Iowa Geological Survey Water Atlas Number 3

AVAILABILITY OF GROUND WATER IN WAYNE COUNTY, IOWA

by

J. W. CAGLE

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

Published by the
STATE OF IOWA
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FOREWORD

Wayne County is one of several counties in south-central Iowa affected by water-supply problems. All classes of water users—individuals, municipalities, and industries—often experience difficulties in obtaining sufficient quantities of good-quality water in many parts of the region. In an effort to aid present and potential water users, the Iowa Geological Survey in cooperation with the U. S. Geological Survey started a comprehensive investigation of the water resources in the region with the overall aim of defining the water-supply problems and determining whether and how these problems could be alleviated. Specifically, the objectives of the investigation are to locate and define the sources of water and to determine the quality and availability from each source.

Because of the pressing needs for this information, it was decided to release the ground-water data as it became available rather than await the completion of the overall investigation. This atlas, which is the second in the series of county reports, is a preliminary report that presents information on the availability and quality of water from underground sources in Wayne County. Preliminary reports on ground-water conditions in the other south-central counties will be forthcoming. These will be followed by a comprehensive report on the total water resources of the region which will encompass both ground-water and surface-water studies.

H. GARLAND HERSHEY
State Geologist

Iowa City, Iowa
August 1969

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ACKNOWLEDGEMENTS

Appreciation is expressed to the many residents of Wayne County who furnished information about their water supplies and who permitted the sampling and measuring of their wells; to city officials for their cooperation in the collection of data on municipal supplies; and to county officials for their cooperation and assistance in the test-drilling program. Thanks are also due to well drillers in the area who furnished drill cuttings and logs of wells.

Special acknowledgement is made to Dr. H. Garland Hershey, Director of the Iowa Geological Survey, and his staff who through the past years have collected and analyzed many rock samples. This information was essential in appraising the geology of the county.

AVAILABILITY OF GROUND WATER IN WAYNE COUNTY, IOWA

By J. W. Cagle

ABSTRACT

Information is presented on the availability and quality of ground water in Wayne County, one of several counties in southern Iowa affected by a shortage of good-quality water. The data indicate that only locally and in limited areas, or only after extensive water-quality treatment, are suitable supplies of ground water available to satisfy the water needs in the county. Bedrock aquifers yield variable amounts of moderately to highly mineralized water. Upper bedrock units at depths of about 200 to 1,000 feet yield up to 50 gpm (gallons per minute) to individual wells; however, the dissolved-solids content of the water ranges from about 2,000 to 5,500 mg/l (milligrams per liter). Lower bedrock units at depths of 2,500 to 2,800 feet are believed capable of furnishing from 300 to 800 gpm to individual wells, but the dissolved-solids content of the water ranges from 800 to 2,500 mg/l. Surficial aquifers comprising glacial drift and alluvium are estimated to yield up to 45 gpm in some areas; an availability map indicates the areas where water supplies can be developed from these deposits. The chemical quality of water from the surficial aquifers varies considerably; dissolved-solids concentrations range from about 470 mg/l in the alluvium to over 3,600 mg/l in the deep (more than 100 feet) glacial drift. Many shallow (100 feet or less) supplies presently in use contain high concentrations of nitrate and chloride, and these concentrations are attributed to localized contamination. Wells in the alluvium and shallow drift that are properly constructed and located are expected to yield satisfactory quality water.

DESCRIPTORS: Keywords listed in WATER RESOURCES THESAURUS (1966 ed.) for indexing and retrieving literature concerning water resources.

*Water supply, *Water quality, Aquifers, Ground water, Nitrates, Saline water, Iowa

INTRODUCTION

The water problem in the region

Wayne County and several other counties in south-central Iowa have been chronically short of good-quality water. Municipalities, industries, and rural water users alike have been affected by the water shortage. Municipalities have experienced serious problems in obtaining potable supplies adequate to keep pace with their growth and development; industrial expansion has been hindered and continues to be hindered by the shortage of good-quality water; and rural supplies for domestic and livestock use are difficult to obtain at many places. The increased use of water for all purposes and periodic drought conditions have greatly magnified an already serious problem of water shortage.

Sources of water in the region

Probably most water used for all purposes in south-central Iowa is ground water that is obtained from wells and springs, but water from surface sources is used to a substantial degree. The two sources of ground water in the area are the bedrock and the unconsolidated deposits of glacial drift and alluvium that lie above the bedrock. Sources of surface water include reservoirs, streams, ponds, and cisterns. Reservoirs are the source of supply for most municipalities in the area and ponds and cisterns supplement rural supplies obtained from wells. Unregulated streams are not a source of supply at present.

Why the problem

Some of the sources of water in the area yield insufficient amounts of water, some have erratic and unpredictable yields, some yield highly mineralized water, and some are not developed or are not completely understood. Collectively, these factors contribute to the water-shortage problem in the area.

Water facts are required to solve problem

Obviously the shortage of water could be alleviated by developing additional supplies of good-quality water from one or more of the sources in the area. Additional development, however, depends on a better understanding of the hydrologic system. In particular, more detailed information is needed on the occurrence, availability, and chemical quality of water from the unconsolidated deposits, on the quality of water from the bedrock, and on the streamflow in the area. The need for these facts on water—facts that could be made readily available to municipalities, industries, and individuals alike—prompted an investigation of the water resources of south-central Iowa. The investigation, which encompasses both ground-water and surface-water studies, will culminate in a comprehensive report that will appraise the total water resources of the region.

Regional study to obtain ground-water facts

The ground-water study, which will provide the basic geologic and ground-water data necessary for the comprehensive regional report, was started in 1962 by the U. S. Geological Survey in cooperation with the Iowa Geological Survey. This project, which involves an extensive amount of test drilling, is being conducted on a county-by-county basis (fig. 1). In order to aid the water users in the respective counties, the results of the ground-water investigation will be released as a series of county reports pending completion of the comprehensive regional report. A report on Decatur County, the first of these county reports, was published in 1967.[1] This report on Wayne County is the second in the series; others will be forthcoming.

[1] Cagle, J. W. and Steinhilber, W. L., 1967, Availabiity of ground water in Decatur County, Iowa: Iowa Geol. Survey Water Atlas No. 2.

Purpose and scope of this report

The objective of this report is to present ground-water information that will help solve the supply problems of some water users in Wayne County. The information presented includes the location, definition, and estimated potential yields of the water-bearing materials in the unconsolidated deposits; an evaluation of the general occurence and availability of water from bedrock sources; and a determination of the chemical quality of water from all ground-water sources.

Methods of study

Test drilling has comprised the major part of the ground-water investigation in Wayne County. A total of 105 test holes were drilled through the unconsolidated deposits and into the uppermost part of the underlying bedrock.[2] Drill samples were taken at intervals of 5 feet or less in the unconsolidated deposits to define boundaries between geologic units more closely and, most importantly, to define as accurately as possible the positions of the beds of sand and gravel that are the sources of water in the unconsolidated deposits. Cores up to a maximum of 20 feet and drill samples to a maximum of 85 feet were taken in the bedrock to (1) make a definite determination that bedrock had been penetrated and (2) determine the character and composition of the bedrock so that a general evaluation of the water-bearing potential and economic value of these rocks could be made. Most of the test holes were logged with an electric logger to confirm the position and thickness of the sands and gravels, to determine the top of bedrock, and to identify bedrock units. In addition to the test drilling, supplemental data were collected by an inventory of rural and municipal water supplies.

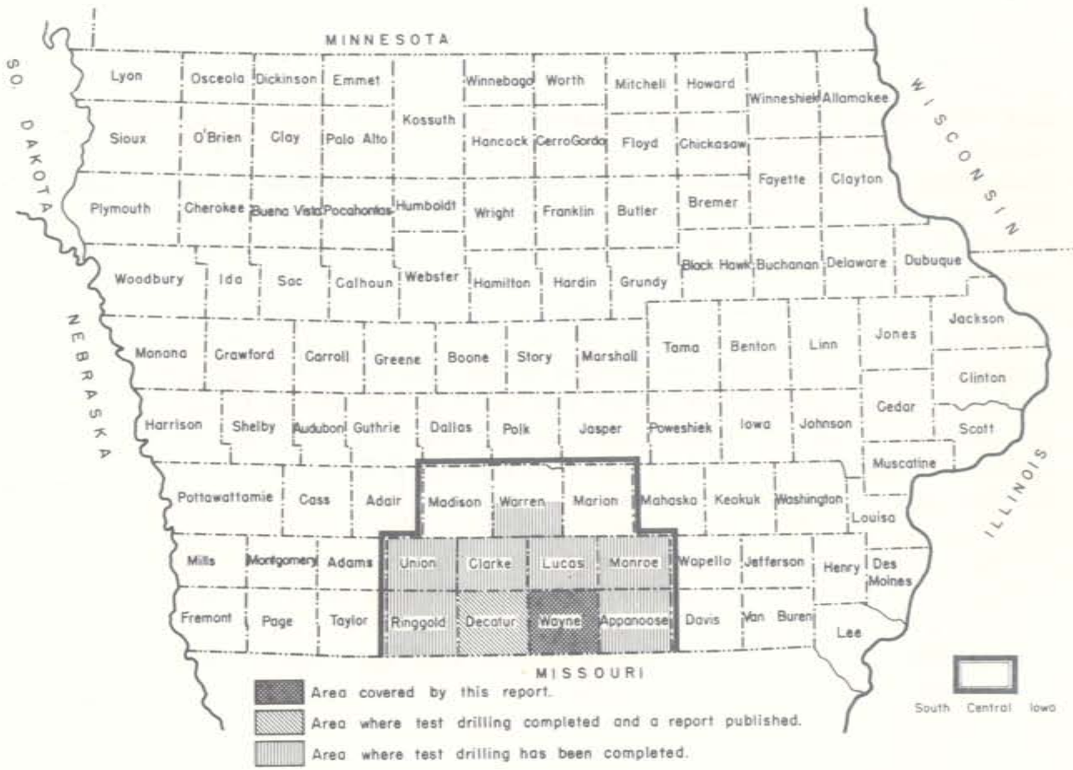


FIGURE 1.—Progress of ground-water investigation in south-central Iowa.

[2] Logs of test holes are not published in this report, but copies are available from the U.S. Geological Survey or the Iowa Geological Survey, Geological Survey Building, Iowa City, Iowa 52240.

GEOGRAPHY AND TOPOGRAPHY

Wayne County has an area of 532 square miles and, according to the 1960 census, has a population of 9,800. The population distribution reflects the water-use pattern in the county, which is largely rural. About 52 percent of the population live on farms or in small communities and towns where the water supply is obtained from private wells, ponds, and cisterns. The remainder of the residents live in towns that have municipal water systems.

The topography of the county is largely the result of the dissection of the "drift plain" which formed the land surface in the county during the Pleistocene Epoch (ice age). For the purposes of this report the county may be divided topographically into two areas—the flood plains and terraces and the uplands. The flood plains and terraces occupy the valleys of the principal streams and are underlain by alluvial deposits. The uplands, which are surfaces that rise above the principal stream valleys, occupy areas underlain by glacial drift. The uplands are for the most part relatively rugged, moderately to highly dissected areas composed of hills, knobs, and ridges; but at places the uplands are gently rolling and only slightly dissected. Land-surface elevations in the county range from about 1,115 feet above mean sea level on upland surfaces to about 900 feet along the flood plain of the Chariton River in the extreme northeastern part of the county, giving a maximum relief of approximately 215 feet between the highest and lowest surfaces.

Topography and geology control the movement and distribution of water both above and beneath the land surface. Wayne County receives an average of about 33 inches of precipitation a year, but topographic and geologic conditions are unfavorable for retaining a significant amount of this water in the area. This is because most of the area is moderately to highly dissected and is underlain by relatively impermeable glacial deposits. These two factors promote rapid runoff which is the cause of flashy streamflow and relatively little ground-water recharge.

Topographic maps indicate by contours the elevation of the land surface and topographic features such as those described above (fig. 2). The principal use of topographic maps in this report is to determine land-surface elevations, which need to be known to compute the depth to a subsurface horizon. (See p. 8 for use of land-surface elevations in this regard.) The approximate land-surface elevation at a given site can be determined from a topographic map in the following manner: locate the site on the map with reference to roads and road junctions, railroad and road intersections, and other reference points; then approximate the elevation of the site from its position relative to the contours and from contour values. For example, if the site is on a contour line the elevation would be the contour value; if the site lies between two contour lines, the elevation would, for all practical purposes, be a value halfway between the two contour values.

The small-scale topographic map (fig. 2) has highly generalized contours and is suitable only for determining approximate land-surface elevations—usually within an accuracy of ±25 feet. However, land-surface elevations with an accuracy of ±5 feet or ±10 feet can be determined in all parts of the county, because the county is covered by modern large-scale topographic maps of the U.S. Geological Survey. (See fig. 10.)

EXPLANATION

1000

Contour line connecting points of equal elevation on the land surface; supplementary contours are indicated by dashed lines.

Contour interval 50 feet with supplementary contours at intervals of 25 feet. Datum is mean sea level.

Map taken from Map Series NK 15-11
See page 24 for additional information.

Scale 1:250,000

5 0 5 Miles

FIGURE 2.—Generalized topography of Wayne County.

THE BEDROCK AS A SOURCE OF WATER SUPPLY

The bedrock is a sequence of consolidated sedimentary rocks that nearly everywhere in the county is covered by younger unconsolidated deposits. These rocks are predominantly shale, limestone, sandstone, and dolomite and contain thin coal beds in the upper few hundred feet. The geologic section (fig. 3) is a composite of data from the Lineville and Corydon (abandoned) town wells and data from deep wells in adjacent counties, and is believed to be generally representative of bedrock of Pennsylvanian to Cambrian age throughout the subsurface in Wayne County. An additional several hundred feet of sedimentary rocks that lie on the "crystalline" basement occur beneath the section shown. This "layer-cake" sequence of strata slopes to the southwest and west so that any rock layer is at a higher elevation in the northeastern and eastern parts of the county and at a lower elevation in the southwestern part (fig. 4). The approximate depth to the Pennsylvanian rocks, which are the top of bedrock in the county, can be determined by the procedure outlined on page 8. The approximate depth to the top of the Mississippian rocks and the Jordan Sandstone—two key stratigraphic horizons—can be determined in a similar manner by using the structure contour map (fig. 4). Therefore, if the depth to the Mississippian or Jordan is known at a given site, the depth to other rock units at the site can be estimated from thickness data given in figure 3.

Ground water occurs and moves in fractures, joints, and solution openings in limestone and dolomite, and in the voids between the grains in sandstone. Shale generally is impervious to the movement of water and is not a source of water supply. The water-bearing consolidated rocks underlying the county are grouped into the upper, middle, and lower bedrock aquifers (fig. 3). The characteristics of each aquifer are discussed below.

Of the bedrock aquifers, the upper is the only one of the three to furnish any ground-water supplies in the county, and this amounts to only a few rural supplies and one municipal supply (Lineville). Corydon formerly obtained its municipal supply from a well tapping the aquifer. The main producing zones in the aquifer are the sandstones of the Pennsylvanian and limestones and dolomites of the Mississippian (fig. 3). The distribution and extent of the Pennsylvanian sandstone units are not known; however, one or more units generally occur in wells completely penetrating these rocks. The total thickness of the Pennsylvanian, which varies considerably throughout the county, can be estimated by subtracting the elevation of the bedrock top (fig. 5) from the elevation of the Mississippian top (fig. 4). Yields from the Pennsylvanian rocks range from 4 to 15 gpm (gallons per minute) (table 6). The Mississippian strata, which are about 400 feet thick (fig. 3), are known to yield moderate amounts of water. The combined Pennsylvanian and Mississippian rocks have been penetrated only by the Lineville and Corydon wells, and the largest yield, 40 gpm, was from the Corydon well (table 4).

The middle bedrock aquifer is not tapped by wells in Wayne County, but an estimate of its water-bearing potential and chemical quality can be based on production and quality data from a municipal well at Lamoni in Decatur County which taps the aquifer. The Lamoni well was test pumped at 100 gpm and has an average yield of about 80 gpm. Production from the middle bedrock aquifer in Wayne County probably would be within the range of 50 to 100 gpm.

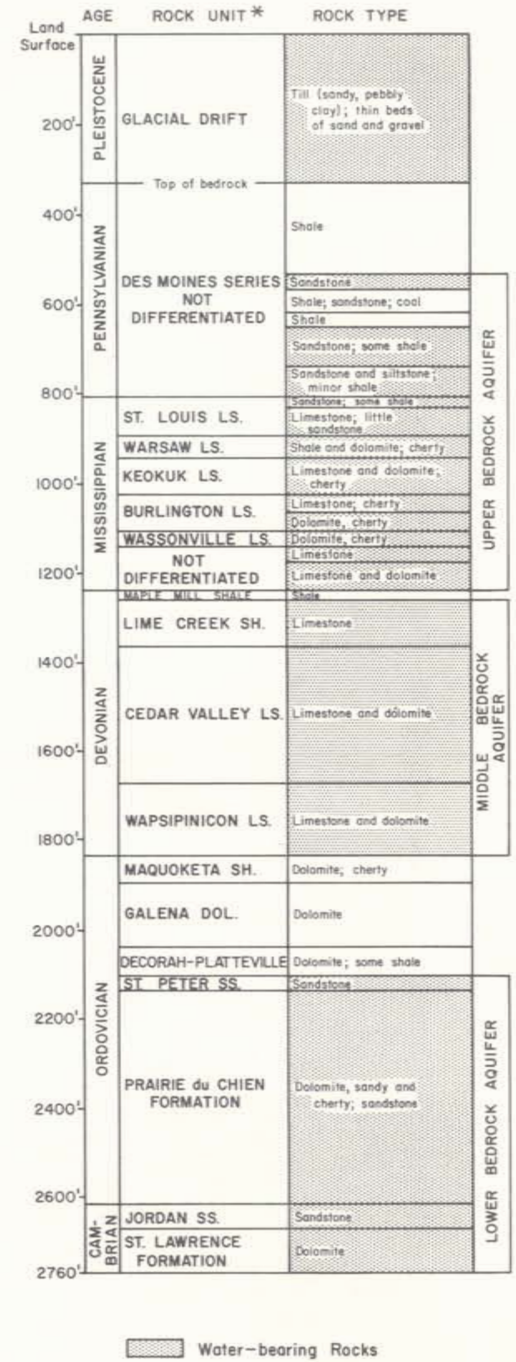


FIGURE 3.—Rock units that underlie the county.

* *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.*

Water from the upper bedrock aquifer is highly mineralized (table 5) and supplies from the middle bedrock aquifer almost certainly would have a high mineral content. Water from these aquifers contains high concentrations of sulfate and dissolved solids and water from the middle bedrock aquifer may have a very high chloride content, based on quality data from the Lamoni well.

The lower bedrock aquifer also is an untapped source of supply in the county. However, data from municipal wells at Leon in Decatur County, Russell in Lucas County, and Centerville in Appanoose County indicate the yield and chemical quality of water that may be expected from the aquifer in Wayne County. The well at Leon produces from the Prairie du Chien at an average rate of about 275 gpm; and the wells at Russell and Centerville, both of which tap the combined Prairie du Chien, Jordan, and St. Lawrence Formations, were test pumped at rates of 160 gpm and 920 gpm, respectively. Yields ranging from 300 to 800 gpm are estimated to be available from the lower bedrock aquifer and the largest yields apparently would be available in the eastern part of the county.

At Leon water in the aquifer contains high concentrations of sulfate and chloride and has a dissolved-solids content of about 2,400 mg/l (milligrams per liter). At Centerville and Russell, however, the dissolved-solids content of the water is 1,100 mg/l or less. These data indicate a progressive increase in mineralization regionally to the southwest, so that at most places in Wayne County the water probably would have a high mineral content. However, in some parts of northeastern and eastern Wayne County, the water is believed to have quality characteristics similar to the water at Centerville and Russell.

In Wayne County moderate-to-large quantities of water can be obtained from the upper, middle, and lower bedrock aquifers by one or more wells. However, the high mineralization limits the use of water from the bedrock aquifers in most parts of the county and is a deterrent to a more extensive development of these sources. Therefore, the future development and large-scale use of water from the bedrock aquifers will depend upon the development of an economical method of demineralization.

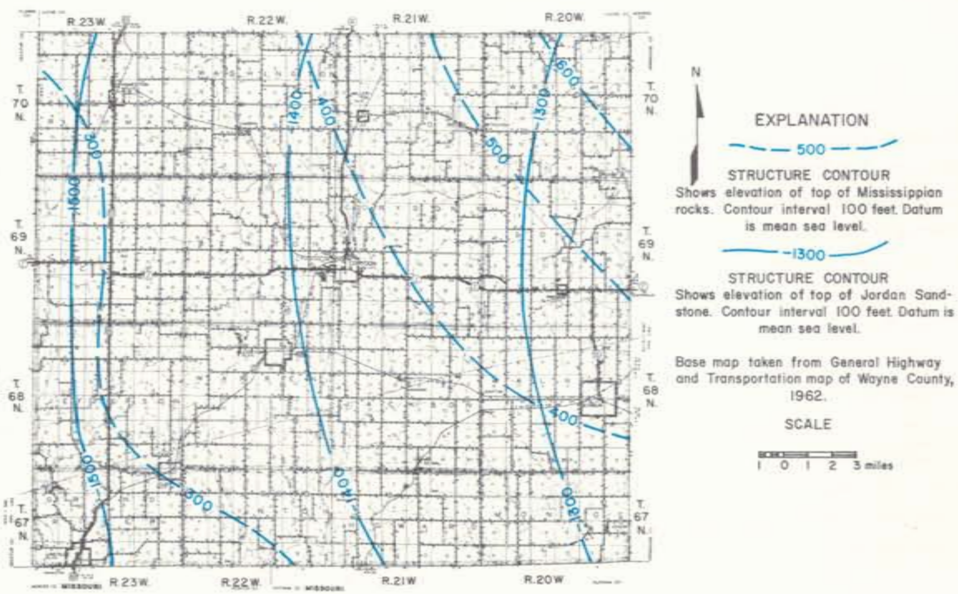


FIGURE 4.—Generalized structure contours on top of Mississippian rocks and the Jordan Sandstone.

THE BEDROCK SURFACE—ITS ELEVATION, CONFIGURATION, AND SIGNIFICANT FEATURES

The bedrock surface in Wayne County is on consolidated sedimentary rocks of Pennsylvanian age and is covered by unconsolidated deposits of glacial drift and alluvium. Figure 5 shows the topography of the buried bedrock surface as it would appear if the unconsolidated deposits were removed. The contour lines depict the elevation and configuration of the bedrock surface and indicate the positions of topographic features, such as buried bedrock valleys and buried bedrock uplands. A profile view of these features along line A-A′ is shown in figure 7. Probably most of the bedrock valleys are pre-glacial channels which were cut in the Pennsylvanian surface prior to coverage of this surface by the glacial drift, but some may represent valley cutting during glaciation. The main bedrock valley enters Wayne County from Decatur County at the northwest corner of Jefferson Township and trends in a general northerly direction before entering Lucas County along the northern boundary of Richman Township. This valley is a continuation of a major pre-glacial channel which enters Decatur County from Missouri and extends north and northeast in Decatur County and into Wayne County.

The physical features of the bedrock surface have a special significance in most glaciated regions. In Wayne County the results of the test drilling indicate a relationship between the bedrock topography and ground-water occurrence in the overlying glacial deposits. Areas underlain by buried bedrock valleys generally are more favorable for the development of ground-water supplies from the glacial deposits than are areas underlain by buried bedrock uplands. (See figs. 7 and 9.)

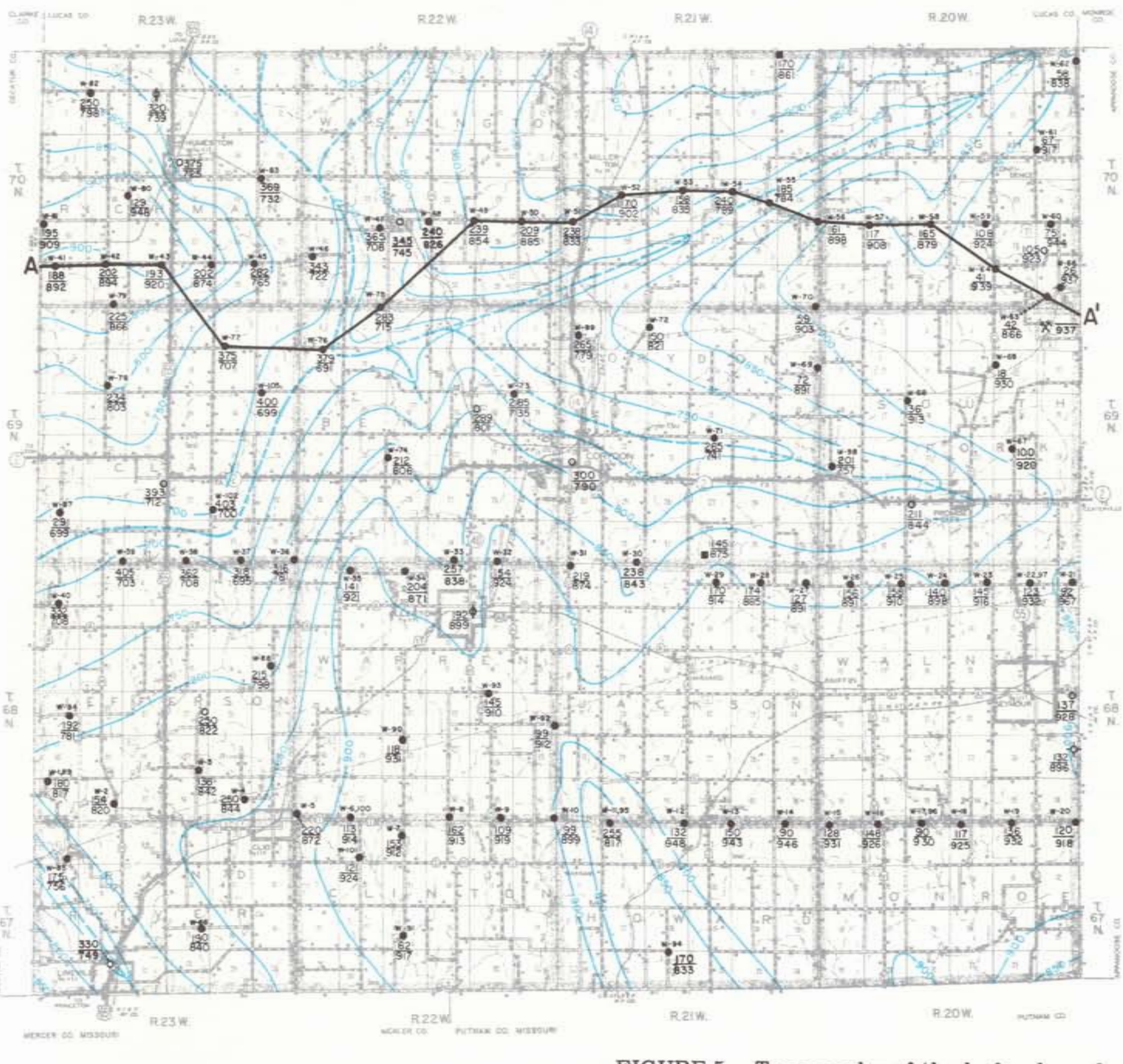
The depth to the bedrock surface below the land surface at a given point in the county is important in planning the construction and development of water wells. The approximate depth to bedrock at a given site is obtained by subtracting the elevation of the bedrock surface (fig. 5) from the elevation of the land surface (determined from topographic maps or other sources).[3]

The following examples show how the elevation of the bedrock surface is obtained and how the depth to bedrock (which is equivalent to the thickness of the unconsolidated deposits) is then computed at two assumed sites.

1. Site is located at a "T" road junction in the approximate center of section 30, T. 68 N., R. 22 W., where the land-surface elevation is about 1,100 feet. The site is about one-half the distance between contours on the bedrock map whose elevations are 850 and 900 feet; therefore, the elevation of the bedrock surface is estimated to be 875 feet. The approximate depth to bedrock is 1,100 − 875 = 225 feet.

2. Site is located at a road intersection at junction of sections 17, 18, 19, and 20, T. 69 N., R. 22 W., where the land-surface elevation is about 1,085 feet. The site is on or very near the 750-foot bedrock contour; hence, the approximate depth to bedrock is 1,085 − 750 = 335 feet.

[3] See page 24 for availability of topographic maps in Wayne County.



N

EXPLANATION

U. S. G. S. test hole

Oil test

Water well

Coal test

Municipal or private test hole

Quarry

$\frac{132}{948}$

Upper number is depth to bedrock, in feet below land surface; lower number is bedrock elevation in feet above mean sea level. (Upper number not shown for quarry.)

800

Contour line connecting points of equal elevation on the bedrock surface. Contour interval is 50 feet; datum is mean sea level.

Line along the center of major buried bedrock valleys.

A ——————— A'

Line of geologic section shown in figure 7.

Note: The bedrock has been cut into in northeastern Wayne County by the Chariton River in Wright Township, and by the South Fork Chariton River in Wright Township and at places in South Fork Township. These narrow, rock-walled valleys have not been contoured.

Base map taken from General Highway and Transportation map of Wayne County, 1962, prepared by the Iowa State Highway Commission.

SCALE

1 0 1 2 3 Miles

FIGURE 5.—Topography of the bedrock surface.

EXISTING WATER SUPPLIES FROM THE GLACIAL DRIFT AND ALLUVIUM

An intensive inventory of rural (farm and small community) water supplies was made in conjunction with the test-drilling operations. Included in the inventory are a few supplies in rural areas used for industrial, commerical, and other purposes. The inventory (fig. 6 and table 6) showed that most of these supplies are obtained from wells tapping the glacial drift and alluvium, but a few wells tap the bedrock; substantial amounts of water also are obtained from ponds and cisterns. The ground-water data were correlated with the test-drilling results to appraise more accurately the availability of ground water in the county.

In Wayne County nearly all supplies obtained from the glacial drift and alluvium are for domestic and stock use, but some water from these sources is used for other purposes (table 6). Yields from wells tapping the glacial drift and alluvium generally range from less than 1 gpm to 5 gpm, but locally yields may be larger. The largest known yield from the glacial drift was from the Humeston Creamery well (No. 87), which reportedly was pumped at a rate of 40 gpm.

Wells tapping the glacial drift and alluvium are predominately bored or dug and most are constructed with brick or cement-tile casing 12 to 48 inches in diameter. These types of shallow wells, unless properly constructed[4], are extremely susceptable to contamination (see quality of ground water section). A few wells that are drilled into the glacial drift have small-diameter steel casing that either is slotted or has an attached screen set opposite the water-bearing sand and gravel. Most wells are equipped with cylinder-type (lift or force) pumps that are operated by hand, windmill, or electric or gasoline pump jacks; some wells have either shallow or deep-well electric jet or submersible pumps.

Most bored and dug wells that tap the glacial drift are ended at depths of 50 feet or less in the first water-bearing sand and gravel encountered. However, yields of many of the shallow wells decrease during periods of drought when water levels decline, and water withdrawn from storage by pumping is not replenished as fast as it is used. Higher sustained yields from the glacial deposits often may be available by locating and developing the deeper sands and gravels, because these deposits generally are affected less by variations in local precipitation. The deeper sands and gravels also usually have a wider distribution and a greater storage volume than the shallower sands and gravels.

Most bored and dug wells that tap the alluvium generally extend only into the upper part of the water-bearing sands. These wells may go dry during drought periods, because water levels in the alluvium, which respond to variations in local precipitation, may fall below the well floor. Therefore, all alluvial wells should tap the full saturated thickness of the alluvial sands.

[4] State Health Department (1962), Sanitary standards for water wells, residential and other small installations: Public Health Bull., Special Engineering Numbers.

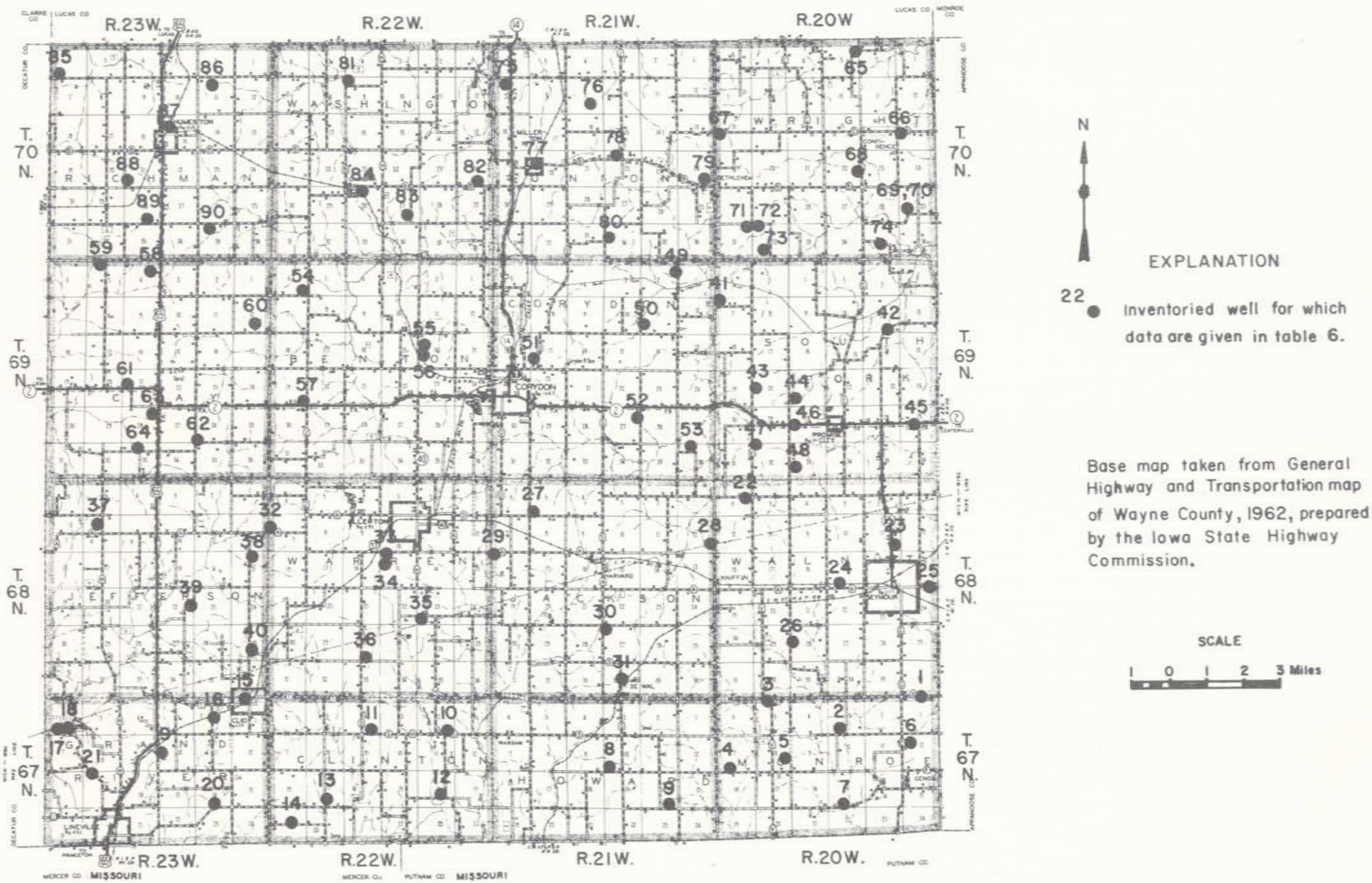


FIGURE 6.—Location of selected wells from the rural inventory.

GLACIAL DRIFT AND ALLUVIUM

Unconsolidated deposits composed of two geologic units, the glacial drift and alluvium, overlie the bedrock and form the land surface in Wayne County (fig. 7). The glacial drift, which is the older of the two units, was laid down by glaciers during the Pleistocene Epoch. Streams later cut deep valleys into and through the glacial drift and deposited the alluvium. The glacial drift is exposed along upland surfaces in the county; whereas, the outcrop of the alluvium is confined to the valleys of the principal streams. The drift deposits everywhere underlie the uplands to bedrock, and in stream valleys they lie on the bedrock except in relatively small areas in the northeastern part of the county. In the valley of the Chariton River and at places in the valley of South Fork Chariton River in northeastern Wayne County, the drift has been removed and the alluvium rests directly on the bedrock. In all other stream valleys the glacial drift is covered by the alluvium. (See figs. 5 and 9.)

Physical Properties

Glacial drift.—The glacial drift is composed predominantly of sandy, pebbly clay (till) that generally contains sand and gravel deposits of varying thickness and extent. The log of test hole W-51 (fig. 8) is representative of the glacial drift in the county; however, parts of the sequence may be missing at places owing to erosion or non-deposition. The glacial drift is absent, or only a few feet thick, at places in some stream valleys in northeastern Wayne County and is thickest in the deepest parts of buried bedrock valleys. The maximum thickness of the glacial drift in the county is believed to be about 420 feet.

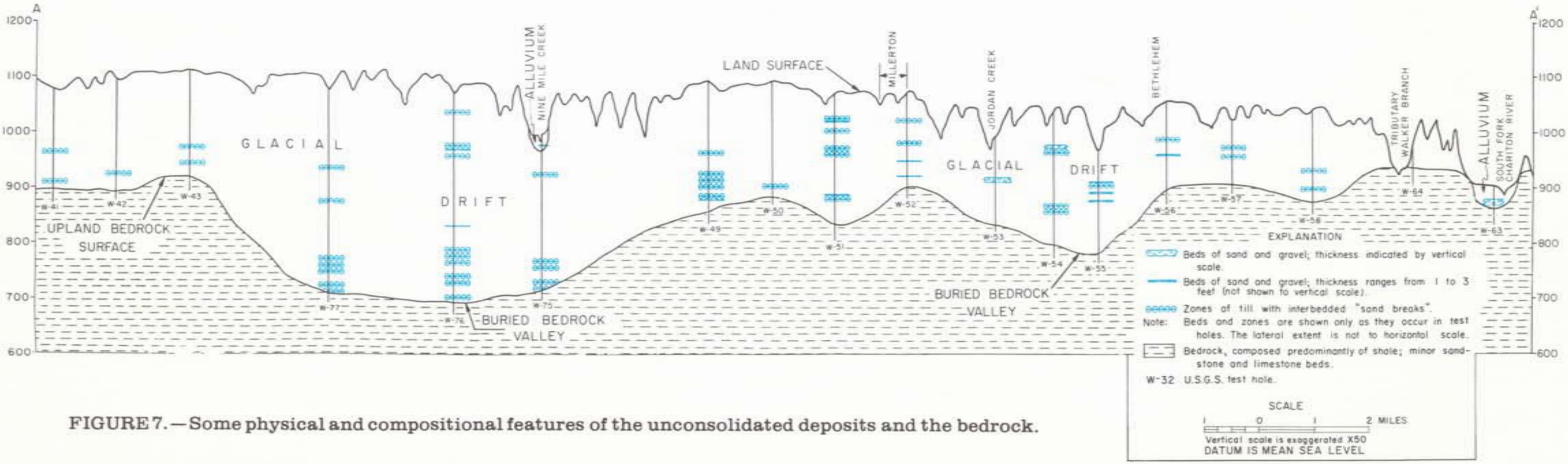


FIGURE 7.—Some physical and compositional features of the unconsolidated deposits and the bedrock.

Sand and gravel was penetrated in about 70 percent of the test holes; the remainder of the test holes did not locate significant amounts of these deposits. Beds of sand and gravel penetrated in test holes usually were from 1 to 3 feet thick and seldom exceeded 5 feet. Sands occur also as very thin stringers or lenses (1/2 to 6 inches thick) interbedded with the till. These interbedded "sand breaks" occur in definable zones, which range from a few feet to as much as 30 feet in thickness. The beds and zones occur at different horizons in the glacial drift and only locally or in relatively small areas could a given horizon be traced between test holes (fig. 9).

Alluvium.—Alluvium, composed of clay, silt, sand and gravel, is at the surface and underlies the flood plains (first bottoms) and terraces (second and third bottoms) in the valleys of the principal streams (fig. 9). Approximate maximum thicknesses of the alluvium in the following stream valleys are: Chariton River, 60 feet; Caleb Creek, 45 feet; South Fork Chariton River and West Fork Medicine Creek, 40 feet; and Jackson, Ninemile, Locust, Walnut, Steele, Jordan, Dick, Wolf, Medicine, and East and Middle Forks Medicine Creeks, 35 feet. Sands and gravels in the alluvium occur in beds that are interlayed with clay and silt; often two or more beds of sand and gravel are present within a given alluvial sequence. The sands and gravels have an aggregate thickness of 15 to 20 feet in the valleys of Caleb Creek, South Fork Chariton River, and East and West Forks Medicine Creeks; about 10 feet in the valley of Chariton River; and about 1 to 8 feet in the alluvial valleys of the other streams listed above. The deposits of sand and gravel generally are thickest near the centers of stream valleys and thin toward the valley margins.

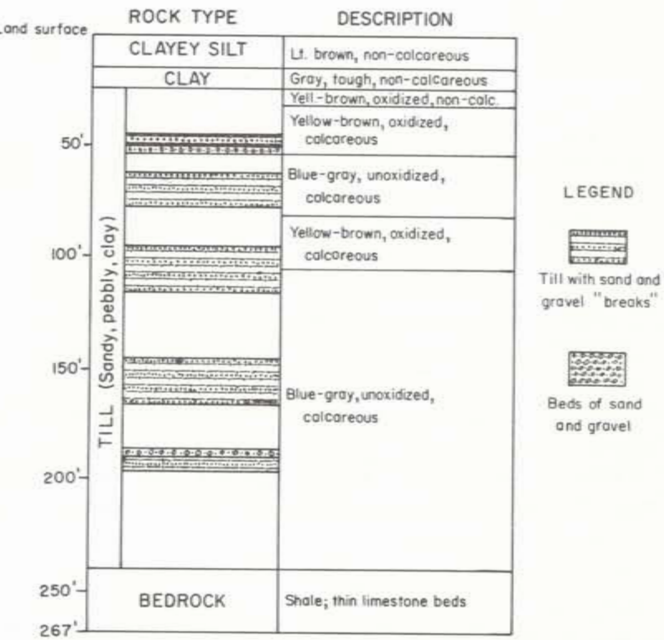


FIGURE 8.—Log of test hole W-51, which is representative of the composition of the glacial drift in the county.

Water-bearing Properties

Ground water, which is derived from precipitation, saturates all of the rock materials comprising the glacial drift and alluvium beneath the water table. However, only the coarse-grained materials, such as sand and gravel, will yield water readily to wells; the fine-grained rocks, such as clays and silts, yield little or no water to wells. Hence, the availability of ground water from the glacial drift and alluvium depends on the occurrence and distribution of the sands and gravels within these deposits. Saturated sand and gravel deposits of widespread distribution are capable of yielding large quantities of water; deposits of limited thickness and areal extent generally yield only small-to-moderate quantities of water.

This investigation shows that widespread deposits of sand and gravel do not occur in the glacial drift in Wayne County; therefore, large yields of water from the glacial drift are not to be expected. However, sands and gravels of limited distribution do occur in the glacial drift and alluvium; therefore, small-to-moderate quantities of water are available from the unconsolidated deposits in the county.

GENERAL AVAILABILITY OF WATER FROM THE GLACIAL DRIFT AND ALLUVIUM

The appraisal of the general availability of ground water from the glacial drift and alluvium is based (1) on the occurrence and characteristics of sand and gravel located by test drilling and (2) on the few quantitative data from the well inventory. The estimated yields from these deposits in various parts of the county are those that can be expected from properly constructed and developed wells. Information is not available to predict pumping water levels or to determine whether the estimated yields can be sustained over an extended period of time. Quantitative information of this type will be obtained for the subsequent comprehensive regional report.

The areas most favorable for the development of ground-water supplies from the glacial drift and alluvium are designated as areas A, B, and C (fig. 9). Most parts of areas B and C coincide with the subsurface positions of buried bedrock valleys. Yields from wells tapping the glacial drift and alluvium in the three areas range generally from less than 1 gpm to 5 gpm; however, test-drilling and well-inventory data indicate that aquifers in these areas have the potential to furnish larger yields. The general availability of ground water in areas A, B, and C is summarized as follows:

Areas A and B.—The alluvium in area A and the glacial drift in area B have the potential to yield moderate quantities of water and are the best sources of ground water from the unconsolidated deposits. Data from well 18 which taps the alluvium and well 87 which taps the glacial drift indicate that yields as high as 45 gpm can be obtained in areas A and B (table 6). Moreover, data from well 63 indicate that the glacial drift in area B is capable locally of furnishing larger yields. The yields estimated to be available in these areas would be adequate for modern-day domestic and stock needs, small-scale irrigation, supplies for small communities and towns, and the needs of light industry. Any development of water from the alluvium should be preceded by drilling several test holes to locate the thickest and most permeable deposits of sand and gravel. The test holes should be drilled to the underlying glacial drift, whose depth beneath the principal stream valleys ranges from about 35 to 60 feet.

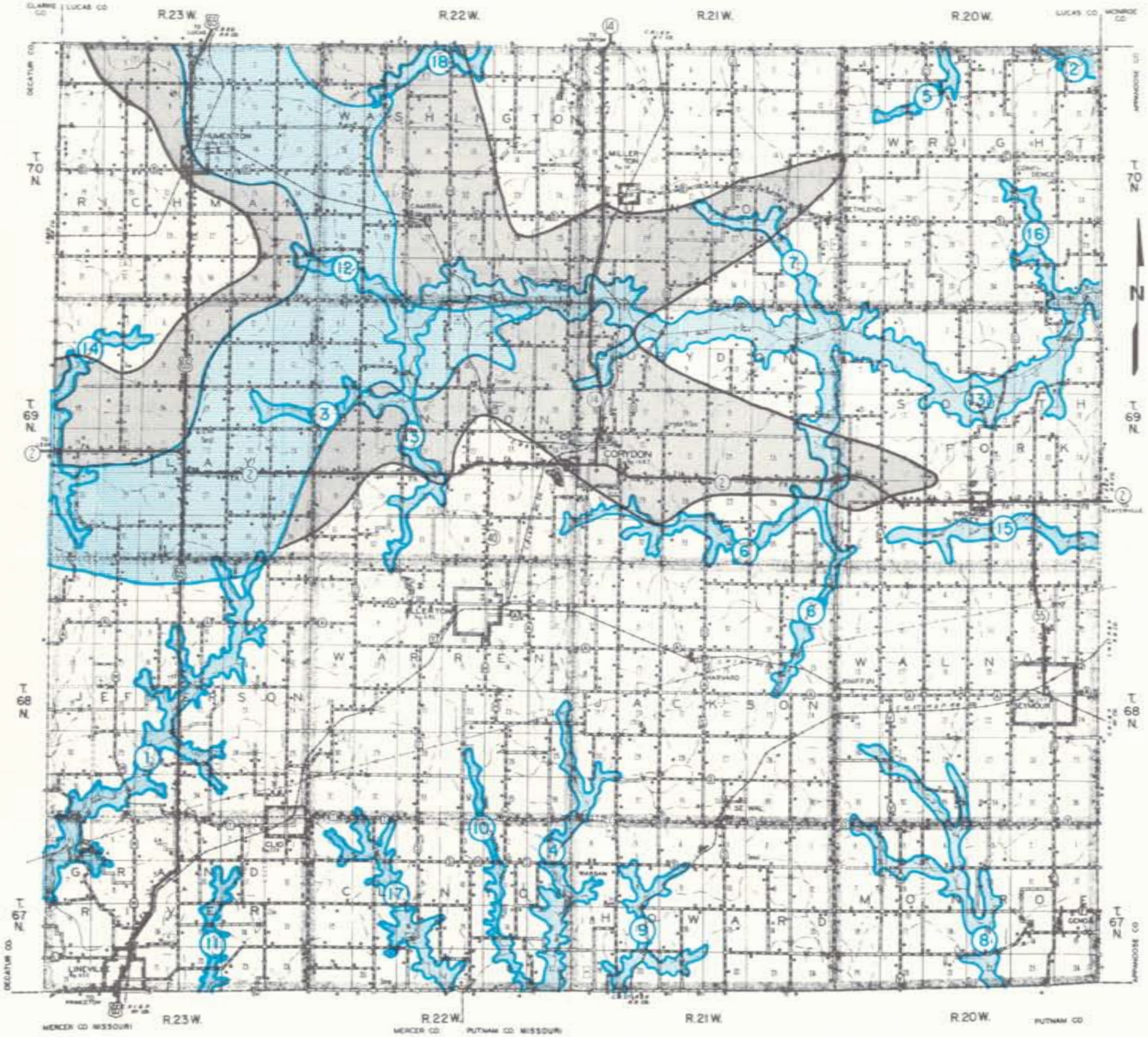
Area C.—The yields estimated to be available from the glacial drift in this area would suffice for modern-day domestic and stock needs where pressure systems are used. The largest known yield in area C was from well 44 (table 6) which had a reported yield of 17 gpm.

The area least favorable for the development of ground-water supplies from the unconsolidated deposits is area D. Yields from wells tapping the glacial drift in this area range from less than 1 gpm to 3 gpm, but locally yields of 5 gpm or more are obtained. The largest reported yield in area D was 15 gpm from well 27 (table 6). The test-drilling data indicate that only locally can enough water be obtained to satisfy modern-day domestic and stock needs. Area D generally overlies a relatively high (upland) bedrock surface.

Many wells in the county probably do not obtain the maximum yields of which they are capable. Some ways of increasing yields are (1) deeper drilling, to bedrock if necessary, to locate all potential water-bearing sands and gravels, (2) improved methods of well construction and development, and (3) multiple screening of water-bearing beds in the glacial drift.

Stream valleys designated in figure 9.

(1) Caleb Creek valley
(2) Chariton River valley
(3) Dick Creek valley
(4) East Fork Medicine Creek valley
(5) Goodwater Creek valley
(6) Jackson Creek valley
(7) Jordan Creek valley
(8) Locust Creek valley
(9) Medicine Creek valley
(10) Middle Fork Medicine Creek valley
(11) Muddy Creek valley
(12) Ninemile Creek valley
(13) South Fork Chariton River valley
(14) Steele Creek valley
(15) Walnut Creek valley
(16) Walker Branch valley
(17) West Fork Medicine Creek valley
(18) Wolf Creek valley



BASE MAP TAKEN FROM GENERAL HIGHWAY AND TRANSPORTATION MAP OF WAYNE COUNTY, 1962

EXPLANATION

Areas Most Favorable for Development of Ground-Water Supplies

A
Alluvium

Alluvium[5/] is confined to and underlies the flood plains and terraces of principal stream valleys to a maximum depth of 60 feet. Glacial drift is beneath the alluvium, except at a few places in northeastern Wayne County where the alluvium lies directly on the bedrock. Yields of 10 to 45 gpm (gallons per minute) are estimated to be available at most places with the largest yields to be expected where the sand and gravel deposits are from 10 to 20 feet thick. It is probable that yields of only 5 gpm or less can be obtained at places where the sands and gravels are relatively thin and clayey.

(Surface distribution of alluvium adopted in part from Soil Survey of Wayne County, Iowa: Iowa Agricultural Experiment Station, Soil Survey Report No. 19, 1921.)

B
Glacial drift

Glacial drift[6/] is at surface and underlies area to bedrock. A zone of till with sand and gravel breaks, which occurs within the lowermost 25 feet of the glacial drift at most places in area B, appears to have the best water-bearing potential. Generally, two or more such zones or beds of sand and gravel, or both, occur above the lowermost zone. Some of the zones and beds appear to be continuous in parts of the area. Yields of 10 to 45 gpm are estimated to be available at most places, but larger yields may be available locally.

C
Glacial drift

Glacial drift is at surface and underlies area to bedrock. Generally, two or more zones of till with sand and gravel breaks or beds of sand and gravel, or both, occur within the glacial drift in area C. Some of the zones and beds appear to be continuous in large parts of the area. Yields of 5 to 15 gpm are estimated to be available at most places, but larger yields can be obtained locally.

Area Least Favorable for Development of Ground-Water Supplies

D
Glacial drift

Glacial drift is at surface and underlies area to bedrock. Sands and gravels in area D occur mostly as discontinuous stringers or lenses and usually could not be traced between test holes. Yields of only 1 gpm or less (about 1,000 gallons per day) are estimated to be available at most places. Locally, yields may be larger but will seldom exceed 5 gpm. Also, locally, the glacial drift will not yield any water.

5/ Alluvium in area A occurs in the stream valleys designated by numbers on map and named on facing page.

6/ Glacial drift in this usage includes the relatively thin mantle of loess and slope wash on the uplands and hillsides.

Scale
0 1 2 3 4 5 Miles

FIGURE 9.—General availability of water from the glacial drift and alluvium.

CHEMICAL QUALITY OF GROUND WATER

Water dissolves minerals from the soils and rocks through which it passes. Some of these dissolved mineral constituents are objectionable in water when they occur in large concentrations; others are objectionable when they occur in only small concentrations. Excessive mineralization of water may restrict its use for human consumption and for agricultural and industrial purposes.

Exact limits of dissolved minerals that can be tolerated for specific uses are difficult to define; however, recommended standards (table 1) for some mineral constituents have been established by the U.S. Public Health Service for drinking water, and water-quality limits have been set or recommended by other agencies for agricultural and industrial supplies. Most mineral constituents in ground-water supplies sampled in Wayne County exceed the recommended maximum for drinking-water standards. However, where domestic and public supplies do not meet these standards, U. S. Public Health Service Publication No. 956 (revised 1962) states that "Although waters of such quality are not generally desirable, it is recognized that a considerable number of supplies with dissolved solids in excess of the recommended limits are used without obvious ill effects."

The mineral constituents and properties most commonly determined in chemical analyses of water are those given in table 1. The chemical quality of ground water in Wayne County, based on analyses presented in table 5 and on data from wells in adjacent counties (p. 6 and 7), is summarized below.

1. Water from the bedrock aquifers is moderately to highly mineralized. Supplies from the upper bedrock aquifer have a high mineral content as shown by analyses of several samples (table 5) that have dissolved-solids concentrations ranging from about 2,000 to about 5,500 mg/l. The data are believed to be representative of the water in this aquifer in all parts of the county. Supplies available from the middle bedrock aquifer, as explained on page 7, almost certainly would be as highly mineralized. Water from the lower bedrock aquifer is believed to have an acceptable mineral content in parts of northeastern and eastern Wayne County, where the dissolved solids are estimated to range from 800 to 1,100 mg/l; elsewhere in the county

TABLE 1.—SIGNIFICANCE OF MINERAL CONSTITUENTS AND PROPERTIES OF WATER [7]

Constituent or Property	Maximum Recommended Concentration	Significance
Iron (Fe)	0.3 mg/l	Objectionable as it causes red and brown staining of clothing and porcelain. High concentrations affect the color and taste of beverages.
Manganese (Mn)	0.05 mg/l	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 mg/l.
Calcium (Ca) and Magnesium (Mg)		Principal causes for hardness and scale-forming properties of water. They reduce the lathering ability of soap.
Sodium (Na) and Potassium (K)		Impart a salty or brackish taste when combined with chloride. Sodium salts cause foaming in boilers.
Sulfate (SO_4)	250 mg/l	Commonly has a laxative effect when the concentration is 600 to 1,000 mg/l, particularly when combined with magnesium or sodium. The effect is much less when combined with calcium. This 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 mg/l. Sulfate combined with calcium forms a hard scale in boilers and water heaters.
Chloride (Cl)	250 mg/l	Large amounts combined with sodium impart a salty taste.
Fluoride (F)	2.0 mg/l	In south-central Iowa, concentrations of 0.8 to 1.3 mg/l are considered to play a part in the reduction of tooth decay. However, concentrations over 2.0 mg/l will cause the mottling of the enamel of children's teeth.
Nitrate (NO_3)	45 mg/l	Waters with high nitrate content should not be used for infant feeding as it may cause methemoglobinemia or cyanosis. High concentrations suggest organic pollution from sewage, decayed organic matter, nitrate in the soil, or chemical fertilizer.
Dissolved Solids	500 mg/l	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 mg/l will have a laxative effect on most persons. Amounts up to 1,000 mg/l are generally considered acceptable for drinking purposes if no other water is available.
Hardness (as $CaCO_3$)		This affects the lathering ability of soap. It is generally produced by calcium and magnesium. Hardness is expressed in milligrams per liter equivalent to $CaCO_3$ as if all the hardness were caused by this compound. Water becomes objectionable for domestic use when the hardness is above 100 mg/l; however, it can be treated readily by softening.
Temperature		Affects the desirability and economy of water use, especially for industrial cooling and air conditioning. Most users want a water supply with a low and constant temperature.

[7] See U. S. Public Health Service Publication No. 956 (revised 1962) and U. S. Geological Survey Water-Supply Paper No. 1473 (both available from Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20242) for further discussion of chemical and physical properties of water.

the concentration of dissolved solids probably exceeds 2,000 mg/l. (See p. 7.)

Without extensive treatment most water from bedrock sources is unsuitable for most domestic and many industrial uses, principally because of a high dissolved-solids, sulfate, and chloride content. However, the water can be used presently without treatment for certain purposes, such as washing, cooling, and fire fighting. The development of a supply of highly mineralized water used solely for these purposes would, for example, allow a municipality or industry to conserve its potable water supplies for higher priority needs. A more complete utilization of this highly mineralized water depends on the development of economical methods of demineralization.

2. Water from shallow depths (100 feet or less) in the glacial drift is very hard and often contains undesirable concentrations of iron, sulfate, nitrate, and dissolved solids. Iron content ranges from 0.02 to 3.3 mg/l; very few supplies contain less than 0.3 mg/l. Sulfate concentrations generally are less than 250 mg/l, but range up to about 700 mg/l with one exception (well 40). Nitrate and chloride concentrations in some water supplies range up to 570 and 200 mg/l, respectively. The dissolved-solids content varies considerably and ranges between 391 and 1,590 mg/l with one exception (well 40).

The high nitrate, chloride, and dissolved-solids concentrations in some water supplies are due to contamination by runoff and infiltration of barnyard wastes. Based on observations at the well sites, the contamination is attributed to poorly constructed and improperly located wells and, hence, is believed to be localized in occurrence. The water samples from these locally contaminated wells, therefore, are not representative of the water under natural conditions in the shallow drift aquifer. The samples that are most representative of the aquifer's chemical quality, particularly with respect to the dissolved-solids content, are those that contain less than 10 to 15 mg/l each of nitrate and chloride (table 5). These indicate that the dissolved-solids content is less than 1,000 mg/l, but occasionally ranges up to 1,500 mg/l.

Based on the above discussion, the following conclusions regarding the quality of water in the shallow drift in the county can be drawn: (1) Water from the upper 100 feet of drift generally will be acceptable for most purposes, **if wells are constructed properly and located away from sources of contamination.** (2) Shallow supplies are subject to contamination; hence, great care should be exercised in locating and constructing new shallow wells, and all supplies from existing shallow wells should be analyzed for nitrate and bacterial content.[8] (3) According to some authorities,[9] water supplies containing nitrate concentrations of several hundred milligrams per liter, which some supplies in Wayne County contain, should not be used for domestic and livestock purposes. Certainly, any water supply containing over 45 mg/l should not be used for infant feeding (table 1).

3. Water from the drift at depths greater than 100 feet generally is highly mineralized (table 5) and is not suitable for most domestic purposes.

4. Water from the alluvium is hard and probably is high in iron at most places, but analyses from the few wells sampled indicate that these supplies have a moderately low dissolved-solids content and that the quality is relatively good. Although the analyses do not show concentrations of nitrate and chloride that would indicate contamination, water in the alluvium is subject to pollution from surface sources. Therefore, alluvial supplies from both existing and newly constructed wells should be tested periodically for nitrate and bacterial content.

[8] Information concerning this type of analysis can be obtained from the State Hygienic Laboratory, University of Iowa, Iowa City, Iowa 52240.

[9] Willrich, T. L., Agricultural Extension Engineer, Iowa State University, Ames, Iowa.

SURFACE WATER AS A SOURCE OF WATER SUPPLY

Surface-water sources in Wayne County include reservoirs, ponds, and cisterns; unregulated streams were not a source of supply at the publication date of this report. All towns in the county that have municipal water systems, except Lineville, obtain their supplies from surface reservoirs. In recent years problems of obtaining adequate supplies of good-quality ground water in rural areas have led to the increased use of surface water from ponds and cisterns.

Surface reservoirs have furnished water for municipal use at Allerton, Corydon, Humeston, and Seymour for a number of years; however, at Corydon and Humeston attempts were made to develop a municipal supply from wells. Corydon drilled a well in 1911 which tapped the upper bedrock aquifer, but the well was later abandoned. A test hole drilled at Humeston in 1956 penetrated the glacial drift and located water-bearing beds, but the potential yield reportedly was not adequate for a municipal supply.

Surface water for municipal use in the county is processed and treated by chemical and physical methods to insure its sanitary condition and to reduce the concentrations of iron and manganese. Comparative analyses of raw and finished water indicate that, except for a reduction in the iron and manganese contents and an increase in hardness, there is no significant change in the chemical quality that affects its use (table 3). The finished water is hard but meets the drinking-water standards.

Comparison of the chemical qualities of surface water from reservoirs (table 3) and ground water from various sources (table 5) shows that the surface water is less mineralized and is of better chemical quality than most ground water. However, municipal or rural supplies obtained from reservoirs or ponds for human consumption would need to be purified. The superior chemical quality of surface water indicates the desirability of developing this resource to a greater extent in order to meet the water needs in the county. The optimum development of surface-water resources requires the collection and evaluation of data on the flow of streams in the county. These data will be collected and evaluated for the comprehensive regional report.

TABLE 2. — DATA ON MUNICIPAL SUPPLIES FROM SURFACE-WATER SOURCES

For additional information on public water supplies in Iowa, see report entitled "Iowa Public Water-Supply Data," compiled by the State Department of Health and published by the State of Iowa, 1964.

Municipality Source of supply	Size of reservoir	Reported pumpage gpd (gallons per day)	Processing and treatment of water
Town of Allerton Impounding reservoir	....	Range 80,000-300,000 gpd. Usage varies with seasonal requirements of local industry	At Allerton, Corydon, Humeston, and Seymour the raw water that is pumped from the surface reservoirs to the treatment plants undergoes several stages of treatment. Treatment plants in the four towns are of the same type (Purification and Disinfection), and the methods of treatment at each plant are essentially the same with minor variations. The methods and stages of treatment at these plants are: (1) aeration for removal of excess iron; (2) mixing basin where lime and alum are added for coagulation, chlorine for disinfection, and carbon and chlorine for taste and odor control; (3) sedimentation (settling basin); (4) filter basin; (5) disinfection (chlorine); (6) clear well; (7) mains. Copper sulfate is added as needed to control algal growth in reservoirs.
Town of Corydon Impounding reservoir	75 acres	Maximum 280,000 gpd; average 180,000 gpd	
Town of Humeston Impounding reservoir	40 acres	Range 35,000-160,000 gpd. Average 90,000 gpd	
Town of Seymour Impounding reservoir	20 acres	....	

TABLE 3.— CHEMICAL ANALYSES OF SURFACE WATER FROM MUNICIPAL RESERVOIRS

Dissolved constituents and hardness are expressed in milligrams per liter (mg/l). Milligrams per liter and parts per million (ppm) are equivalent units of measurement for values given in this table. These values may be converted to grains per gallon by dividing by 17.1. Analysis by the State Hygienic Laboratory of Iowa.

Town	Date of collection	Point of collection	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Potassium (K)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Total Hardness (as $CaCO_3$)	pH	Specific Conductance (micromhos at 25°C)	Remarks
Allerton	6-29-65	Plant intake	11.2	3.3	0.18	29.6	3.3	8.3	97.6	39.9	2.0	0.2	5.8	203	105	7.9	255	Raw sample
	3-01-65	Plant effluent	3.8	.16	.08	60.8	6.6	8.4	111	94.2	10.5	.2	5.1	272	180	7.7	418	Finished sample
Corydon	6-29-65	Plant intake	11.0	3.1	.16	31.2	4.8	8.5	87.8	54.3	4.5	.25	5.1	211	113	8.1	279	Raw sample
	3-01-65	Plant effluent	7.2	.10	.05	73.6	7.0	9.4	92.7	137	21.5	.2	1.6	342	212	7.2	507	Finished sample
Humeston	7-01-65	Plant intake	11.2	3.6	.05	17.6	3.2	3.7	62.2	17.7	1.5	.25	3.9	164	69	7.9	150	Raw sample
	3-01-65	Plant effluent	.6	.02	.05	38.4	3.6	4.5	87.8	35.3	8.0	.25	.9	165	120	8.5	266	Finished sample
Seymour	6-29-65	Plant intake	13.2	2.3	6.2	22.7	3.6	6.0	127	15.5	1.0	.25	1.8	147	102	8.1	248	Raw sample
	3-01-65	Plant effluent	1.0	.06	.05	40.0	5.4	9.1	92.7	58.4	8.5	.2	1.2	197	124	8.2	305	Finished sample
U. S. Public Health Service drinking-water standards				0.3	0.05					250	250	2.0	45	1000	Recommended maximum concentrations (see table 1).			

LOCATING AND DEVELOPING A WATER SUPPLY

This report is designed to provide answers to the following questions that arise when considering a ground-water supply. What are the sources of water in the area and which is the best source for developing a supply? What thickness of rock must be penetrated so that the maximum depth of drilling can be approximated and preliminary plans made for the construction of a well? What yield of water can be obtained? What is the chemical quality of the water and how does it affect the usage of water? The following hypothetical examples will illustrate the use of the report in solving a supply problem. All examples presuppose that the wells will be properly constructed and will be located away from sources of contamination (p. 10 and 17).

Problem: A domestic-stock supply of about 5 gpm is required at a farm site located in the NW corner of section 36, T. 70 N., R. 22 W.

Solution: The potential sources of ground water at this site are the glacial drift and the bedrock. Because the glacial drift in this area has a high probability of yielding the required 5 gpm (fig. 9) and because water-bearing beds (Pennsylvanian sandstones) in the upper bedrock aquifer are fairly deep and yield water that generally is more highly mineralized than water from the drift deposits, the glacial drift should be considered the most likely source. The maximum depth of a well that fully penetrates the glacial drift to the top of bedrock at this site would be about 265 feet, which is determined by the procedure outlined on page 8. The actual depth of the well will depend on the depth of the water-bearing sands that will yield the required amount of water. Because the chemical quality of water in the glacial drift deteriorates with depth (p. 17), an effort should be made to complete the well in the upper part of these deposits. Therefore, the first significant sand bed (at least 3 to 5 feet in thickness) or zone of till with "sand breaks" penetrated during the drilling should be tested for the required yield, and the well completed at that horizon if the yield is sufficient with sustained pumping. If the yield is not sufficient, the well should be drilled to the top of bedrock and all sandy zones should be developed (p. 14). The potential yield of a well finished in the glacial drift in this area is estimated to be 5 to 15 gpm, but the actual yield will have to be determined by test pumping or bailing. The water generally will contain about 400 to 1,000 mg/l of dissolved solids if the well is finished in the upper 100 feet of the drift, and 1,000 mg/l or more of dissolved solids if the well is completed at depths greater than 100 feet (table 5). If the water is obtained from shallow depths, it should be tested periodically for nitrate and bacterial content (p. 17).

Problem: A domestic-stock supply of about 5 gpm is needed at a farm site located in the SW 1/4 sec. 21, T. 68 N., R. 21 W.

Solution: The availability map (fig. 9) indicates that the site is in an area where the glacial drift is the most accessible source of ground-water supply, but where there is a low probability, except locally, that the desired yield can be obtained from these deposits. An alternative ground-water source to be considered for a farm supply is the Pennsylvanian section of the upper bedrock aquifer (p. 6). An attempt should first be made to develop a supply from the glacial drift, and the drilling procedure would be that described in the preceding example. The depth of a well that penetrates the glacial drift to the top of the Pennsylvanian bedrock would be about 200 feet, as determined by the procedure described on page 8. If water-bearing materials are not penetrated or if the yield is not sufficient, the well could, if desired, be extended into the bedrock of Pennsylvanian age. Sandstones, which are the principal water-bearing beds in the Pennsylvanian, should be capable of furnishing adequate yields for domestic and stock use at most places; however, it may be necessary to fully penetrate the Pennsylvanian and to develop several sandstone units to obtain the required supply. Furthermore, test pumping or bailing would be necessary to determine whether an adequate yield for domestic and stock supply is available from either the glacial drift or the Pennsylvanian. The maximum depth of a well that penetrates both the glacial drift and the Pennsylvanian and ends at the top of the Mississippian would be about 650 to 700 feet. This is determined from the contour map (fig. 4) and by the procedure outlined on page 8.

Chemical quality data (table 5) is of special importance to the water user who is planning the development of a supply from deeper parts of the glacial drift and from the Pennsylvanian rocks of the upper bedrock aquifer. Although water from these sources is highly mineralized and has undesirable qualities, it may be satisfactory for a livestock supply and for some limited domestic purposes. However, most users probably will want to obtain supplies for drinking and cooking purposes elsewhere.

An alternate possibility for a water supply, assuming that ground-water sources will not yield the desired supply, would be to use surface water (pond) for household purposes other than cooking and drinking and to haul water or attempt to develop a small supply of ground water for drinking and cooking purposes. Small supplies (usually about 1 gpm) often can be developed in the upper 60 to 80 feet of the glacial drift. The procedure to follow is to drill one or more test holes to depths of about 60 to 80 feet. Any thin sand layer penetrated might be developed as a source of drinking water. Before the water is used, however, it should be tested for nitrate and bacterial content.

Problem: A readily accessible supply of about 50 gpm of good-quality water is required by an industrial plant.

Solution: The only readily accessible ground-water source that can meet both quantity and quality requirements is the alluvium; but it is probable that the alluvium is capable of furnishing the desired yield only in the larger stream valleys, particularly the valleys of Caleb Creek, South Fork Chariton River, and Chariton River. The estimated yield from the alluvium at most places is 10 to 45 gpm (fig. 9); hence, two or more properly spaced wells probably will be needed to obtain the required amount of water. Test drilling to locate the thickest and most permeable deposits should precede the well construction (p. 14).

Alternative possibilities are the glacial drift in area B (fig. 9) and the upper bedrock aquifer (p. 6). Both of these sources will yield the required amount of water from two or more properly spaced wells, but the mineral content will restrict the use of the water to certain industrial purposes. To satisfy the quality requirements, the water would have to be treated to decrease the mineral content to an acceptable level.

Problem: An industry or municipality requires about 1 million gallons of water per day (about 700 gpm).

Solution: The only potential ground-water source in the county to meet this need is the lower bedrock aquifer (p. 7). At least two wells will be needed to produce the required amount of water from this source. The maximum depth of a well fully penetrating the aquifer will range from about 2,550 feet in the northeastern part of the county to about 2,800 feet in the southwestern part. Supplies available from the aquifer are believed to be of relatively good quality in parts of northeastern and eastern Wayne County; however, in other parts of the county, the water probably will be highly mineralized. In the latter areas, the water will have to be demineralized if water quality is a consideration, as it will be for a municipal supply and certain industrial processes.

SUMMARY AND CONCLUSIONS

The purpose of the ground-water investigation in south-central Iowa was to obtain some of the water facts that are needed to help solve the water-shortage problem in the region. This report provides these facts for one county in the region by evaluating data on the occurrence, general availability, and chemical quality of ground water in Wayne County. An evaluation of these data is summarized in the following statements.

Availability of water from unconsolidated deposits

Small-to-moderate supplies of water are available for development from the unconsolidated deposits in the county; large supplies are not available for development. The alluvium of the principal river valleys, and the glacial drift in some areas—particularly areas underlain by buried bedrock valleys—are the best potential sources for the development of moderate quantities of water from the unconsolidated deposits. Yields[10] of 10 to 45 gpm per well are estimated to be available from these sources at most places and, locally, the glacial drift may have the capacity to furnish even larger yields. The glacial drift in another area is capable of yielding an estimated 5 to 15 gpm per well; elsewhere yields will range from less than 1 gpm to 3 gpm and will seldom exceed 5 gpm.

Availability of water from bedrock

Moderate-to-large supplies of water are available from bedrock strata at various depths. Wells in Wayne County do not tap the deep bedrock aquifer; however, it is estimated that yields of several hundred gpm can be obtained from the deep aquifer at maximum depths of about 2,550 to 2,800 feet. The shallow and middle aquifers are believed capable of yielding about 50 gpm per well.

Chemical quality of ground water

Water in the alluvium generally is hard and probably is high in iron at most places, but the dissolved-solids content is indicated to be within acceptable limits and the quality is relatively good. Water at shallow depths (100 feet or less) in the glacial drift is very hard and often contains excessive amounts of iron and sulfate. Locally, excessive concentrations of nitrate and chloride are present which are due to contamination by organic wastes from surface sources. The frequent occurrence of high concentrations of dissolved solids in existing supplies indicates that much of the water is of poor quality; however, in a considerable number of these supplies the high dissolved-solids content is not a true indicator of natural water quality because of local contamination. At most places the dissolved-solids concentration in natural water in the shallow drift aquifer is believed to be within acceptable limits. Generally, the sulfate and dissolved-solids contents increase with depth in the glacial drift; and in the deeper parts of these deposits the water is highly mineralized. Water in the upper part of the bedrock is highly mineralized, particularly with regard to the sulfate and dissolved-solids content, and is of poor chemical quality. Supplies available from intermediate depths in the bedrock (not tapped by wells) are believed to have similar characteristics and, additionally, may have a high chloride content. Water from the deeper bedrock strata is believed to be of relatively good quality in parts of northeastern and eastern Wayne County, but probably has a high mineral content elsewhere in the county.

[10] The yields available from the various ground-water sources discussed in this report were estimated by comparing data from the well inventory with test-drilling data. More quantitative data on actual yields, in addition to water-level data, are needed to evaluate fully the availability of water. These data will be collected for the comprehensive regional report.

The principal conclusion to be drawn from the information presented in this report is that only locally and in limited areas, or only after extensive quality treatment, are adequate supplies of ground water available to satisfy the water needs in the county.

Modern rural (farm and small community) needs for readily accessible, good-quality water can be satisfied only locally and in limited areas, where sufficient good-quality water is available from the alluvium and from shallow depths in the glacial drift. The rural user can develop sufficient water for his needs from the Pennsylvanian sandstones in the shallower bedrock at most places, and from deeper parts of the glacial drift in some areas; but the water is highly mineralized. The mineralized water generally is satisfactory for a livestock supply and for some domestic purposes, but many rural users may find the water unsuitable for drinking and cooking.

See the first two examples on pages 20 and 21

Industrial needs for large quantities of water can be satisfied anywhere in the county by developing water from the deep bedrock, if water quality is not an important consideration or if demineralization is feasible. Light industrial and small-scale irrigation needs for moderate amounts of water can be satisfied at most places from the alluvium and, in parts of the county, from the glacial drift. Some treatment of the water from these sources may be needed for industrial usage, but this would depend on the water-quality requirements of the industry.

See examples 3 and 4 on page 21

Municipal needs for large amounts of good-quality water from the deep bedrock probably can be satisfied only in parts of northeastern and eastern Wayne County; elsewhere, it is likely that the quality of water from the deeper sources is relatively poor and would require extensive quality treatment. An alternate possibility may be the development of a surface-water supply, but this supply also would require treatment.

See example 4 on page 21

Another conclusion necessarily follows—surface-water sources will have to be developed to meet the various needs that ground-water sources cannot satisfy. However, before surface-water sources can be developed for reliable water supplies, data on the flow regimen of streams will have to be collected and evaluated. This study will comprise the next phase of work in the area, and the results will be incorporated in the comprehensive regional report.

AVAILABLE TOPOGRAPHIC MAPS

Published topographic maps, prepared by the U.S. Geological Survey, are available for areas in Wayne County shown in figure 10. The 1:24,000-scale maps (1 inch on the map equals 2,000 feet on the ground) and the 1:62,500-scale maps (1 inch on the map equals approximately 1 mile on ground) can be used to determine land-surface elevations within an accuracy of ±5 feet and ±10 feet, respectively. The 1:24,000-scale maps cover 7 1/2 minutes of latitude and longitude and have a contour interval of 10 feet; the 1:62,500-scale maps cover 15 minutes of latitude and longitude and have a contour interval of 20 feet.

Also available is a 1:250,000-scale NK series map, prepared by the Army Map Service, which covers a large area in south-central Iowa and which includes all of Wayne County.

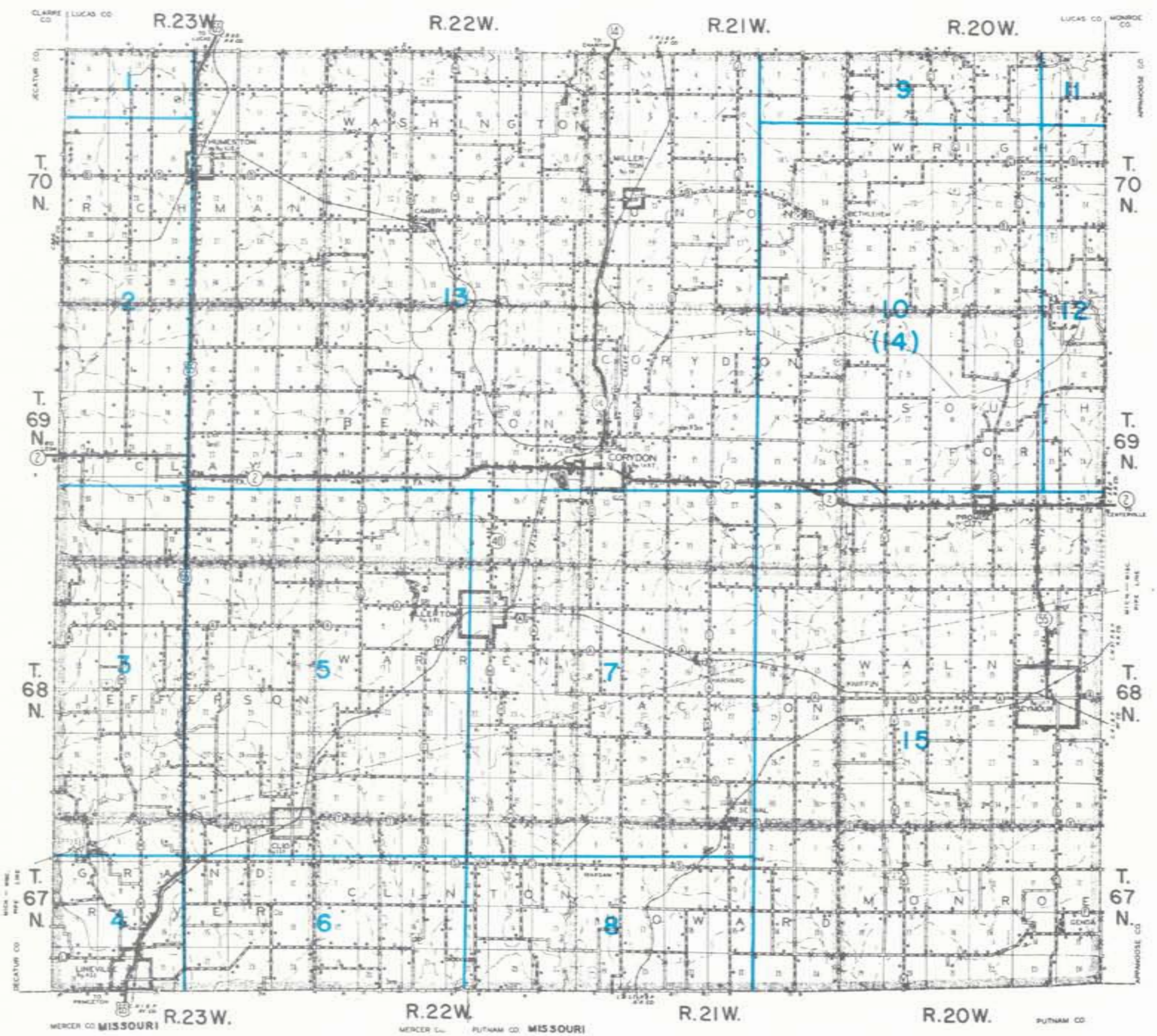
Name of Map	Map Series	Contour Interval (feet)	Remarks
Centerville, Iowa; Missouri	NK 15-11	50 with supplementary 25-foot contours	Scale 1:250,000 (1 inch on map = approximately 4 miles on ground)

Published topographic maps are for sale and may be ordered from governmental agencies at a nominal charge. The map order should include the map name and the map series designation; for example, Clio, Iowa, 7 1/2-minute series; or Centerville, Iowa-Missouri, NK 15-11 series. Maps may be ordered from the following governmental agencies:

Iowa Geological Survey, Geological Survey Building, Iowa City, Iowa 52240
Denver Distribution Center, Geological Survey, Federal Center, Denver, Colorado 80225.

An index map of the state showing areas where topographic maps have been published is available upon request from the Iowa Geological Survey.

Additional information concerning the progress of mapping in Iowa may be obtained from the Topographic Division, U.S. Geological Survey, Box 133, Rolla, Missouri 65401; or the Map Information Office, U.S. Geological Survey, Washington, D.C. 20242.



N

EXPLANATION

Area Number	Map Name
	$7\frac{1}{2}$-minute Quadrangles
1	LeRoy, Iowa
2	Garden Grove, Iowa
3	Woodland, Iowa
4	Lineville, Mo. -Iowa
5	Clio, Iowa
6	Cleopatra, Mo. -Iowa
7	Allerton, Iowa
8	Powersville, Mo. -Iowa
9	Russell, Iowa
10	Confidence, Iowa
11	Not mapped as $7\frac{1}{2}$-min.
12	Plano, Iowa
	15-minute Quadrangles
13	Coryden, Iowa
(14)	Russell, Iowa (includes areas 9, 10, 11, and 12)
15	Seymour, Iowa

Scale

1 0 1 2 3 miles

FIGURE 10.—Availability of quadrangle topographic maps.

TABLE 4.—DATA ON SELECTED DEEP BEDROCK WELLS AND BORINGS[11]

Owner or Name	Source of water	Depth of well when drilled (feet)	Year drilled	Remarks[12]
Town of Corydon	Pennsylvanian (?) Mississippian	1240	1911	Well capped and abandoned. Formerly furnished municipal supply but has not been in use for many years. Well is ended in top of Devonian. Reported yield in 1912 was 40 gpm. Located in SW 1/4 sec. 19, T. 69 N., R. 21 W.
Town of Lineville	Pennsylvanian Mississippian	1285	1954	Municipal supply. Test pumped 35 gpm; average yield about 20 gpm. Casing: 8-inch from 0 to 1000 ft. with perforations opposite water-bearing zones; not cased 1000 to 1285 ft. Located in NE 1/4 sec. 20, T. 67 N., R. 23 W.
Town of Humeston	....	330	1956	Town test well No. 1; not developed. Test ended in top of Pennsylvanian. Located in NE 1/4 sec. 9, T. 70 N., R. 23 W.
Cambria School	Pennsylvanian	602	1925	Drilled for school supply. Use of well when visited June 1965 not determined. Located in NW 1/4 sec. 28, T. 70 N., R. 22 W.
Central Farm Products	....	200	1963	Test hole; not developed. Test ended in top of Pennsylvanian. Located in Allerton in NW 1/4 sec. 11, T. 68 N., R. 22 W.
Coal test	....	370	....	Test hole is ended in Pennsylvanian. Located in SW 1/4 sec. 34, T. 69 N., R. 21 W.
Ivan Edgman	Pennsylvanian	500	1917	Formerly furnished stock supply; now abandoned. Located in NE 1/4 sec. 22, T. 68 N., R. 23 W. For additional information see well 39 in table 6.
Maurice Kent	Pennsylvanian Mississippian (?)	710	1957	Domestic and stock supply. Reported yield 15 gpm on test in 1957; specific capacity about 0.1 gpm per foot of drawdown. Located in SW 1/4 sec. 28, T. 69 N., R. 20 W. For additional information see well 46 in table 6.
William May	....	385	1925	Coal test; ended in Pennsylvanian. Located in NW 1/4 sec. 1, T. 70 N., R. 21 W.
Oil test	....	1000	1926	Test hole is ended in Mississippian. Dry and abandoned; destroyed. Located in NE 1/4 sec. 25, T. 68 N., R. 20 W.
Robert Smith	Pennsylvanian Mississippian	520	1944	Stock supply. Reported yield 15 gpm in 1944; specific capacity about 0.2 gpm per foot of drawdown. Located in SW 1/4 sec. 25, T. 70 N., R. 20 W. For additional information see well well 69 in table 6.

[11] Locations and depth to bedrock data shown in figure 5.
[12] Sample log or driller's log, or both, for all wells and borings are in files of Iowa Geological Survey.

TABLE 5.—CHEMICAL ANALYSES OF GROUND WATER FROM SELECTED WELLS

Dissolved constituents and hardness are expressed in milligrams per liter (mg/l). Milligrams per liter and parts per million (ppm) are equivalent units of measurement for values given in this table. These values may be converted to grains per gallon by dividing by 17.1. Analysis by the State Hygienic Laboratory of Iowa. Well numbers correspond to those shown in figure 6 and table 6.

Well number	Owner	Location	Date of collection	Depth of well	Source of water	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Potassium (K)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness (as $CaCO_3$)	pH	Specific conductance (micromhos at 25°C)
1	Richard Mincks	NE 1/4 Sec 01 T67N, R20W	06-24-65	43	Glacial Drift	55	28	0.04	0.05	136	40	0.6	96	437	227	28	0.4	92	898	496	7.6	1330
2	John Murphy	SW 1/4 Sec 03 T67N, R20W	06-25-65	39	Glacial Drift	52	25	.20	.05	154	56	.9	146	268	50	145	.4	570	1310	616	7.7	2000
8	Glenn Ludington	SW 1/4 Sec 10 T67N, R21W	06-30-65	66	Glacial Drift	53	31	.31	.05	192	61	1.7	83	539	432	9.0	.4	10	1190	732	7.9	1550
9	Donald Liggett	SE 1/4 Sec 14 T67N, R21W	05-19-65	32	Glacial Drift		28	.36	.05	226	70	1.3	125	311	500	110	.4	180	1590	854	7.4	2070
11	Dewey Savely	SE 1/4 Sec 04 T67N, R22W	06-30-65	90	Glacial Drift	53	22	.66	.05	108	30	9.5	59	229	163	53	.5	130	756	396	7.7	1080
12	Clifford Davis	SE 1/4 Sec 14 T67N, R22W	06-30-65	26	Alluvium		23	.16	.05	54	13	.7	32	163	102	9.0	.3	17	362	188	7.8	518
15	Olin Edmonson	NW 1/4 Sec 01 T67N, R23W	06-10-65	40	Glacial Drift	54	29	.04	.05	212	59	3.0	103	378	598	53	.5	15	1380	771	7.4	1820
17	Mich. Wisc. Co.	SW 1/4 Sec 06 T67N, R23W	05-12-65	38	Alluvium	53	31	24	1.6	91	28	.6	20	298	109	9.0	.1	.9	471	342	7.1	667
21	Ervin Gosch	NW 1/4 Sec 17 T67N, R23W	07-02-65	38	Glacial Drift	53	31	.54	.05	231	75	2.5	61	522	188	170	.4	150	1260	887	7.9	1890
	Town Lineville	SE 1/4 Sec 20 T67N, R23W	04-04-62	1285	Bedrock Penn.-Miss.		11	7.2	.15	35	19	13	880	573	1210	220	3.0	1.4	2720	164	7.8	4090
22	L. J. Brown	SE 1/4 Sec 06 T68N, R20W	06-25-65	70	Glacial Drift	54	27	.04	.05	72	21	1.9	66	386	32	15	.5	46	453	265	7.7	797
23	S. Ferris	SE 1/4 Sec 11 T68N, R20W	06-25-65	50	Glacial Drift	53	37	.06	.05	110	34	2.1	84	407	121	29	.4	92	721	416	7.5	1100
25	Mrs. C. McMurray	NE 1/4 Sec 24 T68N, R20W	06-19-68	350	Bedrock Pennsylvanian	57	8.3	2.6	.05	19	10	15	1100	927	630	760	1.5	.1	3040	92	7.8	4900
27	Artie Partridge	SW 1/4 Sec 05 T68N, R21W	05-13-65	176	Glacial Drift		30	3.3	.05	385	164	11	356	410	1990	18	.6	.1	3660	1640	7.5	3450
31	Edgar Demry	SE 1/4 Sec 34 T68N, R21W	05-21-65	75	Glacial Drift		27	.60	.05	252	76	6.8	162	301	589	200	.4	150	1730	942	7.3	2320
34	Harry Winslow	NW 1/4 Sec 15 T68N, R22W	07-01-65	27	Glacial Drift	53	30	3.3	1.3	247	63	2.0	76	344	684	8.0	.5	34	1480	875	8.1	1720
35	Lloyd Cawthorn	SW 1/4 Sec 23 T68N, R22W	05-21-65	38	Glacial Drift		29	.11	.05	160	41	2.5	102	290	392	38	.4	120	1130	571	7.3	1490
40	R. B. Elder	SE 1/4 Sec 25 T68N, R23W	07-02-65	80	Glacial Drift	55	26	.72	.71	457	137	4.7	113	405	1470	18	.4	65	2840	1710	7.9	2990
44	Leslie Tuttle	SW 1/4 Sec 21 T69N, R20W	05-14-65	274	Glacial Drift		14	10	.05	37	14	2.4	306	578	302	22	.4	1.2	1100	150	7.8	1520
46	Maurice Kent	SW 1/4 Sec 28 T69N, R20W	05-21-65	710	Bedrock Penn.-Miss. (?)		13	3.7	.05	161	57	5.5	400	373	1110	35	1.2	.2	2060	636	8.0	2740
47	M. E. Tuttle	NW 1/4 Sec 32 T69N, R20W	06-30-65	73	Glacial Drift	54	33	.10	.05	136	43	1.2	75	490	190	9.0	.4	45	754	516	7.9	1190
49	Lloyd Hughes	NE 1/4 Sec 02 T69N, R21W	06-30-65	27	Alluvium		25	.16	1.6	66	15	2.5	46	271	100	4.0	.5	6.6	407	226	8.1	633
52	Wayne Henderson	NE 1/4 Sec 27 T69N, R21W	07-01-65	39	Glacial Drift	54	29	.02	.05	160	54	1.4	61	361	86	85	.3	270	999	621	8.1	1500
54	H. A. Riley	SE 1/4 Sec 06 T69N, R22W	07-01-65	49	Glacial Drift		24	.08	.05	132	41	1.2	96	405	190	61	.5	120	928	501	8.2	1350
55	Wayne Co. Home	SW 1/4 Sec 14 T69N, R22W	02-11-66	300	Glacial Drift	53	15	2.5	.12	241	80	9.8	368	245	1430	42	.4	5.3	2460	932	7.5	3000
58	W. H. Goodell	NE 1/4 Sec 04 T69N, R23W	07-01-65	40	Glacial Drift		25	.46	.05	65	24	.5	44	375	42	4.0	.8	5.0	391	263	8.4	646
63	Nickel Cafe	NE 1/4 Sec 28 T69N, R23W	07-14-63	400	Glacial Drift	57	13	1.1	.17	240	73	12	568	207	1830	29	.2	.1	3160	902	7.8	3800
64	John Surbaugh	NW 1/4 Sec 33 T69N, R23W	07-01-65	82	Glacial Drift	52	24	1.4	.05	94	24	1.7	48	317	61	14	.4	85	540	332	8.3	842
68	John Lenz	SE 1/4 Sec 22 T70N, R20W	06-29-65	61	Glacial Drift	56	27	.06	.05	112	37	1.5	54	371	193	6.0	.6	15	632	431	8.3	963
69	Robert Smith	SW 1/4 Sec 25 T70N, R20W	06-18-65	324	Bedrock Penn.-Miss.		7.6	3.7	.05	260	46	9.4	1360	396	3140	200	1.3	1.9	5560	841	7.9	6940
72	Harold Hickie	NW 1/4 Sec 32 T70N, R20W	06-29-65	75	Glacial Drift		26	.18	.05	124	24	.7	44	351	155	16	.5	39	632	410	8.2	934
78	Reba Cutler	NW 1/4 Sec 22 T70N, R21W	06-30-65	39	Glacial Drift		28	.14	.05	88	27	.9	41	456	20	5.0	.4	15	414	333	8.2	767
80	Junior Annis	NW 1/4 Sec 34 T70N, R21W	05-18-65	76	Glacial Drift	56	29	.70	.05	196	60	1.5	86	388	179	80	.4	340	1290	738	7.3	1750
82	Milo Burnham	SE 1/4 Sec 24 T70N, R22W	07-01-65	40	Glacial Drift	52	26	.64	.05	80	22	1.2	47	251	62	31	.5	84	520	293	8.2	773
84	B. F. Hotchkiss	NW 1/4 Sec 28 T70N, R22W	05-20-65	60	Glacial Drift	56	27	.02	.05	107	27	1.7	71	299	77	50	.5	130	628	376	7.4	991
89	Olen Sheets	SE 1/4 Sec 28 T70N, R23W	06-17-65	60	Glacial Drift	53	28	.23	.59	206	60	.9	68	178	99	190	.3	440	1280	762	7.2	1900
Recommended maximum concentrations for drinking water (see table 1)								0.3	.05						250	250	2.0	45	1000			

TABLE 6.—RECORDS OF SELECTED WELLS

Well number: Numbers correspond to those shown in figure 6. Additional data on wells 39, 46, and 69 given in table 4.

Type of well: B, bored; Du, dug; Dr, drilled.

Depth of well and water level: Depths and water levels which were measured are indicated by entry in Date of measurement column; those reported have no entry in Date column.

Additional supplies: W, other well(s) for domestic or stock use; P, pond(s) for stock; C, cistern.

Method of lift: M, manual; E, electric motor or pump; W, windmill.

Use: D, domestic; S, stock; C, commercial; I, institutional; N, industrial, P, public supply; U, unused.

Chemical analyses: C, indicates chemical analysis given in table 5.

Geologic log: L, sample log and (or) driller's log in files of Iowa Geological Survey.

Remarks: Specific capacity equals number of gallons per minute per foot of drawdown.

Well number	Owner or Name Location	Type of well	Depth of well (ft.)	Diam. of well (in.)	Source of water	Water level: Below land surface (ft.)	Water level: Date of measurement	Method of lift	Use of water	Chemical analysis	Geologic log	Additional supplies	Remarks
	T. 67 N., R. 20 W.												
1	Richard Mincks NW 1/4 NE 1/4 Sec. 01	DU	43		Glacial Drift	30	6-65	E	D	C		W, P	
2	John Murphy SE 1/4 SW 1/4 Sec. 03	B	39	14	Glacial Drift	14	6-65	M	D	C		W, P	
3	Corr Swan NE 1/4 NW 1/4 Sec. 05	DU	37		Glacial Drift	18	6-65	E	D			W, P, C	
4	Leland Ralston SE 1/4 SW 1/4 Sec. 07	B		85	Glacial Drift	57	6-65	E	D			C	
5	Roy Coates NE 1/4 SE 1/4 Sec. 08	B	19	36	Glacial Drift	10	6-65	—	S		L	W, P, C	Reported yield 1,250 gallons in 24 hours on test in 1961.
6	H. A. Staggs SW 1/4 NW 1/4 Sec. 12	B	47	20	Glacial Drift	17	6-65	—	S		L	W	Main water supply at 23 feet.
7	Lowell Shelley SE 1/4 SW 1/4 Sec. 15	B	43	16	Glacial Drift	24	6-65	E	D			W, P	
	T. 67 N., R. 21 W.												
8	Glenn Ludington SW 1/4 SW 1/4 Sec. 10	B	66	12	Glacial Drift	32	5-65	M	D	C		P, C	
9	Donald Liggett SE 1/4 SE 1/4 Sec. 14	—	32		Glacial Drift	18	5-65	E	D	C			

	T. 67 N., R. 22 W.												
10	Earl Halfhill SE 1/4 SE 1/4 Sec. 02	DU	44	24	Glacial Drift	21	6-65	M	D			W, C	
11	Dewey Savely SE 1/4 SE 1/4 Sec. 04	B	90	12	Glacial Drift	15	—	E	D, S	C		W	
12	Clifford Davis NW 1/4 SE 1/4 Sec. 14	DU	26		Alluvium	13	6-65	E	D	C		P, C	
13	L. H. Marcusson SW 1/4 SE 1/4 Sec. 17	DU	32		Glacial Drift	13	6-65	E	D			W	
14	Charles Craig SW 1/4 NE 1/4 Sec. 19	—	53		Glacial Drift	19	6-65	E	S			W, P	
	T. 67 N., R. 23 W.												
15	Olin Edmondson NE 1/4 NW 1/4 Sec. 01	B	40	36	Glacial Drift	12	6-65	E	S	C	L		Reported yield 300 gallons per hour by bailer test in 1961. Main water supply 25-30 feet.
16	Roy Argo NW 1/4 SE 1/4 Sec. 02	B	80	30	Glacial Drift	4	6-65	E	S				
17	Mich. Wisc. Co. NE 1/4 SW 1/4 Sec. 06	—	38		Alluvium	6	-51	—	N, P	C			Reported yield 23 gpm in 1951; specific capacity 3.7. Sand and gravel from 32-38 feet is source of supply.
18	Mich. Wisc. Co. NW 1/4 SE 1/4 Sec. 06	—	36		Alluvium	7	-51	—	U				Reported yield 45 gpm in 1951; specific capacity 3.5.
19	Clarence Dobson NW 1/4 SW 1/4 Sec. 10	—	44		Glacial Drift	2	6-65	—	S			W	
20	Ernest Nickel SE 1/4 SW 1/4 Sec. 14	B	60	12	Glacial Drift		—	E	S			W, P, C	
21	Ervin Gosch NW 1/4 NW 1/4 Sec. 17	B	38	12	Glacial Drift	18	6-65	M	D	C		P, C	
	T. 68 N., R. 20 W.												
22	L. J. Brown NE 1/4 SE 1/4 Sec. 06	B	70	36	Glacial Drift	16	6-65	E	S, D	C	L		Reported yield 1 gpm on test in 1964; main water supply at 32 feet.
23	S. Ferris SE 1/4 SE 1/4 Sec. 11	B	50	36	Glacial Drift	19	6-65	E	D, S	C		P	
24	C. Davison SE 1/4 SW 1/4 Sec. 15	DU	40	36	Glacial Drift		—	E	D			W	
25	Mrs. C. McMurray NE 1/4 NE 1/4 Sec. 24	DR	350	5	U. Bedrock Aquifer Pennsylvanian	102	3-67	E	S	C	L		Casing: 5-in. from 0-338 ft; open hole 338-350 ft. Reported yield 4 gpm on test in 1967; specific capacity less than 1.0.
26	Homer Mitten NW 1/4 SW 1/4 Sec. 28	B	77		Glacial Drift	63	5-65	E	D, S			P	

TABLE 6.—Records of selected wells—Continued

	T. 68 N., R. 21 W.												
27	Artie Partridge SW 1/4 SW1/4 Sec. 05	DR	176	7	Glacial Drift	42	—	E	S	C		W	Reported: yield 15 gpm; water hard with high iron content and suitable only for stock; furnishes plenty of water.
28	Homer Van Dyne SE 1/4 SE 1/4 Sec. 12	B	40	12	Glacial Drift	20	5-65	E	D				
29	Robert Beavers NW 1/4 NW 1/4 Sec. 18	B	40	18	Glacial Drift	10	—	E	D			P, C	
30	Ray Couchman NW 1/4 NW 1/4 Sec. 27	—	39	36	Glacial Drift	19	5-65	E	D			W	
31	Edgar Demry NW 1/4 SE 1/4 Sec. 34	DU	75	36	Glacial Drift	7	—	E	N, D	C			
	T. 68 N., R. 22 W.												
32	R. Snodgrass SW 1/4 NW 1/4 Sec. 07	B	72	12	Glacial Drift	20	5-65	E	D			W	
33	Harry Winslow NW 1/4 NW 1/4 Sec. 15	—	53		Glacial Drift	13	5-65	E	D			W	
34	Harry Winslow NW 1/4 NW 1/4 Sec. 15	B	27		Glacial Drift	10	7-65	E	S	C			
35	Lloyd Cawthorn SW 1/4 SW 1/4 Sec. 23	DU	38	28	Glacial Drift	19	5-65	E	S, D	C			
36	Doyle Edmonson SW 1/4 SE 1/4 Sec. 28	B	48	12	Glacial Drift	18	5-65	E	D			W, P, C	
	T. 68 N., R. 23 W.												
37	D. Thompson SE 1/4 NW 1/4 Sec. 08	B	65	30	Glacial Drift	50	6-65	—	U		L	W	Reported yield 600 gallons per hour on test in 1961.
38	Holley Stoker NW 1/4 NE 1/4 Sec. 13	B	73		Glacial Drift	38	6-65	W	S			W, C	
39	Ivan Edgman SE 1/4 NE 1/4 Sec. 22	DR	500	6	U. Bedrock Aquifer Pennsylvanian		—	—	U		L	P, C	Well abandoned when visited in 1965. Formerly furnished stock supply but not used for domestic supply because of mineral content.
40	R. B. Elder NW 1/4 SE 1/4 Sec. 25	B	80	36	Glacial Drift	30	6-65	E	S	C	L	P	Main water supply at 52 feet.

	T. 69 N., R. 20 W.												
41	Ellen Hogue NW 1/4 NW 1/4 Sec. 07	B	70	30	Glacial Drift	35	10-61	E	S		L	W, C	Reported yield 720 gallons in 24 hours on test in 1961. Main supply at 45 feet.
42	M. A. Stone SW 1/4 SE 1/4 Sec. 11	B	45		Glacial Drift	5	6-65	—	U			W, C	
43	Creed McIntyre NW 1/4 SW 1/4 Sec. 20	B	79	15	Glacial Drift	29	6-65	E	D			W	
44	Leslie Tuttle SW 1/4 SW 1/4 Sec. 21	DR	274	6	Glacial Drift	65	—	E	S, D	C			Reported yield 17 gpm in 1956; main supply from depth of 266-274 ft. Supplies large number of turkeys and livestock.
45	Tony Kruzich NE 1/4 SW 1/4 Sec. 25	B	42		Glacial Drift	22	—	E	D			W, P	
46	Maurice Kent NW 1/4 SW 1/4 Sec. 28	DR	710	4	U. Bedrock Aquifer Penn.-Miss. (?)	110	4-57	E	S, D	C	L	W	Cased 0-710 ft; casing perforated from 585-710 ft. Reported yield 15 gpm on test in 1957; supplies several hundred livestock.
47	M. E. Tuttle NW 1/4 NW 1/4 Sec. 32	B	73	36	Glacial Drift	35	6-65	E	S	C	L	W, P	Reported yield 110 gallons per hour on test in 1962. Main water supply at 42 feet.
48	Lewis Cobb NW 1/4 SW 1/4 Sec. 33	B	78	36	Glacial Drift	37	6-64	E	S		L	W, P	Reported yield 1,350 gallons in 18 hours on test in 1964; main supply at 35 and 75 feet.
	T. 69 N., R. 21 W.												
49	Lloyd Hughes SE 1/4 NE 1/4 Sec. 02	B	27	36	Alluvium	8	6-65	E	D	C	L	W	Reported yield 10 gpm on test in 1963; main supply at 25-30 feet.
50	Aaron Lake SW 1/4 SW 1/4 Sec. 11	B	38	36	Glacial Drift	2	5-65	E	D, S			W, P	Main supply at 14 feet.
51	L. W. Snyder NW 1/4 SW 1/4 Sec. 17	B	59	48	Glacial Drift	18	5-65	—	D		L		Reported drawdown 5 ft. after bailing 1,000 gallons; main supply at 28-32 ft.
52	Wayne Henderson SE 1/4 NE 1/4 Sec. 27	—	39		Glacial Drift	20	5-65	E	D	C			
53	R. W. Zastrow NE 1/4 NW 1/4 Sec. 36	DU	25	48	Glacial Drift		—	E	D, S			W, P	
	T. 69 N., R. 22 W.												
54	H. A. Riley SE 1/4 SE 1/4 Sec. 06	B	49	12	Glacial Drift	16	5-65	E	D, S	C		W	Well supplies about 100 stock.
55	Wayne Co. Home NW 1/4 SW 1/4 Sec. 14	DR	300	5	Glacial Drift	105	1-66	E	I	C	L		Cased 0-300 ft; casing perforated 210-300 ft. Reported yield 5 gpm on test in 1966; specific capacity about 0.1.
56	Wayne Co. Home NW 1/4 SW 1/4 Sec. 14	B	59	24	Glacial Drift	15	5-65	E	S			W, P	
57	Mardis Sheets SE 1/4 SE 1/4 Sec. 19	DU	17	36	Glacial Drift	1	5-65	—	S			W	

TABLE 6.—Records of selected wells—Continued

	T. 69 N., R. 23 W.												
58	W. H. Goodell SE 1/4 NE 1/4 Sec. 04	B	40	26	Glacial Drift	4	6-65	E	D, S	C			Supplies about 100 livestock.
59	Lester Guinn NE 1/4 NW 1/4 Sec. 05	DU	39		Glacial Drift	24	6-65	E	D, S			W, P	
60	M. Whitely SW 1/4 SE 1/4 Sec. 12	B	65	36	Glacial Drift	22	6-65	—	U				
61	Marvin Caldwell SW 1/4 NW 1/4 Sec. 21	DU	32		Glacial Drift	19	6-65	E	D, S			W	
62	Roy Hart SW 1/4 SW 1/4 Sec. 26	B	50		Glacial Drift	2	6-65	E	S			W	
63	Nickel Cafe NE 1/4 NE 1/4 Sec. 28	DR	400	5	Glacial Drift	140	7-63	E	C	C	L	W	Cased 0-383 ft; screen from 383-393 ft. Measured drawdown 10 ft. after test pumping at 13 gpm in 1963; specific capacity 1.3.
64	John Surbaugh NE 1/4 NW 1/4 Sec. 33	B	82		Glacial Drift	63	6-65	M	D	C		C	
	T. 70 N., R. 20 W.												
65	Stanley Larson SE 1/4 NE 1/4 Sec. 03	DU	44		Glacial Drift	23	6-65	M	D			W, P	
66	Kenneth Hays NW 1/4 SW 1/4 Sec. 13	B	82	24	Glacial Drift	24	6-65	E	S			W	
67	C. H. Walker NW 1/4 SW 1/4 Sec. 18	B	75	30	Glacial Drift	60	8-63	E	D		L	W, P	Reported yield 5 gpm on test in 1963; main supply at 65 feet.
68	John Lenz NE 1/4 SE 1/4 Sec. 22	B	61		Glacial Drift	26	6-65	E	S	C		W, P, C	
69	Robert Smith NW 1/4 SW 1/4 Sec. 25	DR	324	5	U. Bedrock Aquifer Penn.-Miss.	291	6-65	E	S	C	L		Well apparently filled in from original depth of 520 ft. Reported drawdown 85 ft. after test pumping at 15 gpm in 1944.
70	Robert Smith NW 1/4 SW 1/4 Sec. 25	B	66		Glacial Drift	13	6-65	—	U			W, P, C	
71	Harold Hickie NE 1/4 NE 1/4 Sec. 31	B	60	36	Glacial Drift	8	6-65	E	S		L		Main water supply at 33 feet.
72	Harold Hickie NW 1/4 NW 1/4 Sec. 32	B	75	30	Glacial Drift	32	6-65	E	D, S	C			
73	Carl Bennett NE 1/4 SW 1/4 Sec. 32	B	64	36	Glacial Drift	46	6-65	E	S		L	W, P	Main water supply at 34 feet.
74	John Poli NW 1/4 SE 1/4 Sec. 35	—	58		Glacial Drift	31	6-65	M	U			W, P	

	T. 70 N., R. 21 W.												
75	Charles Trumbo NE 1/4 NW 1/4 Sec. 07	B	38	22	Glacial Drift	2	5-65	M	S			W	
76	Milton Hawkins SW 1/4 SE 1/4 Sec. 09	DU	24	30	Glacial Drift	2	5-65	M	S			W, P	
77	J. B. Goodell SW 1/4 NW 1/4 Sec. 20	B	41	15	Glacial Drift	7	5-65	E	D				
78	Reba Cutler NE 1/4 NW 1/4 Sec. 22	DU	39	36	Glacial Drift	28	5-65	E	D, S	C		W	
79	Earl Davis SE 1/4 SE 1/4 Sec. 24	DU	30	36	Glacial Drift	6	5-65	M	D				
80	Junior Annis SW 1/4 NW 1/4 Sec. 34	B	76		Glacial Drift	10	5-65	M	S	C			
	T. 70 N., R. 22 W.												
81	Elwin Sellers NW 1/4 NW 1/4 Sec. 09	B	56	18	Glacial Drift	19	5-65	E	D			W, P	
82	Milo Burnham SW 1/4 SE 1/4 Sec. 24	B	40	18	Glacial Drift	23	5-65	M	S	C		W	
83	Ross Woolis SW 1/4 SE 1/4 Sec. 27	B	55	30	Glacial Drift	12	—	E	D, S			W, P	
84	B. F. Hotchkiss NE 1/4 NW 1/4 Sec. 28	B	60	36	Glacial Drift	13	5-65	E	D	C	L		
	T. 70 N., R. 23 W.												
85	C. S. Anderson SW 1/4 SW 1/4 Sec. 06	B	60	12	Glacial Drift	18	6-65	E	D			P, C	
86	Merwin Williams NW 1/4 NE 1/4 Sec. 11	B	56	36	Glacial Drift	12	6-65	E	S		L	W	Reported yield 1,500 gallons in 12 hours on test in 1963; main water supply 28-30 ft.
87	Creamery Well NW 1/4 SW 1/4 Sec. 15	DR	377	10	Glacial Drift		—	—	U		L		Well filled in and abandoned. Reported yield 40 gpm when drilled in 1920. Cased 0-371 ft; screen from 371-377 ft.
88	Roy Johnson SW 1/4 SW 1/4 Sec. 21	B	49		Glacial Drift	6	6-65	E	S			W	
89	Olen Sheets SW 1/4 SE 1/4 Sec. 28	B	60	30	Glacial Drift	12	6-65	E	S, D	C			Main water supply at 30 feet. Supplies about 125 livestock.
90	Frank Campbell NW 1/4 NW 1/4 Sec. 35	B	40		Glacial Drift	28	6-65	E	D				