Geology and Ground-Water Resources of Barton and Stafford Counties, Kansas

By

BRUCE F. LATTA

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By BRUCE F. LATTA

with sections on oil and gas by Earl K. Nixon and on ceramic materials by Norman Plummer

Prepared by the State Geological Survey of Kansas and the United States Geological Survey, with the coöperation of the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture

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GEOLOGY AND GROUND-WATER RESOURCES OF BARTON AND STAFFORD COUNTIES, KANSAS

By Bruce F. Latta

ABSTRACT

This report describes the geography, geology, and ground-water resources of Barton and Stafford Counties in central Kansas. These counties have an area of about 1,686 square miles and had a population of 35,885 in 1945. Stafford County and most of Barton County are drained by Arkansas River and its tributaries. The northern part of Barton County is drained by tributaries of Smoky Hill River. The climate is subhumid, the average annual precipitation being about 24 inches. Farming and raising of livestock are the principal occupations. Also, Barton and Stafford Counties are among the most important oil-producing counties in the State.

All the rocks exposed in Barton and Stafford Counties are of sedimentary origin and range in age from Cretaceous to Recent. The areal distribution of the formations is shown in Plate 1. The oldest Cretaceous rocks exposed at the surface are Lower Cretaceous (Comanchean) in age and comprise part of the Kiowa shale. The Upper Cretaceous (Gulfian) is represented by the Dakota formation, Graneros shale, Greenhorn limestone, and Carlile shale, which are exposed in the upland areas of Barton County. In northern and western Barton County thin deposits of "Algal limestone" of Tertiary age crop out at scattered localities.

Undifferentiated deposits of silt, clay, and gravel of early Pleistocene age are exposed in a small area in northwestern Barton County where they unconformably overlie the Carlile shale. Unconsolidated deposits of silt, sand, and gravel (Meade formation) of early Pleistocene age cover the eroded surface of Cretaceous and Permian rocks in some areas in southern Barton and all of Stafford Counties. These deposits are exposed along Rattlesnake Creek and North Fork of Ninnescah Creek in southern Stafford County. Later Pleistocene silts, sands, and gravels underlie parts of the upland in southern Barton County, the Cow Creek drainage basin, and terraces along Walnut and Dry Walnut Creek. Quaternary dune sand covers the surface in most of Stafford County and southern Barton County, and alluvium underlies the surface of the larger stream valleys and Cheyenne Bottoms.

The alluvium yields large amounts of water to wells in Arkansas and Walnut Valleys and small to moderate amounts to wells in

Cheyenne Bottoms and smaller stream valleys. It supplies water to many irrigation and a few industrial wells in Arkansas and Walnut Valleys. Waters in most places are hard but otherwise are satisfactory for most purposes. However, waters of poor quality are found in Cheyenne Bottoms and Big and Little Marshes.

Sand and gravel beds of the Meade formation are the most important sources of water in Stafford County and southern Barton County, and yield large supplies. Most of the domestic and stock wells and all the irrigation and public-supply wells south of Arkansas Valley derive water from this formation, and many of the domestic, stock, irrigation, and industrial wells in the Arkansas Valley and the city-supply wells at Great Bend derive all or a part of their water from it. In most areas the water is of good quality, but locally it is highly mineralized.

The report contains a map showing by means of contours the saturated thickness of the water-bearing materials of post-cretaceous age. In parts of the area those water-bearing materials have a total saturated thickness of as much as 200 feet.

The field data upon which most of this report is based are given in tables that include records of 371 wells, 43 of which are irrigation wells, and chemical analyses of water from 100 representative wells and test holes. Logs of 130 test holes, water wells, and oil-test wells, including 106 test holes put down by the State Geological Survey, are given.

INTRODUCTION

Purpose and Scope of Report

This report presents the results of an investigation of the geology and ground-water resources of Barton and Stafford Counties, which was begun in July 1942, by the United States Geological Survey and the State Geological Survey of Kansas, with the coöperation of the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture. Owing to the concentration of Survey activities on war work and the shortage of personnel, the field investigation was interrupted and was not completed until the fall of 1944.

The importance of ground water is indicated by the fact that the entire population of Barton and Stafford Counties obtains its water supply from wells. In addition, wells supply water for livestock, for industrial use, and for the irrigation of more than 1,500 acres of land. Thus, there is definite need for an adequate understanding of this important natural resource. The investigation in Barton and

Stafford Counties was made to determine the quality, quantity, movement, and availability of ground water.

The invesigation was made under the general administration of O. E. Meinzer, geologist in charge of the Ground Water Branch of the Federal Geological Survey until his retirement in November 1946, and under A. N. Sayre, geologist in charge since that time.

The sections on oil and gas and ceramic materials were prepared by geologists of the State Geological Survey.

Location and Extent of the Area

Barton and Stafford are adjacent counties in central Kansas and together they embrace a total of 47 townships containing 1,686 square miles. Barton is the larger of the two counties and has an area of 892 square miles. The location of Barton and Stafford Counties with respect to adjoining counties is shown in Figure 1.

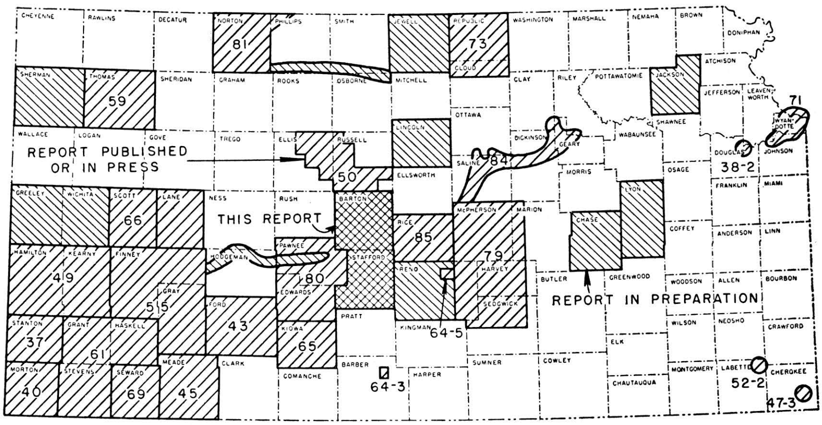

Fig. 1.—Area covered by this report and other areas in Kansas for which coöperative ground-water reports have been published or are in preparation.

Previous Investigations

A detailed study of the geology and ground-water resources of Barton and Stafford Counties had not previously been undertaken. However, brief references to the geology and ground water of parts of these two counties have been made in numerous reports. In an early paper on the salt deposits of Kansas, Hay (1889, pp. 199, 202) describes the discovery and development of salt near Great Bend in Barton County. A few years later Hay (1893) published a report on the geology and mineral resources of Kansas in which he gives a brief description of the salt marshes in northeastern Stafford

County. Physiographic descriptions of the Arkansas River and Cheyenne Bottoms were given by Johnson (1901, pp. 712-713) in his paper on the utilization of the High Plains.

In 1902, Bailey published a special report on the mineral waters of Kansas which includes a description of a deep salt-water well near Great Bend and a chemical analysis of the water from it (Bailey, 1902, p. 197). A preliminary report on the geology and ground-water resources of the Central Great Plains by Darton includes a general description of the water supply in Barton and Stafford Counties (Darton, 1905, pp. 290-291, 319). Brief references to a salt plant at the Big Marsh in northeastern Stafford County and to the quality of water in Cheyenne Bottoms were made by Parker (1911, pp. 47, 55) in a report on the quality of the water supplies of Kansas.

A detailed investigation of the geology of Russell County, adjacent to Barton County on the north, was published by the State Geological Survey in 1925 (Rubey and Bass, 1925). The results of a study of the physiography and geology of south-central Kansas, including all of Stafford County and the southern part of Barton County, are given in an unpublished thesis by Courtier (1934). In 1944, a report was published (Meinzer and Wenzel, 1944, pp. 71-72, 168-171) on water levels and artesian pressures in the United States in 1942, which contains chapters on the observation-well programs in Barton and Stafford Counties. Similar reports have been published for the years 1943-'45 (Meinzer and Wenzel, 1946, pp. 63-65, 152-154; Sayre and others, 1947, pp. 51-54, 126-127; 1948, pp. 51-53, 126-128), and additional reports of this series will be published annually.

Coöperative ground-water investigations have been made in several counties adjacent to, or near, Barton and Stafford Counties (Fig. 1). These include reports on Pawnee and Edwards Counties (McLaughlin, 1949), Kiowa County (Latta, 1948), Rice County (Fent, 1950), and the oil-field areas of Russell and Ellis Counties (Frye and Brazil, 1943).

Methods of Investigation

Approximately 3 months in the summer and fall of 1942 and 3½ months in the summer and fall of 1944 were spent by me in the field in Barton and Stafford Counties collecting data for this report. During that time, the wells listed in Tables 12 and 13 were visited and the depths to water in them were measured. All measurements were made with a steel tape from a fixed measuring point at the top of the well. Allan Graffham measured additional wells in Barton County during the fall of 1944. Observation wells in the two counties were established by me and have been measured periodically by W. W. Wilson, Allan Graffham, Melvin Scanlan, and Howard Palmer.

During the course of the field work, the geology of the county was studied and a geologic map (Pl. 1) was prepared. Information concerning the thickness and character of the geologic formations in the subsurface was obtained by the drilling of 104 test holes in the two counties—80 test holes in Barton County and 24 in Stafford County. The test holes were drilled with a hydraulic rotary drilling machine owned by the State Geological Survey and operated by O. S. Fent, Charles K. Bayne, Delmar Berry, George Yeckel, William Connor, Milford Klingaman, and Joseph Votaw. Samples from the test holes were collected and studied in the field by Fent, Bayne, and Berry and were again studied in the office by me. Additional logs of wells and test holes drilled in the two counties were provided by landowners, drillers, and city officials.

The altitudes of the measuring points of those wells that were measured and of the test-hole locations were determined with an alidade and plane table by level parties headed by Richard Tripp and Charles K. Bayne.

Samples of water were collected from 9 wells and 11 test holes and chemical analyses of them were made by Howard Stoltenberg, chemist, in the Water and Sewage Laboratory of the Kansas State Board of Health. In addition, Stoltenberg determined the chloride content of samples of water collected from three wells and two test holes, and of five samples from Rattlesnake Creek, three from Big Marsh, and one from Little Marsh.

Highway maps of Barton and Stafford Counties compiled by the State Highway Commission of Kansas were used in the field for mapping and were used in the office as base maps in preparing Plates 1 and 2. The drainage was delineated from aerial photographs obtained from the Agricultural Adjustment Administration, United States Department of Agriculture.

Well-Numbering System

The well and test-hole numbers used in this report give the location of wells according to General Land Office surveys and according to the following formula: Township, range, section, 160-acre tract within that section, and the 40-acre tract within that quarter section. This system of numbering wells is shown on Figure 2. If two or more wells are located within a 40-acre tract, the wells are numbered serially according to the order in which they were inventoried. The 160-acre and 40-acre tracts are designated a, b, c, or d in a counterclockwise direction, beginning in the northeast quarter. For example, well 18-13-5da is located in the NE¼ SE¼ sec. 5, T. 18 S., R. 13 W. As all the area is south and west, respectively, of the base line and meridian used for Kansas, no symbols for south and west are included in the well numbers.

Acknowledgments

Thanks and appreciation are expressed to the many residents of Barton and Stafford Counties who kindly supplied information and aided in the collection of field data. Special acknowledgment is due the officials of the many cities who willingly furnished information about their respective public water supplies. Acknowledgment is also made of the information on the Great Bend water supply received from H. S. Kilby and Clifford Getz, president and manager, respectively, of the Kansas Power Company of Great Bend. The Hines Plumbing Company of Ellinwood, Mr. M. Teichmann of Hudson, Mr. Ben Meyers of Great Bend, and the Layne-Western Company of Kansas City, Missouri, furnished many well records and well and test-hole logs that have been invaluable in this study.

The manuscript for this report has been reviewed by several members of the Federal Geological Survey and the State Geological Survey of Kansas; George S. Knapp, Chief Engineer, and Robert Smrha, Senior Engineer, of the Division of Water Resources, Kansas State Board of Agriculture; and Dwight Metzler, Director and Chief Engineer, and Ogden S. Jones, geologist, of the Division of Sanitation, Kansas State Board of Health. The manuscript was edited by Betty J. Hagerman, and the illustrations were drafted in final form by Robert White and Woodrow W. Wilson.

GEOGRAPHY

Climate

The climate of Barton and Stafford Counties is subhumid and is marked by extremes of precipitation and temperature. The average growing season in Barton County is about 174 days and has ranged from about 143 to about 220 days. In Stafford County the average growing season is about 169 days and has ranged from about 117 to about 198 days.

The normal annual precipitation at Great Bend and Hudson, determined by the U. S. Weather Bureau, is 24.18 and 24.58 inches, respectively. However, deviations from the normal are frequent. At Great Bend the recorded annual precipitation for the period

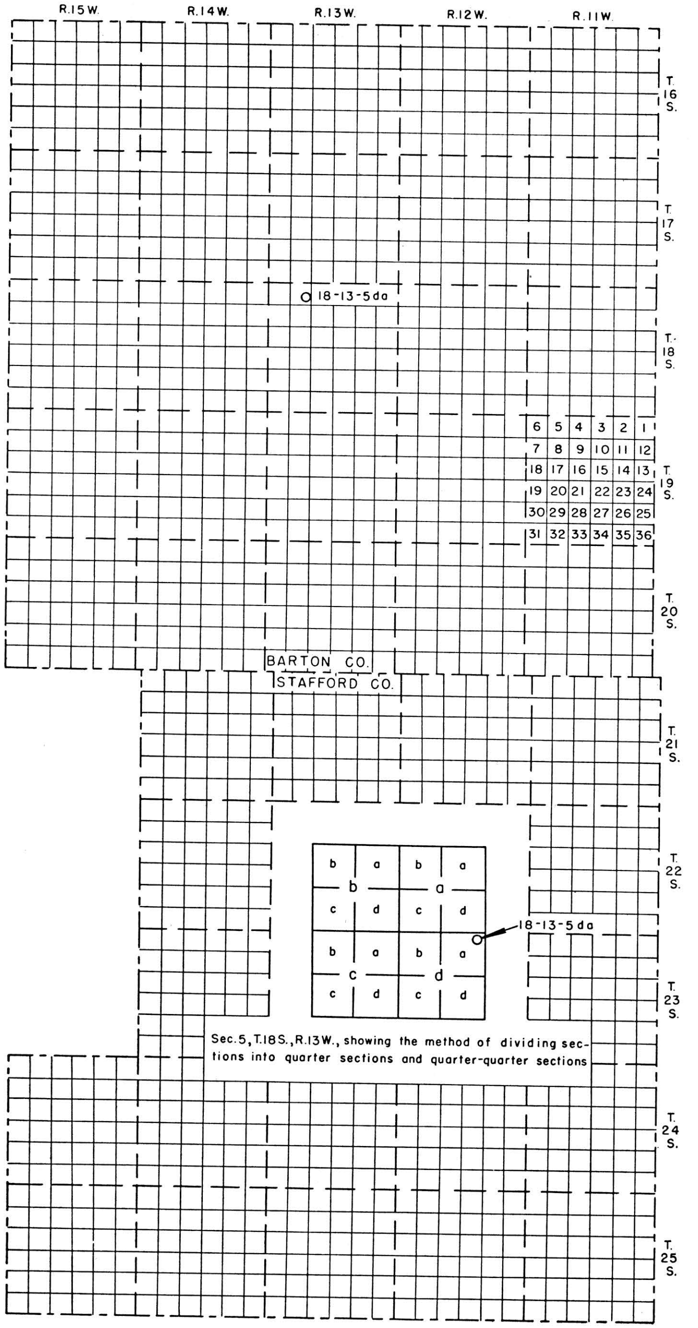

FIG. 2.—Map of Barton and Stafford Counties illustrating the well-numbering system used in this report.

1923-47 has ranged from a minimum of 14.72 inches in 1936 to a maximum of 38.35 inches in 1944, and at Hudson it has ranged from 14.17 inches in 1936 to 34.54 inches in 1944. The annual precipitation for the period of record and the cumulative departure from normal precipitation at Great Bend and Hudson are shown graphically in Figures 3 and 4.

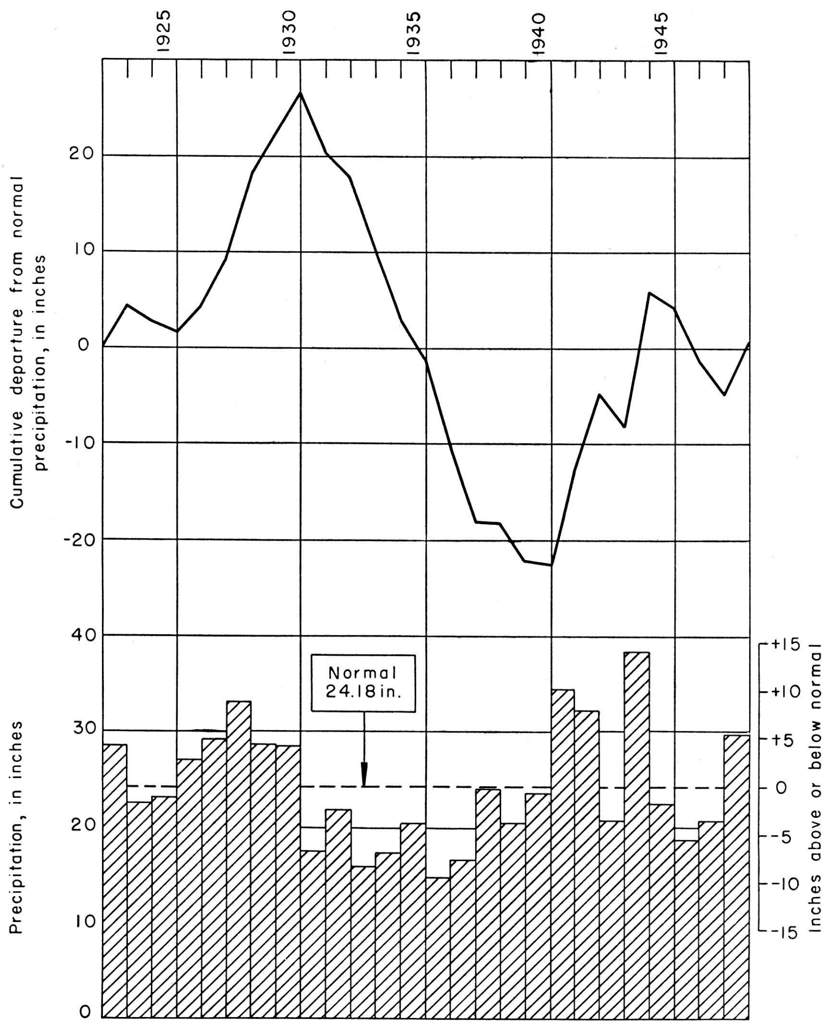

FIG. 3.—Annual precipitation and cumulative departure from normal precipitation at Great Bend. (Data from records of the U. S. Weather Bureau.)

Population

According to the 1945 census by the State Board of Agriculture the population of Barton County was 26,597 and the population of Stafford County was 9,288, a total of 35,885 for both counties. Great Bend, the largest city in the area and the county seat of Barton County, had a population of 10,065 in 1945. Other towns in Barton County and their 1945 populations are Hoisington, 3,875;

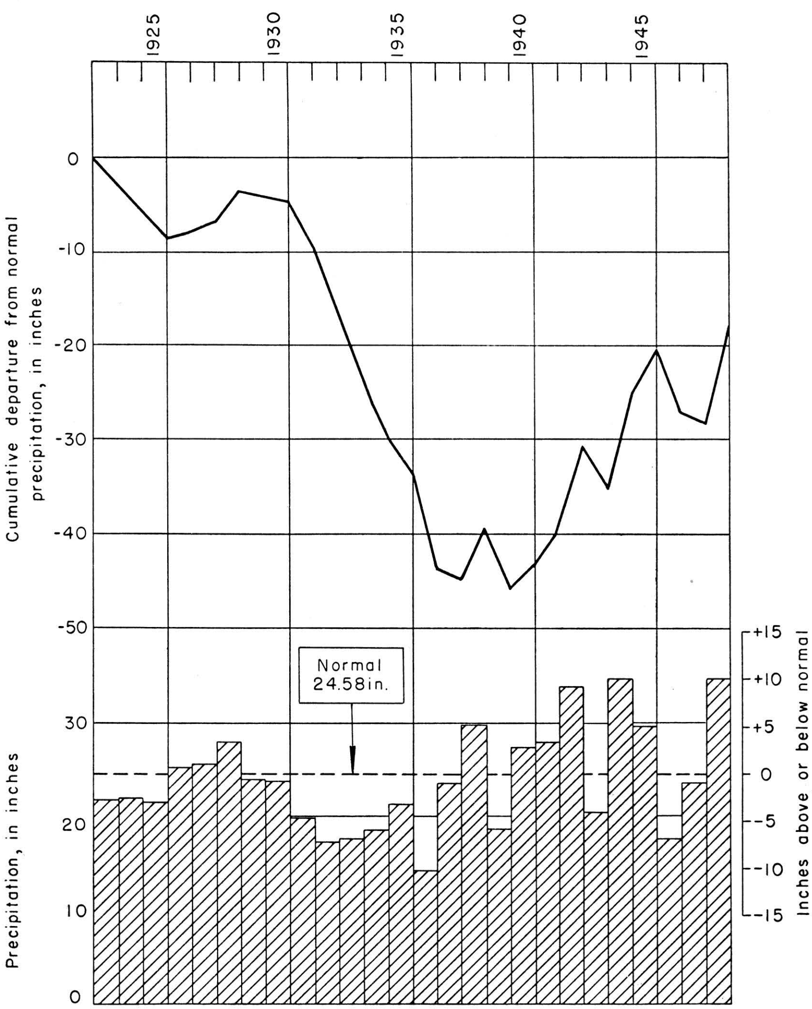

Fig. 4.—Annual precipitation and cumulative departure from normal precipitation at Hudson. (Data from records of the U. S. Weather Bureau.)

Ellinwood, 2,141; Claflin, 708; Pawnee Rock, 339; Albert, 166; Galatia, 124; and Olmitz, 145.

The largest town in Stafford County is Stafford which had a population of 1,969 in 1945. St. John, population 1,614, is the second largest town and the county seat. Other towns in Stafford County and their 1945 populations are Macksville, 540; Hudson, 235; Seward, 130; and Radium, 76.

Population figures are not available for the small towns of Beaver and Heizer in Barton County, or Zenith in Stafford County. Redwing, Dartmouth, and Farhman, in Barton County, and Neola, in Stafford County, serve as supply stations for farmers and as grain-shipping points.

Transportation

Barton and Stafford Counties have excellent transportation facilities. The main line of the Atchison, Topeka, and Santa Fe Railway traverses Stafford County from east to west through Zenith, Stafford, St. John, and Macksville. An alternate route of the Atchison, Topeka, and Santa Fe Railway between Hutchinson and Kinsley passes through Ellinwood, Great Bend, and Pawnee Rock in southern Barton County. The main line of the Missouri Pacific Railway traverses central Barton County from east to west through Claflin, Redwing, Hoisington, and Olmitz.

A branch line of the Missouri Pacific Railway running from Kingman to Larned passes through Stafford, Hudson, Seward, and Radium in Stafford County. Another branch line of the Missouri Pacific runs between Great Bend and Hoisington. A branch line of the Atchison, Topeka, and Santa Fe Railway runs from Great Bend westward to Scott City, passing through Heizer and Albert in west-central Barton County. Another branch line of the Santa Fe runs from Galatia in northwestern Barton County through Susank, Beaver, and Fahrman to McPherson in McPherson County.

Several hard-surfaced Federal and State highways pass through Barton and Stafford Counties. U. S. Highway 281 crosses the central part of the area from north to south, passing through Hoisington, Great Bend, and St. John. U. S. Highway 50N passes from east to west through Ellinwood, Great Bend, and Pawnee Rock in southern Barton County, and U. S. Highway 50S passes from east to west through Zenith, Stafford, St. John, and Macksville in southern Stafford County. State Highway 4 traverses central Barton County from east to west, passing through Claflin and Hoisington. State Highway 96 runs northwest from Great Bend through Heizer and Albert, and State Highway 19 passes from east to west through

Radium and Seward, joining U. S. Highway 281 at a point 2 miles east of Seward. Numerous improved county and township roads serve the remainder of the area (Pl. 1).

Agriculture

Agriculture is the dominant economic activity in Barton and Stafford Counties, wheat being by far the most important crop. Other crops include corn, grain sorghums, barley, oats, rye, and alfalfa. The acreage of the principal crops grown in Barton and Stafford Counties in 1948, as reported by the Kansas State Board of Agriculture, is given in Table 1.

Barton County has a total land area of about 570,880 acres. According to the 1940 census, 98.8 percent of the land was in farms. In 1948 there were 1,522 farms in Barton County, and the average farm comprised about 370 acres. Stafford County has a total land area of about 508,160 acres, 95.8 percent of which was in farms in 1939. In 1948 there were 1,163 farms in Stafford County, averaging about 420 acres in size.

Irrigation by pumping from wells is practiced to a limited extent in the Arkansas Valley and Walnut Creek Valley in Barton County and in parts of the sand-hills area in Stafford County. In 1944 there were 38 pumping plants in the two counties, capable of irrigating more than 1,500 acres of land. In most years a much smaller acreage than this is actually irrigated, however.

Natural Resources and Industries

The urban industries of this area are primarily related to agriculture, general merchandising, and production of oil and gas.

Mineral resources of Barton and Stafford Counties include oil, gas, clay, sand, gravel, limestone, and salt.

Table 1.—*Acreage of principal crops grown in Barton and Stafford Counties, Kansas, in 1948*

Crop	Barton County	Stafford County
Wheat	262,000	196,000
All hay exclusive of sorghums	36,180	40,510
Sorghums	29,860	40,940
Oats	11,560	3,970
Barley	9,520	4,560
Corn	2,000	3,100
Rye	290	1,080

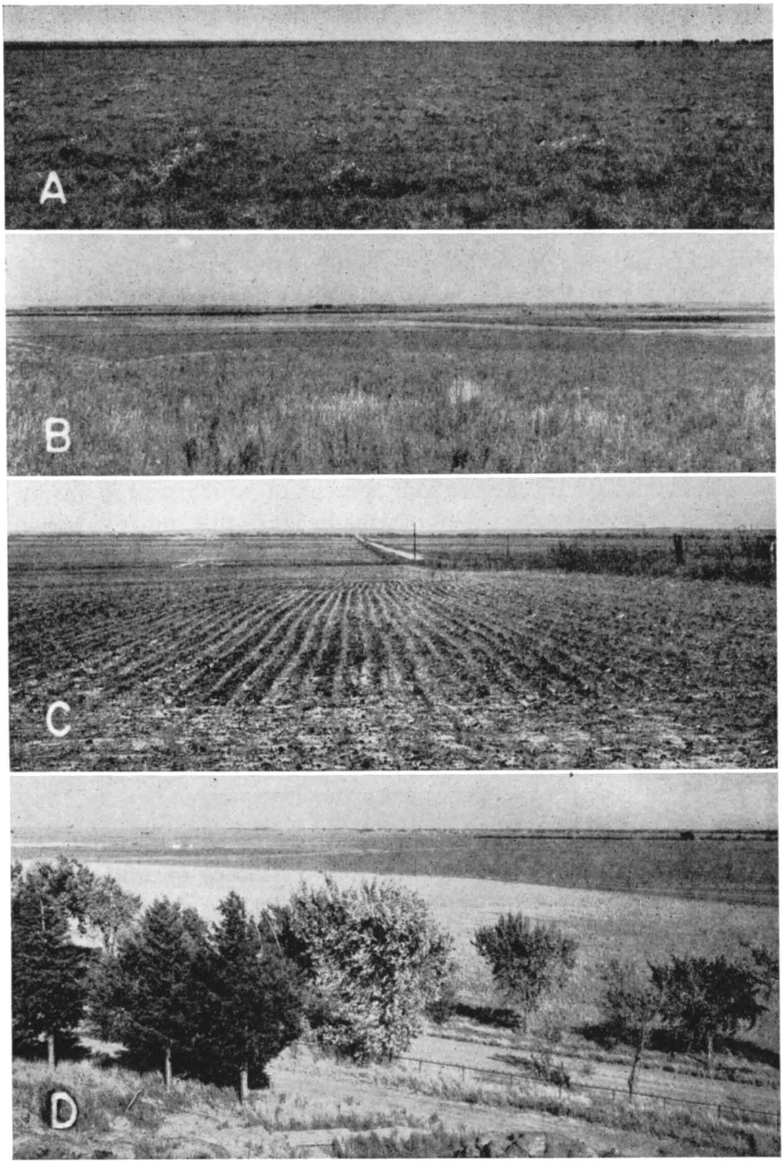

PLATE 4.—*A,* Flat, featureless surface of Cheyenne Bottoms. View looking west from the Cen. W. line sec. 19, T. 18 S., R. 11 W. *B,* View looking northeast across Cheyenne Bottoms from the S. line sec. 28, T. 18 S., R. 13 W. Dark areas are covered with water. *C,* View looking south across Walnut Valley terrace from the SW¼ sec. 8, T. 18 S., R. 15 W., Barton County. Terrace lies between the two dashed lines. The line of trees in the distance marks the course of Walnut Creek. *D,* Arkansas Valley in western Barton County. View looking downstream from Pawnee Rock.

OIL AND GAS

BY EARL K. NIXON

Introduction.—Stafford and Barton are among the most important oil-producing counties in the state. Although oil was first discovered in western Kansas in 1923 (the Fairport pool of Russell County), Stafford and Barton Counties did not join the growing list of Kansas producers until 1930. Meantime, oil had been discovered in the adjacent counties, Ellis, Rice, and Reno. The Davidson pool in Barton and the Richardson pool in Stafford were the initial discoveries in the two counties.

In the 18 years since oil was discovered in the two counties, hundreds of wells have been drilled in each, and numerous pools have been opened. At the end of 1948 there were 59 producing oil and gas pools in Barton County, and 53 in Stafford County. The total area of the producing pools in Barton County was 89,350 acres in 1948, or 15.7 percent of the area of the county. In Stafford County the producing area was 29,680 acres, which was 5.8 percent of the county area.

The number of new wells drilled for oil or gas in Barton County during 1948 was 429; in Stafford County the number was 157. Wildcat wells drilled in the two counties in 1948 resulted in the discovery of 10 new pools in each county.

The Stanolind Oil and Gas Company maintained one secondary oil-recovery operation during 1948. This operation was experimental in that nitrogen, a relatively inert gas, was used as an injection medium to displace the oil and move it toward producing wells. The result of the operation has not been announced. In Stafford County seven secondary-recovery operations were reported for 1948. Six of these were in the Zenith-Peace Creek pool and one in the Kipp.

Geology.—Knowledge of the petroleum geology of Barton and Stafford Counties requires a study of the stratigraphy and sedimentation of Paleozoic rocks, and to the structure of those as well as the overlying or younger beds that crop out in the area.

The younger rocks, the Cretaceous, Tertiary, and Quaternary, that are exposed at the surface in the two-county area do not here produce oil or gas. Petroleum production comes from several of the older rocks or "sands," at points where favorable conditions of sand porosity or structure, or both, occur. Names of most of the geologic divisions and oil-producing formations that are commonly referred to by men in the oil business are shown in Figure 5. The largest producer in both counties, as well as in the state, is the dolomite of the Arbuckle group of Cambrian and Ordovician age. It occurs at depths of 3,000 to 4,000 feet in Barton and Stafford Counties, which today is regarded as an intermediate depth in oil production.

Barton County is in the center and Stafford County on the southern edge of the Central Kansas uplift. The uplift is a broad geologic structure, which in general is favorable for oil accumulation. Especially likely places for oil pools occur where minor structures, such as anticlines and domes, are superimposed on the major structure or uplift. This combination, given satisfactory source beds and sedimentary conditions, probably accounts for the large number of important oil pools in the two counties.

Oil and gas pools.—Tables 2 and 3 show the names and principal features of the oil and gas pools of Barton and Stafford Counties, respectively. The section-township-range location shown under the name of each pool is the location of the discovery well. A one-well pool is given an arbitrary area of 40 acres; the map areas of larger pools have been given or estimated approximately. The oil and gas production figures were supplied by the Kansas Corporation Commission. The geologic names are those in common use by petroleum geologists and engineers, as shown in Figure 5.

Geologic System	Some Subdivisions
Quaternary	Recent— Alluvium (Pleistocene) glacial sediments
Tertiary	(Pliocene) Ogallala
Cretaceous - - - - - - - Jurassic ?	
Permian	Stone Corral dolomite Herington limestone Winfield limestone Ft. Riley limestone Wreford limestone Indian Cave sandstone } Hugoton gas zones
Pennsylvanian	Tarkio limestone Topeka limestone Oread limestone Lansing-Kansas City sequence (limestones) "Wayside sand" "Peru sand" Ft Scott limestone "Squirrel sand" "Bartlesville sand" Sooy conglomerate Atokan rocks
Mississippian	"Chat" "Mississippi lime" Kinderhook (Chattanooga) "Misener sand"
Silurian and Devonian	"Hunton limestone"
Ordovician	Sylvan shale Viola limestone Simpson-St. Peter sandstone Arbuckle dolomite
Cambrian	Lamotte (Reagan) sandstone
Pre-Cambrian	Granite and quartzite

FIG. 5.—Generalized geologic column showing rock units commonly used by drillers and petroleum engineers. (Nixon, 1948, Fig. 3.)

TABLE 2.—*Data on oil and gas pools of Barton County*

Pool and location of discovery well	Discovery year	Area, acres	1948 production	Cumulative production to end of 1948	No. producing wells	Producing zone	Depth to producing zone, feet
Oil production, barrels							
Ainsworth South.... 10–17–13	1937	1,550	1,727	35,213	1	Arbuckle	3,390
Ames.............. 22–18–11	1943	620	231,686	712,369	26	K. C.-Lans. Arbuckle	3,042 3,348
Ames Northwest.... 9–18–11	1947	80	5,584	6,319	2	K. C.-Lans. Arbuckle	3,106 3,312
Ash Creek.......... 31–20–15	1947	600	220,906	283,172	24	Arbuckle	3,787
Bahr.............. 26–18–15	1943	40	None	29,925	0	Reagan	3,495
Barrett............ 36–16–14	1943	600	12,271	87,776	3	Arbuckle	3,463
Beaver............. 16–16–12	1934	1,300	360,554	2,782,995	56	Oread Arbuckle Reagan	2,885 3,348 3,335
Beaver North....... 4–16–12	1937	280	53,217	424,479	6	Arbuckle	3,316
Beaver Northwest... 6–16–12	1942	550	100,346	163,291	10	Shawnee K. C.-Lans. Sooy Arbuckle	
Beaver South....... 27–16–21	1945	160	7,453	41,151	3	Sooy Arbuckle	 3,359
Behrens............ 6–20–15	1944	950	103,208	304,903	19	Arbuckle	3,719
Bergtal............ 22–20–15	1941	40	639	1,331	1	Arbuckle	
Bloomer...........	1936	1,170	616,376	10,669,053	106	K. C.-Lans. Arbuckle	3,044 3,257
Boyd.............. 4–18–14	1942	1,700	395,168	1,507,420	34	K. C.-Lans. Arbuckle	3,438
Bryant............ 27–20–12	1948	300	4,049	4,049	3	Arbuckle	3,383
Carroll............ 21–17–14	1944	1,100	284,471	622,764	31	K. C.-Lans. Arbuckle	3,109 3,356

TABLE 2.—*Data on oil and gas pools of Barton County—Continued*

Pool and location of discovery well	Discovery year	Area, acres	1948 production	Cumulative production to end of 1948	No. producing wells	Producing zone	Depth to producing zone, feet
Oil production, barrels							
Carroll Southwest... 32–17–14	1947	80	11,342	15,324	2	Lansing	3,193
Davidson.......... 4–16–11	1930	390	10,383	210,758	4	K. C.-Lans. Sooy Arbuckle	3,016 3,317 3,314
Dundee............ 29–20–14	1945	40	1,097	4,962	1	Arbuckle	3,507
Eberhardt.......... 14–19–11	1935	320	27,257	355,960	8	K. C.-Lans. Arbuckle	3,194 3,311
Ellinwood North.... 33–19–11	1937	60	3,293	73,947	1	Arbuckle	3,328
Esfeld............. 15–16–11	1947	40	2,838	3,409	1	Arbuckle	3,343
Eveleigh........... 11–18–14	1943	680	159,579	443,576	20	K. C.-Lans. Arbuckle Pre-Cambrian	3,177 3,339 3,311
Feltes North....... 2–16–12	1944	40	Included	with Feltes	NW	Arbuckle	3,338
Feltes Northwest.... 2–16–12	1945	360	64,651	189,364	7	Arbuckle	3,342
Hagan............. 20–20–11	1938	160	39,975	298,853	4	Arbuckle	3,323
Hammer........... 35–19–12	1940	320	58,199	237,210	9	Arbuckle	3,348
Heizer............. 16–19–14	1935	40	2,468	37,491	1	K. C.-Lans.	3,228
Hiss............... 31–20–13	1936	300	179,439	976,749	18	K. C.-Lans.	3,270
Hiss Southeast...... 32–20–13	1948	40	587	587	1	Arbuckle	3,545
Hiss West.......... 36–20–14	1945	400	Included	with Hiss		K. C.-Lans.	3,250
Hoisington......... 21–17–13	1938	600	385,993	649,662	31	K. C.-Lans. Arbuckle	3,222 3,440

TABLE 2.—*Data on oil and gas pools of Barton County—Continued*

Pool and location of discovery well	Discovery year	Area, acres	1948 production	Cumulative production to end of 1948	No. producing wells	Producing zone	Depth to producing zone, feet
Oil production, barrels							
Homestead 22–18–13	1948	40	4,098	4,098	1	Arbuckle	3,310
Kaufman 33–15–12	1947	40	1,588	1,588	1	K. C.-Lans. Arbuckle Pre-Cambrian	 3,311
Klug 28–17–13	1946	80	7,808	23,214	2	Arbuckle	3,414
Klug North 27–17–13W	1948	60	10,675	10,675	2	Arbuckle	3,380
Kowalsky 32–20–11W	1941	200	77,288	89,962	7	Arbuckle	3,378
Kowalsky Northwest 30–20–11W	1947	460	59,263	59,263	9	K. C.-Lans. Arbuckle	3,185 3,381
Kraft-Prusa 10–17–11W	1937	24,060	6,887,650	38,159,450	576	Shawnee K. C.-Lans. Gorham Arbuckle Reagan Pre-Cambrian	2,885 3,160 3,335 3,281 3,310
Kraft-Prusa Northeast 36-16-11W	1941	160	12,641	166,791	3	Arbuckle	3,351
Lake Barton 21–18–13W	1948	60	459	459	1	Arbuckle	3,372
Lanterman 15–19–11W	1934	500	36,879	798,950	9	K. C.-Lans. Arbuckle	3,109 3,235
Laudick 28–16–12W	1948	200	29,616	29,616	5	Arbuckle	3,382
Marchand West 24–20–12W	1939	640	Included	with Silica			
Merten Northeast 36–18–15W	1946	40	2,737	11,106	1	Arbuckle	3,494
Mue-Tam 35–20–11	1942	40	None	17,731	0	Arbuckle	3,312
Odin* 3–17–12	1948	40	428	24,843	1	Arbuckle	3,321

TABLE 2.—*Data on oil and gas pools of Barton County—Continued*

Pool and location of discovery well	Discovery year	Area, acres	1948 production	Cumulative production to end of 1948	No. producing wells	Producing zone	Depth to producing zone, feet
			Oil production, barrels				
Otis-Albert......... 30–18–15	1935	6,400	1,679,672	2,252,518	97	Reagan	3,601
Pawnee Rock....... 13–20–16	1936	500	13,171	118,336	7	Arbuckle	3,832
Pawnee Rock East.. 17–20–15	1941	40	3,969	18,517	1	Arbuckle	3,814
Pritchard.......... 34–20–14	1944	770	194,032	614,039	18	Arbuckle	3,455
Rick............... 1–19–11	1936	600	40,333	728,277	10	K. C.-Lans. Arbuckle	3,106 3,355
Roesler............ 14–18–11	1943	40	2,872	28,928	1	Arbuckle	3,291
Rolling Green...... 36–20–13	1948	100	7,034	7,034	3	K. C.-Lans.	3,257
St. Peter.......... 5–19–11	1944	100	16,683	60,979	2	K. C.-Lans. Arbuckle	3,387
Silica.............. 12–20–11	1931	13,480	4,580,948	57,856,647	528	K. C.-Lans. Arbuckle	2,955 3,328
Silica South........ 24–20–11	1935	2,770	Included	with Silica	0	K. C. Lans. Arbuckle	3,035 3,268
Trapp............. 23–15–14	1936	13,700	4,838,554	37,567,411	488	Shawnee Dodge K. C.-Lans. Arbuckle	2,889 2,966 3,062 3,252
Unruh............. 24–30–15	1945	500	28,540	58,737	9	Arbuckle	3,641
Workman.......... 33–20–12	1944	40	2,601	15,262	1	Arbuckle	3,407
Workman Southeast 34–20–12	1948	40	None	None	0	Arbuckle	3,389
Yeakley........... 17–18–13	1948	100	13,120	13,120	2	Arbuckle	3,318

TABLE 2.—*Data on oil and gas pools of Barton County—Concluded*

Pool and location of discovery well	Discovery year	Area, acres	1948 production	Cumulative production to end of 1948	No. producing wells	Producing zone	Depth to producing zone, feet
Gas production, thousand cubic feet							
Adolph 16–20–15	1947	160	None	None	0	Arbuckle	3,734
Ash Creek (gas) 31–20–15	1948	50	602,150	...	...	Arbuckle	3,769
Behrens (gas) 6–20–15	1944	50	602,150	...	...	...	...
Bergtal (gas) 22–20–15	1941	500	None	None	...	Arbuckle	3,689
Eberhardt (gas) 14–19–11	1935	300	39,823	294,282	...	...	...
Krier 30–16–11	1944	...	47,068 (within Kraft-Prusa pool)	257,217	2	...	...
Otis-Albert (gas) 11–18–16	1930	7,000	1,816,866	...	30	Neva Reagan	3,507
Pawnee Rock (gas) 19 and 20–15 and 16	1936	20	240,860	...	...	...	...
Rick (Silica) (gas) 11–19–11	1941	60	16,500	360,722	2	Arbuckle	3,355
Unruh (gas) 24–20–15	1945	500	2,762,529	6,476,094	3	Arbuckle	3,641

TABLE 3.—*Data on oil and gas pools of Stafford County*

Pool and location of discovery well	Discovery year	Area, acres	1948 production	Cumulative production to end of 1948	No. producing wells	Producing zone	Depth to producing zone, feet
			Oil production, barrels				
Ahnert 26–22–13	1941	40	2,985	36,522	1	Arbuckle	3,784
Bedford 21–23–12W	1940	850	73,614	1,235,645	14	Arbuckle	3,859
Brock 12–23–12W	1944	640	60,004	239,008	10	Arbuckle	3,680
Byron 4–21–12W	1943	40	None	11,146	1	Arbuckle	3,460
Cadman 4–25–13W	1944	40	None	4,571	0	Viola	4,064
Copeland 30–24–13W	1948	60	None	None	0	K. C.-Lans.	3,752
Curtis 6–22–13W	1942	400	87,424	371,287	9	Arbuckle	3,693
Drach 12–22–13W	1937	2,200	547,609	3,340,403	48	Arbuckle	3,690
Drach Northwest 11–22–13W	1944	200	29,819	44,090	5	Arbuckle	3,738
Drach West 14–22–13	1938	40	None	100,738	0	Arbuckle	....
Farmington 34–24–15	1943	650	112,020	744,927	17	Kinderhookian Arbuckle	4,417
Fischer 31–21–12	1938	160	15,099	306,024	3	Arbuckle	3,641
Fischer Northwest 36–21–13	1948	160	19,769	19,769	6	Arbuckle	3,639
Gates 27–21–13	1933	700	159,936	1,562,593	28	Arbuckle	3,679
Gray 11–24–13	1946	120	6,153	26,764	3	K. C.-Lans.	3,762
Grunder 11–25–15	1943	40	1,125	16,090	1	K. C.-Lans.	3,945
Hazel 21–21–13	1942	250	17,021	215,649	6	Arbuckle	3,692

TABLE 3.—*Data on oil and gas pools of Stafford County—Continued*

Pool and location of discovery well	Discovery year	Area, acres	1948 production	Cumulative production to end of 1948	No. producing wells	Producing zone	Depth to producing zone, feet
Oil production, barrels							
Heyen............. 24–22–12	1943	780	83,283	226,392	15	Arbuckle	3,652
Hildebrand......... 2–24–12	1948	40	None	None	0	Viola	....
Hufford............ 33–21–13	1948	150	41,034	41,034	6	Arbuckle	3,755
Jordan............. 15–25–14	1936	300	29,131	641,539	7	K. C.-Lans.	3,722
Kelly.............. 35–23–12	1948	40	2,321	2,321	1	Arbuckle	3,870
Kenilworth......... 15–22–13	1947	200	51,965	58,620	6	K. C.-Lans. Arbuckle	3,505 3,808
Kipp.............. 27–25–14	1937	500	22,145	544,866	11	K. C.-Lans.	3,827
Kipp Northeast..... 23–25–14	1946	120	35,085	100,697	3	K. C.-Lans.	3,844
Leesburgh.......... 12–25–13	1938	700	140,704	2,124,165	16	Arbuckle	4,153
McCandless........ 30–25–13	1944	200	47,563	208,482	4	Simpson	4,251
Max............... 35–21–12	1938	700	175,582	1,157,055	16	K. C.-Lans. Arbuckle	3,356 3,570
Moon.............. 4–22–13	1948	40	370	370	1	K. C.-Lans.	3,530
Mueller........... 29–21–12	1938	1,600	Included	with Sittne	r	Arbuckle	3,594
Nellie............. 28–22–14	1948	40	7,700	7,700	1	K. C.-Lans.	3,696
Neola*............ 15–25–11	1948	40	4,387	4,387	1	Viola	3,921
O'Connor.......... 8–24–15	1948	40	1,470	1,470	1	K. C.-Lans.	3,768
Pundsack.......... 19–21–13	1947	80	21,978	25,366	3	Arbuckle	3,735

TABLE 3.—*Data on oil and gas pools of Stafford County—Continued*

Pool and location of discovery well	Dis-covery year	Area, acres	1948 produc-tion	Cumu-lative production to end of 1948	No. pro-ducing wells	Producing zone	Depth to pro-ducing zone, feet
Oil production, barrels							
Rattlesnake........ 13–24–14	1938	40	4,860	89,035	1	K. C.-Lans.	3,608
Rattlesnake West... 11–24–14	1944	40	4,350	17,940	1	K. C.-Lans.	3,759
Richardson......... 36–22–12	1930	1,200	787,475	9,340,133	60	Arbuckle	3,537
Richland........... 27–24–14	1944	200	25,966	159,097	5	Arbuckle	4,232
Riley.............. 28–23–11	1940	120	8,692	112,521	2	K. C.-Lans.	3,323
Rothgarn.......... 10–21–13	1943	120	5,756	72,519	2	Arbuckle	3,569
Rothgarn East...... 11–21–13	1948	40	4,962	4,962	1	Arbuckle	3,520
St. John........... 23–24–13	1935	980	139,200	2,306,660	24	K. C.-Lans. Arbuckle	3,588 4,075
St. John Townsite... 33–23–13	1944	300	24,547	220,955	6	K. C.-Lans. Arbuckle	 3,919
Sandago........... 12–21–12	1947	250	45,323	63,624	7	Arbuckle	3,480
Sand Hills.......... 19–21–11	1944	80	7,178	35,244	2	Arbuckle	3,548
Saundra........... 14–21–12	1946	300	26,413	78,561	7	Arbuckle	3,546
Shaeffer............ 3–21–13	1941	300	14,599	280,997	4	K. C.-Lans. Arbuckle	3,404 3,546
Sittner............. 33–21–12	1937	400	680,532	2,464,604	56	K. C.-Lans. Arbuckle	3,278 3,600
Sittner South....... 3–22–12	1938	1,700	145,895	1,554,914	22	Arbuckle	3,501
Snider............. 3–21–11	1936	400	25,468	358,899	3	Simpson	3,362

TABLE 3.—*Data on oil and gas pools of Stafford County—Concluded*

Pool and location of discovery well	Discovery year	Area, acres	1948 production	Cumulative production to end of 1948	No. producing wells	Producing zone	Depth to producing zone, feet
Oil production, barrels							
Snider South 16–21–11	1938	580	109,080	813,461	12	Simpson Arbuckle	3,402
Spangenberg 21–22–12	1943	40	9,478	62,601	1	Arbuckle	3,691
Stafford 15–24–12	1940	800	232,176	2,485,196	21	Viola Arbuckle	3,836 3,945
Syms 20–21–12	1943	120	28,512	99,930	2	Arbuckle	3,580
Syms East 21–21–12	1947	40	2,418	2,418	1	Arbuckle	3,565
Van Lieu 20–24–13	1943	120	13,858	174,241	3	Arbuckle	4,069
Zenith-Peace Creek 23–24–11	1937	8,500	442,668	18,593,380	215	Viola	3,860
Gas production, thousand cubic feet							
Bradbridge 6–24–15	1948	100	None	None	0	Arbuckle	4,020
Farmington (gas) 27–24–15	1948	50	201,404	201,404	2	Mississippian	4,207
Macksville 3–24–15	1947	160	670,710	730,691	0	K. C.-Lans.	
O'Connor (gas) 16–24–15	1947	160	None	None	0	Arbuckle	4,061
Zenith-Peace Cr. (gas) 23–24–11	1937	340	485,240	....	0	Viola	3,860

The Trapp pool in Barton and Russell Counties, which produced 10,385,385 barrels of oil in 1948 (4,838,554 in Barton County), at present is the largest producer in Kansas. However, its cumulative production, roughly 100 million barrels (about 38 million in Barton County) is only about half as great as the cumulative production of the much older El Dorado pool in Butler County. The Kraft-Prusa pool, located almost entirely in Barton County, is the second largest producing pool in the State at the present time. The Silica pool, mostly in Barton County but about one-sixth of which lies in Rice County, is the fourth largest producer in the State, and is third —next to the Trapp pool—in cumulative production.

A few pools in the two counties have been abandoned. Both the names and the areas of these have been omitted from the tables. The Salt Marsh and Smallwood pools in Stafford County were discovered and abandoned in 1948.

Figures 6 and 7 show the locations of all oil and gas pools in

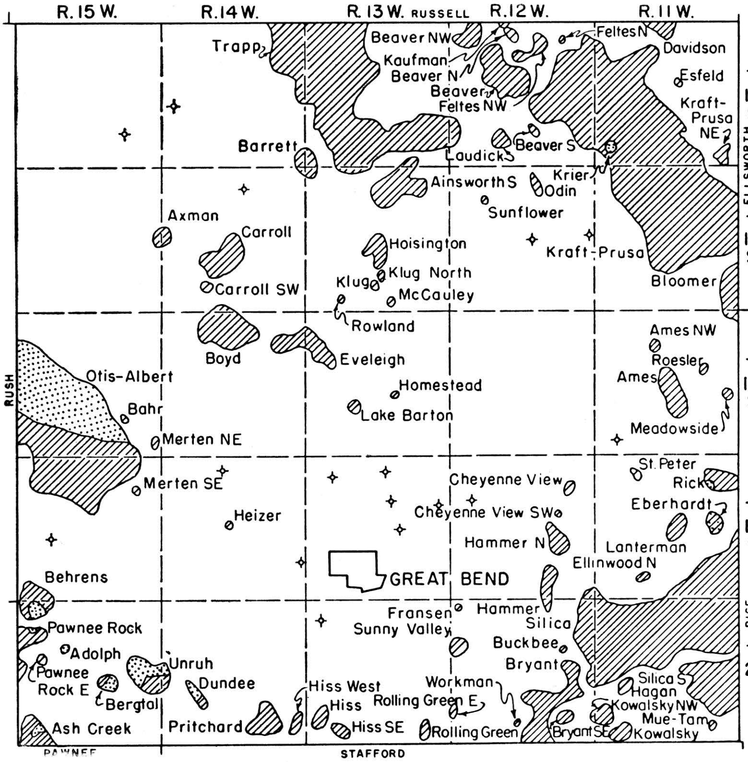

FIG. 6.—Map of Barton County showing oil and gas pools and dry wildcat tests drilled during 1948. (Gas, dots; oil, diagonal lines.)

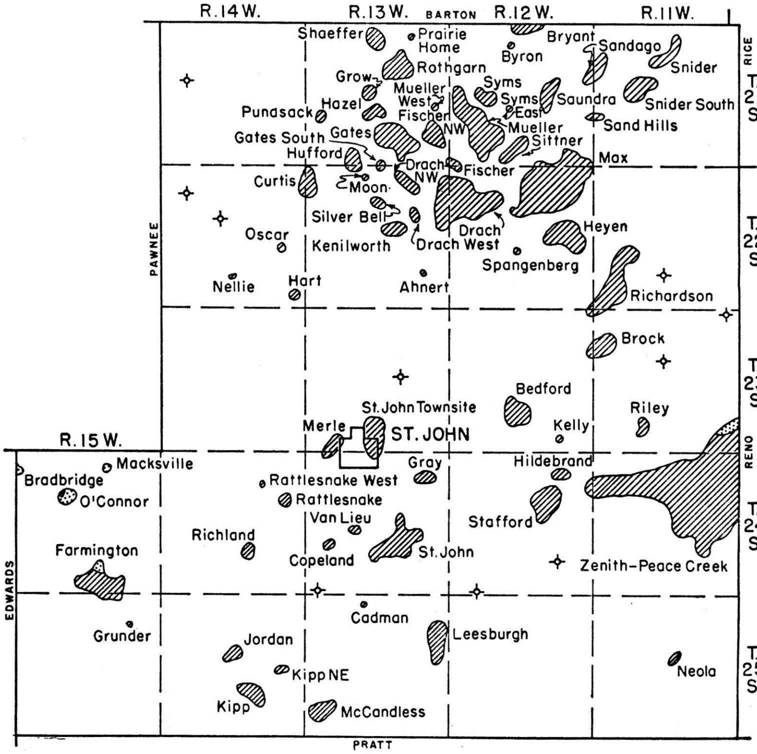

FIG. 7.—Map of Stafford County showing oil and gas pools and dry wildcat tests drilled during 1948. (Gas, dots; oil, diagonal lines.)

Barton and Stafford Counties that were producing in 1948. Wildcat wells also are shown, although many "extension" wells drilled within 2 miles of pool boundaries, classed as wildcats by some oil men, have been omitted to avoid confusion.

Extent and value of production.—During 1948 Barton County produced 21,897,415 barrels of oil and 6,127,946,000 cubic feet of natural gas; Stafford County produced 4,586,702 barrels of oil and 1,357,354,000 cubic feet of gas.

For some years Barton County has been the largest oil producer in the State. As the gravity of the oil, which determines its value, differs among the numerous pools, it is not possible to calculate exactly the value of oil produced in a given county. If the average value of oil produced in Kansas for the year, and the approximate value of natural gas at the wellhead are applied to the production in Barton and Stafford Counties, the totals are impressive, as shown in Table 4.

TABLE 4.—*Approximate value of oil and gas produced in Barton and Stafford Counties during 1948*

County	Production		Approximate value	County total value
Barton	Oil (bbls.)	21,897,415	$56,714,300	$57,041,532
	Gas (M cu. ft.)	6,127,946	327,232	
Stafford	Oil (bbls.)	4,586,702	11,879,558	11,952,041
	Gas (M cu. ft.)	1,357,354	72,483	

The above figures indicate that oil production is important in the economy of these two Kansas counties.

CERAMIC MATERIALS

BY NORMAN PLUMMER

The clays of the Dakota formation that occur in Barton County are suitable for several ceramic uses. Although these clays are exposed over a relatively small area, the amount of clay available totals several million tons. The most important clay area in Barton County is in the north half of T. 19 S., R. 13 W., and in the south half of T. 18 S., R. 13 W., between Great Bend and Hoisington.

The clays of the Dakota formation fire to colors ranging from nearly white to dark red. The clays firing to the lighter colors vary widely in other characteristics, ranging from highly plastic ball clays to extremely siliceous fire clays. Almost all these clays are refractory, having a pyrometric-cone equivalent between cone 26 and cone 30. The more plastic clays have a relatively high drying shrinkage and low firing shrinkage. The siliceous clays have relatively low shrinkages in both drying and firing and tend to be open-burning or rather porous at high temperatures. Optimum temperatures for firing the clays range from about cone 04 (1940° F.) to cone 14 (2550° F.). Individual clays have a long firing range which is seldom less than 200° F. and in many cases is as much as 400° F. The workability of the clays is good if they are neither extremely plastic nor siliceous. Suitable working properties can be obtained by blending the two types of clay.

The refractory clays are suitable for use in the manufacture of fire bricks and other refractory shapes. The white- to buff-firing clays are also excellent materials for use in the manufacture of face bricks, tiles, and pottery.

Red-firing clays also occur in the Dakota formation, and in most places in Barton County are found underlying the lighter-firing clays. The red-firing clays differ from white to buff-firing clays chiefly in that they contain a much higher percentage of iron oxide. Owing to the fluxing action of the iron oxide, these clays are less refractory and require somewhat lower temperatures for firing or "burning." Maturing temperatures for red-firing clays range from about cone 05 (1900° F.) to cone 9 (2345° F.). Like the lighter-firing clays, the red-firing clays have a long firing range; that is, any one sample of clay can be expected to fire to a sound product over a range of 200° to 400° F. This is a decided advantage in the manufacturing process in that a variety of colors can be obtained within this range of temperatures, and close controls need not be maintained on the kilns.

One ceramic plant is now using Barton County clay. The Great Bend Brick and Tile Company started production in the latter part of 1947 and is now producing about 800,000 buff face brick monthly, or the equivalent in structural tile. Clay samples numbers 1, 2, and 4, for which data are given in Table 5, were taken from the

TABLE 5.—*Ceramic properties of clays of the Dakota formation in Barton County, Kansas*

Tests by Norman Plummer in ceramics laboratories of the State Geological Survey of Kansas

	Sample number			
	1	2	3	4
Water of plasticity, percent	19.0	17.7	21.8	14.9
Linear drying shrinkage, percent	5.2	3.7	5.8	4.3
Fired color at cone 3*	Lt B	Cr	Br	Pr
Linear firing shrinkage at cone 3, percent	1.2	0.6	4.6	1.2
Total linear shrinkage, percent	6.4	4.3	11.7	5.5
Absorption, percent	10.9	12.9	4.7	9.1
Apparent porosity, percent	21.7	25.0	10.6	18.7
Apparent specific gravity	2.54	2.59	2.52	2.52
Bulk specific gravity	1.99	1.94	2.25	2.05
Hardness, as to steel†	S	S	H	S
Firing range, cones	3–8	4–9	04–4	3–7

1. Composite of 22 feet of clay of the Dakota (SW sec. 21, T. 18 S., R. 13 W.).
2. Composite of 17 feet of clay of the Dakota (SW sec. 21, T. 18 S., R. 13 W.).
3. Composite of 19 feet of clay of the Dakota (NE sec. 33, T. 18 S., R. 13 W.).
4. Composite of 15 feet of clay of the Dakota (SW sec. 21, T. 18 S., R. 13 W.).

* LtB, light buff; Cr, cream; Br, bright red; Pr, purplish red.

† S, softer than steel; H, harder than steel.

site of the clay-plant pit (SW¼ sec. 21, T. 18 S., R. 13 W.) for preliminary tests by the State Geological Survey. The table contains also the results of tests made by the State Geological Survey on a sample (no. 3) from sec. 33 of the same township.

SAND AND GRAVEL

Thick deposits of sand and gravel are found in the alluvium and terrace deposits along the Arkansas and Walnut Valleys in Barton County and in the Meade formation of Stafford and southern Barton Counties. Sand and gravel of the Meade formation is exposed at the surface in places along Rattlesnake Creek, the North Fork of the Ninnescah River, and around Big Marsh; elsewhere the Meade formation is covered by a few feet to more than 50 feet of dune sand. Sand and gravel deposits of both counties have been exploited for use in road surfacing, in concrete, and in gravel-packing water wells.

LIMESTONE

The top bed of the Greenhorn limestone has been quarried along its outcrop in the northern and western parts of Barton County and used as fence posts, bridge stone, and building stone. This bed is known as the Fencepost limestone. It is a rather hard, slightly sandy, chalky limestone about 8 inches thick. Because it is relatively free from joints, it can be split by wedges into blocks of the size and shape desired.

SALT

According to the logs of oil wells drilled in Barton and Stafford Counties, a bed of rock salt from less than 50 to nearly 200 feet thick occurs about 1,000 feet below the surface nearly everywhere in this area. Because of its great depth, the salt in Barton and Stafford Counties is only a potential resource and is of little economic value at present. Thick deposits of salt lie nearer the surface farther east in Kansas and are being exploited on a large scale.

An attempt was made to manufacture salt at Great Bend in 1888, when salt was first discovered in a boring there and the Great Bend Salt Company was formed. Two wells, each 1,400 feet deep, were drilled into the salt bed. Water was poured into the holes to dissolve the salt and pumped up as a saturated solution. The salt was then recovered by boiling and evaporation. The plant at one time employed 30 people and had a daily capacity of 400 barrels of salt (Hay, 1889, p. 200). The salt plant was abandoned after a few years.

About 20 years before the Great Bend Salt Company was formed, a small plant was built at Big Marsh in northeastern Stafford County and utilized salt water from the marsh in the manufacture of salt (Parker, 1911, p. 47). Salt from this plant was sold locally and used primarily for curing meat.

VOLCANIC ASH

Volcanic ash is exposed in a small area in sec. 28, T. 25 S., R. 11 W., in southeastern Stafford County. Landes (1928, p. 46) analyzed a sample of ash from this deposit and stated that it was of very good textural quality. However, the deposit is too small to be of commercial importance.

The remainder of this report is concerned with ground water, one of the most important natural resources of this area.

PHYSIOGRAPHY

All of the area herein described lies in the Plains Border section of the Great Plains province. The total relief of the area is approximately 370 feet. The highest point, about 3 miles northwest of Pawnee Rock in southwestern Barton County, has an altitude of about 2,080 feet, and the lowest point, where Cow Creek leaves the area, has an altitude of about 1,710 feet. Locally, the maximum relief is less than 200 feet.

The area may be divided into seven physiographic divisions, which exhibit differences in topography, drainage, and origin (Fig. 8). These are the Blue Hills upland, Cheyenne Bottoms, Cow Creek drainage basin, Walnut Valley area, Dry Walnut Valley area, Arkansas Valley area, and the Great Bend prairie. Descriptions of each division are given below.

Blue Hills upland

Most of the northern half of Barton County and two smaller areas in the west-central and southwestern parts of the county constitute the Blue Hills upland in this area (Fig. 8). These areas at one time were joined and were part of an extensive plain that extended westward and northward. The upland in northern Barton County is the divide area between the Smoky Hill River and the Arkansas River. It is a well-drained area that has been deeply dissected by many northward- and southward-flowing tributaries. The largest flat areas that remain are only a few square miles in extent.

The upland in west-central Barton County is a narrow spur between Walnut Valley and Dry Walnut Valley. Like the upland in northern Barton County, its surface has been dissected by short

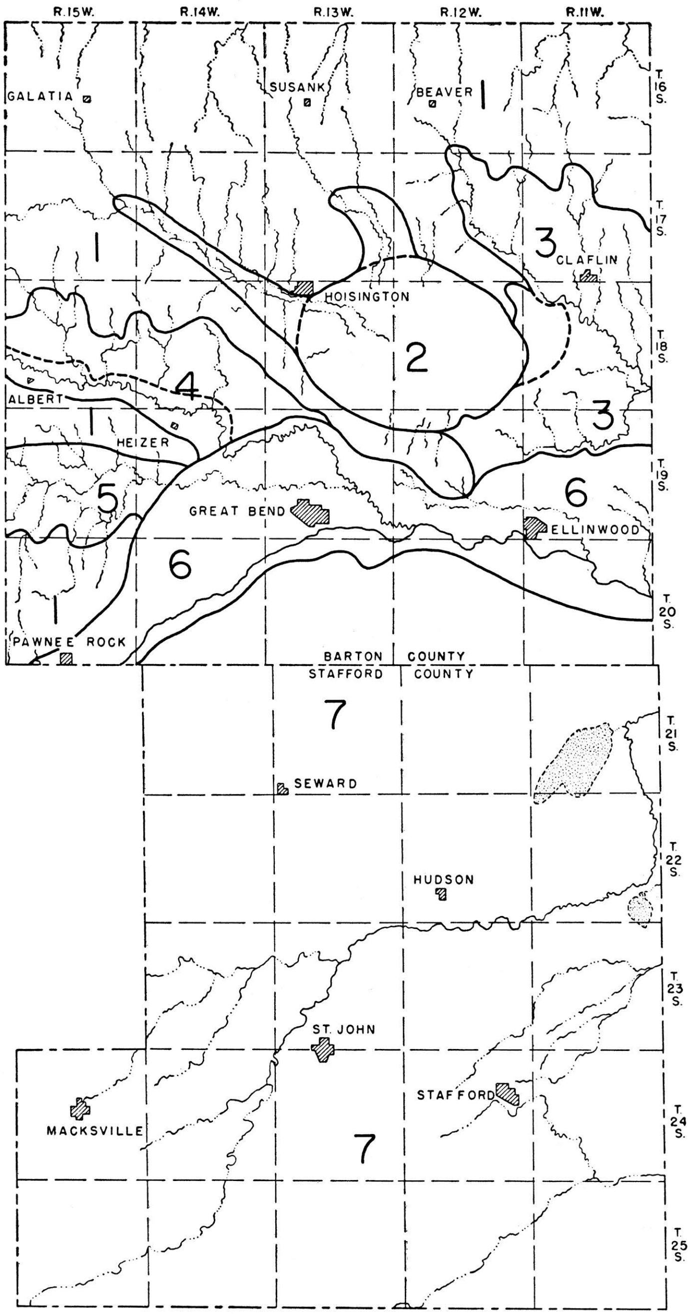

FIG. 8.—Physiographic divisions of Barton and Stafford Counties, Kansas: (1) Blue Hills upland; (2) Cheyenne Bottoms; (3) Cow Creek drainage basin; (4) Walnut Valley area; (5) Dry Walnut Valley area; (6) Arkansas Valley area; and (7) Breat Bend prairie.

streams, resulting in a rugged topography. A third upland area separates Dry Walnut Valley from the Arkansas Valley.

CHEYENNE BOTTOMS

The Cheyenne Bottoms in central Barton County is probably the most interesting physiographic feature in Barton and Stafford Counties. It is a basin that is roughly circular and comprises about 60 square miles. It has a flat, featureless surface that slopes very gently toward the east (Pl. 4, A and B). The bottoms is surrounded on all but the east and southeast sides by steep-sided bluffs composed of sandstone and clay or limestone. The enclosing wall at the east and southeast is composed of dune sand and unconsolidated sand and silt and has gentle slopes.

Blood Creek enters the basin from the west and Deception Creek and an unnamed stream enter from the north. At the southeast is a slightly elevated outlet, Little Cheyenne Creek. Although the elevation of the base of Little Cheyenne Creek is considerably less than that of the adjoining parts of the enclosing wall, it is somewhat greater than the general level of Cheyenne Bottoms. The Kansas Fish and Game Commission and the Federal Wildlife Service have recently acquired title to all the land in the Cheyenne Bottoms and plan to use it as a wildlife-conservation area. It is to be made into a large permanent lake by diverting water from Walnut Creek and Arkansas River into it through a diversion ditch.

Blood Creek originates on the upland in northwestern Barton County, flows southeastward, and enters Cheyenne Bottoms south of Hoisington. Downstream from a point about 10 miles above Cheyenne Bottoms, Blood Creek flows in a relatively flat valley, one-quarter to 1 mile in width, that is bordered by high, steep-sided bluffs capped by resistant sandstone or limestone. Above that point the stream has not yet cut through the limestones of the Greenhorn limestone and Carlile shale and the valley is V-shaped.

Deception Creek and its tributaries are short streams that enter Cheyenne Bottoms from the north. Deception Creek has a peculiarly shaped valley that is unusually wide for its length. The valley is 1 to 1½ miles wide and extends about 4 miles upstream. Its surface is uneven and slopes toward the stream from each side.

COW CREEK DRAINAGE BASIN

This physiographic division comprises the area in east-central Barton County drained by Cow Creek and its tributaries. It is a well-drained area intermediate in level between the uplands on the north and west and the Arkansas Valley on the south. The sur-

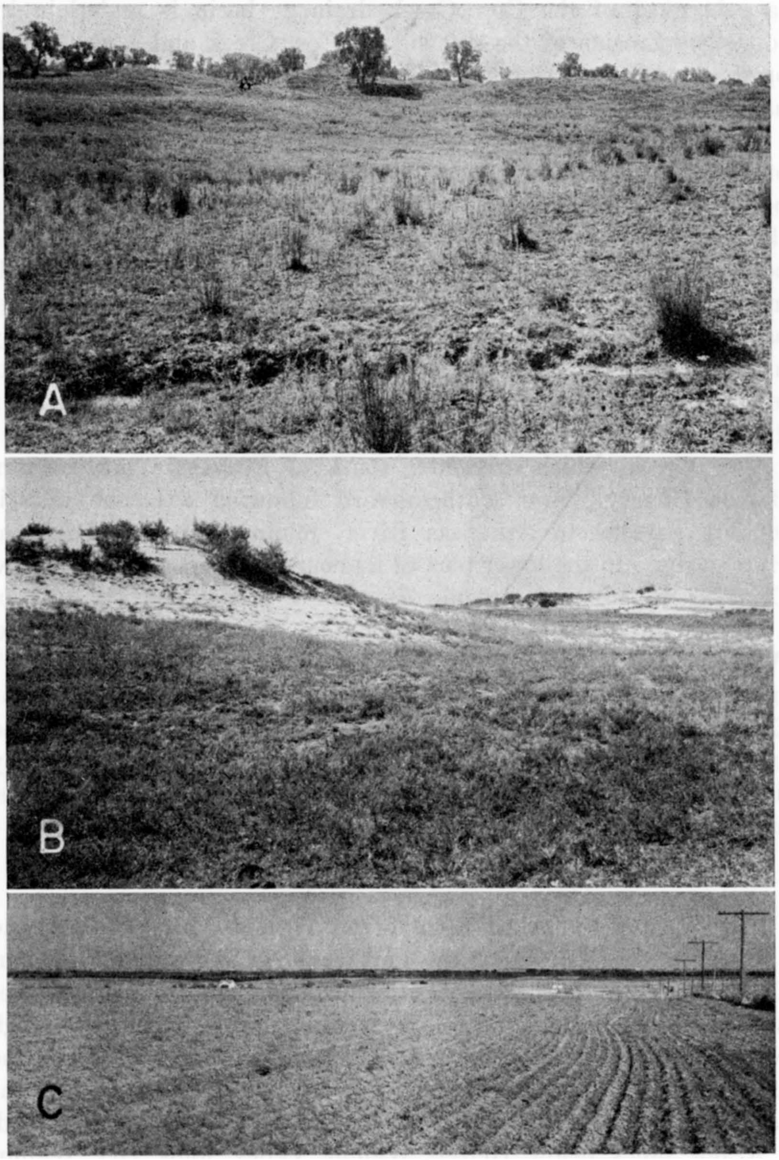

Plate 5.—*A*, Grass-covered sand hills in northeastern Stafford County, looking south from the cen. N. line NW¼ sec. 3, T. 21 S., R. 11 W. *B*, Bare sand dunes in the NE¼ sec. 30, T. 21 S., R. 11 W., Stafford County. *C*, View looking east across the Cow Creek drainage basin. The City of Claflin can be seen in the distance at the right. Taken from the SW cor. SE¼ sec. 35, T. 17 S., R. 12 W., Barton County.

face in most of the Cow Creek drainage basin is underlain by soft silt. Erosion of the soft silt by Cow Creek and a well-developed network of tributaries has produced a rolling topography having moderate to gentle slopes (Pl. 5C).

Included in this division is the small area of sand hills southwest of Claflin that covers about 8 square miles. The sand hills are bordered on the northwest by the Blue Hills upland and on the west by Cheyenne Bottoms. To the east and south the boundary of the sand hills is not sharp, for there the sand hills merge gradually with the surface of the Cow Creek drainage basin. This area is characterized by typical sand-dune topography having moderate slopes and hills separated by small basins. Its indefinite eastern boundary is shown in Figure 8 by means of a dashed line.

Cow Creek, which originates south of Beaver in northeastern Barton County, flows southeastward following a course that is roughly parallel to Arkansas River, joining Arkansas River at Hutchinson. In the lower part of its course in Barton County, Cow Creek is a perennial stream. Its valley proper consists only of a flood plain and is everywhere less than a quarter of a mile wide. With the exception of Little Cheyenne Creek, all of Cow Creek's tributaries of any size enter from the north. Little Cheyenne Creek heads near the southeast edge of Cheyenne Bottoms and enters Cow Creek on the south side near the Barton-Rice County line. Little Cheyenne Creek is perennial throughout all but the upper 2 to 3 miles of its course.

Walnut Valley Area

The Walnut Valley area comprises Walnut Valley proper and a broad terrace bordering the north side of the valley. Walnut Creek originates on the High Plains in Lane County about 85 miles west of Barton County. It follows a general easterly course through Ness and Rush Counties and enters Barton County at about the middle of the west county line. From there it flows east-southeastward and joins Arkansas River 4 miles below Great Bend.

A few miles below Heizer, Walnut Valley joins Dry Walnut Valley and Arkansas Valley to form a wide valley plain in the vicinity of Great Bend. This valley area common to three streams is included in the Arkansas Valley area.

Above this valley plain, Walnut Creek flows in a relatively flat valley that is from about three-fourths of a mile to almost 2 miles in width. Walnut Valley is bordered along its south side by high steep-sided bluffs capped by the Greenhorn limestone. A terrace from less than a mile to about 3 miles wide borders the north side of Walnut Valley in Barton County (Pl. 4C). The edge of this terrace lies 10 to 20 feet above the floor of Walnut Valley proper. Its surface slopes gently upward to the north and is terminated in most places by a low but conspicuous bluff formed by the Greenhorn limestone. In some places, particularly in the eastern part of the terrace area, the surface of the terrace merges gradually with the upland surface and there is no distinct topographic break between the two. Most of the terrace area is well drained by tributaries of Walnut Creek, although there are a few flat, poorly drained areas north and northwest of Heizer.

Dry Walnut Valley Area

This area includes the valley area occupied by Dry Walnut Creek and its tributaries. Dry Walnut Creek heads in southern Rush County about 10 miles west of the west Barton County line and follows a general easterly course to its junction with Walnut Creek northwest of Great Bend in south-central Barton County. In the lower 9 miles of its course Dry Walnut Creek flows across the Arkansas Valley. Above this point, Dry Walnut Creek occupies a valley about 2 miles wide with many broad reëntrant valleys occupied by tributary streams.

The numerous tributaries entering Dry Walnut Creek in this area have formed an uneven valley floor that has a general slope toward Dry Walnut Creek from both sides. Dry Walnut Valley is bordered on both the north and south by low terraces, the surfaces of which have been dissected by many tributary streams.

Arkansas Valley Area

The Arkansas Valley area includes the present flood plain of Arkansas River and associated low terraces bordering the flood plain. Arkansas River rises in the Rocky Mountains in central Colorado and follows an easterly course through eastern Colorado and western Kansas to a point in eastern Ford County, where it turns and flows northeastward. The river continues its northeasterly course into southern Barton County, where it again changes direction and flows southeastward. The Arkansas enters Barton County about 5.5 miles east of the southwest corner of the county and leaves the county at a point about 3 miles north of the southeast corner of the county. It reaches its northernmost position midway between Great Bend and Ellinwood, where it is about 6.5 miles north of the south Barton County line. The course of Arkansas River in this area is part of the large and unusual bend it makes in passing from eastern Ford County to Wichita. The average gradient of the river as it crosses Barton County is about 6 feet to the mile.

The width of the Arkansas Valley, including a low terrace along the north side, ranges from about 2 miles at Dartmouth to about 8.5 miles near the east Barton County line. The width of the valley increases from about 3 miles at Pawnee Rock to about 6 miles in the vicinity of Great Bend where the valleys of Dry Walnut Creek and Walnut Creek join the Arkansas Valley. Below Great Bend the valley narrows to about 2 miles at Dartmouth and again widens to about 8.5 miles below Ellinwood. The northern limit of the valley is marked by a distinct bluff except in the area north of Ellinwood where the Arkansas Valley is bordered by the Cow Creek drainage basin (Pl. 4D). The rise from the Arkansas Valley to the surface of the Cow Creek drainage area in many places is so slight that it is difficult to determine the boundary between the two. Sand hills control the southern limit of the valley, where the slopes in general are more gentle than those on the north side.

The terrace included in this division occurs along the north side of the river and lies 5 to 10 feet above the present flood plain. The edge of the terrace, which is nearly everywhere within a mile of the river, is distinct and easily identified from Pawnee Rock to a point about 3 miles above Great Bend and from Dartmouth to the east county line. In the Great Bend-Dartmouth area, where Arkansas River is at its northernmost position, the terrace was not observed. It is possible that the river in this stretch is flowing against the terrace edge.

Great Bend Prairie

This physiographic division comprises all the country embraced by the great bend of Arkansas River between Dodge City and Wichita and includes that part of Barton County lying south of Arkansas Valley and all of Stafford County. This region seems low because it is but little above the local base level of Arkansas River. In reality, however, it is an extension of the High Plains and is not low with respect to the country north, south, and east of it. The Great Bend prairie is an alluvial plain which in the greater part of this area has been covered by wind-blown sand.

Except for a relatively small area between St. John and Macksville and a small area along the North Fork of Ninnescah Creek southwest of Stafford, this region is characterized by typical sand-dune topography having moderate slopes and hills separated by small basins. Some of the hills stand 50 feet or more above the depressions. Much of this sandy region is covered by vegetation and a large part of it is farmed (Pl. 5A). In some parts of the area, particularly in the northeastern and southwestern parts, there are relatively large areas of bare sand that will not support much vegetation (Pl. 5B).

Two salt marshes interrupt the dune topography in northeastern Stafford County. Big Marsh, in T. 21 S., R. 11 W., covers about 16 square miles and is the larger of the two (Pl. 6). The surface of this marsh seems to be flat, but in reality it slopes gently toward an intermittent lake near the center of the marsh (Pl. 7C). The

PLATE 6.—Aerial mosaic of Big Marsh in northeastern Stafford County. The arrow points north and is about 2 miles long. Point of arrow is about 0.2 mile east of the NE cor. sec. 27, T. 21 S., R. 11 W. (U. S. Dept. Agric. photographs.)

PLATE 7.—*A,* Rattlesnake Creek, looking downstream from U. S. Highway 281, about 2.5 miles north of St. John. Note low terrace in right center of view. *B,* Big Marsh in northeastern Stafford County, looking east from the SW cor. sec. 22, T. 21 S., R. 11 W. Note flat covered with white precipitate in left center of view and the water draining into the road ditch. *C,* Same as B, but looking southwest.

size of this lake depends entirely on the stage of the water table. During dry periods when the water table is low, it is completely dry and its surface is incrusted with a white precipitate (Pl. 7B). During rainy seasons when the water table is high, a shallow lake covering several square miles is formed. Ditches drain part of the marsh area so the water is never more than a few inches deep (Pl. 7B and 7C). Short tributaries lead into the basin of the intermittent lake from the south, west, and north. A ridge of beach sand borders the eastern side of the basin. The only outlet from the basin is in the northeastern part of the marsh area where a short tributary carries the water from the marsh to Rattlesnake Creek.

A smaller marsh occurs about 6 miles southeast of Big Marsh. It is known as Little Marsh and covers about 1 square mile. During wet seasons almost the entire area of this marsh is under water and numerous small hummocks covered by short marsh grasses extend above the water surface. Unlike Big Marsh, this one has no surface outlet.

A relatively small but interesting physiographic feature in this area is the ancient beach ridge that occurs along the east side of the intermittent lake in Big Marsh. It is not a prominent feature from the ground and may be overlooked or confused with a dune ridge by the casual observer visiting this area, but on aerial photographs it is very prominent (Pl. 6). Its chief interest lies in the fact that it represents the shore line of a once more extensive lake. The ridge trends roughly southwest-northeast, is 10 to 15 feet high, and is from about 250 to 900 feet wide. It presents a nearly straight course except at the south where it swings westward around the south end of the intermittent lake. The profile of the ridge in most places is nearly symmetrical and smoothly rounded. A short tributary draw entering the basin from the south and the stream that serves as an outlet at the northeast have cut through the beach ridge, dividing it into three segments. The north segment of the ridge is narrow but is fairly distinct. The northern part of the middle segment has undergone more erosion than other parts of the ridge and therefore is less conspicuous.

The Great Bend prairie in general is poorly drained. The rainfall over a large part of this area collects in the numerous basins and hollows where a part of it seeps into the ground and the remainder is lost through evaporation and transpiration. Three streams drain parts of the area—Rattlesnake Creek, Peace Creek, and the North Fork of Ninnescah Creek.

Rattlesnake Creek heads in southern Ford County and follows a general northeasterly course to its junction with Arkansas River in southwestern Rice County. It enters Stafford County near the southwest corner, flows northeast to a point north of St. John, where it turns and flows eastward, passing within a half mile of Little Marsh. Just beyond Little Marsh, near the eastern edge of the county, it abruptly turns and flows north for about 8 miles, where it makes another sharp turn eastward and leaves Stafford County at a point about 2.5 miles south of the northeast corner. The tributary that drains Big Marsh joins Rattlesnake Creek where it makes the bend to the east.

Rattlesnake Creek is a meandering stream that has reached temporary base level (Pl. 7A). Its average gradient above St. John is about 7 feet to the mile and below St. John about 4 feet to the mile. It is a perennial stream from a point a few miles above St. John to where it turns north near Little Marsh; elsewhere it is intermittent. The valley of Rattlesnake Creek ranges from less than half a mile to about 2 miles in width and is bordered throughout most of its course in Stafford County by low, inconspicuous bluffs composed of dune sand. Marsh lands occupy much of the valley below St. John, especially near the stream, and north of Little Marsh are numerous small intermittent lakes in the valley. The floor of the valley seems to be topographically continuous with the surfaces of both Big and Little Marshes.

Peace Creek is an intermittent stream that heads about 2 miles west of Stafford and flows northeastward, leaving the county about 2 miles south of Little Marsh. It joins Arkansas River southwest of Sterling in southern Rice County. A tributary with several branches rises near the north edge of Stafford and joins Peace Creek half a mile above the county line. Peace Creek and its tributaries flow in narrow valleys bordered by low, inconspicuous bluffs.

The North Fork of Ninnescah Creek heads within half a mile of the south Stafford County line about 12 miles west of the southeast corner of the county, flows northeastward, and leaves the county about 6 miles north of the southeast corner. Except for the upper 4 to 5 miles of its course, it is a perennial stream in this area. Its valley in most places is narrow, with low bluffs having gentle slopes.

GEOLOGY AND ITS RELATION TO GROUND WATER *

Stratigraphy of Rock Formations *

All the rocks that crop out in Barton and Stafford Counties are of sedimentary origin and range in age from Cretaceous to Recent. Outcrops of the formations are shown on Plate 1. The oldest Cretaceous rocks exposed at the surface are lower Cretaceous (Comanchean) in age and comprise part of the Kiowa shale. The Upper Cretaceous (Gulfian) is represented by the Dakota formation, Graneros shale, Greenhorn limestone, and Carlile shale, which are exposed in the upland areas of Barton County. "Algal limestone" in the Ogallala formation of Tertiary age, locally caps Upper Cretaceous formations in parts of Barton County.

Undifferentiated deposits of silts, sands, and gravels of early Pleistocene age are exposed in a comparatively small area in northwestern Barton County. Also unconsolidated deposits of silt, sand, and gravel (Meade formation) of early Pleistocene age cover the eroded surface of the Cretaceous and, in some areas, Permian rocks in southern Barton and all of Stafford Counties. These deposits are exposed along Rattlesnake Creek and the North Fork of Ninnescah Creek in southern Stafford County. Later Pleistocene silts, sands, and gravels (Sanborn formation) underlie parts of the upland in southern Barton County, the Cow Creek drainage basin, and terraces along Walnut and Dry Walnut Creeks. Quaternary dune sand covers the surface in most of Stafford County and southern Barton County, and alluvium underlies the surface of the larger stream valleys and Cheyenne Bottoms.

Information on the unexposed rocks that lie beneath Barton and Stafford Counties has been obtained from test holes drilled during the course of the investigation, from logs of oil and gas test wells, and from exposures of these rocks in other areas. They include sandstones, siltstones, and shales (Cheyenne sandstone) of Lower Cretaceous (Comanchean) age that underlie the Kiowa shale over most of this area; and Paleozoic limestones, dolomites, and shales with lesser amounts of sandstone, gypsum, anhydrite, and salt that are encountered beneath the Cretaceous deposits.

A generalized section of the geologic formations of this area is given in Table 6. The locations of the 106 test holes drilled by the State Geological Survey during the course of the investigation are shown in Figure 9. Geologic cross sections based on these test holes are shown in Figure 10 and Plate 3.

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* The stratigraphic nomenclature used in this report is that of the State Geological Survey of Kansas and differs in some respects from that of the United States Geological Survey.

TABLE 6.—*Generalized section of the geologic formations of Barton and Stafford Counties, Kansas*

System	Series	Subdivision	Thickness	Physical character	Water supply
Quaternary	Recent and Pleistocene	Alluvium	0–125	Very coarse gravel, sand and silt comprising stream deposits in the larger valleys and Cheyenne Bottoms. Includes deposits underlying low terrace on the north side of Arkansas River and marsh deposits beneath Big and Little Marshes in northeastern Stafford County.	Yields large amounts of water to wells in Arkansas and Walnut Valleys and small to moderate amounts to wells in Cheyenne Bottoms and smaller stream valleys. Supplies water to many irrigation and a few industrial wells in Arkansas and Walnut Valleys. Waters in most places are hard, but otherwise are satisfactory for most purposes. Waters of poor quality found in Cheyenne Bottoms and Big and Little Marshes.
		Unconformable on older formations			
		Dune sand	0–50+	Fine- to medium-grained wind-blown sand containing minor amounts of silt, clay, and coarse sand. Covers most of the area in Barton and Stafford Counties south of the Arkansas River and a small area on the east side of Cheyenne Bottoms.	Not known to yield water to wells. Areas underlain by dune sand are excellent areas for ground-water recharge from local precipitation.
		Unconformable on older formations			
	Pleistocene	Sanborn formation	0–138	Silt, sandy silt, and fine sand that locally contains lenses of coarse sand and gravel. Occurs beneath Cow Creek drainage basin, Cheyenne Bottoms-Arkansas Valley divide area, and Dry Walnut Valley-Arkansas Valley divide area, and includes terrace deposits along north side of Walnut Valley and along Dry Walnut Valley.	Supplies water to domestic and stock wells in the Cow Creek drainage area and the Walnut Valley terrace area. Large supplies available from these deposits locally in Walnut Valley terrace area. Waters from the Sanborn formation are moderately hard to hard, samples ranging from 242 to 606 parts per million in hardness.
		Unconformable on older formations			
		Meade formation	0–210+	Interbedded lenses of unconsolidated gravel, sand, and silt. Caliche is common throughout the formation. Meade formation occurs at the surface or at shallow depth beneath dune sand or alluvium over all Stafford County and the southern part of Barton County.	Sand and gravel beds of the Meade formation are the most important sources of water in Stafford County and southern Barton County, and yield large supplies. Most of the domestic and stock wells and all of the irrigation and public-supply wells south of Arkansas Valley derive water from these deposits, and many of the domestic, stock, irrigation, and industrial wells in Arkansas Valley and the city-supply wells at Great Bend derive all or a part of their water from this formation. In most areas the water is of good quality, but locally it is highly mineralized.
		Unconformable on older formations			

TABLE 6.—*Generalized section of the geologic formations of Barton and Stafford Counties, Kansas—Continued*

SYSTEM	Series	Subdivision	Thickness	Physical character	Water supply
Quaternary	Pleistocene	Undifferentiated pleistocene deposits Unconformable on older formations	0–40	Unconsolidated silt, sandy silt, and clay that contains caliche, and, locally, thin lenses of sand and gravel. Restricted to relatively small area surrounding Galatia in northwestern Barton County.	Supplies water to a few domestic and stock wells in the vicinity of Galatia.
Tertiary	Pliocene	Ogallala formation Unconformable on older formations	1–3	In northern and western Barton County, "algal limestone" from less than 1 to 3 feet thick caps small hills at widely scattered localities.	Not known to yield water to wells in this area.
Cretaceous	Gulfian*	Carlile shale (Fairport chalky shale member)	85 (?)	Chalky shale and thin beds of chalky limestone, containing thin flat concretions in the lower part.	Furnishes small to meager supplies of hard to very hard water to a few dug domestic and stock wells in northern Barton County. Not an important water bearer.
		Greenhorn limestone	85–90	Chalky tan to blue-gray shale, alternating with beds of hard chalk; contains thin beds of hard crystalline limestone in lower part.	Furnishes small to meager supplies of water to a few domestic and stock wells in northern Barton County. Not an important water bearer.
		Graneros shale	30–40	Noncalcareous light-gray to blue-gray and brown shale; contains selenite, pyrite, and thin beds of fine-grained sandstone.	Relatively impermeable; not known to yield water to wells in this area.
		Dakota formation	200–300	Alternating beds or lenses of varicolored clay, shale, siltstone, and fine- to coarse-grained sandstone. Contains "ironstone" in thin beds, lignite, and a little pyrite.	About a third of the recorded wells in Barton County derive water from sandstones of the Dakota formation. Is the chief source of water in the upland areas of Barton County. Supplies water to city wells at Claflin and Ellinwood. Yields of wells range from a few gallons a minute to a few hundred gallons a minute. Some wells yield water of good quality, but others yield water too highly mineralized for ordinary uses.

Table 6.—*Generalized section of the geologic formations of Barton and Stafford Counties, Kansas—Concluded*

System	Series	Subdivision	Thickness	Physical character	Water supply
Cretaceous	Comanchean*	Kiowa shale	90–168+	Light-gray to black shale and sandy shale, containing beds or lenses of fine- to medium-grained sandstone and thin beds of hard calcareous sandstone and sandy limestone, Pyrite, gypsum, shell fragments, and cone-in-cone calcite are common. Exposed in two small areas, in southeastern Barton County and northeastern Stafford County.	Unimportant in this area as a water bearer. One recorded well (20–11–12ad) in Barton County taps sandstone of the Kiowa shale. In most of this area water in the Kiowa is probably highly mineralized.
		Cheyenne sandstone	0–134+	Sandstone, very fine- to medium-grained, siltstone, and some clay and shale. Not exposed in Barton and Stafford Counties.	No wells in Barton and Stafford Counties obtain water from the Cheyenne sandstone. Scanty data indicate that the water in this formation is highly mineralized and unfit for ordinary uses.
Permian	Guadalupian and Leonardian*	Undifferentiated red beds		Red siltstone, shale, and sandstone containing lesser amounts of salt, gypsum, anhydrite, limestone, and dolomite. Not exposed in Barton and Stafford Counties	No wells in Barton and Stafford Counties obtain water from Permian rocks. Water is probably too highly mineralized for most ordinary uses.

* Classification of the State Geological Survey of Kansas.

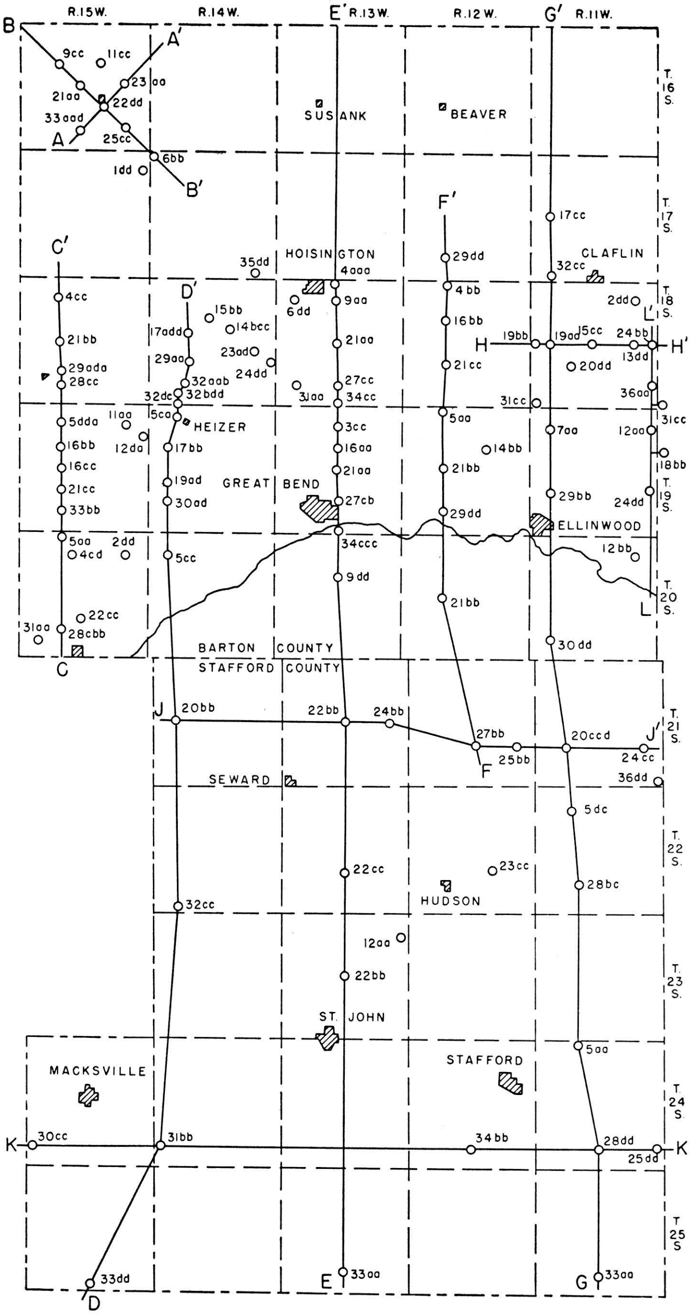

FIG. 9.—Location of test holes drilled in Barton and Stafford Counties (numbered circles) and location of geologic cross sections shown in Figure 10 and Plate 3. The numbers shown give the section, quarter section, and quarter-quarter section in which the test hole is located.

Pre-Permian Rocks

Pre-Permian rocks are not exposed in Barton and Stafford Counties, and their nearest outcrops are in the eastern part of the state, more than 100 miles east of the area under consideration. Knowledge of the character and distribution of these older rocks in central Kansas has been obtained by various geologists by studying the samples and logs of the deep oil wells that have been drilled in this area. The discussion of the Pre-Permian rocks in Barton and Stafford Counties that is given below is based mostly on data obtained from Wallace Lee (oral communication), geologist of the Federal and State Geologic Surveys, but in part on reports by Moore and Jewett (1942), Koester (1935), and Ver Wiebe (1938).

The oldest rocks encountered by deep drilling are granite, schist, gneiss, and other types of igneous and metamorphic rocks of Pre-Cambrian age. These rocks form the "basement" of Kansas, and in Barton and Stafford Counties they are encountered at depths ranging from about 3,500 feet to about 5,000 feet below the surface. Unconformably overlying the Pre-Cambrian "basement" rocks are sandstone, sandy dolomite, and dolomite (Arbuckle group and

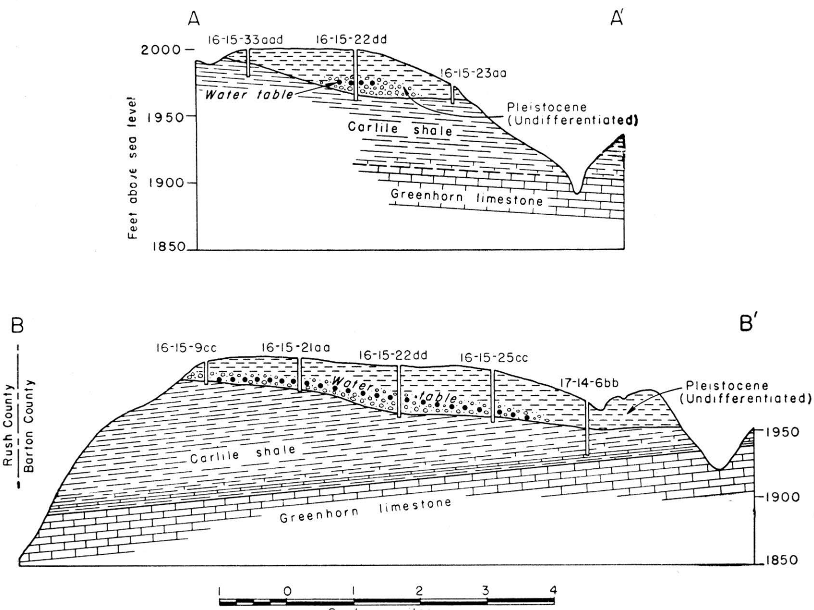

Fig. 10.—Geologic cross sections of Tertiary deposits in northwestern Barton County, along lines A-A′ and B-B′ in Figure 9.

Lamotte sandstone) of Cambrian and Ordovician age, the oldest sedimentary rocks in this area. They are missing entirely in parts of west-central Barton County and attain a thickness of more than 600 feet in southern Stafford County. The Arbuckle group is one of the most important oil-producing zones in this area.

Rocks of Ordovician age include the Simpson group and the Viola limestone. The Simpson group, which consists of green shale and sandstone, occurs only in the southern half and along the eastern edge of Stafford County where it is generally less than 100 feet thick. Oil has been found in the Simpson group in northeastern and south-central Stafford County. The Viola limestone is found only in the southern two-thirds of Stafford County. It lies on the Simpson group in the southern half of the county and overlaps onto older rocks of the Arbuckle group to the north. The thickness of the Viola limestone in this area is everywhere less than 100 feet and in most places is less than 50 feet. It is an important oil-producing formation in the Stafford-Zenith area.

No strata of Silurian age have been encountered in Barton and Stafford Counties. The Chattanooga shale of Mississippian or Devonian age unconformably overlies the Viola limestone in southeastern Stafford County but is missing elsewhere. The thickness of the Chattanooga shale is 100 feet or less. Mississippian limestone and shale having a thickness of 75 feet or less are present in approximately the southeast quarter of Stafford County. These strata overlie the Chattanooga shale where it is present and overlap the older Viola limestone to the north.

Pennsylvanian rocks, consisting predominantly of limestone and shale, underlie the entire area under consideration. They range in thickness from about 1,200 feet in Barton County to 1,400 feet in southern Stafford County. Their base is marked by a prominent unconformity. In southeastern Stafford County, Pennsylvanian strata lie above Mississippian rocks; in west-central Barton County they lie on Pre-Cambrian rocks; elsewhere, they are found on Cambrian or Ordovician rocks. The Pennsylvanian System includes the important oil-producing rocks of the Kansas City and Lansing groups.

Permian Rocks

The Cretaceous rocks, and locally Pleistocene rocks, in Barton and Stafford Counties rest upon an eroded floor of Permian sedimentary rocks—the oldest sediments penetrated in test holes put down during the investigation. Rocks of Permian age are not exposed in this area; their nearest outcrops are to the east in eastern

Rice County and southern Reno County. They are encountered in Barton and Stafford Counties at depths ranging from about 75 feet in northeastern Stafford County to 500 feet or more in parts of northern Barton County and are between 1,500 and 2,000 feet thick.

The upper part of the Permian System (Guadalupian-Leonardian Series) is chiefly nonmarine in origin and is composed of red siltstone, shale, and sandstone with lesser amounts of salt, gypsum, anhydrite, limestone, and dolomite. The salt beds in this area are from less than 50 feet to about 200 feet thick and are encountered about 1,000 feet below the surface (Bass, 1926, p. 90). The lower part of the Permian system (Wolfcampian Series) is largely marine in origin and is composed chiefly of limestone, dolomite, and shale but also contains some sandstone and anhydrite.

No wells obtain water from Permian rocks in Barton and Stafford Counties. Adequate supplies of water are available to wells in most places from rocks overlying the Permian. Furthermore, water obtained from Permian rocks in this area probably would be too highly mineralized for most ordinary uses. A sample of water collected from test hole 22-11-5dc3, which penetrated Permian rocks in sec. 5, T. 22 S., R. 11 W., northeastern Stafford County, contained 8,688 parts per million of dissolved solids and 4,730 parts of chloride, and had a total hardness of 1,386 parts (analysis 22-11-5dc3, Table 10).

Cretaceous System

Rocks of Cretaceous age having an aggregate thickness of more than 500 feet overlie the eroded surface of Permian rocks in Barton County and most of Stafford County. Approximately the lower four-fifths of the Cretaceous section in this area consists of clay, shale, and sandstone and represents the Comanchean Series (Cheyenne sandstone and Kiowa shale) and lower part of the Gulfian Series (Dakota formation and Graneros shale). The upper part of the Gulfian (Greenhorn limestone and Carlile shale) consists chiefly of limy sediments including calcareous shale, thin chalk beds and chalky limestone.

The Cheyenne, Kiowa, and Dakota formations in central and south-central Kansas have been discussed at some length in recent reports by Plummer and Romary (1942), Swineford and Williams (1945), and Latta (1946).

COMANCHEAN SERIES

Cheyenne Sandstone

The Cheyenne sandstone is not exposed in the Barton-Stafford County area, but was penetrated by several test holes drilled during the course of the investigation and by many oil wells at depths ranging from less than 50 feet near the outcrop of the Kiowa shale in northeastern Stafford County (Pl. 1) to more than 350 feet in central Barton County. It is absent in north-central and northeastern Barton County because of non-deposition and in much of eastern Stafford County where it was removed by erosion after the Cretaceous Period. Elsewhere, the Cheyenne overlies Permian rocks and is from a featheredge to more than 100 feet thick. The maximum known thickness in this area is 134 feet and was encountered in test hole 19-14-17bb about a mile southwest of Heizer.

The nearest outcrop of the Cheyenne sandstone is in the type area near Belvidere in southeastern Kiowa County. There it has an average thickness of about 45 feet and consists principally of light-colored fine- to medium-grained, friable, cross-bedded sandstone and lenses of sandy shale and conglomerate (Latta, 1946, p. 235). The material penetrated by test holes and oil wells in Barton and Stafford Counties was principally white to light-gray siltstone and white to light-gray, light pale-green, light gray-green, and gray-green, friable to tightly cemented, very fine to medium-grained sandstone. Beds or lenses of light-colored sandy clay and sandy shale are interbedded with the siltstone or sandstone, and pyrite and carbonaceous material are not uncommon.

So far as is known, no wells in Barton and Stafford Counties obtain water from the Cheyenne sandstone. Water from this formation probably would be highly mineralized. Sometime prior to 1900, a deep test well was drilled near Great Bend. At a depth of 344 feet, which would be in the Cheyenne sandstone, flowing water was encountered. The well is reported to have had a flow of 10 gallons a minute, but the water was too salty to be used (Darton, 1905, p. 291). Flowing water was also encountered in the Cheyenne sandstone in test hole 19-14-17bb in the NW¼ sec. 17, T. 19 S., R. 14 W. A sample of this water was analyzed for chloride and found to contain 33,000 parts per million.

Kiowa Shale

The Kiowa shale is the oldest formation exposed in Barton and Stafford Counties (Pl. 1). It is exposed in the bluff of the Arkansas

Valley along the Barton-Rice County line in the eastern parts of secs. 1 and 12, T. 20 S., R. 11 W., where about 50 feet of tan to brown sandstone is exposed, and in a small area in the northwestern part of T. 22 S., R. 11 W., northeastern Stafford County, where it consists of dark-colored fossiliferous shale and brown sandstone. It is encountered by test holes and oil wells beneath younger deposits in all but the extreme southeastern part of Barton County and in most of the western half of Stafford County. Elsewhere, it was removed by post-Cretaceous erosion except for a small area surrounding its outcrop in northeastern Stafford County. The Kiowa shale is underlain by the Cheyenne sandstone everywhere but in the north-central and northeastern parts of Barton County, where it overlaps the Cheyenne and rests unconformably on Permian rocks. It is overlain conformably by the Dakota formation or unconformably by unconsolidated silt, sand, and gravel of Quaternary age.

The full thickness of the Kiowa shale in Barton and Stafford Counties ranges from about 90 feet in north-central Stafford County to a known maximum of 168 feet in central Barton County (log 18-13-34cc). In northern Barton County its thickness probably does not exceed 125 feet. Frye and Brazil (1943, p. 20) report that the thickness of the Kiowa shale does not exceed 100 to 125 feet in Russell County, and Fent (1950, p. 60) reports its thickness in Rice County as ranging from 95 to 130 feet.

The Kiowa shale is predominantly marine in origin and consists of light- to dark-gray, blue-gray, and black shale, sandstone lenses, and thin beds of limestone. The shale generally is sandy or is interbedded with thin layers of sandstone. Sandstones in the Kiowa are white to gray and yellow-brown and are fine- to medium-grained. Thin hard beds composed of gray to white calcareous or quartzitic sandstone or gray to gray-white sandy limestone were encountered in the lower part of the Kiowa shale in most of the test holes drilled in the Barton-Stafford County area. In a few test holes the drill was unable to penetrate these hard beds. Pyrite, gypsum, shell fragments, and cone-in-cone calcite are common in the Kiowa and lignite is rarely present.

The contact of the Kiowa shale and the overlying Dakota formation is difficult to distinguish in many places for the two formations are conformable and gradational. Lithologic types common to the upper part of the Kiowa shale are also common to the lower part of the Dakota formation. Where similar lithologic types of the two formations are in contact, it is generally impossible to identify the formational boundary. In a few test holes (18-11-13dd, 19-14-17bb, and 20-14-5cc) in Barton and Stafford Counties, it was not possible to mark the contact and, therefore, the Kiowa shale and Dakota formation are shown together on the logs of these test holes and in the cross sections.

The Kiowa shale, which consists chiefly of materials having low permeability, is a poor water-bearing formation. Some water could be obtained by wells from the sandstone lenses, but in most of the area such water probably would be highly mineralized. Test hole 20-14-5cc in the SW cor. sec. 5, T. 20 S., R. 14 W., in southwestern Barton County, encountered artesian water in the Kiowa shale at a depth of 286 feet that was under sufficient pressure to cause it to flow at the surface. A sample of the water was analyzed and found to contain 28,300 parts per million of chloride. Record was obtained of only one well (20-11-12ad) in this area that taps the Kiowa. This well penetrates sandstone and is located in the outcrop area of the Kiowa shale in southeastern Barton County. It is an unused well, 51.5 feet deep, that was formerly used to supply water for drilling an oil well.

GULFIAN SERIES

Dakota Formation

The Dakota formation is composed of alternating beds of varicolored clay, shale, siltstone, and sandstone, in which siderite, hematite, and limonite are abundant. Lignite and thin beds of brown "ironstone" are also commonly found in the formation (Pl. 8B). Pyrite, which is abundant in the underlying Kiowa shale, is much less common in the Dakota formation.

Clay is the dominant type of rock in the Dakota formation and is light to dark gray, white, tan, brown, yellow, and red. White, gray, yellow, tan, and brown fine- to coarse-grained sandstone occurs as thin beds in the clay and as lenses ranging from a few feet to more than 30 feet in thickness. There is no regularity in the occurrence of the thick sandstone lenses. They are discontinuous bodies that may be encountered in any part of the formation. Although clay is more abundant, the sandstones of the Dakota formation are more prominent in the areas of outcrop because of their greater resistance to erosion (Pl. 8A).

Plummer and Romary (1942) subdivide the Dakota formation into two members, the Janssen clay member above, and the Terra Cotta clay member below, and give complete descriptions of each.

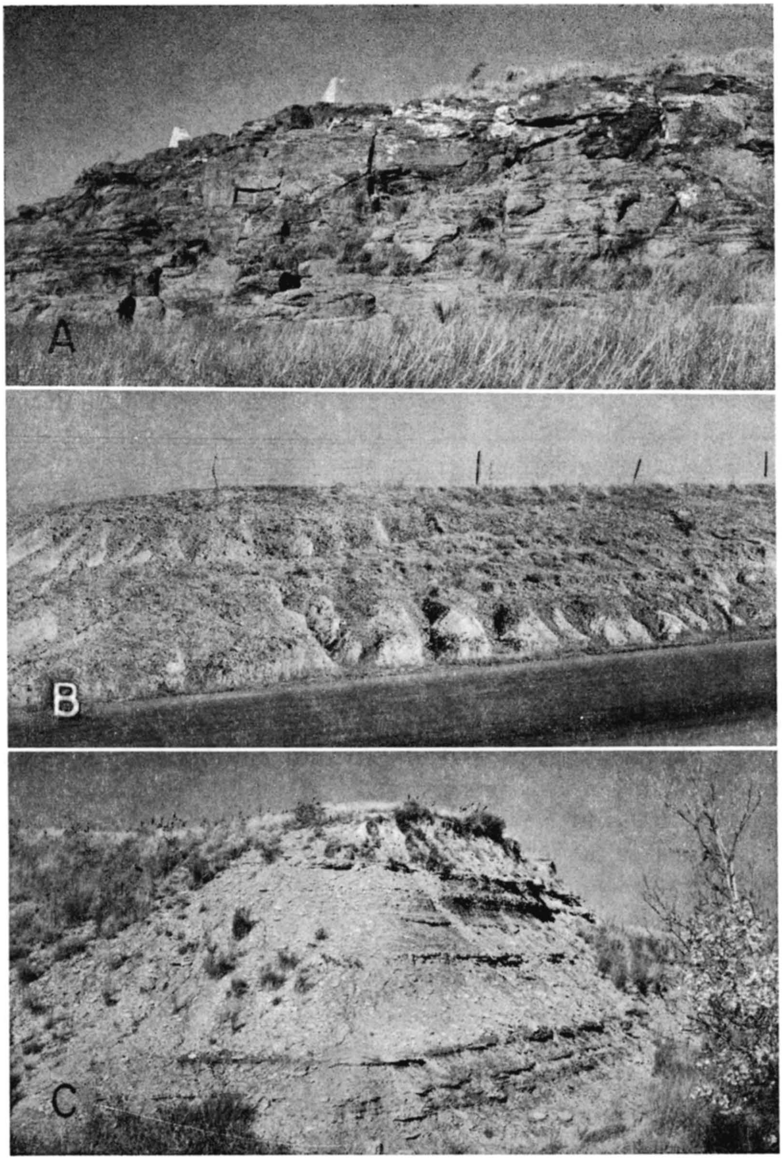

PLATE 8.—*A,* Sandstone of the Dakota formation above Pawnee Rock in the NE¼ sec. 33, T. 20 S., R. 15 W., Barton County. *B,* Clay and thin beds of sandstone and "ironstone" of the Dakota formation. Road cut along U. S. Highway 281 in the SW¼ sec. 21, T. 18 S., R. 13 W., Barton County. *C,* A part of the Graneros shale. South bluff of the Smoky Hill Valley in the NE¼ sec. 19, T. 15 S., R. 15 W., Russell County, about 3 miles north of northwest corner of Barton County.

No attempt was made to differentiate these members in the Barton-Stafford County area.

The Dakota formation is 200 to 300 feet thick in the subsurface in the northern part of the area where the formation occurs in its full thickness. It is exposed along both sides of Blood Creek Valley, in the bluffs on the northern, northeastern, and southwestern sides of Cheyenne Bottoms, along the west side of Cow Creek west of Claflin, along the south side of Walnut Creek Valley, in three small areas north of Pawnee Rock, and in two small areas along the north bluff of Arkansas Valley between Great Bend and Dartmouth (Pl. 1). Only a small part of the total thickness is exposed at any one of these places. The formation is not exposed anywhere in Stafford County.

The Dakota formation lies conformably beneath the Graneros shale or unconformably beneath Quaternary silts, sands, and gravels in all but the southeastern part of Barton County, where it has been removed by erosion. Less than 50 feet of the Dakota unconformably underlies the Meade formation in extreme northwestern Stafford County. Elsewhere in that county it has been completely removed by erosion (Fig. 11).

The Dakota formation is the chief source of water in the upland areas of Barton County. The quantity of water available from this formation is quite variable and cannot be determined with certainty at any locality without test drilling. Wells that tap only the thin fine-grained sandstones have very small yields, whereas those that penetrate the thicker coarser-textured sandstone lenses have yields ranging from a few gallons a minute to a few hundred gallons a minute. About a third of the recorded wells in Barton County obtain water from the Dakota formation. Most of these are domestic and stock wells, but five (wells 18-11-4ad1, 18-11-4ad2, 19-11-31bb, 19-11-31bdc1, and 19-11-31bdc2) are city-supply wells and two (wells 16-13-8aa and 16-13-18aa) are industrial wells (Table 12). The Cities of Claflin and Ellinwood obtain their water supplies from wells penetrating thick sandstones of the Dakota formation.

The quality of the water from wells tapping the Dakota differs considerably; some wells yield water of good quality, whereas water from other wells is too highly mineralized to be suitable for ordinary uses. The analyses of 29 samples of water from the Dakota formation are given in Table 8. These samples contained 305 to 6,323 parts per million of dissolved solids, and their hardness ranged from 29 to 626 parts per million. Seven of the 29 samples

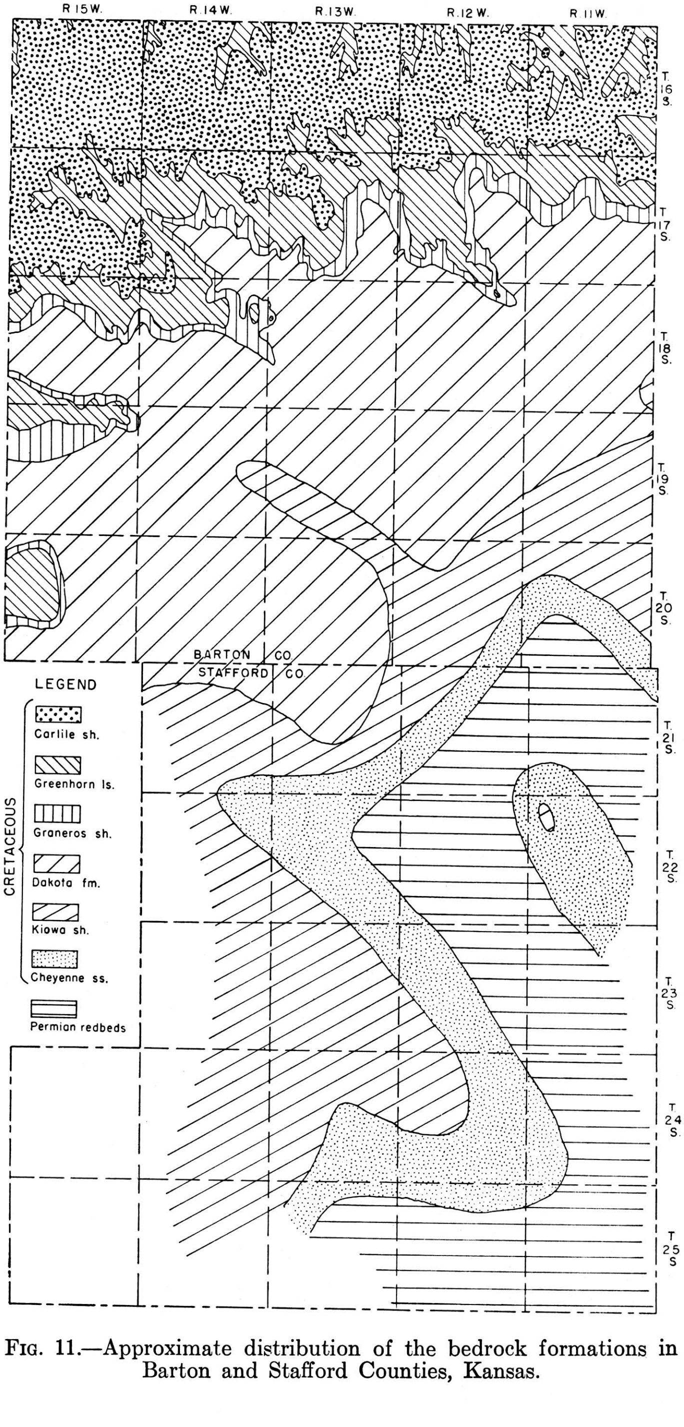

FIG. 11.—Approximate distribution of the bedrock formations in Barton and Stafford Counties, Kansas.

contained more than 1,000 parts of chloride and many of them were high in fluoride and iron.

Graneros Shale

The Graneros shale consists of 30 to 40 feet of light- to dark-gray, blue-gray, and brown noncalcareous shale overlying the Dakota formation and overlain by the Greenhorn limestone. The shale contains selenite and pyrite and has thin yellow streaks of iron sulfate along bedding planes and joints. Thin beds of brown to dirty-white fine-grained sandstone occur in the formation in some areas and, locally, thin beds of hard, sandy fossiliferous limestone occur near the top of the formation. The Graneros shale is poorly exposed in the central, west-central, and southwestern parts of Barton County where it forms a gentle slope beneath the more resistant beds of the Greenhorn limestone. In most places in the outcrop area, exposures of the Graneros shale are obscured by soil. Better exposures of the formation are found in parts of Russell County (Pl. 8C). In Barton County the Graneros shale is found in the subsurface beneath the Greenhorn limestone, or beneath Quaternary sediments in narrow belts adjacent to the Greenhorn, but is not present anywhere in Stafford County (Fig. 11).

Where the Graneros shale is sandy, it probably would yield small supplies of water to wells; but in most places, because of the low permeability of the shale, it would yield little or no water to wells. None of the wells visited in Barton County yield water from this formation.

Greenhorn Limestone

The Greenhorn limestone underlies the surface or is found beneath the Carlile shale in the northern and western parts of Barton County (Pl. 1). It is 85 to 90 feet thick in this area and consists of alternating beds of hard chalk and chalky shale containing, in the lower part, thin beds of hard crystalline limestone. The individual chalk and limestone beds are generally less than a foot thick. On fresh exposures and in test-hole cuttings the chalks, limestones, and shales are light to dark gray and blue gray in color. Upon weathering, the color changes to tan, orange tan, or light gray.

Previous workers (Rubey and Bass, 1925, p. 45; and Bass, 1926, pp. 31-35) have subdivided the Greenhorn into four members, which from top to bottom are the Pfeifer shale, Jetmore chalk, Hartland shale, and Lincoln limestone.

The Pfeifer shale member comprises about the upper 20 feet of the Greenhorn limestone. It consists of chalky shale containing

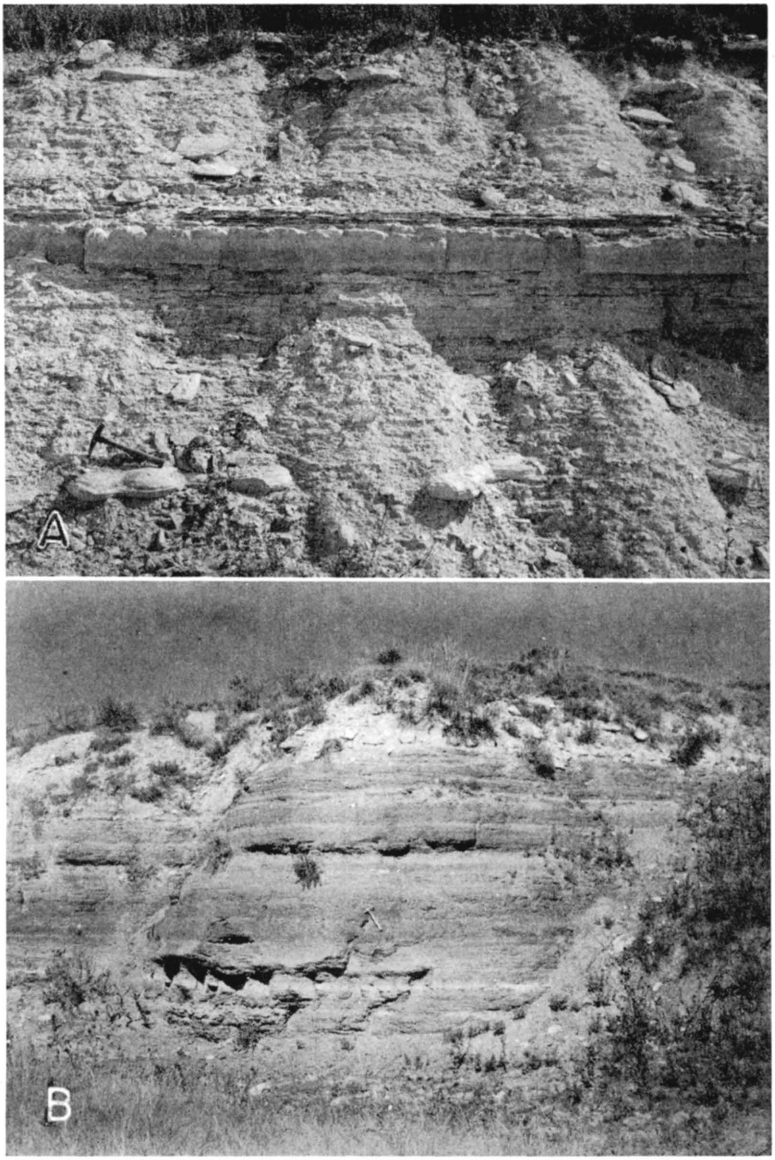

PLATE 9.—*A*, Contact of the Fairport chalky shale member of the Carlile shale and the Pfeifer shale member of the Greenhorn limestone. Contact is at top of the Fencepost limestone bed in center of picture. Note the thin, flat concretions above and below the contact. In road cut along U. S. Highway 281 in the NW¼ sec. 11, T. 16 S., R. 14 W., Barton County. *B,* Contact of the Jetmore chalk member and the Hartland shale member of the Greenhorn limestone. Contact is at top of dark-colored beds. Bluff of draw in the SW¼ sec. 36, T. 15 S., R. 15 W., Russell County, about 0.2 mile west of northwest corner of Barton County.

thin beds, 3 to 10 inches thick, of chalk and chalky limestone. At the top of the member is the Fencepost limestone—a bed of hard chalk about 9 inches thick that weathers yellow gray or cream and has a prominent iron-stained median line (Pl. 9A). It has been quarried for building stone, bridge masonry, and fence posts (Pl. 10C). Several layers of thin, flat concretions occur in the soft chalky shale underlying the Fencepost limestone bed (Pl. 9A).

The Jetmore chalk member, which underlies the Pfeifer shale member, consists of about 20 feet of alternating thin chalk beds and chalky shale. It is capped by a hard, fossiliferous bed of chalky limestone approximately 1 foot thick. Thin, flat chalky concretions occur in the shale immediately underlying this capping bed. The thin chalk beds of this member decrease in thickness downward, those in the lower part being about an inch in thickness. The chalky shale beds separating the chalk beds decrease in thickness from about 2 feet in the upper part to 2 inches near the base.

Below the Jetmore chalk member lies the Hartland shale member, consisting of 30 to 40 feet of chalky shale that contains a few thin beds of chalk and clay (Pl. 9B). The Lincoln limestone member, the basal member of the Greenhorn limestone, is about 20 feet thick and is composed of alternating beds of chalky shale and chalky limestone (Pl. 10C). Thin beds of hard crystalline limestone occur at the base and top of this member.

A few domestic and stock wells in the northern half of Barton County derive small supplies of water from the Greenhorn limestone. Most of these are shallow dug wells of large diameter that tap the near-surface weathered part of the formation, although some are deeper drilled wells. The yields of most of these wells are meager. Chemical analysis of a sample of water from well 16-14-2cb, which obtains water from the Greenhorn limestone, is given in Table 8. The water is hard but otherwise of good quality.

Carlile Shale

The Carlile shale, which conformably overlies the Greenhorn limestone, has been divided into three members by workers in other areas—the Codell sandstone member at the top, the Blue Hill shale member, and the Fairport chalky shale member at the base. Only a part of the lower, the Fairport chalky shale member, is present in the area under consideration.

The Fairport chalky shale member forms the surface of most of the upland area in northern Barton County (Pl. 1). In Russell County, where the full thickness of the member is present, it is 85

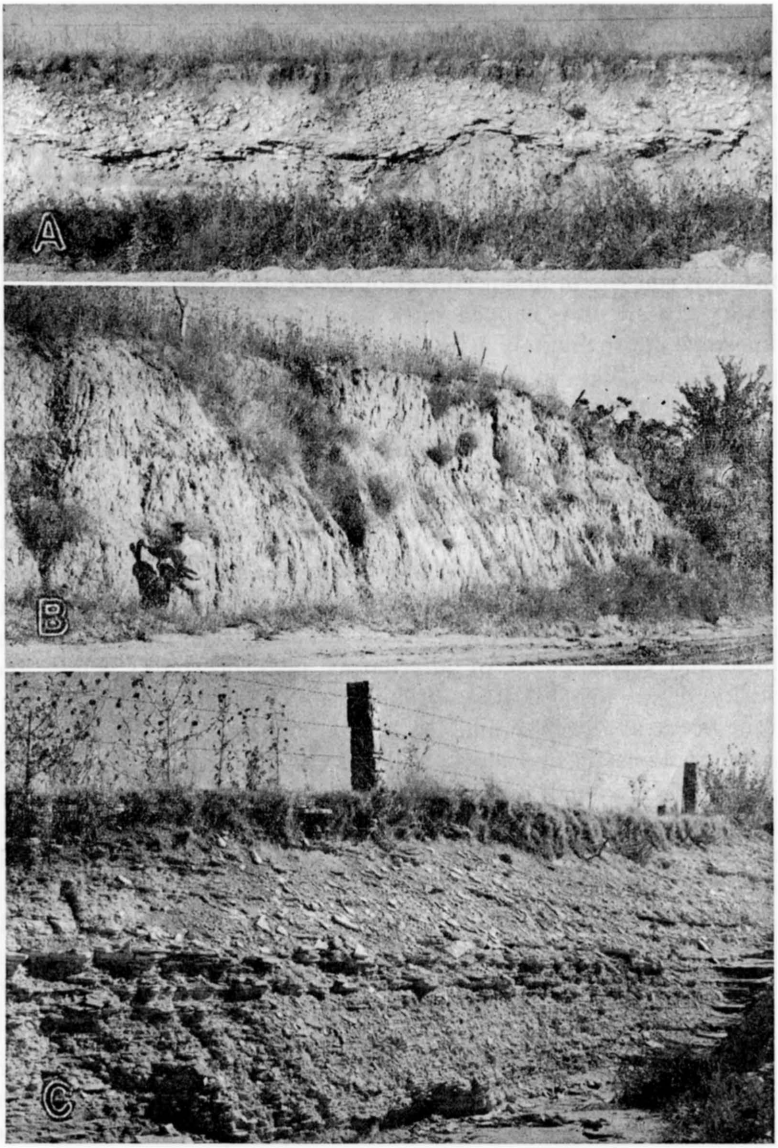

PLATE 10.—*A*, "Algal limestone" in road cut at center of east line sec. 20, T. 17 S., R. 13 W., Barton County. *B*, Silt of the Sanborn formation. Road cut along west line SW¼ sec. 5, T. 18 S., R. 11 W., Barton County. *C*, A part of the Lincoln limestone member of Greenhorn limestone. Road cut at cen. W. line sec. 32, T. 17 S., R. 14 W., Barton County. The fence posts shown were quarried from the Fencepost limestone, the top bed of the Pfeifer shale member of the Greenhorn limestone.

feet thick (Rubey and Bass, 1925, p. 40), but only the lower 50 feet or less remains in most of Barton County. Nearly the full thickness may be present in the vicinity of Galatia where it is covered by Tertiary sediments. The Fairport is lithologically similar to the underlying Greenhorn limestones and consists of chalky shale and thin beds of chalky limestone (Pl. 9A). Thin, flat concretions similar to those found near the top of the Greenhorn limestone occur in the lower part of the Fairport chalky shale member of the Carlile shale.

A few wells on the upland in northern Barton County obtain small to meager supplies of water from the Carlile shale for domestic and stock use. Records of seven such wells (16-11-24cc, 16-11-27cd, 16-12-12cb, 16-12-15ad, 16-14-26bb1, 16-15-28ca, and 17-15-18aa) are given in Table 12. All these are large-diameter dug wells less than 50 feet in depth. Samples of water from wells 16-11-27cd and 16-14-26bb1 contained, respectively, 673 and 2,277 parts per million of dissolved solids, 247 and 440 parts of chloride, and had hardness of 442 and 1,564 parts.

Tertiary System

PLIOCENE SERIES

Ogallala Formation

In the northern and western parts of Barton County a hard grayish-white arenaceous limestone marked with pinkish irregular concentric bands at the top is found capping small hills at widely scattered localities. At different places, it was found unconformably overlying the Dakota formation, Greenhorn limestone, and Carlile shale. In most places it is only a few inches thick and is broken into irregular blocks of different sizes. The greatest thickness noted was in a road cut 0.4 mile south of the NW cor. sec. 21, T. 17 S., R. 12 W., where it is somewhat more than 3 feet thick (Pl. 10A). The individual areas underlain by this limestone are only a few acres in extent, although at one time they probably had wider distribution. This limestone is believed to be equivalent to the "Algal limestone" or capping limestone of the Ogallala formation of other areas (Elias, 1931, pp. 136-141; Frye, 1945, pp. 89-91). It lies everywhere above the water table and does not yield water to wells in this area.

Quaternary System

PLEISTOCENE SERIES

Unconsolidated deposits composed of clay, silt, sand, and gravel of Pleistocene age overlie the eroded surface of Cretaceous and

Permian rocks in all of Stafford County, much of the southern half of Barton County, in the vicinity of Galatia, and in the Cow Creek drainage basin in east-central Barton County. These materials comprise undifferentiated early Pleistocene sediments, the Meade formation, and the Sanborn formation.

Undifferentiated Pleistocene Deposits

Unconsolidated clay, silt, sand, and gravel unconformably overlie the Carlile shale and form the surface rock of the upland in the vicinity of Galatia in northwestern Barton County (Pl. 1). The area underlain by these deposits is roughly elongate, is 1 to 4 miles wide and about 7 miles long, and trends northwest-southeast. Nine test holes (16-15-9cc, 16-15-11cc, 16-15-21aa, 16-15-22dd, 16-15-23aa, 16-15-25cc, 16-15-33aad, 17-14-6bb, and 17-15-1dd) were put down to determine the character, thickness, and distribution of these sediments. Geologic cross sections based on these test holes are shown in Figure 10. Although similar in lithology to the Ogallala formation these sediments occupy a lower topographic position and are believed to represent deposits laid down by an early Pleistocene stream that crossed this area. Because of their local extent and the doubt as to their exact age, no formation name is assigned to them in this report.

In the Galatia area these deposits range from a featheredge to about 40 feet in thickness. They consist chiefly of light-colored silt, sandy silt, and clay containing caliche and, locally, thin lenses of fine to coarse sand. Six of the nine test holes penetrated from less than 1 foot to 14 feet of poorly sorted granitic sand and gravel at the base. Some of the gravel is coarse, but it is mostly fine to medium in texture. Test hole 16-15-25cc penetrated about 6 inches of white, very hard lime-cemented gravel just above the Carlile shale and below 8 feet of loose sand and gravel.

A few domestic and stock wells in the immediate vicinity of Galatia obtain water from these early Pleistocene sands and gravels. A sample of water from well 16-15-15dc2, which taps these deposits, was analyzed and found to be a relatively soft sodium chloride water.

Meade Formation

The character of the Meade formation is well shown by the logs of test holes that penetrated these deposits in Barton and Stafford Counties, and its distribution and relation to older and younger deposits are shown by cross sections in Plate 3.

The Meade formation consists chiefly of sand, gravel, and silt, the proportions of which differ greatly from place to place. The materials making up the formation generally are poorly sorted, and gradations from one lithologic type to another take place within short distances, both laterally and vertically. The sands, gravels, and silts form lenses that overlap one another irregularly. Some of the beds have been loosely cemented by calcium carbonate.

The finer materials of the Meade formation are composed mostly of silt and in general include only small amounts of clay. Test hole 21-11-36dd in northeastern Stafford County penetrated 21 feet of blue-gray clay between depths of 126 and 147 feet, but this seems to be an exceptional occurrence. Lenses of sandy silt ranging in thickness from a few inches to more than 50 feet are common and are likely to be encountered in any part of the formation. The color of the silt is tan to brown, buff, yellow, and various shades of gray. Some of the lenses are very calcareous and are white to gray.

Interbedded with the silt and sandy silt are thick lenses of granitic sand and gravel. Beds composed entirely of sand or gravel are uncommon, but beds composed of a mixture of sand and gravel in different proportions make up more than half the formation. Silt is also a common constituent intermixed with the sand and gravel. The sand ranges in texture from fine to coarse, and the gravel ranges from fine to very coarse. Pebbles from 1 to 4 inches in diameter occur with the coarser gravel. Lenses of cross-bedded sand and gravel ranging in thickness from a few inches to more than 100 feet may be encountered in any part of the formation. Most of the material has been derived from crystalline igneous and metamorphic rocks, although pebbles of Cretaceous sandstone and "ironstone" are common in gravel pits in Stafford County and were found in the gravels near the base of the formation in a few test holes. (See logs 21-11-24cc, 22-11-28bc, and 24-11-5aa.)

Caliche in the form of nodular calcium carbonate is common in the silt, sand, and gravel throughout the Meade formation. Volcanic ash, although not common, also occurs in the Meade formation. A 2-foot bed of ash was penetrated between depths of 135 and 137 feet in test hole 19-10-18bb in sec. 18, T. 19 S., R. 10 W., Rice County. Ash is poorly exposed in the NW¼ SE¼ sec. 28, T. 25 S., R. 11 W., in southeastern Stafford County. Most of the deposit there is covered by dune sand.

The Meade formation is exposed in two areas in Stafford

County—the one lies west and southwest of St. John and the other lies south and southeast of Stafford (Pl. 1). Excellent exposures of the sands and gravels are found in commercial gravel pits in these two areas. This formation occurs in the subsurface beneath dune sand or alluvium over all Stafford County and the southern part of Barton County. It was difficult to differentiate the Meade formation from the alluvium of the Arkansas Valley; therefore, a dashed line has been drawn separating the two in the cross sections. The Meade formation also occurs beneath the Sanborn formation in the lower part of the deep channel north and northeast of Ellinwood. (See logs 18-11-36aa, 19-11-12aa, and 19-10-18bb; and section L-L′, Pl. 3.)

The thickness of the Meade formation in this area ranges from a featheredge to more than 200 feet. Its thickness is controlled largely by the uneven surface on which these sediments were deposited (Fig. 10). It is thinnest in the northwestern part of T. 22 S., R. 11 W., and the central and north-central parts of T. 21 S., R. 13 W., where it overlies buried Cretaceous highs (Pl. 3, E-E′, G-G′, and J-J′). It is thickest in the buried lowland areas of Stafford County. The greatest thickness penetrated was 210 feet in test hole 25-15-33dd in sec. 33, T. 25 S., R. 15 W., near the southwest corner of Stafford County. An oil test in sec. 17, T. 22 S., R. 14 W., in west-central Stafford County, penetrated 205 feet of the Meade (log 22-14-17baa), and test hole 21-11-36dd at the southeast corner of T. 21 S., R. 11 W., encountered 203.5 feet of material that has been assigned to this formation. In the buried channel north and northeast of Ellinwood in Barton County, the thickness of the Meade formation ranges from a featheredge to about 60 feet.

The sand and gravel lenses of the Meade formation are the most important sources of ground water in Stafford County and southern Barton County. Most of the domestic and stock wells and all the irrigation and public-supply wells south of Arkansas Valley derive water from these deposits, and many of the domestic, stock, irrigation, and industrial wells in Arkansas Valley and the city-supply wells at Great Bend derive all or a part of their water from the Meade formation.

The beds of sand and gravel in the Meade formation, particularly those composed dominantly of gravel, are very good water bearers and generally yield abundant supplies of water. The yields of wells tapping these deposits range from a few gallons a minute for small domestic and stock wells to several hundred gallons a minute for the larger irrigation, industrial, and public-supply wells. Some irrigation wells in Stafford County yield 700 to 900 gallons a minute, and a few irrigation wells in the Arkansas Valley that penetrate both the Meade formation and alluvium have yields greater than 1,000 gallons a minute.

Waters in the Meade formation, although moderately hard, are in most places of good quality and suitable for most ordinary uses. In the vicinity of Big and Little Marshes in the northeastern part of Stafford County, waters in the Meade formation locally are highly mineralized and contain excessive concentrations of chloride. In some places the waters from the middle and upper parts of the formation are of good quality, whereas waters from the basal part of the formation are highly mineralized. The chemical character of the waters in the Meade formation are discussed in more detail on pages 132-134.

Sanborn Formation

The term Sanborn formation was first used in 1931 by M. K. Elias (p. 163) to describe Pleistocene deposits in northwestern Cheyenne County, Kansas, that were composed chiefly of loess. Courtier (1934, p. 34) used the term Sanborn formation in a similar sense in south-central Kansas, including Stafford County. Since that time, the term has been used in central Kansas to include not only loess but also Pleistocene sand and gravel deposits younger than the Meade formation (Frye and Fent, 1947, p. 42). This latter usage has been accepted by the State Survey and will be followed in this paper.

Silt and associated sediments of the Sanborn formation underlie the surface in the following areas in Barton County: (1) the divide between Cheyenne Bottoms and Arkansas Valley; (2) terraces along Dry Walnut Valley and the upland divide between Dry Walnut and Arkansas Valleys; (3) the terrace along the north side of Walnut Creek; and (4) the Cow Creek drainage basin. The areal distribution of the Sanborn formation in these areas is shown on Plate 1, and each area is described in the following paragraphs.

Cheyenne Bottoms—Arkansas Valley divide.—The divide area between Cheyenne Bottoms and Arkansas Valley is from 1 to 3 miles wide and extends roughly from U. S. Highway 281, north of Great Bend, to a point northwest of Ellinwood. Unconformably overlying the Dakota formation in this narrow area is loess or loess-like silt of the Sanborn formation. The silt is tan, yellow tan, buff, brown, light to dark gray, or white and contains some fine sand, clay, and caliche nodules. (See logs 18-13-34cc and 19-12-21bb.) Fragments of "Algal limestone," Cretaceous sandstone, and "ironstone" are common at the base of the formation. The thickness of the Sanborn formation in this area ranges from a featheredge to more than 50 feet (Pl. 3, E-E′ and F-F′). The materials making up the Sanborn here are relatively impervious and would yield little or no water to wells. As far as is known, no wells in this area derive water from the Sanborn formation.

Terraces along Dry Walnut Valley and Pawnee Rock upland area.—The low terraces bordering Dry Walnut Valley and part of the upland area that separates Dry Walnut Valley from Arkansas Valley, here called the Pawnee Rock upland area, are underlain by silt, sandy silt, and clayey silt of the Sanborn formation. (See logs of test holes 19-14-17bb, 19-15-5dda, 19-15-11aa, 19-15-12da, 20-15-2dd, 20-15-4cd, 20-15-5aa, 20-15-22cc, 20-15-28cbb, and 20-15-31aa; and Pl. 3, C-C′ and D-D′.) The silts are tan, buff, brown, and light to dark gray and contain caliche nodules. Fragments and pebbles of sandstone, "ironstone," and limestone are commonly found at the base of the formation. Test hole 20-15-2dd in sec. 2, T. 20 S., R. 15 W., encountered 6 feet of fine sand, clay, and sandstone fragments at the base of the formation. The deposits of the Sanborn formation in this area overlie the dissected surface of the Dakota formation, Graneros shale, or Greenhorn limestone and range in thickness from a featheredge to about 60 feet.

In part of the Pawnee Rock upland area the Sanborn formation lies above the water table and, therefore, could not yield water to wells. In the lower terrace areas along Dry Walnut Valley, however, the lower part of the formation is saturated and would yield small supplies of water to wells where the materials making up the lower part of the formation are sufficiently permeable. Locally, sand or the zone of sandstone and "ironstone" pebbles and fragments at the base of the formation will yield water to wells. Well 19-15-32db, in sec. 32, T. 19 S., R. 15 W., is the only recorded well known to tap the Sanborn formation in this area. It is a drilled stock well, 6 inches in diameter and 37 feet deep, in which the measured water level was 30.2 feet below the ground surface on July 24, 1944.

Walnut Valley terrace area.—A terrace ranging from about 0.5 mile to nearly 4 miles in width borders the north side of Walnut Creek Valley (Pl. 1). Also included in this area is the small terrace remnant south of Walnut Creek and northwest of Great Bend. The sediments underlying this terrace are in the Sanborn formation and consist of silt, sandy silt, and clayey silt that contain lenses of sand and gravel. The character of these deposits is shown by logs 18-

13-31aa, 18-14-14bcc, 18-14-15bb, 18-14-17add, 18-14-23add, 18-14-24dd, 18-14-29aa, 18-14-32aab, 18-15-4cc, 18-15-21bb, and 19-13-6db, and their relation to other deposits is shown by cross sections C-C′ and D-D′ on Plate 3.

Silt, commonly containing fine sand or clay, is the dominant constituent of the Sanborn formation in the Walnut Valley terrace area. Many of the silt beds contain caliche in nodular form or as a cementing material. Beds containing much caliche are gray white, whereas those silt beds containing little or no caliche are light to dark gray, brown, buff, or yellow. Fragments of Cretaceous sandstone and "ironstone" were encountered in the silts in many of the test holes. Such fragments are most common at the base of the formation but are also found higher up in the formation. The lower 6 feet of silt at test hole 18-15-4cc, near the north edge of the terrace, contained granules and pebbles of limestone and much sand.

Lenses of loose sand and fine to coarse gravel ranging from a few inches to more than 50 feet thick occur interbedded with the silt. Most of the test holes drilled near the northern edge of the terrace failed to penetrate any sand and gravel. Most of the holes drilled within a mile or so of the south edge of the terrace encountered a single lens of sand and gravel at the base of the formation. Test hole 18-14-32aab, near the south edge of the terrace north of Heizer, encountered three distinct lenses of gravel and sand, 3, 9, and 24 feet in thickness, separated by lenses of silt. According to the driller's log, well 19-13-6db at the edge of the terrace in sec. 6, T. 19 S., R. 13 W., penetrated 60 feet of sand and fine to very coarse gravel between 55 and 115 feet. Well 19-13-18db, located on the terrace remnant south of Walnut Creek, is reported to have penetrated 25 feet of sand and gravel between 55 and 80 feet. The sand and gravel encountered near the northern edge of the Walnut Valley terrace is locally derived and composed of Cretaceous sandstone and "ironstone" grains and granules, whereas the sand and gravel found elsewhere is chiefly granitic and has been derived from crystalline igneous and metamorphic rocks. Locally, the sands and gravels have been tightly cemented by calcium carbonate (logs 18-14-15bb, 18-14-23add, and 19-13-6db).

The Sanborn formation in the Walnut Valley terrace area is more than 100 feet thick near the south edge and thins to a featheredge against the Cretaceous bluffs along the northern edge. The greatest thickness encountered was 134.5 feet in test hole 18-14-29aa, drilled about 1¼ miles north of the south edge of the terrace north of Heizer. Throughout most of the area the Sanborn formation unconformably overlies the Dakota formation, but it overlaps the Graneros shale and Greenhorn limestone at the north.

Most of the domestic and stock wells in the Walnut Valley terrace area derive water from sand and gravel of the Sanborn formation. Irrigation wells 19-13-6db and 19-13-18db, each having a reported yield of more than 1,000 gallons a minute, also tap these deposits. Analyses of samples of water from wells 18-14-25cb and 18-14-30cb indicate that waters in the Sanborn formation in this area are hard and contain excessive iron, but otherwise are of suitable chemical quality for most uses.

Cow Creek drainage basin.—The Sanborn formation covers an area of about 85 square miles in the Cow Creek drainage basin in Barton County, east and northeast of Cheyenne Bottoms (Pl. 1), and extends to the east and southeast into Rice County. The material composing the Sanborn formation in this area consists of silt, clayey silt, sandy silt, and very fine to medium sand (logs 17-11-17cc, 17-11-32cc, 18-11-2dd, 18-11-13dd, 18-11-15cc, 18-11-19aa, 18-11-20dd, 18-11-24bb, 18-11-31cc, 18-11-36aa, 19-11-7aa, 19-11-12aa, and 18-10-31cc). The silts are tan to brown, light to dark gray, and white, and contain caliche nodules. Gravel composed of Cretaceous-derived sandstone and "ironstone" pebbles is commonly found at the base of the formation. The gravel generally contains much sand and silt and in most places is less than 10 feet thick. The greatest thickness of sand and gravel, 20.5 feet, was encountered in test hole 18-11-15cc at the SW cor. sec. 15, T. 18 S., R. 11 W. Six of the test holes drilled in this area failed to encounter any coarse material in the Sanborn formation other than scattered sandstone or "ironstone" pebbles in silt near the base of the formation. Surface exposures of the formation consist entirely of silt (Pl. 10B).

The thickness of the Sanborn formation in the Cow Creek drainage basin ranges from a featheredge to a known maximum of 138 feet (Pl. 3), secs. G-G′, H-H′, and L-L′). In most parts of the area it overlies the eroded surface of the Dakota formation.

Small to moderate supplies of water for domestic and stock use are available from the Sanborn formation in the Cow Creek drainage basin. All the recorded domestic and stock wells in this area are thought to derive water from these deposits. The quality of the water from the Sanborn formation is indicated by the analysis of samples of water collected from wells 17-11-31dc, 17-11-36cc, 18-11-15bc, 19-11-6dd, and 19-12-13ad, given in Table 8. The content of dissolved solids in these samples ranged from 320 to 1,502 parts per million and their hardness ranged from 270 to 606 parts.

PLEISTOCENE AND RECENT SERIES

Dune Sand

Dune sand ranging in age from Pleistocene to Recent covers most of the area in Barton and Stafford Counties south of the Arkansas Valley and smaller areas north of the Arkansas Valley in eastern Barton County (Pl. 1). The dune sand is composed predominantly of fine- to medium-grained quartz sand and contains minor amounts of clay, silt, and coarse sand. The sand has been accumulated by the wind to form low mounds and small hills, some of which are 50 feet or more high (Pl. 5A and 7B).

The dune sand in the Barton-Stafford County area probably is of at least two ages (Smith, 1937, p. 290). A large part of the area south of Arkansas Valley is covered by older dune sand which is semiconsolidated and contains a larger percentage of clay and silt than does the younger sand. Areas underlain by the older dune sand have a low, hummocky topography and have a sufficiently well-developed soil to support vegetation. Such areas are in farms and are cultivated. The younger dune sand is clean and loose and locally does not have a protective covering of vegetation. The largest areas of bare, unprotected sand occur in the northeastern, central, and southwestern parts of Stafford County. Such areas are subject to wind erosion.

As far as is known, no wells obtain water from dune sand in Barton and Stafford Counties. Because the sand is loose and highly permeable, the sand dunes favor ground-water recharge from local precipitation.

Marsh and Beach Deposits

Unconsolidated marsh deposits consisting of clay, silt, sand, and fine to medium gravel that were derived mostly from dune sand, but in part from the Meade formation and the Kiowa shale, underlie the flat areas of Big and Little Marshes in northeastern Stafford County. The maximum thickness of these deposits is not known, but it probably does not exceed 10 or 15 feet. The upper 1 to 2 feet consists of fossiliferous sandy silt and clay, below which are layers of poorly sorted silty and clayey fine to coarse sand containing only minor amounts of fine to medium gravel.

A ridge of beach sand having a maximum thickness of about 15 feet occurs along the east and southeast sides of the intermittent lake that occupies the central part of Big Marsh (Pl. 1). The beach sands are composed chiefly of fine to medium sand and are lithologically similar to the dune sand from which they were derived.

They are not as well sorted as the dune sand and contain a larger percent of silt, clay, and coarse sand. Some medium to fine gravel is also found locally in the beach sands. The beach sands are gray to gray tan and have a dirty appearance caused by the silt and clay in them. Fragments of shells occur sparingly in these deposits.

No wells obtain water from the beach sands, but a few shallow wells are known to obtain water of very poor quality from the marsh deposits beneath Big Marsh. Well 21-11-22cb is the only recorded well deriving water from marsh deposits.

Alluvium

Alluvium of late Quaternary age occurs in Arkansas Valley, Walnut Valley, Dry Walnut Valley, Blood Creek Valley, Cheyenne Bottoms, Cow Creek Valley, Rattlesnake Valley, and North Fork Ninnescah Valley (Pl. 1), and in the valleys of many of the smaller streams. The alluvium in Cow Creek Valley, North Fork Ninnescah Valley, the upper part of Rattlesnake Valley, and the valleys of smaller streams is thin and occurs only as narrow bands along the present channels; therefore, it is not shown on the geologic map. The alluvium consists of stream-laid deposits that range in texture from clay and silt to sand and very coarse gravel.

Arkansas Valley.—The area mapped as alluvium in the Arkansas Valley includes those materials underlying the low terrace on the north side of the river. The edge of this terrace is shown by a dashed line on the geologic map where it was possible to identify it. The sediments immediately underlying this terrace deposit are lithologically similar to the alluvium but are somewhat older, probably of late Sanborn age.

The upper 2 to 20 feet of the alluvium in the Arkansas Valley consists of silt and fine to coarse sand. Beneath these finer surficial deposits are thick beds of coarse granitic sand and gravel that are lithologically similar to the sands and gravels of the Meade formation. Because of this similarity, it was not possible to differentiate the alluvium in the Arkansas Valley from the underlying Meade formation.

The alluvial sands and gravels in the Arkansas Valley are excellent sources of ground water, and wells that tap them yield large quantities of water. The alluvium is the source of supply for many domestic, stock, and irrigation wells, and for a few industrial wells. Records were obtained of 27 wells that tap the alluvium in the Arkansas Valley in Barton County. These include nine domestic wells (nos. 19-11-33bb, 19-12-26aa, 19-12-28cc, 19-12-31ab, 20-11-2ba, 20-11-18ba, 20-12-10ab, 20-14-20bc, and 20-15-33db), four stock wells (nos. 19-12-28da, 20-11-2aa, 20-11-3dd, and 20-14-18dd), one domestic and stock well (no. 19-11-20bb), seven irrigation wells (nos. 19-11-31bc, 19-12-19bc, 19-13-29cc, 19-14-22ac, 19-14-32ac, 20-15-33ad, and 20-15-35bc), two industrial wells (nos. 19-13-33bd1 and 19-13-33bd2), and four wells (nos. 19-11-15cd, 19-11-24bb, 20-11-16ab, and 20-14-29cc) that were formerly used to supply water for oil-well drilling operations. Five additional wells, including four irrigation wells (nos. 19-14-23bb, 19-14-26cb, 19-14-32db, and 19-14-36bb) and one industrial well (no. 19-13-33db), derive water from both the alluvium and the underlying Meade formation. The yields of the wells tapping the alluvium in the Arkansas Valley range from a few gallons a minute to about 1,200 gallons a minute.

The quality of the ground waters in the Arkansas Valley alluvium is indicated by the analyses (nos. 19-12-28cc, 20-11-2ba, 20-11-18ba, 20-14-20bc, and 20-15-33db) of five samples of water taken from wells that tap the alluvium. The ground water in the alluvium is hard but otherwise it is suitable for most ordinary uses. The five samples analyzed contained between 508 and 898 parts per million of dissolved solids and had between 242 and 450 parts of hardness. Three of the samples contained less than 0.1 part per million of iron, and two samples (19-12-28cc and 20-15-33db) contained 0.16 and 0.72 part of iron. The fluoride content of the samples was low. The chloride content ranged from 24 to 260 parts per million.

Walnut Valley.—In Walnut Valley, the upper 20 to 30 feet of alluvium consists of silt, clay, and sandy silt, beneath which are thick beds of coarse granitic sand and gravel. Thin lenses of silt occur locally in the beds of sand and gravel. The thickness of the alluvial deposits beneath Walnut Valley, as revealed by test drilling, ranges from about 40 feet to nearly 100 feet. The alluvium grades into terrace deposits of the Sanborn formation that border Walnut Valley on the north. The lower part of the valley fill in some places probably is of late Pleistocene age and represents the basal part of a cut-and-fill terrace deposit.

The alluvial sands and gravels in Walnut Valley are highly permeable and wells that tap them yield large quantities of water. The alluvium is the source of supply for many domestic and stock wells, several irrigation wells, and two industrial wells. The yields of wells tapping alluvium in Walnut Valley range from a few gallons a minute to about 1,000 gallons a minute. The water is hard but otherwise of good chemical quality.

Dry Walnut Valley.—Test holes drilled in Dry Walnut Valley penetrated 50 to 125 feet of unconsolidated deposits above the Cretaceous bedrock. (See logs 19-14-19ad, 19-15-16cc, 19-15-21cc, and 19-15-33bb.) Most of this material consists of clay, silt, and sandy silt containing only minor amounts of poorly sorted silty sand and gravel. The beds of sand and gravel are generally found at the base of the alluvial deposits and are thickest where the valley was cut deepest. Test hole 19-15-33bb on section C-C′ (Pl. 3) penetrated 50 feet of silt and sandy silt but no course material, and test hole 19-15-16cc penetrated 84 feet of alluvial material, the lower 5 feet of which consisted of poorly sorted lime-cemented silt, sand, and gravel. Test hole 19-15-21cc on the same line encountered 106 feet of clay, silt, and sandy silt above 19 feet of poorly sorted silty sand and fine to coarse gravel.

Many domestic and stock wells derive water from the alluvium in Dry Walnut Valley. Most of these wells are shallow and have small yields. Larger yields probably could be obtained locally from deeper wells tapping the basal gravels in the alluvium.

Blood Creek Valley.—Test holes 17-14-35dd and 18-13-6dd were drilled in Blood Creek Valley to ascertain the character and thickness of the alluvium in that valley. Both test holes were located near the middle of the valley. Test hole 18-13-6dd, which was drilled 0.5 mile southwest of Hoisington, penetrated 88 feet of alluvial deposits. Test hole 17-14-35dd was drilled about 2 miles above Hoisington and penetrated 78 feet of alluvium. The alluvium is undoubtedly much thinner upstream and along the margins of the valley. The alluvium consists of clay, silt, and sandy silt containing lenses of sand and gravel that range from a few inches to 15 or 20 feet in thickness. The sand and gravel generally is poorly sorted and contains silt.

The alluvium in Blood Creek Valley supplies water to numerous domestic and stock wells.

Cheyenne Bottoms.—The Cheyenne Bottoms is underlain by unconsolidated clay, silt, sand, and, locally, gravel that range in age from Pleistocene to Recent. The thickness of these deposits ranges from less than 20 feet near the margins of the Bottoms to more than 100 feet in the deepest part of the old buried channel that trends northwest-southeast through the central part of the Bottoms in line with Blood Creek Valley. (See sections E-E′ and F-F′ in Plate 3).

Fine-grained sediments, including clay, silt, and sandy silt, make up the greatest part of the fill in Cheyenne Bottoms. Beds of silty very fine to medium sand ranging in thickness from 2 feet to 22 feet were encountered in three (test holes 18-11-19bb, 18-13-9aa, and 19-12-5aa) of the eight test holes drilled in this area. Test hole 18-12-21cc, which penetrated the greatest known thickness of alluvium in the Bottoms, encountered 11 feet of fine gravel containing much sand and silt at the base of the alluvium between depths of 101 and 112 feet. The gravel is composed chiefly of sandstone and "ironstone" fragments that were derived from the Dakota formation.

The alluvium in Cheyenne Bottoms supplies water to numerous stock and domestic wells, most of which are shallow wells that tap fine to medium sand and sandy silt and have low yields. The quality of the water in the alluvium in most places is poor. The analyses of four samples of water collected from wells that tap the alluvium in Cheyenne Bottoms are given in Table 8 (nos. 17-12-31dc1, 18-11-19bb, 18-13-15da, and 19-12-6bc). They contained 449 to 2,728 part per million of dissolved solids and had 310 to 904 parts of hardness.

Rattlesnake Valley.—The alluvium in Rattlesnake Valley is relatively thin, probably being less than 20 feet thick everywhere. It is composed chiefly of poorly sorted sand and gravel that was derived from the Meade formation. The alluvium is everywhere underlain by thick deposits of the Meade formation.

Records were obtained of five wells (nos. 21-11-26ad, 22-11-3cd, 23-11-1bc, 23-12-2cd, and 24-14-1aa) that derive water from the alluvial deposits in Rattlesnake Valley. They are shallow wells less than 15 feet deep that yield small supplies of water for domestic and stock use.

GEOLOGIC HISTORY

Throughout much of Paleozoic time the Barton-Stafford County area was alternately submerged and elevated. During periods of submergence, marine sediments accumulated and were subsequently eroded during periods when the area was above sea level. Deposits laid down in early Paleozoic time consisted chiefly of marine limestone, shale, and sandstone. Prior to the deposition of Mississippian sediments, there was regional arching of the strata along a northwest-southeast axis, and subsequent erosion that truncated the earlier Paleozoic rocks and removed all of them in part of Barton County. Following this period of uplift and erosion, the sea again invaded the area and limestones and shales of Mississippian age were deposited. Sometime prior to Pennsylvanian deposition, the rocks of central Kansas were again uplifted and warped to form the structural feature now called the Central Kansas uplift, and erosion removed all the Mississippian limestone and shale from this area except in the southeastern quarter of Stafford County. The sea again invaded the area during Pennsylvanian time and marine deposits accumulated over all of central Kansas. Minor withdrawals of the sea took place during the latter part of Pennsylvanian time and during the Permian Period, at which times continental deposits were laid down. Near the end of Permian time continental deposition became predominant, forming the redbeds that are encountered below Cretaceous and younger deposits by test holes and oil wells. By the close of Paleozoic time the sea withdrew completely from the area and the surface was eroded, uplifted, and warped. Erosion probably continued throughout all of Triassic and Jurassic time, for sediment of these periods are not known to occur in Barton and Stafford Counties. For a more detailed account of the Paleozoic history of the central Kansas area the reader is referred to reports by Koester (1935) and Moore and Jewett (1942).

Cretaceous deposits were laid down on the long-eroded, deeply weathered Permian surface. During the Comanchean (Lower Cretaceous) Epoch of the Cretaceous Period the sea once more invaded this area, and clastic sediments, composed chiefly of sand but containing minor amounts of finer material, were deposited at or near the shore line of this advancing sea. These sediments make up the Cheyenne sandstone—a dominantly continental deposit. As the Comanchean sea advanced northward, all the Barton-Stafford County area was inundated, and the marine sediments composing the Kiowa shale were deposited.

A general withdrawal of the sea marked the end of Early Cretaceous time. This withdrawal of the sea was not continuous but was marked by minor readvances that resulted in marine and continental beds being interbedded. After the retreat of the Early Cretaceous sea, continental deposits of clay and sand (Dakota formation) accumulated in stream channels, on flood plains and beaches, and in lagoons. After the deposition of the Dakota formation, the area was covered by a shallow sea, and great thicknesses of clay and limestone (Graneros shale, Greenhorn limestone, and Carlile shale) were deposited.

At the close of the Cretaceous Period, the sea withdrew and since that time the area has been continuously above sea level. During most of the Tertiary Period the surface was subject to erosion which truncated the Cretaceous rocks. Late in Tertiary time, during the Pliocene epoch, sediments of the Ogallala formation were laid down on the eroded Cretaceous surface in the region by streams carrying material from the highlands to the west.

The Pleistocene history of this area is very complex and was marked by the cutting and filling of deep valleys and by major changes in drainage. Sufficient data are not available to give a detailed account of the events that took place during Pleistocene time. Erosion in late Tertiary or early Pleistocene time removed the Ogallala formation from most of the area and some of the Cretaceous rocks. Prior to the deposition of the Meade formation, erosion had removed all the Cretaceous rocks and the upper part of the Permian in parts of Stafford County and southeastern Barton County (Fig. 11). Widespread deposition of silt, sand, and gravel (Meade formation) in Stafford County and southern Barton County followed this period of erosion. These sediments were deposited by streams carrying material from the Rocky Mountains and from the areas of Tertiary rock to the west. The surface on which the Meade was deposited in Stafford County and southern Barton County was an erosional surface of hills and valleys, as shown by the contours in Figure 12. Figure 12 indicates that a large valley existed in southern Barton County in approximately the same position as the present course of Arkansas Valley. Another valley, that trends from south to north in eastern Stafford County, is shown joining this valley in the extreme southeastern part of Barton County. Deposition of sediments of the Meade formation probably started in these valley areas. During early Pleistocene time the ancestral Arkansas River, instead of following the present course around the "great bend," is thought to have flowed eastward or southeastward across south-central Kansas. At the same time the ancestral Smoky Hill River flowed southward through McPherson County and joined the ancestral Arkansas River in southern Kansas.

The early Pleistocene valley in southern Barton County is probably part of a major tributary that joined the Smoky Hill-Arkansas drainage north of Wichita. Later in Pleistocene time this tributary, through lateral shifting and a series of captures, became the major drainageway for Arkansas River from eastern Ford County to Wichita, thus forming the present "great bend."

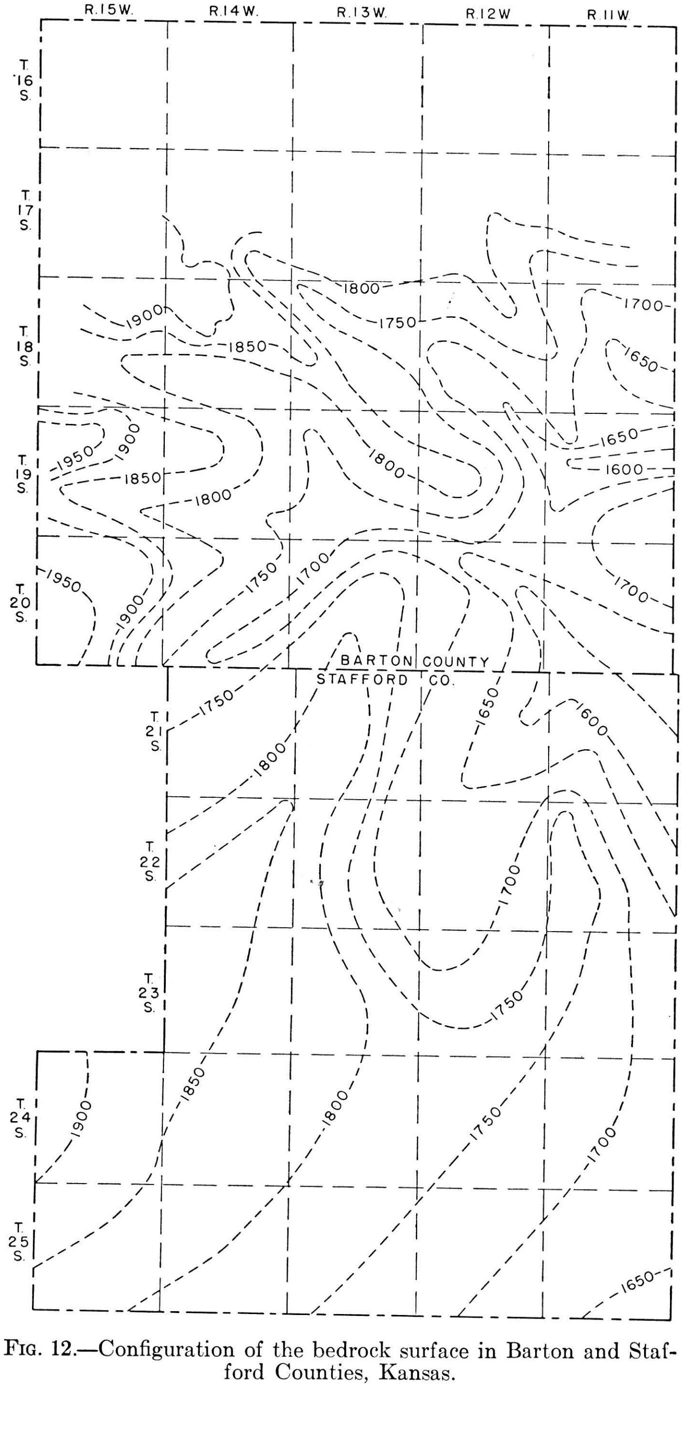

FIG. 12.—Configuration of the bedrock surface in Barton and Stafford Counties, Kansas.

Late in Pleistocene time erosion was resumed in the Dry Walnut, Walnut, Cow Creek, and Blood Creek-Cheyenne Bottoms Valleys and they were cut somewhat below their present depths. This was followed by the deposition of stream-laid silt, sand, and gravel in the valleys and wind-blown silt on the divides (Sanborn formation). Deposition by the wind of dune sand in Stafford and southern Barton Counties probably started at about the same time and has continued into Recent time.

Much of the present topography of Barton and Stafford Counties is the result of erosion and deposition that started during the latter part of the Pleistocene Epoch and have continued to the present time. Channels were cut in the Pleistocene valley fill and partially refilled by alluvium, leaving prominent terraces underlain by the Sanborn formation, and downcutting by relatively short tributary streams has removed more of the Cretaceous rocks in Barton County.

Origin of Cheyenne Bottoms

Two theories have been advanced to explain the origin of Cheyenne Bottoms. Haworth, who was the first to write on the subject, ascribed the formation of the Bottoms to stream erosion and quoted the following description that was credited to B. L. Miller, one of his assistants (Haworth, 1897, pp. 44-45):

> In past time the two streams, Blood Creek and Deception Creek, which are the only streams of importance entering the basin, probably flowed about as they do now. We suppose at one time their channels were cut into the Benton and the Dakota sandstones. These materials resisting erosion quite well necessarily made the deepening of their channels and the widening of their valleys slow processes. But finally, having cut through these harder strata to the softer stratum of saliferous shales beneath, the processes of erosion were greatly increased, and it was therefore a comparatively short time until the streams had cut their channels entirely through this stratum of shales to the harder layer of sandstone beneath. They now began to widen their valleys, or their valley; for the two streams probably united in one when this shale was first encountered. This widening was likewise rapid, so that a wide valley was soon formed. Had the sandstone overlying this shale bed been very hard we should doubtless have had falls produced of about 30 feet in height, which would have slowly retreated up stream. There are good reasons for believing that the point where the stream first encountered the shale bed was considerably farther east than the present limits of the basin. Evidence of this is furnished by the fact that river sands cover the surface for some distance in this direction. Thus the valley has been extending up stream as well as widening on either side. The upper courses of the two streams mentioned have not even yet reached the soft, saliferous shales, and consequently have narrow valleys.
>
> But while this was going on, the Arkansas River was slowly working its way northward by wearing away the soft Dakota sandstones and shales along

its northern bank. As the course of the river to this point was northeast and the course of the creek to the southeast, their valleys finally met. A long, wedge-shaped ridge remains, which separates the upper courses of their valleys.

The breaking down of so much sandstone necessarily left behind great quantities of sand. In the great quantity of sand lying to the south of this wedge-shaped mass of land and in frequent southerly winds, we have the conditions requisite for producing the present basin. The sand blown by the wind across the mouth of this valley formed a drift back of the point of this wedge between the valleys. The drift gradually increased in length and height until it became a barrier entirely across the valley of the small creek and formed a great basin. The drifting of snow often produces similar results, though on a smaller scale. Could the stream have had considerable water flowing in it continually, it might have been able to keep its channel clear; but probably there was not water enough or current strong enough to carry away the sand that drifted into the channel.

Johnson (1901, pp. 712, 713) advanced the theory that Cheyenne Bottoms was a basin of subsidence resulting from removal of soluble masses of salt within the underlying rock, but noted that the gap in the rock wall on the southeast side did not favor this theory. In 1926, Bass prepared a map of salt thicknesses in western Kansas that shows thinning of the salt beds beneath Cheyenne Bottoms (Bass, 1926, p. 90). He (Bass, 1926, pp. 94-95) believed that this evidence tended to confirm Johnson's subsidence theory.

Subsidence may have been in part responsible for the formation of Cheyenne Bottoms; however, test-drilling data gathered during the present investigation indicate that a buried stream channel exists beneath the southeast side of Cheyenne Bottoms (Fig. 12). This evidence suggests that in Pleistocene time a stream flowed across the Cheyenne Bottoms area in line with Blood Creek. From Cheyenne Bottoms it followed approximately the present course of Little Cheyenne Creek and entered Rice County through a now deeply buried channel at about the cen. E. line T. 19 S., R. 11 W. (Fig. 12 and L-L′, Pl. 3). Fent (1950) refers to this channel as the Chase channel and has traced its course through Rice County. A narrow divide in the vicinity of Ellinwood separated this channel from the ancestral Arkansas channel. After material began accumulating in the ancestral Arkansas channel, the main stream overflowed the divide and followed the Chase channel. The Cheyenne Bottoms channel became a tributary and was later choked either by accumulating sand, as suggested by Miller (in Haworth, 1897, p. 45), or because of more rapid accumulation of sediments in the main stream. Since that time, deposition in the Cheyenne Bottoms area has taken place in shallow intermittent ponds.

GROUND WATER

Occurrence of Ground Water

In order to assist the reader in a better understanding of the ground-water conditions in Barton and Stafford Counties, certain basic principles of the occurrence of ground water adapted from Meinzer (1923) are discussed briefly in the pages that follow. For a more detailed treatment of the subject the reader is referred to Meinzer's report and also to a report by Moore and others (1940).

Ground water, or underground water, is the water that supplies springs and wells. The rocks that form the outer crust of the earth are at very few places solid throughout, but contain numerous open spaces, called voids or interstices. These open spaces are the receptacles that hold the water that is found below the surface of the land and is recovered in part through wells and springs. There are many kinds of rocks, and they differ greatly in the number, size, shape, and arrangement of their interstices and hence in their properties as containers of water. Therefore, the character, distribution, and structure of the rocks of any region, together with the climate and topography, determine the occurrence of water.

The amount of water that can be stored in any rock depends upon the volume of rock occupied by open spaces—that is, the porosity of the rock. Porosity is expressed as the percentage of the total volume of rock that is occupied by interstices. A rock is said to be saturated when all its interstices are filled with water. The porosity of a sedimentary rock is controlled by (1) the shape and arrangement of its constituent particles; (2) the degree of assortment of its particles; (3) the cementation and compaction to which it has been subjected since its deposition; (4) the removal of mineral matter through solution by percolating waters; and (5) the fracturing of the rock resulting in joints and other openings. Well-sorted deposits of unconsolidated silt, sand, or gravel have a high porosity, regardless of the size of the grains. Poorly sorted deposits have a much lower porosity because the small grains fill the voids between the large grains, thus reducing the amount of open space. The pore space in some well-sorted deposits of sand or gravel may gradually be filled with cementing material gradually reducing the porosity.

The capacity of a rock to hold water is determined by its porosity, but its capacity to yield water is determined by its permeability. The permeability of a rock may be defined as its capacity for transmitting water under hydraulic head. It is measured by the rate at which the rock will transmit water through a given cross section under a given difference of head per unit of distance. Rocks that will not transmit water may be said to be impermeable. Some deposits, such as well-sorted silt or clay, may have a high porosity but because of the minute size of the pores will transmit water only very slowly. Other deposits, such as well-sorted gravel containing large openings that communicate freely with one another will transmit water very readily. Part of the water in any deposit is not available to wells because it is held against the force of gravity by molecular attraction—that is, by the cohesion of the water itself and by its adhesion to the walls of the pores. The ratio of the volume of water that a rock will yield by gravity, after being saturated, to its own volume is known as the specific yield of the rock.

Below a certain level, which ranges from the land surface to about 200 feet below the surface in Barton County and from the land surface to about 30 feet in Stafford County, the permeable rocks are saturated with water under hydrostatic pressure. These saturated rocks are said to be in the zone of saturation, and the upper surface of this zone is called the water table. Wells dug or drilled into the zone of saturation will become filled with ground water to the level of the water table.

The amount of water available to wells depends on the saturated thickness of the water-bearing materials and the permeability and specific yield of the material. The amount of water that can be pumped perenially depends also on the periodic ground-water replenishment from precipitation, by percolation from streams, and movement of ground water into the pumped area from the sides.

The saturated thickness of the post Cretaceous deposits in Barton and Stafford Counties is shown in Figure 13. The contours showing saturated thickness were prepared by superimposing the water-table contour map (Pl. 1) on the map showing the configuration of the bedrock surface (Fig. 12) and drawing the contours through points of equal thickness. As shown by Figure 13, the water-bearing materials have a thickness of as much as 200 feet in parts of the area. In the area shown outside the zero contour line the water table occurs in the Cretaceous rocks.

ARTESIAN CONDITIONS

Artesian or confined conditions are said to exist where a water-bearing bed is overlain by an impermeable or relatively impermeable

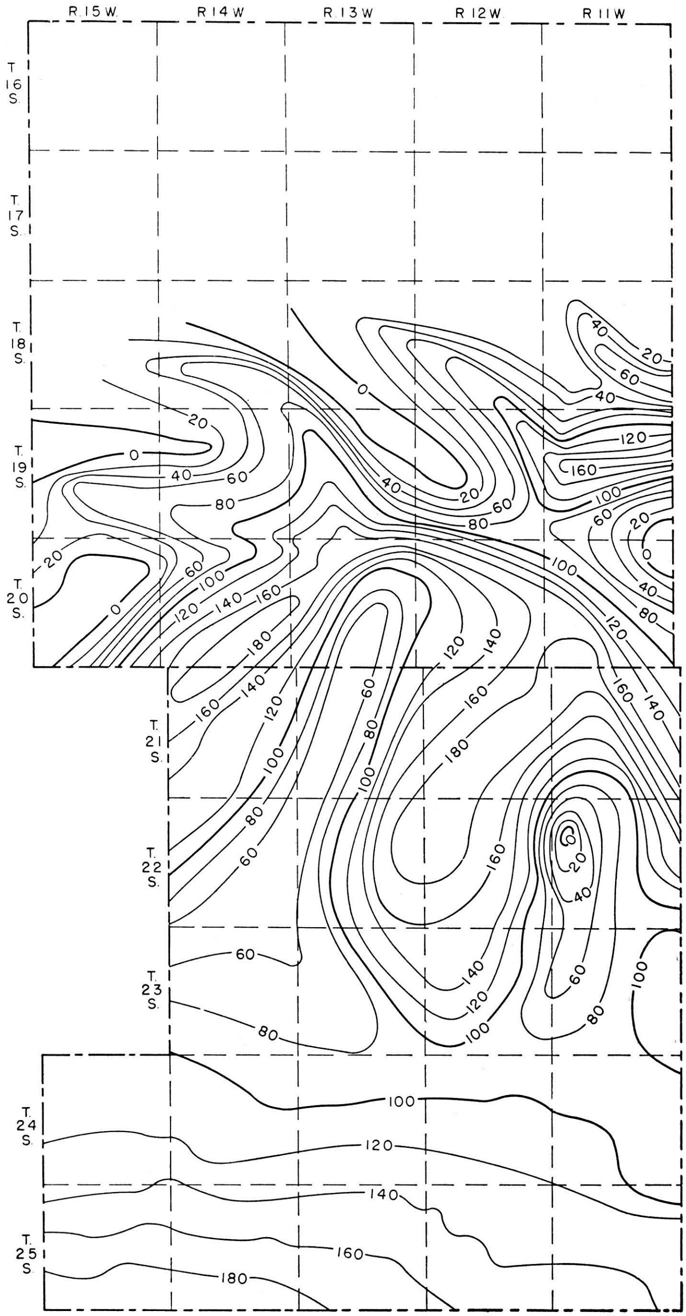

FIG. 13.—Saturated thickness of the post Cretaceous deposits in Barton and Stafford Counties. Prepared by Kenneth L. Walters and Woodrow W. Wilson.

bed that dips from its outcrop to the discharge area. Water enters the water-bearing bed at the outcrop and percolates slowly downward to the water table and then down the dip in the water-bearing bed beneath the overlying confining bed. Down the dip from the outcrop area the water exerts considerable pressure against the confining bed, so that when a well is drilled through the confining bed into the water-bearing bed the pressure is released and the water rises in the well. Because of loss in head resulting from friction as the water percolates down the dip, the water level will not rise to an elevation as high as that of the water table in the outcrop area, and where the land surface is sufficiently low the artesian pressure may be sufficient to raise the water above the surface and flowing wells may be obtained.

The imaginary surface (piezometric surface) defined by the height to which artesian water will rise in wells may be above or below the water table or, especially where the confining bed is of small areal extent, may coincide with the water table. Where there is some degree of interconnection between the artesian aquifer and an overlying unconfined aquifer, the position of the piezometric surface with respect to the water table may be significant in relation to the movement of the water. Where the piezometric surface is higher than the water table, artesian water may be escaping into the unconfined aquifer; where it is lower, the artesian aquifer may be receiving recharge from the unconfined aquifer. Where there is no interconnection between the aquifers, the relative position of the piezometric surface and water table has no particular significance.

Records were obtained of five flowing wells (22-11-9bb, 22-11-10cc, 22-11-35ab, 22-12-12db, and 23-13-3aa) in Stafford County that tap sand and gravel of the Meade formation. All these flowing wells are in topographically low areas and the ground water at each well probably is confined beneath a local lens of relatively impermeable silt or clay. Water encountered in the sand and gravel below the impermeable lenses will rise above the land surface to the level of the water table in the surrounding higher areas; thus, the artesian conditions are strictly local.

Wells 22-11-9bb, 22-11-10cc, and 22-12-12db on the south side of Big Marsh in northeastern Stafford County (Pl. 2), are 40, 37, and 44 feet deep, respectively. Well 22-11-9bb had a measured flow on October 19, 1942, of 6 gallons a minute and the water rose 4.57 feet above the land surface (Pl. 11A). Well 22-12-12db also had a flow of 6 gallons a minute and the water rose 3.65 feet above the land surface on October 26, 1942 (Pl. 11B). Measurements were not made of the flow and head at well 22-11-10cc.

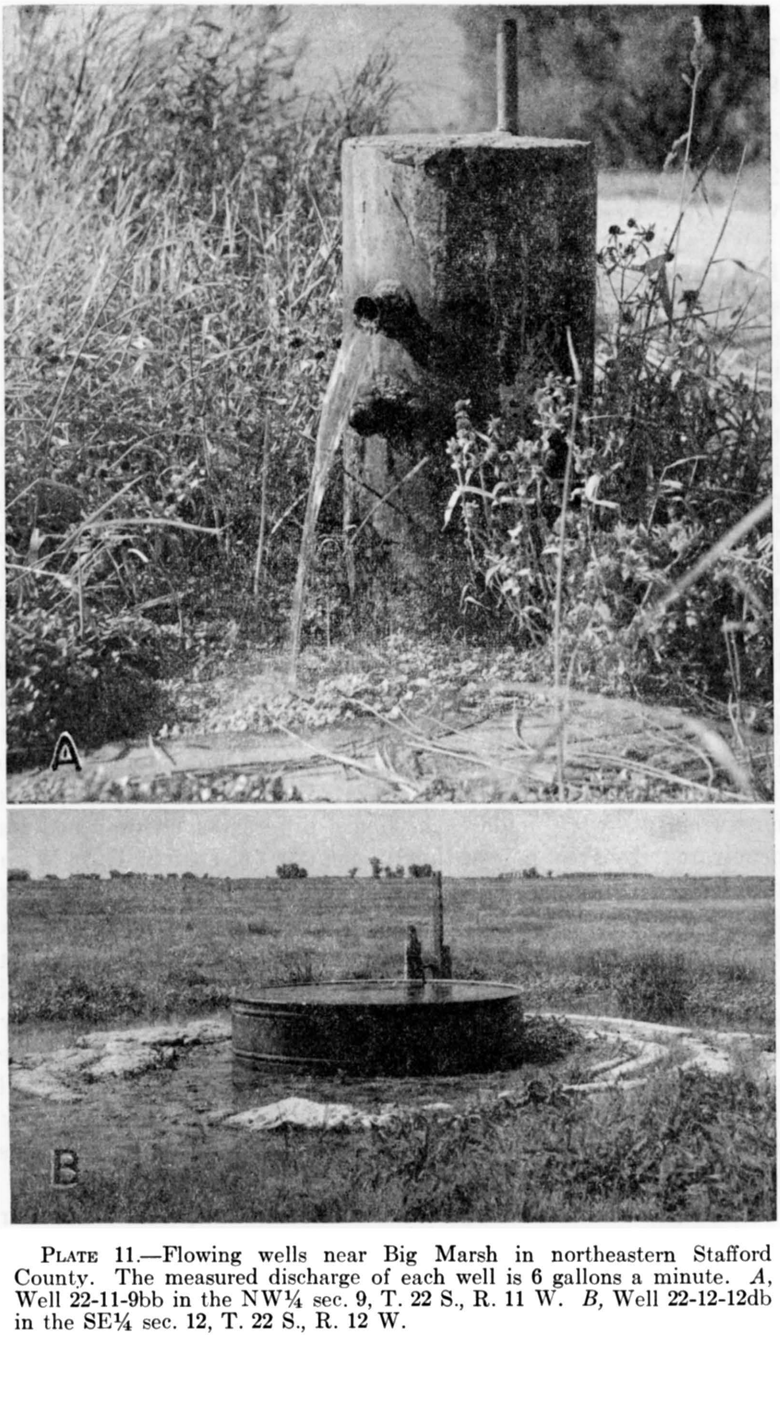

PLATE 11.—Flowing wells near Big Marsh in northeastern Stafford County. The measured discharge of each well is 6 gallons a minute. *A*, Well 22-11-9bb in the NW¼ sec. 9, T. 22 S., R. 11 W. *B*, Well 22-12-12db in the SE¼ sec. 12, T. 22 S., R. 12 W.

Well 22-11-35ab is on the northwest side of Little Marsh. It is 75 feet deep and on October 26, 1942, had a measured flow of 10 gallons a minute. It was not feasible to measure the head.

Well 23-13-3aa is in Rattlesnake Valley in the NE¼ sec. 3, T. 23 S., R. 13 W. It is 24 feet deep. On October 19, 1942, well 23-13-3aa was flowing at the rate of 6.5 gallons a minute and the water rose 4.7 feet above the land surface.

Wells in Barton County that are drilled into sandstones in the Dakota formation generally encounter confined water under hydrostatic pressure. In most of these wells the water rises considerably above the level at which it is first encountered; however, as far as is known, it does not rise above the general level of the water table anywhere in Barton County. In many places the water level in wells tapping sandstones of the Dakota formation is more than 100 feet lower than the water level in nearby wells that tap younger deposits at shallower depths. For example, on August 8, 1944, the depth to water level in well 16-14-26bb1, a shallow well in the Carlile shale, was 15.4 feet below land surface; whereas in well 16-14-26bb2, less than 50 feet distant and penetrating a sandstone in the Dakota formation, the depth to water level was 140.7 feet below land surface (Table 12). In studying the ground-water conditions in Russell County, which borders Barton County on the north, Frye and Brazil (1943, pp. 53, 56) found that the pressure of water in the Dakota formation varies in the different sandstone beds. This was determined in several test holes in which water-level measurements were made each time a different sandstone bed was penetrated. In a test hole at the SW cor. sec. 31, T. 15 S., R. 14 W., on the Barton-Russell County line, water-level measurements were made in six distinct sandstones at depths ranging from 200 to 533 feet and the levels of water encountered in the sandstones, in descending order, were as follows: 158.54, 158.78, 168.53, 161.31, 159.28, 164.35, and 28.65 feet (Frye and Brazil, 1943, p. 56). According to Frye and Brazil, in most places in Russell County the water in the deeper sandstone beds is under much greater head than water in the shallower sandstone beds of the Dakota formation; however, they (Frye and Brazil, 1943, p. 56) point out that this situation did not exist in all test holes.

Although data are scanty, it is known that in places the waters in the Kiowa shale, Cheyenne sandstone, and Permian rocks in this area are under artesian head and, locally, the pressure is great enough to cause surface flows. A small flow of water was encountered in the Kiowa shale at a depth of 286 feet in test hole 20-14-5cc at the SW cor. sec. 5, T. 20 S., R. 14 W., Barton County. The flow was estimated by O. S. Fent to be 0.5 gallon a minute or less. A sample of the water was analyzed and found to contain 28,300 parts per million of chloride (Table 10); therefore, it is too highly mineralized for ordinary uses.

A much greater flow of salt water was encountered in the Cheyenne sandstone in test hole 19-14-17bb at the NW cor. sec. 17, T. 19 S., R. 14 W., Barton County. A small flow was encountered between depths of 350 and 356 feet. The flow increased somewhat between depths of 360 and 362 feet, and between depths of 416 and 420 feet the flow increased by about four times. O. S. Fent, the driller, estimated the aggregate flow to be 50 gallons a minute or more. A sample of the water contained 33,000 parts per million of chloride (Table 10). An oil-test well drilled about 2 miles southeast of test hole 19-14-17bb in the SE¼ SE¼ sec. 16, T. 19 S., R. 14 W., also encountered a flow of artesian salt water in the Cheyenne sandstone. According to Mr. Warne Otte of Great Bend, a strong flow of salt water was encountered in this well in a sandstone at a depth of 310 feet. The well was reported to have flowed for about a year before it was properly plugged. That the water was extremely high in salt cannot be doubted, for the area around the well and along the ditch that drained the water away is completely barren of vegetation.

The only information available regarding artesian water in Permian rocks in this area is given in a report by N. H. Darton. He (Darton, 1916, p. 33) states that a well drilled in 1887 about 3 miles north of Great Bend encountered artesian water at a depth of 744 feet under sufficient pressure to cause it to rise to a height of 30 feet above the ground.

THE WATER TABLE AND MOVEMENT OF GROUND WATER

The upper surface of the zone of saturation in ordinary permeable rock has been defined as the water table, except where the upper surface is formed by impermeable material, as it is in parts of Barton and Stafford Counties. The water table is not a static, level surface; generally it is a sloping surface having many irregularities. The causes of the irregularities of the water table in Barton and Stafford Counties are discussed on the following pages.

Shape and slope.—The shape and slope of the water table in Barton and Stafford Counties are shown on Plate 1 by means of contour lines. Each point on the water table along a given contour line has the same altitude; hence these water-table contours show the configuration of the water surface just as topographic contours show the configuration of the land surface. Ground water moves in the direction of slope of the water table, at right angles to the water-table contours.

Plate 1 shows that ground water enters Stafford County and southern Barton County from the west and southwest and moves through this area in a general northeasterly direction, but that the direction of movement and slope are not everywhere the same. The average gradient of the water table beneath the Great Bend prairie and the Arkansas Valley area (pp. 43-48) is about 7.5 feet to the mile and ranges from about 2.5 feet to the mile east of Ellinwood to about 30 feet to the mile along the west side of Big Marsh. In the Cow Creek drainage basin (pp. 40-42), the water table slopes from less than 8 feet to the mile to about 75 feet to the mile; whereas beneath Cheyenne Bottoms the slope is everywhere very gentle, being in places only about 2 feet to the mile.

Irregularities in the water table may be the result of various conditions. In places where conditions are exceptionally good for recharge, the water table may be built up to form a mound or low ridge from which the water spreads out, but this spreading takes place very slowly because of the frictional resistance offered by the small interstices through which the water must move. In material of low permeability these mounds or ridges may be very sharp, but in very permeable material the slopes generally are gentle. Depressions in the water table indicate places where ground water is being discharged and may occur along streams that are below the normal level of the water table or in places where water is withdrawn by wells or by vegetation. The permeability of the water-bearing material affects the slope of the water table. If the water is moving through fine-grained sediments the frictional resistance to the movement of the water is great, requiring a steeper slope than when the same quantity of water moves through a more permeable material.

The slight down-slope flexure of the contours between Rattlesnake Creek and the North Fork of Ninnescah Creek indicates that a very broad, low ridge or divide has been formed on the water table in this area. Part of the ground water in this area moves northeastward, thence eastward out of Stafford County. Part moves southeastward toward and is discharged into the North Fork of Ninnescah Creek. A part moves northward and is discharged into Rattlesnake Creek. Similar low divides occur between Rattlesnake Creek and Arkansas River and between Arkansas River and Big

Marsh. A more prominent ridge is displayed between Big Marsh and Rattlesnake Creek. The sharp, pronounced down-slope flexure of the contours here indicates that ground-water recharge in this area is unusually high, for there is no evidence that the water-bearing materials are less permeable here than elsewhere.

Rattlesnake Creek and the North Fork of Ninnescah Creek are effluent streams throughout most of their courses in Stafford County; that is, they are perennial streams, the channels of which have been cut down below the water table and are thereby gaining water from the zone of saturation. This movement of water from the underground reservoir to the channels of these streams has caused troughs to be formed on the water table that follow the courses of the North Fork of Ninnescah Creek and Rattlesnake Creek, as indicated by the upstream flexure of the contours. During periods of below-normal rainfall, such as was experienced between 1934 and 1939, when the water table is lower, the upper courses of these two streams in Stafford County are above the water table and, instead of gaining water from the underground reservoir, they lose water to the ground-water reservoir. Under these conditions, a ridge would be formed on the water table beneath the stream channels instead of a trough.

It will be noted on Plate 1 that as the contours cross Arkansas River some of them are flexed slightly upstream whereas others cross without changing direction. This indicates that in places Arkansas River was a gaining stream at the time the water-level measurements were made, but in other places there was an apparent balance between the level of water in the stream and the adjacent water table so that the stream was neither gaining nor losing water.

A depression on the water table has been caused by the discharge of ground water into Big Marsh, the level of which is lower than the surrounding water table. A bedrock ridge trending roughly north-south beneath Big Marsh and the resulting thinning of the pervious water-bearing material is a major factor in causing ground water to be discharged here (Pl. 3, J-J′). The contours show that ground water is moving toward Big Marsh from the northwest, west, and south. On nearing the point of discharge the water table also assumes a much steeper gradient than it has to the west. The shape and slope of the bedrock floor formed by the underlying Cretaceous and Permian rocks may control the slope of the water table in this area to a small extent, but the discharging of ground water into Big Marsh probably is the chief factor causing the steeper slope.

Plate 1 shows that a mound has been developed on the water table beneath the upland area northwest of Pawnee Rock. Water from local rainfall enters the Dakota formation in this area where it is exposed or lies at shallow depth beneath younger unconsolidated deposits of the Sanborn formation. After reaching the underground reservoir, part of the ground water moves south, southeast, and east toward Arkansas Valley and a part moves northeastward into Dry Walnut Valley. The steeper slope of the water table beneath the Pawnee Rock upland area is the result of the low permeability of the fine-grained sandstones in the Dakota formation, through which the ground water moves.

Ground water moves into Dry Walnut Valley from both sides, as shown by the upslope flexure of the contours, and thence down the valley at an average gradient of about 7 feet to the mile. It will be noted that the upstream flexures of the contours in Dry Walnut Valley do not coincide with the stream. This indicates that the channel of Dry Walnut Creek is above the water table and does not receive water from the ground-water reservoir; however, the valley acts as a drain for the adjacent upland areas.

Walnut Creek, on the other hand, is a perennial stream that gains water from the ground-water reservoir. The water-table contours beneath Walnut Valley flex upstream and change direction at the stream channel. Ground water moves toward Walnut Valley from both sides and thence down the valley at an average gradient of about 4 feet to the mile.

The water-table contours beneath the Cow Creek drainage basin are very irregular, owing to the unequal addition of water to the underground reservoir, to the discharge of ground water into Cow Creek and Little Cheyenne Creek, and to differences in the permeability of the water-bearing materials at different places. Recharge is unusually high in the area of sand hills southwest of Claflin. This area is underlain by porous dune sand and a large part of the water that falls as rain seeps rapidly downward to the underground reservoir, where it has built up a prominent ridge on the water table as shown by the long down-slope flexure of the contours. Part of the water beneath this dune area moves eastward toward Cow Creek, a part moves southward toward Little Cheyenne Creek, and a part moves southwestward into Cheyenne Bottoms. The upstream flexure of the contours along Cow Creek and Little Cheyenne Creek indicate that water-table troughs have been formed here because the channels of these two streams in the lower parts of their courses are below the water table. Ground water moves toward and is discharged into these streams from both sides.

A shallow, broad trough has been formed on the water table beneath Cheyenne Bottoms, the shape of which conforms closely with the shape of the underlying Cretaceous bedrock. Ground water moves into the alluvial fill in the Bottoms from all directions except the southeast. It leaves the Bottoms at the southeast side through a narrow, restricted part of the ground-water trough, which coincides with the deep buried channel cut in the bedrock (p. 84.) After leaving the Bottoms, the ground water is either discharged into Little Cheyenne Creek or joins the ground water beneath Little Cheyenne Creek.

It will be noted that no contours were drawn in the northern part of Barton County or in parts of central and western Barton County. These areas are underlain by Cretaceous shales, limestones, and sandstones and do not have normal water-table conditions.

Fluctuations.—The water table in any area does not remain in a stationary position but fluctuates much like the water in a surface reservoir. Whether the water table rises or declines depends upon the amount of recharge into the ground-water reservoir and the amount of discharge. If the inflow to the underground reservoir exceeds the draft, the water table will rise; conversely, if the draft exceeds the inflow the water table will decline. Thus, the net rate at which the underground reservoir is replenished or depleted controls the rate and magnitude of fluctuation of the water table.

The principal factors controlling the rise of the water table in Barton and Stafford Counties are the amount of precipitation that passes through the soil and descends to the water table, the amount of water added to the ground-water reservoir by seepage from streams, and the amount of water entering the county beneath the surface from areas to the west. Factors controlling the decline of the water table are the amount of water pumped from wells, the amount of water absorbed directly from the water table by plants (transpiration), the amount of water lost from the ground-water reservoir by evaporation, the loss of water from springs, the amount of water discharged by effluent seepage into streams, and the amount of water leaving the county beneath the surface toward the east. The factors causing the water table to rise are discussed in detail under ground-water recharge, and the factors causing the water table to decline are discussed under ground-water discharge.

To determine the character and magnitude of fluctuations of the water table, a group of wells was selected for observation and the

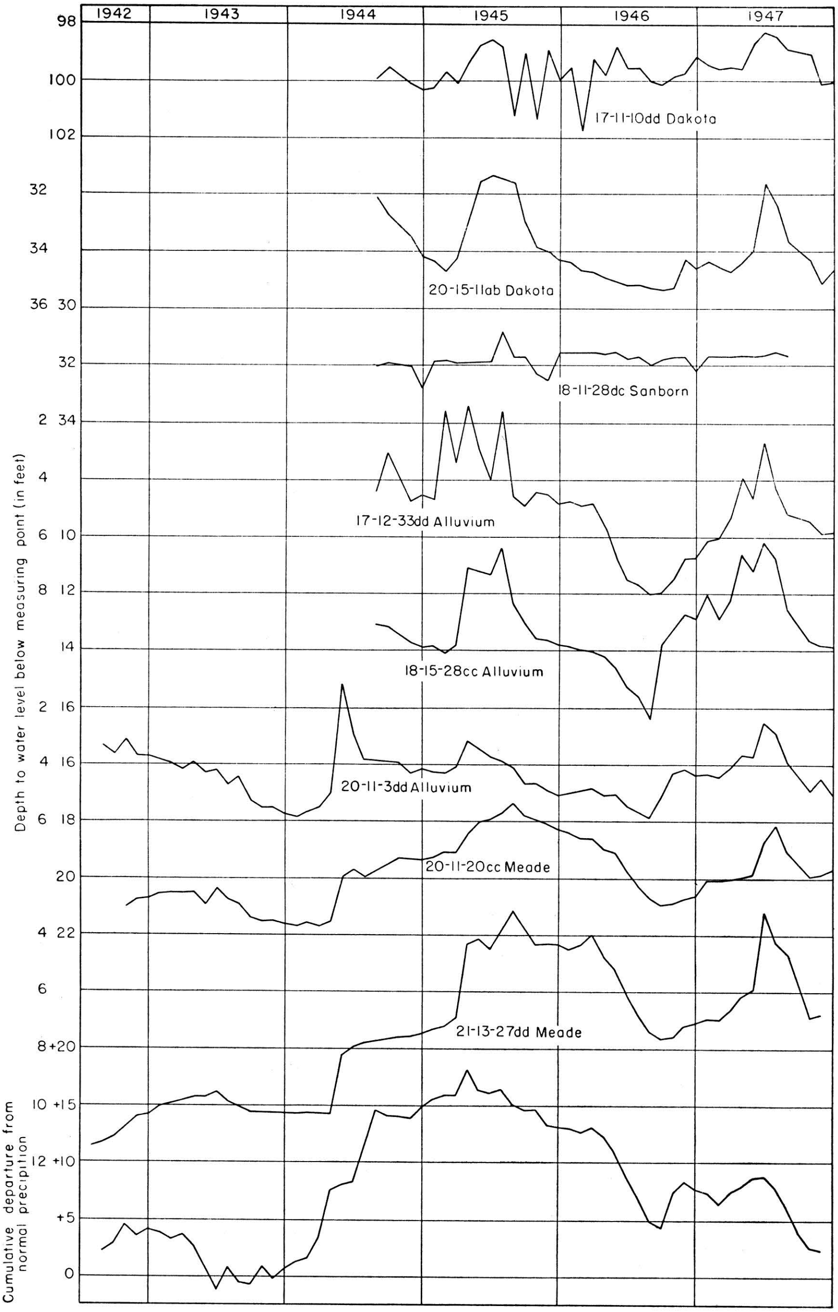

FIG. 14.—Hydrographs of eight typical observation wells in Barton and Stafford Counties and the cumulative departure from normal precipitation at Great Bend.

water levels in them were measured monthly. Measurements were begun in eight wells in Stafford County and six wells in Barton County during the summer and fall of 1942. Observations were begun in 11 additional wells in Barton County during July 1944. Measurements have been discontinued in four wells in Barton County and three wells in Stafford County. The observation wells were selected by me and periodic measurements were made by W. W. Wilson, A. A. Graffham, K. D. McCall, and Howard Palmer.

The descriptions of the wells and the water-level measurements are given in the annual water-level reports of the Federal Geological Survey (Meinzer and Wenzel, 1944, pp. 71 and 168; 1946, pp. 63 and 152; Sayre and others, 1947, pp. 51 and 126; 1948, pp. 51 and 126). Ensuing annual water-level reports in the same series will give subsequent water-level measurements. Table 7 correlates the observation-well numbers used in this report with those given

TABLE 7.—*Observation wells in Barton and Stafford Counties*

Well number in this report	Well number in Water-Supply Papers 946, 988, 1018, and 1025	Date measurements started	Date measurements stopped
	Barton County:		
16–14–34dd	112	July 13, 1944	
17–11–10dd	107	July 8, 1944	
17–12–24bc	111	July 12, 1944	Sept. 1, 1945
17–12–33dd	103	July 7, 1944	
17–13–33dc	104	July 7, 1944	Feb. 1, 1946
17–14–33aa	110	July 12, 1944	
18–11–28dc	105	July 8, 1944	
18–15–28cc1	109	July 12, 1944	
19–11–15cd	35	Oct. 9, 1942	Feb. 19, 1943
19–13–29cc	5	Oct. 5, 1942	June 2, 1943
19–14–16bb	2	Aug. 7, 1942	
19–15–17cb	101	July 7, 1944	
19–15–22dd	131	July 22, 1944	
20–11–3dd	1	Aug. 7, 1942	
20–11–20cc	43	Oct. 12, 1942	
20–13–12ad	16	Oct. 7, 1942	
20–15–11ab	100	Aug. 14, 1944	
	Stafford County:		
21–13–27dd	19	Aug. 1, 1942	
22–12–3cc	26	Aug. 3, 1942	
23–12–12cc	3	July 29, 1942	
23–14–27dd	38	Aug. 6, 1942	Apr. 28, 1943
24–11–16aa	63	Aug. 26, 1942	Dec. 1, 1945
24–13–28aa	29	Aug. 4, 1942	
24–15–3cd	40	Aug. 8, 1942	Mar. 24, 1943
25–13–12ab	25	Aug. 1, 1942	

in Water-Supply Papers 946, 988, 1018, and 1025. The location and description of each well are given in Tables 12 and 13.

Fluctuations in the water levels in seven typical observation wells in Barton County and one in Stafford County are shown by hydrographs in Figure 14, together with cumulative departure from normal precipitation at Great Bend.

Recharge of Ground Water

The amount of water in storage in the underground reservoir does not remain the same for any long period, as indicated by the fluctuations of water levels in wells. There is visible evidence that water is continually being discharged from the underground reservoir through streams, marshes, and wells; and the addition of water to the ground-water reservoir is clearly indicated by the fact that the water levels in the observation wells rise in response to precipitation.

The addition of water to the underground reservoir is termed recharge and may occur in several different ways. All ground water within a practical drilling depth beneath Barton and Stafford Counties is derived from the water that falls as rain or snow either within this area or on areas to the west. The underground reservoir in Barton and Stafford Counties is recharged by local precipitation, by seepage from streams and intermittent ponds, and by subsurface percolation from the west.

RECHARGE FROM LOCAL PRECIPITATION

A part of the precipitation that falls on the surface of this area recharges the underground reservoir. The normal annual precipitation in Barton and Stafford Counties is about 24 inches, but only a small percentage of this amount passes through the soil and reaches the zone of saturation. Of the total precipitation, part is lost by evaporation and transpiration, part leaves the county as surface runoff, and the remainder finds its way to the underground reservoir and eventually is discharged.

The amount of water lost through evaporation into the air varies from one season to another, the rate of evaporation being highest in summer when temperatures are highest. In an average year most of the precipitation in the counties comes during the summer, when the rate of evaporation is greatest. It is reasonable to assume, therefore, that a large proportion of the annual precipitation in Barton and Stafford Counties returns to the atmosphere through evaporation.

A part of the precipitation that falls is used by plants through the process of transpiration. The amount consumed in this way is obviously greatest during the growing season, which closely coincides with the period of maximum rainfall.

The amount of water leaving the county by runoff in streams is determined principally by the duration and intensity of the rainfall, the slope of the land surface, and the type of soil and vegetation. The runoff from a gentle rain as a rule is much smaller than the runoff from a heavy downpour; hence the amount of ground-water recharge from a gentle rain of long duration generally is greater than the recharge from a heavy downpour of short duration, providing all other factors are equal. The slope of the land is an important factor in determining the amount of runoff, and in general the steeper the slope the greater the runoff. Runoff is also greater in places where the surface is underlain by fine-grained, relatively impermeable material than in places where the surface material is sandy and loosely compacted. The latter type of material allows a part of the water to percolate into the ground, thus decreasing the amount of surface runoff. Vegetation tends to decrease the velocity of the runoff, thereby offering a better opportunity for the water to seep into the ground.

The most favorable areas for recharge in Barton and Stafford Counties are those areas underlain by dune sand. They include most of the area south of Arkansas River and the small area of sand hills southwest of Claflin (Pl. 1). Because of the high porosity of the dune sand and the presence of many undrained basins that serve as catchment areas for the rainfall, much water percolates downward to the zone of saturation. The sandy surficial material and the gentle slopes in this area reduce surface runoff to a minimum, so that very little water is lost by runoff in the sand hills except in narrow belts along the few streams. Throughout most of the areas of sand hills the material between the land surface and the water table is sufficiently permeable to allow water to percolate downward with little interruption. In a few places, lenses of relatively impermeable material probably hinder downward movement of water. Such lenses, however, are believed to be of limited horizontal extent so that the water detours around them and eventually reaches the water table.

The hydrographs of wells 20-11-20cc and 21-13-27dd in Figure 14 indicate that during periods of abundant rainfall a large amount of water is added to the Meade formation by precipitation in the sand-dune area south of Arkansas River. This is shown by the close relation between the precipitation graph and the hydrographs.

The rainfall as recorded at Great Bend was below normal in 1943, but during 1944 and the early part of 1945 it was considerably above normal. As a result, the net rise of water level in well 20-11-20cc was about 3.6 feet from October 1942 to August 1945, and the net rise of water level in well 21-13-27dd was about 8 feet from August 1942 to August 1945.

The valley areas in Barton and Stafford Counties are also excellent areas for ground-water recharge from precipitation. The factors that favor recharge in valley areas are the shallow depth to ground water, the sandy, porous soil, and the relatively flat surface which keeps runoff to a minimum. The water levels in shallow wells tapping alluvium in valley areas respond quickly to precipitation. This is shown by the hydrographs of well 18-15-28cc1 in Walnut Valley and well 20-11-3dd in Arkansas Valley. The high peaks on the hydrographs of wells 18-15-28cc1 and 20-11-3dd are probably the result of recharge from high water in Walnut Creek and Arkansas River, since the wells are near the streams. The general trend of the hydrographs, however, is directly controlled by the local precipitation.

A large amount of water also reaches the water table from precipitation on Cheyenne Bottoms. Water will also be diverted into Cheyenne Bottoms from Walnut Creek and Arkansas River. Since there is no runoff in this area, the amount of rainfall that eventually joins the underground reservoir is the total precipitation less the loss from evaporation and transpiration. The superficial material underlying Cheyenne Bottoms consists of silt and clay and is relatively impervious. During dry seasons the floor of Cheyenne Bottoms in many places is honeycombed with cracks that are several inches in width. A part of the water that falls as precipitation probably moves downward through the impervious cover to the shallow water table through these sod cracks and through rodent burrows. The close relation between rainfall and the increment to underground water storage beneath Cheyenne Bottoms is indicated by comparing the hydrograph of well 17-12-33dd with the curve showing cumulative departure from precipitation in Figure 14. Well 17-12-33dd is a shallow well located in the northern part of the Bottoms.

The amount of water that reaches the water table from precipitation on areas underlain by the Sanborn formation is very small in most places compared with the sand-dune and valley areas, for the areas underlain by the Sanborn have thick silt beds between the surface and the water table. The silt, which has a low permeability, retards the downward movement of water. It will be noted that the hydrograph of well 18-11-28dc, located in the Cow Creek drainage area where the surface is underlain by thick silt, shows little or no correlation with the precipitation. This indicates that recharge from local precipitation in this area is very small or does not occur at all.

The underground reservoir beneath the area underlain by the Pleistocene deposits in the vicinity of Galatia in northwestern Barton County probably receives water directly from local precipitation. Recharge from precipitation may be particularly high in those places where Pleistocene sand and gravel is exposed at the surface. Very little of the water from local precipitation reaches the underground reservoir in most of northern Barton County, for most of this area is underlain by impervious Cretaceous clay and shale. Some water may enter the Dakota formation in those areas of its outcrop where sandstone is at the surface, but the amount is probably small because of the steep slopes, which favor rapid runoff.

RECHARGE FROM STREAMS AND PONDS

Two factors determine whether a stream is capable of supplying water to the underground reservoir: (1) the water surface of the stream must be above the water table, and (2) the material between the stream channel and the water table must be sufficiently permeable to permit water to percolate downward and outward from the stream. Streams that satisfy these conditions are called influent or losing streams. Although no evidence of recharge from streams is apparent on the water-table contour map, it seems probable that some of the streams are supplying water to the underground reservoir. Arkansas River in Barton County is normally an effluent or gaining stream—that is, the stream surface is lower than the water table; hence, ground water moves toward the river. During flood stages of the river, however, the direction of movement of the ground water with respect to the river would be reversed and there would then be recharge from the river. The channels of Rattlesnake Creek and the North Fork of Ninnescah Creek in Stafford County and of Cow and Little Cheyenne Creeks in east-central Barton County are above the water table in the upper part of their courses and below the water table in the lower part. Where their channels lie above the water table and when they are flowing, these streams probably furnish some water to the underground reservoir. Where their channels lie below the water table, they are receiving water from the ground-water reservoir. The channels of Peace

Creek in east-central Stafford County and Dry Walnut Creek in southwestern Barton County are above the water table throughout this area and may lose water to the ground-water reservoir. The same is true of many smaller streams in Barton and Stafford Counties at times when they are flowing.

During rainy seasons water draining from the adjacent uplands accumulates in Cheyenne Bottoms and forms a large, shallow temporary lake. The water remains there for several weeks or months. Since there is no surface outlet, the water is lost through evaporation, transpiration, and seepage downward to the water table. The amount of water that is added to the ground-water reservoir by this means is thought to be relatively small because of the low permeability of the materials underlying the surface of Cheyenne Bottoms. Cracks and crevices that develop in the Bottoms during dry periods may provide a pathway for the downward movement of water for a time after Cheyenne Bottoms is flooded, but they may become sealed after water has stood over them for several days.

RECHARGE FROM OUTSIDE THE AREA

The water-table contours on Plate 1 show that the ground water in this area is moving from west to east, indicating that water percolates into the ground-water reservoir of this area from Rush, Pawnee, and Edwards Counties.

Discharge of Ground Water

Ground water is discharged from the underground reservoir in Barton and Stafford Counties by seepage into streams and marshes, evaporation and transpiration, and subsurface movement from the area, and by wells.

SEEPAGE INTO STREAMS AND MARSHES

The water-table contours in Plate 1 show that ground water is moving toward many of the streams in this area and, in places, is discharging as effluent seepage into those streams. Ground water is discharged by this means into Arkansas River, into Rattlesnake, North Fork of Ninnescah, Cow, Walnut, and Little Cheyenne Creeks, and into Big and Little Marshes.

EVAPORATION AND TRANSPIRATION

Transpiration is the process by which water is taken into the roots of plants directly from the zone of saturation or from the capillary fringe just above it, and is discharged into the atmosphere. The depth from which plants will lift the ground water varies with different plant species and different types of soil. Ordinary grasses and field crops will not send their roots more than a few feet in the search for water, but alfalfa and certain desert plants may send their roots several tens of feet to reach the water table.

In Barton and Stafford Counties the discharge of ground water by transpiration and evaporation occurs in the valley areas, near Big and Little Marshes, and in low places in the sand hills where the water table is shallow. Discharge of ground water by these two processes is particularly high in areas where the water table intersects the land surface or where the capillary fringe extends to the surface. Such areas are rather common in Big and Little Marshes and in the valleys of Rattlesnake, North Fork of Ninnescah, and Little Cheyenne Creeks, where seepage areas and marshy lands with abundant vegetation are characteristic. Ground water is also lost through transpiration and evaporation in parts of Arkansas and Blood Creek Valleys, in Cheyenne Bottoms, and in parts of the sand hills in Stafford and southern Barton Counties, where the water table is less than 10 feet below the surface. In Walnut, Dry Walnut, and Cow Creek Valleys the discharge of ground water from the zone of saturation by transpiration and evaporation is limited to areas adjacent to the stream channels where the water table is comparatively close to the surface.

WELLS

The above discussion treats of the natural discharge of ground water, which probably accounts for the greatest part of ground water discharged in Barton and Stafford Counties. Additional ground water is discharged from the underground reservoir through wells for domestic, stock, municipal, industrial, and irrigation use. The total amount thus discharged annually is not known.

The development of ground-water supplies from wells is discussed in the following section.

Development of Ground Water

Records for 371 wells were obtained durmg the investigation and are tabulated on pages 146-167. Of the 371 wells for which records are given, 257 are in Barton County, 111 are in Stafford County, 1 is in Rice County, 1 in Edwards County, and 1 in Pratt County. Included are 246 wells that are, or have been, used for domestic and stock purposes, 43 irrigation wells, 15 public-supply wells, 14 industrial wells, 52 wells that formerly suppled water for drilling oil wells, and 1 well that supplies water for a swimming pool. Records for all the large wells in Barton and Stafford Counties were obtained, but no attempt was made to obtain records for all domestic and stock wells.

DOMESTIC AND STOCK SUPPLIES

All the domestic water supplies and most of the stock-water supplies in Barton and Stafford Counties are obtained from wells. Streams and ponds are also important sources of stock water in some areas. Of the 246 domestic and stock wells listed in Tables 12 and 13, 193 are in Barton County, 51 are in Stafford County, 1 is in Rice County, and 1 is in Pratt County.

Although several methods have been used in constructing domestic and stock wells in this area, drilling has been the most common method. Of the 246 domestic and stock wells, 146 are drilled wells, 64 are driven wells, 34 are dug wells, 1 is a bored well, and 1 is a combination dug and drilled well.

Most of the drilled domestic and stock wells are in the upland areas of Barton County, where water is obtained from consolidated rocks. Only 10 of the 146 drilled wells are in Stafford County. The drilled wells range from 3 to 12 inches in diameter, but most of them are 5, 5½, or 6 inches in diameter. Galvanized-iron casing is most generally used, although a few domestic and stock wells are cased with iron, tile, or steel oil-well casing.

The driven well is the most common type of domestic and stock well in Stafford County and southern Barton County, where the water table is shallow and ground water occurs in soft unconsolidated deposits. Forty of the 51 recorded domestic and stock wells in Stafford County are driven wells. A screened drive point on 1¼-inch galvanized pipe is generally used in constructing these wells, although a few are constructed with 1½-inch or 2-inch galvanized pipe.

All but one of the dug wells for which records are given are in Barton County, and most of them are in the upland areas. They are usually shallow wells that have low yields. All are walled with rock, and they range from 24 to 72 inches in diameter.

Most of the domestic and stock wells in this area are equipped with lift or force pumps in which the cylinders are below the pump heads and may be far below the surface. Some lift or force pumps are operated by hand, but most of them are operated by windmills or are equipped for either hand or windmill operation. Many wells, particularly driven wells in Stafford County and southern Barton County, are equipped with hand-operated pitcher pumps that have their working parts at the base of the pump heads. A few domestic and stock wells have cylinder pumps operated by gasoline or electric motors, and a few are equipped with small centrifugal pumps powered by electric motors. Although the practice as yet is not common in this area, a few farms have been equipped with small pneumatic pressure systems in which the water is forced against air pressure into an air-tight tank from which it flows under pressure to any part of the home or farm. Five wells in Stafford County flow at the surface and therefore do not have to be pumped. One of these flowing wells (22-11-35ab) supplies domestic water to a hunting club, the others supply stock water. Of the 246 domestic and stock wells visited, the pumping equipment had been removed from 19 in Barton County and 12 in Stafford County.

Ground water in parts of the upland area of northern Barton County and in the vicinity of Big Marsh in northeastern Stafford County is highly mineralized and locally is unfit for domestic use. Cisterns are commonly used in these areas for domestic supplies and wells are used for stock-water supplies. In other parts of the Barton-Stafford County area, the ground waters, although moderately hard to very hard, are suitable for domestic and stock use.

PUBLIC SUPPLIES

Seven municipalities in the area have public water supplies obtained from wells. They are Claflin, Ellinwood, Hoisington, and Great Bend in Barton County and Stafford, St. John, and Macksville in Stafford County. Except for that of Great Bend, all the municipal supplies are publicly owned and operated. Each public supply is described briefly in the following paragraphs.

Claflin.—The City of Claflin has two wells (18-11-4ad1 and 18-11-4ad2) located a quarter of a mile south of town. In August 1944 the entire supply was derived from well 18-11-4ad1. Well 18-11-4ad2, which is to be used as a standby well, was completed just a few weeks earlier and was not yet equipped with a pump. Both wells tap sandstone of the Dakota formation. Well 18-11-4ad1 is 160 feet deep and is cased with 12-inch steel casing to a depth of 107 feet and with 6-inch perforated steel casing from 107 to 160 feet. The static water level is reported to be 37 feet below the surface. It is equipped with a turbine pump powered by a 15-horsepower electric motor and is reported to yield 200 gallons a minute with a 30-foot drawdown. Well 18-11-4ad2 is 25 feet west of well 18-11-4ad1, is 162 feet deep and is cased with 12-inch steel casing to a depth of 100 feet and 6-inch perforated steel casing below 100 feet. The static water level in this well, as measured August 14, 1944, was 32.46 feet below the land surface.

Water is pumped from well 18-11-4ad1 directly into the mains, and the excess flows into a 50,000-gallon elevated steel tank at the north edge of town. Mr. Fred Adams, water superintendent, reported that the average daily consumption of water at Claflin during the summer was about 50,000 gallons, and during the winter months it was considerably less than this amount. The maximum daily consumption is not known. The water, except for being hard, is of good quality and is not treated. (See analysis 18-11-4ad1.)

Ellinwood.—The water supply of Ellinwood is obtained from two wells (19-11-31bdc1 and 19-11-31bdc2) at the water plant in the west-central part of town and one well (19-11-31bb) in the northwest part of town. The wells derive water from sandstones of the Dakota formation, water in the overlying alluvium having been cemented off. The static water level in all three wells is reported to be 11 feet below the surface. One well (19-11-31bdc1) near the water plant is 90 feet deep, has 10-inch oil-well casing, and is equipped with a turbine pump powered by a 15-horsepower electric motor. It is reported to yield 185 gallons a minute with a drawdown of 12 feet. The other well (19-11-31bdc2) at the plant is 140 feet deep, is cased with 12-inch oil-well casing, and is equipped with a turbine pump powered by a 40-horsepower electric motor. The yield of this well is reported to be 485 gallons a minute. The well in the northwest part of town (19-11-31bb) is 138 feet deep, has 12-inch oil-well casing, and is equipped with a turbine pump and 15-horsepower electric motor. During a pumping test it is reported to have discharged 350 gallons a minute with a 22-foot drawdown. The operating yield of this well is reported to be 225 gallons a minute.

The water from the wells is pumped directly into the mains and the excess flows into a 50,000-gallon elevated steel tank located at the water plant. The maximum daily water consumption at Ellinwood is reported to be about 65,000 gallons and the average daily consumption about 35,000 gallons, all of which is used by the inhabitants. An analysis (19-11-31bdc1) of a sample of water from well 19-11-31bdc1 is given in Table 8. The water is hard but otherwise is of good quality and is not treated.

Hoisington.—Water for the city of Hoisington is obtained from two wells (19-13-4cc1 and 19-13-4cc2) that tap alluvium and are located on the north bank of Walnut Creek about 6 miles south of town. The two wells were drilled in 1936 and are identical in construction. They are gravel-packed wells 42 feet deep with 12-inch steel casing. The static water level stands 22 feet below the surface. Equipped with turbine pumps powered by 15-horsepower electric motors, each is reported to yield about 400 gallons a minute.

Water is pumped from the wells through 6⅓ miles of 10-inch pipe line to a treatment plant in town, where the water is softened. From there, two pumps discharge the treated water directly into the mains and the excess water flows into two elevated steel tanks having storage capacities of 180,000 and 200,000 gallons, respectively.

The maximum daily consumption of water at Hoisington is about 500,000 gallons and the average daily consumption is about 220,000 gallons. Not all of these amounts, however, are consumed by the inhabitants. The Missouri Pacific Railroad, which has a roundhouse and repair depot in Hoisington, takes approximately 250,000 gallons of water a month, and a local ice plant uses about 400,000 gallons a month for 6 months each year. A chemical analysis of the raw water from the city wells is not available; however, the water is reported to be extremely hard and, therefore, is given softening treatment. An analysis (19-13-4cc1) of the treated water is given in Table 8.

Great Bend.—Two wells (19-13-28bc and 19-13-28cd), owned and operated by the Kansas Power Company, supply water to Great Bend. Both wells tap the Meade formation. One well (19-13-28cd) is located in the rear of the Kansas Power Company's office in downtown Great Bend. This well, drilled in 1937, is a gravel-packed well 113 feet deep with 24-inch concrete casing. The static water level stands about 13 feet below the surface. It is equipped with a turbine pump and electric motor and is reported to yield 800 gallons a minute. The other well (19-13-28bc) was drilled in 1930 and is located on O'Dell Street in the northern part of town. It is a gravel-packed well 69.5 feet deep, and also has 24-inch concrete casing. The static water level in this well is reported to be 7.5 feet below land surface. It is equipped with a turbine pump and electric motor, but the yield is not known.

The well (19-13-28cd) at the office supplies most of the water used by the city. Water from this well (19-13-28cd) is pumped directly into the mains, the pump operating automatically as the pressure in the system changes. There are no storage reservoirs at Great Bend. The pump at the O'Dell Street well (19-13-28bc) also operates automatically and pumps only when the pressure in the system declines to a certain point.

The average daily consumption of water at Great Bend is about 850,000 gallons. An analysis (19-13-28cd) of a sample of water from the office well is given in Table 8. The water is hard but otherwise is of good quality. It receives no treatment.

Stafford.—Two closely spaced wells (24-12-11cd1 and 24-12-11cd2), about 0.25 mile northwest of town, supply the City of Stafford with water. Both wells tap the Meade formation, are 60 feet deep, and have 30-inch concrete casings. Each is equipped with a turbine pump and electric motor. The measured static water level in the south well (24-12-11cd2) was 20.90 feet below land surface on September 21, 1942. This well (24-12-11cd2) is reported to yield 500 gallons a minute with an 18-foot drawdown. The north well (24-12-11cd1) has a reported yield of 250 gallons a minute with an 8-foot drawdown. The water is pumped from the wells directly into the mains, and the excess flows into a 50,000-gallon elevated steel storage tank in the northern part of town and into a 150,000-gallon elevated steel storage tank in the southern part of town.

The maximum daily consumption of water at Stafford is about 320,000 gallons and the average daily consumption is about 120,000 gallons. An analysis (24-12-11cd1) of the water, which receives no treatment, is given in Table 9.

St. John.—The water supply of St. John is obtained from seven wells (24-13-4b1, 24-13-4b2, and 24-13-4b3), all of which are located near the city power plant in the south-central part of town and tap sand and gravel in the Meade formation. Five (24-13-4b3) of these wells are spaced very closely together and are connected to one centrifugal pump powered by a 20-horsepower electric motor. Each of these five wells is 50 feet deep and consists of an 8-inch steel casing on the lower end of which is an 8-inch screened sand point 10 feet long. The five wells (24-13-4b3) have a reported aggregate yield of 400 gallons a minute. A sixth (24-13-4b1 is a 16-inch gravel-packed well equipped with a turbine pump and 20-horsepower electric motor. This well is 83 feet deep, had a measured static water level of 20.39 feet on September 14, 1942, and is cased with concrete casing. It has a reported yield of 400 gallons a minute with a drawdown of 10 feet. The seventh (24-13-4b2) is a 26-inch gravel-packed well that is 83 feet deep and is cased with concrete casing. The static water level in this well is about 20 feet below the surface. Equipped with a centrifugal pump and a 50-horsepower electric motor, it has a reported yield of 750 gallons a minute with a drawdown of 6 feet. Water is pumped from these wells directly into the mains, and the excess flows into a 50,000-gallon elevated steel storage tank located near the center of town.

The maximum daily pumpage from the St. John wells is more than 200,000 gallons and the average daily pumpage is about 145,000 gallons. Of this amount, an average of about 512,000 gallons a month is used by the Atchison, Topeka, and Santa Fe Railway. The water receives no treatment. It is hard but otherwise of good quality. (See analysis 24-13-4b1, Table 9.)

Macksville.—Macksville obtains its water from three wells (24-15-15cc) in the east-central part of town. The wells are spaced about 20 feet apart and tap sand and gravel in the Meade formation. Each well is 73 feet deep and is cased with 6-inch iron casing on the end of which is a screened sand point 9 feet long. The static water level stands about 20 feet below the surface in each well. Three centrifugal pumps, each of which pumps from all three wells, are housed in one pump house. One pump is powered by an 8-horsepower electric motor and is reported to discharge 275 gallons a minute. Another pump is powered by a 20-horsepower electric motor and has a reported capacity of 300 gallons a minute. The third pump, which is used only in case of power failure or other emergency, is powered by a tractor and reportedly discharges 475 gallons a minute. Water is pumped directly from the wells into the mains, and the excess flows into a 60,000-gallon elevated steel tank.

The maximum daily consumption of water at Macksville is about 120,000 gallons and the average daily consumption is about 60,000 gallons. The water is not treated. An analysis (24-15-15cc) of the water is given in Table 9.

INDUSTRIAL SUPPLIES

Records were obtained of 12 wells in Barton County and 2 wells in Stafford County that supply water principally for industrial use.

Seven of the twelve industrial wells in Barton County are located in Great Bend. Water used by the Dr. Pepper Bottling Company in Great Bend is obtained from one 1¼-inch driven well (19-13-33ba) that is 70 feet deep and taps sand and gravel of the Meade formation. Equipped with a small cylinder pump and electric motor, it yields 1,000 gallons an hour. About 100,000 gallons of water a year is pumped from this well for use in the bottling plant. The water is chlorinated but receives no other treatment. The Great Bend Poultry Company has three driven wells (19-13-33bd1, 19-13-33bd2, and 19-13-33bd3) that supply water for a variety of uses in their plant. Two of them (19-13-33bd1 and 19-13-33bd2) are shallow wells, 30 feet deep, that derive water from the alluvium in the Arkansas Valley. Both these wells are equipped with centrifugal pumps and electric motors. One well (19-13-33bd1) is constructed with 1¼-inch galvanized pipe and a screened sand point and has a reported yield of 20 to 30 gallons a minute. The other shallow well (19-13-33bd2) is constructed with 2-inch galvanized pipe and a screened sand point and is reported to yield 125 gallons a minute. About 30,000 gallons of water a month is pumped from these two shallow wells. A third well (19-13-33bd3) is 75 feet deep and derives water from the Meade formation. It is constructed with 2-inch galvanized pipe and a screened sand point and is equipped with a centrifugal pump and electric motor. It has a reported yield of 1,500 gallons an hour. The monthly pumpage from the deep well (19-13-33bd3) is 12,000 to 14,000 gallons. Water from this well is used in boilers and is treated to reduce the hardness.

The Armour Creameries Company of Great Bend has one drilled well (19-13-33bd4), 69 feet deep, 6 inches in diameter, and cased with steel casing. The static water level in this well is about 8 feet below the surface. It is equipped with a piston-type pump and electric motor. A maximum of about 500,000 gallons a month is pumped from the Armour well. The water, which is derived from the Meade formation, receives no treatment. The Atchison, Topeka, and Santa Fe Railway has one well (19-13-33bd5) at Great Bend that supplies water for locomotive boilers. It is a 10-inch drilled well, 90 feet deep, and is cased with oil-well casing. The static water level stands about 10 feet below the surface. The well is equipped with a centrifugal pump and electric motor and is reported to yield about 330 gallons a minute. The maximum daily pumpage is about 135,000 gallons. The water comes from the Meade formation and is reported to be hard. It is treated with lime and soda ash to reduce the hardness before it is used in the locomotive boilers. The largest industrial well (19-13-33db) at Great Bend is at the power plant of the Kansas Power Company. It is a gravel-packed well, 75 feet deep, cased with 18-inch concrete casing, that taps the Meade formation. It is equipped with a large turbine pump and electric motor and is reported to yield 533 gallons a minute with a 22.5-foot draw-down. The static water level is 8 feet. More than 10,000,000 gallons of water a month is generally pumped from this well. The water is not treated.

The Empire Oil Company has two wells (16-13-8aa and 16-13-18aa) and the Simpson Oil Company one well (20-13-31ab) in Barton County that supply water to oil-field tank batteries. Both of the Empire Oil Company wells derive water from sandstones in the Dakota formation. One well (16-13-8aa) is in the NE¼ NE¼ sec. 8, T. 16 S., R. 13 W., 3 miles north of Susank. It is a 6-inch drilled well, 252 feet deep and cased with oil-well casing. The measured water level was 202.52 feet below the surface on August 8, 1944. It is equipped with a cylinder pump and windmill. The water is of poor quality, being high in chloride (Table 8). The other Empire Oil Company well (16-13-18aa) is in the NE¼ NE¼ sec. 18, T. 16 S., R. 13 W., about 2.5 miles northwest of Susank. This is a 6-inch drilled well, 270 feet deep, cased with oil-well casing, and equipped with a cylinder pump and gasoline engine. The measured water level in this well was 198.08 feet below the surface on August 8, 1948.

The Simpson Oil Company well (20-13-31ab) is in the sand hills about 6 miles south of Great Bend, in the NW¼ NE¼ sec. 31, T. 20 S., R. 13 W. It is a drilled well, 90 feet deep, cased with 7-inch oil-well casing, and taps the Meade formation. The water level was measured October 5, 1942, and found to be 14.94 feet below the surface. The well is equipped with a large cylinder pump and gasoline engine. A part of the water from this well is pumped to a near-by house where it is used for domestic purposes.

The Natural Gas Pipeline Company obtains cooling and condenser water from two drilled wells (19-14-6bb1 and 19-14-6bb2) in the NW¼ NW¼ sec. 6, T. 19 S., R. 14 W., about 2 miles northwest of Heizer. These wells tap alluvium in Walnut Valley, are 51.5 and 53.5 feet deep, are cased with 18-inch steel casing, and are equipped with turbine pumps and electric motors. The static water level in them stands at about 14 feet. Each is reported to yield 200 gallons a minute. The average daily pumpage from the two wells is about 100,000 gallons. The water, which is reported to be hard and to contain excessive iron, is softened before it is used.

One (well 21-13-31cd) of the industrial wells in Stafford County is owned by the Missouri Pacific Railroad and is located in Seward. This well supplies water for locomotive boilers. It is 60 feet deep, cased with 4.5-inch oil-well casing, and taps the Meade formation. Equipped with a plunger pump and gasoline engine, it is reported to yield 45 gallons a minute. The other industrial well (22-12-29dd) in Stafford County is at the Stafford County Flour Mills Company in Hudson. It also derives water from the Meade formation. It is a drilled well, 70 feet deep, cased with 6-inch galvanized-iron casing, and equipped with a plunger pump and Diesel engine. The yield of this well is reported to be 20 gallons a minute.

IRRIGATION SUPPLIES

The pumping of water from wells for irrigation, although not extensive, is carried on to a limited extent in Barton and Stafford Counties. Most of the irrigation wells in this area are used only to supply supplemental water. During years of normal or above-normal rainfall, sufficient moisture is available to guarantee the growth of most crops, and very little water is pumped from wells for irrigation. During dry years the rainfall is supplemented by water pumped from wells. The chief crops irrigated are feed crops, small grains, and alfalfa. In addition to the water pumped from wells some water is pumped from the perennial streams in the area.

During the investigation, 42 irrigation wells were visited in Barton and Stafford Counties. Records of these wells are given in Tables 8 and 9 and the locations of the wells are shown on Plate 2. Seven of the wells for which records were obtained are small irrigation wells that supply water to irrigate gardens, trees, and lawns. Of the 35 larger wells used for irrigation, 12 are in the Arkansas Valley, 8 are in Walnut Valley, 2 are on the Walnut Valley terrace, and 13 are widely distributed in the Great Bend prairie south of the Arkansas Valley. Of the 13 in the Great Bend prairie, 12 are in Stafford County and 1 is in Barton County.

Yields of Irrigation Wells.—The recorded irrigation wells in Barton and Stafford Counties range widely in yield. Small wells used to irrigate gardens, lawns, and trees yield from a few gallons a minute to about 100 gallons a minute, whereas the yields of larger irrigation wells range from about 200 gallons a minute to more than 1,000 gallons a minute. The yields of irrigation wells given in Tables 12 and 13 were reported by the owners.

The reported yields of 9 of the 12 large irrigation wells in the Arkansas Valley ranged from 450 to 1,370 gallons a minute and the average was about 1,060 gallons a minute. The specific capacities, that is, the number of gallons of water discharged per foot of drawdown of seven of these wells ranged from 34 to 152 and the average was about 67.

The reported yields of only three of the eight large irrigation wells in Walnut Valley were obtained. Each of the three wells (18-15-33ad, 19-14-4ca, and 19-14-9aa) was reported to yield 1,000 gallons a minute. The drawdown in well 18-15-33ad was reported to be 45 feet at that rate.

Well 19-13-6db, on the edge of the Walnut Valley terrace northwest of Great Bend (Pl. 2), has a reported yield of 1,100 gallons a minute with a drawdown of 20 feet. Well 19-13-18db, which is located on a remnant of the Walnut Valley terrace about 2 miles northwest of Great Bend, has the largest reported yield (1,500 gallons a minute) of any of the irrigation wells.

The yields of irrigation wells in the Great Bend prairie are less than the yields of irrigation wells in the other areas. Reported yields were obtained for 6 of the 13 large irrigation wells in the Great Bend prairie. They ranged from 200 to 900 gallons a minute and averaged 650 gallons a minute. The specific capacities of wells 20-14-26ab, 23-13-28ca, and 23-14-20bc in this area, the only wells for which the drawdowns were known, were 20, 53, and 100, respectively.

Many factors determine the yield of wells, including the methods of construction, the character and thickness of the water-bearing formation, the diameter of the casing, the material used for casing, the quality of the water—whether neutral, corrosive, or likely to form incrusting material readily, the type and placing of the screen, the development of the well, the finishing of the well—whether gravel-packed or not, the age of the well, and, for battery wells, the spacing of the wells. There are doubtless other factors, but the most important ones are listed. The relative importance of the different factors varies for different wells and under different conditions.

Depth and diameter of irrigation wells.—The depth of the irrigation wells in Barton and Stafford Counties range from 18 to 115 feet. Of those in the Arkansas Valley, two wells are less than 30 feet deep, five are between 30 and 60 feet deep, and six are between 60 and 79 feet deep. Irrigation wells in Walnut Valley range in depth from 45.6 to 80 feet and most of them are 60 to 80 feet. In the Great Bend prairie, the irrigation wells are 26 to 85 feet deep. Of 16 wells in the prairie, 6 are less than 40 feet deep and 10 are 40 to 85 feet deep. The deepest irrigation well (19-13-6db) in the Barton-Stafford County area is 115 feet deep and is on the Walnut Valley terrace.

The diameters of the irrigation wells range from 1¼ inches for a small driven garden well (19-13-29cc) to 24 inches for a well (24-12-4dd) cased with old oil barrels. Most of the irrigation wells, however, are 15 to 20 inches in diameter.

Types of equipment on irrigation wells.—All the irrigation wells in the Great Bend prairie and about half of those in the Arkansas and Walnut Valleys are equipped with centrifugal pumps. Ten wells in Arkansas and Walnut Valleys and the two wells on the Walnut Valley terrace are equipped with turbine pumps. Two cylinder-type pumps were observed, but doubtless there are many other pumps of this type used for small-scale irrigation of gardens, lawns, and trees. Most of the cylinder-type pumps are probably powered by wind.

Gasoline engines are those most commonly used for pumping from wells for irrigation in Barton and Stafford Counties. These include stationary gasoline engines, automobile engines, and combine engines. Six of the irrigation wells visited were powered by electric motors, two by tractors, one by a natural gas engine, and one by a Diesel engine. Three were not equipped with power at the time of my visit.

Construction of irrigation wells.—Most of the irrigation wells in Barton and Stafford Counties have been put down by professional drillers using either cable-tool or rotary drilling machines. Two types of wells are used for irrigation, depending on the character of the water-bearing material—wells that are gravel-packed and wells that are not. The methods of construction are slightly different, although either rotary or cable-tool equipment may be used with either method. In constructing a gravel-packed well, the hole is made somewhat larger than the casing and an outer "dummy" casing is generally used. The annular space between the outer blank casing and the inner screened or perforated casing is filled with screened gravel, and the outer casing is pulled up slowly as gravel-filling progresses. Where a rotary drilling machine is used it is not necessary to use a "dummy" casing, since the drilling mud prevents the hole from caving while the inner casing and gravel are being placed.

The other type of irrigation well is not gravel-packed and is constructed in the same way as the cased domestic and stock wells. Most of the irrigation wells of this type have been put down by drillers using cable-tool drilling machines and are constructed by sinking a screened or perforated casing as the well is being drilled. The casing is forced downward by sand-bag weights or other type of pressure as the material is removed by a sand bucket. In putting down this type of well by the hydraulic-rotary method, no casing is used until the drilling has been completed, then a casing slightly smaller than the hole is placed in the well.

The most common type of casing used for irrigation wells in Barton and Stafford Counties is that made of galvanized-iron casing, which can be obtained in factory-perforated sections or plain sections. Used oil-well casing has been used in a few wells and one well (24-12-4dd) is cased with old oil barrels, the bottoms and tops of which have been cut out. Galvanized pipe ranging in diameter from 1¼ to 3 inches has been used in the smaller garden and lawn irrigation wells.

Most of the irrigation wells in Stafford County and many of them in Barton County are partly dug and partly drilled. Generally, a pit is first dug to near the water table and the well is then drilled in the bottom of the pit. The sides of the pit are cribbed with brick, concrete, or wood. In this type of well, a centrifugal pump is generally installed over the casing on the floor of the pit. Pits are not used where the well is equipped with a turbine pump.

One irrigation plant (well 24-14-12dd) in Stafford County consists of three wells connected to one centrifugal pump. The wells, which are 52 feet deep and 10 to 15 inches in diameter, are closely spaced and are connected to one pump by a suction pipe laid in the ground just above the water table. The middle well and pumping equipment are in a pit over which a pump house has been built.

Irrigation well 19-12-19bc in the Arkansas Valley area in Barton County is a battery of two wells spaced about 50 feet apart and connected to one centrifugal pump. Each well is 30.5 feet deep and is cased with 20-inch steel casing. The pump is set in one of the well pits over which a pump house has been built. A buried suction line runs from the pit to the other well.

For a detailed discussion of methods of constructing different types of irrigation wells, the reader is referred to Davison (1939) and Rohwer (1940).

OTHER TYPES OF SUPPLIES

Of the 371 wells visited in Barton and Stafford Counties, 52 were wells that had been put down to supply water for drilling oil wells. Of the 52 wells, 35 were in Stafford County and 17 were in Barton County. Most of these wells are drilled for a temporary water supply. After the drilling of the oil well or wells is completed, the water well is abandoned and sometimes the casing is pulled. Wells of this type are drilled wells that range in depth from about 15 feet to more than 200 feet. In northern Barton County, where the wells must penetrate sandstones of the Dakota formation to obtain an adequate supply, they are from about 100 feet to more than 200 feet deep. Elsewhere adequate supplies for oil drilling are usually available at shallower depth. Wells of this type in the Arkansas Valley are between 15 and 55 feet deep. In the Great Bend prairie they range from 31 to 98 feet in depth, but most of them are 60 to 90 feet deep. Used oil-well casing is most commonly used in these wells, although a few have been cased with galvanized-iron casing. Their diameters range from 5 inches to 12 inches, but 6-inch and 6½-inch casing is most common. The wells are generally pumped with large cylinder-type pumps and portable gasoline engines, which are removed as soon as the drilling of the oil well is completed.

One well (25-12-27ab) in Stafford County is used to supply water to a swimming pool at Camp Carlile, a church camp in the NW¼ NE¼ sec. 27, T. 25 S., R. 12 W. This is a plant consisting of three wells, each 14.5 feet deep and cased with 12-inch galvanized-iron casing, that are connected to one centrifugal pump. The aggregate yield of the three wells is reported to be 200 gallons a minute. The water is derived from the Meade formation.

Chemical Character of Ground Water

The chemical character of the ground waters in Barton and Stafford Counties is shown by the analyses of water from 62 representative wells in Barton County (Table 8) and 27 representative wells in Stafford County (Table 9). The amounts of chloride in samples of water from three wells in Stafford County are given in Table 9. In addition, the chemical analyses of 11 samples of water collected from test holes in Stafford County and the amounts of chloride in 2 samples collected from test holes in Barton County are given in Table 10. The analyses, which were made by Howard Stoltenberg in the Water and Sewage Laboratory of the Kansas State Board of Health, show only the dissolved mineral content of the waters and do not in general indicate the sanitary condition of the waters. The constituents given were determined by the methods used by the U. S. Geological Survey.

CHEMICAL CONSTITUENTS IN RELATION TO USE

The following discussion of the chemical constituents of ground water has been adapted from publications of the United States Geological Survey.

Dissolved solids.—The residue left after a natural water has evaporated consists of rock materials which may include some organic material and some water of crystallization. Waters containing less than 500 parts per million of dissolved solids generally are entirely satisfactory for domestic use, except for the difficulties resulting from their hardness and, in some areas, excessive iron content or corrosiveness. Waters having more than 1,000 parts per million are as a rule not satisfactory, for they are likely to contain enough of certain constituents to produce a noticeable taste or to make the water unsuitable in some other respects.

The ground waters from about half the wells sampled in Barton and Stafford Counties contained less than 500 parts per million of dissolved solids and are entirely satisfactory for most ordinary purposes. The waters from 23 of the wells sampled contained between 500 and 1,000 parts per million of dissolved solids, the waters from 16 wells contained between 1,000 and 3,000 parts, and the water from 5 wells (16-11-11cc, 16-13-8aa, 16-14-9bc, 16-14-26bb, and 17-15-2ad) contained more than 3,000 parts. The highest concentration of dissolved solids, 6,323 parts per million, was in the sample of water from well 17-15-2ad.

The areal distribution of dissolved solids in the well waters of Barton and Stafford Counties is shown in Figure 15.

Hardness.—The hardness of water, which is the property that generally receives the most attention, is most commonly recognized by its effects when soap is used with the water. Hard water is objectionable because it forms with soap a sticky insoluble curd difficult to remove from containers and fabrics; requires greater quantities of soap to produce lather; and forms scale in boilers and pipes with resultant loss in heat transfer and boiler failure. Calcium and magnesium cause virtually all the hardness of ordinary waters. These constituents are also the active agents in the formation of the greater part of the scale in steam boilers and in other vessels in which water is heated or evaporated.

In addition to the total hardness the table of analyses shows the carbonate hardness and the noncarbonate hardness. The carbonate hardness is that due to the presence of calcium and magnesium bicarbonates. It is almost completely removed by boiling. In some reports this type of hardness is called temporary hardness. The noncarbonate hardness is due to the presence of sulfates or chlorides of calcium and magnesium, but it cannot be removed by boiling and has sometimes been called permanent hardness. With reference to use with soap there is no difference between the carbonate and noncarbonate hardness. In general the noncarbonate hardness forms harder scale in steam boilers.

Water having a hardness of less than 50 parts per million is generally rated as soft, and its treatment for removal of hardness under ordinary circumstances is not necessary. Hardness between

TABLE 8.—*Analyses of water from typical wells in Barton County, Kansas*

Analyzed by H. A. Stoltenberg. Dissolved constituents given in parts per million [a], and in equivalents per million [b] (in italics)

Well No.	LOCATION	Depth (feet)	Geologic source	Date of collection	Temperature (°F)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: Carbonate	Hardness as $CaCO_3$: Noncarbonate
	T. 16 S., R. 11 W.																		
16–11–11cc	SW SW sec. 11	260	Dakota formation	Oct. 16, 1944	59	3,281	......	2.4	29 *1.45*	32 *2.63*	1,191 *51.79*	414 *6.79*	279 *5.80*	1,520 *42.86*	2.4 *.13*	18 *.29*	204	204	0
16–11–27cd	SE SW sec. 27	42.7	Carlile shale	Oct. 12, 1944	58	673	......	.18	156 *7.78*	13 *1.07*	78 *3.40*	273 *4.48*	23 *.48*	247 *6.96*	.3 *.02*	19 *.31*	442	224	218
16–11–36dc	SW SE sec. 36	188.3	Dakota formation	Oct. 15, 1944	58	318	......	3.5	77 *3.84*	11 *.90*	32 *1.41*	322 *5.28*	9.5 *.20*	22 *.62*	.5 *.03*	1.4 *.02*	237	237	0
	T. 16 S., R. 12 W.																		
16–12–12cb	NW SW sec. 12	190.5	do	Oct. 15, 1944	59	564	......	6.4	5.6 *.28*	3.6 *.30*	215 *9.34*	381 *6.25*	48 *1.00*	91 *2.57*	1.2 *.06*	2.8 *.04*	29	29	0
	T. 16 S., R. 13 W.																		
16–13–8aa	NE NE sec. 8	252	do	Oct. 15, 1944	59	3,745	......	6.9	36 *1.80*	35 *2.88*	1,367 *59.47*	427 *7.00*	227 *4.72*	1,850 *52.17*	2.8 *.15*	7.1 *.11*	234	234	0
16–13–12ad	SE NE sec. 12	227	do	Oct. 15, 1944	60	1,982	......	1.4	19 *.95*	13 *1.07*	727 *31.62*	546 *8.95*	275 *5.72*	660 *18.61*	3.8 *.20*	9.7 *.16*	101	101	0
16–13–33da	NE SE sec. 33	165.5	do	Sept. 7, 1944	59	1,780	......	6.7	21 *1.05*	15 *1.23*	630 *27.38*	565 *9.27*	388 *8.07*	430 *12.13*	2.2 *.12*	4.3 *.07*	114	114	0
	T. 16 S., R. 14 W.																		
16–14–2cb	NW SW sec. 2	42.6	Greenhorn limestone	Oct. 16, 1944	58	356	......	1.2	106 *5.29*	10 *.82*	13 *.58*	327 *5.36*	9.0 *.19*	23 *.65*	.2 *.01*	30 *.48*	306	268	38
16–14–9bc	SW NW sec. 9	190	Dakota formation	Oct. 15, 1944	61	4,334	......	6	45 *2.24*	35 *2.88*	1,571 *68.32*	468 *7.68*	416 *8.65*	2,015 *56.82*	2.8 *.15*	8.8 *.14*	256	256	0
16–14–26bb1	NW NW sec. 26	20	Carlile shale	Sept. 7, 1944	59	2,277	......	.68	581 *28.99*	28 *2.30*	81 *3.51*	412 *6.76*	103 *2.14*	440 *12.41*	.1 *.01*	837 *13.48*	1,564	338	1,226
16–14–26bb2	NW NW sec. 26	167.5	Dakota formation	Sept. 7, 1944	60	4,646	......	2.8	70 *3.49*	49 *4.03*	1,639 *71.28*	577 *9.46*	523 *10.88*	2,065 *58.23*	2.4 *.13*	6.2 *.10*	376	376	0
	T. 16 S., R. 15 W.																		
16–15–6dd	SE SE sec. 6	209.5	do	Oct. 15, 1944	59	2,603	......	1.8	24 *1.20*	19 *1.56*	952 *41.39*	382 *6.26*	272 *5.66*	1,130 *31.87*	3.8 *.20*	9.7 *.16*	138	138	0
16–15–11da	NE SE sec. 11	187.5	do	Sept. 7, 1944	60	1,421	......	1.5	37 *1.85*	15 *1.23*	492 *21.38*	359 *5.89*	119 *2.48*	555 *15.65*	2.2 *.12*	20 *.32*	154	154	0
16–15–15dc	SW SE sec. 15	40	Undifferentiated Pleistocene	Oct. 15, 1944	59	1,203	......	1.2	14 *.70*	9.2 *.76*	447 *19.44*	372 *6.10*	81 *1.68*	460 *12.97*	2.2 *.12*	2.0 *.03*	73	73	0

17-11-31dc	*T. 17 S., R. 11 W.* SW SE sec. 31	71.4	Sanborn formation	Oct. 12, 1944	58	390	......	1.7	92 *4.59*	10 *.82*	42 *1.81*	315 *5.17*	19 *.40*	45 *1.27*	.2 *.01*	23 *.37*	270	258	12
17-11-36cc	SW SW sec. 36	60	do	Oct. 12, 1944	58	320	......	1	92 *4.59*	9.2 *.76*	20 *.88*	337 *5.53*	6.2 *.13*	16 *.45*	.4 *.02*	6.2 *.10*	268	268	0
17-12-2cb	*T. 17 S., R. 12 W.* NW SW sec. 2	150	Dakota formation	Oct. 15, 1944	57	519	......	.26	66 *3.29*	16 *1.32*	108 *4.68*	349 *5.72*	100 *2.08*	46 *1.30*	1.6 *.08*	6.6 *.11*	230	230	0
17-12-27cc	SW SW sec. 27	153.6	do	Oct. 15, 1944	58	818	......	.80	176 *8.78*	24 *1.97*	74 *3.21*	410 *6.72*	310 *6.45*	25 *.71*	1.2 *.06*	1.5 *.02*	538	336	202
17-12-31dc1	SW SE sec. 31	27.3	Alluvium	Oct. 15, 1944	58	1,272	......	.86	261 *13.02*	35 *2.88*	131 *5.71*	392 *6.43*	348 *7.24*	256 *7.22*	.6 *.03*	43 *.69*	795	322	473
17-12-31dc2	SW SE sec. 31	60	Dakota formation	Oct. 15, 1944	57	972	......	1	154 *7.68*	28 *2.30*	158 *6.88*	461 *7.56*	240 *4.99*	140 *3.95*	1 *.05*	19 *.31*	499	378	121
17-13-10dd	*T. 17 S., R. 13 W.* SE SE sec. 10	65.6	do	Oct. 16, 1944	58	523	......	.44	138 *6.89*	15 *1.23*	33 *1.43*	414 *6.79*	21 *.44*	46 *1.30*	.4 *.02*	62 *1.00*	406	340	66
17-13-28bb	NW NW sec. 28	260	do	Sept. 7, 1944	59	1,150	......	.50	146 *7.28*	37 *3.04*	207 *9.00*	372 *6.10*	367 *7.63*	185 *5.22*	1 *.05*	20 *.32*	516	305	211
17-13-31dd	SE SE sec. 31	58	do	Oct. 15, 1944	59	2,174	......	2	86 *4.29*	34 *2.79*	706 *30.70*	356 *5.84*	133 *2.77*	1,030 *29.05*	1.1 *.06*	3.5 *.06*	354	292	62
17-14-11cc	*T. 17 S., R. 14 W.* SW SW sec. 11	180	do	Sept. 7, 1944	59	430	......	1.2	57 *2.84*	14 *1.15*	93 *4.05*	353 *3.79*	31 *.64*	54 *1.52*	.7 *.04*	3.1 *.05*	200	200	0
17-14-33dd	SE SE sec. 33	87.5	do	Sept. 7, 1944	60	622	......	1.3	120 *5.99*	28 *2.30*	61 *2.65*	260 *5.90*	202 *4.20*	27 *.76*	1 *.05*	2 *.03*	414	295	119
17-15-2ad	*T. 17 S., R. 15 W.* SE NE sec. 2	198	do	Sept. 7, 1944	60	6,323	......	1.9	62 *3.09*	58 *4.77*	2,300 *100.07*	486 *7.97*	427 *8.88*	3,320 *90.80*	2.6 *.14*	8.8 *.14*	393	393	0
17-15-23ad	SE NE sec. 23	77.5	do	Sept. 7, 1944	58	759	......	.76	50 *2.50*	16 *1.32*	217 *9.44*	551 *9.04*	151 *3.14*	15 *.42*	3.4 *.18*	30 *.48*	191	191	0
18-11-4ad	*T. 18 S., R. 11 W.* SE NE sec. 4	160	do	Aug. 27, 1945	......	512	29	0	86	12	82	317	22	111	.4	2.4	264	260	4
18-11-15bc	SW NW sec. 15	32.4	Sanborn formation	Oct. 12, 1944	59	844	......	5	142 *7.08*	28 *2.30*	115 *5.00*	339 *5.56*	108 *2.25*	174 *4.91*	.3 *.02*	102 *1.64*	469	278	191
18-11-19bb	NW NW sec. 19	16	Alluvium	Oct. 16, 1944	58	449	......	0	98 *4.89*	16 *1.32*	44 *1.91*	346 *5.67*	40 *.83*	28 *.79*	.8 *.04*	49 *.79*	310	284	26
18-12-12bc	*T. 18 S., R. 12 W.* SW NW sec. 12	41.2	Dakota formation	Oct. 12, 1944	58	330	......	.84	96 *4.79*	7.8 *.64*	22 *.94*	327 *5.36*	2.3 *.05*	28 *.79*	.2 *.01*	9.7 *.16*	272	268	4
18-13-15da	*T. 18 S., R. 13 W.* NE SE sec. 15	33.4	Alluvium	Oct. 16, 1944	57	647	......	.20	140 *6.99*	21 *1.73*	70 *3.03*	354 *5.80*	49 *1.02*	154 *4.34*	.2 *.01*	36 *.58*	436	290	146
18-14-7cc	*T. 18 S., R. 14 W.* SW cor. sec. 7	61.5	Dakota formation	Sept. 6, 1944	58	305	......	1.9	76 *3.79*	9.9 *.81*	26 *1.12*	259 *4.25*	31 *.64*	26 *.73*	.5 *.03*	4.3 *.07*	230	212	18
18-14-25cb	NW SW sec. 25	55	Sanborn formation	Sept. 6, 1944	58	387	......	10	82 *4.09*	16 *1.32*	45 *1.96*	350 *5.74*	32 *.67*	31 *.87*	.4 *.02*	4.2 *.07*	270	270	0
18-14-30cb	NW SW sec. 30	61.5	do	Sept. 6, 1944	59	317	......	7.7	82 *4.09*	9.2 *.76*	26 *1.15*	307 *5.03*	13 *.27*	23 *.65*	.1 *.01*	2.8 *.04*	242	242	0

TABLE 8.—*Analyses of water from typical wells in Barton County, Kansas—Concluded*

Analyzed by H. A. Stoltenberg. Dissolved constituents given in parts per million[a], and in equivalents per million[b] (in italics)

Well No.	Location	Depth (feet)	Geologic source	Date of collection	Temperature (°F)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$		
																	Total	Carbonate	Noncarbonate
	T. 18 S., R. 15 W.																		
18-15-1bc	SW NW sec. 1	220.2	Dakota formation	Oct. 16, 1944	60	858	......	4.6	8.4 *.42*	5.8 *.48*	321 *13.98*	359 *5.89*	76 *1.58*	260 *7.33*	1 *.05*	1.8 *.03*	45	45	0
18-15-30dd	SE SE sec. 30	35	Alluvium	Oct. 16, 1944	58	385	......	1.6	99 *4.94*	13 *1.07*	29 *1.27*	350 *5.74*	49 *1.02*	17 *.48*	.3 *.02*	1.3 *.02*	300	287	13
18-15-34ab	NW NE sec. 34	30	do.	Oct. 16, 1944	58	502	......	1.8	103 *5.14*	14 *1.15*	68 *2.97*	404 *6.62*	73 *1.52*	38 *1.07*	.4 *.02*	2 *.03*	314	314	0
	T. 19 S., R. 11 W.																		
19-11-6dd	SE cor. sec. 6	61	Sanborn formation	Oct. 12, 1944	58	864	......	1.7	182 *9.08*	29 *2.38*	70 *3.04*	351 *5.76*	50 *1.04*	161 *4.54*	.3 *.02*	195 *3.14*	573	288	285
19-11-31bdc1	SW SE NW sec. 31	90	Dakota formation	Aug. 10, 1945	......	1,231	17	0	159	43	157	251	565	82	.8	4	573	206	367
	T. 19 S., R. 12 W.																		
19-12-6bc	SW NW sec. 6	15.3	Alluvium	Oct. 24, 1942	59	2,728	......	4.4	239 *11.93*	75 *6.16*	615 *26.77*	439 *7.20*	897 *18.66*	665 *18.75*	1.1 *.06*	12 *.19*	904	360	544
19-12-13ad	SE NE sec. 13	33.5	Sanborn formation	Oct. 24, 1942	59	1,502	......	.71	195 *9.73*	29 *2.38*	304 *13.23*	276 *4.53*	120 *2.50*	560 *15.79*	.3 *.02*	155 *2.50*	606	226	380
19-12-15dd	SE SE sec. 15	85.5	Dakota formation	Oct. 24, 1942	58	405	......	4.1	109 *5.44*	11 *.90*	28 *1.24*	300 *4.92*	13 *.27*	77 *2.17*	.2 *.01*	13 *.21*	317	246	71
19-12-28cc	SW SW sec. 28	25	Alluvium	Oct. 16, 1944	58	898	......	.72	134 *6.69*	28 *2.30*	160 *6.95*	340 *5.58*	141 *2.93*	260 *7.33*	.7 *.04*	3.9 *.06*	450	279	171
	T. 19 S., R. 13 W.																		
19-13-4cc (c)	SW SW sec. 4	42	do.	Jan. 10, 1945	......	270	28	.04	20	13	55	124	44	48	.4	2.7	104	104	0
19-13-11cb	NW SW sec. 11	47.5	Dakota formation	Oct. 24, 1942	57	1,236	......	3.6	197 *9.83*	32 *2.63*	158 *6.85*	259 *4.25*	110 *2.29*	248 *6.99*	.3 *.02*	358 *5.76*	623	212	411
19-13-28cd	SE SW sec. 28	113	Meade formation	July 31, 1945	......	564	14	0	78	16	89	193	115	121	.7	3.5	260	158	102
19-13-34cd	SE SW sec. 34	70	do.	Oct. 27, 1942	58	379	......	0	72 *3.59*	14 *1.15*	50 *2.16*	267 *4.38*	69 *1.44*	33 *.93*	.8 *.04*	6.6 *.11*	237	219	18

	T. 19 S., R. 14 W.																		
19–14–6bb	NW NW sec. 6	58	Alluvium	Oct. 27, 1942	58	413	......	0.58	106 *5.29*	14 *1.15*	40 *1.73*	367 *6.02*	35 *.73*	48 *1.35*	.3 *.02*	3.4 *.05*	322	301	21
19–14–7dd	SE SE sec. 7	75	do.	Oct. 27, 1942	58	470	......	.05	96 *4.79*	8.9 *.73*	69 *3.00*	334 *5.48*	16 *.33*	72 *2.03*	.3 *.02*	41 *.66*	276	274	2
19–14–33cd	SE SW sec. 33	75	do.	Oct. 27, 1942	58	422	......	.26	85 *4.24*	18 *1.48*	49 *2.13*	290 *4.76*	53 *1.10*	68 *1.92*	.6 *.03*	2.8 *.04*	286	238	48
	T. 19 S., R. 15 W.																		
19–15–20aa	NE NE sec. 20	34.1	do.	Sept. 7, 1944	59	271	......	1	66 *3.29*	9 *.74*	28 *1.20*	265 *4.35*	11 *.23*	21 *.59*	.3 *.02*	2.2 *.04*	202	202	0
19–15–24bc	SW NW sec. 24	28.5	do.	Sept. 7, 1944	58	1,163	......	1.3	104 *5.19*	20 *1.64*	293 *12.75*	428 *7.02*	196 *4.08*	254 *7.16*	.5 *.03*	80 *1.29*	342	342	0
19–15–34aa	NE NE sec. 34	30	do.	Sept. 6, 1944	59	768	......	.60	150 *7.48*	19 *1.56*	95 *4.15*	334 *5.48*	53 *1.10*	168 *4.74*	.3 *.02*	115 *1.85*	452	274	178
	T. 20 S., R. 11 W.																		
20–11–2ba	NE NW sec. 2	25	do.	Oct. 16, 1944	58	582	......	.02	109 *5.44*	18 *1.48*	72 *3.12*	233 *3.82*	170 *3.54*	91 *2.57*	.7 *.04*	4.4 *.07*	346	191	155
20–11–18ba	NE NW sec. 18	31	do.	Oct. 24, 1942	59	508	......	.04	77 *3.84*	12 *.99*	101 *4.38*	254 *4.16*	36 *.75*	148 *4.17*	.5 *.03*	6.2 *.10*	242	208	34
	T. 20 S., R. 12 W.																		
20–12–26ad	SE NE sec. 26	43.7	Meade formation	Oct. 24, 1942	59	301	......	1.1	70 *3.49*	7.4 *.61*	35 *1.51*	260 *4.26*	17 *.35*	28 *.79*	.4 *.02*	12 *.19*	205	205	0
	T. 20 S., R. 13 W.																		
20–13–19aa	NE NE sec. 19	32	do.	Oct. 27, 1942	59	358	......	0	82 *4.09*	11 *.90*	39 *1.68*	294 *4.82*	36 *.75*	33 *.93*	.4 *.02*	9.3 *.15*	250	241	9
	T. 20 S., R. 14 W.																		
20–14–20bc	SW NW sec. 20	20	Alluvium	Oct. 16, 1944	59	535	......	.05	93 *4.64*	22 *1.81*	60 *2.62*	235 *3.85*	210 *4.37*	24 *.68*	.7 *.04*	8 *.13*	322	192	130
	T. 20 S., R. 15 W.																		
20–15–19dd	SE SE sec. 19	163.4	Dakota formation	Sept. 6, 1944	59	368	......	1.5	85 *4.24*	19 *1.56*	30 *1.30*	315 *5.17*	17 *.35*	51 *1.44*	.8 *.04*	6.2 *.10*	290	258	32
20–15–22ba	NE NW sec. 22	69.5	do.	Sept. 6, 1944	......	515	......	5.9	81 *4.04*	14 *1.15*	98 *4.27*	322 *5.28*	23 *.48*	129 *3.64*	.3 *.02*	2.5 *.04*	260	260	0
20–15–33db	NW SE sec. 33	35	Alluvium	Sept. 7, 1944	59	611	......	.16	103 *5.14*	23 *1.89*	94 *4.09*	311 *5.10*	78 *1.62*	153 *4.31*	.5 *.03*	3.8 *.06*	352	255	97

a. One part per million is equivalent to one pound of substance per million pounds of water or 8.33 pounds per million gallons of water.

b. An equivalent per million is a unit chemical equivalent weight of solute per million unit weights of solution. Concentration in equivalents per million is calculated by dividing the concentration in parts per million by the chemical combining weight of the substance or ion.

c. Analysis of treated water. Sample taken from tap at city auditorium.

TABLE 9.—*Analyses of water from typical wells in Stafford County, Kansas*

Analyzed by H. A. Stoltenberg. Dissolved constituents given in parts per million[a], and in equivalents per million[b] (in italics)

Well No.	LOCATION	Depth (feet)	Geologic source	Date of collection	Temperature (°F)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$ Total	Carbonate	Noncarbonate
21-11-20ab	*T. 21 S., R. 11 W.* NW NE sec. 20	25	Meade formation	Oct. 26, 1942	...	...	...	...	...	...	...	...	...	8	...	...	...	...	...
21-11-25ad	SE NE sec. 25	36	do	Oct. 26, 1942	60	460	...	.30	42 *2.10*	10 *.82*	119 *5.16*	259 *4.25*	28 *.58*	91 *2.57*	.7 *.04*	40 *.64*	146	146	0
21-11-27aa	NE NE sec. 27	32	do	Oct. 26, 1942	59	2,150	...	.11	131 *6.54*	10 *.82*	664 *28.89*	382 *6.26*	116 *2.41*	895 *25.24*	1 *.05*	142 *2.29*	368	313	55
21-11-30bc	SW NW sec. 30	53	do	June 15, 1944	59	261	...	.08	73 *3.64*	6.4 *.53*	17 *.74*	243 *3.98*	2.5 *.05*	18 *.51*	.3 *.02*	22 *.35*	208	199	9
21-12-28bb	*T. 21 S., R. 12 W.* NW NW sec. 28	85	do	June 15, 1944	58	214	...	.06	59 *2.94*	4.2 *.34*	20 *.88*	223 *3.66*	2.7 *.06*	14 *.39*	.3 *.02*	2 *.03*	164	164	0
21-13-3cc	*T. 21 S., R. 13 W.* SW SW sec. 3	40	do	Oct. 26, 1942	58	323	...	.06	74 *3.69*	7.6 *.62*	42 *1.85*	296 *4.85*	14 *.29*	33 *.93*	.3 *.02*	4.2 *.07*	216	216	0
21-13-26bb	NW NW sec. 26	50	do	June 15, 1944	58	297	...	.02	70 *3.49*	7.2 *.59*	37 *1.62*	285 *4.67*	14 *.29*	25 *.70*	.4 *.02*	1.3 *.02*	204	204	0
21-13-31cd	SE SW sec. 31	58	do	Oct. 26, 1942	59	247	...	.07	69 *3.44*	8.5 *.70*	14 *.62*	244 *4.00*	8.2 *.17*	14 *.39*	.4 *.02*	11 *.18*	207	200	7
21-14-15cc	*T. 21 S., R. 14 W.* SW SW sec. 15	40	do	Oct. 26, 1942	58	203	...	.31	50 *2.50*	7.2 *.59*	14 *.60*	163 *2.67*	9.5 *.20*	13 *.37*	.4 *.02*	27 *.43*	154	134	20
22-11-2cd1	*T. 22 S., R. 11 W.* SE SW sec. 2	100	do	June 15, 1944	58	1,959	...	.48	86 *4.29*	22 *1.81*	631 *27.44*	362 *5.94*	159 *3.31*	835 *23.55*	.5 *.03*	44 *.71*	305	297	8
22-11-2cd2	SE SW sec. 2	100	do	Oct. 21, 1942	...	...	...	...	...	...	...	...	...	1,020	...	...	...	...	...
22-11-9bb	NW NW sec. 9	40	do	Oct. 26, 1942	57	154	...	.10	42 *2.10*	5.8 *.48*	10 *.44*	166 *2.72*	2.1 *.04*	6.5 *.18*	.2 *.01*	4.4 *.07*	129	129	0
22-11-10bb	NW NW sec. 10	18	do	June 15, 1944	57	252	...	.06	48 *2.40*	7.6 *.62*	39 *1.70*	206 *3.38*	8.8 *.18*	34 *.96*	.4 *.02*	11 *.18*	151	151	0
22-11-19dd	SE SE sec. 19	46.5	do	Oct. 26, 1942	59	170	...	.18	48 *2.40*	6.2 *.51*	9.2 *.40*	177 *2.90*	7.2 *.15*	6.5 *.18*	.3 *.02*	3.5 *.06*	146	145	1
22-11-35ab	NW NE sec. 35	75	do	Oct. 26, 1942	57	676	...	0	50 *2.50*	9.8 *.80*	198 *8.60*	211 *3.46*	24 *.50*	272 *7.67*	.2 *.01*	16 *.26*	165	165	0

22–12–1ad	*T. 22 S., R. 12 W.* SE NE sec. 1	35	do	Oct. 21, 1942	......	......	......	......	......	......	......	......	......	1,145	......	......	......	......	......
22–12–9bc	SW NW sec. 9	116	do	Oct. 25, 1942	58	236	......	.03	70 *3.49*	4.5 *.37*	16 *.72*	242 *3.97*	8.8 *.18*	13 *.37*	.4 *.02*	2.3 *.04*	193	193	0
22–14–32ab	*T. 22 S., R. 14 W.* NW NE sec. 32	38	do	Oct. 26, 1942	58	274	......	.14	78 *3.89*	7.2 *.59*	17 *.75*	259 *4.25*	13 *.27*	18 *.51*	.4 *.02*	11 *.18*	224	212	12
23–12–7ad	*T. 23 S., R. 12 W.* SE NE sec. 7	22.6	do	Oct. 25, 1942	59	272	......	.22	59 *2.94*	8.2 *.67*	34 *1.47*	189 *3.10*	13 *.27*	56 *1.58*	.3 *.02*	7.1 *.11*	180	155	25
24–11–11cc	*T. 24 S., R. 11 W.* SW SW sec. 11	50	do	Oct. 25, 1942	57	340	......	0	70 *3.49*	8.3 *.68*	51 *2.20*	255 *4.18*	14 *.29*	64 *1.80*	.4 *.02*	5.3 *.08*	208	208	0
24–12–11cd	*T. 24 S., R. 12 W.* SE SW sec. 11	60	do	Oct. 29, 1945	......	372	15	.05	68	5.8	63	238	15	80	.3	8.8	194	194	0
24–13–4b	*T. 24 S., R. 13 W.* Center NW sec. 4	83	do	Apr. 30, 1945	......	298	9.6	.16	59	9	37	238	17	29	.4	13	184	184	0
24–13–28cc	SW SW sec. 28	68	do	Oct. 25, 1942	58	183	......	.03	49 *2.44*	3.7 *.30*	16 *.68*	165 *2.71*	6.4 *.13*	12 *.34*	.5 *.03*	13 *.21*	137	136	1
24–14–22bc	*T. 24 S., R. 14 W.* SW NW sec. 22	45	do	Oct. 25, 1942	58	281	......	.06	74 *3.69*	7.2 *.59*	25 *1.08*	266 *4.36*	16 *.33*	19 *.54*	.4 *.02*	6.6 *.11*	214	214	0
24–15–15cc	*T. 24 S., R. 15 W.* SW SW sec. 15	73	do	March 1947	......	280	......	.5	67 *3.34*	6 *.49*	32 *1.39*	231 *3.79*	35 *.73*	23 *.65*	.5 *.03*	1.5 *.02*	192	189	3
25–11–15dd	*T. 25 S., R. 11 W.* SE SE sec. 15	41	do	Oct. 25, 1942	59	288	......	11	68 *3.39*	6 *.49*	21 *.90*	183 *3.00*	17 *.35*	20 *.56*	.3 *.02*	53 *.85*	194	150	44
25–12–11cb	*T. 25 S., R. 12 W.* NW SW sec. 11	39.3	do	Oct. 25, 1942	58	367	......	.14	85 *4.24*	7.9 *.65*	44 *1.91*	256 *4.20*	16 *.33*	72 *2.03*	.4 *.02*	14 *.22*	244	210	34
25–12–31dc	SW SE sec. 31	26.7	do	Oct. 25, 1942	60	274	......	.06	72 *3.59*	7.1 *.58*	22 *.97*	237 *3.89*	11 *.23*	26 *.73*	.4 *.02*	17 *.27*	208	194	14
25–14–29ad	*T. 25 S., R. 14 W.* SE NE sec. 29	47.5	do	Oct. 25, 1942	59	262	......	.10	74 *3.69*	7.8 *.64*	14 *.61*	244 *4.00*	8.6 *.18*	15 *.42*	.4 *.02*	20 *.32*	216	200	16
25–15–8cb	*T. 25 S., R. 15 W.* NW SW sec. 8	48	do	Oct. 25, 1942	59	164	......	0	54 *2.69*	6.3 *.52*	.46 *.02*	176 *2.89*	3.1 *.06*	6 *.17*	.4 *.02*	5.8 *.09*	160	144	16

a. One part per million is equivalent to one pound of substance per million pounds of water or 8.33 pounds per million gallons of water.

b. An equivalent per million is a unit chemical equivalent weight of solute per million unit weights of solution. Concentration in equivalents per million is calculated by dividing the concentration in parts per million by the chemical combining weight of the substance or ion.

TABLE 10.—*Analyses of water from test holes in Barton and Stafford Counties, Kansas*

Analyzed by H. A. Stoltenberg. Dissolved constituents given in parts per million[a], and in equivalents per million[b] (in italics)

No. on Figure 9	LOCATION	Depth from which sample was taken (feet)	Geologic source	Date of collection	Temperature (°F)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$ Total	Carbonate	Noncarbonate
19-14-17bb	*T. 19 S., R. 14 W.* NW cor. sec. 17.....	Surface flow	Cheyenne sandstone	Oct., 1943	......	......	......	......	......	......	......	......	......	33,000	......	......	......	......	......
20-14-5cc	*T. 20 S., R. 14 W.* SW cor. sec. 5.......	Surface flow	Kiowa shale	Oct., 1943	......	......	......	......	......	......	......	......	......	28,300	......	......	......	......	......
21-11-24cc	*T. 21 S., R. 11 W.* SW cor. sec. 24......	160-165	Meade formation	May 17, 1945	......	24,167	......	0.96	433 *21.61*	315 *25.89*	8,377 *364.22*	372 *6.10*	1,803 *37.50*	13,050 *368.01*	0.6 *.03*	5.3 *.08*	2,375	305	2,070
21-12-25bb	*T. 21 S., R. 12 W.* NW cor. sec. 25.....	207-212	do......	May 17, 1945	......	44,660	......	2.1	712 *35.53*	391 *32.14*	15,880 *690.46*	310 *5.08*	3,113 *64.75*	24,400 *688.08*	1.3 *.07*	9.3 *.15*	3,384	254	3,130
21-13-24bb	*T. 21 S., R. 13 W.* NW cor. sec. 24.....	152-157	do......	May 17, 1945	......	15,365	......	3.2	290 *14.47*	181 *14.88*	5,331 *231.78*	373 *6.12*	1,269 *26.40*	8,100 *228.42*	.9 *.05*	8.8 *.14*	1,468	306	1,162
22-11-5dc1	*T. 22 S., R. 11 W.* SW cor. SE¼ sec. 5	Surface flow	do......	May 17, 1945	......	295	......	6.3	37 *1.85*	5.5 *.45*	69 *3.02*	172 *2.82*	12 *.25*	70 *1.97*	.3 *.02*	16 *.26*	115	115	0
22-11-5dc2	SW cor. SE¼ sec. 5	50-55	do......	May 17, 1945	......	369	......	5.7	39 *1.95*	5.6 *.46*	97 *4.21*	188 *3.08*	15 *.31*	107 *3.02*	.3 *.02*	12 *.19*	120	120	0
22-11-5dc3	SW cor. SE¼ sec. 5	85-90	Permian rocks	May 17, 1945	......	8,688	......	24	361 *18.01*	118 *9.70*	2,787 *121.19*	188 *3.08*	591 *12.29*	4,730 *133.39*	.6 *.03*	7.1 *.11*	1,386	154	1,232
22-11-28bc	SW cor. NW¼ sec. 28	51-56	Meade formation	May 17, 1945	......	287	......	41	36 *1.80*	5.5 *.45*	65 *2.84*	195 *3.20*	12 *.25*	38 *1.07*	.3 *.02*	34 *.55*	112	112	0
22-12-23cc	*T. 22 S., R. 12 W.* SW cor. sec. 23......	154-159	do......	May 17, 1945	......	27,032	......	3.4	491 *24.50*	233 *19.15*	9,550 *415.26*	255 *4.18*	1,923 *40.00*	14,700 *414.54*	.9 *.05*	8.4 *.14*	2,182	209	1,973

	T. 23 S., R. 13 W.																		
23-13-12aa	NE cor. sec. 12......	162-167	do......	May 17, 1945	......	62,178	......	5.6	954	416	22,442	139	3,341	34,950	1.6	5.3	4,090	114	3,976
									47.60	*34.20*	*975.72*	*2.28*	*69.49*	*985.59*	*.08*	*.08*			
23-13-22bb	NW cor. sec. 22.....	59-64	do......	Oct. 27, 1943	......	323	......	.30	48	9.6	62	220	37	47	.5	8.8	160	160	0
									2.40	*.79*	*2.68*	*3.61*	*.77*	*1.32*	*.03*	*.14*			
	T. 24 S., R. 11 W.																		
24-11-28dd	SE cor. sec. 28......	101-106	do......	May 17, 1945	......	1,584	......	13	96	23	481	244	100	760	.5	3.1	334	200	134
									4.79	*1.89*	*20.91*	*4.00*	*2.08*	*21.43*	*.03*	*.05*			

a. One part per million is equivalent to one pound of substance per million pounds of water or 8.33 pounds per million gallons of water.

b. An equivalent per million is a unit chemical equivalent weight of solute per million unit weights of solution. Concentration in equivalents per million is calculated by dividing the concentration in parts per million by the chemical combining weight of the substance or ion.

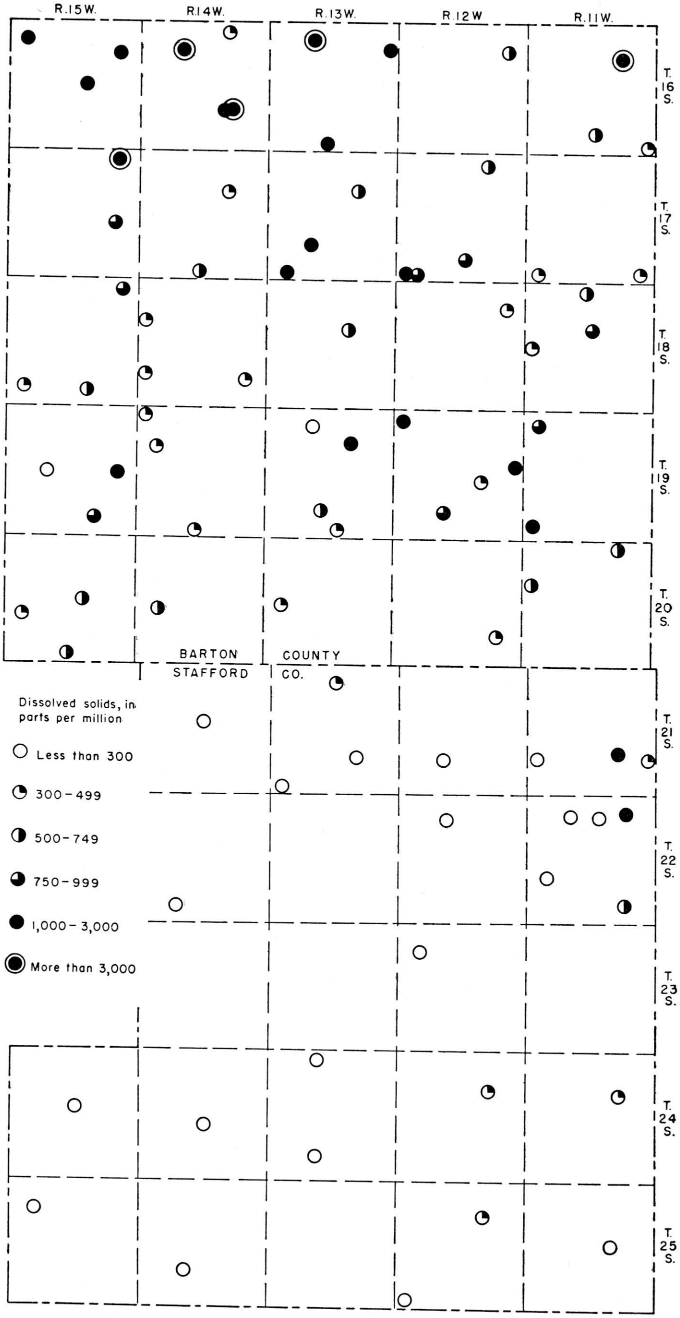

FIG. 15.—Content of dissolved solids of well waters in Barton and Stafford Counties, Kansas.

50 and 150 parts per million does not seriously interfere with the use of water for most purposes, but it does increase somewhat the consumption of soap, and its removal by a softening process is profitable for laundries or other industries using large quantities of soap. Waters in the upper part of this range of hardness will cause considerable scale in steam boilers. Hardness of more than 150 parts per million can be noticed by anyone, and if the hardness is 200 or 300 parts per million, it is common practice to soften water for household use or to install cisterns to collect soft rain water. Where municipal water supplies are softened, an attempt is generally made to reduce the hardness to 50 to 80 parts per million. The additional improvement from further softening of a whole public supply is not deemed worth the increase in cost.

Samples of water collected from wells in the Barton-Stafford area ranged in hardness from 29 to 1,564 parts per million. Of the samples of water, 2 (wells 16-12-12cb and 18-15-1bc) had less than 50 parts per million of hardness, 9 had between 50 and 150 parts, 14 had between 151 and 200 parts, 55 had between 201 and 500 parts, 8 had between 501 and 1,000 parts, and the water from well 16-14-26bb had 1,564 parts. Of the public water supplies in the area only that of Hoisington is treated, but some of the industrial supplies are softened.

Iron.—Next to hardness, iron is the constituent of natural waters that in general receives the most attention. The quantity of iron in ground waters may differ greatly from place to place, even though the waters are derived from the same formation. If a water contains much more than 0.1 part per million of iron the excess may separate out and settle as a reddish sediment. Iron, which may be present in sufficient quantity to give a disagreeable taste and to stain cooking utensils, fixtures, and fabrics, may be removed from most waters by simple aeration and settling or filtration, but a few waters require the addition of lime or some other substance.

Of the 89 samples of water collected from wells in Barton and Stafford Counties, 25 contained less than 0.1 part per million of iron, 31 contained between 0.1 and 1.0 part, 19 contained between 1.1 and 3.0 parts, 13 contained between 3.1 and 10 parts, and 1 (well 25-11-15dd) contained 11 parts.

Chloride.—Chloride is an abundant constituent of sea water. It is dissolved in small quantities from rock materials and in some localities comes from sewage. The sources of chloride are many, however, and its presence in large quantities cannot be taken as a definite indication of pollution. Chloride has little effect on the suitability of water for ordinary use unless there is enough to give the taste of salt. Waters high in chloride may be corrosive when used in steam boilers.

The quantity of chloride was determined for 92 samples of water collected from wells in the Barton-Stafford area. Of these 92 samples, 62 contained less than 50 parts per million of chloride, 15 contained between 150 and 500 parts, 6 contained between 501 and 1,000 parts, and 9 contained more than 1,000 parts. The greatest concentrations of chloride were found in waters from the Dakota and Meade formations. A further discussion on this subject is given on pages 131-134.

Fluoride.—Although determinable quantities of fluoride are not so common as are fairly large quantities of the other constituents of natural waters, it is desirable to know the amount of fluoride present in waters that are likely to be used by children. Fluoride in water has been shown to be associated with the dental defect known as mottled enamel, a permanent condition which may appear on the teeth of children who drink water containing fluoride during the period when their permanent teeth are formed. It has been said that waters containing 1.5 part per million or more of fluoride are likely to produce mottled enamel, although the effect of 1.5 part per million is not usually very serious (Dean, 1936, pp. 1269-1272). If the water contains as much as 4 parts per million of fluoride, 90 percent of the children who drink it are likely to have teeth with mottled enamel, and 35 percent or more of these cases will be classified as moderate or worse. Small quantities of fluoride, not sufficient to cause mottled enamel, are likely to be beneficial by inhibiting dental caries (tooth decay) (Dean, Arnold, and Elvove, 1942, pp. 1155-1179).

The fluoride content of most of the water samples from wells in Barton and Stafford Counties was low. Of the 89 samples analyzed, 69 contained less than 1 part per million of fluoride, 9 contained between 1 and 1.9 parts, 8 contained between 2 and 3 parts, and those from wells 16-13-12ad, 16-15-6dd, and 17-15-23ad contained 3.8, 3.8, and 3.4 parts, respectively.

WATER FOR IRRIGATION

The suitability of water for use in irrigation is commonly considered to depend mainly on the total quantity of soluble salts and on the ratio of the quantity of sodium to the total quantity of sodium, potassium, calcium, and magnesium together. The quantity of chloride may be large enough to affect the use of the water, and in some areas other constituents, such as boron, may be present in sufficient quantity to cause difficulty. In a discussion of the interpretation of analyses with reference to irrigation in southern California, Scofield (1933) states that if the total concentration of dissolved salts is less than 700 parts per million there is not much probability of harmful effects in irrigation use. If it exceeds 2,100 parts per million there is a strong probability of damage to either the crops or the land or both. Water containing less than 50 percent sodium (the percent-sodium factor is the ratio of the quantity of sodium to the total quantity of sodium, calcium, potassium, and magnesium) is not likely to be injurious, but if it contains more than 60 percent its use is inadvisable. Similarly, a chloride content of less than 142 parts per million is not objectionable, but more than 355 parts per million is undesirable. Later writers, notably Magistad and Christiansen (1944), have modified the percent-sodium standards to show a class 1 water as having below 60 percent sodium; a class 2 from 60 to 75 percent; and a class 3 over 75 percent. It is recognized that the harmfulness of irrigation water is so dependent on the nature of the land, the crops, the manner of use, and the drainage that no hard-and-fast limits can be adopted.

At the time of this investigation all irrigation wells obtained their water supply from the Meade formation. Ground water in the Meade formation is everywhere moderately hard but in most places it is suitable for irrigation use. In northeastern Stafford County the ground water locally is highly mineralized. Because of the uneven topography and sandy soil, irrigation is not feasible in this part of Stafford County except perhaps in very local areas. In other parts of Stafford County, the quality of the water taken from wells in the Meade formation was suitable for irrigation use. However, some of the samples taken from test holes that penetrated the lower part of the Meade formation were highly mineralized and were not suitable for irrigation (Table 10). Before a well is constructed for irrigation anywhere in Stafford County, it is recommended that a sample from a test hole be analyzed first to determine the chemical suitability of the water.

CHEMICAL CHARACTER IN RELATION TO STRATIGRAPHY

Ground waters in the various water-bearing formations in Barton and Stafford Counties have a wide range in quality. There is also a wide difference in the quality of waters from different places and from different depths in the same formation. Although no wells

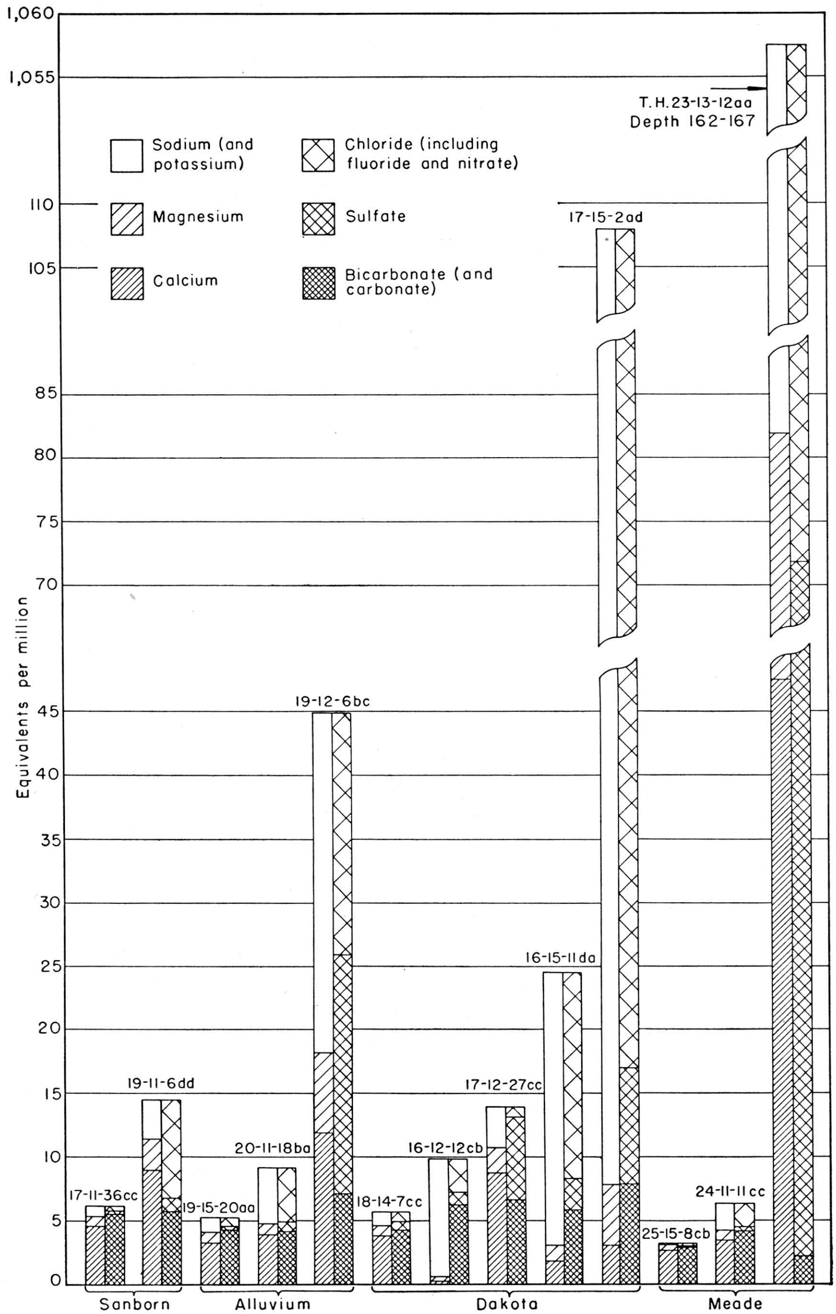

FIG. 16.—Quality of water from the four major water-bearing formations in Barton and Stafford Counties, Kansas.

derive water from Permian rocks or the Cheyenne sandstone in this area, scanty data indicate that the waters contained in them are highly mineralized and probably unfit for ordinary uses. The same is true for the Kiowa shale except possibly in its area of outcrop.

The quality of water found in the seven principal water-bearing formations of Barton and Stafford Counties is discussed below. The typical quality of water in the four major water-bearing formations is shown graphically in Figure 16.

Dakota formation.—Waters from wells tapping sandstones of the Dakota formation have a wide range in chemical composition; a few are low in mineral content and comparatively soft, whereas others are highly mineralized and hard. Thirty samples of water from the Dakota formation were collected and analyzed. The samples of water from wells 16-12-12cb and 18-15-1bc in sandstones of the Dakota formation were the softest waters of any of those analyzed from the Barton-Stafford County area, having hardnesses of 29 and 45 parts per million, respectively. Both of these are soft sodium bicarbonate waters that probably have resulted from a natural softening process in which calcium bicarbonate water has exchanged part of its calcium and magnesium for sodium by a base-exchange process. This is the same process used in the common zeolite-type home water softeners. Hardnesses of the other 28 samples from the Dakota ranged from 101 to 626 parts per million. More than half of these samples had less than 300 parts of hardness, 7 had between 301 and 500 parts, and 4 had more than 500 parts.

The dissolved solids in samples collected from wells tapping the Dakota ranged from 305 parts per million in the sample from well 18-14-7cc to 6,323 parts in the sample from well 17-15-2ad. Only 7 of the samples contained less than 500 parts per million of dissolved solids, 10 contained between 500 and 1,000 parts, and 13 contained more than 1,000 parts. Chloride is both the most variable and most objectionable constituent of many waters from the Dakota. The chloride concentration in the samples ranged from 15 parts per million in well 17-15-23ad to 3,220 parts in well 17-15-2ad. Seventeen of the 30 samples contained less than 150 parts per million of chloride, 4 contained between 150 and 500 parts, 2 contained between 501 and 1,000 parts and 7 contained more than 1,000 parts.

The fluoride content of 14 of the 30 samples from the Dakota formation was greater than 1 part per million, and the samples from wells 16-13-12ad and 16-15-6dd had the highest fluoride contents of any of the samples analyzed—3.8 parts per million. Many of the samples analyzed had excessive concentrations of iron. Only 3 of the 30 samples had less than 0.1 part per million of iron, 7 had between 0.1 and 1.0 part, 11 had between 1.1 and 3.0 parts, and 11 had between 3.1 and 6.9 parts.

Greenhorn limestone.—A few domestic and stock wells in the northern half of Barton County derive water from the Greenhorn limestone. Only one sample of water from the Greenhorn limestone was analyzed (well 16-14-2cb); it contained 356 parts per million of dissolved solids and had a hardness of 306 parts. Both the chloride and fluoride contents were low and the iron concentration was 1.2 parts per million.

Carlile shale.—The Fairport chalky shale member of the Carlile shale yields small quantities of water to a few dug wells on the upland in northern Barton County. Samples of water from wells 16-11-27cd and 16-14-26bb, which tap these rocks, differed considerably in quality; they contained, respectively, 673 and 2,277 parts per million of dissolved solids and had 442 and 1,564 parts of hardness.

Undifferentiated Pleistocene.—A few domestic and stock wells in the immediate vicinity of Galatia in northwestern Barton County obtain small supplies of water from sands and gravels of the undifferentiated Pleistocene deposits. Only one sample of water from these deposits was analyzed (well 16-15-15dc); it was a relatively soft sodium chloride water that contained 1,203 parts per million of dissolved solids and had a hardness of 73 parts. The chloride content of this sample was 460 parts per million.

Meade formation.—Analyses of 42 samples of water from the Meade formation were made, 32 of which were collected from wells (Tables 8 and 9) and 10 from test holes (Table 10). In addition, three samples were collected from wells and analyzed for their chloride content only. Most of the waters analyzed were moderately hard to hard calcium bicarbonate waters. Of the 32 samples of water collected from wells, 4 had less than 200 parts per million of dissolved solids, 14 had between 201 and 300 parts, 11 had between 301 and 676 parts, 1 (well 22-11-2cd1) had 1,959 parts, and 1 (well 21-11-27aa) had 2,150 parts. The hardness of the 32 samples from wells ranged from 129 to 368 parts per million. The iron content of these samples was relatively low—18 of the 32 samples contained 0.1 part per million or less of iron, 13 contained between 0.11 and 1.1 parts, and 1 (well 25-11-15dd) contained 11 parts. Locally, waters in the Meade formation in the immediate vicinity of Big Marsh and Little Marsh in northeastern Stafford County are high in chloride. Samples of water from wells 21-11-27aa, 22-11-2cd1, 22-11-35ab, and 22-12-1ad contained, respectively, 895, 835, 272, and 1,145 parts per million of chloride. The chloride content of the other samples from wells in the Meade formation in Barton and Stafford Counties ranged from 6 to 121 parts per million.

In the buried lowland areas of Stafford County, waters near the base of the Meade formation are highly mineralized. Wells in these areas do not extend to the base of the Meade formation; therefore, analyses of water samples from them do not show the quality of the water at the base of the formation. Analyses of samples of water collected from the lower part of the Meade formation from nine test holes are given in Table 10. The mineral

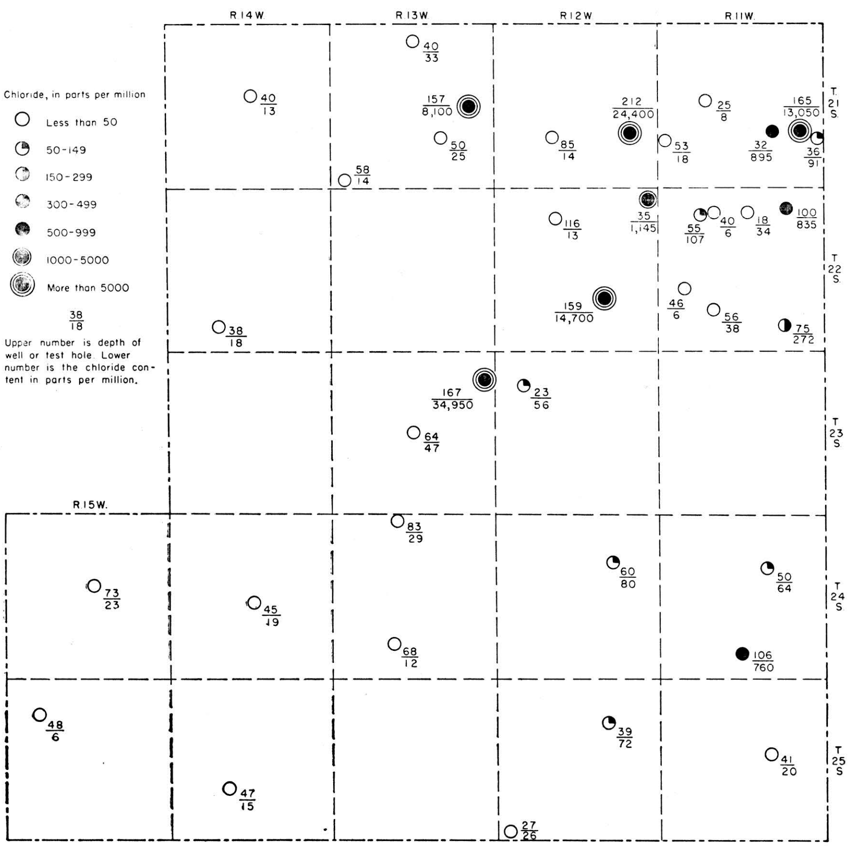

FIG. 17.—Chloride content of waters in the Meade formation in Stafford County, Kansas.

content of waters from test holes 22-11-5dc, 22-11-28bc, and 23-13-22bb, which encountered bedrock at shallow depths, was relatively low. Samples of water from test holes 21-11-24cc, 21-12-25bb, 21-13-24bb, 22-12-23cc, 23-13-12aa, and 24-11-28dd, which are located in areas of greater depth to bedrock (buried lowlands), were highly mineralized. The dissolved solids in these samples ranged from 1,584 to 62,178 parts per million and the chloride ranged from 760 to 34,950 parts. The distribution of chloride in the Meade formation from place to place and with depth in Stafford County is shown in Figure 17.

The highly mineralized waters in the Meade formation probably have their source in the underlying rocks—the Permian rocks, Cheyenne sandstone, and Kiowa shale. These rocks are known to contain highly mineralized waters. Where the highly mineralized waters in these bedrock formations is under greater head than the water in the overlying Meade formation, it moves upward into the Meade formation. The highly mineralized water tends to concentrate in the basal part of the Meade formation and in the lowest places on the bedrock floor because of its greater specific gravity. At the same time the upper part of the Meade formation is receiving fresh water from infiltration of local rainfall. The resultant mineralization of the water of the Meade varies with depth and with position above the bedrock floor. A high bedrock ridge trending approximately perpendicular to the direction of movement of ground water (Fig. 11) has caused the highly mineralized waters at the base of the Meade formation to be forced upward in northeastern Stafford County. At Big and Little Marshes the waters are discharged at the surface, causing high salinity in the waters in the marshes, which is further concentrated by evaporation.

Sanborn formation.—The quality of water in the Sanborn formation is indicated by the analyses of seven samples of water from wells (17-11-31dc, 17-11-36cc, 18-11-15bc, 18-14-25cb, 18-14-30cb, 19-11-6dd, and 19-12-13ad) tapping these deposits. These samples contained 317 to 1,502 parts per million of dissolved solids and had 242 to 606 parts of hardness. Samples from wells 18-11-15bc, 18-14-25cb, and 18-14-30cb contained excessive iron, having 5.0, 10, and 7.7 parts per million, respectively. One sample (19-12-13ad) contained 560 parts per million of chloride; the chloride content of the other six samples ranged from 16 to 174 parts per million. The fluoride was low in all of the samples.

Alluvium.—Sixteen samples from wells tapping alluvium in Barton County were analyzed. One (well 19-13-4cc) of these represents treated water and, therefore, will not be considered in this discussion. The other 15 samples were collected from widely scattered wells in Arkansas, Dry Walnut, and Walnut Valleys, and Cheyenne Bottoms. As would be expected, there is considerable variation in the chemical character of the waters.

The hardness of samples of water from wells in alluvium ranged from 202 to 904 parts per million, and the dissolved solids ranged from 271 to 2,728 parts per million. In all but one sample (19-12-6bc) analyzed, the fluoride was less than 1 part per million, and in this sample it was only 1.1 parts. Four (17-12-31dc1, 19-12-6bc, 19-12-28cc, and 19-15-24bc) of the fifteen samples had more than 200 parts per million of chloride and eleven had between 17 and 168 parts of chloride.

Chemical Character of Surface Water in Big Marsh Vicinity

The chloride analyses of five samples of water collected from Rattlesnake Creek on October 2, 1942, indicate that highly mineralized waters enter this stream in the lower part of its course in Stafford County. The results of the analyses are given in Table 11. According to these analyses, the chloride content increases downstream and reaches the greatest concentration below Big Marsh at the Stafford-Rice County line. A sample of water collected from Little Marsh on the same day had 1,440 parts per million of chloride. Two samples were collected from Big Marsh on October 10, 1942, one sample being collected at the south side of sec. 6, T. 22 S., R. 11 W., from the small stream entering Big Marsh from the southwest and had 1,690 parts per million of chloride. The other sample, which was taken from the drainage ditch at the north side of sec. 27, T. 21 S., R. 11 W., contained 4,060 parts of chloride. A sample of water from Big Marsh collected from the same spot on July 10, 1944, contained 10,870 parts per million of dissolved solids, 5,900 parts of chloride, 1.3 parts of iron, and had a hardness of 439 parts. The above analytical results reported for creek waters represent conditions at the time of sampling only and are not necessarily average conditions that would be obtained if the sampling period extended over a long period of time.

Ground-water Conditions by Areas

On the following pages the ground-water conditions in Barton and Stafford Counties are described by areas that are classified primarily on the basis of geologic source and depth to water level. The eight major areas are (1) the upland and terrace areas of Barton County in which the principal source of water is the Dakota formation; (2) the Galatia upland area, in which most of the wells tap the Ogallala (?) formation; (3) the Great Bend prairie area; (4) the Claflin terrace area; (5) the Cheyenne Bottoms-Blood Creek Valley area; (6) the Walnut Valley and terrace area; (7) the Dry Walnut Valley area; and (8) the Arkansas Valley area (Fig. 18). The upland and terrace areas of Barton County in which the principal source of ground water is the Dakota formation have been subdivided into the (1a) Olmitz-Susank-Beaver upland area; (1b) Hoisington area; (1c) Albert-Heizer upland area; and (1d) the Pawnee Rock upland area. The Walnut Valley area has been divided into the valley proper (6a) and the Walnut Valley terrace area (6b).

OLMITZ-SUSANK-BEAVER UPLAND AREA

The Olmitz-Susank-Beaver upland area comprises most of the uplands in the northern half of Barton County and is underlain by the Carlile shale and Greenhorn limestone (Fig. 18 and Plate 1). About two-thirds of the wells in this area are deep wells that derive water from sandstones in the Dakota formation. These wells range in depth from about 35 to 275 feet, but most of them are 150 to 275 feet deep. The water level in them stands 18 to 203 feet below the surface, although in most of them it is between 100 and 200 feet. Adequate supplies of water for domestic and stock use can be obtained from the Dakota formation almost everywhere in the Olmitz-Susank-Beaver area. In some places, however, the water is highly mineralized and unfit for many uses (p. 131). Chloride is the most objectionable constituent in these highly mineralized waters. Of 17 samples of water collected from the Dakota formation in this area, 6 contained more than 1,000 parts per million of chloride and most of them were high in iron and fluoride.

A few shallow wells in the Olmitz-Susank-Beaver upland area

TABLE 11.—*Concentration of chloride in five samples of water collected October 2, 1942, from Rattlesnake Creek in Stafford County, Kansas*

SAMPLING POINT	Chloride (parts per million)
NE¼ sec. 13, T. 24 S., R. 14 W., about 3 miles above St. John	14
West side sec. 1, T. 23 S., R. 13 W., about 3 miles above Hudson	400
West side sec. 1, T. 23 S., R. 12 W., about 6 miles above Little Marsh	1,220
West side sec. 26, T. 22 S., R. 11 W., opposite Little Marsh	1,355
Stafford-Rice County line	1,810

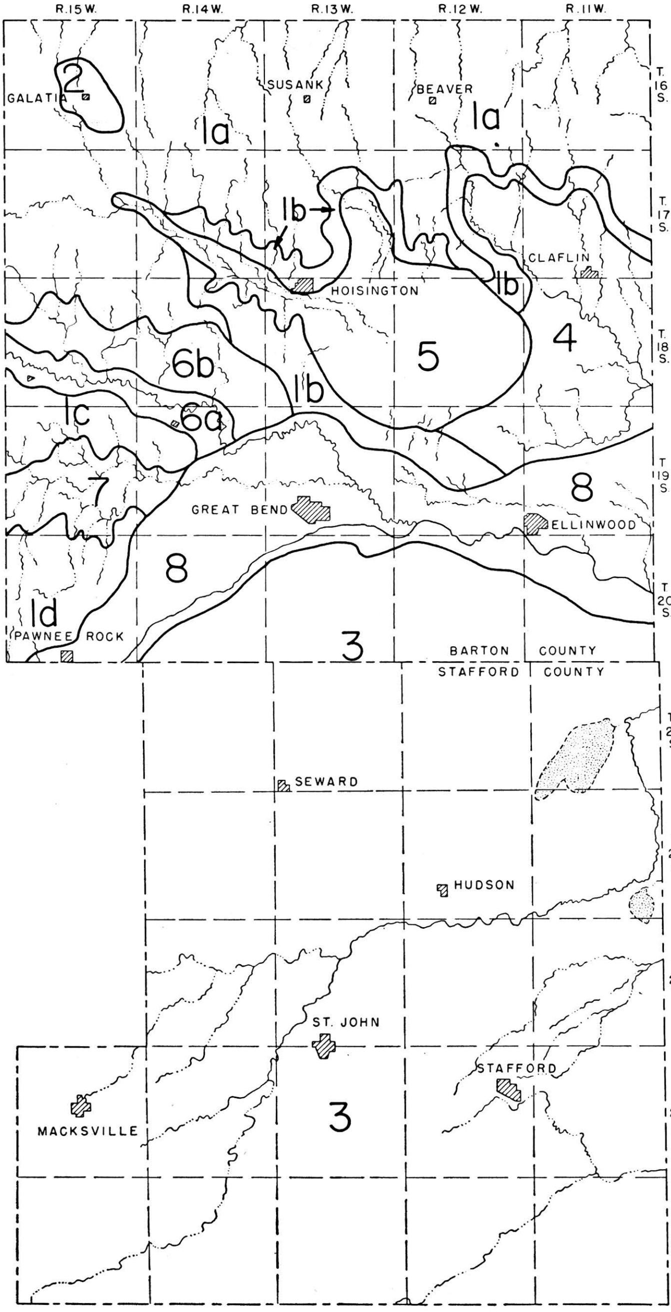

Fig. 18.—Ground-water areas in Barton and Stafford Counties. 1a, Olmitz-Susank-Beaver upland area; 1b, Hoisington area; 1c, Albert-Heizer upland area; 1d, Pawnee Rock upland area; 2, Galatia upland area; 3, Great Bend prairie; 4, Claflin terrace area; 5, Cheyenne Bottoms-Blood Creek Valley area; 6a, Walnut Valley area; 6b, Walnut terrace area; 7, Dry Walnut Valley area; and 8, Arkansas Valley area.

obtain small supplies of water for domestic and stock use from the Greenhorn limestone or Carlile shale, or from alluvium in some of the small valleys. Supplies from these sources in many places are inadequate even for domestic or stock use. The depth of the wells in alluvium ranged from 9 to 19 feet, those in the Carlile shale ranged from 20 to 48 feet, and those in the Greenhorn limestone ranged from 23 to 124 feet.

Large supplies of water are not available anywhere in the Olmitz-Susank-Beaver upland area, and locally it is difficult to obtain adequate water of good quality even for domestic or stock use.

HOISINGTON AREA

The Hoisington area comprises two separate areas (1b, Fig. 18). The one is a narrow strip, 0.25 to 2 miles wide, that includes the dissected slopes between the uplands of northern Barton County and the low areas of Blood Creek, Cheyenne Bottoms, and the Claflin terrace area. The other part of the Hoisington area is the divide area that separates Cheyenne Bottoms and Blood Creek from the Arkansas Valley and the Walnut Valley terrace. The surface formations in the Hoisington area include the Dakota formation, Graneros shale, and Sanborn formation.

All the 20 wells in this area for which records were obtained are small domestic and stock wells that tap the Dakota formation. They range in depth from 30 to about 90 feet and the depth to water level in them ranges from 15 to 78 feet below the surface. Samples of water from seven wells (17-12-2cb, 17-13-10dd, 17-13-31dd, 17-14-33dd, 18-12-12bc, 19-12-15dd, and 19-13-11cb) in the Hoisington area were collected and analyzed. The dissolved solids in these samples ranged from 330 (well 18-12-12bc) to 2,174 parts per million (well 17-13-31dd) and the hardness ranged from 272 (well 18-12-12bc) to 626 parts (well 19-13-11cb). The chloride was high in only one sample (well 17-13-31dd)—1,030 parts per million.

Adequate water of satisfactory quality for domestic and stock use is available from the Dakota formation almost everywhere in the Hoisington area.

ALBERT-HEIZER UPLAND AREA

The Albert-Heizer upland area comprises the hilly divide between Walnut Valley and Dry Walnut Valley in west-central Barton County (Fig. 18 1c). The northern and highest part of this area is underlain, from west to east, by the Greenhorn limestone, Graneros shale, and Dakota formation. In the south part of the area these formations are covered by a comparatively thin mantle of terrace deposits of the Sanborn formation.

Records were obtained for eight domestic and stock wells (19-14-7dd, 19-14-16bb, 19-15-2ad, 19-15-3dc, 19-15-6ab, 19-15-7cd, 19-15-13ad, and 19-15-17cb) in this area, all but one (well 19-15-6ab) of which derive water from sandstones of the Dakota formation. Well 19-15-6ab is an unused domestic dug well, 23 feet deep, in the Greenhorn limestone. The water level in this well stands 11 feet below the surface. The depths of the seven wells in the Dakota formation range from 56 to 99 feet and the depths to water level in them range from 25 to 61 feet below the surface. An analysis of a sample of water from well 19-14-7dd showed it to be moderately hard but otherwise of good chemical quality.

PAWNEE ROCK UPLAND AREA

The upland and terrace areas separating Dry Walnut Valley from Arkansas Valley in the southwestern corner of Barton County are here referred to as the Pawnee Rock upland area. This is a dissected area having moderate to steep slopes. The highest or west-central part of the area is underlain by the Greenhorn limestone, Graneros shale, and Dakota formation. The Dakota formation is also exposed in the bluff of Arkansas Valley above Pawnee Rock. Elsewhere in the Pawnee Rock upland area, the dissected surface of these formations is covered by from less than 10 to about 60 feet of silt and sandy silt of the Sanborn formation.

All but one (well 19-15-32db) of the nine recorded wells in the Pawnee Rock upland area are in the upper part of the Dakota formation. Well 19-15-32db, which is a small stock well 37 feet deep, obtains its water from a thin lens of sand and gravel in the lower part of the Sanborn formation. Wells 20-15-17bc and 20-15-19dd in the highest or west-central part of the area are 146 and 163 feet deep, respectively, and the water levels in them are 105 and 89 feet below the surface. Elsewhere, the depths of the wells penetrating sandstones in the upper part of the Dakota formation range from 40 to 84 feet and the depths to water level range from 12 to 62 feet. The analyses of two samples (20-15-19dd and 20-15-22ba) of water indicate that the waters in the Dakota formation in this area are hard but otherwise of satisfactory quality for most uses.

Small to moderate yields are available to wells in the Pawnee Rock upland area. Most of the existing wells are small wells drilled to supply water for domestic and stock use. Although no detailed record is available for it, a well drilled in 1947 for compressor water at a gas booster station in the SE¼ SW¼ sec. 6, T. 20 S., R. 15 W., had a reported yield of about 75 gallons a minute. The reported depth of this well is 250 feet. Similar yields could probably be obtained from deep wells in other parts of this area.

GALATIA UPLAND AREA

The Galatia upland area comprises about 6 square miles in the vicinity of Galatia in northwestern Barton County (Fig. 18, area 2). It is an elongate area trending northwest-southeast that is situated on the high divide separating tributaries of Arkansas River drainage from those of Smoky Hill River drainage. The surface is nearly flat around Galatia and has gentle to moderate slopes around the borders of the area. Unconsolidated clay, silt, sand, and some gravel of early Pleistocene age, ranging in thickness from about 10 to 40 feet, overlie the dissected surface of the Carlile shale and form the surface rock in the Galatia upland area.

Most of the wells in this area are shallow wells that obtain small supplies of water from relatively thin deposits of sand and gravel at the base of the Pleistocene deposits. The five recorded wells (16-15-15dc1, 16-15-15dc2, 16-15-16da, 16-15-22dc, and 16-15-25bc) range in depth from 10 to 40 feet and the water levels in them range from 7 to 32 feet below the surface. An analysis of a sample of water from well 16-15-15dc2 shows it to be a relatively soft sodium chloride water. It had a hardness of 73 parts per million and contained 1,203 parts of dissolved solids, 460 parts of chloride, 1.2 parts of iron, and 2.2 parts of fluoride.

All existing wells in the Galatia upland area are domestic and stock wells having small yields. Supplies of water adequate for irrigation or industrial use probably are not available in this area.

GREAT BEND PRAIRIE AREA

The area covered by the Great Bend prairie is the same area as described in the section on physiographic divisions under the same name (pp. 44-48.) The Great Bend prairie includes all of Stafford County and that part of Barton County lying south of the Arkansas Valley. Nearly all the wells in the Great Bend prairie obtain water from sand and gravel deposits of the Meade formation, which underlies the surface or is found at shallow depth beneath younger deposits everywhere in the area. A complete description of the thickness and water-bearing characteristics of the Meade formation is given on pages 68-71 of this report.

The Meade formation furnishes water to all irrigation, public-supply, industrial, and most of the domestic and stock wells in the

Great Bend prairie. These wells range in depth from about 15 to 116 feet, but most of them are between 25 and 75 feet deep. The water table is shallow, being less than 25 feet below the surface everywhere except beneath the highest sand dunes. In the valleys of Rattlesnake Creek and the North Fork of Ninnescah Creek and in the marshes the water table is generally less than 10 feet below the surface and at a few wells (22-11-9bb, 22-11-10cc, 22-11-35ab, 22-12-12db, and 23-13-3aa) in northeastern Stafford County local artesian conditions exist and the head is above the surface (pp. 88-90). A few shallow domestic and stock wells (21-11-22cb, 21-11-26ad, 22-11-3cd, 23-11-1bc, 23-12-2cd, and 24-14-1aa), less than 15 feet deep, obtain water from alluvium in Rattlesnake Valley and Big Marsh.

Ground water in the Meade formation beneath the Great Bend prairie is everywhere moderately hard, but in most places it is suitable for domestic, stock, irrigation, and public-supply use. In northeastern Stafford County the ground water locally is highly mineralized and is not satisfactory for most uses. In some parts of the Great Bend prairie, water in the lower part of the Meade formation is too highly mineralized for most uses, but in these areas most wells obtain adequate water of good quality from the upper part of the Meade formation.

The sands and gravels of the Meade formation beneath the Great Bend prairie are highly permeable and capable of yielding large supplies of water to properly constructed wells. The yields of existing wells in this area range from a few gallons a minute for the small driven domestic and stock wells to nearly 1,000 gallons a minute for the larger irrigation wells.

CLAFLIN TERRACE AREA

The Claflin terrace area includes approximately the same area as the Cow Creek drainage basin (Fig. 8), the areal extent and physiographic features of which have been described on pages 40-42.

The Sanborn formation underlies most of the surface of this area and is the principal water-bearing formation. In the west-central part of the Claflin terrace area the Sanborn formation is overlain by dune sand. The Sanborn formation rests on the dissected surface of the Dakota formation everywhere in this area.

Twenty-two of the 24 recorded wells in the Claflin terrace area end in the Sanborn formation. These are small domestic and stock wells having small to moderate yields. They range in depth from about 20 feet to about 95 feet. The depth to the water table ranges from less than 10 feet in the valleys of Little Cheyenne and Cow Creeks to about 60 feet beneath the higher hills in the northern part of the area. The analyses of five samples (17-11-31dc, 17-11-36cc, 18-11-15bc, 19-11-6dd, and 19-12-13ad) of water from wells in the Claflin area indicate that the water in the Sanborn formation is moderately hard to hard, but otherwise is of satisfactory quality for ordinary uses. The most highly mineralized water (sample 19-12-13ad) contained 1,502 parts per million of dissolved solids and 560 parts of chloride, and had a hardness of 606 parts.

Wells 18-11-4ad1 and 18-11-4ad2 in the Claflin terrace area are public-supply wells that furnish water to the City of Claflin. They are about 160 feet deep and derive water from sandstones in the Dakota formation. The static water level in them stands about 32 feet below the surface. Well 18-11-4ad1 is reported to yield 200 gallons a minute with a 30-foot drawdown. The water is of good chemical quality (analysis 18-11-4ad1, Table 8).

CHEYENNE BOTTOMS-BLOOD CREEK VALLEY AREA

Descriptions of Cheyenne Bottoms and Blood Creek Valley are given in the section on physiography (p. 40). Nearly all the wells in this area derive water from alluvial deposits at relatively shallow depth. The water table is everywhere less than 20 feet below the surface, and in many places it is less than 10 feet.

The depths of 15 recorded domestic and stock wells in Cheyenne Bottoms range from 15 to 63 feet. Most of these wells have low yields because the alluvial materials that they tap are fine-grained and have low permeability. The water from the alluvium beneath Cheyenne Bottoms in many places is of poor quality. Four samples (17-12-31dc, 18-11-19bb, 18-13-15da, and 19-12-6bc) of water from wells in the alluvium of this area contained 449 to 2,728 parts per million of dissolved solids and had 310 to 904 parts of hardness. A few wells in the Bottoms, especially near the edge where the alluvium is thin, may obtain water from the underlying Dakota formation. A shallow well in alluvium (17-12-31dc), 27.5 feet deep, in the SW¼ SE¼ sec. 31, T. 17 S., R. 12 W., was replaced by a deeper well (17-12-31dc) in the Dakota formation because of the hardness of the shallow water. Water from the shallow well (17-12-31dc) contained 1,272 parts per million of dissolved solids and had a hardness of 795 parts. Water from the well in the Dakota (17-12-31dc), which is 60 feet deep, contained

972 parts per million of dissolved solids and had a hardness of 499 parts.

Small to moderate supplies of water are obtained from shallow wells tapping alluvium in Blood Creek Valley. Wells 17-14-33aa, 17-14-36cb, and 18-14-1da in Blood Creek Valley are 48, 16, and 52 feet deep, respectively, and the water levels in them in 1944 were 18, 5, and 7 feet below the surface.

WALNUT VALLEY AND TERRACE AREA

The Walnut Valley area is divided into two areas—the one comprising the valley proper (6a, Fig. 18) and the other comprising the terrace that borders the north side of the valley (6b, Fig. 18). Physiographic descriptions of these two areas are given on pages 42-43.

Walnut Valley proper is underlain by thick deposits of highly permeable sand and gravel that furnish moderate to large supplies of water to wells. The water table there is shallow, being less than 25 feet below the surface everywhere according to reports and measurements made in 14 wells in 1944. In 1944 there were eight irrigation wells (18-15-28cc1, 18-15-28cc2, 18-15-30bd, 18-15-33ad, 18-15-34aa, 18-15-36ba, 19-14-4ca, and 19-14-9aa), two industrial wells (19-14-6bb1 and 19-14-6bb2), and an unknown number of domestic and stock wells that tapped the alluvium in Walnut Valley. Most of the small drilled or driven domestic and stock wells are 30 to 60 feet deep, whereas the larger irrigation and industrial wells are 50 to 80 feet deep. The yields of the wells range from a few gallons a minute for the shallow driven wells to about 1,000 gallons a minute for the larger-diameter and deeper irrigation wells. The analyses (18-15-30dd, 18-15-34ab, and 19-14-6bb3, Table 8) of three samples of water indicate that, except for being hard, the ground water beneath Walnut Valley is of good quality.

The water-bearing materials beneath the Walnut Valley terrace area consist of terrace deposits of the Sanborn formation. They are similar to the alluvium beneath Walnut Valley proper except that the lenses of sand and gravel are not as widespread and in most places are not as permeable. In some places, particularly along the northern part of the area, little or no gravel is encountered. The depths to water level in 12 wells in this area ranged from 20 to 54 feet below the surface in 1944. All the recorded domestic and stock wells in this area tap sand or sand and gravel in the Sanborn formation and furnish small to moderate supplies of water. The depths of these wells range from 28 to 90 feet. In 1944 there was one irrigation well (19-13-6db) in the Walnut Valley terrace area, in the

NW¼ SE¼ sec. 6, T. 19 S., R. 13 W. This well is 115 feet deep and has a reported yield of 1,100 gallons a minute. According to the driller's log (pp. 193-194), 59 feet of saturated sand and coarse gravel was encountered in well 19-13-6db between depths of 55 and 115 feet. Analyses were made of samples of water from two wells (18-14-25cb and 18-14-30cb) in the Walnut Valley terrace area. Both samples were moderately hard but otherwise of good quality and satisfactory for most ordinary uses.

DRY WALNUT VALLEY AREA

The Dry Walnut Valley area (7, Fig. 18) includes the valley area occupied by Dry Walnut Creek and several short, broad reëntrant valleys occupied by tributary streams (p. 43). Unconsolidated alluvial deposits consisting chiefly of clay, silt, and sandy silt but containing minor amounts of sand and gravel and ranging in thickness from 50 to 125 feet underlie this area. Most of the sand and gravel is poorly sorted and occurs at the base of the alluvial fill. The depths to water level in nine recorded wells ranged from 9 to 31 feet below the surface in 1944.

Most of the wells in this area are shallow domestic and stock wells having small yields. The depths of eight of the nine recorded wells ranged from 24 to 34 feet. One well (19-15-15bb) is 235 feet deep and obtains water from sandstones in the Dakota formation. It was drilled to supply water for drilling an oil-test well. Samples of water from wells 19-15-20aa, 19-15-24bc, and 19-15-34aa, which tap the alluvium at shallow depths, contained 271, 1,163, and 768 parts per million of dissolved solids and had 202, 342, and 452 parts of hardness, respectively.

The yields of the existing shallow wells in the Dry Walnut Valley area, although small, are adequate in most cases for domestic and stock use. Greater yields could be obtained in some places by deeper wells that penetrated the full thickness of the alluvium. It is doubtful, however, that supplies adequate for irrigation could be obtained anywhere in this area.

ARKANSAS VALLEY AREA

The Arkansas Valley area includes the present flood plain of Arkansas River and associated low terraces bordering the flood plain (Fig. 18 and pp. 43-44). It is an elongate area ranging in width from about 2 to 8.5 miles. The surface of this area in most places is relatively level and is underlain by unconsolidated silt, sand, and gravel (alluvium and the Meade formation) ranging in thickness from less than 50 feet to approximately 200 feet.

The depths of 49 recorded domestic, stock, irrigation, industrial, and public-supply wells in this area range from about 15 feet to 140 feet and the depths to water in them range from 2 to 26 feet below the surface. Most of these wells derive water from the alluvium or the Meade formation, or both. The yields of wells in the Arkansas Valley area range from a few gallons a minute for the small driven domestic wells to more than 1,000 gallons a minute for the larger irrigation wells. Most of the 13 recorded irrigation wells have reported yields of 1,000 gallons a minute or more. Irrigation wells 19-13-18db and 19-13-21cc have reported yields of 1,500 and 1,370 gallons a minute, respectively.

Waters from the alluvium and the Meade formation beneath the Arkansas Valley are of satisfactory quality for most uses. Five samples (19-12-28cc, 20-11-2ba, 20-11-18ba, 20-14-20bc, and 20-15-33db) of water from the alluvium contained between 508 and 898 parts per million of dissolved solids and had between 242 and 450 parts of hardness. Samples from wells 19-13-28cd, 19-13-34cd, and 19-14-33cd in the Meade formation contained, respectively, 564, 379, and 422 parts per million of dissolved solids and had 260, 237, and 286 parts of hardness. For some industrial uses these waters must be treated to reduce the hardness.

RECORDS OF TYPICAL WELLS

Descriptions of the wells visited in Barton and Stafford Counties are given in Tables 12 and 13. All information classed as "reported" was obtained from the owner, tenant, or driller. Depths of wells not classed as "reported" are measured and given to the nearest tenth of a foot below the measuring point described in the tables, and depths to water level not classed as "reported" are measured and given to the nearest hundreth of a foot.

TABLE 12.—*Record of wells in Barton County, Kansas*

Well No. (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.) (4)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 16 S., R. 11 W.															
16-11-2bb	NW NW sec. 2	Mrs. Lena Peirano	Dr	152.2	6	GI	Sandstone	Dakota	N	N	Top of casing	+1.0	1,848.0	145.77	10- 6-44	Unused domestic well.
16-11-11cc	SW SW sec. 11	Joe Pichner	Dr	260.0	6	GI	do	do	Cy, W	D, S	....	....	....	160.00	....	Water is salty.
16-11-12ad	SE NE sec. 12	C. Horejesi	Dr	196.2	6	GI	do	do	Cy,W, H	D, S	Top edge of pump base.	+ .3	1,890.8	195.90	10- 6-44	
16-11-15aa	NE NE sec. 15	A. E. Redetz	Du	23.0	30	R	Limestone	Greenhorn	Cy, W	S	Top of wooden platform.	+1.7	....	9.12	10-12-44	
16-11-24cc	SW SW sec. 24	F. Pichner	Du	23.2	30	R	....	Carlile	Cy, W	S	Top of pump base.	+ .9	....	19.90	10-12-44	
16-11-27cd	SE SW sec. 27	F. A. Burmeister	Du	42.7	48	R	....	do	Cy, W	D	Lower edge of pump base.	+ .8	....	27.70	10- 6-44	
16-11-30cd	SE SW sec. 30	W. H. Oeser	Dr	229.0	6	GI	Sandstone	Dakota	N	N	Top of concrete curb.	+ .6	1,920.9	128.46	10- 6-44	Unused stock well.
16-11-36dc	SW SE sec. 36	William Blue	Dr	188.3	6	GI	do	do	Cy, W	D, S	Top of wooden platform.	+1.1	1,898.7	155.82	10- 6-44	
	T. 16 S., R. 12 W.															
16-12-5aa	NE NE sec. 5	C. Hilgenberg	Dr	10.5	6	GI	....	Alluvium	Cy,W, H	S	Top of casing	+1.9	....	4.37	10-12-44	
16-12-12cb	NW SW sec. 12	N. J. Weber	Dr	190.5	5	GI	Sandstone	Dakota	Cy,W, H	D, S	do	+ .4	1,887.8	172.10	10- 5-44	
16-12-12cb	NW SW sec. 12	do	Du	26.9	48	R	....	Carlile	Cy,W, H	D	Top of wooden platform.	+ .8	....	10.29	10- 5-44	
16-12-15ad	SE NE sec. 15	W. Hoffman	Du	47.2	30	R	....	do	Cy,W, H	N	do	+ .8	....	16.46	10- 5-44	Unused stock well.
16-12-16bb	NW NW sec. 16	P. Martin	Dr	253.0	5.5	(?)	Sandstone	Dakota	Cy, W	N	Top of concrete platform.	+ .5	1,903.8	173.66	8- 9-44	Unused domestic well.
16-12-27cc	SW SW sec. 27	R. V. Hitschman	Dr	184.3	5	I	do	do	Cy,W, H	S	Top of pump case.	+3.2	1,898.3	127.70	10- 7-44	
	T. 16 S., R. 13 W.															
16-13-5bc	SW NW sec. 5	H. Bitter	Dr	214.0	6	GI	do	do	Cy, W	S	Top of casing	+ .7	1,884.1	152.18	8- 3-44	Water reported salty.

16-13-8aa	NE NE sec. 8	Empire Oil Co.	Dr	252.0	6	OW	do.	do.	Cy, W	In	do.	— .3	1,933.6	202.22	8- 8-44	Supplies water to oil-field tank battery.
16-13-12ad1	SE NE sec. 12	E. Miller	Dr	204.5	5.5	GI	do.	do.	N	N	Top of concrete platform.	+1.5	1,901.5	19.21	8- 9-44	Well abandoned because of inadequate yield. Replaced by well 18.
16-13-12ad2	SE NE sec. 12	do.	Dr	227.0	5.5	GI	do.	do.	Cy, W, H	D, S	......	......	......	......	......	About 200 feet west of well 17. Water reported salty.
16-13-18aa	NE NE sec. 18	Empire Oil Co.	Dr	270.0	6	OW	do.	do.	Cy, G	In	Top of casing	+ .3	1,940.4	198.38	8- 8-44	Supplies water to oil-tank battery.
16-13-20ad	SE NE sec. 20	J. Prusa	Dr	275.0	6	GI	do.	do.	Cy, W, H	S	Top of concrete platform.	0	1,961.5	196.66	8- 3-44	
	T. 16 S., R. 13 W.															
16-13-23aa	NE NE sec. 23	C. R. Allen	Dr	182.0	(?)	(?)	Sandstone	Dakota	Cy, W, H	S	Top of plate over casing.	+ .5	1,939.6	175.50	8- 9-44	
16-13-32bc	SW NW sec. 32	......	Dr	219.5	5.5	GI	do.	do.	Cy, W	D, S	Top of wooden platform.	+ .3	1,946.6	168.57	8- 3-44	
16-13-33da	NE SE sec. 33	L. W. Ainsworth	Dr	165.5	(?)	(?)	do.	do.	Cy, W	D	Top of board over casing.	+1.8	......	156.38	8- 8-44	
16-13-36bc	SW NW sec. 36	S. Reif	Dr	165.5	5	I	do.	do.	Cy, W, H	D, S	Top of casing	+ .5	1,891.1	115.39	8-11-44	
	T. 16 S., R. 14 W.															
16-14-2cb	NW SW sec. 2	Paul Schwein	Du	42.5	36	R	Limestone	Greenhorn	Cy, W, H	D, S	Top of concrete cover.	+ .9	......	36.41	9-30-44	
16-14-6bd	SE NW sec. 6	G. V. Stienert	Du	14.2	36	R	......	Alluvium	Cy, G, H	S	Top of wooden platform.	+1.3	......	5.92	9-30-44	
16-14-8cc	SW SW sec. 8	E. Karst	Dr	263.5	6	GI	Sandstone	Dakota	Cy, W	N	Top of casing	+ .3	1,948.5	181.97	8- 2-44	Unused stock well.
16-14-9bc	SW NW sec. 9	E. Nuss, Jr.	Dr	190.0	(?)	(?)	do.	do.	Cy, W	S	......	......	......	160.00	......	
16-14-12cb	NW SW sec. 12	E. Sausen	Du	9.3	24	R	......	Alluvium	Cy, H	S	Top of concrete platform.	+1.2	......	5.12	9-30-44	
16-14-19dc	SW SE sec. 19	J. Eurich	Dr	142.2	6	GI	......	......	Cy, W, H	D, S	Lower edge of pump base.	+ .3	1,929.7	124.32	9-29-44	
16-14-24dd	SE SE sec. 24	M. Peach	Dr	200.0	5.5	GI	Sandstone	Dakota	Cy, W	S	Top of casing	+ .2	1,951.0	177.55	8-11-44	
16-14-26bb1	NW NW sec. 26	G. J. Streck	Du	20.0	60	R	Shale and limestone.	Carlile	Cy, H	D	Top of wooden platform.	+ .2	......	15.61	8- 8-44	
16-14-26bb2	NW NW sec. 26	do.	Dr	167.5	......	......	Sandstone	Dakota	Cy, W	S	Top of wooden well cover.	+ .3	1,927.9	140.97	8- 8-44	
16-14-29dc	SW SE sec. 29	School District	Dr	68.5	6	GI	......	Greenhorn	Cy, H	D	Top of casing	+ .3	2,001.5	50.69	8- 1-44	School well.
16-14-34dd	SE SE sec. 34	P. P. Kingston	Dr	123.9	5.5	GI	......	Greenhorn (?)	N	N	do.	+ .6	1,962.7	118.55	7-13-44	Unused stock well.

TABLE 12.—*Record of wells in Barton County, Kansas—Continued*

Well No. (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 16 S., R. 15 W.															
16-15-3ad	SE NE sec. 3	Herman Keil	Du	25.8	30	R	.....	Greenhorn (?)	Cy,W, H	S	Lower edge of pump base.	+ .7	.....	15.84	9-30-44	
16-15-6dd	SE SE sec. 6	Rudolph Funk	Dr	209.5	6	GI	Sandstone	Dakota	Cy, W	S	Top of board over casing.	+ .2	1,947.9	151.60	8- 9-44	Water of poor quality. Cistern water used for house.
16-15-9aa	NE NE sec. 9	J. G. Boxberger	Du	13.0	40	R	.....	Alluvium	Cy,W, H	S	Top of wooden well cover.	0	.....	3.68	8- 9-44	Water of poor quality. Cistern water used for house
16-15-11da	NE SE sec. 11	J. Karst	Dr	187.5	6	GI	Sandstone	Dakota	Cy,W, H	D, S	Top of casing	+ .5	1,950.8	160.56	8- 9-44	Water is salty.
16-15-15dc1	SW SE sec. 15	George T. Hester	Du	9.8	30	R	.....	Early Pleistocene.	N	N	Top of concrete platform.	+ .6	1,987.0	7.65	10- 9-44	Unused stock well.
	T. 16 S., R. 15 W.															
16-15-15dc2	SW SE sec. 15	George T. Hester	Dr	40.0	.....	.....	Sand	do	Cy, W	D, S	.....	.....	.....	28.00	.....	See well 16-15-15dc1
16-15-16da	NE SE sec. 16	A. Dietz	Du	24.5	48	R	.....	do	Cy, W	S	Top of concrete platform.	+ .3	2,004.9	23.75	8- 1-44	
16-15-20aa	NE NE sec. 20	Constantine Steintz	Dr	48.0	5.5	GI	.....	Carlile	Cy, W	N	Top of casing	0	2,005.0	36.70	8- 1-44	Tape encountered obstruction at 48 feet; well may be deeper. Unused stock well.
16-15-22dc	SW SE sec .22	E. M. Burchfield	Du	36.2	48	R	Sand	Early Pleistocene.	Cy,W, H	S	Top of wooden platform.	+1.3	2,004.0	32.93	9-29-44	
16-15-25bc	SW NW sec. 25	F. L. Seidel	Du	33.1	.....	.....	do	do	N	N	Top edge rock curb.	+1.0	1,988.3	31.60	7- 7-44	Unused stock well.
16-15-28ca	NE SW sec. 28	C. Schneider	Du	37.3	60	R	.....	Carlile (?)	Cy,W, H	S	Top of wooden platform.	+ .9	2,000.8	31.14	9-29-44	
16-15-31ad	SE NE sec. 31	.....	Dr	161.5	4.5	GI	Sandstone	Dakota	N	N	Top of casing	+1.0	1,995.3	110.12	7-24-44	Unused domestic and stock well.
16-15-34cb	NW SW sec. 34	B. H. Scheck	Du	40.0	48	R	.....	Carlile and/or Greenhorn.	Cy, W	N	Top of wooden platform.	+ .3	1,992.7	19.90	8- 1-44	Unused domestic well.

	T. 17 S., R. 11 W.														
17-11-3bc	SW NW sec. 3	C. E. Rudenburg	Dr	170.5	......	......	Sandstone	Dakota	Cy, H	N	Top of casing	+ .5	1,888.5	110.61	10- 5-44	Unused domestic well. Water reported to be salty.
17-11-10dd	SE SE sec. 10	Carter Oil Co.	Dr	168.1	6.5	OW	do	do	N	O	do	+ .2	1,871.4	100.18	7- 8-44	Formerly used to supply water for drilling oil test.
17-11-11cd	SE SW sec. 11	W. Krautwerst	Dr	158.5	4	GI	do	do	Cy,W, H	N	do	+1.0	1,914.3	127.92	10- 6-44	Unused stock well.
17-11-16dd	SE SE sec. 16	C. Gibler	Du	31.0	30	R	....	Sanborn	Cy, W	S	Top of wooden platform.	+ .6	1,814.8	21.69	7- 8-44	
17-11-19dd	SE SE sec. 19	School District	Dr	61.7	5	GI	....	do	Cy, H	D	Top of casing	+ .3	1,841.2	47.98	10- 7-44	School well.
17-11-23bb	NW NW sec. 23	L. Disque	Dr	109.9	6	OW	Sandstone	Dakota	N	N	do	+ .2	1,855.7	76.92	10- 6-44	Formerly supplied drilling water for oil-test well.
17-11-26ad	SE NE sec. 26	School District	Dr	62.1	6	GI	....	Dakota (?)	Cy, H	D	do	+1.2	1,833.2	51.68	10-12-44	School well.
17-11-27bc	SW NW sec. 27	M. Schlessiger	Dr	42.1	5	GI	....	Sanborn	Cy, W	S	do	+ .5	1,817.9	32.69	10-12-44	
17-11-31dc	SW SE sec. 31	Anna Keiser	Dr	71.4	6	GI	Sand	do	Cy,W, H	S	Lower edge of pump base.	+ .8	1,824.4	39.97	10- 5-44	Also used to irrigate small garden.
17-11-36cc	SW SW sec. 36	Harmon Gemeinhardt	Dr	58.5	8	GI	Gravel	do	Cy,W, H	D, S	do	+ .6	1,804.7	36.27	10-25-44	
	T. 17 S., R. 12 W.														
17-12-2cb	NW SW sec. 2	P. O. Meyer	Dr	(?)	......	......	Sandstone	Dakota	Cy,W, H	S	Top of wooden well cover.	+ .4	1,885.3	70.52	8-11-44	
17-12-16cd	SE SW sec. 16	F. J. Demel	Du	56.0	60	R	....	Greenhorn and /or Dakota.	Cy,W, H	D, S	Lower edge of pump base.	+1.1	1,876.8	33.20	10- 7-44	
17-12-20ba	NE NW sec. 20	C. Gibler	Dr	132.0	5	GI	Sandstone	Dakota	Cy, W	N	Top edge of rock well cover.	+ .8	1,946.8	124.74	8-11-44	Unused domestic well.
17-12-22ab	NW NE sec. 22	Alois Birzer	Dr	36.0	12	GI	"Sand and small rock."	Sanborn	Cy, H	S	Top of casing	+9.0	1,834.2	14.83	10- 7-44	
17-12-24bc	SW NW sec. 24	F. Beran	Dr	94.3	6.5	OW	....	do	N	O	do	+ .6	1,866.4	61.36	7-12-44	Formerly supplied water for drilling oil-test well.
17-12-27cc	SW SW sec. 27	F. Kroester	Dr	153.5	5.5	GI	Sandstone	Dakota	Cy, W	S	do	+ .5	1,932.7	116.97	10- 7-44	
17-12-31dc1	SW SE sec. 31	Francis Peirano	Dr	27.3	6	GI	Fine sand	Alluvium	Cy, H	N	do	+ .4	1,813.0	16.15	10- 5-44	Unused stock well.
17-12-31dc2	SW SE sec. 31	do	Dr	60.0	6	GI	Sandstone	Dakota	Cy, W	D, S	....	....	....	16.00	....	About 100 feet south of well 17-12-31dc1.
17-12-33dd	SE SE sec. 33	F. Konarek	Dr	25.6	5	GI	....	Alluvium	Cy, H	O	Top of casing	+ .4	1,805.6	3.74	7- 7-44	Unused domestic well.
17-12-35dd	SE SE sec. 35	K. Werner	Du	41.3	48	R	Sandstone	Dakota	Cy, H	N	Top of wooden cover.	+ .2	1,851.0	33.34	7-14-44	do
	T. 17 S., R. 13 W.														
17-13-10dd	SE SE sec. 10	Elmdale School Dist.	Dr	65.5	5.5	GI	do	do	Cy, H	D	Top of casing	+ .5	1,853.6	22.45	8- 8-44	School well.
17-13-12dd	SE SE sec. 12	J. Finger	Dr	35.5	(?)	(?)	do	do	Cy,W, H	N	Top of metal well covering.	+ .8	1,866.6	25.50	8- 9-44	Unused stock well.
17-13-18aa	NE NE sec. 18	F. N. Ney	Dr	174.5	(?)	(?)	do	do	Cy, W	S	Lower edge, hole in pump base.	+1.5	1,930.0	159.45	8- 3-44	
17-13-19dc	SW SE sec. 19	John Lust	Du	18.5	72	R	....	Alluvium	Cy,W, H	S	Top of wooden platform.	+ .7	1,843.0	10.63	10- 9-44	

TABLE 12.—*Record of wells in Barton County, Kansas—Continued*

Well No. (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 17 S., R. 13 W.															
17-13-25bb	NW NW sec. 25	E. Demel	Dr	28.5	5.5	GI	....	Alluvium	Cy, W	S	Top of concrete platform.	+ .4	1,823.9	8.72	8-11-44	
17-13-27bb	NW NW sec. 27	School District	Dr	111.3	6	GI	Sandstone	Dakota	Cy, H	D	Top of casing	+ .4	1,906.0	91.92	10- 7-44	School well.
17-13-28bb	NW NW sec. 28	Wayne Stoskopf	Dr	260.0	5.5	GI	do	do	Cy,W, H	D, S	do	+ .6	1,887.6	76.75	8- 8-44	Difficult to find water here; five wells, 200-230 feet deep, had been abandoned.
17-13-31dd	SE SE sec. 31	K. Sette	Dr	58.0	5	GI	do	do	Cy,W, H	S	do	— .5	1,836.4	18.88	10- 9-44	
17-13-33dc	SW SE sec. 33	J. Hennessey	Dr	89.9	5	GI	do	do	N	O	do	0	1,846.0	35.69	7- 7-44	Unused stock well.
	T. 17 S., R. 14 W.															
17-14-7cd	SE SW sec. 7	F. Janke	Dr	133.5	6	GI	do	do	Cy, W	S	Top of wooden pipe clamp.	+ .5	1,906.5	45.71	8- 1-44	
17-14-9cd	SE SW sec. 9	S. B. Dryden	Dr	124.0	5.5	GI	do	do	Cy, W	N	Lower edge of pump base.	0	1,937.5	98.22	8- 5-44	Unused stock well.
17-14-11cc	SW SW sec. 11	E. Hester	Dr	180.0	6-4	GI	do	do	Cy, W	D, S	....	....	....	90.00	....	Encountered water at 164 feet in white sandstone.
17-14-12bb	NW NW sec. 12	P. Dyer	Du	31.1	36	R	....	Carlile and/or Greenhorn.	Cy,W, H	N	Top of well cover	+1.2	....	15.18	9-30-44	Unused stock well.
17-14-15dd	SE SE sec. 15	G. W. Boyle	Dr	34.7	8	GI	....	Dakota (?)	Cy,W, H	D	Top of hole in pump base.	+1.0	1,890.8	26.02	10- 9-44	
17-14-21da	NE SE sec. 21	School District	Dr	39.2	5.5	GI	....	Dakota	Cy, H	D	Top of casing	+ .8	1,871.1	17.63	8- 3-44	School well.
17-14-27ad	SE NE sec. 27	Olivet Cemetery	Dr	40.0	5.5	GI	Sandstone	do	Cy, H	D	do	+ .4	1,851.2	21.84	8- 3-44	
17-14-33aa	NE NE sec. 33	Prudential Ins. Co.	Dr	48.4	6	GI	....	Alluvium	Cy,W, H	O	Top of wooden platform.	+ .5	1,857.1	18.19	7-12-44	Unused stock well.
17-14-33dd	SE SE sec. 33	Mrs. J. Murdy	Dr	87.5	5	GI	Sandstone	Dakota	Cy, W	S	Top of casing	+1.1	1,929.4	79.20	7-28-44	
17-14-36cb	NW SW sec. 36	H. J. Wigton	Du	15.6	36	R	....	Alluvium	Cy, H	D	Top of wooden platform.	+1.6	1,836.7	6.33	10- 9-44	
17-14-36da	NE SE sec. 36	W. G. Eveleigh	Dr	43.5	5.5	GI	Sandstone	Dakota	Cy, H	N	Top of concrete platform.	+1.5	1,854.4	31.06	8- 5-44	Unused domestic well.

	T. 17 S., R. 15 W.													
17-15-2ad	SE NE sec. 2	Ellen Quinby	Dr	198.0	(?)	(?)	do.	do.	Cy, W	S	Top of metal plate over casing.	+2.0	1,987.6	161.84	8- 9-44	Cistern water used for domestic purposes.
17-15-16ad	SE NE sec. 16	C. Menzer	Dr	36.5	6	GI	......	Greenhorn	Cy, H	N	Top of casing	+1.3	......	19.66	8- 1-44	Unused domestic well.
17-15-18aa	NE NE sec. 18	J. M. Lebsack	Du	24.2	48	R	......	Carlile (?)	Cy, W	S	Top of pipe clamp.	+ .5	......	13.19	7-24-44	
17-15-21cd	SE SW sec. 21	H. J. Pospishel	Dr	198.2	(?)	(?)	do.	Dakota	Cy, W, H	S	Top edge of hole in pump jacket.	+1.2	2,045.6	180.57	9-27-44	
1 -15- 3ad	SE NE sec. 23	J. M. Axman	Dr	77.5	5.5	GI	do.	do.	Cy, W, H	S	Lower edge hole in pump base.	+ .6	1,906.7	34.08	8- 2-44	
1 -15-25dd	SE SE sec. 25	J. Boyd	Dr	197.5	6	GI	do.	do.	Cy, W, H	N	Top of concrete platform.	+ .4	1,976.3	123.64	7-22-44	Unused domestic well.
17-15-32dd	SE SE sec. 32	C. Reidl	Dr	157.5	6	GI	do.	do.	Cy, W	N	Top edge of hole in pump base.	+1.0	1,997.2	115.38	7-22-44	do.
17-15-34ab	NW NE sec. 34	Fred Schreiber	Dr	218.0	5	GI	do.	do.	Cy, W, H	D, S	Lower edge of pump base.	+ .9	2,015.0	162.80	10- 9-44	
	T. 18 S., R. 11 W.															
18-11-4ad1	SE NE sec. 4	City of Claflin	Dr	160.0	12-6	Bs	do.	do.	T, E	P	......	......	......	37.00	......	Reported yield 200 g. p. m., drawdown 30 feet.
18-11-4ad2	SE NE sec. 4	do.	Dr	162.0	12-6	Bs	do.	do.	N	P	Top of casing	+ .5	1,798.8	32.96	8-14-44	Twenty-five feet west of well 18-11-4ad1. Pump to be installed and well to be used as stand by.
18-11-9cc	SW SW sec. 9	Ed Oeser	Dr	52.5	5	GI	......	Sanborn	Cy, W, H	D, S	do.	+1.0	1,803.0	20.30	8- 7-44	
18-11-13aa	NE NE sec. 13	A. L. Zink	Dr	34.7	4	GI	......	do.	Cy, W	S	do.	+1.3	1,775.6	28.32	7-27-44	Tape hit cylinder, depth questionable.
18-11-13bb	NW NW sec. 13	E. R. Roesler	Dr	39.7	6	GI	......	do.	Cy, H	N	Top of casing	+ .4	1,773.5	21.68	10-11-44	Unused stock well.
18-11-15bc	SW NW sec. 15	W. M. Drews	Dr	32.4	5	GI	......	do.	Cy, W, H	S	do.	+ .4	1,771.5	22.18	10-11-44	Also used to irrigate garden.
18-11-16dd	SE SE sec. 16	C. N. Klapper	Dr	40.6	5.5	GI	......	do.	Cy, W, H	S	do.	+ .6	1,787.0	17.15	7-27-44	
18-11-17cc	SW SW sec. 17	J. Liebel	Dr	33.0	5	OW	......	do.	Cy, W, H	S	do.	+ .9	1,821.7	17.72	10-11-44	
18-11-19bb	NW NW sec. 19	M. F. Schrepel	Du	16.0	60	R	Sand	Alluvium	Cy, W	S	Top of concrete platform.	0	1,800.5	7.30	8- 7-44	
18-11-28dc	SW SE sec. 28	Lizzie Nagel	Dr	66.5	8	T	......	Sanborn	Cy, H	O	Lower edge of pump base.	0	1,801.6	32.07	7- 8-44	Unused stock well.
18-11-29cc	SW SW sec. 29	P. P. Kimpler	Du	55.8	54	R	......	do.	Cy, W, H	D, S	Top of concrete platform.	+ .3	1,836.2	44.32	10-11-44	
18-11-35aa	NE NE sec. 35	J. Musenberg	Dr	33.1	(?)	(?)	......	do.	N	N	Lower edge of pump base.	+1.4	1,745.5	4.82	9-27-44	Unused stock well.

TABLE 12.—*Record of wells in Barton County, Kansas—Continued*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 18 S., R. 12 W.															
18-12-12bc	SW NW sec. 12	H. W. Bortz	Dr	41.2	6	GI	Sandstone	Dakota	Cy, H	N	Top of casing	+ .4	1,819.8	25.95	7-14-44	Unused domestic well.
18-12-33cc	SW SW sec. 33	Barton Co. Oil Co.	Dr	45.3	6	GI		Alluvium	N	N	Top of concrete platform.	0	1,799.3	6.38	10- 9-42	Unused stock well.
18-12-35aa	NE NE sec. 35	W. P. Roth	Dr	56.3	5	OW		do.	Cy, W	S	Top of casing	+2.1	1,795.1	15.25	10-11-44	
	T. 18 S., R. 13 W.															
18-13-3bc	SW NW sec. 3	Matilda Riedel	Dr	26.6	12	GI		do.	N	N	do.	+ .4	1,820.3	17.58	10-13-44	Unused domestic well.
18-13-8cd	SE SW sec. 8	J. F. Riedel	Dr	37.5	6	GI		Dakota (?)	Cy, W	S	do.	+1.2	1,816.9	16.63	7-28-44	
18-13-15da	NE SE sec. 15	Elmer Cook	B	33.4	6	GI		Alluvium	Cy,W, H	D, S	do.	+ .7	1,803.1	9.75	10-13-44	
18-13-16ab	NW NE sec. 16	W. G. Eveleigh	Dr	10.0	6	GI		do.	Cy,W, H	S	do.	+1.3		4.79	10-13-44	
18-13-21bb	NW NW sec. 21	L. E. Campbell	Dr	31.0	6	GI		do.	Cy,W, H	S	do.	+ .6	1,810.4	11.05	10-13-44	
18-13-23ab	NW NE sec. 23	A. M. Bates	Dr	63.2	(?)	(?)		do.	Cy, W	S	Lower edge of pump base.	+ .3	1,801.0	8.89	10-13-44	
18-13-27cb	NW SW sec. 27	F. J. Haberman	Dr	23.9	5	GI		do.	P, H	D	Top of casing	+1.3	1,807.1	6.40	10-13-44	
18-13-30dc	SW SE sec. 30	M. M. Hoskins	Dr	89.5	5	GI		Sanborn	Cy,W, H	N	Lower edge of pump base.	+ .3	1,902.9	52.39	7-28-44	Unused stock well.
18-13-34dd	SE SE sec. 34	School District	Dr	36.0	5	GI		Alluvium	Cy, H	D	do.	+ .3	1,810.9	19.11	10- 6-42	School well.
	T. 18 S., R. 14 W.															
18-14-1da	NE SE sec. 1	J. F. Riedel	Dr	52.2	4	GI		do.	N	N	Top of casing	+ .3	1,827.3	7.66	10- 9-44	Unused stock well.
18-14-3dd	SE SE sec. 3	W. G. Eveleigh	Dr	27.1	6	GI		do.	Cy, W	S	do.	+2.3	1,851.5	13.95	9-29-44	In Boyd, Kansas.
18-14-7cc	SW cor. sec. 7	School District	Dr	61.5	5	GI		Dakota (?)	Cy, H	D	do.	+ .5	1,939.6	40.59	7-28-44	School well.
18-14-8ad	SE NE sec. 8	J. Murdy	Dr	158.5	5	GI	Sandstone	Dakota	Cy,W, H	N	do.	+ .5	1,991.0	108.83	8- 3-44	Unused stock well.
18-14-12cb	NW SW sec. 12	F. N. Eveleigh	Dr	30.0	5.5	GI	do.	do.	N	N	do.	0	1,852.9	16.05	8- 3-44	do.
18-14-14da	NE SE sec. 14	G. H. Durand	Dr	40.5	5.5	GI	do.	do.	Cy,W, H	S	do.	+ .2	1,870.7	16.31	8- 3-44	
18-14-15cd	SE SW sec. 15	School Dist. No. 45	Dr	72.0	6	GI		Sanborn	Cy, H	D	do.	+ .3	1,919.3	53.90	7-28-44	School well.

18-14-20ad	SE NE sec. 20	C. Cook	Dr	81.1	6	GI		do	Cy, W, H	N	do	0	1,930.1	54.34	7-28-44	Unused domestic well.
18-14-24aa	NE cor. sec. 24	School District	Dr	76.5	5	GI	Sandstone	Dakota	Cy, H	D	do	+ .3	1,897.2	50.49	7-28-44	School well.
18-14-25cb	NW SW sec. 25	Fred Maneth	DD	55	24-5	R		Sanborn	Cy, W, H	D	Top of concrete platform.	+1.0	1,896.7	38.76	8- 3-44	
18-14-30cb	NW SW sec. 30	School Dist. No. 20	Dr	61.5	6	GI		do	Cy, H	D	Top of casing	0	1,924.3	35.69	7-22-44	School well.
18-14-33ab	NW NE sec. 33	Clara Trester	Dr	37.0	5.5	GI		do	Cy, W	S	do	+ .7	1,892.9	23.60	7-28-44	
18-14-35cc	SW SW sec. 35	A. L. Langford	Du	35.0	30	R		do	B, H	N	Top of wooden cover.	+3.0	1,898.1	33.46	10- 7-42	Unused domestic well.
	T. 18 S., R. 15 W.															
18-15-1bc	SW NW sec. 1		Dr	220.2	6	GI	Sandstone	Dakota	Cy, W, H	D	Lower edge of pump base.	+ .4	2,014.1	152.56	9-29-44	In Olmitz. Water reported to cause iron stains on pipes, etc.
18-15-6da	NE SE sec. 6	M. E. Schneider	Dr	30.0	5.5	GI		Greenhorn (?)	Cy, W, H	S	Top of casing	+ .4	1,964.6	12.68	8- 1-44	
18-15-9cb	NW SW sec. 9	School District	Dr	27.5	5	GI		Sanborn	Cy, H	D	do	+ .3	1,949.3	23.57	8- 1-44	School well.
18-15-10bb	NW NW sec. 10	F. V. Reidl	Du	38.2	36	R		do	Cy, W, H	S	Lower edge of pump base.	+1.0	1,956.5	30.90	7-22-44	
18-15-11ad	SE NE sec. 11	O. Maneth	Dr	190.5	5.5	GI	Sandstone	Dakota	Cy, W	S	Top of casing	+ .5	1,989.2	115.75	8- 9-44	
18-15-16dd	SE SE sec. 16	R. Kuhlmann	Dr	53.5	5.5	GI		Sanborn	Cy, W, H	S	do	+ .5	1,937.3	34.09	7-22-44	
18-15-23ad	SE NE sec. 23	F. Nordiman	Dr	43.3	5.5	GI		do	Cy, W, H	S	do	+1.5	1,911.2	21.29	7-22-44	
18-15-28cc1	SW SW sec. 28	J. C. Cook	Dr	45.6	(?)	(?)	Sand and gravel.	Alluvium	N	O	Top of concrete curb.	+1.0	1,913.7	14.82	7-12-44	Unused irrigation well.
18-15-28cc2	SW SW sec. 28	H. R. Arnold	Dr	60.0	20	GI	do	do	C, G	I				14		Gravel-packed well.
18-15-30bb	NW NW sec. 30	(?)	Dr	39.1	6	I	do	do	P, H	N	Lower edge of pump base.	+2.9	1,922.3	16.18	7-21-44	
18-15-30bd	SE NW sec. 30	H. R. Arnold	Dr	65.0	19	GI	Gravel	do	C, T	I	Top of wooden curb.	0	1,926.3	17.36	10-13-44	
18-15-30dd	SE SE sec. 30	E. J. Schreiner	Dn	35.0	1.5	GP	Sand and gravel.	do	Cy, W	D, S				15		
18-15-33ad	SE NE sec. 33	H. C. Bird	Dr	74.0	16	OW	do	do	T, NG	I				13		Gravel-packed well. Reported yield 1,000 g. p. m.; drawdown 45 ft.
18-15-34aa	NE NE sec. 34	H. J. Bahr	Dr	80.0	25-16	GI	do	do	C, G	I				22		
18-15-34ab	NW NE sec. 34	Mrs. Mary Bahr	Dn	30.0	1.5	GP	do	do	Cy, W, H	D, S				18		Water reported to be hard. Deeper water in alluvium reported to be of better quality.
18-15-36ba	NE NW sec. 36	____ Kuhlman	Dr	(?)	(?)	(?)	do	do	C, T	I	Top of wooden cover.	+ .3	1,907.3	18.88	10-11-44	Unable to measure depth because of obstruction in well.

TABLE 12.—*Record of wells in Barton County, Kansas—Continued*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 19 S., R. 11 W.															
19-11-1dd	SE SE sec. 1	H. Musenburg	Dr	83.0	5	GI	....	Sanborn	Cy, W	N	Top of casing	+ .3	1,779.0	24.43	10- 6-42	Unused stock well.
19-11-3dd	SE SE sec. 3	J. H. Klepper	Dr	20.3	6	GI	....	do.	Cy, W	S	Top of wooden cover.	+ .7	1,772.9	5.09	10- 6-42	
19-11-6dd	SE cor. sec. 6	F. Robl	Dr	61.0	8	T	....	do.	Cy, W	D	Top of concrete platform.	0	1,809.7	26.42	10- 9-42	
19-11-15cd	SE SW sec. 15	Lario Oil Co.	Dr	24.5	5	OW	....	Alluvium	N	N	Top of casing	+1.5	1,783.7	22.65	10- 9-42	Formerly supplied water for drilling oil well.
19-11-20bb	NW NW sec. 20	A. Kowalski	DD	40.3	18	C	Sand and gravel.	do.	Cy, W	D, S	Top of platform	+ .3	1,795.1	22.30	9-11-44	Also used to irrigate garden.
19-11-24bb	NW NW sec. 24	E. W. Eberhart	Dr	55.0	12	GI	do.	do.	N	N	Top of casing	+ .2	1,776.6	15.09	10-11-44	Formerly supplied water for drilling oil well.
19-11-31bb	NW NW sec. 31	City of Ellinwood	Dr	138.0	12	OW	Sandstone	Dakota	T, E	P	....	....	....	11	....	Reported yield 225 g. p. m.
19-11-31bdc1	SW SE NW sec. 31	do.	Dr	90.0	10	OW	do.	do.	T, E	P	....	....	....	11	....	Reported yield 185 g. p. m., drawdown 12 ft.
19-11-31bdc2	SW SE NW sec. 31	do.	Dr	140.0	12	OW	do.	do.	T, E	P	....	....	....	11	....	Reported yield 485 g. p. m.
19-11-31bc	SW NW sec. 31	Fred Wolf	Dr	26.0	10	GI	Sand and gravel.	Alluvium	C, E	I	Top of casing	0	1,790.31	7.26	9- 5-42	Reported yield 450 g. p. m.
19-11-33bb	NW NW sec. 33	E. Thomas	Dn	25.8	1¼	GP	do.	do.	N	N	Top of pipe	+2.6	1,783.7	16.42	10- 9-42	Unused stock well.
	T. 19 S., R. 12 W.															
19-12-3ad	SE NE sec. 3	Louis Hammke	Dr	36.0	5	GI	Sand and gravel.	Sanborn	Cy, H	S	Top of casing	+ .9	1,807.6	13.29	10- 9-42	
19-12-6bc	SW NW sec. 6	F. W. Henning	Dr	15.3	6	GI	Sand	Alluvium	Cy, W	S	Top of wooden platform.	+1.2	1,802.5	10.43	10- 9-42	
19-12-12bb	NW NW sec. 12	D. L. Kultgen	Du	18.7	....	....	do.	Sanborn	Cy, W	S	do.	+ .5	1,789.1	3.87	9-11-44	

19-12-13ad	SE NE sec. 13	W. W. Rinker	Dr	33.5	6	GI	Gravel	do	Cy, E	D	Top of concrete platform.	+ .8	1,800.9	26.43	10- 6-42	
19-12-15dd	SE SE sec. 15	E. M. Pfluge	Dr	85.5	6	GI	....	Dakota	Cy, W	D, S	Top of wooden platform.	+ .7	1,852.27	75.48	10- 9-42	
19-12-16bb	NW NW sec. 16	C. H. Rasco	Dr	66.0	5	GI	....	do	Cy, W	S	Top of casing	+ .3	1,850.87	44.46	10- 9-42	
19-12-19bc	SW NW sec. 19	H. C. McIlbrath	2 Dr	30.5	20	Bs	Gravel	Alluvium	C, G	I	Top of concrete curb.	+ .3	1,830.9	7.09	10- 6-42	Battery of two wells. Reported yield 1,100 g. p. m.; drawdown 23 ft.
19-12-26aa	NE NE sec. 26	M. Apel	Dn	39.3	1¼	GP	Sand and gravel.	do	P, H	D	Top edge of pump.	+3.2	1,803.60	18.93	10- 9-42	
19-12-28cc	SW SW sec. 28	Wolf's Elevator	Dn	25.0	1½	GP	do	do	P, H	D	....	....	....	10	....	
19-12-28da	NE SE sec. 28	W. A. Koch	Dn	29.3	1¼	GP	Sand	do	P, H	S	Top edge of pump.	+2.8	1,816.6	14.58	10-12-42	
19-12-31ab	NW NE sec. 31	A. F. Kohler	Dn	55.7	1¼	GP	Sand and gravel.	do	P, H	N	do	+3.3	1,829.93	13.43	10-12-42	Unused domestic well.
	T. 19 S., R. 13 W.															
19-13-3da	NE SE sec. 3	J. R. Hayes	Dr	74.7	......	......	Sandstone	Dakota	Cy, W	S	Top edge of casing.	+ .6	1,848.6	61.46	9-13-44	
19-13-4cc1	SW SW sec. 4	City of Hoisington	Dr	42.0	12	Bs	Sand and gravel.	Alluvium	T, E	P	....	....	....	22	....	Gravel-packed well. Reported yield 415 g. p. m.
19-13-4cc2	SW SW sec. 4	do	Dr	42.0	12	Bs	do	do	T, E	P	....	....	....	22	....	Gravel-packed well. Reported yield 415 g. p. m.
19-13-6db	NW SE sec. 6	Elmer Amerine	Dr	115.0	19	GI	do	Sanborn	T, G	I	Top of opening	+ .4	1,890.4	38.72	10- 7-42	Gravel-packed well. Reported yield 1,100 g. p. m.; drawdown 20 ft.
19-13-11cb	NW SW sec. 11	P. Schmidt	Dr	47.5	5	Bs	Sandstone	Dakota	Cy, H	D	Top of casing	+ .4	1,868.6	31.44	10- 6-42	
19-13-18db	NW SE sec. 18	Thomas Taylor	Dr	80.0	20	GI	Sand and gravel.	Sanborn	T, D	I	Top of opening	0	1,865.3	15.32	10- 7-42	Gravel-packed well. Reported yield 1,500 g. p. m.
19-13-21cc	SW cor. sec. 21	____ Rathborn	Dr	79.0	19	GI	do	Meade	T, E	I	....	....	....	8	....	Gravel-packed well. Reported yield 1,370 g. p. m.; drawdown 9 ft.
19-13-26bb	NW NW sec. 26	Mrs. Frank Wood	Dr	61.0	16	OW	do	do	T, E	I	Top of pump plate.	+1.0	1,847.3	17.27	10- 6-42	Reported yield 1,150 g. p. m.; drawdown 34 ft.
19-13-28bc	SW NW sec. 28	Kansas Power Co.	Dr	69.5	24	C	do	do	T, E	P	....	....	....	7.5	....	Gravel-packed well.
19-13-28cd	SE SW sec. 28	do	Dr	113.0	24	C	do	do	T, E	P, In	....	....	....	13.00	....	Gravel-packed well. Reported yield 800 g. p. m.; drawdown 18 ft. after pumping 8 hours.

Table 12.—*Record of wells in Barton County, Kansas—Continued*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 19 S., R. 13 W.															
19–13–29cc	SW SW sec. 29	L. C. Miller	Dn	18.2	1¼	GP	Sand and gravel.	Alluvium	Cy, W	I	Top of pipe coupling.	+ .5	1,861.8	9.93	10– 5–42	Irrigates small garden; observation well.
19–13–33ba	NE NW sec. 33	Dr. Pepper Bottling Co.	Dn	70.0	1¼	GP	do	Meade	Cy, E	In	...	...	...	10	...	Reported yield 16.6 g. p. m.
19–13–33bd1	SE NW sec. 33	Great Bend Poultry Co.	Dn	30.0	1¼	GP	do	Alluvium	C, E	In	...	...	...	...	...	Reported yield 20-30 g. p. m.
19–13–33bd2	SE NW sec. 33	do	Dn	30.0	2	GP	do	do	C, E	In	...	...	...	...	...	Reported yield 125 g. p. m.
19–13–33bd3	SE NW sec. 33	do	Dn	75.0	2	GP	do	Meade	C, E	In	...	...	...	...	...	Reported yield 25 g. p. m.
19–13–33bd4	SE NW sec. 33	Armour's Creameries.	Dr	69.0	6	Bs	do	do	Cy, E	In	...	...	...	8	...	
19–13–33bd5	SE NW sec. 33	Santa Fe Railroad	Dr	90.0	10	OW	do	do	C, E	In	...	...	...	10	...	Reported yield 350 g. p. m. Water treated for hardness.
19–13–33db	NW SE sec. 33	Kansas Power Co.	Dr	75.0	18	C	do	Meade and/or alluvium.	T, E	In	...	...	...	8	...	Gravel-packed well. Reported yield 533 g. p. m.; drawdown 22.5 ft.
19–13–34cd	SE SW sec. 34	H. Bartholomew	Dn	70.0	1¼	GP	do	Meade	C, E	D	...	...	...	10	...	
	T. 19 S., R. 14 W.															
19–14–4cab	NE SW sec. 4	Charles Stevens	Dr	76.0	18	GI	do	Alluvium	T, G	I	...	...	...	20	...	Gravel-packed well. Reported yield 1,000 g. p. m.
19–14–6bb1	NW NW sec. 6	Natural Gas Pipeline Co.	Dr	53.5	18	Bs	do	do	T, E	In	...	...	...	14	...	Reported yield 200 g. p. m.

19–14–6bb2	NW NW sec. 6	do.	Dr	53.5	18	Bs	do.	do.	T, E	In				14		do.
19–14–6bb3	NW NW sec. 6	P. Dyer	Dr	58.0	6	GI	do.	do.	Cy, W	S	Top of concrete platform.	+ .3	1,904.8	21.74	10– 7–42	
19–14–7dd	SE SE sec. 7	H. Neuforth	Dr	74.0	6	GI		Dakota	C, E	D				45		
19–14–9aab	NE NE sec. 9	W. A. Brown	Dr	70.0	20	GI	Sand and gravel.	Alluvium	T, G	I	Top of casing	+1.5	1,885.42	15.63	10– 8–42	Gravel-packed well. Reported yield 1,000 g. p. m.
19–14–16bb	NW NW sec. 16	W. Otte	Dr	59.1	5½	GI	Sandstone	Dakota	N, N	N	Top of casing	+ .3	1,903.10	34.03	8– 7–42	Unused stock well; observation well.
19–14–22ac	SW NE sec. 22	A. Essmiller	Dr	55.0	20	GI	Sand and gravel.	Alluvium	T, G	I	Top of opening	+ .5	1,885.9	20.72	10– 8–42	Gravel-packed well. Reported yield 1,000 g. p. m.; drawdown 22 ft.
19–14–23bb	NW NW sec. 23	Walter Clark	Dr	73.0	20	GI	do.	Meade and/or alluvium.	T, G	I				15		Gravel-packed well. Reported yield 1,100 g. p. m.; drawdown 16 ft.
19–14–26cbd	NW SW sec. 26	Essmiller Bros	Dr	73.0	19	GI	do.	do.	T, G	I				11.5		Gravel-packed well. Reported yield 1,200 g. p. m.; drawdown 20.5 ft.
19–14–32ac	SW NE sec. 32	W. A. Brown	Dr	44.5	20	GI	do.	Alluvium	C, G	I	Top of casing	—23.2	1,880.55	3.07	10– 8–42	Reported yield 1,200 g. p. m.; drawdown 18 ft.
19–14–32db	NW SE sec. 32	Glazner	Dr	70.0	20	GI	do.	Meade and/or alluvium.	T, G	I				26		Reported yield 1,000 g. p. m.
19–14–33cd	SE SW sec. 33	L. H. Damm	Dn	75.0	1¼	GP	do.	Meade	Cy, H	D				12		
19–14–36bb	NW NW sec. 36	Barton County Home	Dr	60.5	18	GI	do.	Meade and/or alluvium.	C, E	I	Top of casing	—6.5	1,866.7	3.12	10– 8–42	
	T. 19 S., R. 15 W.															
19–15–2ad	SE NE sec. 2	H. P. Schwartz	Dr	81.4	6	GI	Sandstone	Dakota	Cy, G	S	do.	+ .2	1,955.2	61.20	9–10–44	
19–15–3dc	SW SE sec. 3	I. A. Marten	Du	56.0	48	R		do.	Cy, W	S	Top edge of platform.	+1.0	1,948.7	36.64	9–10–44	
19–15–6ab	NW NE sec. 6	L. Morris	Du	22.5	(?)	R		Greenhorn	Cy, H	N	Lower edge of pump base.	+1.0		11.36	7–21–44	Unused domestic well.
19–15–7cd	SE SW sec. 7	Edward Peterson	Du	68.0	48	R	Sandstone	Dakota	Cy, W	D	Top of concrete platform.	+ .3	1,976.5	42.46	9–10–44	
19–15–13ad	SE NE sec. 13	F. Kruckenberg	Dr	98.5	6	GI		do.	Cy, W	N	Top of board	+ .6	1,928.22	36.33	10– 7–42	Unused stock well.
19–15–15bb	NW NW sec. 15	A. Willcutt	Dr	234.9	6½	OW		do.	N	N	Top of casing	+ .5	1,938.6	31.23	7–13–44	Formerly used as a drilling supply.
19–15–17cb	NW SW sec. 17	(?)	Dr	60.9	6½	OW		Dakota (?)	N	N	do.	+ .3	1,953.2	24.95	7– 7–44	do.
19–15–20aa	NE NE sec. 20	(?)	Dr	34.1	6	GI		Alluvium	Cy, W	S	Top of pump base.	+ .5	1,933.8	24.95	7–21–44	
19–15–20dc	SW SE sec. 20	Cemetery	Dr	25.2	8	N		do.	Cy, H	I	Top of concrete block.	+ .2	1,928.6	12.63	7–21–44	

TABLE 12.—*Record of wells in Barton County, Kansas—Continued*

Well No. (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 19 S., R. 15 W.															
19-15-22bb	NW NW sec. 22	Mary E. Breeden	Dr	29.3	4½	GI	....	Alluvium	Cy, W	S	Top of casing	+1.1	1,917.3	13.62	7-22-44	
19-15-22dd	SE SE sec. 22	W. Gagleman	Dr	25.0	5	GI	....	do.	Cy, H	N	do.	+ .3	1,915.4	13.48	7-22-44	Unused domestic well.
19-15-24bc	SW NW sec. 24	E. J. Russell	Du	28.5	(?)	(?)	....	do.	Cy, H	D	Top of wooden platform.	+1.0	1,907.1	16.32	7-14-44	
19-15-32db	NW SE sec. 32	H. Tammen	Dr	36.5	6	GI	....	Sanborn	Cy,W, H	S	Top of casing	+ .5	1,957.3	30.70	7-24-44	
19-15-33da	NE SE sec. 33	A. Feleske	Dr	24.3	5	GI	....	Alluvium	Cy,W, H	D, S	Edge of pump base.	+1.3	1,930.6	15.42	7-21-44	
19-15-34aa	NE NE sec. 34	School Dist. No. 40	Dr	30.0	6	GI	....	do.	Cy, H	D	Top of concrete platform.	+ .5	1,915.2	9.29	7-22-44	
19-15-35dc	SW SE sec. 35	H. Ewing	Dr	32.8	(?)	(?)	....	do.	Cy,W, H	S	Top of concrete base.	+ .8	1,920.5	21.31	7-14-44	
	T. 20 S., R. 11 W.															
20-11-2aa	NE cor. NE sec. 2	F. Panning	Dr	14.1	6	GI	Sand	do.	N	N	Top of casing	+1.4	1,765.9	7.98	10-12-42	
20-11-2ba	NE NW sec. 2	Louis Sharks	Dn	25.0	1½	GP	do.	do.	P, H	D	....	....	....	8	....	
20-11-3dd	SE cor. SE sec. 3	F. Panning	Dn	12.5	1¼	GP	do.	Alluvium	N	O	Top of pipe	+ .4	1,761.0	3.35	8- 7-42	Unused stock well; observation well.
20-11-12ad	SE NE sec. 12	C. W. Hilligos and others.	Dr	51.5	6	GI	Sandstone	Kiowa	N	N	Top of timber	+ .5	1,784.2	30.62	10-12-42	Formerly supplied water for drilling oil well.
20-11-16ab	NW NE sec. 16	L. Mauser	Dr	22.5	10	GI	Sand and gravel.	Alluvium	N	N	Top of casing	+1.0	1,766.5	3.95	10-13-42	do.
20-11-18ba	NE NW sec. 18	Scharz	Dr	31.0	6	GI	do.	do.	P, H	D	do.	+1.2	1,784.9	4.79	10- 7-42	
20-11-20cc	SW SW sec. 20	M. Hagen	Dr	36.5	6½	OW	....	Meade	N	N	do.	+ .5	1,798.6	21.02	10-12-42	Formerly supplied water for drilling oil well.
20-11-25bb	NW NW sec. 25	(?)	Dr	28.5	8	GI	Sand	Alluvium	N	N	do.	+ .5	1,749.1	4.64	10-12-42	do.
20-11-32ca	NE SW sec. 32	Sinclair Prairie Oil Co.	Dr	98.0	6	OW	Sand and gravel.	Meade	N	N	do.	+ .5	1,802.4	24.34	10-13-42	do.

	T. 20 S., R. 12 W.													
20-12-10ab	NW NE sec. 10	Busch	Dn	38.2	1¼	GP	do	Alluvium	P, H	D	Top of pitcher pump.	+2.8	1,806.1	7.12	10-14-42	
20-12-14ba	NE NW sec. 14	A. F. Pohlman	Dn	30.0	1¼	GP		Meade	P, H	N	do	+3.2	1,803.6	7.40	10-17-42	Unused domestic well.
20-12-26ad	SE NE sec. 26	W. Schrepel	Dn	43.7	1¼	GP		do	N	N	Top of pipe	+2.1	1,819.4	19.72	10-13-42	do.
20-12-27cc	SW SW sec. 27	W. F. Bryant	Dn	39.1	1¼	GP		do	P, H	N	Top of pitcher pump.	+4.9	1,829.1	16.32	10-12-42	
20-12-31db	NW SE sec. 31	O. A. Brown	Dr	90.0	6	OW		do	N	N	Top of casing	+ .4	1,853.7	18.87	10-13-42	Formerly supplied water for drilling oil well.
	T. 20 S., R. 13 W.													
20-13-2cc	SW SW sec. 2	Mrs. M. Shaffer	Dn	23.5	1¼	GP		do	P, H	N	Top of pitcher pump.	+3.5	1,856.2	18.48	10-13-42	Unused domestic well.
20-13-8cd	SE SW sec. 8	D. P. Robertson	Dn	41.2	1¼	GP		do	P, H	S	do	+2.3	1,882.3	20.27	10-17-42	
20-13-12ad	SE NE sec. 12	Teichmann	Dr	48.6	6½	OW		do	N	N	Top of casing	+1.1	1,857.2	30.43	10- 7-42	Unused drilling-supply well; observation well.
20-13-14ba	NE NW sec. 14	P. P. Moore	Dr	65.0	8	OW	Gravel	do	C, G	I				29		Irrigates trees, yard, and garden.
20-13-15ca	NE SW sec. 15	K. Schneider	Dr	27.5	5	OW		do	N	N	Top of casing	0	1,871.6	17.13	10-12-42	Formerly supplied water for drilling oil test. Reported depth 86 feet; filled with sand.
20-13-19aa	NE NE sec. 19	D. G. Weathers	Dn	32.0	1¼	GP		do	Cy, W, H	D, S				13		
20-13-23dd	SE SE sec. 23	Mabel Fryberger	Dn	39.0	1¼	GP		do	P, H	N	Top of pitcher pump.	+2.8	1,865.2	24.45	10-13-42	Unused stock well.
20-13-31ab	NW NE sec. 31	Simpson Oil Co.	Dr	90.0	7	OW	Sand and gravel.	do	Cy, G	D, In	Top of casing	0	1,898.4	14.94	10- 5-42	
	T. 20 S., R. 14 W.													
20-14-18dd	SE SE sec. 18	J. J. Schmidt	Dn	15.2	1¼	GP		Alluvium	P, H	N	Top of pitcher pump.	+2.8	1,909.03	14.39	10-14-42	Unused stock well.
20-14-20bc	SW NW sec. 20	W. H. Unruh	Dn	20.0	1½	GP		do	P, H	D				5		
20-14-26ab	NW NE sec. 26	I. M. Bailey	Dr	31.0	8	GI	Coarse gravel	Meade	C, G	I	Top of wooden platform.	+ .2	1,894.7	8.17	10-17-42	Reported yield 200; drawdown 10 ft.
20-14-29cc	SW SW sec. 29	(?)	Dr	14.7	6	OW	Gravel	Alluvium	N	N	Top of casing	0	1,912.35	1.64	10-14-42	Formerly supplied water for drilling oil test.
	T. 20 S., R. 15 W.													
20-15-5cc	SW SW sec. 5	B. Smith	Dr	83.5	5	GI	Sandstone	Dakota	Cy, H	N	Top of pump base.	0	1,997.2	59.61	7-14-44	Unused stock well.
20-15-9ab	NW NE sec. 9	Mrs. Katy Base	Dr	69.7	6	GI	do	do	Cy, W, H	S	Top of concrete platform.	+ .5	1,977.8	54.41	7-21-44	
20-15-11ab	NW NE sec. 11	M. Unruh	Dr	76.5	5	GI	do	do	Cy, W, H	N	Top of casing	+ .7	1,937.5	33.60	7- 7-44	Unused domestic and stock well.

TABLE 12.—*Record of wells in Barton County, Kansas—Concluded*

Well No. (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed		Method of lift (5)	Use of water (6)	Measuring point			Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
							Character of material	Geologic source			Description	Distance above (+) or below (—) land surface (feet)	Height above mean sea level (feet)			
	T. 20 S., R. 15 W.															
20–15–17bc	SW NW sec. 17.....	A. R. Unruh........	Dr	145.5	6½	OW	Sandstone....	Dakota......	N	N	Top of casing...	+ .2	2,072.5	105.28	7–12–44	Formerly supplied water for drilling oil-test well.
20–15–19dd	SE SE sec. 19.......	F. Smith...........	Dr	163.4	5	GI	do........	do........	Cy, W	D	do..........	+ .8	2,073.3	90.24	4–11–45	
20–15–22ba	NE NW sec. 22.....	A. A. Deckert.......	Dr	69.5	5	GI	do........	do........	Cy,W, H	D, S	Top of concrete platform.	+ .3	1,981.0	62.27	7–21–44	
20–15–29dd	SE SE sec. 29.......	Lawrence Koehn....	Dr	70.0	6	GI	do........	do........	Cy, W	S	Edge of pump base.	+ .4	1,991.0	12.60	7–21–44	
20–15–31cb	NW SW sec. 31.....	N. Spraier..........	Dr	40.5	6½	GI	do........	do........	Cy, W	S	Top of casing...	+ .6	1,997.6	29.35	7–13–44	
20–15–33ad	SE NE sec. 33......	B. C. Unruh........	Dr	32.0	19	GI	Sand and gravel.	Alluvium.....	C, G	N	....	....	....	17	....	Formerly used for irrigation; destroyed by flood.
20–15–33db	NW SE sec. 33......	Consolidated Flour Mills Co.	Dn	35.0	2	GP	do........	do........	Cy, H	D	....	....	....	15	....	
20–15–35bc	SW NW sec. 35.....	J. Unruh...........	Dr	38.0	......	......	do........	do........	T, G	I	Edge of pump base.	0	1,938.5	16.45	7–13–44	

1. Location number: Well numbers give the location of wells according to General Land Office surveys and according to the following formula: Township-Range-Section, 160-acre tract within that section, and the 40-acre tract within the quarter section. If two or more wells are located within a 40-acre tract, the wells are numbered serially according to the order in which they were inventoried. The 160-acre and 40-acre tracts are designated a, b, c, or d in a counterclockwise direction, beginning in the northeast quarter. For example: well 20-15-35bc is located in SW¼ NW¼ sec. 35, T. 20 S., R. 15 W.

2. B, bored well; DD, dug and drilled well; Dn, driven well; Dr, drilled well; Du, dug well; Sp, spring.

3. Reported depths below the land surface are given in feet; measured depths are given in feet and tenths below measuring points.

4. Bs, Boiler steel; C, concrete; GI, galvanized sheet iron; GP, galvanized-iron pipe; I, iron; N, none; OB, oil barrels; OW, oil-well casing; R, rock; T, tile; W, wood.

5. Method of lift: B, bucket and rope; C, horizontal centrifugal; Cy, cylinder; F, natural flow; N, none; P, pitcher pump; S, submersible turbine; T, turbine; VC, vertical centrifugal. Type of power: B, butane; E, electric; G, gas engine; H, hand-operated; NG, natural gas; T, tractor; W, windmill.

6. D, domestic; I, irrigation; In, industrial; N, not being used; O, observation; P, public supply; S, stock.

7. Reported depths to water level are given in feet; measured depths to water level are given in feet, tenths, and hundredths.

TABLE 13.—*Record of wells in Stafford County, Kansas*

Well No. (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 21 S., R. 11 W.															
21-11-3bb	NW NW sec. 3......	....	Dr	......	8	OW	Sand and gravel	Meade.....	N	N	Top of casing...	+0.8	1,766.6	12.02	10-10-42	Formerly supplied water for drilling oil well.
21-11-9bd	SE NW sec. 9.......	Shell Oil Co......	Dr	50.5	6	OW	do.........	do......	N	N	do.........	+ .1	1,765.4	9.77	10-10-42	do
21-11-20ab	NW NE sec. 20.....	Kaiser...........	Dn	25	1¼	GP	do.........	do......	P, H	D	....	....	....	5	....	
21-11-20cd	SE SW sec. 20......	M. E. Richardson	Dn	17.1	1¼	GP	do.........	do......	N	N	Top of pipe.....	+ .6	1,753.3	2.60	7-27-42	Unused stock well.
21-11-22cb	NW SW sec. 22.....	E. Pelton.........	Dn	10.2	1¼	GP	Sand..........	Alluvium...	P, H	N	Top of pitcher pump.	+2.6	1,742.9	4.32	10-10-42	Unused domestic well.
21-11-25ad	SE NE sec. 25......	R. S. Estey.......	Dn	36	1¼	GP	Sand and gravel	Meade.....	P, H	D	....	....	....	10	....	
21-11-26ad	SE NE sec. 26......	E. Jordan........	Dn	10.8	2	GP	....	Alluvium...	N	N	Top of pipe.....	+ .3	1,746.4	4.54	10- 1-42	Unused stock well.
21-11-27aa	NE NE sec. 27......	P. I. Miller.......	Dn	32	1¼	GP	....	Meade.....	P, H	D	....	....	....	10	....	
21-11-30bc	SW NW sec. 30.....	F. D. McMullin...	Dn	53	1½	GP	Sand and gravel	do......	Cy,H,W	D, S	....	....	....	12	....	
	T. 21 S., R. 12 W.															
21-12-8dc	SW SE sec. 8.......	F. R. Westafer....	Dr	......	10	GI	do.........	do......	Cy, W	D	Top of board over well pit.	+ .1	1,858.4	25.3	8-12-42	Water dripped on tape; measurement questionable.
21-12-10cd	SE SW sec. 10......	C. C. Christiansen	Dr	32.7	4	GI	do.........	do......	C, N	I	do.........	+ .2	1,843.3	21.91	8-12-42	Not used for several years.
21-12-28bb	NW NW sec. 28.....	E. A. Grow.......	Dn	85	1½	GP	do.........	do......	Cy, W	D, S	....	....	....	20	....	
21-12-31cb	NW SW sec. 31.....	....	Dr	87.4	6	OW	do.........	do......	Cy, W	N	Top of casing...	+ .9	1,872.0	14.89	8- 4-42	Formerly supplied water for drilling oil well.
	T. 21 S., R. 13 W.															
21-13-3cc	SW SW sec. 3.......	C. J. Shaeffer.....	Dn	40	1¼	GP	do.........	do......	Cy, H	D	....	....	....	18	....	
21-13-3cd	SE SW sec. 3.......	....	Dr	82.0	6	OW	do.........	do......	N	N	Top of casing...	+ .5	1,878.9	19.90	8-10-42	Formerly supplied water for drilling oil well.
21-13-21cd	SE SW sec. 21......	Hazel Ward......	Dr	70.0	6	OW	do.........	do......	Cy, G	N	do.........	+ .5	1,912.2	23.11	8- 1-42	do
21-13-26bb	NW NW sec. 26.....	L. E. Walter......	Dn	50	1¼	GP	do.........	do......	Cy, W	S	....	....	....	16	....	
21-13-27dd	SE SE sec. 27.......	Atlantic Refining Co.	Dr	63.3	6	OW	do.........	do......	N	N	Top of casing...	+ .4	1,877.6	11.44	8- 1-42	Unused oil-well drilling supply well; observation well.

TABLE 13.—*Record of wells in Stafford County, Kansas—Continued*

Well No. (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 21 S., R. 13 W.															
21-13-31cd1	SE SW sec. 31	Phillips Station	Dn	58.0	1¼	GP	Sand and gravel	Meade	P, H	D	Top of pitcher pump.	+2.3	1,917.4	14.19	8- 5-42	
21-13-31cd2	SE SW sec. 31	Missouri Pac. Rld.	Dr	60	4½	OW	do	do	Pl, G	In	....	....	....	12	....	Reported yield 45 g.p.m.
	T. 21 S., R. 14 W.															
21-14-5dc	SW cor. SE sec. 5	H. H. Frey	Dn	32.0	1¼	GP	Sand and gravel	do	N	N	Top of pipe	+2.4	1,928.2	14.85	9-10-42	Unused domestic well.
21-14-10db	NW SE sec. 10	R. B. Anshutz	Dr	67.0	15	GI	do	do	C, G	I	Top of concrete platform.	+ .6	1,936.2	30.92	8-27-42	Gravel-packed well.
21-14-14da	NE SE sec. 14	Mary Schartz	Dn	47.2	1¼	GP	do	do	P, H	N	Top of pitcher pump.	+3.3	1,926.3	26.17	8-10-42	Unused domestic well.
21-14-15cc	SW SW sec. 15	B. Krampe	Dn	40	1¼	GI	do	do	Cy,W,H	D, S	....	....	....	20	....	
21-14-20bd	SE NW sec. 20	J. Russell	Dr	......	8	OW	do	do	N	N	Top of casing	—1.0	1,940.3	18.50	9-10-42	Formerly supplied water for drilling oil test. Plugged at 20 feet.
	T. 22 S., R. 11 W.															
22-11-2cd	SE SW sec. 2	Homer Hamilton	Dn	100	1¼	GP	do	do	Cy,W,H	D	....	....	....	4	....	Shallow water reported to be saltier than deeper water.
22-11-3cd	SE SW sec. 3	F. O. White	Dn	13.5	1¼	GP	do	Alluvium	P, H	D	Top of pitcher pump.	+3.0	1,757.7	6.67	8- 4-42	
22-11-9bb	NW NW sec. 9	J. H. Fair	Dr	40	3	I	do	Meade	F	S	Top of pipe	+3.1	1,754.2	+1.47 (8)	10-19-42	Flowing artesian well; measured flow 6 g. p. m.
22-11-10bb	NW NW sec. 10	do	Dn	18	1½	GP	do	do	Cy, W	D, S	....	....	....	8	....	
22-11-10cc	SW SW sec. 10	do	Dn	37	1½	GP	Fine sand	do	F	S	....	....	....	....	....	Flowing artesian well.
22-11-19dd	SE SE sec. 19	Stanolind Oil Co.	Dr	46.5	6	OW	Sand and gravel	do	Cy, W	S	Edge of pump base.	+ .3	1,838.9	20.86	8- 5-42	
22-11-35ab	NW NE sec. 35	Artesia Hunting Club.	Dr	75	6	OW	do	do	F	D	....	....	....	....	....	Flowing artesian well; measured flow 10 g. p. m.

	T. 22 S., R. 12 W.													
22-12-1bd	SE NW sec. 1	Stanolind Oil Co.	Dr	81.0	6	OW	do	do	N	N	Top of casing	+ .9	1,814.1	11.79	8- 3-42	Formerly supplied water for drilling oil well.
22-12-1ad	SE NE sec. 1	F. H. Meillies	Dn	35	1¼	GP	do	do	P, H	D				8		
22-12-3cc	SW SW sec. 3	Stanolind Oil Co.	Dr	85.2	6	OW	do	do	N	N	Top of casing	+ .7	1,853.0	20.81	8- 3-42	Unused drilling-supply well; observation well.
22-12-9bc	SW NW sec. 9	O. H. Teichmann	Dn	116	1½	GP	do	do	Cy, W	D, S				36		
22-12-12db	NW SE sec. 12	Joe Willinger, Jr.	Dn	44	1¼	GP	Sand	do	F	S	Top of 1¼-inch pipe.	+1.0	1,793.0	+2.65 (8)	10-26-42	Flowing artesian well; measured flow 6 g.p.m.
22-12-18ba	NE NW sec. 18	E. Fischer	Dr	83.2	6	OW	Sand and gravel	do	N	N	Top of casing	+ .4	1,877.4	19.44	8- 1-42	Formerly supplied water for drilling oil well.
22-12-29dd	SE SE sec. 29	Stafford Co. Flour Mills Co.	Dr	70	6	GI	do	do	Cy, D	In				20		Reported yield 20 g. p. m.
	T. 22 S., R. 13 W.													
22-13-9cb	NW SW sec. 9		Dr	72.2	5	OW	do	do	N	N	Top of casing	+3.4	1,898.4	11.74	9-10-42	Formerly supplied water for drilling oil well.
22-13-26aa	NE NE sec. 26		Dr				do	do	N	N	Land surface	0	1,890.4	17.8	9- 9-42	Formerly supplied water for drilling oil well; casing pulled.
	T. 22 S., R. 14 W.													
22-14-7bb	NW NW sec. 7	Ada Elfsten	Dr	54.0	6½	OW	do	do	N	N	Top of casing	+ .5	1,956.6	19.66	9-10-42	Formerly supplied water for drilling oil-test well.
22-14-9ca	NE SW sec. 9		Dr	60.4	6	OW	do	do	N	N	do	+ .8	1,943.1	17.43	8- 5-42	do
22-14-12db	NW SE sec. 12		Dr	78	6	OW	do	do	N	N	do	0	1,923.4	10.35	8- 5-42	do
22-14-32ab	NW NE sec. 32	Joe McAllister	Dn	38	1¼	GP	do	do	Cy, W, H	D				15		
	T. 23 S., R. 11 W.													
23-11-1bc	SW NW sec. 1	Hunting Club	Dn	13.0	1¼	GP	do	Alluvium	P, H	D	Top of pitcher pump base.	+3.0	1,790.3	6.17	9- 9-42	
23-11-3cb	NW SW sec. 3	W. C. Krug	Dr		8	OW	do	Meade	N	N	Top of casing	+1.1	1,802.9	5.95	8- 5-42	
23-11-14cd	SE SW sec. 14	E. F. Allen	Dn	24.6	1¼	GP	do	do	P, H	N	Top of pitcher pump.	+2.7	1,799.0	13.14	8-28-42	Unused stock well.
23-11-29cc	SW SW sec. 29	H. Wendelburg	Dr	34.5	8	GI	do	do	C, G	I	Top of well curb	0	1,830.0	17.98	7-30-42	
	T. 23 S., R. 12 W.													
23-12-2cd	SE cor. SW sec. 2	M. D. Hill	Dn	12.7	1¼	GP	do	Alluvium	N	N	Top of pipe	+1.3	1,830.5	3.14	7-25-42	Unused stock well.
23-12-7ad	SE NE sec. 7	M. Jameson	Dn	22.6	1¼	GP	do	Meade	P, H	D	do	+2.9	1,858.4	7.62	8-10-42	
23-12-12cc	SW cor. SW sec. 12	B. Fritzmeyer	Dr	31.2	8	OW	do	do	N	N	Top of casing	+ .5	1,845.2	18.89	7-29-42	Unused drilling-supply well; observation well.
23-12-21bb	NW NW sec. 21	F. Heyen	Dr	25.0	6	GI	do	do	N	N	do	+1.0	1,864.7	5.91	7-30-42	Unused stock well.
23-12-32cd	SE SW sec. 32	L. E. Davis	Dr	58.5	6	OW	do	do	N	N	do	+ .6	1,875.0	13.23	9-10-42	Formerly supplied water for drilling oil-test well.
23-12-35ad	SE NE sec. 35	LeRoy Kelley	Dr	43.8	19	GI	do	do	C, N	N	Top of well curb	0	1,856.6	11.75	7-29-42	Unused irrigation well.
	T. 23 S., R. 13 W.													
23-13-1ad	SE NE sec. 1	G. P. Witt	Dn	29.8	1¼	GP	do	do	P, H	N	Top lip of pump	+2.6	1,854.9	2.99	8-10-42	Unused domestic well.
23-13-3aa	NE NE sec. 3	F. Kaufman	Dn	24.0	1¼	GP	do	do	F	S	Top of 1¼-inch pipe.	+1.6	1,861.0	+3.10 (8)	10-19-42	Flowing artesian well; measured flow 6.5 g. p. m.
23-13-28ca	NE SW sec. 28	J. B. O'Conner	Dr	58.5	19	GI	Coarse gravel	do	C, G	I	Lower edge of plank over well.	0	1,896.9	16.76	8- 8-42	Gravel-packed well; reported yield 900 g. p. m.; drawdown 17 ft.

TABLE 13.—*Record of wells in Stafford County, Kansas—Continued*

Well No. (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 23 S., R. 14 W.															
23-14-1bd	SE NW sec. 1		Dr	......	6	OW	Sand and gravel	Meade	N	N	Top of casing	+ .5	1,921.3	20.06	8- 6-42	Formerly supplied water for drilling oil-test well.
23-14-20bc	SW NW sec. 20	Sam Chrissman	Dr	70	22	GI	do	do	C, G	I	Top of concrete curb.	0	1,964.4	12.55	7-30-42	Reported yield 800 g. p. m.; drawdown 8 ft.
23-14-27dd	SE SE sec. 27	H. F. Cornwell	Dn	39.7	1¼	GP	do	do	N	N	Lower edge of plank over well pit.	+ .5	1,944.7	23.28	8- 6-42	Unused stock well; observation well.
	T. 24 S., R. 11 W.															
24-11-2ad	SE NE sec. 2		Dr	......	6	OW	do	do	N	N	Top of casing	+ .2	1,804.7	20.35	8-26-42	Formerly supplied water for drilling oil well.
24-11-4dd	SE SE sec. 4		Dr	65.3	6	OW	do	do	N	N	do	+ .7	1,817.1	20.08	8-26-42	do
24-11-11cc	SW SW sec. 11	A. Fuller	Dn	50	1¼	GP	do	do	Cy, W, H	D	....	....	....	20	....	
24-11-12dc	SW SE sec. 12		Dr	49.0	6½	OW	do	do	N	N	Top of casing	+ .6	1,787.7	7.46	8-26-42	Formerly supplied water for drilling oil well.
24-11-16aa	NE NE sec. 16	G. W. Buckles	Dr	58.0	6½	OW	do	do	N	N	do	+ .6	1,821.0	21.26	8-26-42	Unused drilling-supply well; observation well.
24-11-22ab	NW NE sec. 22		Dr	62.9	6	OW	do	do	N	N	do	+ .5	1,810.6	17.28	7-31-42	Formerly supplied water for drilling oil well.
24-11-25dc	SW SE sec. 25	C. W. Learned	Dn	28	1¼	GP	do	do	Cy, W	D	Top of concrete curb.	+ .3	1,764.4	16.30	8-26-42	
	T. 24 S., R. 12 W.															
24-12-4aa	NE NE sec. 4	John C. Haynen	Dn	34	3	GP	do	do	C, G	I	....	....	....	22	....	Used to irrigate garden.
24-12-4dd	SE SE sec. 4	C. J. Kohrs	Dr	48	24	OB	do	do	C, N	N	Top of concrete curb.	0	1,880.4	25.12	7-30-42	Unused irrigation well.
24-12-11cd1	SE SW sec. 11	City of Stafford	Dr	60	30	C	do	do	T, E	P	....	....	....	21	....	Reported yield 250 g. p. m.; drawdown 8 ft.
24-12-11cd2	SE SW sec. 11	do	Dr	60	30	C	do	do	T, E	P	Floor of pump house.	+1.5	1,869.3	22.40	9-21-42	Reported yield 500 g. p. m.; drawdown 18 ft.
24-12-15ba	NE NW sec. 15	Stanolind Oil Co.	Dr	63.0	6½	OW	do	do	N	N	Top of casing	+ .3	1,875.8	20.50	8- 4-42	Formerly supplied water for drilling oil-test well.

24-12-25ca	NE SW sec. 25		Dr	63.0	6½	OW	do	do	N	N	do	+ .8	1,853.7	21.87	8-17-42	do
24-12-30cb	NW cor. SW sec. 30		Dr	64.4	6	OW	do	do	N	N	do	+ .5	1,909.1	27.09	9-10-42	do
	T. 24 S., R. 13 W.															
24-13-4b1	Center NW sec. 4	City of St. John	Dr	83	16	C	do	do	T, E	P	Top of opening in pump base.	+3.0	1,911.4	23.39	9-14-42	Gravel-packed well; reported yield 400 g. p. m.; drawdown 10.3 ft.
24-13-4b2	Center NW sec. 4	do	Dr	83	26	C	do	do	C, E	P				20		Gravel-packed well; reported yield 750 g. p. m.; drawdown 6 ft.
24-13-4b3	Center NW sec. 4	do	5 Dn	50	8	OW	do	do	C, E	P				20		Battery of five wells finished with 10-foot screened points. Reported yield 400 g. p. m.
24-13-23bd	SE NW sec. 23	Stanolind Oil Co.	Dr	52.2	6	GI	do	do	N	N	Top of casing	+1.7	1,912.1	21.12	8- 4-42	Formerly supplied water for drilling oil well.
24-13-28aa	NE NE sec. 28	Atlantic Refining Co.	Dr	74.9	6½	OW	do	do	N	N	do	+ .4	1,930.5	23.24	8- 4-42	Formerly supplied water for drilling oil well; observation well.
24-13-28cc	SW SW sec. 28	S. H. Van Lieu	Dn	68	1¼	GP	do	do	Cy, W, H	S				21		
	T. 24 S., R. 14 W.															
24-14-1aa	NE NE sec. 1	C. H. Vanhoozer	Du	8.8	36	N	Sand	Alluvium	N	S	Top of well	0	1,905.9	4.65	8- 8-42	
24-14-9bc	SW NW sec. 9	Paul R. Reynolds	DD				Sand and gravel	Meade	C, G	I	Top of board platform.	+ .2	1,970.0	24.46	7-30-42	
24-14-12dd	SE SE sec. 12	C. R. Rixon	3 Dr	52	10-15	GI	Sand	do	C, G	I	Top of casing	—5.9	1,909.4	0.53	8- 1-42	Battery of three wells; measured well in pump house; reported aggregate yield 600 g. p. m.
24-14-13bb	NW NW sec. 13	Atlantic Refining Co.	Dr	64.0	6	OW	Sand and gravel	do	N	N	Top of board over casing.	0	1,920.8	7.84	8- 1-42	Formerly supplied water for drilling oil well.
24-14-22bc	SW NW sec. 22	N. A. Suiter	Dn	45	1¼	GP	do	do	Cy, W	S				20		
	T. 24 S., R. 15 W.															
24-15-3cd	SE SW sec. 3	W. Nagel	Dr	74.1	7	GI	do	do	N	N	Top of casing	+ .5	2,017.0	18.26	8- 8-42	Formerly supplied water for drilling oil well.
24-15-15cc	SW SW sec. 15	City of Macksville	3 Dr	73	6	I	do	do	C, E, T	P				19		Battery of three wells; three pumps have reported capacities of 275, 300, and 475 g. p. m.
24-15-21aa	NE NE sec. 21	J. T. Smith	Dr	85	6	GI	Gravel	do	C, E	I	Top of concrete cover over well.	0	2,027.7	19.02	9- 9-42	Used to irrigate lawn and trees.

TABLE 13.—*Record of wells in Stafford County, Kansas—Concluded*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above (+) or below (—) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 25 S., R. 11 W.															
25-11-2ca	NE SW sec. 2	C. J. Smith	Dn	17.0	1¼	GP	Sand and gravel	Meade	N	N	Top of 1¼-inch pipe.	—1.0	1,780.0	10.39	7-31-42	Unused domestic well.
25-11-5bb	NW cor. NW sec. 5	Eureka Methodist Church.	Dn	38.6	1¼	GP	do.	do.	P, H	D	Top of opening in pump base.	—2.9	1,818.5	9.34	8-17-42	Church well.
25-11-15dd	SE SE sec. 15	Neola Elevator Co.	Dr	41	6	GI	do.	do.	Cy, H	D	Top of casing	+ .3	1,807.9	20.69	7-31-42	
25-11-27cc	SW SW sec. 27	Helmerich & Payne, Inc.	Dr	50	6	OW	do.	do.	N	N	do.	0	1,821.9	22.19	8-18-42	Formerly supplied water for drilling oil-test well.
25-11-36ab	NW NE sec. 36	W. C. Smith	Dr	......	6	T	do.	do.	Cy, W	S	Top of plank over casing.	+ .6	1,810.4	27.19	8-17-42	
	T. 25 S., R. 12 W.															
25-12-11cb	NW SW sec. 11	J. A. McFadden	Dr	39.3	6	GI	do.	do.	Cy, E	D	Top of casing	—5.3	1,843.9	3.33	8-12-42	
25-12-27ab	NW NE sec. 27	Camp Carlile	3 Dr	14.5	12	GI	do.	do.	C, E	Sw	do.	0	1,846.1	3.66	8-12-42	Battery of three wells; measured southernmost well; reported aggregate yield 200 g. p. m.
25-12-31dc	SW SE sec. 31	W. A. Shinkle	Dn	26.7	1¼	GP	do.	do.	P, H	D, S	Top of pitcher pump.	+2.0	1,886.0	12.65	8-19-42	
25-12-35ba	NE NW sec. 35	....	Dr	46.3	8	OW	do.	do.	N	N	Top of casing	+ .2	1,866.6	27.79	8-19-42	Formerly supplied water for drilling oil-test well.
	T. 25 S., R. 13 W.															
25-13-3bb	NW NW sec. 3	M. L. Halley	Dr	29.6	4	I	do.	do.	N	N	Top of oil barrel	+2.0	1,934.1	20.15	8-19-42	Unused domestic well.
25-13-12ab	NW NE sec. 12	Continental Oil Co.	Dr	64.0	6	OW	do.	do.	N	N	Top of casing	+ .4	1,918.8	25.75	8- 1-42	Unused drilling-supply well; observation well.
25-13-13ac	SW NE sec. 13	do.	Dr	63.4	6	OW	do.	do.	N	N	do.	+ .6	1,913.7	23.02	8- 1-42	Formerly supplied water for drilling oil well.
25-13-28cc	SW SW sec. 28	R. J. Kipp	DD	56	19	GI	do.	do.	C, G	I	Top of concrete well curb.	0	1,947.1	21.01	7-31-42	Reported yield 700 g. p. m.

	T. 25 S., R. 14 W.															
25-14-4da	NE SE sec. 4	L. T. Spencer	Dr	69	14.10	GI	do.	do.	C, G	I	Top of concrete well curb.	0	1,965.9	21.30	7-30-42	Gravel-packed well; reported yield 700 g. p. m.
25-14-9dc	SW SE sec. 9	F. M. Hammond	Dr	36.5	6	GI	do.	do.	C, G	I	Top of board over casing.	+ .6	1,975.1	13.19	7-31-42	Used to irrigate garden.
25-14-13ba	NE NW sec. 13	J. T. Kachelman	DD	26.5	16	GI	do.	do.	N	N	Top of concrete well curb.	0	1,958.5	16.16	7-31-42	Unused irrigation well.
25-14-26bb	NW NW sec. 26	....	Dr	52.0	6	OW	do.	d.	N	N	Top of casing	+ .3	1,975.0	14.10	8- 1-42	Formerly supplied water for drilling oil well.
25-14-29ad	SE NE sec. 29	C. N. Waters	Dn	47.5	1¼	GP	do.	do.	P, H	D	Top of pitcher pump.	+3.0	1,997.3	22.15	8-26-42	
25-14-30bb	NW NW sec. 30	G. Hall	Dn	21.2	1¼	GP	do.	do.	N	N	Top of pipe	+1.7	1,995.3	7.33	8-26-42	Unused stock well.
	T. 25 S., R. 15 W.															
25-15-2cc	SW SW sec. 2	P. R. Barstow	Dn	56.0	1¼	GP	do.	do.	Cy, W	N	Lower edge of board over well pit.	+ .5	2,023.8	19.56	8-26-42	Unused domestic well.
25-15-8cb	NW SW sec. 8	C. E. Peacock	Dn	48	1¼	GP	do.	do.	Cy, W, H	D, S	....	....	....	16	....	
25-15-27bb	NW NW sec. 27	George V. Hart	Dr	45	6	GI	do.	do.	C, G	I	Top of board over well pit.	0	2,017.5	8.95	8-21-42	
	RICE COUNTY *T. 21 S., R. 10 W.*															
21-10-7cc	SW SW sec. 7	....	Dn	14.0	1¼	GP	do.	do.	N	N	Top of pipe	+ .4	1,730.7	2.45	10-10-42	Unused stock well.
	PRATT COUNTY *T. 26 S., R. 15 W.*															
26-15-6ba	NE NW sec. 6	S. C. Spencer	Dn	45.4	1¼	GP	do.	do.	P, H	S	Top of pitcher pump.	+1.0	2,040.1	12.25	9- 9-42	
	EDWARDS COUNTY *T. 24 S., R. 16 W.*															
24-16-24dc	SW SE sec. 24	Floyd Ulsh	Dr	79.0	6	GI	do.	do.	C, E	I	Top of casing	+ .3	2,057.7	15.54	8-21-42	Used to irrigate garden; reported yield 40 g. p. m.

1. Location number: Well numbers give the location of wells according to General Land Office surveys and according to the following formula: Township-Range-Section, 160-acre tract within that section, and the 40-acre tract within the quarter section. If two or more wells are located within a 40-acre tract, the wells are numbered serially according to the order in which they were inventoried. The 160-acre and 40-acre tracts are designated a, b, c, or d in a counterclockwise direction, beginning in the northeast quarter. For example: well 20-16-24dc is located in the SW¼ SE¼ sec. 24, T. 24, R. 16 W.
2. B, bored well; DD, dug and drilled well; Dn, driven well; Dr, drilled well; Du, dug well; Sp, spring.
3. Reported depths below the land surface are given in feet; measured depths are given in feet and tenths below measuring points.
4. Bs, Boiler steel; C, concrete; GI, galvanized sheet iron; GP, galvanized-iron pipe; I, iron; N, none; OB, oil barrels; OW, oil-well casing; R, rock; T, tile; W, wood.
5. Method of lift: C, horizontal centrifugal; Cy, cylinder; F, natural flow; N, none; P, pitcher pump; Pl, plunger-type pump; S, submersible turbine; T, turbine; VC, vertical centrifugal. Type of power: B, butane; D, diesel; E, electric; G, gas engine; H, hand-operated; T, tractor; W, windmill.
6. D, domestic; I, irrigation; In, industrial; N, not being used; O, observation; P, public supply; S, stock; SW, swimming pool.
7. Reported depths to water level are given in feet; measured depths to water level are given in feet, tenths, and hundredths.
8. Water level in feet above measuring point.

LOGS OF TEST HOLES AND WELLS

On the pages that follow are listed the logs of 127 test holes and water wells and 3 partial logs of oil-test wells in Barton and Stafford Counties. Of the logs, 106 are of test holes drilled by the State Geological Survey (Fig. 9), 20 are of test holes and water wells drilled by private drillers, and 3 are partial logs of oil tests. The samples of test holes drilled by the State Geological Survey were collected and studied in the field by O. S. Fent, C. K. Bayne, or Delmar Berry and were studied in the office by me.

16-15-9cc. *Sample log of test hole at the SW cor. sec. 9, T. 16 S., R. 15 W., Barton County; drilled 1945. Surface altitude, 2,003.0 feet.*

	Thickness, feet	Depth, feet
Soil, gray-brown	1.5	1.5
QUATERNARY		
Undifferentiated Pleistocene		
Silt, gray, buff, and brown	5.5	7
Silt and clay, light-gray and fine gravel, sand, and caliche	1.5	8.5
Gravel, fine to medium, and sand; contains caliche and some coarse gravel	6.5	15
CRETACEOUS—Gulfian		
Carlile shale		
Shale, calcareous, yellow	2	17

16-15-11cc. *Sample log of test hole at the SW cor. sec. 11, T. 16 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,988.9 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	3	3
QUATERNARY		
Undifferentiated Pleistocene		
Silt, greenish-gray and brown	8	11
Silt and clay, white to light-gray; contains fine gravel, sand, and caliche	6.5	17.5
Gravel, fine to medium, and sand	0.5	18
CRETACEOUS—Gulfian		
Carlile shale		
Shale, calcareous, yellow and white	2	20

16-15-21aa. *Sample log of test hole at the NE cor. sec. 21, T. 16 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 2,005.0 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	3	3
QUATERNARY		
Undifferentiated Pleistocene		
Silt, greenish-gray to yellow-gray	7	10
Silt, light-gray to brown; contains fine gravel and sand,	8	18
Gravel, fine to medium, and sand	6	24

	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian		
Carlile shale		
Shale, calcareous, yellow	1	25

16-15-22dd. *Sample log of test hole at the SE cor. sec. 22, T. 16 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,999.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Undifferentiated Pleistocene		
Silt, gray, buff, and brown	15	15
Silt, sandy, buff; interbedded with fine to coarse sand from 18 to 20 feet	7	22
Gravel, fine to medium, and sand	14	36
CRETACEOUS—Gulfian		
Carlile shale		
Shale, calcareous, dark-gray	3	39

16-15-23aa. *Sample log of test hole at the NE cor. sec. 23, T. 16 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,973.0 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	3	3
QUATERNARY		
Undifferentiated Pleistocene		
Silt and clay, gray and yellow	8	11
CRETACEOUS—Gulfian		
Carlile shale		
Shale, calcareous, white, yellow, and yellow-brown	4	15

16-15-25cc. *Sample log of test hole at the SW cor. sec. 25, T. 16 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,996.3 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Undifferentiated Pleistocene		
Silt, gray, brown, and buff; contains nodules of caliche	25	27
Gravel, fine to medium, and sand	8	35
Sand and gravel, lime-cemented, very hard, white	0.5	35.5
CRETACEOUS—Gulfian		
Carlile shale		
Shale, calcareous, yellow and white	4.5	40

16-15-33aad. *Sample log of test hole in the SE¼ NE¼ NE¼ sec. 33, T. 16 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,998.9 feet.*

	Thickness, feet	Depth, feet
Soil, dark-gray	3	3
QUATERNARY		
Undifferentiated Pleistocene		
Silt, gray and gray-brown	6	9
Silt and clay, sandy, yellow	1	10
CRETACEOUS—Gulfian		
Carlile shale		
Shale, calcareous, yellow	10	20

17-11-17cc. *Sample log of test hole at the SW cor. sec. 17, T. 17 S., R. 11 W., Barton County; drilled, 1945. Surface altitude, 1,859.5 feet.*

	Thickness, feet	Depth, feet
Road fill and soil, dark-gray	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt and clay, greenish-gray	10	12
Silt, buff; contains sandstone pebbles from 50 to 52 feet and caliche nodules throughout	40	52
CRETACEOUS—Gulfian		
Graneros shale		
Clay, gray and white, and yellow and white fine- to medium-grained sandstone	4	56

17-11-32cc. *Sample log of test hole at the SW cor. sec. 32, T. 17 S., R. 11 W., Barton County; drilled, 1945. Surface altitude, 1,824.8 feet.*

	Thickness, feet	Depth, feet
Road fill and soil, gray-brown	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt and clay, gray to brown	3	5
Silt, sandy, buff	15	20
Silt and clay, buff, gray-buff, light-gray, and light-brown; contains fine to medium sand and nodules of caliche	80	100
Silt, sandy, gray-buff; contains sandstone and "iron-stone" pebbles in lower part	11	111
CRETACEOUS—Gulfian		
Dakota formation		
Clay and shale, yellow and gray-white, and white fine- to medium-grained sandstone	4	115

17-12-29dd. *Sample log of test hole at the SE cor. sec. 29, T. 17 S., R. 12 W., Barton County; drilled, 1945. Surface altitude, 1,849.4 feet*

	Thickness, feet	Depth, feet
Road fill and soil	3.5	3.5
QUATERNARY—Pleistocene		
Slope deposits		
Silt, gray to brown	9.5	13
Silt, buff and gray; contains many weathered fragments derived from Dakota formation and Greenhorn limestone	15	28
CRETACEOUS		
Dakota formation (Gulfian)		
Sandstone, fine- to medium-grained, white; contains some limonite and gray, white, and red clay	14	42
Clay, light- to dark-gray and mottled red and yellow; contains some fine to medium sand	43	85

	Thickness, feet	Depth, feet
Clay, light- to dark-gray mottled red and yellow, interbedded with sandstone from 85 to 92 feet, 100 to 104 feet, and 127 to 131 feet	65	150
Sandstone, fine- to medium-grained, white; contains thin beds of dark-gray clay and carbonaceous material	31	181
Clay, gray and red	50	231
Kiowa shale (Comanchean)		
Shale, sandy, dark-gray; contains pyrite	9	240
Clay, light-gray, interbedded with white fine-grained sandstone; contains pyrite	14.5	254.5
Sandstone, fine-grained, white, and light-gray shale	1.5	256
Shale, light- to dark-gray; contains much fine to medium sand and some pyrite; interbedded with sandstone from 278 to 286 feet	58	314
Sandstone, fine-grained, hard, gray, and blue-gray sandy shale; contains thin bed of hard pyritic sandstone at 314 feet	8	322
Shale, sandy, dark blue-gray to black, and fine-grained hard sandstone; contains some pyrite	48	370

17-14-6bb. *Sample log of test hole at the NW cor. sec. 6, T. 17 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1972.0 feet.*

	Thickness, feet	Depth, feet
Soil, gray	1.5	1.5
QUATERNARY		
Undifferentiated Pleistocene		
Silt, gray and tan to brown; contains nodules of caliche	14.5	16
Silt and clay, sandy, calcareous, white and yellow	4	20
CRETACEOUS—Gulfian		
Carlile shale		
Shale, calcareous, light- to dark-gray and yellow; thin bed of gray hard limestone at 39 feet	21	41

17-14-35dd. *Sample log of test hole at the SE cor. sec. 35, T. 17 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,832.1 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay, sandy, light- to dark-gray, blue-gray and gray-green	38	40
Sand, fine, to medium gravel; silty	16	56
Silt, sandy, gray	9	65
Gravel, fine to very coarse, and sand; contains some gray clay	7	72
Silt, sandy, yellow-gray to blue-gray	6	78

	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian		
Dakota formation		
Clay, white; contains sand and thin beds of fine-grained sandstone	5	83
Sandstone, fine- to medium-grained, white	7	90

17-15-1dd. *Sample log of test hole at the SE cor. sec. 1, T. 17 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,961.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Undifferentiated Pleistocene		
Silt, gray to brown	4	4
Silt and clay, light-gray and tan; contains caliche	9	13
Silt and clay, light gray; contains caliche, sand, and fine to medium gravel	7	20
Gravel, fine to medium, and sand	3.5	23.5
CRETACEOUS—Gulfian		
Carlile shale		
Shale, calcareous, buff and dark-gray; contains thin beds of limestone at 23.5, 26.5, 28, and 29.5 feet	6.5	30

18-10-31cc. *Sample log of test hole at the SW cor. sec. 31, T. 18 S., R. 10 W., Rice County; drilled, August 1946. Surface altitude, 1,760.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Sand, very fine to medium, and silt; dark-gray and gray-brown	3	3
Silt and clay, light greenish-gray; contains some fine to medium sand	5	8
Silt, calcareous, buff and tan; contains much medium fine sand	20	28
Sand, fine to very fine	9	37
Silt, light-gray and buff, and medium to fine sand	14	51
Silt, calcareous, tan; contains some fine sand and concretionary calcium carbonate	27	78
CRETACEOUS		
Dakota formation (Gulfian)		
Clay, light-gray, mottled red and yellow	12	90
Sandstone, silty, very fine to fine, gray and yellow-brown	15	105
Kiowa shale (Comanchean)		
Shale, fissile, blue-gray	1	106

18-11-2dd. *Sample log of test hole at the SE cor. sec. 2, T. 18 S., R. 11 W., Barton County; drilled, 1946.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, sandy, tan to brown and dark-gray	4.5	6.5
Silt, buff, brown, and gray; contains nodules of caliche	9.5	16

	Thickness, feet	Depth, feet
Silt, sandy; contains caliche	29	45
Silt, tan; contains sand, gravel, and caliche	5	50
Silt, sandy, white and tan to brown; contains some caliche	22	72
Silt, tan; contains gravel from the Dakota formation	5	77
CRETACEOUS—Gulfian		
Dakota formation		
Clay and shale, light-gray, red, and yellow	13	90

18-11-13dd. *Sample log of test hole at the SE cor. sec. 13, T. 18 S., R. 11 W., Barton County drilled, 1945. Surface altitude, 1,768.0 feet.*

	Thickness, feet	Depth, feet
Road fill	2.5	2.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt and clay, light-gray, greenish-gray, tan, and brown; contains some caliche nodules	104.5	107
Gravel, fine to coarse, sand, and silt; gray; gravel is derived from the Dakota	2	109
CRETACEOUS—Gulfian and Comanchean		
Dakota formation and Kiowa shale, undifferentiated		
Sandstone, fine- to medium-grained, white to yellow, and light blue-gray and pale-yellow shale; contains bedded "ironstone" in upper part	75	184
Clay, dull yellow	2	186
Shale, fissile, blue-gray; contains limonite and pyrite	11.5	197.5
Claystone, very hard, gray	0.5	198
Shale, light blue-gray, and thin beds of hard limestone and sandstone	15	213
Shale, gray and light-gray, interbedded with gray-white fine-grained sandstone; contains very hard calcareous zone at 213 to 214 feet and pyrite	11	224
Shale, dark-gray; contains shell fragments between 224 to 232 feet and gypsum at 249 feet	25	249
Cheyenne (?) sandstone (Comanchean)		
Shale, sandy, white	2	251
Siltstone, hard, white	3	254
Shale, sandy, gray-pink and gray-white	4	258
Shale, light greenish-gray, interbedded with fine-grained sandstone	15	273
PERMIAN		
Shale, red	7	280

18-11-15cc. *Sample log of test hole at the SW cor. sec. 15, T. 18 S., R. 11 W., Barton County; drilled, 1945. Surface altitude, 1,784.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, and clay, light-gray	2.5	2.5
Silt, and clay; sandy, tan to brown, gray-white, and light blue-gray; contains nodules of caliche	77.5	80

	Thickness, feet	Depth, feet
Silt, buff to light gray-brown	10	90
Silt, tan, yellow-brown, and light-gray to blue-gray; and fine to medium sand	30	120
Gravel, fine to medium, and sand; derived from Cretaceous rocks; contains some coarse gravel and buff silt	20.5	140.5
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light blue-gray; contains siderite pellets	3.5	144

18-11-19aa. *Sample log of test hole at the NE cor. sec. 19, T. 18 S., R. 11 W., Barton County; drilled, 1945. Surface altitude, 1,820.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Sand, fine to medium, silty	31	31
Sanborn formation (Pleistocene)		
Silt, buff and light-gray; contains nodules of caliche	47	78
Silt and clay, tan and white; contains few pebbles of sandstone	3	81
CRETACEOUS		
Dakota formation (Gulfian)		
Clay, varicolored; contains small limonite nodules from 96 to 106 feet	56	137
Clay, mottled light-gray and red; contains fine sand and sandstone pellets	4	141
Clay, varicolored	32	173
Clay, white; contains fine to medium sand and pyrite	7	180
Clay, gray	6	186
Clay, bright-green, and medium sand	5	191
Clay, gray, and gray fissile shale; contains pyrite and thin beds of hard claystone	19	210
Sandstone, fine-grained, white, and gray-white clay; contains pyrite	16	226
Kiowa shale (Comanchean)		
Shale, gray	9	235
Sandstone, fine-grained, partly calcareous, light-gray to white	3	238
Clay, light-gray, interbedded with white fine-grained sandstone; contains some carbonaceous material	12	250
Shale, gray and blue-gray	16	266
Sandstone, fine-grained, very hard, calcareous, white to light-gray; contains pyrite	3.5	269.5
Shale, light-gray to blue-gray; contains thin beds of light-gray fine-grained sandstone	33.5	303
Siltstone, very hard, partly calcareous, sandy; contains pyrite	6	309

18-11-19bb. *Sample log of test hole at the NW cor. sec. 19, T. 18 S., R. 11 W., Barton County; drilled, 1945. Surface altitude, 1,799.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, fine to medium, silty, gray to buff	4	4
Silt and clay; brown to buff and gray-green; contains some sand and nodules of caliche	5	9
Sand, fine to medium	3	12
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light-gray and yellow	6	18
Sandstone, fine-grained, and light-gray, red, and yellow sandy clay	7	25
Clay, light- to dark-gray and mottled gray and red	73	98
Sandstone, fine-grained, hard, calcareous, light-gray to buff	1	99
Clay, light blue-gray, mottled red and yellow	45	144
Clay, gray-white, interbedded with white fine-grained sandstone	3	147
Shale, dark blue-gray and green; contains some sandstone and pyrite	9	156
Shale, gray	7	163
Sandstone, fine- to medium-grained, white; interbedded with gray shale	7	170
Clay, pyritic, sandy, blue-gray	6	176
Clay, gray-white to light blue-gray; contains some sandstone, carbonaceous material, and pyrite	20	196

18-11-20dd. *Sample log of test hole at the SE cor. sec. 20, T. 18 S., R. 11 W., Barton County; drilled, 1946.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, gray and gray-brown	7	9
Sand, very fine to fine, buff	3	12
Silt and sand, buff to brown	11	23
Silt, sandy, tan to brown and gray to white	12	35
Sand, very fine to fine, and silt	11	46
Silt, sandy, gray, white, and brown	16	62
CRETACEOUS—Gulfian		
Dakota formation		
Clay, varicolored	12.5	74.5

18-11-24bb. *Sample log of test hole at the NW cor. sec. 24, T. 18 S., R. 11 W., Barton County; drilled, 1945. Surface altitude, 1,771.8 feet.*

	Thickness, feet	Depth, feet
Road fill and soil; dark-gray	2	2

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, tan to brown and gray	8	10
Silt, sandy, buff; contains caliche	64	74
Silt and clay; sandy, light-gray and buff	36	110
Gravel, fine to medium, and sand; derived from Cretaceous rocks; contains some buff silt	3	113
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light-gray and yellow, and some "ironstone"	3	116

18-11-31cc. *Sample log of test hole at the SW cor. sec. 31, T. 18 S., R. 11 W., Barton County; drilled, 1946.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, sandy, gray and brown	7	8
Sand, very fine to medium	3	11
Silt, sandy, buff	16	27
Silt and very fine to fine sand; partly iron-stained, buff,	8	35
Silt, sandy, tan to brown and gray to white	45	80
Silt, light-brown; contains gravel composed of sandstone, "ironstone," caliche, and clay pebbles	4	84
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, red, tan, and brown, and a small amount of white clay	18	102

18-11-36aa. *Sample log of test hole at the NE cor. sec. 36, T. 18 S., R. 11 W., Barton County; drilled, August 1946. Surface altitude, 1,749.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Sand, very fine to fine, and silt; dark-gray	3	3
Sand, very fine to fine, and silt; light gray-buff; contains some concretionary calcium carbonate	4	7
Silt, light-gray; contains much very fine to fine sand	29	36
Gravel, fine to coarse, and sand	7	43
Sand, very fine to medium, and silt; gray	5	48
Silt, calcareous, buff, and very fine sand; contains some concretionary calcium carbonate	30	78
Meade formation		
Silt, light-gray, and very fine sand; contains a few "ironstone" pebbles	7	85
Gravel, fine to medium, and sand	9	94
Sand, fine, and silt; light-buff	6	100
Gravel, medium to fine, and sand	5	105
CRETACEOUS—Comanchean		
Kiowa shale		
Sandstone, fine, white	13	118

18-12-4bb. *Sample log of test hole at the NW cor. sec. 4, T. 18 S., R. 12 W., Barton County; drilled, 1945. Surface altitude, 1,805.0 feet*

	Thickness, feet	Depth, feet
Road fill and soil	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay; gray, gray-brown, and gray-green	11	13
Silt, light-brown, and fine to medium sand	5	18
Silt, light-brown, gray, and blue	11	29
Silt, light-brown and blue, and very fine to medium sand	7	36
CRETACEOUS		
Dakota formation (Gulfian)		
Clay, light blue-gray and mottled red and yellow; contains limonite pellets from 48 to 50 feet and from 60 to 70 feet	40	76
Clay, gray; contains streaks of carbonaceous material, pyrite, and thin beds of sandstone	12	88
Clay, gray and green-gray, lignitic in lower part	13	101
Sandstone, fine-grained, silty, gray-white	2	103
Clay, gray; contains fine sand and thin beds of hard siltstone	7	110
Sandstone, fine- to medium-grained, light gray-brown to white, interbedded with gray carbonaceous clay	8	118
Clay, light blue-gray and mottled red and yellow green; contains small iron pellets from 120 to 126 feet	52	170
Clay, white	3	173
Kiowa shale (Comanchean)		
Shale, sandy, dark-gray; contains pyrite	7	180
Sandstone, fine- to medium-grained, light-gray and gray clay	5	185
Clay, pyritic, sandy, gray, and light gray-brown sandstone	13	198
Sandstone, fine-grained, very hard, gray	1	199
Clay, sandy, gray and blue-gray; contains pyrite and thin beds of sandstone	31	230
Shale, gray; contains pyrite	26	256

18-12-16bb. *Sample log of test hole at the NW cor. sec. 16, T. 18 S., R. 12 W., Barton County; drilled, 1946.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, light to dark-gray and black	10	10
Silt, sandy, yellow-brown	3	13
Silt, brown	2.5	15.5
Clay and silt; light-gray to light-blue	2	17.5
Silt, sandy, brown	2.5	20
Silt, clayey, light-gray, light-blue, and buff	10	30

	Thickness, feet	Depth, feet
Silt and clay; sandy, light to dark-gray, brown and buff,	28	58
Silt and sand; tan to brown	5	63
CRETACEOUS—Gulfian		
Dakota formation		
Shale, white to gray, red, and yellow	7	70

18-12-21cc. *Sample log of test hole at the SW cor. sec. 21, T. 18 S., R. 12 W., Barton County; drilled, 1946.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, light-gray to black; contains shell fragments	12	12
Silt, sandy, brown	5	17
Silt, clayey, light-gray, buff, and brown	3	20
Silt, brown	10	30
Clay, blue-gray	20	50
Clay and silt; blue-gray and buff	10	60
Silt, sandy, buff to brown	10	70
Silt, sandy, gray and blue-gray; contains fragments of sandstone, "ironstone," and shells	31	101
Gravel, fine, sand, and silt; poorly sorted; derived mainly from Dakota formation	11	112
CRETACEOUS—Gulfian		
Dakota formation		
Shale, blue-gray; contains pyrite	8	120

18-13-4aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 4, T. 18 S., R. 13 W., Barton County; drilled, 1945. Surface altitude, 1,854.3 feet.*

	Thickness, feet	Depth, feet
Silt, yellow-gray and light tan; contains caliche nodules and sandstone fragments	7	7
CRETACEOUS		
Dakota formation (Gulfian)		
Sandstone, fine-grained, yellow, brown, and white, interbedded with blue-gray clay; contains some "ironstone"	21	28
Clay, light blue-gray; contains very small pellets of hard sandstone	11	39
Clay, light blue-gray, red, and yellow; contains hematite	34	73
Sandstone, fine- to medium-grained, yellow-brown	14	87
Clay, blue-gray, red, and yellow; contains white fine-grained sandstone from 94 to 95 feet and "ironstone" from 153 to 158 feet	93	180
Clay, light blue-gray; contains thin beds of coal from 185 to 186 feet and pyrite from 186 to 190 feet	10	190
Clay, light-gray; contains pyrite	6	196
Sandstone, very fine- to medium-grained, hard, gray	1	197

	Thickness, feet	Depth, feet
Clay, light-gray to blue-gray, and pyrite	15	212
Clay, gray-white; contains fine sand, thin beds of sandstone, and many small sandstone pellets	8	220
Kiowa shale (Comanchean)		
Clay, gray	6	226
Sandstone, fine-grained, hard, gray and gray-white	5	231
Clay, light- to dark-gray; contains much sand and a few thin beds of sandstone	19	250
Shale, gray	23	273
Limestone, pyritic, very hard, sandy, gray-white	1	274

18-13-6dd. *Sample log of test hole at the SE cor. sec. 6, T. 18 S., R. 13 W., Barton County; drilled, 1945. Surface altitude, 1,821.4 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray and buff	28	30
Silt, light-gray to blue-gray, and fine to coarse sand	20	50
Sand, fine to coarse, and silt; contains some fine to medium gravel	20	70
Gravel, fine to medium, and sand; coarse material is Cretaceous derived	7	77
Silt, sandy, gray-green and white	5	82
Gravel, fine to coarse, and sand	6	88
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light-gray and red	2	90

18-13-9aa. *Sample log of test hole at the NE cor. sec. 9, T. 18 S., R. 13 W., Barton County; drilled, 1945. Surface altitude, 1,805.2 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay; light-gray to greenish-gray and light-blue; contains caliche nodules	16	18
Sand, very fine to fine, and silt; brown	2	20
Silt and clay; blue-gray	10	30
Silt and clay; sandy, blue-gray and brown	7	37
CRETACEOUS		
Dakota formation (Gulfian)		
Clay, red, yellow-brown, and light- to dark-gray; contains some fine to medium sand	37	74
Sandstone, silty, white to gray; contains some blue-gray shale and carbonaceous material	24	98
Lignite, brown to black	1	99
Sandstone, medium-grained, white; contains pyrite and some light-gray carbonaceous clay	25	124

	Thickness, feet	Depth, feet
Shale, light-gray, and fine- to very coarse-grained sandstone	3	127
Shale, partly carbonaceous, gray; contains sandstone pellets from 135 to 137 feet and thin beds of coal from 145 to 148 feet	21	148
Kiowa shale (Comanchean)		
Shale, sandy, light-gray to dark blue-gray	18	166
Sandstone, fine-grained, very hard, silty, white	3	169
Shale, light- to dark-gray, interbedded with some light-gray very fine-grained sandstone	76	245
Sandstone, very hard, calcareous, white; contains pyrite,	0.5	245.5

18-13-21aa. *Sample log of test hole at the NE cor. sec. 21, T. 18 S., R. 13 W., Barton County; drilled, 1945. Surface altitude, 1,806.3 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	3	3
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay; gray-buff, light-gray to greenish-gray, light-brown, and yellow-brown	45	48
CRETACEOUS		
Dakota formation (Gulfian)		
Clay, sandy, carbonaceous, dark-gray and mottled yellow-brown	10	58
Sandstone, fine- to medium-grained, white; contains thin beds of gray clay, lignite, and pyrite	5	63
Clay, gray	7	70
Sandstone, medium-grained, white, interbedded with gray shale; contains carbonaceous material and pyrite	8	78
Clay, light-gray; contains pellets of hard iron-cemented sandstone	4	82
Sandstone, fine- to medium-grained, white, interbedded with light-gray clay	8	90
Clay, light-gray, red, and yellow; contains limonite and thin beds of sandstone	39	129
Kiowa shale (Comanchean)		
Clay, sandy, pyritic, blue-gray	16	145
Shale, hard, greenish-gray; contains pyrite and light-gray fine-grained hard lignitic sandstone	15	160
Shale, light-gray	3	163
Sandstone, fine- to medium-grained, hard, pyritic, light-gray	4	167
Shale, light- to dark-gray; contains thin beds of hard fine-grained sandstone and pyrite	22	189
Sandstone, medium-grained, light-gray, and white shale; contains hard pyritic zone at 195.5 feet	8	197
Shale, blue-gray	24	221

	Thickness, feet	Depth, feet
Siltstone and sandstone, fine-grained; calcareous, light-gray; contains pyrite	3	224
Shale, dark-gray, and gray sandstone	16.5	240.5
Limestone, pyritic, sandy, white	0.5	241
Shale, sandy, gray	10	251
Sandstone, very fine- to medium-grained, white, and light-gray shale	10	261
Sandstone, very fine-grained, pyritic, very hard	4	265

18-13-27cc. *Sample log of test hole at the SW cor. sec. 27, T. 18 S., R. 13 W., Barton County; drilled, 1945. Surface altitude, 1,817.0 feet.*

	Thickness, feet	Depth, feet
Soil, gray-brown	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, sandy, brown	4	6
Silt and clay; light-brown; contains caliche nodules	6	12
Silt and clay; sandy, light-brown to gray	5	17
Silt and clay; buff, gray, brown, and gray-green	13	30
CRETACEOUS		
Dakota formation (Gulfian)		
Clay, light- to dark-gray and red	20	50
Sandstone, fine- to medium-grained, white to gray; contains some clay, carbonaceous material, and pyrite	13	63
Shale, carbonaceous, dark-gray	15	78
Sandstone, medium- to coarse-grained, yellow-gray, interbedded with gray shale	2	80
Shale, very hard, gray-brown	2	82
Clay, light-gray to gray-white; contains some sand and hard sandstone pellets	11	93
Sandstone, fine- to medium-grained, white	2	95
Clay, sandy, light-gray, red, yellow, and white; contains many sandstone pellets from 100 to 110 feet	33	128
Kiowa shale (Comanchean)		
Shale and clay; dark-gray and greenish-gray	14	142
Shale, dark-gray	11	153
Sandstone, fine- to medium-grained, white to gray	2	155
Shale, sandy, gray	11	166
Sandstone, fine-grained, light-gray	2	168
Sandstone, quartzitic, very hard, gray-white	0.5	168.5

18-13-31aa. *Sample log of test hole at the NE cor. sec. 31, T. 18 S., R. 13 W., Barton County; drilled, 1945. Surface altitude, 1,913.8 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, gray and gray-brown	15	17

	Thickness, feet	Depth, feet
Silt, buff and gray-buff; contains caliche nodules; many hard caliche-cemented beds from 73 to 90 feet	73	90
Silt, sandy, buff	33	123
Gravel, fine to medium, and sand; derived from the Dakota formation	6	129
Silt, buff, and weathered sandstone and "ironstone" fragments	2	131
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, medium-grained, brown, and light blue-gray and yellow clay	9	140

18-13-34cc. *Sample log of test hole at the SW cor. sec. 34, T. 18, S., R. 13 W., Barton County; drilled, 1943. Surface altitude, 1,899.3 feet.*

	Thickness, feet	Depth, feet
Soil, gray-brown	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, clayey, light to dark-gray and yellow-tan	10	12
Silt, sandy, white, brown, and buff; contains caliche nodules	38	50
Silt, yellow; contains hematite pebbles	5	55
CRETACEOUS		
Dakota formation (Gulfian)		
Clay, blue-gray; contains some yellow to brown fine-grained sandstone and limonite concretions	35	90
Siltstone, yellow, and blue-gray clay; contains thin beds of hard sandstone	10	100
Sandstone, fine-grained, white, and white and yellow clay; contains hematite at 108 feet	10	110
Clay, yellow and blue-gray, and thin beds of white to yellow-brown medium-grained sandstone	10	120
Sandstone, medium-grained, yellow to yellow-brown; contains hematite	17	137
Clay, mottled light-gray, red and yellow	53	190
Clay, mottled light-gray, red, and yellow, and white to dark-gray clay; contains many pellets of white fine-grained hard sandstone and some pyrite	20	210
Kiowa shale (Comanchean)		
Clay, gray and dark blue-gray; contains pyrite	10	220
Shale, fissile, dark-gray, and gray clay; contains some gray fine-grained sandstone and pyrite. Bed of white hard limestone from 256 to 257 feet	60	280
Shale, fissile, dark-gray, and gray clay; contains pyrite. Thin very hard layers at 286 and 289 feet	20	300
Siltstone, sandy, gray to white, and dark-gray fissile shale; contains a few sandstone pellets	20	320

	Thickness, feet	Depth, feet
Siltstone, sandy, gray, and dark-gray clay	16	336
Clay, gray, and dark-gray fissile shale; contains shells and pyrite	42	378
Cheyenne (?) sandstone (Comanchean)		
Siltstone, clayey, light-gray, and fine-grained sandstone,	22	400
PERMIAN		
Siltstone, micaceous, sandy, red-brown	40	440

18-14-14bcc. *Sample log of test hole in the SW¼ SW¼ NW¼ sec. 14, T. 18 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,916.8 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, gray to brown	10	11
Silt, buff; contains caliche	12	23
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, medium-grained, white, and light blue-gray clay	4	27

18-14-15bb. *Sample log of test hole at the NW cor. sec. 15, T. 18 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,938.1 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, light-gray, gray-brown, brown, and buff	15	17
Silt, yellow-buff; contains caliche nodules and fragments of sandstone and "ironstone"	36	53
Silt and clay; sandy, yellow	4	57
Gravel, fine to medium, lime-cemented, hard; gravel is derived from Cretaceous rocks	2	59
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light blue-gray	3	62

18-14-17add. *Sample log of test hole in the SE¼ SE¼ NE¼ sec. 17, T. 18 S., R. 14 W., Barton County; drilled, 1945.*

	Thickness, feet	Depth, feet
Road fill	2.5	2.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, gray to brown	9.5	12
Silt, tan to yellow buff; contains caliche	8	20
CRETACEOUS—Gulfian		
Graneros shale		
Clay, light blue-gray and yellow-brown	10	30

18-14-23add. *Sample log of test hole in the SE¼ SE¼ NE¼ sec. 23, T. 18 S., R. 14 W., Barton County; drilled, 1945. Surface altitude 1,897.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, gray and brown	9	9
Silt, buff; contains caliche nodules and sand	61	70
Silt, yellow-buff; contains sandstone fragments and caliche	15	85
Gravel, fine to medium, sand, and silt; derived from Cretaceous rocks	3	88
Gravel, fine to medium, and sand; lime-cemented, hard,	3	91
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light blue-gray and red	2	93

18-14-24dd. *Sample log of test hole at the SE cor. sec. 24, T. 18 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,897.0 feet.*

	Thickness, feet	Depth, feet
Road fill	2.5	2.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, greenish gray and brown	5.5	8
Silt, buff; contains caliche nodules and sandstone fragments from 37 to 38 feet	30	38
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, medium-grained, brown, and gray and yellow clay	4	42

18-14-29aa. *Sample log of test hole at the NE cor. sec. 29, T. 18 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,920.8 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt and clay; gray	5	7
Silt and clay; sandy, gray and light-brown	15	22
Silt, sandy, buff; contains caliche and some fine to medium gravel in lower part	98	120
Gravel, fine to coarse, and sand	16.5	136.5
CRETACEOUS—Gulfian		
Dakota formation		
Clay, yellow, light blue-gray, and red	3.5	140

18-14-32aab. *Sample log of test hole in the NW¼ NE¼ NE¼ sec. 32, T. 18 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,912.1 feet.*

	Thickness, feet	Depth, feet
Road fill	2.5	2.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, tan to dark-brown and gray; contains some sand, clay, caliche nodules, and a few thin lenses of fine to medium gravel	78.5	81
Sand, fine to coarse, and silt	4	85
Gravel, fine to medium, and sand; partly cemented	9	94
Silt and clay; light-gray and yellow-brown	4	98
Gravel, fine to coarse, and sand; contains silt in lower part	24	122
Silt, light-gray and buff	4	126
Gravel, fine to coarse, and sand	3	129
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light-gray and red	5	134

18-14-32bdd. *Sample log of test hole in the SE¼ SE¼ NW¼ sec. 32, T. 18 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,888.4 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY		
Alluvium		
Silt, sandy, gray, gray-brown, and yellow-gray	25	28
Gravel, fine to medium, and sand	8	36
Silt, sandy, gray to buff; interbedded with thin layers of fine to medium gravel and sand	24	60
Sand, fine to coarse; contains some fine to coarse gravel and silt	11	71
Silt, sand, and gravel; poorly sorted	6	77
Gravel, fine to coarse, and sand	20	97
CRETACEOUS—Gulfian		
Dakota formation		
Shale, gray; contains carbonized and pyritized plant fragments	3	100

18-14-32dc. *Sample log of test hole at the SW cor. SE¼ sec. 32, T. 18 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,891.1 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY		
Alluvium		
Silt and clay; light to dark-gray	21	24
Silt, sandy, yellow-gray	4	28
Gravel, fine, and sand; contains some medium to coarse gravel	15	43

	Thickness, feet	Depth, feet
Gravel, fine to medium, and sand; contains thin beds of silt	7	50
Gravel, fine to medium, and sand; contains some coarse gravel	17	67
Silt, light-gray	2	69
Gravel, fine to medium, and sand; contains some coarse gravel and yellow-gray silt	10	79
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light blue-gray, mottled red and yellow	5	84

18-15-4cc. *Sample log of test hole at the SW cor. sec. 4, T. 18 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,955.9 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
Soil, gray-brown	2	3
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, buff, gray, and brown; contains caliche nodules from 9 to 17 feet and from 19 to 37 feet	34	37
Silt, buff and light-gray; contains some fine to coarse gravel and sand; gravel is composed of Greenhorn limestone fragments	6	43
CRETACEOUS—Gulfian		
Graneros shale		
Limestone, hard, sandy, fossiliferous	0.5	43.5
Shale, light-gray to brown	6.5	50

18-15-21bb. *Sample log of test hole at the NW cor. sec. 21, T. 18 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,933.2 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt and clay; tan, brown, and gray; contains caliche nodules	28	30
Silt, buff to tan; contains fine to medium gravel and sand	10	40
Silt, gray-white to dark-buff	20	60
Silt, sandy, light-gray and buff; contains fine to medium gravel in lower part	32	92
Gravel, fine to coarse, and sand	9	101
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, fine- to medium-grained, yellow, and light-gray and yellow clay	2	103

18-15-28cc. *Sample log of test hole at the SW cor. sec. 28, T. 18 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,912.1 feet.*

	Thickness, feet	Depth, feet
Soil, dark gray to brown	3	3
QUATERNARY		
Alluvium		
Silt and clay; gray	21	24
Gravel, fine to medium, and sand; contains some coarse gravel from 40 to 66 feet and thin beds of gray-green silt and clay from 48 to 60 feet	42	66
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light-gray, red, and yellow	4	70

18-15-29ada. *Sample log of test hole in the NE¼ SE¼ NE¼ sec. 29, T. 18 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,912.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay; light to dark-gray	23	23
Silt, gray-white, and fine to medium sand	5	28
Sand, fine to coarse; contains some fine gravel from 28 to 40 feet and much white to buff silt from 40 to 50 feet	22	50
Gravel, fine to coarse, and sand	37	87
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light blue-gray, and light-gray fine-grained sandstone	3	90

19-10-18bb. *Sample log of test hole at the NW cor. sec. 18, T. 19 S., R. 10 W., Rice County; drilled, August 1946. Surface altitude, 1,782.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Sand, fine to medium, and silt; dark-gray	7	7
Sanborn formation (Pleistocene)		
Silt, light-gray, and very fine to medium sand	8	15
Sand, very fine to medium	25	40
Sand, coarse to fine	35	75
Gravel, fine to medium, sand, and silt; buff	21	96
Gravel, fine to coarse, sand and silt; buff	7	103
Silt, calcareous buff and very fine sand (lower part of interval may be Upland member of Meade formation),	32	135
Meade formation (Pleistocene)		
Volcanic ash, partly indurated, white (Pearlette ash lentil)	2	137
Silt, gray, and very fine to fine sand	15	152
Gravel, fine to medium and sand	5	157
Silt, gray, and very fine to coarse sand	22	179
Gravel, fine to coarse, and sand	14	193

	Thickness, feet	Depth, feet
CRETACEOUS—Comanchean		
Kiowa shale		
Shale, gray, and white fine sandstone; contains some charcoal	4.5	197.5

19-11-7aa. *Sample log of test hole at the NE cor. sec. 7, T. 19 S., R. 11 W., Barton County; drilled, 1943. Surface altitude, 1,811.0 feet.*

	Thickness, feet	Depth, feet
Road fill	2.5	2.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, clayey, black	1.5	4
Silt, clayey, yellow-gray	4	8
Silt and fine sand; light greenish-gray	8	16
Silt, light greenish-gray	8	24
Silt, sandy, gray and yellow-brown; contains caliche nodules	20	44
Sand, fine to medium, and silt; gray and buff	6	50
Silt, sandy, light-gray, gray, and buff; contains caliche	30	80
Sand, fine to medium, and fine gravel; derived from Dakota formation	7	87
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, yellow-brown, and yellow and light blue-gray clay; contains some hematite	6	93

19-11-12aa. *Sample log of test hole at the NE cor. sec. 12, T. 19 S., R. 11 W., Barton County; drilled, August 1946. Surface altitude, 1,778.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-gray; contains some fine to medium sand	1.5	1.5
Silt and clay; gray; contains some fine sand	1.5	3
Silt, light-gray and buff, very fine to medium sand. Much concretionary calcium carbonate in lower part of interval	35	38
Silt, calcareous, buff; contains some very fine sand	18	56
Silt, light-tan and buff; contains some very fine to fine sand	9	65
Silt, calcareous, light-tan and buff; contains some concretionary calcium carbonate	65	130
Meade formation		
Silt, calcareous, light-tan; contains some very fine to fine sand and many pebbles derived from Cretaceous rocks	9.5	139.5
Gravel, medium to fine, sand, and silt; light-tan	1.5	141
CRETACEOUS—Comanchean		
Kiowa shale		
Shale, fissile, gray	5	146

19-11-24dd. *Sample log of test hole at the SE cor. sec. 24, T. 19 S., R. 11 W., Barton County; drilled, August 1950. Surface altitude, 1,775.7 feet.*

	Thickness, feet	Depth, feet
Road fill	1.5	1.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, light-gray, and fine to medium sand	4.5	6
Silt, light-gray and buff; contains much fine to coarse sand, fine gravel, and some concretionary calcium carbonate	10	16
Sand, fine to coarse, and much buff calcareous silt; contains much concretionary calcium carbonate	11	27
Gravel, fine to coarse, and sand	29	56
Gravel, coarse to fine, and sand	6.5	62.5
Silt, calcareous, buff; contains much fine to medium sand	6	68.5
CRETACEOUS—Comanchean		
Kiowa shale		
Sandstone, fine, silty, white	29.5	98
Shale, micaceous, yellow-gray	6	104
Sandstone, fine, brown, and gray shale; contains some charcoal	2	106

19-11-29bb. *Sample log of test hole at the NW cor. sec. 29, T. 19 S., R. 11 W., Barton County; drilled, 1943. Surface altitude, 1,789.5 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY		
Alluvium and Sanborn formation—Pleistocene and Recent		
Silt, yellow-gray and gray-brown, and fine to medium sand	9	10
Silt, dark-gray; contains some fine to coarse sand and fine gravel	3	13
Gravel, fine to coarse, and sand	52	65
Silt, sandy, buff; contains caliche	59	124
Silt, yellow and buff; contains some fine to medium sand and gravel	5	129
Meade (?) formation—Pleistocene		
Gravel, fine to medium; contains some silt, fine sand, and coarse gravel	27	156
CRETACEOUS—Comanchean		
Kiowa shale		
Clay, dark blue-gray; contains some yellow to brown sandstone, hematite, and pyrite	15	171
Sandstone, fine-grained, hard, light-gray, and dark blue-gray clay; contains pyrite and hematite pellets	9	180
Clay, light to dark-gray, and gray hard sandstone; contains thin bed of hard limestone at 203 feet, "cone-in-cone" calcite from 200 to 210 feet, and pyrite	30	210

	Thickness, feet	Depth, feet
Clay, dark-gray, and dark-gray fissile shale; contains pyrite and shells	20	230
Clay, partly lignitic, light to dark-gray	10	240
Cheyenne sandstone		
Clay, sandy, light gray-green, and fine- to medium-grained sandstone	10	250
Siltstone and very fine-grained sandstone; gray-green...	11	261
PERMIAN		
Siltstone, sandy, red-brown	19	280

19-11-31bb. *Driller's log of city-supply well at Ellinwood in the NW¼ NW¼ sec. 31, T. 19 S., R. 11 W., Barton County.*

	Thickness, feet	Depth, feet
Soil	5	5
Silt, soft, gray	3	8
Sand, fine	4	12
Sand, coarse, and gravel	15	27
Clay, yellow	1.5	28.5
Sand and gravel	4	32.5
Sandstone, fine-grained, solid, light	105.5	138
Shale, blue	3	141

19-12-5aa. *Sample log of test hole at the NE cor. sec. 5, T. 19 S., R. 12 W., Barton County; drilled, 1943. Surface altitude, 1,799.6 feet.*

	Thickness, feet	Depth, feet
Soil, clayey, black	1.5	1.5
QUATERNARY		
Alluvium		
Silt and clay; gray-brown	5.5	7
Silt, clayey, gray-green; contains some very fine sand..	3	10
Silt, blocky, gray-green and yellow-brown; contains caliche nodules	6	16
Silt, gray and brown, and fine to medium sand	1	17
Clay, silty, gray, brown, and yellow	3	20
Silt, dark-gray and brown, and fine to medium sand; contains a few caliche nodules	4	24
Sand, fine to medium, and silt; gray and yellow-brown,	22	46
Silt, sandy, yellow-brown and gray; contains a few caliche nodules	16.5	62.5
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, medium-grained, yellow, lavender, and white,	7.5	70

19-12-14bb. *Sample log of test hole at the NW cor. sec. 14, T. 19 S., R. 12 W., Barton County; drilled, 1946.*

	Thickness, feet	Depth, feet
Road fill and soil	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, gray-green, iron-stained	3	5

	Thickness, feet	Depth, feet
Silt, sandy, tan to brown	31	36
Sand and silt; tan and buff; contains sandstone fragments and caliche nodules	4	40
Silt, sandy, white to buff, and brown; contains caliche nodules	19	59
Gravel, fine to coarse, composed of sandstone, "ironstone," and caliche pebbles; very silty, poorly sorted,	11	70
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, tan, brown, and yellow	3	73

19-12-21bb. *Sample log of test hole at the NW cor. sec. 21, T. 19 S., R. 12 W., Barton County; drilled, 1943. Surface altitude, 1,884.6 feet.*

	Thickness, feet	Depth, feet
Road fill	1.5	1.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, sandy, tan-gray	3.5	5
Silt, buff, brown, and reddish-brown; contains caliche nodules	33	38
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, medium- to coarse-grained, yellow-gray and brown, and some pink clay	23	61
Clay, varicolored; contains some fine sand from 76 to 90 feet	49	110
Clay, dark-gray to white; contains some brown fine-grained sandstone and hematite	20	130
Clay, gray and red	5	135
Clay, sandy, dark-gray; contains pyrite	5	140
Siltstone, sandy, gray-white; contains pyrite and some black carbonaceous silt	10	150
Clay and shale; light to dark-gray, red, and red-brown; contains pyrite	56.5	206.5

19-12-29dd. *Driller's log of test hole in the SE¼ SE¼ sec. 29, T. 19 S., R. 12 W., Barton County; drilled by the Layne-Western Company for the Kansas Power Company of Great Bend.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay	6	9
Sand, coarse	4	13
Sand and gravel	5	18
Clay, blue	2	20
Sand and gravel	17	37

	Thickness, feet	Depth, feet
Clay, yellow	3	40
Clay, gray	10	50
CRETACEOUS—Gulfian		
Dakota (?) formation		
Sandrock	18	68

19-12-29dd. *Sample log of test hole at the SE cor. sec. 29, T. 19 S., R. 12 W., Barton County; drilled, 1943. Surface altitude, 1,814.8 feet.*

	Thickness, feet	Depth, feet
Road fill	1.5	1.5
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, silty, gray	4.5	6
Silt, sandy, gray and blue-gray; contains caliche	7	13
Gravel, fine to medium, and medium to coarse sand	17	30
Gravel, fine to coarse, and coarse sand; contains some yellow clay	25	55
CRETACEOUS		
Dakota formation (Gulfian)		
Sandstone, fine- to medium-grained, white to yellow-brown, and light-yellow and gray siltstone	32	87
Clay, blue-gray	3	90
Clay, blue-gray, and white to brown fine- to medium-grained sandstone	10	100
Sandstone, medium-grained, yellow and brown	10	110
Siltstone, soft, yellow-gray, interbedded with brown medium-grained sandstone	7	117
Clay, light-blue-gray and yellow gray, and brown medium-grained sandstone	6	123
Kiowa shale (Comanchean)		
Clay, blue-gray; contains a thin bed of very hard calcareous sandstone at 135.5 feet and a layer of hard pyrite at 140 to 141 feet	18	141

19-13-3cc. *Sample log of test hole at the SW cor. sec. 3, T. 19 S., R. 13 W., Barton County; drilled, 1945. Surface altitude, 1,846.6 feet.*

	Thickness, feet	Depth, feet
Road fill and soil; dark-gray	4	4
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay; light-gray and brown-gray	13	17
Silt, gray and brown; contains some sand and gravel	7	24
Gravel, fine to coarse, and sand; contains some light-gray clay	6	30
Gravel, fine to coarse, and sand; coarse gravel is derived from Cretaceous rocks	11	41
Silt, sandy, yellow-brown; contains some gravel	3	44

	Thickness, feet	Depth, feet
Sand and poorly sorted gravel; derived from the Dakota formation	7	51
Gravel, fine to coarse; contains much sand and silt; derived from the Dakota formation	2	53
Conglomerate, hard, brown; consists of Dakota fragments	2	55
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light-gray mottled red	2	57

19-13-4cc1. *Driller's log of city-supply well in the SW¼ SW¼ sec. 4, T. 19 S., R. 13 W.; drilled for the City of Hoisington by the Layne-Western Company, 1936.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	18	20
Sand, coarse	2	22
Sand and gravel	2	24
Clay, sandy	1	25
Sand, coarse	1	26
Sand, coarse, and gravel	18	44
Clay	1	45

19-13-5cc. *Driller's log of test hole at the SW cor. sec. 5, T. 19 S., R. 13 W., Barton County; drilled by the Layne-Western Company for the City of Hoisington, 1935.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Gumbo, black	5	5
Hard pan	11	16
Sand and clay	3	19
Sand, coarse	2	21
Sand, coarse, and small gravel	9	30
Sand, fine to coarse	11	43
Sand, coarse, and clay	4	47
Sand, coarse, and small gravel	11	58
Sand, fine, and gumbo; very tight	7	65
Sand, fine, silty, and clay	5	70
Sand, fine, silty, tight	8	78
Sand, coarse, brown; some fine sand, clay	12	90

19-13-6db. *Driller's log of irrigation well in the NW¼ SE¼ sec. 6, T. 19 S., R. 13 W., Barton County; owned by Elmer Amerine. Surface altitude, 1,890.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Soil, clayey	28	28

	Thickness, feet	Depth, feet
Sand, clayey	9	37
Sand	8	45
Clay, tough	10	55
Sand and gravel	34	89
Sand, cemented	1	90
Sand and gravel	25	115
Rock, hard	1	116

19-13-8da. *Driller's log of test hole at the NE cor. SE¼ sec. 8, T. 19 S., R. 13 W., Barton County; drilled by the Layne-Western Company for the City of Hoisington, 1935.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy, brown	11	13
Sand, medium, brown	5	18
Sand, fine, blue, and clay	2	20
Sand, coarse, brown	3	23
Sand, coarse, and gravel	5	28
Sand, medium, and little gravel	2	30
Sand, coarse, and small gravel	13	43
Clay, blue-green and white, and a few gravels	5	48

19-13-16aa. *Sample log of test hole at the NE cor. sec. 16, T. 19 S., R. 13 W., Barton County; drilled, 1945. Surface altitude, 1,851.5 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay; gray	5	8
Silt, brownish-gray; contains some sand and gravel	6	14
Gravel, fine to coarse, and sand	28.5	42.5
CRETACEOUS—Gulfian		
Dakota formation		
Clay, blue-gray and yellow, and brown medium-grained sandstone	7.5	50

19-13-21aa. *Sample log of test hole at the NE cor. sec. 21, T. 19 S., R. 13 W., Barton County; drilled, 1943. Surface altitude, 1,846.5 feet.*

	Thickness, feet	Depth, feet
Soil, silty, black	3	3
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray-black; contains some coarse sand and fine gravel	2	5

	Thickness, feet	Depth, feet
Silt, sandy, gray, contains caliche nodules	9	14
Gravel, fine to medium, and sand; contains some coarse gravel from 14 to 20 feet and yellow silt from 30 to 40 feet	46	60
CRETACEOUS—Gulfian		
Dakota formation		
Clay, silty, white, red, gray, and yellow	20	80
Clay, sandy, light-gray and yellowish; contains some lignite from 85 to 87 feet	10	90
Clay, light blue-gray; contains thin beds of maroon hard siltstone from 110 to 120 feet	30	120

19-13-21cc. *Driller's log of irrigation well at the SW cor. sec. 21, T. 19 S., R. 13 W., Barton County; drilled by James Frasier for Mr. Rathborn, owner.*

	Thickness, feet	Depth, feet
Soil	8	8
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand and gravel, coarse	39	47
Clay, gummy	9	56
Sand and gravel	23	79

19-13-25dd. *Driller's log of test hole in the SE¼ SE¼ sec. 25, T. 19 S., R. 13 W., Barton County; drilled by the Layne-Western Company for the Kansas Power Company of Great Bend.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay	9	11
Sand and gravel	17	28
Sand and gravel; contains clay balls	10	38
Sand, fine	5	43
Clay	9	52
Sand, coarse	6	58
Clay, yellow	16	74
CRETACEOUS—Gulfian		
Dakota (?) formation		
Sand rock	1	75

19-13-27cb. *Sample log of test hole at the NW cor. SW¼ sec. 27, T. 19 S., R. 13 W., Barton County.*

	Thickness, feet	Depth, feet
Road fill	5	5
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, sandy, light-gray and blue-gray	5	10

	Thickness, feet	Depth, feet
Gravel, fine to coarse, and sand	18	28
Silt, sandy, gray and yellow-buff; contains gravel in lower part	24	52
Gravel, fine to medium, and sand	12	64
Silt, buff and light blue-gray, interbedded with sand and gravel	16	80
Gravel, fine to medium, and sand; contains much silt and some clay	27	107
Silt, buff; contains sand, gravel, and caliche	19	126
Gravel, fine to medium, and sand	7	133
CRETACEOUS—Comanchean		
Kiowa shale		
Shale, gray; contains pyrite	7	140

19-13-28bc. *Driller's log of city-supply well (Odell St. well) at Great Bend in the SW¼ NW¼ sec. 28, T. 19 S., R. 13 W., Barton County; drilled by the Layne-Western Company for the Kansas Power Company, 1930.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay	4	6
Sand, coarse	2	8
Sand and gravel	16	24
Clay	8	32
Sand, fine	6	38
Sand, coarse, and gravel	6	44
Clay	3	47
Sand and gravel	20	67
Clay	1	68
Sand and gravel	9	77
Sand, gravel, and clay balls	8	85
Sand and gravel	35	120
Clay	2	122
Sand and gravel	6	128

19-13-28cd. *Driller's log of city-supply well (Office well) at Great Bend in the SE¼ SW¼ sec. 28, T. 19 S., R. 13 W., drilled by the Layne-Western Company for the Kansas Power Company, 1937.*

	Thickness, feet	Depth, feet
Road fill, cinders, and soil	5	5
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	4	9
Sand, coarse, and gravel	20	29
Clay, yellow	8	37
Clay, sandy	11	48
Pack sand	3	51

	Thickness, feet	Depth, feet
Clay, blue	10	61
Clay, sandy, yellow	6	67
Sand and gravel	20	87
Clay, yellow	3	90
Sand and gravel, with clay streaks	5	95
Sand and gravel	16	111
Sand and gravel, cemented	2	113
Sand, fine, and clay	4	117
Clay	1	118

19-13-33db. *Driller's log of well in the NW¼ SE¼ sec. 33, T. 19 S., R. 13 W., Barton County; drilled by the Kelly Well Company for the Kansas Power Company, 1923.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand and gravel	28	28
Clay	25	53
Sand	3	56
Clay	7	63
Gravel, cemented	4	67
Gravel	8	75
Clay	1	76

19-13-34cc. *Sample log of test hole at the SW cor. sec. 34, T. 19 S., R. 13 W., Barton County; drilled, 1945.*

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY—Pleistocene and Recent		
Alluvium		
Gravel, fine to coarse, and sand	18	22
Silt, sandy, buff	6	28
Gravel, fine to medium, sand, and silt; poorly sorted	17	45
Silt and clay; light- to dark-gray	13	58
Gravel, fine to medium, sand, and silt; poorly sorted	12	70
Silt and clay; yellow-buff	3	73
Gravel, fine to medium, and sand; contains some silt	66	139
CRETACEOUS—Comanchean		
Kiowa shale		
Sandstone, medium-grained, white to light-brown	11	150

19-14-4cab. *Driller's log of irrigation well in the NW¼ NE¼ SW¼ sec. 4, T. 19 S., R. 14 W., Barton County; drilled by Jim Frasier for Charles Stevens.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	20	20
Sand	5	25
Sand and gravel	35	60
Sand rock	0.5	60.5
Sand and gravel	15.5	76

19-14-5caa. *Sample log of test hole in the NE¼ NE¼ SW¼ sec. 5, T. 19 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,884.8 feet.*

	Thickness, feet	Depth, feet
Road fill and soil; dark-gray	3	3
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, dark-buff and gray	22	25
Silt, dark-gray; contains some sand and fine gravel	5	30
Gravel, fine, and sand; silty	10	40
Gravel, fine to medium, and sand; contains some coarse gravel which is derived mostly from Cretaceous rocks	33	73
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light-gray	7	80

19-14-6bbl. *Driller's log of well in the NW¼ sec. 6, T. 19 S., R. 14 W., drilled for the Natural Gas Pipeline Company.*

	Thickness, feet	Depth, feet
Soil, black	3	3
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sticky	24	27
Sand, coarse	3	30
Sand, coarse, silty	11	41
Sand and gravel	13	54
Clay	1	55

19-14-9aab. *Driller's log of irrigation well of W. A. Brown in the NW¼ NE¼ NE¼ sec. 9, T. 19 S., R. 14 W., Barton County. Surface altitude, 1,883.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay and soil	20	20
Sand, fine	8	28
Sand and medium gravel	41	69
CRETACEOUS—Gulfian		
Dakota formation		
Shale, blue	41	110

19-14-17bb. *Sample log of test hole at the NW cor. sec. 17, T. 19 S., R. 14 W., Barton County; drilled, 1943. Surface altitude, 1,914.9 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, clayey, yellow-gray and brown	8	10
Silt, sandy, buff; contains caliche nodules	27	37
Silt, sandy, yellow; contains caliche nodules and pebbles of sandstone	5	42

	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian and Comanchean		
Dakota formation and Kiowa shale, undifferentiated		
Clay, yellow, yellow-brown, and blue-gray, and brown and dark-gray fine-grained hard sandstone; contains hematite	28	70
Clay and silt; light-gray, buff, and red; contains many gray sandstone pellets	30	100
Clay, red, red-brown, and gray; contains hematite	17	117
Sandstone, pellet form, fine-grained, gray	7	124
Clay, light blue-gray, gray, and red-brown, and white hard sandstone pellets	16	140
Clay, light- to dark-gray, red-brown, and yellow	20	160
Clay, light- to dark-gray; contains some fine sand, sandstone pellets, charcoal, and pyrite	40	200
Siltstone, light-gray; contains thin beds of fine-grained sandstone, some charcoal and pyrite	28	228
Sandstone, fine-grained, gray	1	229
Siltstone, gray, and buff and gray fine-grained sandstone; contains thin beds of limestone from 250 to 260 feet	41	270
Clay and shale; dark-gray, and light-gray and gray fine- to medium-grained sandstone; contains shells from 305 to 310 feet	40	310
Clay, dark-gray, and gray to black fissile shale; contains thin beds of limestone from 327 to 330 feet and pyrite	31	341
Cheyenne sandstone (Comanchean)		
Siltstone, sandy, and fine-grained sandstone; white, greenish-white, and light-gray	69	410
Sandstone, fine-grained, white	65	475
PERMIAN		
Sandstone, fine-grained, red; and red siltstone	15	490

19-14-19ad. *Sample log of test hole at the SE cor. NE¼ sec. 19, T. 19 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,896.9 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, tan to buff	8	10
Silt, light-brown to light-gray, and very fine to coarse sand	18	28
Gravel, fine, and sand; silty	13	41
Silt, gray, gray green, and yellow-green	24	65
CRETACEOUS—Gulfian		
Dakota formation		
Clay, sandy, light blue-gray	3	68
Sandstone, light-brown	12	80

19-14-22ac. *Driller's log of irrigation well of A. Essmiller in the SW¼ NE¼ sec. 22, T. 19 S., R. 14 W., Barton County. Surface altitude, 1,885.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay and soil	13	13
Sand	28	41
Clay	1	42
Gravel	13	55
Clay	20	75
Gravel	5	80
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone	1	81

19-14-26cbd. *Driller's log of irrigation well of Essmiller Brothers in the SE¼ NW¼ SW¼ sec. 26, T. 19 S., R. 14 W., Barton County; drilled by Roy Delp, 1939.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay and soil	10	10
Gravel, good	26	36
Sand, fine	22	58
Sand, fine; contains clay balls	4	62
Gravel, good	9	71
Clay	2	73
Sand	2	75
Gravel	17	92

19-14-30ad. *Sample log of test hole at the SE cor. NE¼ sec. 30, T. 19 S., R. 14 W., Barton County; drilled, 1945. Surface altitude, 1,903.8 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray to brown	8	10
Silt, sandy, tan and yellow-gray; contains caliche nodules and some fine to medium gravel	17	27
Gravel, fine to medium, and sand	2	29
Silt, buff; contains fine to medium gravel and sand	5	34
Gravel, fine to coarse, and sand	13	47
Silt, buff	10	57
Gravel, fine to coarse, sand, and gray silt	15	72
Silt and clay; light- to dark-gray; contains fine sand	32	104
Sand, fine to coarse	3	107
Silt, sandy, gray and gray-green	13	120
Silt, buff to tan	20	140
Gravel, fine to coarse, and sand; derived from the Dakota formation	6	146
CRETACEOUS—Gulfian		
Dakota formation		
Shale, sandy, gray	4	150

19-15-5dda. *Sample log of test hole in the NE¼ SE¼ SE¼ sec. 5, T. 19 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,985.6 feet.*

	Thickness, feet	Depth, feet
Road fill and soil; gray	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, light-gray, yellow-gray, and tan; contains caliche nodules and limestone and sandstone fragments from 18 to 29.5 feet	27.5	29.5
CRETACEOUS—Gulfian		
Graneros shale		
Shale, thin bedded, blue-gray and yellow, and brown to white fine-grained sandstone	10.5	40

19-15-11aa. *Sample log of test hole at the NE cor. sec. 11, T. 19 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,944.5 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, gray, tan, and brown; contains caliche nodules in lower 20 feet	28	30
Silt, yellow-gray to buff; contains fragments of Cretaceous rocks	21	51
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, medium-grained, white, and light-gray clay	7	58

19-15-12da. *Sample log of test hole at the NE cor. SE¼ sec. 12, T. 19 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,956.5 feet*

	Thickness, feet	Depth, feet
Road fill and soil; dark gray	2.5	2.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, gray to brown	5.5	8
Silt, brown to light-buff; contains fragments of sandstone	8.5	16.5
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, fine- to medium-grained, brown, and light blue-gray clay	1.5	18

19-15-16bb. *Sample log of test hole at the NW cor sec. 16, T. 19 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,972.1 feet.*

	Thickness, feet	Depth, feet
Road fill	2.5	2.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark gray-brown and greenish-gray	5.5	8

	Thickness, feet	Depth, feet
Silt and clay; tan to buff; contains caliche nodules	10	18
Silt, buff, and sandstone and "ironstone" rubble	1	19
CRETACEOUS—Gulfian		
Graneros shale		
Clay, light blue-gray and yellow; contains iron pellets	4	23

19-15-16cc. *Sample log of test hole at the SW cor. sec. 16, T. 19 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,934.6 feet.*

	Thickness, feet	Depth, feet
Road fill and soil; gray	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, buff to light-brown and gray	19	21
Silt, sandy, buff; contains caliche nodules	42	63
Silt, gray	12	75
Silt, tan; contains sandstone rubble	4	79
Silt, sand, and gravel; lime-cemented; coarse gravel composed of sandstone and "ironstone" fragments	5	84
CRETACEOUS—Gulfian		
Dakota formation		
Clay, light-gray mottled red	6	90

19-15-21cc. *Sample log of test hole at the SW cor. sec. 21, T. 19 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,928.6 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, tan to gray	9.5	11.5
Silt, sandy, buff; contains caliche nodules	63.5	75
Silt and clay; gray to blue-gray; contains sandstone fragments and shells	18	93
Clay, sandy, buff	13	106
Sand and fine to coarse gravel; silty, poorly sorted	19	125
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone and clay; gray	5	130

19-15-33bb. *Sample log of test hole at the NW cor. sec. 33, T. 19 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,936.5 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, tan to brown	10	12.5
Silt, sandy, tan; contains caliche	37.5	50
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, fine-grained, red-brown	15	65

20-11-12bb. *Sample log of test hole at the NW cor. sec. 12, T. 20 S., R. 11 W., Barton County; drilled, 1943. Surface altitude, 1,761.0 feet.*

	Thickness, feet	Depth, feet
Road fill	1.5	1.5
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, yellow-gray; contains some fine sand to fine gravel	5.5	7
Silt, sandy, yellow-gray; contains caliche	9	16
Clay, silty, black, green, and buff	2	18
Gravel, fine to coarse	12	30
Gravel, fine to medium; contains some medium to coarse sand and yellow-brown clay	7	37
CRETACEOUS—Comanchean		
Kiowa shale		
Clay, silty, light-gray	16	53
Sandstone, fine- to medium-grained, yellow-brown	13	66
Clay, light-gray to gray; contains thin beds of white, light-gray, and yellow-brown sandstone and pyrite	44	110
Shale, fissile, dark-gray; contains a thin bed of hard limestone at 135 feet and pyrite	40	150
Siltstone, lignitic, gray-brown	2	152
Cheyenne sandstone		
Siltstone, sandy, light gray-green	17	169
PERMIAN		
Siltstone and very fine-grained sandstone; red-brown	6	175

20-11-30dd. *Sample log of test hole at the SE cor. sec. 30, T. 20 S., R. 11 W., Barton County; drilled, 1943. Surface altitude, 1,806.4 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Sand, fine to medium, silty	8	10
Sand, fine to coarse, and silt; gray and tan	10	20
Meade formation (Pleistocene)		
Sand, fine to coarse; contains some fine gravel, silt, and caliche	20	40
Gravel, fine to coarse, and sand	21	61
Silt, sandy, buff	12	73
Gravel, fine; contains some sand and medium gravel	27	100
Sand, fine to coarse; contains some fine to medium gravel and layers of silt	80	180
Silt, gray and buff; contains some sand and fine to medium gravel	15	195
Gravel, fine to medium, and sand	8	203
Silt, sandy, light-gray	4	207

PERMIAN	Thickness, feet	Depth, feet
Shale, silty, white to dark-red	13	220
Shale, silty, red-brown	14	234

20-12-21bb. *Sample log of test hole at the NW cor. sec. 21, T. 20 S., R. 12 W., Barton County; drilled, 1943. Surface altitude, 1,844.0 feet.*

QUATERNARY	Thickness, feet	Depth, feet
Dune sand (Pleistocene and Recent)		
Sand, fine to medium, and silt	3	3
Silt and fine to coarse sand	4	7
Meade formation (Pleistocene)		
Silt and clay; gray and green-gray	19	26
Sand, fine to coarse; contains some fine gravel and silt	24	50
Gravel, fine to medium, and sand	15	65
Silt, yellow and gray; contains fine to medium sand and gravel	13	78
Gravel, fine to medium, and medium to coarse sand	8	86
Silt, sandy, yellow, and clay	3	89
Gravel, fine to coarse, and sand	23	112
Sand, coarse, and fine gravel	8	120
Gravel, fine to medium, and sand	16	136
CRETACEOUS—Comanchean		
Kiowa shale		
Sandstone, medium-grained, white, yellow, and brown	9	145
Clay, light- to dark-gray, and a few thin beds of sandstone	25	170
Clay, gray, and dark-gray fissile shale; contains pyrite, calcite, and shells	40	210
Clay, sandy, gray; contains lignite from 214 to 215 feet and pyrite	5	215
Cheyenne (?) sandstone		
Siltstone, sandy, gray-white	15	230
Silt and clay; sandy, light blue-gray	10	240

20-13-9dd. *Sample log of test hole at the SE cor. sec. 9, T. 20 S., R. 13 W., Barton County; drilled, 1943. Surface altitude, 1,861.5 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Silt and fine to medium sand	10	12
Meade formation (Pleistocene)		
Silt, sandy, gray, and yellow-brown clayey silt	6	18
Sand, fine to coarse; contains a little fine gravel	12	30
Gravel, fine to medium, and sand; contains coarse gravel from 58 to 72 feet	42	72

	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, fine-grained, brown, and pink and buff clay,	8	80
Sandstone, fine- to medium-grained, light to dark-brown, red, and white	30	110

20-14-1aa. *Driller's log of test hole at the NE cor. sec. 1, T. 20 S., R. 14 W., Barton County; drilled by the Layne-Western Company for the Kansas Power Company of Great Bend.*

	Thickness, feet	Depth, feet
Soil	1	1
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay	2	3
Sand, coarse, and gravel	16	19
Sand, fine, cemented	11	30
Sand, coarse	3	33
Magnesium and clay	5	38
Sand and gravel	1	39
Clay	7	46
Sand, coarse, and gravel	25	71
Clay, yellow	10	81
Sand, coarse	7	88
Sand, fine	7	95
Sand and gravel	3	98
Sand, fine	5	103
Sand, coarse, and gravel	5	108
Clay, sandy	5	113
Sand, coarse, and gravel	5	118
Sand, fine	2	120
Clay, sandy	6	126

20-14-2da. *Driller's log of test hole in the NE¼ SE¼ sec. 2, T. 20 S., R. 14 W., Barton County; drilled by the Layne-Western Company for the Kansas Power Company of Great Bend.*

	Thickness, feet	Depth, feet
Soil	1	1
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, fine	7	8
Sand and gravel	13	21
Clay	3	24
Sand, fine	3	27
Clay	14	41
Sand, coarse	9	50
Sand, fine	5	55
Sand, coarse	5	60
Clay, yellow	10	70
Sand, coarse	5	75
Clay, yellow	3	78

20-14-5cc. *Sample log of test hole at the SW cor. sec. 5, T. 20 S., R. 14 W., Barton County; drilled, 1943. Surface altitude, 1,905.6 feet.*

	Thickness, feet	Depth, feet
Soil, silty, dark-brown	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray to yellow-brown	9	11
Gravel, fine to very coarse; contains some fine to coarse sand	29	40
Sand, fine to fine gravel; contains some medium to coarse gravel	14	54
Silt, cream; contains caliche	2	56
Gravel, fine to medium, and sand; interbedded with buff silt	14	70
Gravel, fine to medium, and sand; contains some coarse gravel from 80 to 86 feet	16	86
CRETACEOUS—Gulfian and Comanchean		
Dakota formation and Kiowa shale, undifferentiated		
Clay, silty, sandy, light-gray to yellow-brown, some mottled light-gray, red, and yellow	14	100
Clay, mottled light-gray and red	20	120
Siltstone, gray-white; contains sandstone pellets	8	128
Clay, light- to dark-gray; contains some gray-black fissile shale, sandstone, and pyrite	32	160
Siltstone, clayey, micaceous, dark-gray, and thin beds of tan sandy limestone	10	170
Clay, light- to dark-gray, and gray-black fissile shale; contains thin beds of hard limestone	69	239
Clay, light- to dark-gray, and dark-gray fissile shale; contains some sandstone and shells	47	286

20-14-10ad. *Driller's log of test hole in the SE¼ NE¼ sec. 10, T. 20 S., R. 14 W., Barton County; drilled by the Layne-Western Company for the Kansas Power Company of Great Bend.*

	Thickness, feet	Depth, feet
Soil	1	1
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay	2	3
Sand, coarse	7	10
Sand and gravel	10	20
Clay	2	22
Sand and gravel	6	28
Clay	2	30
Sand and gravel	2	32
Clay, yellow	13	45
Sand and gravel	5	50
Sand, coarse, and gravel	13	63
Clay, yellow	10	73

	Thickness, feet	Depth, feet
Sand and gravel	3	76
Clay, yellow	2	78

20-14-16aaa. *Driller's log of test hole in the NE¼ NE¼ NE¼ sec. 16, T. 20 S., R. 14 W., Barton County; drilled by the Layne-Western Company for the Kansas Power Company of Great Bend.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, coarse	6	8
Sand and gravel	16	24
Clay	1	25
Sand and gravel	5	30
Sand, coarse, and some gravel	8	38
Clay, yellow	8	46
Sand, fine	2	48
Sand and gravel	12	60
Sand, coarse	8	68
Clay, yellow	7	75
Sand, coarse	18	93
Sand and gravel	7	100
Sand, coarse	5	105
Sand and gravel	3	108

20-15-2dd. *Sample log of test hole at the SE cor. sec. 2, T. 20 S., R. 15 W., Barton County; drilled, 1945.*

	Thickness, feet	Depth, feet
Road fill and soil	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, tan to dark-brown; contains caliche nodules	46	49
Sand, fine, and clay; contains sandstone fragments	6	55
CRETACEOUS—Gufian		
Dakota formation		
Sandstone, fine-grained, white to tan	13	68

20-15-4cd. *Sample log of test hole at the SE cor. SW¼ sec. 4, T. 20 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,971.4 feet.*

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, tan, dark-brown, and buff; contains caliche nodules,	22	26
Silt; contains fragments of sandstone and "ironstone"	6	32
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, fine- to medium-grained, white	6	38

20-15-5aa. *Sample log of test hole at the NE cor. sec. 5, T. 20 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,976.6 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	2.5	2.5
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, tan to brown and buff; contains sandstone fragments at base and caliche nodules	40	42.5
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, fine-grained, brown to white, and white clay,	5.5	48

20-15-22cc. *Sample log of test hole at the SW cor. sec. 22, T. 20 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 1,990.3 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	4	4
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, tan to brown and buff; contains caliche nodules	58	62
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, fine- to medium-grained, and white and yellow clay	5	67

20-15-28cbb. *Sample log of test hole in the NW¼ NW¼ SW¼ sec. 28, T. 20 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 2,035 feet.*

	Thickness, feet	Depth, feet
Soil, silty, buff	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, clayey, tan to brown	14.5	17.5
Silt, sandy, buff; contains caliche nodules	30.5	48
Clay, buff; contains limestone and sandstone fragments,	4	52
CRETACEOUS—Gulfian		
Dakota formation		
Sandstone, dark-brown	3	55
Clay, yellow-tan	5	60

20-15-31aa. *Sample log of test hole at the NE cor. sec. 31, T. 20 S., R. 15 W., Barton County; drilled, 1945. Surface altitude, 2,030.5 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, brown	6	9
Silt, buff; contains fine sand, caliche nodules, and sandstone fragments	36.5	45.5
Silt and sandstone fragments	2.5	48

	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian		
Dakota formation		
Clay, sandy, white	2	50

21-11-20ccd. *Sample log of test hole at the SE cor. SW¼ SW¼ sec. 20, T. 21 S., R. 11 W., Stafford County; drilled, 1943. Surface altitude, 1,753.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Marsh deposits (Recent)		
Silt, black, interbedded with fine to medium sand	5	5
Sand, fine to coarse	5	10
Meade formation (Pleistocene)		
Gravel, fine to medium, and sand; contains yellow clayey silt in upper 30 feet	48	58
Silt, sandy, buff	1	59
Gravel, fine to medium, and sand; silty	23	82
Silt, sandy, gray and light-gray	15.5	97.5
PERMIAN		
Siltstone, and very fine-grained sandstone; brownish-red	7.5	105

21-11-24cc. *Sample log of test hole at the SW cor. sec. 24, T. 21 S., R. 11 W., Stafford County; drilled, 1945. Surface altitude, 1,741.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Sand, medium, and silt	2	2
Meade formation (Pleistocene)		
Gravel, fine to coarse, and sand	1.5	3.5
Clay and silt; yellow and light blue-gray; contains some fine gravel and sand	3.5	7
Gravel, fine to medium, and sand	13	20
Silt, gray-white; contains some sand and gravel	4	24
Sand and poorly sorted gravel	4	28
Silt and fine to coarse sand; light-gray, yellow, and buff; and caliche	15	43
Sand and fine to coarse gravel; silty	8	51
Silt and very fine to medium sand; buff to light-brown,	5	56
Sand and fine to medium gravel; silty	8	64
Silt, yellow-gray and buff, and fine to coarse sand	2	66
Sand and fine to coarse gravel	2	68
Silt and fine to coarse sand; light-gray and buff; contains caliche	15	83
Silt, yellow-gray, interbedded with fine gravel and sand,	10	93
Silt, sandy, light-gray to gray-blue	27	120
Sand, fine to coarse, and silt; gray and gray-green	20	140
Gravel, fine to medium, and sand; contains many pebbles derived from Cretaceous rocks	24	164
PERMIAN		
Shale, sandy, red	6	170

14—3191

21-11-36dd. *Sample log of test hole in the SE cor sec. 36, T. 21 S., R. 11 W., Stafford County; drilled, July 1946. Surface altitude, 1,763.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Meade formation		
Sand, fine to coarse, and some silt; dark-gray	1.5	1.5
Sand, coarse to fine; contains a small amount of fine gravel	4	5.5
Silt, light-gray	9.5	15
Gravel, fine, and sand	11	26
Silt, calcareous, buff, and fine to medium sand	12	38
Silt and clay; calcareous, gray and buff; contains some fine sand. Much concretionary calcium carbonate in lower part	12	50
Gravel, fine, and sand; contains a small amount of medium gravel	12	62
Silt and clay; yellow-gray and gray; contains some fine sand	13	75
Silt, calcareous, buff; contains much very fine to medium sand	21	96
Sand, fine to coarse; contains some silt; buff	14	110
Sand, medium to fine	16	126
Clay, blue-gray	21	147
Gravel, fine, sand, and silt; light-gray	10	157
Gravel, fine to medium, and sand	46.5	203.5
PERMIAN—Leonardian		
Shale, red	6.5	210

21-12-25bb. *Sample log of test hole at the NW cor. sec. 25, T. 21 S., R. 12 W., Stafford County; drilled, 1945. Surface altitude, 1,819.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Sand, fine to medium, and silt; dark-gray to tan	8	8
Silt and fine to coarse sand; buff	14	22
Meade formation (Pleistocene)		
Sand, fine to coarse, and fine gravel; silty	18	40
Silt and fine to coarse sand; buff and yellow-gray; contains caliche	13	53
Gravel, fine, and sand	1	54
Silt, sandy, yellow-gray	6	60
Gravel, fine to coarse, and sand	12	72
Silt, yellow and white; contains sand and fine gravel	5	77
Gravel, fine to medium, and sand; contains some coarse gravel and layers of silt	62	139
Silt, light-gray and buff, and caliche	19	158
Silt, light blue-gray and buff; contains some sand and fine gravel	18	176
Gravel, fine to medium, and sand; contains some silt and a little coarse gravel	35	211
PERMIAN		
Shale, sandy, pink and red	9	220

21-12-27bb. *Sample log of test hole at the NW cor. sec. 27, T. 21 S., R. 12 W., Stafford County; drilled, 1943. Surface altitude, 1,841.1 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Silt and sand; buff, tan, gray, and white; contains caliche nodules in lower part	31	33
Meade formation (Pleistocene)		
Sand, fine to coarse	3	36
Silt, sandy, gray and buff; contains caliche nodules	14	50
Sand, fine to coarse	6	56
Silt, sandy, tan; contains some fine to medium gravel	7	63
Gravel, fine to coarse; contains much sand and some silt,	27	90
Gravel, fine, and fine to coarse sand	6	96
Silt, sandy, yellow and gray	3	99
Gravel, fine to coarse, and sand	19	118
Silt, sandy, gray and buff; contains some fine to medium gravel	15	133
Gravel, fine to medium, and fine to coarse sand	6	139
Silt, clayey and sandy, gray and yellow-gray	19	158
Gravel, fine to medium, and sand; silty	8	166
Silt, clayey and sandy, light-gray	30	196
Gravel, fine, and fine to coarse sand	1	197
Silt, sandy, light-gray	3	200
Gravel, fine, and sand	5.5	205.5
PERMIAN		
Siltstone and very fine-grained sandstone; dark-red	14.5	220

21-13-27db. *Driller's log of oil well (No. 1 Gates) in the Cen. NW¼ SE¼ sec. 27, T. 21 S., R. 13 W., Stafford County; drilled by the Atlantic Producing Company, 1933.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Meade formation		
(Samples missing)	8	8
Silt, sandy, yellow-tan	10	18
Silt, yellow tan, and fine to coarse sand	7	25
Sand, fine, to medium gravel	20	45
Sand, fine to coarse; contains little gravel	10	55
Sand, fine, to medium gravel; contains much tan silt	16	71
Sand, fine, to medium gravel; contains some coarse gravel in lower part	37	108
Sand, fine to medium	8	116
Sand, fine to medium gravel	8	124
Sand, fine, to medium	8	132
(Samples missing)	6	138
Sand and fine to medium gravel	2	140

	Thickness, feet	Depth, feet
Sand, fine to coarse; contains some fine to coarse gravel	16	156
Sand, fine to medium; contains some coarse sand and gravel	6	162
CRETACEOUS—Comanchean		
Kiowa shale		
Shale, sandy, dark-gray	8	170
Shale, sandy, dark-gray; contains pyrite and shell fragments	11	181
Cheyenne sandstone		
Sandstone, fine-grained, white	13	194
Sandstone, fine-grained, white; contains some dark-gray shale	11	205
Sandstone, very fine-grained, silty, white; contains carbonaceous material in lower part	10	215
Sandstone, fine-grained, white, and some dark-gray shale; contains pyrite and some yellow and red sandstone	30	245
PERMIAN		
Siltstone, sandy, red and mottled red and white	10	255
Sandstone, fine- to medium-grained, and siltstone; red	30	285

21-13-22bb. *Sample log of test hole at the NW cor. sec. 22, T. 21 S., R. 13 W., Stafford County; drilled, 1943. Surface altitude, 1,884.0 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Sand, fine to medium, silty	14	16
Meade formation (Pleistocene)		
Silt, sandy, white, gray, tan, and cream; contains caliche	9	25
Gravel, fine to coarse; contains much sand	21	46
Silt, sandy, gray and buff, and caliche	4	50
Gravel, fine to medium; contains some sand and a little caliche	6	56
Gravel, fine to coarse, sand, and silt; partially cemented by caliche	4	60
CRETACEOUS		
Dakota formation (Gulfian)		
Clay, silty, sandy, cream and green-gray	3	63
Sandstone, fine- to medium-grained, hard, yellow-tan	25	88
Clay and shale; yellow-gray, and brown and red-brown medium-grained hard sandstone; contains hematite	8	96
Kiowa shale (Comanchean)		
Clay, dark blue-gray; contains hematite and pyrite	14	110
Clay, gray, and black fissile shale; contains pyrite, thin beds of hard limestone, and shell fragments	20	130

21-13-24bb. *Sample log of test hole at the NW cor. sec. 24, T. 21 S., R. 13 W., Stafford County; drilled, 1945. Surface altitude, 1,861.5 feet.*

	Thickness, feet	Depth, feet
Soil, sandy, dark-gray	1.5	1.5
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Silt, blocky, gray	3.5	5
Sand, fine to coarse, silty, gray and tan	15	20
Meade formation (Pleistocene)		
Sand, fine to coarse; contains some fine to coarse gravel and silt	20	40
Gravel, fine to coarse, and sand; contains some gray-green silt	100	140
Gravel, fine to medium, and sand; contains some yellow and gray silt	16	156
CRETACEOUS—Comanchean		
Kiowa shale		
Shale, yellow-gray to dark blue-gray; contains shell bed and pyrite near base	13	169
Cheyenne sandstone		
Sandstone, fine-grained, white, and gray to white shale; contains pyrite and carbonaceous material	41	210
Clay, sandy, light greenish-gray, and very fine to fine sand	22	232
PERMIAN		
Siltstone, hard, light-gray, and red and light-gray shale,	28	260

21-14-20bb. *Sample log of test hole at the NW cor. sec. 20, T. 21 S., R. 14 W., Stafford County; drilled, 1943. Surface altitude, 1,940.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Sand, fine to coarse, silty, tan	6	6
Silt and sand; gray and tan	11	17
Meade formation (Pleistocene)		
Gravel, fine to medium, and fine to coarse sand; contains some coarse gravel and a few thin layers of buff silt	75	92
Silt, sandy, gray and buff	8	100
Sand, fine, to medium gravel	3	103
Silt, sandy, buff	31	134
Gravel, fine; contains sand and silt	5	139
Silt, sandy, buff	9	148
Gravel, fine to medium; contains some coarse gravel, sand, and silt	26	174
Silt, sandy, blue-gray and buff	11	185
CRETACEOUS—Comanchean		
Kiowa shale		
Clay, blue-gray, gray, hard siltstone, and gray hard sandstone; contains some limestone and shell fragments	11	196

	Thickness, feet	Depth, feet
Clay, light-gray, and dark-gray fissile shale; contains some gray hard sandstone	14	210
Shale, fissile, dark-gray; contains pyrite and shell fragments	5	215

22-11-5dc3. *Sample log of test hole at the SW cor. SE¼ sec. 5, T. 22 S., R. 11 W., Stafford County; drilled, 1945. Surface altitude, 1,772.6 feet.*

	Thickness, feet	Depth, feet
Road fill and dark-gray sandy soil	2	2
QUATERNARY—Pleistocene		
Meade formation		
Sand, fine, to medium gravel, and silt; yellow-buff and light-gray	8	10
Gravel, fine, and sand	4	14
Silt, sandy, gray to buff	19	33
Sand, fine to coarse; contains some fine to coarse gravel and buff silt	21	54
CRETACEOUS—Comanchean		
Cheyenne sandstone		
Shale, sandy, yellow and green-gray	5	59
Sandstone, very fine- to fine-grained, silty, light blue-gray, interbedded with light blue-gray shale	16	75
PERMIAN		
Shale, sandy, red-brown	1	76
Sandstone, fine-grained, light-gray, and blue-gray, pink, and red-brown shale	14	90
Shale, sandy, red brown, and fine- to medium-grained sandstone	20	110

22-11-7bbb. *Partial sample log of oil test (No. 1 Wolf) at the SW cor. NW¼ NW¼ NW¼ sec. 7, T. 22 S., R. 11 W., Stafford County, drilled by the Shell Oil Company, 1943.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Meade formation		
Sand, fine to coarse, tan	20	20
Sand, coarse, tan; contains some fine to medium sand and fine gravel	5	25
CRETACEOUS—Comanchean		
Cheyenne sandstone		
Sandstone, very fine-grained, micaceous, white, and some tan, brown, red, and yellow very fine-grained sandstone	45	70
PERMIAN		
Siltstone, red-brown; contains some very fine sand	20	90

22-11-28bc. *Sample log of test hole at the SW cor. NW¼ sec. 28, T. 22 S., R. 11 W., Stafford County; drilled, 1945. Surface altitude, 1,818.8 feet.*

	Thickness, feet	Depth, feet
Road fill and gray sandy soil	2	2

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Silt and sand; tan and light-gray; contains some fine gravel in lower part	20	22
Meade formation (Pleistocene)		
Gravel, fine to medium, sand, and silt; tan	2	24
Silt, tan; contains sand and fine to medium gravel	4	28
Gravel, fine, and sand; contains much silt and a few pebbles of Cretaceous rocks	28	56
CRETACEOUS—Comanchean		
Cheyenne sandstone		
Sandstone, very fine- to fine-grained, argillaceous, light-gray, and yellow sandy shale	7	63
Shale, sandy, light blue-gray and yellow; contains thin beds of sandstone	13	76
PERMIAN		
Shale, sandy, red and light-gray	14	90

22-12-23cc. *Sample log of test hole at the SW cor. sec. 23, T. 22 S., R. 12 W., Stafford County; drilled, 1945. Surface altitude, 1,854.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Sand, fine to medium, silty	6	6
Meade formation (Pleistocene)		
Silt, brown, gray, and yellow buff, and fine to coarse sand	29	35
Silt and fine to coarse sand; contains some fine gravel in lower part	25	60
Sand, fine to coarse gravel	14	74
Silt, buff, and fine to medium sand; contains a few cemented beds	26	100
Sand, fine, to coarse gravel	13	113
Silt and fine to coarse sand; contains some fine to medium gravel in lower part	9	122
Silt and clay; sandy, light-gray and yellow-gray	5	127
Sand, fine to coarse, silty; contains some fine to medium gravel	23	150
Gravel, fine to medium, and sand	8	158
PERMIAN		
Shale, red; contains some gray sandstone	10	168

22-13-22cc. *Sample log of test hole at the SW cor. sec. 22, T. 22 S., R. 13 W., Stafford County; drilled, 1943. Surface altitude, 1,897.4 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Silt and sand; tan and yellow-gray	6	8

	Thickness, feet	Depth, feet
Sand, fine to coarse, silty, tan	7	15
Meade formation (Pleistocene)		
Silt and fine to coarse sand; tan, buff, and white; contains caliche in lower part	15	30
Sand, fine to coarse, silty, white; contains caliche	10	40
Gravel, fine to coarse, and sand	65	105
Silt, clayey, micaceous, green-gray	2	107
Gravel, fine to coarse, and sand; contains a few layers of silt	83	190
CRETACEOUS—Comanchean		
Cheyenne sandstone		
Sandstone, fine-grained, white, greenish-gray, and light-yellow; contains some silt and pellets of brown hard sandstone	30	220
Siltstone and sandstone, fine-grained; light buff and white	20	240
Sandstone, silty, blue-gray	18	258
PERMIAN		
Shale, silty, dull-red, and red-brown and blue-gray medium-grained hard sandstone	12	270

22-14-17baa. *Partial sample log of oil test (No. 1 Pinkston) in the center NE¼ NE¼ NW¼ sec. 17, T. 22 S., R. 14 W., Stafford County; drilled by Kessler and Simpson. Approximate surface altitude, 1,955.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Meade formation		
(No sample)	30	30
Sand, fine, to medium gravel; contains some silt layers	80	110
Gravel, medium to coarse, and sand; contains some silt	60	170
Gravel, coarse; contains some medium sand to medium gravel and silt. Includes many pebbles of brown sandstone and "ironstone"	35	205
CRETACEOUS—Comanchean		
Kiowa shale		
Shale, dark-gray to black; contains pyrite and shell fragments	35	240
Sandstone, very fine-grained, gray, brown, and red-brown, and some gray shale. Contains pyrite and shell fragments	30	270
Cheyenne sandstone		
Sandstone, very fine-grained, white to light-gray; contains pyrite	33	303
PERMIAN		
Siltstone, sandy, red	7	310

22-14-32cc. *Sample log of test hole at the SW cor. sec. 32, T. 22 S., R. 14 W., Stafford County; drilled, 1943. Surface altitude, 1,966.3 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Silt and sand; gray, brown, and buff	28	30
Meade formation		
Silt, yellow-gray and gray; contains some fine sand to coarse gravel	10	40
Silt, sandy, white and yellow	2.5	42.5
Gravel, fine to medium, and sand	25.5	68
Clay, silty, yellow-gray, and caliche	7	75
Silt, gray and tan; contains some fine to coarse sand and fine to coarse gravel	7	82
Gravel, medium to very coarse; contains some sand and fine gravel	8	90
CRETACEOUS—Comanchean		
Kiowa shale		
Clay, silty, light blue-gray and yellow-buff; contains hematite from 98 to 100 feet	10	100
Clay and shale; gray, blue-gray, and buff; contains a few thin beds of gray hard limestone	50	150
Clay and shale; gray, and gray fine-grained sandstone; contains shells from 152 to 153 feet	10	160
Clay, gray-white, and some black fissile shale; contains pyrite	10	170
Clay and shale; light-gray to black; contains some fine to medium sand	75	245
Cheyenne sandstone		
Clay and fine sand; gray-white; contains a few pellets of medium-grained hard sandstone	15	260

23-13-12aa. *Sample log of test hole at the NE cor. sec. 12, T. 23 S., R. 13 W., Stafford County; drilled, 1945. Surface altitude, 1,862.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Sand, fine to medium	4	4
Meade formation (Pleistocene)		
Silt, sand, and gravel; poorly sorted	5	9
Gravel, fine to coarse, and sand; contains some light-gray and brown silt	115	124
Silt, gray buff; contains caliche	19	143
Gravel, fine to coarse, and sand; silty	24	167
CRETACEOUS—Comanchean		
Cheyenne sandstone		
Sandstone, fine- to medium-grained; contains some yellow and light-green clay	25	192
Shale, sandy, blue-gray	2	194
PERMIAN		
Shale, sandy, red-brown, blue-gray, and pink	6	200

23-13-22bb. *Sample log of test hole at the NW cor. sec. 22, T. 23 S., R. 13 W., Stafford County; drilled, 1943. Surface altitude, 1,873.5 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY—Pleistocene		
Meade formation		
Silt, sandy, gray-buff; contains caliche nodules	3	4
Gravel, fine to coarse, and sand; contains some silt	13	17
Silt, sandy, gray	2	19
Gravel, fine to coarse, and sand	44	63
Silt, clayey, buff; contains some fine gravel, sand, and caliche nodules	6	69
CRETACEOUS—Comanchean		
Kiowa shale		
Shale, clayey, light-gray and yellow-gray; contains gypsum	21	90
Shale, fissile, gray-black to black; contains thin shell beds and some sandstone	40	130
Cheyenne (?) sandstone		
Clay, gray-white, and white fine-grained hard sandstone	3	133
PERMIAN		
Shale, red-brown	12	145
Clay and fine-grained sandstone; gray-white	5	150
Shale, red-brown	5	155

23-13-28ca. *Driller's log of irrigation well of J. B. O'Conner in the NE¼ SW¼ sec. 28, T. 23 S., R. 13 W., Stafford County; drilled in 1937. Surface altitude, 1,896.9 feet.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY—Pleistocene		
Meade formation		
Clay	8	10
Sand, fine, grading downward into very coarse gravel	48	58
Clay	0.5	58.5

24-11-5aa. *Sample log of test hole at the NE cor. sec. 5, T. 24 S., R. 11 W., Stafford County; drilled, 1943. Surface altitude, 1,822.6 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Silt, gray and gray-brown	5	6
Silt and sand; gray, gray-brown, tan, and yellow	22	28
Meade formation (Pleistocene)		
Gravel, fine to medium, and sand	18	46

	Thickness, feet	Depth, feet
Silt, sandy, gray and gray-brown; contains caliche.....	10	56
Silt, sandy, yellow, buff, and gray; contains some fine to medium gravel and caliche.....................	24	80
Gravel, fine to medium, and sand; contains caliche and many pebbles of "ironstone"......................	22	102
PERMIAN		
Shale, silty, brick-red and green-gray..................	8	110

24-11-25dd. *Sample log of test hole at the SE cor. sec. 25, T. 24 S., R. 11 W., Stafford County; drilled, 1943. Surface altitude, 1,771.0 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Meade formation		
Silt, sandy, tan	16	18
Clay, light-gray	2	20
Gravel, fine to coarse, and sand; contains a few pebbles,	28	48
Silt, sand, and gravel; poorly sorted..................	5	53
Gravel, fine to medium, and sand.....................	4	57
Silt, sandy, buff	4	61
Gravel, fine to medium, and sand.....................	3	64
Silt, clayey, yellow	6	70
Gravel, fine to coarse, and sand......................	20	90
Sand, fine to coarse; contains some fine to medium gravel and some light-gray silt.....................	22	112
PERMIAN		
Shale, silty, dull red................................	3	115

24-11-28dd. *Sample log of test hole at the SE cor. sec. 28, T. 24 S., R. 11 W., Stafford County; drilled, 1945. Surface altitude, 1,791.9 feet.*

	Thickness, feet	Depth, feet
Road fill and soil; gray brown.......................	3	3
QUATERNARY—Pleistocene		
Meade formation		
Silt and fine to coarse sand; tan to light-gray; contains some fine to medium gravel in lower part......	24	27
Gravel, fine to coarse, and sand; contains some silt and many pebbles	6	33
Silt and sand, fine to coarse; contains some fine to coarse gravel from 50 to 60 feet..........................	27	60
Gravel, fine to coarse, and sand; silty.................	10	70
Silt, buff and greenish-gray; interbedded with silty sand and gravel	25	95
Gravel, fine to medium, and sand.....................	3	98
Silt, buff	4	102
Gravel, fine to medium, and sand.....................	2	104
PERMIAN		
Shale, sandy, red and yellow-gray....................	9	113
Shale, sandy, red-brown and blue-gray; contains some gray-white fine-grained sandstone	37	150

24-12-34bb. *Sample log of test hole at the NW cor. sec. 34, T. 24 S., R. 12 W., Stafford County; drilled, 1943. Surface altitude, 1882.1 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Silt and fine to medium sand; gray, gray-brown, and yellow	8	10
Meade formation (Pleistocene)		
Silt, sandy, tan and gray; contains some fine gravel	10	20
Silt, buff and gray; contains fine to coarse sand	20	40
Silt, yellow buff; contains fine to medium gravel and sand	8	48
Gravel, fine to coarse, and sand; contains some yellow silty clay in lower part	25	73
Silt and clay; light-gray, gray, and buff; contains some caliche	47	120
Silt, clayey and sandy, gray; contains caliche	17	137
Gravel, fine to medium, and sand	6.5	143.5
CRETACEOUS—Comanchean		
Cheyenne sandstone		
Siltstone, light greenish-gray; contains some fine to medium sand and gray fine- to medium-grained hard sandstone	47.5	191
PERMIAN		
Shale, silty, red-brown and blue-gray	19	210

24-14-31bb. *Sample log of test hole at the NW cor. sec. 31, T. 24 S., R. 14 W., Stafford County; drilled, 1943. Surface altitude, 1,999.1 feet.*

	Thickness, feet	Depth, feet
Soil, sandy, gray-brown	2	2
QUATERNARY—Pleistocene		
Meade formation		
Silt and sand; tan and gray	16	18
Silt and fine to coarse sand; buff and white; contains some fine gravel and caliche	12	30
Sand, fine, to medium gravel; contains some silt and caliche	30	60
Gravel, fine to medium, and sand	22	82
Sand, fine to medium, silty; contains caliche and some fine to medium gravel	8	90
Silt, sandy, gray-buff; contains caliche	45	135
Sand, fine to coarse, and buff silt	5	140
Sand, fine to coarse, and fine gravel	9	149
Silt, sandy, buff; contains caliche	4	153
CRETACEOUS—Comanchean		
Kiowa shale		
Clay, blue-gray, and a few thin shell beds; contains pyrite	17	170
Clay, gray, and dark-gray fissile shale; contains a shell bed from 189.5 to 190 feet	20	190

	Thickness, feet	Depth, feet
Shale, fissile, gray to black; contains many shells	50	240
Cheyenne sandstone		
Clay and silt, and fine-grained hard sandstone; gray	9	249
Siltstone and fine-grained sandstone; white; contains some blue-green siltstone	6	255
PERMIAN		
Siltstone, brown-red; contains gypsum	5	260
Claystone, silty, dull-red	20	280

24-15-30cc. *Sample log of test hole at the SW cor. sec. 30, T. 24 S., R. 15 W., Stafford County; drilled, 1943. Surface altitude, 2,053.1 feet.*

	Thickness, feet	Depth, feet
Soil, sandy, gray-brown	3	3
QUATERNARY—Pleistocene		
Meade formation		
Silt and fine to coarse sand; gray and tan	23	26
Gravel, fine, and sand	4	30
Silt, sandy, tan and gray-white, interbedded with fine to coarse gravel	30	60
Gravel, fine to medium, and sand	6	66
Silt, sandy, gray; contains caliche	1	67
Gravel, fine to medium, and sand	9	76
Silt, sandy, gray and tan	4	80
Gravel, fine to medium, and sand	7	87
Silt, sandy, buff; contains caliche	50	137
Gravel, fine to medium, and sand; contains some silt	5	142
CRETACEOUS—Comanchean		
Kiowa shale		
Sandstone, medium-grained, hard, brown	8	150
Clay, light to dark-gray, and gray shale; contains thin beds of gray hard limestone	30	180

25-11-33aa. *Sample log of test hole at the NE cor. sec. 33, T. 25 S., R. 11 W., Stafford County; drilled, 1943. Surface altitude, 1,821.4 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY—Pleistocene		
Meade formation		
Silt, clayey, gray-buff and yellow; contains some fine to medium sand and caliche	24	25
Gravel, fine to coarse, and sand	55	80
Silt and fine to coarse sand; buff	3	83
Gravel, fine to medium, and sand; contains some coarse gravel and a few layers of yellow and buff silt	61	144
Silt and fine to coarse sand; buff and white; contains caliche	16	160
Silt, clayey, sandy, pink-brown	3	163
Gravel, fine to medium, and sand; silty	10	173
PERMIAN		
Shale, brownish-red, and some light-gray shale	7	180

25-13-33aa. *Sample log of test hole at the NE cor. sec. 33, T. 25 S., R. 13 W., Stafford County; drilled, 1943. Surface altitude, 1,925.8 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Meade formation		
Silt, sandy, yellow, gray, and buff; contains some caliche,	27	29
Gravel, fine to coarse, and sand	7	36
Silt, soft, white	2	38
Gravel, fine to coarse, and sand	6	44
Silt and fine to coarse sand; buff	5	49
Gravel, fine, and sand	5	54
Silt, sandy, gray-buff	3	57
Sand, fine to medium, loosely cemented	3	60
Gravel, fine, and sand	5	65
Silt, sandy, buff and gray-green; contains some caliche	10	75
Gravel, fine to medium, and sand	61	136
Silt and fine to coarse sand; gray-buff	13	149
Gravel, fine to medium, and sand	5	154
Silt and fine to coarse sand; buff	2	156
Gravel, fine to medium, and sand	25	181
PERMIAN		
Shale, brick-red; contains some light-gray shale and gray-white fine-grained sandstone	9	190

25-15-33dd. *Sample log of test hole at the SE cor. sec. 33, T. 25 S., R. 15 W., Stafford County; drilled, 1943. Surface altitude, 2,026.9 feet.*

	Thickness, feet	Depth, feet
Soil, sandy, brown	3	3
QUATERNARY		
Dune sand (Pleistocene and Recent)		
Silt and fine to coarse sand; tan and gray	7	10
Meade formation (Pleistocene)		
Gravel, fine to coarse; contains some sand and silt	10	20
Silt, sandy, gray-white, buff, and gray-brown; contains some fine to medium gravel and caliche	14	34
Gravel, fine to coarse, and sand; contains a few layers of gray-brown, yellow, and buff silt	72	106
Silt and fine to coarse sand; light-tan and buff	27.5	133.5
Gravel, fine to medium, and sand	28.5	162
Silt and fine to coarse sand; tan and gray	15	177
Gravel, fine to medium	9	186
Silt and fine to coarse sand; gray	1	187
Gravel, fine to medium, and sand; silty	18	205

	Thickness, feet	Depth, feet
Silt, sandy, gray	4	209
Gravel, fine to medium, and sand	11	220
CRETACEOUS—Comanchean		
Kiowa shale		
Clay, dark-blue gray, gray fissile shale, and thin beds of gray fine-grained sandstone	10	230
Shale, fissile, black; contains some pyrite	11	241
Cheyenne sandstone		
Sandstone, fine-grained, hard, white and gray white; contains some white siltstone and pyrite	9	250
Siltstone, sandy, white	4	254
PERMIAN		
Shale, silty, brick-red	6	260

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AREAL GEOLOGY OF BARTON AND STAFFORD COUNTIES, KANSAS

With Water-Table Contours

State Geological Survey of Kansas

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Plate 1

MAP OF BARTON AND STAFFORD COUNTIES, KANSAS

Showing the Location of Wells for which Records are given

by Bruce F. Latta

1942, 1944

State Geological Survey of Kansas

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Plate 2

Base modified from map prepared by State Highway Commission of Kansas

Drainage from aerial photographs of the U. S. Dept. of Agriculture

State Geological Survey of Kansas

GEOLOGIC CROSS SECTIONS IN BARTON AND STAFFORD COUNTIES, KANSAS

by Bruce F. Latta