WATER RESOURCE AVAILABILITY

EXECUTIVE SUMMARY

March, 1978

Foreword

The information presented in this summary document has been based on the comprehensive, "Task Force Report on Water Resource Availability", prepared by the Iowa Geological Survey and filed with the Iowa Natural Resources Council. The reader should refer to the task force document for more detailed information.

INTRODUCTION

Iowa's early communities were established adjacent to the Mississippi and the state's interior rivers, lakes and springs where water was readily available. The demand for water in Iowa's early history was small compared to the present. In Iowa, water is now used at a rate of 60 to 150 gpcd (gallons per capita per day), varying with the size and economic characteristics of communities. In 1970, the total water withdrawn from surface and ground water sources was about 2.5 million acre-feet, or about 2 billion gallons per day. By 1975, this amount more than doubled to 5 million acre-feet and is projected to reach at least 10 million acre-feet by the mid 1990's (Barnard and Dent, 1976, Projections of Population, Employment, Income and Water Use for Iowa River Basins, 1975-2020).

As the use of water continues to increase, the role of water in providing goods and services becomes even more critical. The production and processing of livestock and crops, building materials, energy, manufacturing and mining all require great amounts of water. For instance, it takes about 5 gpd (gallons per day) to water each head of hogs and about 10 gpd per head of cattle; it takes about 4,000 gallons of water to process 1,000 pounds of beef and 1 acre-foot (325,850 gallons) of water to irrigate an acre of land. All human activity, in some way, depends upon adequate and suitable supplies of fresh water.

In the past, Iowan's have grown to accept a philosophy of water development based on faith in natural abundance and dependence upon the renewability of the supply. By and large, nature has provided abundantly, except for episodes of drought experienced during the 1930's, 1950's and now in the 1970's. However, this philosophy has neither been totally satisfactory nor has it benefited all water interests in the state, and holding to it has caused some disconcerting precedents to be set in water resources development. Conflicts between water user groups are becoming much more common as each sector attempts to meet its demands for larger and more reliable water supplies. A quick look into the future indicates that Iowans are only beginning to feel the gravity of the imbalance between water supply and demand; and, very soon water managers and developers must fully address the issue of water resources allocation, which, in the past, was a mechanism used only by those states with less abundant water than Iowa.

What then is this water resources trust that Iowans must protect, conserve, manage and allocate?

The Water Cycle

The earth's water is constantly in motion, from the oceans to the atmosphere, to the land, and back to the oceans as shown schematically in Figure 1.

About 75 percent of the precipitation that falls in Iowa is returned directly to the atmosphere through the process of evapotranspiration. About 20 percent of the precipitation becomes runoff and eventually leaves the state as streamflow. The remaining few percent soaks into the land and slowly percolates downward to become ground water. During dry periods, the majority of perennial streams owe most or all of their flow to discharges of ground water at the surface.

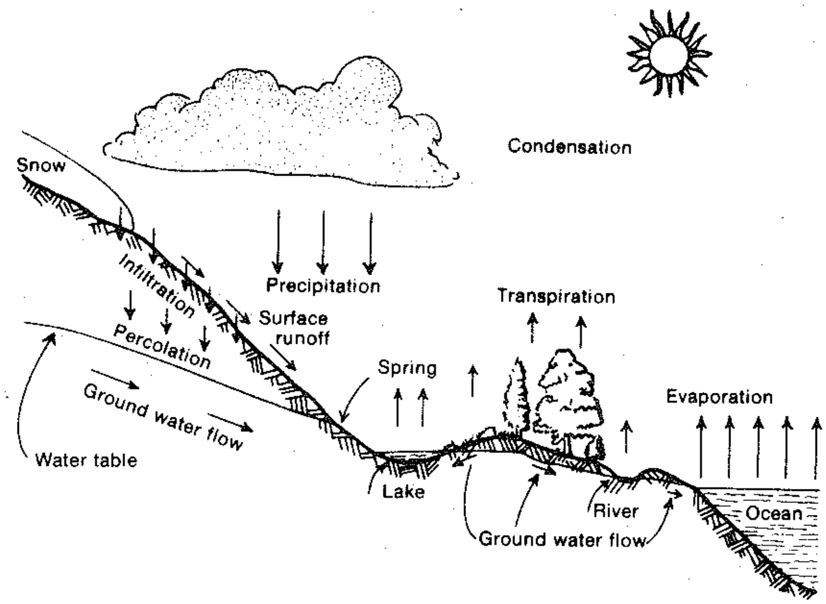


Figure 1. DIAGRAM OF THE WATER CYCLE

Precipitation

Precipitation is part of the water cycle and occurs in Iowa as rain, snow, drizzle, ice pellets, and dew. In Iowa rainfall accounts for nearly 90 percent of the annual precipitation received, snow for about 10 percent, and other forms for only minor quantities.

Iowa's normal annual precipitation varies from about 35 inches in the southeast to about 25 inches in the northwest, as shown in Figure 2. Over 70 percent of the precipitation received falls

NORMAL ANNUAL PRECIPITATION IN INCHES (1941-1970)

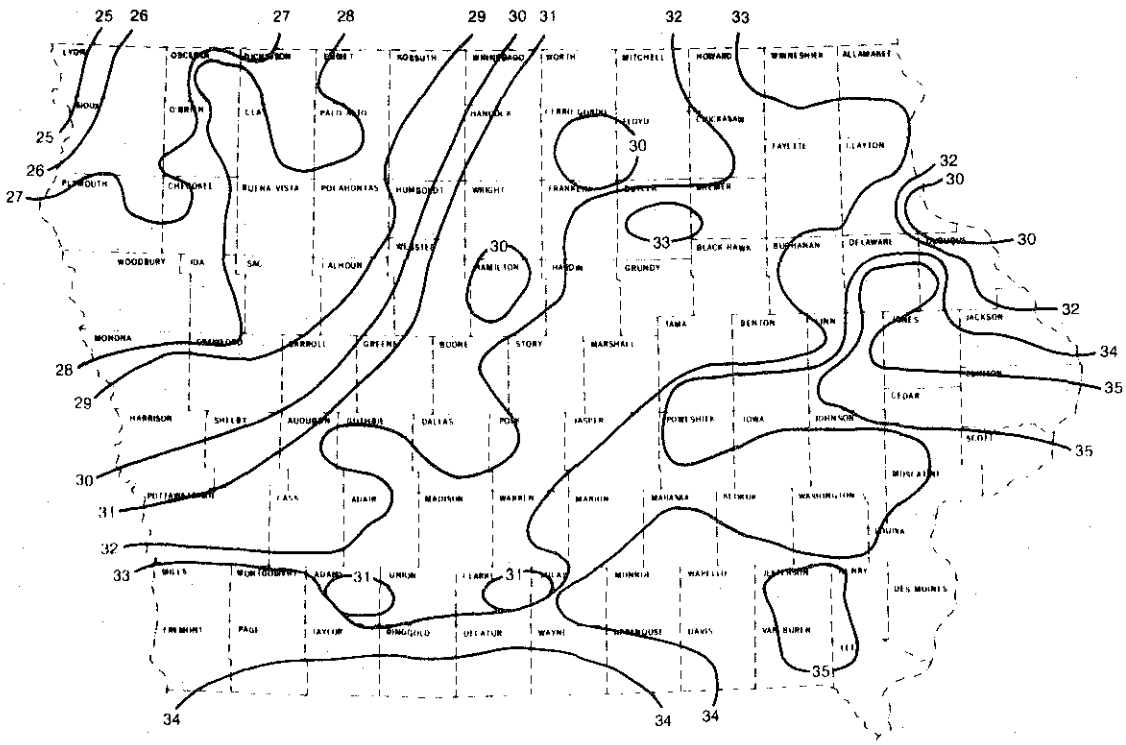


Figure 2

NORMAL CROP SEASON PRECIPITATION IN INCHES

(APRIL THROUGH SEPTEMBER)

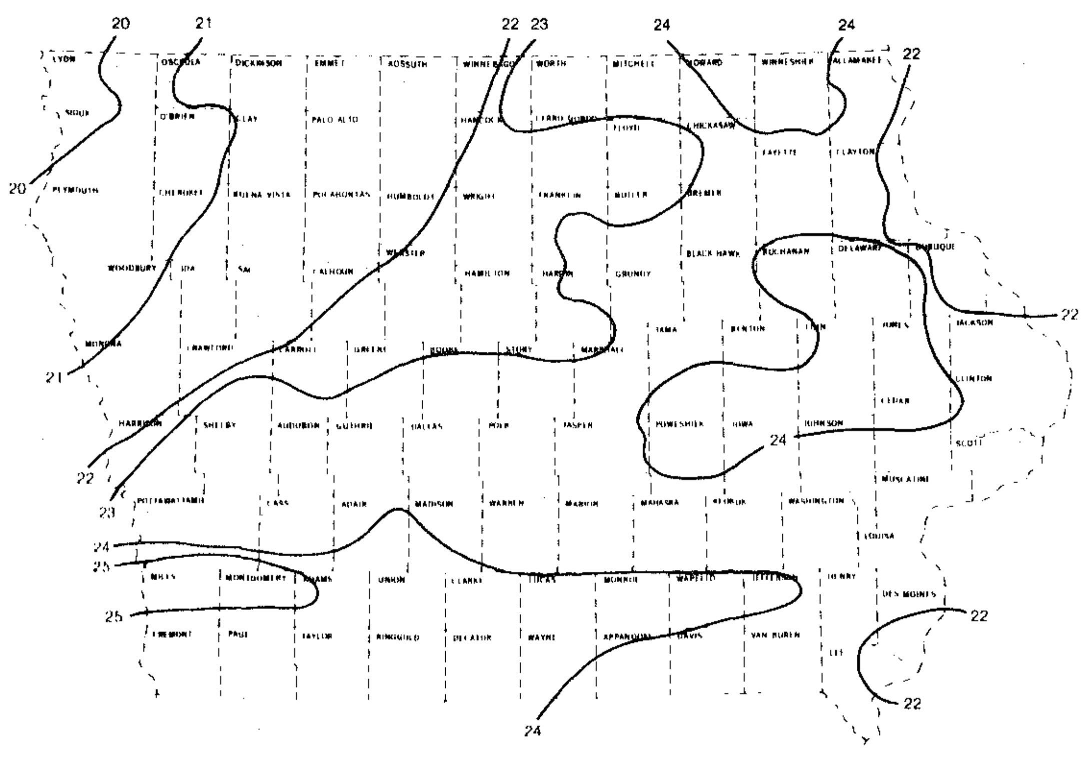


Figure 3

during the crop season which extends from April to September, Figure 3. Rainfall in Iowa is relatively well distributed in space and time as contrasted with the more arid western states. The normal monthly precipitation in Iowa varies from a maximum of 5 inches in June to 1 inch in both January and February.

On nearly 180 days of the year, a trace or more of precipitation falls at all Iowa locations. Rainfall exceeding 0.1 inch per day falls on each of about 60 days per year. Normal annual precipitation, averaged for the state, is 32 inches.

Evaporation and Evapotranspiration

Evaporation is the process by which water is transformed from liquid to vapor. The rate at which evaporation occurs primarily depends upon the amount of heat received by the body of water, the ambient temperature of the water, wind velocity and the level of saturation of the air (humidity). Evaporation losses vary between 45 inches, in northeastern counties, to 60 inches, in southwestern counties.

Evapotranspiration is the combined loss of water by evaporation and plant transpiration, and includes losses from surface water bodies, subsurface soil moisture and the surfaces of vegetation. About 75 percent of the moisture that is returned to the atmosphere through evapotranspiration occurs during the growing season.

Natural Lakes and Reservoirs

Approximately 870,000 acre-feet of water is impounded by Iowa's lakes and reservoirs. The total surface area of impoundments in the state exceeds 130,000 acres, which is equal to only about 0.4 percent of the state's land.

The natural lakes of Iowa are generally shallow and small, ranging in surface area from 5,684 acres (Spirit Lake) to fewer than 10 acres (Lake Park Pond in Dickinson County). These lakes have maximum depths which vary from 4 to 134 feet, the latter being the maximum depth of West Okoboji. Most of Iowa's natural lakes are in the north-central part of the state. The water stored in these lakes is estimated at about 300,000 acre-feet. State-owned reservoirs (artificial lakes) are estimated to contain an additional 50,000 acre-feet of water.

There are over 47,000 farm ponds in Iowa, and their total storage capacity exceeds 119,000 acre-feet, Figure 4. Most of these are located in the southern half of the state, where surface water is limited during dry summer months and ground water is sometimes chemically unsuitable or too deep to develop economically.

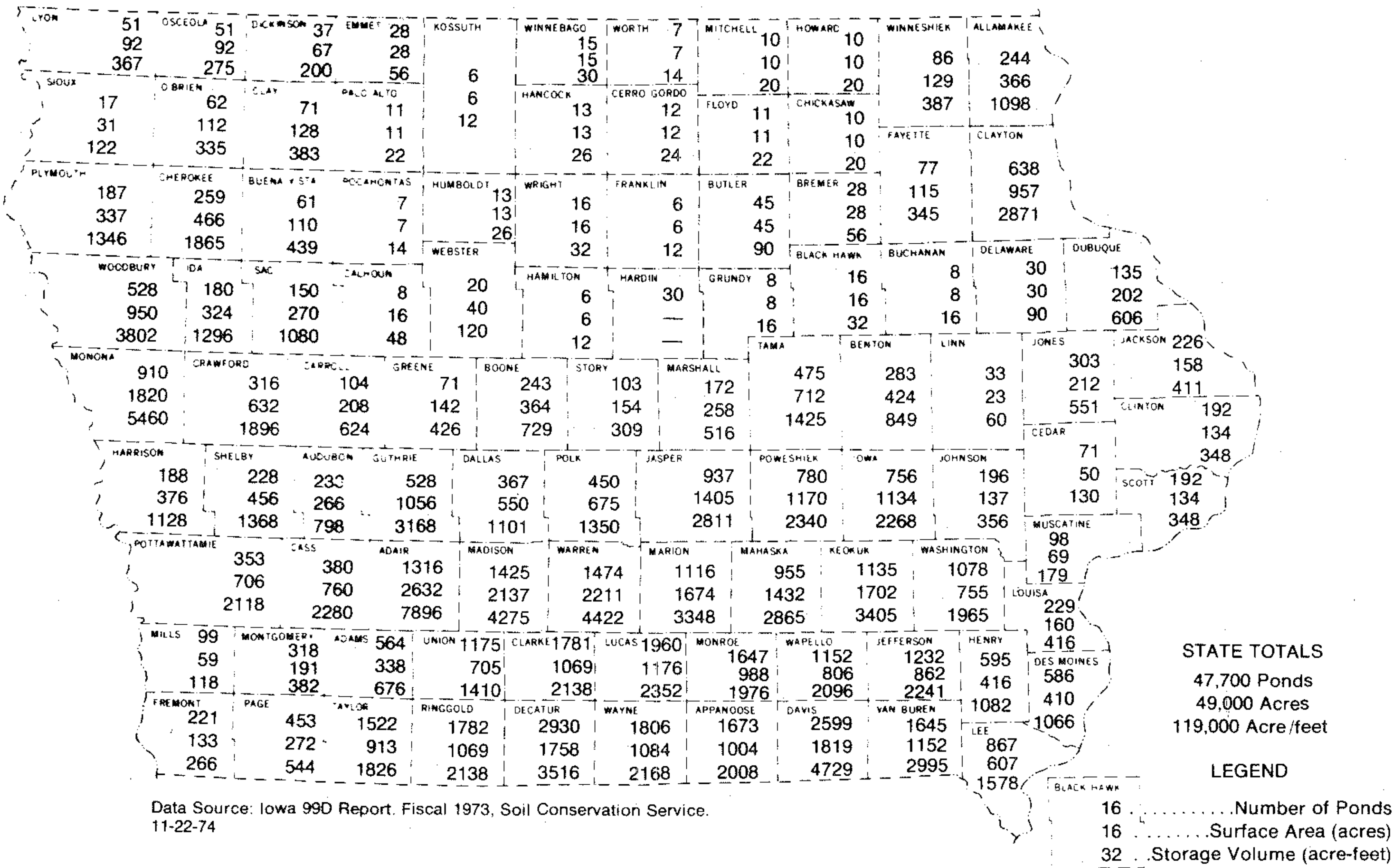
There are four U.S. Army Corps of Engineers multiple-purpose reservoirs in Iowa: Coralville, Redrock, Rathbun and Saylorville, Figure 5. At normal pool level these reservoirs have a total combined storage capacity of about 400,000 acre-feet.

Streamflow

River Basins and Annual Runoff

Figure 8 shows the six major river basins of Iowa. The spatial variability of flow in Iowa's interior streams ranges widely,

FARM PONDS IN IOWA



Data Source: Iowa 99D Report, Fiscal 1973, Soil Conservation Service.
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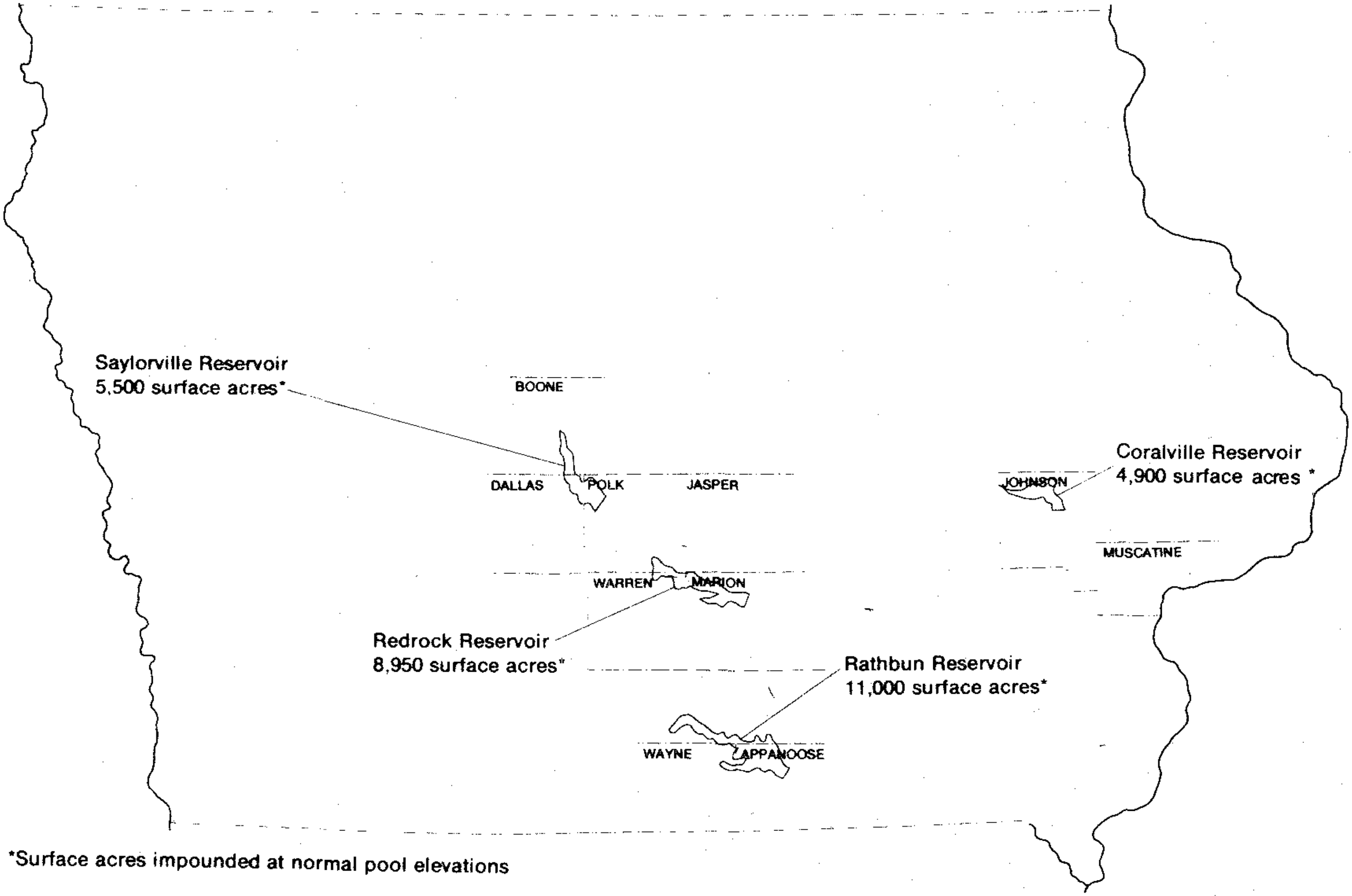
Figure 4

FEDERAL RESERVOIRS



*Surface acres impounded at normal pool elevations

Figure 5

as is shown in Figure 6. For Iowa's interior streams, average runoff ranges between 8 inches in the eastern part of the state, to less than 2 inches in northwestern counties. Annual runoff, averaged for the state, equals about 6 inches or a total flow of 18 million acre-feet. Figure 7 shows the average yearly flows for the principal rivers of Iowa. Usually, peak flows occur in the spring and/or early summer, with low flows occurring in the late summer and winter months.

The Border Rivers of Iowa

The Mississippi River at McGregor has an average (39 year) discharge of 33,830 cfs (cubic feet per second) or 24,510,000 acre-feet per year, and 62,570 cfs (97 year) or 45,330,000 acre-feet per year at Keokuk. The Missouri River at Sioux City has an average (78 year) discharge of 31,910 cfs or 23,120,000 acre-feet per year, and 34,960 cfs (46 year) or 24,330,000 acre-feet at Nebraska City, Nebraska.

Water Quality In Iowa Streams

During periods of high runoff and above average flow, Iowa rivers usually have relatively low concentrations of dissolved solids. However, during low flow periods, when streamflows are largely sustained by ground water discharges, dissolved solids concentrations in streams are observed to increase. In terms of dissolved solids concentrations, the water in Iowa streams is generally ranked as being of good to excellent quality.

RIVER BASIN DISTRICTS AND AVERAGE ANNUAL RUNNOFF IN INCHES

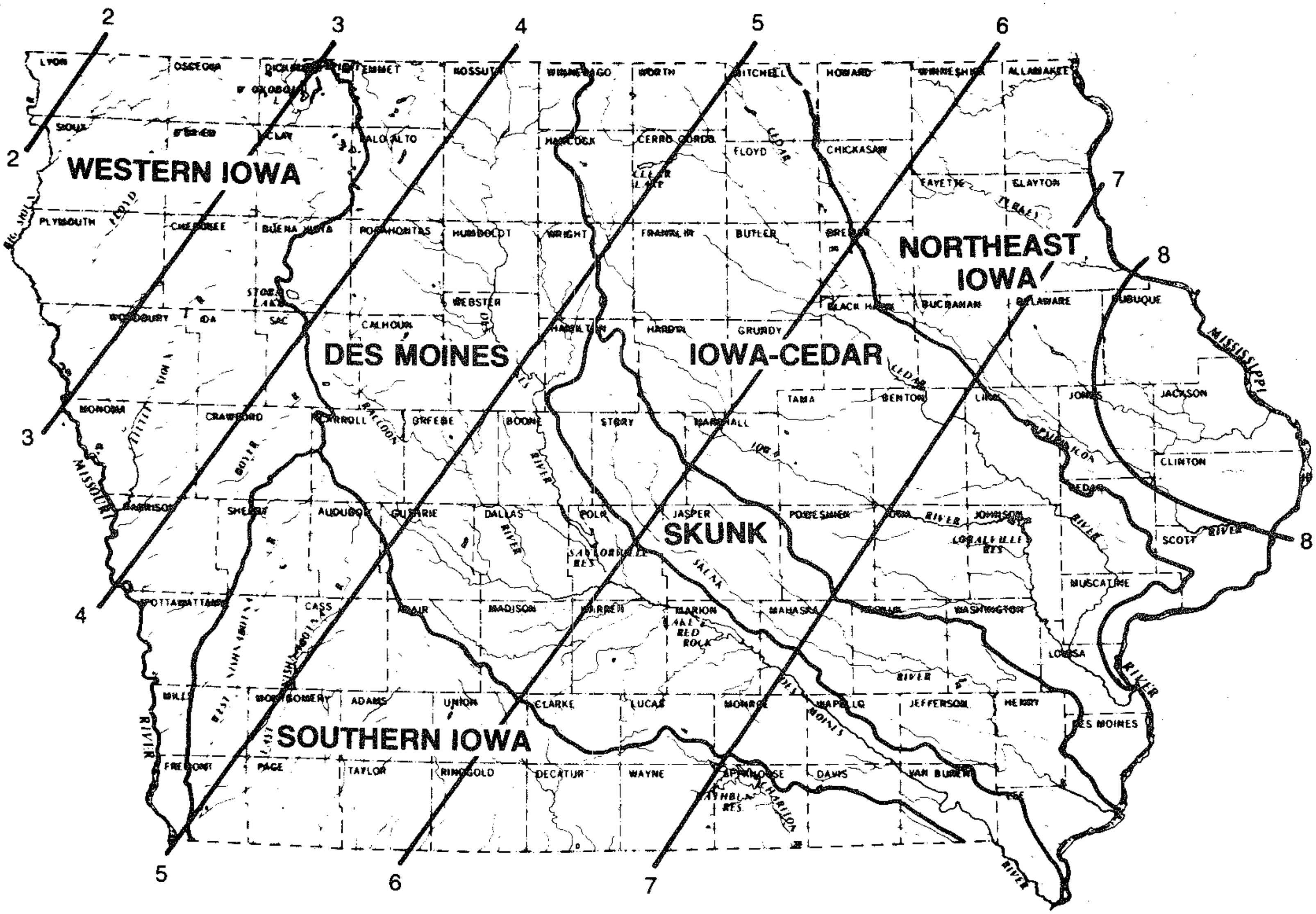
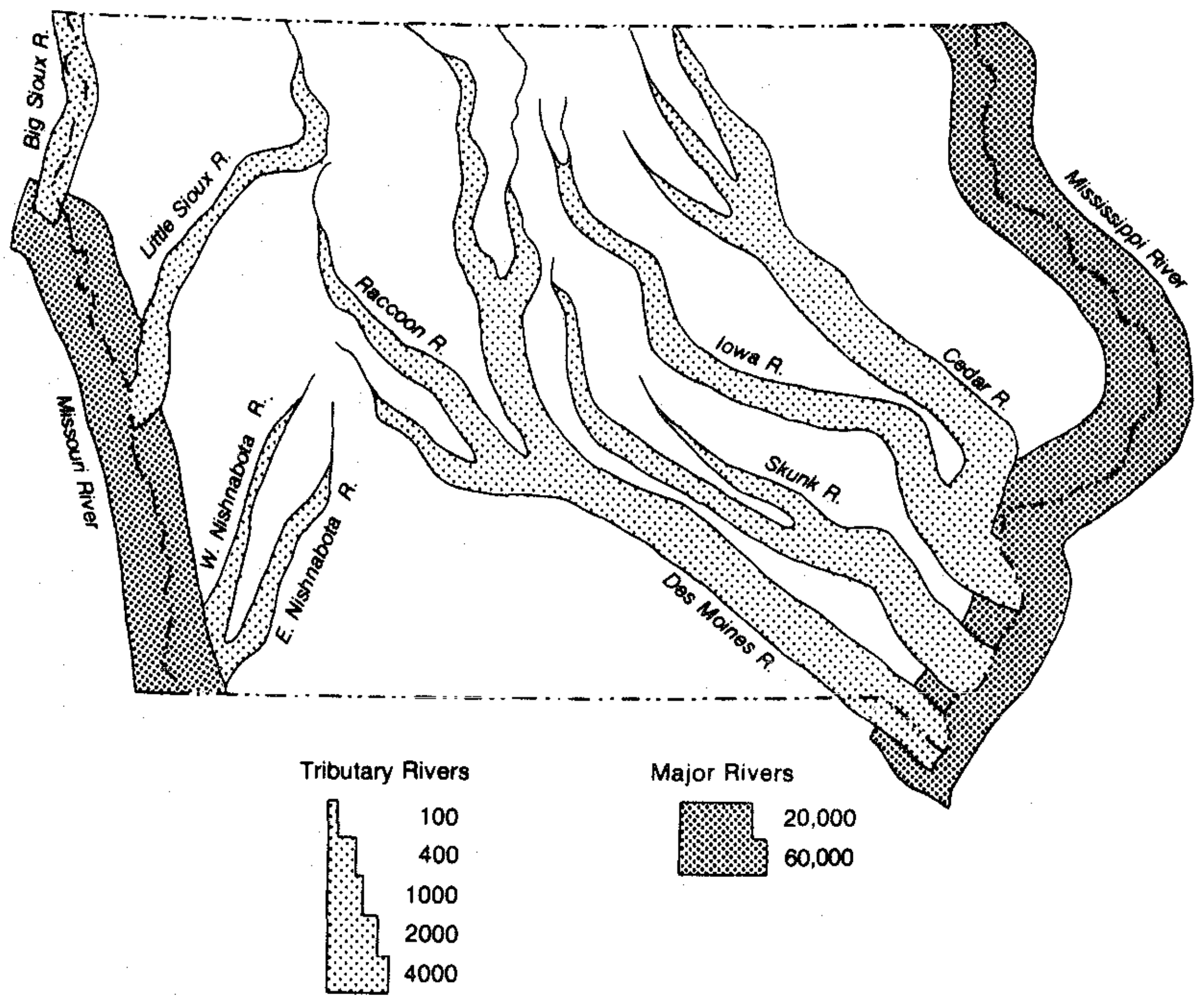


Figure 6

AVERAGE DISCHARGE OF THE PRINCIPAL RIVERS



Width of river indicates average discharge in cubic feet per second.
Source: U.S.G.S. Surface Water Division, Iowa

Figure 7

Sediment is a problem in many Iowa streams. Historical data clearly show that the major factors that determine the amount and rate of sediment discharge are precipitation, terrain, soil type and vegetation cover. Sediment discharges are higher in the hilly western and south-central part of the state than in the flatter areas of north-central and eastern Iowa. Stream sediment measurements indicate losses of about 10 tons per square mile per day along the East Nishnabotna at Red Oak. However, only about one-sixth this amount is indicated for the Iowa River at Iowa City (before construction of the Coralville Reservoir), and less than one-tenth of this amount for the Turkey River at Garber.

Surface Water Availability In Iowa

Not all of the water flowing in the streams of Iowa is available for use. When the flow at any location on a river is equal to or less than 84 percent duration flow, water cannot be withdrawn for consumptive purposes. The 84 percent duration flow is the regulated "protected flow" for streams and rivers in Iowa.

The combined yearly streamflow for the interior rivers of Iowa is estimated to be about 18 million acre-feet; that which is in excess of protected flow amounts, could potentially be made available for use. This volume is associated with peak discharge periods, occurring primarily from April through September, and can only be made available by a system of storage and flow regulation structures. Table 1 shows the estimated total runoff and the potential yield (assuming 100 percent retention of all water above the 84 percent duration flow) that can be developed or withdrawn from the river basins of Iowa. All estimates are based on averaged values.

Table 1. ESTIMATED YEARLY STREAMFLOW AND POTENTIAL YIELD IN ACRE-FEET

River Basin	Estimated Average Total Runoff (acre-feet/year)	Estimated Average Potential Yield (acre-feet/year)
1. Northeast	3,379,000	2,032,120
2. Iowa-Cedar	4,301,000	3,189,170
3. Skunk	1,720,000	1,459,430
4. Des Moines	4,065,000	3,408,860
5. Western	1,807,000	1,783,240
6. Southern	2,727,000	2,138,870
Total	17,999,000	14,011,690

Geology of Ground Water

Ground water in Iowa occurs in several different water-bearing units or aquifers. In simple terms, an aquifer is a body of natural earth materials (soil or rock) of sufficient volume, porosity and permeability to store and transmit water. The aquifers of Iowa are subdivided into two general categories. The first category includes several types of sand and gravel aquifers within the surficial (unconsolidated) materials that mantle the bedrock. The principal aquifers in this category are: localized sand and gravel bodies within the glacial drift (collectively the glacial drift aquifer); sands and gravels associated with the major streams of the state (alluvial aquifers); and sands and gravels buried in pre-glacial bedrock valleys (buried channel aquifers). The second category of aquifers is comprised of water-bearing limestone and sandstone units at several horizons in the bedrock beneath the state - - the bedrock aquifers.

Ground water is stored and transmitted under two conditions - - artesian (confined) and water table (unconfined). The water in artesian aquifers is confined under pressure by overlying, impermeable formations. In a well penetrating such an aquifer, water will rise above the bottom of the confining bed, shown in Figure 8. Water enters confined aquifers where the aquifer rises to the surface or where the confining bed ends underground. An unconfined aquifer is one in which a water table (the upper limit at which the ground is saturated with water) develops. Water levels in unconfined aquifers correspond to the undulating form and position of the water table. Regionally, the water table generally follows the land surface, rising beneath hills, declining toward stream valleys and intersecting the surface in streams, lakes and ponds, Figure 9.

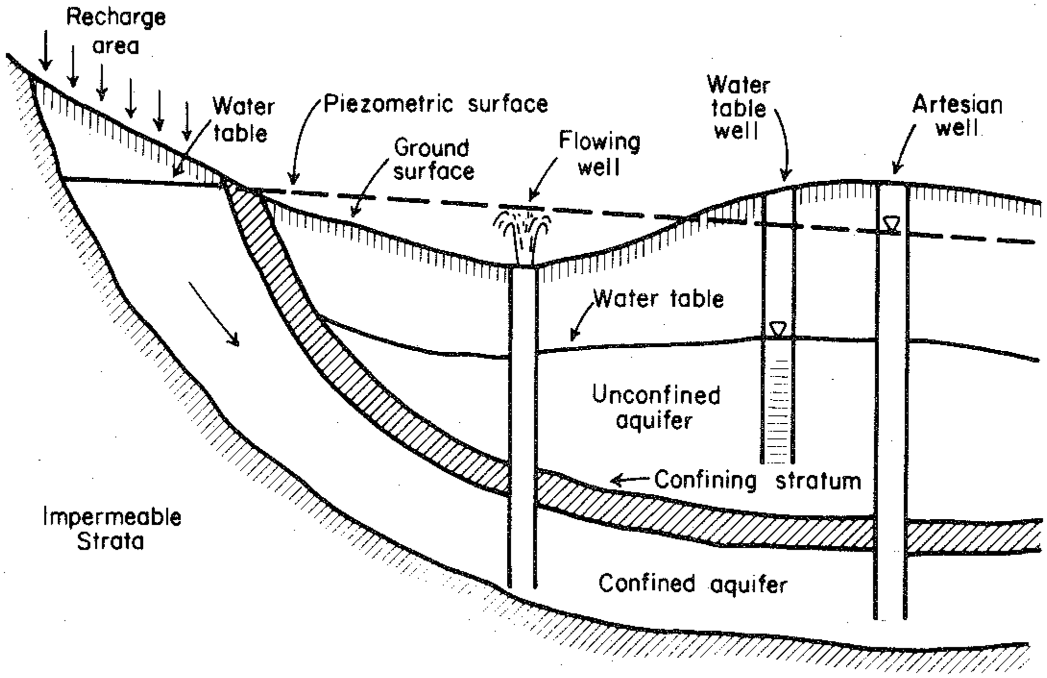


Figure 8. SCHEMATIC OF ARTESIAN AQUIFER SYSTEM

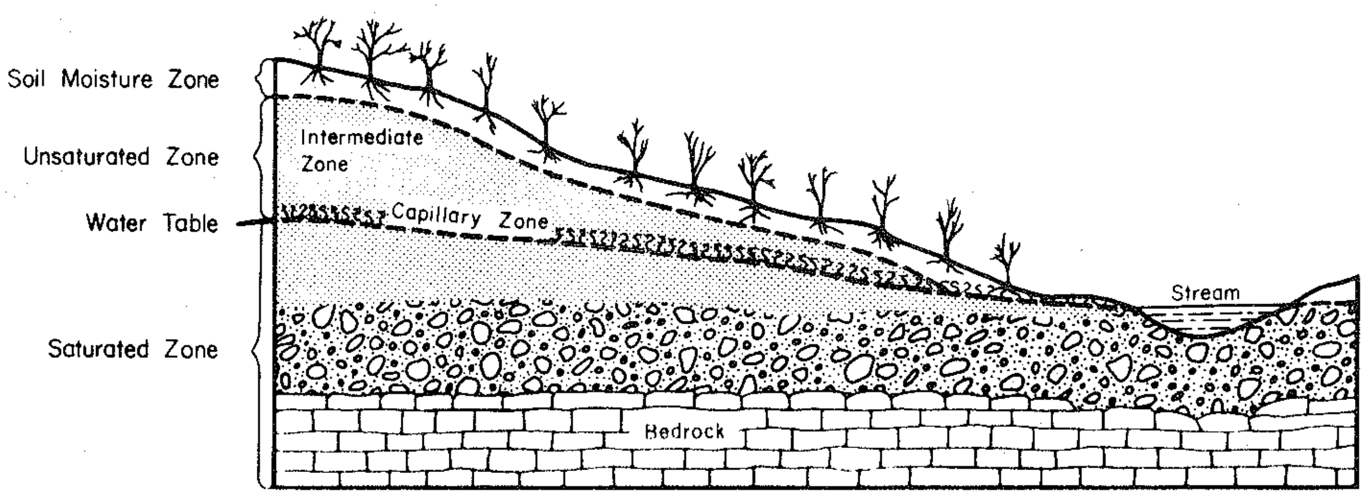
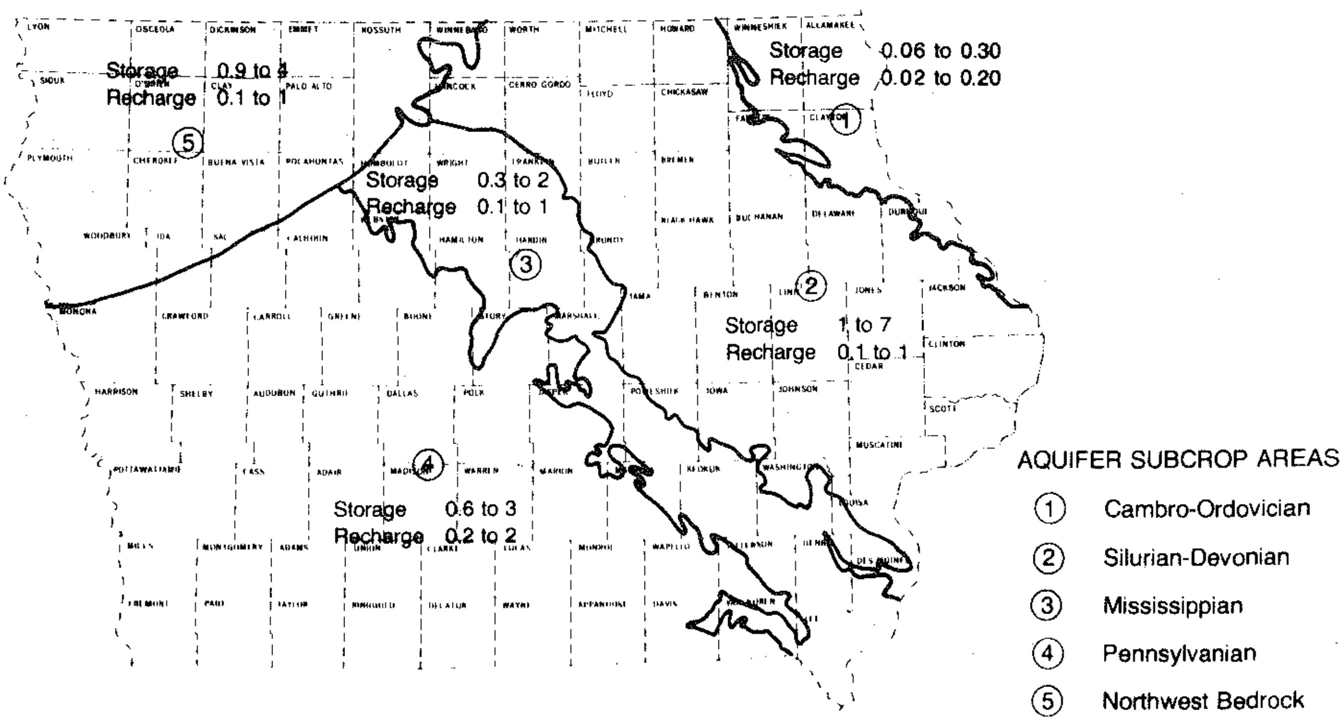


Figure 9. IDEALIZED DIAGRAM OF WATER DISTRIBUTION UNDER UNCONFINED (WATER TABLE) CONDITIONS

Glacial Drift Aquifer

At comparatively shallow depths over most of the state, generally less than 100 feet, small quantities of water can usually be obtained from wells drilled into the glacial drift. Typically, drift wells penetrate local, thin pockets of sand and/or gravel. During dry periods, in the southern and western parts of the state, these wells frequently "go dry" because of seasonal declines in the elevation of the water table. Figure 10 shows the distribution and storage estimates for the drift aquifer.

THE GLACIAL DRIFT AQUIFER
GROUND WATER IN STORAGE ESTIMATES
(IN MILLION ACRE-FEET)



Glacial Drift Aquifer Subareas correspond to the subcrop areas of Iowa's principal bedrock aquifers.

Figure 10

The Alluvial Aquifers

Many communities and large industrial water users in Iowa currently depend on alluvial sands and gravels as sources of water supply. Deposits of this type are associated with most of Iowa's major rivers and streams. Figure 11 shows the distribution, storage estimates, and yield potential for some of the major alluvial systems of the state.

ESTIMATED AQUIFER STORAGE AND POTENTIAL YIELD
ALLUVIAL AQUIFERS

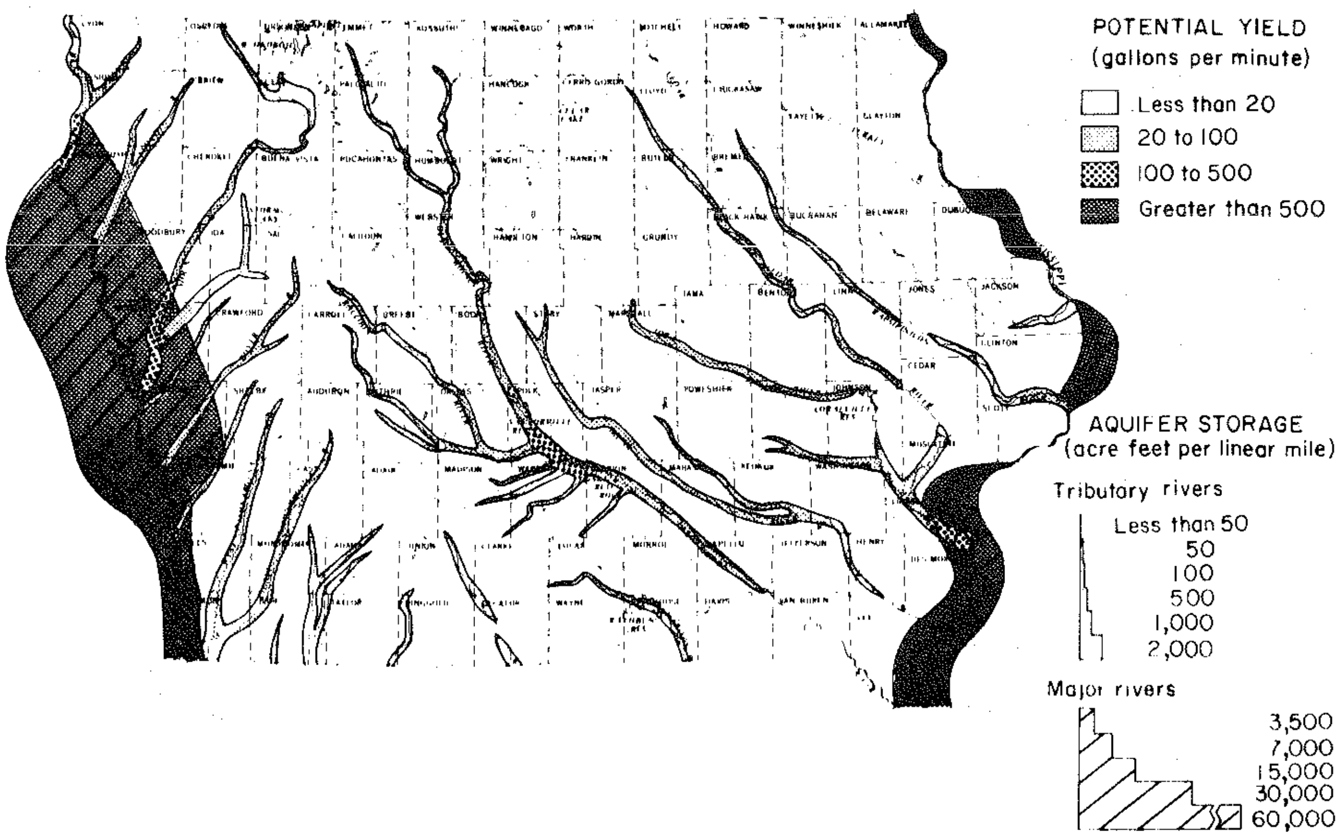


Figure 11

Buried Channel Aquifers

In certain areas of the state, predominantly in central and east-central Iowa, pre-glacial bedrock valleys exist beneath the glacial drift, Figure 12. Buried channel aquifers frequently are connected with overlying alluvial aquifers, and the two systems function as a single aquifer.

RECOGNIZED BURIED-CHANNEL AQUIFER SYSTEMS

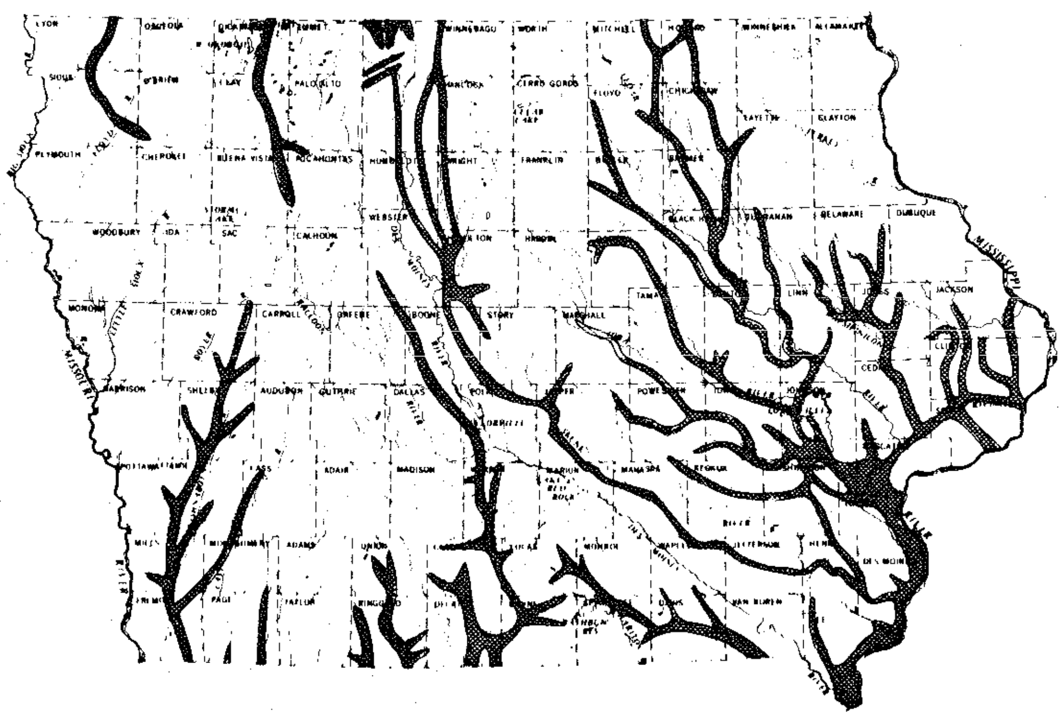


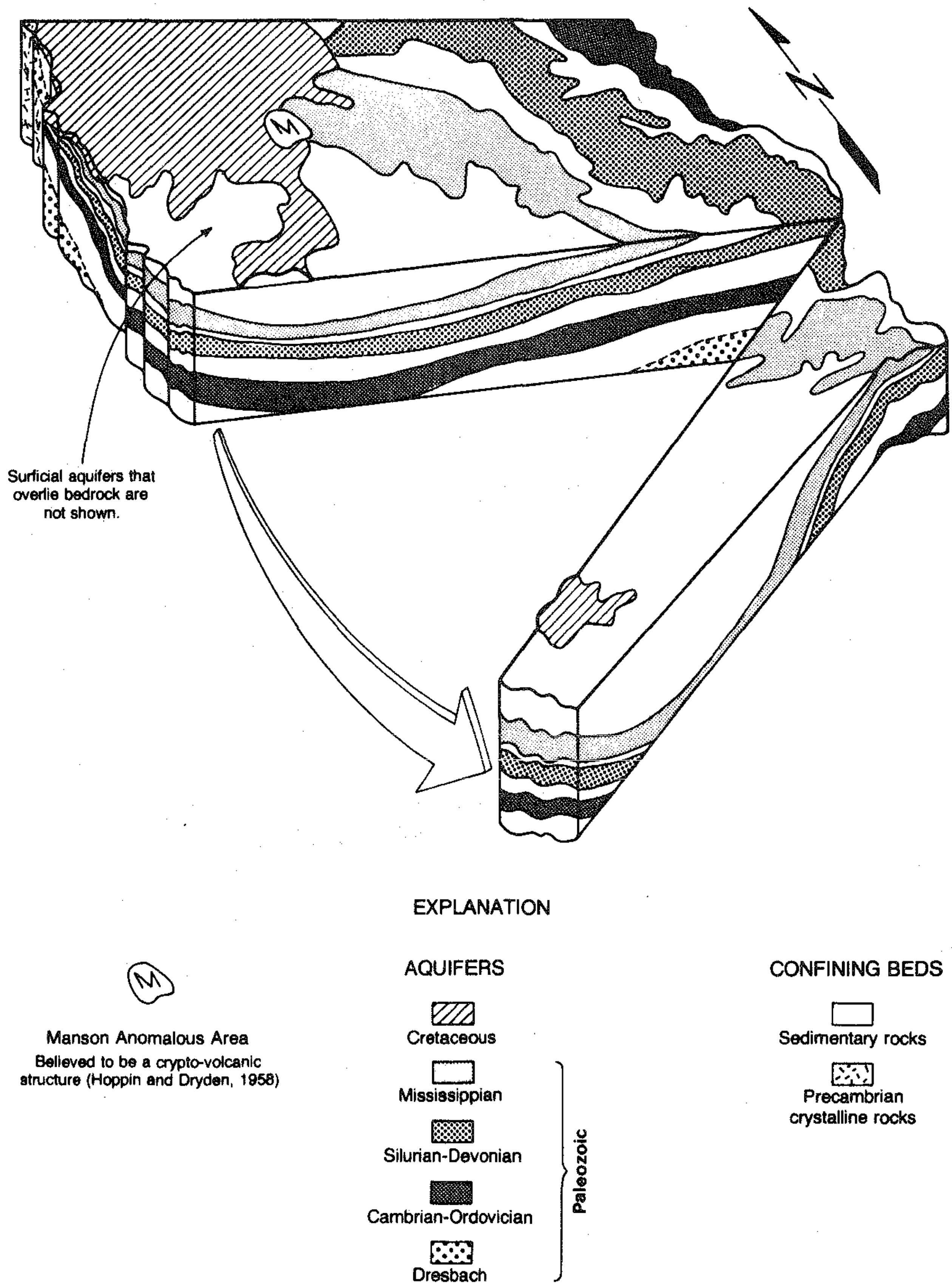
Figure 12

Bedrock Aquifers of Iowa

In the subsurface, beneath the unconsolidated materials of Iowa, the Paleozoic (Cambrian through Pennsylvanian) bedrock formations of the state slope toward a shallow basin, centered in the southwestern corner of the state. These older rock units (Paleozoics) constitute a relatively thick sequence of alternating rock layers comprised of limestone, dolomite, shale, siltstone and sandstone, Table 2. Within the sequence the thicker carbonate formations (limestones and dolomites) where fractured, creviced and otherwise permeable function as aquifers. The Mississippian and Silurian-Devonian aquifer systems are of this type. The lower portion of the Paleozoic sequence in Iowa contains several thick, permeable sandstone formations or units which are aquifers, notably the Jordan formation and the Dresbach group, Figure 13. As may be seen in Table 2 not all of the bedrock formations beneath Iowa are water producers. Many of these are comprised of dense, only slightly permeable siltstone, carbonate and shale formations. In many cases these units exist as impermeable barriers (aquicludes) which inhibit the cross flow of water between aquifer formations.

The northwestern part of the state is underlain by Cretaceous rocks which are younger (deposited later) than the Paleozoic units of the rest of the state. The rocks of the Cretaceous system are dominantly comprised of shales and sandstones. Within this sequence the Dakota sandstone formation is an important regional aquifer.

Generalized Bedrock Section of Iowa



Source: Modified from Steinhilber and Horick, 1970

Figure 13

Table 2. GEOLOGIC AND HYDROGEOLOGIC UNITS IN IOWA*

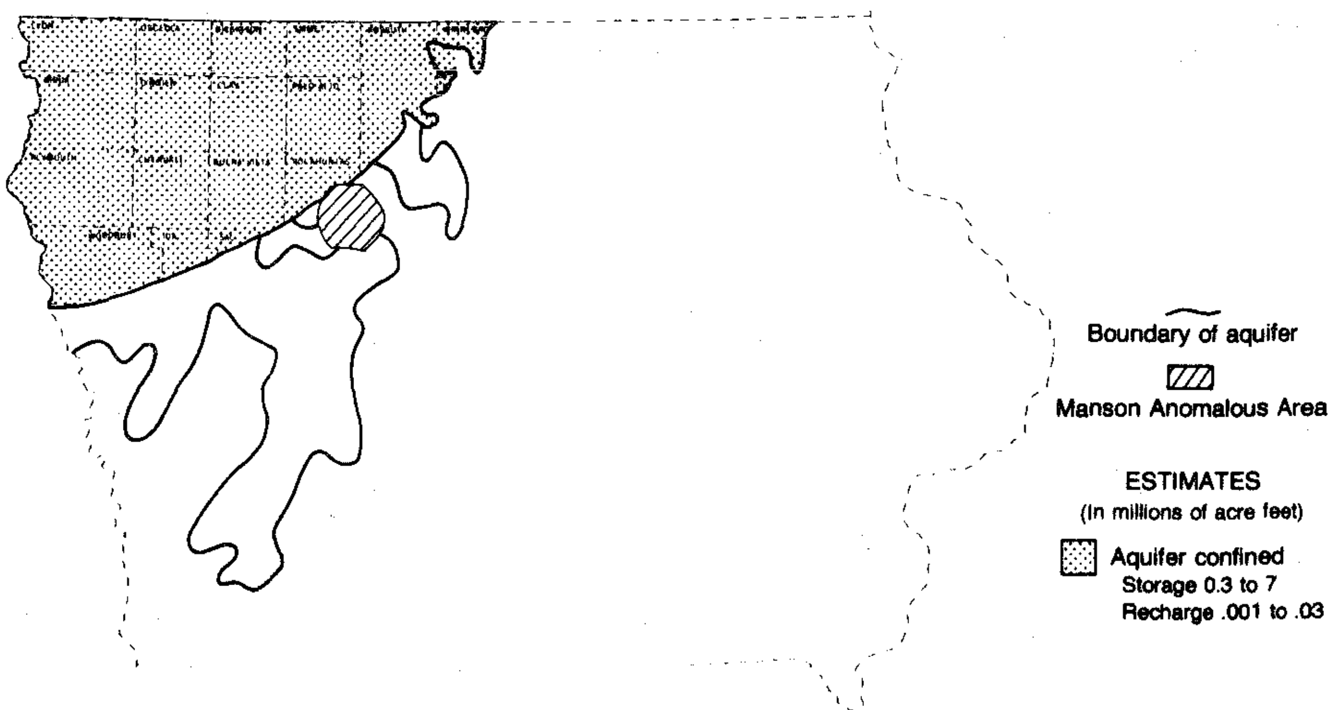
AGE		ROCK UNIT	DESCRIPTION	HYHDROGEOLOGIC UNIT	WATER-BEARING CHARACTERISTICS
Cenozoic	Quarternary	Alluvium	Sand, gravel, silt and clay	Surficial aquifer	Fair to large yields
		Glacial drift (undifferentiated)	Predominantly till containing scattered irregular bodies of sand and gravel		Low yields
		Buried channel deposits	Sand, gravel, silt and clay		Small to large yields
Mesozoic	Cretaceous	Carlile Formation Granerous Formation	Shale	Aquiclude	Does not yield water
		Dakota Group	Sandstone and shale	Dakota aquifer	High to fair yields
	Jurassic	Fort Dodge Beds	Gypsum, shale	Aquitard	Does not yield water
Paleozoic	Pennsylvanian	Virgil Series Missouri Series	Shale and limestone	Aquiclude	Low yields only from limestone and sandstone
		Des Moines Series	Shale; sandstones, mostly thin		
	Mississippian	Meramec Series	Limestone, sandy	Mississippian aquifer	Fair to low yields
		Osage Series	Limestone and dolomite cherty		
		Kinderhook series	Limestone, oolitic, and dolomite, cherty		
	Devonian	Maple Mill Shale Sheffield Formation Lime Creek Formation	Shale; limestone in lower part	Devonian aquiclude	Does not yield water
		Cedar Valley Limestone Wapsipinicon Formation	Limestone and dolomite; contains evaporites in southern half of Iowa	Silurian-Devonian aquifer	High to fair yields
	Silurian	Niagaran Series Alexandrian Series	Dolomite, locally cherty		
	Ordovician	Maquoketa Formation	Shale and dolomite	Maquoketa aquiclude	Does not yield water, except locally in northwest Iowa
		Galena Formation	Limestone and dolomite	Minor aquifer	Low yields
		Decorah Formation Platteville Formation	Limestone and thin shales; includes sandstone in SE Iowa	Aquiclude	Generally does not yield water; fair yields locally in southeast Iowa
		St. Peter Sandstone	Sandstone		Fair yields
		Prairie du Chien Formation	Dolomite, sandy and cherty	Cambrian-Ordovician aquifer	High yields
	Cambrian	Jordan Sandstone	Sandstone		
		St. Lawrence Formation	Dolomite	Aquiclude (wedges out in northwest Iowa)	Does not yield water
		Franconia Sandstone	Sandstone and shale		
		Dresbach Group	Sandstone	Dresbach aquifer	High to low yields
Precambrian		Sioux Quartzite	Quartzite	Base of groundwater reservoir	Not known to yield water except at Manson cryptovolcanic area
		Undifferentiated	Coarse sandstones; crystalline rocks		

*Adapted from Steinhilber and Horick

The Dakota Aquifer

Although more information is needed to adequately define the geology and hydrology of the Dakota aquifer, its known extent and estimates of storage are given in Figure 14. Throughout most of its area of occurrence the Dakota aquifer contains considerable amounts of shale and has water-bearing sands in both its upper and lower parts. In the eastern-most counties where the Dakota is present, only a single sandstone unit usually is found. The Dakota attains a maximum thickness of about 260 feet and averages 50-75 feet.

NORTHWEST BEDROCK AQUIFER SYSTEM*



a. Storage and Annual Recharge Estimates

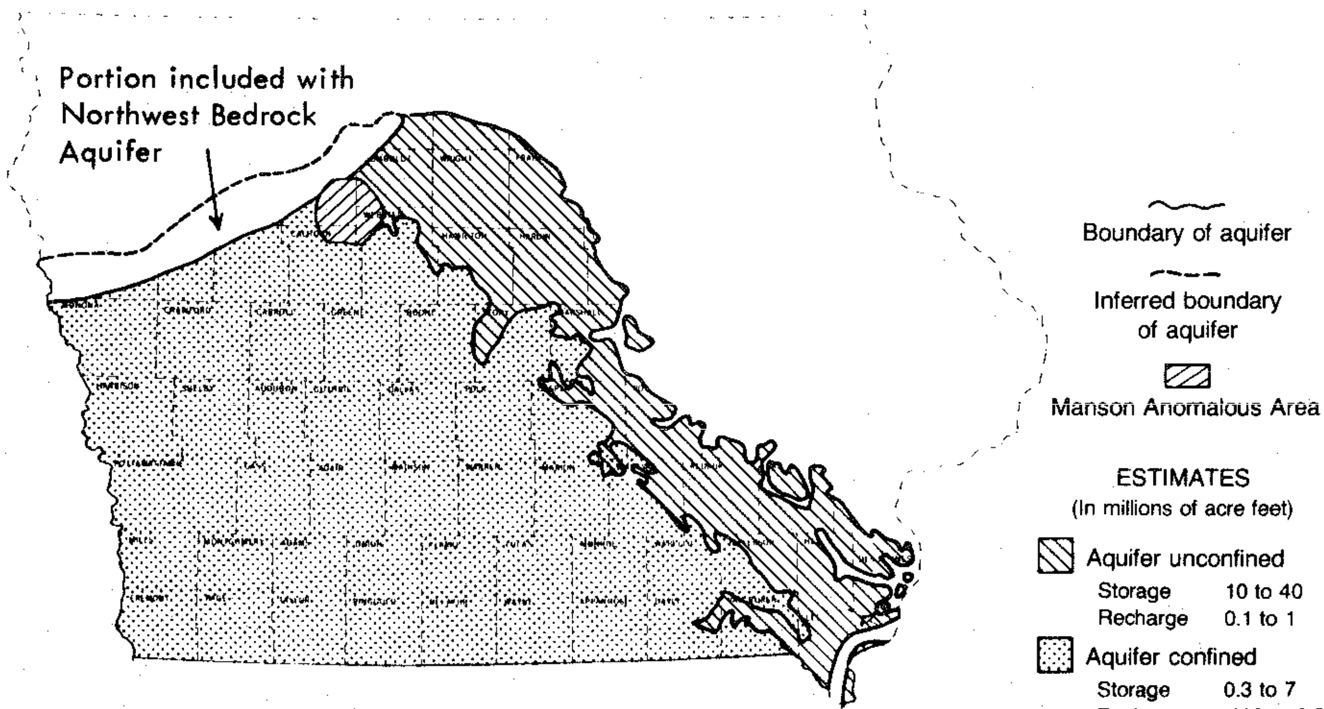
*Primarily the Dakota, but includes portions of the Mississippian, Silurian-Devonian, and Cambro-Ordovician.

Figure 14

The Mississippian Aquifer System

The Mississippian aquifer system is variable in thickness, ranging from 0 to 600 feet with an average thickness of approximately 350 feet. Its distribution and estimates of storage are given in Figure 15.

MISSISSIPPIAN AQUIFER SYSTEM



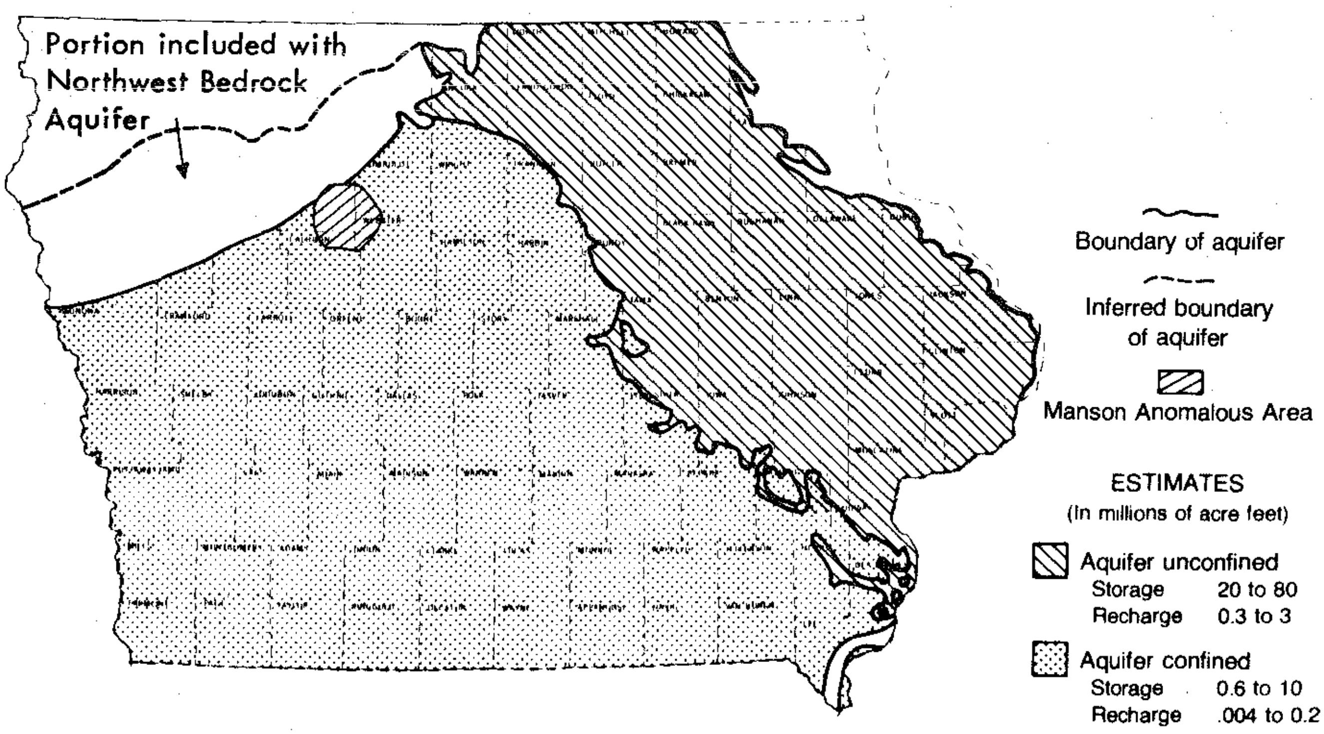
a. Storage and Annual Recharge Estimates

Figure 15

The Silurian-Devonian Aquifer System

The Silurian-Devonian aquifer system is comprised of a thick sequence of predominantly carbonate rock formations whose porosity and permeability are principally dependent on fractures, joints, and solution openings. Where these features are poorly developed or are absent, the water producing capability of the aquifer diminishes. The aquifer thickens progressively from its exposed thin edge in eastern Iowa to a maximum of 650 feet in western Iowa. Storage estimates and the distribution of the aquifer are given in Figure 16.

SILURIAN-DEVONIAN AQUIFER SYSTEM



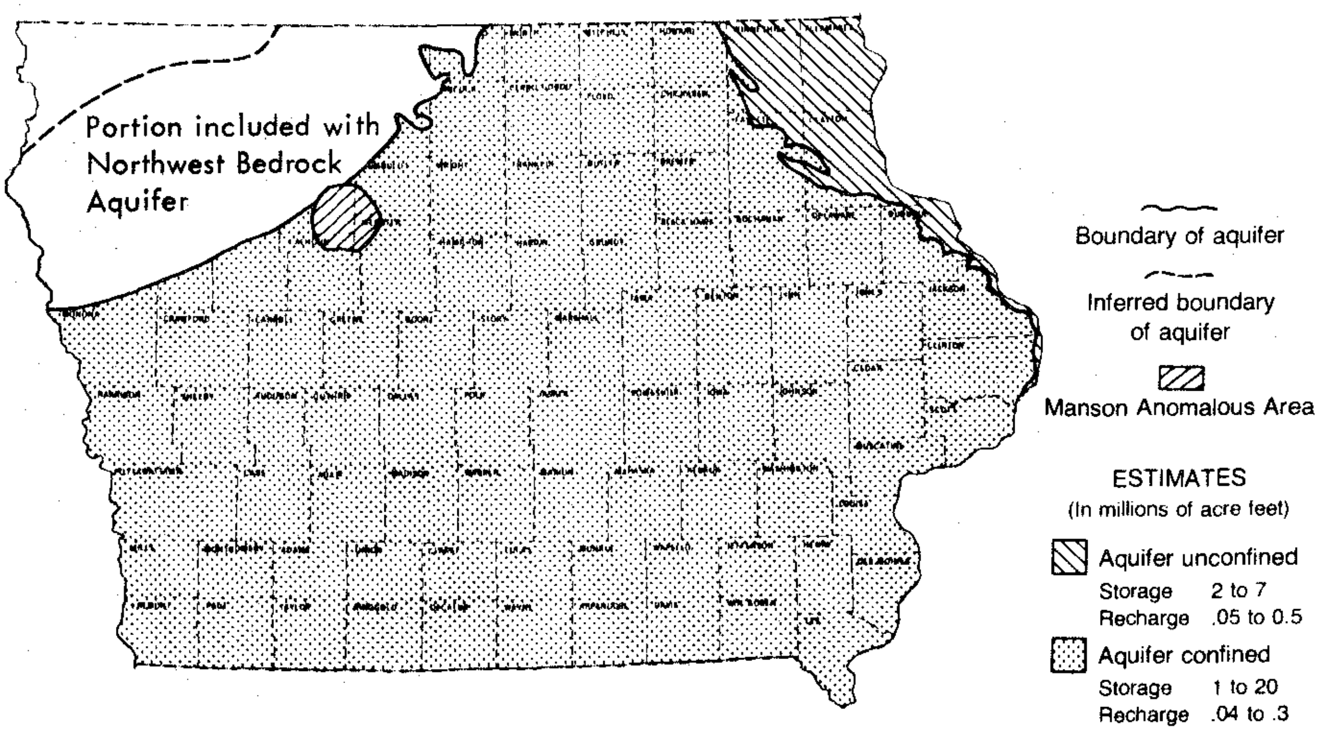
a. Storage and Annual Recharge Estimates

Figure 16

The Cambro-Ordovician Aquifer System

Except for a few northwestern Iowa counties, the Cambro-Ordovician aquifer system underlies the entire state, Figure 17. This aquifer, particularly the Jordan and St. Lawrence formations, is used as a major water supply source by communities and industry in nearly three-fourths of the state. The upper rock formations of the aquifer system are exposed at the surface in limited areas in northeast Iowa, and to the northwest they lie beneath younger Cretaceous rocks. In southwest Iowa the aquifer is buried under more than 3,000 feet of younger rock and unconsolidated materials. The total thickness of the Cambro-Ordovician aquifer system ranges between 0 and 600 feet and averages between 400 and 500 feet in thickness across the state.

CAMBRO-ORDOVICIAN AQUIFER SYSTEM



a. Storage and Annual Recharge Estimates

Figure 17

Ground Water Availability In Iowa

Iowa's stored ground water reserves, including annual replenishment through natural recharge probably represent more water than future Iowans might conceivably use. However, because much of this water is of unacceptable quality, is difficult to extract, or is not uniformly distributed across the state, only a small proportion is available to users. An economically developable ground water supply must meet several criteria. First, it must be accessible by wells of reasonable depth and at costs that are within limits determined by the user. Second, it must be extractable at sustained rates of yield that will satisfy anticipated or required delivery rates. Finally, it must be of a quality suitable to meet the developer's use or be treatable.

The distribution of Iowa's ground water resources and many of the state's availability problems relative to quantity and quality are most easily defined on a regional basis. For this reason the state has been sub-divided into four ground water districts: the Northeastern, Central, Southwestern, and Northwestern, Figure 18. These districts are based on hydrologic and geologic similarities. The various potential sources of ground water supply for each ground water district are evaluated in terms of: median storage (a middle value gross storage estimate), median annual recharge (a middle value gross annual recharge estimate), potential yield (expected yield rate according to historical pumping data), accessibility (depth to aquifer) and finally, general water quality (based on acceptability for drinking, according to U. S. Public

IOWA GROUND WATER DISTRICTS

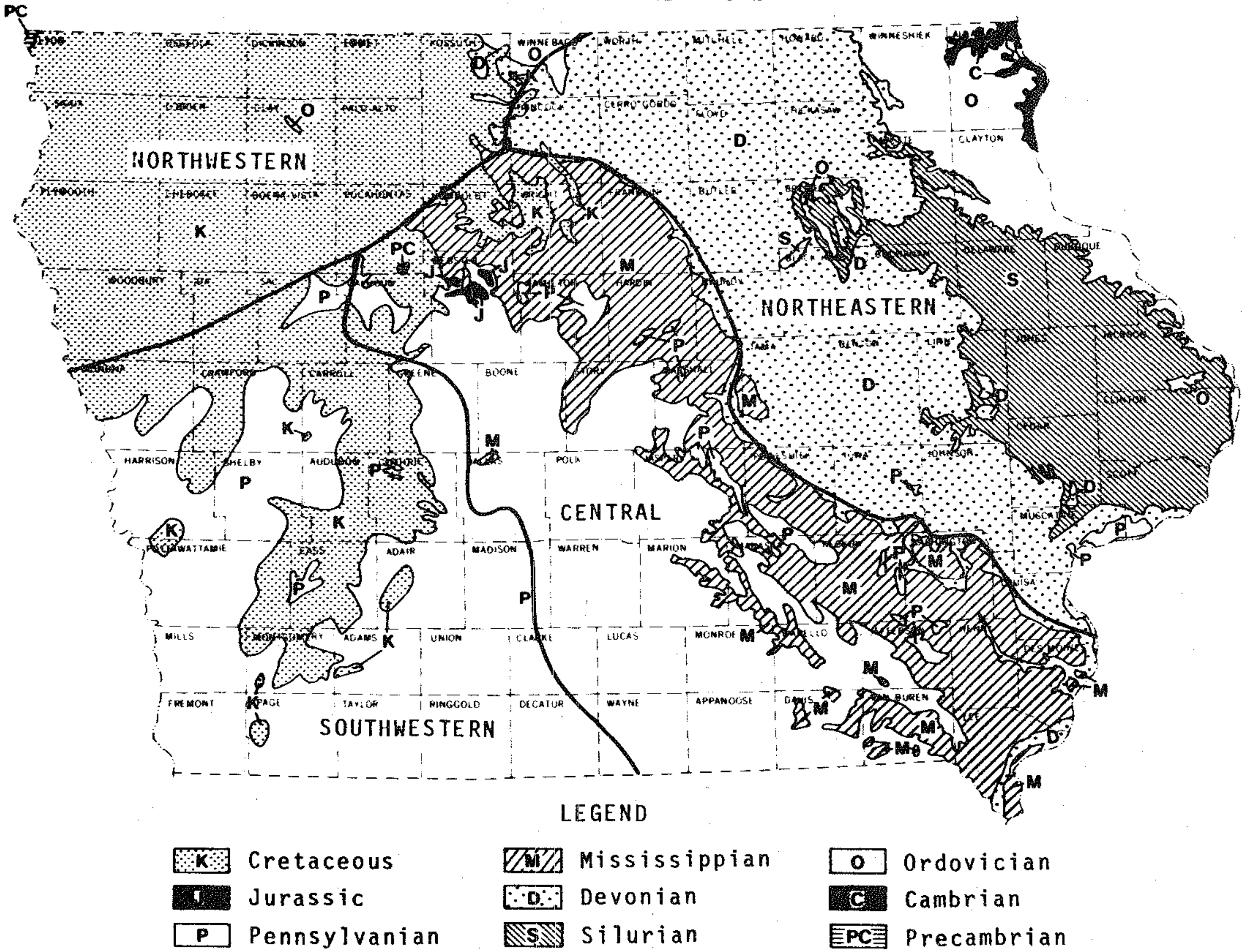


Figure 18

Health Service standards).

Ground Water Availability in the Northeastern Iowa Ground Water District

The most abundant and best quality ground water in the state occurs in this district. The major aquifers that have been developed here are the glacial drift, alluvial deposits of interior streams and the Mississippi River, and the Silurian-Devonian, Cambro-Ordovician and Dresbach aquifer systems.

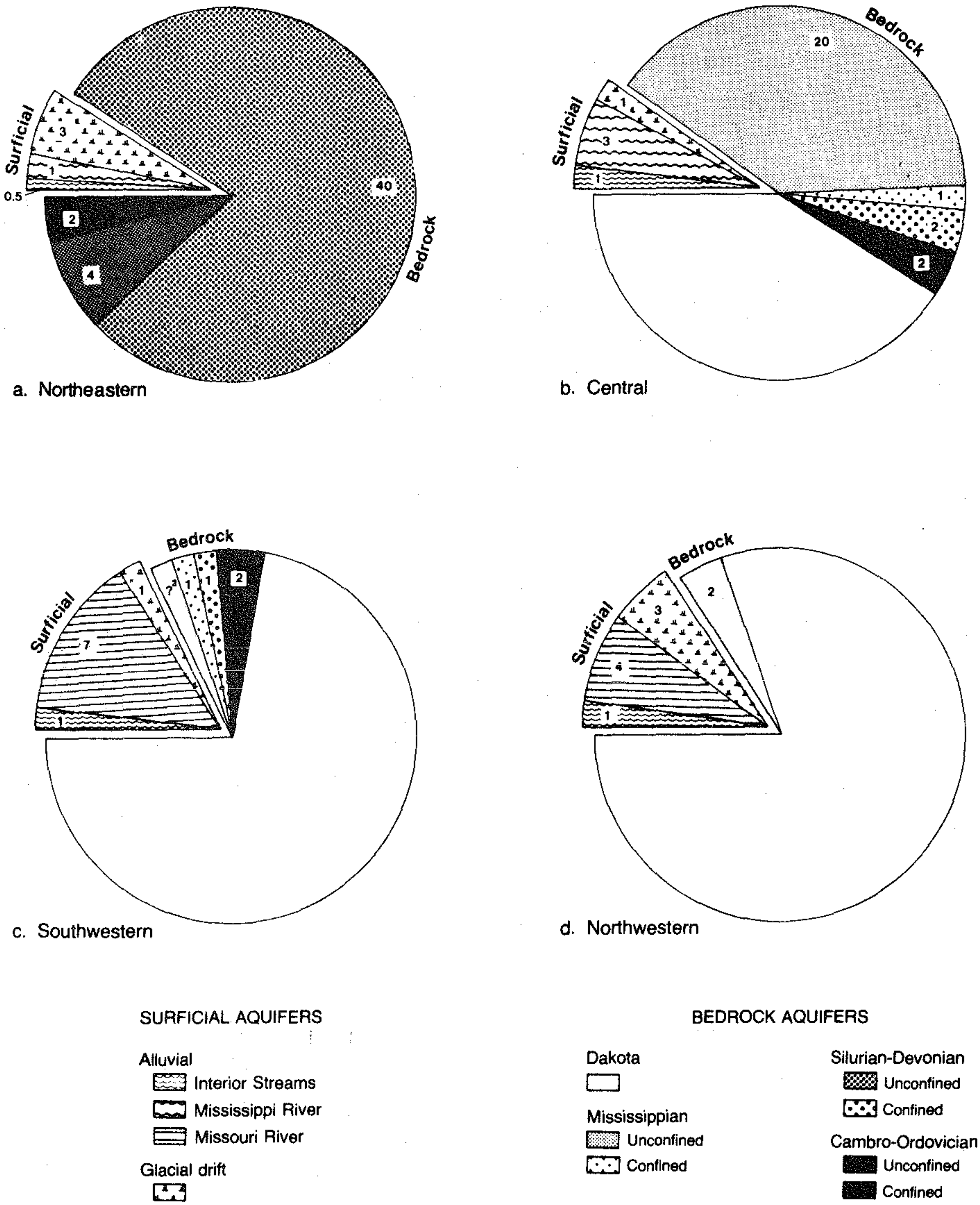
Storage and Recharge

It is estimated that the ground water reserves from all available sources of this district exceed 50 million acre-feet. The annual rate of recharge to all aquifers of the district is estimated to be in excess of 1.5 million acre-feet. Figures 19a and 20a indicate that the unconfined portions of the Silurian-Devonian and Cambro-Ordovician aquifer systems, the glacial drift, and Mississippi River alluvium account for the majority of water in storage. They also receive the largest volumes of annual recharge. The Dresbach aquifer is a significant ground water source only along the eastern margin of the district. Because it is only locally important, the Dresbach aquifer is not discussed in this summary.

Yield and Accessibility

Many domestic wells in the Northeastern Ground Water District obtain their water from the glacial drift. Although the drift

GROUND WATER STORAGE ESTIMATES FOR INDIVIDUAL AQUIFERS
BY GROUND WATER DISTRICT[1]
(IN MILLIONS OF ACRE-FEET)

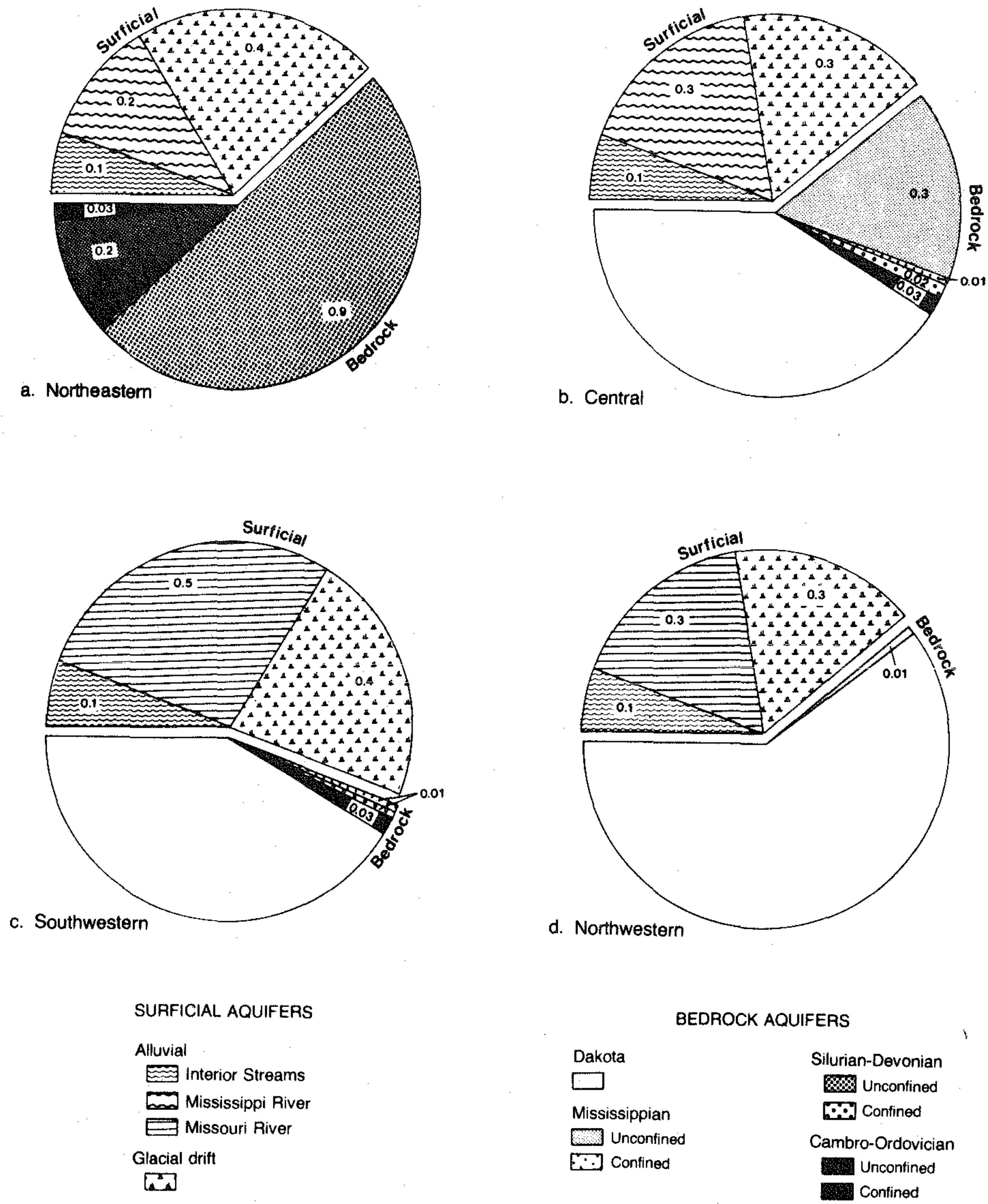


[1] Based on median values obtained from annual recharge range estimates.

[2] No estimates were made for the Dakota outside of the Northwestern Aquifer District owing to its obscure geologic and hydrologic relations.

Figure 19

ANNUAL RECHARGE ESTIMATES FOR INDIVIDUAL AQUIFERS BY GROUND WATER DISTRICT[1] (IN MILLIONS OF ACRE-FEET)



[1] Based on median values obtained from annual recharge range estimates.

Figure 20

stores large volumes of water, and its annual recharge is significant, the potential for its development is limited by low yields. Drift wells seldom yield more than 10 gpm and more commonly only between 3 and 5 gpm, Figure 21. There are several local exceptions in the north-central part of the district where basal drift sands and gravels and drift-filled bedrock valleys are highly productive, often yielding up to 500 gpm.

Alluvial deposits along the Mississippi River and major interior streams are sources of large volumes of ground water. Water from these sources generally can be obtained from wells not exceeding 100 feet in depth. About 95 percent of the wells developed in deposits of the Mississippi River alluvial system are capable of delivering more than 1,000 gpm on a sustained basis. The remaining 5 percent probably can produce between 500 and 1,000 gpm. Along the major interior streams, alluvial sands and gravels generally support yields at rates between 200 and 400 gpm. There are notable exceptions where much larger yields are obtained because of significant induced recharge from adjacent streams. Examples are wells at Waterloo, where yields of 2,000 gpm have been achieved, and at Cedar Rapids, where alluvial wells produce between 500 and 1,000 gpm.

Two bedrock aquifer systems, the Silurian-Devonian and the Cambro-Ordovician, underlie nearly the entire district. Throughout most of the area, Figure 22, wells penetrate these aquifers at shallow to intermediate depths. In about 60 percent of the district, Silurian-Devonian wells can be expected to yield from 100

POTENTIAL YIELD FOR INDIVIDUAL AQUIFERS BY GROUND WATER DISTRICT

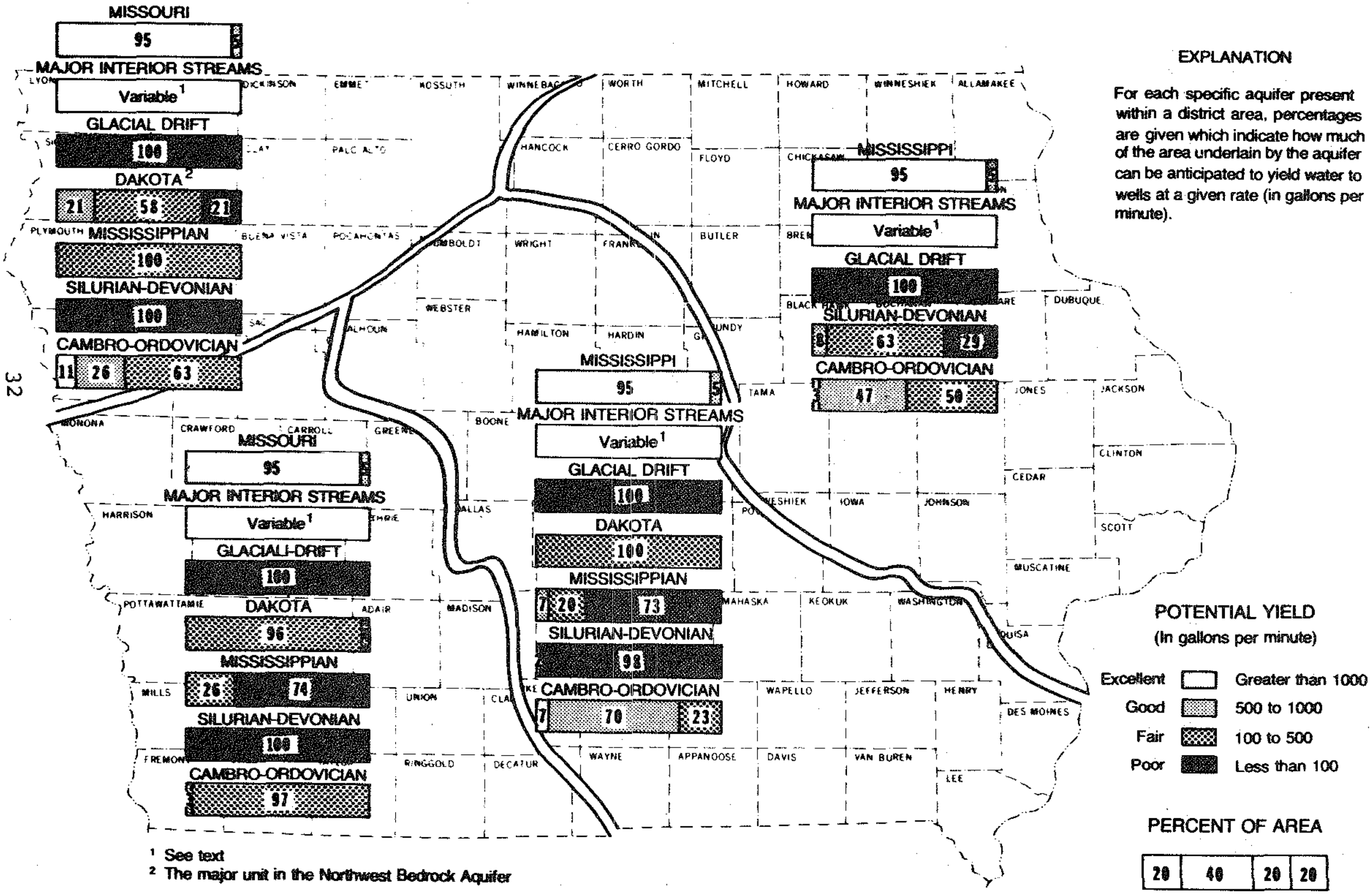


Figure 21

ACCESSIBILITY OF INDIVIDUAL AQUIFERS BY GROUND WATER DISTRICT

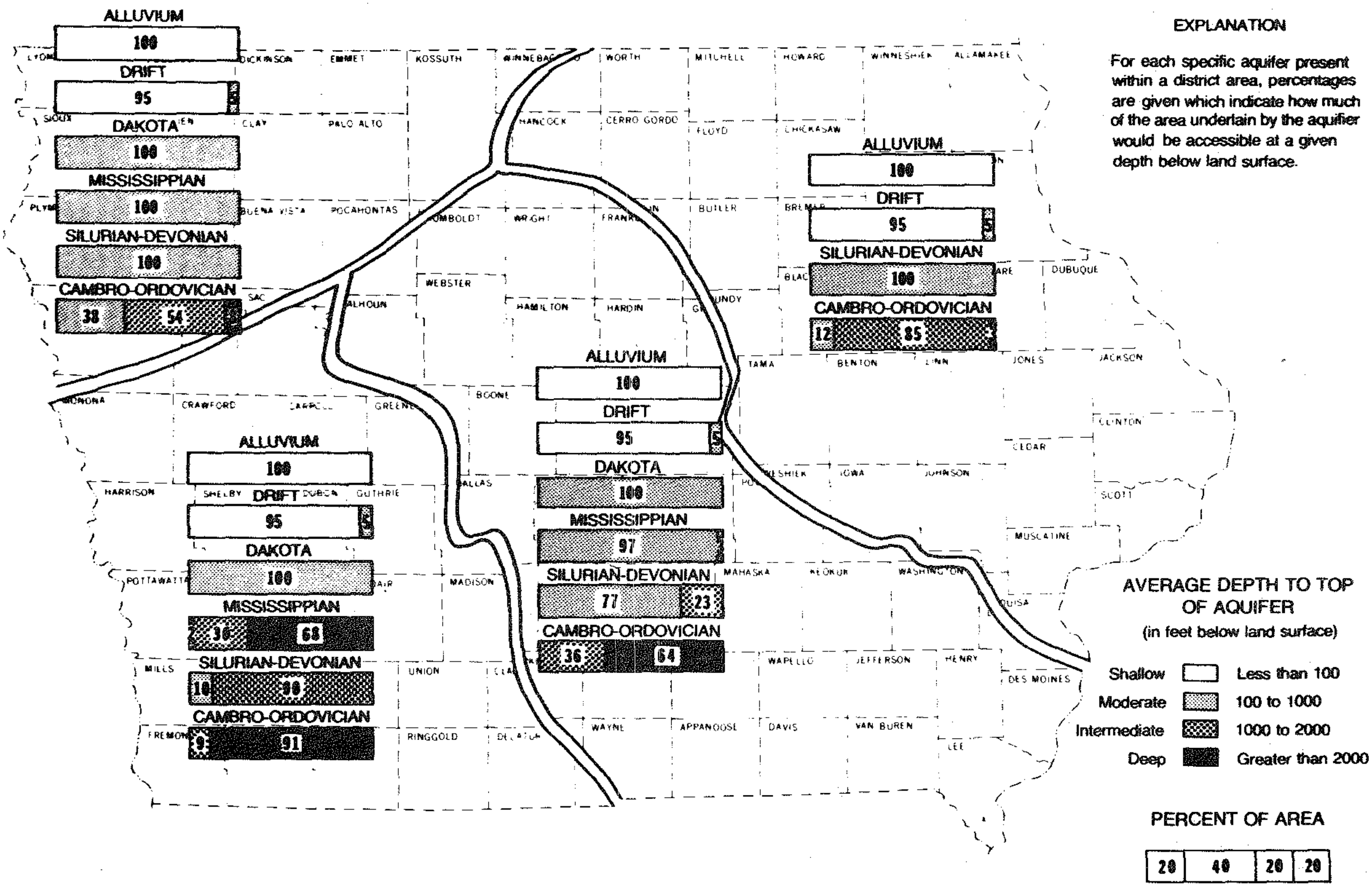


Figure 22

to 500 gpm and in the remaining 40 percent less than 100 gpm. The Cambro-Ordovician is deeper throughout the district, but its yield potential to wells is greater - - 500 to 1,000 gpm or more for 50 percent of the district and between 100 and 500 gpm throughout the remainder.

Adequate supplies for most domestic uses may be obtained at shallow to moderate depths from the glacial drift, alluvial, and the Silurian-Devonian Aquifer System. Greater demands (100-500 gpm), such as those of smaller communities, light industry,and large livestock operations, can be satisfied at shallow to moderate depths from the alluvial and Silurian-Devonian aquifers, but only rarely from the glacial drift. At moderate depths in the northeastern part of the district, and at intermediate depths throughout the rest of the district, Figure 22, the Cambro-Ordovician aquifer will supply these same demands. Very large (greater than 1,000 gpm) ground water demands, such as those of heavy industry and large municipal supplies, can generally be met only by wells in the alluvial deposits of the Mississippi River and from the Cambro-Ordovician aquifer. Infrequently, yields in this range have been obtained from the alluvium of interior streams and the Silurian-Devonian aquifer, where induced recharge is the major contributor (mainly along the Cedar River).

Water Quality

Ground water quality is generally not a problem within the Northeastern Iowa Ground Water District. Although hardness is a common problem in the district, as it is for much of Iowa, water quality, as indexed by total dissolved solids concentrations, is not. As noted in Figure 23, most of the ground water in this region is of good to fair quality (less than 1,000 mg/l TDS).

Ground Water Availability in the Central Iowa Ground Water District

The ground water reserves of the Central Iowa Ground Water District are nearly as large as those of the Northeast District. However, they are unevenly distributed relative to quantity, quality, and potential yield. Within this district there is a marked imbalance in the available water between the northern and southern halves of the region, primarily in terms of low yield potentials and inferior water quality.

Storage and Recharge

Figures 19b and 20b present median estimates for storage and annual recharge. The aggregate totals for the district are 30 and 1 million acre-feet respectively.

About 70 percent of the ground water stored within this district is present within the unconfined (water table) portion of the Mississippian Aquifer System. These reserves are predominantly limited to the eastern one-third of the district. The remaining reserves of the district are about equally divided among the various unconsolidated aquifer units and the confined (artesian) portions of the Mississippian, Silurian-Devonian and Cambro-Ordovician bedrock aquifer systems. The alluvial sediments of the Mississippi

GROUND WATER QUALITY FOR INDIVIDUAL AQUIFERS BY GROUND WATER DISTRICT

EXPLANATION

For each specific aquifer present within a district area, percentages are given which indicate how much of the area underlain by the aquifer can be anticipated to yield water of a given quality. The index of water quality is the U.S. Public Health Service drinking water standard for total dissolved solids concentrations.

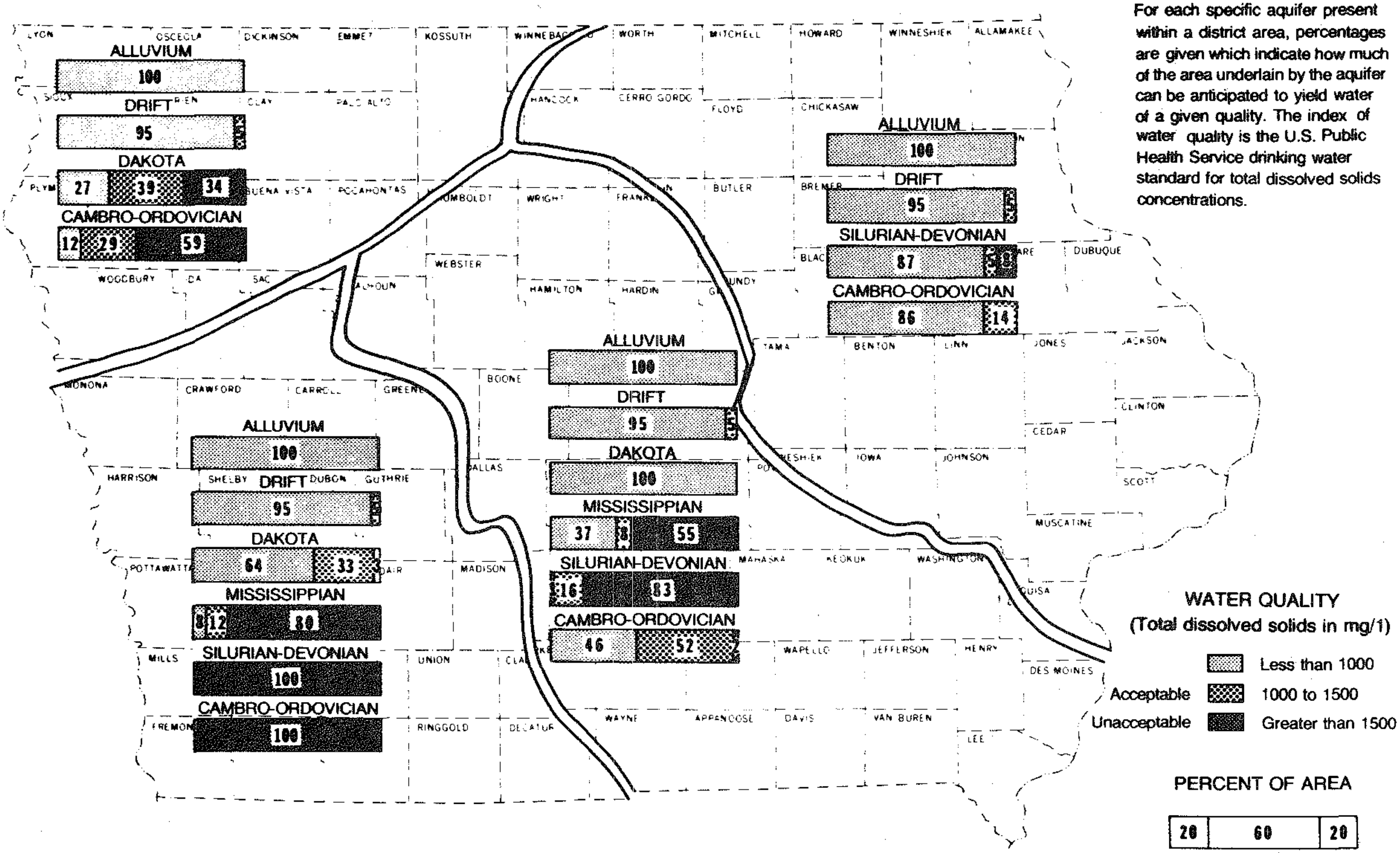


Figure 23

River, the glacial drift, and the unconfined portion of the Mississippian aquifer receive about equal annual recharge. In combination they receive about 90 percent of the district's annual total. In the central portion of this district, Pennsylvanian sandstones are locally important sources of water for several small communities and farmsteads. The development potential and reserves of these sandstone units are not large and therefore are not discussed in this regional summary.

Yield and Accessibility

A great number of the private domestic and/or farmstead water systems in the Central Iowa District are supplied by shallow wells developed in the drift aquifer. Most wells developed in the drift aquifer in the northern part of the district are capable of yielding water at rates of 3 to 5 gpm and in many instances up to 10 to 20 gpm. To the south, drift wells rarely supply more than 5 gpm and generally range between 1 and 3 gpm. During extended dry periods, when the water table recedes markedly, the yields of drift wells in the southern part of the district are impaired, and frequently many wells "go dry".

The sands and gravels of the alluvial systems associated with the Raccoon, Iowa, Skunk and Des Moines rivers are important shallow sources of ground water in this district. Generally, these sand and gravel systems will yield about 200 to 400 gpm to wells. However, on a more local scale, alluvial aquifers along all of these major streams have been reported to yield from 500 to more than 1,000 gpm to wells. Some of the notable examples are at

Marshalltown, Ames, Des Moines, and Fort Dodge .

The Central Iowa Ground Water District is underlain by three bedrock aquifer systems: the Mississippian, Silurian-Devonian and Cambro-Ordovician. Figure 19 indicates that about 83 percent of the available water in the district is stored within these three aquifer systems. The Mississippian Aquifer is estimated to contain the largest reserves and can be reached at moderate depths in about 97 percent of the region, Figure 22, but has a variable potential. As shown in Figure 21, the Mississippian wells yield 500 gpm in only about 7 percent of the district. In about 20 percent of the district Mississippian wells yield between 100 and 500 gpm, but in most of the district (73 percent) they yield fewer than 100 gpm. The Silurian-Devonian aquifer is accessible at moderate depths in about 75 percent of the district.

Water Quality

Generally, ground water from shallow sources (alluvium and drift) in the district is of good to acceptable quality. However, within the Paleozoic aquifers underlying the region, water becomes progressively poorer in quality from northeast to southwest. In about 45 percent of the district the Mississippian aquifer is uppermost and unconfined, and the water is of good to acceptable quality. South of an east-west line extending through the city of Des Moines, water from the Mississippian aquifer is of unacceptable quality. This does not include portions of Washington, Jefferson, Louisa, and Des Moines counties, where Mississippian water is of good to acceptable quality. The water of the Silurian-Devonian aquifer system is considered unacceptable for drinking throughout the entire district, except for a limited area in Franklin, Hardin, and Grundy counties. Figure 23 indicates that 98 percent of the Central Ground Water District is underlain by the Cambro-Ordovician aquifer with water of acceptable quality or better. Along the eastern margin and mid-section of the district, the Cambro-Ordovician rocks yield water of good to fair quality, with concentrations of total dissolved solids fewer than 1,000 mg/l.

Ground Water Availability in the Southwestern Iowa Ground Water District

The district lacks abundant and good quality ground water. The Southwestern District and Northwestern Ground Water District combined represent approximately one-third of the land area of the state, but together share only about 23 percent of the estimated ground water reserves.

Storage and Recharge The district has estimated ground water reserves of 13 million acre-feet in storage, amounting to about 13 percent of the total storage for the state. Over half of this water is stored in the alluvial sands and gravels of the Missouri River floodplain, Figure 19c. The remainder is fairly uniformly distributed across the district in the Paleozoic bedrock aquifers, drift aquifer, and alluvial deposits of interior streams. About two-thirds of these reserves are stored in the three Paleozoic bedrock aquifers underlying the district. The Dakota aquifer furnishes water for many private supplies and several communities along the northern boundary of the district and in a wide band extending from Sac and Carroll counties to Montgomery County.

During years of normal precipitation the aquifers in the Southwestern Ground Water District receive about 1 million acre-feet of water as annual recharge, Figure 20c. About one-half of that estimated for the district, excluding that which the Dakota receives, (possibly 1 million acre-feet) recharges the sands and gravels of the Missouri River alluvial system. Most of the rest recharges the glacial drift. The Paleozoic bedrock units and the alluvial materials of the interior streams receive only a little over a tenth of the annual total recharge.

Yield and Accessibility Throughout most of the district the drift aquifer can provide only limited amounts of ground water to shallow wells, Figure 21. Most of these wells do not yield more than 3 to 5 gpm. Drift wells in the area frequently "go dry" or experience significantly reduced capacity during periods of deficient rainfall. The alluvial sediments along the interior streams of the district provide adequate supplies of water to many communitites and rural water developers. Shallow wells along the two branches of the Nishnabotna yield between 200 and 400 gpm, with instances recorded where yields have exceeded 500 gpm. Alluvial wells along the smaller streams yield considerably less, and most do not deliver more than 100 gpm at a maximum. Some communities in this region encounter problems in maintaining capacity from alluvial wells because of fine sand. With extended, heavy pumping the fine sand migrates toward wells, clogging screens, filling the well bore and drastically impairing performance of wells.

At intermediate depths, the Dakota Sandstone provides a source for water supply over approximately one-third of the district, Figure 22. Yields from the Dakota vary considerably, but in most cases wells produce between 100 and 500 gpm.

Large quantities of ground water may be obtained from the thick alluvial deposits of the Missouri River floodplain. Wells penetrating these sands and gravels are shallow, most being under 100 feet in depth. In Pottawattamie, Harrison, and Monona counties, irrigation wells are known to sustain yields of 1,000 to 2,000 gpm. It is estimated that Missouri River alluvial deposits will provide yields in this range in nearly 95 percent of the area where they occur in the district, Figure 28.

The Mississippian, Silurian-Devonian, and Cambro-Ordovician aquifers are accessible to intermediate and deep wells throughout the region, Figure 22. The yield potential of the Mississippian and the Silurian-Devonian systems is estimated to range between 100 and 500 gpm. The deeper Cambro-Ordovician aquifer will yield water to wells at between 500 and 1,000 gpm over most of the area.

Water Quality In the Southwest Ground Water District the general quality of ground water from shallow aquifers (the drift, alluvium and the Dakota sandstone) is good to acceptable, Figure 23. Water from the Dakota sandstone is typically hard, as is all ground water in this district, and in about 36 percent of the area Dakota water has high sulfate concentrations. Water from alluvial sources in some areas of the district is reported to contain excessive nitrate.

Within the district the water of the three Paleozoic aquifer systems is nearly everywhere of unacceptable quality. A few industries and communities, in the absence of suitable alternatives, have developed wells in the Paleozoic bedrock, but water quality is usually only marginally acceptable. In some instances these supplies are unacceptable according to U.S. Public Health Service Standards but are still used for drinking purposes.

Ground Water Availability in the Northwestern Iowa Ground Water District

Northwestern Iowa has the least ground water supplies of any area in the state. Moreover, this area receives the least amount of precipitation and has lower streamflows.

Storage and Recharge The total ground water estimated in storage in this region is about 10 million acre-feet, Figure 19d. Of this amount, 40 percent is found in the alluvial aquifer system of the Missouri River. Thirty percent of the ground water is found throughout the district in the glacial drift. Twenty percent is stored in the Northwestern Bedrock Aquifer which is primarily the Dakota Sandstone, but also includes portions of the Mississippian, Silurian-Devonian, and Cambro-Ordovician systems. The alluvial sands and gravels of the interior streams are estimated to contain about 10 percent of the ground water for the district.

Even during years of normal precipitation, it is estimated that the aquifers of this district receive annual recharge amounting to less than 1 million acre-feet, Figure 20. Nearly 90 percent of the annual recharge of the district is received by the drift aquifer and the alluvium associated with the Missouri River. The alluvial aquifers of the major interior streams receive about 0.1 million acre-feet of annual recharge.

Yield and Accessibility Wells at shallow to moderate depths in the alluvium and glacial drift of the district can produce a variety of results depending on source and location. Typically, shallow drift wells in the region yield between 3 and 5 gpm to wells. However, in the northeastern part of the region, drift wells may produce as much as 10 or 15 gpm. Yields are variable for wells developed in the alluvial sands and gravels along the interior streams and the Big Sioux River, but are generally less than 200 gpm and rarely exceed 400 gpm. Where conditions are favorable for inducing recharge, yields may range from 500 gpm to more than 1,000 gpm, Figure 21. In Woodbury and Monona counties, yields of from 500 to more than 1,000 gpm are obtained from the Missouri River alluvium.

The principal bedrock aquifer of the region is the Dakota Sandstone which lies at moderate to intermediate depths throughout the district, Figure 22. In about half of the district the Dakota Sandstone will yield between 100 and 500 gpm to wells. Near the Missouri River, in Woodbury and Plymouth Counties, the Dakota Sandstone is quite productive and is known to yield more than 500 gpm. The Dakota is nearly as productive in the northeastern corner of the district in portions of Kossuth, Emmet, and Palo Alto counties. Only in about one-fourth of the district does the Dakota yield fewer than 100 gpm.

The extent of the Paleozoic bedrock aquifers in this district is not well known. Wells completed at moderate to intermediate depths in the Mississippian aquifer (where present in the district) should produce yields of between 100 and 500 gpm. At similar depths wells in the Silurian-Devonian aquifer probably will produce fewer than 100 gpm. The Cambro-Ordovician aquifer system is generally the most productive of the Paleozoic aquifers. Most of the moderate to deep wells completed in the aquifer yield between 100 and 500 gpm. In about one-third of the district, where the aquifer is present, potential yields are estimated at between 500 and 1,000 gpm, Figure 21.

Water Quality Ground water quality is a problem in many areas of the Northwestern Iowa Ground Water District. In most instances ground water in the drift aquifer and in alluvial sands and gravels is of good to fair quality. However, in certain areas, mainly in portions of Osceola, Dickinson and Emmet counties, drift and alluvial water quality is poor.

In general the quality of ground water from bedrock sources in the district is poor. For the Dakota Sandstone, 27 percent of its area provides water that is classified as good to fair quality, 39 percent provides water that is acceptable, and 34 percent provides water that is unacceptable. Although no data is available for the Mississippian and Silurian-Devonian systems, data from other areas suggest that water quality from these aquifers is unacceptable. In about 12 percent of the district underlain by the Cambro-Ordovician aquifer, the ground water is classified as being of good to fair quality, in 29 percent it is acceptable, and in 59 percent it is unacceptable for drinking purposes, Figure 23.

RECOMMENDATIONS AND CONCLUSIONS

Conclusion

During normal years Iowa's interior streams discharge an average of 18 million acre-feet of water. Most of this flow occurs during the late spring and early summer. Low flows usually occur during late summer and winter months. The larger flow volumes are generally the result of peak discharge periods of short duration. Total stream runoff ranges from 2 to 8 inches, from west to east across the state. Although large quantities of water are discharged by Iowa's streams, natural variability of flow results in only a small proportion of this water being available for consumptive purposes throughout any given year.

Recommendation

In order to increase the state's total water resources base, particularly in the northwestern, southwestern and south-central counties, programs should be developed to investigate the potential for more fully managing the water in streams and rivers. These programs should consider the feasibility of siting and constructing impoundments and structures to regulate flows in order that more water would be available throughout the year.

Conclusion

Large volumes of water are available from both the Mississippi and the Missouri Rivers.

Recommendation

New water-intensive industries should be encouraged to locate in regions where they can take advantage of these sources.

Programs should be established, particularly for the more water deficient areas of western Iowa, to investigate the feasibility of transport of Missouri River water to augment existing sources.

Conclusion

High silt loads in many Iowa streams is a major aesthetic and water quality problem.

Recommendation

A. Conservation programs should be given a higher priority in the state, and the conservancy program should be strongly enforced.

B. New regulatory programs should be considered, based on the planning recommendations derived from the Iowa 208 studies.

Conclusion

The states ground water resources, with respect to quantity, quality, yield potential and accessibility are unevenly distributed in the state.

Recommendation

These regional imbalances should be mitigated by programs that:

A. Set priorities for water use and development in relation to the available supply within regions,

B. Define withdrawal limitations, according to use priorities, for the various aquifers within regions,

C. Determine alternative supply sources which would augment existing reserves within regions,

D. Evaluate the feasibility of treating inferior ground water available to the region (primarily desalting), and

E. Assess regional water needs and demands to determine the effectiveness of various conservation measures for existing and/or potential deficiencies.

Conclusion

Some regions within the state have several options for the development of water supplies.

Recommendation

Programs and/or policies should be developed to prevent needless stresses on single aquifers. Such stresses could be prevented by allocation practices that promote conjunctive use, well spacing controls and reversion to other available sources.

Conclusion

Many shallow wells in Iowa are contaminated with nitrate and bacteria. The problem is both long term and intermittent.

Recommendation

A program should be initiated to define the magnitude of this problem, the sources of contamination and measures which will alleviate shallow well bacterialogical and nitrate contamination.