Geology and Ground-Water Resources of the Big Blue River Basin Above Crete, Nebraska

By C. R. JOHNSON *and* C. F. KEECH

With a section on

CHEMICAL QUALITY OF THE WATER

By ROBERT BRENNAN

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GEOLOGY AND GROUND-WATER RESOURCES OF THE BIG BLUE RIVER BASIN ABOVE CRETE, NEBRASKA

By C. R. Johnson and C. F. Keech

ABSTRACT

Most of the Big Blue River basin above Crete, Nebr., is underlain by sand and gravel of Pleistocene age that normally yields large quantities of water to wells. Deposits of till underlie the eastern part of the area, and here ground-water supplies are not abundant.

Generally, the ground water is of the calcium bicarbonate type; however, some water in the western part of the area has appreciable amounts of sulfate. The high sulfate may be attributed to oxidation of iron sulfides in the Niobrara formation. Because of its low total salt content, low boron content, and low percent sodium, the ground water is suitable for irrigation. Although the water is hard and locally contains high concentrations of iron, it generally is potable and suitable for domestic use.

The general movement of the ground water is eastward toward the main stem of the Big Blue River.

Principal sources of ground-water recharge are precipitation on the area and underflow from adjacent areas to the west. Streams in the area generally receive water from, rather than contribute water to, the ground-water reservoir. As of 1953, the natural discharge of ground water into streams was about 150,000 acre-feet per year and was much more than the amount pumped from wells.

The major use made of ground water in the area is for irrigation. About 60,000 acres is irrigated annually. The annual withdrawal of ground water for irrigation is about 61,000 acre-feet; for domestic and stock use, about 25,000 acre-feet; and for municipal use, 8,000 acre-feet.

The number of irrigation wells increased from 14 in 1938 to 672 by June 30, 1953. During 1948, 140 irrigation wells were constructed, and the average rate of construction from 1944 through 1952 was 53 wells per year.

Use of ground water for irrigation is steadily increasing, but in most parts of the area the available supplies are more than sufficient for present withdrawals. The past average annual rate of increase in ground-water withdrawals, if distributed over the area, could continue for perhaps 25 or 30 years without serious depletion of the ground-water reservoir, but the base flow of streams in the area probably would be reduced considerably. Because of the interest in, and the rate of development of, the ground-water resources, systematic collection of more adequate hydrologic data should be undertaken, and detailed quantitative studies should be made so that the perennial yield of the aquifer can be determined before serious depletion of the ground-water supply occurs.

INTRODUCTION

The drainage basin of the Big Blue River above Crete, Nebr., is an area of about 2,700 square miles. It includes all of York County and parts of Adams, Butler, Clay, Fillmore, Hall, Hamilton, Polk, Saline, and Seward Counties, Nebr. The location of the area is shown in figure 1.

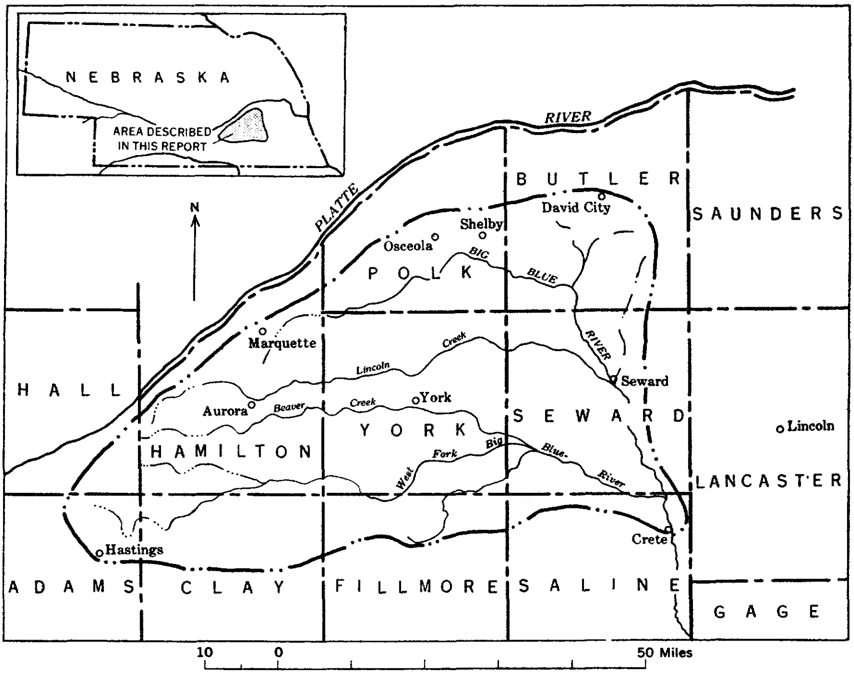

FIGURE 1.—Index map showing location of the Big Blue River basin above Crete, Nebr.

PURPOSE AND SCOPE OF THE INVESTIGATION

Nearly all domestic, municipal, industrial, and irrigation water supplies in the area are obtained from wells. The use of ground water for irrigation is rapidly increasing, and this study was made in order to gain a better understanding of the geology and hydrology of the area as they pertain to the replenishment, discharge, storage, and additional development of ground water. Increased use of ground water, especially for irrigation, eventually could exceed the average annual recharge to the ground-water reservoir and lower the regional water table to such an extent that pumping costs would become economically prohibitive. Also, the perennial flow of streams dependent on the outflow of ground water could be so reduced as to impair the supply of surface water for downstream uses. However, the proper conservation of ground-water resources can be defined to include the withdrawal of ground water in such a way that, although water levels may be lowered in the vicinity of heavily pumped wells, they will not decline to a level at which pumping costs will be prohibitive or at which discharge from the aquifers will persistently exceed recharge. Thus the purpose of this study was to assist in determining the current use of ground water and the amount of ground water that could be pumped without deleterious effects. The study was made as a part of the program of the Department of the Interior for development of the Missouri River basin.

In this report, the geology and hydrology of the area are described briefly; information on municipal and irrigation-well pumpage, collected during the investigation, is presented; an evaluation of existing hydrologic data is made; the effect of present and potential withdrawal of ground water upon the ground-water supply and the base flow of streams is discussed; and additional studies are suggested.

PREVIOUS INVESTIGATIONS AND REPORTS

The earliest investigation dealing specifically with the ground-water resources of parts of the Big Blue River basin was made by Darton (1898), who described the physiography, geology, and ground water in Lancaster, Seward, York, Fillmore, Hamilton, Clay, Hall, and Adams Counties. Lugn and Wenzel (1938) included Hall and Adams Counties and part of Hamilton and Clay Counties in an investigation extending from 1929 through 1933.

Geologic and ground-water data for Adams, Clay, Fillmore, Hamilton, Polk, Saline, Seward, and York Counties were compiled by Reed (1946a, b, c; 1947a, b; 1948, 1952, 1953). These data include maps showing the type of land, the water-table contours, the depth to ground water, the thickness of saturated sand and gravel, and geologic sections.

Test-hole drilling has been carried on for a number of years by the Conservation and Survey Division of the University of Nebraska in cooperation with the United States Geological Survey. Information derived from this drilling has been compiled by Schreurs and Keech (1953) in county reports, which include test-hole location maps, logs of test holes, and altitudes of the land surface at the test-hole locations.

WELL-NUMBERING SYSTEM

Wells and test holes listed in this report are numbered according to their location within the United States Bureau of Land Management's survey of the area. The first numeral of the well number denotes the township, the second the range, and the third the section in which the well is situated. The capital letter "A" preceding the first numeral indicates a range east of the sixth principal meridian; numbers not preceded by the letter "A" indicate a range west of the sixth principal meridian. The lowercase a, b, c, and d after the section number locate the well within the section; the first indicates the quarter section, and the second the quarter-quarter section. These letters are assigned in a counterclockwise direction, beginning with "a" in the northeast quarter. (See fig. 2.) If two or more wells are situated

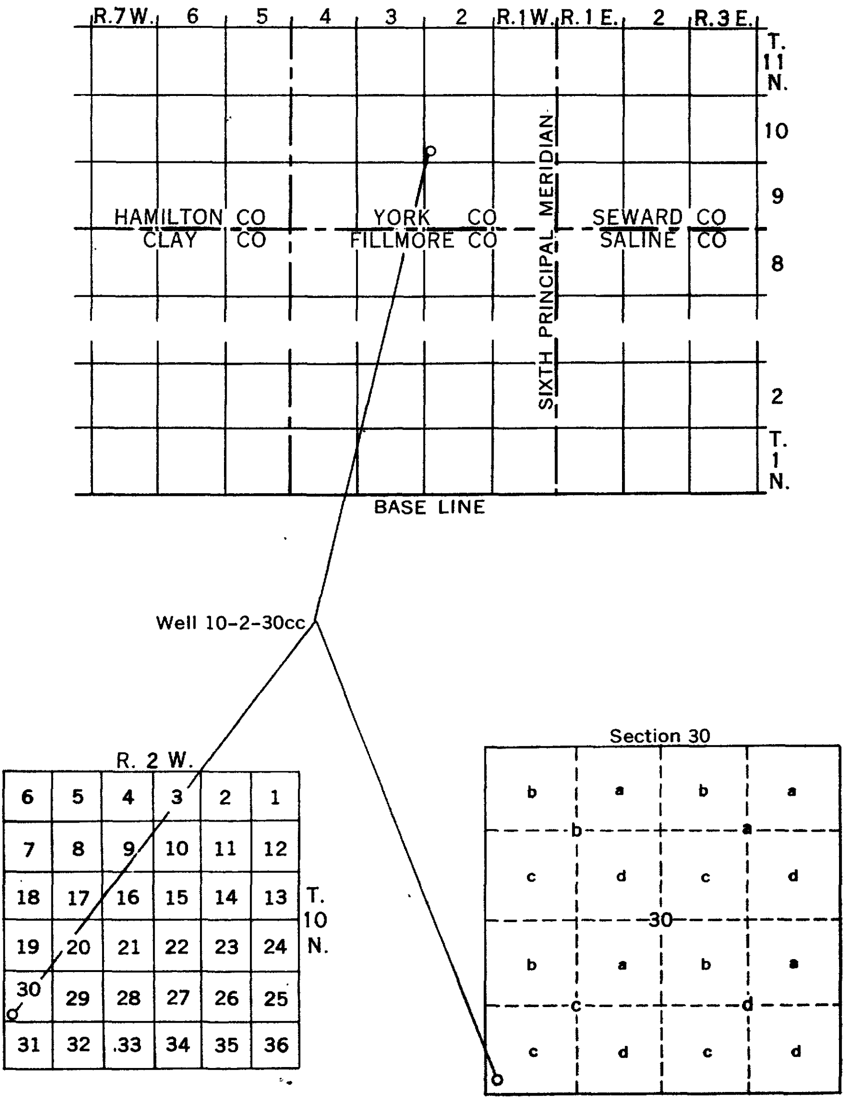

FIGURE 2.—Well-numbering system.

within the same 40-acre tract, consecutive numbers, beginning with 1, follow the lowercase letters.

METHODS OF INVESTIGATION

Reports of previous investigations were reviewed and additional data were collected in the field during the spring and early summer of 1953. All irrigation and municipal wells in the area were inventoried. (See table 4.) For some irrigation wells, more complete data regarding the wells, pumping plants, and irrigation practices and costs were collected. (See table 3.) During 1952–53, the Geological Survey collected and analyzed 19 samples of water from representative wells to determine the mineral content of the ground water. Analyses were available of eight additional samples of water collected from wells in the area during 1945–47.

Well drillers, county agents, soil conservationists, well owners, and superintendents of public water supplies were interviewed to obtain information on water use. Farmers were interviewed to determine irrigation practices, current use of water, and the rate of increase in ground-water development.

The amount of ground water withdrawn for domestic and stock use was estimated from the number and distribution of the wells rather than by recording individual wells. Industries, railroads, and public institutions other than municipal waterworks in the area use relatively little ground water as compared with the amount required for irrigation, municipal, domestic, and livestock uses; therefore, detailed data concerning the industrial, railroad, and institutional wells were not collected.

The investigation was made under the general supervision of G. H. Taylor, regional engineer in charge of ground-water investigations under the Missouri River basin program, and under the direct supervision of C. F. Keech, district engineer of the Ground Water Branch, Geological Survey, in Nebraska. The investigation of the chemical quality of the ground water was made under the direct supervision of P. C. Benedict, regional engineer of the Quality of Water Branch.

ACKNOWLEDGMENTS

Well drillers provided well logs and other data; county agricultural agents and members of the Soil Conservation Service of the U. S. Department of Agriculture helped locate newly drilled wells; municipal officials gave information concerning municipal pumping and distribution systems. The farmers were especially cooperative in permitting depth-to-water measurements to be made in their wells and in providing data on irrigation.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

The Big Blue River basin above Crete, Nebr., is, for the most part, a gently rolling loess plain of low relief, dissected by small, meandering streams which occupy wide, shallow valleys. A few shallow marshy depressions, some as large as several hundred acres, lie in the area. Some of these depressions occasionally contain water throughout the year, but most are dry during the summer even in years of normal or above-normal precipitation.

The gently rolling upland plains generally are mantled by thick loamy soil developed from the underlying loess; consequently, most of the land is suitable for irrigation. The plain becomes more rolling and the slopes become steeper near the larger streams; thus, irrigation of these areas is difficult. Terraces and flood plains of the larger streams are irrigated in places, but the advantages of the lower pumping lift and the thicker soil of such areas are offset by the smaller size of the plots that are suitable for irrigation.

The Big Blue River heads south of Marquette, Nebr., and flows northeastward, in a course a few miles from the northwestern boundary of its basin, to near Shelby, Nebr., and thence southeastward in a course a few miles west of the eastern boundary of the basin. (See fig. 1.) Lincoln Creek, Beaver Creek, and the West Fork of the Big Blue River, the largest tributaries of the Big Blue River, head near the edge of the Platte River valley and, in general, flow eastward and parallel to each other. The largest of the tributaries is the West Fork of the Big Blue River, which heads about 10 miles northwest of Hastings, Nebr., and joins the Big Blue River 5 miles north of Crete, Nebr.

Throughout most of its course, the West Fork of the Big Blue River has cut its valley about 100 feet into the plain. The valley is relatively narrow and deep in Adams and Clay Counties but its width progressively increases in a downstream direction, and its flood plain near Crete, Nebr., is nearly 2 miles wide.

The stream channels generally are cut in deposits of Quaternary age; only in a few places have the valleys been incised into the underlying Cretaceous rocks.

PRECIPITATION

The mean annual precipitation in the area ranges from about 25 inches in the western part to 27 inches in the eastern part. The least recorded annual precipitation in the area, 11.49 inches, fell at David City, Nebr., during 1936. The greatest recorded annual precipitation, 63.09 inches, fell at Sutton during 1883. Most precipitation is received during local thunderstorms in the growing season, May through September. Rainfall usually is well distributed during May and June, although droughts occur occasionally. The distribution in July normally is less uniform, and long periods of deficient rainfall are not unusual during August and September.

Annual evaporation from a class *A* pan of the U. S. Weather Bureau totals about 55 inches from April through October. It usually exceeds 10 inches during July, the month of the greatest evaporation.

The annual precipitation at Aurora and York is shown in figure 3.

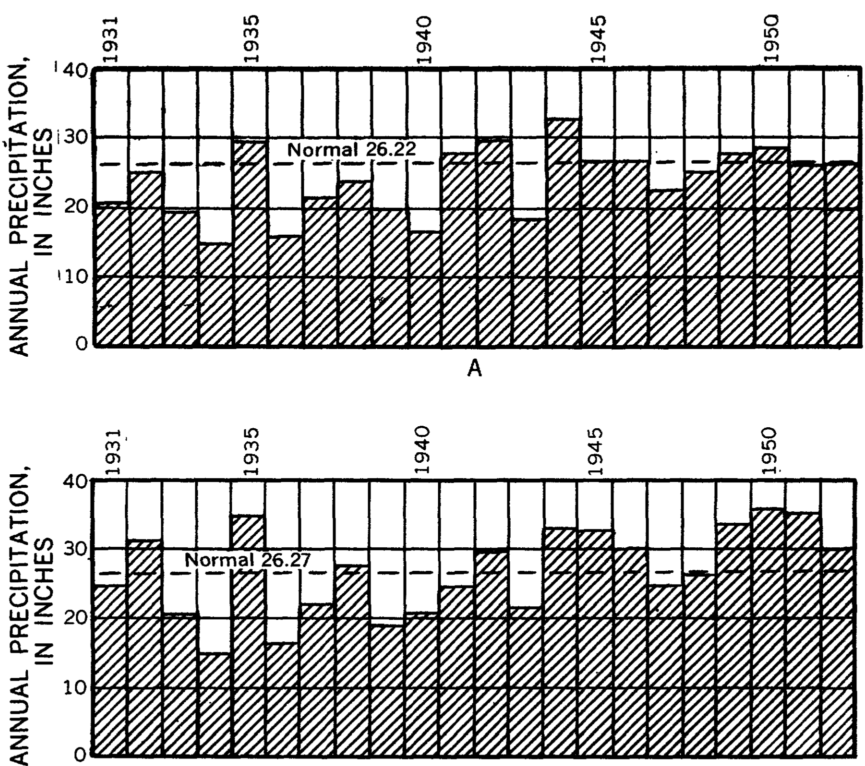

FIGURE 3.—Annual precipitation, 1931-52: *A*, at Aurora, Nebr.; *B*, at York, Nebr. (From records of the U. S. Weather Bureau.)

The precipitation at Aurora during the period 1941–52 was almost normal; the precipitation at York during the same period exceeded the normal. The subnormal precipitation from 1931 through 1940 and the nearly normal to above-normal precipitation from 1941 through 1952 are similar to those at other precipitation stations in the area.

SUMMARY OF GEOLOGIC HISTORY

At the beginning of Late Cretaceous time, the area described in this report was nearly flat and close to sea level; rocks of Paleozoic age were exposed throughout the area. An extensive sheet of fresh-water sand and silt (the Dakota group) was deposited on this eroded surface. The sea then advanced and, except perhaps for brief withdrawals, covered the area during the remainder of Cretaceous time. Clay, silt, and fine sand were carried into the sea by the wind and by rivers draining the adjacent landmass. These fine-grained materials settled into the calcareous ooze on the sea floor and, in time, were compacted into a succession of calcareous shales and shaly limestones (in ascending order, the Graneros shale, Greenhorn limestone, Carlile shale, and Niobrara formation). The sea then retreated from the area, and in the period of crustal unrest that followed the rock layers were tilted westward.

In early Tertiary time, erosion truncated the tilted rocks and produced a generally eastward-sloping surface. Because the rocks were not uniformly resistant, erosion produced asymmetrical ridges, or cuestas, having a steeper slope on their east-facing side. In the Pliocene epoch of Tertiary time, streams draining highlands to the west built coalescing alluvial fans (the Ogallala formation) that almost completely buried the Cretaceous rocks. There is no evidence of other deposition in the area during Tertiary time.

In Pleistocene time, continental glaciers advanced at least twice into the easternmost part of the area, and the valleys of eastward-flowing streams, dammed by the ice sheets, were filled to overflowing with sand and gravel. Later, a thick layer of windblown silt was deposited as a mantle over all the earlier sediments. Several times during the Pleistocene, conditions were sufficiently stable for the development of widespread soils.

In Recent time, the Big Blue River has cut through the unconsolidated and semiconsolidated materials of Pleistocene and Tertiary age and into the uppermost beds of Cretaceous age. Although still actively eroding in its uppermost reaches, it now is aggrading its main valley.

A relatively large number of test holes have been drilled in the area (Schreurs and Keech, 1953), and logs of other wells were collected during this study. (See table 5.) Plate 1 shows seven geologic sections across the area. Because of the complexity of the Quaternary deposits, they are undifferentiated in plate 1; only the sand and gravel deposits are given a pattern. The soil, silt, and clay deposits are shown in only a generalized manner; many relatively thin layers are too small to be shown on the scale of the geologic sections. Figure 4

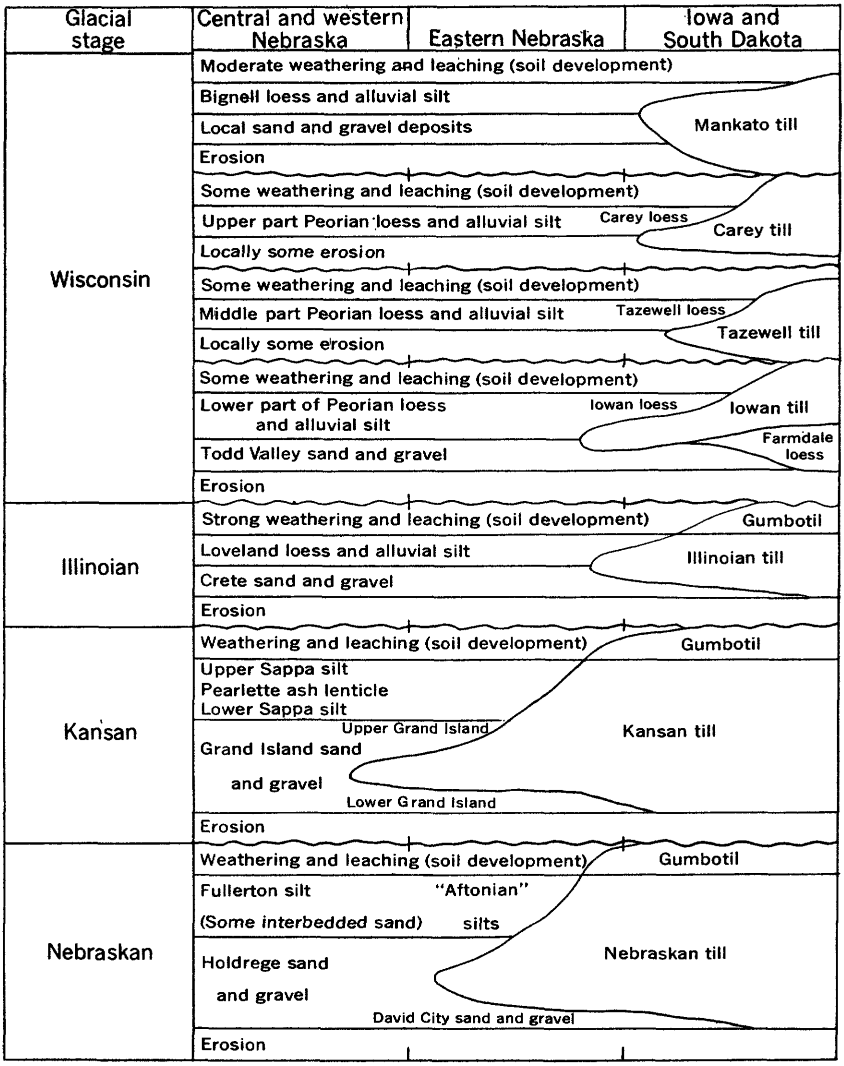

FIGURE 4.—Correlation table showing the relationship of the Pleistocene formations to continental glaciation in Nebraska. (After Condra, Reed, and Gordon, 1950.)

is a correlation table after Condra, Reed, and Gordon (1950, fig. 6), showing the stratigraphic units of the Pleistocene as used by the Nebraska Geological Survey. Much of the following description of the geologic formations is after Condra and Reed (1943) and Condra, Reed, and Gordon (1950).

ROCK FORMATIONS AND THEIR WATER-YIELDING PROPERTIES

Although no wells in the area are know to obtain water from the Dakota group, sandstone beds in the group possibly will yield some water, though of poor quality. The David City formation will yield water to wells for municipal and other uses in the eastern part of the basin. The Holdrege formation is important as an aquifer where the overlying Grand Island formation is thin or fine textured. The Grand Island formation is the most important aquifer in the area, yielding water to many irrigation and municipal wells. The sand and gravel of the Crete formation yield water to numerous domestic and stock wells, and irrigation and municipal wells obtain water from the formation in some places. The Peorian loess, although not a good aquifer, yields small amounts of water to a few wells.

CRETACEOUS SYSTEM

LOWER CRETACEOUS SERIES

Formations of Cretaceous age underlie the entire area. Of these formations, only the sandstones of the Dakota group could yield substantial amounts of water, which probably would be under artesian pressure. Because of their generally impermeable nature, the overlying Niobrara, Carlile, Greenhorn, and Graneros formations form an aquiclude between the Dakota group and the overlying aquifers of Tertiary and Quaternary age. Ground water in the Tertiary and Quaternary rocks moves, in general, eastward down the regional slope of this aquiclude; the saturated thickness of the overlying aquifers is controlled largely by the relief on the surface of the rocks of Cretaceous age. This series is exposed only at a few places along the river valleys. (See pl. 1, section *G–G′*.)

DAKOTA GROUP

The term Dakota group is used in this report as defined by the Nebraska Geological Survey to include the Omadi sandstone, the Fuson shale, and the Lakota sandstone (Condra and Reed, 1943); however, the group is not subdivided in this report.

The Dakota group, which underlies most of Nebraska, ranges in thickness from about 300 feet in eastern Nebraska to nearly 700 feet in western Nebraska; in the area covered by this investigation, it ranges in thickness from about 350 to about 400 feet. The group consists of sandstone, interbedded sandstone and shale, sandy and clayey shale, and some carbonaceous shale. The upper formation of the group, the Omadi sandstone, consists of fine- to medium-grained sandstone interbedded with shale. The sandstones are massive and generally crossbedded; hematite concretions are common.

Because these sandstones lie at greater depths than aquifers of younger age and because the water from them is likely to be highly mineralized, water generally is not obtained from them in the Big Blue River basin. However, a few domestic and stock wells in the eastern part of the basin, where other aquifers are thin or absent, probably obtain water from the group.

UPPER CRETACEOUS SERIES

GRANEROS SHALE

The average thickness of the Graneros shale is about 70 feet. The shale is dark gray and is interbedded with thin layers of calcareous material and some sandstone and sandy shale. The lower part contains some carbonaceous material. It is not present under the eastern part of the area, and no wells in the area are known to obtain water from it.

GREENHORN LIMESTONE

The Greenhorn limestone is composed of thin gray medium-soft limestone interbedded with gray shale. Its thickness in the area averages about 50 feet. The Greenhorn limestone is not present in the eastern part of the area and does not yield water to wells where present in the area.

CARLILE SHALE

The Carlile shale consists of bluish-gray shale that contains thin chalky layers in its lower part and fine-grained sandy zones in its upper part. It has been subdivided into three members, in ascending order the Fairport chalky shale, the Blue Hill shale, and the Codell sandstone members. It is not present under about the eastern quarter of the report area. The average thickness of the Carlile shale in the area is between 150 and 200 feet. It is not a source of water supply.

NIOBRARA FORMATION

The Fort Hays limestone member and the overlying Smoky Hill chalk member constitute the Niobrara formation. The Fort Hays limestone member consists of gray to yellowish-gray massive limestone. The Smoky Hill consists of gray and yellow shaly chalk ranging in thickness from a featheredge to more than 250 feet. The thickness of the entire Niobrara formation ranges from a featheredge to about 400 feet. No wells are known to derive water from this formation.

TERTIARY SYSTEM

In the area covered by this investigation, rocks of early Tertiary age either were not deposited or were entirely eroded, for the Ogallala formation of late Tertiary age is in direct contact with rocks of late Cretaceous age.

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PLIOCENE SERIES

OGALLALA FORMATION

The Ogallala formation consists of lime-cemented sand and gravel, loesslike silt, and unconsolidated sand and gravel. In this area, the Ogallala formation dips gently toward the southeast, for it was deposited on the eroded, southeastward-sloping surface of the underlying Cretaceous rocks.

Geologic cross sections (see pl. 1) show that the Ogallala formation generally is thin or absent over the higher parts of the surface of the underlying rocks; it is thickest in the ancient water gaps in the cuestas formed by the Fort Hays limestone member of the Niobrara formation, the Greenhorn limestone, and other resistant underlying rocks, and in the depressions between the cuestas. The post-Ogallala topography also had considerable relief, and early Pleistocene streams completely removed the Ogallala formation in places. In this area, the thickness of the Ogallala formation ranges from a featheredge to as much as 200 feet.

The formation will yield small amounts of water to wells where coarse sand and gravel of adequate thickness are present. Many domestic and stock wells obtain water from the formation in places where no overlying aquifers are present. The municipal water supply for Giltner, Nebr. (well 9–7–6da2), is obtained in whole or in part from the Ogallala. However, the formation in this area generally is not sufficiently permeable to yield sufficient water for irrigation, industrial, or municipal purposes. In parts of the area where other aquifers are not present, extensive test drilling into the formation might reveal the presence of sand and gravel sufficiently permeable and thick to yield larger amounts of water.

QUATERNARY SYSTEM

PLEISTOCENE SERIES

The Nebraskan glacier advanced southward into the eastern part of the area during early Pleistocene time. Poorly sorted, unconsolidated sand and gravel, the David City formation, were deposited in preglacial valleys in the Ogallala formation in the eastern part of the area as the glacier advanced. The glacier formed a barrier across streams entering the area from the west and caused those streams to deposit poorly sorted, crossbedded sand and gravel, the Holdrege formation, adjacent to and interfingering with till laid down by the glacier itself as its front melted. Fluvial deposits rather than till underlie most of the area west of York. The entire area is mantled by loess deposited after the till and fluvial sediments of Nebraskan and later Pleistocene stages were laid down. The thin alluvium in stream valleys and in undrained basins was deposited in Recent time.

DAVID CITY FORMATION

Although the David City formation is permeable enough to yield sufficient quantities of water to municipal and irrigation wells, the formation is small in areal extent. No irrigation wells are known to obtain water from the formation.

In Butler County, where overlying aquifers are absent or are too thin to yield adequate amounts of water, some municipal wells, including those of David City and Ulysses, obtain water from the David City formation. The formation is about 300 feet below the land surface and its thickness ranges from a featheredge to perhaps 150 feet. Because of the lenticular and elongated shape of the deposits, the construction of wells in the formation should be preceded by exploratory drilling.

HOLDREGE FORMATION

The Holdrege formation underlies the entire area, except in the eastern part where glacial till occupies its stratigraphic horizon and in a few areas elsewhere in which the Holdrege laps up on but does not cross high ridges of the Ogallala formation. In places, erosion has removed part or all of the Holdrege. The formation is present under most of the area westward from Seward County and lies between 150 and 200 feet below the surface of the upland plains. The thickness of the formation ranges from a featheredge to about 200 feet and averages about 75 feet. It is thickest near the border of the Nebraskan till.

Ground water occurs in the Holdrege formation under water-table, semiartesian, and artesian conditions. Many flowing wells of considerable yield are drilled into an artesian basin in the formation along the valley of the West Fork of the Big Blue River in western Seward and eastern York Counties. Among the first flowing wells in Nebraska were those in and near Beaver Crossing, where their yield is sufficient to irrigate some small acreages.

The overlying Fullerton formation is less permeable than the Holdrege formation and is believed to act as a relatively efficient aquiclude, thus confining water under artesian pressure in the Holdrege formation.

The Holdrege formation is completely saturated, and a considerable number of municipal and irrigation wells obtain water from it in areas where overlying aquifers, particularly the Grand Island formation, are too thin or too low in permeability to yield water readily to wells. These areas include the following: the Adams County part of the area covered by this investigation; the localities of Inland and Trumbull, Clay County; Fairmont, Exeter, and the area southwest from Grafton, Fillmore County; the southeast corner of Hall County;

Utica, Seward County; Lushton, Waco, York, and Gresham, York County; and the areas near Osceola and in the southeast corner of Polk County.

NEBRASKAN TILL

As the front of the Nebraskan glacier melted back, the Nebraskan till, which consists of bluish-gray clay, gravel, and boulders, was deposited over the Ogallala formation or, where present, the David City formation. The deposit was widespread but erosion removed it completely at some places. The thickness of the till in this area ranges from a featheredge to more than 50 feet. No wells in the area are known to obtain water from the till.

FULLERTON FORMATION

The areal extent of the Fullerton formation is about the same as that of the Holdrege formation. The Fullerton formation is composed of dark silt and calcareous clay and grades locally into fine sand. In some localities, the formation is absent because of erosion after its deposition.

The Fullerton formation is believed to have been deposited during the Aftonian interglacial stage and is composed of fine windblown and reworked local materials. It was conformably deposited on the sand and gravel of the Holdrege formation. The Fullerton formation ranges in thickness from a featheredge to about 30 feet and is overlain unconformably by the Grand Island formation. The permeability of the Fullerton formation is very low and the formation is not known to yield water to wells in the area. As stated above, it acts as a confining bed for artesian water in the underlying Holdrege formation.

GRAND ISLAND FORMATION

The interbedded and unconsolidated fluvial sand and gravel of the Grand Island formation were laid down during the Kansan glacial stage, and the relation of the formation to the Kansan till is believed to be similar to that of the Holdrege formation to the Nebraskan till. The lower part of the Grand Island is a deposit of coarse gravel; the upper part is fine sand that may have been, in part, windblown.

The Grand Island formation is more continuous than either the Holdrege or the Fullerton formation, but it has about the same areal extent. The thickness of the Grand Island formation ranges from a featheredge to about 150 feet, of which as much as 120 feet is saturated. It is overlain by the Sappa formation.

Although the fine sand of the Grand Island is difficult to distinguish from that of the Sappa formation, the depth to the Grand Island generally is believed to range from 100 to 120 feet. However, it may be more in some places, for the depth to water in the Grand Island formation beneath the divide between the Platte and Big Blue Rivers, along the northern border of the area, is about 200 feet.

The Grand Island formation is the most productive aquifer in the area and is the source of water for most of the irrigation and municipal wells. Water occurs in the formation under water-table and semiartesian conditions. Where the Kansan till is present, as in Butler County, north of Milford in eastern Seward County, and isolated other places, the Grand Island formation is thin or entirely absent and can supply little if any water to wells. The formation is thin also over buried ridges of Cretaceous rocks in the vicinity of Trumbull in Clay County, north of Exeter in Fillmore County, and south of Giltner in Hamilton County, and wells obtain only small amounts of water from the aquifer in those localities. The Grand Island formation is thickest in eastern York County but is coarsest and most permeable farther west in western York and Hamilton Counties. The permeability of the Grand Island formation in the Platte River valley near Grand Island, Nebr., was determined by 2 pumping tests to be approximately 1,000 gallons per day per square foot (Wenzel, 1942). The permeability of the Grand Island formation is relatively uniform, and wells of large yield can be developed where the formation is sufficiently thick. Where the formation is thin, however, such as over till or buried ridges of Cretaceous rocks, only small quantities of water can be obtained from the formation. In eastern York County, in Seward County, and in a few other localities, test drilling is required in order to locate materials permeable enough to yield water at all. However, at least small yields generally can be obtained from the Grand Island formation wherever it is present.

KANSAN TILL

The Kansan till is very similar to the Nebraskan till but tends to have a yellowish-gray rather than a dark-gray color, and it contains more boulders of quartzite and granitic rocks than the Nebraskan till. The thickness of the Kansan till ranges from a featheredge to about 120 feet in the area. The till is thickest in the easternmost part of the area, but it is present also in places in the central part of York County, south of Fairmont and Exeter in Fillmore County, and north and east of Oceola in Polk County. The till is relatively impermeable and is not an aquifer.

SAPPA FORMATION

During the interglacial stage that followed the Kansan glaciation, the Sappa formation was deposited (Condra, Reed, and Gordon, 1950). Greenish- or yellowish-gray clay and fine sand and a bed of volcanic ash, called the Pearlette ash member, compose the Sappa formation. Deposition of the Sappa formation immediately followed that of the sand and gravel of the Grand Island formation. The old soil on the Sappa formation correlates with the Yarmouth soil found below the Illinoian till in parts of Iowa and Illinois. Much of the

Sappa formation was removed by erosion prior to the deposition of the overlying Crete formation, and, although the Sappa formation is as much as 50 feet thick in some parts of the area, it is absent in certain localities, such as in the vicinity of Henderson and Hampton.

The Sappa formation is of low permeability, and it is not known to yield water to wells in the area.

CRETE FORMATION

The widespread sand and gravel deposits of the Crete formation were laid down by the streams that removed a large part of the Sappa formation, and they cover practically all the post-Sappa topography although naturally they are thickest in the valleys cut into or through the Sappa. The deposits are reddish gray in some places, generally are coarse at the base of the formation, and grade upward into the silts of the Loveland formation. The thickness of the deposits ranges from a featheredge to about 70 feet. In some places the formation is completely saturated.

The Crete formation is the shallowest of the important aquifers in the area. It is the principal source of water for domestic and livestock wells and for all or most of the water pumped by many irrigation wells in western York and Hamilton Counties. It probably is the most important source of water in the area for livestock and domestic uses, and it ranks second as a source of water for irrigation and municipal uses. Although the formation is permeable, it is believed to be less permeable than the Grand Island formation.

In some parts of the area, the Crete formation is as much as 120 feet below the land surface; generally, however, the depth to the formation ranges from 60 to 80 feet except in the larger stream valleys where it is much closer to the land surface. Ground water occurs in the formation under water-table or semiartesian conditions.

Some of the ground water in the Crete formation is perched above the regional water table on relatively impermeable deposits of the Sappa formation and the Kansan till. In such areas the Crete formation is capable of yielding water to shallow wells for livestock and domestic use. Perched water underlies an area in the vicinity of Fairmont, where the water level in wells is about 15 to 40 feet below the land surface. The depth to water in wells that penetrate below the regional water table is 80 to 90 feet, and water from the Crete formation trickles, sometimes audibly, down the casings of wells that are open in both the perched zone and the main zone of saturation.

Test holes generally are not drilled specifically to determine the more permeable parts of the Crete formation. If the formation is not permeable enough to yield the desired amount of water, drilling is continued and the well is finished in a deeper aquifer. In much of Hamilton and western York Counties, the Crete formation yields sufficient water to supply irrigation and municipal wells, but most of the wells of large yield derive only a part of their supply from the Crete.

LOVELAND FORMATION

The Loveland formation comprises two phases—valley, or alluvial, and upland. The valley phase of the Loveland consists of stratified silt and clay and some laminae of fine sand. Generally, it is light gray to buff in the lower and middle parts and grades to pinkish brown in the upper part. This phase grades upslope into massive loess of the eolian, or upland, phase, which generally is thinner than the valley phase. The loess generally is pinkish brown to reddish. The two phases are, in some places, separated by a colluvial or slope phase.

The thickness of the formation in the area ranges from a featheredge to as much as 40 feet. Generally the formation lies above the water table and is hydrologically important principally as it affects the downward movement of water. In a few places a perched zone of saturation in the formation will yield small amounts of water to wells.

TODD VALLEY SAND

The Todd Valley sand is a grayish fine sand. It is limited, in the report area, largely to northern Hamilton County, where it overlies the loess of the Loveland formation and ranges in thickness from less than a foot to about 50 feet. It is not important as a source of ground water because of its limited distribution and because generally it lies above the water table. However, some shallow wells may obtain water from zones of perched water in the formation.

PEORIAN LOESS

The eolian Peorian loess is similar to the loess of the Loveland formation. Probably it originated from silty alluvium exposed along the larger rivers and was carried by winds and deposited on an upland plain. It mantles most of the older formations throughout the area, and thick belts of it border the valleys. The loess is a light-brown to nearly white calcareous silt having a vertical columnar structure and little stratification. Ancient soil horizons and nodular calcareous concretions are common in typical exposures of this formation.

The Peorian loess is above the water table in most of the area, and its chief hydrologic importance is its function as a transmitting agency for recharge to the water table and its influence on the topography and drainage of the area. The loess is relatively impermeable, but in some localities in Butler County it provides small amounts of water to shallow wells that tap zones of perched water within it.

PLEISTOCENE AND RECENT SERIES

BIGNELL LOESS

The gray Bignell loess is in part reworked Peorian loess and probably is of Pleistocene to Recent age. The formation is only a few feet thick and yields no water to wells.

RECENT SERIES

ALLUVIUM

Alluvium of Recent age is not an important aquifer in the area because it is thin and is limited to stream valleys. It is composed chiefly of poorly sorted local materials that are stratified or arranged in small fluvial crossbedded deposits. Some wells in the flood plains probably derive a part of their water from the alluvium.

HYDROLOGIC PROPERTIES OF THE WATER-BEARING FORMATIONS

The quantity of water that a water-bearing material will yield and the rate at which water will move through it are governed by its physical and hydrologic properties. Sediments seldom are homogeneous; their physical and hydrologic properties range widely, being governed by the size, shape, number, and degree of interconnection of the voids between the constituting mineral particles.

POROSITY AND SPECIFIC YIELD

The amount of water that can be stored in a water-bearing formation is dependent upon the porosity of the formation. Porosity is expressed quantitatively as the ratio of the volume of interstices of the material to the total volume of the material. Saturated rocks of high porosity do not necessarily yield large quantities of water to wells; one may yield most of the water contained in its pores, but another having equal porosity but smaller pores may retain practically all its water. Materials having small pores will hold by molecular attraction more water against the force of gravity or hydrostatic pressure than will materials having large pores. This effect of molecular attraction becomes increasingly significant as the size of the pores decreases.

The specific yield of a water-bearing formation is a measure of the capacity of the formation to yield water. It is the ratio of the volume of water which the formation, after being saturated, will yield by gravity to its own volume. Generally the ratio is stated as a percentage.

PERMEABILITY AND TRANSMISSIBILITY

Water in permeable materials moves in the direction of the downward slope of the water table toward points of lower head, to places where it is naturally discharged by seeps, springs, and evaporation and transpiration or is artificially discharged through wells. The rate at which an aquifer will transmit water is governed by the permeability of the aquifer—that is, by the ability of the aquifer to transmit water under pressure.

Permeability is expressed as a coefficient which in Meinzer's units, or meinzers, is the rate of flow of water in gallons per day through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent at a temperature of 60°F (Wenzel, 1942, p. 7). The field coefficient of permeability is the same except that it is not corrected for temperature.

The coefficient of transmissibility is the same as the field coefficient of permeability except that it pertains to the total saturated thickness of the water-bearing material, whereas the coefficient of permeability pertains to a thickness of only 1 foot. The coefficient of transmissibility is the number of gallons of water per day transmitted through each 1-foot vertical strip of the aquifer under a unit gradient at the prevailing temperature of the water. The coefficient of transmissibility may be expressed also as the number of gallons of water per day transmitted through each section of aquifer 1 mile wide extending the height of the aquifer under a hydraulic gradient of 1 foot per mile. Thus, the coefficient of transmissibility is equal to the average field permeability multiplied by the thickness of the aquifer, in feet.

GROUND WATER

Below a certain level, the permeable rocks generally are saturated with water under hydrostatic pressure and are said to be in the zone of saturation. The water table is the upper surface of the zone of saturation except where that surface is formed by an impermeable body (Meinzer, 1923, p. 22). If the upper surface of the zone of saturation is formed by an impermeable body, no water table exists. The water level in a well drilled into saturated materials under water-table conditions will stand at the level at which it was struck. Although many of the wells in the area being considered exhibit some artesian characteristics and may reflect local confinement, for the purpose of this report most of them can be considered to be water-table wells.

Artesian conditions exist when a water-bearing bed, overlain by an impermeable or relatively impermeable bed, dips away from its recharge area and the water becomes confined under pressure. Under these conditions, water percolates downward to the water table in an area of recharge and then moves down dip and under the confining bed. The water in a well drilled into an artesian aquifer will rise to a level that is higher than the level at which it was struck, and the water is said to be under artesian pressure. The artesian pressure is caused by the difference in the level of the water table in the recharge area and the point at which the water is struck. If the pressure is great enough to lift the water in the well above the land surface, the well will flow. Flowing wells occur in the report area only in the vicinity of Beaver Crossing. The water in many wells in the Big Blue River basin is under some artesian pressure; however, except in the vicinity of Beaver Crossing, the artesian effects are believed to be small. The head in the Beaver Crossing area was not measured.

The percolation of water from the land surface to the regional water table is retarded in part of the Big Blue River basin by extensive silt and clay lenses of low permeability. Thus, in some places, water accumulates above the less permeable materials and establishes at some distance above the regional aquifer a saturated zone, the surface of which is called a perched water table. The water level in a well that is drilled into the perched water zone and to a point into or just above the less permeable lens will stand at the level at which it was struck, which level represents the perched water table. However, no water will accumulate in a well that is drilled through the perched water zone to a point below the less permeable lens and above the regional water table, because the water in the perched water zone either is cased out of the well or the well merely serves to drain water through the less permeable lens, and permits the water to percolate downward to the regional water table. The water level in wells drilled through the perched water zone and into the underlying regional aquifer will stand at the level of the regional water table unless water leaks freely into the well from the perched water zone, raising the water level to a point intermediate between the regional and the perched water table.

DEPTH TO WATER

The depth to water below the land surface in the area ranges from less than a foot in some places to a maximum of about 200 feet along the divide between the Platte and Big Blue Rivers near David City in northern Butler County. The greatest depth to water was reported at David City, where the water level in the municipal wells is 197 feet below the land surface. Depths to water of 60 to 90 feet are common in most of the loess plain, but generally they are greater along the interstream divides.

Depth to water in the stream valleys is less than that in the loess plain. The depth generally is less than 25 feet in the flood plain and the low terraces of the valleys of the perennial streams. In the ephemeral sections of the streams, the water table is below the stream beds; for example, the water table is about 75 feet below the floor of the valley of the West Fork of the Big Blue River north of Hastings.

In Butler County, and at places in other counties, the depth to a perched water table in many rural wells is less than 20 feet, whereas the regional water table is much deeper.

CONFIGURATION OF THE WATER TABLE

The principal factors that control the shape and slope of the water table are the topography of the land surface and the underlying bedrock, the transmissibility of the materials through which the ground water moves, the relative location of areas of recharge and discharge from the ground-water reservoir, and the relative rates of recharge and discharge.

The water table usually is of the same general shape as the land surface except that the water table is more subdued and generalized in shape, and it normally is constantly fluctuating. If recharge to the ground-water reservoir exceeds discharge from it, the water table will rise; locally, this situation will create a mound or ridge on the water table, which sometimes is only temporary. An excess of discharge over recharge to the ground-water reservoir will cause the water table to lower; locally, this situation will create a depression or trough in the water table, which also may be only temporary. However, an essentially permanent mound or ridge on the water table may indicate a constant rate of recharge, in which condition the water is moving away from the mound or ridge as fast as recharge occurs, and the recharge-discharge ratio is in balance. Likewise, a persistent depression or trough in the water table may mean that water is being discharged as fast as it is being recharged under a balanced recharge-discharge ratio. In these circumstances, the water table is said to be in equilibrium.

Where the land surface intersects the water table, ground water emerges at the surface. If the topography is such that the ground water emerging at the surface can drain, a perennial stream results; if no natural drainageway exists, a ground-water lake or marsh will form and the water will be discharged by evaporation and transpiration; but in either situation, a depression or trough is formed in the water table resulting from ground-water outflow to the discharge area.

To move equal equantities of water through equal areas, the gradient of the water surface in the direction of discharge must be greater in materials of low permeability than in materials of high permeability. Thus, a clue to the relative permeability and transmissibility of aquifers can be obtained by an examination of the spacing of the contour lines on the water table. For equal volumes of flow, where contour lines are widely spaced the gradient is gentler and the aquifer is either thicker or more permeable, or both, than where the contour lines are closely spaced and the gradient is steeper.

The approximate shape and slope of the regional water table in the area studied is shown on plate 2 by lines connecting points of equal elevation on the water table. Because artesian conditions exist at some places, the contour lines on plate 2 may in part reflect artesian rather than water-table conditions, especially in the vicinity of Beaver Crossing. The elevation of the water surface was obtained by subtracting the depth to water in the wells and test holes from the elevation of the measuring point. Where available, elevations of measuring points that had been determined by instrumental leveling were used; otherwise, elevations were interpolated from topographic maps. Inasmuch as many of the elevations were obtained by the latter method, the water-table contour lines on plate 2 are somewhat generalized.

On plate 2, contour lines that bow eastward indicate highs or ridges on the water table; contour lines that bow westward indicate lows or depressions in the water table. Widely spaced contour lines indicate a gently sloping water table, and closely spaced contour lines indicate a steeply sloping water table. The water table in this area slopes eastward at a gradient ranging from 4 to 25 feet per mile and averaging about 7 feet per mile.

MOVEMENT OF GROUND WATER

Ground water moves downgradient in the direction of the slope of the water table and at right angles to the water-table contour lines. The water-table contour lines on plate 2 show the regional movement of ground water to be eastward.

Ground water moves at widely different rates in different aquifers, and its movement will vary greatly in relatively small distances. However, if the permeability of the principal aquifer in this area is assumed to be 1,000 gpd per square foot (see section on "Grand Island formation") and the porosity of the aquifer is assumed to be 20 percent, the average rate of movement of ground water in the area is less than a foot per day.

FLUCTUATIONS OF THE WATER TABLE

The water table rises and falls somewhat like the water level in a lake or reservoir. In general, the water level rises when the rate of recharge to the aquifer exceeds the rate of discharge from it and declines when the rate of discharge exceeds the rate of recharge. Thus, changes in the elevation of the water table reflect changes in the amount of ground water stored in the aquifer.

The water level in wells tapping an artesian or semiartesian aquifer fluctuates in response to changes in atmospheric pressure; these changes in the water level are called barometric fluctuations and represent essentially no change in ground-water storage. Because of the relative inelasticity and impermeability of the materials overlying an artesian or semiartesian aquifer, the changes in atmospheric pressure are almost immediately effective upon the water level in wells penetrating those aquifers. The water level in such a well will rise when the barometric pressure falls, and fall when the pressure rises. If the amount of these barometric fluctuations approximate the actual change in barometric pressure, the "barometric efficiency" of the well is approximately 100 percent. The nearer the barometric efficiency is to 100 percent, the more perfectly artesian is the aquifer. Even though the water level in many wells in the area covered by this report have barometric fluctuations, the barometric fluctuations in most wells in the area amount to only hundredths of a foot. Thus, most of the aquifers are only slightly artesian—that is, they are essentially water-table aquifers. Therefore, in most parts of the area, changes in the water table represent changes of the ground water in storage.

Determination of the amounts of recharge to, and discharge from, a ground-water reservoir is difficult because of the complexity of the many factors involved. However, as the change in storage, which is caused by differences in the rates of recharge and discharge, is reflected by changes in the water level in wells, a qualitative measure of the changes in the recharge and discharge rates can be obtained by making periodic measurements of the water level in wells. By the application of certain factors to the qualitative measure, relatively accurate quantitative estimates of the amounts of water involved can be made if the distribution of observation wells is adequate.

The water levels in some wells in the area have been measured periodically for several years. The water-level fluctuations in some of these observation wells are shown in figures 5 and 6. Figure 5 shows that the water level in well 11–6–13cb, Hamilton County, declined from 1934 through 1940, rose in 1941, declined slightly from 1942 through 1948, rose from 1949 through 1951, and declined again

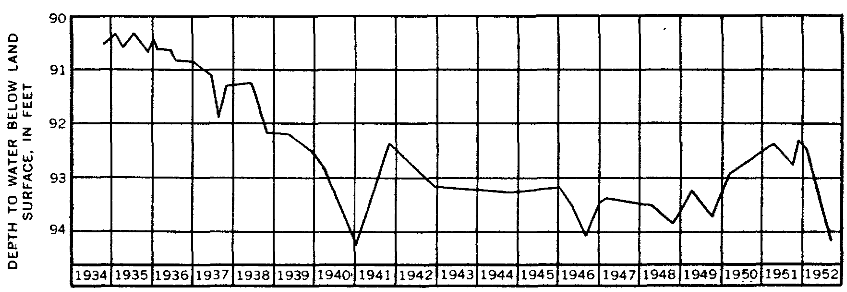

FIGURE 5.—Water-level fluctuations in well 11-6-13cb, Hamilton County, 1934-52.

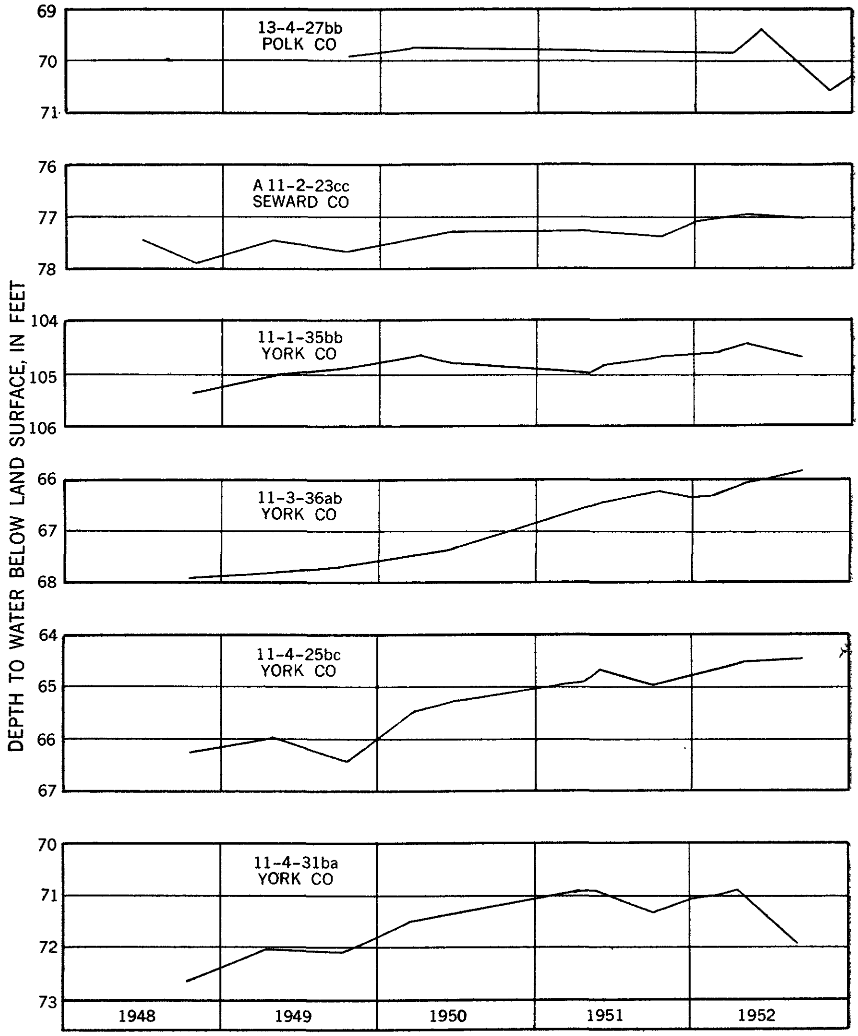

FIGURE 6.—Water-level fluctuations in six wells, 1948–52.

in 1952. In figure 6, the water-level measurements in six wells from 1948 through 1952 show that the water table in the area was rising.

Ground-water reservoirs usually contain large quantities of water in storage, which water is important because it can be drawn upon during years of low precipitation. Therefore, a decline of the water table during a year of below-normal precipitation does not necessarily mean an excessive withdrawal of water from the ground-water reservoir. In dry years, when the amount of water contributed to the ground-water reservoir by precipitation is decreased, the amount of water withdrawn by transpiration, evaporation, and pumping often is increased, and the water table falls. During wet years, on the other hand, the amount of water supplied by precipitation is increased, water withdrawals generally are decreased, and the water table rises accordingly, perhaps to, or above, its previous high level.

A comparison of the hydrographs of the wells shown by figures 5 and 6 with the annual precipitation (fig. 3) shows a relationship between the water level in the wells and the amount of precipitation received. The water level declined significantly during the dry period from 1934 to 1941, even though only a few irrigation wells were being pumped. During the years of normal or above-normal precipitation that followed 1941 the water level in the wells remained almost at a constant level, and during the period 1948–52 it rose considerably even though the rate of ground-water withdrawals by pumping for irrigation was increasing rapidly. (See fig. 7.)

SATURATED THICKNESS OF WATER-BEARING MATERIALS

In the deposits of Pleistocene and Tertiary age in the area, the saturated thickness ranges from less than a foot to as much as 400 feet; the saturated thickness is greatest in the ancient stream valleys that were cut into rock of Cretaceous age. The deposits of Pleistocene age, which form the principal aquifers, generally are thinnest in the western part of the area; they thicken progressively eastward to Seward County and then become thinner in the glaciated eastern part of the area.

A minimum saturated thickness of 50 feet of sand and gravel is considered necessary for irrigation wells or other wells from which a high yield over a long period is required. Generally, in areas where the saturated thickness of the permeable materials exceeds this minimum, test drilling for suitable well locations is unnecessary, drawdowns are less, and mutual interference with nearby wells is less severe.

Areas that are underlain by less than 50 feet of saturated sand and gravel are not favorable for the development of wells of large yield, although perhaps a few such wells could be developed. These areas are delineated on plate 2 on the basis of data from test holes drilled cooperatively by the U. S. Geological Survey and the Conservation and Survey Division of the University of Nebraska and from well logs (table 5) collected from well owners and drillers.

RECHARGE

Addition of water to the zone of saturation in an aquifer is called ground-water recharge. Practically all water for ground-water recharge originates directly or indirectly from precipitation. Recharge to the ground-water reservoir in the report area is by direct infiltration of precipitation, by seepage from topographic depressions and stream channels, and by movement of ground water eastward into the area.

Of the total precipitation on the area, some runs off as streamflow; some is collected in shallow, undrained topographic depressions; some is evaporated; some enters the soil zone, whence it is evaporated or transpired; and some infiltrates to the zone of saturation.

The amount of precipitation that runs off directly in streams is governed principally by the slope of the land surface and by the infiltration capacity of the soil and underlying materials. Although the slope of the land surface generally is not great, the area is moderately well drained. The relative impermeability of the loess, with which the uplands are mantled, is responsible in part for the fact that a considerable amount of the precipitation runs off directly.

In those portions of the stream channels that are above the water table, some of the water that flows over coarse sand and gravel in the stream beds percolates downward to the water table. The initial flow over a dry stream bed often is completely absorbed in this manner. In the area covered by this investigation, water percolates from the stream beds only in the ephemeral parts of the streams and during the relatively brief periods of streamflow after heavy rains or snowmelt. For the purposes of this report, the recharge from the ephemeral streams is considered to be a part of the general recharge from precipitation.

Some precipitation collects, at times, in undrained depressions on the surface of the upland plain. Although some of this water then infiltrates to the water table, it is believed that most of the water is evaporated or transpired.

Some precipitation is evaporated as it falls or immediately after it contacts the land surface. Some penetrates the soil zone where it is stored temporarily, later to be evaporated from the land surface or to be withdrawn and transpired by plants. If the amount of water entering the soil zone is more than enough to supply the water that can be held in the soil zone against the force of gravity, the excess infiltrates to the water table.

The thick loess of the upland plain as well as the soils of rather low permeability that form on the loess, tends to restrict infiltration of precipitation. However, because of the vertical columnar structure, the average vertical permeability of the loess is greater than that of stratified materials of the same grain size. Cady and Scherer (1946) estimated the average annual ground-water recharge from precipitation on the central, upland areas of Box Butte County, Nebr., to be about 1.75 inches. Theis (1937) computed the average annual recharge from precipitation in the southern High Plains to be less than 0.5

inch. The area covered by this investigation resembles the Box Butte County area more than it does the southern High Plains, and the average annual precipitation is greater than in either; thus, it is believed that the average annual ground-water recharge from precipitation on the area covered by this investigation is not less than 1½ to 2 inches.

Contour lines on the water table (see pl. 2) show that ground water moves eastward across the Platte-Big Blue River topographic divide and into the Big Blue River basin. This water has been contributed to the ground-water reservoir west of the area principally by precipitation but also by percolation of water from the channel of the Platte River and by infiltration of irrigation water. The magnitude of this eastward ground-water movement cannot be estimated accurately until additional test-hole drilling is done and pumping tests are made along the western boundary of the area.

Although some surface water is used for irrigation, most of the irrigation in the area is done with water from wells. The amount of water that returns to the water table by percolation of irrigation water is governed by several variable factors, such as type of soil, initial moisture content of the soil, and amount and rate of the application of water. The amount of irrigation water that infiltrates back to the water table in the Big Blue River basin is estimated to be not more than 10 percent of that applied.

Artificial recharge of the ground-water reservoir by deliberate application of water for that purpose is not practiced in the area.

NATURAL DISCHARGE

Ground water is discharged from the zone of saturation by evaporation in places where the water table is close to the land surface; by transpiration from vegetation; through springs and seeps; into surface streams; from wells; and by subsurface ground-water movement out of the area.

In the uplands of the report area the water table generally is 60 feet or more below the land surface and the quantity of ground water discharged by evapotranspiration is small. However, in the perennial stretches of the streams and in the vicinity of the seeps and springs feeding the streams, some ground water is evaporated and transpired in places where the water table and capillary fringe are at or near the land surface. The roots of some plants, such as alfalfa, penetrate to a depth of 20 feet or a little more, but those of field crops penetrate only a few feet. Some of the ground water that feeds the streams through springs and seeps is evaporated from the surface of the streams. In the eastern part of the area the depth to the perched water table commonly is less than 20 feet.

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A large percentage of the streamflow in the area is base flow—that is, ground water contributed to the streams through springs and seeps. The flow in the perennial parts of the streams is almost wholly ground-water discharge when both overland runoff into the streams and evapotranspirative water losses are nonexistent or are at a minimum. Thus, the ground-water discharge into streams can be computed by measuring the base flow in the streams during the late fall or winter months.

Cady and Scherer (1946, p. 60) showed that the base flow in the Niobrara River from its drainage basin above Dunlap, Dawes County, Nebr., an area similar to the Big Blue River basin, equaled about 3 percent of the precipitation over the basin during the 1936–37 water year, or about 0.36 inch of water over the 1,550 square miles. The base flow in Ladder Creek above Elkader, Kans., from April 1951 to April 1952 was estimated to be equivalent to about 0.14 inch of water over the drainage basin (Bradley and Johnson, 1957).

The annual base flow of the Big Blue River at Crete, based on streamflow measurements made by personnel of the U. S. Geological Survey, is equivalent to about 1.0 inch of water over the drainage basin above Crete, or about 150,000 acre-feet.

The contour lines on the water table (see pl. 2) indicate that ground water may move eastward across the eastern boundary of the Big Blue River basin. However, without more closely spaced observation wells and more accurate determinations of elevation, the main water table in the eastern part of the area, especially in the glacial deposits, is difficult to identify. A considerable amount of the eastward-moving ground water may be intercepted by the southward-flowing part of the Big Blue River above Crete. Some ground water also may move northeastward out of the area, toward and into the Platte River drainage basin.

DISCHARGE BY WELLS

DOMESTIC AND LIVESTOCK USE

Most water for domestic and livestock use in the area is obtained from small wells equipped with windmills and force pumps; some pumps are operated by gasoline or electric motors or by hand. Small amounts of water can be obtained from wells in almost all parts of the area.

Commonly, wells are drilled 10 to 20 feet below the water table and are cased with small-diameter galvanized steel casing perforated below the water table. Their yield generally is less than 5 gpm. Probably about 25,000 acre-feet of water is pumped annually from the domestic and stock wells, an important discharge from the ground-water reservoir.

PUBLIC SUPPLY

Thirty-three villages and cities in the Big Blue River basin above Crete, have municipal water wells, storage reservoirs, and distribution systems. The wells generally are cased with 8-inch or larger steel or concrete pipe and are equipped with electrically driven turbine pumps. Most of the water is pumped directly into the mains and forced into an elevated tank or a pressure tank. In some towns, the water is first pumped into cisterns or reservoirs and then pumped into the mains by centrifugal pumps.

Increases in population, in per capita use of water, and in the use of water for air conditioning have necessitated expansion of municipal water-supply facilities. Many of the smaller towns now have wells and distribution systems. Most towns in the area are modernizing their equipment and some of the larger cities sell water to local industries and railroads.

All municipal water-supply systems in the area were inventoried during this study. (See table 1.) Because the water generally is not metered, the water-consumption data shown in the table are reported or estimated. Pumpage for municipal use in the area is estimated to be about 8,000 acre-feet per year.

Other public supplies, such as those for state and county institutions and schools, were not inventoried; their total pumpage is believed to be relatively small.

INDUSTRIAL USE

The amount of ground water used by industries in the area is small compared with that required for domestic and stock use. Most industries and railroads purchase water from the municipalities in which they are located, but some have their own wells.

The ground water generally is suitable for most industrial uses, and large quantities are available.

TABLE 1.—*Municipal water supplies*

Town or city	Population (1950)	Number of wells	Consumption	
			Gallons per day per capita	Acre-feet per year
Adams County				
Hastings	20,211	7	203	[1] 4,600
Butler County				
David City	2,321	3	73	189
Dwight	218	1	94	23
Rising City	374	2	55	14
Ulysses	374	1	138	58

See footnotes at end of table.

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TABLE 1.—*Municipal water supplies*—Continued

Town or city	Population (1950)	Number of wells	Consumption	
			Gallons per day per capita	Acre-feet per year
Clay County				
Harvard	774	4	147	[2] 128
Sutton	1,353	2	147	[2] 223
Trumbull	150	1	272	46
Fillmore County				
Exeter	747	2	138	115
Fairmont	729	2	147	[2] 120
Grafton	159	2	311	54
Hall County				
Doniphan	412	2	13	6
Hamilton County				
Aurora	2,455	2	124	340
Giltner	284	2	9	3
Hampton	289	2	179	58
Hordville	116	1	46	6
Marquette	218	1	20	5
Phillips	190	1	216	46
Polk County				
Oceola	1,098	2	147	[2] 181
Polk	508	1	145	83
Shelby	624	1	147	[2] 103
Stromsburg	1,231	3	69	93
Saline County				
Crete	3,692	3	147	[2] 608
Seward County				
Beaver Crossing	425	1	130	62
Milford	951	4	89	95
Seward	3,154	6	65	[3] 230
Utica	550	3	147	[2] 91
York County				
Benedict	206	1	147	[2] 35
Bradshaw	352	2	118	48
Gresham	267	2	23	7
Henderson	536	2	147	[2] 88
Waco	180	1	114	23
York	6,178	6	100	694

[1] Reported for 1947.
[2] Estimated. Based on average per capita consumption in towns that reported.
[3] Reported for 1945.

IRRIGATION

Most of the ground water pumped in the area is used for irrigation. The 672 irrigation wells that were inventoried (see pl. 2) are distributed as follows: Adams County, 39; Butler County, 1; Clay County, 74; Fillmore County, 12; Hall County, 27; Hamilton County, 296; Polk County, 36; Saline County, 3; Seward County, 15; and York County, 169.

The reported average annual pumping rate of 202 wells was 91.4 acre-feet per well. Thus, if the average pumpage of all 672 irrigation wells is 91.4 acre-feet per well, about 61,000 acre-feet of ground water is pumped each year for irrigation use. Then, if no irrigation water is wasted and if 10 percent of the ground water pumped for irrigation infiltrates back to the ground-water reservoir (see section on "recharge"), the annual consumptive use of ground water is about 55,000 acre-feet. This consumptive use is about 0.9 acre-foot per acre per year.

Most irrigation wells are equipped with 2- to 5-stage turbine pumps powered by electric motors or internal-combustion engines. Commonly, the fuel for the latter is tractor fuel, propane, or natural gas. Some pumps are driven by tractors. (See tables 3 and 4.)

The depths of the irrigation wells range from 50 to 320 feet, and most of them are gravel packed and lined with 18-inch metal or concrete casing that is perforated in its lower part. Nearly all the irrigation wells extend 50 feet or more below the water table, and therefore minor water-table fluctuations do not seriously affect the yield of the wells. Distribution of water commonly is by gravity through unlined ditches, although some pipe and sprinkler systems are used. Grass and grain crops sometimes are irrigated by flooding small level plots.

Corn is the principal irrigated crop; alfalfa ranks next. Other irrigated crops are wheat, barley, oats, clover, brome and wheat grass, sugar beets, sweetclover, and grain sorghum. The amount of land irrigated from the 202 wells on which acreages were reported averaged 88 acres per well; the average irrigable land per farm unit was 208 acres. Applying those averages to all 672 irrigation wells, about 59,000 acres was irrigated during 1953, and the total irrigable land on the farm units was about 140,000 acres.

The rate at which irrigation wells are constructed in the area is governed by many factors, some of which are intangible. Perhaps among the more important factors are the success of prior irrigation ventures, the vagaries of the precipitation, the current economy, technical advances in equipment and methodology, and advancement in knowledge of the ground-water resources.

Dates of construction were reported for 626 of the 672 irrigation wells inventoried. Of the 626, 14 were constructed prior to 1939. The number of irrigation wells constructed annually in the area from 1939 through June 1953 and the annual cumulative number constructed during the same period are shown in figure 7.

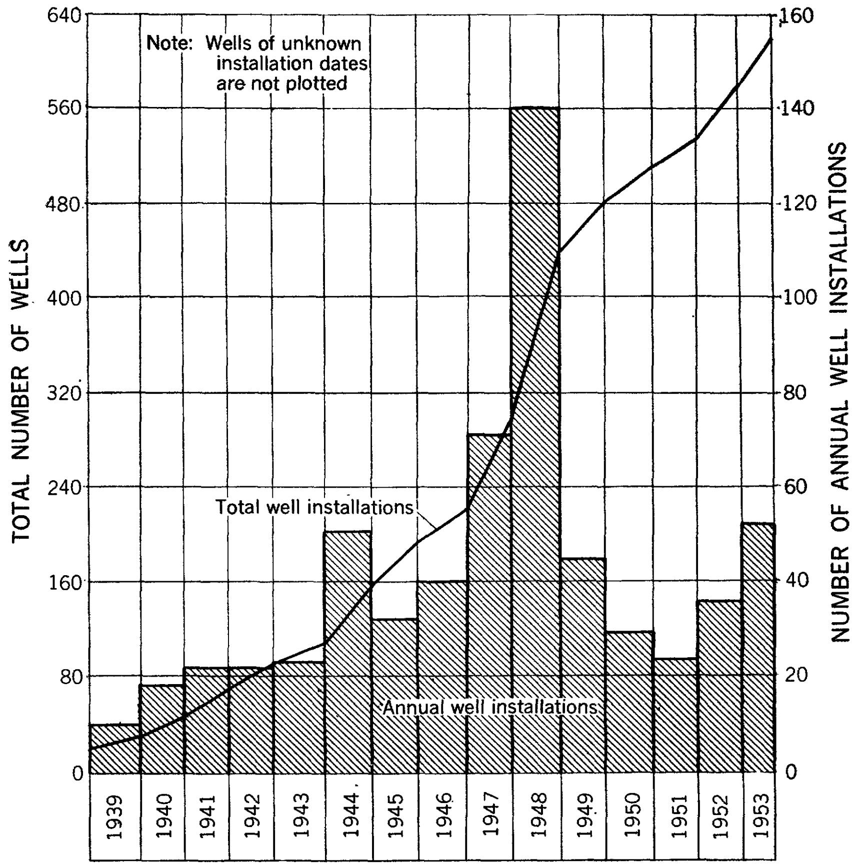

FIGURE 7.—Rate of installation of irrigation wells.

The greatest number of wells constructed in any single year during the period 1944 through 1952 was 140, during 1948, and the least number of wells constructed in any year during that period was 24, during 1951; the average rate of construction was about 53 wells per year. Irrigation tends to stabilize farm economy in the area, and the construction of new irrigation wells probably will continue unless one of the following occurs: a prolonged period when precipitation is sufficient to make irrigation unnecessary, a serious decline in crop prices, or an overdevelopment of the available ground water. A prolonged period of deficient precipitation might have the same result by increasing irrigation costs unduly.

POTENTIAL GROUND-WATER DEVELOPMENT

When the rate of discharge from a ground-water reservoir equals the rate of recharge to it, the water table is in equilibrium. This condition generally exists prior to withdrawals of ground-water through wells, although there are fluctuations from one season to another and from periods of wet years to periods of dry years. Prolonged changes in the rates of discharge or recharge will change the position of the water table. The effect that a development of the ground-water resources has upon the water table, upon the quantity of water stored in the reservoir, and upon the flow of perennial streams depends upon the quantity of water discharged by wells, the distribution of the wells, and the amount of recharge to the ground-water reservoir.

The present (1953) development of well irrigation in the area has had only a minor and undetectable effect on the total amount of water stored in the ground-water reservoir, on the water table, and on the base flow of streams. Hydrographs of wells in the most intensely irrigated area show no great or widespread lowering of the water table (see figs. 5 and 6); in fact, the water level in many wells has risen apparently because of an increase in recharge to the ground-water reservoir during years of relatively high precipitation. However, increased irrigation eventually could deplete the ground-water supplies and reduce the base flow of streams.

Collection of detailed quantitative data pertaining to the rates of recharge and discharge to the ground-water reservoir was not within the scope of this investigation. However, a qualitative estimate of the effect of a lowering of the water table in future years is given in the following paragraphs. This estimate is made to assist in determining whether, and when, detailed quantitative studies may be required to provide data needed for preventing or correcting overdevelopment of the ground-water resources.

Overdevelopment might be defined as a lowering of the water table such that most, if not all, of the existing wells of all types would require considerable modification or replacement to maintain their rate of yield. If the regional water table were lowered no more than 10 feet, the cost of modification of wells and pumping equipment probably would not be greatly in excess of that involved in normal depreciation and obsolescence. A decline of the water table of more than about 10 feet, however, would require the deepening of most domestic and livestock wells, because generally they penetrate only the upper 10 to 20 feet of the aquifer. Also, most of the pumps in irrigation and municipal wells would require resetting at a lower depth in the well. Some power units would have to be replaced by more powerful units. Increased pumping costs and perhaps a decrease in yield of wells would be general throughout the area. For the purpose of the following estimate, therefore, increased development of ground water in the area will be assumed to be free of deleterious effects until an average 10-foot lowering of the water table results.

Because of the current rapid rate of ground-water development in the area and of the knowledge that the resource is exhaustible, detailed quantitative studies should be undertaken as soon as it becomes apparent that a decline of the water table approaching 10 feet is likely to occur, in order to enable determining more accurately the effects of the lowering, and especially to determine the average annual recharge to the ground-water reservoir. The amount of ground water that can be withdrawn without "mining" the reservoir is essentially an amount equal to the average annual recharge, less any remaining natural discharge that cannot be salvaged.

Only that part of the area in which extensive irrigation is likely to occur is considered in making the following estimate of the number of years that may elapse before the water table is lowered 10 feet. The part of the area thus considered contains about 2,000 square miles and lies between the York-Seward, Polk-Butler, and Fillmore-Saline County lines and the western boundary of the area. In at least 20 percent of this part of the area the aquifer will not yield sufficient water to wells, or the land is unsuitable, for irrigation. Thus, the irrigable area is assumed to be about 1,024,000 acres.

According to table 3, the average farm includes about 208 acres of irrigable land, of which the average area irrigated annually is about 88 acres. Normally, each farm has only one irrigation well, which irrigates approximately the same amount of land each year but not necessarily the same tract. Thus, if this practice is continued, only about 42 percent of the irrigable land of each irrigated farm will be irrigated each year. Therefore, the amount of ground water consumed annually by irrigation in the area would be about 387,000 acre-feet ($0.42 \times 1{,}024{,}000 \times 0.9$).

If in current irrigation practice 0.9 acre-foot of ground water is consumed per acre irrigated per year, and if only 42 percent of each farm unit of 208 acres is irrigated, the ground water removed from under each acre of each farm unit of 208 acres is 0.38 (0.42×0.9), or about 0.4 acre-foot.

The current rate of development of farm-unit acreage (53 wells per year at 208 acres each) is about 11,000 acres per year, or about 1.07 percent of the 1,024,000 acres assumed to be available. About 140,000 acres, or 14 percent, was developed in farm units before July 1953.

Existing data indicate that the present development has not lowered the water table appreciably. The maximum development that will not affect the water table cannot be determined from the existing data. However, if the present rate of development is assumed to be the maximum and if the present discharge-recharge relationship holds, then the minimum period required to lower the water table 10 feet can be estimated as follows. Let

n = period, in years, to lower the water table 10 feet, and
A = irrigable area (1,024,000 acres),

then,

$$0.0107 \times A \times n = \text{acreage developed in } n \text{ years.}$$

If the consumptive use from the ground-water reservoir is 0.4 acre-feet per acre per year, the net discharge is

$0.0107 \times A \times 1 \times 0.4$ acre-feet at the end of the first year,
$0.0107 \times A \times 2 \times 0.4$ acre-feet at the end of the second year,
$0.0107 \times A \times n \times 0.4$ acre-feet at the end of the nth year.

If the storage coefficient of the aquifer is assumed to be 0.2, then the volume of the aquifer that is dewatered is 5 times the volume of the discharge; hence,

$0.0107 \times A \times 1 \times 0.4 \times 5 = 0.0214 \times A$ acre-feet = volume dewatered the first year, and
$0.0107 \times A \times n \times 0.4 \times 5 = 0.0214 \times A \times n$ acre-feet = volume dewatered by the nth year.

Therefore, the total volume dewatered in n years is the sum of an arithmetical progression:

$$0.0214 \times A \times \frac{n}{2}[1+n]$$

If the water table is lowered 10 feet in the area, the total volume dewatered is $10 \times A$ acre-feet. Therefore,

$$0.0107 \times A \times n\ (1+n) = 10 \times A, \text{ or,}$$
$$0.0107 \times n\ (1+n) = 10,$$

Solving the latter equation, n, the minimum period required to lower the water table 10 feet, is about 30 years, on the assumption that all the water is pumped from storage.

The present (1953) ground-water withdrawal for irrigation and other purposes, plus the outflow into streams, are assumed to be equal to the present average annual recharge. The annual base flow of the streams in the area, measured at Crete, is about 150,000 acre-feet. If the water table is lowered, the hydraulic gradient of the water table toward the streams will become less. Because the movement of water toward the streams is in direct proportion to the slope of the water table, the quantity of water discharged to the streams will be reduced by an amount which is presently undeterminable but which ultimately will be essentially equal to the consumptive use of the ground water pumped from wells. Thus, ultimately, the ground-water development would approach stability at the expense of the base flow in the streams, and the period required for an average 10-foot lowering would be lengthened.

Terraces are extensive along the Big Blue River and principal tributaries and lie in wide, continuous bands on both sides of the streams. These terraces are entrenched by shallow, steep-sided drainage channels issuing from the uplands. Thus, as the land near the streams is rough and rolling, it is not irrigated extensively. The water table under these areas would not be lowered as much as under the irrigated uplands, and to reach an average decline of 10 feet over the entire area, the water table would need to be lowered more than 10 feet beneath the irrigated lands—or, to put it in a different way, the specified limit of 10 feet of lowering would be reached earlier in the irrigated tracts than it would be in the area as a whole.

The preceding estimates are based on several assumptions and factors that are most difficult to determine accurately. The estimates should not be considered to be quantitatively significant; rather, they are interpretations made from available data and serve principally to point out trends.

Many conditions that cannot now be foreseen will affect the future ground-water supply. Some of these are weather, rate of well installation, rate of pumping, changes in irrigation practices, development of surface-water supplies, and changes in land-use practices. Furthermore, future legislation affecting water use may influence development. Because of these unknowns and the fact that present knowledge of ground-water conditions in the report area is not complete, the future of ground water in the area cannot be predicted accurately at this time. The foregoing evaluation does indicate, however, that the water resources are large and that considerable additional development appears possible without immediate serious depletion. It indicates also, however, that the water resources, though great, are exhaustible if development proceeds unrestrained. Thus, it behooves the users of ground water to conserve the supply, to develop it wisely, and to measure and record the trends in the available supply. From studies of the trends, more specific prediction of overdevelopment will be possible before the condition becomes serious in any part of the area.

CHEMICAL QUALITY OF THE GROUND WATER

By Robert Brennan

As part of this investigation, 19 samples of water from wells were collected and analyzed. The analyses of 8 ground-water samples collected in the area during the period 1945–47 also are included in this report. Most of the samples were taken from public-supply wells. Figure 8 is a map of the area showing the location of the 27 sampling points.

CHEMICAL CHARACTERISTICS OF THE GROUND WATER IN RELATION TO SOURCE

The principal sources of ground water in the area are sand and gravel of Pleistocene age. The water is of the calcium bicarbonate type; however, some water, particularly in the western part of the area, contains appreciable amounts of sulfate. The results of analyses are shown in table 2. Concentrations of dissolved solids ranged from 245 to 804 ppm; calcium and magnesium hardness, calculated as calcium carbonate, from 165 to 529 ppm; percent sodium, from 10 to 45; and sulfate, from 19 to 315 ppm.

Figure 9 shows the sulfate concentration of each of the water samples. The chemical-quality data indicate that recharge from the Platte River to the ground-water reservoir of the Big Blue River basin above Crete is not the major source of the high concentrations of sulfate. Although the concentrations of sulfate and dissolved solids in the ground water in the western part of the report area are similar to those in the Platte River water (Love, 1956, 1957), calcium constitutes a higher percentage and sodium a lower percentage of the dissolved solids in the ground water than in the river water. If recharge from the Platte River were the major source of sulfate in the ground water, sodium in the river water would have had to be exchanged for calcium in the ground; such an exchange is unlikely.

A more credible source of the higher concentrations of sulfate in the western part of the report area is the underlying Niobrara formation. (The dashed line in fig. 9 shows the approximate eastern edge of this formation.) High, buried ridges of the Niobrara formation extend eastward from the Adams and Hall County lines. One ridge extends diagonally across the southern border of Hamilton County; another probably extends northeastward through Phillips and Marquette. Water from wells adjacent to these ridges probably is affected by materials from the Niobrara formation. The Niobrara formation contains appreciable amounts of iron sulfides, and generally water

TABLE 2.—*Chemical analyses of ground*

[Water-bearing formation: Qc, Crete formation; Qd, David City formation; Qg, Grand Island

Location	Water-bearing formation	Depth (feet)	Date of collection	Temperature (° F)	Silica (SiO_2)	Total iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
Adams County:												
7-9-8bc	Qg-Qh	195	6-17-47	56	29	0.04	------	51	9.6	14	10	171
8-9-12bd	Qg-Qh	138	7- 9-53	56	29	.06	0.04	93	14	27	8.7	274
8-9-14aa	Qg	152	8-22-47	55	40	.5	------	55	16	30	5	100
Butler County:												
A13-2-28bd	--------	72	6-18-53	54	39	.12	.03	65	13	36	5.8	323
A13-4-19bb	Qd	392	9-26-52	66	45	1.7	.32	88	29	21	11	432
A14-1-10bd	--------	------	9-26-52	57	29	.59	.01	168	27	44	9.6	330
Clay County:												
8-7-34ac1	--------	------	9-25-52	58	28	.03	.01	91	14	26	6.3	222
Fillmore County:												
8-1-20da	Qh	250	4-15-53	56	34	.23	.40	77	16	21	5.1	272
8-2-30bd1	Qh-Qg	245	9-26-52	56	30	.43	.03	71	11	23	3.9	265
Hall County:												
9-9-5ca1	Qg	133	7- 9-53	55	25	.16	.03	63	12	20	8.4	206
Hamilton County:												
9-7-6da2	--------	260	9-25-52	56	24	.38	1.2	88	15	26	4.8	244
11-5-33ad1	Qc	------	5-28-53	55	41	.01	.03	62	10	18	6.7	235
11-8-27ab	Qg	170	6-11-53	56	24	.44	.02	76	15	25	5.4	190
12-6-16cd	Qg	145	5-20-53	57	24	.05	.02	119	15	44	12	319
13-5-21da	Qc	160	5-14-53	55	32	.01	.04	92	13	26	7.4	302
Polk County:												
13-4-21cc	Qc	145	9-26-52	55	30	.02	.02	83	12	24	6.6	328
14-2-16da1	--------	190	3-10-53	55	38	.01	.03	106	17	25	6.9	373
Saline County:												
A8-3-25aa	--------	140	3-29-45	54	----	------	------	----	------	58		284
A8-4-34bd	--------	182	3-30-45	55	----	------	------	78	14	21		294
A8-4-35aa	--------	246	3-30-45	53	----	------	------	----	------	63		302
Seward County:												
A9-1-2dd	Qh	120	3-29-45	55	----	------	------	82	15	14		306
A10-2-17da	Qg	90	3-29-45	53	----	------	------	----	------	37		230
A11-2-26ad1	Qg	115	4- 2-45	53	----	------	------	64	13	33		260
York County:												
9-4-6ad2	Qg-Qc	170	3-31-53	----	34	.03	.02	55	9.0	22	5.3	206
10-2-6ab1	Qg	137	9-26-52	56	34	.15	.01	74	14	42	7.5	290
12-1-11bc2	Qg	156	3- 9-53	54	41	.09	.03	75	11	24	5.7	317
12-3-13dc	--------	------	9-25-52	56	30	.05	.02	74	10	23	6.4	293

[1] Residue on evaporation at 180°C.

from this formation is characterized by high concentrations of sulfate. Iron sulfides, in the presence of oxygen, may react with carbonates or bicarbonates in water from the overlying material to yield a sulfate-type water. The following equations illustrate the reaction:

$$4FeS+9O_2+4H_2O \rightarrow 2Fe_2O_3+8H^{+}+4SO_4^{--}$$
$$Ca^{++}+CO_3^{--}+2H^{+}+SO_4^{--} \rightarrow Ca^{++}+SO_4^{--}+CO_2\uparrow+H_2O$$

A local gypsum deposit in the till might be the source of the high concentration of sulfate in the water at Rising City.

Some of the area is underlain by extensive lenses of clay and silt, which may be of the Sappa formation, and perched water bodies are *water in the Big Blue River basin above Crete*

formation; Qh, Holdrege formation. Analytical results are in parts per million except as indicated]

Location	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids [1]	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Adams County:												
7-9-8bc	9	30	9.2	0.3	12	0.19	245	167	11	15	388	8.3
8-9-12bd	0	119	11	.3	1.4	.04	444	290	65	16	667	7.3
8-9-14aa	0	168	11	.2	.9	.25	370	203	121	23	522	8.1
Butler County:												
A13-2-28bd	0	19	4.5	.3	7.4	.05	359	214	0	26	554	7.3
A13-4-19bb	0	37	7.5	.3	.7	.08	448	338	0	11	696	7.4
A14-1-10bd	0	315	7.5	.2	54	.07	804	529	258	15	1,100	6.9
Clay County:												
8-7-34ac1	0	147	16	.1	1.7	.05	462	285	103	16	646	7.2
Fillmore County:												
8-1-20da	0	73	9.0	.3	.4	.06	376	258	35	15	579	7.3
8-2-30bd1	0	39	19	.2	1.1	.04	342	224	7	18	511	7.3
Hall County:												
9-9-5ca1	0	68	7.5	.3	13	.04	320	206	37	17	497	7.2
Hamilton County:												
9-7-6da2	0	132	10	.2	1.8	.03	434	281	81	16	632	7.2
11-5-33ad1	0	21	12	.1	12	.03	307	196	3	16	472	7.0
11-8-27ab	0	132	14	.5	4.5	.03	399	251	95	17	604	7.4
12-6-16cd	0	162	13	.8	27	.07	583	358	96	20	863	7.2
13-5-21da	0	76	13	.2	3.2	.04	414	282	34	16	650	7.3
Polk County:												
13-4-21cc	0	28	11	.2	10	.04	372	258	0	16	579	7.2
14-2-16da1	0	67	7.5	.1	9.4	.04	477	333	27	14	723	7.2
Saline County:												
A8-3-25aa	0	45	8.0	------	2.7	------	------	168	0	43	544	----
A8-4-34bd	0	40	10	.2	.8	------	------	252	11	15	540	----
A8-4-35aa	0	30	6.0	------	19	------	------	165	0	45	519	----
Seward County:												
A9-1-2dd	0	31	9.0	.2	.2	------	------	266	15	10	528	----
A10-2-17da	0	60	6.0	------	17	------	------	192	3	30	600	----
A11-2-26ad1	0	52	6.0	.2	12	------	------	213	0	25	522	----
York County:												
9-4-6ad2	0	34	15	.3	5.1	.04	293	174	5	21	447	7.2
10-2-6ab1	0	58	19	.1	23	.04	430	242	4	27	635	7.1
12-1-11bc2	0	19	6.0	.2	10	.05	360	234	0	18	550	7.1
12-3-13dc	0	31	9.0	.2	5.4	.07	334	226	0	18	526	7.1

present because the relatively impermeable clay and silt retard the infiltration of precipitation to the underlying sand and gravel. Thus, because of the reduction in recharge from above and perhaps also because some water may percolate through the perching bodies of clay and silt and may dissolve considerable mineral matter from them, the water from sand and gravel underlying the perched water bodies is harder than the water from sand and gravel not underlying such bodies. Direct recharge from precipitation in areas not underlain by relatively impermeable clay and silt is indicated by the lower hardness of the water in such areas. Only one sample of perched water (A10–2–17da) was analyzed; the hardness was 192 ppm.

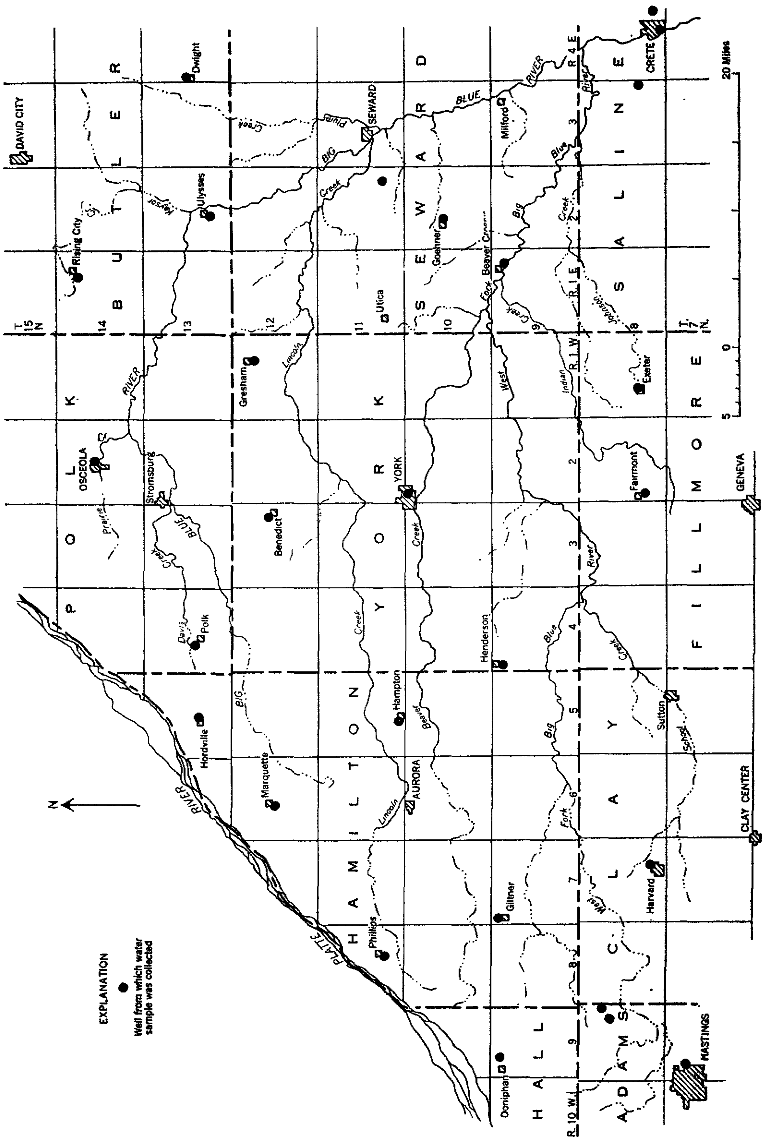

FIGURE 8.—Location of quality-of-water sampling points in the Big Blue River basin above Crete, Nebr.

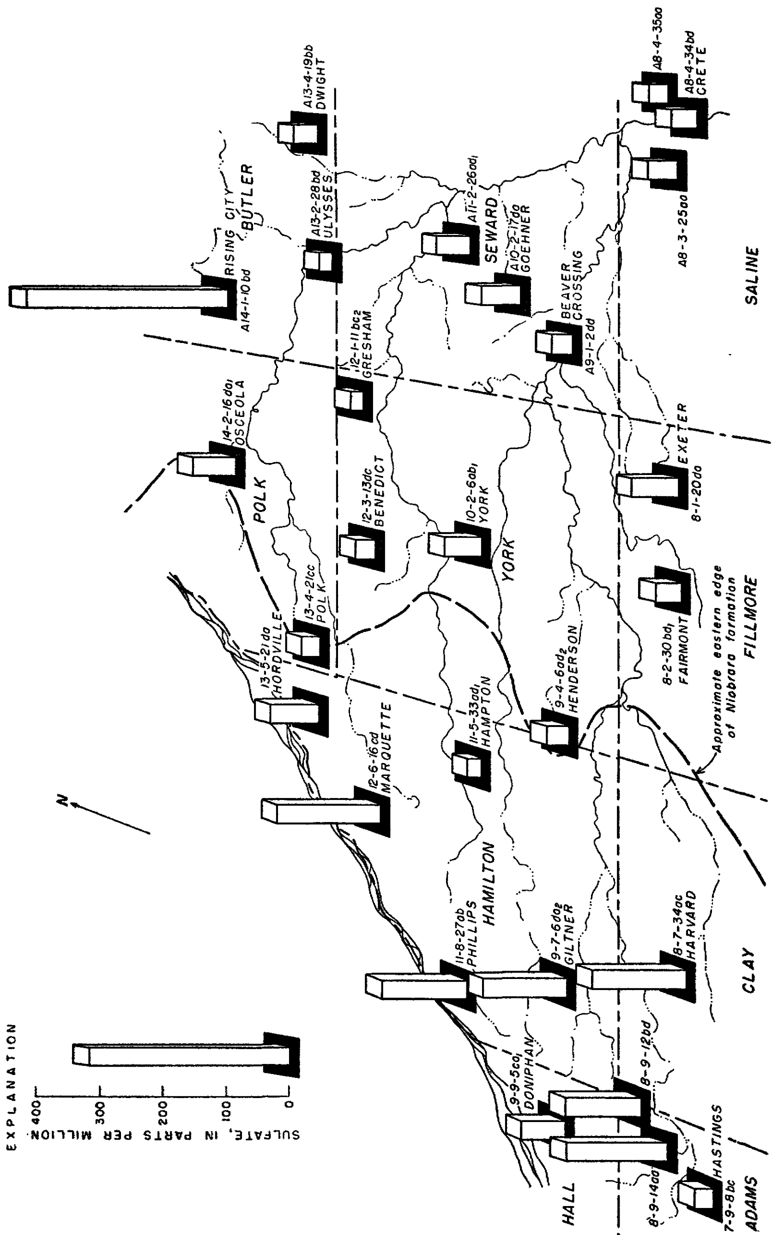

FIGURE 9.—Sulfate concentrations of water samples from the Big Blue River basin above Crete, Nebr.

Hardness of ground water in relation to perched water bodies

Source of the water	Number of samples	Hardness		
		Maximum (ppm)	Minimum (ppm)	Average (ppm)
Sand and gravel underlying a perched water body	21	529	167	269
Sand and gravel not underlying a perched water body	5	252	165	191

USABILITY OF THE WATER

The drinking water standards of the U. S. Public Health Service (1946) for water used on interstate carriers have been accepted by the American Water Works Association and many State health departments as criteria for public supplies. Although these standards are not compulsory for water that is used locally, they are measures of the suitability of water for domestic use. The maximum allowable concentrations, according to the standards, for certain chemical constituents are as follows:

Constituent	*Concentration (ppm)*
Iron plus manganese	0.3
Magnesium	125
Sulfate	250
Chloride	250
Fluoride	1.5
Dissolved solids	[1]500

[1] 1,000 ppm permitted if water of better quality is not available.

Generally, the concentrations of chemical constituents in ground water in the area were less than the suggested concentrations except for the iron and manganese in water from seven wells. The iron in such high concentrations may come from till; although iron may come from other sediments also, it probably has not been as thoroughly leached from the relatively impermeable till in the past as it has from the other sediments. The well at Giltner (9–7–6da2), however, is not known to be in an area of till. All the ground water sampled in the report area is hard, but generally it is potable and suitable for domestic use.

The total salt concentration, boron concentration, and percent sodium are especially important in water used for irrigation. However, other factors, such as soil texture and drainage, climate, and type of crops grown, also are important.

Wilcox's classification (1948) of water for irrigation is well known. A more recent empirical classification, embodying most of the features of Wilcox's criteria but modified to include soil and drainage characteristics in the interpretation, is given by Thorne and Thorne (1951). (See fig. 10.) The quality of water for irrigation is designated on

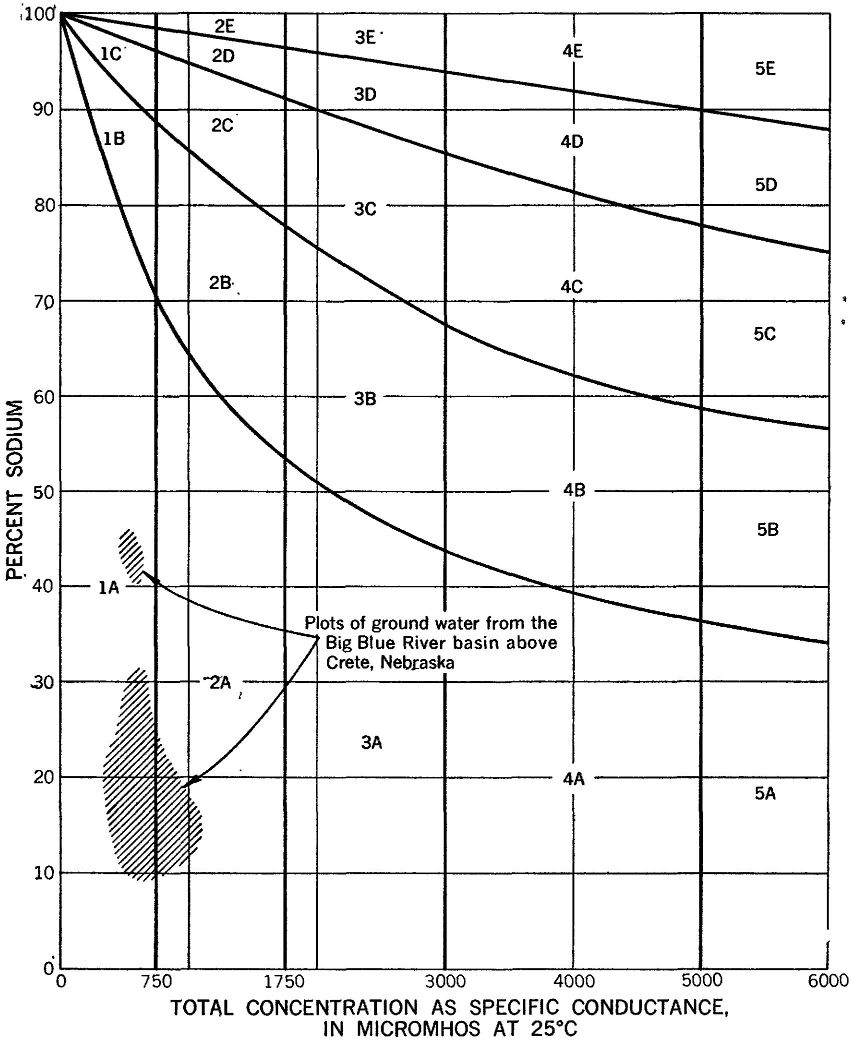

FIGURE 10.—Classification of water for irrigation. (After Thorne and Thorne, 1951.)

figure 10 by number and letter. Increases in the numbers or letters designate water of progressively poorer quality for irrigation. Ground water in the report area is classed as 1*A* except for water from two wells, which is classed as 2*A*. Water that is classed as 1*A* is considered to be suitable for irrigation on all soils. Water classed as 2*A* can cause salt problems in soils where drainage is poor and where salts from previous applications of water have not been leached out.

Results of analyses indicate that if water from some of the wells were used for irrigation, evaporation and concentration of the soil solution could cause the formation of "residual sodium carbonate" (Eaton, 1950). However, the amount of residual sodium carbonate that could form in the water is so small that it would not seriously affect the soil.

Boron concentrations of less than 0.3 ppm are not harmful to even the most sensitive crops. Ground water in the report area had less than 0.3 ppm of boron.

EVALUATION OF ADEQUACY OF BASIC HYDROLOGIC DATA

A considerable amount of basic data concerning the aquifers underlying the Big Blue River basin above Crete and other data concerning the water resources of the area have been collected. Particularly, the cooperative test-hole-drilling program of the Conservation and Survey Division of the University of Nebraska and the U. S. Geological Survey has provided valuable subsurface data. Some of these data have been tentatively analyzed, and preliminary reports for most of the counties in the area have been prepared by the Conservation and Survey Division. These data are available for inspection at the University of Nebraska. Measurement of the water levels in many wells in the area have been made periodically by personnel of the U. S. Geological Survey and the Conservation and Survey Division, and these data are published annually. Records of the higher streamflows in the Big Blue River at Crete are available from 1945 through 1953, and a recording gage was installed on the river at Crete in 1954. Streamflow records are kept by the U. S. Geological Survey in cooperation with the Nebraska Bureau of Roads and Irrigation.

The existing hydrologic data are adequate to enable estimating in a general manner the water resources of the area but are inadequate for quantitative estimates of either the ground- or the surface-water resources or conditions. Because of the rapid development of the water resources, the value of these resources, and the competition for them that may occur in this area, a detailed quantitative appraisal of the resources should be made before serious overdevelopment takes place. Such studies are necessary also as a guide to the most economical utilization of the available water. These studies not only should make full use of available data, but also should bring those data up to date and expand on them. Some of the additional data that would be needed are cited in the following paragraphs.

To evaluate properly the water resources of the area, the surface-water resources and their relationship with the ground-water resources must be determined; they are closely interrelated and the use of one will eventually affect the other. The existing stream-gaging station should be maintained and others should be installed. Additional stations can best be located after a preliminary study of the ground-surface-water relationships is made. Observation of any significant changes in the base flow of the streams and in the points of effluence is necessary in a comprehensive study.

The number, distribution, and frequency of water-level measurements in wells will need to be increased for detailed studies. Recording gages should be installed on some wells, especially in Hamilton County where the development of ground water for irrigation is most intensive.

Test holes should be drilled in western Seward County to delineate more accurately the eastern border of the major aquifers and to determine the extent of artesian conditions. Shallow test holes should be drilled to obtain more data about the perched aquifers and their relationships with the principal aquifers. Test holes and aquifer tests are needed along the western border of the area to assist in determining the amount of recharge to the area that occurs by eastward movement of ground water.

Aquifer tests should be made to determine the coefficients of permeability, transmissibility, and storage of the major aquifers. Records should be maintained of all new wells of large yield constructed after June 1953. The annual ground-water pumpage should be determined. Changes in the annual rate of well construction and significant changes in irrigation practices and in the annual amount of ground water pumped should be recorded.

Altitudes at all observation wells should be determined by instrumental leveling and more accurate water-table contour maps should be prepared at periodic intervals. Studies should be made of precipitation and infiltration rates to help determine the total ground-water recharge; these studies probably would require recording precipitation gages as well as additional nonrecording stations.

More detailed studies of the chemical quality of the surface and ground water should be made to assist in determining the source and movement of the ground water and to establish bases from which to determine the long-term effect of the circulation of water used for irrigation purposes, especially upon the chemical quality of the ground water.

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SUMMARY

Much of the Big Blue River basin above Crete is underlain by aquifers in which wells of high yield can be developed. Ground water is obtained principally from sand and gravel of Pleistocene age. The greatest amount of the water pumped is used for irrigation; lesser amounts are pumped for domestic, stock, and industrial uses. All municipal water supplies in the area are obtained from ground-water sources, but only small amounts of ground water are used for industrial purposes.

The number of irrigation wells in the area increased from 14 in 1938 to 672 as of June 30, 1953. They were constructed at an average rate of 53 per year from 1944 through 1952; 140 were constructed during 1948. The withdrawal of ground water is estimated to be about 61,000 acre-feet per year. Withdrawals for domestic and stock uses are about 25,000 acre-feet per year; those for municipal use are about 8,000 acre-feet per year, more than one-half of which is for the city of Hastings, Nebr.

Streams draining the area are perennial over part of their courses, and the contribution of ground water to their base flow above Crete is about 150,000 acre-feet per year.

Ground water in the area is of the calcium bicarbonate type. Appreciable amounts of sulfate in water from the western part of the area are attributed principally to oxidation of iron sulfide in the Niobrara formation; in other parts of the area local deposits of gypsum in the glacial till may be the source of the sulfate. In areas in which the principal aquifers are not overlain by relatively impermeable lenses of clay and silt, direct recharge by precipitation is indicated by the lower hardness of the water. The water is hard and locally contains high concentrations of iron and manganese; however, it generally is suitable for domestic use. Because of its low total salt content, low boron content, and low percent sodium, the ground water is suitable for irrigation on all soils.

Fluctuations of the water table are unavoidable in the proper use and conservation of the available water supplies. The rate of ground-water withdrawals as of 1953 seems to have had little effect upon the position of the water table during the period observations were made.

Preliminary estimates indicate that the ground-water resources in the area are large and that considerable additional development appears possible; and the estimates indicate that the current rate of increase in ground-water use could continue for perhaps 20 to 40 years before the regional water table would be lowered an average of 10 feet. A decline of the water table greater than 10 feet probably

would cause many of the shallower wells, especially the domestic and stock wells, to become dry and necessitate remodeling or replacing many of the pumps in wells of greater yield if their rate of discharge were to be maintained. The decline of the water table would be greatest in areas farthest from the streams, and the 10-foot decline could occur quite soon in some areas, depending upon where the development becomes most extensive and the capability of the aquifer to store and transmit water to wells.

Even though the ground-water supply is large and replenishable, it can be overdeveloped. Because of the enthusiastic and rapid construction of irrigation wells of high yield, it is very important for the safe development and economical conservation of the water resources that the systematic collection of sufficient basic, historic records of the ground-water levels and withdrawals and similar data be undertaken. It is equally important that timely quantitative studies of the water resources of the area be made so that the average amount of ground water that can be withdrawn annually from the area without an undue lowering of the water table or reduction in the base flow of streams can be determined more accurately.

RECORDS

Data collected during the investigation are given in the following tables:

Table 3 gives detailed information on 208 irrigation wells in the area. Included for most of the wells are data on the pumping lift, the fuel used, the average yield, the annual number of hours pumped, the annual pumpage, the irrigable area available, the area irrigated, the principal crop irrigated, the distribution system used, and the consumptive use of the water. The fuel cost is given for about half the wells.

Table 4 gives data on 764 wells and 7 test holes in the area. Of the wells, 672 are irrigation wells, 71 are public-supply wells, and the remainder are used for other purposes or are not used at all. In addition to the date of drilling and construction features of the wells, information is given as to the aquifer tapped, the depth to water, water-level drawdown when wells are pumped, the rate of discharge, and the use made of the water.

Table 5 consists of previously unpublished logs of 80 wells and 7 test holes.

TABLE 3.—*Irrigation data*

Well: See text for explanation of well-numbering system.
Fuel: D, diesel oil; E, electricity; G, gasoline; N, none; NG, natural gas; P, propane or butane; TF, tractor fuel.
Principal crops irrigated: A, alfalfa; C, corn; O, orchard.
Other crops irrigated: A, alfalfa; C, corn; Cv, clover; G, grass; Gs, grain sorghum; N, none; O, oats; R, rye; S, soybeans; T, truck garden; W, wheat.
Distribution system: D, ditches; P, pipe; S, sprinklers.

[Additional data concerning the wells are given in table 4]

Well	Owner of well or tenant of property	Pumping lift (feet)	Fuel	Average yield (gpm)	Fuel cost per acre-foot	Annual use (hours)	Annual pumpage (acre-feet)	Available irrigable area (acres)	Average area irrigated per year (acres)	Principal crop irrigated	Other crops irrigated	Distribution system	Consumptive use (acre-feet per acre)
Adams County													
8- 9-6dc	Jacob Leonhardt, Jr.	91	P	600	$4.90	720	80	136	70	C		S	1.1
15bc	Homer Berck	88+	NG	500	1.08	840	93	160	80	C	A, W, G	S, P	1.2
31dd	do	90+	NG	550	2.17	300	28	75	40	C	A, W, G	S, P	.7
10- 1bc	Bernard J. Kline	76+	P	700		1,080	139	320	100	A		S	1.4
Butler County													
A13- 2-30bc	George McGowan	60+	TF	350		300	13	120	100	C	G	P, S	0.1
Clay County													
7- 6- 3ab	Roland Johnson	63	P	400	$4.50	590	43	160	80	C	A	S	0.5
7- 2db	George Pauley	68+	NG	300	2.35	600	33	100	85	C	A, G, R	S	.4
16bd	Morrison & Quirk	75+	NG	1,600		2,880	850	} 1,920	1,920	A	C	S	.9
17ac	do	82+	NG	1,100		2,880	850						
27da	L. S. Yost	75+	P	1,000		600	111	125	85	C		D	1.3
8- 4db	Robert Donahue	112	N	1,100				200	80	C	A	P	
10ab	Chas. W. Roback	98	TF	1,000	3.40	720	133	145	100	C	A, Gs	D	1.3
8- 5- 6cc	E. K. Nuss	127	P	600	4.00	1,180	130	146	98	C	A	D	1.3
18ca	H. V. Nuss	79	P	850	4.20	600	94	150	95	C	A, G	P	1.0
33dc1	Earl Vauck	82	TF	1,000				120	120	C		P	
6- 2cd	C. J. Helzer	92	TF	1,000				72	60	C		P	
9ad	Dale Nelson	112	TF	600				80	30	C		S	
10ca	Glen Nelson	64+	TF	600				80	60	C		S	
12bb	Paul Helzer	77+	P	925		480	82	140	75	C	A, O	S	1.1
15cd	Clayton England	62+	P	1,000	3.25	320	59	160	85	C	A, G	P	.7

20dc	Roger G. Anderson	85	TF	650	3.16	336	62	60	35	C	A, Gs	P, D	1.8
27ac	Vic. Englehardt	85	P	1,000		430	80	140	80	C	A	D	1.0
36cb	Edward C. Walther	75	P	900		360	60	85	85	C	A	P, S, D	.7
7-20cc	Harold Smith	100	G, TF	800	6.50	720	100	120	65	C	O, Cv	P	1.5
22bb	Harry Frank	76+	NG	1,000		540	100	120	80	C	A	D	1.2
28ac	H. V. Brenneman	91	P	900	2.65	720	120	150	90	C	A	P	1.3
29ac	Anderson Bros.	96	TF	800	3.80	720	106	160	90	C	A, O	D	1.2
29bc	William F. Wendt	81+	P	800		720	106	130	80	C	A	D	1.3
31da	Harold Smith	98	P	800	3.20	720	106	135	90	C		P	1.2
33ac	Ralph Keller	98	P	850	4.55	720	113	90	50	C		P	1.8
36db	C. G. Yost	86	NG	1,000	.43	720	133	140	100	C	A, G	P, S, D	1.3
8- 4ad	Ray Ochsner	110	NG	950	.46	840	147	80	70	C		D	2.1
7db	Roy Andrews	102+	NG	1,000		648	120	90	80	C	A, O	P, S, D	1.5
8db	Lillian Holm	99+	NG	1,000	.87	360	66	120	90	C		P, D	.7
17ab	do	104+	NG	1,000		360	57	140	70	C	A, Cv, O	P, D	.8

Fillmore County

7- 4- 5cc	Ervin Schmer	79+	P	1,000	$2.86	500	92	240	150	C	A, G, W	P, S	0.6
6da	Walter Maser	94	TF	1,000	3.79	180	27	85	65	C	A	P	.4
8dd	Edward Girmus	90	NG	1,046	.49	252	49	146	100	A	C	P, S	.5
8- 2-31bc	George C. Meier	98	NG	1,000	.68	400	74	150	100	C	A, G	D	.7
4- 5ab	J. G. Kroeker	130	TF	850	2.68			80	60	C		D	

Hamilton County

9- 5- 2db	Henry P. Buller	79+	TF	1,000		378	70	60	60	C		D	1.2
3cb	H. A. Buller	81+	D	1,500		670	185	150	150	C		P, D	1.2
16bc	John Thieszen	122	P	1,000		500	92	160	160	C		P	.6
26cc	Gideon Redler	43	P	1,000				100	70	C	A	P, S	
6-22ca	L. E. Tucker	73+	P	1,000		252	47	94	80	C	A	D	.6
7- 3cd	O. A. Kostal	77+	P	1,100	$2.16	500	100	220 }	200	C		P	1.0
4aa	do	69+	NG	1,000		500	92	80 }					
9ca	Lloyd Hinrichs	91	P	1,000		500	92	110	90	C	A, Gs	P	1.0
12cc	Ruth Pitts Estate	73+	TF	900	4.20	500	83	50	50	C	N	D	1.7
21ab	D. J. Wilson	83	P	800	2.98	210	32	70	60	C		P	.5
21da	do	103	P	700	4.25	210	27	120	60	C		P	.5
27cd	Floyd Bieck	97+	D	800	3.00	600	89	180	95	C		D	.9
35cb	do	80+	D	1,050	2.17	700	135	160	90	C		D	1.5
8- 9cb	E. P. Leinert	99	P	1,250	2.38	500	115	105	80	C	S	D	1.4
11bb	Matilda Springer	102	NG	1,000	.54	1,440	266	160	110	C	A, G	P, S	2.4
27da	Elmer Nuss	95	TF	80	14.20	360	5	90	15	C	A	S	.3

TABLE 3.—*Irrigation data*—Continued

Well	Owner of well or tenant of property	Pumping lift (feet)	Fuel	Average yield (gpm)	Fuel cost per acre-foot	Annual use (hours)	Annual pumpage (acre-feet)	Available irrigable area (acres)	Average area irrigated per year (acres)	Principal crop irrigated	Other crops irrigated	Distribution system	Consumptive use (acre-feet per acre)
Hamilton County—Continued													
9- 8-35dd	D. E. and Art Kline	91	NG	800	$0.92	360	53	210	80	C		D, P, S	0.7
10- 5- 2cc	C. G. Bamesberger	33+	G	1,000		378	70	65	55	C			1.3
6dd	Adolph Medow	83+	NG	1,000		460	84	140	100	C			.8
7ab	John A. Peters	72+	NG	1,000		336	62	110	70	C			.9
10ab	John J. Ediger	36	G	1,000		378	70	65	50	C		D	1.4
22db	Jacob B. Goertzen	83+	TF	1,000		670	124	145	125	C		D	1.0
23da	Herman Friesen	85+	G	600		540	50	80	80	C		D, P	1.9
23dd	do	98	G	1,000		540	100						
24ac	B. L. Wall	90	G	1,000		350	65	100	80	C	A	D, P	.8
29db	Isaac Goertzen	85+	NG	1,000		720	133	130	115	C			1.2
31dd	Peter J. Siebert	83+	G	1,000		224	41	153	80	C		D	.5
36da	W. K. Regier	76+	P	1,000		500	92	175	135	C	A	D, P	.7
6- 8db	Claire Cass	73+	NG	1,000		960	180	160	60	C	A	D, P	3.0
23da	F. E. Edgerton	85+	P	1,000		720	133	160	125	C		D	1.1
24aa1	E. E. George	92+	NG	1,000		720	133	200	175	C		D	1.5
24aa2	do	92+	NG	1,000		720	133						
26bb	Ted Regier	102	TF	1,100		600	122	280	140	C	Cv, O	D, P	.9
27ba	Ralph Wright	87	P	1,000		720	92	160	110	C		D	.8
28bb	John Schaffert	56	TF	600		336	37	120	60	C		P	.6
32bd	Bruce T. Arnold	82+	G	1,000		250	46	200	90	C	A	D, S	.5
34dc	Herman Epp	83+	TF	1,000		500	92	150	100	C		D, P	.9
7- 2aa	Earl Oswald	82+	P	1,000		350	65	100	90	C		D, P	.7
22bc	Gimpel Bros	80+	TF	950		240	44	80	80	C	A	D	.5
33dc	O. A. Kostal	70+	NG	1,000		1,000	184	450	300	C		D, P	1.2
34cc	do	88	NG	1,000		1,000	184						
35db	George H. Mersch	83	TF	1,000		140	39	110	65	C		D, P	.6
36dc	Walter L. Wilson	79+	P	1,000		720	92	60	30	C		D	3.0
8-10ab	Ed Daniel	75+	TF	1,000		670	124	160	100	C	A, G	D, P	1.2
11ab	Harvey E. Otto	102+	TF	850		670	61	160	100	C	A	D, P	.6
16cb	W. M. Sundermeier	78+	NG	1,000		720	92	120	90	C		P	1.0
17da	do	74+	NG	1,000		720	92	120	120	C	G	P	1.5
17dd	do	99	NG	1,000		720	92						

19ab	Earnest Kuehner	85	P	600		500	55	160	80	C	A	P, S	.7
20ab	Theo. Jessen	73+	NG	1,000		960	180	130	100	C	N	P	1.8
20bc	Art Sundermeier	94	NG	1,000		1,440	266	160	160	C	A, G	S	1.7
26cb	Gerald Hunnicutt	82+	NG	1,000		700	77	80	55	C	A	D	1.4
11- 5- 6ac	George Hansen	91+	P	1,000		720	92	160	100	C		P	.9
10ca	Art. Miller	78+	G	1,000		315	58	59	45	C		D	1.3
13bb	Henry Rhode	73+	P	1,000		420	77	120	65	C		P	1.2
13db	Clarence Heiden	70+	G	1,000		288	53	100	80	C		D	.7
14ab	Walter Paneitz	74+	G	1,000		420	77	135	80	C	A, O	P	1.0
27db	G. W. Klute	90	NG	1,000		1,080	199	130	100	C	Cv	D	2.0
27dd	R. F. Klute Estate	90	NG	1,000		720	92	70	70	C	Cv	D	1.3
36da	Walter Klute	81	TF	1,000		720	92	186	125	C	G, O	D	.7
6-18db	Ackerson Bros	131	TF	800		1,000	186	220	90	C		P	2.0
7-26ac	Paul Hanson	84+	P	1,000		670	124	140	140	C		D	.9
27dc	Sandy L. Cameron	92+	P	1,000		500	92	130	55	C		P	1.7
28ac	Day Bros	77+	P	1,000		280	52	90	65	C		D	.8
34ab	Roy Luthy	95	TF	1,000		252	47	100	60	C		D	.8
12- 5-25ad	Harvey Wochner	99+	G, TF	1,000		1,200	222	240	125	C			1.8
25bd	Carl Doze		TF	1,000		500	92	140	120	C			.8
33cb	George W. Hansen	96	G	1,000		720	133	200	120	C		P	1.1
35cb	Paul Budnick	83+	D	1,000	3.47	216	40	70	40	C		D	1.0

Polk County

13- 1-20cc	G. H. Bond	107	E	750		450	62	90	55	C	N	P	1.1
26cc	Robert Nelson	139	D	1,800		300	100	160	100	A	C	P, S	1.0
29bb	G. H. Bond	111	D	800	$3.46	500	72	120	70	C		P	1.0
32bd	Brown Bros	87	P	800	3.86	360	53	200	55	C	A	D	1.0
3- 6cb	Dewey Anderson	116	TF	500		1,000	92	100	100				.9
19dcl	Norris M. Anderson	92	P	1,000	2.38	336	62	160	80	C		D	.8
4- 2aa	Elmer Gleim	79+	P	750	3.18	380	52	200	55	C		P	.9
10db	Paul L. Stevens	78+	D	900	2.10	275	46	80	50	C		D	.9
12cd	Nettie Carlson	105	P	1,000		500	92	160	150	C	A, G	D, P, S	.6
24ab	Harold Carlson	79	TF	800	3.32	430	64	128	55	C		D	1.2
24dd	Cliff Carlson	74+	TF	800		430	64	140	60	C		P	1.1
32ad	R. C. Werner	93	G	1,000	5.40	400	75	130	90	C		P	.8
33ac	Wilmer Rodine	89+	G	1,000	4.34	336	62	180	80	C		D	.8
14- 1-31bb	R. J. Mangelson	73	TF	850	2.68	400	63	65	65	C	A	D	1.0

Saline County

A8- 2- 9ca	Archie McAlpin	110+	P	800		250	37	85	50	C	A	P	0.7
4-17bc	Henry Pomajzl	105	NG	1,000	$0.97	240	44	143	60	C		P	.7

TABLE 3.—*Irrigation data*—Continued

Well	Owner of well or tenant of property	Pumping lift (feet)	Fuel	Average yield (gpm)	Fuel cost per acre-foot	Annual use (hours)	Annual pumpage (acre-feet)	Available irrigable area (acres)	Average area irrigated per year (acres)	Principal crop irrigated	Other crops irrigated	Distribution system	Consumptive use (acre-feet per acre)
							Seward County						
A10- 2-18bd	Katie Belle Olston	79	E	500	$5.60	200	19	200	50	C	T	D	0.4
A11- 1-23cd	Ethel Wolvin	94	G	1,000	5.40	400	75	160	70	C	A, G	S	1.1
2-6db	Leo Wolvin	93	P	600	3.00	400	59	150	100	C	A	S	.6
							York County						
9- 1- 7ad	Mrs. Albert Baller	19+	TF	1,000	$1.70	336	62	90	45	C		D	1.4
8ab	J. C. Peterson	32+	E	850		240	38	80	40	C	A	D	1.0
10bc	Pearl Dyer	17+	E	500		500	46	80	45	C			1.0
3-20da	H. J. Bredenkamp	102	G	800	5.40	540	80	80	40	C		P	2.0
21ba	Wade E. Moore	89+	P	1,100	2.70	250	51	80	70	C		D	.7
25ca	Curtis S. Reed	41	G, TF	500	2.70	170	16	25	20	C		D	.8
31ba	William Kleinholz	103	G	1,050		840	163	130	80	C		D	2.0
36dc	Gene Henning	40+	G	1,000	2.17	170	32	160	80	C		D, S	.4
4- 9bd	Henry C. Otte	186	TF	1,000	3.00	500	92	115	110	C	Gs	P	.8
10ca	John J. Thieszen	194	D	1,100	1.70	500	102	144	144	C	A	D, P	.7
18cb	Clarence E. Peters	97	TF	750	4.05	750	57	85	75	C	A	D	.8
23dd	Aaron P. Siebert	72+	TF	800	3.80	360	53	100	75	C		D	.7
29dd	Oscar J. Griess	45	TF	1,000		336	62	110	85	C		D	.7
30ac	George Hiebner	52	G	950	2.30	360	63	95	80	C		D, S	.8
32cb	August Griess	90+	P	900	2.50	840	142	60	90	C	A	D, P	1.6
33cb	Sidney F. Smith	92+	G	1,000	4.30	450	83	140	90	C	A	D	.9
36cb	C. P. Baller	34	G	800	1.55	360	53	100	60	C		S	.9
10- 1-18da	Ruth Tucker	100+	G	850		315	58	56	56	C	A	D	1.0
2- 4bc	Leslie Foster	79+	P	800	3.70	216	32	75	45	C		P	.7
5bc	A. L. Speece	72+	E	120		120	2.5	3	3	C		D	.8
13ad	A. J. Bredenkamp	119	TF	700	3.25	126	16	80	30	C	A	D	.5
18ac	Ross A. Fate	90	G	1,000	3.16	336	62	110	50	C		P	1.2
30dd	F. R. Scott	96	P	800	4.05	400	59	100	60	C		D	1.0
3- 5ab	R. J. Kreifels	57+	NG	850	.57	700	110	120	80	C		D	1.4
18cc	J. E. Towle	130	P	650	3.25	336	40	70	70	C		D	.6

4- 4ac	D. D. Ediger	62+	TF	700		190	25	50	35	C		D	.7
16dd	Jacob C. Goertzen	83	TF	1,000		600	110	140	100	C		D	1.1
20cd	John R. Doell	97	TF	1,000	2.28	430	80	155	110	C	A	D, P	.7
20dc	J. J. Kroeker Estate	81+	G	1,450	5.20	500	134	150	150	C		D	.9
24aa	Leonard G. Faustman	140	P	900		336	56	70	70	C		D, P	.8
29bb	John R. Doell	98	P	900	3.00	430	71	145	90	C	A	D, P	.8
11- 1-18ad	Paul Staehr	138	G	750	5.00	480	66	160	80	C	N	D, P	.8
21ac	Robert Stuhr	138	P	938	3.80	250	43	120	60	C		D, P	.7
22ad	Melvin Schlechte	113	TF	1,000	2.30	500	92	130	80	C	A, G	P	1.1
34aa	Harold W. Schlechte	121	D	1,100	2.46	500	102	120	70	C		P	1.4
2-15bd	Matilda Maronde	98	P	1,000	2.40	960	180	240	160	C		D	1.1
19da	F. H. Kohtz	70+	P	700		126	16	120	100	C		D, P	.3
19dd	do	75+	P	700		126	16						
20ca	Victor E. Bors	103	G	1,000	4.05	100	18	80	50	C		D	.4
32bc	Hilmer Smith	115	E	520		1,010	121	160	120	C		D	1.0
3- 3ac	George Lunny	55	G	1,050	3.10	550	107	145	105	C		D	1.0
7aa	Russell Williams	57+	G	200	3.60	480	116	80	50	C		D	2.1
32dd	Wesley C. Moore	92	TF	427	3.00	300	33	60	50	C	N	D	.7
4- 4aa	Robert Russell	135	G	1,000	5.40	300	55	120	80	C		P	.7
4bb	W. W. Buckley, Jr.	67+	P	850	2.90	325	51	85	65	C		D	.8
8ad	Lichtenberger Bros.	90	P	1,400	3.00	480	124	200	165	C		D, P	.8
9da	Edgar Thompson	100	P	1,050	3.40	840	162	194	100	C	A	D, P, S	1.6
10ca	do	89	P	1,100		500	102	140	140	C	A	D	1.5
10cc	do	90	P	1,100		500	102						
15ba	Raymond Fenster	66+	P	1,000	3.00	360	66	120	90	C		P	.7
17aa	R. C. Werner	68	G	1,200	4.50	400	88	120	90	C		P	1.0
18ac	Warner Driewer	73	P	900		500	83	65	50	C		D	1.7
19dd	A. J. Goodban	47	TF	750		380	52	80	65	C	A	D	.8
23dc	Donald Wahl	83	E	1,000		350	65	65	65	C		D, P	1.0
24cb	First Trust Co.		G	900	4.20	600	100	120	100	C		D	1.0
26db	Howard Morrison	89	P	1,000		500	92	120	100	C		D	.9
28ac	C. A. Cinninger	87	G	827	4.50	720	110	160	95	C	A, O	D	1.2
30ac	Albert Klone	70+	G	900	3.60	315	52	120	70	C		D	.7
33ad	Raymond Fenster	80	NG	1,050		480	93	160	130	C		D, P	.7
33da	Adolph Friesen	67+	NG	1,000	.54	720	133	150	100	C		D	1.3
34cb	G. H. Holdeman	65+	NG	1,000		500	92	85	80	C	A	D	1.2
35ab	Edgar Thompson	77+	NG	1,000		500	110	110	110	C		D	1.0
12- 1- 1aa	Mark A. Romohr	134	G	850	4.80	650	107	94	70	C	G	D, P	1.5
6da	George Funk	108	TF	900		168	28	85	60	C		P	.5
31da	Mrs. L. J. Treakle	108	P	800	3.70	400	59	100	60	C		P	1.0
2- 7bc	Bruce Dovenbarger	110	P	600		1,200	133	160	80	C	A	S	1.7
13db	Paul Gowdy	87	G	1,200	4.50	300	66	125	60	C		D	1.1
29cb	Walter H. Stuhr	84	E	980		336	61	100	75	C		D	.8
32cc	Floyd McCartney	65+	E	900		216	36	70	45	C		D	.8
3- 3bb	Elmer Richters	74+	P	900	2.50	480	84	160	100	C		P	.8

TABLE 3. *Irrigation data*—Continued

Well	Owner of well or tenant of property	Pumping lift (feet)	Fuel	Average yield (gpm)	Fuel cost per acre-foot	Annual use (hours)	Annual pumpage (acre-feet)	Available irrigable area (acres)	Average area irrigated per year (acres)	Principal crop irrigated	Other crops irrigated	Distribution system	Consumptive use (acre-feet per acre)
York County—Continued													
12- 3-14da	Clyde McCarty	98	G	1,000	$4.90	224	41	160	100	C		D	0.4
18bc	W. W. Harington Estate	53+	G	1,000		100	18	80	60	C			.3
23ab	Sidwell Estate	66+	P	1,000		224	41	160	100	C		P	.4
34ab	Guy Foster	53+	G	1,000	4.30	670	124	140	120	C	A, G	P, S	1.0
4-13ac	W. W. Harrington Estate	127	D	1,000		484	89	705	140	C			.6
13bd	do	83+	D	1,000		700	130		175	C			.7
30bc	Morris Flick	108	G	550		550	56	60	30	C	A	P	1.9
30bd	do	105	P	700		550	71	85	50	C	A	P	1.4
31cb	Earl Wagner	94+	P	1,000	2.40	300	55	100	70	C		D	.8
33bc	John Wochner	98	G	1,000	5.40	600	110	240	160	C	A	P	.7
35bd	Mary C. Welles	79+	TF	1,000	3.40	500	92	180	120	C		P	.8

TABLE 4.—*Record of wells and test holes*

Well: See text for explanation of well-numbering system.
Type of pump: C, centrifugal; Cy, cylinder; N, none; T, turbine.
Type of power or fuel: D, diesel oil; E, electricity; G, gasoline or tractor fuel; H, hand; N, none; NG, natural gas; P, propane or butane; W, wind.
Type of casing: B, brick; C, concrete; S, steel; T, tile.
Aquifer, major and minor: Qal, alluvium; Qc, Crete formation; Qd, David City formation; Qg, Grand Island formation; Qh, Holdrege formation.
Aquifer, type of material: G, gravel; S, sand.

Measuring point, description: Ep, end of discharge pipe; Hb, hole in pump base; Ls, land surface; Tc, top of casing; Tp, top of platform.
Depth to water: Measured depths are given in feet, tenths, and hundredths; reported depths are given in feet.
Use of water: D, domestic or stock; I, irrigation; O, observation; P, public; N, none R, recreation.
Remarks: Ca, sample collected for chemical analysis; F, flowing well; L, log; T, test hole.

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer			Measuring point			Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
								Major	Minor	Type of material	Description	Height above land surface (feet)	Altitude above mean sea level (feet)						
								Adams County											
7- 9- 2ad	W. H. Bohke	1948	204	T		18	S	Qg	Qh	S, G	Hb	1.0	1,909.18	128.10	8-11-48	9	1,200	I	
6ba	C. J. Newkirk	1950	157	T	NG	18	S	Qg		S, G	Hb	.0		87.95	10-16-52			I	
7dd	City of Hastings	1943	190	N	N	18	S	Qg	Qh	S, G				110	10- -44			N	
8bc	do	1944	195	T	E	18	S	Qg	Qh	S, G				110	10- -44		1,000	P	Ca, L
12dc	Eugene Halloran	1947	205	T		24	S	Qg	Qh	S, G	Hb	1.0	1,891.48	112.50	4- 2-48			I	
16ba	Chas. Anderson	1940	182	T		18	S	Qg		S, G	Hb	.0	1,914.09	116.83	7-23-48	10	1,000	I	
16cc	Robert Lautz	1948	180	T		18	S	Qg		S, G	Hb	1.0	1,914.24	115.62	6-25-48	40	1,200	I	
10- 1ab	Neilson Bros.																	I	
1da	City of Hastings		186	T	E	36	C	Qg		S, G				110	6-17-47		2,000	P	
1dc1	do	1929	180	T	E	24	C	Qg		S, G				110	6-17-47		1,000	P	L
1dc2	do	1930	194	T	E	25	C	Qg		S, G				110	6-17-47		2,000	P	
1dc3	do	1929	180	T	E	25	C	Qg		S, G				110	6-17-47		1,000	P	
2da	L. B. Phillips	1947	144	T	E	18	S	Qg		S, G	Hb	.0	1,921.25	92.80	8-12-48		700	R	
2dd	L. E. Fisher	1944	180	T		18	S	Qg		S, G	Hb	.0	1,932.86	109.14	8-13-48			I	
11ab	Chas. Anderson	1946	168	T		18	S	Qg		S, G	Hb	.5	1,938.18	109.70	8-13-48			I	
11ca	City of Hastings		180	T	E	18	S	Qg		S, G				106	6-17-47		1,000	P	
13ab	do		180	T	E	24	C	Qg		S, G				110	6-17-47		1,000	P	
13dd	Geo. Overturf	1944	151	T		18	S	Qg		S, G	Hb	1.0	1,922.98	111.66	8-11-48			I	
14bb	Don Orcutt	1948	186	T	NG	18	C	Qg		S, G	Hb	.5		121.40	10- 7-52		900	I	
8- 9- 5cc	Chas. Hargeroad	1943	185	T		18	S	Qg		S, G	Hb	1.0	1,958.96	93.12	11-13-47	8	800	I	

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
Adams County—Continued																			
8-9-6dc	Jacob Leonhardt, Jr	1950	180	T	P	18	S	Qg		S, G	Hb	0.0		78.99	10-16-52	12	600	I	
7ab	John Schaefer	1951	168	T	P	18	S	Qg		S, G	Hb	.0		86.09	10-16-52	28	1,000	I	
9db	Art. Anderson	1945	184	T		18	S	Qg		S, G	Hb	.0	1,928.69	86.60	8-11-48			I	
10ab1	Chas. Anderson	1942	149	T		18	C	Qg		S, G	Hb	.0	1,914.05				900	I	
10ab2	do	1952	143	T	G	18	S	Qg		S, G	Hb	.5		76.48	4-22-53	48	1,000	I	
11aa	Cleo Harmon	1944	154	T		18	S	Qg		S, G	Hb	1.0	1,910.28	100	8-11-48	25	400	I	
12bb	do	1944	154	T		18	S	Qg		S, G	Hb	.5	1,907.42	95	8-11-48		500	I	
12bd	do	1948	138	T		18	S	Qg	Qh	S, G	Hb	.0	1,891.79	90	8-11-48		300	I	Ca
14aa	Chas. Anderson	1944	152	T		18	S	Qg		S, G	Hb	.5	1,908.97	110.10	11-13-47	50	400	I	Ca
14ab	do	1945	148	T		18	S	Qg		S, G	Hb	.0	1,894.65	100	7- -48		400	I	
14ac1	do	1948	160	N	N	18	S	Qg		S, G	Tc	.2	1,907.91	112.18	7-16-48			N	
14ac2	do	1948	160	T		18	S	Qg		S, G	Hb	1.0	1,904.76	110	7-16-48		400	I	
14ca	Cleo Harmon	1947	156	T		18	S	Qg		S, G		.5	1,909.91	106	8-11-48	32	340	I	
15bc	Homer Berck	1951	143	T	NG	18	S	Qg		S, G	Hb	.0		87.88	10-16-52	31	500	I	
15dc	G. E. Gaymon	1948	150	T		18	S	Qg		S, G	Hb	.5	1,910.67	104.47	8-11-48		750	I	
17cd	Mr. Batterman		149	T				Qg		S, G	Hb	1.0	1,931.08	90.62	8-11-48			I	
20dc	Otto Reinerstacher	1948	146	T		18	S	Qg		S, G	Hb	1.0	1,926.09					I	
25da	Mohlman Bros	1946	160	T		18	S	Qg		S, G	Hb	.0	1,897.99	118.00	7-26-48	8	1,200	I	
31dd	Homer Berck	1941	129	T	NG	12	S	Qg		S, G							550	I	
32dd	Willard Schlachter	1952	149	T	NG	18	S	Qg		S, G	Hb	.0		88.59	10-16-52	16	1,000	I	
10-1bc	Bernard J. Kline	1948	150	T	P	18		Qg		S, G	Hb	.0	1,958.59	75.61	10-17-52		700	I	
1db	Chas. Anderson	1951	184	T	D	18	S	Qg	Qh	S, G	Hb	.0		77.98	10-16-52	14	1,000	I	
2bb	Orville Schafer	1951	178	T	P	18	S	Qg	Qh	S, G	Hb	.0		80.25	10-17-52	16	750	I	
3ca	H. F Janssen	1944	194	T		18	S	Qg	Qh	S, G	Hb	.0	1,988.14	91.00	6-5-48			I	
10bb	Wallace Olp	1947	187	T		18	S	Qg	Qh	S, G	Hb	.5	1,985.03	88.10	6-5-48		1,000	I	
11bb	Thomas Frink	1951	180	T	NG	18	S	Qg	Qh	S, G	Hb	.0		81.33	10-17-52	23	1,000	I	
24cc	Carl I. Starr	1948	170	T	NG	18	S	Qg		S, G	Tc	.5		113.04	10-17-52	8	800	I	
25bb	Harvey Borchers	1944	158	T	NG	18	S	Qg		S, G	Hb	1.4	1,956.33	111.88	11-13-47			I	
26da	Carrol Stolts	1948	159	T	NG	18	S	Qg		S, G	Hb	.0		97.04	10-17-52	17	1,000	I	

Butler County

A13- 2-28bd	Village of Ulysses	1930	72	T	E	10	S			S, G				30	6-18-53	15	175	P	Ca
30bc	George McGowan	1951	128	T	G	18	C			S, G	Hb	0.5		59.39	6-18-53		350	I	L
4-19bb	Village of Dwight	1936	392	T	E	10	S	Qd		S, G				212	7- -52	16	200	P	Ca
A14- 1-10bd	Village of Rising City	1948		T	E					S, G							33	P	Ca
10dd	do.									S, G								P	
3- 8ba	Univ. of Nebr.	1940	30	N	N	1¼	S			S, G	Tc	1.7		18.33	5-16-40			O	
A15- 3-19aa	City of David City	1948	424	T	E	10	S	Qd		S, G				197	8-30-48	12	350	P	
19dd1	do.	1948	383	T	E	10	S	Qd		S, G				181	5-10-48	26	350	P	
19dd2	do.	1952	415	T	E	10	S	Qd		S, G				175	6- -52	29	250	P	

Clay County

7- 5- 2ab	City of Sutton	1954	210	T	E	16	S	Qg		S, G	Ls			80	7-10-53		600	P	
2cc	do.	1946		T	E					S, G								P	
5cb	Clarence Carlson	1942	141	T	G	18	S	Qg		S, G	Hb	0.5		51.98	4-23-53	18	1,000	I	
8dd	Martin Mau	1949	202	T	P	18	C	Qg	Qh	S, G	Hb	1.0		81.47	4-23-53	24	1,000	I	L
15ca	Albert Boom	1953	210	T	P	18	C	Qg	Qh	S, G	Hb	1.0		77.8	7-10-53		1,000	I	
6- 1ab	Edward C. Walther	1947	161	T	P	18	S	Qg	Qc	S, G	Hb	.5		66.88	4-27-53	7	900	I	
3ab	Roland Johnson	1947	164	T	P	18	C	Qg	Qc	S, G	Hb	.5		59.20	4-27-53	4	400	I	
24dd	L. C. Schneller	1948		T	NG	18				S, G	Hb	.0		72.52	4-27-53			I	
7- 2db	George Pauley	1948	164	T	NG	18	S	Qg	Qc	S, G				68	4-30-53		300	I	
3ba		1953		T	N	18	C			S, G	Hb	.5		68.20	7-10-53			I	
3cd	North E. Moger	1948	163	T	NG	18	C	Qg	Qc	S, G	Hb	.0		57.40	4-30-53	23	1,000	I	
3da	Walter Yost	1948		T	NG	18	C			S, G	Hb	.5		69.00	4-30-53			I	
4dc	Walter C. Fitzke			T	NG	12	S			S, G	Hb	2.0		69.00	4-30-53			I	
14ba	Arthur Anderson	1948		T	NG	18	S			S, G	Hb	.0		65.83	4-30-53			I	
15ac	do.	1947		T	NG	18	S			S, G	Hb	.5		66.24	4-30-53			I	
15ca	do.	1948		T	NG	18	S			S, G	Hb	.5		69.90	4-30-53			I	
15da	do.	1953		T	NG	18	S			S, G	Hb	.5		65.37	4-30-53			I	
16bd	Morrison E. Quirk	1948		T	NG	18	S			S, G	Hb	.5		74.80	5- 1-53		1,600	I	
17ac	do.	1948	199	T	NG	18	S	Qg		S, G	Hb	.0		81.90	5- 1-53	10	1,100	I	
23ac	Robert Kinyoun	1953		T	N	18	C			S, G	Hb	.0		68.50	7-10-53			I	
27da	L. S. Yost	1948	189	T	P	18	C	Qg		S, G	Hb	.0		75.03	5- 1-53		1,000	I	
8- 4db	Robert Donahue	1953	200	T	N	18	S	Qh	Qg	S, G	Hb	.5		95.72	4-21-53	16	1,100	I	L
5db	Herman Knudson	1947		T	P	18				S, G	Hb	.5		102.77	4-21-53			I	
10ab	Chas. W. Roback	1948	200	T	G	18	S	Qh	Qg	S, G	Hb	.5		91.03	4-21-53	7½	1,000	I	
10db	George Ablott	1953		T	P					S, G								I	
8- 5- 6cc	E. K. Nuss	1948	130	T	P	18	C	Qc		S, G	Hb	.5		79.36	4-28-53	50	600	I	
18ca	H. V. Nuss	1948	165	T	P	18	C			S, G	Hb	.5		69.35	4-27-53	10	850	I	
33cc	Earl Vauck	1953		T	G	18	S			S, G	Hb	.5		67.09	7-10-53			I	
33dc1	do.	1952	168	T	G	18	S	Qg		S, G	Hb	.5		72.20	4-27-53	16	1,000	I	
33dc2	do.	1953	180								Ls			72	1953				L, T

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
Clay County—Continued																			
8- 5-33dd	Earl Vauck	1953		T	G	18	S			S, G	Hb	0.5		64.79	7-10-53			I	
6- 2bb	Dayton Bouder	1952	149	T	P	18	C	Qc	Qg	S, G	Hb	.5		71.74	4-28-53	15	1,000	I	
2cd	C. J. Helzer	1948	168	T	G	18	C	Qc	Qg	S, G	Hb	.5		70.74	4-28-53	20	1,000	I	L
3ad	Adam Ross	1949	156	T				Qc	Qg	S, G	Hb	1.0		76.10	4-28-53			I	
9ad	Dale Nelson	1952	167	T	G	18	S	Qc	Qg	S, G	Hb	.0		64.55	4-28-53	18	600	I	
10ca	Glen Nelson	1952	167	T	G	18	S	Qc	Qg	S, G	Hb	.0		64.16	4-28-53	18	600	I	
12bb	Paul Helzer	1950	135	T	P	18	C	Qc		S, G	Hb	.5		77.30	4-28-53	55	925	I	L
14bc	Mr. Spielman	1953		T	P	18	S			S, G	Hb	.5		65.41	7-10-53			I	
14cb	Lester Rath	1953		T	P	18				S, G	Hb	2.0		65.50	7-10-53			I	
14db	H. J. Ochsner	1948		T	G	18	S			S, G	Hb	.0		61.25	4-27-53			I	
15cd	Clayton England	1948	170	T	P	18	S	Qg	Qc	S, G	Hb	.5		61.82	4-27-53		1,000	I	
20ba	Earl England	1948	140	T	P	18	S	Qg	Qc	S, G	Hb	.5		63.29	4-28-53			I	
20dc	Roger G. Anderson	1942	140	T	G	18	C	Qg	Qc	S, G	Hb	1.0		70.55	4-28-53	34	650	I	L
24bc	Harold G. Traudt	1953		T	P	18	C			S, G	Hb	.5		67.80	7-10-53			I	
25ca	Marvin L. Schultz	1953		T	N	18				S, G	Hb	.5		73.34	7-10-53			I	
26ca	Lloyd Hultine	1948		T	G	18	C			S, G	Hb	1.0		69.22	4-27-53			I	
27ac	Vic. Englehardt	1948	150	T	P	18	C	Qg	Qc	S, G	Ep	6.5		59.47	4-27-53		1,000	I	
35ba	Albert Hultine	1948		T	G	18	C			S, G	Hb	.5		73.96	4-27-53			I	
36ca	Edward C. Walther	1953		T	P	18				S, G	Hb	.5		75.27	7-10-53			I	
36cb	do	1943	163	T	P	18	C	Qg	Qc	S, G	Hb	.5		72.36	4-27-53	13	900	I	
7-15db	Raymond Keller	1949		T		18	C			S, G	Hb	.5		86.15	4-28-53			I	
16dd	Joseph Frank	1945	158	T	NG	18	S	Qh	Qg	S, G	Hb	.0		80.87	4-20-53			I	
17cd	Daniel H. Schultz	1947	165	T	G	18	S	Qh	Qg	S, G	Hb	.0		83.28	4-20-53		1,000	I	
20cc	Harold Smith	1939	165	T	G	18	S	Qh	Qg	S, G	Hb	.5		78.40	4-21-53	30	800	I	L
20dc	Forrest A. Pense	1939	140	T	D	18	S	Qg	Qc	S, G	Hb	1.0		76.85	4-21-53			I	
22bb	Harry Frank	1945		T	NG	18	S			S, G	Hb	.0		76.10	4-20-53		1,000	I	
28ac	H. V. Brenneman	1948	156	T	P	18	S	Qg	Qh	S, G	Hb	.5		80.88	4-21-53	10	900	I	
29ac	Anderson Bros.	1941	154	T	G	18	S	Qg	Qh	S, G	Hb	.5		76.05	4-21-53	20	800	I	
29bc	William F. Wendt	1948?	160	T	P	18	S	Qg	Qh	S, G	Hb	.5		81.17	4-21-53		800	I	
30ca	Fred Schliep	1946	168	T	G	18	S	Qg	Qh	S, G	Hb	.5		102.70	4-21-53	8	1,000	I	

31da	Harold Smith	1949	161	T	P	18	C	Qg	Qh	S, G	Hb	.5		77.89	4-21-53	17	800	I	
33ac	Ralph Keller	1941	153	T	P	18	S	Qg	Qh	S, G	Hb	.5		80.97	4-30-53	17	850	I	
34ac1	City of Harvard			T	E					S, G								P	Ca
34ac2	do	1924	200	T	E	6				S, G	Ls			67	10-28-54		150	P	
34ac3	do	1942	200	T	E	8				S, G	Ls			67	10-28-54		400	P	
34db	do	1954	200	T	E	8				S, G	Ls			67	10-28-54		400	P	
36db	C. G. Yost	1941	150	T	NG	18	S	Qg	Qc	S, G	Hb	.5		67.50	4-30-53	19	1,000	I	
8- 1ca	Prissler Bros	1950?		T	P	18	C			S, G	Hb	.5		87.35	4-20-53			I	
2bd	Earl Strong			T	NG	18	S			S, G	Hb	.5		87.26	4-20-53			I	
3bd	Blake Mankin	1950	157	T	NG	18	S	Qg		S, G	Hb	.5		96.65	4-20-53	13	1,000	I	
4ad	Ray Ochsner	1947	151	T	NG	18	S	Qg		S, G	Hb	.5		96.50	4-20-53	13½	950	I	
5ad	H. L. Haberman			T	NG	18				S, G	Hb	.5		106.85	4-20-53			I	
5cd	Walter Knicely	1944		T	NG	18	S			S, G	Hb	.0		100.37	4-20-53			I	
7ac	George Murray	1953	158	T	NG	18		Qg		S, G	Hb	.5		96.13	4-22-53		1,000	I	
7bd	Village of Trumbull	1936	125	T	E	8	S	Qc		S, G							200	P	
7ca	Earnest Ormsby	1948	160	T	NG	18		Qg		S, G	Hb	.5		102.92	4-22-53			I	
7db	Roy Andrews	1946	162	T	NG	18	S	Qg		S, G	Hb	.5		101.80	4-22-53		1,000	I	
8db	Lillian Holm	1940?	155	T	NG	18	S	Qg		S, G	Hb	.5		98.97	4-22-53		1,000	I	
16cc	Ellen Wilson	1946	160	T	G	18	S	Qg		S, G	Hb	.5		98.91	4-22-53		1,000	I	
17ab	Ray O'Donnel	1946?	155	T	NG	18	S	Qg		S, G	Hb	.5		104.07	4-22-53		1,000	I	
26cb	Mike Glantz	1949?		T	P	18				S, G	Hb	.5		92.50	4-21-53			I	
30ac	Bernie Carrieker	1944?		T	G	18	S			S, G	Hb	.5		109.07	4-22-53			I	

Fillmore County

7- 4- 5cc	Ervin Schmer	1950	182	T	P	18	C	Qg		S, G	Hb	0.5		78.78	4-16-53	17	1,000	I	
6da	Walter Maser	1947	170	T	G	18	S	Qg		S, G	Hb	.5		83.66	4-16-53	20	1,000	I	
7ab	Ervin Schmer	1952	192	T	P	18	C	Qg		S, G	Hb	.5		82.59	4-16-53		1,000	I	
8dd	Edward Girmus	1950	196	T	NG	18	C	Qg		S, G	Hb	.5		72.16	4-16-53	18	1,046	I	L
17bd	George Stutzman	1953	186	T	P	18	C	Qg		S, G	Hb	.5		76.47	7-10-53			I	
8- 1-20da	Village of Exeter	1914	250	T	E	8	S	Qh		S, G				92	4-15-53		200	P	Ca
20db	do	1934	254	T	E	12	S	Qh		S, G				92	4-15-53		300	P	
2-29db	Frazier & Rasmussen	1949	250	T	G	18	C	Qh	Qc	S, G	Hb	1.0		88.16	4-22-53			I	
30bd1	City of Fairmont	1952	245	T	E	18	S	Qh	Qg	S, G							450	P	Ca
30bd2	do	1930	240	T	E			Qh		S, G							450	P	
31bc	George C. Meier	1950	253	T	NG	18	C	Qh	Qc	S, G	Hb	1.0		88.72	4-22-53	10	1,000	I	
3-17ba	Mr. Nichols			T	G	18				S, G	Hb	.0		57.72	4-16-53			I	
4- 2bc	N. L. Parsons		140	T	G	18	C	Qg		S, G	Hb	.0		18.24	4-13-53			I	
4dc	Mr. Rath	1950		T	G	18	S			S, G	Hb	.5		85.77	4-13-53			I	
5ab	J. G. Kroeker	1951	168	T	G	18	C	Qg		S, G	Hb	.5		86.32	4-13-53	44	850	I	
7ac	John Sietz	1939?		T	G	18	S			S, G	Hb	1.0		94.44	4-13-53			I	
25dd1	Village of Grafton	1932	160	T	E	6	S	Qg		S, G				70	4-16-53		260	P	
25dd2	do	1913	130	Cy	G	4	S	Qg		S, G				70	4-16-53		40	P	

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
										Hall County									
9- 9- 2cb	Ray England	1948	165	T		18	S	Qh	Qg	S, G	Hb	0.5		66.90	4-29-49			I	
3cd	Lee Richmond	1945	170	T	G	18		Qh	Qg	S, G	Hb	.0		77.48	6-12-53		900	I	
4ac	Louis Spiehs	1944		T	G	18	S			S, G	Hb	.5		63.27	6-12-53		1,000	I	
4bb	Dale Young	1951	160	T	NG	18	S	Qh	Qg	S, G	Hb	.5		63.93	6-12-53	19	1,000	I	
4cb	Roy Westfall	1951	164	T	P	18	S	Qh	Qg	S, G	Hb	.0		54.64	6-12-53	15	1,000	I	
5ca1	Village of Doniphan	1918	133	T	E	8	S	Qg		S, G				67	7- 8-53			P	Ca
5ca2	do	1918	133	T	E	8	S	Qg		S, G				67	7- 8-53			P	
8cb	N. L. Lautenschlager	1947	168	T		18	C	Qh	Qg	S, G	Hb	.5		72.63	6- 2-48	12	1,000	I	
9ab	Emert R. Lheweux	1949	178	T	P	18	S	Qh	Qg	S, G	Hb	.0		63.33	6-12-53	16	1,000	I	
9dc	W. Haskins	1948	172	T		18	S	Qh	Qg	S, G	Hb	.0		66.42	4-29-49			I	
10ac	John W. Harris	1944	200	T	G	18	S	Qh	Qg	S, G	Hb	.5		68.50	6-12-53		1,000	I	
11aa	Mr. Schultz	1953		T	NG	18	C			S, G	Hb	.5		67.94	6-11-53			I	
11ab	P. Kreider	1946	170	T	G	18	C	Qh	Qg	S, G	Hb	.5		64.75	6-11-53		1,000	I	
12ba	Ed. Stulken	1942	168	T		18	C	Qh	Qg	S, G	Hb	.0		67.75	6- 2-48		1,000	I	
13dc	Alden Heassler	1939	135	T		18	S	Qg		S, G	Hb	.0		63.72	4-28-49		1,000	I	
17dc	Earnest Lepin	1950		T	G	18	S			S, G	Hb	1.0		72.37	6-12-53		1,000	I	
20ac	Frank Bowden	1952	178	T	G	18	S	Qh	Qg	S, G	Hb	.5		77.45	6-12-53	14	1,000	I	
20cb	M. C. Hollister	1948	168	T	P	18	C	Qh	Qg	S, G	Hb	.5		69.35	6-12-53		1,000	I	
21dc				T	NG					S, G								I	
26ca	C. R. Anderson	1951	165	T	P	18	C	Qg	Qc	S, G	Hb	.5		63.73	7- 9-53	53	820	I	L
27bc	Albert Alber	1942	167	T		18	C	Qg	Qc	S, G	Hb	.5		67.15	6- 5-48	23	1,000	I	
10-12db	T. A. Herr	1953	170	T	G	18	C	Qh	Qg	S, G	Hb	.5		73	7- 9-53			I	
13cb	E. W. Graf	1942		T	G					S, G	Ep	5.0		74.50	6-12-53			I	
23ab	William Thaden	1943	171	T	G	18	C	Qg		S, G	Hb	.0		78.53	6- 2-48	17	1,200	I	
24ca	Earnest Lepin			T	G	18	S			S, G	Hb	.5		72.75	6-12-53			I	
24cb	do	1948	165	T		18	S	Qg		S, G	Hb	.6		74.34	4-29-49			I	
24dc	Arthur Anderson	1944		T	G	18	S			S, G	Hb	.5		72.70	6-12-53	13	1,000	I	
34ba			112	N	N	2	S	Qc			Tc	.5		80.25	4-29-49			N	
10- 9-26bb	James Morton	1953	159	T	P	18	C	Qg		S, G	Hb	.5		47.60	7- 9-53	13	1,000	I	
35ad				T		18	S			S, G	Hb	.0		61.10	4-28-49			I	

9-5-1bb	J. J. Janzen	1948		T	G	18	C			S, G	Hb	0.5		78.54	5-25-53			I	
2ad	Ben Friezen	1948	153	T	G	18	C	Qg	Qc	S, G	Hb	1.0		79.20	5-25-53	20	1,035	I	
2db	Henry P. Buller	1948	150	T	G	18	C	Qg	Qc	S, G	Hb	.5		78.81	5-25-53	17	1,000	I	
3cb	H. A. Buller	1947	164	T	D	18	C	Qg	Qc	S, G	Hb	.5		80.74	5-25-53	35	1,500	I	
4db	do	1953		T	P	18	C			S, G	Hb	1.0		83.43	7-8-53			I	
5aa	Frank Dick	1952	184	T	P	18	C	Qh	Qg	S, G	Hb	.0		93.76	5-25-53	18½	1,000	I	L
6ca	Eldon Epp	1952	195	T	P	18	C	Qh	Qg	S, G	Hb	.5		100.00	5-26-53	22	1,000	I	
9ca	John Thieszen	1948		T	P	18	C			S, G	Hb	.5		82.74	5-26-53			I	
9da	do	1939		T	G	18	C			S, G	Hb	.5		82.85	5-26-53			I	
10ab	Reuben Epp	1948	166	T	G	18	C	Qg		S, G	Hb	1.0		80.68	5-25-53	18	1,050	I	L
14cd	D. K. Ediger	1945		T		18	C			S, G	Hb	.5		82.89	5-26-53			I	
15cc	Reinhold Huebert	1948	175	T	G	18	C	Qg	Qc	S, G	Hb	.5		89.23	5-26-53	16	1,000	I	L
16bc	John Thieszen	1948	200	T	P	18	C	Qg	Qh	S, G	Hb	.5		95.86	6-1-53		1,000	I	
16bd	do	1948		T	G	18	C			S, G	Hb	.0		91.57	5-26-53			I	
16cd	Harlan Nickalaus	1948		T	G	18	C			S, G	Hb	2.0		102	5-26-53			I	
16db	K. F. Wiems	1948		T	G	18	C			S, G	Hb	.0		97.54	5-26-53			I	
17ad	R. D. Epp	1947		T		18	C			S, G	Hb	.5		96.34	5-26-5			I	
18ca	H. H. Huebert			T	G	18				S, G	Hb	.0		84.36	5-26-53			I	
21aa	Harlan Nickalaus	1949		T	E					S, G								R	
21bd	do	1944		T	G	18	C			S, G	Hb	.5		96.70	5-26-53			I	
26cc	Gideon Redler	1953	106	T	P	18	C	Qg	Qc	S, G	Hb	.0		25.46	6-1-53	19	1,000	I	L
27cb	John O. Griess	1953	56	C	G	18	C	Qc		S, G	Tp	1.0		10.40	6-1-53			I	L
27cd	do	1944	80	T	G	18	C	Qc		S, G	Ep	4.0		24.47	6-1-53			I	
27dd	Joe Komarek			T	G					S, G								I	
29dc	George Peters	1943		T	G	18	C			S, G	Hb	.0		27.67	5-26-53			I	
30ba	Forrest M. Stockham			T	G					S, G	Hb	.5		31.48	5-26-53			I	
6-3bb	Mert. Titman	1944		T		18	C			S, G	Hb	.0		89.16	6-1-53			I	
4bc	Sylvia Mills			T	G	18	C			S, G	Hb	.0		79.67	3-28-53			I	
5bc	Henry Goertzen, Jr			T	G	18	C			S, G	Hb	.5		75.47	3-28-53			I	
6da	George Campbell			T	G	18	C			S, G	Hb	.5		73.80	3-28-53			I	
7ab	Melvin Tucker			T	P	18				S, G	Hb	.5		69.25	3-29-53			I	
9ba	Gustav Thieszen			T		18	C			S, G	Hb	.5		81.17	7-8-53			I	
9bd	do			T		18	C			S, G	Hb	.5		76.74	7-8-53			I	
9dc	Andrew Nachtigal	1948	176	T		18	C	Qg	Qh	S, G	Hb	.0		79.91	3-28-53			I	L
10cd	W. J. Epp	1947	184	T	G	18	C	Qh	Qg	S, G	Hb	.5		77.00	6-1-53			I	
11bb	Frank Eaton	1949		T	P					S, G	Hb	.5		76.60	6-1-53			I	
11cb	do	1948		T	P					S, G	Hb	.5		78.41	6-1-53			I	
20ac	Fred Arent	1947?		T	G	18	S			S, G	Hb	.0		70.10	3-28-53			I	
22ca	L. E. Tucker	1948	170	T	P	18	C	Qg		S, G	Hb	.5		72.53	6-1-53		1,000	I	
24bd	Mrs. Aaron Slefert	1948		T	G	18	S			S, G	Tc	.0		82.59	6-1-53			I	

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
Hamilton County—Continued																			
9- 6-34ba	Tom Wild	1949	103	T	G	18	S	Qg	Qc	S, G	Hb	0.0		21.30	10-19-49	12	1,000	I	L
7- 2ab	Sam Campbell	1938?		T	G		S			S, G	Tp	.0		74.05	3-29-53			I	
3cd	O. A. Kostal	1939?	150	T	P		S	Qg	Qc	S, G	Hb	.5		76.90	3-29-53		1,100	I	
4aa	do	1951	155	T	NG	18	C	Qg	Qc	S, G	Ep	3.0		68.59	3-29-53		1,000	I	
6bb	O. C. Hunnicutt	1943	174	T		18	C	Qg	Qc	S, G	Hb	2.0		79.85	6-25-48	15	1,000	I	
6da1	Village of Giltner	1910?		T	E					S, G								P	
6da2	do	1949	260	T	E		S			S, G								P	Ca
9ca	Lloyd Hinrichs	1948	175	T	P	18	S	Qg	Qc	S, G	Hb	.0		80.19	3-29-53	10½	1,000	I	
12cc	Ruth Pitts Estate		180	T	G	18		Qg	Qc	S, G	Hb	.0		72.82	3-29-53		900	I	
21ab	D. J. Wilson	1947	183	T	P	18	C	Qg	Qc	S, G	Hb	.0		72.71	3-29-53	10	800	I	L
21da	do	1944	181	T	P	18	C	Qg	Qc	S, G	Hb	.0		92.74	3-29-53	10	700	I	
27cd	Floyd Bieck	1947	165	T	D	18	C	Qg	Qc	S, G	Tp	.5		96.93	3-29-53		800	I	
34ab	Reinhold Englehart	1946	165	T	G	18	S	Qg	Qc	S, G	Hb	.5		88.25	3-29-53			I	
35cb	Floyd Bieck	1948	180	T	D	18	S	Qg	Qc	S, G	Hb	.0		80.13	3-29-53		1,050	I	
36bb	Joe Mihm	1953	160	T	D	18		Qg	Qc	S, G	Hb	.5		77.46	7-10-53			I	
8- 4ab	Oran R. Bish	1948	186	T	G	18	C	Qh	Qg	S, G	Hb	1.0		80.15	3-30-53	13	1,000	I	L
5bc	Henry Marquette	1943	160	T		18	C	Qg	Qc	S, G	Hb	.5	1,907.42	68.35	6- 2-48		1,000	I	
5dc	Art. Sundermeier	1948	170	T	NG	18	S	Qg	Qh	S, G	Hb	.0		81.64	3-30-53		1,000	I	
8bd	Harold Breitnfeldt	1953	178	T	NG	18	C	Qh	Qg	S, G	Tc	.5		64.34	3-30-53	20	1,000	I	
9cb	E. P. Leinert	1949	170	T	P	18	C	Qh	Qg	S, G	Hb	.5		73.84	3-30-53	25	1,250	I	
9dc	Robert Phillips	1922	67	N	N	5½	S	Qc		S, G	Tc	1.8	1,850.33	56.26	10- 1-34			N	
11bb	Matilda Springer	1948	162	T	NG	18	C	Qg		S, G	Hb	.0		67.70	3-30-53	34	1,000	I	
27da	Elmer Nuss	1947	102	T	G	18	C	Qc		S	Hb	.5		79.85	3-30-53	15	80	I	L
35dd	D. E. and Art. Kline	1950	158	T	NG	18	S	Qg	Qc	S, G	Hb	.5		79.00	4-20-53	12	800	I	
10- 5- 2cc	C. G. Bamesberger	1941	143	T	G	18	C	Qg	Qc	S, G	Tc	.0		32.54	5-21-53		1,000	I	
4cb	Hans and Chris Holm		168	T	NG	18	S	Qg	Qc	S, G	Tp	.0		79.35	5-21-53	26½	1,200	I	
6dd	Adolph Medow	1945	155	T	NG	18	C	Qg	Qc	S, G	Hb	.5		82.65	5-21-53		1,000	I	
7ab	John A. Peters	1947	155	T	NG	18	C	Qg	Qc	S, G	Hb	1.0		72.08	5-21-53		1,000	I	
8bb	C. Klute			T	NG					S, G	Hb	.5		78.33	5-21-53			I	
8cc	J. Troester	1953		T		18	C			S, G	Hb	.5		65.41	5-21-53			I	

10ab	John J. Ediger	1945	95	T	G	18	C	Qg		S, G	Hb	1.0		25.55	5-21-53	10	1,000	I	
10dc	Henry Dick	1947	185	T	G	18	C	Qg	Qh	S, G	Hb	.5		76.02	5-21-53			I	
12ca	Alfred Peters	1949	186	T		18	C	Qg	Qh	S, G	Hb	.5		78.54	5-21-53	18	1,000	I	L
15bd	Isaac Braun	1948	196	T	G	18	C	Qh	Qg	S, G	Hb	1.0		80.23	5-21-53			I	L
16dd	Peter G. Kroeker	1948?		T	G					S, G	Hb	.5		80.46	5-21-53			I	
19ac	Walter Troester	1945	175	T	NG	18	C	Qg		S, G	Hb	.5		77.65	5-22-53		1,000	I	
19da	John Troester	1947		T	NG	18	C			S, G	Hb	.5		72.46	5-22-53			I	
20bc	W. C. Troester	1944		T	NG	18	C			S, G	Hb	1.0		73.69	5-21-53			I	
22db	Jacob B. Goertzen	1945	184	T	G	18	C	Qg	Qh	S, G	Hb	.5		83.16	5-22-53		1,000	I	
23cb	Henry I. Goertzen	1948	194	T	P	18	C	Qg	Qh	S, G	Hb	.5		82.18	5-22-53	22	1,000	I	L
23da	Herman Friesen	1947	165	T	G	18	C	Qg	Qc	S, G	Hb	1.0		84.67	5-22-53		600	I	
23dd	do	1942	162	T	G	18	C	Qg	Qc	S, G	Hb	1.0		77.99	5-22-53	20	1,000	I	
24ac	B. L. Wall	1947	204	T	G	18	C	Qh	Qg	S, G	Hb	1.0		73.03	5-25-53	17	1,000	I	
25ac	D. D. Regier	1949		T		18	C			S, G	Hb	.5		75.20	5-25-53			I	
25dc	Walt. Goosen	1951	185	T	P	18	C	Qg	Qc	S, G	Hb	.5		85.94	5-25-53	12½	1,000	I	L
26bb	John Thieszen	1944		T	P	18	C			S, G	Hb	1.0		80.97	5-22-53			I	
26bd	do	1945		T	P	18	S			S, G	Hb	1.0		78.83	5-22-53			I	
28cc	Wilbur Splinter	1950	196	T	P	18	C	Qg	Qc	S, G	Hb	.5		84.68	5-22-53	35	1,050	I	L
29bd	Sam Troester	1946	180	T	NG	18	S	Qg	Qc	S, G	Hb	.5		85.47	5-21-53			I	
29cb	Isaac Goertzen	1948		T	NG	18	C			S, G	Hb	.5		76.87	5-21-53			I	
29db	do	1941	174	T	NG	18	C	Qg	Qc	S, G	Hb	1.0		84.78	5-22-53		1,000	I	
30ad	Sam Troester	1953	186	T	NG	18	C	Qg	Qc	S, G	Hb	1.0		82.57	5-21-53			I	L
30bc	C. Erlen Busch	1948		T	G	18	C			S, G	Hb	.5		74.58	5-22-53			I	
30cb	W. C. Troester	1948	185	T		18	C	Qg	Qc	S, G	Hb	.0		74.60	5-22-53	11	1,000	I	
31cc	Fred Troester	1948		T	G	18	C			S, G	Hb	1.0		84.55	5-25-53			I	
31dd	Peter J. Siebert	1944	170	T	G	18	C	Qg	Qc	S, G	Hb	.0		83.33	5-25-53		1,000	I	
32cb	Don McNerney	1942	184	T		18	C	Qg	Qc	S, G	Hb	1.0		82.43	5-25-53			I	
33dc	P. K. Goertzen	1944		T		18	C			S, G	Hb	.5		85.65	5-25-53			I	
35db	Daniel Thieszen	1939	148	T	G	18	C	Qg	Qc	S, G	Hb	.0		78.46	5-25-53			I	
36da	W. K. Regier	1950	186	T	P	18	C	Qg	Qc	S, G	Hb	.5		75.71	5-25-53		1,000	I	L
6– 3cd	John Wert	1947	176	T	NG	18	C	Qc	Qg	S, G	Hb	1.0		70.88	7- 8-53		1,000	I	
4ad1	City of Aurora		120	T	NG	18	C			S, G				60	7- 8-53		900	P	
4ad2	do		120	T	E	18	C			S, G				60	7- 8-53		1,000	P	
4cc	M. L. Kremer	1946	160	T		18	C	Qc	Qg	S, G	Hb	.0	1,786.56	73.30	6-22-48		700	I	
5bb	C. A. Kemper	1948	176	T	P	18	C	Qc	Qg	S, G	Hb	.5		80.55	6- 3-53			I	L
8ba	Frank Eaton	1946	182	T	NG			Qc	Qg	S, G	Hb	1.0		73.47	6- 3-53	10	1,040	I	
8db	Claire Cass	1945	180	T	NG	18	C	Qc	Qg	S, G	Hb	.5		72.78	6- 3-53		1,000	I	
9ac	Soren Nelson	1953	96	Cy	G	4	S	Qc		S, G								I	
9bc	M. L. Kremer	1942		T						S, G	Tp	.0		74.78	6- 2-53			I	
9ca	F. E. Edgerton	1948?		T	NG	18	C			S, G	Hb	1.0		70.54	6- 3-53			I	
9db	do	1932?	225	T	NG		C	Qc	Qg	S, G	Hb	3.0		77.95	6- 3-53			I	
10ac	Willis George	1948	160	T	NG	18	C	Qc	Qg	S, G				75	7- 8-53		1,000	I	
10cb	Farms, Inc.			T	NG	18	C			S, G	Hb	.5		74.34	6- 3-48			I	
10da	do	1932		T	NG		C			S, G	Tp	.5		80.79	6- 3-48			I	
11ba	Eugene Strotman	1950	154	T	G	18	C	Qc		S, G	Ep	5.0		78.65	7- 8-53			I	

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
Hamilton County—Continued																			
10- 6-13ac	J. F. Bamesberger			T	NG					S, G	Hb	0.5		92.22	6- 2-53			I	
13db	John Bamesberger	1953		T	NG	18	C			S, G	Hb	.5		91.17	6- 2-53			I	
16ab	Black Bros	1948		T	NG	18	C			S, G								I	
18ac	Homer Smith	1948		T	NG	18	C			S, G	Hb	.5					800	I	
20ab	E. K. Steenberg	1948		T	G	18	C			S, G	Hb	.5		74.86	6- 2-53			I	
23cc	Fern Field	1946		T						S, G	Hb	.5		89.83	6- 2-53			I	
23da	F. E. Edgerton	1948	189	T	P	18	C	Qg		S, G	Hb	1.0		84.64	6- 2-53		1,000	I	
24aa1	E. E. George	1945	201	T	NG	18	C	Qg		S, G	Hb	.5		91.47	6- 2-53		1,000	I	
24aa2	do	1947	194	T	NG	18	C	Qg		S, G	Hb	.5		91.52	6- 2-53		1,000	I	
24db	J. F. Bamesberger	1946	180	T	NG	18	C	Qg		S, G	Hb	1.0		84.80	6- 2-53			I	
25bd	Paul Troester	1952	195	T	G	18	C	Qg	Qc	S, G	Hb	.5		75.13	6- 2-53		1,000	I	
25db	Frank Eaton	1947	190	T	P	18	S	Qg	Qc	S, G	Hb	.5		78.14	6- 2-53		1,100	I	
26ac	W. H. Troester	1953	183	T	P	18	C	Qg	Qc	S, G	Hb	.5		76.13	6- 2-53		1,000	I	
26bb	Ted Regier	1951	187	T	G	18	C	Qg	Qc	S, G	Hb	1.0		91.79	6- 2-53	10	1,100	I	
27ba	Ralph Wright	1948	176	T	P	18	C	Qg	Qc	S, G	Hb	1.0		87.15	6- 2-53		1,000	I	
27db	George Franz	1947		T	G	18	C			S, G	Hb	.5		81.79	6- 2-53			I	
28bb	John Schaffert	1942	126	T	G	18	C	Qg	Qc	S, G	Hb	.0		40.20	6- 2-53	16	600	I	
31ad	Richard McKelvey	1943		T	G	18	C			S, G	Hb	.5		78.20	6- 2-53			I	
32bd	Bruce T. Arnold	1948		T	G	18	C			S, G	Hb	.0		82.12	6- 2-53		1,000	I	
33cb	H. Wakken	1942	164	T	G	18	C	Qg	Qc	S, G	Hb	.0		82.61	6- 2-53	20	1,000	I	
34ac	George Franz	1947	186	T		18	C	Qg	Qc	S, G	Hb	.5		78.15	6- 1-53	9	1,000	I	
34bc	do	1948	186	T	G	18	C	Qg	Qc	S, G	Hb	1.0		81.75	3-29-53	18	1,000	I	L
34dc	Herman Epp	1948	192	T	G	18	C	Qg	Qc	S, G	Hb	.5		82.60	6- 1-53		1,000	I	
35db	John R. Freisen	1948		T	G	18	S			S, G	Hb	.5		77.40	6- 1-53			I	
7- 1bb	Pete Refschlage	1947		T		18	C			S, G	Hb	.5		82.62	6- 9-53			I	
2aa	Earl Oswald	1952	176	T	P	18	C	Qg	Qc	S, G	Hb	.0		82.07	6- 9-53		1,000	I	L
2dc	do	1948	175	T	G	18	C	Qg	Qc	S, G	Hb	1.0		76.56	6- 9-53			I	

3ba	Aaron Oswald	1948	199	T		18	C	Qg	Qc	S, G	Hb	.5	1,857.00	98.15	5-25-48	11	1,080	I	
4ad	Frank Eaton	1947		T	P		S			S, G	Hb	.5		89.33	6-10-53			I	
4da	Archie Roberts	1944?		T	P		C			S, G								I	
5bb	Frank C. Sims	1945?		T						S, G	Hb	1.5	1,865.55	87.33	7- 1-49			I	
5cd	do	1945?		T	G					S, G	Hb	1.0		82.82	6-11-53			I	
9bc	E. R. Springer	1949		T	G					S, G	Hb	2.0		64.39	6-10-53			I	
9cd	do	1952		T	P	18	C			S, G	Hb	.5		64.88	6-10-53			I	
11bb	Harold Oswald	1951	180	T		18	C	Qg	Qc	S, G	Hb	.5		82.50	6- 9-53	13	1,000	I	L
11ca	Ray Vetter	1951	175	T		18	C	Qg	Qc	S, G	Hb	.5		77.22	6- 9-53	15	1,000	I	
12cd	Albert Oswald	1946	170	T		18	C	Qg	Qc	S, G	Hb	1.5	1,820.41	80.95	6-22-48		800	I	
13bc	E. C. Kremer	1946	168	T	P		C	Qc	Qg	S, G	Hb	.5		82.32	6- 9-53			I	
15ab	Albert Oswald	1948		T	N	18	C			S, G	Hb	.0		76.75	6-10-53			I	
15ad	do	1951		T	E					S, G								I	
15dc	do	1942	165	T	E	18	C	Qg	Qc	S, G	Hb	.0		76.30	6-10-53	12	1,000	I	
17ad	Harl Petersen	1944	165	T	E	18	C	Qg	Qc	S, G	Hb	.5		75.30	7- 9-53	11	1,000	I	
21aa	Arthur Gimpel	1942	169	T		18	S	Qg	Qc	S, G	Hb	.0	1,840.01	81.91	7- 1-49	10	1,000	I	
22bc	Gimpel Bros	1943	182	T	G	18	C	Qg	Qc	S, G	Hb	.0		79.45	6-10-53		950	I	
24cb	Frank Vetter	1953	176	T	NG	18	C	Qg	Qc	S, G	Hb	1.0		81.14	7- 8-53	16	1,000	I	
25bb	J. M. Woodward	1953		T	NG	18	C			S, G	Tc	1.0		85.51	6- 9-53			I	
25cc	Carl Huenefeld	1944	170	T	NG	18	C	Qg	Qc	S, G	Hb	.5		84.56	6- 9-53		1,000	I	
26da	Charles Huenefeld	1953	155	T	NG	18	C	Qg	Qc	S, G	Tc	1.0		82.87	6- 9-53			I	
31ba	Harvey Springer	1953	160	T	E	18	C	Qg	Qc	S, G	Hb	.5		68.57	7- 9-53		1,000	I	
33dc	O. A. Kostal	1948	160	T	NG	18	S	Qg	Qc	S, G	Hb	.0		69.75	6- 9-53		1,000	I	
34cc	do	1941	160	T	NG	18	S	Qg	Qc	S, G	Hb	.5		76.16	6- 9-53	12	1,000	I	
35aa	Charles Huenefeld	1946	180	T		18	C	Qg	Qc	S, G	Hb	.5	1,820.78	81.75	6- 9-53			I	
35db	George H. Mersch	1948	187	T	G	18	C	Qg	Qc	S, G	Hb	.5		77.26	6- 9-53	6	1,000	I	
36ba	Wesley Huenefeld	1945?		T	NG	18	C			S, G	Hb	.5		80.43	6- 9-53			I	
36bc	do	1947		T	NG	18	C			S, G	Hb	.5		78.47	6- 9-53			I	
36dc	Walter L. Wilson	1949	183	T	P	18	C	Qg	Qc	S, G	Hb	.5		78.70	6- 9-53		1,000	I	
8- 2dc	P. A. Webber	1942	151	T		18	S	Qg	Qc	S, G	Hb	.0	1,891.78	94.00	5-25-48	16	1,000	I	
8dd	George Falmlen	1948	172	T		18	S	Qh	Qg	S, G	Hb	1.0	1,897.54	77.55	5-24-48	10	1,000	I	
9aa	E. K. Steenberg	1952		T	P	18	C			S, G	Hb	.5		84.79	6-11-53			I	
10ab	Ed. Daniel	1947	180	T	G	18	C	Qh	Qg	S, G	Hb	.5		74.91	6-11-53		1,000	I	
11ab	Harvey E. Otto	1944	182	T	G	18	C	Qh	Qg	S, G	Hb	.5		102.17	6-11-53		850	I	
11ba	P. A. Webber	1947		T	G	18	C			S, G	Hb	.5		106.30	6-11-53			I	
13ba	Albert Schultz	1949	197	T	G	18	S	Qh	Qg	S, G	Hb	.5		99.98	7- 8-53	13	1,000	I	
15ad	A. R. Plith	1951		T	P	18	C			S, G	Hb	.0		69.62	7- 9-53			I	
16bb	D. B. Steenberg	1949		T	NG					S, G	Hb	.0		99.81	6-11-53			I	
16cb	Wm. Sundermeier	1947	172	T	NG	18	S	Qh	Qg	S, G	Hb	.0		78.15	6-10-53		1,000	I	
17da	do	1951	162	T	NG	18	C	Qg	Qh	S, G	Hb	.0		74.11	6-10-53		1,000	I	
17dd	do	1941	152	T	NG	18	S	Qg	Qh	S, G	Hb	.0		76.60	6-10-53	20	1,000	I	
19ab	Earnest Kuehner	1949	160	T	P	18	S	Qg	Qh	S, G	Hb	.0		66.74	6-11-53		600	I	
20ab	Theo. Jessen	1940	150	T	NG	18	S	Qg	Qh	S, G	Hb	.5		73.16	6-11-53		1,000	I	
20bc	Art. Sundermeier	1949	170	T	NG	18	S	Qh	Qg	S, G	Hb	.0		80.50	6-11-53	14	1,000	I	
20cd	Wm. Kuehner	1945	172	T		18	S	Qh	Qg	S, G	Hb	.0	1,906.31	76.86	4-29-49			I	

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
Hamilton County—Continued																			
10- 8-21ad	Grant Falmlen	1953		T		18	S			S, G	Hb	0.5		84.17	6-10-53			I	
21bd	Raymond Falmlen			T	D					S, G	Hb	.5		75.91	6-10-53			I	
21da	Willard Marsh	1946		T	NG	18	S			S, G	Hb	.5		87.49	6-10-53			I	
22ac	Paul Schuster	1949	170	T	NG	18	C	Qg		S, G	Hb	.5		84.23	7- 9-53	15	1,000	I	
24ab	Eldon L. Bish	1948	185	T		18	C	Qg		S, G	Hb	1.0	1,869.03	82.86	6-25-48	7	1,000	I	
26cb	Gerald Hunnicutt	1948	180	T	NG	18	C	Qg		S, G	Hb	.5		81.38	6-10-53		1,000	I	
30cd	Olga Brummond	1944	153	T	G	18	C	Qg		S, G	Hb	.0		65.02	6-11-53			I	
31cb	Hugo Schacht	1949		T	G	18	S			S, G	Hb	.5		63.99	6-11-53		700	I	
33ab	R. H. Kreutz			T						S, G	Hb	.5	1,895.57	86.22	7- 1-49			I	
35ba	Charles Adams	1948		T	NG	18	C			S, G	Hb	.5		88.84	6-10-53			I	
35db	Donald Detmore	1949	174	T	NG	18	C	Qg	Qc	S, G	Hb	.0		88.00	7- 9-53	12	1,000	I	
11- 5- 2dc	Ralph Budnick	1952	196	T	N	18	C	Qg	Qc	S, G	Hb	.5		88.37	5-19-53	17	1,000	I	L
5ba	Anderson & Madsen	1944	158	T		18	C	Qg	Qc	S, G	Hb	.0		84.00	5-26-48			I	
5ca	Fred Weber	1947		T	G	18	C	Qg	Qc	S, G	Hb	.5		86.28	5-18-53			I	
5cb	Harold Henthorne	1942	161	T	G			Qg	Qc	S, G	Hb	.0		85.10	5-18-53			I	L
5da	Joe Fagan	1947	180?	T	G	18	C	Qg	Qc	S, G	Hb	.5		81.34	5-18-53			I	
6ac	George Hansen	1943	159	T	P	18	C	Qg	Qc	S, G	Hb	.0		90.80	5-18-53		1,000	I	
6cc	Philip Olson	1953	182	T	N	18	C	Qg	Qc	S, G	Hb	.5		90.53	5-18-53	25	1,000	I	
7ca	Herman Wall	1946	197	T		18	C	Qg	Qc	S, G	Hb	.5		91.10	5-18-53			I	
8bc	Jensen Bros	1949	226	T	G	18	C	Qg	Qc	S, G	Ep	5.0		104.98	5-18-53	35	1,000	I	L
8db	Mrs. P. C. Williams	1953	204	N	N	18	C	Qg	Qc	S, G	Tc	1.0		86.58	5-18-53			I	
10ca	Art. Miller	1945	150	T	G	18	C	Qc	Qg	S, G	Hb	.5		78.27	5-19-53		1,000	I	
12cb	Ed. Klute	1946?		T	P					S, G	Hb	.5		78.57	5-19-53			I	
12db	R. H. Klute Estate	1946?		T	G					S, G	Hb	1.0		78.16	5-19-53			I	
13ab	Raymond Parpart	1949	186	T	P	18	C	Qg	Qc	S, G	Hb	.5		74.69	5-19-53			I	L
13bb	Henry Rhode	1949	185	T	P	18	C	Qg	Qc	S, G	Hb	.5		72.91	5-19-53	11	1,000	I	
13db	Clarence Heiden	1948	168	T	G	18	C	Qg	Qc	S, G	Hb	.5		70.00	5-19-53		1,000	I	
14ab	Walter Paneitz	1946	169	T	G	18	C	Qg	Qc	S, G	Hb	.5		74.22	5-19-53		1,000	I	
17cb	E. K. Steenberg	1953	186	N	N	18	C	Qg	Qc	S, G	Tc	2.0		89.66	5-18-53	36	1,000	I	L
21ab	John Faber	1950	66	T	G	18	C	Qc		S, G	Hb	.5		26.77	5-19-53	38	720	I	L

21da	Mark Eskelson	1944	128	T	P	18		Qc		S, G	Hb	.5		62.62	5-19-53		1,000	I	
22cb	Walter Griess	1952	125	T	P	18	C	Qc		S, G	Hb	.5		63.82	5-19-53	10	1,000	I	
25ca	C. Henry Meyer	1942	151	T	G	18	C	Qc	Qg	S, G	Hb	.5		74.92	5-19-53	10	1,000	I	
26ac	Bertha Zierotte	1945	160	T	G	18	C	Qc	Qg	S, G	Hb	1.0		74.35	5-19-53	12	1,000	I	L
26co	Herbert Klute	1944	138	T		18	S	Qc		S, G	Hb	.0		82.88	6-23-48	11	1,000	I	
27bc	Erwin Larson	1947		T	NG	18				S, G	Ep	4.0		73.96	5-19-53			I	
27cc	Ardean Peterson	1952		T	NG	18	C			S, G	Hb	.5		77.00	5-19-53			I	
27db	G. W. Klute	1944	163	T	NG	18	C	Qc	Qg	S, G	Hb	1.0		81.34	5-19-53	8½	1,000	I	
27dd	R. F. Klute Estate	1946	173	T	NG	18	C	Qg	Qc	S, G	Hb	.5		81.25	5-19-53	8½	1,000	I	
28ab	Ardean Peterson	1952		T	NG	18	C			S, G	Hb	.5		65.71	5-19-53			I	
28da	do	1945?		T	NG	18				S, G	Hb	.5		84.91	5-19-53			I	
33ad1	Village of Hampton			T	E		S	Qc		S, G				80.00	5-28-53		245	P	Ca
33ad2	do	1931?	120?	T	E		S	Qc		S, G				80.00	5-28-53		245	P	
35dd	Lowell Schroeder	1953	142	T	G	18	C	Qc		S, G	Hb	.5		78.99	5-19-53	10	1,000	I	L
36da	Walter Klute	1940	123	T	G	18	S	Qc		S, G	Hb	.0		72.84	5- 7-53	8	1,000	I	
6- 9ab	Don. Enderle	1952	191	T	G	18	C	Qg	Qc	S, G	Hb	.5		85.10	5-20-53	20	872	I	L
11cb	E. W. Foss	1952	201	T	P	18	C	Qg	Qc	S, G	Hb	.0		81.45	5-20-53	13	1,000	I	
12db	Hickman Estate	1949	193	T	P	18	C	Qg	Qc	S, G	Hb	.5		102.52	5-18-53	35	800	I	
13cb	O. S. Swedberg	1934	193	T		24	S	Qg	Qc	S, G	Ep	2.4		94.21	9-11-52			I	
13db	Richard Bristol	1947	184	T	P	18	S	Qg	Qc	S, G	Hb	.5		85.90	5-20-53		1,000	I	
14ba	Carl Bamesberger	1948		T	G	18	C			S, G	Hb	1.0		81.85	5-20-53			I	
14da	Ralph Murphy	1944	190?	T	G	18	S	Qg	Qc	S, G	Hb	.5		93.82	5-20-53			I	
15cb	C. C. Hansen	1945	188	T		18	C	Qg	Qc	S, G	Hb	.6	1,801.02	84.10	7- 1-49		1,000	I	
17cc	Hans Jensen	1944	187	T		18	C	Qg	Qc	S, G	Hb	.5	1,837.84	98.82	5-26-48	33	1,080	I	
18db	Ackerson Bros	1947	185	T	G	18	C	Qg	Qc	S, G	Hb	.5		101.19	6- 4-53	30	800	I	
24ac	Herluff Hansen	1948	189	T	G	18	C	Qg	Qc	S, G	Hb	.5		73.29	5-20-53	20	1,000	I	L
27bb	Hickman Estate	1948		T	G	18	C			S, G	Hb	.0		78.92	5-20-53			I	
29ca	Albert Springer	1946		T	G	18	C			S, G	Hb	1.0		82.44	6- 3-53			I	
30cb	Don. Biens	1952	186	T	P	18	C	Qg	Qc	S, G	Hb	.5		83.37	6- 4-53	32	1,024	I	L
31ab	Byers Estate	1940		T		18	S			S, G	Tp	.5	1,811.93	72.58	6-24-48		1,200	I	
34cd	Hans Jensen	1950	64	T	E	18	C	Qc		S, G	Hb	1.0		38.25	5-20-53		250	R	
34db	L. L. Aalborg	1940?	134	N	N	60	C	Qc		S, G	Tp	.5		69.96	5-20-53			N	
36aa	Lawrence Keller	1948	118	T	G	18	S	Qc		S, G	Hb	.5		31.69	7- 8-53			I	
7- 2dc	Elton Elge	1940	160	T		60	C	Qg	Qc	S, G	Tp	.0	1,844.90	91.22	5-26-48			I	
9ad	E. E. Goethe	1939	182	T		18	S	Qg	Qc	S, G	Tp	.5	1,858.40	91.60	5-26-48	19	900	I	
14ca	Joe E. Olson	1952	206	T	P	18	C	Qg	Qc	S, G	Hb	.5		98.87	6- 4-53		1,000	I	
19bb	Alvin Purdy	1944	156	T		18	C	Qg	Qc	S, G	Hb	.5	1,878.05	91.85	5-26-48	20	1,000	I	
26ac	Paul Hanson	1950	198	T	P	18	C	Qg	Qc	S, G	Hb	.5		83.57	6- 4-53		1,000	I	
27dc	Sandy L. Cameron	1951	203	T	P	18	C	Qg	Qc	S, G	Hb	.5		92.30	6- 4-53	20	1,000	I	L
28ac	Day Bros	1950	196	T	P	18	C	Qg	Qc	S, G	Hb	.5		76.70	6- 4-53	20	1,000	I	
34ab	Roy Luthy	1948	202	T	G	18	S	Qg	Qc	S, G	Hb	.5		94.82	6- 4-53		1,000	I	
34ba	George Vetter	1948	196	T	G	18	C	Qg	Qc	S, G	Hb	1.5		96.56	6- 4-53	17	1,000	I	
34cc	Clayton Wanek	1949		T	P	18	C			S, G	Hb	.0		97.08	6- 4-53			I	
35ac	Gerald Bremer	1948?	190	T	P	18	C	Qg	Qc	S, G	Hb	.0		78.45	6- 4-53		1,000	I	
8-26ac	Carl Ackerman	1943	185	T		18	C	Qg		S, G	Hb	.0	1,886.85	89.67	4-29-49			I	

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
Hamilton County—Continued																			
11- 8-27ab	Village of Phillips	1947	170	T	E	18	S	Qg		S, G				96	6-11-53			I	Ca
27cc	Alfred Spiehs	1945	171	T		18	S	Qg		S, G	Hb	0.3	1,891.64	81.82	10-24-47			P	
28cd	Robert Scott	1946	163	T	G	18	S	Qg	Qc	S, G	Hb	1.0		77.17	6-11-53			I	L
28dd	Scott Heinzman	1947	168	T	G	18	S	Qg	Qc	S, G	Hb	.0		78.18	6-11-53	19	1,000	I	
33bd	do	1944		T	G	18	S	Qg	Qc	S, G	Hb	.0		74.83	6-11-53			I	
12- 5- 1ca	C. A. Broehl	1952	131	T	D	18		Qc		S, G	Hb	.5		43.23	5-14-53	20	1,035	I	
7dc	Larson Estate	1953		N	N	18	S			S, G	Tc	.5		82.76	5-14-53			I	
9da	Carrol Erickson	1948	142	T		18	S	Qc		S, G	Hb	1.0	1,768.72	77.82	6- 3-49	12	1,200	I	
13cd	Mrs. Arnold Blase	1944	185	T	G	18	S	Qg	Qc	S, G	Hb	.5		73.64	5-15-53			I	
13dc	do	1944	182	T	G	18	S	Qg	Qc	S, G	Hb	.5		74.99	5-15-53			I	
14bc	Art Doze	1953		T		18	C	Qg	Qc	S, G	Hb	.0		80.14	5-15-53			I	
15ca	Melvin Heiden	1952	170	T	P	18	C	Qg	Qc	S, G	Hb	.5		77.62	5-15-53	20	1,000	I	L
21cb	L. C. Beyers	1944	140	T		18	C	Qc		S, G	Hb	2.5	1,761.17	73.45	6-24-48	40	800	I	
23ab	Carl Doze	1940	160	T		22	S	Qg	Qc	S, G	Hb	.0	1,766.39	83.10	5-26-48	30	800	I	
23cd	T. A. Williamson	1953		N	N	18	C			S, G	Tc	2.0		80.15	5-15-53			I	
24bc	Mr. Pabn	1943?		T	G	18				S, G	Hb	1.0		77.84	5-15-53			I	
25ad	Harvey Wochner	1940	206	T	G	18	C	Qh	Qg	S, G	Hb	.5		99.25	5-15-53		1,000	I	L
25bd	Carl Doze	1946	194	T	G	18		Qh	Qg	S, G	Hb	.5		88.76	5-15-53		1,000	I	
26bc	T. A. Williamson	1947		T	G	18				S, G	Hb	.5		86.09	5-15-53			I	
28ca	Kelvin Hansen	1953	169	T	N	18	C	Qg	Qc	S, G	Hb	.5		71.58	5-15-53			I	
28dd	Dan Janzen	1948	172	T	P	18	C	Qg	Qc	S, G	Hb	.5		78.02	5-15-53	5½	1,000	I	
29ac	Albert Hoegh	1948	176	T	P	18	C	Qg	Qc	S, G	Hb	.5		73.74	5-15-53	19	1,015	I	L
29cb	Hans Hoegh	1948		T		18	C			S, G	Hb	.5	1,767.05	73.10	4-27-49			I	
31ad	Johnson Bros	1953	160	N	N	18	S	Qg	Qc	S, G	Tc	1.5		96.88	5-14-53		900	I	
33cb	George W. Hansen	1941	147	T	G	18	S	Qg	Qc	S, G	Hb	.0		75.71	5-18-53	20	1,000	I	
35cb	Paul Budnick	1949	176	T	D	18	C	Qg	Qc	S, G	Hb	.5		82.41	5-18-53		1,000	I	
35cd	Ray Budnick	1948		T	G	18				S, G	Hb	.5		95.39	5-15-53			I	
36cc	Erwin Driewer	1953	206	N	N	18	C	Qg	Qh	S, G	Tc	.0		91.28	5-15-53			I	
6- 2cc	Victor O. Nelson	1947	155	T		18	S	Qg	Qc	S, G	Hb	.5	1,809.54	99.45	5-26-48			I	
16cd	Village of Marquette	1950	145	T	E	18	C	Qg		S, G				95	5-20-53			P	Ca

17bb	Herluff Anderson	1945	150	T		24	C	Qg		S, G	Hb	.0	1,835.79	103.45	2-18-47			I	
33cd	George Vetter	1948	195	T		18	C	Qg		S, G	Hb	.5	1,821.91	98.67	4-29-49			I	
7-24ca	Don Vetter	1948	162	T		18	C			S, G	Hb	1.0	1,856.88	111.60	5-26-48	37	1,200	I	
35dd	Harold Henthorne	1945	184	T		18	C			S, G	Hb	1.0	1,861.77	107.80	4-29-49	37	600	I	
13- 5-14da	A. M. Floodman	1943	250	T		18	S	Qh	Qg	S, G	Hb	.5	1,769.56	88.12	6- 2-49	26	1,100	I	
21da	Village of Hordville	1944	160	T	E	18	C	Qc		S, G				90	5-14-53		500	P	Ca
22bb	John Veburg	1951	216	T	P	18	C	Qh	Qc	S, G	Hb	.0		97.38	5-14-53			I	
23db	Chas. A. Johnson	1940	148	T		18	S	Qc		S, G	Hb	.0		85.10	5-14-53			I	
26cb	Arlo Stevens	1953	150	T	P	18	C	Qc		S, G	Hb	.5		79.50	5-14-53			I	
28ca	Gilbert Driewer	1940	152	T	P	18	S	Qc		S, G	Hb	.5		96.78	5-14-53	8	1,000	I	
28db	Charles Biber	1950	160	T	G	18	C	Qc		S, G	Hb	1.0		97.56	5-14-53			I	
34bc	K. Clayton	1949	146	T				Qc		S, G	Hb	1.0	1,769.05	84.70	6- 2-49	27	1,000	I	L
36ab	Wallace E. Sandell	1943		T	G	18	C			S, G	Hb	.0		70.05	5-14-53			I	
36bc	Henry Schulse	1952	134	T	P	18	C	Qc	Qg	S, G	Hb	.5		67.40	5-14-53		1,000	I	
36dc1	Mrs. Gilbert Benson	1947	240	T	D	18	C	Qh	Qc	S, G	Hb	.0	1,757.58	81.65	5-26-48	14	1,200	I	
36dc2	do	1936	165	T	D	18		Qc	Qg	S, G	Hb	.0		77.53	5-14-53			I	

Polk County

13- 1-10db	Howard White	1949	182	T		18	S	Qg	Qc	S, G	Hb	1.0		92.70	10-18-49		800	I	
20cc	G. H. Bond	1945	180	T	E	18	S	Qg	Qc	S, G	Hb	1.0		81.55	3-10-53	25	750	I	
26cc	Robert Nelson	1949	278	T	D	18	C	Qh	Qg	S, G	Hb	.5		112.65	3- 9-53	26	1,800	I	L
29bb	G. H. Bond	1948	180	T	D	18	S	Qg		S, G	Hb	1.0		80.64	3-10-53	30	800	I	
32bd	Brown Bros.	1948	187	T	P	18	S	Qg		S, G	Hb	1.0		81.90	3- 9-53	5?	800	I	
2- 6dd	Erickson Bros.	1948	203	T	E	18	S	Qg	Qh	S, G	Hb	1.0		71.76	5-28-48		1,400?	I	L
7bc1	City of Stromsburg		156	T	E	8	S	Qg	Qc	S, G				100	3-10-53		150	P	
7bc2	do		156	T	E	8	S	Qg	Qc	S, G				100	3-10-53		150	P	
7bc3	do	1952	212	T	E	18	C	Qg	Qh	S, G				100	3-10-53		500	P	
30dc	Carlson Bros.	1940?	145	T	G	18	S	Qg	Qc	S, G	Hb	1.0		79.53	3-10-53		750	I	
31bc	Scott E. Anderson	1947		T						S, G	Ep	4.0		74.59	3-10-53			I	
3- 4bd	Florence Waller	1946		T	P	18	C			S, G	Hb	.0		64.47	3-12-53			I	
5cb	Arthur I. Larson	1941	111	T		18	S	Qg	Qc	S, G	Hb	.5		65.10	5-28-53	40	700	I	
6cb	Dewey Anderson	1940?	132	T	G	18		Qg	Qc	S, G	Hb	.5		74.10	3-12-53	42	500	I	
6dc	Irvin Anderson			T	G	18				S, G	Hb	.0		69.05	3-12-53			I	
19cd	Helen Scott	1952	220	T	P	18	C	Qg	Qh	S, G	Hb	.5		69.44	3-12-53		1,100	I	
19dc1	Norris M. Anderson	1949	215	T	P	18	C	Qg	Qh	S, G	Hb	.0		71.57	3-12-53	20	1,000	I	
19dc2	do	1949	215																L, T
30aa	Elmer Richters	1948	200	T		18	S	Qg	Qh	S, G	Hb	.5		77.74	5-28-48		700	I	
34cc	W. L. Doremus	1947	180	T	P	22	S	Qg		S, G	Hb	.5		76.70	3-12-53		1,400?	I	
36bd	Carlson Bros.	1940?	135	T	G	18	S	Qg		S, G	Hb	.5		75.99	3-11-53		600	I	
4- 2aa	Elmer Gleim	1950	128	T	P	18	S	Qc		S, G	Hb	.0		78.55	3-13-53		750	I	
10db	Paul L. Stevens	1951	136	T	D	18		Qc		S, G	Hb	.5		77.53	3-13-53		900	I	
12cd	Nettie Carlson	1948	160	T	P	18	C	Qg	Qc	S, G	Hb	1.0		70.33	3-13-53	40	1,000	I	
12dc	Forrest Anderson	1948	163	T	P	18	S	Qg	Qc	S, G	Hb	.5		71.88	3-13-53		1,000	I	

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer			Measuring point			Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
								Major	Minor	Type of material	Description	Height above land surface (feet)	Altitude above mean sea level (feet)						
								Polk County—Continued											
13- 4-16bc	M. G. Lindberg	1944	180	T		18	S	Qg	Qc	S, G	Hb	0.5		97.15	5-28-48		800	I	
20dc	Mrs. Oscar Strand			T						S, G	Hb	.0		76.45	3-13-53			I	
21cc	Village of Polk	1932	145	T	E		S	Qc		S, G				85	9-26-52		200	P	Ca
24ab	Harold Carlson	1947	176	T	G	18	C	Qg	Qc	S, G	Hb	.5		66.61	3-12-53	12	800	I	L
24dd	Cliff Carlson	1947	202	T	G	18	C	Qg	Qc	S, G	Hb	.5		73.94	3-12-53		800	I	
27bb	Jerold Ruzicka	1949	142	T	G	18	S	Qc		S, G	Hb	1.0		70.90	10-18-49			I	
28cd	Virgil Bush	1947		T	D					S, G	Hb	.5		80.00	3-13-53			I	
28dc	Elwood Sandell			T	G					S, G	Hb	.0		83.78	3-13-53			I	
32ad	R. C. Werner	1948	185	T	G	18	C	Qg	Qc	S, G	Hb	.5		73.04	3-13-53	20	1,000	I	
33ac	Wilmer Rodine	1948	190	T	G	18	S	Qg	Qc	S, G	Hb	.0		88.97	3-13-53		1,000	I	
34cc	State of Nebraska	1936	19	N	N	3	S	Qal		S	Tc	2.4		15.02	12-16-36			O	
14- 1- 9da	Village of Shelby	1948	232	T	E	10	S	Qh	Qg	S, G	Hb	2.0		111.50	6-29-49		400	P	
20da	Ed. Watke	1948	300	T	P	18	S	Qh	Qg	S, G	Hb	1.0		127.20	5-26-48	35	1,200	I	L
31bb	R. J. Mangelson	1950	126	T	G	18	S	Qg	Qc	S, G	Hb	.5		22.54	3-10-53	50	850	I	
2- 5bc	Wm. Donnell		108	Cy	W	2	S	Qc			Tp	1.0		86.0	6-30-49			D	
12cc	Albert Anderson	1944	190	T	E	22	S			S, G	Hb	1.0		110.18	5-26-48	25	1,000	I	
16da1	City of Osceola		190	T	E					S, G				90	3-10-53		100	P	Ca
16da2	do		240	T	E			Qh		S, G				90	3-10-53		200	P	
19bb	C. R. Carlson	1880	92	Cy	W	6	T	Qc			Tc	.0		54.30	6-30-49			D	
3-15bc	Ed. Jones		264	Cy	W	4	S	Qh		S, G	Tc	1.0		108.35	6-30-49			D	
26ad	Albert Swanson	1943	126	T	E	18	S	Qg	Qc	S, G	Hb	.5		70	5-27-48	37	320	I	
31da	David Waller		130	T	P	18		Qg	Qc	S, G	Hb	.5		85.17	3-12-53	30	500	I	
4-36cc	Dewey Anderson	1941		T		18	S			S, G	Hb	1.0		81.25	5-26-48			I	

Saline County																			
A8- 2- 9ca	Archie McAlpin	1945	251	T	P	18	S			S, G	Hb	0.5		109.46	4-16-53		800	I	
3-17ca	Dan Miller			T	NG					S, G	Hb	1.0		96.85	4-23-53			I	
25aa	Henry F. Bals		140	Cy	W	2	S				Ls			130	3-29-45			D	Cs
4-17bc	Henry Pomajzl	1949	264	T	NG	18	S			S, G	Hb	1.0		81.68	4-16-53	23	1,000	I	L
27cb1	City of Crete	1912	170	C	E	10	S			S, G				17	3-30-45		300	P	
27cb2	do	1912	170	C	E	10	S			S, G				17	3-30-45		400	P	
34bd	do	1939	182	T	E	10	S				Ls			23	3-30-45	23	370	P	Cs, L
35aa	J. A. Lathrop	1911	246	Cy	E	2	S				Ls			170	3-30-45			D	Cs
Seward County																			
A9- 1- 2db	Village of Beaver Crossing.	1938	130	N	N	6	S	Qh		S, G		10.0		0	4-13-53		100	P	F
2dd	Smiley's Gardens	1937	120	N	N	3	S	Qh		S, G					3-29-45		150	I	Cs, F
2-21ac	Kenneth L. Miller	1948		T	G	18				S, G	Hb	.0		13.31	4-13-53			I	
22cb	H. E. Harvey	1949		T	G	18				S, G	Hb	1.0		11.46	4-13-53			I	
3- 2dc	City of Milford	1906	65	T	E	216	B							40	8- 6-53	20	65	P	
2dd	do	1906	60	T	E	216	B									6	100	P	
11bd1	do	1934	36	T	E	18	S							6	8- 6-53	10	150	P	
11bd2	do		35	T	E	18	S							6	8- 6-53		70	P	
A10- 1- 4ba	Harlan Liggett	1950	134	N	N	18	C	Qc	Qg	S, G	Tp	1.5		83.55	4- 6-53			N	
24ae	Daniel F. Schulz	1948	136	T	G	18	C	Qc	Qg	S, G	Hb	.5		75.12	4-10-53	35	730	I	L
26ac	Art. Pariset	1953	235	N	N	18	C	Qh	Qg	S, G	Tc	1.5		85.12	4-10-53	8	1,024	I	
33db	Norval Hansen			T	G	18	S	Qg		S, G	Tc	1.0			4-10-53			I	F
2- 7cc	Emil H. Thonen	1942	103	T	G	18	S	Qc		S, G	Hb	.5		68.22	4-10-53	20	600	I	
9cc	Ernest Tempel	1948	151	T	P	18	C	Qg	Qc	S, G	Hb	.5		63.13	4-10-53		800	I	
17da	Martin Madison		90	Cy	H			Qg		S, G				65	3-29-45			D	Cs
18bd	Katie Belle Olston	1942	103	T	E	18	C	Qg		S, G	Hb	1.0		74.02	4-10-53	25	500	I	
3-29cc	City of Lincoln	1931	168								Ls		1,503.5	60	1931				L, T
A11- 1- 7ab	John Peters	1953	170	N	N	18	C	Qg		S, G	Tc	1.0		96.55	4-10-53			I	
23cd	Ethel Wolvin	1949	165	T	G	18	C	Qg		S, G	Hb	.5		84.00	4- 6-53	10	1,000	I	
28ab	John P. Hanson	1941	140	T	G	18	S	Qg		S, G	Hb	.0		85.50	4- 6-53	13	700	I	
29bd1	Village of Utica	1910	125	Cy	G	4	S	Qg		S, G								P	
29bd2	do	1910	125	Cy	E	4	S	Qg		S, G								P	
29bd3	do	1925	125?	T	E			Qg		S, G								P	
29bd4	C. B. & Q. R. R.	1908	292								Ls			80	1908				L, T
29db	William Klemz	1930	142	T	G	18	S	Qg		S, G	Hb	.5		76.79	4- 6-53		600	I	
2- 6db	Leo Wolvin	1952	151	T	P	18	C	Qg		S, G	Tc	.5		81.68	4- 6-53	25	600	I	
6dd	do	1952	152	N	N	18	C	Qg		S, G	Tc	.5		83.46	4- 6-53	10	800	N	
23cc	August Rolfsmeier	1940	127	T		18	C	Qg		S, G	Hb	.5		77.93	6-23-48	30	750	I	
25cb	City of Seward	1941	118	T	E	12	S	Qg		S, G				72.50	10-27-41		225	P	

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
Seward County—Continued																			
A11- 2-26ad1	City of Seward	1918	115	T	E	10	S	Qg		S, G				71	4- 2-45	39	200	N	Ca
26ad2	do	1918	115	T	E	10	S	Qg		S, G				70	4- 2-45			P	
26ad3	do	1918	115	T	E	10	S	Qg		S, G							150	P	
26ad4	do	1946	120	T	E	12	S	Qg		S, G				70	6-18-53			P	
26ad5	do	1953	120	T	E	12	S	Qg		S, G				70	6-18-53			P	
3-22aa	Kilpatrick Estate		37	Cy	H	12	T			S, G		1.0		28.49	12-20-36			N	
York County																			
9- 1- 6ca	F. C. Nielson	1947	122	T	G	18		Qg		S, G	Hb	0.5		44.68	3-20-53			I	L
7ad	Mrs. Albert Baller	1949	81	T	G	18	S	Qg	Qc	S, G	Hb	.0		18.85	3-20-53		1,000	I	
8ab	J. C. Peterson	1940	75	T	E	18	S	Qg	Qc	S, G	Hb	.5		31.30	3-20-53		850	I	
9ad	W. W. Harrington Estate		82	T		18		Qg	Qc	S, G	Hb	.0		19.46	3-20-53			I	
10bc	Pearl Dyer	1936	60	T	E	18	S	Qg	Qc	S, G	Ep	4.0		17.01	3-20-53		500	I	
2-15bc	Cliff Miller Estate	1934	42	C	G	24	S	Qc		S, G	Tp	.6		26.69	10-6-34			I	
3-20da	H. J. Bredenkamp	1941	160	T	G		S	Qg		S, G	Hb	1.0		81.50	3-26-53	20	800	I	
21ba	Wade E. Moore	1949	201	T	P	18	C	Qg		S, G	Hb	1.0		88.99	3-26-53	17	1,100	I	
24aa	John Heins	1945	62	T	G	18	S	Qg		S, G	Hb	.5		20.90	3-24-53		600	I	
24dd	Charles Phillips			T	G			Qg		S, G	Hb	.0		15.25	3-24-53			I	
25ca	Curtis S. Reed	1946	58	T	G	18	S	Qg		S, G	Hb	.0		17.54	3-24-53	23½	500	I	
30cd	J. E. Towle	1948	206	T	P	18	C	Qh	Qg	S, G	Hb	1.0		95.12	3-24-53		1,600	I	L
31ba	Wm. Kleinholz	1948	233	T	G	18	C	Qh	Qg	S, G	Hb	1.0		89.56	3-24-53	13	1,050	I	L
33ba	Leroy Jackson	1941?		T	G					S, G	Hb	.0		68.94	3-28-53		1,000	I	
36da	J. A. McGowan	1950		T	E			Qg		S, G	Hb	.5		36.83	3-24-53	14	1,000	I	
36dc	Gene Henning	1944		T	G	18	S	Qg		S, G	Hb	.0		40.04	3-24-53		1,000	I	
4- 6ad1	Village of Henderson	1940	100?	T	G	8	S	Qc		S, G				80	3-31-53			P	
6ad2	do	1948	170	T	E	18	C	Qg	Qc	S, G				80	3-31-53			P	Ca
6dc	H. H. Huebert	1953		N	N	13	C			S, G	Tc	1.5		78.70	6- 1-53			I	
9bd	Henry C. Otte	1946	173	T	G	18	C	Qg	Qc	S, G	Hb	1.0		87.35	3-27-53	13	1,000	I	

10ca	John J. Thieszen	1947	183	T	D	18	C	Qg	Qc	S, G	Hb	.5		80.12	3-27-53	11	1,100	I	
12ab	Raymond Ronne	1948	173	T	G	18	C	Qg	Qc	S, G	Hb	2.0		74.46	3-26-53			I	
13bc	J. T. Rempel	1948	195	T		18		Qh?	Qg	S, G	Hb	.5		73.27	3-26-53	16	1,140	I	
17db	Geo. Kroeker	1947		T		18				S, G	Ep	5.0		77.45	3-28-53			I	
18cb	Clarence E. Peters	1946	162	T	G	18	C	Qg	Qc	S, G	Ep	5.0		82.02	3-27-53	15	750	I	
23dd	Aaron P. Siebert	1948	181	T	G	18	C	Qg	Qc	S, G	Hb	.5		71.58	3-26-53	17	800	I	
26bc	C. C. Siebert	1947		T	P	18				S, G	Hb	.5		84.82	3-26-53			I	
29dd	Oscar J. Griess	1948	104	T	G	18	C	Qc		S, G	Hb	.5		33.14	3-27-53	12	1,000	I	
30ac	George Hiebner	1948	105	T	G	18	C	Qc		S, G	Hb	.5		40.34	3-27-53	12	950	I	
32cb	August Griess	1948	160	T	P	18	S	Qg	Qc	S, G	Ep	4.0		89.31	3-27-53		900	I	
33cb	Sidney F. Smith	1946	200	T	G	18	S	Qh?	Qg	S, G	Hb	1.0		92.48	3-26-53		1,000	I	L
35cb	Edmund Ulmer	1953		N	N	18	C			S, G	Tc	.5		29.30	4-23-53			I	
36cb	C. P. Buller	1946	72	T	G	18	S	Qc		S, G	Hb	.0		15.95	3-26-53	18	800	I	
10- 1-18da	Ruth Tucker	1948	162	T	G	18		Qg		S, G	Hb	1.0		99.89	3-19-53		850	I	L
27cc	Harry C. Berger	1947	137	T		18		Qg		S, G	Hb	.0		50.26	3-20-53	16	1,040	I	L
2- 4bc	Leslie Foster	1949	239	T	P	18	C	Qh	Qg	S, G	Hb	.5		78.21	3-19-53		800	I	
5bc	A. L. Speece	1944	98	T	E	12	S	Qg		S, G	Hb	.5		72.14	3-19-53		120	I	
6ab1	City of York	1940	137	T	E	12	S	Qg		S, G							500	P	Ca
6ab2	do	1946	137	T	E			Qg		S, G							500	P	
6cc1	do		80	Cy	E	8	S	Qg		S, G				25	9-26-52		60	P	
6cc2	do		80	Cy	E	8	S	Qg		S, G				25	9-26-52		60	P	
6cc3	do	1925	80	T	E	24	C	Qg		S, G				25			200	P	
6cc4	do	1934	80	T	E	12	S	Qg		S, G				25			400	P	
13ad	A. J. Bredenkamp	1941	160	T	G	18	S	Qg		S, G	Hb	.5		99.36	3-19-53	20	700	I	
18ac	Ross A. Fate			T	G	18	S			S, G	Tp	1.0		75.29	3-19-53		1,000	I	
28bc	B. W. Jaeger	1952	145	T	G	18	C	Qg		S, G	Hb	2.5		78.61	3-20-53	11	1,000	I	
30cc	George Lunney	1948	163	T	G	18	C	Qg		S, G	Hb	.5		90.96	3-23-53	18	800	I	L
30dd	F. R. Scott	1946	160	T	P	18	S	Qg		S, G	Hb	1.0		85.30	3-23-53	11	800	I	
32ca	do	1934		T	D	18	S			S, G	Hb	.0		86.90	3-23-53		1,000	I	
34ab	Cliff Miller Estate			T	D					S, G								I	
3- 1ac	Mason's Nursery	1930	45	C				Qc						20	7- 1-53			I	
3ba	E. H. Gerken	1948	114	T	P	18	S	Qg	Qc	S, G	Hb	.5		60.36	3-23-53		850	I	
3db	Sutton Hise	1950	124	T	NG	18	C	Qg	Qc	S, G	Hb	.5		64.57	3-23-53	33	1,050	I	
5ab	R. J. Kreifels	1950	115	T	NG	18	C	Qg	Qc	S, G	Hb	.5		56.46	5- 4-53	37	850	I	
12aa	Dean Sack	1948		T	NG	18		Qg	Qc	S, G	Hb	.5		32.29	7- 1-53		350	I	
14ac	Carl F. Grotz			T						S, G	Hb	1.0		77.61	3-23-53			I	
14cd	Alfred Grotz		148	T		18	S	Qg	Qc	S, G	Hb	.0		83.70	3-23-53	13	950	I	
18cc	J. E. Towle	1948	133	T	P	18	C	Qg	Qc	S, G	Hb	.5		79.92	3-23-53	50	650	I	
25ab	George Barrett	1953	150?	T	N	18	S	Qg	Qc	S, G	Hb	.5		82.47	7- 1-53			I	
25cc	Mrs. Edwards			T	P	18	S			S, G	Hb	.0		81.37	3-23-53			I	
26b	T. D. McCarthy		310								Ls			86					L, T
29ac	L. D. Ellis	1952	164	T	G	18	C	Qg	Qc	S, G	Hb	.0		84.94	5- 6-53	25	1,000	I	L
35cb	F. A. Saddoris			T	G					S, G	Hb	.0		75.58	3-23-53			I	
4- 4ac	D. D. Ediger	1944	137	T	G	18	C	Qg	Qc	S, G	Hb	.5		61.50	5- 7-53		700	I	
5cd	Thomas Hiebner	1948	120	T	G	18	C	Qg	Qc	S, G	Hb	.5		76.20	5- 6-53			I	

TABLE 4—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
York County—Continued																			
10- 4- 6cc	Henry I. Goertzen			T	G					S, G	Hb	0.0		24.65	3-31-53			I	
16bb	R. A. Franz	1948		T	G	18	C			S, G	Hb	1.0		72.34	5- 6-53			I	
16dd	Jacob C. Goertzen	1947	183	T	G	18	C	Qg	Qc	S, G	Hb	.0		68.36	5- 6-53	15	1,000	I	
19cb	Abraham Thieszen	1940		T	P	18	C			S, G	Hb	.5		70.52	5-25-53			I	
20ad	A. E. Thieszen	1950	176	T	P	18	C	Qg	Qc	S, G	Hb	.5		71.76	5- 6-53	16	1,000	I	
20cd	John R. Doell	1943	178	T	G	18	C	Qg	Qc	S, G	Hb	.5		80.93	5- 6-53	20	1,000	I	
20dc	J. J. Kroeker Estate	1948	210	T	G	18	C	Qg	Qh	S, G	Ep	4.0		80.98	3-31-53		1,450	I	
21ad	Harry C. Goertzen	1953	166	T	P	18	C	Qg	Qc	S, G	Hb	1.0		73.90	5- 6-53	20	1,100	I	
23dc	H. I. Friesen	1952	153	T	P	18	C	Qg	Qc	S, G	Hb	1.0		72.53	5- 6-53			I	
24aa	Leonard G. Faustman	1948	140	T	P	18	C	Qg	Qc	S, G	Hb	.5		85.79	3-23-53	50	900	I	
29aa	Gustav Thieszen			T	P	18	C			S, G	Tc	.5		74.10	5- 6-53			I	
29bb	John R. Doell	1949	179	T	P	18	C	Qg	Qc	S, G	Hb	.5		81.55	5—6-53	16	900	I	
29db	Johann Thieszen			T	G					S, G	Hb	.5		75.90	5- 6-53		1,000	I	
32ab	Herman Regier	1949		T	P	18	C			S, G	Hb	.5		75.19	5- 6-53			I	
32cc	H. H. Huebert	1953		T	N	18	C			S, G	Hb	.5		77.49	5-25-53			I	
11- 1-18ad	Paul Staehr	1947	140	T	G	18	S	Qg	Qc	S, G	Hb	.5		97.94	3-19-53	40	750	I	
19cd	G. H. Liggett	1949		T	P					S, G	Hb	1.0		111.05	3-17-53	21	1,070	I	
21ac	Robert Stuhr	1947	161	T	P	18	S	Qg		S, G	Hb	.5		101.17	3-17-53	38	938	I	
22ad	Melvin Schlechte	1948	290	T	G	18	C	Qh	Qg	S, G	Hb	.5		104.86	3-17-53	8	1,000	I	
26ac	Victor Rogers	1952	195	T	P	18	C	Qg		S, G	Hb	.5		103.33	3-20-53			I	
29bc	Village of Waco	1923	138	T	E	8	S	Qg		S, G				90	3-19-53	40	60	P	
34aa	Harold W. Schlechte	1947	287	T	D	18	S	Qh	Qg	S, G	Hb	.5		110.93	3-17-53	10	1,100	I	
35bb	Wilbur Schlechte	1947	283	T		18	C	Qh	Qg	S, G	Hb	1.5		106.85	6-22-48	9	1,000	I	
2-15bd	Matilda Maronde	1944	145	T	P	18	S	Qg		S, G	Hb	.5		78.39	3-16-53	20	1,000	I	
18dd	H. Tietmeyer, Jr.	1949	66	T	P	18	C	Qc		S, G	Hb	.5		24.24	3-19-53		650	I	L
19da	F. H. Kohtz	1944		T	P	18	S			S, G	Tc	.0		69.48	3-17-53		700	I	
19dd	do	1943		T	P	18	S			S, G	Hb	.0		74.89	3-17-53		700	I	
20ca	Victor E. Bors	1949	246	T	G	18	C	Qh	Qg	S, G	Hb	.5		74.90	3-17-53	28	1,000	I	
23da	Samuel Beaver	1952	241	T	G	18	C	Qh	Qg	S, G	Hb	.0		85.00	3-17-53	69	890	I	
26cc	Arthur Maronde	1944		T	P	18	S			S, G	Hb	.5		88.84	3-17-53			I	

30ba	Dean Sack	1948	318	T	P	18		Qh	Qg	S, G	Hb	.0		70.65	3-17-53			I	
32bc	Hilmer Smith	1936	128	T	E	24	S	Qg	Qc	S, G	Hb	.5		79.34	3-19-53	35½	520	I	
3- 3ac	George Lunney	1948	146	T	G	18	C	Qg	Qc	S, G	Hb	.5		48.98	5-12-53	18	1,050	I	L
6bc	Russell Williams	1940		T	P	18	S			S, G	Hb	1.0		71.72	5-12-53			I	
6cb	do	1942?		T	G					S, G	Hb	.0		68.55	5-12-53			I	
7aa	do	1944	170	T	G	18	S	Qg	Qc	S, G	Hb	.5		57.03	5-12-53		1,200	I	
12c	John Dougherty		207																L, T
19db	Glen Myers	1946		T	G	18	S			S, G	Hb	.5		79.58	5- 5-53			I	
22bc	Guy Barr, Jr	1948	107	T	G	18	C	Qg	Qc	S, G	Hb	.5		69.20	5- 5-53		500	I	
22cb1	Walt. Haack		108																L, T
22cb2	do	1947	98	T	P	18		Qg	Qc	S, G	Hb	.5		68.58	5- 5-53		650	I	L
32dd	Wesley C. Moore	1948	113	T	G	18	S	Qg	Qc	S, G	Hb	.5		61.54	5- 7-53	30	427	I	
36ab	Mother Jewels Home	1932		T	E	12				S, G	Hb	.0		68.00	6-23-48			I	
36cb	do	1933		T	G					S, G	Hb	.5		54.23	5- 7-53			I	
4- 2db	Roscoe Hitchcock	1945		T	G	18				S, G	Hb	1.0		71.56	5-12-53			I	
4aa	Robert Russell	1948	195	T	G	18	S	Qg	Qc	S, G	Hb	.5		79.90	5-11-53	55	1,000	I	L
4bb	W. W. Buckley, Jr	1951	203	T	P	18	C	Qg	Qh	S, G	Hb	1.0		66.39	5-11-53		850	I	
5da	Henry Stuhr	1947	183	T	G	18	C	Qg	Qc	S, G	Hb	.0		79.15	5-11-53	21	1,000	I	
8ad	Lichtenberger Bros	1943	153	T	P	18	C	Qg	Qc	S, G	Hb	.0		72.43	5-11-53	18	1,400	I	L
9da	Edgar Thompson	1944	164	T	P	18	C	Qg	Qc	S, G	Hb	1.5		79.58	5- 4-53	20	1,050	I	
10aa	L. S. Christianson	1944		T	G	18	S			S, G	Hb	.5		69.24	5-12-53			I	
10ca	Edgar Thompson	1949	157	T	P	18	C	Qg	Qc	S, G	Tc	.5		71.14	5- 4-53	18	1,100	I	
10cc	do	1951	157	T	P	18	S	Qg	Qc	S, G	Tp	.0		71.87	5- 4-53	18	1,100	I	
13cb	Elvin Nichols	1948	97	T	G	18	C	Qg	Qc	S, G	Hb	.5		17.23	5- 5-53	30	1,000	I	
15ba	Raymond Fenster	1952	151	T	P	18	C	Qg	Qc	S, G	Hb	.5		66.19	5- 4-53		1,000	I	
17aa	R. C. Werner	1946	145	T	G	18	C	Qg	Qc	S, G	Hb	.5		60.25	5- 5-53	8	1,200	I	
18ac	Warner Driewer	1948	176	T	P	18	C	Qg	Qc	S, G	Hb	1.0		62.62	5-11-53	10	900	I	
18cb	Clarence Driewer	1952	175	T	P	18	C	Qg	Qc	S, G	Hb	.5		62.00	5- 7-53		1,000	I	
19ab	Alton E. Driewer	1953	93	T	P	18	C	Qg	Qc	S, G	Hb	.5		26.45	5- 7-53		900	I	
19dd	A. J. Goodban	1942	91	T	G	18	C	Qg	Qc	S, G	Hb	.5		39.38	5- 7-53	8	750	I	
22ad	Henry Meyer	1941		T	G	18	S			S, G	Hb	.5		20.46	5- 5-53			I	
23dc	Donald Wahl	1948	114	T	E	18	C	Qc		S, G	Hb	1.5		71.65	5- 5-53	12	1,000	I	
24cb	First Trust Co	1946	112	T	G	18	C	Qc		S, G	Hb	.0		75.99	5- 5-53		900	I	
24db	Agnes Scamehorn	1946		T	G	18	S			S, G	Hb	1.0		75.30	5- 5-53			I	
24dd	Alice M. Otto	1947		T	G	18				S, G	Hb	.5		73.10	5- 5-53			I	
25ba	do			T	G	18				S, G	Hb	.5		70.39	5- 5-53			I	
25bc	Bryce Tracy	1944	114	T	E	18	C	Qc		S, G	Hb	2.0		68.22	6-24-48	12	800	I	
26db	Howard Morrison	1947	130	T	P	18	C	Qg	Qc	S, G	Hb	.5		77.31	5- 5-53	23	1,000	I	
28ac	C. A. Cinninger	1941	131	T	G	18	C	Qg	Qc	S, G	Hb	.5		75.99	5- 4-53	11	827	I	
29ad	Roy Foster	1945?		T	G	18				S, G	Hb	.5		68.50	5- 5-53			I	
30ac	Albert Klone	1946	140	T	G	18	C	Qg	Qc	S, G	Hb	.5		70.13	5-11-53		900	I	
30dc	Herman Fenster	1945		T	G	18	S			S, G	Hb	.5		70.14	5-11-53			I	
31ba	do	1943	140	T		18	C	Qg	Qc	S, G	Hb	.0		72.40	6-23-48	7	1,000	I	
31cd	Gus. Pohl	1946	150?	T	P	18	C?	Qg	Qc	S, G	Hb	.5		71.11	5- 7-53			I	
33ad	Raymond Fenster	1941	142	T	NG	18	C	Qg	Qc	S, G	Hb	.5		71.44	5- 4-53	9	1,050	I	

TABLE 4.—*Record of wells and test holes*—Continued

Well	Owner of well or tenant of property	Year drilled	Depth of well (feet)	Type of pump	Type of power or fuel	Diameter of casing (inches)	Type of casing	Aquifer: Major	Aquifer: Minor	Aquifer: Type of material	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date measured	Drawdown (feet)	Yield (gpm)	Use of water	Remarks
York County—Continued																			
11- 4-33bb	Dale Leuthje	1948	139	T		18	C	Qg	Qc	S, G	Hb	2.0		70.85	6-24-48	17	1,000	I	
33da	Adolph Friesen	1946	156	T	NG	18	C	Qg	Qc	S, G	Hb	.5		68.94	5- 7-53		1,000	I	
34cb	G. H. Holdeman	1947	215	T	NG	18	C	Qg	Qc	S, G	Hb	.5		64.77	5- 7-53		1,000	I	L
35ab	Edgar Thompsen	1947	142	T	NG	18	S	Qg	Qc	S, G	Hb	.5		76.77	5- 4-53		1,000	I	L
35bb1	Village of Bradshaw	1907	117	Cy	E		S	Qg		S, G								P	
35bb2	do	1907	117	T	E		S	Qg		S, G								P	
35cb	Guy V. Watt	1952	134	T	NG	18	C	Qg	Qc	S, G	Hb	.5		64.31	5- 4-53	19	1,064	I	L
36bd	R. J. Kreifels	1947	120	T	NG	18	C	Qg	Qc	S, G	Hb	.5		67.40	5- 4-53		1,250	I	L
36cc	do	1945?	128	T	NG	18		Qg	Qc	S, G	Hb	.5		70.00	5- 4-53			I	
12- 1- 1aa	Mark A. Romohr	1948	282	T	G	18	C	Qh	Qg	S, G	Hb	1.0		113.74	3- 9-53	20	850	I	L
6da	George Funk	1942	180	T	G	18	C	Qg		S	Hb	.0		81.98	3-10-53	26	900	I	
11bc1	Village of Gresham	1930?	126	T	E	6	S	Qg		S, G				115	3- 9-53		300	P	
11bc2	do	1946	156	T	E	8	S	Qg		S, G				115	3- 9-53		600	P	Ca
31da	Mrs. L. J. Treakle	1949	180	T	P	18	C	Qg		S, G	Hb	.5		87.97	3-19-53	20	800	I	L
2- 7bc	Bruce Dovenbarger	1939	163	T	P	18	S	Qg		S, G	Hb	.0		90.58	3-16-53	20	600	I	
13db	Paul Gowdy	1941	150	T	G	18	S	Qg		S, G	Hb	1.0		66.60	3-10-53	20	1,200	I	
29cb	Walter H. Stuhr	1943	170	T	E	18	S	Qg		S, G	Hb	.5		63.64	3-16-53	20	980	I	L
32cc	Floyd McCartney	1945	130	T	E	18	S	Qg		S, G	Hb	.5		64.95	3-16-53		900	I	
3- 1cb	Lowell Calhoon	1950		T	E	8	S			S, G	Hb	.5		64.28	5-12-53			I	
3bb	Elmer Richters	1947	205	T	P	18	S			S, G	Hb	.0		73.88	3-12-53	32	900	I	L
13dc	Village of Benedict			T	E					S, G								P	Ca
14cb	Arthur Dahlke	1947	144	T	G	18	C	Qg	Qc	S, G	Hb	.5		69.26	5-12-53		1,000	I	
14da	Clyde McCarty	1948	169	T	G	18	C	Qg	Qc	S, G	Hb	1.0		78.47	5-12-53	20	1,000	I	L
18bc	W. W. Harrington Estate	1950	140	T	G	18	S	Qg	Qc	S, G	Hb	.0		53.16	5-13-53		1,000	I	
23ab	Sidwell Estate	1950	150?	T	P	18	S	Qg	Qc	S, G	Hb	.5		65.93	5-12-53		1,000	I	
24aa	Peter Meehan	1950	182	T	P			Qg	Qc	S, G	Hb	1.0		69.78	5-12-53	28	1,000	I	L
34ab	Guy Foster	1950	151	T	G	18	C	Qg	Qc	S, G	Hb	.5		53.32	5-12-53	20	1,000	I	
4- 1bc	William Chapman	1953	196	T	P	18	C	Qg	Qh	S, G	Tc	.5		68.92	3-13-53		600	I	
4cd	William D. Cline	1941		T	G	18	S			S, G	Hb	.0		29.65	5-13-53			I	
10cb	Fred Bedient	1952		T	P	18	C			S, G	Hb	.5		73.66	5-13-53			I	

13ac	W. W. Harrington Estate	1941	186	T	D	18	S	Qg		S, G	Hb	.5		83.25	5-13-53	39	1,000	I	
13bd	do	1948	186	T	D	18	S	Qg		S, G	Hb	.5		82.51	5-13-53		1,000	I	
18ac	Merchant Bros	1944	168	T	P	18	S	Qg	Qc	S, G	Hb	.5		70.00	5-13-53			I	
21cd	T. D. Otte			T	P	18				S, G	Hb	.5		81.59	5-13-53			I	
22bc	Albert Shockey			T	G	18				S, G	Hb	.5		87.63	5-13-53			I	
25ca	Werner Roehrs	1940		T	P	18	S			S, G	Hb	.5		75.70	5-13-53			I	
27ba	George Otte	1944		T	P	18				S, G	Hb	1.0		88.17	5-13-53			I	
30bc	Morris Flick	1947	205	T	G	18	C	Qg	Qc	S, G	Hb	.5		98.93	5-11-53	9	550	I	
30bd	do	1943	198	T	P	18	S	Qg	Qc	S, G	Hb	.5		91.73	5-11-53	13	700	I	
31cb	Earl Wagner	1947	192	T	P	18	C	Qg	Qc	S, G	Hb	.5		94.02	5-11-53		1,000	I	
32ca	E. A. Levitt	1947	208	T	G	18	S	Qg	Qc	S, G	Hb	.0		97.36	5-11-53			I	L
32cd	J. E. Wagner	1947?	204	T	G	18	C	Qg	Qc	S, G	Hb	1.0		97.12	5-11-53		1,200	I	
33bc	John Wochner	1943	187	T	G	18	C	Qg	Qc	S, G	Hb	.0		79.50	5-11-53		1,000	I	
33cb	John Wessel	1944	180	T	G	18		Qg	Qc	S, G	Hb	.5		84.48	5-11-53			I	
33dd	H. C. Kaiser	1951		T	P	18	C			S, G	Hb	.0		77.58	5-11-53			I	
35bd	Mary C. Welles	1943	180	T	G	18	S	Qg	Qc	S, G	Hb	.0		78.78	5-12-53		1,000	I	

TABLE 5.—*Logs of wells and test holes*

[The name of the owner or tenant of the property is given with each well]

Adams County

Well 7-9-8bc. City of Hastings.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil	10	10	Gravel, coarse	5	118
Clay	50	60	Sand, fine	5	123
Sand	30	90	Clay	3	126
Clay	1	91	Gravel	15	141
Gravel	12	103	Clay and sand	5	146
Sand	7	110	Gravel	45	191
Gravel, fine	3	113	(No record)	4	195

Well 7-10-1dc1. City of Hastings.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil, loess	17	17	Sand, coarse	21	98
Clay, brown	7	24	Sand, coarse; contains clay balls	11	109
Clay, sandy, yellow	32	56	Sand and gravel, coarse	4	113
Clay, hard, yellow	17	73	Sand, fine; yellow clay	30	143
Sand, fine, yellow	4	77	Sand and gravel, coarse	37.7	180.7

Butler County

Well A13-2-30bc. George McGowan. Log from owner's memory.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil, clay	36	36	Sand	15	102
Sand	11	47	Gravel, fine	13	115
Clay, blue	2	49	Sand	13	128
Sand	23	72	Rock		
Gravel, fine	15	87			

Clay County

Well 7-5-8dd. Martin Mau.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil (?)	59	59	Sand, and gravel; some clay	2	131
Sand, fine; clay	10	69	Clay	14	145
Sand, fine	2	71	Sand, gravel, and clay	2	147
Sand; some gravel	4	75	Sand and gravel	16	163
Sand; gravel	18	93	Sand and gravel; some clay	2	165
Sand; gravel; some clay	2	95	Sand and clay	2	167
Clay, sandy	4	99	Sand and gravel	12	179
Sand, fine; clay	4	103	Sand and gravel; some clay	2	181
Clay	14	117	Sand and gravel, coarse	16	197
Sand and clay	2	119	Saud, gravel, and some clay	2	199
Sand, coarse	2	121	Sand, packed	3	202
Sand and gravel	8	129			

Well 7-8-4db. Robert Donahue. Log from owner's memory.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil, clay, and fine sand	124	124	Clay and gravel layers	16	180
Clay and gravel layers	22	146	Gravel	20	200
Clay	18	164			

Test hole 8-5-33dc2. Earl Vauck. Log from owner's memory.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay	50	50	Sand, fine	5	120
Sand	25	75	Sand and gravel	60	180
Clay	40	115			

Well 8-6-2cd. C. J. Helzer. Log from owner's memory.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil, clay, and fine sand	85	85	Sand and gravel	10	165
Sand and gravel	45	130	(No record)	3	168
Clay	25	155			

TABLE 5.—*Logs of wells and test holes*—Continued

Clay County—Continued

Well 8-6-12bb. Paul Helzer. Log from owner's memory.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil, clay	80	80	Sand and gravel	30	135
Sand, fine	25	105			

Well 8-6-20dc. Roger G. Anderson. Log from owner's memory.

Clay	68	68	Sand and gravel	35	140
Sand and gravel	27	95	Clay, blue		
Clay	10	105			

Well 8-7-20cc. Harold Smith. Log from owner's memory.

Topsoil, clay	60	60	Gravel	20	120
Gravel	20	80	Clay	10	130
Clay	20	100	Gravel	35	165

Fillmore County

Well 7-4-8dd. Edward Girmus. Log from owner's memory.

Topsoil, clay, and fine sand	133	133	Clay	6	167
Sand and gravel	28	161	Sand and gravel	29	196

Hall County

Well 9-9-26ca. C. R. Anderson.

Clay	40	40	Gravel	15	151
Sand, fine; clay	50	90	Sand, fine; clay	9	160
Gravel	18	108	Sand, hard	5	165
Sand, fine; clay	28	136			

Hamilton County

Well 9-5-5aa. Frank Dick.

Clay and fine sand	78	78	Gravel, rusty-colored	2	128
Sand, fine	4	82	Sand	6	134
Clay	14	96	Sand; contains clay balls	4	138
Sand, fine	6	102	Sand and some gravel	9	147
Clay	2	104	Sand, fine	3	150
Sand and gravel	4	108	Clay	5	155
Gravel, rusty-colored	10	118	Sand and gravel	29	184
Sand	8	126			

Well 9-5-10ab. Reuben Epp.

Topsoil(?)	73	73	Sand and gravel	22	125
Sand, fine; clay	2	75	Sand and clay	2	127
Sand, fine	2	77	Sand, fine	2	129
Sand, medium	6	83	Sand and gravel	2	131
Sand and gravel	12	95	Gravel, road-size	2	133
Gravel and clay	2	97	Sand, coarse, and clay	2	135
Clay	4	101	Gravel, coarse	12	147
Sand and clay	2	103	Sand and gravel, coarse	19	166

Well 9-5-15cc. Reinhold Huebert.

Topsoil(?)	65	65	Gravel	14	117
Sand, very fine	16	81	Sand	4	121
Sand	4	85	Clay	8	129
Sand and gravel	10	95	Sand and gravel	46	175
Clay	8	103			

TABLE 5.—*Logs of wells and test holes*—Continued

Hamilton County—Continued

Well 9-5-26cc. Gideon Redler.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	40	40	Gravel	8	64
Sand, medium	6	46	Sand and gravel	13	77
Sand	6	52	Clay	8	85
Sand and gravel	4	56	Sand and gravel	21	106

Well 9-5-27cb. John O. Griess.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	15	15	Sand, fine	4	31
Sand and gravel	12	27	Sand and gravel	25	56

Well 9-6-9dc. Andrew Nachtigal.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	73	73	Sand and gravel, some clay	4	125
Sand, fine	12	85	Clay, some gravel	2	127
Sand, coarse	2	87	Clay, sandy	4	131
Sand, coarse; gravel	6	93	Sand, coarse	2	133
Clay	10	103	Sand, and gravel, coarse	24	157
Sand and clay	2	105	Gravel, some clay	2	159
Gravel, some clay	2	107	Sand and gravel, coarse	17	176
Sand and gravel, coarse	14	121			

Well 9-6-34ba. Tom Wild.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand, fine	33	33	Sand, medium	4	51
Sand	2	35	Sand, coarse	6	57
Gravel, rusty-colored	2	37	Sand and gravel	10	67
Sand, coarse	10	47	(No record)	36	103

Well 9-7-21ab. D. J. Wilson.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	67	67	Clay	14	103
Sand	8	75	Sand	2	105
Gravel	4	79	Sand, coarse	15	120
Sand, fine	5	84	Clay	7	127
Gravel	5	89	Gravel	56	183

Well 9-8-4ab. Oran R. Bish.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	37	37	Clay	2	99
Sand, fine; clay	14	51	Clay and gravel	2	101
Sand, fine	8	59	Sand and gravel	32	133
Sand, fine; clay	16	75	Sand and clay	10	143
Clay	2	77	Clay	2	145
Sand, fine; clay	2	79	Sand, coarse; clay	2	147
Sand, fine	18	97	Sand and gravel, coarse	39	186

Well 9-8-27da. Elmer Nuss. Log from owner's memory.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay	50	50	Sand, fine	7	102
Sand and gravel	38	88	Ocher, yellow	--------	--------
Clay	7	95			

Well 10-5-12ca. Alfred Peters.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil (?)	75	75	Sand and gravel	12	145
Sand, fine; clay	8	83	Sand, gravel, and clay	2	147
Sand, fine	4	87	Clay	6	153
Clay	2	89	Sand, fine; clay	2	155
Sand	10	99	Sand and gravel; some clay	6	161
Sand and gravel	24	123	Sand and gravel	25	186
Sand, coarse	10	133			

TABLE 5.—*Logs of wells and test holes*—Continued

Hamilton County—Continued

Well 10-5-15bd. Isaac Braun.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil (?)	86	86	Gravel and clay	2	126
Sand, fine; clay	2	88	Clay	2	128
Sand, fine	8	96	Sand and gravel	20	148
Sand, fine; clay	4	100	Gravel, coarse	8	156
Sand and gravel	8	108	Clay	6	162
Gravel, rusty-colored	4	112	Sand, coarse; clay	6	168
Sand and gravel, coarse	8	120	Gravel, coarse	28	196
Gravel, coarse	4	124			

Well 10-5-23cb. Henry I. Goertzen.

Topsoil (?)	65	65	Clay and gravel	2	119
Sand, very fine	28	93	Sand and gravel	46	165
Sand	4	97	Clay, some sand	4	169
Sand, coarse	4	101	Sand and gravel	25	194
Clay	16	117			

Well 10-5-25dc. Walt Goosen.

Topsoil (?)	70	70	Gravel	26	132
Sand, fine	20	90	Sand	4	136
Sand, rusty-colored	4	94	Clay	6	142
Gravel, rusty-colored	2	96	Sand and gravel	10	152
Sand and gravel	10	106	Gravel	33	185

Well 10-5-28cc. Wilbur Splinter.

Topsoil(?)	68	68	Sand, some gravel	20	146
Sand, fine	22	90	Sand and gravel	16	162
Clay	2	92	Gravel	8	170
Sand, medium, rusty-colored	10	102	Sand, medium	6	176
Sand, some gravel	2	104	Sand and gravel	10	186
Gravel, rusty-colored	8	112	Clay	2	188
Sand and gravel	10	122	Sand and gravel	8	196
Gravel, coarse	4	126			

Well 10-5-30ad. Sam Troester.

Topsoil (?)	65	65	Sand and gravel	19	143
Sand, fine	9	74	Sand, medium-fine	5	148
Sand, dry	4	78	Sand and gravel	17	165
Sand, fine	18	96	Clay	9	174
Sand and gravel	20	116	Gravel	12	186
Sand, fine	8	124			

Well 10-5-36da. W. K. Regier.

Topsoil (?)	68	68	Sand and gravel	10	116
Sand and clay	12	80	Sand, some gravel	9	125
Sand	6	86	Gravel	55	180
Sand and gravel	6	92	Sand	6	186
Clay	14	106			

Well 10-6-5bb. C. A. Kemper.

Topsoil (?)	45	45	Sand and gravel	18	113
Sand, very fine	6	51	Gravel, some sand	22	135
Clay	2	53	Sand and gravel, some clay	2	137
Clay, sandy	8	61	Clay	4	141
Sand, medium	6	67	Clay, some sand	4	145
Sand	14	81	Sand, fine	2	147
Sand and gravel	12	93	Sand and gravel	29	176
Sand, fine	2	95			

TABLE 5.—*Logs of wells and test holes*—Continued

Hamilton County—Continued

Well 10-6-34bc. George Franz.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil (?)	61	61	Sand, fine	2	123
Sand, fine; clay	10	71	Sand, medium	6	129
Sand, fine	8	79	Sand and gravel	10	139
Sand, medium	8	87	Sand	4	143
Sand and gravel	16	103	Clay	6	149
Clay	8	111	Sand, fine	8	157
Clay, sandy	10	121	Sand and gravel	29	186

Well 10-7-2aa. Earl Oswald.

Topsoil (?)	58	58	Sand and gravel	12	118
Sand, fine	18	76	Sand, fine	2	120
Sand, medium	10	86	Gravel, coarse	14	134
Sand and gravel	6	92	Sand and gravel	4	138
Gravel, rusty-colored	6	98	Gravel	6	144
Gravel	2	100	Sand, fine; clay	10	154
Clay, yellow	6	106	Gravel	22	176

Well 10-7-11bb. Harold Oswald.

Topsoil (?)	76	76	Gravel	6	122
Sand, medium	6	82	Sand and gravel	8	130
Sand, fine	6	88	Gravel	10	140
Sand and gravel	14	102	Sand, fine	2	142
Clay	4	106	Sand	8	150
Sand and gravel	4	110	Gravel	30	180
Sand	6	116			

Well 11-5-2dc. Ralph Budnick.

Topsoil (?)	86	86	Sand, fine	4	150
Sand, fine	26	112	Clay	4	154
Sand	14	126	Sand, fine	4	158
Clay	2	128	(No record)	2	160
Sand, fine	6	134	Sand and gravel	36	196
Sand, medium	12	146			

Well 11-5-5cb. Harold Henthorne.

Clay	53	53	Clay	5	125
Sand rock	25	78	Gravel	15	140
Clay	27	105	Sand, fine	17	157
Sand	4	109	Gravel	4	161
Gravel	11	120			

Well 11-5-8bc. Jensen Bros.

Topsoil, fine sand	74	74	Sand	4	132
Sand, very fine	18	92	Sand and gravel	10	142
Clay	10	102	Sand, fine	10	152
Sand, very fine	4	106	Sand, medium-fine	8	160
Sand, medium-fine	10	116	Sand, fine	20	180
Sand, very fine	6	122	Gravel	42	222
Sand, medium-fine	6	128	Sand	4	226

Well 11-5-13ab. Raymond Parpart.

Topsoil, fine sand	87	87	Sand and gravel	6	135
Sand, fine	10	97	Clay and fine sand	10	145
Sand	8	105	Gravel	18	163
Gravel	20	125	Sand, medium-fine	10	173
Sand, medium-fine	4	129	Sand, coarse; fine gravel	13	186

TABLE 5.—*Logs of wells and test holes*—Continued

Hamilton County—Continued

Well 11-5-17cb. E. K. Steenburg.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil, clay	96	96	Sand, fine	8	148
Sand, fine	10	106	Clay	8	156
Sand, fine, rusty-colored	4	110	Sand, medium	8	164
Sand, rusty-colored	2	112	Sand	3	167
Sand and gravel	28	140	Gravel	19	186

Well 11-5-21ab. John Faber.

Topsoil(?)	30	30	Gravel, rusty-colored	8	42
Sand, medium	3	33	Sand and gravel	24	66
Sand and gravel	1	34			

Well 11-5-26ac. Bertha Zierotte.

Topsoil(?)	55	55	Gravel	10	106
Sand, fine	15	70	Clay	1	107
Sand and gravel	5	75	Gravel	13	120
Gravel	10	85	Clay and fine sand	12	132
Sand	2	87	Gravel and sand	28	160
Gravel, coarse	9	96			

Well 11-5-35dd. Lowell Schroeder.

Topsoil(?)	54	54	Sand	2	100
Sand, medium-fine	18	72	Sand and gravel	18	118
Sand, fine	6	78	Sand	6	124
Sand and gravel	8	86	Sand and gravel	17	141
Sand, medium; some gravel	6	92	Clay	1	142
Gravel	6	98			

Well 11-6-9ab. Don Enderle.

Topsoil(?)	64	64	Clay	4	130
Sand, very fine	10	74	Sand, fine	12	142
Sand, medium	6	80	Sand	10	152
Sand, fine	12	92	Sand and gravel	6	158
Sand	6	98	Sand	6	164
Sand and gravel	14	112	Sand, fine	14	178
Clay	4	116	Sand, medium	8	186
Gravel	6	122	Sand, fine, and clay	2	188
Sand, fine	4	126	Clay	3	191

Well 11-6-24ac. Herluff Hansen.

Topsoil(?)	81	81	Sand, coarse	8	125
Sand, fine; clay	4	85	Sand, medium	8	133
Sand, fine	10	95	Clay	4	137
Sand, medium	4	99	Sand, fine; clay	2	139
Sand, coarse	2	101	Sand, fine	4	143
Gravel, coarse, rusty-colored	10	111	Sand and gravel	30	173
Gravel, coarse, rusty-colored; clay	2	113	Sand, fine; clay	4	177
Sand, fine; clay	2	115	Sand, medium	4	181
Sand, coarse; clay	2	117	Sand and gravel	8	189

TABLE 5.—*Logs of wells and test holes*—Continued

Hamilton County—Continued

Well 11-6-30cb. Don Biens.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	60	60	Sand and gravel	6	148
Sand, fine	4	64	Sand, medium-fine	4	152
Clay	10	74	Sand	4	156
Sand, fine	4	78	Sand, fine	6	162
Clay	8	86	Gravel	4	166
Sand, fine	20	106	Sand	4	170
Sand	4	110	Sand and gravel	10	180
Sand and gravel	12	122	Gravel	6	186
Gravel	20	142			

Well 11-7-27dc. Sandy L. Cameron.

Clay	82	82	Gravel	9	131
Sand	13	95	Clay and gravel	4	135
Clay	7	102	Gravel	21	156
Sand and clay	4	106	Clay	9	165
Gravel	14	120	Sand	11	176
Clay	1	121	Gravel	27	203
Sand	1	122			

Well 11-8-28cd. Robert Scott.

Topsoil(?)	65	65	Sand, fine; blue clay	6	144
Sand, fine; clay	30	95	Sand, fine	19	163
Sand	43	138			

Well 12-5-15ca. Melvin Heiden.

Topsoil(?)	76	76	Gravel	4	132
Sand, fine	2	78	Sand, fine	6	138
Sand	2	80	Gravel	6	144
Sand and gravel	28	108	Sand, blue; gravel	16	160
Sand, fine	4	112	Gravel	8	168
Gravel, coarse, loose	8	120	Clay	2	170
Sand	8	128			

Well 12-5-25ad. Harvey Wochner. Log from owner.

Clay	40	40	Clay, blue	4	184
Sand, fine; some clay streaks	140	180	Gravel	22	206

Well 12-5-29ac. Albert Hoegh.

Topsoil(?)	63	63	Sand, fine; clay	2	71
Sand, fine; clay	4	67	Sand	6	77
Clay	2	69	Sand and gravel	99	176

Well 13-5-34bc. K. Clayton.

Topsoil(?)	73	73	Sand, some gravel	2	103
Clay, sandy	4	77	Sand	8	111
Sand, fine	8	85	Sand and gravel	10	121
Clay	4	89	Sand, coarse	2	123
Sand and clay	2	91	Sand and gravel	19	142
Sand, coarse	10	101	Clay	4	146

TABLE 5.—*Logs of wells and test holes*—Continued

Polk County

Well 13-1-26cc. Robert Nelson. Log from Floyd Bond, by memory.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil, clay	78	78	Sand and gravel; contains many shells	82	278
Sand	62	140	Boulder		
Clay, blue	56	196			

Well 13-1-32bd. Brown Bros. Log furnished by U. S. Soil Conservation Service.

Topsoil(?)	84	84	Sand, coarse	28	147
Sand	5	89	Clay	5	152
Clay, sandy	10	99	Sand, fine	15	167
Sand and gravel, coarse	19	118	Sand, coarse	18	185
Clay	1	119	Clay	2	187

Well 13-2-6dd. Erickson Bros. Log from owner's memory.

Topsoil, clay	70	70	Clay	1	91
Sand and gravel	20	90	Sand and gravel	112	203

Test hole 13-3-19dc2. Norris M. Anderson. Near irrigation well 13-3-19dc1.

Topsoil(?)	80	80	Sand, fine	30	159
Sand, fine	5	85	Sand, medium-fine	6	165
Clay	16	101	Sand, fine	10	175
Sand, fine	4	105	Sand, medium	4	179
Sand	8	113	Gravel	16	195
Gravel	12	125	Sand, fine	4	199
Sand, fine	2	127	Clay and gravel	7	206
Gravel	2	129	Sand and gravel	9	215

Well 13-4-24ab. Harold Carlson. Log from owner's memory.

Topsoil, clay	70	70	Sand and gravel	60	150
Sand	8	78	Clay	8	158
Clay	12	90	Sand and gravel	18	176

Well 14-1-20da. Ed Watke. Log furnished by owner.

Topsoil(?)	71	71	Sand	8	153
Sand	14	85	Clay	24	177
Clay	39	124	Sand	12	189
Gravel	7	131	Clay	56	245
Clay	2	133	Sand, coarse	23	268
Gravel	11	144	Clay	8	276
Clay	1	145	Gravel	32	308

Saline County

Well A8-4-17bc. Henry Pomajzl. Log from owner's memory.

Clay and sand	75	75	Gravel	64	264
Sand, fine	125	200			

Well A8-4-34bd. City of Crete. Log from city water commissioner.

Clay	18	18	Sand, gravel, some clay	15	90
Sand	7	25	Sand, medium-sized	55	145
Clay, blue	7	32	Sand, fine and coarse	20	165
Sand, some clay	38	70	Sand	18	183
Sand, boulders	5	75	Clay, blue	3	186

TABLE 5.—*Logs of wells and test holes*—Continued

Seward County

Well A10-1-24ac. Daniel F. Schulz. Log furnished by owner.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	40	40	Sand	20	115
Clay and sand, very fine	5	45	Sand and gravel	6	121
Sand, fine	6	51	Clay and sand, fine	8	129
Sand	6	57	Sand, medium-fine	4	133
Sand, coarse	12	69	Sand, fine; blue clay	2	135
Sand, fine	8	77	Clay, blue	1	136
Sand and gravel, coarse	18	95			

Test hole A10-3-29cc. City of Lincoln.

Topsoil	3	3	Gravel	2	94
Clay, yellow (loess)	17	20	Sand, fine; some gravel	38	132
Clay, brown (loess)	10	30	Clay, blue	36	168
Sand, fine; some coarse sand and gravel	62	92			

Test hole A11-1-29bd4. Chicago, Burlington & Quincy Railroad.

Clay	50	50	Sand and gravel	28	244
Gravel, dry	5	55	Gravel, cemented	1	245
Clay	25	80	Gravel, water-bearing	7	252
Sand and clay, water-bearing	80	160	Clay, blue	40	292
Clay, blue	56	216			

York County

Well 9-1-6ca. F. C. Nielson. Log furnished by U. S. Soil Conservation Service.

Topsoil(?)	40	40	Gravel	70	118
Clay, blue	8	48	Clay	4	122

Well 9-3-30cd. J. E. Towle. Log furnished by U. S. Soil Conservation Service.

Topsoil(?)	81	81	Sand and gravel	26	147
Sand, very fine; clay	4	85	Sand	2	149
Sand, very fine	10	95	Sand and gravel	26	175
Sand, fine	10	105	Sand, coarse	4	179
Sand, medium	4	109	Sand and gravel	12	191
Sand, medium-fine	4	113	Sand, gravel, and some clay	6	197
(No record)	2	115	Sand	2	199
Sand	6	121	Sand and gravel	7	206

Well 9-3-31ba. William Kleinholz. Log furnished by U. S. Soil Conservation Service.

Topsoil	3	3	Sand, some gravel and clay	5	144
Clay, yellow	18	21	Sand and gravel	15	159
Clay, dark	13	34	Sand, fine	11	170
Clay, gray	8	42	Sand and rice-sized gravel	4	174
Clay, yellow; some soft lime rock	20	62	Sand, fine; some gravel	4	178
Sand, fine; clay	16	78	Sand and gravel, fine and medium, stratified	13	191
Quicksand and some clay	13	91	Sand, medium; some gravel	22	213
Sand, very fine, packed	11	102	Clay	1	214
Quicksand with trace of clay	4	106	Sand, fine	14	228
Sand, very fine, packed	13	119	Clay	1	229
Sand and gravel, packed	16	135	Sand, some clay	4	233
Clay, sandy	4	139			

TABLE 5.—*Logs of wells and test holes*—Continued

York County—Continued

Well 9-4-33cb. Sidney F. Smith. Log furnished by U. S. Soil Conservation Service.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	77	77	Clay	2	122
Sand and blue clay	2	79	Sand and gravel	8	130
Sand and gravel	8	87	Clay	1	131
Sand, fine	5	92	Sand, fine; gravel	4	135
Clay	1	93	Sand and rice-sized gravel	6	141
Sand, fine	18	111	Sand and some gravel	5	146
Sand and gravel	5	116	Sand and gravel	33	179
Sand, fine; some gravel	2	118	Sand, fine; gravel	9	188
Sand and rice-sized gravel	2	120	Clay	12	200

Well 10-1-18da. Ruth Tucker. Log furnished by U. S. Soil Conservation Service.

Topsoil	4	4	Clay	3	85
Clay, yellow (Peorian)	44	48	Sand and gravel, coarse	2	87
Sand, coarse	4	52	Sand and gravel	75	162
Gravel	30	82	Clay, yellow		

Well 10-1-27cc. Harry C. Berger. Log furnished by U. S. Soil Conservation Service.

Topsoil, clay	22	22	Sand, medium-sharp; some gravel	3	74
Clay, sandy, dark-colored	7	29	Sand, sharp	6	80
Sand	2	31	Sand, some gravel and clay	5	85
Clay, gray	6	37	Sand and gravel	11	96
Sand and gravel	6	43	Quicksand	10	106
Sand, sharp	8	51	Clay, blue	5	111
Sand, fine; trace of clay	4	55	Sand, fine	5	116
Sand and gravel	9	64	Clay, blue; stratified with some sand	21	137
Sand and rice-sized gravel	6	70			
Shale, blue	1	71			

Well 10-2-30cc. George Lunney. Log furnished by U. S. Soil Conservation Service.

Topsoil (?)	61	61	Sand	8	113
Sand, fine; clay	4	65	Sand, fine; clay	2	115
Sand, fine	12	77	Sand	8	123
Sand, coarse	20	97	Sand and gravel	34	157
Sand, fine; clay	4	101	Gravel and clay	2	159
Sand, fine	4	105	Clay	4	163

Test hole 10-3-26b. T. D. McCarthy. Log furnished by U. S. Soil Conservation Service.

Topsoil	2	2	Sand and rice-sized gravel	10	107
Clay, yellow	18	20	Sand	12	119
Clay, dark	14	34	Sand, fine	6	125
Clay, yellow	28	62	Sand	6	131
Clay, gray	4	66	Sand and gravel	21	152
Clay, sandy	6	72	Sand, some gravel	7	159
Sand, fine; clay	4	76	Clay, yellow	32	191
Sand, some gravel	6	82	Clay, sandy, blue	6	197
Clay, yellow	7	89	Clay, blue	9	206
Clay, sandy	5	94	Clay, gray; some limy rock	104	310
Sand, trace of clay	3	97			

Well 10-3-29ac. L. D. Ellis. Log from owner's memory.

Clay and sand	76	76	Sand and gravel	56	162
Sand and gravel	24	100	Clay, hard, yellow	2	164
Clay	6	106			

TABLE 5.—*Logs of wells and test holes*—Continued

York County—Continued

Well 11-2-18dd. H. Tietmeyer, Jr. Log furnished by U. S. Soil Conservation Service.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay	27	27	Clay	5	43
Sand, fine	5	32	Sand	4	47
Sand	2	34	Gravel	14	61
Gravel	4	38	Clay	5	66

Well 11-3-3ac. George Lunney. Log furnished by U. S. Soil Conservation Service.

Topsoil(?)	57	57	Clay, sandy	10	117
Sand and clay	2	59	Sand, coarse	2	119
Sand and gravel	14	73	Sand and gravel	8	127
Sand	8	81	Sand, coarse	4	131
Sand and gravel	8	89	Sand	12	143
Gravel	14	103	Sand, fine	3	146
Sand, coarse	4	107			

Test hole 11-3-12c. John Dougherty. Log furnished by U. S. Soil Conservation Service.

Topsoil(?)	50	50	Sand	22	90
Sand	3	53	Sand and gravel, mixed	30	120
Clay, sandy	15	68	Clay	87	207

Test hole 11-3-22cb1. Walt. Haack. Log furnished by U. S. Soil Conservation Service.

Soil	3	3	Gravel	6	74
Clay, yellow	51	54	Clay, yellow	1	75
Sand, coarse	12	66	Gravel	23	98
Sand, coarse; fine gravel; some thin clay layers	2	68	Clay, yellow	10	108

Well 11-4-4aa. Robert Russell. Log furnished by U. S. Soil Conservation Service.

(No record)	87	87	Clay	3	128
Sand	17	104	Sand	52	180
Sand and gravel	16	120	Clay	3	183
Sand	5	125	Sand	12	195

Well 11-4-8ad. Lichtenberger Bros. Log from owner's memory.

Topsoil, clay	68	68	Clay	1	138
Sand, fine	67	135	Gravel	15	153
Gravel	2	137			

Well 11-4-34cb. G. H. Holdeman. Log furnished by U. S. Soil Conservation Service.

Topsoil(?)	54	54	Sand, fine; clay	11	159
Sand, fine	11	65	Clay	24	183
Sand, fine; clay	6	71	Lime rock and clay	5	188
Sand; some gravel	8	79	Clay	13	201
Sand and gravel	56	135	Lime rock	8	209
Clay	1	136	Clay	6	215
Quicksand	12	148			

Well 11-4-35ab. Edgar Thompson. Log furnished by U. S. Soil Conservation Service.

Clay	65	65	Gravel, large	2	101
Sand, very fine	4	69	Gravel, medium	8	109
Sand, fine	4	73	Clay, sandy; fine sand	4	113
Clay	9	82	Gravel, small to medium	6	119
Gravel, very small; some large stones	7	89	Gravel, medium	15	134
Gravel, small to medium	10	99	Clay, stiff, plastic, buff-colored	8	142

TABLE 5.—*Logs of wells and test holes*—Continued

York County—Continued

Well 11-4-35cb. Guy V. Watt. Log furnished by owner.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	69	69	Sand and gravel	23	116
Sand, rusty-colored; some gravel	5	74	Sand, medium	15	131
Sand and gravel	15	89	Clay, hard	3	134
Clay	4	93			

Well 11-4-36bd. R. J. Kreifels. Log furnished by owner.

Clay	37	37	Clay, sandy; some gravel	3	69
Clay, sandy	5	42	Sand and gravel	24	93
Sand, fine	10	52	Clay, sandy; some gravel	3	96
Clay, sandy	3	55	Sand and gravel	18	114
Sand, fine	8	63	Clay	6	120
Clay, sandy	3	66			

Well 12-1-1aa. Mark A. Romohr. Log by owner's son, from memory.

Topsoil, clay, and fine sand	120	120	Sand and gravel	32	282
Sand and gravel	30	150	Clay	--------	--------
Clay	100	250			

Well 12-1-31da. Mrs. L. J. Treakle. Log furnished by U. S. Soil Conservation Service.

Topsoil	4	4	Sand, coarse	11	79
Clay, yellow	52	56	Gravel, fine	3	82
Hardpan	2	58	Clay, yellow	9	91
Clay	7	65	Gravel	89	180
Clay, blue	3	68			

Well 12-2-29cb. Walter H. Stuhr. Log furnished by owner.

Topsoil, black	3	3	Gravel	25	110
Clay, yellow	23	26	Sand, fine	10	120
Gumbo	3	29	Gravel	30	150
Clay, red	44	73	Clay	20	170
Sand, fine	12	85			

Well 12-3-3bb. Elmer Richters. Log furnished by U. S. Soil Conservation Service.

Topsoil, clay	74	74	Clay	2	146
Sand	5	79	Gravel	30	176
Clay, sandy; sand layers	26	105	Clay	16	192
Sand, coarse	13	118	Sand, fine	13	205
Gravel	26	144			

Well 12-3-14da. Clyde McCarty. Log furnished by U. S. Soil Conservation Service.

Topsoil(?)	70	70	Sand, fine	3	133
Sand, fine	8	78	Sand and gravel	2	135
Sand, cemented; some clay	12	90	Gravel	33	168
Sand, fine	10	100	Clay	1	169
Sand and gravel	30	130	Gravel	--------	--------

Well 12-3-24aa. Peter Meehan. Log furnished by U. S. Soil Conservation Service.

Topsoil	3	3	Sand, fine	6	94
Clay, yellow	22	25	Gravel, coarse	11	105
Clay, dark	10	35	Clay, yellow	4	109
Clay, yellow	46	81	Gravel	73	182
Clay, sandy	7	88	Clay, yellow	--------	--------

TABLE 5.—*Logs of wells and test holes*—Continued

York County—Continued

Well 12-4-32ca. E. A. Levitt. Log furnished by U. S. Soil Conservation Service.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil(?)	76	76	Clay	6	146
Sand	11	87	Sand and gravel	28	174
Clay	29	116	Clay	3	177
Sand	4	120	Gravel	31	208
Gravel	20	140			

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