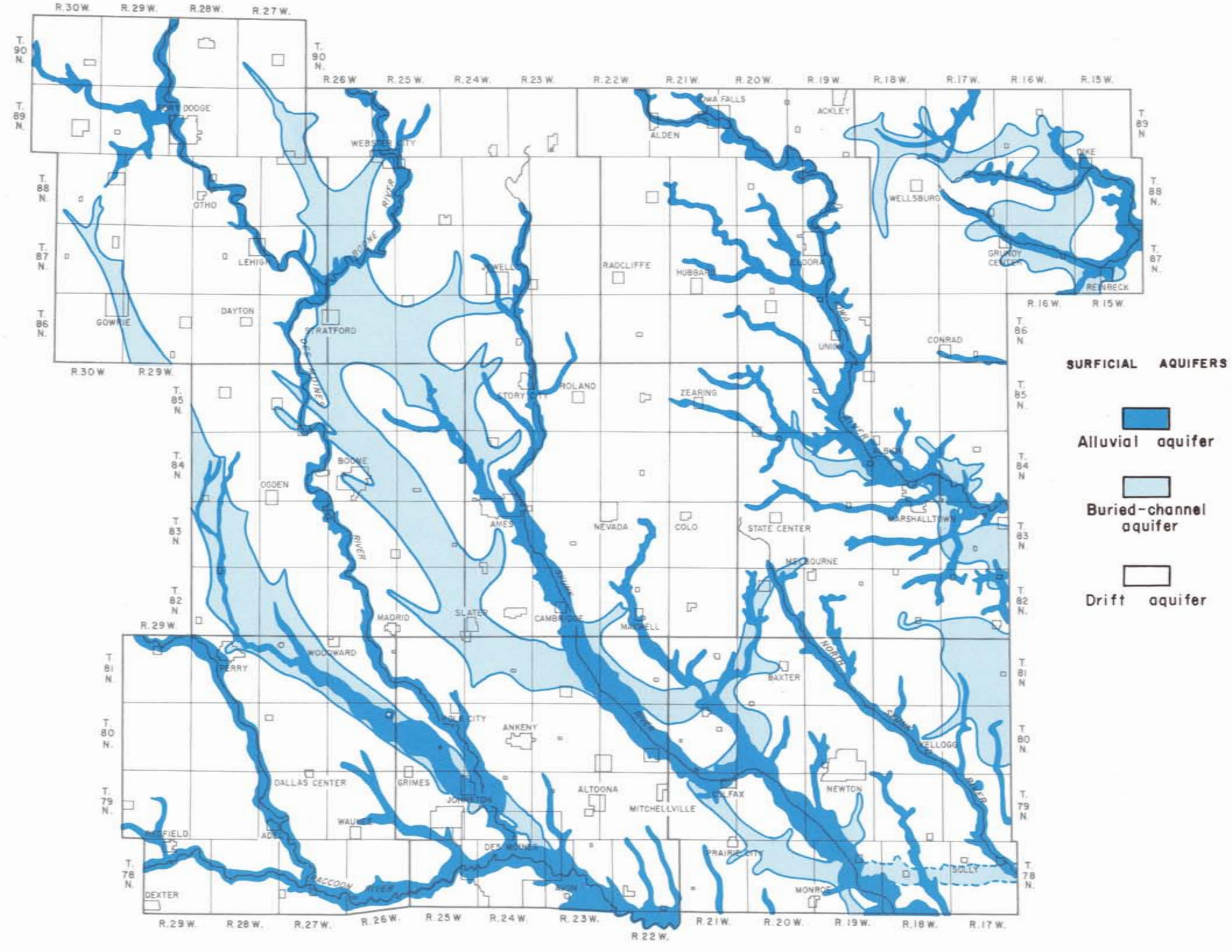


About 20 cities and communities obtain water from the middle bedrock aquifer.

Only 12 cities and communities take water from the lower bedrock aquifer.



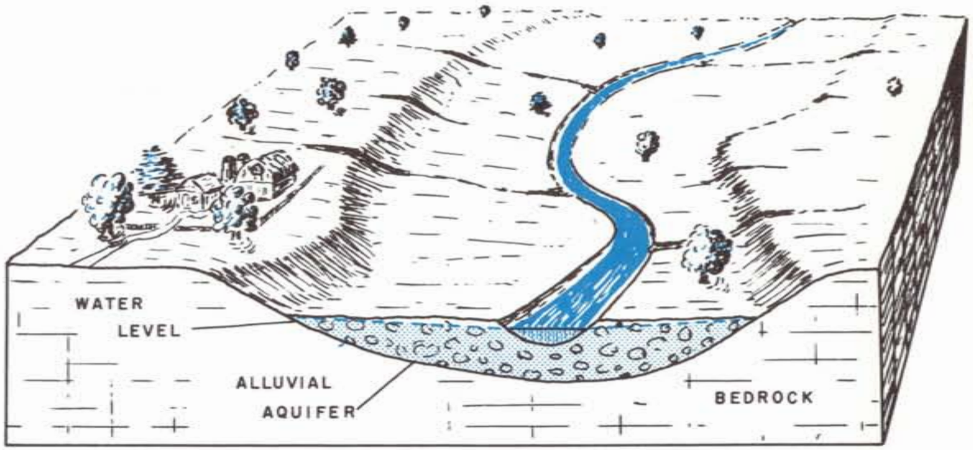
Clare, Fernald, Monroe, and Owasa obtain water from sources other than those shown here. Water for these communities is obtained from permeable zones of limited thickness and extent in the undifferentiated bedrock that overlies the bedrock aquifers.


SURFICIAL AQUIFERS
Alluvial aquifer
Buried-channel aquifer
Drift aquifer
R.30W.
R.29W.
R.28W.
R.27W.
R.26W
R.25W.
R.24W.
R.23W.
R.22W.
R.21W.
R.20W.
R.19W.
R.18W.
R.17W.
R.16W.
R.15W.
T. 90 N.
T. 89 N.
T. 88 N.
T. 87 N.
T. 86 N.
T. 85 N.
T. 84 N.
T. 83 N.
T. 82 N.
T. 81 N.
T. 80 N.
T. 79 N.
T. 78 N.
FORT DODGE
OTHO
LEHIGH
DAYTON
GOWRIE
WEBSTER CITY
BOONE RIVER
STRATFORD
DES MOINES RIVER
BOONE
OGDEN
JEWELL
STORY CITY
ROLAND
AMES
NEVADA
COLO
SLATER
CAMBRIDGE
MAXWELL
MADRID
WOODWARD
PERRY
POLK CITY
ANKENY
GRIMES
JOHNSTON
DALLAS CENTER
WAUKEE
ADEL
REDFIELD
DEXTER
RACCOON RIVER
DES MOINES
ALTOONA
MITCHELLVILLE
RADCLIFFE
HUBBARD
IOWA FALLS
ALDEN
ACKLEY
ELDORA
IOWA RIVER
UNION
ZEARING
STATE CENTER
MARSHALLTOWN
MELBOURNE
BAXTER
SKUNK RIVER
COLFAX
PRAIRIE CITY
MONROE
NEWTON
KELLOGG
NORTH SKUNK RIVER
SULLY
WELLSBURG
DIKE
GRUNDY CENTER
REINBECK
CONRAD

Surficial aquifers—how they occur

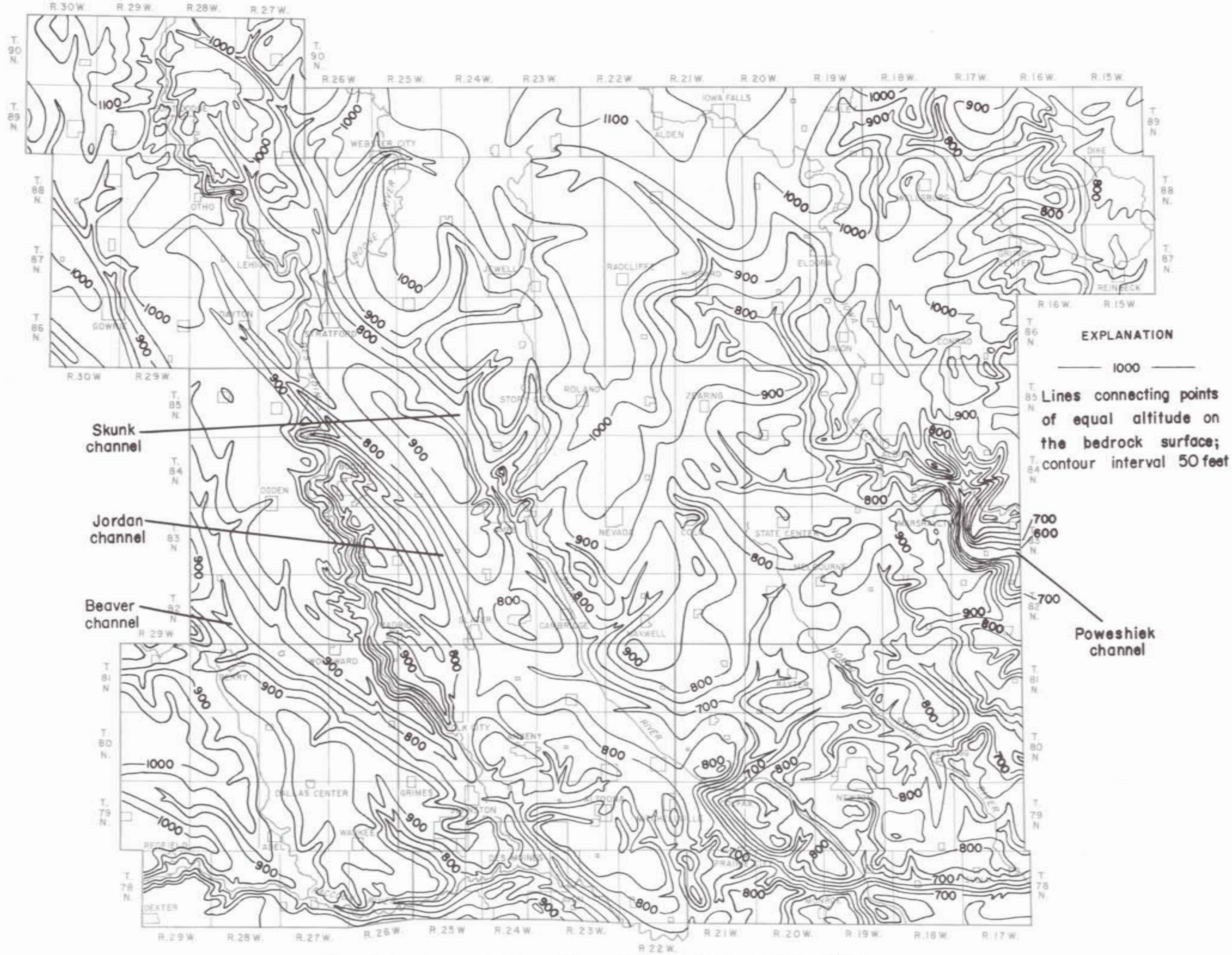
The surficial aquifers are not uniform or continuous in occurrence. They are completely missing in some areas, are isolated patches in others, and are thick and widespread in still others. Because of these variations, the surficial aquifers are discussed as three separate sub-units. Where these aquifers are along streams and are materials deposited primarily by streams, they are referred to as alluvial aquifers. In ancient buried channels, carved by preglacial or interglacial streams, they are referred to as buried channel aquifers. Where they occur in the upland areas and are materials deposited primarily by glaciers they are referred to as drift aquifers.

The alluvial aquifer, although not widespread, is a prime source of water. This aquifer lies in valleys sculptured by streams; its general areal extent is identified by the stream's floodplain and terraces. Its sands and gravels will usually yield large quantities of good quality water which is readily recharged by water from precipitation and runoff.



The buried channel aquifer is confined to older channels scoured in bedrock; channels which may or may not coincide with the present stream system. These channels are deeper than those carved by more recent streams; correspondingly, the aquifer is usually thicker. The buried channel aquifer generally is a good water producer. In some localities, however, the water may not be potable.

The drift aquifer occurs in the higher land areas between streams and is the most widespread of the surficial aquifers. The drift is composed of water-bearing and non-water-bearing rocks that are randomly distributed throughout central Iowa. The water-bearing rocks, principally sand and gravel, often are not extensive; therefore, the capacity of the drift aquifer to store and transmit water is limited. However, the value of the aquifer lies in the fact that it provides water from shallow depths in interstream areas where water from other sources may not be easily accessible. Thus, the drift aquifer is important as a source of small water supplies for rural-domestic and livestock use.



The bedrock surface; its altitude and configuration

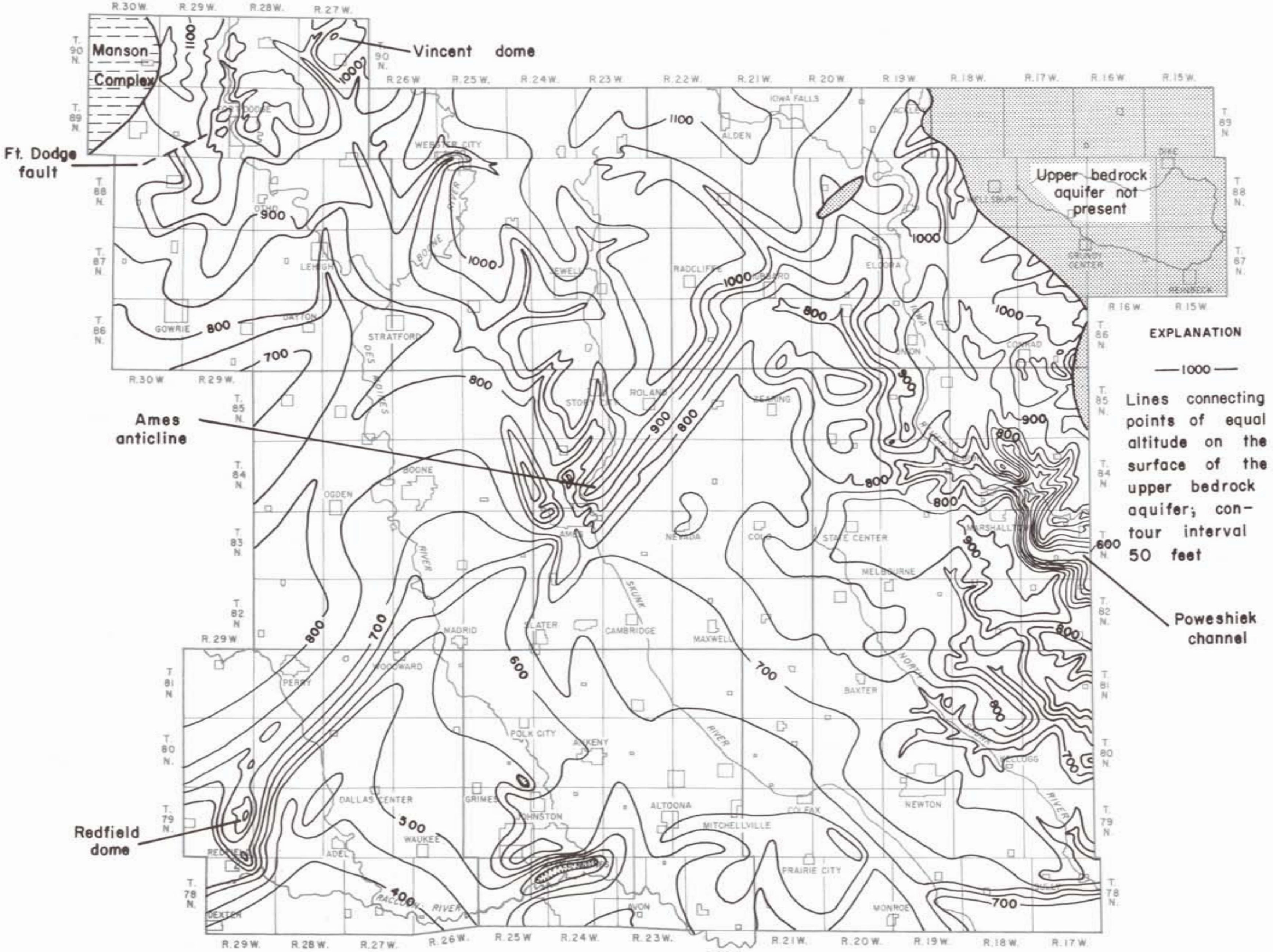
The bedrock surface reveals the location of the better water-bearing rocks in the surficial aquifers

The altitude and configuration of the bedrock surface in central Iowa is shown by the map on the opposite page. In effect, this map shows the bedrock surface as it would appear if the surficial aquifers were removed.

The map of the bedrock surface also shows the location of channels carved in bedrock. Some channels presently are associated with streams and, as such, provide storage for large quantities of water. Others, however, such as the Beaver, Jordan, Poweshiek, and Skunk channels, appear to be associated with none of the present-day streams; rather, they are ancient channels carved by ancient streams. Where these channels are filled with unconsolidated rocks and contain sand and gravel, they may provide large storage reservoirs for ground water.

In general, the surficial aquifers, especially those in channels, yield moderate to large quantities of water. However, there are many local variations in the thickness, areal extent, or type of water-bearing materials comprising the aquifers. Therefore, it is wise to conduct a test-drilling program in order to define the water-producing zones.

The bedrock map in conjunction with the topographic map can be used to determine the approximate thickness of the surficial aquifers. If, for example, someone in the area along the Iowa River just northeast of Marshalltown is interested in locating a water supply and wants to know the depth to bedrock, he will first determine the altitude of bedrock. Using the bedrock map he finds that the altitude of bedrock is more than 600 feet, probably about 625 feet. Referring then to the topogrpahic map (p. 5), he finds that the altitude of the land surface is less than 900 feet, probably about 880 feet. On the basis of the data from these two maps he would conclude that bedrock was at a depth of about 255 feet. The depth to bedrock in other areas can be determined by following the same procedures. For persons interested in the thickness of the unconsolidated rock comprising the surficial aquifers, the thickness figure would be the same as the figure obtained for depth to bedrock.



The upper bedrock aquifer, its altitude and surface configuration

The bedrock aquifers—their altitude and configuration.

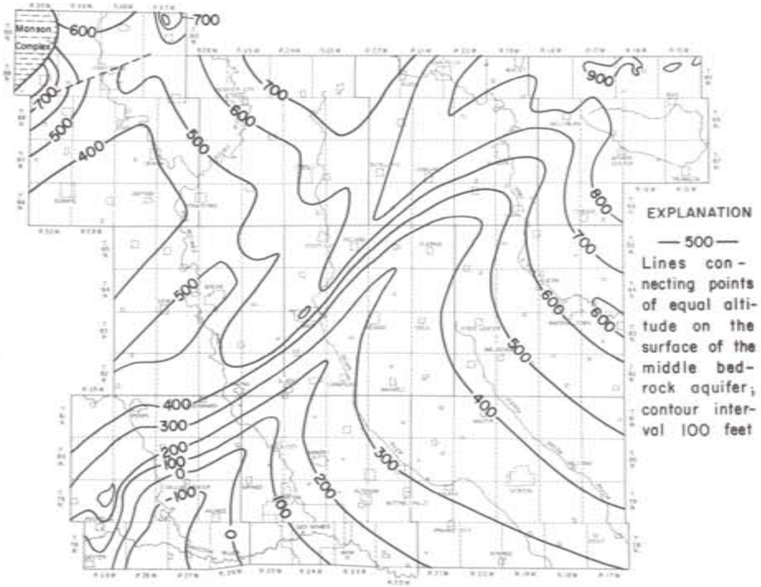
The upper surfaces of the bedrock aquifers have different altitudes throughout central Iowa. The surface of any one aquifer generally is highest in the north and northeast part of the area and lowest in the southwest. This difference in altitude, which may be as great as 1,200 feet, is attributed to the regional dip of the rock layers to the south and southwest.

As shown by the map on the opposite page, there are many irregularities on the surface of the bedrock aquifers. These irregularities occur for two major reasons:

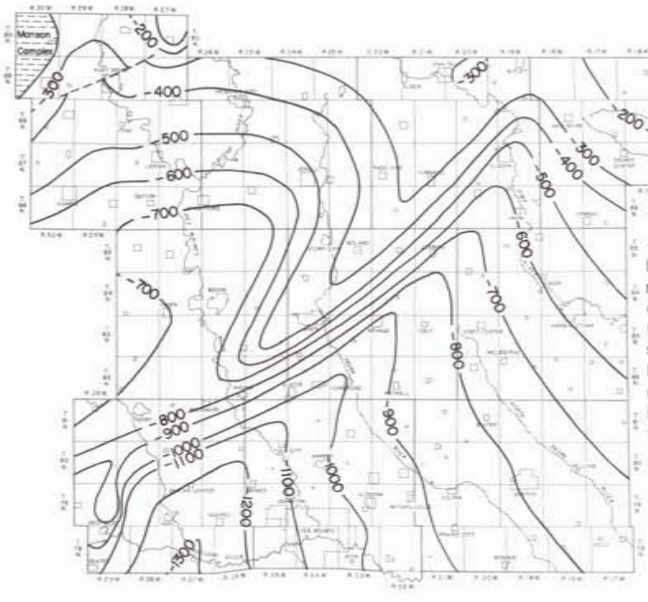
Some were formed by erosion of the bedrock subsequent to deposition of younger rocks. The effect of this is especially noticeable on the upper bedrock aquifer in the east and northeast part of the area where most of the features shown are erosional.

The major irregularities were formed by structural deformation of the rock layers. The most prominent feature is the buckle, or Ames anticline, which trends in a northeast-southwest direction through the central part of the area. Associated with this structure are the sags which lie to the northwest and southeast. Smaller features are the Fort Dodge fault across which some rock units have been displaced 100 feet or more, and the Redfield and Vincent domes which have been or are being developed into natural gas storage sites.

The Manson complex, part of which is shown on many maps in this report, has been referred to as a cryptovolcanic structure (Hale, 1955; Hoppin and Dryden, 1958). The portion of this structure in Webster County is a depression filled with as much as 1,200 feet of generally non-water-producing rocks of Cretaceous age. The bedrock aquifers in the peripheral zone of the cryptovolcanic structure have been greatly disturbed and in part of the structure may be missing entirely. Because of this and because detailed information about this apparently complex structure is lacking, the Manson complex is not discussed further in this report.



Some wells must extend below sea level before they reach the middle bedrock aquifer.

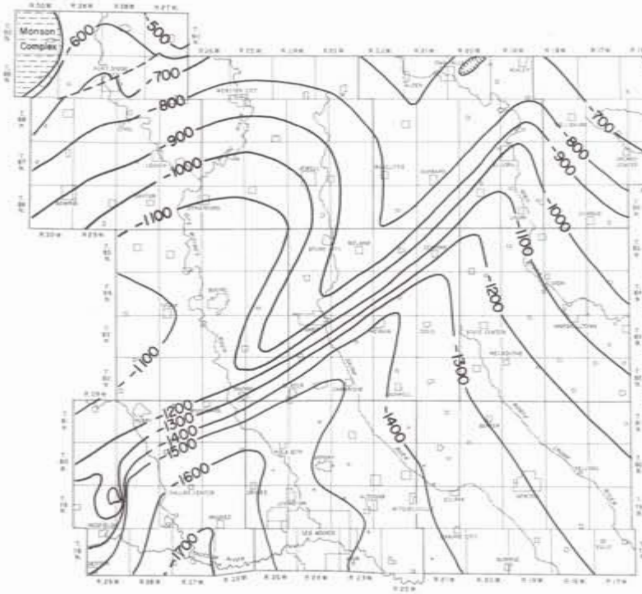


EXPLANATION

— - 1000 —
Lines connecting points of equal altitude on the surface of the lower bedrock aquifer; contour interval 100 feet

The lower bedrock aquifer lies from 100 to 1,300 feet below sea level.

The Jordan Sandstone, principal water-bearing unit in the lower bedrock aquifer, is 500 to 1,700 feet below sea level.

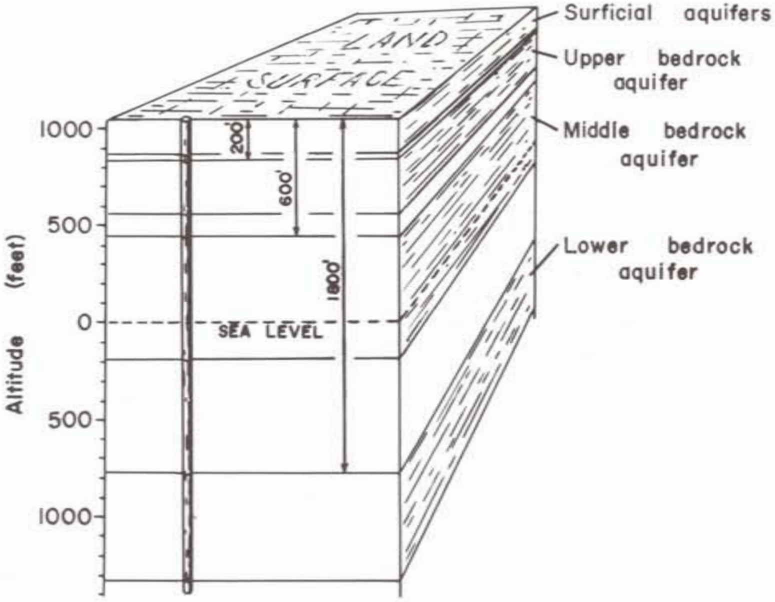


EXPLANATION

— - 1000 —
Lines connecting points of equal elevation on the surface of Jordan Sandstone; contour interval 100 feet

Altitude maps can be of great assistance for determining the depth to a ground-water supply. As an example let's assume that a water supply is needed in State Center. This report shows that there are three possible bedrock sources—the upper, middle, and lower bedrock aquifers. In order to determine the depth to the different aquifers, the first thing needed is the land surface altitude. By checking the topographic map (p. 5), the land surface altitude is found to be about 1,050 feet. The altitude maps shown here indicate that the altitudes for the tops of the aquifers are 850 feet for the upper, 450 feet for the middle, and —750 for the lower; thus, the depths to the aquifers are 200 feet, 600 feet, and 1,800 feet respectively. Because a well must penetrate a part of the aquifer before a water supply can be developed, the depth of the well necessarily will be greater than the depth to the aquifer.

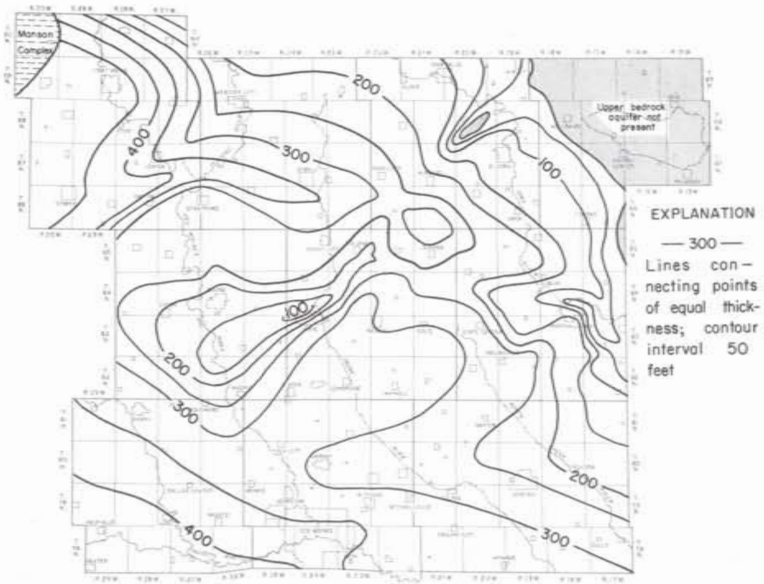
Obviously, depth is not the only factor that needs consideration when selecting an aquifer for a water supply. The final selection will depend on several other factors; these are discussed in the following pages.



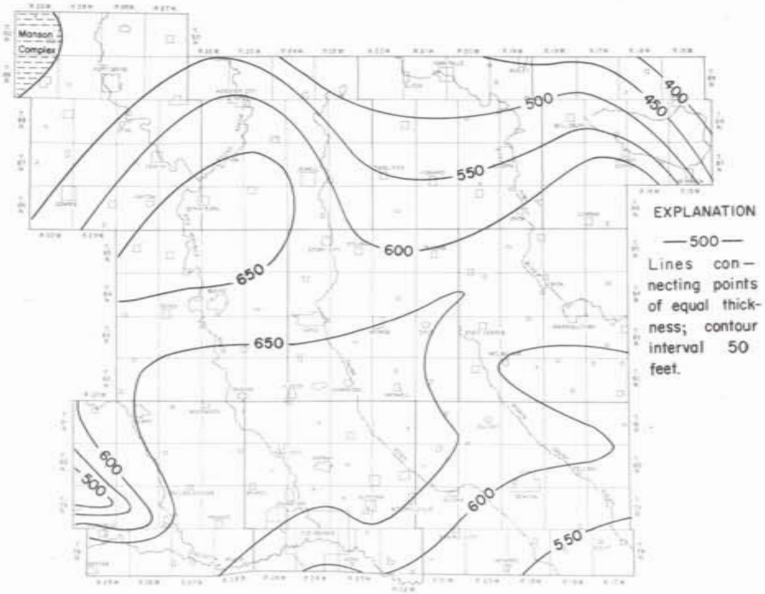
Thickness of the bedrock aquifers

An aquifer seldom has a uniform thickness over a large area. Variation rather than uniformity is the standard rule. In general, variation in thickness results because of three factors. First, the sediments were distributed unevenly; therefore, the thickness of the rock layers varies from place to place. Second, the surface upon which the rocks were deposited was not necessarily flat; irregularities were commonplace. And finally, post-depositional erosion often removed more rocks from some areas than others.

The thickness of the upper bedrock aquifer ranges from a knife-edge to more than 450 feet. The aquifer is thickest in the northwest and southwest parts of central Iowa but thins to the northeast. It is relatively thin in the vicinity of Ames and is completely absent in the northeast part of the area. Much of this variation in thickness is a result of post-depositional erosion.

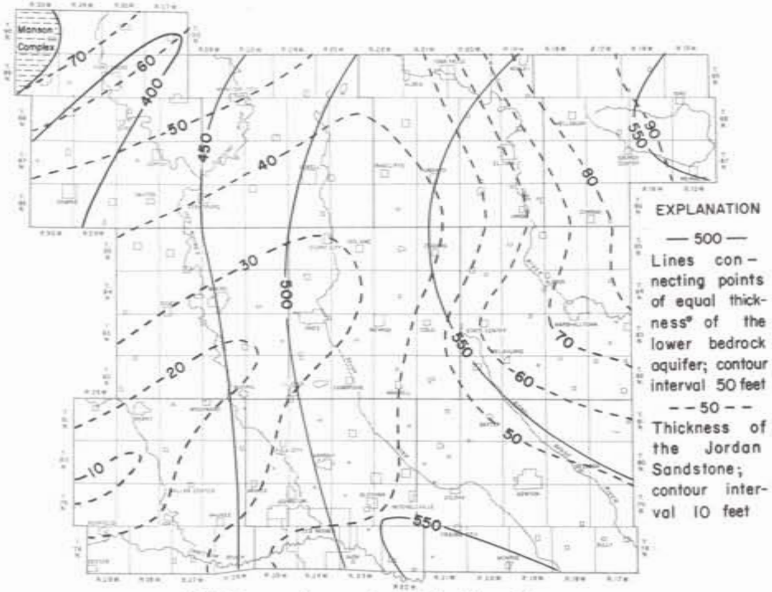


The middle bedrock aquifer is 400 to 700 feet thick. It is thickest in the vicinity of Stratford and in an area just north of Des Moines but thins to the northeast and southwest. Some of the thinning of the aquifer is a result of erosion; erosion definitely has reduced the aquifer's thickness in the northeast part of the area.



The thickness of the lower bedrock aquifer ranges from just less than 400 feet to slightly more than 550 feet: this variation in thickness probably is the result of a combination of all three of the factors previously discussed. In a unit this thick, a difference of 150 feet appears unimportant. However, part of the variation in thickness is attributable to a drastic reduction in the thickness of the Jordan Sandstone. This sandstone is about 90 feet thick in the northeast part of the area but thins to less than 10 feet in the southwest. Because the Jordan Sandstone is the principal water-bearing unit in the lower bedrock aquifer, the thickness of this unit controls the quantity of water that the entire aquifer will yield. The greater the thickness of the Jordan, the greater is the ability of the lower bedrock aquifer to store and yield water.

Wells will yield the largest quantity of water possible when the total thickness of the aquifer is fully penetrated. Therefore, the maps showing the thickness of the aquifers when used in conjunction with the maps showing their altitudes will give the total depth to which a well should be drilled to give the largest yield.



*Thickness does not include the St. Lawrence Dolomite, as wells seldom fully penetrate this formation.

WATER IN THE AQUIFERS

HOW IT OCCURS and HOW IT MOVES

Water in the aquifers is called ground water. This water saturates all open spaces, such as solution channels, fissures, or voids between fragments in the rocks. All rocks that have open spaces are capable of storing water but not all yield water to wells. It is the number and size of these spaces that determine the water-bearing characteristics of rocks and whether or not the rocks can be aquifers. Only those rocks that have many, large, interconnected open spaces, such as those in sand and gravel, in sandstone, and in some limestones and dolomites, will yield great quantities of water—these rocks are aquifers. Some rocks such as clay, shale, and other fine-grained rocks have many open spaces and can store large quantities of water but, because the spaces are extremely small, the rocks do not readily transmit or yield water—these rocks are aquicludes.

Although aquifers are of primary concern in our water story, the aquicludes also play an important role. It is these rocks that confine the water within the aquifers and prevent or retard interaquifer movement. This is especially important in areas where some aquifers contain good water and others poor. Where no aquicludes lie between aquifers, such as in the northeast part of the area where the surficial aquifers rest directly on the upper and middle bedrock aquifers, the water in the aquifers is free to intermingle.

Aquifers that are not overlain by aquicludes, such as the surficial aquifers and parts of the upper and middle bedrock aquifers, contain water that is unconfined; that is, the water is free to move up or down. Water in a well tapping an unconfined aquifer will not rise above the level at which it was first encountered. Under this condition the aquifer is referred to as a water-table aquifer and the upper surface of the water is called the water table.

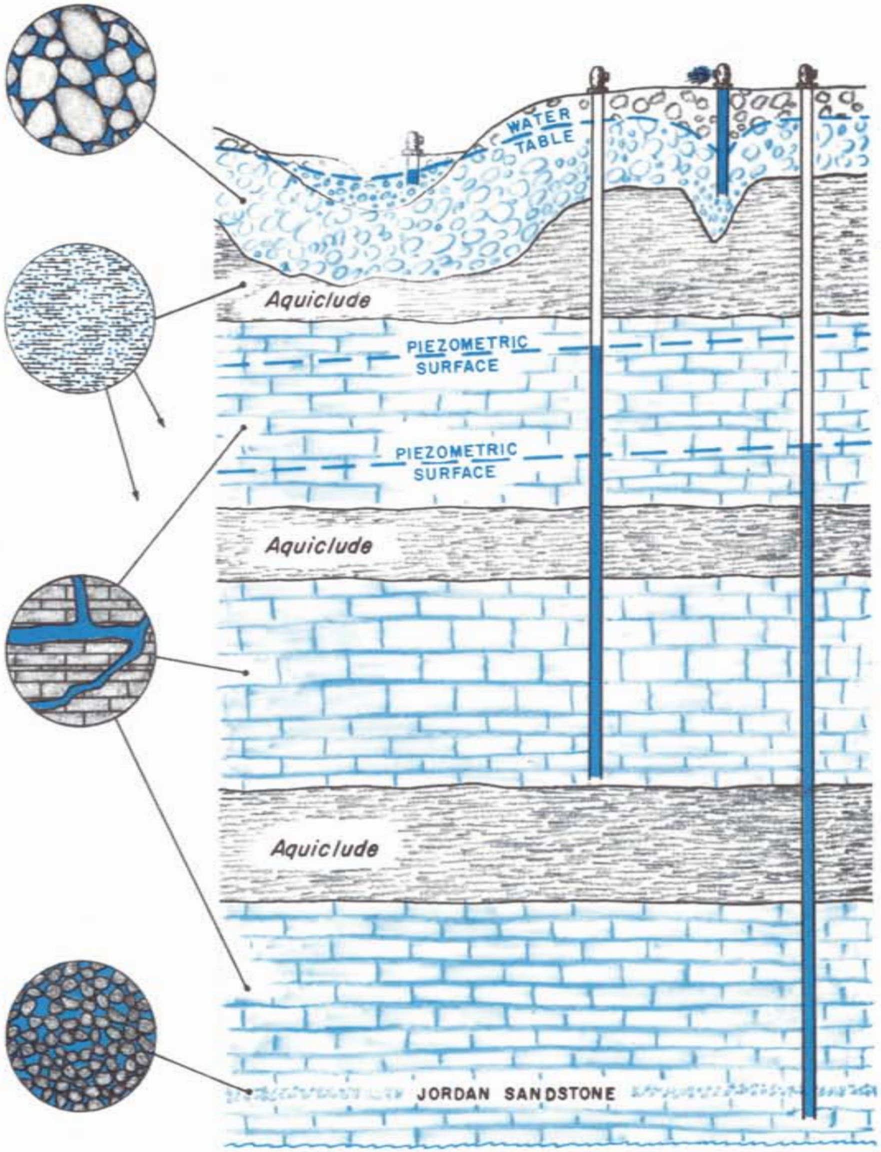
In the bedrock aquifers, where they are overlain and underlain by aquicludes, water can be confined under pressure. If under sufficient pressure, the water will rise above the top of the aquifer when tapped by a well; it may rise only several feet or it may rise from great depths to land surface. Under this condition, the aquifer is called an artesian aquifer and the water is referred to as artesian water. The level to which water from any one artesian aquifer will rise in a well represents a point on an imaginary surface referred to as a piezometric surface. Each artesian aquifer in central Iowa has its own piezometric surface.

Water is easily stored and flows freely in the open spaces between grains of sand or gravel.

Water is stored in large quantities in aquicludes but, because the open spaces in the rocks are extremely small it is not transmitted readily.

Solution channels and fissures in limestone are conduits in which ground water can move and be stored.

Water is stored and readily transmitted in the open spaces in sandstone.



General
water-bearing
characteristics

SURFICIAL AQUIFERS
Gravels and sands in this zone produce moderate-to-large quantities of good quality water

In general, this zone does not yield water or yields small quantities of poor quality water. Locally, some sandstones yield small quantities of good water

UPPER BEDROCK AQUIFER
Yields small-to-moderate quantities of water; the Gilmore City and Hampton Formations (p. 38) generally are the better producers

For the most part, this unit produces little water although locally, some beds produce small-to-moderate quantities

MIDDLE BEDROCK AQUIFER
Yields moderate quantities of fair-to-good quality water in the northern part of the area; elsewhere the water is highly mineralized

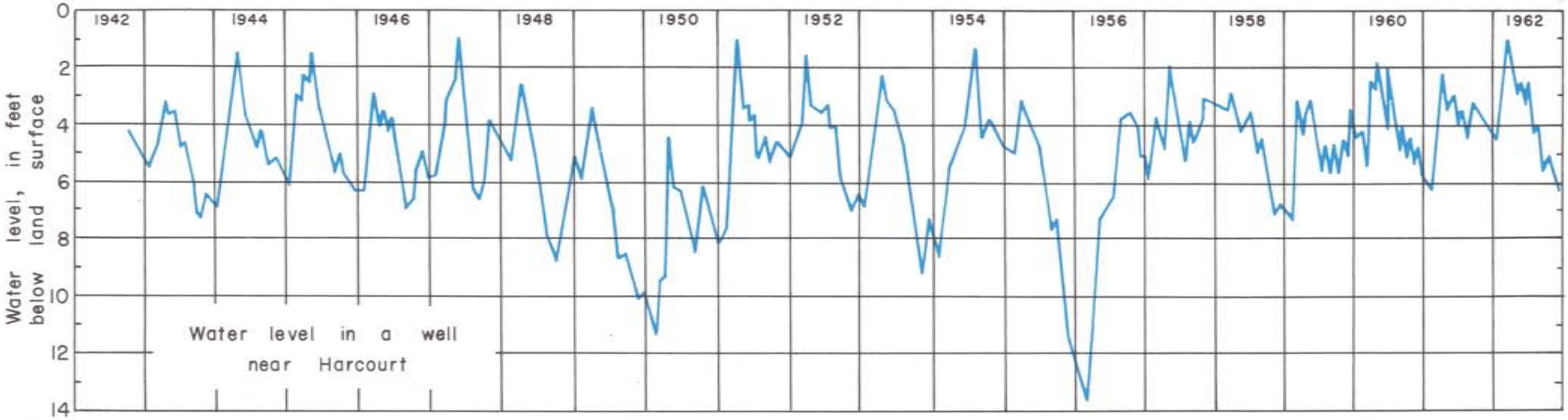
In general, this zone is not considered a good water-producing zone and is usually bypassed in favor of water from the lower bedrock aquifer

LOWER BEDROCK AQUIFER
Yields moderate-to-large quantities of relatively good quality water. Water is increasingly mineralized to the southwest.

Water levels

The water level in a water-table or artesian well represents a point on the water table or on the piezometric surface of an aquifer; therefore, the fluctuations of the water level in the well tell a story about the discharge-recharge relationship in the aquifer. Because discharge is a continual process, the water level can rise only when recharge exceeds discharge; at all other times, the water level drops. Hence, the fluctuations of water levels in wells reflect fluctuations in precipitation or, stated another way, changing weather conditions.

The effects of weather are directly correlative with water levels in aquifers that are under water-table conditions. The recharge area for these aquifers is usually local and any change within the immediate area, such as a change in precipitation or temperature, is reflected by a change in the water level. In aquifers that are under artesian conditions, however, the effect of weather on water levels cannot be detected with short-term water-level records. The area of recharge for artesian aquifers is usually tens of hundreds of miles away and the effects on the piezometric surface of any variations in weather, such as an increase or decrease in recharge during exceptionally wet or dry seasons, will be smoothed out during the long time it takes the water to travel through the aquifer from the recharge area.



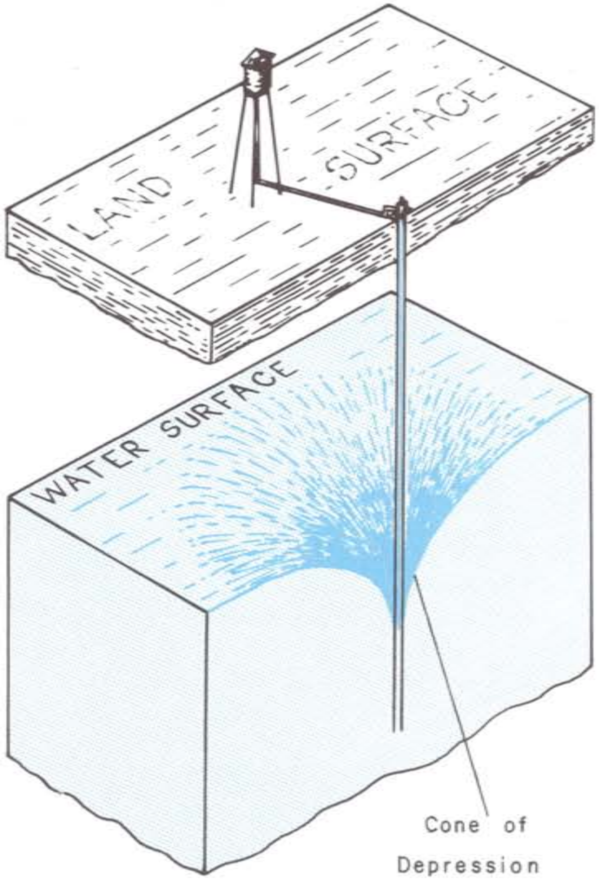
Changes in weather are reflected by the water levels in a water-table well near Harcourt. Over a 20-year period the average conditions of weather have not changed noticeably in central Iowa (p. 22); neither has the general trend of the water levels. However, weather conditions have changed from season to season and so have water levels. For instance in the early spring, when precipitation increases, large quantities of water generally are available for recharge and the water table rises. In the summer, when evapotranspiration is great and less of the water from precipitation is avaliable for recharge, the water levels begin to decline. Except for a small upward surge in the fall this decline continues into the winter.

During periods of drought, when little water is available to replenish the aquifers, the decline in the water table will be greater than normal. Such a decline occurred in the well at Harcourt during the latter part of 1955, and early part of 1956. Conversely, during periods of above-normal precipitation, water levels remain high as shown by the records for 1951.

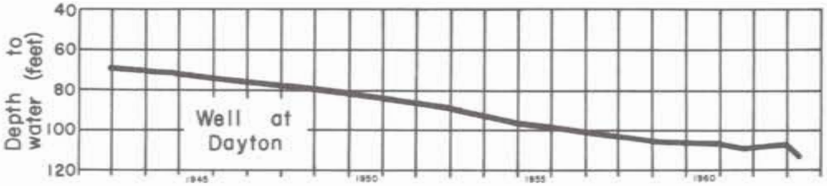
Some shallow wells in the water-table aquifers of central Iowa "go dry" during extended periods of drought because the water table is lowered. Increased pumping during this time further aggravates the problem. This recurring problem often can be alleviated by drilling deeper wells that fully penetrate the aquifer and by placing the pump intake well below the water table.

In addition to fluctuations produced by weather, water levels also fluctuate when artificial discharge through pumping wells is imposed on the system. When water is removed by a pumping well from an aquifer that is under water-table conditions, the water table at and near the well is lowered quickly. This causes a conical depression, referred to as a cone of depression, in the water table around the pumped well. In aquifers that are under artesian conditions, the withdrawal of water has a similar effect in that it produces a cone in the piezometric surface, although in reality, this cone represents a decrease in the hydrostatic pressure around the well.

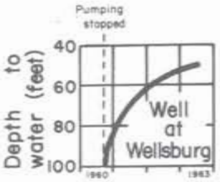
The size and shape of a cone of depression depends on the characteristics of the aquifer and the rate of pumping from the well. The higher the rate of pumping, the wider and deeper the cone. Generally speaking, under the same pumping rate, the cone of depression in an artesian aquifer is larger than one in a water-table aquifer. The diameter of the cone in an artesian aquifer generally is measured in thousands of feet; whereas the diameter of the cone in a water-table aquifer is measured in hundreds of feet. When one or more additional wells are within the area of influence of a pumping well, a natural interference occurs and water levels decline in all the wells. For this reason, wells pumping from the same aquifer should be spaced some distance apart.



Long-term records of water levels in a pumping artesian well indicate a constant lowering of the piezometric surface in the vicinity of the well. If the pumping regimen remains constant, the water level will eventually tend to level off, as shown in the Dayton well. Any increase in pumping from the aquifer, however, will cause a sharp downward trend.

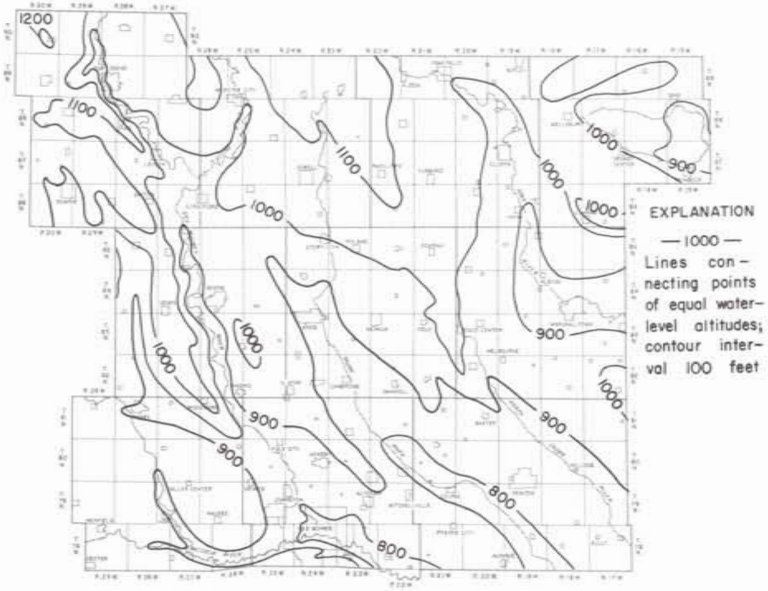


If pumping is reduced, the water levels will rise until the cone of depression adjusts to the lower pumping rate. If pumping ceases entirely, the cone of depression will eventually cease to exist and water levels will be sensibly back to what they were before pumping began.

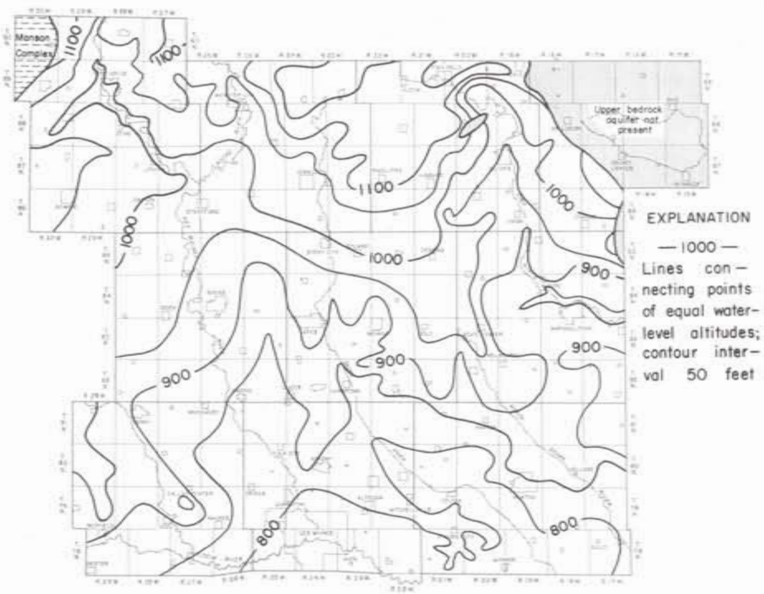


The same phenomenon, on a much lesser magnitude, is observed in water-table wells. Unless the well is overpumped, the cone of depression in this aquifer reaches a sensible equilibrium with recharge to the aquifer much quicker than the cone of an artesian aquifer. Hence, water levels tend to level off fairly rapidly.

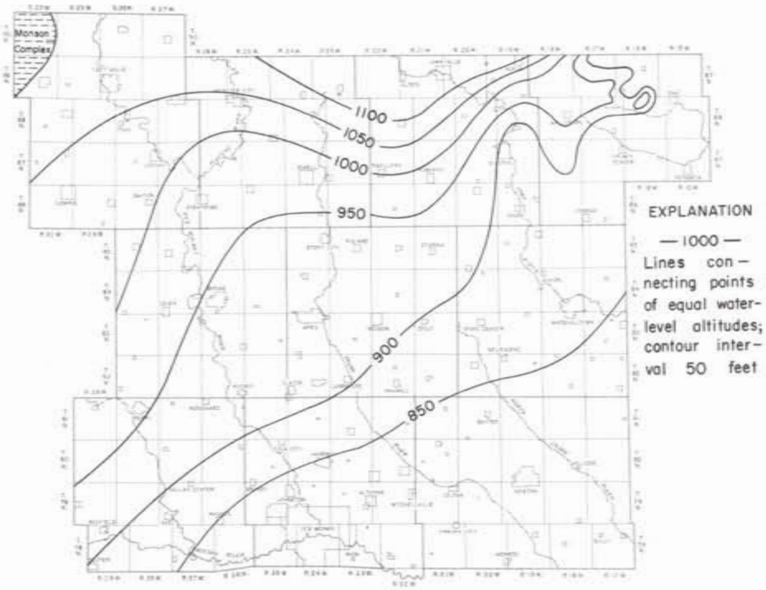
Owing to the inherent characteristics of water-table and artesian aquifers, each has its advantages and disadvantages. A water-table aquifer can usually yield a moderate-to-large supply of water by receiving local recharge and several wells can be placed in a relatively small area. An artesian well that is pumping moderate-to-large amounts of water generally will develop a large cone of depression. Thus, most wells will have to be widely spaced so that interference between their cones will not be too great. The water levels in water-table wells are not excessively deep; therefore, the cost of lifting the water will not be high. The water levels in artesian wells are often lower than in water-table wells, and because they usually continue to drop with sustained pumping, the cost of lifting the water will be relatively high. However, a water-table aquifer is readily affected by local changes in weather; whereas, an artesian aquifer is not.



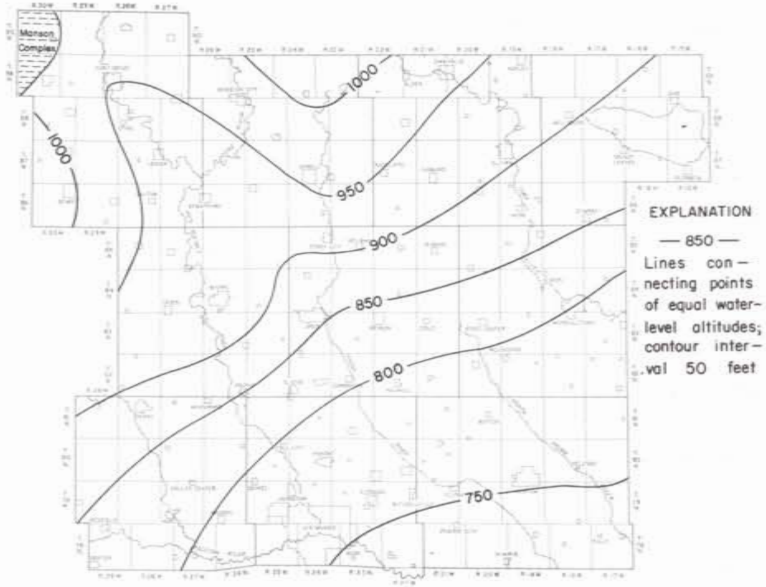
Water levels in the surficial aquifer reflect the configuration of the land surface.



The altitude of water levels in wells in the upper bedrock aquifer ranges from 800 to 1,150 feet.



Water from the middle bedrock aquifer rises in wells until it reaches altitudes above 850 feet.



Water levels in wells in the lower bedrock aquifer generally are above an altitude of 750 feet even though the aquifer itself is below sea level.

Where will the water level be?

This problem will be of concern during any planning phase for a new well. For it is the water level or depth to water in the finished well, along with the quantity of water needed and the water-producing capabilities of the aquifer, that will determine the depth at which the pump will be set. This, in turn, dictates the expenditures required to pump water from the well.

The altitude and configuration of the water table or the piezometric surface for each of the aquifers is shown in the accompanying maps. In effect, these maps give the altitudes of the static or non-pumping water levels for water from any given aquifer and can be used to determine what the depth to water will be in a finished non-pumping well. For example, at Roland, the land-surface altitude (see topographic map on page 5) is about 1,020 feet above sea level. The altitude of the water table in the surficial aquifer is just slightly more than 1,000 feet, or probably about 1,010 feet. By subtracting the water-table altitude from the land-surface altitude, we find that the depth to water in the surficial aquifer will be about 10 feet. Similarly, the altitude of the water levels in wells drilled into the upper, middle, and lower bedrock aquifers are 1,000, 935, and 900 feet respectively. By subtracting from land-surface datum, we find that the depths to water in these wells will be 20, 75, and 120 feet respectively. These figures represent the non-pumping water levels; the pumping levels, as explained in the previous section, will be somewhat lower.

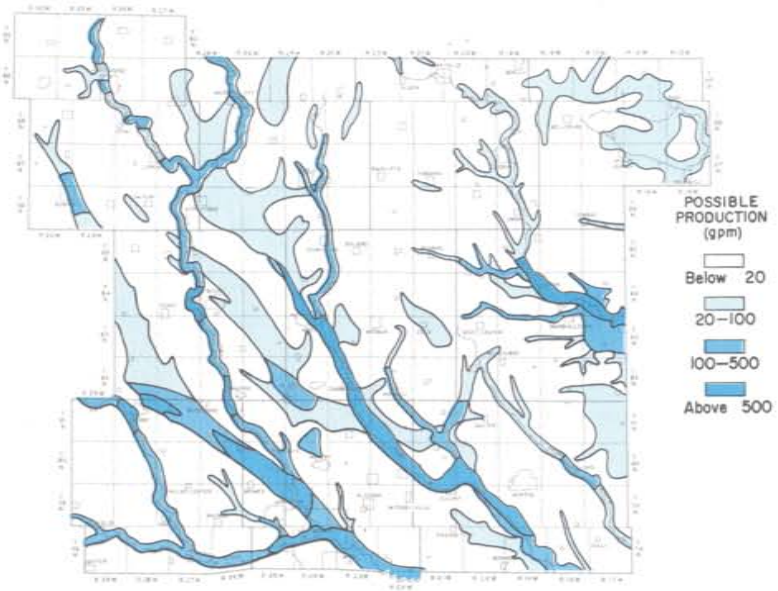
The configuration of the water-table and piezometric surfaces also tell an important story about ground-water movement in the area. Water in each aquifer moves from areas of high pressure (high contour values) to areas of low pressure (low contour values) and the direction of flow is perpendicular to the contour lines. Inspection of the maps indicates water in each aquifer is moving in a general southeasterly direction. More important, however, recharge and discharge of the middle and lower bedrock aquifers are outside the area because the contours show that water is moving into the area from the north and leaving the area in the south. This explains why local weather conditions do not effect water levels in these aquifers. Conversely, recharge and discharge in the surficial and most of the upper bedrock aquifer takes place within the area. Hence, local weather conditions strongly influence water levels in these aquifers.

Because water-table aquifers are readily affected by local recharge-discharge relationships, the maps showing the water levels for aquifers that are near land surface, especially the map showing water levels in the surficial aquifers, should be used with care when determining water levels. As shown in the section on page 56, the water levels in these aquifers fluctuate considerably from season to season; therefore, at any given time and place they may be higher or lower than those shown on the accompanying maps.

The artesian aquifers generally are unaffected by local recharge-discharge relationships; thus, the maps showing the water levels for these aquifers can be used with a greater degree of reliability. If, however, there are pumping wells in an aquifer within the area being considered, the water levels for that aquifer may be lower than shown.

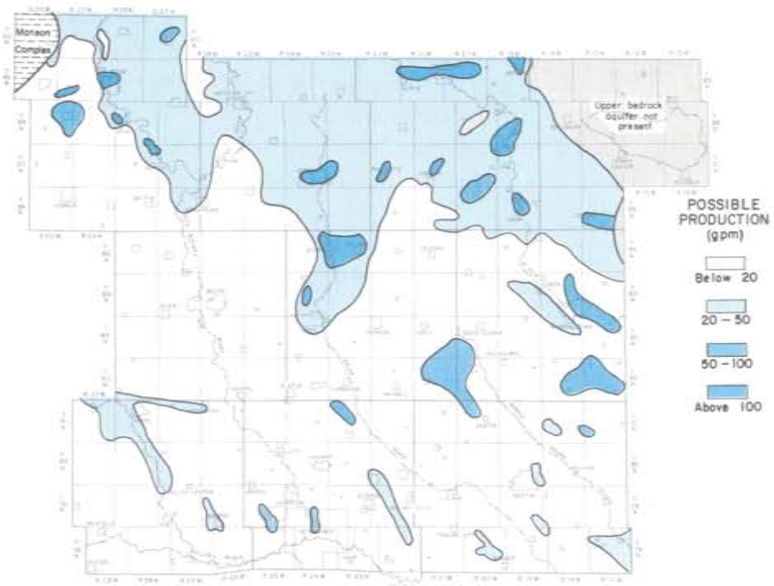
How much water can be pumped?

The amount of water that aquifers in central Iowa will yield to individual wells varies not only from aquifer to aquifer, but within each aquifer. The accompanying maps show the ranges within which ground-water production can be expected from individual wells. If larger supplies than those shown are desired, two or more wells can be used. Care must be taken in this practice, however, as a well field must be planned so that the interference between the cones of depression of the various wells will not be too great. Several wells that are too closely spaced will not produce much more water than one well.

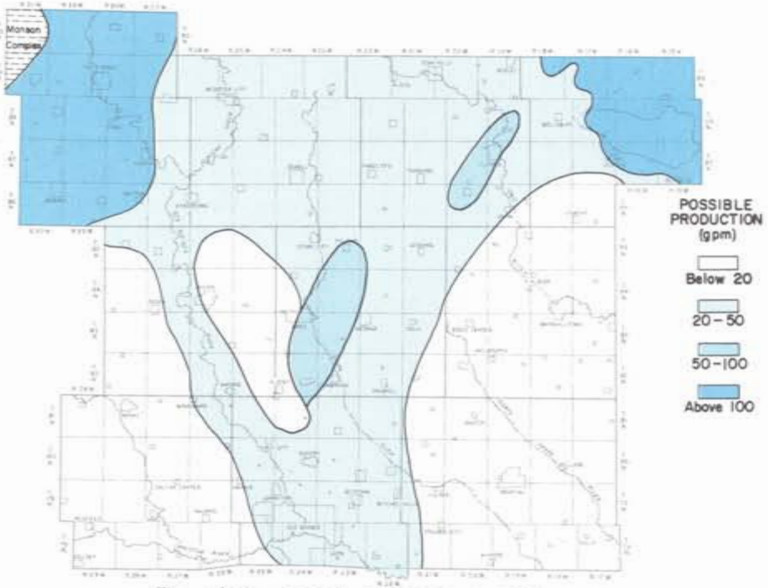


In the surficial aquifers, the sands and gravels in the alluvial aquifer are the best source of large supplies. The buried-channel aquifer usually will yield moderate-to-large amounts of water and the drift aquifer will usually yield only small amounts. There are some areas where no sand or gravel layers exist in the surficial aquifers and yields are negligible; data are generally insufficient to outline these areas. If large supplies are needed, test drilling is recommended.

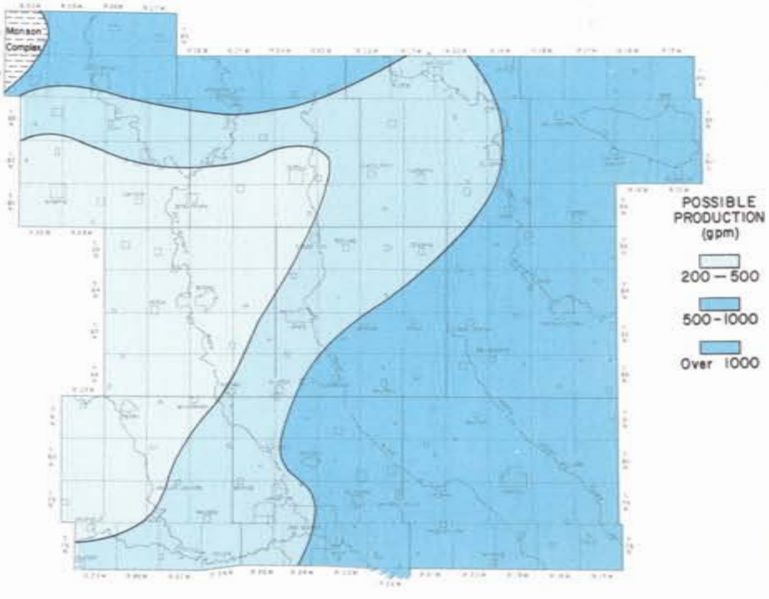
The upper and middle bedrock aquifers often yield large amounts of water where they lie near land surface. Since these aquifers are primarily composed of limestone and dolomite, their yields are related to fissures and solution channels, which, in general, are more numerous in rocks near land surface. Where the upper and middle bedrock aquifers are near land surface, they are readily recharged and here, also, the water usually is under water-table conditions. Elsewhere, the water in these aquifers is artesian.



The upper bedrock aquifer yields water in sufficient quantities to meet most domestic needs



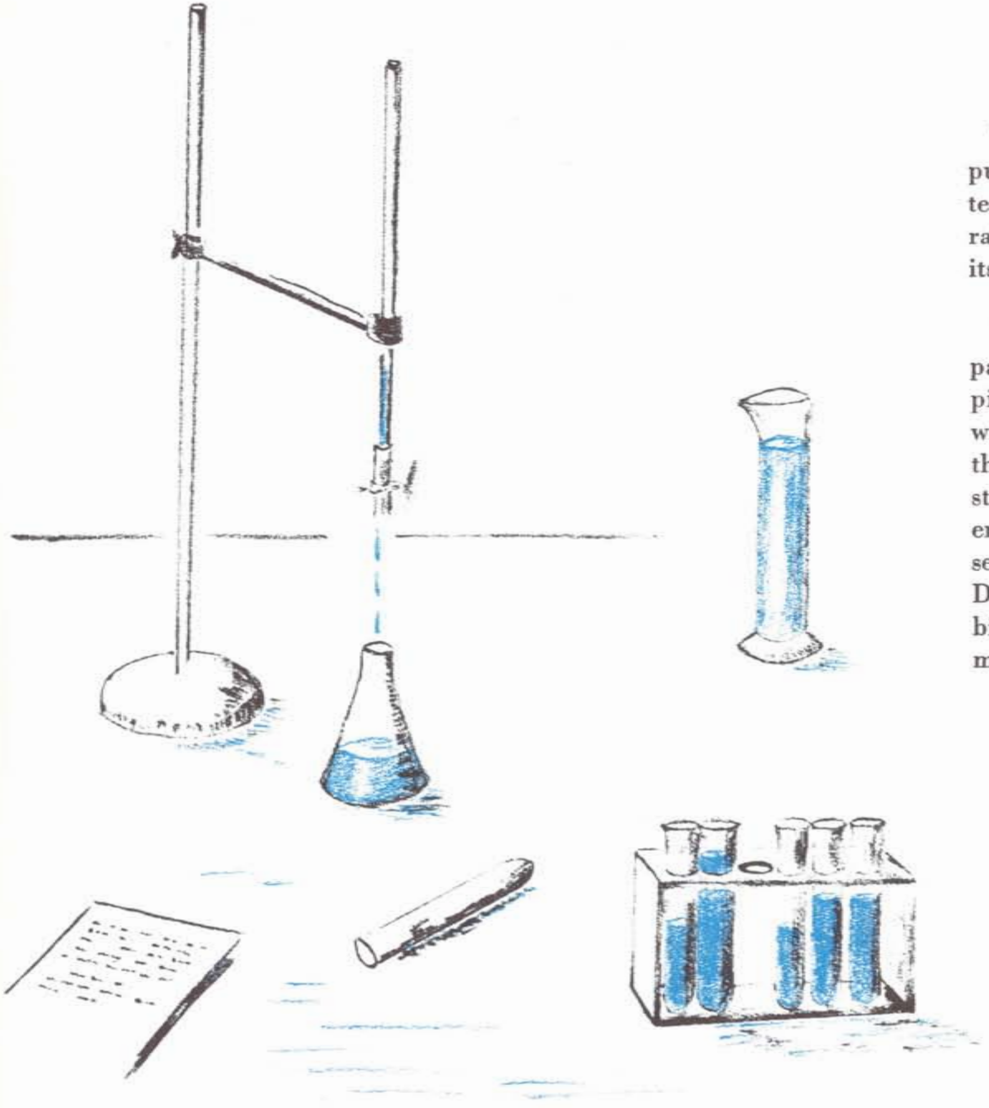
The middle bedrock aquifer is a good water producer in parts of central Iowa



Yields from the lower bedrock aquifer are influenced by the thickness of the Jordan Sandstone and the fractures and solution channels in the thick dolomite which overlies it. Yields from this aquifer are greatest in the northern and eastern parts of the area where the Jordan Sandstone is thickest.

These maps on production are an extrapolation of limited production data from wells in the various aquifers and a general knowledge of aquifer similarities. Interpretations were made by comparing areas where information was lacking with areas in which the aquifers are similar in rock type, thickness, and proximity to recharge. If these features of the aquifers are similar, then similar production is inferred. In addition, a few other assumptions were made. If wells within an area produce large amounts of water, then it is assumed that large amounts can be obtained from other wells in that area. Where wells are equipped with small pumps, as in many cases only small amounts of water are needed, and the water levels are not lowered greatly by pumping, then it is assumed that a larger supply is available.

WATER–HOW GOOD IS IT?



The chemical quality of water that is to be used for any particular purpose is as important as the availability of a sufficient quantity of water. In parts of central Iowa, the chemical characteristics of the water rather than the amount available is the limiting factor with respect to its use.

Water under natural conditions is never pure. Rain water contains dust particles, minute amounts of salt, and dissolved gases that have been picked up from the atmosphere. Ground water that has been in contact with the soil and rocks for long periods of time contains mineral matter that has been dissolved from these earth materials. The water in our streams, derived originally from precipitation, picked up additional mineral matter as it flowed from the surface of the ground as runoff, or as it seeped through the rocks as ground water before reaching the channel. Domestic and industrial wastes are also a source of mineral matter and biological contamination in both our streams and ground waters; all need more study.

What is the significance of dissolved mineral matter in water? Any substances in large amounts are undesirable; some even in relatively small amounts make the water deleterious for many purposes. The limitations for several constituents are shown in the accompanying table. In general, these limitations are nationally accepted standards that more nearly reflect the quality requirements of an ideally acceptable water supply. Much of the ground water in central Iowa, especially that in the bedrock aquifers, exceeds these standards. However, most people after using such water regularly, are acclimated to it and suffer no ill effects. In fact, many people are well satisfied with their water supply and consider it to be about the best.

Most chemical analyses of water express the constituents as ions in parts per million (ppm) by weight. One part per million of an ion is equal to 1 pound of that ion in 1,000,000 pounds of water.

Significance of mineral constituents and physical properties of water

Constituent or Property	Maximum Recommended Concentration	Significance
Iron (Fe)	0.3 ppm	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 an accurate study. Reported concentrations range from 0.02 to 36 ppm for ground water, and from 0.04 to 2.8 for stream water in central Iowa.
Manganese (Mn)	0.05 ppm	Objectionable for the same reasons as iron. When both iron and manganese are present, it is recommended that the total concentration not exceed 0.3 ppm. Micro-organisms also affect the concentration. Special techniques are needed for an accurate study. Reported concentrations range from 0.03 to 3.3 ppm for stream and ground waters in central Iowa.
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 ppm	Commonly has a laxative effect when the concentration is 600 to 1,000 ppm, particularly when combined with magnesium or sodium. The effect is much less when combined with calcium. This laxative 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 ppm. Sulfate combined with calcium forms a hard scale in boilers and water heaters.
Chloride (Cl)	250 ppm	Large amounts combined with sodium impart a salty taste.
Fluoride (F)	2.0 ppm	In central Iowa, concentrations of 0.8 to 1.3 ppm are considered to play a part in the reduction of tooth decay. However, concentrations over 2.0 ppm will cause the mottling of the enamel of children's teeth.
Nitrate (NO_3)	44 ppm	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 sewage, 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 ppm	This refers to all of the material in water that is in solution. It affects the chemical and physical properties of water for many uses. Amounts over 2,000 ppm will have a laxative effect on most persons. Amounts up to 1,000 ppm 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 ppm; 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.

See U. S. Public Health Service (1962) and Hem (1959) for further discussion of chemical and physical properties of water.

Physical and chemical properties of streams change

The quality of stream water changes continually. Most of the variation is related to the amount of water being discharged at any particular time.

Chemical analyses of the water from the Des Moines River give some insight into the quality changes in the water of streams in central Iowa. In general, the high dissolved-solids contents of this water are during times of low discharge, and vice versa. This relationship generally holds true although it may not for small differences in either discharge or dissolved solids.

Why does this happen?

During times of high discharge the major portion of the streamflow is derived from direct runoff from precipitation or melting snow. This water enters the stream system after having flowed rapidly over land surface; therefore, its contact with the minerals in the soil and rocks is for a short period of time only. Thus, time is too short to allow much of the minerals to be dissolved and the dissolved-solids content is low. During time of low discharge, the streamflow is composed largely of water that has seeped into the stream channel from the ground-water reservoir. Because this water has been in contact with the rocks for long periods of time and consequently contains dissolved mineral from them, the dissolved-solids content is high.

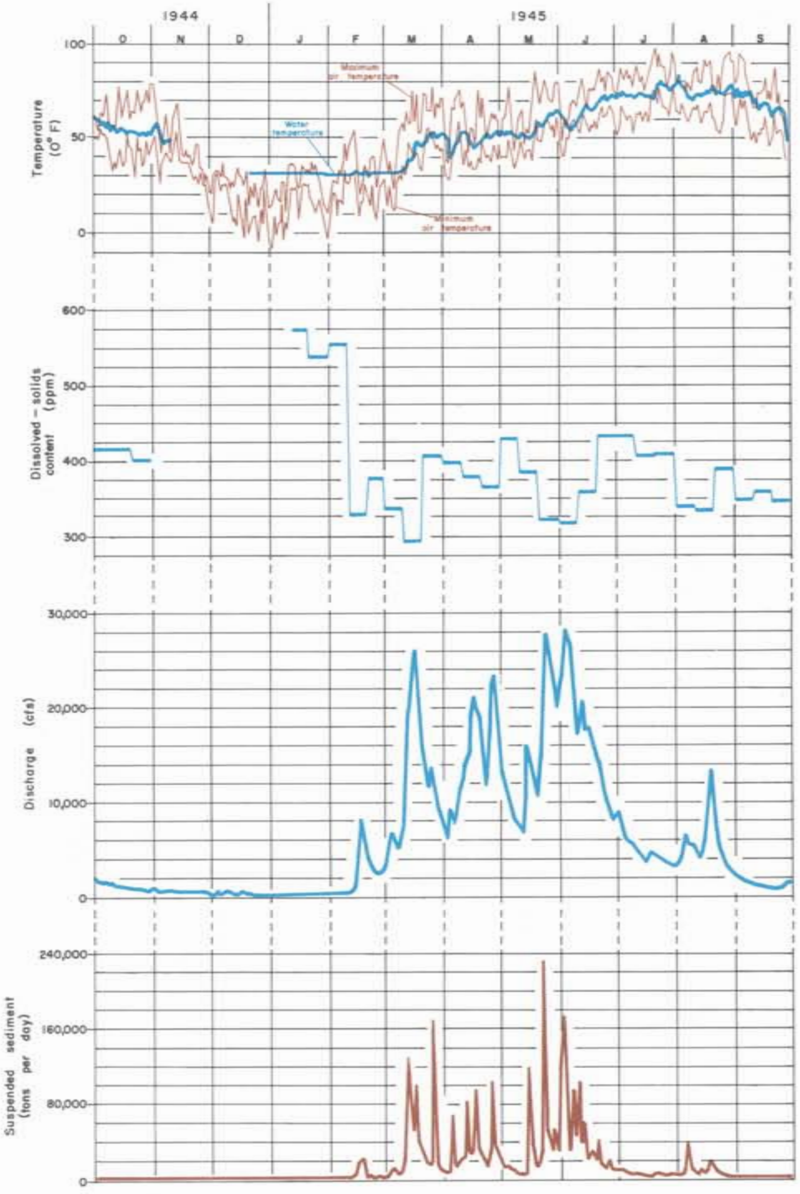
Representative chemical analyses of water from the major rivers are tabulated to show the relation between chemical quality and discharge. Those from the Des Moines, Raccoon, and Skunk show the effect of high, average, and low discharges on the chemical composition of the water. No chemical analyses are available for the Iowa River within the central Iowa area during periods of extreme high or low flow. However, its quality of water characteristics probably are similar to those of the other streams in central Iowa. For the most part, the dissolved solids are less than 700 ppm and the concentration of any one constituent, except bicarbonate, is less than 160 ppm. Bicarbonate, the chief constituent in all of the stream water, ranges from 98 to 512 ppm.

Chemical character of water in streams
(Results in parts per million)[1]

Date of collection	Mean discharge (cfs)	Water temperature (°F)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Hardness (as $CaCO_3$)
Des Moines River below Raccoon River at Des Moines														
2/1-10/45	566	32	556	18	0.02	112	40	20.0	2.5	400	116	12.0	0.3	444
4/1-10/45	8,598	40-53	397	19	0.06	85	27	8.6	2.2	277	77	5.0	0.5	323
6/1-10/45	23,930	55-65	319	17	0.04	68	21	6.3	2.1	226	53	3.2	0.4	256
9/21-30/45	1,101	52-66	348	14	0.20	62	30	12.0	3.3	248	89	7.4	0.3	278
Des Moines River at Des Moines														
7/16/57	876	82	424	9	0.20	69	30	17.6	3.9	210	126	16.0	0.4	188
1/27/59	50	32	768	14	0.28	133	48	59.0	6.6	512	157	65.0	0.5	420
6/2/59	14,900	64	295	14	0.06	54	18	5.7	3.5	181	47	5.0	0.2	148
9/27/60	1,030	63	498	16	0.04	91	28	17.1	4.0	261	118	18.0	0.3	222
Raccoon River at Des Moines														
2/5/57	64	32	419	13	0.08	87	28	19.3	3.6	345	71	17.5	0.3	283
6/18/57	19,200	71	230	17	2.96	30	6	5.8	3.5	98	21	0.5	0.3	80
7/16/57	608	80	395	15	0.22	79	26	12.2	3.0	244	73	12.0	0.4	212
9/27/60	532	61	359	16	0.06	72	20	10.0	4.0	246	53	8.5	0.3	210
Skunk River near Ames														
5/13/57	200	57	349	12	0.08	60	21	11.6	4.1	224	45	14.0	0.3	184
8/11/58	65	82	521	23	0.12	111	38	10.5	2.5	395	72	12.5	0.4	344
1/26/59	2	32	678	22	0.50	128	46	50.0	5.6	542	69	65.0	0.6	444
10/12/59	51	42	656	26	0.06	123	13	12.9	2.7	449	66	18.5	0.5	368
Iowa River at Marshalltown														
6/27/60	580	75	386	15	0.04	84	25	7.1	1.8	278	51	9.0	0.4	248
11/28/60	170	43	367	10	0.14	92	24	7.3	2.3	321	50	6.0	0.3	271
1/3/61	115	36	437	16	0.04	101	27	10.0	2.0	371	54	11.0	0.2	304
5/29/61	429	66	316	3	0.16	66	27	7.0	1.1	244	58	9.0	0.3	212

[1] Analysis by the State Hygienic Laboratory of Iowa.

Some characteristics of water in the Des Moines River in Des Moines—this is the only continuous record available for stream discharge, sediment load, and chemical quality at any one observation point in central Iowa.



During most of the year, the temperature of water in streams varies with air temperature except when the air temperature changes rapidly. During the colder months, when the minimum air temperature is freezing or below, the water temperature will remain at constant 32°-34°F.

Dissolved-solids content is high when streamflow is low. Water samples were taken everyday for most of the year; samples from 10 consecutive days were mixed and then analyzed. The plateaus on this graph represent the dissolved-solids content of each 10-day composite sample.

Streamflow

The amount of suspended sediment carried by streams is related to discharge. Low sediment loads are carried during low-flow discharge, but increase during high streamflow. Many of the large sediment loads occur several hours prior to peak discharge.

Good water in the shallower surficial aquifers

The alluvial aquifer (area 2) yields large quantities of good quality water, although generally very hard, throughout most of central Iowa. The average dissolved-solids content is about 500 ppm. Locally the total solids may be much higher than shown, but these occurrences can usually be traced to man-made pollution and are not characteristic of the natural water. The large yields of good quality water from wells in this aquifer make it obvious why 59 percent of the ground-water withdrawals in central Iowa come from the alluvial aquifer.

Water from the buried-channel aquifer (areas 3 through 11) has a higher dissolved-solids content than that from the other surficial aquifers but is usually less than that from the underlying bedrock aquifer in the same area. There are high concentrations of sulfate in areas 5, 9, 10, and 11 where the range is from 566 to 1,535 ppm. Sulfates are high in the upper bedrock aquifer at these locations also.

Although the water in the deeper parts of the buried channels may be of poor quality, most water from shallower depths can be expected to be good although hard. As an example, the water from a 305-foot deep well at Slater in southwestern Story County has 950 ppm dissolved solids with 499 ppm sulfates; whereas, water from a 180-foot deep well has 473 ppm dissolved solids with 52 ppm sulfates.

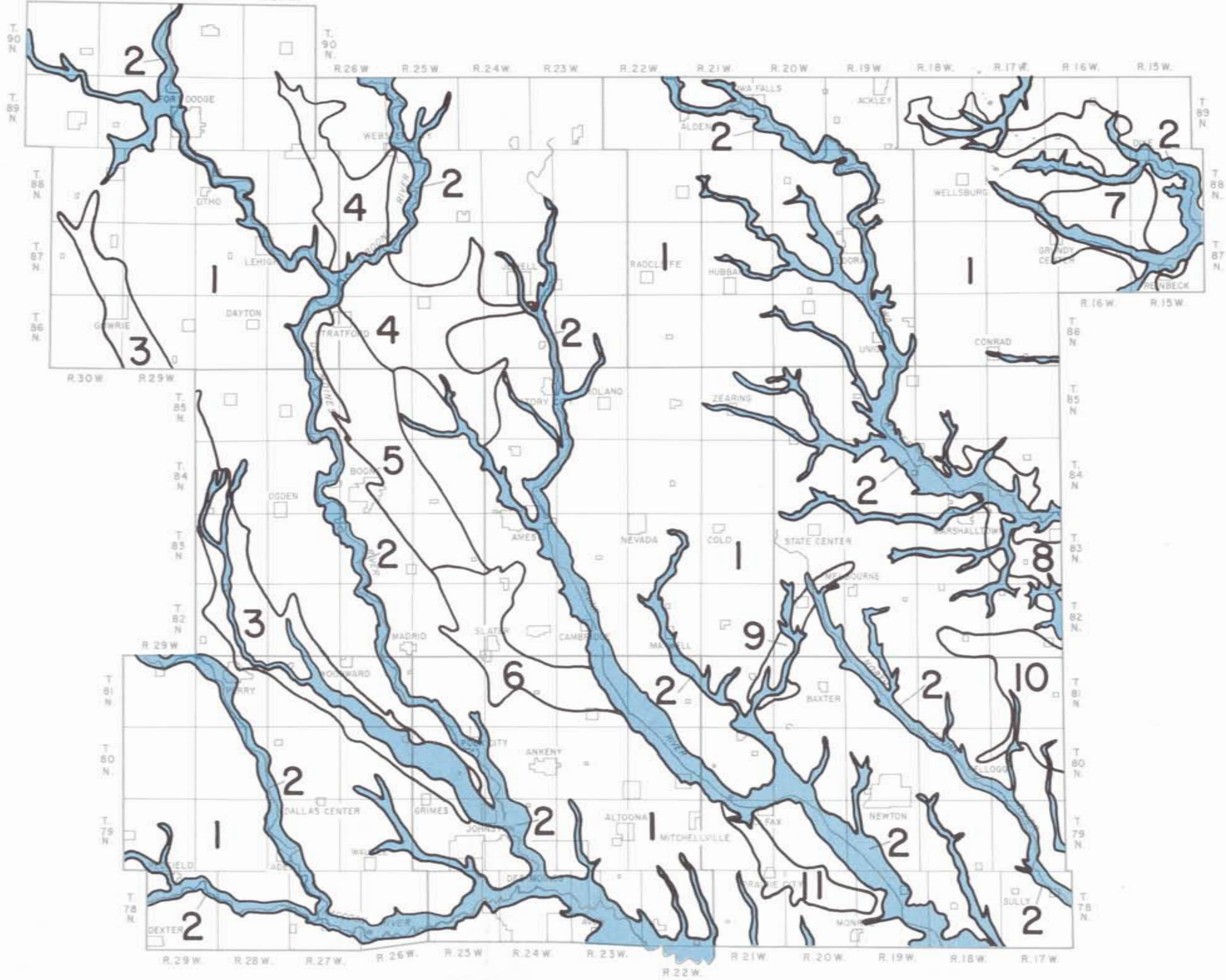
The twelve wells used to define the drift aquifer (area 1) range in depth from 20 to 160 feet. The quality of water produced from these wells is good and compares with that from the stream alluvium.

The temperature of water from the surficial aquifers averages 52°F. In most wells, the temperature does not deviate more than 2 or 3 degrees from average, although a few wells contain water having temperatures as low as 45°F and as high as 58°F.

Chemical character of water in the surficial aquifer
(Results in parts per million)[1]

Area	Average and Range	Calcium (Ca)	Magnesium (Mg)	Sodium & potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved Solids	Hardness (as $CaCO_3$)	Number of analyses
Water from the drift aquifer											
1	A	99	28	27	451	41	6	0.5	462	375	12
	R	78-118	23-42	12-66	312-594	8-113	0.5-18	0.2-0.9	330-632	295-468	
Water from the alluvial aquifer											
2	A	101	32	20	356	102	12	0.4	497	384	56
	R	64-147	19-54	8-48	224-471	7-248	1-37	0.2-1.3	305-769	236-590	
Water from the buried-channel aquifer											
3	A	77	35	92	483	122	7	1.0	600	365	4
	R	63-104	30-54	60-129	400-545	26-291	1-13	0.3-1.6	469-794	281-480	
4	A	145	46	92	709	144	0.7	0.45	806	585	3
	R	137-150	42-51	75-105	671-766	88-231	0.5-1	0.4-0.6	673-892	566-615	
5	A	209	82	167	262	936	6	0.5	1723	860	2
	R	164-253	59-106	160-174	249-276	782-1090	5-7	0.5	1400-2046	651-1070	
6	A	94	44	91	388	271	3	0.41	719	423	5
	R	74-126	27-72	66-118	307-489	52-499	1-8	0.35-0.5	473-950	306-547	
7	A	74	24	62	484	21	0.5	0.4	431	359	3
	R	54-91	21-30	53-80	459-529	5-40	0.5	0.3-0.6	414-449	321-380	
8	A	106	34	33	370	144	2	0.5	549	406	6
	R	91-120	29-40	17-55	266-466	107-179	0.5-5	0.25-1.5	473-642	375-464	
9		148	60	19	359	566	3.5	0.55	1207	615	1
10		322	110	245	159	1535	10	0.8	2554	1257	1
11	A	301	93	64	601	743	5	0.8	1747	1138	3
	R	232-353	88-101	59-72	483-734	696-810	2-7	0.4-1	1715-1808	1002-1246	

[1] Analysis by the State Hygienic Laboratory of Iowa.



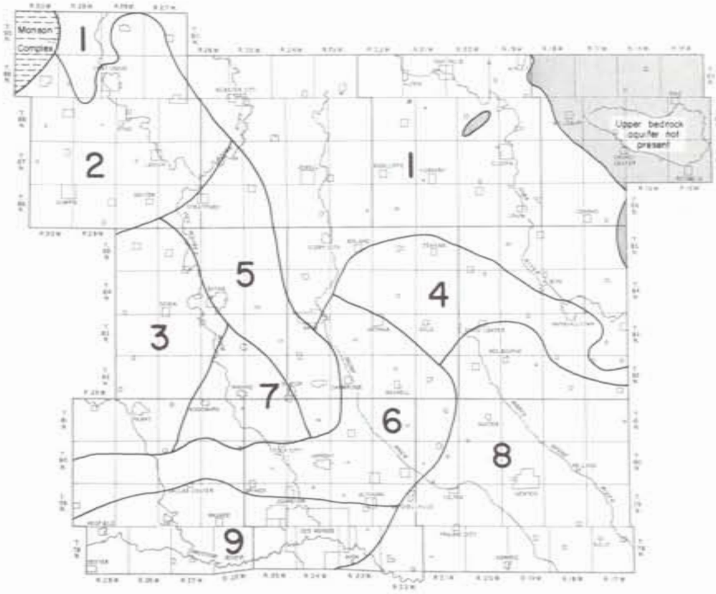
Good water can be obtained from the surficial aquifer in most areas

Some good water, some poor, in the upper bedrock aquifer

The upper bedrock aquifer is the source of water for a major portion of the communities and industries in the northeastern part of central Iowa. Here, in area 1, the aquifer yields ample supplies of good quality (although very hard) water. In most of this area the upper bedrock aquifer lies near the land surface and is overlain only by surficial deposits. Thus, the aquifer is readily recharged with water of good quality.

Throughout the rest of central Iowa the water from the upper bedrock aquifer is of poorer quality. The dissolved-solids content of water in areas 2 through 9 is more than 500 ppm. Water in the southern parts of Dallas and Polk counties has the highest dissolved-solids content; water from one well had 3,996 ppm dissolved solids.

A few wells in the area produce water of a quality considerably better than what is reported here. These wells penetrate only the top rock units (p. 38) of the upper bedrock aquifer. They are used for domestic and livestock purposes and apparently are not heavily pumped. If pumpage were heavy, the quality of the water might deteriorate as water from the lower part of the aquifer moved to the wells.



Chemical character of water in the upper bedrock aquifer
(Results in parts per million)[1]

Area	Average and Range	Calcium (Ca)	Magnesium (Mg)	Sodium & Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved Solids	Hardness (as $CaCO_3$)	Number of Analyses
1	A R	78 23-116	30 12-45	23 7-66	383 215-545	37 5-116	5 1-16	0.7 0.3-2.2	399 202-547	321 107-396	24
2	A R	118 101-140	42-60	51 36-69	460 386-505	197 132-240	7 2-13	1.7 0.7-2.4	692 593-822	498 427-582	10
3	A R	64 58-74	29 20-43	137 118-155	305 256-337	286 241-345	19 11-30	1.9 1.5-2.7	715 642-812	281 236-360	3
4	A R	144 98-187	51 35-67	68 30-128	363 307-390	361 264-455	7 5-8[2]	0.8 0.2-1.1	914 806-1126	569 388-743	6
5	A R	113 109-117	58 49-66	96 75-118	337 332-343	412 393-431	7 5-9	1.5 0.6-2.9	971 894-1049	520 474-565	2
6	A R	34 11-85	13 6-25	421 201-563	454 312-593	615 192-844	40 10-88	5.6 3.0-9.0	1388 628-1806	139 53-248	13
7	A R	133 114-152	65 51-79	246 220-272	317 295-339	722 551-888	67 59-75	2.7 2.4-3.0	1486 1230-1742	600 496-705	2
8	A R	245 119-421	103 50-121	203 61-340	274 133-644	1198 500-1440	12 1-28	0.8 0-2.0	2107 1061-2527	1034 503-1553	12
9	A R	301 264-310	85 72-97	531 312-760	311 222-345	1820 1469-2311	87 11-132	2.9 2.6-3.0	3325 2973-3996	1107 1010-1224	4

[1] Analysis by the State Hygienic Laboratory of Iowa.

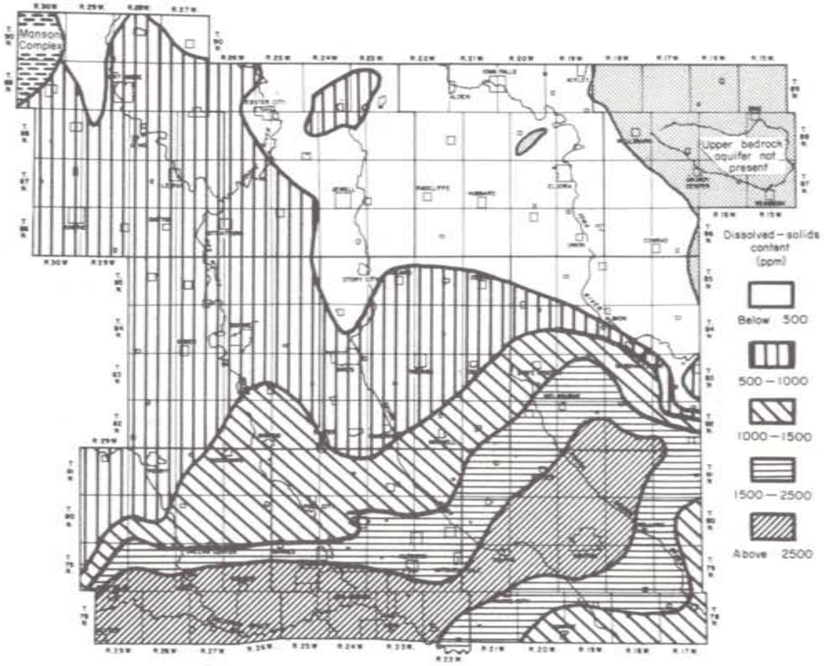
[2] Three wells have chloride concentrations of from 43-85; however, these higher concentrations may be due to man-made contamination.

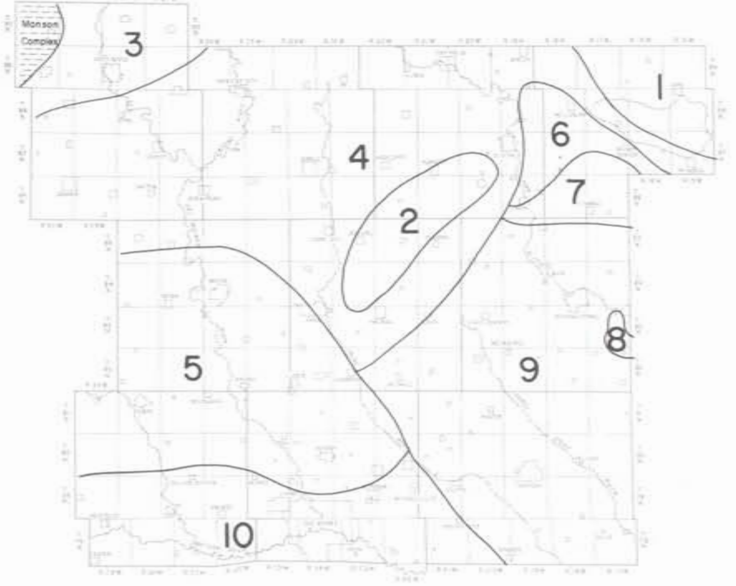
Some wells in area 6 yield water with exceptionally high concentrations of fluorides. Here, the concentrations of fluorides range from 3.0 to 9.0 ppm, well in excess of the recommended 2 ppm. Also, water from the upper bedrock aquifer in this area is less hard than most other water in central Iowa.

The high concentrations of sulfate, from 500 to 2,300 ppm, in areas 8 and 9 and parts of areas 6 and 7 are related to the presence of the evaporite minerals gypsum ($CaSO_4 \cdot 2H_2O$) and anhydrite ($CaSO_4$).

The water temperatures average 53°F and range from 50°F to 55°F. Two exceptions exist. The temperature of water from a well near Otho was 63°F and from a well at Bondurant (just north of Altoona) was 57°F.

Dissolved solids content of water from the upper bedrock aquifer ranges from less than 500 to more than 3,000 ppm.





Poor quality water – a general characteristic of the middle bedrock aquifer

The quality of water from the middle bedrock aquifer is best in northeastern Grundy County (area 1) where the aquifer lies near land surface and is covered only by drift. Good quality water can be obtained from parts of area 2 also but, because information is lacking, the extent of good water in this area is not known definitely. Elsewhere in central Iowa, the dissolved-solids content of water from this aquifer is above 700 ppm. Water from some areas, notably 9 and 10, exhibit the highest dissolved-solids content of any water in central Iowa.

Fluoride concentrations average over 2 ppm in areas 2, 5, 9, and 10 and are as high as 6.5 ppm in area 5.

Chemical character of water in the middle bedrock aquifer
(Results in parts per million)[1]

Area	Average and Range	Calcium (Ca)	Magnesium (Mg)	Sodium & Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved Solids	Hardness (as $CaCO_3$)	Number of Analyses
1	A	63	25	21	303	38	2	0.9	326	263	3
	R	61-66	22-28	9-28	276-327	30-45	0.5-4	0.8-1	303-350	255-268	
2	A	92	30	25	352	95	4	2.1	420	358	2
	R	54-130	18-42	17-32	298-407	21-169	3-5	2-2.2	240-601	214-503	
3		124	54	31	544	161	3	0.8	715	530	1
4	A	166	67	41	324	469	6	1.9	1019	690	7
	R	123-215	44-106	13-57	266-365	374-734	0.5-12	1-2.8	911-1482	596-967	
5	A	111	48	320	265	858	40	3.1	1620	481	5
	R	61-141	38-68	266-448	207-320	655-1160	5-110	0.9-6.5	1182-2035	309-660	
6	A	312	113	48	286	1047	6	1.4	1850	1244	5
	R	229-422	83-138	6-67	273-293	727-1166	1-9	0.2-2.1	1384-2241	960-1622	
7	A	479	224	175	260	2110	33	1.7	3429	2084	3
	R	281-657	159-290	4.9-316	239-273	1943-2209	18-46	1.4-2.2	3084-3623	1793-2295	
8	A	120	50	382	249	1019	45	1.7	1808	506	2
	R	90-151	38-62	355-409	212-286	961-1077	35-54	1.6-1.8	1691-1926	381-632	
9	A	443	113	773	207	2787	155	2.4	4551	1578	3
	R	360-496	88-143	642-893	106-259	2550-3071	121-183	1.7-3	4369-4913	1262-1782	
10	A	386	112	373	177	1714	196	2.1	3067	1429	8
	R	96-560	43-169	191-654	56-232	978-2850	84-331	1-3.5	1840-4786	417-2061	

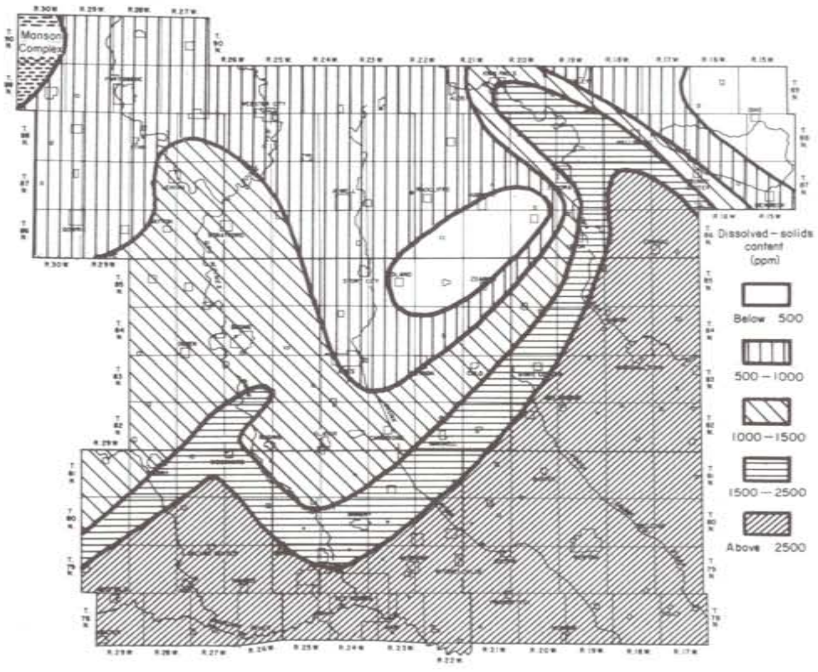
[1] Analysis by the State Hygienic Laboratory of Iowa.

The high concentrations of sulfates, ranging from 1,000 to 3,000 ppm, in areas 6, 7, 8, 9, and 10, are related to the presence of evaporite minerals.

Because the evaporite minerals principally occur in the middle and lower rock units of the middle bedrock aquifer, it is often possible to obtain small supplies of a better quality of water by penetrating only the upper portion of the aquifer in some areas. For example, at Wellsburg in northwestern Grundy County, water from a well 765 feet deep in the Cedar Valley and the Wapsipinicon Formations (p. 38) had 2,241 ppm dissolved solids, whereas water from a shallower well in the Lime Creek Formation at the same location had 1,037 ppm. A similar situation occurs in area 10 where, in the same vicinity, water from a deep well has 3,300 ppm dissolved solids; whereas water from a shallow well in the same aquifer has about 1,800 ppm.

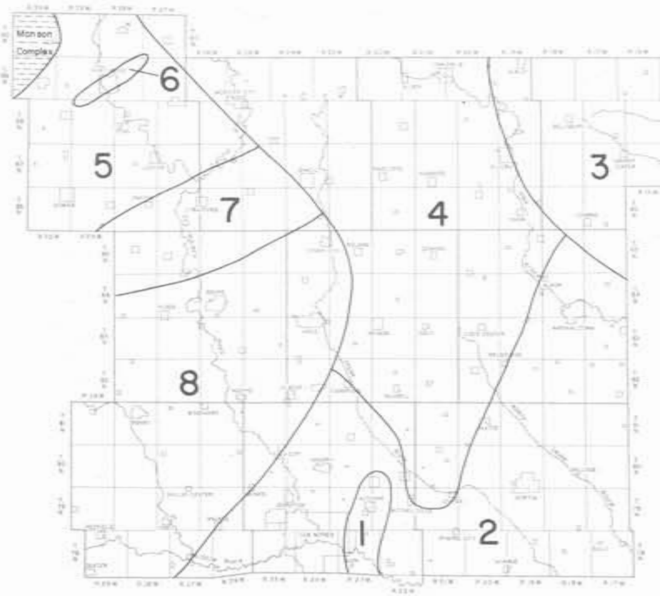
Water in the middle bedrock aquifer has an average temperature of 54°F; it ranges from 50°F to 57°F.

Dissolved solids content of most water from the middle bedrock aquifer is greater than 500 ppm.



Potable water in much of the lower bedrock aquifer

Of the bedrock aquifers, only the lower bedrock aquifer will yield relatively good quality water, although it may be hard, in most of central Iowa. This is especially true in the southern and southeastern parts of the area where the other bedrock aquifers contain water of poor quality. Only in the west and southwest are the dissolved solids much in excess of 1,000 ppm. In these areas sulfates are high, ranging from 740 to almost 1,100 ppm. Also, fluoride concentrations in areas 2, 7. and 8 slightly exceed 2 ppm.

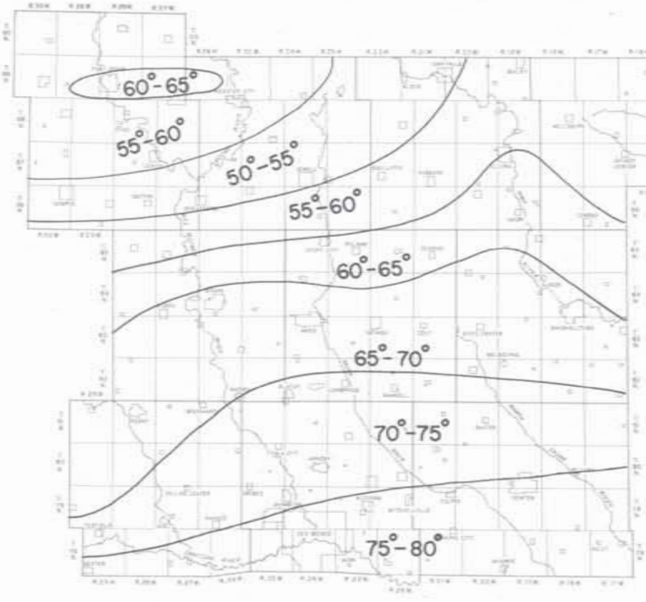


Chemical character of water in the lower bedrock aquifer
(Results in parts per million)[1]

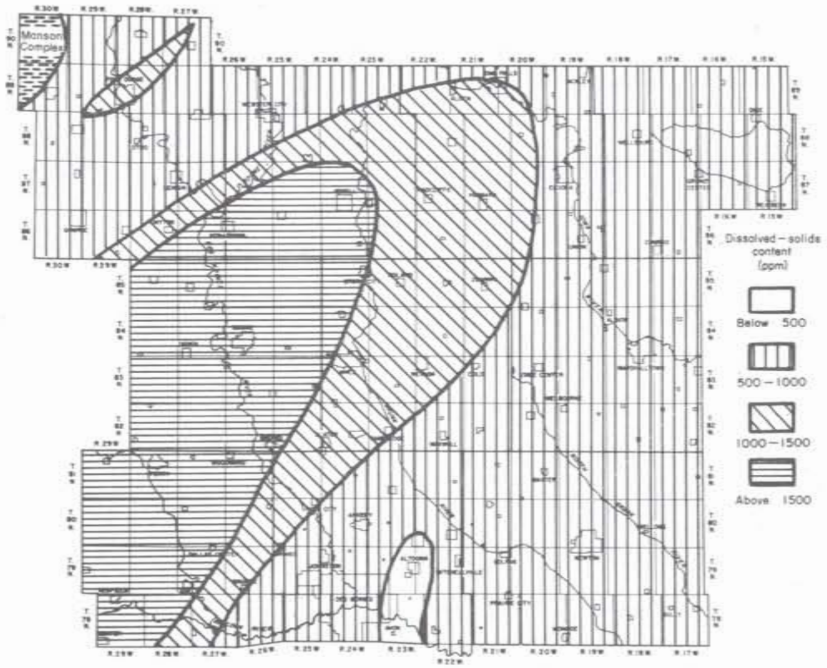
Area	Average and Range	Calcium (Ca)	Magnesium (Mg)	Sodium & Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved Solids	Hardness (as $CaCO_3$)	Number of Analyses
1	A R	62 58-67	28 28	79 77-81	314 305-323	135 117-153	16 15-17	1.8 1.6-2	472 434-510	271 259-283	2
2	A R	79 69-84	32 20-40	341 119-371	341 325-371	263 245-280	30 21-36	2.0 1.4-2.6	735 722-752	330 266-362	4[2]
3	A R	86 85-87	32 31-33	94 93-94	389 383-395	191 183-202	5.6 1.2-10	1.1 1.1	611 604-618	346 340-352	2
4	A R	117 101-136	49 32-75	152 71-208	344 306-366	436 355-567	48 7-69	1.6 1.2-1.8	1002 883-1193	595 384-655	7
5	A R	108 101-117	56 48-61	80 63-112	410 391-425	253 199-299	24 10-46	1.7 1.5-1.8	738 661-785	498 452-535	4
6	A R	115 112-118	38 36-40	211 210-212	379 377-381	240 237-244	237 235-240	1.2 1.1-1.2	1070 1048-1092	444 442-445	2
7	A R	262 256-268	96 75-117	184 172-196	312 288-337	1066 1050-1082	41 38-45	2.6 2.2-2.9	2006 1967-2045	1050 980-1120	2
8	A R	144 128-162	55 32-70	377 264-394	248 215-300	773 740-871	181 92-240	2.4 1.8-2.8	1712 1470-1866	596 451-693	5[3]

[1] Analysis by the State Hygienic Laboratory of Iowa.
[2] Includes two analyses just outside the central Iowa area.
[3] Includes one analysis just outside the central Iowa area.

The temperature of the water in the lower bedrock aquifer, unlike that in the other aquifers, has a wide range—as much as 30 degrees. In general, the temperatures are lowest in the northern part of the area and become progressively warmer southward. Inconsistent with this general trend are the higher water temperatures around Fort Dodge. This anomaly may be the result of warmer water from rocks below the Jordan Sandstone, moving upward through the fractured rocks in the Fort Dodge fault complex and into the lower bedrock aquifer. This may also explain why the chemical quality of the water from the lower bedrock aquifer in this area is slightly different from that in the surrounding region.



Most water from the lower bedrock aquifer has a dissolved-solids content that ranges between 500 to 1,000 ppm.



Some water-quality problems can be solved

Several towns in central Iowa have had difficulty obtaining good water supplies. In general, the problems encountered were related to water quality. In some towns, water of good quality was not always available within the confines of the town and, inevitably, these towns turned to the alluvial aquifer for a satisfactory municipal supply.

Dallas Center's water supply from the upper bedrock aquifer was of very poor quality. Test drilling the drift aquifer proved unsuccessful. Finally, water of good quality was obtained from the alluvial aquifer 4 miles from town. The source made a difference.

Dallas Center's water supply in the 1930's, from upper bedrock aquifer.

The drift aquifer was tested in the 1940's but yielded water of poor quality.

Dallas center's present (1963) water supply; from alluvial aquifer along the Raccoon River 4 miles from town.

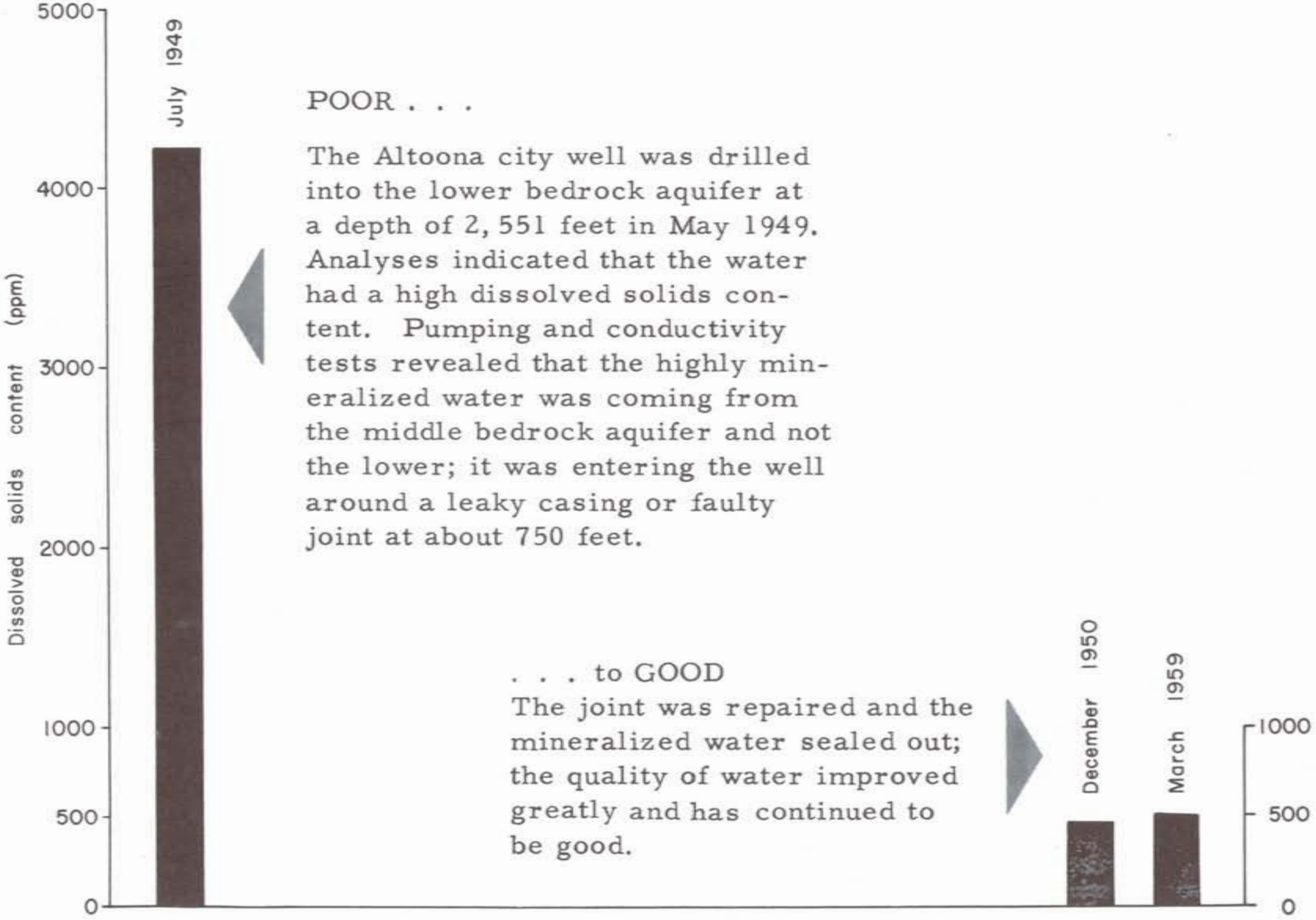
Other towns have had similar experiences. Some of the towns that have abandoned bedrock, buried-channel, and drift aquifers and have gone to the alluvial aquifer for water are: Prairie City, Boone, Ogden, Woodward, Madrid, Mitchellville, Baxter, Gilman, Albion, and Newton. The story of Prairie City's water supply is typical. This story, as quoted below, is from the "Prairie City News," November 17, 1955.

"Although Prairie City installed a town water system in 1895, it did not prove adequate. First shallow wells then deep wells were drilled in succeeding attempts to get sufficient water. The water, however, contained a high mineral content which not only had an adverse taste but also raised havoc with plumbing facilities and was not widely accepted by the town residents.

"A real success story is the history of the modern water system installed in Prairie City in 1951. It not only supplies an excellent quality water now in a quantity that is sufficient for today's use but all indications are that the source can stand a large increase with no strain. It is a project well worthy of study.

"Source of the water is a well which protrudes 54 feet through a gravel bed [alluvial aquifer]. From this source, water is pumped about 5½ miles through a 6-inch cast iron underground pipeline to the reservoir at the Prairie City Waterworks at the west edge of town. This reservoir has a capacity of 150,000 gallons. Another pump takes the water from the reservoir and forces it into the 60,000-gallon tower which furnishes the pressure for the town's water system."

Some water-quality problems can be solved right at home by the proper application of known water facts. A quality problem at Altoona was solved in this way. Available data in the files of the Geological Surveys indicated that good water could be obtained from a well in the lower bedrock aquifer. However, when the well was completed in this aquifer, it yielded poor quality water. The inconsistency between the quality of water that was expected and the quality of water obtained from the well prompted a thorough study of the situation. As shown below, the study, along with previously known water facts, provided a solution to the problem.



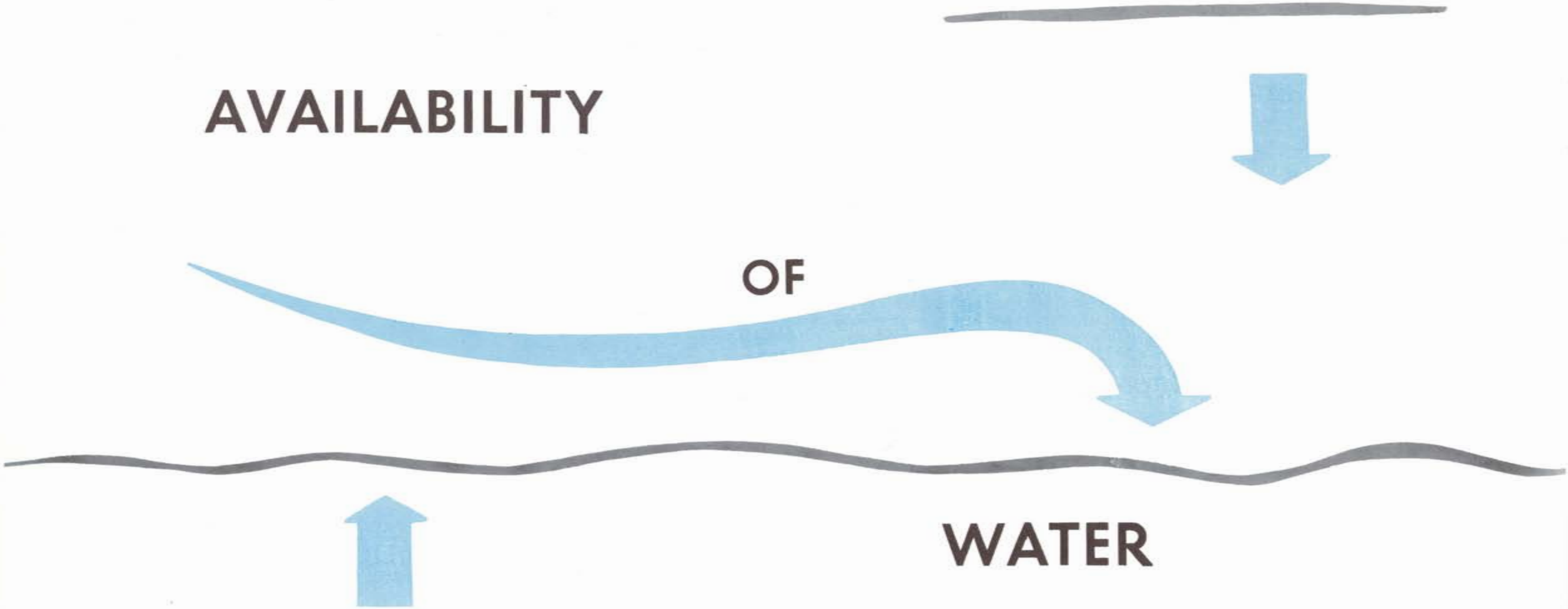
POOR . . .

The Altoona city well was drilled into the lower bedrock aquifer at a depth of 2, 551 feet in May 1949. Analyses indicated that the water had a high dissolved solids content. Pumping and conductivity tests revealed that the highly mineralized water was coming from the middle bedrock aquifer and not the lower; it was entering the well around a leaky casing or faulty joint at about 750 feet.

. . . to GOOD

The joint was repaired and the mineralized water sealed out; the quality of water improved greatly and has continued to be good.

AVAILABILITY OF WATER



Central Iowa has plenty of good water—it is plentiful today and will be plentiful tomorrow if handled properly. However, the problem of availability of water for a satisfactory supply involves not only the quantity and quality of water but also the availability of money. "How much good-quality water is available?" often means "How much money is available to get the water?" If money is available to lay pipelines, build storage reservoirs, or drill deep wells, then good-quality water can always be obtained. For somewhere within a short distance of each city or community in central Iowa is a stream or surficial aquifer that will yield large quantities of good-quality water. This water needs only to be transported to the user.

AVAILABILITY FROM STREAMS

QUANTITY

Surface water is abundant in central Iowa. The total average flow of the 3 major streams, the Des Moines, Iowa, and Skunk rivers, is about 3 billion gallons per day. Only one-twentieth of this flow will be necessary to supply the 850,000 people who will be living in central Iowa in the year 2000. HOWEVER

QUALITY

Nearly all water in streams is of a quality suited for domestic use. Climatic factors, more than any others except man, influence the quality of surface water. Water temperatures increase during the summer months when air temperatures are high, sediment load increases with increased precipitation and runoff, and mineral content may increase during dry periods when stream flow is low. Otherwise the water is good and should continue to be so in the future—only man's contamination will cause the water to deteriorate. BUT

STREAM FLOW FLUCTUATES

It does not occur as a constant amount of flow; rather, it is high during certain periods of the year and low during others. It cannot be depended upon for a constant sustained yield, and pumping water directly from streams without storage facilities may be risky. However, if proper storage facilities are provided for low-flow carry-over, the streams in central Iowa can supply many people with large quantities of usable water in the years to come.

AVAILABILITY FROM SURFICIAL AQUIFERS

QUANTITY

Surficial aquifers contain an estimated 500 billion gallons of water in storage. In comparison with other sources this appears to be a small quantity, especially when a large part of the water used in central Iowa is from this source. HOWEVER

QUALITY

Most water in the surficial aquifers is suited for domestic use. Not only is the quality of this water generally good at present but it will continue to be so in the future if properly managed.

AND

RECHARGE IS GENERALLY ABUNDANT

The surficial aquifers are replenished often with large quantities of water from precipitation and runoff. In some aquifers, primarily the drift aquifers, discharge may exceed recharge, especially during droughts, with a resultant decrease of stored water. However, in the buried channel and alluvial aquifers, recharge often balances discharge, and sustained withdrawal of large quantities of water from these aquifers is possible. Only during periods of extended drought is stored water greatly reduced; during these times the aquifers may yield little or no water. Otherwise, future supplies appear to be adequate to meet most demands.

AVAILABILITY FROM UPPER AND MIDDLE BEDROCK AQUIFERS

QUANTITY

The upper and middle bedrock aquifers contain about 17 trillion gallons of water in storage. Without considering recharge, this is enough water to provide sufficient supplies for 850,000 people for about 300 years. HOWEVER

QUALITY

Not all water in these aquifers is of a quality suited for domestic use. In some areas, neither aquifer will yield water of a satisfactory quality for domestic supplies; whereas, in other areas, good water may be obtained from both aquifers. In the future, as more good water is withdrawn, the quality of water in the bedrock aquifers may deteriorate because of movement of poorer quality water from other rocks. THUS

QUANTITY OF WATER AVAILABLE IS LIMITED BY QUALITY

Because of quality, the water in storage that is suited for domestic use may be reduced to 8 trillion gallons and this water can be obtained only by *proper selection of area and aquifer.* In most areas where quality *is* satisfactory, the upper and middle bedrock aquifers will supply a quantity of water sufficient to meet most needs for many years. In areas where the quality is not satisfactory, demineralization plants may provide additional supplies.

AVAILABILITY FROM LOWER BEDROCK AQUIFER

QUANTITY

The lower bedrock aquifer contains at least 16 trillion gallons of water in storage or enough water to supply the people of central Iowa for more than 250 years. Production from this aquifer is good—most wells in the aquifer produce over 1,000 gpm in 50 percent of the area and over 500 gpm in 75 percent of the area. AND

QUALITY

The lower bedrock aquifer differs from the other bedrock aquifers in that it contains relatively good water throughout most of central Iowa. The dissolved-solids content of water from this aquifer is less than 1,500 ppm in about 80 percent of the area and less than 1,000 ppm in 60 percent of the area. THUS

PLENTY OF RELATIVELY GOOD WATER BUT AT DEPTH

Water of relatively good quality and in large quantities can be obtained from the lower bedrock aquifer. However, in most areas, wells penetrating this aquifer will need to be more than 2,000 feet deep and, in many areas, will need 1,000 feet or more of casing to seal out the poorer quality water in the overlying rocks.

A good water supply—where is it?

Although there is water nearly everywhere in central Iowa, not all of it can be used for a water supply. Where then, can a good water supply be obtained? This report and the summary chart at the end of this section (p. 85) can be used to determine the possible sources of good water supplies.

To show how the report and chart can be used, the authors have chosen to analyze a factual case—the water quality problem that exists at Waukee in Dallas County. This analysis presents water facts that provide alternate possibilities for a better water supply. A similar procedure can be used to analyze water problems in other areas in central Iowa.

THE PROBLEM. Waukee is a community that has a population of about 700. The water supply is from two deep wells in the upper bedrock aquifer and has more than 3,000 ppm dissolved solids. It is difficult to treat and is harmful to plumbing facilities. Can sufficient quantities of better quality water be obtained?

WATER FACTS. Check the chart. The major streams are a good source of water. However, the topographic map (p. 5) indicates that the nearest major stream is 5 miles away. Since, at first glance, this does not appear to be the most convenient source, others should be checked.

The alluvial aquifer appears to be a good source but the surficial aquifer map (p. 44) shows that the nearest good alluvial aquifer is also about 5 miles away.

No deep buried channels are known to exist in the Waukee area, so this aquifer can be eliminated as a possible source.

The drift aquifer might be a good source. The map on page 44 reveals that this aquifer underlies Waukee and therefore is readily accessible. After studying the quality-of-water map, it appears that the water is good. The water-bearing potential of the drift aquifer can never be estimated with assurance. It will probably yield some water but the exact quantity is not known. Therefore, the only sure way to determine its water-producing capabilities is by test drilling.

All three bedrock aquifers underlie Waukee. However, as noted on the chart, these aquifers in Dallas County may contain poor-quality water. The present water supply for Waukee is from the upper bedrock aquifer and the quality of water is poor. The map on page 72 shows that the middle bedrock aquifer also can yield nothing but poor-quality water in the Waukee area. However, the lower bedrock aquifer is a source of fair quality water (p. 74). Therefore, this is the only bedrock aquifer that can be considered. As noted on the chart, this aquifer lies at considerable depth. By comparing the map showing the altitude of the lower bedrock aquifer on page 50 with the topographic map, we find that the aquifer is about 2,275 feet below land surface at Waukee. The principal water-bearing zone, the Jordan Sandstone, is another 425 feet below this. An examination of the water-level map (p. 60) shows that the water will have to be lifted from a depth of at least 200 feet.

ALTERNATE SOLUTIONS. There are four sources that offer good-to-fair possibilities for water—the stream, the alluvial aquifer, the drift aquifer, and the lower bedrock aquifer.

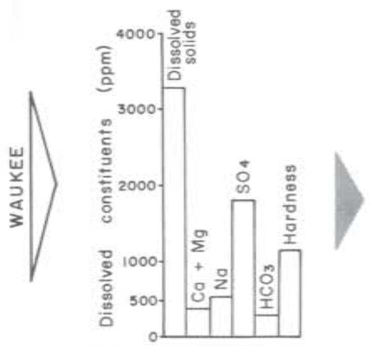
The Raccoon River and the alluvial aquifer can provide large quantities of good quality water but they are not easily accessible. A pipeline and possibly booster pumps will be required to transport this water to Waukee. Which of these two, the river or the alluvial aquifer, would be the best source of water? From the data in the preceding pages, we find that the alluvial aquifer yields water of a more constant temperature than the streams. Also, water from the alluvial aquifer generaly does not contain suspended sediment whereas water from the river does. Water from the alluvial aquifer needs little or no treatment; whereas possible biological contamination of the river water necessitates extensive purification. Streamflow fluctuates and during dry periods may not supply an adequate quantity of water; thus, a reservoir might be necessary.

The drift aquifer is the most easily accessible and, therefore, would be the most economical source of water. Thus, it warrants further investigation by exploratory drilling.

A deep well will be needed to penetrate the lower bedrock aquifer. The casing must extend below the middle bedrock aquifer and be tightly sealed in order to prevent the poor-quality water in this aquifer and the overlying rocks from entering the well.

Thus, the data in this report and the summary chart have shown that Waukee has four alternate sources for a water supply; any one of which might provide the desired quantity and quality of water.

THE
PROBLEM



Dissolved constituents are high in the town's present water supply

WATER
FACTS

FROM THE SUMMARY CHART
AND DATA IN THE REPORT

ALTERNATE SOLUTIONS TO
WATER SUPPLY PROBLEM

Stream--Raccoon River
Large quantities of good quality water are available; however, a 5-mile pipeline would be necessary and storage facilities may be required. The water would need treatment for biological contamination.

Alluvial aquifer
About 5 miles of pipeline would be required but large quantities of good quality water are available.

Drift aquifer
Exploratory drilling may reveal small-to-moderate quantities of good quality water.

Bedrock aquifers
Moderate quantities of fair quality water probably available from the lower bedrock aquifer at a depth of about 2, 700 feet.

Probability for a water supply—A summary chart

This chart is a simplified summary of the probabilities of obtaining water from different sources. In order to make the chart, all data in the preceding pages of this report and in the files of the Geological Surveys were considered. To define a source as being excellent, good, fair, or poor, the items considered were: the purpose for which the water might be used, the ease with which water can be obtained, the quantity of water that is available, and the quality of water. In general, the source is considered to be *excellent* when it will yield readily large quantities of excellent quality water (less than 500 ppm) that needs little or no treatment. The source is considered *good* when it will yield good quality water in sufficient quantities to supply a town of about 500 people (50 to 100 gpm). The source is considered only *fair* when the quantity of water is insufficient to supply a town of this size, when the water is not easily available, or when the dissolved solids in the water are between 1000 and 1500 ppm. The source is considered *poor* when it will yield only small quantities of water, when the water can be obtained only with difficulty, or when the water is of a quality generally conceded to be unsatisfactory for human use; that is, the dissolved solids content is high or some of the constitutents generally exceed the accepted standards.

COUNTIES SOURCE OF WATER		BOONE	DALLAS	GRUNDY	HAMILTON	HARDIN	JASPER	MARSHALL	POLK	STORY	WEBSTER
Streams		GOOD Purification needed	GOOD Purification needed	GOOD Purification needed; limited quantity	GOOD Purification needed	GOOD Purification needed	GOOD Purification needed	GOOD Purification needed	GOOD Purification needed	GOOD Purification needed; limited quantity	GOOD Purification needed
Surficial Aquifers	Alluvial Aquifer	EXCELLENT Aquifer thin or not present in some areas	EXCELLENT	EXCELLENT Aquifer thin or not present in some areas	EXCELLENT	EXCELLENT Aquifer thin or not present in some areas	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT Aquifer thin or not present in some areas
	Buried Channel Aquifer	GOOD to POOR See data on quality	GOOD	GOOD to FAIR Quantity may be limited	GOOD to FAIR Quantity may be limited	POOR Aquifer not known to be present	FAIR to POOR See data on quality	EXCELLENT to FAIR See data on quality	EXCELLENT to GOOD	EXCELLENT to GOOD	GOOD to FAIR Quantity may be limited
	Drift Aquifer	FAIR Quantity limited	FAIR Quantity limited	FAIR Quantity limited	FAIR Quantity limited	FAIR Quantity limited	FAIR Quantity limited	FAIR Quantity limited	FAIR Quantity limited	FAIR Quantity limited	FAIR Quantity limited
Upper Bedrock Aquifer		POOR Quantity limited	POOR See data on quality; quantity limited	EXCELLENT to GOOD	EXCELLENT to FAIR Quantity limited in some areas	EXCELLENT to GOOD	FAIR to POOR See data on quality; quantity limited	GOOD to POOR See data on quality; quantity limited in some areas	POOR See data on quality	EXCELLENT to POOR See data on quality	EXCELLENT to FAIR Quantity limited in some areas
Middle Bedrock Aquifer		POOR	POOR	EXCELLENT to POOR See data on quality	GOOD to POOR Quantity limited	GOOD to POOR See data on quality	POOR	POOR	POOR	GOOD to POOR See data on quality; quantity limited in some areas	GOOD to FAIR See data on quality; quantity limited in some areas
Lower Bedrock Aquifer		POOR See data on quality	GOOD to POOR See data on quality	EXCELLENT to GOOD	GOOD to POOR See data on quality	GOOD to FAIR See data on quality	GOOD	GOOD	EXCELLENT to FAIR See data on quality	GOOD to POOR See data on quality	GOOD to POOR See data on quality

WHERE MORE INFORMATION CAN BE FOUND ABOUT . . .

. . . Basic water facts, principles, and problems:

Baldwin, H. L., and McGuinness, C. L., 1963, A primer on ground water: U. S. Geol. Survey special report.

Brown, R. H., 1953, Selected procedures for analyzing aquifer test data: Jour. Amer. Wat. Works Assoc., v. 45, p. 844-869.

Fair, G. M., and Geyer, J. C., 1954, Water supply and waste-water disposal: New York, John Wiley & Sons, Inc., 973 p.

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Detailed information and data about the geology and hydrology of this area may be obtained by contacting the following agencies:

Iowa Geological Survey
Geological Survey Building, Iowa City, Iowa
U. S. Geological Survey
Ground-Water District Office, Geological Survey Building, Iowa City, Iowa
U. S. Geological Survey
Surface-Water District Office, 508 Hydraulics Building, Iowa City, Iowa