Geology and Ground-Water Resources of Scott County, Kansas

By

HERBERT A. WAITE

UNIVERSITY OF KANSAS PUBLICATIONS
STATE GEOLOGICAL SURVEY OF KANSAS
Bulletin 66
1947

THE UNIVERSITY OF KANSAS
STATE GEOLOGICAL SURVEY OF KANSAS

BULLETIN 66

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By HERBERT A. WAITE

with analyses by

ELZA H. HOLMES

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

Printed by authority of the State of Kansas
Distributed from Lawrence

UNIVERSITY OF KANSAS PUBLICATIONS

JULY, 1947

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1947

21-6532

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CONTENTS

ILLUSTRATIONS

TABLES

GEOLOGY AND GROUND-WATER RESOURCES OF SCOTT COUNTY, KANSAS

By Herbert A. Waite

ABSTRACT

This report describes the geography, geology, and ground-water resources of Scott County in southwestern Kansas. Scott County embraces a total of 723 square miles, and had a population of 3,769 in 1945. About 85 percent of the county consists of upland plains and the remainder of stream flood plains and intermediate slopes. It is drained by Beaver (Ladder) Creek in the northwestern part of the county and by tributaries of Smoky Hill River in the northern part. The most unusual topographic feature is the large depressional area southeast of Scott City at the terminus of Whitewoman Creek known as the Scott Basin—a part of a broad shallow asymmetrical depression extending southward into the Finney Basin in Finney County. The climate is semiarid, the average annual precipitation being about 20 inches. Wheat farming, some cattle raising, and general farming are the principal occupations in the area. Irrigation is practiced extensively in the Scott Basin.

The exposed rocks are sedimentary and range in age from Upper Cretaceous to Recent. A map showing the rock formations that crop out in the county is included with the report. Most of the county is underlain by Quaternary and Tertiary sands and gravels. In the northern part of the county tributary streams have cut below the Tertiary sediments and exposed Cretaceous shales and limestones (Niobrara formation). In the southeastern part of the county the presence of a Cretaceous bedrock high is revealed by exposures of chalk and chalky shale of the Niobrara in shallow draws tributary to Dry Lake, an undrained depressional area near the southeastern corner of the county.

The principal water-bearing formations in Scott County are the Pliocene (Ogallala formation) and undifferentiated Pleistocene deposits. A few wells obtain water from shallow alluvium along the principal stream valleys and a few others obtain water from the Niobrara formation in the southeastern quarter of the county.

The report contains a map of the area showing by means of shading the depth to water level. The water table ranges in depth from less than 25 feet to about 160 feet in the upland areas in the northern part of the county. A map showing the shape and slope of the water table by contours is also included with the report. This map shows that ground water moves through Scott County in an easterly direction, the average slope being about 10 feet to the mile in the northern half of the county and about 6 feet to the mile in the southern part of the county in the vicinity of Shallow Water. In the northeastern quarter of the county the contours show that the water table slopes northeastward, and in the southeastern part of the county the contours show that the direction of movement is in a southeast direction. The contours also show that a cone of depression exists in the vicinity of the heavily-pumped area southwest of Scott City.

The ground-water reservoir is recharged principally by precipitation that falls within the area, by the addition of water from flood runoff from Whitewoman Creek that spreads out at its terminus onto the floor of the Scott Basin, and by ground water moving in from adjacent areas. Ground water is discharged from the ground-water reservoir by pumpage from wells; by movement eastward, northeastward, and southeastward into adjacent areas; by evaporation and transpiration in areas of shallow water table; and by seepage into Beaver (Ladder) Creek and other tributary streams in the northern part of the county. All of the domestic, stock, public, industrial, and irrigation water supplies are obtained from wells.

Most of the wells in the area are drilled, but a few are dug. Records of 131 irrigation wells in Scott County were obtained. In 1945 a total of 129 wells supplied 18,400 acre-feet of water to irrigate 21,002 acres of land.

The ground water in Scott County, although generally hard, is suitable for most ordinary uses. The waters from the Pliocene (Ogallala formation) and undifferentiated Pleistocene deposits are similar in composition and hardness. Water from the alluvium was slightly harder than from the two sources mentioned above.

The field data upon which most of this report is based are given in tables which include records of 282 wells and springs and chemical analyses from 29 representative wells and one typical spring. Logs of 77 test holes, water wells, and oil and gas wells in or adjacent to the county, including 23 test holes put down by the State Geological Survey, are given.

INTRODUCTION

Purpose and Scope of the Investigation

The investigation upon which this report is based is part of an extended program of ground-water investigations in Kansas begun in July 1937 by the United States Geological Survey and the State Geological Survey of Kansas in coöperation with the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture. The Investigation in Scott County is similar to studies that have been completed or are being conducted in other counties in southwestern Kansas. Studies of this type are important because of the progressive increase in the use of ground water for irrigation in this part of the State as a result of a prolonged period of subnormal precipitation from 1932 to 1939. Pumping from wells for irrigation has been practiced for many years in favorable areas in western Kansas. These new ground-water developments cannot be expanded indefinitely without causing overdevelopment. Investigations of the geology and ground-water resources of such areas should show to what extent the ground-water supplies will be perennial. In this connection systematic observations of water-levels in carefully selected wells have been and are being made in order to determine the changes in ground-water storage and to check preliminary conclusions as to the safe yield of the water-bearing formations. This report gives the results of a study of the geology and ground-water resources of Scott County that was begun in September 1939.

The shallow-water basin in central-southern Scott County and the adjacent part of northern Finney County is quite well known because ground water is obtainable from irrigation wells at reasonably shallow depths. The development and use of ground water for irrigation in that part of the basin lying in Scott County began about 1910 and reached its peak during the last decade as a result of a prolonged period of subnormal precipitation. According to records of the Division of Water Resources of the State Board of Agriculture, the irrigated acreage in the Scott shallow-water basin has increased from 1,021 acres in 1932 to 21,320 acres in 1943. At the end of 1936 there were approximately 30 operating irrigation wells in the area, whereas in 1945 there were 129.

Location and Extent of the Area

Scott County lies in the third tier of counties east of the western border of the state and about midway between the north and south borders; it embraces a total of 723 square miles. Its location with respect to adjoining counties is shown by Figure 1.

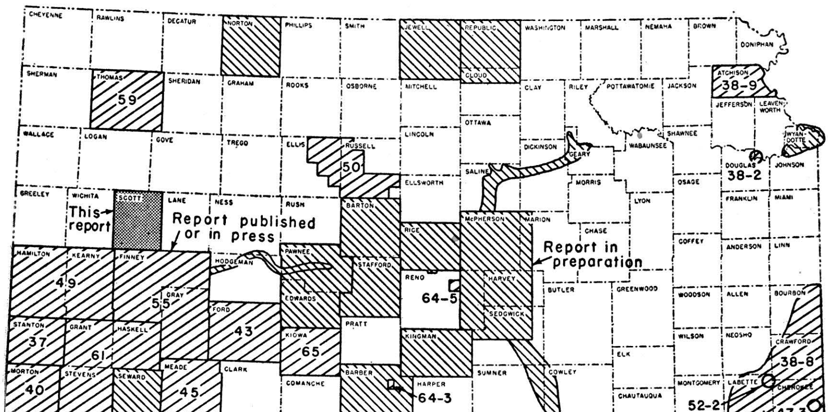


Fig. 1. Area covered by this report and other areas in Kansas for which cooperative ground-water reports have been published or are in preparation.

Previous Investigations

The more important studies dealing with the geology and ground-water resources of southwestern Kansas that have a bearing on Scott County are cited below. Specific references are cited at appropriate places in the text by author and date of issue and are listed in the bibliography at the end of the report.

In 1892, Colonel Nettleton (1892, pp. 26-27, appendix No. 10) reported on the results of some underflow surveys along the Arkansas River Valley including a discussion and plat of a north-south profile of the water table extending from Beaver or Ladder Creek near Scott City south through Garden City to an abandoned post office called Loco. In 1897, Haworth (1897, p. 94 and pp. 110-112; 1897a) made reference to geologic and hydrologic conditions in parts of Scott County. Two other papers were contributed by Haworth in 1897, one (1897b) on the physiography of western Kansas and the other (1897c) on the physical properties of the Tertiary rocks in Kansas. Johnson's report on the utilization of the High Plains (1901) dealt with the physiography, underground waters, and the land economy of the High Plains. A second report (Johnson, 1902) contained conclusions and a summary of the first paper. In 1905, Darton (1905, p. 316) published a preliminary report on the geology and ground-water resources of the central Great Plains, in which he made brief reference to Scott County. In 1911 a report which contained a brief reference to the chemical quality of several waters collected in Scott County was published by Parker (1911, pp. 179-180). A report that contained the results of a reconnaissance soil survey of the western half of Kansas, including Scott County, was published by Coffey and Rice in 1912. Haworth (1913, pp. 61, 66-68) contributed a report on well waters in southwestern Kansas in which specific reference was made to Scott County. In 1931 the Division of Water Resources of the Kansas State Board of Agriculture published a report (Anon., 1931) that contained a description of some of the most common types of pumping plants in Kansas with approximate costs of construction. In 1933, Moss described briefly the ground-water resources of the shallow-water basin in Scott and Finney Counties. In 1935, Theis, Burleigh, and Waite (1935) described briefly the water-bearing formations and the availability of ground water in the southern High Plains. In the same year a popular bulletin (Landes, 1935) containing a brief description of Scott County State Park was published. In 1936 a report on irrigation with ground water in the

Scott County, Kansas, area by Burleigh (1936) was released confidentially. A report by Throckmorton and others (1937, pp. 69-71) on the agricultural resources of Kansas including important statistical data for Scott County was published in 1937. In 1938, the Division of Water Resources of the Kansas State Board of Agriculture published a report (Anon., 1938) containing the results of tests of deep-well pumping plants with special attention to fuel consumption. Several of the plants tested are located in Scott County. In 1939, Davison (1939) contributed a report on the construction and costs of irrigation pumping plants in Kansas. Also in 1939, McCall and Davison (1939) contributed a report on the costs of pumping for irrigation that includes data on several tests of irrigation pumping plants in Scott County. A report (Meinzer and Wenzel, 1940, pp. 184-198) on water levels and artesian pressures in the United States in 1939, which contains a chapter on the observation well program in Scott County, was published in 1940. Similar reports have been published for the years 1940, 1941, and 1942 (Meinzer and Wenzel, 1942, pp. 152-163; 1943, pp. 132-139; and 1944, pp. 153-158), and additional reports of this series will be published annually. In 1940, Moore prepared a generalized report on the ground-water resources of Kansas which includes a section on Scott County. A report by Smith (1940) includes several references to the geology of Scott County. In 1939 and 1940 McLaughlin (1943) made a study of the geology and ground-water resources of Hamilton and Kearny Counties adjoining the southwest corner of Scott County. In 1939 and 1940 Latta (1944) made a study of the geology and ground-water resources of Finney and Gray Counties which border Scott County on the south. Other county reports describing the geology and ground-water resources of southwestern counties include Stanton County (Latta, 1941), Morton County (McLaughlin, 1942), Ford County (Waite, 1942), and Meade County (Frye, 1942). In 1942 Bird made reference to ground-water conditions in the Scott County shallow-water basin in a report on the western ground waters and food production. A geologic map of Kansas, which includes Scott County, was prepared under the supervision of Moore and Landes in 1937. In 1941, I (Waite, 1941) contributed a paper on the cause of the decline in ground-water levels in Scott County. A report on the availability of ground-water supplies in Kansas for national defense industries (Lohman and others, 1942, pp. 37-39) that includes a discussion of a part of Scott County was published in 1942. A report (McCall, 1944) on the growth of irrigation in Scott County was prepared by the Kansas State Board of Agriculture in 1944. Moore, Frye, and Jewett prepared a tabular description of all outcropping rocks in the state in 1944. In 1945 (Edson) the State Geological Survey of Kansas published a subsurface geologic cross section that extends through Scott County.

Methods of Investigation

Most of the field work upon which this report is based occupied about 1 month in the fall of 1939 and about 3½ months in the summer and fall of 1940. Approximately 282 wells in the county were visited and the total depth and depth to water level below land surface in most of them were measured with a steel tape. Well owners and drillers were interviewed regarding the nature and thickness of the water-bearing formations penetrated by the wells, and all available logs were collected. Records of wells that furnish public, domestic, and irrigation supplies were collected. Information regarding the yield, drawdown, temperature, chemical character, and use of ground water was obtained. Since 1931 an annual survey of the acreage irrigated has been made by Kenneth McCall, Melvin Scanlan, or Howard Palmer of the Division of Water Resources, State Board of Agriculture.

Samples of water were collected from 29 representative wells and 1 spring and were analyzed by Elza H. Holmes, chemist, in the Water and Sewage Laboratory of the Kansas State Board of Health at Lawrence. In addition an analysis of water from the public supply at Scott City (well 112) was furnished by the Kansas State Board of Health, making a total of 30 analyses for Scott County.

During the investigation 23 test holes (Fig. 2) were put down at strategic points in Scott County by Ellis Gordon, Perry McNally, and Laurence Buck with a portable hydraulic-rotary rig owned by the State Geological Survey. Samples of drill cuttings were collected and studied in the field by Perry McNally and were examined later in the office under binocular microscope.

Altitudes of the measuring points at 207 wells and at each of the test holes put down by the drilling rig were established with a Dumpy level. The levels were run from elevations established in 1938 and 1939 by the Topographic Branch of the U. S. Geological Survey and in part from bench marks of the United States Coast and Geodetic Survey by me assisted by J. Milton Sears and Richard B. Christy. The water-table contour map (Pl. 1) is based upon these altitudes together with the measured depths to water-level in wells.

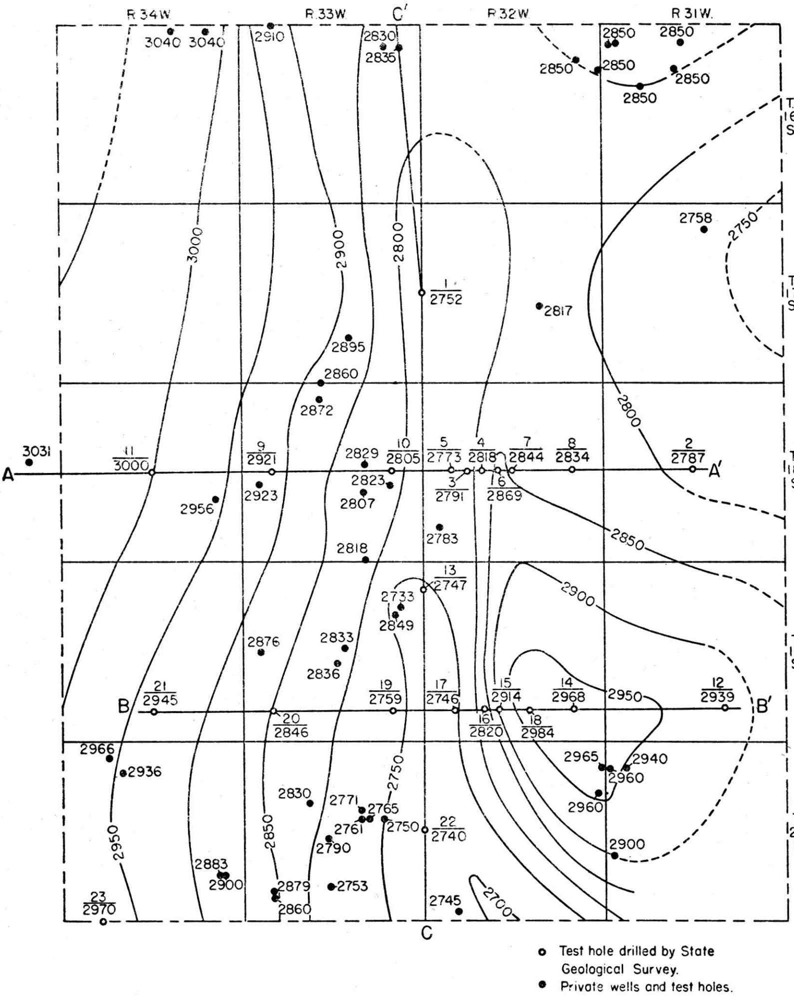


FIG. 2. Configuration of the pre-Tertiary surface of Scott County by means of contours, location of test holes, and locations of cross sections shown in Figure 5.

Field data were compiled on preliminary topographic sheets of the U. S. Geological Survey and on an ownership map of Scott County. The base maps for Plates 1 and 2 were prepared from a county map compiled by the State Highway Department. The locations of the roads were corrected from observations in the field and the drainage was corrected from aerial photographs obtained from the United States Department of Agriculture, Agricultural Adjustment Administration.

The areal geology shown in Plate 1 was compiled from field studies supplemented by use of the aerial photographs and by available geologic reports. The boundaries of the areas of dune sand were taken from aerial photographs supplemented by observations in the field.

The locations of all wells for which descriptions are given in the tables of well records are shown in Plate 2. Two numbers are shown opposite each well symbol, the upper one corresponding with that used in the well tables in the text, and the lower one corresponding with the depth to water level below the land surface.

The wells are numbered consecutively by townships from north to south and by ranges from east to west. Within each township the wells are numbered in the same order as the sections. Within each section the wells are numbered in the sequence of the sixteen 40-acre tracts into which sections are divided by the General Land Office, as shown in the explanation of Plate 2.

At the beginning of the field investigation 29 observation wells were selected at strategic points throughout the county and monthly measurements of the water levels in them were begun in order to obtain essential information concerning the effects of recharge and depletion of the ground-water reservoir. Two wells of this group were equipped with automatic water-stage recorders during the period from September 1939 to July 1941 for the purpose of obtaining continuous records of water-level fluctuation. The Division of Water Resources of the State Board of Agriculture has maintained similar records on 2 other wells in the same area for several years. The water levels have been observed continuously in one of the wells since October 23, 1931, and in the other since April 18, 1934. A third well was constructed and equipped with a continuous recorder in August 1940 by the Division of Water Resources after the water level in the well with the oldest record was lowered as a result of pumping from a new irrigation well that was drilled near by. These water-level records have proven invaluable in interpreting the trends in movement of water levels in the Scott Basin and in determining the effects of pumpage and of subnormal precipitation during the last several years.

Acknowledgments

The writer is indebted to the many residents of the county who readily gave permission to measure their wells and who supplied helpful information regarding them. Special acknowledgment should be given to the fine coöperation of all the well drillers in the county for making available to the writer well logs and in some cases samples of water-bearing materials. George S. Knapp, Chief Engineer of the Division of Water Resources, Kansas State Board of Agriculture, made available unpublished data relating to wells and assigned members of his staff to make an irrigated acreage survey in collaboration with me and to conduct pumping tests on several irrigation wells. He has made many helpful suggestions regarding the preparation of this report and has assisted in its preparation in many ways. Harold T. U. Smith, of the Department of Geology, University of Kansas, made many helpful suggestions both in the field and in the office. Claude W. Hibbard, formerly curator of vertebrate paleontology of the Dyche Museum of Natural History, University of Kansas, identified vertebrate and invertebrate material collected in Scott County. Identifications of Pleistocene fresh-water mollusks collected in Scott County were made by A. Byron Leonard, associate professor, Department of Zoölogy, University of Kansas. The writer is indebted to Mr. Knapp and to members of the Geological Survey office in Lawrence for assistance during the completion of this report.

Acknowledgment for helpful information is given to the following persons: Myron F. Robbins, John Boyer, Howard A. Geer, W. A. Laughlin, Thomas L. Sherry, and Claude Beckley, all of Scott City.

The manuscript for this report has been reviewed critically by several members of the Federal Geological Survey; Raymond C. Moore, State Geologist and Director of Research, and John C. Frye, Executive Director, State Geological Survey of Kansas; George S. Knapp, Chief Engineer, and Robert Smrha, Assistant Chief Engineer, Division of Water Resources of the Kansas State Board of Agriculture; and Paul D. Haney, Director, and Ogden S. Jones, Geologist, Division of Sanitation of the Kansas State Board of Health. The illustrations were drafted by Robyn Ashby Addis of the Kansas Geological Survey and W. W. Wilson and Murl H. Rush, Jr., of the Federal Geological Survey. The manuscript was edited by Betty J. Hagerman of the Kansas Geological Survey.

GEOGRAPHY

Topography and Drainage

Scott County is situated in the Great Plains physiographic province, some of the eastern part of the county falling within the subdivision known as the Plains Border section (Fenneman, 1930). About 85 percent of the county consists of upland plains and 15 percent of stream flood plains and intermediate slopes. The upland plain slopes slightly south of east from altitudes of about 3,170 feet along the western boundary at a point about 1 mile south of the northwest corner of the county to about 2,900 feet along the eastern boundary at a point about 9 miles south of the northeastern corner of the county. Near the southeastern corner there is a small lake which occupies an elongate depression. This lake, known as Dry Lake, receives its drainage water from several short draws north of it, and is generally dry. The altitude of the floor of Dry Lake is approximately 2,830 feet—the lowest part of the undissected upland plains. In general the undissected surfaces of the upland are comparatively flat and featureless, but locally the surface is gently undulating and is characterized by broad gentle swells and shallow depressions. Sinkholes or swales are most abundant on the uplands in the northern half of the county.

Perhaps the most unusual topographic feature in Scott County is the large depressional area southeast of Scott City at the terminus of Whitewoman Creek, known as the Scott Basin. Whitewoman Creek rises in Colorado about 20 miles west of the state line and flows eastward to a point about 4 miles south of Scott City, where it disappears entirely on the western side of Scott Basin. Throughout its course in Greeley County and the western part of Wichita County, Whitewoman Creek has a prominent channel, often with bluffs from 40 to 75 feet high, and a valley ranging in width from one quarter of a mile to nearly 1 mile. In the western part of Scott County the general inclination of the plains surface to the southeast is approximately 25 feet to the mile, but as the Scott Basin is approached the inclination of the surface declines until at the basin proper it is almost entirely flat. Throughout part of its course in western Scott County, Whitewoman Creek retains definite bluffs and banks (Pl. 3B), but these features gradually disappear as the Scott Basin is approached. A similar change takes place in the valley of Rocky Draw which is tributary to Whitewoman Creek.

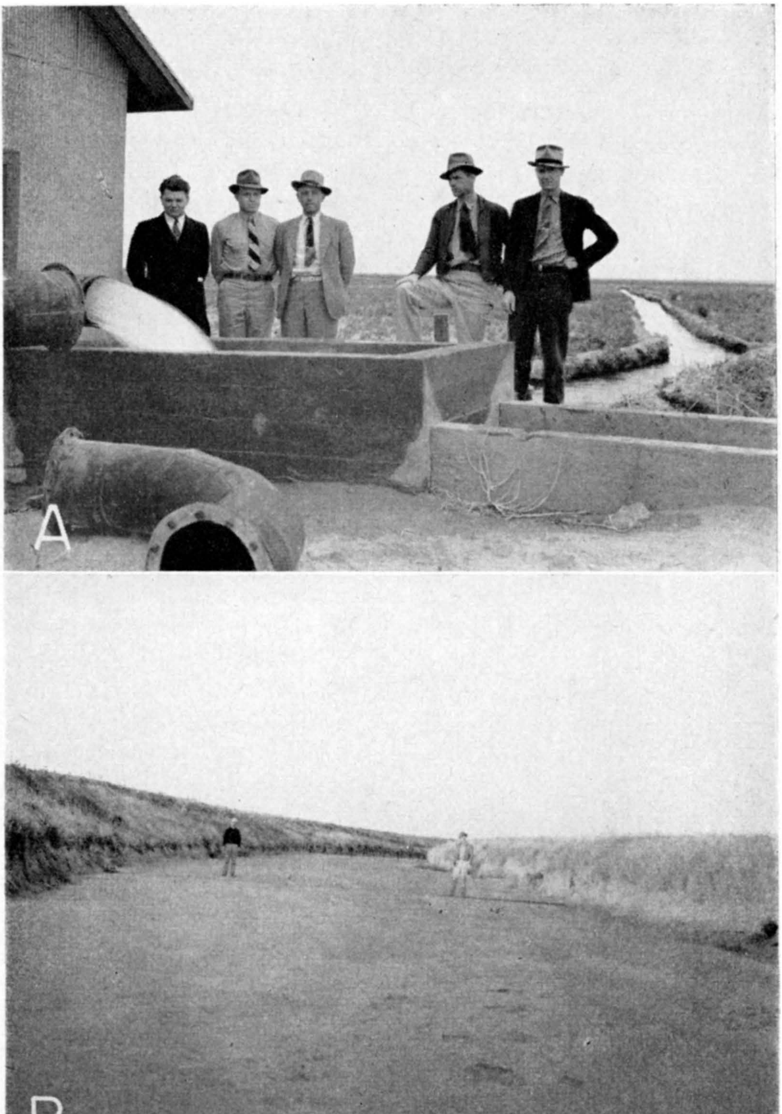


Plate 3. *A,* View of discharge of well 200. Well is discharging about 1,850 gallons a minute, but when tested yielded 2,900 gallons a minute with a drawdown of 30.7 feet (Photo by S. W. Lohman). *B,* View of dry floor of Whitewoman Creek at site of well 212 located on left bank just outside photo.

The Scott Basin is dry during most of the year, but occasionally it becomes flooded after receiving the flood waters of Whitewoman Creek as a result of heavy precipitation in the western part of its drainage basin. During periods of flood flow considerable water stands in the basin, forming a lake that sometimes covers several square miles. Most of this water sinks rapidly into the ground, disappearing completely in a relatively short time.

The northwestern quarter of the county is drained by Beaver Creek or Ladder Creek which heads in Colorado just west of the state line, flows eastward, and enters Scott County at a point about 8½ miles south of the northwest corner. From this point it continues eastward for approximately 9 miles, then turns rather abruptly to the north, continues in this direction until it leaves the county about midway along the northern boundary, and eventually joins Smoky Hill River in Logan County.

Along the northern border of the county there are a number of short canyons which are tributary to Smoky Hill River to the north. In the northeastern quarter of the county most of the short northeastward-trending canyons are tributary to Rattlesnake Creek which flows in an easterly direction in Logan County and practically parallels the county line for a distance of several miles before it turns northward to join Smoky Hill River. Most of these tributaries have deep, rugged canyons and where dissecting streams have cut through the Ogallala formation into the underlying Smoky Hill chalk, the valleys are deep and have strong bluff lines (Pl. 4B). In northern Scott County the State of Kansas has purchased an area of decidedly picturesque appearance and by means of a dam across Beaver Creek has impounded a lake, known as Lake McBride, with a shoreline several miles long (Pl. 1). In the vicinity of the park the bluffs bordering Beaver Creek are lined with nearly horizontal beds of resistant sandstone and grit of the Ogallala formation (Pl. 5B).

Population

According to the census of 1945, Scott County had a population of 3,769 and an average density of population of 5.2 inhabitants to the square mile, as compared with 21.9 for the entire state. The population in 1930 was 3,976, indicating a reduction of 199 during the decade. Scott City, the county seat, had a population of 2,022 in 1945, having increased from a population of 1,544 in 1930. Population figures are not available for Modoc, Manning, Grigston, or Shallow Water.

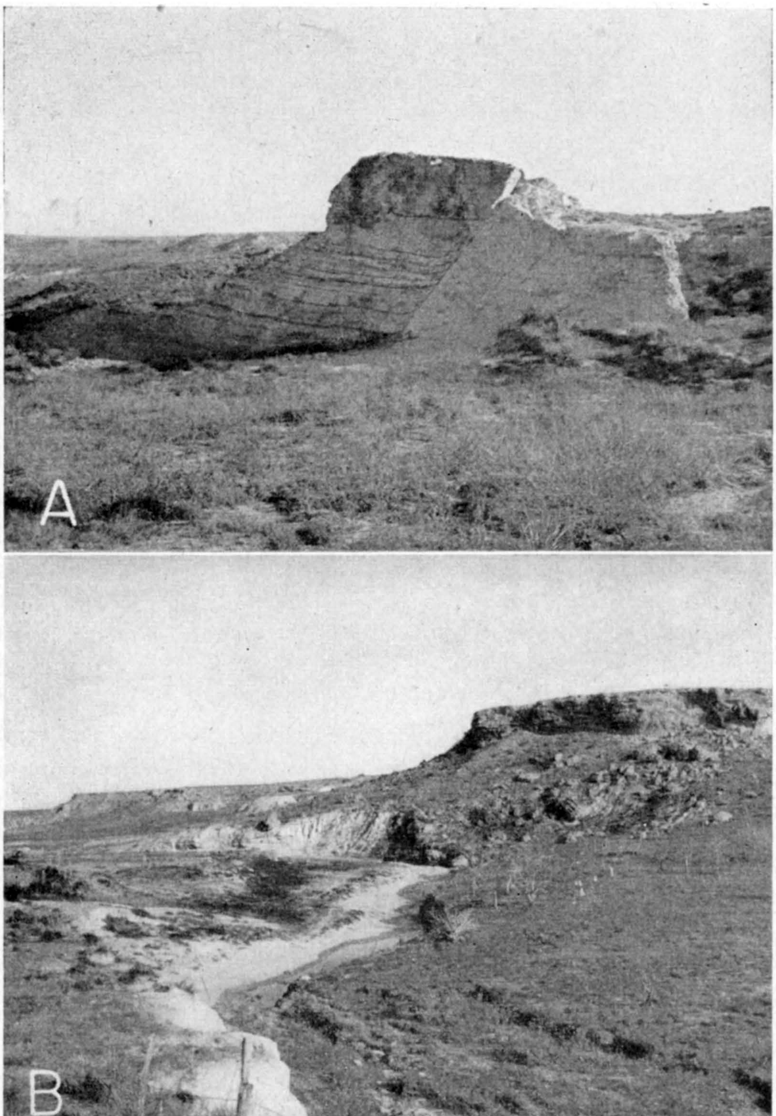


PLATE 4. *A*, Normal fault in Smoky Hill chalk member of the Niobrara formation in the NE¼ NE¼ sec. 1, T. 16 S., R. 32 W. Approximate displacement, 20 feet. *B*, Typical view of a tributary stream in the NE¼ SW¼ sec. 1, T. 16 S., R. 32 W. Ogallala formation caps bluff in background; Smoky Hill chalk member of the Niobrara in lower slope. Looking east.

Transportation

Scott County is served by the main line of the Missouri Pacific Railway as well as by a branch line of the Atchison, Topeka, and Santa Fe Railway. The main line of the Missouri Pacific Railway enters the county about 2 miles northeast of Manning, continuing diagonally southwest to Scott City, then due west to the county line. The Great Bend and Garden City branch of the Atchison, Topeka, and Santa Fe Railway enters the county about 2 miles east of Grigston, continuing due west to Scott City where it turns due south and joins the main line at Garden City.

U. S. Highway 83 (oil-surfaced) extends across the county in a north-south direction, entering the county about midway along the northern border, continuing south through Scott City to Garden City. State Highway 96 (oil-surfaced) extends across the county in an east-west direction and passes through Scott City. State Highway 4 (gravel-surfaced) enters the county 7 miles south of the northeast corner and continues due west for 12 miles where it terminates at its junction with U. S. Highway 83. Many of the farm-to-market roads have been improved but most of them have not been surfaced. Many of the county roads are graveled and are kept in good condition throughout the year, and many of the section roads have been graded.

Agriculture

Agriculture is the dominant economic activity in Scott County, the principal types of agriculture being wheat farming, some cattle raising, and general farming. Wheat is the most important crop grown in the county but other principal crops are barley, corn, the grain sorghums, alfalfa, oats, potatoes, and melons. Scott City serves as a distributing center and trading point for much of the county. The presence of a shallow water basin in Scott County has made possible irrigation by pumping from wells. In 1943 approximately 21,320 acres were irrigated from wells in the county and there were 118 pumping plants in operation. By June 1945 the number of operating pumping plants had increased to 129.

Scott County has a total area of approximately 462,720 acres. According to the census of 1940, about 38 percent of the land in use in 1939 was devoted to crops and about 62 percent to grazing. In 1940, 6 percent of the farms were less than 100 acres in size, 14 percent of the farms ranged in size from 100 to 259 acres, 25 percent ranged from 260 to 499 acres, 29 percent ranged from 500 to 999 acres, and 26 percent were 1,000 acres or larger. On April 1, 1940, Scott County had 528 farms with an average area of 822.8 acres.

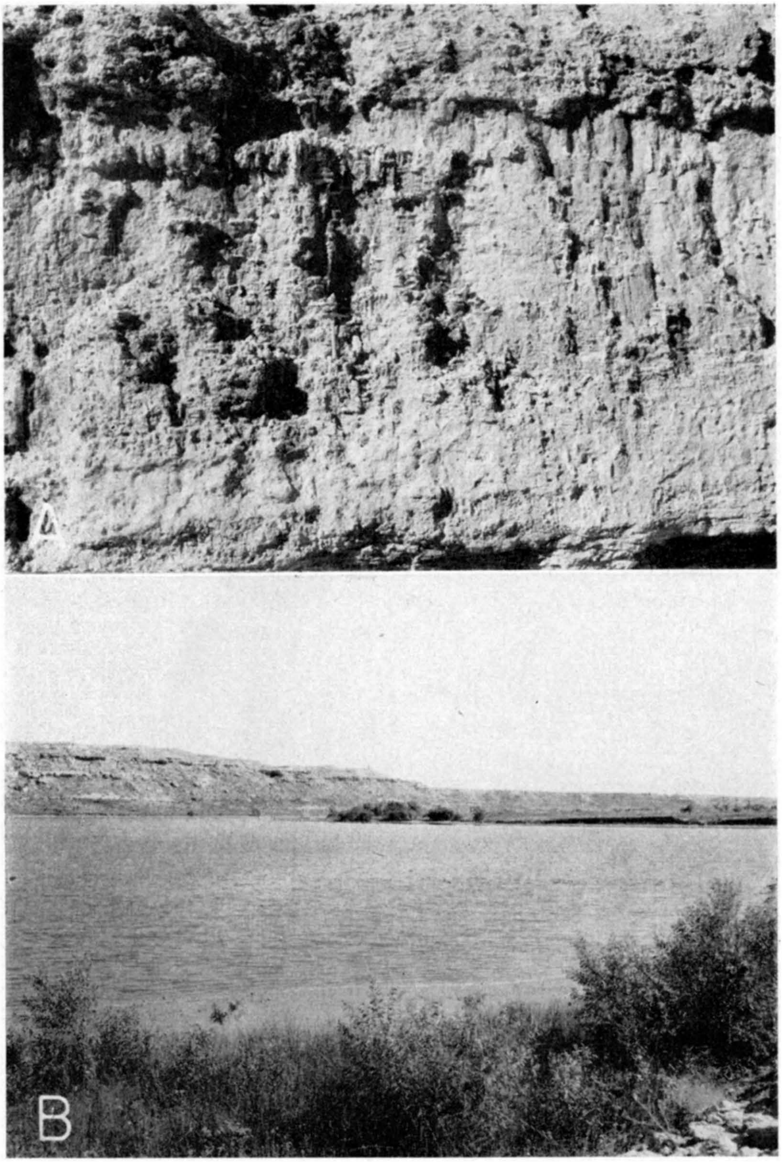


Plate 5. *A,* Lime concretions in the Ogallala formation in a road cut through the Devil's Backbone at the south end of Scott County State Park. *B,* View looking southeast across Lake McBride in Scott County State Park. Ledges of Ogallala formation are prominent in bluffs in background.

NATURAL RESOURCES AND INDUSTRIES

The chief industry in Scott County is an oil refinery, known as the Shallow Water Refining Company, situated 4 miles south of Shallow Water. Crude oil obtained from the adjoining Shallow Water oil pool is processed at this refinery which has a capacity of 1,500 barrels daily. The Shallow Water oil pool, in secs. 11, 14, and 15, T. 20 S., R. 33 W., was discovered by the Atlantic Oil Producing Company when the first well on the Vaniman farm was completed in December 1934. Oil with an unusually heavy gravity of 26 degrees Baume was found 5 feet below the top of the "Mississippi lime" which was encountered at a depth of 4,665 feet. At the end of 1942 there were 9 wells in the Shallow Water pool. According to Ver Wiebe (1943, p. 72), the Shallow Water pool produced 112,948 barrels of oil in 1942. The cumulative total production to the end of 1942 was 1,152,560 barrels.

The other principal mineral resources in Scott County are the deposits of sand and gravel found along the sides of Beaver Creek and in the Scott Basin and the deposits of caliche near the top of the Ogallala formation. The sand and gravel are quarried extensively for local use. The locations of the more important pits are shown in Plate 1. All of the gravel pits are worked by open-pit methods and are excavated by shovels. The locations of the two most important caliche quarries are also shown in Plate 1. One is located 2 miles south and 2 miles east of Scott City and is used extensively for road-surfacing material for county roads (Pl. 6B), and the other is located near the SE cor. sec. 2, T. 17 S., R. 33 W. The latter quarry was the principal source of crushed caliche that was used in 1940 and 1941 for surfacing U. S. Highway 83 north from Scott City to the county line.

In 1937 samples of rock were collected from exposures of the Ogallala formation at two localities in Scott County, and tests were made to determine their suitability for making rock wool (Plummer, 1937, pp. 25-27). Samples were collected from an escarpment of the Ogallala formation on the east edge of Scott County State Park in a road cut on the highway which extends east from the park to U. S. Highway 83. Of a vertical distance of 53 feet which was sampled at this locality, only the upper 20 feet contained sufficient calcium carbonate to be classed as wool rock. Samples were collected also from an outcrop of the Ogallala on the John Kittle farm about 300 yards east of the Wichita-Scott County line in sec. 6, T. 19 S., R. 34 W., about 3½ miles south of State Highway 96. One

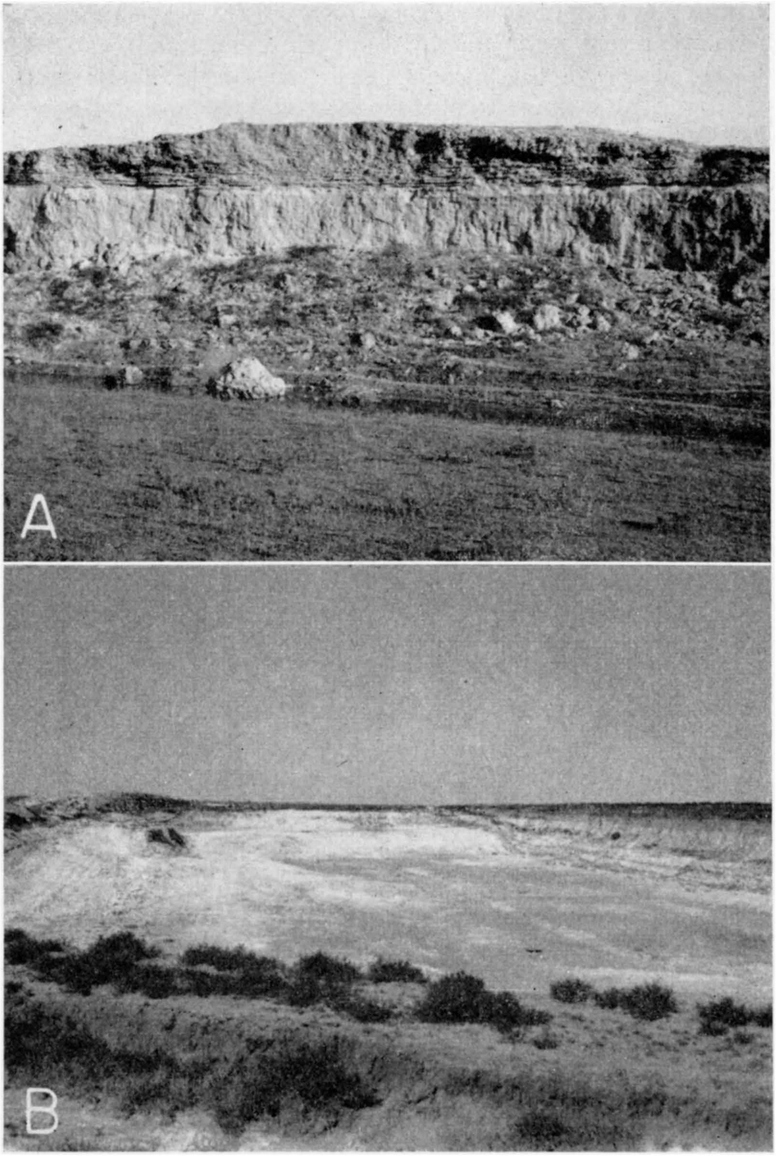


Plate 6. *A,* Series of many thin parallel "mortar beds" resting on structureless cemented sandy silt of the Ogallala formation. East side of Salt Creek in the NE¼ sec. 24, T. 16 S., R. 31 W. *B,* "Caliche" of the Ogallala formation exposed in county quarry in the SW¼ sec. 28, T. 18 S., R. 32 W.

of the samples collected at this locality produced an excellent quality of white wool at a pouring temperature of 1525° C. with the steam pressure varying from 50 to 55 pounds. Plummer (1937) reports that an outcrop of the "mortar beds" (Ogallala formation) similar to the exposure near the Wichita-Scott County line was observed about 8 miles west of Scott City, a short distance south of State Highway 96 on the banks of Lion Creek.

CLIMATE

In general the climate of Scott County is typical of semiarid regions and is characterized by abundant sunshine, moderate precipitation, relatively good wind movement, relatively low humidity, and a high rate of evaporation. Occasionally during the summer months hot winds which blow during a dry heated period are the cause of great crop damage and much discomfort.

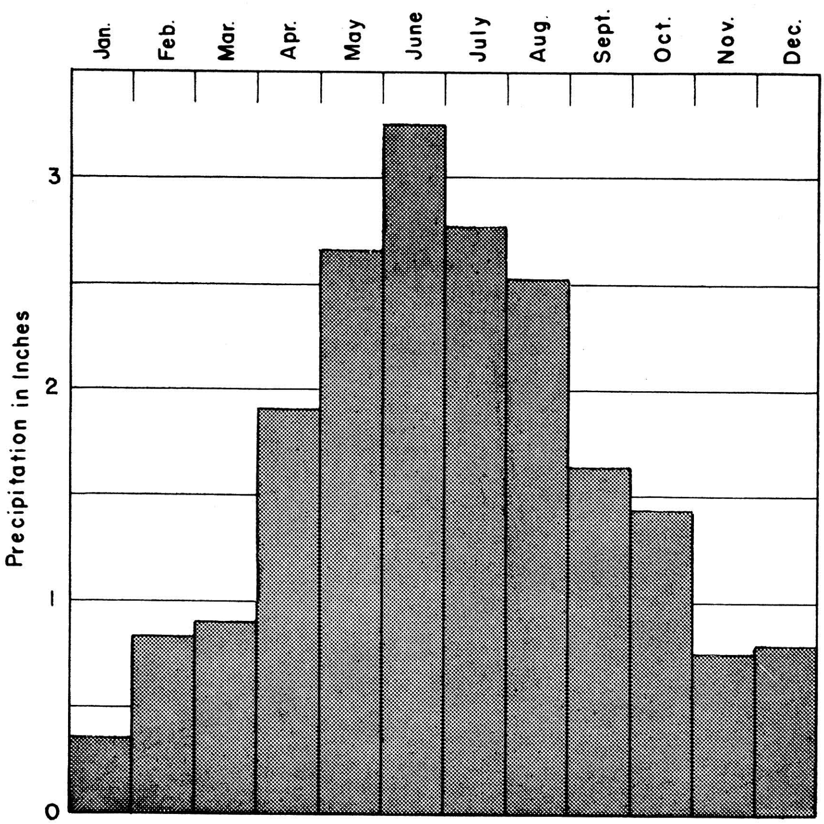


FIG. 3. Normal monthly precipitation during the 35-year period of record at Scott City, Kansas.

Winter months generally are slightly colder and windier than in eastern Kansas and somewhat drier. Snowfall is normally light and is often accompanied by high winds with a resultant uneven distribution.

The amount of precipitation and its seasonal distribution are the chief limiting factors of crop growth. During the years for which records have been kept approximately 75 percent of the annual precipitation falls in the six months from April to September inclusive, when the growing season is at its height and moisture is needed. The normal monthly precipitation during the period of record at Scott City is shown in Figure 3.

According to the U. S. Weather Bureau the normal annual precipitation at Scott City is 18.61 inches. The annual precipitation and the cumulative departure from normal precipitation at Scott City are shown in Figure 4. During the period from 1930-1940, the precipitation was below normal in 1931 and from 1934 through 1940. The cumulative deficiency during the 7-year period from 1934 through 1940 amounted to 26.41 inches, or 1.4 year's normal

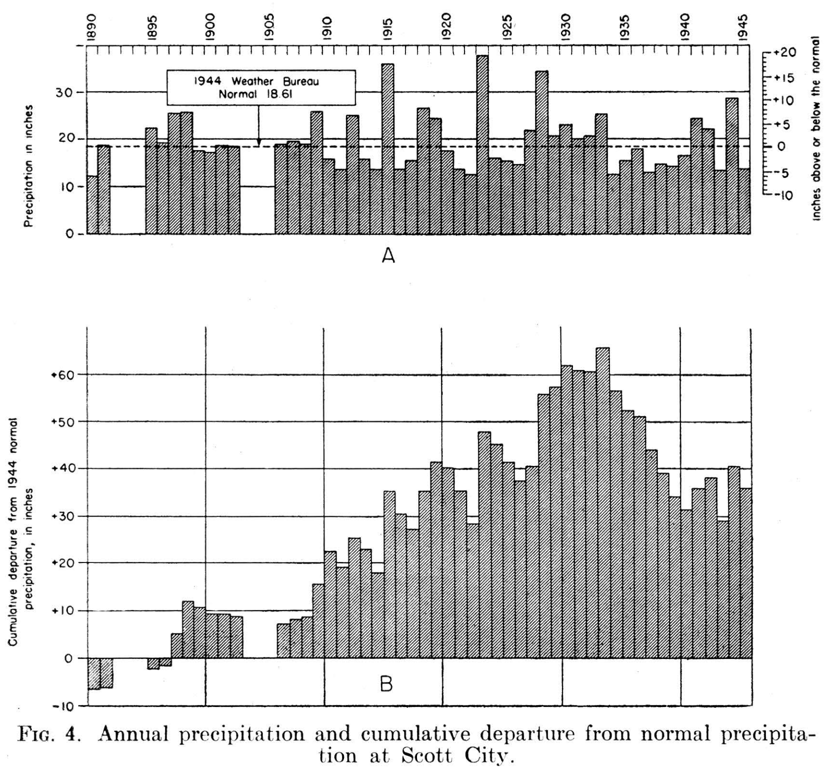


FIG. 4. Annual precipitation and cumulative departure from normal precipitation at Scott City.

annual precipitation. The precipitation was above normal in 1941 and 1942, but fell below normal again in 1943. In 1943 the precipitation was below normal for each of the 12 months during the year, a total departure of –8.23 inches being recorded, or almost one-half of the total normal annual supply. In 1944, the precipitation was 11.31 inches above normal and in 1945 it was 4.39 inches below normal.

The average annual mean temperature as recorded at Scott City is 53.5 degrees F. The average length of the growing season is about 168 days, and it has ranged from 132 to 199 days. Killing frosts have occurred as late as May 27 and as early as September 25.

GEOLOGY

Summary of Stratigraphy

The rocks exposed in Scott County range in age from Upper Cretaceous to Recent. The areal distribution of the formations is shown on Plate 1. The oldest rocks cropping out in the county belong to the Smoky Hill chalk member of the Niobrara formation. This member is best exposed in the northern and northeastern part of the county where streams tributary to Smoky Hill River have cut through the plains surface into the underlying Smoky Hill chalk (Pl. 4B). Other exposures of the Smoky Hill are found also in the sides of several small tributary streams entering Dry Lake from the north and west near the southeastern corner of the county (Pl. 7A). The Pierre shale, which overlies the Niobrara formation in other areas, is absent in Scott County. The Ogallala formation of Tertiary age, which rests unconformably on the Smoky Hill chalk member of the Niobrara formation, is exposed in the sides of many of the stream valleys, but over large areas it is covered by younger deposits of sand and gravel overlain by loess. The undissected plains surface is mantled by deposits of loess ranging in age from Pleistocene to Recent. Dune sand covers an area of approximately 18 square miles near the southeastern corner of the county. A narrow belt of alluvium occupies the valley of Beaver Creek throughout its course in Scott County. The soils, alluvium, drifting dune sand, and terrace deposits are the most recent deposits in the area.

The character and ground-water supply of the geologic formations in Scott County are described briefly in the generalized section given in Table 1 and in more detail in the section on geologic formations and their water-bearing properties.

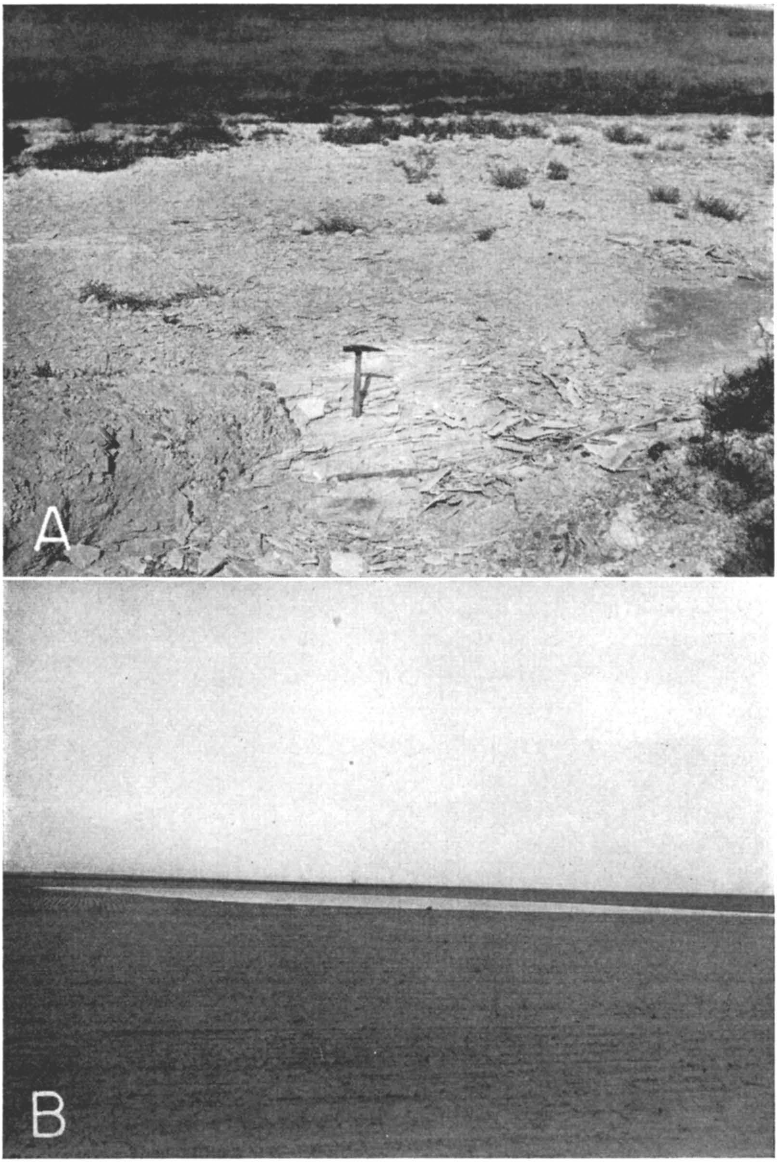


PLATE 7. *A,* Thin-bedded Smoky Hill chalk member of the Niobrara formation exposed in SW¼ SE¼ sec. 6, T. 20 S., R. 31 W. *B,* Typical view of sink filled with water. Photograph after rains in October 1940. Near SW cor. sec. 26, T. 18 S., R. 32 W.

TABLE 1.—*Generalized section of the geologic formations in Scott County, Kansas*

System	Series	Formation	Member	Thickness (feet)	Physical character	Water supply
Quaternary	Pleistocene and Recent	Alluvium		0–20±	Gravel, sand, silt and clay comprising stream deposits in Beaver (Ladder) Creek Valley.	Yields small supplies of relatively hard water to wells in Beaver (Ladder) Creek Valley.
		unconformable on older formations				
		Dune sand		0–50±	Fine to medium sand. Mantles small areas in the southeastern part of the county. Except where reopened by recent blowouts, the dunes are stabilized by vegetation.	Probably does not supply water directly to wells but is important as a favorable catchment area for ground-water recharge to adjacent and underlying formations.
		unconformable on older formations				
		Loess		0–30	Light buff-colored silt containing fine sand and some clay.	Loess deposits occur mostly above the water table and are relatively impermeable.
		unconformable on older formations				
	Pleistocene	Undifferentiated deposits, including channel deposits along Beaver (Ladder) Creek		0–200±	Predominantly unconsolidated sands and gravels containing silt and clay. Basal channel deposits are cemented in at least one small exposure along Beaver Creek.	Where saturated yield large supplies of moderately hard water to most of the wells in the shallow-water basin. Channel deposits are relatively permeable but generally occur above the water table.
		unconformity				
Tertiary	Pliocene	Ogallala formation		0–160	Gravel, sand, silt, caliche, and some silty clay. Contains hard and soft layers of sandstone and conglomerate, much of which is cross bedded and cemented with lime. Lower part locally contains mottled bentonitic clay ranging in color from reddish brown to olive green.	Yields moderate to large supplies of moderately hard water to domestic and stock wells in many parts of the county. Constitutes the principal source of supply for many of the irrigation wells in Scott Basin.
		unconformity				
Cretaceous	Gulfian*	Niobrara formation	Smoky Hill chalk	0–130±	Alternating beds of soft chalk and chalky shale.	Yields limited supplies of hard to very hard water to wells in the southeastern quarter of the county.
			Fort Hays limestone		Massive chalk beds separated by thin, soft, chalky shale.	Not known to yield water to wells in Scott County.

Cretaceous	Gulfian*	Carlile shale	Codell sandstone	180-230	Sandstone and sandy shale.	Not known to yield water to wells in Scott County. The Codell sandstone member is reported to yield meager quantities of water to wells in Finney County. The Blue Hill shale and Fairport chalky shale members of the Carlile shale are relatively impermeable.
			Blue Hill shale		Bluish-gray clay shale containing septarian concretions in upper part.	
			Fairport chalky shale		Yellow chalky shale with thin limestone beds.	
		Greenhorn limestone	Pfeifer shale Jetmore chalk Hartland shale Lincoln limestone	0-55	Alternating beds of chalky shale and thin chalky limestones.	Not known to yield water to wells in Scott County.
		Graneros shale		25-100	Dark bluish-gray clay shale containing thin-bedded limestone and sand lenses.	Relatively impermeable; not known to yield water to wells in Scott County.
		Dakota formation		260-550±	Sandstones, shales, and clays.	Not known to yield water to wells in Scott County. The sandstones of the Dakota formation yield moderate supples of soft water to wells in southeastern Gray County and in Ford County. The Kiowa shale is relatively impermeable.
	Comanchean*	Kiowa shale			Black marine shale and a few thin limestone beds.	
		Cheyenne sandstone			Fine to coarse-grained sandstone and sandy shale.	
		unconformity				
Permian	Leonardian and Guadalupian*	Undifferentiated redbeds		1,150±		

* Classification of the State Geological Survey of Kansas.

Geologic History

Parts of the following discussion are taken from a report by Darton (1906, pp. 45-46).

The exposed rocks in Scott County are underlain by older sedimentary rocks of pre-Cambrian age. The stratigraphic sequence of the rocks underlying the surface is fairly well known from the logs and well cuttings of each of the oil tests in the Shallow Water oil pool in south-central Scott County.

PALEOZOIC ERA

Cambrian and Ordovician Periods

Although very little is known of the conditions existing in western Kansas during early Paleozoic time, it is believed that Scott County, along with a large part of west-central United States, was a land surface during early Cambrian time. In the middle part of Cambrian time there began the development of an interior sea with a resultant change to marine conditions. Submergence of the land continued through most of Ordovician time with extensive deposition of lime sediments that were later indurated to form limestones and dolomites. The sandy, cherty dolomite that forms the Arbuckle limestone or "Siliceous lime" of Cambrian and Ordovician age was deposited in the earlier part of this interval. In Scott County the Arbuckle is encountered in one well at a depth of about 5,470 feet.

A well in the Shallow Water oil pool penetrates the Viola limestone and Simpson group of Ordovician age. The Viola is a sugary, dolomitic, and very cherty limestone at the top, but becomes finer grained and noncherty below, grading into the Simpson group at a depth of about 5,450 feet.

Silurian and Devonian Periods

There is little or no evidence that rocks of Silurian and Devonian age are present under Scott County. Either they were never deposited in this area or they were removed by erosion prior to the deposition of the overlying Mississippian strata.

Mississipian and Pennsylvanian Periods

During early Mississippian time there was extensive deposition of marine dolomitic limestone and some shale. According to the logs of oil wells in the Shallow Water pool, Mississippian strata are present under Scott County, the top being encountered at a depth of about 4,650 feet. When production was found initially in the

Shallow Water pool it was believed that the producing limestone was of Chesterian (upper Mississippian) age (Ver Wiebe, 1938, p. 138). Norton (1938), however, reports that this oölitic limestone is probably the equivalent of the Ste. Genevieve limestone of middle Mississippian age. In later Mississippian time there was an uplift, during which the surface of the early Mississippian strata was subjected to erosion.

A long period of erosion intervened between the deposition of the youngest Mississippian rocks and the oldest Pennsylvanian rocks. During this interval the limestone of Chesterian age, if deposited originally, may have been removed in Scott County. Alternate subsidence below and emergence above sea level were repeated many times during the Pennsylvanian, giving rise to both marine and continental deposits consisting of sandstone, shale, coal, and limestone. This sequence of deposition was interrupted at times when the land surface was elevated and subjected to erosion. The Pennsylvanian rocks are approximately 1,400 feet thick in Scott County. According to Ver Wiebe (1938, p. 138) the top of the Topeka limestone lies at a depth of 3,600 feet and the top of the Lansing group is approximately 350 feet lower. Below the Lansing-Kansas City-Bronson sequence of limestones are shales and limestones which may correspond to the Marmaton group and Cherokee shale of eastern Kansas. In Scott County these shales are subordinate to coarse-grained limestones of gray to black color. The composition of the lower Pennsylvanian rocks is somewhat different also, notably in the presence of considerable chert. The basal conglomerate may be represented by red and green shales near the base of the system.

Permian Period

A transitional period intervened in which marine conditions during early Permian time were somewhat comparable to those existing during late Pennsylvanian time, and alternate successions of limestones, dolomites, and shales (Wolfcampian Series) were deposited. Following this there was an interval when beds of continental origin were deposited alternately with beds of marine origin. Gradually continental deposition became the dominant mode of origin for late Permian sediments. Most of the deposition took place in shallow water, so that subsidence must have kept pace with deposition during this interval. It is probable that an arid climate prevailed and evaporation must have taken place in shallow basins giving rise to extensive deposits of salt and anhydrite interbedded with deposits of gypsum of the Leonardian Series. According to the logs of oil wells in the Shallow Water pool the top of the Permian is encountered at a depth of approximately 1,150 feet. Gypsum of the Blaine formation is encountered at a depth of about 1,430 feet, and anhydrite of the Stone Corral dolomite lies at a depth of about 2,100 feet. Beneath the red beds the gray shales and anhydrites of the Wellington formation are encountered and these beds continue to a depth of about 2,800 feet where the first dolomite of the Wolfcampian Series appears.

MESOZOIC ERA

Cretaceous Period

At the close of the Paleozoic, deposition was terminated by an uplift that brought the region above water. This condition probably prevailed throughout most of Triassic time and through Jurassic time, during which there was no deposition and probably considerable erosion. Rocks of Triassic and Jurassic age are not known to occur in Scott County.

As the result of an early Cretaceous uplift there was at first a land surface followed by a shallow-water body in Comanchean time during which the sandstone and shale of the Cheyenne sandstone were deposited. The deposits were laid down either by streams or in a shallow sea or perhaps they were deposited in part on the beach by wind, suggesting that the place of deposition was not far above or far from a shore line (Twenhofel, 1924, pp. 19-21).

Following this there was a change from continental to marine conditions as a result of submergence of the land surface during which time the Kiowa shale was deposited. It is believed that Cheyenne sandstone and Kiowa shale underlie at least a part of Scott County, but in subsurface studies of oil-well samples no attempt has been made to segregate either of the formations from the underlying Dakota. None of the test holes drilled by the State and Federal Geological Surveys in Scott County were drilled deep enough to penetrate strata below the Niobrara formation.

In late Cretaceous time there was a return to conditions similar to those under which the Cheyenne sandstone was deposited and the sandstones, shales, and clays of the Dakota formation were laid down. The Dakota formation is a fresh-water deposit that was laid down on beaches and near the shore during an uplift in which the sea retreated far to the south. The top of the Dakota formation is encountered at a depth of about 700 feet in Scott County. The combined thickness of the Dakota formation, the Cheyenne sandstone, and the Kiowa shale in Scott County is approximately 550 feet.

After the Dakota formation was laid down there was a rapid change in the conditions of sedimentation to those under which several thousand feet of shale, lime, and chalk were deposited, beginning with the Graneros shale and including the Greenhorn limestone, the Carlile shale, the Niobrara formation and the Pierre shale. This marks the beginning of very extensive later Cretaceous submergence, in which marine conditions prevailed over a large area for a long time. Sedimentation was interrupted from time to time by emergence of the land to a point at or near sea level. According to the logs of oil wells in the Shallow Water pool, the base of the Niobrara formation is encountered at a depth of about 310 feet, and the top of the Greenhorn limestone is found at about 540 feet, indicating a thickness of about 230 feet for the Carlile shale.

CENOZOIC ERA

Tertiary Period

Prior to the deposition of Tertiary sediments there was a period of folding during which the major features of the bedrock depression in Scott and Finney Counties may have been formed. A broad asymmetrical trough, with its axis extending from Garden City to Scott City and northward, was developed. At the beginning of Tertiary time an extensive land surface existed in western Kansas; this surface was subjected to erosion largely effected by through-flowing streams. During this interval great thicknesses of Upper Cretaceous sediments were removed, so that in Scott County all Cretaceous strata above the Niobrara are missing and variable thicknesses of the upper part of the Niobrara have been removed. The present shape of the trough in cross section is shown by sections A-A′, B-B′, and C-C′ in Figure 5, and the approximate configuration of the pre-Tertiary surface possibly modified by post-Tertiary erosion is shown in Figure 2.

In late Tertiary time erosion (possibly peneplanation) was followed by an epoch of deposition which started with the accumulation in some parts of the county of beds of plastic greenish and maroon-brown bentonitic clays interbedded with soft grit and sand. This zone may be equivalent to the Woodhouse clays of Wallace County that

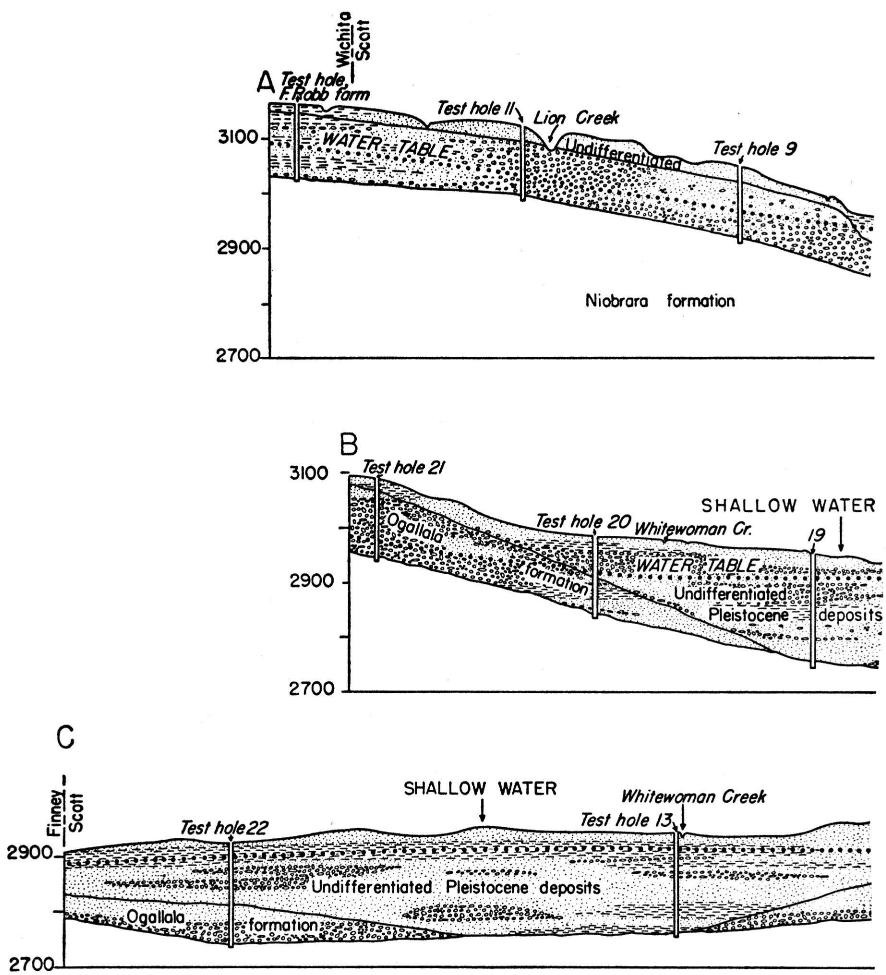
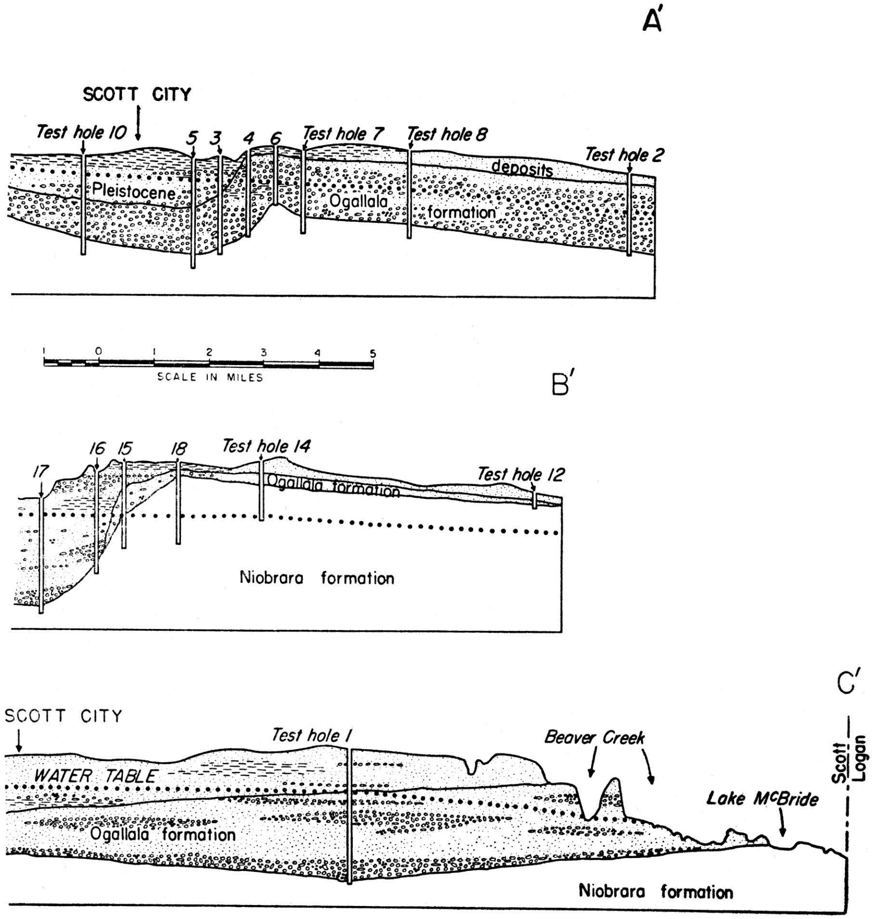


FIG. 5. *A*, East-west geologic profile along Kansas Highway 96 through Scott City; north-south geologic profile across



B, east-west geologic profile along section road 0.5 mile south of Shallow Water; *C,* the middle of Scott County.

were described by Elias (1931, pp. 153-158). It is possible that these clays represent a mixture of altered volcanic ash of the Ogallala formation with the clayey products of disintegration of pre-Tertiary beds and that they were deposited under somewhat different conditions. This was followed by an interval during which heavily laden streams from the Rocky Mountains traversed western Kansas and deposited the sediments of the Ogallala formation in a broad alluvial plain.

Some crustal deformation may have taken place after the deposition of the Ogallala, probably along preëstablished lines of weakness.

Quaternary Period

Pleistocene Epoch.—A period of erosion preceded the beginning of the Pleistocene during which the pre-Pleistocene surface was subjected to subaerial erosion. In early Pleistocene time, streams were rejuvenated as a result of uplift to the west and because of climatic changes, so that erosion followed by sedimentation was resumed. The trough which had been deepened by down-warping or erosion or both was filled with sands and gravels which in turn were mantled by wind-blown loess. The sand and gravel deposits were laid down by heavily laden streams that probably shifted laterally at frequent intervals. Stream deposition was followed by eolian activity, indicated by the fact that the fluvial deposits grade upward into loess. This seems to indicate that during the latter part of the Pleistocene there was a climatic change with considerable wind movement. Loess deposition has continued intermittently until Recent time.

Recent Epoch.—At the beginning of the Recent Epoch, streams began the down cutting that has produced the present topography. It was during this period also that the courses of the several streams were established. The presence of a Cretaceous ridge in eastern Scott County has affected the behavior of streams traversing the county. Beaver Creek or Ladder Creek, a tributary of Smoky Hill River, enters the county from the west and flows eastward to a point about midway across the county from east to west, where it turns abrubtly northward, continuing in this direction to its junction with the Smoky Hill. This anomalous change in direction is probably directly related to the structure of the underlying bedrock. Whitewoman Creek is another notable example of a stream whose course has been affected by the position of the underlying bedrock. This stream differs from most other streams in that it has no connection with any other stream, and in times of flood it empties its water into the broad shallow depression at its terminus, known as the Scott Basin.

Terrace deposits of sand and gravel are found in a belt immediately bordering the flood plain of Beaver Creek. Much of the material in the terrace gravels was derived from source areas to the west and was deposited by Beaver Creek at some time during the Pleistocene when it was flowing at a higher level than at present. The terraces are of cut-and-fill origin and probably are of late glacial or post-glacial age.

Dune sand mantles the surface in the southeastern part of the county (Pl. 1). Although its age is not definitely known, it is believed that accumulation of some of the sand started in late Pleistocene time and continued until Recent time. The sand originated possibly from eroded slopes cut in the Ogallala formation and from the Pleistocene sands and gravels. It is possible that the sand was derived either wholly or in part from the strand flats of a lake that formerly occupied the depression now known as Dry Lake. The dune-building winds of the past were in a northerly direction, whereas those of the present time are predominantly southerly. Smith (1940, p. 168) suggested that the presence of a continental ice sheet during one or more of the Pleistocene glacial stages would have provided ready cause for altered wind direction.

GROUND WATER

Source

Ground water, or underground water, is the water that supplies springs and wells. In Scott County, ground water is derived almost entirely from precipitation in the form of rain or snow. Part of the water that falls as rain or snow is carried away by surface runoff and is lost to streams; part of it percolates downward into the rocks until it reaches the water-table where it joins the body of ground water known as the zone of saturation; and part of it may evaporate or be absorbed and transpired by the vegetation and thus returned directly to the atmosphere.

The ground water percolates slowly through the rocks in directions determined by the topography and geologic structure until it is discharged eventually through springs or wells, through seepage into streams, or by evaporation and transpiration in bottom lands adjacent to the streams. Most of the water obtained from shallow wells and springs in Scott County is obtained largely from precipitation in the general vicinity—that is, in Scott County and adjacent areas. The water in the Dakota formation under Scott County, however, is derived from precipitation and small streams in the areas of outcrop, which are mainly in southwestern Kansas and southeastern Colorado at higher altitudes.

Principles of Occurrence

HYDROLOGIC PROPERTIES OF WATER-BEARING MATERIALS

This discussion of the principles governing the occurrence of ground water takes account of conditions in Scott County. Preparation of the discussion has been based chiefly on the detailed treatment of the occurrence of ground water by Meinzer (1923), to which the reader is referred for more extended consideration. A general discussion of the principles of ground-water occurrence, with special reference to Kansas, has been made by Moore (1940).

Porosity.—The rocks that form the crust of the earth are in general not solid throughout but contain numerous open spaces, called voids or interstices. It is in these spaces that water is found below the surface of the land and from which it is recovered in part through springs and wells. There are many kinds of rocks and they differ greatly in the number, size, shape, and arrangement of their interstices and in their water-holding capacities (Waite, 1942, p. 45). The occurrence of ground water in any region, therefore, is determined by the geology of the region.

The amount of water that can be stored in any rock depends upon the porosity of the rock. Porosity is expressed quantitatively as the percentage of the total volume of rock that is occupied by interstices. When all its interstices are filled with water a rock is said to be saturated. In a saturated rock the porosity is practically the percentage of the total volume of the rock that is occupied by water.

Specific yield.—The specific yield of a water-bearing formation is defined by Meinzer (1923, p. 28) as the ratio of (1) the volume of water which, after being saturated, it will yield by gravity to (2) its own volume. This ratio is generally stated as a percentage. Thus if 100 cubic feet of saturated water-bearing material when drained will supply 20 cubic feet of water the specific yield of the material is said to be 20 percent.

Permeability and transmissibility.—The rate of movement of ground water is determined by the size, shape, quantity, and degree of interconnection of the interstices and by the hydraulic gradient from one point to another. The capacity of a water-bearing material for transmitting water under hydraulic head is its permeability. The coefficient of permeability may be expressed as the rate of flow of water, in gallons a day, through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent at a temperature of 60° F. (Meinzer's coefficient). The coefficient of transmissibility is a similar measure and may be defined as the number of gallons of water a day transmitted through each one-foot strip extending the height of the aquifer under a unit gradient (Theis, 1935, p. 520). The coefficient of transmissibility may also be expressed as the number of gallons of water a day transmitted through each section 1 mile wide extending the height of the aquifer, under a hydraulic gradient of 1 foot to the mile.

The coefficient of transmissibility is equivalent to the coefficient of permeability (corrected for temperature) multiplied by the thickness of the aquifer.

The permeability of the water-bearing materials in Scott County was determined by four pumping tests using the recovery method involving the following special formula developed by Theis (1935, p. 522) and also described by Wenzel (1942, p. 94) for computing the transmissibility of an aquifer.

$$T = \frac{264q}{s} \log_{10} \frac{t}{t^1}$$

in which T = coefficient of transmissibility, q = pumping rate, in gallons a minute, t = time since pumping began, in minutes, t^1 = time since pumping stopped, in minutes, and s = residual drawdown at the pumped well, in feet, at time t^1.

The residual drawdown (s) is computed by subtracting the static water level before pumping began from appropriate water levels taken from the recovery curve.

The proper ratio $\frac{\log_{10} t/t^1}{s}$ is determined graphically by plotting $\log_{10} t/t^1$ against corresponding values of s. By plotting t/t^1 on the logarithmic coördinate of semilogarithmic paper this procedure is simplified. For any convenient value of $\log_{10} t/t^1$ the corresponding value of s may be obtained from the curve. Theoretically this curve is a straight line that passes through the origin. For all pumping tests, however, it does not do so and for some tests results are obtained that do not agree with results obtained by other pumping-test methods. Wenzel (1942, p. 96) has found that results generally consistent with other pumping test methods can be obtained by applying a correction factor to the Theis formula to make the straight line pass through the origin. The Theis formula modified to include the empirical correction factor is

$$T = \frac{264q}{s} \log_{10} \frac{t \pm c}{t^1}$$

where c is a constant arbitrarily chosen so that the straight line determined by plotting $\log_{10} \frac{t \pm c}{t^1}$ against s will pass through the origin.

Pumping Tests—During the course of the investigation pumping tests on four irrigation wells in the Scott Basin were conducted by Melvin Scanlan of the Division of Water Resources, Kansas State Board of Agriculture, and Woodrow Wilson of the Federal Geological Survey. In each test the well was pumped for approximately three hours and measurements of the discharge of the well, using a Collins flow gage, were made periodically. Where possible, measurements of the drawdown in the pumped well mere made at frequent intervals. The pump was then shut down and the water level in the well was allowed to recover. A series of water-level

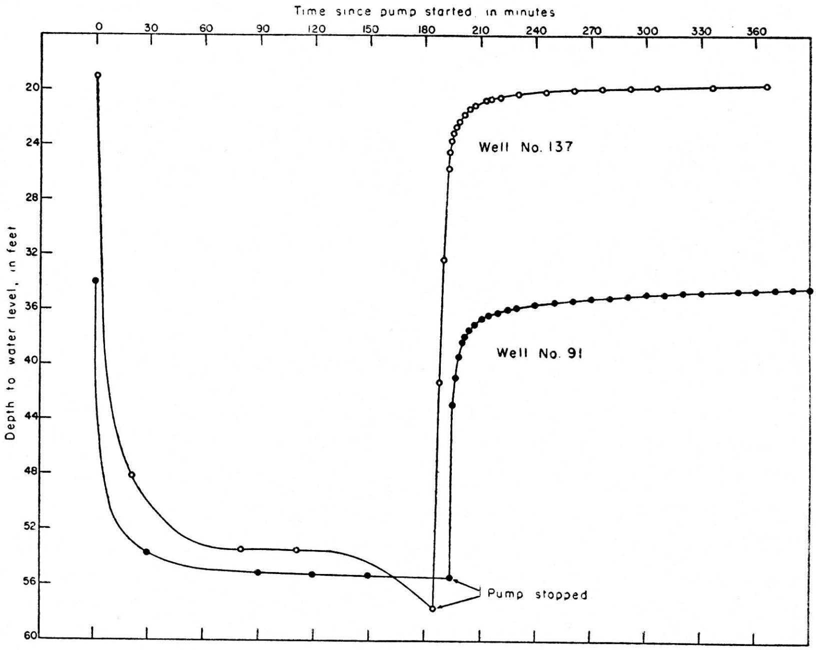


FIG. 6. Drawdown and recovery curves for wells 91 and 137 during pumping tests on December 8, 1941, and May 19, 1942, respectively.

measurements, using a steel tape, were made periodically during the recovery period. Recovery curves were plotted for each of the tests, two of which are shown in Figure 6. The coefficient of transmissibility and thus the field coefficient of permeability may be computed from the recovery of the water level in the pumped well by using the Theis formula. The temperature of the water during the tests was 60° F.; hence no correction for temperature needs to be applied.

A pumping test on an irrigation well (172) owned by George Duff and situated in the NW¼ SW¼ sec. 12, T. 19 S., R. 33 W. was made on December 9, 1941. The pumping rate, depth to water level before, during, and after pumping, and values for t/t^1 and for s (residual drawdown) are given in Table 2.

The ratio t/t^1 was determined graphically by plotting t/t^1 against corresponding values of s on semilogarithmic paper and using for the ratio the slope of the straight line drawn through the plotted points (Fig. 7). Thus

$$T = \frac{264 \times 567 \times 1}{8.8} = 17{,}010$$

$$P = \frac{17{,}010}{60} = 280$$

The transmissibility is computed to be 17,010 and the coefficient of permeability is determined by dividing the transmissibility by the thickness of the aquifer, or 280. The specific capacity of the well is computed to be 16.3 gallons per foot of drawdown.

A pumping test on an irrigation well (91) owned by V. M. Harris and situated in the SE¼ NW¼ sec. 29, T. 18 S., R. 32 W. was made on December 8, 1941. The pumping rate, depth to water level before, during, and after pumping, and values for t/t^1 and for s (residual drawdown) are given in Table 3.

TABLE 2. *Data on pumping test of well 172, Scott County, made on December 9, 1941*

Time since pumping started, minutes	Time since pumping stopped, minutes	t/t[1]	Yield, gallons per minute	Depth to water level, feet	Draw-down, feet	Remarks
....	....	....	....	28.80	....	Pump started
....	....	....	603	55.05	....	
....	....	....	585	54.85	....	
....	....	....	574	55.27	....	
....	....	....	567	55.25	....	
....	....	....	561	55.97	....	
....	....	....	559	....	....	
....	....	....	555	63.27	....	
....	....	....	553.5	63.80	....	
....	....	....	546	63.84	....	
197	....	....	....	....	....	Pump stopped
199	2	99.5	....	44.48	15.68	
200½	3½	57.3	....	43.20	14.40	
201½	4½	44.8	....	42.36	13.56	
202½	5½	36.8	....	42.03	13.23	
203	6	33.8	....	41.84	13.04	
205	8	25.6	....	41.53	12.73	
210	13	16.1	....	40.33	11.53	
215	18	11.9	....	38.32	.52	
220	23	9.6	....	37.40	8.60	
230	33	7.0	....	36.19	7.39	
240	43	5.6	....	35.31	6.51	
250	53	4.7	....	34.70	5.90	
260	63	4.1	....	34.17	5.37	
270	73	3.7	....	33.70	4.90	
295	98	3.0	....	32.86	4.06	
310	113	2.7	....	32.51	3.71	
325	128	2.5	....	32.15	3.35	
340	143	2.4	....	31.89	3.09	
355	158	2.2	....	31.65	2.85	
370	173	2.1	....	31.43	2.63	

TABLE 3. *Data on pumping test of well 91, Scott County, made on December 8, 1941*

Time since pumping started, minutes	Time since pumping stopped, minutes	t/t^1	Yield, gallons per minute	Depth to water level, feet	Draw-down, feet	Remarks
....	....	....	....	34.06	....	Pump started
....	....	....	692	57.16	....	
....	....	....	677	57.84	....	
....	....	....	670	58.50	....	
....	....	....	670	58.76	....	
....	....	....	653	58.99	....	
....	....	....	661	59.19	....	
....	....	....	653	59.15	....	
195	....	....	....	....	....	Pump stopped
196	1	196.	....	42.89	8.83	
197	2	98.5	....	40.98	6.92	
199	4	49.7	....	39.45	5.39	
201	6	33.5	....	38.26	4.20	
202	7	28.8	....	37.91	3.85	
204	9	22.6	....	37.43	3.37	
207	12	17.2	....	37.08	3.02	
211	16	13.1	....	36.64	2.58	$\frac{t-135}{16}=4.8$
215	20	10.7	....	36.36	2.30	
220	25	8.8	....	36.10	2.04	
225	30	7.5	....	35.89	1.83	
230	35	6.6	....	35.78	1.72	
240	45	5.3	....	35.55	1.49	
250	55	4.5	....	35.35	1.29	
260	65	4.0	....	35.20	1.14	
270	75	3.6	....	35.05	.99	
280	85	3.3	....	34.98	.92	
290	95	3.1	....	34.89	.83	
300	105	2.9	....	34.78	.72	
310	115	2.7	....	34.71	.65	$\frac{t-135}{115}=1.5$
320	125	2.5	....	34.65	.59	
330	135	2.4	....	34.58	.52	
350	155	2.2	....	34.47	.41	
360	165	2.2	....	34.44	.38	
370	175	2.1	....	34.40	.34	
380	185	2.0	....	34.39	.33	
390	195	2.0	....	34.36	.30	

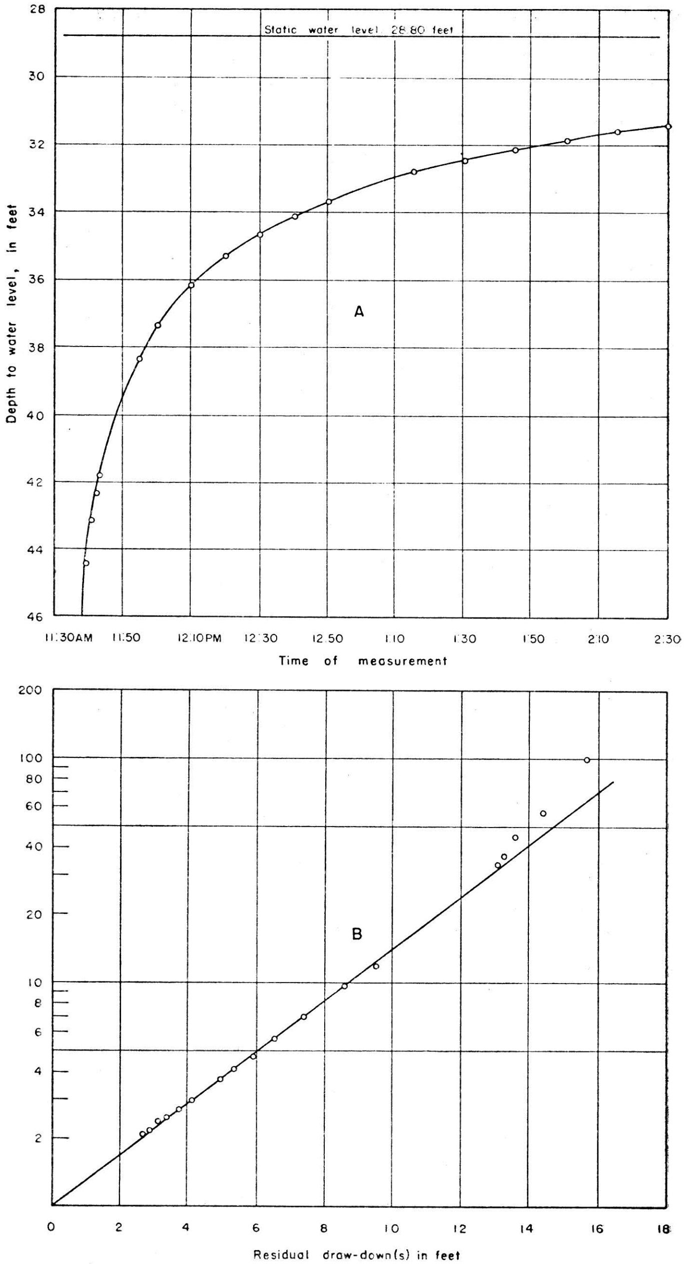


FIG. 7. Curves for pumping tests on well 172 owned by George Duff.

Using the Theis formula, the coefficient of transmissibility may be computed from the recovery of the water level in the pumped well. The ratio t/t^1 was determined graphically by plotting t/t^1 against corresponding values of s on semilogarithmic paper and using for the ratio the slope of the straight line drawn through the plotted points. An empirical correction to make the straight line pass through the origin was applied. The correction c was determined by trial and error and found to be –135. Thus

$$T = \frac{264 \times 666 \times 1}{3.8} = 46{,}270$$

$$P = \frac{46{,}270}{38} = 1{,}200$$

The transmissibility is computed to be 46,270 and the coefficient of permeability is determined by dividing the transmissibility by the thickness of the aquifer, or 1,200. The specific capacity of the well is computed to be 26.8 gallons per foot of drawdown.

A pumping test on an irrigation well (139) owned by M. K. Armantrout and situated in the NE¼ NW¼ sec. 36, T. 18 S., R. 33 W. was made on May 22, 1942. The pumping rate, depth to water level before, during, and after pumping, and values for t/t^1 and for s (residual drawdown) are given in Table 4.

The ratio t/t^1 was determined graphically by plotting t/t^1 against corresponding values of s on semilogarithmic paper and using the slope of the straight line drawn through the plotted points. Thus

$$T = \frac{264 \times 729 \times 1}{18.7} = 10{,}300$$

$$P = \frac{10{,}300}{54} = 190$$

The transmissibility is computed to be 10,300 and the coefficient of permeability is determined by dividing the transmissibility by the thickness of the aquifer, or 190. The specific capacity of the well is computed to be 20.1 gallons per foot of drawdown.

A pumping test on an irrigation well (137) owned by C. T. Hutchins and situated in the SE¼ SE¼ sec. 35, T. 18 S., R. 33 W. was made on May 19, 1942. The pumping rate, depth to water level before, during, and after pumping, and values for t/t^1 and for s (residual drawdown) are given in Table 5.

TABLE 4. *Data on pumping test of well 139, Scott County, made on May 22, 1942*

Time since pumping started, minutes	Time since pumping stopped, minutes	t/t[1]	Yield, gallons per minute	Depth to water level, feet	Draw-down, feet	Remarks
....	....	....	....	18.47	....	Depth to water level on May 6, 1942.
						Pump started
....	....	....	730	54.64	....	
....	....	....	732	54.80	....	
....	....	....	729	54.80	....	
....	....	....	725	54.70	....	
....	....	....	718	54.65	....	
....	....	....	716	54.65	....	
800	....	....	....	....	....	Pump stopped
805	5	161	....	42.58	24.11	
806	6	134.3	....	37.05	18.58	
808	8	101	....	33.65	15.18	
810	10	81	....	32.60	14.13	
811½	11½	70.5	....	32.04	13.57	
813	13	62.5	....	31.37	12.90	
816	16	51	....	31.11	12.64	
818	18	45.5	....	30.87	12.40	
820	20	41	....	30.54	12.07	
825	25	33	....	29.88	11.41	
830	30	27.6	....	29.02	10.55	
836	36	23.2	....	28.74	10.27	
847	47	18	....	28.19	9.72	
855	55	15.5	....	27.88	9.41	
865	65	13.3	....	27.52	9.05	
880	80	11	....	27.06	8.59	
902	102	8.8	....	26.46	7.99	
932	132	7	....	25.87	7.40	
962	162	5.9	....	25.40	6.93	
992	192	5.1	....	25.03	6.56	

TABLE 5. *Data on pumping test of well 137, Scott County, made on May 19, 1942*

Time since pumping started, minutes t	Time since pumping stopped, minutes t¹	t/t¹	Yield, gallons per minute	Depth to water level, feet	Draw-down, feet	Remarks
....	....	....	....	19.03	....	Pump started
....	....	....	582	51.25	....	
....	....	....	582	55.95	....	
....	....	....	580	56.65	....	
....	....	....	578.5	56.65	....	
....	....	....	579	57.05	....	
....	....	....	578.5	59.17	....	
185	....	....	....	....	....	Pump stopped
187½	2½	75.0	....	41.33	22.30	
189	4	47.2	....	32.29	13.26	
190½	5½	34.6	....	27.52	8.49	
191½	6½	29.5	....	25.72	6.69	
192½	7½	25.6	....	24.53	5.50	
193½	8½	22.7	....	23.70	4.67	
194½	9½	20.5	....	23.15	4.12	
195½	10½	18.6	....	22.77	3.74	
197	12	16.4	....	22.30	3.27	
200	15	13.3	....	21.74	2.71	
203	18	11.3	....	21.37	2.34	
206	21	9.8	....	21.10	2.07	
209	24	8.7	....	20.93	1.90	
212	27	8.0	....	20.79	1.76	
215	30	7.1	....	20.67	1.64	
220	35	6.3	....	20.51	1.48	
230	45	5.1	....	20.33	1.30	
245	60	4.0	....	20.15	1.12	
260	75	3.4	....	20.05	1.02	
275	90	3.0	....	19.95	.92	
290	105	2.8	....	19.89	.86	
305	120	2.5	....	19.83	.80	
335	150	2.2	....	19.75	.72	
365	180	2.0	....	19.71	.68	

TABLE 6. *Results of pumping tests made on wells in Scott County, Kansas, using the Theis recovery method for determining permeability*

Well No.	Water-bearing formation	Discharge, gallons a minute	Drawdown, feet	Duration of pumping, minutes	Specific capacity[1]	Coefficient of transmissibility	Approximate thickness of water-bearing material, feet	Coefficient of permeability[2]
91	Pleistocene sand and gravel and/or Ogallala formation	666	24.86	195	26.8	46,270	38	1,200
137	Pleistocene sand and gravel and/or Ogallala formation	580	38.06	185	15.2	79,400	93	850
139	Pleistocene sand and gravel	729	36.2	800	20.1	10,300	54	190
172	Pleistocene sand and gravel	567	34.83	197	16.3	17,010	60	280

1. The specific capacity of a well is its rate of yield per unit of drawdown and is determined by dividing the tested capacity in gallons a minute by the drawdown in feet.

2. Coefficient of transmissibility divided by thickness of saturated water-bearing material; water temperature 60° F.; hence no correction for temperature is needed.

The ratio t/t^1 was determined graphically by plotting t/t^1 against corresponding values of s on semilogarithmic paper and using the slope of the straight line drawn through the plotted points.

$$\text{Thus } T = \frac{264 \times 580.3 \times 1}{1.93} = 79{,}400 \qquad P = \frac{79{,}400}{93} = 850$$

The transmissibility is computed to be 79,400 and the coefficient of permeability is determined by dividing the transmissibility by the thickness of the aquifer, or 850. The specific capacity of the well is computed to be 15.2 gallons per foot of drawdown.

Data on the four pumping tests in Scott County are listed in Table 6.

As indicated in Table 6, the coefficient of permeability of the combined Pleistocene and Pliocene water-bearing formations penetrated by irrigation wells in Scott County is much greater than that of water-bearing formations of Pleistocene age only. Some of the largest yields obtained from irrigation wells in the county are believed to be derived from wells penetrating deposits of sand and gravel of the Ogallala formation of Pliocene age. One of the largest groups of successful irrigation wells obtaining water from this source is situated in an area covering several square miles about 3 miles west of Shallow Water.

WATER IN SAND AND GRAVEL

Much of Scott County is underlain by unconsolidated deposits of sand and gravel of Pleistocene and Pliocene age. Sand and gravel are also found in the alluvium in several of the stream valleys. The history of their deposition is given under Geologic History, and their distribution, character, thickness, and water-yielding capacity are described under Geologic formations and their water-bearing properties.

These stream deposits were subjected to the sorting action of water with the result that distinct beds of gravel, sand, silt, or clay were deposited. The source of material and degree of sorting determined the texture of this material, whether coarse or fine, some deposits being composed of clean well-sorted gravel while in others finer materials predominate. In some poorly sorted deposits finer materials occupy the pore spaces between the larger grains reducing the effective porosity. Coarse, clean, well-sorted gravel or sand has a high porosity and high permeability. Properly constructed wells in material of this type yield large quantities of water.

The sand and gravel deposits of the Ogallala formation constitute the principal source of water in Scott County. In the Scott Basin the sand and gravel deposits of Pleistocene age are also an important source of ground water. The sand and gravel deposits of the alluvium in the principal stream valleys, particularly in the valley of Beaver Creek, furnish water to many domestic and stock wells. The sand and gravel deposits of the Ogallala formation and the water-bearing sands and gravels of Pleistocene age furnish water to a great many domestic and stock wells and to many irrigation wells as well as to the public-supply wells at Scott City. Approximately 130 irrigation wells in the Scott Basin are supplied with water from these deposits.

WATER IN CHALK AND SHALE

Chalk and associated chalky shales are not important sources of water in Scott County, although many of the wells in the southeastern quarter of the county are known to end in either chalk or chalky shale.

Water occurs in limestone in fractures or in solution openings that have been dissolved out of the rock by water containing dissolved carbon dioxide. The occurrence of fractures and solution openings is very irregular, making it difficult to predict where water will be found in a limestone. One well drilled to limestone may encounter water-filled fractures or solution openings and have a good yield, whereas another well drilled only a few feet from the first well may not encounter any fractures or solution openings and yield little or no water. In drilling for water in an area underlain by limestone, it is generally necessary to put down several test holes to locate water-bearing fractures or solution openings before the final well can be drilled.

Shale is one of the most unfavorable of rocks from which to obtain water. Shale, if not too tightly indurated, may have a fairly high porosity and contain much water. The interstices between the individual particles are so small, however, that the water is held by molecular attraction and hence is not available to wells. Available water in shale is found only in joints and along bedding planes.

The Water Table and Movement of Ground Water

The permeable rocks that lie below a certain level in Scott County and elsewhere generally are saturated with water under hydrostatic pressure. These saturated rocks are said to be in the zone of saturation, the upper surface of which is called the water table. The permeable rocks that lie above the water table may be said to be in the zone of aeration (Waite, 1942, p. 53). The water that enters from the surface into the soil is slowly drawn down by gravity through the zone of aeration to the zone of saturation, except that which is retained by molecular attraction. In fine-grained material the earth is nearly saturated for several feet above the water table due to capillarity. This nearly saturated belt is called the capillary fringe. Water in the capillary fringe or in transit in the zone of aeration is not available to wells; hence wells must be sunk to the water table before water enters them.

SHAPE AND SLOPE

The shape and slope of the water table in Scott County are shown on the map (Pl. 1) by means of contours drawn on the water table. Each contour line has been drawn through points on the water table having approximately the same altitude. Collectively they show the configuration of the upper surface of the ground-water body in much the same manner as contours on topographic maps show the general shape of the land surface. The altitudes of the water surfaces in each of the wells that were used in compiling the map have been referred to sea-level datum. Ground water moves in the direction of maximum slope, which is at right angles to the contours. The position of the contours indicates that the water table in general slopes eastward, but that the amount of slope varies considerably because of irregularities of the water table.

The shape of the water table, which in turn determines the rate and direction of movement of ground water, is controlled by several factors. Irregularities in the shape of the water table under Scott County may be caused by (1) the configuration of the underlying Cretaceous floor; (2) discharge of ground water into perennial streams; (3) recharge of the ground-water body by ephemeral streams; (4) local differences in the permeability of the deposits; and (5) local depressions on the water table caused by the pumping of water from wells.

The shape and slope of the water table beneath Scott County conform in general to the eastward-sloping bedrock floor, the average slope being about 10 feet to the mile in the northern half of the county and about 6 feet to the mile in the southern part of the county in the vicinity of Shallow Water. The relation of the water table to the underlying bedrock floor is shown by the cross sections in Figure 5. The water-table contours in Plate 1 show that in general the water table beneath the western half of the county slopes eastward and that in the area of the heaviest pumping, about 7 miles southwest of Scott City, a cone of depression has been established. The area of heavy pumping includes about 8 square miles and is approximately delineated by the closed 2,910-foot contour line. In the northeastern quarter of the county the contours show that the water table slopes northeastward. Near the southeastern corner of the county the contours show that the direction of movement is in a southeast direction. The presence of a bedrock high in this vicinity has undoubtedly been partially responsible for this change in the direction of movement. It is interesting to note that the configuration of the water table, as shown by the water-table contours on Plate 1, in general is similar to the configuration of the pre-Tertiary surface as shown in Figure 2. The countours on the pre-Tertiary surface indicate the presence of a bedrock high in the southeastern quarter of the county. They show further that in the western half of the county the pre-Tertiary surface slopes rather uniformly eastward, and in the northeastern part of the county the contours show that the pre-Tertiary surface in general slopes northeastward. The contours also reveal the presence of a long, narrow trough running southward near the middle of the county.

In the northern part of the county the plains surface has been dissected by Beaver Creek and several of the smaller northward-flowing tributaries of Smoky Hill River, and in some instances the valleys of these streams have been cut below the water table. Thus, along the lower reaches of Beaver Creek, the water-table contours show that the water table in the vicinity of Beaver Creek Valley slopes toward the areas of discharge along the stream. The presence of a long narrow ground-water divide on the east side of Beaver Creek after it turns abruptly northward is indicated by the water-table contours in that vicinity. Streams which gain water from the zone of saturation are said to be effluent streams (Waite, 1942, p. 55).

In the vicinity of the heavily-pumped area southwest of Scott City the water-table contours are not uniformly spaced suggesting that the configuration of the water table in this part of the county has been rather extensively altered as a result of heavy pumping from irrigation wells in the Scott Basin (Pl. 1). This is indicated by the cone of depression enclosed by the 2,910-foot contour and by the bunching of the contours up-gradient from the heavily pumped area—the steeper gradients resulting from the extension of the cone of depression. The effects of pumping are suggested also by the area of relatively flattened gradients just east of the heavily pumped area, which has been caused in part by pumping and in part by heavy recharge in the vicinity of the terminus of Whitewoman Creek.

Streams that flow only after rains are classed as ephemeral or intermittent streams. Their channels are above the water table and are dry much of the time. During periods of stream flow part of the water in an ephemeral stream may seep into the stream bed and descend to the water table. Streams of this type are called influent streams. The lower part of Whitewoman Creek is influent and the water table near the point where the creek debouches into Scott Basin receives contributions following occasional periods of stream flow. To a lesser degree, Lion Creek and Rocky Draw may be influent near their respective termini. As shown by the dashed 2,915-foot contour (Pl. 1), the water table in the vicinity of the terminus of Whitewoman Creek has been affected by recharge from flood waters.

Local differences in the permeability of the water-bearing beds affect the shape of the water table. Other things being equal the slope of the water table in any area in general varies inversely with the permeability of the water-bearing material. Thus, the flow of ground water varies from place to place according to the thickness and permeability of the water-bearing material. The permeability of the Ogallala formation is extremely variable as a result of changes in the character of the deposits from one locality to another. The permeability of the Smoky Hill chalk member of the Niobrara formation also is extremely variable as a result of differences in the character of the cracks and crevices that were produced by the adjustment of the brittle chalk following crustal deformation. Prior to the deposition of the Ogallala the upper surface of the Niobrara formation was subjected to weathering with the result that cracks and crevices along joints and bedding planes were developed extensively. Structural forces originating in the earth's crust produced faulting locally in the Smoky Hill chalk member of the Niobrara. The faulting apparently increases toward the top of the Smoky Hill chalk and it is also greater in certain areas than others. The permeability of the Smoky Hill chalk, therefore, is largely dependent on the presence or absence of cracks and fissures along joints and bedding planes and along fault planes.

The extreme flattening of the water-table gradient in the vicinity of the Scott Basin, as shown by the water-table contours, is due in a large measure to the greater permeability of the thick Pleistocene fill in the deepest part of the structural trough. Because of the absence of cemented beds in this part of the county, the opportunity for the flood waters of Whitewoman Creek to be absorbed readily by the unconsolidated sediments underlying Scott Basin is also afforded.

RELATION TO TOPOGRAPHY

In Scott County the depth to water level below the land surface is controlled largely by the configuration of the land surface. A map (Pl. 2) has been prepared showing the depths to water level in wells in Scott County by means of isobath lines—lines of equal depths to water level. These lines delimit areas in which the depth to water level lies within specified ranges. As shown on this map, the depth to water level ranges from less than 25 feet to about 160 feet. In general the depth to water level is less than 25 feet in the Scott Basin and in the Dry Lake area in the southeastern part of the county. In a much larger area in the central and southern part of the county the depth to water level is less than 75 feet. The water table lies deepest in the northern third of the county. In most of the principal stream valleys the depth to water level in general is less than 50 feet. The relation between the water table and the land surface is shown in the 3 geologic sections across Scott County in Figure 5.

For the purposes of discussion Scott County may be divided into several areas based upon the depth to water level: (1) shallow-water areas, (2) deep-water areas, and (3) areas of intermediate depth to water level. The shallow-water areas may be subdivided into the Scott Basin, the Cretaceous area in the vicinity of Dry Lake in the southeastern part of the county, and the shallow-water areas along stream valleys. In general the deep-water areas occur in the northern part of the county and in other parts of the county lying outside of the Scott Basin.

Scott Basin shallow-water area.—The Scott Basin is the largest and most important shallow-water area in the county. As shown by the map (Pl. 2) the water table stands less than 75 feet below the land surface in an area covering approximately 200 square miles. The water table stands less than 50 feet below the land surface in an area approximately half this large. In the lowest part of the Scott Basin, about 3 miles south of Scott City, the water table stands less than 25 feet below the land surface in an area covering about 14 square miles. Most of the wells in the Scott Basin obtain water from sands and gravels of Pleistocene and Pliocene age.

Cretaceous shallow-water area in the vicinity of Dry Lake.—In an area embracing approximately 10 square miles in the vicinity of Dry Lake near the southeastern corner of the county, the depth to water level is less than 25 feet. The Niobrara formation of Cretaceous age lies at or near the surface in this part of the county, the Ogallala formation either being thin or locally absent. The shallow depth to water level in this part of the county is due in part to the shallow depth of the Niobrara formation which supplies water to many of the wells and in part to the relatively low altitude of the land surface in this area, the Dry Lake depression being the lowest point in the county.

Shallow-water areas along stream valleys.—Small shallow-water areas occur in the narrow valleys of the principal streams in the county, notably along parts of Whitewoman Creek and along Beaver Creek. Most of the wells along Whitewoman Creek obtain water from the sands and gravels of Pleistocene and Pliocene age, since the alluvium in Whitewoman Valley is limited to a shallow deposit of sand and gravel comprising the actual stream bed. Most of the wells located on the flood plain of Beaver Creek obtain water from the alluvium, but some of the wells located along the valley sides obtain water from the Ogallala formation. Springs occur in some of the valleys that have been cut below the water table, principally in the northern part of the county. The springs issue from the basal part of the Ogallala formation near the contact with the underlying Niobrara formation.

Deep-water areas.—The deep-water areas in general are located outside the Scott Basin and are most extensive in the northern third of the county (Pl. 2). The depth to water level in most of the areas is more than 100 feet and in the northern part of the county the depth to water level is locally more than 150 feet. The deepest water level (well 10) observed in the county is located about 12 miles north and 2 miles east of Scott City. With the exception of several deep-water areas in the southeastern quarter of the county, practically all the wells in the deep-water areas in Scott County obtain water from the Ogallala formation. In some parts of the southeastern quarter of the county the Ogallala formation is thin or entirely absent and some of the wells have been drilled into the underlying Niobrara formation of Cretaceous age to obtain water supplies.

Areas of intermediate depth to water level.—The areas of intermediate depth to water level in general are confined to narrow belts along the valley sides of streams where the depth to water level ranges from 50 to 100 feet (Pl. 2). Most of the wells obtain water from the Ogallala formation. In the southeastern quarter of the county the Ogallala formation is thin or absent and some of the wells obtain water from the Niobrara formation.

FLUCTUATIONS IN WATER LEVEL

The water table in Scott County is not a stationary surface, but a surface that fluctuates up and down much like the water level in a lake or reservoir. In general, the water table rises when the amount of recharge exceeds the amount of discharge and declines when the discharge is greater than the recharge. Thus changes in the water levels in wells indicate to what extent the ground-water reservoir is being depleted or replenished.

The principal factors controlling the rise of the water table in Scott County are the amount of rainfall penetration, the amount of water added to the underground reservoir by influent streams, and the amount of water entering the county beneath the surface from areas to the west. The principal factors controlling the decline of the water table are the amount of water pumped from wells, the amount of water lost through transpiration and evaporation where the water table is shallow as in the Scott Basin and in stream valleys, the amount of water lost through natural discharge areas along streams, and the amount of water leaving the county beneath the surface toward the east. In the Scott Basin the water table fluctuates in response to the heavy draft made upon the ground-water reservoir by pumping from irrigation wells and to changes in storage as a result of seepage of flood waters at the terminus of Whitewoman Creek. 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.

The water levels in wells that penetrate water-bearing formations having a relatively impervious confining bed above the zone of saturation may fluctuate in response to changes in atmospheric pressure. The pressure on the water surface in a well increases with an increase of atmospheric pressure. If this increase in pres-

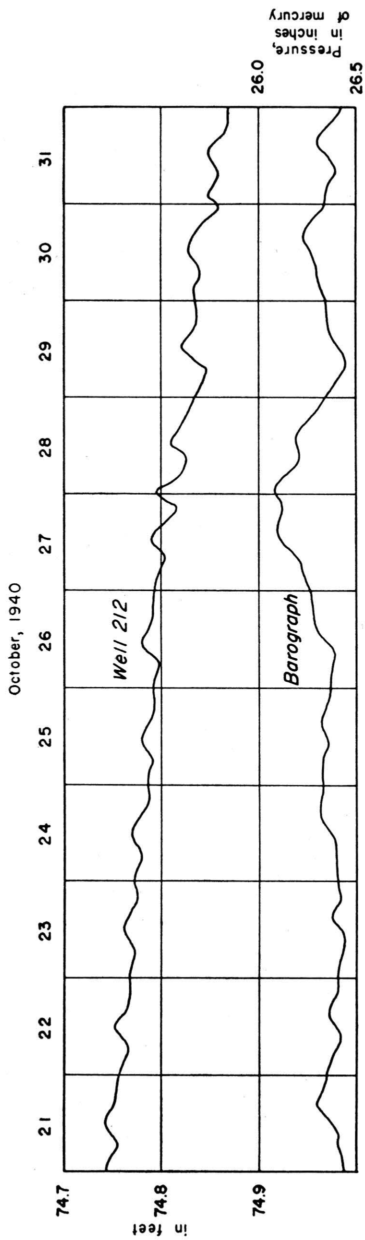


FIG. 8. Changes of water level in well 212 caused by changes of atmospheric pressure.

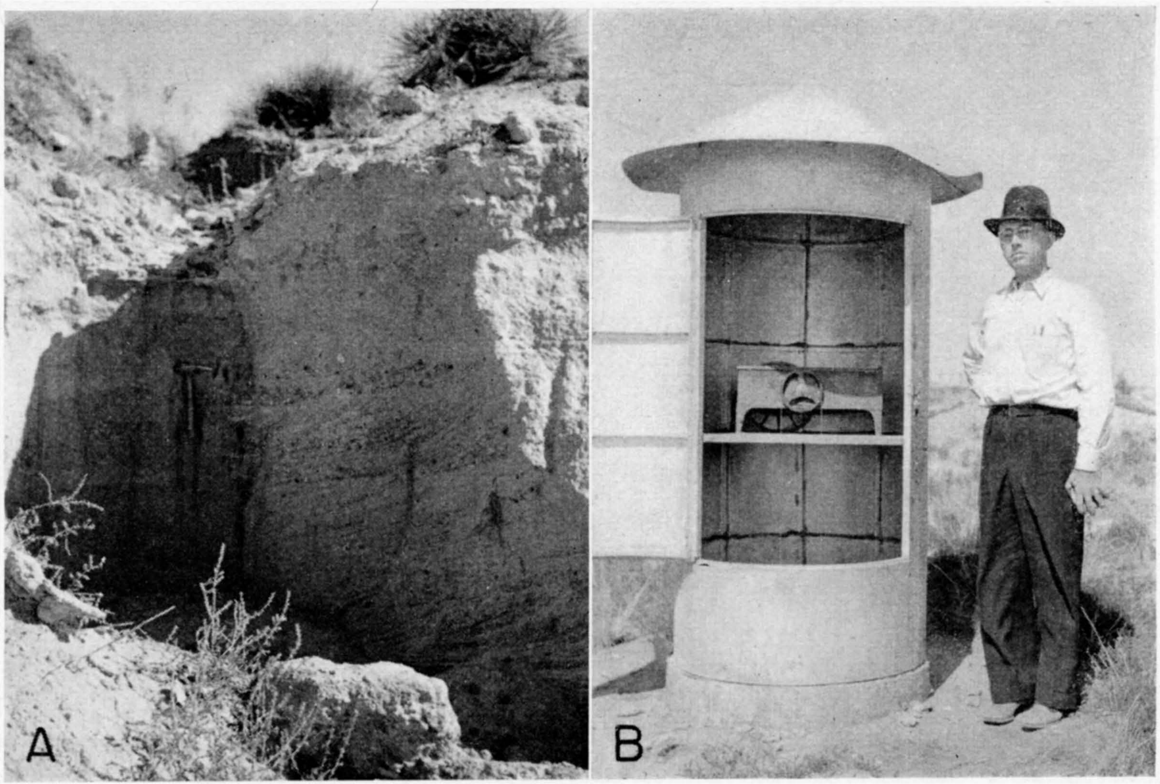


PLATE 8. *A*, View of north face of gravel pit in Scot t County State Park showing cross-bedding of deposits of sand and gravel of Tertiary age. *B*, Automatic wate r-stage recorder installed on well 130. Owned and maintained by the Division of Water Resources, Kansas Sta te Board of Agriculture.

sure is not transmitted uniformly to the entire ground-water body but acts only on the exposed water surface in the well, the water level in the well fluctuates according to the changes in pressure. If the pressure is transmitted freely through the pore spaces of the soil above the zone of saturation to the ground water, however, there is no barometric fluctuation of the water level. A hydrograph of well 212, obtained from an automatic water-stage recorder and an inverted barograph obtained from a recording micro-barograph, are shown in Figure 8. The barograph is inverted because an increase in atmospheric pressure causes the water levels in wells to decline.

In the fall of 1939, 29 wells at strategic points in Scott County were selected, and periodic measurements of water level in them were begun in order to obtain information concerning the fluctuation in storage of the underground reservoir. Two of these wells (196 and 212) were equipped with Stevens 8-day automatic water-stage recorders. Continuous automatic water-stage recorders have been maintained also on two wells (130 and 248) for several years by the Division of Water Resources of the Kansas State Board of Agriculture (Pl. 8B). In 1940 monthly observations were discontinued in wells 93 and 158 and measurements were begun in wells 228 and 157. In the spring of 1940 an irrigation well (249) was drilled 278 feet south of observation well 248. Because the pumping of this near-by irrigation well lowered the water level in the observation well (248), a new observation well (245) was constructed in August 1940 by the Division of Water Resources 1 mile east and 0.3 mile north of well 248, at a safer distance from local pumping influence (Pl. 9B). Complete water-level records of these wells (130, 131, 245, and 248) have been made available by George S. Knapp, Chief Engineer. The description of the wells and the water-level measurements in 1939, 1940, 1941, 1942, and 1943 are given in the annual water-level reports of the Federal Geological Survey for 1939, 1940, 1941, 1942, and 1943 (Meinzer and Wenzel, 1940, pp. 184-198; 1942, pp. 152-163; 1943, pp. 132-139; and 1944, pp. 153-158). The following table correlates the observation-well numbers used in this report with those given in Water-Supply Papers 886, 908, 938, 946, and 988. The location and description of each well appears in the table of well records at the end of this report.

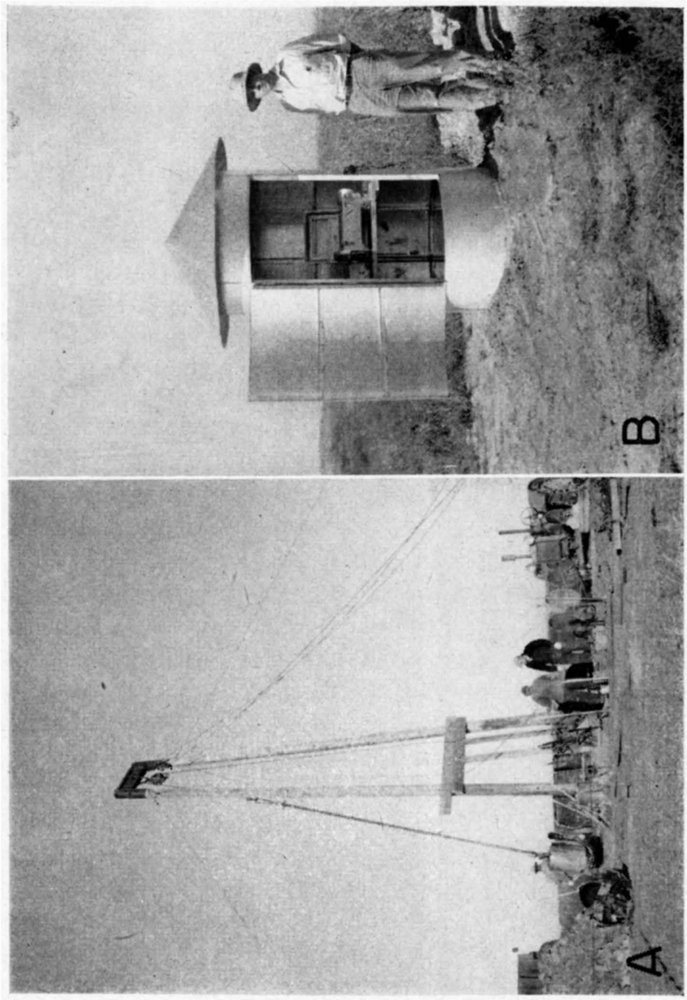


PLATE 9. *A*, Auger-type bucket used in drilling irrigation wells. Bipod set up over site of well 139. *B*, Automatic water-stage recorder installed on well 245. Owned and maintained by the Division of Water Resources, Kansas State Board of Agriculture.

TABLE 7. *Observation-well numbers used in this report and corresponding numbers given in Water-Supply Papers 886, 908, 938, 946, and 988*

Well no. in this report	Well no. in Water-Supply Papers	Well no. in this report	Well no. in Water-Supply Papers	Well no. in this report	Well no. in Water-Supply Papers	Well no. in this report	Well no. in Water-Supply Papers
24	36	107	19	162	50	228	54
27	35	118	27	163	17	232	49
34	40	123	3	195	5	244	13
42	41	128	23	196	b32	245	a1A
50	37	130	a2	198	42	248	a1
51	38	145	34	207	6	267	48
69	39	149	4	212	b33	270	44
90	47	157	55	217	8	....	....
93	24	158	45	218	9	....	....

(a) Equipped with a continuous automatic water-stage recorder and maintained by the Division of Water Resources of the Kansas State Board of Agriculture.

(b) Equipped with automatic water-stage recorder during the period from September 1939—July 1941.

RECHARGE

Recharge is the addition of water to the zone of saturation. Recharge in Scott County is derived from precipitation within the county, from influent streams, from infiltration as a result of the spreading of water for irrigation, and from subsurface inflow from areas to the west of the county. In the Scott Basin recharge to the underground reservoirs is accomplished by infiltration of flood waters discharged on to the basin at the terminus of Whitewoman Creek.

RECHARGE FROM LOCAL PRECIPITATION

Most of the ground-water recharge in Scott County is derived from precipitation. The normal annual precipitation in Scott County as determined by the U. S. Weather Bureau in 1944 is 18.61 inches, and only a small part of this amount reaches the zone of saturation. Part of the water that falls on the surface of the county runs off through surface channels and is drained from the area by tributaries of Smoky Hill River, part is evaporated, part is transpired by plants, and part seeps downward through the soil zone and other rock material and recharges the ground-water reservoir. The amount and frequency of this replenishment depend in part upon the permeability of the intake materials. There is generally a lag between the time of precipitation and the time the water levels in wells begin to rise, and in areas where the water table is deep, recharge

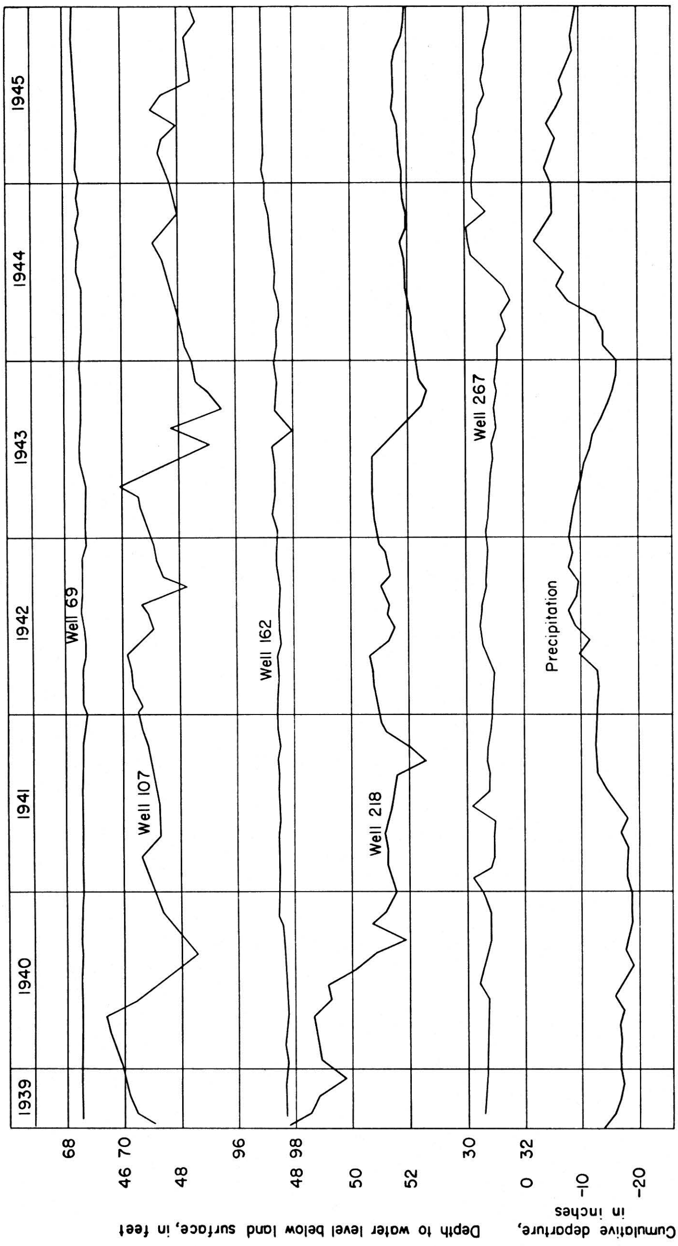


FIG. 9. Fluctuations of the water levels in five wells in Scott County and cumulative departure from normal precipitation at Scott City.

from infiltration from the surface occurs only infrequently or at a rate so low that the effect upon water levels in wells cannot be observed except over long periods. The amount of precipitation necessary to produce recharge depends upon the season of the year and the character of the materials in the soil zone and in the zones of aeration and saturation.

Fluctuations in ground-water levels in Scott County are related in some measure to the amount of recharge derived from the downward seepage of surface water, either directly from rain or melted snow or from streams and lakes supplied by rain and snow. The relation between the fluctuations of water levels and the depth to the water level in wells is shown best by the hydrographs of wells 69, 162, and

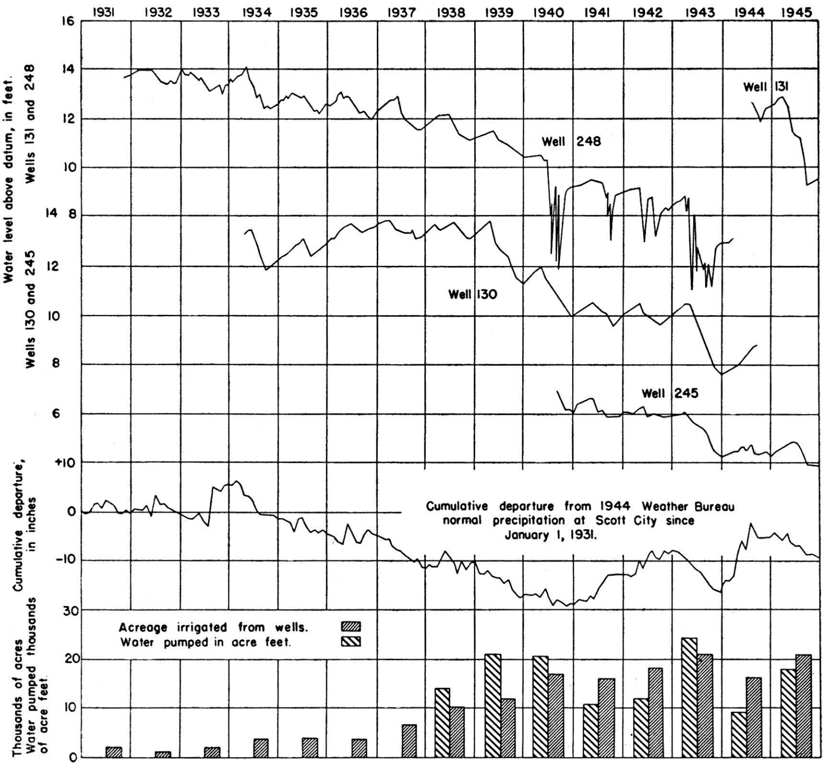


FIG. 10. Graphs showing the water levels in four wells equipped with recorders, the cumulative departure from normal precipitation at Scott City since January 1, 1931, and the acreage irrigated from wells in the Scott Basin. (Water levels from automatic water-stage recorder charts and figures for irrigated acreage supplied by the Division of Water Resources, Kansas State Board of Agriculture. Cumulative departure compiled from records of the U. S. Weather Bureau.)

267 in Figure 9. Wells 69 and 162 are upland wells situated in the eastern part of Scott County. The depth to water level in well 69 is about 69 feet and in well 162 about 98 feet. Well 267 is a shallower well situated about 5 miles south of Shallow Water. The depth to water in this well is about 32 feet and the hydrograph shows that the water level in the well rises in response to heavy precipitation. According to the hydrographs of wells 69 and 162 shown in Figure 9, the water levels in these wells seem to be only slightly affected by precipitation. The water levels in wells 107 and 218 whose hydrographs are shown in Figure 9 are affected by near-by pumping. For this reason the effects of precipitation upon the water levels in these wells have been obscured by the more dominant influence of the pumping.

The fluctuations of the water level in four observation wells equipped with automatic water-stage recorders in the Scott County shallow water basin, the cumulative departure from normal precipitation at Scott City and the acreage irrigated from wells in the shallow water basin are shown in Figure 10.

The water level in well 248 had a net decline during the period from October 23, 1931 through December 31, 1943 of 6.81 feet, which represents an average annual decline of 0.57 foot. The fluctuations of the water level in this well seem to correlate with the cumulative departure from normal precipitation, suggesting that the subnormal precipitation might be entirely responsible for the lowering of the water level in the well and in other wells in the area. It is shown in Figure 10, however, that the irrigated acreage in the shallow-water area has increased from 1,021 acres in 1932 to 21,320 acres in 1943 (Table 8). A somewhat similar correlation seems to exist between the fluctuations of water level in wells 130 and 245 and the cumulative departure from normal precipitation. A part of the decline in water level in each of these wells has been caused by a mounting deficiency in precipitation and a part has resulted from the effects of pumping as evidenced by the increase in irrigated acreage.

Throughout the growing season the moisture supply in the soil zone is depleted by the steady draft made by the plants and is replenished from time to time by rains or by irrigation. When rain occurs, this deficiency in the soil moisture supply must be satisfied before water will pass through the belt of soil moisture and move downward by gravity, either directly to the permanent zone of saturation or into the intermediate belt of the zone of aeration. The

TABLE 8. *Annual precipitation at Scott City, annual departure from normal, acreage irrigated from wells in the Scott Basin, and the annual net rise or net decline in water levels in wells 130, 245, and 248*

Year	Annual precipitation at Scott City, inches[1]	Annual departure from normal precipitation, inches	Acreage irrigated from wells in the Scott Basin[2]	Annual net rise (+) or net decline (—) in water level, feet		
				Well 248	Well 130	Well 245
1931	18.38	—0.23	2,265	....	....	....
1932	20.06	+1.45	1,021	+0.01	....	....
1933	24.84	+6.23	2,035	— .43	....	....
1934	12.65	—5.96	3,859	— .83	....	....
1935	15.54	—3.07	4,234	— .06	+0.62	....
1936	18.24	— .37	3,849	— .31	+ .71	....
1937	13.11	—5.50	6,828	— .59	— .22	....
1938	14.92	—5.80	10,355	— .40	— .03	....
1939	14.63	—3.98	12,298	— .79	—2.07	....
1940	16.88	—1.73	17,164	—1.15	—1.37	....
1941	24.63	+6.02	16,427	— .20	+ .05	—0.33
1942	22.24	—3.63	18,651	— .52	+ .09	— .12
1943	10.38	—8.23	21,320	—1.71	—2.49	—1.60
1944	29.92	+11.31	16,890	+ .18	+ .84	+ .10
1945	14.22	—4.39	21,002	— .73	—1.55	— .43
Normal	18.61	....	Average	— .54	— .39	....

1. Compiled from records of the U. S. Weather Bureau.
2. Acreage figures released by the Division of Water Resources of the Kansas State Board of Agriculture.

water table generally declines somewhat during the summer months owing to the withdrawal of water by plant transpiration and evaporation and by pumping for irrigation even though the precipitation may be greater than in the winter. During the winter months in places where the soil freezes to depths of a few feet the frozen soil may be quite impermeable and may function as a formidable barrier to infiltration from the surface. In the spring when thawing commences, the soil becomes saturated with the water from the rains and melted snow. Some of the water released in this manner sinks rapidly and eventually joins the zone of saturation. In the areas of deep water table in Scott County this thawing process may provide the principal additional ground-water storage for the year. There is relatively little evaporation and transpiration during the winter months, and at that time optimum conditions for recharge prevail.

Theis (1937) presented evidence to show that the average annual ground-water recharge from rainfall in the southern High Plains is somewhat less than half an inch. The intake materials near the surface in the upland areas lying outside the Scott Basin in Scott County are comparable to those of the southern High Plains, although the total annual precipitation is somewhat greater. Recharge as a result of rainfall penetration in Scott County probably averages slightly less than half an inch a year for several reasons: (1) most of the rainfall occurs during the growing season when the amount of water lost by transpiration and evaporation is the greatest; (2) the downward movement of water is impeded in most of the county lying outside of the Scott Basin by cemented beds of caliche in the Ogallala formation; and (3) some of the storm water remains in depressions for long periods after heavy rains, showing that very little infiltration takes place at these points. No figures regarding the annual amount of evaporation in Scott County are available, but the average rates of evaporation from a free water surface for the months of the growing season based on the 30-year record from 1908 to 1938 at the Garden City experimental farm are (Smith, 1940, p. 28): April, 6.68 inches; May, 8.46 inches; June, 10.25 inches; July, 11.90 inches; August, 10.42 inches; September, 8.10 inches. It is noteworthy that maximum evaporation occurs during the month of maximum rainfall and that the rate of evaporation greatly exceeds the rate of precipitation. It seems likely, therefore, that a rather large proportion of the annual precipitation in Scott County is lost through evaporation.

A part of the precipitation that falls is lost through runoff in streams, the amount being determined largely by the intensity of the rainfall, the slope of the land, the porosity of the soil, and the type and amount of vegetative cover. Conditions generally are much more favorable for rainfall penetration during a gentle rain of long duration than during a torrential downpour when the rate of runoff is high.

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. The slope of the land surface in nearly all of Scott County is relatively gentle, but steep slopes occur along Beaver Creek and smaller streams tributary to Smoky Hill River.

The type of soil also determines in part the proportion of the precipitation that will be lost as runoff and the part that will percolate into the underground reservoir. In general, runoff is greater in places where the soils are tightly compacted and fine-grained than in places where the soils are sandy and loosely compacted.

The velocity of the runoff is decreased by a suitable vegetative cover and under such conditions there is a better opportunity for part of the water to seep into the ground.

The loss of precipitation by runoff in Scott County is very small. Some runoff occurs along Beaver Creek in the northern part of the county as well as along several smaller tributary streams to Smoky Hill River. In the remainder of the county there is practically no surface runoff.

The most favorable areas in Scott County for ground-water recharge are the large depressional area south of Scott City known as the Scott Basin, locally along certain stretches of Whitewoman Creek and its tributaries, and the areas in the southeastern quarter of the county mantled by dune sand. There may be some ground-water recharge from storm water in shallow surface depressions on the uplands in Scott County.

Recharge in the Scott Basin

Scott Basin offers unusually good opportunities for recharge from precipitation and from infiltration of storm water during periods when the floor of the basin is covered by flood runoff from Whitewoman Creek. The temporary lake that forms at the terminus of Whitewoman Creek following heavy precipitation on its watershed to the west shrinks in volume in a relatively short time and a part of this water sinks into the ground. After passing through the soil zone much of this water moves on down through more permeable intake materials to join the water table. There is little or no resistance to the downward movement of this water because of the relative absence of impermeable materials beneath the floor of the basin.

The configuration of the water table in the vicinity of the Scott Basin, as shown by the water-table contours in Plate 1, suggests that recharge is occurring in that part of the county. The contours along the eastern and southeastern side of the basin have been shifted progressively down-gradient as a result of the heavy recharge in the area approximately enclosed by the 2,915-foot dashed contour. The amount and frequency of this recharge depend in large part upon the volume of water that is discharged into the basin, the approximate area that is inundated, and the length of time that the area is flooded. There is no opportunity for any of the storm water to leave the basin as runoff because of its low topographic position. It is probable that maximum recharge occurs during periods when the basin is inundated after the growing season at a time when transpiration and evaporation losses are low. The majority of the freshets that fall on the watershed of Whitewoman Creek occur during the growing season, however.

Recharge from Whitewoman Creek and its Tributaries

There is a possibility that some recharge occurs locally along certain stretches of Whitewoman Creek, particularly that part of its course which traverses the Scott Basin, during periods of stream flow. It is also possible that some recharge occurs along some of the larger tributaries of Whitewoman Creek, including Lion Creek and Rocky Draw. The magnitude of the contribution to the zone of saturation during periods of excessive runoff is not known, but in general it is believed to be rather small. The periods when these watercourses carry storm runoff are infrequent and of short duration and very little opportunity is afforded for very much water to sink into the shallow stream bed and move downward to be added to the zone of saturation. The bulk of the storm water moves rapidly downstream and is debouched on the floor of the Scott Basin at the lower end of Whitewoman Creek.

Recharge in Depressions

Shallow depressions, or sinks, dot the uplands and parts of the Scott Basin in Scott County. The widespread occurrence of these depressional areas is strikingly portrayed on the aerial photographs of the county that were obtained from the Agricultural Adjustment Administration. The outlines of nearly all of them have also been shown on the topographic maps of the four 15-minute quadrangles that cover the county. The greatest concentration of these sinklike depressions occurs in the northeast quarter of the county. They are conspicuously absent in an area southwest of Scott City bounded on the north by State Highway 96 and on the south by Whitewoman Creek and extending westward to the county line. Sinks are quite common in the upland area northwest of Beaver Creek near the northwestern corner of the county. In the area that lies south and southeast of Beaver Creek, the sinks are less numerous than in the northeast quarter of the county. Their distribution is somewhat scattered in the southern part of the county—south, east, and southeast of Whitewoman Creek, and east and southeast of Shallow Water. After heavy rains, storm water collects in these small basins, forming temporary lakes. The water in some of these ponds disappears rather quickly, while in others it may remain for periods ranging from a week to several months. One of these storm-water lakes is shown in Plate 7B. The ability of such depressional areas to hold or lose water is entirely dependent on the character of the underlying materials. If the deposits beneath the floor of the sink are fine-textured and relatively impermeable, water will stand in the sink until it is evaporated. On the other hand, if the materials beneath the floor of the sink are relatively permeable, the accumulated water will sink rapidly downward until all of it is thus dissipated. Some studies of the character of the deposits underlying similar depressions in the High Plains of Texas have ben made by White, Broadhurst, and Lang (1940, p. 7). Several hundred test holes were drilled in the beds of depression ponds on the High Plains. These holes were drilled to an average depth of about 30 feet and spaced 100 to 300 feet apart in lines across the depressions. The studies showed that subsurface conditions beneath the depressions were extremely variable. In some of the depressions relatively little caliche was encountered, in others caliche was found all the way across but was relatively soft, and in still others the cemented beds were dense enough to be designated rock by the drillers. In areas where the caliche was absent the sediments penetrated in many of the holes were relatively permeable from the surface to the bottom of the hole. This investigation also disclosed that (White, Broadhurst, and Lang, 1940, p. 7):

> The bottom of most of the depressions is covered with deposits of silt and soil, in places resembling gumbo and ranging from two to ten feet in thickness. After the ponds become dry, fractures and crevices several feet in depth frequently develop in their beds. In some of the depressions small sinks, apparently developed by solution channelling in the underlying caliche deposits, are present. These crevices and solution channels may provide a pathway for the downward movement of water for a time after the ponds are filled, although they may become sealed after water has stood over them for several days. . . . In some of the ponds the rate of decline was small and apparently was due mostly to losses from evaporation. In others, it was quite rapid, amounting in some cases to two inches or more a day for 10 days or so after the rains and then gradually slowing down.

Latta (1944, pp. 73-74) presented evidence to show that the fluctuations of the water level in a well in Finney County, which is situated in a depression similar to those under discussion, reflected the effects of recharge resulting from water percolating to the water table from storm water accumulated in the depression. This response was obvious in spite of the fact that the water level in the well was about 112 feet below the surface. He pointed out that as a result of recharge from this depressional area, a small mound on the water table was formed temporarily and that the mound was gradually reduced as the water moved out laterally. He also concluded that other depressions on the uplands probably act as catchment areas for recharge in the same manner.

It is believed that similar conditions exist in Scott County. Some of the floors of the depressions appear to be sealed rather tightly by an effective soil cover, while the floors of others seem to be traversed by cracks.

Summary

Much of the annual recharge to the ground-water reservoir in Scott County is derived from precipitation that falls on the county, from precipitation on the surface of the High Plains west of Scott County, and from infiltration of flood waters at the terminus of Whitewoman Creek. The amount and frequency of recharge from precipitation depend upon many variable factors. A part of the local precipitation enters the ground through areas of sand dunes and sandy soil, some of the storm water that collects in the numerous depressions scattered over the county sinks into the ground to join the water table, and small amounts of water move downward through channels of normally dry streams during periods of flood flow. Theis (1937) presented evidence to show that the average annual ground-water recharge from precipitation in the southern High Plains is somewhat less than half an inch.

DISCHARGE

Ground water is discharged in Scott County by transpiration and evaporation, by seepage into streams, springs, and underground percolation that leaves the county, and by wells. The rate at which it is discharged is controlled by many factors, but especially by the stage of the water table and by the season of the year. Transpiration and evaporation of water from the zone of saturation are confined exclusively to areas where the water table is very shallow, such as in the lowest part of the Scott Basin. More ground water is pumped from irrigation wells in the Scott Basin than in the upland parts of the county. Seepage of ground water into streams occurs only along Beaver Creek and other smaller tributaries of Smoky Hill River in the northern part of the county. There is little or no natural discharge of ground water where the water table lies at great depth except for the water that is moving slowly out of the county to the east as indicated by the water-table contours on Plate 1. The amount of water that moves out of the county is approximately the amount that enters from the west plus whatever additions to or subtractions from the ground-water reservoir have been made within the county.

Transpiration and Evaporation

Water may be drawn into the roots of plants directly from the zone of saturation or from the capillary fringe, and discharged from the plants into the atmosphere by the process of transpiration (Meinzer, 1923a, p. 48). The rate at which water is withdrawn by this process varies with the type of plants, the depth to the water table, the climate and season of year, the character of the soil, and possibly other factors. The limit of lift by ordinary grasses and field crops is not more than a few feet, but some types of desert plants are known to have roots which penetrate to the water table 60 feet or more below the surface (Meinzer, 1923, p. 82). In most of Scott County, with the possible exception of the lowest part of the Scott Basin, the water table is considerably below the root tips of most plants, and water is withdrawn from the belt of soil moisture, thereby depleting the supply of soil moisture. In the lowest part of the Scott Basin south and east of Scott City and in some of the stream valleys many of the plants draw water directly from the zone of saturation, Evaporation of water directly from the zone of saturation is confined almost exclusively to land adjoining streams, where the water table is very shallow. In most parts of Scott County where the water table lies at considerable depth no water from the zone of saturation is lost by direct evaporation; in such places only the soil moisture is evaporated.

The amount of water discharged annually by plant transpiration in Scott County is not definitely known, but it is probably very small in those areas where the water table lies more than 20 feet below the suface. In the lowest parts of the Scott Basin and in some of the stream valleys where the water table is shallow, the amount of ground water discharged by plants is somewhat greater. It is believed that the total quantity of water withdrawn by plant transpiration in the lowest part of the Scott Basin and in stream valleys is relatively small and much less than in the central Platte Valley in Nebraska.

Seepage into Streams

A stream that stands lower than the water table may receive water from the zone of saturation, and is known as an effluent stream. The principal streams that receive ground-water discharge in Scott

County are Beaver Creek and several of the small northward-flowing tributaries of Chalk and Hell Creeks in the northern part of the county.

As pointed out under the discussion of shape and slope of the water table, ground water moves in toward the lower part of Beaver Creek Valley from both sides as shown by the water-table contours on Plate 1. Beaver Creek is a gaining stream, starting at a point about 5 miles northwest of Scott City and continuing throughout the remainder of its course northward; that is, it is effluent with respect to the water table. Where tributary streams have cut their channels below the water table, their flows are also augmented by ground water during most of the year.

Discharge from Springs

In Scott County some water is discharged through springs. All springs observed are in the northern part of the county along the lower stretches of Beaver Creek and its larger tributaries, and along several of the northward-flowing tributaries to Chalk and Hell Creeks which are just north of the Logan-Scott County line. All the springs are along the valley sides of streams and are at or near the contact between the water-bearing sands and gravels of the Ogallala formation and the underlying chalk and chalky shale of the Smoky Hill chalk member of the Niobrara formation. The total quantity of water discharged by springs in Scott County is not definitely known, but it is thought to be small as compared to discharge by other means. It is probable that there is a large amount of seepage along the escarpments bordering the stream valleys that is not discernible, the water probably being dissipated by evaporation and transpiration as fast as it issues near the contact of the Ogallala and Niobrara formations. The known springs are described below under recovery.

Discharge from Wells

Discharge of ground water from wells in Scott County constitutes the principal discharge from the ground-water reservoir. Large amounts of water are pumped from irrigation wells in Scott County in addition to that pumped from industrial, public supply, and domestic wells. Most of the rural residents of the county derive their domestic and livestock supplies from wells, but the total amount of water pumped from these wells is comparatively small.

RECOVERY

Springs

In Scott County, some water is recovered from springs for domestic and stock use and, in at least one case, for public supply, but the supplies thus obtained, with the exception of several of the larger springs in Scott County State Park, are generally small. Small springs are found in the northern part of the county along the valley sides of Beaver Creek and its principal tributaries and along northward-flowing tributaries of Chalk and Hell Creeks. The locations of several of the more important springs are shown on Plate 2.

Most of the springs observed in this area are gravity springs; the water does not issue under artesian pressure, but is at the outcrop of the water table. Seepage areas were also observed along the valley sides of these streams. The water in this type of spring or seepage area percolates from permeable material or flows from openings in the rock, under the action of gravity, as a surface stream flows down its channel. Gravity springs may be further classified as seepage springs, in which the water percolates from numerous small openings in permeable material; as contact springs, in which water flows to the surface from permeable material over the outcrops of less permeable or impermeable material that retards or prevents the downward percolation of the ground water and thus deflects it to the surface; and as depression springs, in which water flows to the surface from permeable material simply because the surface extends down to the water table (Meinzer, 1923a, pp. 50-55). The distinctions between these types of springs are somewhat arbitrary and all may grade into one another.

Most of the springs in Scott County are either contact springs or seepage springs and issue from permeable beds at or near the base of the Ogallala formation near its contact with the underlying Niobrara formation. Water is discharged from many springs of this type on both sides of Beaver Creek and its principal tributaries in Scott County State Park. At some of the seeps there is no visible discharge of water, but the vegetation near the contact is much greener and more luxuriant, indicating that the plants are transpiring ground water as fast as it is being discharged. Although some of these seepage areas are rather extensive, they have not been shown as springs on Plate 2.

Some of the springs in Scott County State Park have been developed for public use. The best known of this group of springs

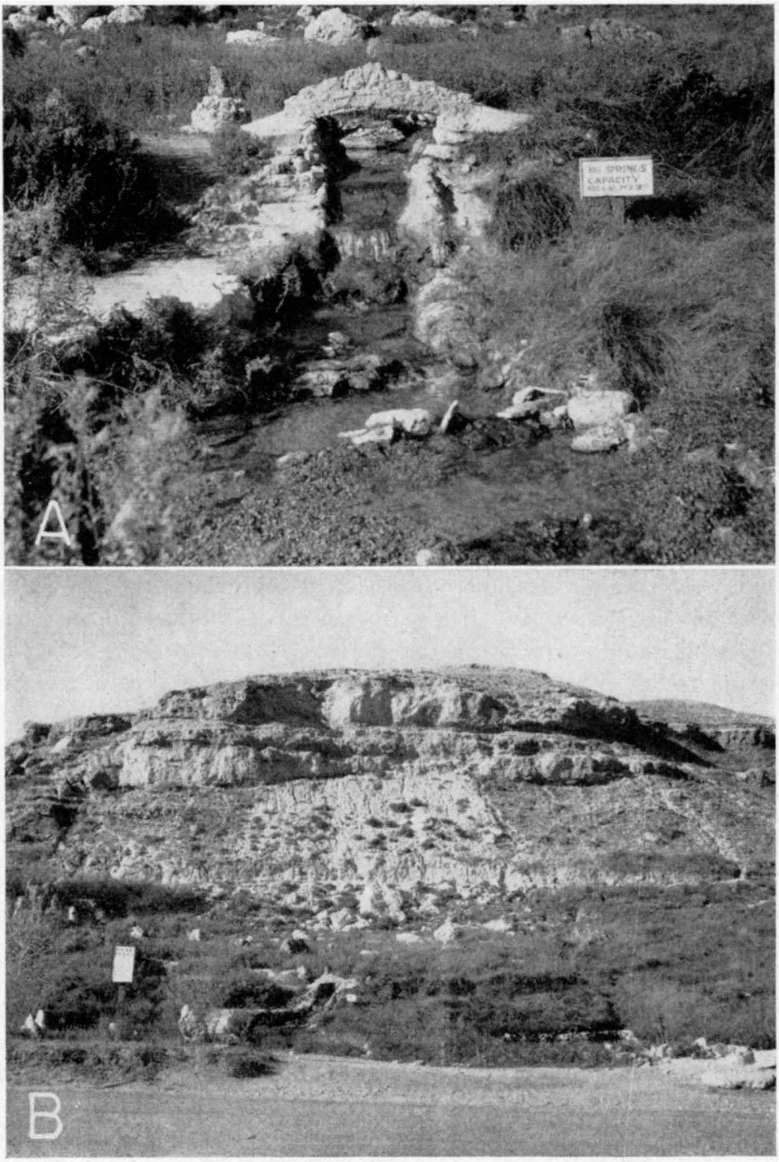


PLATE 10. *A,* Closeup view of Big Springs located in Scott County State Park. *B,* Distant view of above, showing characteristic exposure of Ogallala formation in bluff in background. Springs issue from base of Ogallala formation near its contact with the underlying Smoky Hill chalk member of the Niobrara formation.

are the "Old Steele Home" in the park, "Big Springs," and "Barrel Springs" (numbers 16, 17, and 18, respectively). The largest spring observed in the county was "Big Springs" (Pl. 10). This spring has a reported yield of 400 gallons a minute. The yields of other springs in the county are somewhat less and range from a few gallons a minute up to possibly 100 gallons a minute and greater.

WELLS

PRINCIPLES OF RECOVERY FROM WELLS

When a well is pumped there is a difference in head between the water inside the well and the water in the material outside the well. The water table in the vicinity of a pumped well declines and assumes a form comparable to an inverted cone, the apex of which is at the well. When a well is discharged under artesian conditions, there is a comparable lowering of the "piezometric surface"—the imaginary surface to which artesian water will rise under its full head. Under artesian conditions the cone of depression exists only as an imaginary cone whose apex is the point of discharge of the well. In any given well the greater the pumping rate the greater will be the drawdown and the greater will be the extent of the cone of depression. Thus the effects of the discharge will be felt at greater distances from the pumped well, and, if heavy pumping continues, the water levels in wells several hundred feet or even a mile or more distant may be lowered somewhat.

The specific capacity of a well is its rate of yield per unit of drawdown and is usually stated in gallons a minute per foot of drawdown. For example, well 91 has a measured yield of 666 gallons a minute with a drawdown of 24.8 feet. Its specific capacity, therefore, is about 26.8 gallons a minute per foot of drawdown. When a well is pumped the water level drops rapidly at first and then more slowly until conditions of approximate equilibrium are approached, and, in some wells, the water level may continue to decline for several hours or days before approximate equilibrium is established. Drawdown and recovery curves for wells 91 and 137 are shown in Figure 6. In determining the specific capacity of a well, therefore, it is important to continue pumping until the water level remains approximately stationary. When pumping stops, the water level rises rapidly at first, but the rate of recovery becomes progressively slower and may continue long after pumping has ceased.

The cost of pumping water can be reduced by increasing the specific capacity of a well, as the cost of pumping increases with the drawdown. The specific capacity of wells sometimes can be increased by modern methods of well construction, some of which are described under "Drilled Wells."

METHODS OF LIFT

Most of the rural residents in Scott County derive their domestic and stock supplies from wells equipped with lift or force pumps, which are operated by windmills, engines, electric motors, or in some cases by hand. Some of the 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.

All irrigation wells in Scott County are equipped with deep-well turbine pumps. A series of connected turbines or bowls are submerged below the water table (or just above in some wells) and are connected by a vertical shaft to a pulley or vertical motor at the top, or to internal combustion engines through geared heads. The number of such units varies, depending on the height the water must be forced, but the average installation in irrigation wells in Scott County comprises 3 stages. Approximately 45 percent of the irrigation wells in Scott County are powered by electric motors, about 31 percent are powered by natural-gas engines, approximately 13 percent are powered by gasoline engines, and a few are operated by diesel engines and tractors.

Practically all industrial wells in the area, including the railroad and municipal wells in Scott County, are equipped with deep-well turbine-type pumps driven by electric motors.

DUG WELLS

Of 280 wells in Scott County visited in 1940, 7 were dug wells. Of these 7 dug wells, 2 supplied water for domestic and stock use and 5 were out of use. Most dug wells tap rather poor water-bearing material, but because of their large diameter they have a large infiltration area and ample storage capacity. Dug wells generally are curbed with native rock, but four of the dug wells in Scott County are left uncased and one well has been curbed with old steel boilers. Practically all the dug wells are approximately 4 feet in diameter and the total depths of the wells range from about 20 to 85 feet.

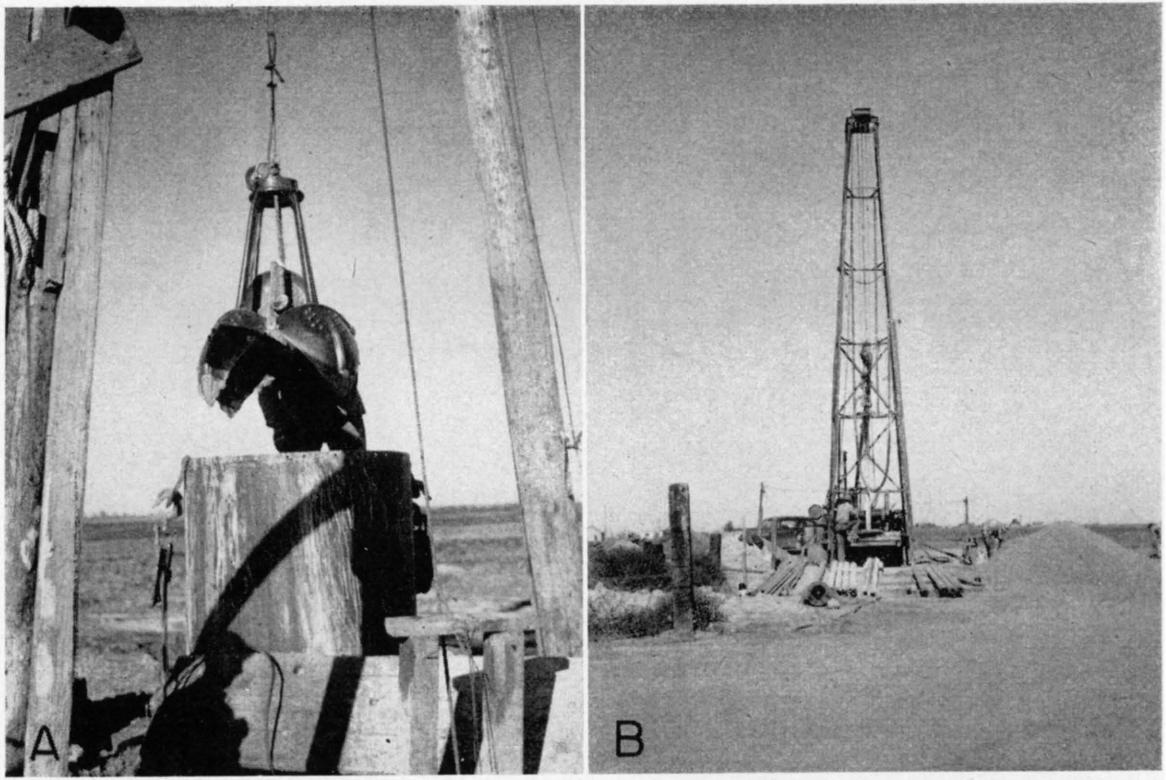


PLATE 11. *A,* Orange-peel bucket in open position ready to be lowered into hole during construction of well 114. *B,* Rotary hydraulic drilling rig used in putting down irrigation wells.

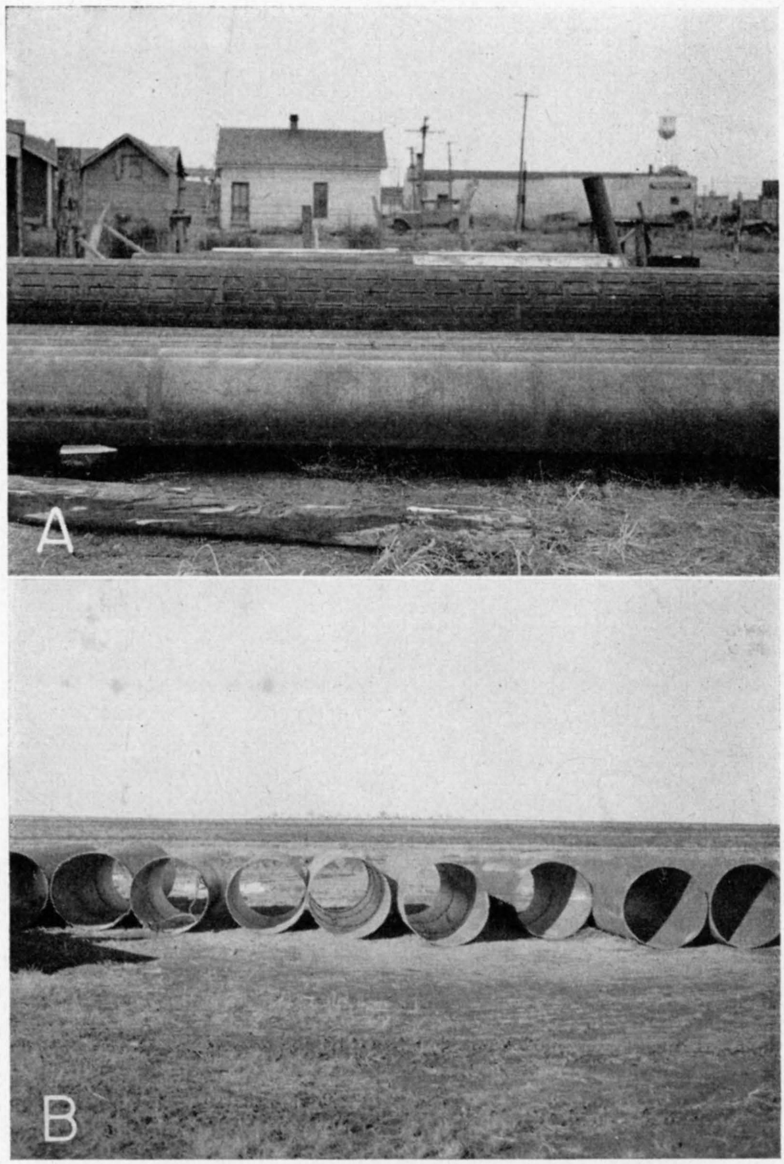


PLATE 12. *A,* View of 18-inch boiler-steel casing used for irrigation wells. Sections of blank casing in foreground; torch-perforated screen casing in background. *B,* End view of 42-inch blind or dummy casing used in constructing gravel-packed irrigation wells.

DRILLED WELLS

Several methods of drilling wells have been employed in Scott County. Most of the domestic and stock wells in the county have been drilled by cable-tool rigs. The cable-tool method is also known as the percussion method and is sometimes referred to as the churn-drill method. Several other special methods for drilling irrigation wells in the county have been developed by local drillers. One of these methods makes use of a large-diameter auger-type bucket (Pl. 9A) that is used in conjunction with an orange-peel bucket (Pl. 11A). In this method blind or dummy casing (Pl. 12B), 42 to 46 inches in diameter, is used in constructing gravel-packed wells. The hydraulic-rotary method as well as the jetting method have been employed in connection with the drilling of small-diameter test holes for irrigation supplies. In 1940, hydraulic-rotary methods were also used for constructing irrigation wells, and several wells have been put down by this method since that time. A portable hydraulic-rotary drilling rig was used for this purpose (Pl. 11B). Another method that has been very successful in the construction of large wells is an adaptation of the California mud-scow method with some modification. In this method a heavy bailer with a cutting shoe and a reaming attachment is used (Pl. 13B).

A standard cable-tool rig consists essentially of a mast, 2-line hoist (cable drum), one for the tools and the other to operate the bailer or sand bucket, a walking beam (spudder) for raising and dropping the tools, and an engine for power. The unit is generally mounted on a truck or trailer. The mast is made so that it can be folded down over the machine for moving. Drilling is accomplished by the breaking up of the rock by the impact of a heavy bit that is lifted and dropped at regular intervals. The crushed material is removed from the hole by means of a bailer or sand bucket. In the hydraulic rotary method, the equipment necessary consists of drill pipe, drill bits, mud pump, derrick or mast hoist with drill line for handling pipe, power unit, rotary table, swivel, and hose. This equipment is generally mounted on a truck or trailer unit. The rotary table is at the rear, and the mast is in a vertical position above the rotary table when drilling and folds down over the truck when moving. Mud is pumped from a pit by the mud pump to the drill pipe under pressure and out through the openings in the drill bit. The pipe is rotated continuously while drilling. The drill pipe is rotated by the rotary table either

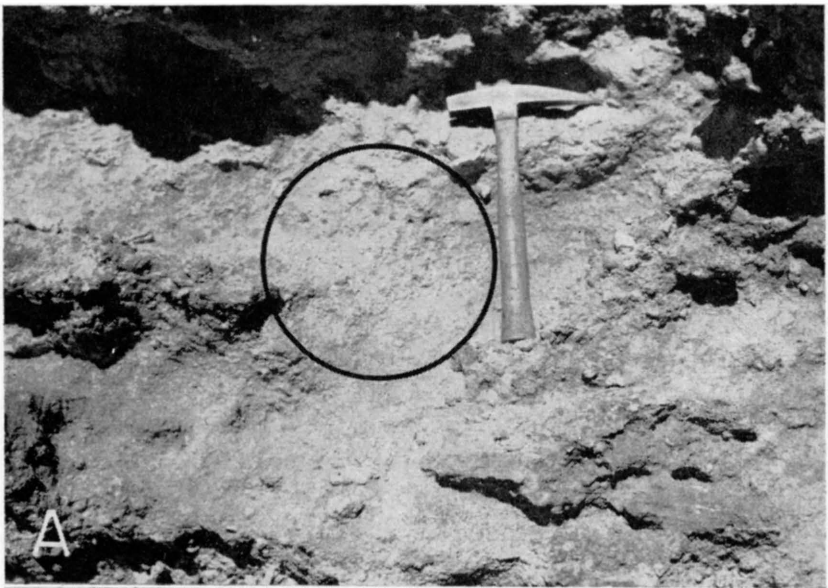


PLATE 13. *A,* Cluster of *Biorbia fossilia* seeds in Ogallala formation at north end of Scott County State Park in the NW¼ SE¼ sec. 2, T. 16 S., R. 33 W. *B,* Bailer with cutting shoe and a reaming attachment used in constructing large wells by a modified California mud-scow process. Bailer is 18 feet long and 17 inches in diameter; weight approximately 2,000 pounds.

by use of a Kelly or clamps that fasten to the drill pipe. In this method, removal of the cuttings is accomplished by circulating mud-laden fluid down through the drill pipe and up through the annular space between the drill pipe and the hole. The cuttings are brought to the surface as fragments suspended in the mud and are allowed to settle out into a sump or pit. The mud fluid is then picked up by the mud pump and recirculated. The mud also serves to plaster the walls of the hole and to prevent the formations from caving until the casing is installed.

The equipment used in the jetting method consists of a string of pipe, a jetting bit, a pressure pump for forcing water through the bit, and a hoisting mechanism for handling pipe. Drilling is done by means of water forced through the drill bit under pressure. The bit is turned slowly by hand or where hard formations are encountered the drill stem with bit attached to lower end is raised and dropped by use of spudding equipment, this action pulverizing the formation being drilled so that the water that is forced through the bit under pressure will carry the drill cuttings to the surface. An adaptation of this method has been used by local drillers in the county for test-drilling purposes only. Small portable drilling machines have been built by the drillers for this purpose.

Construction of wells in consolidated rocks.—A few drilled wells in the southeastern quarter of Scott County obtain water from consolidated rocks—shale and limestone. In most of these wells the water enters only in the lower end of the casing; these are called open-end wells. In some wells, however, the casing extends to the bottom of the hole and the water enters the well through a section of screen or slotted casing placed opposite the water-bearing material. This type of well is generally cased only a short distance into the rock, the lower part of the hole being left uncased. The yields of drilled wells in the several consolidated deposits in Scott County are discussed on pages 114 and 118; the records of all wells visited are given in Table 19.

Construction of wells in unconsolidated deposits.—Most of the drilled wells in Scott County obtain water from unconsolidated material (sand or gravel). The principal unconsolidated water-bearing deposits are the Tertiary Ogallala formation and the undifferentiated Pleistocene sands and gravels. Wells in these deposits generally are cased nearly to the bottom of the hole with galvanized-iron or wrought-iron casing. In some wells the water enters only at the lower open end of the casing, but in many wells—particularly those used for irrigation—the casing is perforated below the water table to provide greater intake facilities.

The principal type of domestic and livestock well in Scott County is a cased drilled well containing a separate pipe and cylinder for conducting the water to the surface. The wells are generally from 4 to 6 inches in diameter. Many of the larger municipal and industrial wells and practically all the irrigation wells that have been drilled in the county in the last several years are gravel-packed. In places where the water-bearing materials are fine-grained, the gravel-packed wells have several advantages that offset the greater initial cost. The envelope of selected gravel that surrounds the screen increases considerably the effective diameter of the well, thereby decreasing the velocity of the water entering the well. This reduction in velocity prevents the movement of fine sand into the well and increases the production of sand-free water. Owing to the increased effective area offered by this type of construction, the entrance friction of the water is reduced and the drawdown may be reduced materially. As stated above, a reduction in drawdown at a given yield means an increased specific capacity and reduces the cost of pumping.

Assuming that a well of the best possible construction is employed, then the maximum amount of water that can be withdrawn from the well is fixed by nature and nothing more can be done to make the well yield more than the water-bearing material will provide. The problem for the driller, then, is to construct each individual well in such a manner as to obtain the greatest yield with the smallest amount of drawdown that is possible under the existing conditions. For further discussion of gravel-packed wells the reader is referred to a report by Rohwer (1940, p. 62). Some of the factors that influence the cost of pumping water have been summarized by McCall and Davison (1939, p. 29):

> First, the well should be put down through all valuable water-bearing material. Second, the casing used should be properly perforated so as to admit water to the well as rapidly as the surrounding gravel will yield the water. Third, the well should be completely developed so that the water will flow freely into the well. . . . Increasing the diameter of the well will decrease the drawdown but little, all else remaining equal. The small saving in lift due to use of a large casing usually will not offset the extra cost of the larger well. It is much better to put a 16-inch casing down through all valuable water-bearing material than to start a 24-inch casing and have to stop short of the desired depth. Increasing the depth of the well will have a greater effect on reducing the drawdown than will increasing the diameter, so long as additional water-bearing formations are encountered.

For a description of different types of pumping plants, the conditions for which each is best adapted, construction methods, and a discussion of construction costs, the reader is referred to a report by Davison (1939).

In constructing a gravel-packed well a common practice is to use an auger-type bucket to drill down through the materials underlying the surface until the walls of the open hole will no longer stand. This type of equipment can sometimes be used effiectively to depths as great as 70 feet. In one instance an auger-type bucket, 24 inches in diameter and 30 inches long, has been used (Pl. 9A). The bucket is equipped with a reamer at the top that will cut up to a 50-inch hole and the 24-inch bucket at the bottom acts as a pilot. The bucket is rotated by means of a square Kelly rod that operates through a rotary table at the surface. An orange-peel bucket is very effectively used in conjunction with the auger-type bucket for removing sand and soft clays from the hole (Pl. 11A). Blind or dummy casing from 42 to 46 inches in diameter is placed in the hole as drilling progresses. The usual practice is to drill slightly ahead of the dummy casing, and as the hole increases in depth, the dummy casing is lowered correspondingly. After reaching the total depth the well screen or perforated casing, generally from 16 to 24 inches in diameter, is then lowered into the hole and graded gravel is placed in the annular space between the permanent well screen and the blank or outside casing. The outer casing is then withdrawn to uncover the screen and allow the water to flow through the packing from the water-bearing material. One driller uses a method for constructing large-diameter wells that is an adaptation of the California mud-scow process. Pre-perforated steel casing is used entirely and locations that have been previously investigated through test drilling are drilled. Vertical slots are cut in the casing using a torch and the sections are torch-welded (Pl. 12A). In this method, a 30-inch open hole is first drilled down to the water-bearing strata. Steel casing, 16 inches in diameter, with a 26-inch bell on the bottom, is then placed in the hole. The larger-diameter bell on the bottom serves as a cutting shoe. As drilling progresses the hole is bailed clean until it is free from all mud, and the annular space between the casing and the open hole is then back-filled with graded gravel. An ordinary bailer, 15 inches in diameter and 18 feet in length weighing approximately 1,200 pounds is operated inside the casing for removing the materials from the hole. Another type of bailer is also commonly used in this method and is equipped with a reaming attachment 26 inches in diameter that acts as a cutting shoe. This type of bailer is 17 inches in diameter and 17 feet long and weighs more than 2,000 pounds (Pl. 13B). In constructing irrigation wells with this type of equipment, cable-tool methods are used entirely. A set of jaws that weigh approximately 1,000 pounds are also used with this equipment.

There are several advantages in using this method of constructing wells. When the large bailer is operated inside the well casing, a surging effect is established with the result that fine sand moves inside the casing through the perforations and can be removed with the bailer. The well can then be developed by back-filling with graded gravel. The gravel replaces the fine sand that is drawn into the well by the surging process. After the well is completed, the surging is continued by operating the large bailer in connection with the drilling motion throughout the length of the perforated portion of the screen. This process is continued until fine sand ceases to come into the well, and gravel is added at the surface as needed. A solid drilling stem is not used in this method—the heavy bailer with the reamer attachment acting essentially as a drilling tool. A standard rig weighing approximately 7 tons and mounted on a trailer has been used for this type of equipment.

Nearly all the drillers have designed small test-drilling rigs for the purpose of putting down small-diameter test holes. Most of the smaller rigs are homemade and are equipped with small rotary mud pumps powered by small gasoline engines. Ordinarily the drill pipe is rotated by wrenches that are operated by hand. One such test rig used 1¼-inch pipe with a drill bit on the end which drills a 3-inch hole. Another outfit is equipped with 1-inch pipe for drill stem.

Test-drilling prices in 1940 ranged from about 10 to 15 cents per foot for drilling in clay and sand. If hard-cemented strata were encountered, the drilling costs ranged from 25 to 35 cents per foot. One driller charged 50 cents per foot for test drilling, but if the test hole was used eventually as a pilot hole for the permanent well, no charges were made for the test drilling.

In 1940, several irrigation wells were also put down with a portable hydraulic-rotary drilling rig (Pl. 11B). In this method a hole is first drilled using a 10-inch fish-tail bit mounted on the end of 4-inch drilling pipe. This type of bit is usually used for soft formations and when hard-cemented beds are encountered, a three-cone, rock bit (Hughes rock bit) 10 inches in diameter is used. After the

10-inch pilot hole has been completed to the total depth, the 10-inch bit is removed and a 28-inch three-blade reaming bit with a 10-inch pilot below is attached to the end of the drill pipe. The 10-inch hole is then enlarged to a 28-inch hole by hydraulic rotary methods, the sides of the hole being mudded up with the drilling mud that is used in connection with this method. Casing ranging in diameter from about 16 to 20 inches is then lowered into the hole until the bottom end is about 3 inches off bottom. The casing is suspended on guides in the hole. The drill pipe is then lowered into the bottom of the hole and circulation is again started to wash away the mud from the inside and outside the casing. Screened gravel is introduced slowly from the surface into the annular space between the casing and the side of the hole as this washing process continues. The washing process helps remove much of the mud fluid from the sides of the hole. When the top of the perforated screen is reached with the gravel pack, the wash pipe is removed and is then put down on the outside of the casing and the annular space between the casing and the hole is back-filled with gravel to the land surface. The mud is then bailed out of the hole down to water level to allow free entry of the water into the well. As soon as the gravel pack is completed to the surface, clear water is introduced throughout the gravel pack before the mud becomes fixed. A bailer 10 inches in diameter and 20 feet in length with a dart valve on the bottom and having a capacity of 65 gallons is lowered into the hole and the well is then bailed for an extensive period. Following this, a belting swab is lowered into the hole for the purpose of surging the well. Clear water is introduced through the gravel pack during all of these operations. Swabbing operations are alternated with bailing operations.

The hydraulic rotary rig that was used in Scott County was mounted on a truck chassis, and the derrick was constructed of tubular steel and was 40 feet high in drilling position. The 4-inch standard oil-well drill pipe was operated by a 4-inch square Kelly that passed through a rotary table mounted at the rear of the drilling rig. A 4-inch core barrel 20 feet long equipped with three 8-inch wash pipes running the length of the barrel on the outside was used for obtaining core samples of any promising gravel.

UTILIZATION OF WATER

Information on 282 wells and springs in Scott County was obtained during the course of the investigation. All known irrigation, public supply, and industrial wells in the county were visited, and all available data concerning them were obtained. No attempt was made to obtain data on all the domestic and stock wells. Of the wells listed in Table 19, 87 are out of use, either temporarily or permanently. The water supplies of the others are as follows: domestic use only, 2; stock use only, 20; domestic and stock, 35; irrigation, 132; public supply, 4; and industrial, 2. Four wells (130, 131, 245, and 248) are used exclusively as observation wells by the Division of Water Resources of the Kansas State Board of Agriculture. Of these 4, wells 131 and 245 were drilled by the Division of Water Resources for this purpose.

Domestic and Stock Supplies

Practically all of the domestic and stock supplies in the rural areas and in small towns that have no public water supplies are obtained from wells. In the early days springs and dug wells were used, but in later years drilled wells became more predominant. Springs are the source of supply in some parts of the Scott County State Park and in the northern part of the county. Some of the dug wells have gradually fallen into disfavor because they are subject to pollution and as they are generally not very deep, they are apt to fail in dry weather. Practically all new wells put down in the area are drilled.

On many of the farms drilled wells supply water for livestock and on many farms, the same well supplies water both for domestic use and for watering livestock. Some wells have been put down in pastures for the sole purpose of watering livestock. Springs that yield sufficient water for livestock are found in the northern part of the county. Most of the domestic and stock wells are equipped with windmills capable of pumping a few gallons of water a minute, and some are provided also with auxiliary pump jacks operated by small gasoline engines.

Industrial Supplies

Ground water is used by the Missouri Pacific Railroad at Scott City for boiler supplies for locomotives and by the Shallow Water Refinery south of Shallow Water for cooling and condensing. For some industrial purposes water must be of a certain chemical character and for others its temperature is the most important factor. Water used in boilers should be relatively free from foaming and scale-forming constituents. The ground water in much of the county must be treated to reduce the hardness to make it suitable for boiler use. Some ground water is used in Scott City for air-conditioning, but practically all of the water thus used is purchased from the city. The advantage of using ground water for this purpose is its relatively low uniform temperature throughout the year. The temperature of the ground water in Scott County ranges from about 57° to 60° F.

The largest single industrial use of ground water in the county is the Missouri Pacific Railroad at Scott City. The water, used principally for filling locomotive boilers, is pumped from a well (79) situated just east of the Missouri Pacific depot in Scott City. This well, which is 18 inches in diameter and cased to the total depth of 80 feet with cast-iron casing, derives water from sands and gravels of the Ogallala formation. The well is equipped with an electrically driven, direct-connected deep-well turbine. When drilled in 1927, the reported yield was 150 gallons a minute with a drawdown of 17 feet. Water is stored in a steel tank 44 feet high and 24 feet in diameter having a capacity of 145,880 gallons and in a wooden tank 16 feet high and 16 feet in diameter having a capacity of 31,000 gallons. The water used for locomotive boilers is first treated with the soda-lime process. The total consumption by the Missouri Pacific Railroad at Scott City for the period from December 6, 1939, to December 6, 1940, was 43,034,300 gallons.

The Shallow Water Oil Refinery about 4 miles south of Shallow Water utilizes water from a well (257) drilled in 1942 for cooling and condensing purposes at the refinery. The well, 16 inches in diameter and 180 feet deep, is reported to end in the Niobrara formation and is equipped with a deep-well turbine pump operated by a natural gas power unit. It is reported that the well is pumped continuously at a rate of about 300 gallons a minute.

Public Supplies

Scott City, the only municipality in Scott County with a public water-supply system, obtains its water supply from wells. The smaller communities depend entirely upon private wells. Water obtained from "Big Springs" (17 in Table 19 and shown in Pl. 10) constitutes the principal supply for picnickers and visitors to Scott County State Park in the northern part of the county.

Scott City (population, 2,022) is supplied by three drilled wells (82, 111, and 112, Table 19 and Pl. 2), all of which are within the city limits and all of which derive water from the Ogallala formation. Well 82, under the elevated steel tank near the center of Scott City, is 79 feet deep and its concrete casing is 24 inches in diameter. This well which is equipped with an electrically driven deep-well turbine pump, has a reported yield of 125 gallons a minute. Well 112, situated in the power plant, is 81 feet deep and its galvanized-iron casing is 16 inches in diameter. This well, also equipped with an electrically-driven deep-well turbine pump, has a reported yield of 770 gallons a minute. Well 111, just east of the power plant and the newest of the three wells, was drilled in December 1943 to a depth of 225 feet and is reported to end in the Niobrara formation. The well, cased with 18-inch iron casing, is equipped with an electrically-driven deep-well turbine pump. Mr. Weishaar, the driller, reported that when the well was tested it yielded 1,246 gallons a minute with a drawdown of 11 feet after several hours of pumping.

Water is pumped from the wells directly into the mains, the excess going into a 40,000-gallon elevated steel storage tank in town. The daily capacity of the system, exclusive of the newest well (111), is about 1,290,000 gallons. No figures on water consumption were obtainable. An analysis of a sample of the water from well 112 is given in Table 15. The water is moderately hard and is not treated.

Irrigation Supplies

Many large wells in Scott County supply water to irrigate crops. A discussion of the early history of irrigation and of its subsequent growth is given by McCall (1944) who points out that irrigation from ground-water supplies in Scott County was practiced as early as 1888. This early development was limited principally to irrigating small garden plots from windmills. According to McCall, the next phase of irrigation development began in June 1908, when E. E. Coffin operated an irrigation plant near the Cen. S. line sec. 36, T. 18 S., R. 33 W. The well was 90 feet deep with a 9-inch casing and was equipped with a small centrifugal pump driven by a small gasoline engine. Its reported yield was 120 gallons a minute.

Other irrigation wells were soon constructed, so that as early as 1910 there were perhaps a dozen or more irrigation plants using wells. In 1911, two large-scale windmill plants were constructed.

One such plant consisted of a circular reservoir 200 feet in diameter and 4 feet deep with a metal side wall set in a concrete foundation. This reservoir was surrounded by 10 wells and irrigated 50 acres of alfalfa.

In addition to the individual irrigation projects already mentioned several large financial interests were early attracted by the irrigation possibilities of Scott County. In 1909 the Great Western Irrigation Company attempted a development whereby ground water in the immediate vicinity of Whitewoman Creek would be brought to the surface by gravity flow. After some small experimental construction work, this project was abandoned.

At about the same time Marks and Son of Chicago bought a large block of land in the southwestern part of the area and for more than 20 years this tract of land was partially developed and managed by the company. Some development was also started on a 25,000-acre tract near Shallow Water by the Garden City Development Company, a group of investors associated with the railroad construction from Garden City north through Scott City. In 1916, the Garden City Company, owners of the sugar beet plant at Garden City and of electric lines in the Arkansas Valley, purchased 22,880 acres in south-central Scott County, constructed several irrigation wells, and built a power line to the area. The wells were equipped with deep-well turbines powered by very large direct-connected electric motors. Well sites were selected largely on the basis of favorable topographic position without any preliminary test drilling. As a result, the yields of some of these wells were rather disappointing.

By 1917, J. W. Lough, who has been called the "father of pump irrigation in Scott County," had completed a $75,000 electric generating plant to furnish power to his own pumping plants. The major development prior to 1920 was near Whitewoman Creek in T. 19 S., R. 33 W. where the J. W. Lough and Marks holdings are located. Knapp (1923, pp. 217, 223) reported that 4,921 acres of land in Scott County were under irrigation with water pumped from wells. McCall (1944) points out that the irrigated acreage in Scott County seems to have reached its maximum with the amount reported in 1922 and thereafter it declined until the early thirties. The use of a great many of the pumping plants was discontinued and very few new wells were drilled. The probable reasons for this decline are discussed by McCall.

A continuous and more detailed record of development in Scott County is available since 1930. Beginning in 1931, the Division of Water Resources of the State Board of Agriculture has made annual surveys of the acreage irrigated from wells. Other pertinent information has been gathered also regarding crops irrigated and the irrigation plants used. The annual survey has been made at or near the end of the pumping season when the actual acreage irrigated on each farm could be readily determined. The following table, which is taken from McCall's report (1944, p. 17) and from data in the files of the Division of Water Resources, shows the manner in which expansion has occurred.

TABLE 9. *Development of irrigation in Scott County for the period 1931 to 1945*

YEAR	Rainfall	Irrigated acreage	Number of pumping plants	Acres per pumping plant
1931	18.38	2,265	13	174
1932	20.06	1,021	10	102
1933	24.84	2,035	19	107
1934	12.65	3,859	28	138
1935	15.54	4,234	29	146
1936	18.21	3,849	30	128
1937	13.11	6,828	43	159
1938	14.92	10,355	53	195
1939	14.63	12,298	64	192
1940	16.88	17,164	84	202
1941	24.63	16,427	85	194
1942	22.24	18,651	97	192
1943	10.38	21,320	118	181
1944	29.92	16,890	127	133
1945	14.22	21,002	129	162

The irrigated acreage reached its lowest point in 1932. Following 1932 it increased slowly until 1937 when it began to expand rapidly reaching a peak of 21,320 acres in 1943.

McCall (1944) points out that a relatively large acreage may be irrigated during years of more than normal rainfall, but the amount of water pumped may be less as compared with other years when rainfall is deficient. In Scott County the total pumping for different years can be compared since electric and natural gas utilities furnish almost all of the energy for pumping. Electricity has been available to irrigators for nearly two decades, and since 1937 natural gas has been piped through the area. The data for Table 10 were obtained from McCall's report (1944, p. 18) and from the files of the Division of Water Resources.

TABLE 10. *Use of electricity and natural gas for irrigation, amount of pumpage, and the acreage irrigated in Scott County for the period 1938 to 1945*

Year	Electricity, total KWH	Natural gas, total cu. ft.	Indicated pumpage acre-feet	Acres irrigated	Acre-feet per acre	Departure from normal rainfall
1938	1,050,712	9,544,300	14,200	10,355	1.4	—5.80
1939	1,326,677	27,092,300	21,200	12,298	1.7	—3.98
1940	1,143,837	29,164,210	20,800	17,164	1.2	—1.73
1941	654,105	15,562,400	10,800	16,427	.7	+6.02
1942	712,729	18,112,000	12,200	18,651	.7	—3.63
1943	1,589,461	33,802,000	24,700	21,320	1.2	—8.23
1944	562,898	13,660,000	9,400	16,890	.6	+11.31
1945	1,350,000	22,663,000	18,400	21,002	.9	—4.39

For the past eight years records of quantities of electricity and natural gas used for irrigation are available and the analyses of these data shown in the above table indicate how total pumping declines or increases with variations in acreage and rainfall.

During the summer and fall of 1940 an inventory of the irrigation wells in Scott County was made and estimates of the total pumpage and number of acres irrigated were obtained. In June 1944, an inventory of all irrigation wells installed after 1940 was made. Detailed records of all irrigation wells are given in Table 19 and the locations of the wells are shown on Plate 2. Records on 129 irrigation wells in Scott County were obtained. As given in Table 10, the total reported area irrigated from these wells in 1940 was 17,164, an average of about 202 acres per pumping plant. An attempt to determine the quantity of water pumped annually from irrigation wells in Scott County was made. Reported estimates were obtained from well owners. Pumpage estimates for wells that are pumped by electricity were computed from records supplied by the Inland Utilities Company of the total number of kilowatt-hours of electricity consumed in 1940. Pumpage estimates for wells that are pumped by natural gas were computed from records supplied by the Tri-County Gas Company of Holcomb. Mr. Kenneth D. McCall, Engineer for the Division of Water Resources of the Kansas State Board of Agriculture, assisted in obtaining these data. The estimated total quantity of water pumped for irrigation in Scott County in 1940 was about 20,800 acre-feet (Table 10).

YIELDS OF IRRIGATON WELLS

Irrigation wells in Scott County yield from about 300 to 2,900 gallons a minute. Yields of most of the irrigation wells given in Table 19 were reported by the owners or operators, but the yields of 27 wells or approximately 25 percent of the total plants used in Scott County were measured by K. D. McCall, M. H. Davison, and Melvin Scanlan of the Division of Water Resources of the Kansas State Board of Agriculture and Woodrow Wilson of the Federal Geological Survey. The yields of wells determined by pumping tests are given in Tables 11 and 19.

All wells tested were equipped with deep well turbine pumps operated either by electric motors or by natural gas engines. Measurements of the discharge were made with a Collins flow gage. Drawdowns in pumping wells were measured by an electrical contact device, and a steel tape was used for measuring the water levels when the pumps were not running.

According to K. D. McCall (personal communication), well 200 (Pl. 3A), about 2¾ miles west of Shallow Water in the NW¼ NE¼ sec. 28, T. 19 S., R. 33 W., had a measured yield in 1938 of 2,900 gallons a minute with a drawdown of 30.7 feet or a total operating lift of 93.5 feet. On this test the plant was operated at maximum speed. When this plant was tested under normal operating conditions, it had a measured yield of 1,850 gallons a minute with a drawdown of 21.2 feet. This well had the largest capacity of all wells tested.

The pumping tests emphasized the fact that the irrigation wells in Scott County differ greatly in yield and over-all efficiency. The yields of the wells range from 308 to 2,900 gallons a minute and the specific capacities range from 10.5 to 94.5. The drawdown in most wells ranges from 13 to 50 feet. There are many factors that determine the yields 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 type of perforations, the quality of the water (whether harmless or corrosive or whether likely to form incrusting material readily), the type and placing of the screen, the development and finishing of the well (whether gravel-packed or not), the age of the well, and the space between pumping wells to prevent mutual interference. The relative importance of these factors varies for different wells and under different conditions.

TABLE 11. *Yield, total lift, drawdown, and specific capacity of 27 irrigation wells in Scott County, Kansas*

Well No. (Pl. 2, Table 19)	Date of pumping test[1]	Discharge (gallons a minute)	Total lift (feet)	Draw-down (feet)	Specific capacity (gallons a minute per foot of draw-down)
74	Summer, 1938	1,050	88.2	27.5	38.2
		1,085	91.4	31.4	34.6
76	Summer, 1939	1,115	86.2	23.3	47.8
		1,200	84.9	22.0	54.5
91	Dec. 8, 1941	666	58.9	24.9	26.8
92	July 26, 1940	1,210	62.5	19.0	63.7
97	July 18, 1940	904	45	18	50
109	Summer, 1938	1,335	69.2	14.4	92.7
123	Summer, 1938	1,380	103.1	26.5	52
125	Summer, 1939	1,055	85	50	21.1
129	Summer, 1939	1,150	64.8	18.5	62.1
136	Aug. 27, 1941	499	65.4	47.4	10.5
137	May 19, 1940	580	57.1	38	15.2
139	May 22, 1942	729	54.8	36.2	20.1
148	July 8, 1940	452	....	....	....
149	Sept. 3, 1941	1,108	110[2]	19±	58[3]
172	Dec. 9, 1941	567	63.8	34.8	16.3
177	July 18, 1940	404	....	....	....
	Sept. 6, 1940	340	....	....	....
178	July 18, 1940	394	....	....	....
	Sept. 6, 1940	308	....	....	....
185	Summer, 1938	845	93.4	20.5	41.2
189	Summer, 1938	1,300	87.0	24.5	53
200	Summer, 1938	1,850[4]	84.0	21.2	87.3
		2,900[5]	93.5	30.7	94.5
201	Summer, 1938	690	94.2	25	27.6
205	Summer, 1938	1,040	88.8	13	80
	July 23, 1940	1,025	95.8	17	60.3
215	July 25, 1940	1,210	92.6[2]	18[3]	67[3]
241	July 12, 1940	1,720	71.7	21	82
243	Summer, 1939	1,320	62.8	15[3]	88[3]
247	Summer, 1939	1,000	111.1	48.3	20.7
249	July 25, 1940	1,346	80[2]	18[3]	74.8[3]

1. Pumping tests made by the Division of Water Resources of the Kansas State Board of Agriculture. Wells 74, 76, 109, 123, 125, 129, 185, 189, 200, 201, 205, 243, and 247 were tested by K. D. McCall and M. H. Davison; wells 92, 97, 148, 177, 178, 205, 215, 241, and 249 were tested by K. D. McCall; wells 91, 137, 139, 149, and 172 were tested by Melvin Scanlan and W. W. Wilson; well 136 was tested by McCall, Scanlan, and Wilson.

2. Not accurate.

3. Estimated.

4. Plant running at normal operating speed.

5. Plant running at maximum speed.

DEPTH AND DIAMETER OF IRRIGATION WELLS

The depth and diameter of irrigation wells are given in Tables 12 and 13. Most of the irrigation wells in Scott County are less than 150 feet deep. About 70 of them are between 100 and 150 feet deep and only a few exceed 150 feet in depth.

TABLE 12. *Irrigation wells in Scott County classified according to depth*

Depth, feet	Number of wells
50- 60	1
61- 70	5
71- 80	11
81- 90	12
91-100	10
101-125	39
126-150	31
151-175	8
176-200	3
201-225	2
Not known	9

TABLE 13. *Irrigation wells in Scott County classified according to diameter*

Diameter, inches	Number of wells
12	1
12.5	1
16	49
18	47
19	9
20	1
21	3
24	19
26	1

The diameter of the irrigation wells ranges from 12 inches to 26 inches and of the 129 irrigation wells visited in the county, 96 are between 16 and 18 inches in diameter.

TYPES OF PUMPS ON IRRIGATION WELLS

All the irrigation wells in Scott County are equipped with deep well turbine pumps. The number of stages, or bowls, in each well ranges from 2 to 5. The turbine pumps range in size from 6 to 10 inches, but 6- and 8-inch pumps are the most common sizes.

The turbine pump is best adapted for pumping water from deep irrigation wells. The advantages of this type of pump are several—they are constructed so as to operate in relatively small diameter wells, no priming is necessary because the pump bowls are submerged, and the power unit is at the surface, thereby eliminating the need for a pump pit.

TYPE OF POWER USED FOR PUMPING IRRIGATION WELLS

The types of power used to pump irrigation wells in Scott County are given in Table 14. The table shows that 60 wells are equipped with electric motors and 41 wells are equipped with power units powered by natural gas. Seventeen wells are operated by gasoline engines, 6 wells are equipped with diesel engines, and 5 wells in the county are operated with farm tractors.

TABLE 14. *Type of power used for pumping irrigation wells in Scott County, Kansas*

Type of power	Number of wells
Electric motor	60
Natural-gas engine	41
Gasoline engine	17
Diesel engine	6
Tractor	5
None	2
Total	131

POSSIBILITIES OF FURTHER DEVELOPMENT OF IRRIGATION SUPPLIES

The amount of water that can be pumped from an underground reservoir without causing excessive permanent lowering of the water table depends on the amount of annual recharge to the reservoir. If water is withdrawn from an underground reservoir by pumping faster than water enters it, the water levels in wells will decline and the supply eventually will be depleted. The amount of water that can be withdrawn annually from the ground-water reservoir over a long period of years without causing depletion of the available supply is termed the safe yield of the reservoir. The feasibility of developing additional water supplies from wells for irrigation in Scott County is dependent upon the safe yield of the underground reservoir which is governed by geologic and hydrologic factors.

The question of whether further irrigation is possible or practical in a specific area is of extreme importance, not only to the present irrigators but also to those persons who may contemplate investing money in an irrigation well. Overdevelopment in an irrigation area will cause lowering of the water table, thereby increasing the total pumping lift. This is important to those who own irrigation wells for the cost of lifting water to the surface increases in proportion to the total pumping lift. The most important question to the farmer who is contemplating the construction of an irrigation well is whether or not the ground water can be developed and pumped to the surface at a cost low enough to permit a profit from the crops produced. The depth to water level determines in part the original cost of the well and the cost of the operation. The height a given quantity of water must be lifted is a prime factor in determining the cost of operating a well. It is generally not possible to state the limit of economical pumping lift in a given locality, for it depends on such factors as the cost of fuel for operating the pump, efficiency of the pump, kind and price of the crops being irrigated, and the skill and management of the individual.

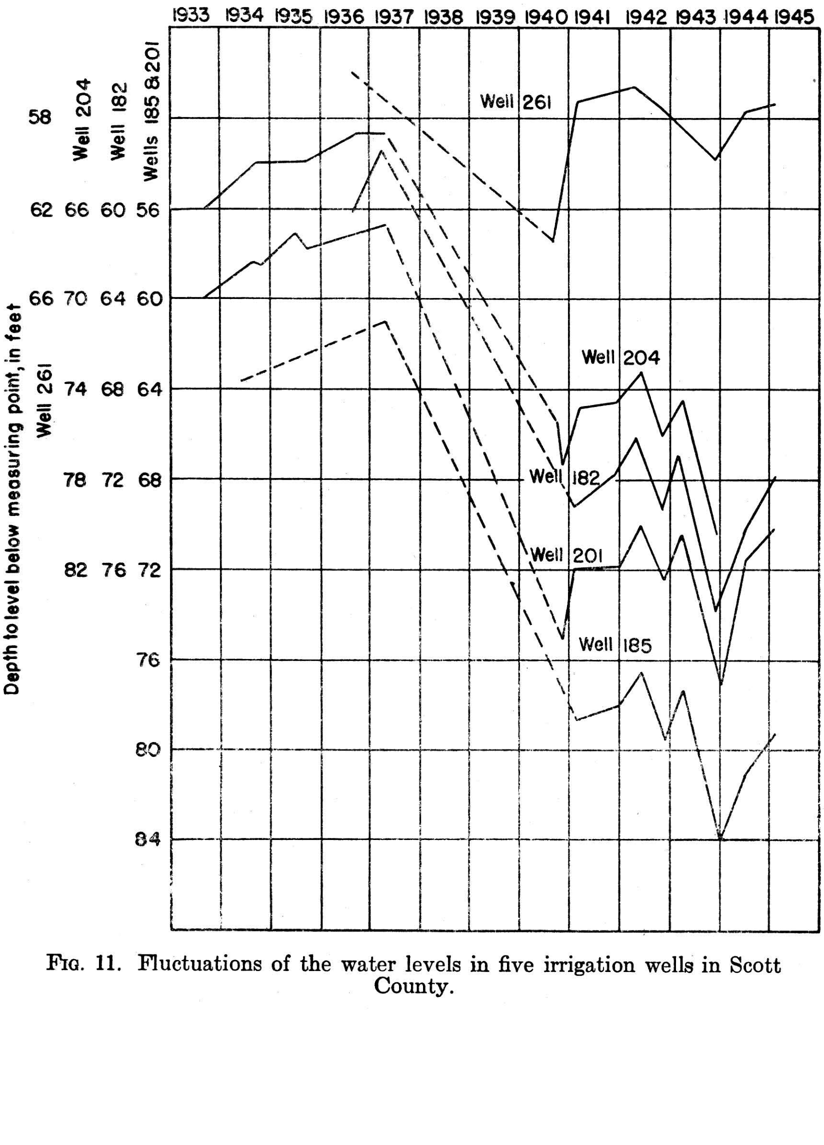


FIG. 11. Fluctuations of the water levels in five irrigation wells in Scott County.

The amount of water available for irrigation in the Scott Basin depends on the saturated thickness of the water-bearing materials and the specific yield of the material. The amount of water that can be pumped perennially depends also on the periodic ground-water replenishment from precipitation, by percolation from streams, and movement of ground water into the area from the sides.

Periodic measurements of the depth to the water levels in many of the irrigation wells are being made. Measurements were started on some of the wells in 1933 and on others at later intervals. The hydrographs of five of these wells are shown in Figure 11. No measurements of the water levels of these five wells were made between the spring of 1937 and the fall of 1940 but the hydrographs show that the water levels declined on an average of about 15 feet during that time. From the fall of 1940 to the present time the water levels have fluctuated annually in response to pumpage and recharge. In 1945 the water levels in some of these wells were higher than they were in 1940 while the water levels in others were somewhat lower in 1945 than they were in 1940. Much of the rise in 1944 probably was caused by a reduction of pumpage for irrigation. The pumpage for irrigation in 1943 amounted to 24,700 acre-feet (Table 10) but in 1944 it was only 9,400 acre-feet and in 1945 it was 18,400 acre-feet.

The saturated thickness of the Pliocene and Pleistocene deposits in Scott County is shown in Figure 12 (see also Fig. 5). The contours showing saturated thickness were prepared by superimposing the water-table contour map (Pl. 1) on the map showing the configuration of the pre-Tertiary surface (Fig. 2) and drawing the contours through points of equal thickness. As shown by the contours a narrow tongue of thick deposits extends into the middle of Scott County from the Arkansas Valley in Finney County. The extension of this tongue in Finney County is known as the Finney Basin (Latta, 1944, pp. 21, 119). The water-bearing materials have a saturated thickness of more than 180 feet in the deepest part of the basin. In an area 4 to 8 miles wide and about 25 miles long comprising about 100,000 acres the saturated thickness is more than 100 feet. Irrigation wells having large yields have been developed in this part of Scott County.

A part of the Scott Basin may be approaching overdevelopment but in other parts of the basin the water table has not yet been affected by pumping. An attempt to determine the status of de-

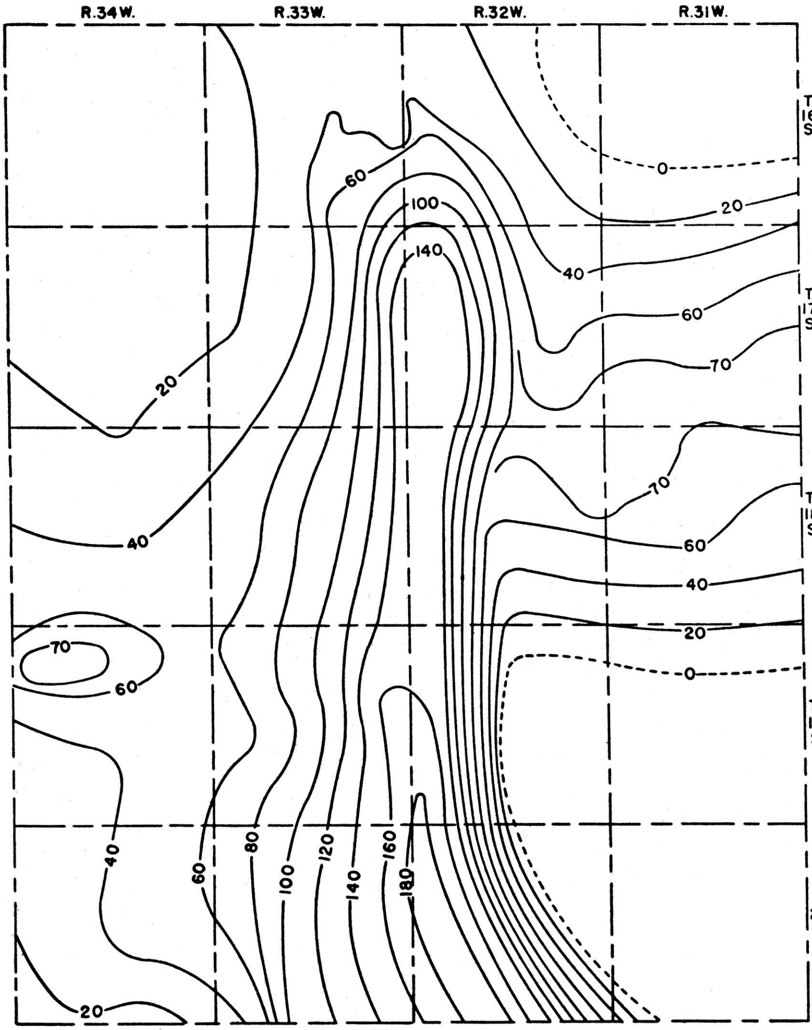


FIG. 12. Saturated thickness of the Tertiary and Quaternary deposits in Scott County.

velopment was made by preparing periodic maps of the area showing the change in water level in comparison with the water level in 1936. Water-table contour maps for the years 1936 and 1945 are shown in Figures 13 and 14. The change in water level between map periods was determined by superimposing one water-table contour map over the other and connecting the points of equal change of water level. A change in water level map for the period from

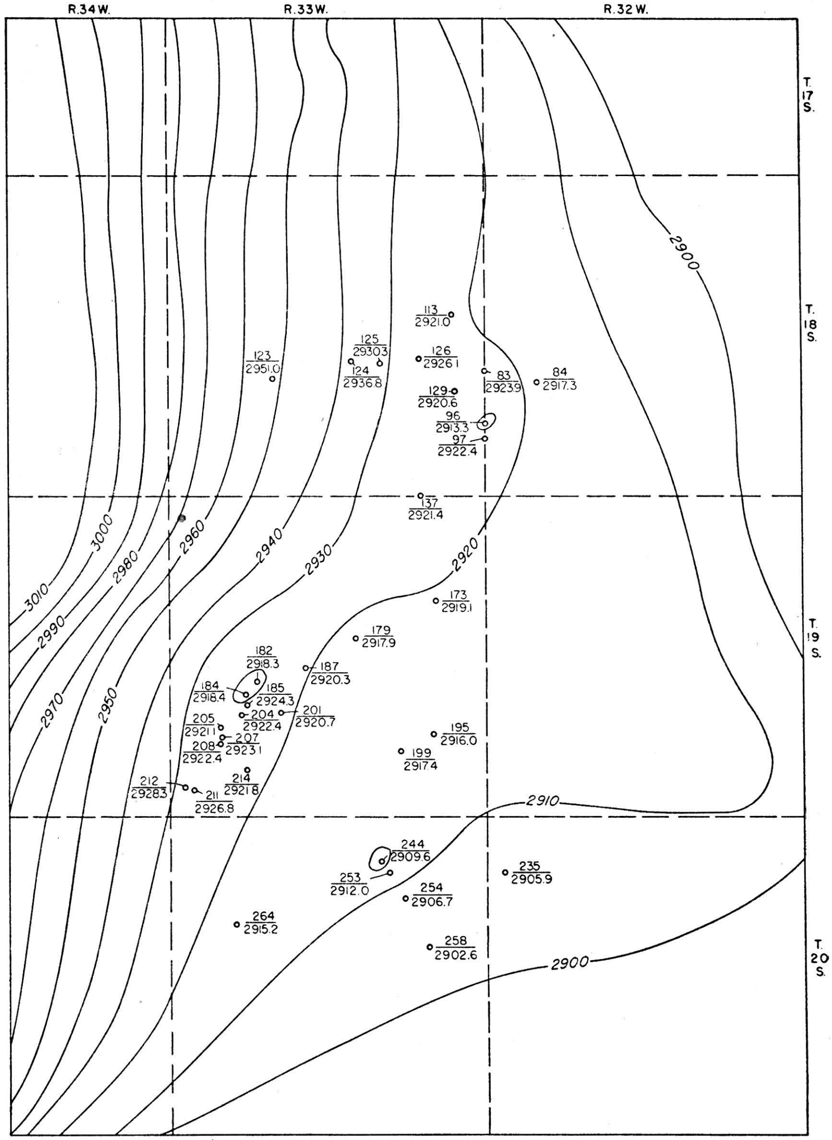


FIG. 13. Water-table contours of the Scott Basin as of the summer of 1936.

the summer of 1936 to December 1945, is shown in Figure 15. As shown on Figure 15, the maximum amount of lowering of the water table between the summer of 1936 and December 1945, was in a heavily pumped area and amounted to about 24 feet.

From the summer of 1936 to December 1945, the reduction in

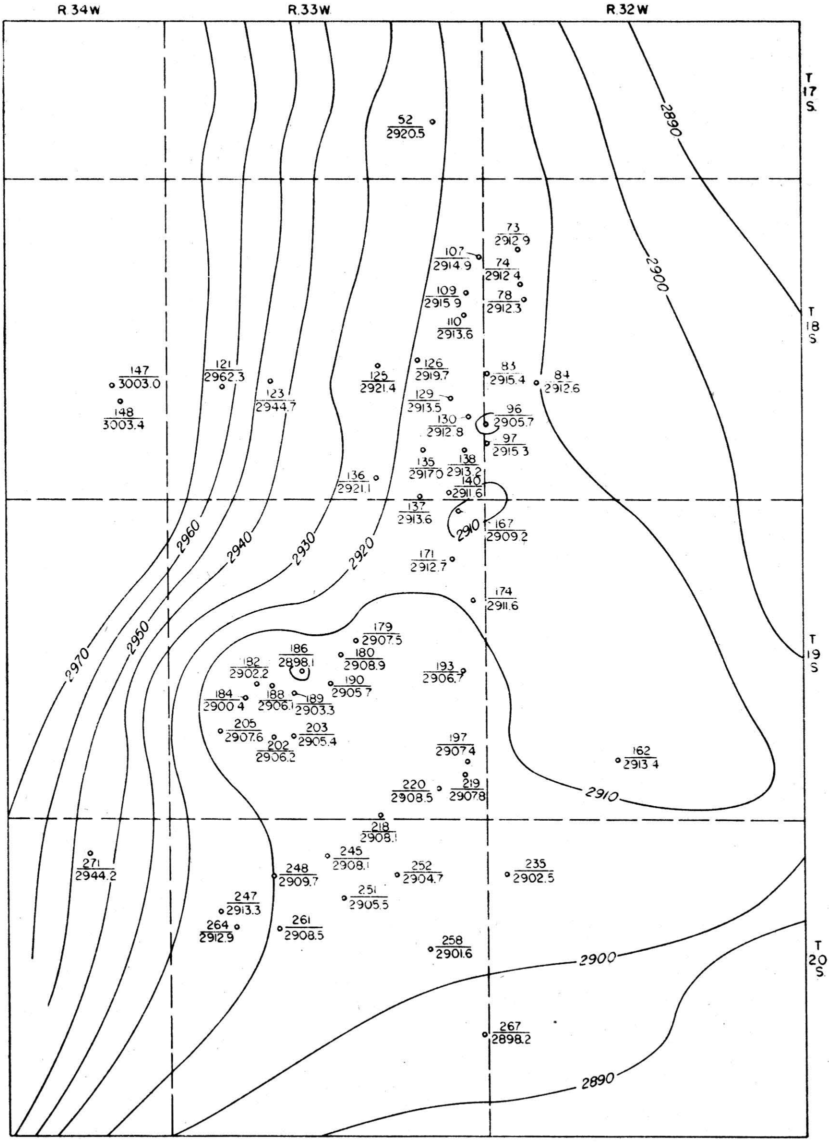


FIG. 14. Water-table contours of the Scott Basin as of December 1945.

volume of the saturated water-bearing materials was about 550,000 acre-feet. The area affected by the reduction at this time is approximately 100,000 acres. Assuming a specific yield of 17 percent, the amount of water pumped from storage would be about 93,500 acre-feet. The pumpage for irrigation from 1936 through 1945

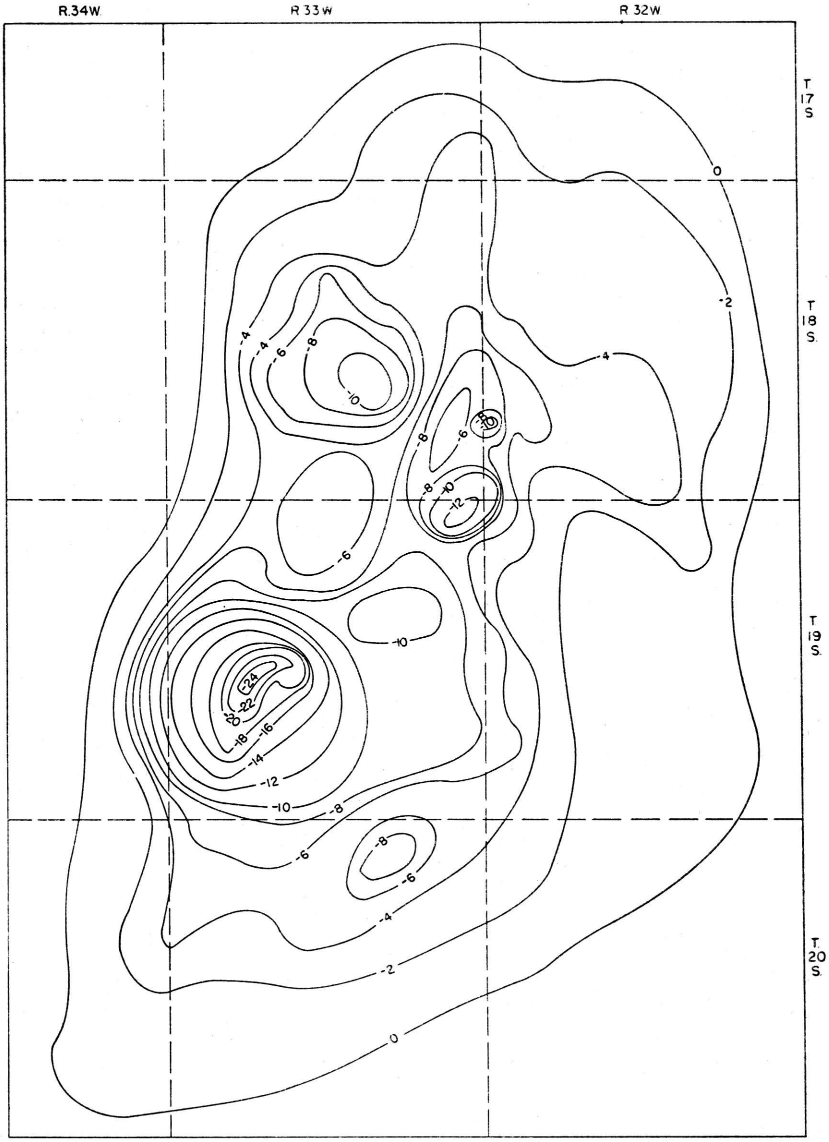


FIG. 15. Change in the water table of the Scott Basin from the summer of 1936 to December 1945.

amounted to approximately 145,900 acre-feet. Thus, approximately 93,500 acre-feet came from storage and approximately 52,400 acre-feet came from recharge.

On the basis of this analysis, the average quantity that could be pumped annually without progressive lowering of the water table is about 5,520 acre-feet. Any amounts withdrawn in excess of this are taken from storage. If the present rate of pumping continues, the water table in time will be lowered beyond the economic limit of use. If the rate of pumping is increased, that point will be reached sooner than if use is stabilized at present production.

Under this 100,000-acre area there is at this time a total volume of approximately 11,500,000 acre-feet of saturated deposits overlying the Cretaceous rocks. Assuming a specific yield of 17 percent, this reservoir would contain 1,900,000 acre-feet of water. If the specific yield is less, there is, of course, less water available in storage. Likewise, the amount of water being withdrawn from storage is also less and the amount coming from recharge is more.

A further lowering of the water table and extension of the area of the resulting cone of depression may be expected to produce some slight increase in recharge to the extent that the slope of portions of the water table is changed and the movement of recharge which formerly was away from the area will then be toward it. An increase in recharge gained in that manner will be at the expense of higher construction and operation costs for pumping plants, and of smaller yields of water from wells, all due to the lower water table.

The actual specific yield is at this time the most important unknown factor needed to determine more precisely the relationship between recharge, storage, and discharge. Studies and investigations of the area directed toward determining the value of specific yield more accurately should be continued for a few years, after which computations made herein should be reviewed.

CHEMICAL CHARACTER OF WATER

The general chemical character of the ground waters in Scott County is indicated by the analyses of samples of water from 29 wells and 1 spring distributed as uniformly as practicable within the county and among the principal water-bearing formations (Table 15). The wells include the water supply at Scott City (well 112.) The samples of water were analyzed by Elza H. Holmes, chemist in the Water and Sewage Laboratory of the Kansas State Board of Health.

Chemical Constituents in Relation to Use

The following discussion of the chemical constituents of ground water in relation to use has been adapted from publication of the U. S. Geological Survey.

TABLE 15. *Analyses of water from wells in Scott County, Kansas*

Analyzed by Elza H. Holmes. Parts per million[a] and equivalents per million[b] in italics

No. on Plate 2	LOCATION, DEPTH, AND GEOLOGIC HORIZON	Date of collection 1940	Temperature (°F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K) (2)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness (calculated as $CaCO_3$)		
														Total	Carbonate	Noncarbonate
	T. 16 S., R. 31 W.															
3	SW NW sec. 4, 27.2 feet, alluvium	Nov. 18	59	2.1	125 *6.24*	19 *1.56*	3.5 *.15*	238 *3.90*	171 *3.56*	9 *.25*	1 *.05*	12 *.19*	462	394	195	199
6	SW SE sec. 25, 121.1 feet, Ogallala	Nov. 18	58	.8	48 *2.40*	25 *2.06*	.5 *.02*	200 *3.28*	32 *.67*	11 *.31*	1.8 *.09*	8 *.13*	227	225	164	61
	T. 16 S., R. 32 W.															
8	SW NW sec. 2, 126.9 feet, Ogallala	Nov. 18	58	2	54 *2.69*	14 *1.15*	1.2 *.05*	198 *3.25*	18 *.37*	6 *.17*	1 *.05*	2.9 *.05*	198	196	162	34
12	NE SW sec. 32, 96.5 feet, Ogallala	June 26	58	.08	74 *3.69*	19 *1.56*	26 *1.14*	203 *3.33*	84 *1.75*	22 *.62*	1.8 *.09*	37 *.60*	366	263	166	97
	T. 16 S., R. 33 W.															
14	SW SE sec. 5, 143.1 feet, Ogallala	Nov. 19	57	1.5	44 *2.20*	17 *1.40*	19 *.84*	206 *3.38*	31 *.64*	7 *.20*	1.8 *.09*	8 *.13*	232	183	169	14
17	NE NW sec. 13, Big Spring, Ogallala	June 26	59	0	44 *2.20*	16 *1.32*	21 *.93*	205 *3.36*	33 *.69*	7 *.20*	1.8 *.09*	7.1 *.11*	233	176	168	8
	T. 16 S., R. 34 W.															
30	SE cor. SW sec. 33, 131.1 feet, Ogallala	Nov. 19	57	.36	40 *2.00*	21 *1.73*	21 *.89*	205 *3.36*	38 *.79*	9.3 *.26*	2 *.11*	6.2 *.10*	240	187	168	19
	T. 17 S., R. 32 W.															
43	SW cor. sec. 21, 98.5 feet, Ogallala	Nov. 18	57	2.2	64 *3.19*	29 *2.38*	8.1 *.35*	200 *3.28*	67 *1.39*	36 *1.02*	2.2 *.12*	7.1 *.11*	316	283	164	119
	T. 17 S., R. 33 W.															
47	SW cor. SE sec. 4, 125.1 feet, Ogallala	Nov. 19	57	.67	42 *2.10*	23 *1.89*	24 *1.06*	215 *3.53*	43 *.89*	14 *.39*	2.3 *.12*	7.5 *.12*	264	201	176	25
54	NW cor. sec. 27, 61 feet, Ogallala	Nov. 19	57	.19	55 *2.74*	30 *2.47*	13 *.57*	205 *3.36*	78 *1.62*	20 *.56*	2.7 *.14*	6.2 *.10*	308	261	168	93

TABLE 15.—*Concluded*

No. on Plate 2	LOCATION, DEPTH, AND GEOLOGIC HORIZON	Date of collection 1940	Temperature (°F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K) (2)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness (calculated as $CaCO_3$) Total	Carbonate	Noncarbonate
	T. 17 S., R. 34 W.															
61	SW cor. NW sec. 30, 99.5 feet, Ogallala.....	Nov. 19	57	2.9	60 *2.99*	40 *3.29*	8.1 *.35*	225 *3.69*	73 *1.52*	27 *.76*	2.4 *.13*	33 *.53*	359	319	184	135
	T. 18 S., R. 30 W. (c)															
63	SW cor. sec. 31, 91.3 feet, Ogallala.........	Nov. 18	58	.17	47 *2.35*	31 *2.55*	15 *.67*	239 (d) *3.92*	50 *1.04*	14 *.39*	2.1 *.11*	1.9 *.03*	283	246	200	46
	T. 18 S., R. 31 W.															
65	NE SE sec. 4, 88.8 feet, Ogallala...........	Nov. 18	58	.19	45 *2.25*	30 *2.47*	15 *.65*	246 *4.03*	42 *.87*	9 *.25*	3 *.16*	4 *.06*	271	237	202	35
70	SE SW sec. 31, 120.9 feet, Ogallala and/or Niobrara........................	Nov. 18	57	5.8	341 *17.02*	116 *9.54*	181 *7.87*	163 *2.67*	1315 *27.35*	145 *4.09*	1.5 *.08*	15 *.24*	2,202	1,339	133	1,206
	T. 18 S., R. 32 W.															
87	NW NW sec. 27, 68.9 feet, Ogallala.........	Nov. 19	57	.1	49 *2.45*	33 *2.71*	19 *.81*	249 (d) *4.08*	64 *1.33*	9 *.25*	2.8 *.15*	4.9 *.08*	309	258	208	50
	T. 18 S., R. 33 W.															
107	SE cor. NE sec. 12, 83 feet, Pleistocene and/or Ogallala........................	Nov. 19	57	.49	58 *2.89*	25 *2.06*	8.3 *.36*	239 *3.92*	41 *.85*	12 *.34*	1.7 *.09*	7.1 *.11*	273	249	196	53
112	NE SE sec. 13, 81 feet, Pleistocene and/or Ogallala (public supply at Scott City).....	Apr. 8	......	0	53 *2.64*	20 *1.64*	24 *1.06*	198 (e) *3.25*	34 *.71*	15 *.42*	2 *.11*	7.5 *.12*	277	214	198	16
123	SW SW sec. 21, 138.2 feet, Ogallala.........	June 26	57	0	45 *2.25*	21 *1.73*	14 *.59*	214 *3.51*	28 *.58*	8 *.23*	2 *.11*	8.4 *.14*	233	199	175	24
	T. 18 S., R. 34 W.															
142	SE cor. sec. 2, 100.2 feet, Ogallala..........	Nov. 19	57	0.44	44 *2.20*	27 *2.22*	15 *.64*	224 *3.67*	41 *.85*	11 *.31*	2.2 *.12*	6.6 *.11*	259	222	183	39
149	SE cor. NW sec. 31, 134.3 feet, Ogallala.....	Nov. 18	57	.02	52 *2.59*	25 *2.06*	14 *.61*	224 *3.67*	54 *1.12*	13 *.37*	1.1 *.06*	2.2 *.04*	273	233	183	50
	T. 19 S., R. 32 W.															
166	NE NE sec. 35, 126.6 feet, Niobrara........	Nov. 18	59	1.4	67 *3.34*	17 *1.40*	8.3 *.36*	256 *4.20*	34 *.71*	3.3 *.09*	.7 *.04*	4 *.06*	264	240	210	30

	T. 19 S., R. 33 W.															
174	SE SE sec. 12, 76 feet, Pleistocene and/or Ogallala, possibly underlain by Niobrara...	Nov. 19	57	.16	70 *3.49*	41 *3.37*	72 *3.14*	307 *5.03*	194 *4.04*	26 *.73*	2.7 *.14*	3.3 *.06*	563	344	252	92
	T. 19 S., R. 34 W.															
223	SE SW sec. 30, 96.3 feet, Ogallala..........	Nov. 18	57	1.5	50 *2.50*	12 *.99*	10 *.44*	198 *3.25*	24 *.50*	4 *.11*	.5 *.03*	2.7 *.04*	204	177	162	15
	T. 20 S., R. 31 W.															
229	SW cor. SE sec. 12, ______, Ogallala and/or Niobrara........................	Nov. 18	57	1.6	61 *3.04*	33 *2.71*	58 *2.53*	276 *4.53*	136 *2.83*	27 *.76*	2.5 *.13*	1.6 *.03*	459	291	226	65
230	NW NE sec. 19, 36.1 feet, Ogallala and/or Niobrara........................	Nov. 18	58	.49	112 *5.59*	35 *2.88*	22 *.95*	359 *5.89*	99 *2.06*	47 *1.33*	.7 *.04*	6.2 *.10*	502	425	294	131
	T. 20 S., R. 32 W.															
236	SW SW sec. 8, 44.2 feet, Pleistocene and/or Ogallala, possibly underlain by Niobrara..	Nov. 18	58	3.3	64 *3.19*	24 *1.97*	99 *4.29*	342 *5.61*	145 *3.02*	26 *.73*	1 *.05*	2.4 *.04*	536	264	264 (f)	0
	T. 20 S., R. 33 W.															
252	NE NW sec. 11, 107.5 feet, Pleistocene and/or Ogallala........................	June 26	57	.0	48 *2.40*	16 *1.32*	23 *.99*	220 *3.61*	33 *.69*	10 *.28*	1.4 *.07*	3.5 *.06*	245	186	180	6
262	NW SW sec. 16, 102 feet, Pleistocene and/or Ogallala........................	Nov. 18	57	.1	44 *2.20*	15 *1.23*	13 *.57*	190 (g) *3.12*	26 *.54*	2.5 *.07*	1 *.05*	3.8 *.06*	205	172	164	8
	T 20 S., R. 34 W.															
271	NW SE sec. 2, 109.1 feet, Ogallala..........	June 26	58	.0	46 *2.30*	15 *1.23*	20 *.87*	211 *3.46*	27 *.56*	7 *.20*	.8 *.04*	8.8 *.14*	231	177	173	4
276	SW SW sec. 16, 126.1 feet, Ogallala.........	Nov. 18	58	.19	43 *2.15*	13 *1.07*	3.9 *.17*	185 *3.03*	8.4 *.18*	3 *.08*	.3 *.02*	4.9 *.08*	169	162	152	10

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. Situated in Lane County.
d. Sample also contains 2.4 parts per million carbonate (0.08 equivalents per million).
e. Sample also contains 22 parts per million carbonate (0.73 equivalents per million).
f. Total alkalinity, 280 parts per million; excess alkalinity, 16 parts per million.
g. Sample also contains 4.8 parts per million carbonate (0.16 equivalents per million).

Dissolved Solids.—When water is evaporated, the residue that is left consists mainly of the mineral constituents listed below and generally includes a small quantity of organic matter and a little water of crystallization. Waters containing less than 500 parts per million of dissolved solids generally are entirely satisfactory for domestic use except for difficulties rising from the hardness or occasionally excessive content of iron. Waters containing more than 1,000 parts per million are likely to include enough of certain constituents to produce a considerable taste or to make the water unsuitable in some other respect.

The dissolved solids in the samples of ground water collected in Scott County are given in Table 16. This table indicates most of the ground waters in Scott County contain total dissolved solids ranging from 200 to 400 parts per million. Five samples of water contained total dissolved solids of more than 400 parts per million.

Hardness.—The hardness of water is commonly recognized by the increase in the amount of soap needed to produce a lather and by the curdy precipitate that forms before a permanent lather is obtained. Calcium and magnesium are the constituents that cause practically all the hardness of ordinary waters and are also the active agents in the formation of the greater part of all the scale formed in steam boilers and in other vessels in which the 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 and can be almost entirely removed by boiling. In some reports this type of hardness is called temporary hardness. The noncarbonate hardness is due to calcium and magnesium sulfates or chlorides. It cannot be removed by boiling and has sometimes been called permanent hardness. With reference to use with soaps, there is no difference between 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 the removal of hardness is rarely justified. Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most purposes, but it does slightly increase the consumption of soap and its removal by a softening process is profitable for laundries or other industries that use large quantities of soap. Treatment for the prevention of

TABLE 16. *Summary of the chemical character of the samples of water from typical wells in Scott County*

RANGE IN PARTS PER MILLION	Number of samples			
	Alluvium	Ogallala	Ogallala and/or Niobrara	Pleistocene and/or Ogallala
Dissolved Solids				
101–200	....	2	....	....
201–300	....	12	1	4
301–400	....	5	....	....
401–500	1	....	1	....
501–600	....	....	1	2
More than 600	....	....	1a	....
Hardness				
101–200	....	8	....	2
201–300	....	10	2	3
301–400	1	1	....	1
401–500	....	....	1	....
More than 500	....	....	1b	....
Fluoride				
Less than 0.5	....	2	....	....
0.6–1.0	1	2	2	2
1.1–1.5	....	1	1	1
1.6–2.0	....	6	....	2
2.1–2.5	....	6	1	....
2.6–3.0	....	2	....	1
Iron				
Less than 0.19	....	10	....	4
0.2–0.5	....	2	1	1
0.6–1.0	....	2	....	....
1.1–1.5	....	2	1	....
1.6–2.0	....	1	1	....
2.1–5.0	1	2	....	1
5.1–8.0	....	....	1	....

a. 2,202 parts per million.
b. 1,339 parts per million.

scale is necessary for the successful operation of steam boilers that use water in the upper part of this range of hardness. Hardness of more than 150 parts per million can be noticed by anyone. Where public supplies are softened, an attempt is generally made to reduce the hardness to about or less than 80 parts per million. The additional improvement from further softening of a public supply is not deemed worth the additional cost. The hardness of the 30 samples of water that were analyzed is given in Table 16. This table indicates that most of the ground waters in Scott County range in hardness from 100 to 300 parts per million. Ten samples had hardness ranging from 100 to 200 parts per million and 15 samples had hardness ranging from 200 to 300 parts per million. The other 5 samples of water that were analyzed had a hardness of more than 300 parts per million.

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 in waters from the same formation. If a water contains much more than 0.1 part per million of iron, the excess may separate out after exposure to the air and settle as a reddish sediment. Iron which may be present in sufficient quantity to give a disagreeable taste and to stain cooking utensils may be removed from most waters by simple aeration and filtration but a few waters require the addition of lime or some other substance.

The iron content of the samples of ground water that were analyzed is given in Table 16. About half of the samples of water collected in Scott County contained less than 0.2 parts per million of iron. The other samples contained iron ranging up to more than 5 parts per million.

Fluoride.—Although determinable quantities of fluoride are not so common as fairly large quantities of 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 a dental defect known as mottled enamel which may appear on the teeth of children who drink water containing fluoride during the period of formation of the permanent teeth. It has been stated that waters containing more than 1 part per million of fluoride are likely to produce mottled enamel (Dean, 1936, pp. 1269-1272). If the water contains as much as 4 parts per million of fluoride, most of the children exposed are likely to have mottled enamel. Small quantities of fluoride, not sufficient to cause mottled enamel, are likely to be beneficial by decreasing dental caries (Dean, Arnold, and Elvove, 1942, pp. 1155-1179).

The fluoride content of the samples of ground water that were analyzed is given above in Table 16. Of the 30 samples of water collected in Scott County, 9 contained less than one part per million of fluoride, 11 contained between 1 and 2 parts per million of fluoride, and 10 samples contained more than 2 parts per million of fluoride.

Water for Irrigation.—The suitability of water for use in irrigation is commonly believed 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, 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 the 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 the crop or to the land or to both. Water containing less than 50 percent sodium (the percentage being calculated as 100 times the ratio of the sodium to the total bases, in equivalents) 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. It is recognized that the harmfulness of irrigation water is so dependent on the nature of the land and the crops and on the manner of use and the drainage that no hard and fast limits can be adopted.

All but one of the samples of water collected in Scott County are within the limits suggested by Scofield for safe waters for use in irrigation. The sample of water from well 70 contained 2,202 parts per million of total dissolved solids and it is probable that this water would not be suitable for irrigation. All of the samples of water collected from wells receiving their entire supply from the Ogallala formation are well within the limits suggested by Scofield.

Sanitary Considerations

The analyses of water given in Table 15 show only the amount of dissolved mineral matter in the water and do not indicate the sanitary quality of the water. An abnormal amount of certain mineral matter, such as nitrate, however, may indicate pollution of the water.

Dug wells and springs are more likely to become contaminated than are properly constructed drilled wells but great care should be taken to protect from pollution every well and spring used for domestic and public supply. It is important that the top of the casing be sealed in such a manner as to prevent surface water from entering the well and where pump pits are used, the top of the casing should extend above the floor of the pit so that surface water cannot drain into the well. In constructing wells equipped with ordinary lift or force pumps, it is a good plan to allow the casing to extend several inches above the platform so that the pump base will set down over the top of the casing thus effecting a tight seal. If the casing is left flush with the top of the platform, opportunity is afforded for drainage into the well and for possible contamination. Wells should not be located where there are possible sources of contamination such as drainage from the vicinity of buildings or cesspools.

Chemical Character in Relation to Water-bearing Formations

Nearly all the water wells in Scott County obtain water from the sand and gravel beds of the Ogallala formation but a few wells draw water from the alluvial deposits along the valleys and from the Niobrara formation in the northern and southern parts of the county. Some wells penetrate water-bearing material in both the alluvium and the Ogallala formation, the Niobrara and Ogallala formations, and the Pleistocene deposits and the Ogallala formation.

The quality of the water in relation to the water-bearing formations is summarized in Table 16 and shown graphically in Figure 16. The Pliocene deposits, comprising the Ogallala formation, and the sands and gravels of Pleistocene age yield water to most of the wells in this area. Samples of water from these deposits range in hardness from 162 to 344 parts per million; the average hardness is about 240 parts per million. The total dissolved solids in waters from the Pliocene and Pleistocene sediments ranged from 169 to 366 parts per million. The waters from the alluvium and the Niobrara formation are very hard and contain high amounts of dissolved solids. Fifteen of the nineteen samples of water from wells in the Ogallala formation contained more than one part per million of fluoride indicating that this water may be harmful to children's teeth.

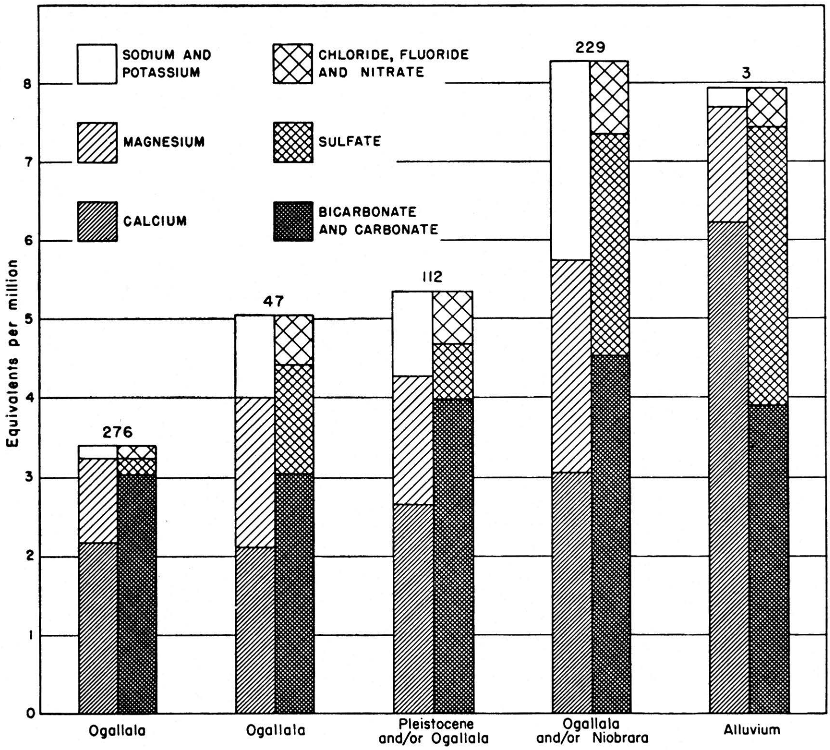


FIG. 16. Analyses of waters from the principal water-bearing formations in Scott County.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

PERMIAN SYSTEM

Rocks of Permian age are not exposed in Scott County, but they are found beneath younger rocks in all parts of the county. They are encountered at depths ranging from about 1,100 feet in the southern part to about 1,400 feet in the northern part. Data concerning these rocks are obtained from the logs of 23 oil and gas tests that have been drilled in Scott County.

The upper part of the Permian System (Guadalupian-Leonardian Series) is chiefly of nonmarine origin and is composed of red siltstone, shale, and sandstone with lesser amounts of salt, gypsum, anhydrite, limestone, and dolomite. This upper part, which is characterized by a predominance of red beds, ranges in thickness from about 1,200 feet in the northern part of Scott County to about 1,600 feet in the southern part. The lower part, or Wolfcampian Series, of the Permian System is largely of marine origin and is composed chiefly of limestone, dolomite, and shale, but also contains some sandstone. The thickness of the Wolfcampian Series ranges from about 600 feet in the southern part of the county to about 700 feet in the northern part.

The Permian strata underlying Scott County includes representatives of all the formations recognized by the State Geological Survey of Kansas from the Towle shale to the Taloga formation.

Because of their great depth and because adequate supplies of water can be obtained from the overlying rocks, the Permian rocks have not been utilized as a source of water in Scott County. Furthermore, it is believed that the water from Permian rocks would be too highly mineralized for most uses.

Cretaceous System

Rocks belonging to the Niobrara formation of Cretaceous age are exposed at the surface in Scott County. The outcrops of these rocks are shown on Plate 1. Cretaceous rocks older than the Niobrara formation are not exposed in this area and, therefore, are known only from subsurface data. They include representatives of the Carlile shale, Greenhorn limestone, Graneros shale, and the Dakota-Kiowa-Cheyenne sequence. The Niobrara formation furnishes water to wells in parts of the county, but because of their greater depth and because adequate supplies of water can generally be found above them, the rocks lying below the Niobrara formation have not been utilized as a source of water.

PRE-NIOBRARA FORMATIONS

The following discussion of the pre-Niobrara Cretaceous rocks of Scott County is based on the logs of oil wells drilled in the Shallow Water pool and on published reports (Elias, 1931, pp. 26-43; Landes and Keroher, 1939, pp. 10-16, 22-24; Latta, 1944, pp. 141-160; McLaughlin, 1943, pp. 116-136) that describe the geology of adjacent or near-by areas.

The oldest Cretaceous rocks present in Scott County belong to the Cheyenne-Dakota sequence or what was formerly called the Dakota group. They unconformably overlie the Permian rocks and consist of light- to dark-colored shale and sandy shale, variegated clay, and light-colored, fine- to coarse-grained sandstone. They are between 400 and 500 feet thick in this area. No attempt has been made here to differentiate these deposits into smaller units. In central and south-central Kansas they have been subdivided into three formations, which are, in ascending order, the Cheyenne sandstone, Kiowa shale, and Dakota formation.

The Cheyenne-Dakota sequence is overlain by the Graneros shale, which consists of gray noncalcareous shale and thin beds or lenses of sandstone and sandy shale. In Hamilton County, where the Graneros shale is exposed, it contains a thin bed of bentonitic clay and thin-bedded fossiliferous limestone (McLaughlin, 1943, p. 126). The thickness of the Graneros shale in Scott County is not known. It is a few feet to about 43 feet thick in Ford County (Waite, 1942, p. 148), 61 feet thick in Hamilton County (McLaughlin, 1943, p. 128), and 90 feet thick in western Logan County (Landes and Keroher, 1939, p. 24).

Approximately 100 feet of interbedded light-gray to dark-gray chalky limestone and calcareous shale of the Greenhorn limestone occurs above the Graneros shale.

The Greenhorn limestone is overlain by the Carlile shale, the lower part of which consists of chalky shale containing thin beds of chalk and the upper part consists chiefly of dark noncalcareous fissile shale. The thickness of the Carlile in this area is approximately 200 feet. The Carlile shale is composed of three members which are, from oldest to youngest, the Fairport chalky shale member, the Blue Hill shale member and the Codell sandstone member. An oil well drilled in the SE¼ sec. 15, T. 20 S., R. 33 W., encountered about 10 feet of medium-gray soft sandy shale at the top of the Carlile shale that probably represents the Codell sandstone member in this area. It was not possible to recognize the other members of the Carlile in this area.

NIOBRARA FORMATION

Character.—The Niobrara formation is divided into two members —The Fort Hays limestone member below and the Smoky Hill chalk member above.

The Fort Hays limestone member does not crop out in Scott County, but was encountered in test hole 23 near the southwest corner of the county. The Fort Hays is composed of thick massive beds of chalky limestone and chalk separated by thin beds of chalky shale. The limestone and chalk beds range in thickness from less than 1 foot to several feet and are light to dark gray where unweathered. Weathered exposures of the Fort Hays limestone member in areas adjacent to Scott County are white, tan, or cream. The contained fossils include *Inoceramus deformis, Ostrea congesta,* and abundant foraminifera (Moss, 1932, p. 21).

The Fort Hays limestone member is conformably overlain by the Smoky Hill chalk member of the Niobrara formation. The Smoky Hill chalk member crops out in the northern and southeastern parts of Scott County, in the western part of the county in a small area on the south side of Rocky Draw about 5½ miles south of Modoc, and was encountered below younger rocks in all of the test holes. It consists of alternating beds of soft chalky shale and chalk. Where unweathered the beds are light to dark gray or gray brown, but on weathered exposures they are white, tan, buff, or yellowish pink. It is difficult to differentiate the individual beds in the subsurface. The slight differences in the composition of different beds are brought out on weathered exposures through differential erosion so that even the thinnest beds stand out. The member also contains thin beds of bentonite and pyrite concretions. The bentonite beds are light colored when unweathered, but weather to a rusty brown.

Both vertebrate and invertebrate fossils occur in the Smoky Hill chalk. The vertebrates include birds, dinosaurs, crocodiles, mosasaurs, turtles, and fish. *Inoceramus grandis* and *Ostrea congesta* are most abundant among the larger invertebrates (Moss, 1932, p. 19). Foraminifera, chiefly *Globigerina* and *Gumbelina,* are abundant in the chalky beds, and, according to Moss (1932, p. 19), probably make up more than half of the calcareous material of the chalk.

Some of the most striking features of the Smoky Hill chalk are the tilted fault blocks that occur in the northern part of the county where the chalk lies at the surface. With a few minor exceptions, the faults are all normal faults, and are commonly marked by a slickensided calcareous gouge (Pls. 4A and 14). Russell (1929, pp. 594-604) described the stratigraphy and structure of the Smoky Hill chalk member in western Kansas and concluded that the faulting probably occurred during the Tertiary and was presumably produced by the adjustment of the brittle chalk to deformation and not to compaction.

Distribution and thickness.—Only the Smoky Hill chalk member of the Niobrara formation is exposed in Scott County. It is best exposed in the northern and northeastern parts of the county where streams tributary to Smoky Hill River have cut down through the plains surface into the underlying Smoky Hill chalk (Pls. 1 and 4B).

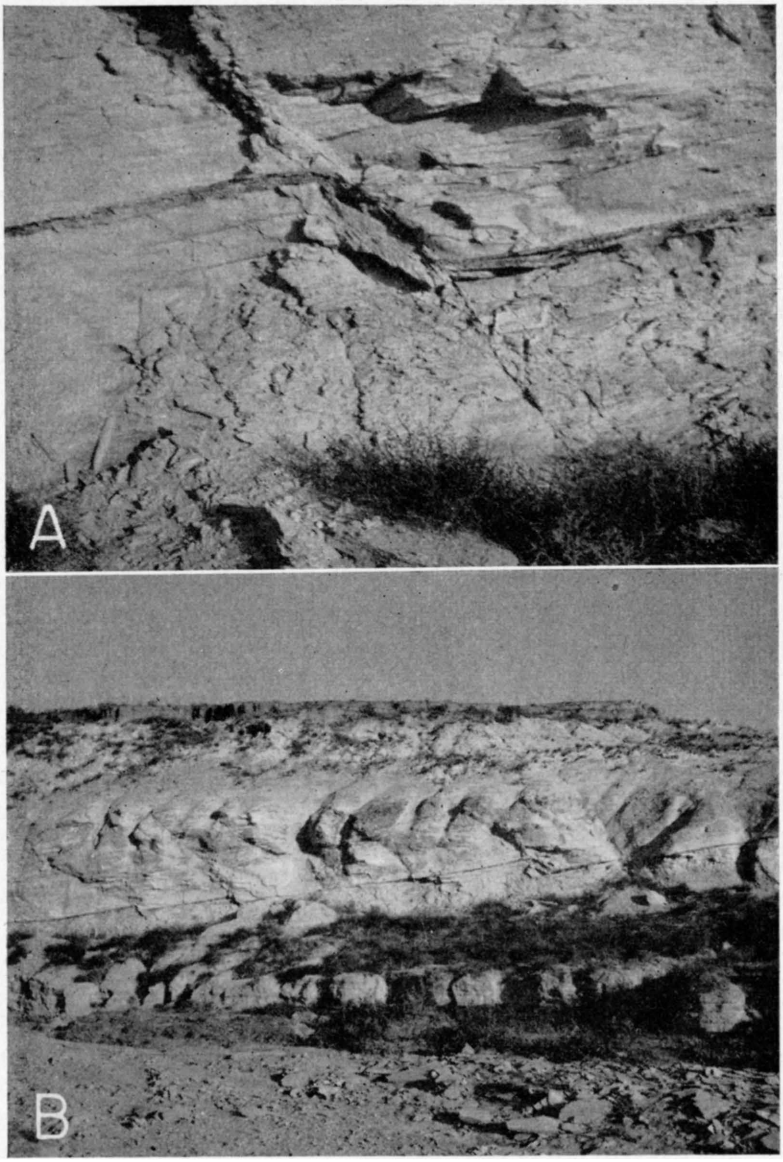


PLATE 14. *A,* Small normal fault in the Smoky Hill chalk member of the Niobrara formation. Note crystalline calcite filling the fault fissure and curvature of the dark band near the fault plane as a result of drag. Displacement is 2 feet. SE¼ NE¼ sec. 1, T. 16 S., R. 32 W. *B,* Series of small step faults in the Smoky Hill chalk member. Same exposure as shown in above closeup view.

Exposures of this member in the southeastern part of the county occur in short draws west and northwest of Dry Lake. Both members of the Niobrara formation are present beneath younger sediments everywhere in Scott County.

The thickness of the Niobrara formation in western Logan County, Kansas, where it is overlain conformably by the Pierre shale, is approximately 600 feet. Pre-Ogalalla erosion, however, has truncated the Niobrara to the south and east so that the maximum remaining thickness of the formation in Scott County is much less. The thickness of the formation in north-central Finney County is only about 300 feet (Latta, 1944, p. 159). Only the lower part of the Smoky Hill chalk member is present in Scott County. The total thickness of the Fort Hays limestone member is present beneath the Smoky Hill chalk member in this area. In the southwestern corner of the county the Fort Hays member is 55 feet thick (log 23).

Water supply.—The Niobrara is relatively unimportant as a water-bearing formation in Scott County. The Fort Hays limestone member does not supply water to any wells in this area. The beds of chalky shale and chalk that make up the Smoky Hill chalk member are relatively impervious and transmit water chiefly through fractures and solution channels. Several of the recorded wells (Nos. 154-156, 160, 162, and 166) in the southeastern part of Scott County tap the Smoky Hill chalk member. In this part of the county the overlying Pliocene and Pleistocene sands and gravels are above the water table and, therefore, are barren of water. Of the wells that are known to derive their entire supply from the Smoky Hill chalk member only well 166 was in use at the time the wells were visited in 1940.

An analysis of a sample of water collected from well 166 indicates that the water is similar to many from the overlying Pliocene and Pleistocene deposits. The water from this well had 264 parts per million of total solids, 240 parts of hardness, and 1.4 parts of iron.

Tertiary System

PLIOCENE SERIES

Ogallala formation

Character.—The Ogallala formation is composed of silts, sands, and gravels and contains layers of sandstone and conglomerate, much of which is cross-bedded and cemented with lime. In general, the fine-grained sediments alternate with the coarser lime-cemented beds at different horizons. The Ogallala sediments are generally buff colored to pinkish, although some of the more limy silts and sands are white to whitish gray. The coarser sediments are present at all horizons but are most prominent in the lower part of the formation, and it is this part that yields water most freely to wells. Locally, the lower part of the Ogallala formation may be comprised of bentonitic clays of bright mottled colors ranging from reddish brown to olive green. These basal clays represent a local lateral change in lithology in the lower part of the Ogallala formation and may be equivalent to the Woodhouse clays of either Miocene or Lower Pliocene age of Wallace County, Kansas, described by Elias (1931, pp. 155-158).

Sand constitutes the principal material of the Ogallala formation and ranges in texture from fine- to coarse-grained, some of the coarser material containing scattered pebbles and thin beds of pebbles (Pl. 8A). The finer-textured materials of the Ogallala formation are composed chiefly of silt that generally is intermixed with fine sand. Lenses or beds of sandy silt occur in all parts of the formation, but principally in the upper part. The color of the silt ranges from gray to buff to light tan. Some of the beds of silt are impregnated with lime giving them a white to light-gray color. Gradations from one lithologic type to another may take place both laterally and vertically—sometimes within relatively short distances.

The coarser-textured materials of the Ogallala formation are composed of fine to very coarse gravel and they may occur in almost any part of the formation from the base to the top. Smith (1940, pp. 42, 43) described two distinct facies of gravel in the Ogallala formation, one composed principally of sandstone, ironstone, and quartzite, and the other made up mainly of crystalline igneous and metamorphic rocks. The former facies occurs at the base of the formation and the latter is widespread along Beaver (Ladder) Creek in outcrops above the base of the formation. The sandstone-ironstone-quartzite facies is composed of material similar to that found in the Dakota formation and other Cretaceous formations, whereas the granite facies that occurs above the base of the formation is composed of granite, feldspar, quartzite, quartz, felsite and other crystalline igneous and metamorphic rocks.

The Ogallala formation is characterized by lenticular bedding; thus, individual beds of sand or gravel are not continuous over wide areas, but generally are discontinuous lenses that may grade laterally into finer materials such as silt or clay, in some places within relatively short distances. The deposits range from those that show definite bedding to those that show no bedding whatever. The structureless layers are commonly found in the upper part of the formation, are rather fine-grained, and contain some silt and small amounts of clay and lime. Irregular limy concretions are abundant in these layers, typical exposures of which occur in the bluffs on both sides of Beaver (Ladder) Creek in the vicinity of Scott County State Park. They are well displayed in both sides of the road cut that was constructed through the "Devil's Backbone," about 1 mile south of the south entrance to Scott Couny State Park (Pl. 5A). The color of this structureless part of the Ogallala ranges from buff, tan to light reddish brown.

In many places the deposits are consolidated by calcium carbonate, forming beds of caliche. In some places the cemented beds resemble true limestone; elsewhere they may consist of sand and pebbles imbedded in a lime matrix. Calcium carbonate is distributed through the deposits both as fine material and in the form of small and medium-sized nodules, pipy concretions, and in irregular lenses and beds. The caliche is white to gray and generally is fairly soft. It has been used locally in the construction of roads and highways in Scott County (Pl. 6B). In many places the sedimentary materials of the Ogallala formation are so firmly cemented with calcium carbonate as to produce a series of hard ledges, interbedded with only slightly cemented beds (Pls. 5B and 6A). The hard ledges are usually unevenly cemented and form rough weathered benches and cliffs. Because of their resemblance to old mortar, these beds have long been referred to as "mortar beds."

The thickness of some of the cemented caliche beds is very irregular and ranges from a few inches to about 11 feet. In some places the Ogallala formation is capped by a rather distinctive limestone layer, referred to as the capping limestone by Smith (1940, pp. 44-45). It is commonly massive, and weathers to a knobby, cavernous, or irregular surface, and has a maximum thickness of about 5 feet. Elias (1931, pp. 136-141) described an equivalent horizon in Wallace County and adjacent areas and referred to it as "Algal limestone" because of its peculiar concentrically banded structure. In Scott County, outcrops similar to the capping limestone described by Smith and Elias were found in which algal structure was very prominent. The most notable of these was an outcrop in the southeastern part of the county in the SW¼ SE¼ sec. 5, T. 20 S., R. 31 W. A thin development of the same bed resting directly on the Niobrara formation was noted in an exposure in the SW¼ SE¼ sec. 12, T. 20 S., R. 32 W. Two other outcrops were noted in which the algal structure was less prominent, one situated about 1 mile south and 5 miles west of Scott City near the SW cor. sec. 20, T. 18 S., R. 33 W., the other situated about 5½ miles south of Modoc, in the NW¼ SE¼ sec. 16, T. 19 S., R. 34 W. The former represents a very poor exposure and consists principally of fragments of limy rubble strewn along the side slopes of Lion Creek, but the individual fragments exhibited poor algal structure. The general lithology of the Ogallala formation at the surface is indicated by the following measured sections.

Section of Ogallala formation on the east side of Lake McBride in Scott County State Park near the NE cor. NW¼ sec. 12, T. 16 S., R. 33 W.

	Thickness, feet
Surface covered with unconsolidated sand and gravel	
TERTIARY—Pliocene	
11. Silt, sandy, lime-cemented, hard, gray to white; contains scattered coarse gravel and some pebbles; grades upward into a lime-cemented silt and becomes whiter in color near top; resembles a true "caliche"	28
10. Sand, silty, lime-cemented, dirty gray, extremely hard and resistant; contains pebbles up to 1 inch in diameter and larger imbedded firmly in the coarse sandy matrix; forms distinct caprock ledge	2
9. Silt, sandy, cemented, hard, gray to buff	1
8. Sand and silt, cemented, gritty, irregular ("mortar bed"); into lighter gray structureless sandy silt	6
7. Sand, silty, lime-cemented, dirty gray; grades upward into white limy silt	5
6. Sand, silty, cemented, buff colored; contains pebbles up to ½-inch in diameter and larger imbedded in sandy matrix; forms resistant ledge	8
5. Sand, silty, cemented, massive, hard, somewhat siliceous, dark gray to buff; contains a seam of extremely hard dense blue chert ranging from about 1 to 3 inches in thickness at top	4
4. Sand, silty, cemented, brown to buff; forms distinct smooth-faced bench in bordering bluffs	7
3. Sand, silty, cemented, hard, gray; contains scattered coarse gravel; also contains some rather thin-bedded layers in the lower part that tend to break off in thin slabs ranging in thickness from about 1 to 3 inches	17

2.	Sand, cemented, gritty, gray; contains coarse gravel and scattered pebbles; grades upward near the top to a hard cemented silty sand, brownish-buff in color; forms a resistant ledge at the top that stands out in the bluffs bordering the lake	47
1.	Clay, plastic, brown to chocolate brown, mottled in part with pale-green splotches (Woodhouse clays?)	16
	Total thickness of Ogallala exposed	141

CRETACEOUS (Upper)
Niobrara formation

Section of Ogallala formation at the north end of Scott County State Park in the NW¼ SE¼ sec. 2, T. 16 S., R. 33 W. (Measured by H. T. U. Smith, H. A. Waite, and L. P. Buck.)

TERTIARY—Pliocene

		Thickness, feet
11.	"Limestone," sandy, cemented ("mortar bed"); weathers chunky, somewhat porous, harder near the top	11
10.	Sand, cemented, calichiferous (covered interval)	9.5
9.	Sand, cemented, hard, resistant ("mortar bed"); weathers very knobby and irregular; cavernous throughout	6
8.	Sand and silt, cemented, gritty, irregular ("mortar bed"); slabby in lower part, cavernous in upper part; contains some pebbles and limy concretions that look like reworked caliche nodules	6
7.	Gravel, cemented, sandy, gritty, structureless	4.5
6.	Sand and gravel (covered interval)	35
5.	Silt, sand, and gravel, cemented, hard, gritty ("mortar bed"), weathers cavernous in lower part and slabby above; contains some short vertical concretions	6
4.	Caliche, massive, gritty, structureless; contains small scattered pebbles and irregular limy concretions, some having root shape —weathers irregularly knobby; contains fossil grass seeds *Biorbia fossilia* (middle Pliocene)	11
3.	Sand, covered interval	29.5
2.	Sand and gravel, cross-bedded, locally cemented; fossil bone found at a point 14 feet above bottom. (Sand and gravel have been excavated at this interval for use in the State Park.) View of gravel pit in Plate 8A	20
1.	Clay, buff, massive; contains some gray layers and is somewhat silty in upper part (Woodhouse clays?)	23
	Total thickness of Ogallala exposed	161.5

CRETACEOUS (Upper)
Niobrara formation

Distribution and thickness.—Exposures of the Ogallala formation occur along Beaver (Ladder) Creek and in tributary draws in the northwestern part of the county (Pl. 1). The Ogallala formation is also exposed in the northern part of the county along the sides of draws tributary to Chalk Creek which flows eastward across the southern part of Logan County to the north. Exposures of the Ogallala formation occur above the Cretaceous rocks in the northeastern part of the county along draws tributary to Hell Creek which flows eastward near the southeastern boundary of Logan County and along the southern boundary of Gove County. Outcrops of the Ogallala formation occur along Lion Creek from near Modoc to a point about 4 miles west of Scott City and along Rocky Draw from the west county line to a point about 5½ miles south of Modoc. Isolated exposures of the Ogallala formation have been noted near the heads of draws tributary to Dry Lake in the southeastern part of the county. Most of the upland surface in Scott County is underlain by deposits of Pleistocene age. The Ogallala formation, however, is found beneath younger deposits over most of the area. It is thin to practically absent in the Dry Lake vicinity near the southeastern corner of Scott County occupied by the buried Cretaceous hill shown in Figure 2.

The Ogallala formation was not encountered in test holes 13, 16, 17, and 19 (logs 13, 16, 17, and 19), all of which are situated in the deepest part of the buried trough (Fig. 5, sections B-B′ and C-C′). It is probable that the Ogallala formation was removed by erosion and in its place sediments of Pleistocene age were deposited. Section B-B′ shown in Figure 5 shows that the Ogallala formation is very thin in the vicinity of test holes 12, 14, 15, and 18 in the eastern part of the county east of Shallow Water. In certain areas in the southeastern part of the county deposits of dune sand overlie the Ogallala formation.

The Ogallala formation ranges in thickness from a few feet to about 160 feet. The variable thickness of the Ogallala formation is shown in the three profile sections in Figure 5. The thickness of the Ogallala in the 23 test holes drilled during the investigation ranges from about 6 feet in test hole 12 in the eastern part of the county to 159 feet in test hole 1 situated about 6 miles north of Scott City. In general, the test drilling revealed that the Ogallala becomes progressively thinner from north to south and in a southeasterly direction toward the southeastern corner of the county. The thickness of the Ogallala formation ranges within wide limits because of the uneven surface on which the sediments were deposited and also in part because of the fact that all or part of the sediments were removed during post-Ogallala erosion. At one time the Ogallala formation probably was much thicker in the vicinity of the buried trough in the vicinity of Scott City and Shallow Water but most of it was removed by post-Ogallala erosion.

Origin.—As pointed out under Geologic History the sediments comprising the Ogallala formation were deposited by heavily-laden streams that flowed from the Rocky Mountain region. The pebbles of igneous and metamorphic rocks in the gravels and abundance of quartz and feldspar in the sands are believed to have been derived from the Rocky Mountains. Locally, the basal gravels also contain some reworked material from less distant sources, including water-worn fragments derived from Cretaceous rocks in or just west of the county. Smith (1940, pp. 85-86) describes the mode of deposition of the Ogallala formation as follows:

> The deposition of the Ogallala was mainly of the channel and floodplain type. The coarser beds of sand, gravel, and grit represent channel deposits. . . . The finer materials are best interpreted as representing flood-water deposits formed by the overflow of shallow channels, perhaps approaching the character of sheet-floods locally. No recognizable deposits of eolian sand or silt have been found in the Ogallala in the area studied, but the presence of ventifacts indicates that there must have been appreciable wind action. . . .
>
> The deposition of the Ogallala formation began with the change from stream degradation to aggradation. . . . During the early stages of deposition, there was a topography of moderate relief. The main valleys were occupied by through-going streams from the Rocky Mountains, and the valley bottoms were mantled by normal floodplain deposits. . . . Deposition probably began with the filling of stream channels, leading to more frequent overflow and thus to the upbuilding of the floodplains. This soon led to shifting of the channels themselves, and probably to the development of anastomosing patterns. As filling progressed, the valley flat overlapped farther and farther on the slopes of the bordering hills. . . . Relief was lowered, the valley plains grew broader, and finally the divides were overtopped, and there followed overlapping and coalescing of the depositional zones of individual streams.

The origin of the abundant calcium carbonate in the Ogallala has been discussed by Smith (1940, p. 79) who concluded that

> The transported calcareous matter in the Ogallala originated mainly, if not only, in the Rocky Mountain area from weathering of Paleozoic limestone and calcic minerals in the crystalline rocks. . . . Additional lime may have been provided also by weathering *in situ* after deposition.

Smith also suggested that the silt and clay of the Ogallala formation probably were derived from soils and weathering products in the mountain area and to a lesser extent from the wearing down of coarser materials in transit. The sandstone and conglomerate in the Ogallala represent beds of sand and gravel that have been cemented by underground waters. Deposits of sandy silt, cemented with calcium carbonate and often referred to as caliche, probably are a product of surficial calichification formed during a relatively long pause in deposition, at a time when streams had shifted to some other part of the region. The concentration of calcium carbonate, in the soil zone, by surficial processes was accomplished during such periods, and was halted by recurring periods of deposition to give rise to caliche zones at varying intervals throughout the formation. Smith (1940, pp. 77-94) gave a much more detailed discussion of the origin of the Ogallala formation.

Age and correlation.—The Ogallala formation originally was named and described by Darton (1899, pp. 732, 734) and its age was given as late Tertiary, or Pliocene (?). Darton later (1920, p. 6) designated the type locality near Ogallala station in western Nebraska. The conclusions of later workers regarding the age and correlation of the Ogallala formation in western Kansas have been summarized by Smith (1940, pp. 73-74).

Smith (1940, pp. 75-76) concluded that the Ogallala of southwestern Kansas, insofar as it is represented by exposures at the surface, may be assigned to middle Pliocene age. According to this definition, the top of the Ogallala formation is marked by the top of the capping limestone. No upper Pliocene beds were recognized in Scott County, and no attempt has been made to subdivide the Ogallala formation.

So far as is known, no vertebrate fossils have been taken from the Ogallala formation in Scott County. In Ford County, a horse tooth was recovered from the Ogallala at a depth of 113 feet during the drilling of an irrigation well in the SW¼ sec. 6, T. 27 S., R. 26 W. The tooth was identified by C. W. Hibbard as a right molar of *Pliohippus* cf. *interpolatus* (Waite, 1942, p. 160). Schoff (1939, pp. 61-62) reported that large collections of vertebrate remains taken from excavations in the vicinity of Optima and Guymon, Texas County, Oklahoma, were considered by Stovall to be middle Pliocene in age. According to Schoff, the fossils were found in the upper 100 feet of the formation.

Fossil grass and hackberry seeds collected from the Ogallala formation have been described by Elias (1932, pp. 333-340). In a later paper (Chaney and Elias, 1936) it was shown that certain of the fossil seeds are of widespread occurrence and have a short vertical range making them useful as guide fossils. Fossil grass and hackberry seeds were collected by me from the Ogallala formation in

Scott County, notably from exposures in the bluffs just west of the dam at the north end of Lake McBride near the Cen. sec. 2, T. 16 S., R. 33 W. (Pl. 13A) and from exposures in the bluffs on the east side of Lake McBride below the McBride monument in the NW¼ NE¼ sec. 12, T. 16 S., R. 33 W. In both localities the seeds were collected from massive layers of cemented grit and coarse sand from 5 to 10 feet in thickness that formed prominent benches along the sides of the valley. Fossil grass and hackberry seeds were also collected from exposures of the Ogallala formation in the northeastern part of the county in the SE¼ NE¼ sec. 1, T. 16 S., R. 32 W. Fragments of grass and hackberry seeds were found in test hole 23 in the southwestern corner of Scott County between depths of 103.5 and 119 feet. From comparisons with forms described by Elias, the grass seeds are believed to be *Biorbia fossilia* and the hackberry seeds are believed to be *Celtis willistoni.*

Water supply.—In Scott County, as in many other parts of the High Plains, the Ogallala formation is the most important water-bearing formation. Most of the domestic and stock wells in the outlying upland areas surrounding the Scott Basin, as well as many of the irrigation wells and industrial and public supply wells, derive water from the Ogallala formation. Many of the wells in the Scott Basin derive water from the undifferentiated Pleistocene deposits overlying the Ogallala formation and some of the wells penetrate these deposits as well as the Ogallala formation below and may obtain water from both sources. The Ogallala formation also supplies water to springs in the northern part of the county, notably Big Springs, Barrel Springs, and Old Steele Home Springs, all situated in the Scott County State Park (Pl. 1, springs 16, 17, 18). The yields of wells tapping the Ogallala range from several gallons a minute from small domestic and stock wells to about 2,900 gallons a minute for some of the large irrigation wells (200). The largest yields from the Ogallala are obtained from the coarser materials generally in the lower part of the formation. The beds of the Ogallala formation once extended from the Rocky Mountains eastward to perhaps as far as the eastern third of Kansas, but they have been removed by erosion from much of the territory they once occupied. A much greater thickness of the formation may have been saturated at one time, but streams such as Beaver (Ladder) Creek in the northern part of the county and tributaries to streams in Logan and Gove Counties to the north of Scott County have cut below the zone of saturation and are draining part of the water from the formation. In parts of southeastern Scott County the Ogallala and

Pleistocene beds are comparatively thin and lie entirely above the water table (sec. B-B′, Fig. 5). The thickness of saturated material, as shown by the profile sections in Figure 5, differs greatly. Logs of test holes indicate that a large percentage of the saturated zone in the Ogallala and the Pleistocene deposits is composed of sand and gravel, so the amount of water available is large.

In recent years there has been an increase in the number of wells tapping the Ogallala formation in Scott County, largely as a result of increased demands for irrigation and industrial supplies.

The water from the Ogallala formation is hard. The analyses of typical waters from the Ogallala formation are shown in Figure 16. Samples of water were collected from 19 wells that derived water from the Ogallala formation, from 6 wells that derived water from the Ogallala formation and/or undifferentiated Pleistocene deposits, and from 3 wells that derived water from the Ogallala and/or Niobrara formations. Analyses of the 19 samples of water collected from the Ogallala formation indicate that the hardness ranged from 162 to 319 parts per million and averaged about 221 parts. The analyses also indicate that the amount of iron contained in these samples of water from the Ogallala ranged from 0.0 to 2.9 parts per million. The fluoride content of these 19 samples ranged from 0.3 to 3.0 parts per million. Three samples of water from this group contained less than 1 part per million of fluoride, 6 contained more than 1 part, 9 contained between 2 and 3 parts, and 1 contained 3 parts. Because the fluoride content of some of the water from the Ogallala formation is relatively high, some water derived from this source may be harmful to children's teeth. The analyses show also that the amount of sulfate contained in these 19 samples of water from the Ogallala ranged from 8.4 to 84 parts per million and averaged about 44 parts. The analyses indicate that the water from the Ogallala is well within the suggested safe use for irrigation. The water in the Ogallala is generally softer than the water in the overlying undifferentiated Pleistocene deposits.

Quaternary System

PLEISTOCENE SERIES

Undifferentiated Deposits

Deposits of gravel, sand, silt, and clay overlie the Ogallala formation and although somewhat similar lithologically to the Ogallala formation, they are of Pleistocene age. It has not been practicable to subdivide these deposits into smaller units, so they are referred to as undifferentiated Pleistocene deposits.

Character.—The undifferentiated Pleistocene deposits consist principally of unconsolidated gravel, sand, silt, and clay. Sand and gravel are the most abundant materials and silt and clay occur in lesser amounts but locally may be the predominant constituents. The coarse sand and the gravel are composed of quartz, feldspar, and other material derived from igneous rock. Waterworn pebbles of caliche derived from the Ogallala formation are common in these deposits, particularly in the lower part near the contact between these deposits and the underlying Ogallala formation. In places where the Ogallala formation is relatively thin or absent, waterworn pebbles of materials derived from rocks of Cretaceous age, principally from the Niobrara formation, are scattered through the deposits.

The Pleistocene deposits are poorly sorted and very lenticular. Individual beds are discontinuous and may grade laterally or vertically from one lithologic type to another within relatively short distances. Interbedded with the sands and gravels are many lenses of silt, sandy clay, and clay. Clay in the form of rounded "clay balls" that range in diameter from a few inches to more than a foot are interspersed throughout the deposits. These deposits are for the most part unconsolidated. Some beds, however, are cemented by calcium carbonate to form hard "mortar beds" resembling concrete, a notable example being the cemented deposits occurring along the south bank of Beaver (Ladder) Creek, just above the water surface, at a point just below the bridge in the NW¼ SW¼ sec. 21, T. 17 S., R. 33 W.

The undifferentiated Pleistocene deposits include the terrace deposits of Beaver (Ladder) Creek Valley which are composed mainly of gravel containing intermixed sand, silt, and clay. The sand and gravel is composed principally of material derived from igneous rocks. The terrace deposits are patchy in character and occur as isolated terrace remnants of channel deposits that were formerly much more extensive. Downcutting by Beaver Creek was responsible for the removal of most of the channel deposits, leaving scattered isolated remnants along the valley sides. The terrace deposits are of commercial importance and are the source of sand and gravel used for construction materials locally. The Geist (Christy) gravel pit, situated in the NE¼ SW¼ sec. 21, T. 17 S., R. 33 W., has been in operation intermittently for several years and large amounts of gravel and sand have been removed for construction purposes. Although not used in 1940 as extensively as the Geist (Christy) pit, two other gravel pits have been operated on terrace deposits along Beaver (Ladder) Creek Valley—the Garvin gravel pit, situated on the section line between secs. 22 and 23, T. 17 S., R. 34 W. about a quarter of a mile south of the north section line, and the Gilbert Lenz gravel pit, situated in the SE¼ NW¼ sec. 22, T. 17 S., R. 34 W. The sand and gravel deposits at the Garvin pit are about 15 feet thick according to a measurement of the south vertical face of the workings in 1940. Similarly, the deposits of sand and gravel at the Lenz pit were from 15-18 feet in thickness in 1940, the deposits consisting of cross-bedded sand and gravel interspersed with green clay balls and waterworn pebbles of white Ogallala caliche material. A fourth gravel pit was also visited in the SW¼ SE¼ sec. 15, T. 17 S., R. 33 W. The deposits occurred as a terrace remnant on the west side of Beaver (Ladder) Creek and there was evidence that the pit has been worked extensively.

The finer materials of the Pleistocene deposits consist of clay and silt. Clay was encountered in about half of the 23 test holes (1, 5, 10, 13, 15, 16, 17, and 19-23 incl.) drilled in Scott County. The clay ranges from silty to sandy and is tan, blue gray, light gray, dark gray, yellow gray, light greenish gray, pale green, brown, yellow, pinkish, and black. The individual beds range in thickness from 1.5 to 50 feet. Many of the clay beds contain small invertebrate fossils.

Lenses of silt and sandy silt ranging in thickness from about 1.5 to 68 feet were penetrated in test drilling. Beds of silt were encountered throughout the entire vertical range of the Pleistocene deposits in Scott County. The silt is tan, brown, yellow tan, grayish tan, light gray, gray, light green gray, yellow gray, and pinkish brown. Some of the silt layers are calcareous and are white to light gray in color.

The sands in the Pleistocene deposits are generally poorly sorted and range in texture from very fine- to coarse-grained and often contain a few pebbles. Fine to very coarse gravels make up the coarser sediments of the Pleistocene. Lenses of intermixed sand and gravel are common. The thickness of most of the sand and gravel lenses encountered in test holes ranges from a few feet to 21 feet. Test hole 22 in southern Scott County penetrated 21 feet of sand and medium to fine gravel between depths of 67 and 88 feet.

The upper part of the undifferentiated Pleistocene deposits is well exposed in two gravel pits—one about 1.5 miles north and 1 mile west of Scott City in the NW¼ SW¼ sec. 12, T. 18 S., R. 33 W., and the other about 1 mile east of Shallow Water in the SE¼ sec.

30, T. 19 S., R. 32 W. The deposits of sand and gravel in these two gravel pits are lithologically similar and contain intermixed silt and clay and scattered clay balls.

Distribution and thickness.—Pleistocene deposits are present nearly everywhere in Scott County except in the northern part where tributary streams have removed them and exposed Pliocene and Cretaceous rocks. In most places they are covered with a mantle of loess of variable thickness, and in the southeastern part of the county they are covered by dune sand.

The thickness of the Pleistocene deposits ranges from a few feet to 196 feet. The maximum thickness in this area was encountered in test holes 17 and 19 in south-central Scott County near Shallow Water, where 196 feet of sediments of Pleistocene age were penetrated in each of the test holes. These test holes were drilled in what is believed to be the deepest part of the buried trough in Scott County. Test hole 13, drilled near the terminus of Whitewoman Creek where the creek loses its identity and merges with the Scott Basin, penetrated 190 feet of undifferentiated Pleistocene deposits. Test hole 16, drilled about 2 miles east of Shallow Water, penetrated 168 feet of Pleistocene deposits. The Pleistocene deposits thin eastward and westward from the vicinity of the buried trough whose course is revealed by the contours showing the configuration of the pre-Tertiary bedrock surface in Figure 2.

Origin.—Most of the materials in the undifferentiated Pleistocene deposits represent channel and flood plain sediments that were laid down in much the same manner as the stream-laid deposits of the Ogallala formation. The sediments that were deposited in the deepest part of the buried trough were the result of channel filling by an ancestral stream that formerly occupied the north-south trending trough whose axis passed near Scott City and Shallow Water and extended southward into Finney County. The trough was cut to its maximum depth early in the Pleistocene after which a period of alluviation or perhaps several successive periods of channel filling resulted in the great thickness of undifferentiated Pleistocene deposits in the buried trough. The origin of the Pleistocene deposits occurring as terrace remnants along the valley sides of Beaver (Ladder) Creek in the northwestern quarter of the county have been discussed on page 39.

Age and correlation.—Fossils collected from these deposits in Scott County indicate that they are of Pleistocene age. Fossil material collected in 1939 from two gravel pits in Scott County by H.

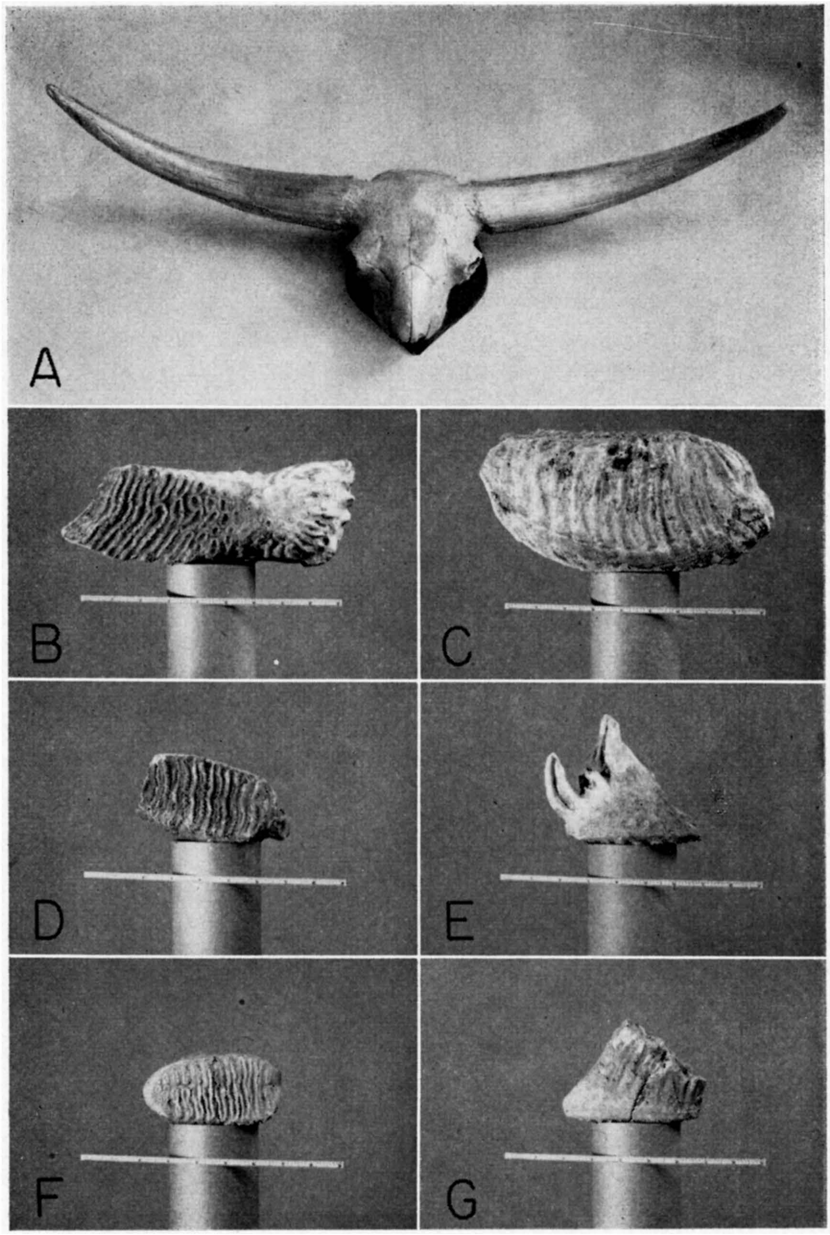


PLATE 15. Vertebrate fossils collected from gravel pits along Beaver (Ladder) Creek in Scott County. *A*, Skull of *Superbison latifrons*. *B* and *C*, Top and side views, respectively, of lower molar (M_3) of *Paraelephas* cf. *columbi*. *D* and *E*, Top and side views, respectively, of upper molar of *Paraelephas* cf. *columbi*. *F* and *G*, Top and side views of upper premolar of *Paraelephas* cf. *columbi*.

T. U. Smith has been identified by Claude W. Hibbard. Six teeth that were collected by Smith from the Geist (Christy) pit, located about 5 miles north and 3.5 miles west of Scott City, were identified by Hibbard as *Bison bison*. Fossil material collected by Smith from the gravel pit located about 1 mile east of Shallow Water was identified by Hibbard as *Bison bison* material.

A crew of W. P. A. workmen at the Geist (Christy) gravel pit unearthed two large fossil horns in February and March 1939. The two horns, together with a skull that was found later, were mounted and placed on display in the Ford Garage in Scott City. These horns measured 72 inches from tip to tip. This specimen was identified by Hibbard from a photograph as *Superbison latifrons* (Pl. 15A).

In 1940, a large fossil molar was unearthed by a W. P. A. crew at the same Geist (Christy) gravel pit. It was identified by Hibbard as a lower molar (M_3) of *Paraelephas* cf. *columbi* (Pl. 15B and C). Another tooth that was unearthed at the Geist (Christy) gravel pit is shown in Plate 15D and E. Hibbard identified this tooth as an upper molar *Paraelephas* cf. *columbi*. A small tooth was unearthed from a gravel pit on the west side of Beaver (Ladder) Creek in the SE¼ NE¼ sec. 15, T. 17 S., R. 33 W. Hibbard identified this specimen as an upper premolar of *Paraelephas* cf. *columbi* (Pl. 15F and G).

Fragmentary teeth collected by me in 1940 from the Gilbert Lenz gravel pit in the SW¼ NE¼ sec. 22, T. 17 S., R. 34 W. were subsequently identified by Hibbard as *Procamelus*, a Tertiary form. A fragment of a horse tooth, either *Pliohippus* or *Hipparion* was also identified. Because of the fragmentary condition of the material exact identification was not possible.

The undifferentiated Pleistocene deposits have also yielded invertebrate fossils. Mollusks recovered from several of the test holes drilled in Scott County are listed below. Identifications were made by A. B. Leonard.

Mr. Leonard reported that all of these forms seemed to be well fossilized, but pointed out that fossilization in snails is sometimes very difficult to determine with accuracy. He also reported that *Vallonia* and *Succinea* exist in this part of Kansas today and therefore cannot be used to identify Pleistocene deposits.

The invertebrate fossils collected from the undifferentiated deposits in Scott County are additional evidence indicating Pleistocene age for these beds. Many of the mollusks given in the preceding

Fossil material recovered from test holes in Scott County

Test hole No.	Depth below land surface, feet	Fossils
2	3–14	*Vallonia costata; Lymnea parva;* (aquatic, Recent).
2	16–18	*Vallonia costata.*
3	11–18	*Lymnea rustica;* Has been found in Kingman County (probably Recent).
5	30–33.5	*Vallonia costata; Succinea grosvenori;* Both terrestrial; both probably in the area today, questionable value.
8	15–22	*Vallonia costata;* see above.
10	72–76	*Helisoma* cf. *trivolvis* (fragment); A pond snail that is likely found in the area today.
11	4–11	*Vallonia costata; Succinea grosvenori;* Both terrestrial; both probably in the area today.
12	2.5–14	*Vallonia costata;* see above.
13	180–190	*Lymnea sp.;* The value of this form is lost because of its fragmentary condition which makes specific identification impossible.
15	26–31	*Vallonia costata;* see above.
17	44–51	*Helisoma sp.* (fragmentary); A pond snail.
17	51–56	*Vallonia costata;* see above.
18	4.5–16.5	*Vallonia costata; Succinea grosvenori;* Terrestrial forms—both probably Recent.
19	11–16	*Succinea grosvenori.*
19	16–22	*Pupilla muscorum; Succinea grosvenori.*
19	22–26	*Pupilla muscorum; Vallonia costata.*
19	26–30	*Vallonia costata.*
19	37–39.5	*Gyraulus deflectus.*

Pupilla muscorum, a woodland form, and *Gyraulus deflectus*, an inhabitant of permanent pools, are both extinct in this area, and suggest that the deposit is Pleistocene.

20	53–58.5	*Vallonia costata;* see above.
22	20–24	*Lymnea parva;* A pond snail, Recent?
22	39–43	*Succinea grosvenori; Vallonia costata.*

Although these snails seem to be well fossilized their stratigraphic value is limited inasmuch as these forms seemingly live in the area today.

23	1.5–12.5	*Vallonia costata.*

list are identical with forms found in the Meade formation of Meade County (Frye and Hibbard, 1941, pp. 413-415) where they are associated with Pleistocene vertebrates. Similar invertebrate fossils were recovered from several of the test holes drilled in Finney and Gray Counties (Latta, 1944, p. 175). Latta also called attention to similar forms collected by Thad G. McLaughlin from a bed of silty clay in the SE¼ NE¼ sec. 3, T. 27 S., R. 31 W., in the northeastern corner of Haskell County.

The presence of waterworn caliche and "mortar bed" pebbles also indicate Pleistocene age for these deposits in Scott County. As has been pointed out earlier, waterworn fragments of Ogallala material are common in the Pleistocene gravels.

Water supply.—Many of the wells in the Scott Basin derive water from the undifferentiated Pleistocene deposits. Some wells penetrate these deposits as well as the water-bearing section of the Ogallala formation below and may obtain water from both sources. The terrace deposits found in isolated patches along the valley sides of Beaver (Ladder) Creek in the northwestern quarter of the county are relatively permeable but generally occur above the water table and are therefore not important as a source of water in that vicinity.

The yields of wells in the undifferentiated Pleistocene deposits range from several gallons a minute from small domestic and stock wells to more than 1,000 gallons a minute from some of the large irrigation wells. Where wells penetrate the Pleistocene deposits and the water-bearing beds in the underlying Ogallala formation, it is practically impossible to determine the quantity of water being furnished from each of the two sources. The thickness of saturated material in the Pleistocene deposits differs greatly, as shown by the profile sections in Figure 5. Logs of test holes show that a large percentage of the saturated zone in these deposits is composed of sand and gravel, so the amount of water available is believed to be large.

Six samples of water were collected from wells (107, composite sample from 82 and 112, 174, 236, 252, and 262) obtaining water from undifferentiated Pleistocene deposits and/or the underlying water-bearing beds in the Ogallala formation. All of the wells were situated in the Scott Basin, in the vicinity of the deep buried trough where maximum thicknesses of Pleistocene deposits occur. The total dissolved solids in the six samples ranged from 205 to 563 parts per million, two of the samples (wells 174 and 236) having 563 and 536 parts respectively of total dissolved solids. The total hardness ranged from 172 to 344 parts per million and averaged 238 parts. The iron content in the six samples ranged from 0 to 3.3 parts per million, and the fluoride content ranged from 1.0 to 2.7 parts per million, four of the samples (wells 107, 236, 252, and 262) having 1 part or more of fluoride, and two samples (composite of wells 82 and 112, and 174) having 2.0 and 2.7 parts per million of fluoride, respectively. The sulfate content in all 6 samples showed a greater range in concentration—four of the six samples (wells 107, composite sample of 82 and 112, 252, and 262) had a sulfate content ranging from 26-41 parts per million. Samples

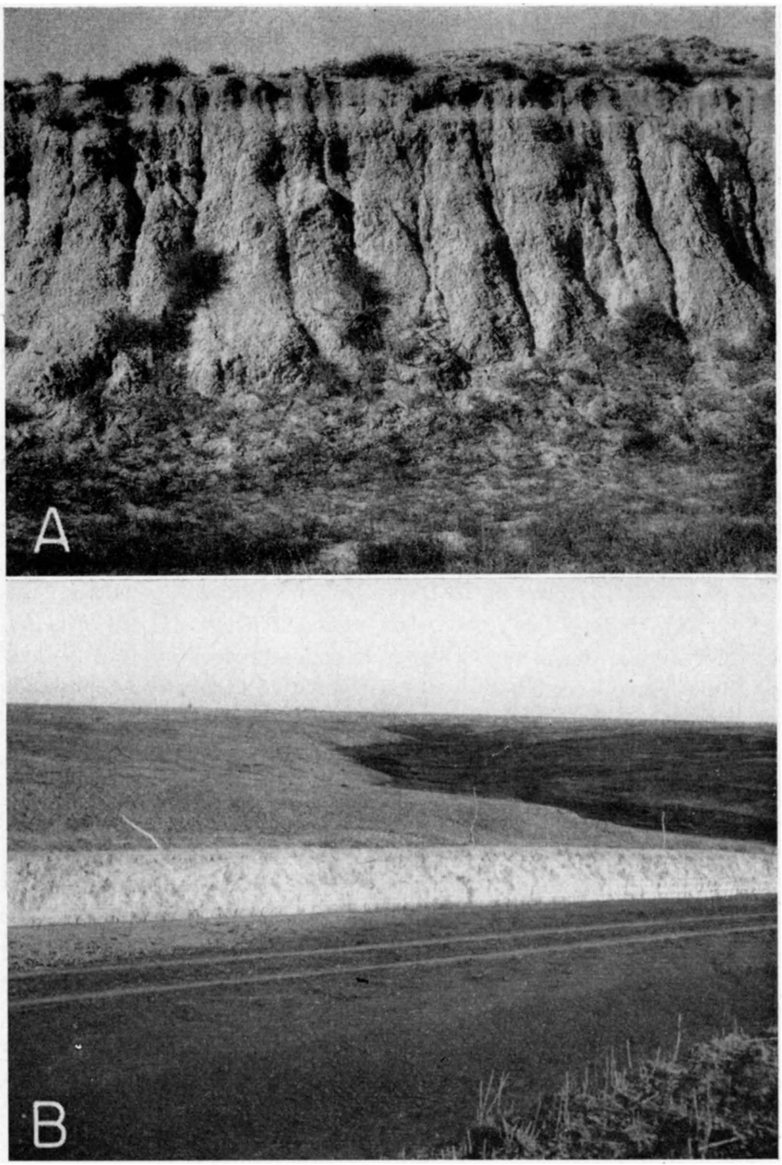


PLATE 16. *A,* Typical loess exposed in abandoned railroad cut near the NE cor. sec. 36, T. 16 S., R. 33 W.; *B,* loess exposed on east side of freshly graded road in the SW cor. NW¼ NW¼ sec. 17, T. 16 S., R. 33 W.

of water from wells 174 and 236 had sulfate contents of 194 and 145 parts per million, respectively. The fluoride content in some of the water derived from the undifferentiated Pleistocene deposits and/or the water-bearing beds of the underlying Ogallala formation is relatively high. The composite sample collected from the public supply at Scott City (wells 82 and 112) at a time when both wells were pumping had a fluoride content of 2.0 parts per million.

The analyses of these six samples of water from the undifferentiated Pleistocene deposts and/or Ogallala formation in Scott County indicate that the water is well within the safe limits for use in irrigation according to the principles discussed by Scofield (1933).

PLEISTOCENE AND RECENT SERIES

Loess

A relatively thin deposit of loess overlies the undifferentiated Pleistocene deposits in much of Scott County. In places where the undifferentiated Pleistocene deposits are absent the loess may rest directly on the Ogallala formation. The loess is exposed in road and highway cuts in the northern half of the county; typical exposures of loess are shown in Plate 16. The loess is generally light buff to light brown but may grade upward into a darker brown to black soil zone at the top. The material is structureless and lacks bedding. Exposures of loess in road cuts are typical in appearance to loess found elsewhere, except that vertical parting may be less prominent. In places it contains small scattered concretionary nodules of lime carbonate. It is composed principally of silt but contains some very fine sand. Mechanical analyses made by Smith (1940, p. 122) included analyses of two samples of loess (11 and 12) collected from road cuts near the north county line in northern Finney County. One sample was collected in the northwest corner of Finney County in the NW¼ sec. 6, T. 21 S., R. 34 W., and the other in the NE¼ sec. 2, T. 21 S., R. 29 W., near the Lane-Finney County line. These analyses (Table 17) indicated maxima in the 0.062-0.031 mm division. Fractions larger than 0.062 mm were separated by screening; those smaller than 0.062 mm were separated by the pipette method.

Natural exposures of loess are relatively few and small because of the incoherent character of the material. Because road cuts and other excavations are generally shallow, the complete thickness of the loess is not readily determinable and the irregularities of the buried pre-loess surface are concealed. It is estimated that the thickness of the loess in Scott County ranges from a few feet to

TABLE 17. *Mechanical analyses of loess and associated materials*[1]

No. of sample	LOCATION	Mechanical composition					
		0.5 mm	0.5-0.25 mm	0.25-0.125 mm	0.125-0.062 mm	0.062-0.031 mm	0.031 mm
11	NW¼ sec. 6, T. 21 S., R. 34 W.	0.2	0.7	5.2	26.2	52.0	15.8
12	NE¼ sec. 2, T. 21 S., R. 29 W.	0	.03	3.5	22.6	69.5	4.4

1. Modified from Smith (1940, p. 122).

about 30 feet. Most of the test holes in Scott County encountered deposits of loess that ranged in thickness from 5 to 28 feet. The maximum thickness was encountered in test hole 3. Gastropod shells were collected from an exposure of loess in an abandoned railroad cut in the northern part of the county in the NE¼ NE¼ sec. 36, T. 16 S., R. 33 W. (Pl. 16A). Gastropod shells and fragments of pelecypod shells were recovered from the upper part of most of the test holes drilled in Scott County, some of which came from the upper loessial part of the test holes.

The age of the loess can be stated only in relative terms, for as A. B. Leonard has pointed out, the fossilization of snails is sometimes very difficult to determine with accuracy, and some of the forms are of doubtful value because they exist in western Kansas today. At least in part, the loess probably belongs somewhere in the upper Pleistocene and may grade imperceptibly upward into loess of Recent age. It is younger than volcanic ash, and older than dune sand at the few localities where it is found in contact with one or the other of these, according to Smith (1940, pp. 124-125). He also suggests that it may be contemporaneous with and in part grade laterally into the Kingsdown formation. More than one age of loess may be present in Scott County, but no attempt was made to subdivide it. The loess lies above the water table in Scott County, hence it furnishes no water to wells.

Dune Sand

Dune sand of Quaternary age occurs in an area of approximately 9 square miles in the southeastern corner of Scott County and in smaller scattered areas in the southeastern part of the county (Pl. 1). The dune sand is composed predominantly of uniform fine- to medium-grained well-rounded quartz sand and contains smaller amounts of silt and clay. The sand has been accumulated by the wind to form small hills and ridges. The exact thickness of this material in Scott County has not been determined, but it is believed that the dune sand mantle ranges in thickness from a few feet to perhaps as much as 50 feet. In places the soil zone is thin and attempts at cultivation have stripped the protective vegetative cover allowing the upper surface to be subjected to renewed wind action. The dune sand probably was derived from the denudation of near-by Pliocene and Pleistocene deposits. Smith (1940, pp. 127-128; 153-168) gives a detailed discussion of the origin of sand dunes in western Kansas.

No wells obtain water directly from the dune sand in Scott County, for it is everywhere above the water table, but sand dunes serve as valuable intake areas for ground-water recharge from local precipitation because the porous materials comprising them are highly permeable and permit infiltration readily.

Alluvium

Alluvium of late Quaternary age is found in Beaver (Ladder) Creek Valley in Scott County (Pl. 1). Some of the tributary streams in the extreme northern part of the county are still in the process of downcutting so that there is little or no alluvium along the greater part of their courses in Scott County. Where present, the alluvium is thin and occurs as very narrow bands along the northern part of their present channels; accordingly, it is not shown on the geologic maps.

The character of the alluvium in Beaver Valley is typical of streamlaid deposits and ranges in texture from silt to sand and coarse gravel. The youngest deposits consist largely of sand and silt deposited over the flood plain in time of flood or in normal conditions in the channel of the stream. Beneath the finer surface deposits are layers of sand and gravel slightly older but of similar origin. The alluvium grades into the terrace deposits, so the lower part of the valley fill in some places is of late Pleistocene age and represents the basal part of a cut and fill terrace deposit.

The alluvium is underlain by the Ogallala formation in most parts of Beaver Creek Valley, but in the vicinity of Scott County State Park the alluvium rests uncomformably on the Niobrara formation. Scanty data indicate that the thickness of the alluvium along Beaver Valley ranges from a few feet to an estimated maximum of about 20 feet. The yields of wells tapping the alluvium in Beaver Valley generally are adequate for domestic and livestock purposes.

The analysis of one sample of water (3) collected from a well in shallow alluvium of a tributary drainage in the northeastern part of the county in the SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 4, T. 16 S., R. 31 W. showed dissolved solids, 462 parts per million; total hardness, 394 parts; sulfate, 171 parts; fluoride, 1.0 part; and iron, 2.1 parts. The well from which the water was collected is in an area in which the Niobrara formation is at or near the surface and the chemical quality of the water in the alluvium in that vicinity is doubtless affected somewhat by the underlying chalk of that formation.

RECORDS OF WATER LEVELS IN IRRIGATION WELLS

The measurements of water levels in 81 irrigation wells in Scott County are given in Table 18. This table includes all measurements from the beginning of record through December 1945.

TABLE 18. *Records of water levels in irrigation wells in Scott County, Kansas*

(Depths to water levels are referred to the measuring points described in Table 19; other data pertaining to these wells are also given in that table. Measurements furnished by Division of Water Resources, State Board of Agriculture.)

Date	Depth to water level, feet	Date	Depth to water level, feet	Date	Depth to water level, feet
26. (Field No. 1002). Pat Meyers. SW¼ NW¼ sec. 17, T. 16 S., R. 34 W.					
Apr. 1941	117.37	Mar. 1945	117.36	....	.....
52. (Field No. 1003). Sam Filson. SW¼ SW¼ sec. 25, T. 17 S., R. 33 W.					
June 1944	72.23	Apr. 1945	72.48	Dec. 1945	73.55
73. (Field No. 98). S. W. Filson. SW¼ NE¼ sec. 7, T. 18 S., R. 32 W.					
Sept. 1940	58.42	Dec. 1942	58.29	June 1944	58.09
Feb. 1941	57.55	Apr. 1943	57.16	Jan. 1945	58.36
Jan. 1942	57.20	Dec. 1943	59.35	Apr. 1945	57.93
Apr. 1942	56.81	Mar. 1944	58.49	Dec. 1945	59.00
74. (Field No. 97). S. W. Filson. SW¼ SE¼ sec. 7, T. 18 S., R. 32 W.					
Sept. 1940	59.03	Dec. 1942	58.24	June 1944	58.46
Oct. 1940	59.59	Apr. 1943	57.41	Jan. 1945	58.78
Feb. 1941	58.06	Dec. 1943	59.79	Apr. 1945	58.23
Jan. 1942	57.68	Mar. 1944	59.05	Dec. 1945	59.75
Apr. 1942	57.16	....	.....	....	.....
77. (Field No. 118). J. E. Kirk. SW¼ SW¼ sec. 17, T. 18 S., R. 32 W.					
Oct. 1940	49.58	Jan. 1942	47.92	May 1942	47.50
Feb. 1941	48.36	....	.....	....	.....
78. (Field No. 162). S. W. Filson. NE¼ NE¼ sec. 18, T. 18 S., R. 32 W.					
Oct. 1940	59.22	Dec. 1943	58.19	Jan. 1945	57.07
Nov. 1942	56.33	Mar. 1944	57.23	Apr. 1945	56.55
Apr. 1943	55.41	June 1944	56.86	Dec. 1945	58.09

80. (Field No. 120). John Hasz. SW¼ SE¼ sec. 18, T. 18 S., R. 32 W.

Sept. 1940	54.94	Jan. 1942	51.03	May 1942	51.04

83. (Field No. 76). Jess Bright. NW¼ SW¼ sec. 19, T. 18 S., R. 32 W.

Sept. 1933	40.0	Jan. 1942	41.71	Mar. 1944	43.15
Sept. 1934	37.0	Apr. 1942	41.05	Dec. 1944	42.48
Sept. 1935	37.0	Nov. 1942	42.13	Jan. 1945	42.72
Sept. 1936	36.1	Apr. 1943	41.21	Apr. 1945	43.22
Feb. 1941	41.97	Dec. 1943	44.22	Dec. 1945	44.58

84. (Field No 46). American Life Insurance Company. SW¼ SW¼ sec. 20, T. 18 S., R. 32 W.

Mar. 1910	37.3	June 1935	37.38	Jan. 1942	40.89
Nov. 1926	39.7	Sept. 1935	38.17	Apr. 1942	40.22
Aug. 1933	40.0	Sept. 1939	39.21	Nov. 1942	41.02
May 1934	37.20	Sept. 1940	41.50	Dec. 1943	43.33
Sept. 1934	38.58	Feb. 1941	40.93	Dec. 1945	45.36
Nov. 1934	37.38	....	.....	....	.....

85. (Field No. 225). J. E. Kirk. SE¼ NW¼ sec. 21, T. 18 S., R. 32 W.

Nov. 1940	64.0	Nov. 1942	67.01	June 1944	66.97
Feb. 1941	64.08	Apr. 1943	66.02	Jan. 1945	66.46
Jan. 1942	66.04	Dec. 1943	69.34	Apr. 1945	66.31
May 1942	66.11	Mar. 1944	66.46	Dec. 1945	66.52

88. (Field No. 231). Vern Harris. NE¼ NW¼ sec. 29, T. 18 S., R. 32 W.

Nov. 1942	36.67	Mar. 1944	37.58	Jan. 1945	36.93
Apr. 1943	35.99	June 1944	36.99	Apr. 1945	36.56
Dec. 1943	38.72	....	.....	....	.....

91. (Field No. 61). V. M. Harris. SE¼ NW¼ sec. 29, T. 18 S., R. 32 W.

Sept. 1940	33.85	Nov. 1942	34.63	June 1944	34.89
Feb. 1941	34.17	Mar. 1943	34.28	Jan. 1945	35.02
Dec. 1941	34.06	Dec. 1943	36.26	Apr. 1945	34.87
Apr. 1942	34.04	Mar. 1944	35.68	....	.....

95. (Field No. 69). R. B. Christy. SE¼ NE¼ sec. 30, T. 18 S., R. 32 W.

Sept. 1940	34.37	Nov. 1942	33.78	June 1944	34.03
Feb. 1941	33.50	Mar. 1943	33.06	Jan. 1945	34.07
Jan. 1942	33.49	Dec. 1943	36.21	Apr. 1945	33.94
Apr. 1942	32.95	Mar. 1944	34.75	....	.....

TABLE 18. *Records of water levels in irrigation wells in Scott County, Kansas —Continued*

Date	Depth to water level, feet	Date	Depth to water level, feet	Date	Depth to water level, feet
96. (Field No. 25). Elvin Deng. NW¼ SW¼ sec. 30, T. 18 S., R. 32 W.					
Sept. 1936	27.2	Dec. 1941	31.86	Mar. 1944	33.40
Sept. 1939	29.83	Apr. 1942	31.06	June 1944	32.65
Sept. 1940	32.52	Nov. 1942	31.90	Jan. 1945	32.84
Oct. 1940	33.73	Mar. 1943	31.14	Apr. 1945	32.31
Feb. 1941	31.69	Dec. 1943	34.46	Dec. 1945	34.84
97. (Field No. 18). Elvin Deng. SW¼ SW¼ sec. 30, T. 18 S., R. 32 W.					
Sept. 1936	18.8	Dec. 1941	24.46	Mar. 1944	24.57
Sept. 1939	20.41	Apr. 1942	21.74	June 1944	23.39
Sept. 1940	22.49	Nov. 1942	22.65	Jan. 1945	23.77
Oct. 1940	23.66	Mar. 1943	21.97	Apr. 1945	23.29
Feb. 1941	22.34	Dec. 1943	25.30	Dec. 1945	25.86
107. (Field No. 19). Fouquet. SE cor. NE¼ sec. 12, T. 18 S., R. 33 W.					
Sept. 1939	48.09	Mar. 1944	49.03	Apr. 1945	48.94
Mar. 1943	47.62	June 1944	48.56	Dec. 1945	49.45
Dec. 1943	49.52	Jan. 1945	48.55	....	.....
109. (Field No. 123). S. W. Filson. NW¼ NE¼ sec. 13, T. 18 S., R. 33 W.					
Sept. 1940	55.54	Nov. 1942	55.56	June 1944	55.37
Feb. 1941	55.12	Mar. 1943	54.79	Jan. 1945	56.75
Jan. 1942	54.78	Dec. 1943	57.25	Apr. 1945	55.16
Apr. 1942	54.35	Mar. 1944	55.96	Dec. 1945	56.86
110. (Field No. 121). J. E. Kirk. NW¼ SE¼ sec. 13, T. 18 S., R. 33 W.					
Feb. 1941	51.72	Nov. 1942	52.58	Jan. 1945	53.01
Jan. 1942	52.04	Mar. 1943	51.93	Apr. 1945	52.51
Apr. 1942	51.45	Dec. 1943	54.22	Dec. 1945	54.43
113. (Field No. 51). Dr. G. A. Greene. NE cor. SE¼ sec. 13, T. 18 S., R. 33 W.					
May 1934	36.18	Sept. 1939	41.36	....	.....

121. (Field No. 127). Claude Hughes. SW¼ SW¼ sec. 20, T. 18 S., R. 33 W.

Sept. 1939	70.73	Nov. 1942	72.14	Jan. 1945	71.97
Feb. 1941	71.26	Mar. 1943	71.04	Apr. 1945	71.63
Jan. 1942	70.78	Dec. 1943	71.70	Dec. 1945	73.53
Apr. 1942	70.57	June 1944	71.57	....	.....

123. (Field No. 3). Claude Hughes. SW¼ NE¼ sec. 22, T. 18 S., R. 33 W.

May 1934	69.44	Feb. 1941	70.68	Mar. 1944	71.03
Aug. 1936	68.9	Jan. 1942	70.39	June 1944	70.88
Sept. 1939	71.28	Apr. 1942	70.06	Jan. 1945	71.16
Oct. 1940	72.16	Nov. 1942	70.81	Apr. 1945	70.64
Nov. 1940	71.43	Mar. 1943	69.43	Dec. 1945	72.27
....	.....	Dec. 1943	70.85	....	.....

124. (Field No. 22). G. H. Cheney. SW¼ NE¼ sec. 22, T. 18 S., R. 33 W.

Sept. 1936	24.3	Sept. 1939	28.12	Nov. 1940	28.43

125. (Field No. 117). E. Brookover. SW¼ NW¼ sec. 23, T. 18 S., R. 33 W.

Sept. 1936	29.0	Nov. 1942	29.66	June 1944	29.48
Feb. 1941	30.56	Mar. 1943	29.51	Jan. 1945	29.78
Jan. 1942	29.73	Dec. 1943	31.20	Apr. 1945	30.56
Apr. 1942	29.45	Mar. 1944	30.55	Dec. 1945	37.88

126. (Field No. 73). C. L. Harpham. SE¼ NE¼ sec. 23, T. 18 S., R. 33 W.

Aug. 1936	34.9	Nov. 1942	38.45	June 1944	38.96
Sept. 1940	38.82	Mar. 1943	37.73	Jan. 1945	38.89
Feb. 1941	38.34	Dec. 1943	39.91	Apr. 1945	38.96
Jan. 1942	38.25	Mar. 1944	39.47	Dec. 1945	41.27
Apr. 1942	37.81	....	.....	....	.....

129. (Field No. 68). Geo. Weishaar. NE¼ NW¼ sec. 25, T. 19 S., R. 33 W.

Sept. 1933	46.0	Sept. 1940	46.36	June 1944	46.62
May 1934	42.01	Feb. 1941	45.63	Jan. 1945	47.51
Sept. 1934	43.3	Jan. 1942	45.61	Apr. 1945	46.17
Sept. 1935	43.6	Apr. 1942	44.93	Dec. 1945	48.86
July 1936	41.8	Nov. 1942	45.86	....	.....

135. (Field No. 229). Walter Proudfoot. NE¼ NE¼ sec. 35, T. 18 S., R. 33 W.

Feb. 1941	18.20	Dec. 1942	18.63	June 1944	18.29
Dec. 1941	18.78	Mar. 1943	18.05	Jan. 1945	19.94
May 1942	17.28	Dec. 1943	22.34	Apr. 1945	19.54
Nov. 1942	20.85	Mar. 1944	21.03	Dec. 1945	23.52

TABLE 18. *Records of water levels in irrigation wells in Scott County, Kansas —Continued*

Date	Depth to water level, feet	Date	Depth to water level, feet	Date	Depth to water level, feet
136. (Field No. 230). C. T. Hutchins. NW¼ SW¼ sec. 35, T. 18 S., R. 33 W.					
Feb. 1941	17.20	Nov. 1942	18.69	June 1944	17.93
May 1941	18.94	Mar. 1943	18.31	Jan. 1945	19.02
Dec. 1941	18.39	Dec. 1943	22.26	Apr. 1945	19.43
May 1942	18.26	Mar. 1944	20.88	Dec. 1945	21.93
137. (Field No. 75). C. T. Hutchins. SE¼ SE¼ sec. 35, T. 18 S., R. 33 W.					
July 1936	18.0	May 1942	19.06	Mar. 1944	25.57
Sept. 1940	22.09	Nov. 1942	20.67	June 1944	20.75
Oct. 1940	20.91	Mar. 1943	19.70	Jan. 1945	22.69
Feb. 1941	19.75	Dec. 1943	25.56	Dec. 1945	25.84
Dec. 1941	20.71	....	.....	....	.....
138. (Field No. 65). M. K. Armantrout. NW¼ NE¼ sec. 36, T. 18 S., R. 33 W.					
Sept. 1940	20.45	Dec. 1943	24.89	Jan. 1945	22.11
Feb. 1941	20.45	Mar. 1944	22.96	Apr. 1945	21.56
Nov. 1942	20.85	June 1944	21.51	Dec. 1945	24.82
Mar. 1943	20.06	....	.....	....	.....
139. (Field No. 64). M. K. Armantrout. NE¼ NW¼ sec. 36, T. 18 S., R. 33 W.					
Aug. 1940	21.17	May 1942	18.47	Mar. 1944	22.88
Oct. 1940	21.22	Nov. 1942	20.46	June 1944	19.98
Feb. 1941	19.99	Mar. 1943	18.84	Jan. 1945	21.86
Dec. 1941	20.42	Dec. 1943	24.14	Apr. 1945	21.26
140. (Field No. 74). S. H. Hull. SE¼ SW¼ sec. 36, T. 18 S., R. 33 W.					
Sept. 1940	23.06	Nov. 1942	24.87	June 1944	22.42
Oct. 1940	23.17	Mar. 1943	23.88	Jan. 1945	24.52
Feb. 1941	21.97	Dec. 1943	28.80	Apr. 1945	23.94
Dec. 1941	23.57	Mar. 1944	25.94	Dec. 1945	28.77
May 1942	22.05	....	.....	....	.....
147. (Field No. 128). Claude Hughes. SW¼ SW¼ sec. 24, T. 18 S., R. 34 W.					
Feb. 1941	95.63	Mar. 1943	95.14	Jan. 1945	95.53
Jan. 1942	95.16	Dec. 1943	95.55	Apr. 1945	95.16
Apr. 1942	95.05	Mar. 1944	95.64	Dec. 1945	95.56
Nov. 1942	95.75	June 1944	95.53	....	.....

148. (Field No. 124). Claude Hughes. NW¼ NW¼ sec. 25, T. 18 S., R. 34 W.

Sept. 1940	91.94	Nov. 1942	88.73	June 1944	88.26
Feb. 1941	89.73	Mar. 1943	88.16	Jan. 1945	88.35
Jan. 1942	89.28	Dec. 1943	88.61	Apr. 1945	88.07
Apr. 1942	89.12	Mar. 1944	88.36	Dec. 1945	88.62

149. (Field No. 4). W. N. Robinson. SE cor. NW¼ sec. 31, T. 18 S., R. 34 W.

Sept. 1919	92.1	July 1936	89.90	Nov. 1942	91.90
May 1934	91.84	Sept. 1939	91.48	Mar. 1943	91.80

167. (Field No. 1001). Roland Beach. NW¼ NE¼ sec. 1, T. 19 S., R. 33 W.

Apr. 1941	24.82	Dec. 1943	31.67	Jan. 1945	28.36
Dec. 1942	25.98	Mar. 1944	28.76	Apr. 1945	27.79
Mar. 1943	25.07	June 1944	27.12	Dec. 1945	32.81

168. (Field No. 75A). Pete Hutchins. NW¼ NE¼ sec. 1, T. 19 S., R. 33 W.

Apr. 1945	31.80	Dec. 1945	36.52	....	.....

171. (Field No. 77). J. E. Hushaw. NE¼ NW¼ sec. 12, T. 19 S., R. 33 W.

Feb. 1941	25.67	Mar. 1944	29.58	Apr. 1945	27.81
Nov. 1942	26.85	June 1944	27.26	Dec. 1945	31.24
Mar. 1943	26.39	Jan. 1945	28.10	....	.....

172. (Field No. 228). Geo. L. Duff. SW¼ SW¼ sec. 12, T. 19 S., R. 33 W.

Feb. 1941	26.94	Dec. 1943	31.94	Jan. 1945	28.72
Dec. 1941	28.75	Mar. 1944	30.82	Apr. 1945	28.71
Apr. 1942	27.41	June 1944	29.15	Dec. 1945	32.78

173. (Field No. 59). Geo. L. Duff. SW¼ SW¼ sec. 12, T. 19 S., R. 33 W.

Aug. 1936	22.4	Dec. 1941	28.82	Apr. 1942	27.20
Aug. 1940	29.18	....	.....	....	.....

174. (Field No. 58). Geo. L. Duff. SE¼ SE¼ sec. 12, T. 19 S., R. 33 W.

Sept. 1940	26.19	Dec. 1943	28.82	Jan. 1945	26.19
Feb. 1941	25.93	Mar. 1944	28.33	Apr. 1945	26.34
Dec. 1941	26.63	June 1944	26.96	Dec. 1945	29.25
Apr. 1942	26.06	....	.....	....	.....

TABLE 18. *Records of water levels in irrigation wells in Scott County, Kansas —Continued*

Date	Depth to water level, feet	Date	Depth to water level, feet	Date	Depth to water level, feet
179. (Field No. 86). Otto Gesseka. NW¼ SE¼ sec. 15, T. 19 S., R. 33 W.					
Aug. 1936	47.10	May 1942	56.22	June 1944	58.10
Sept. 1940	57.4	Nov. 1942	56.65	Jan. 1945	57.10
Feb. 1941	58.03	Mar. 1943	55.73	Apr. 1945	56.03
Jan. 1942	56.88	Dec. 1943	59.85	Dec. 1945	57.50
180. (Field No. 85). Leo Collingwood, SE¼ SW¼ sec. 15, T. 19 S., R. 33 W.					
Sept. 1940	62.25	Mar. 1943	59.00	Jan. 1945	63.16
Jan. 1942	60.90	Dec. 1943	64.23	Apr. 1945	62.59
May 1942	59.59	June 1944	61.52	Dec. 1945	61.09
Nov. 1942	60.35	....	.....	....	.....
182. (Field No. 111). J. A. Sweeney. SW¼ NE¼ sec. 20, T. 19 S., R. 33 W.					
July 1936	60.20	May 1942	70.07	June 1944	74.25
Apr. 1937	57.4	Nov. 1942	73.40	Jan. 1945	71.98
Feb. 1941	73.2	Mar. 1943	70.77	Apr. 1945	75.44
Dec. 1941	71.77	Dec. 1943	77.84	Dec. 1945	76.34
184. (Field No. 110). Victory Life Insurance Company. SW¼ SE¼ sec. 20, T. 19 S., R. 33 W.					
July 1936	63.63	June 1944	78.32	Apr. 1945	76.01
Nov. 1942	77.26	Jan. 1945	76.37	Dec. 1945	81.64
Mar. 1943	74.9	....	.....	....	.....
185. (Field No. 107). Victory Life Insurance Company. SW cor. SE¼ sec. 20, T. 19 S., R. 33 W.					
May 1934	63.63	May 1942	76.44	Dec. 1943	84.14
Apr. 1937	61.00	Nov. 1942	79.57	June 1944	81.08
Feb. 1941	78.55	Mar. 1943	77.23	Jan. 1945	79.31
Dec. 1941	77.90	....	.....	....	.....
186. (Field No. 30). Victory Life Insurance Company. NW¼ NE¼ sec. 21, T. 19 S., R. 33 W.					
Sept. 1939	62.68	June 1944	62.86	Apr. 1945	59.82
Dec. 1943	68.85	Jan. 1945	60.98	Dec. 1945	68.66

187. (Field No. 31). Victory Life Insurance Company. NW¼ NE¼ sec. 21, T. 19 S., R. 33 W.

Aug. 1933	46.0	Nov. 1934	46.13	Apr. 1937	45.9
May 1934	45.87	May 1935	46.3	Sept. 1939	61.53
Sept. 1934	45.7	Sept. 1935	46.4	....	.....

188. (Field No. 112). Victory Life Insurance Company. SW cor. NW¼ sec. 21, T. 19 S., R. 33 W.

Oct. 1940	72.93	May 1942	67.74	Dec. 1943	74.48
Feb. 1941	71.13	Nov. 1942	70.68	June 1944	71.63
Dec. 1941	69.54	Mar. 1943	68.12	Jan. 1945	69.15

189. (Field No. 29). Victory Life Insurance Company. NE¼ SW¼ sec. 21, T. 19 S., R. 33 W.

Sept. 1939	69.67	Nov. 1942	68.91	Jan. 1945	68.26
Feb. 1941	69.34	Mar. 1943	66.62	Apr. 1945	66.52
Dec. 1941	68.79	Dec. 1943	73.68	Dec. 1945	70.37
May 1942	66.53	June 1944	69.80	....	.....

190. (Field No. 84). Lee Collingwood Estate. SW¼ NW¼ sec. 22, T. 19 S., R. 33 W.

Feb. 1941	63.26	Nov. 1942	62.56	Apr. 1945	60.94
Jan. 1942	63.20	Jan. 1945	63.71	Dec. 1945	63.54
May 1942	61.11	....	.....	....	.....

193. (Field No. 78). R. H. Teeter. NW¼ NE¼ sec. 24, T. 19 S., R. 33 W.

Oct. 1940	39.50	Nov. 1942	39.78	June 1944	39.53
Feb. 1941	38.35	Mar. 1943	38.65	Jan. 1945	38.82
Dec. 1941	39.25	Dec. 1943	45.09	Apr. 1945	38.76
Apr. 1942	38.17	Mar. 1944	41.02	Dec. 1945	43.76

195. (Field No. 5). Mrs. Rosine Smith. SW cor. NW¼ sec. 25, T. 19 S., R. 33 W.

May 1934	39.79	Nov. 1940	43.44	Jan. 1942	47.24
July 1936	40.3	Feb. 1941	45.96	Apr. 1942	47.20
Sept. 1939	43.13	Dec. 1941	47.93	....	.....

197. (Field No. 60). Marvin Bastin. SW¼ SE¼ sec. 25, T. 19 S., R. 33 W.

Nov. 1940	42.64	Nov. 1942	45.83	June 1944	44.33
Feb. 1941	42.94	Mar. 1943	44.10	Jan. 1945	44.83
Jan. 1942	44.00	Dec. 1943	45.17	Apr. 1945	44.82
Apr. 1942	43.28	Mar. 1944	45.14	Dec. 1945	45.73

TABLE 18. *Records of water levels in irrigation wells in Scott County, Kansas —Continued*

Date	Depth to water level, feet	Date	Depth to water level, feet	Date	Depth to water level, feet
199. (Field No. 103). Mrs. Rosine Smith. NE¼ SW¼ sec. 26, T. 19 S., R. 33 W.					
Aug. 1936	62.6	Sept. 1940	69.40	....	.....
200. (Field No. 28). Victory Life Insurance Company. NW¼ NE¼ sec. 28, T. 19 S., R. 33 W.					
Sept. 1939	67.95	May 1942	68.32	Dec. 1943	75.41
Oct. 1940	72.54	Nov. 1942	70.25	June 1944	73.52
Feb. 1941	69.76	Mar. 1943	68.22	....	.....
201. (Field No. 113). Victory Life Insurance Company. NW¼ NW¼ sec. 28, T. 19 S., R. 33 W.					
Aug. 1933	60.0	Apr. 1937	56.7	Nov. 1942	72.42
Sept. 1934	58.13	Oct. 1940	75.21	Mar. 1943	70.31
Nov. 1934	58.20	Feb. 1941	72.05	Dec. 1943	77.38
June 1935	57.2	Dec. 1941	71.71	June 1944	71.62
Sept. 1935	57.7	May 1942	69.83	Jan. 1945	70.13
202. (Field No. 116). Victory Life Insurance Company. SW cor. NW¼ sec. 28, T. 19 S., R. 33 W.					
Feb. 1941	71.12	Nov. 1942	72.36	June 1944	73.63
Dec. 1941	71.36	Mar. 1943	70.44	Dec. 1945	74.54
May 1942	70.04	Dec. 1943	77.35	....	.....
203. (Field No. 108). Victory Life Insurance Company. SE¼ NW¼ sec. 28, T. 19 S., R. 33 W.					
Sept. 1940	77.56	May 1942	70.06	Dec. 1943	77.47
Oct. 1940	73.88	Nov. 1942	72.26	Apr. 1945	69.27
Feb. 1941	71.24	Mar. 1943	70.30	Dec. 1945	74.27
204. (Field No. 106). American Life Insurance Company. NE¼ NW¼ sec. 29, T. 19 S., R. 33 W.					
Sept. 1933	66.0	Sept. 1940	75.45	May 1942	73.17
Sept. 1934	64.0	Oct. 1940	77.56	Nov. 1942	76.09
Sept. 1935	64.1	Feb. 1941	74.83	Mar. 1943	74.38
Sept. 1936	62.6	Dec. 1941	74.65	Dec. 1943	80.64
Apr. 1937	62.6	....	.....	....	.....

205. (Field No. 109). C. W. Umpleby. SW¼ NW¼ sec. 29, T. 19 S., R. 33 W.

Nov. 1926	73.2	Sept. 1936	70.3	Mar. 1943	79.62
Aug. 1933	75.0	Apr. 1937	69.5	Dec. 1943	83.69
Sept. 1934	71.4	Feb. 1941	78.50	June 1944	82.32
Nov. 1934	70.9	Dec. 1941	79.33	Jan. 1945	82.02
June 1935	70.0	May 1942	78.41	Apr. 1945	81.34
Sept. 1935	71.5	Nov. 1942	80.93	Dec. 1945	83.78

207. (Field No. 6). American Life Insurance Company. NW¼ SW¼ sec. 29, T. 19 S., R. 33 W.

Sept. 1936	71.7	Sept. 1940	79.71	....	.....

208. (Field No. 7). American Life Insurance Company. NW¼ SW¼ sec. 29, T. 19 S., R. 33 W.

Mar. 1910	71.0	May 1934	70.89	Sept. 1935	70.9
Nov. 1926	75.2	Sept. 1934	72.1	Apr. 1937	69.7
Aug. 1933	75.0	June 1935	70.8	Sept. 1940	(a)79.70

(a) Had been pumping.

211. (Field No. 224). American Life Insurance Company. NW cor. SE¼ sec. 31, T. 19 S., R. 33 W.

Sept. 1936	70.8	Nov. 1940	74.62	....	.....

212. (Field No. 33). American Life Insurance Company. NE¼ SW¼ sec. 31, T. 19 S., R. 33 W.

Nov. 1926	74.0	Nov. 1934	71.3	Sept. 1936	71.2
Aug. 1933	74.0	June 1935	71.3	Apr. 1937	70.6
Sept. 1934	71.4	Sept. 1935	71.0	Sept. 1939	73.22

214. (Field No. 87). American Life Insurance Company. NW¼ NE¼ sec. 32, T. 19 S., R. 33 W.

Nov. 1926	67.9	June 1935	66.6	Apr. 1937	66.0
Sept. 1934	67.0	Sept. 1935	66.3	Sept. 1940	75.70
Nov. 1934	66.8	Sept. 1936	66.8	Feb. 1941	73.85

219. (Field No. 105). I. C. Kerr. NW¼ NE¼ sec. 36, T. 19 S., R. 33 W.

Sept. 1940	40.28	Nov. 1942	40.86	June 1944	40.97
Feb. 1941	39.7	Mar. 1943	40.78	Jan. 1945	41.51
Jan. 1942	40.69	Dec. 1943	41.77	Apr. 1945	41.50
Apr. 1942	40.10	Mar. 1944	41.72	Dec. 1945	42.33

TABLE 18. *Records of water levels in irrigation wells in Scott County, Kansas —Continued*

Date	Depth to water level, feet	Date	Depth to water level, feet	Date	Depth to water level, feet
220. (Feld No. 129). Nancy D. Curtis. SW¼ NW¼ sec. 36, T. 19 S., R. 33 W.					
Sept. 1940	43.73	Nov. 1942	43.16	Jan. 1945	43.76
Feb. 1941	42.1	Mar. 1943	43.17	Apr. 1945	43.79
Jan. 1942	42.98	Dec. 1943	43.71	Dec. 1945	44.29
Apr. 1942	42.93	June 1944	43.51	....	.....
235. (Field No. 16). Frank Roark, NE¼ NW¼ sec. 7, T. 20 S., R. 32 W.					
Nov. 1934	36.3	Jan. 1942	39.13	June 1944	38.37
Aug. 1940	41.35	Apr. 1942	37.98	Jan. 1945	41.62
Oct. 1940	38.43	Dec. 1942	37.96	Apr. 1945	38.21
Feb. 1941	37.96	Mar. 1943	37.93	Dec. 1945	42.22
241. (Field No. 10). Mrs. Rosine Smith. NW¼ NW¼ sec. 2, T. 20 S., R. 33 W.					
Sept. 1939	50.64	Jan. 1942	53.39	Apr. 1942	52.95
Feb. 1941	52.9	....	.....	....	.....
243. (Field No. 104). A. J. Collingwood. NW cor. SE¼ sec. 2, T. 20 S., R. 33 W.					
Feb. 1941	50.73	Dec. 1943	52.43	Jan. 1945	51.74
Apr. 1942	50.33	Mar. 1944	52.38	Apr. 1945	51.47
Mar. 1943	50.25	June 1944	52.55	....	.....
244. (Field No. 13). Mrs. Rosine Smith. SW¼ SW¼ sec. 2, T. 20 S., R. 33 W.					
Nov. 1934	50.1	Oct. 1940	54.77	Dec. 1941	54.66
Sept. 1939	51.56	Nov. 1940	55.93	Jan. 1942	54.17
Aug. 1940	56.87	Feb. 1941	53.57	Apr. 1942	53.78
Sept. 1940	57.49	May 1941	53.48	....	.....
247. (Field No. 92). Delmar C. Keysel. NW¼ SW¼ sec. 8, T. 20 S., R. 33 W.					
May 1934	58.52	Dec. 1942	63.13	June 1944	63.55
Sept. 1940	66.14	Mar. 1943	62.34	Jan. 1945	63.37
Feb. 1941	63.19	Dec. 1943	65.43	Apr. 1945	63.14
Dec. 1941	62.8	Mar. 1944	64.18	Dec. 1945	65.56
Apr. 1942	62.02	....	.....	....	.....

250. (Field No. 66). L. F. Roark. NW¼ SE¼ sec. 10, T. 20 S., R. 33 W.

Apr. 1937	48.8	Apr. 1942	50.64	June 1944	51.43
Aug. 1940	51.52	Dec. 1942	50.53	Jan. 1945	52.74
Sept. 1940	52.62	Mar. 1943	50.53	Apr. 1945	51.29
Feb. 1941	50.82	Dec. 1943	51.11	Dec. 1945	52.17
Dec. 1941	51.05	Mar. 1944	51.87	....	.....

251. (Field No. 15). L. F. Roark. NE¼ SW¼ sec. 10, T. 20 S., R. 33 W.

Sept. 1939	57.42	Apr. 1942	53.76	June 1944	54.79
Aug. 1940	54.27	Dec. 1942	53.80	Jan. 1945	56.05
Oct. 1940	55.70	Mar. 1943	53.51	Apr. 1945	54.76
Feb. 1941	53.92	Dec. 1943	55.62	Dec. 1945	55.70
Dec. 1941	54.12	Mar. 1944	55.19	....	.....

252. (Field No. 12). C. C. Hamlin. NE¼ NW¼ sec. 11, T. 20 S., R. 33 W.

Sept. 1939	45.61	Dec. 1943	50.51	Apr. 1945	47.76
Dec. 1942	47.34	Jan. 1945	48.14	Dec. 1945	48.18
Mar. 1943	46.96	....	.....	....	.....

253. (Field No. 14). Estate of C. C. Hamlin. NE¼ NW¼ sec. 11, T. 20 S., R. 33 W.

May 1934	45.51	Sept. 1939	44.94	....	.....

254. (Field No. 93). Estate of C. C. Hamlin. NW cor, SE¼ sec. 11, T. 20 S., R. 33 W.

Oct. 1916	37.6	Sept. 1940	46.57	July 1944	45.50
Nov. 1934	40.4	....	.....	....	.....

258. (Field No. 56). Harvey Dague. SE cor. NE¼ sec. 14, T. 20 S., R. 33 W.

Nov. 1934	30.5	Apr. 1942	32.37	June 1944	32.78
Aug. 1940	35.14	Nov. 1942	33.05	Jan. 1945	33.18
Oct. 1940	33.41	Mar. 1943	32.83	Apr. 1945	33.21
Feb. 1941	33.05	Dec. 1943	34.11	Dec. 1945	33.83
Dec. 1941	33.46	Mar. 1944	33.71	....	.....

261. (Field No. 90). L. F. Roark. NW¼ NW¼ sec. 16, T. 20 S., R. 33 W.

Nov. 1934	56.0	Apr. 1942	56.52	June 1944	57.77
Sept. 1940	63.41	Nov. 1942	57.41	Jan. 1945	57.32
Feb. 1941	57.25	Dec. 1943	59.4	Apr. 1945	57.08
Dec. 1941	56.78	Mar. 1944	58.47	Dec. 1945	59.57

TABLE 18. *Records of water levels in irrigation wells in Scott County, Kansas —Concluded*

Date	Depth to water level, feet	Date	Depth to water level, feet	Date	Depth to water level, feet
263. (Field No. 91). L. F. Roark. SW¼ SE¼ sec. 16, T. 20 S., R. 33 W.					
Nov. 1934	51.5	Sept. 1940	54.92	....	.....
264. (Field No. 88). R. L. Crist. NE¼ NW¼ sec. 17, T. 20 S., R. 33 W.					
Nov. 1934	57.2	Dec. 1941	59.81	Dec. 1943	62.27
Sept. 1940	62.82	Apr. 1942	58.99	Mar. 1944	61.13
Oct. 1940	61.35	Dec. 1942	60.17	Apr. 1945	59.65
Feb. 1941	60.28	Mar. 1943	59.22	Dec. 1945	62.14
271. (Field No. 43). Melchoir Lang. NW¼ SE¼ sec. 2, T. 20 S., R. 34 W.					
Sept. 1939	72.20	Dec. 1942	71.17	June 1944	71.48
Nov. 1940	71.5	Mar. 1943	70.61	Jan. 1945	71.54
Feb. 1941	70.61	Dec. 1943	71.49	Apr. 1945	71.63
Dec. 1941	70.83	Mar. 1944	71.62	Dec. 1945	71.72
Apr. 1942	70.49	....	.....	....	.....

RECORDS OF TYPICAL WELLS AND SPRINGS

Descriptions of the wells and springs visited in Scott County are given in Table 19. The wells and springs are listed in order by townships from north to south and by ranges from east to west. Within a township the wells are listed in the order of the sections. Depths of wells and water levels that were reported rather than measured are given only to the nearest foot. Depths of wells not classed as "reported" are given to the nearest 0.1 foot below the measuring point described in the table, and measured water levels are given to the nearest 0.01 foot. Records of a few wells in adjoining counties are included.

Table 19.—*Records of wells and springs in Scott County*

No. on Pl. 2	Location	Owner or tenant	Date completed	Type of well (1)	Depth of well (feet) (2)	Diameter of well (in.)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic subdivision	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Height above (+) or below (—) land surface (feet)	Measuring point: Height above sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Remarks—(yield given in gallons a minute; draw-down in feet)
	T. 15 S., R. 32 W. (6)																
1	NW NW sec. 34	R. B. Christy		Dr	126.5	5½	GI	Sand and gravel	Ogallala	N	N	Top of casing, south side	+1.0	2,998.6	123.75	11- 7-40	Unused domestic well
	T. 15 S., R. 34 W. (6)																
2	SW cor. NW sec. 32	Wood		Dr	25.5	5½	GI	do.	do.	N	N	Top of 5½-inch hole in concrete base, east side	+ .8	3,030.9	21.80	10-26-40	Unused stock well
	T. 16 S., R. 31 W.																
3	SW NW sec. 4	John Fick		Dr	27.2	6	GI	do.	Alluvium	Cy, W	D, S	Top of casing, north side	+ .5	2,720.2	19.56	10-14-40	See analysis
4	NW cor. sec. 16	Sol Scheuerman		Dr	130.1	5½	GI	do.	Ogallala	Cy, W	D, S	Top of casing, west side	+ .5	2,926.0	101.46	10-11-40	———
5	SW SW sec. 20	Mrs. Etta Jewell		Dr	135.4	6	GI	do.	do.	Cy, W	D, S	Top of 2x8 plank under pump	+1.0	2,945.8	125.44	10-11-40	———
6	SW SE sec. 25	John Zeller		Dr	121.1	5½	GI	do.	do.	Cy, W	D, S	Top of casing, west side	+1.2	2,897.2	115.30	11- 6-40	See analysis
7	NW NE sec. 35	R. B. Christy		Dr	15.6	5½	GI	do.	do.	N	N	Top of 6-inch hole in concrete platform	+ .4		13.56	11- 6-40	———
	T. 16 S., R. 32 W.																
8	SW NW sec. 2	Arthur Browning		Dr	126.9	5½	GI	do.	do.	Cy, W	D, S	Top of casing, south side	+ .4	2,974.5	121.49	10-30-40	See analysis
9	SW cor. sec. 14	R. B. Christy		Dr	144.9	5	GI	do.	do.	Cy, W	D, S	Top of casing, west side	+ .4	2,979.4	138.96	10- 5-40	Unused domestic well
10	SE SE sec. 17	A. E. Ryan		Dr	171.3	5½	GI	do.	do.	Cy, W	D, S	Top of casing, south side	+ .5	3,001.4	157.12	10-30-40	———
11	SE NE sec. 27	Lester Beebe		Dr	170.5	5½	GI	do.	do.	N	N	Top of casing, north side	+ .4	2,986.0	142.35	10- 5-40	Unused stock well
12	NE SW sec. 32	Estes Christy Estate		Dr	96.5	8	GI	do.	do.	Cy, W	S	Top of casing, east side	+ .8	2,954.4	80.18	3-11-40	See analysis
	T. 16 S., R. 33 W.																
13	SE SE sec. 4	Wm. Stevens		Dr	140.6	5½	GI	do.	do.	Cy, W	D, S	Top of casing, north side	.0	3,051.8	136.33	10-29-40	———
14	SW SE sec. 5	R. B. Christy		Dr	143.1	5½	GI	do.	do.	Cy, W	D, S	Top of casing, north side	+1.0	3,073.6	127.53	10-15-40	See analysis
15	SW SW sec. 6	Robt. Beasley		Dr	41.3	5½	GI	do.	do.	Cy, W	D, S	Top of casing, south side	+1.4		38.65	11- 8-40	———
16	NE SW sec. 12	Old Steele Home (in park)							do.		D	Top of casing, south side					
17	NE NW sec. 13	Big Spring in State Park							do.		PS						2 springs reported to yield total of about 50
18	SE cor. NW sec. 13	Barrel Springs in State Park							do.								Reported yield 400; see analysis ———

19	SW SW sec. 19	C. R. Ewert		Dr	136.1	5½	GI	Sand and gravel	Ogallala	Cy, W	D, S	Top of casing, east side	+1.0	3,098.4	121.84	10–29–40	———
20	NW NW sec. 21	F. Wendelburg		Dr	158.4	5½	GI	do	do	Cy, W	D, S	Top of casing, east side	+1.0	3,080.5	146.46	10–15–40	Unused domestic well
21	NE NW sec. 25	R. B. Christy		Dg	20.3	48	R	do	do	Cy, W	D, S	Top of wooden platform	+1.9	2,888.8	17.53	11– 4–40	———
22	NE NW sec. 26	Estate of Lee Taylor		Dr	130.3	5½	GI	do	do	Cy, W	D, S	Top of casing, south side	+1.2	3,011.5	122.36	10–29–40	Unused domestic well
	T. 16 S., R. 34 W.																
23	SE cor. NE sec. 8	W. M. Carpenter		Dr	130.1	5½	GI	do	do	N	D	Top of casing, west side	+1.7	3,151.4	122.48	10–26–40	Unused domestic well
24	SE NE sec. 11	Henry S. Mix		Dr	137.8	5½	GI	do	do	Cy, W	D, S	Top of 6-inch hole in concrete platform	+1.0	3,109.3	126.14	9–22–39	Unused domestic well; observation well
25	SE NE sec. 12	Mrs. Mattie Wright		Dr	139.1	5½	GI	do	do	Cy, W	S	Top of casing, east side	+ .5	3,095.7	125.77	10–19–40	Unused stock well
26	SW NW sec. 17	Pat Meyers	1941	Dr	150.0	18	WI	do	do	T, G	I	Top of casing, north side	+ .5	3,152.0 (7)	117.37	4–25–41	———
27	SE SE sec. 18	Mrs. Lily Miller		Dr	140.1	5½	GI	do	do	N	S	Top of casing, north side	+ .4	3,158.9	117.70	9–22–40	Unused stock well; observation well
28	NE cor. sec. 27	Iris Pendleton		Dr	128.8	5½	GI	do	do	Cy, W	D, S	Top of casing, east side	+ .3	3,121.8	116.90	10–28–40	———
29	NE cor. SE sec. 31	R. B. Christy		Dr	122.2	5½	GI	do	do	Cy, W	D, S	Top of casing, north side	+1.2	3,161.2	115.07	10–29–40	———
30	SE cor. SW sec. 33	Merton Rose		Dr	131.1	5½	GI	do	do	Cy, W	D, S	Top of casing, east side	+ .7	3,140.9	113.74	10–28–40	See analysis
	T. 16 S., R. 35 W. (8)																
31	SW SE sec. 1	E. M. Carson		Dg	80.8	48	N	do	do	Cy, W	S	Top of 2 x 12 plank under pump base	+1.6	3,132.8	78.69	10–26–40	———
32	NE cor. SE sec. 26	Margaret L. Kliesen		Dr	122.5	5½	GI	do	do	Cy, W	D, S	Top of bolt hole in pump base	+1.9	3,181.4	112.78	10–24–40	Unused domestic well
	T. 17 S., R. 31 W.																
33	NE SE sec. 1	F. A. Cook		Dr	121.7	5½	GI	do	do	Cy, W	D, S	Top of casing, west side	+1.0	2,897.5	107.16	10–12–40	Used occasionally
34	SW NW sec. 2	Michael McLaughlin		Dr	119.7	5½	GI	do	do	Cy, W	D, S	Top of 3 x 3 wooden pipe clamp, north side	+ .9	2,913.5	111.15	9–23–39	Unused domestic well; observation well
35	NE cor. SE sec. 5	J. C. Ogle		Dr	136.2	5½	GI	do	do	Cy, W	D, S	Top of casing, northeast side	+ .7	2,946.0	127.16	10–11–40	———
36	NE NW sec. 25	Wm. Rodenburg		Dr	108.2	5½	GI	do	do	Cy, W	D, S	Top of casing, north side	+ .5	2,909.7	88.82	10–10–40	Unused domestic well
37	SW NW sec. 25	Wm. Rodenburg	1941	Dr	170.0	16	GI	do	do	T, G	I	Hole in pump base, north side	+ .4		88.85	6–16–44	Well ended in Niobrara formation
38	SE NE sec. 29	R. B. Christy		Dr	120.0	5½	GI	do	do	Cy, W	D, S	Top of casing, north side	+ .5	2,946.3	92.42	10–10–40	———
39	SE SW sec. 30	A. B. Rose		Dr	110.0	4½	GI	do	do	Cy, H	D, S	Top of casing, east side	+ .3	2,965.6	100.21	10– 5–40	Unused domestic well
	T. 17 S., R. 32 W.																
40	NW NE sec. 5	Mrs. Estes Christy	1944	Dr	210.0	16	I	do	dn	T, T	I	Top of casing, north side	+ .5	2,985.0 (7)	107.40	6–16–44	———
41	NE NE sec. 8	R. B. Christy		Dr	98.7	5½	GI	do	do	Cy, W	D, S	Top of casing, north side	+1.0	2,970.2	82.49	10–11–40	Unused domestic well
42	NW NW sec. 12	Almada King		Dr	144.8	5½	GI	do	do	N	S	Top of casing, south side	.0	2,982.4	131.76	9–23–39	Unused stock well; observation well
43	SW cor. sec. 21	Jacob H. Eikelberger		Dr	98.5	5½	GI	do	do	Cy, W	D, S	Top of casing, east side	+ .5	2,986.2	82.62	10–30–40	See analysis
44	NE SE sec. 22	Ed Brookover		Dr	167.0	16	OW	do	do	N	I	Top of casing, east side	+ .2	2,982.7	99.06	9–12–40	Has only been test pumped
45	SW SW sec. 30	John Weishman	1944	Dr	140.0	16	I	do	do	T, E	I			2,983.0 (7)			———
46	SE SW sec. 35	L. A. Callen		Dr	93.1	4	N	do	do	N	N	Land surface	.0	2,971.3	88.05	10–30–40	Uncased irrigation test

TABLE 19.—Records of wells and springs in Scott County—*Continued*

No. on Pl. 2	Location	Owner or tenant	Date completed	Type of well (1)	Depth of well (feet) (2)	Diameter of well (in.)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic subdivision	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Height above (+) or below (—) land surface (feet)	Measuring point: Height above sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Remarks—(yield given in gallons a minute; drawdown in feet)
	T. 17 S., R. 33 W.																
47	SW cor. SE sec. 4	George Moritz	......	Dr	125.1	5½	GI	Sand and gravel	Ogallala	Cy, W	D, S	Top of 6-inch hole in concrete base	+2.0	3,070.5	119.01	10-23-40	See analysis
48	NE NW sec. 6	R. L. Mason	......	Dr	133.7	5½	GI	do	do	Cy, W	D, S	Top of 6-inch hole in concrete base, east side	+1.2	3,095.3	117.18	10-29-40	—
49	NE NE sec. 12	Harold Ellis	......	Dr	82.9	5½	GI	do	do	Cy, W	D, S	Top of 8-inch hole in concrete base	+2.2	2,977.1	80.32	11- 2-40	—
50	NE SE sec. 16	Jos. Hickey Estate	......	Dr	99.2	5½	GI	do	do	Cy, W	D	Top of square wooden platform	+1.9	3,039.0	97.78	9-22-39	Unused domestic well; observation well
51	NE SE sec. 24	Brandt	......	Dr	83.7	5½	GI	do	do	Cy, W	D, S	Bottom edge of pump base, southwest side	+1.3	2,987.6	72.33	9-22-39	Unused domestic well; observation well
52	SW SW sec. 25	Sam Filson	1941	Dr	124.0	16	GI	do	do	T, E	I	1-inch hole in base, northwest side	+1.6	2,994.0 (7)	72.33	6-16-44	—
53	SE cor. sec. 26	E. C. Rudolph	......	Dr	93.2	4	GI	do	do	Cy, W	D, S	Top of casing, east side	+1.2	3,015.6	86.89	10-23-40	—
54	NW cor. sec. 27	F. P. Geist	......	Dr	61.0	5½	GI	do	do	Cy, W	D, S	Top of casing, west side	+1.2	2,980.4	32.97	10-23-40	See analysis
55	SE SW sec. 28	Lloyd Stockwell	1944	Dr	190.0	16	I	do	do	T, G	I	Top of casing, south side	+1.0	3,035.0 (7)	88.27	6-16-44	Measurement taken before pump was installed
56	SW cor. NW sec. 31	Reinholt Hasz	......	Dr	141.2	......	N	do	do	N	I	Top of railroad tie across north end of hole	.0	3,083.9	103.49	10-19-40	Incomplete irrigation well
57	NE SW sec. 36	Fred Krause	1944	Dr	140.0	16	I	do	do	T, E	I	Edge of rectangular hole, in pumphead	+1.2	2,991.0 (7)	71.60	6-16-44	—
	T. 17 S., R. 34 W.																
58	SE NE sec. 21	John M. Nelson	......	Dr	32.0	5½	GI	do	do	Cy, W	D, S	Top of casing, west side	+1.0	3,045.0	23.31	11- 9-40	—
59	SE SW sec. 24	Mrs. Rose Shirk	......	Dr	124.9	5½	GI	do	do	Cy, W	D, S	Top of casing, north side	+ .5	3,100.4	108.35	10-19-40	Unused domestic well
60	SE NE sec. 28	Adolph Herinck	......	Dr	112.2	7	GI	do	do	Cy, W	S	Top of casing, north side	+1.2	3,125.2	102.06	10-19-40	—
61	SW cor. NW sec. 30	Mrs. E. B. Spangler	......	Dr	99.5	5½	GI	do	do	Cy, W	D, S	Top of casing, south side	+1.0	3,161.8	92.76	10-24-40	See analysis
	T. 17 S., R. 35 W. (8)																
62	SE SE sec. 12	Ava Hargrove	......	Dr	116.2	5½	GI	do	do	Cy, W	S	Top of casing, southeast side	+ .6	3,152.9	92.05	10-24-40	—
	T. 18 S., R. 30 W. (9)																
63	SW cor. sec. 31	Mrs. Mary Norman	......	Dr	91.3	5½	GI	do	do	Cy, W	S	Top of casing, west side	+1.0	2,911.6	77.21	10- 9-40	See analysis

	T. 18 S., R. 31 W.															
64	SE SE sec. 2	B. L. Strothman		Dr	93.7	5½	GI	Sand and gravel	Ogallala	Cy, H	D, S	Top of 2 x 8 plank under pump base	+0.5	2,915.2	81.36	11-16-40	Unused domestic well
65	NE SE sec. 4	Frank French		Dr	88.8	5½	GI	do	do	Cy, W	D, S	Top of casing, west side	+ .3	2,932.9	83.97	10-12-40	See analysis
66	NW SW sec. 6	Sadie Tysell		Dr	85.9	5½	GI	do	do	N	N	Top of casing, north side	.0	2,968.8	81.03	10- 5-40	Unused domestic well
67	NE SE sec. 12	A. E. Bradstreet		Dr	69.5	5½	GI	do	do	Cy, W	S	Top of casing, north side	.0	2,901.3	61.51	10-10-40	Unused stock well
68	NW NE sec. 20	R. B. Christy		Dr	93.2	5½	GI	do	do	Cy, W	S	Top of casing, north side	+ .5	2,951.3	83.02	10-12-40	———
69	NE NE sec. 26	Estate of Henry F. Poos		Dr	82.2	5½	GI	do	do	N	N	Top of casing, northeast side	+ .7	2,916.8	69.23	9-23-39	Unused stock well; observation well
70	SE SW sec. 31	R. B. Christy		Dr	120.9	5½	GI	do	Ogallala and/or Niobrara	Cy, W	S	Top of broken pump base	+1.5	2,983.0	101.46	10- 4-40	Unused stock well; see analysis
71	NE cor. sec. 32	S. Stucky		Dr	107.5	5½	GI	do	do	N	N	Top of casing, south side	+1.7	2,968.9	94.99	10- 4-40	Unused domestic well
	T. 18 S., R. 32 W.															
72	NE cor. sec. 6	Jesse C. Gowin		Dr	121.1	6	I	do	do	Cy, W	S	Top of casing, east side	+ .8	2,981.0	67.23	10-30-40	———
73	SW NE sec. 7	S. W. Filson	1940	Dr	97.6	18	GI	do	Pleistocene and/or Ogallala	T, E	I	Bottom edge of pump base, west side	+1.3	2,971.9	58.42	9-10-40	Reported yield 1,400
74	SW SE sec. 7	S. W. Filson	1937	Dr	100.0	18	GI	do	do	T, E	I	Bottom edge of oval break in base of pumphead	+2.0	2,972.1	59.03	9-10-40	Measured yield 1,050; drawdown 27.5 (10)
75	NW NE sec. 17	Ed Pitman		Dr	65.6	6	GI	do	do	Cy, W	S	Top of casing, southeast side	+ .5	2,970.0	59.33	9-10-40	———
76	NW NE sec. 17	Ed Pitman	1936	Dr	107.5	18	BS	do	do	T, NG	I			2,971.0			Measured yield 1,115; drawdown 23.3 (10)
77	SW SW sec. 17	J. E. Kirk	1939	Dr	81.0	18	GI	do	do	T, T	I	Top of egg-shaped hole in pump base	+ .5	2,962.0	49.58	10-31-40	Reported yield 1,000
78	NE NE sec. 18	S. W. Filson	1940	Dr	100.9	19	GI	do	do	T, E	I	Top of casing, south side	+1.9	2,970.4	59.22	10-11-40	Reported yield 1,400
79	NW SW sec. 18	Mo. Pacific Rly. Co		Dr	80.0	18	I	do	do	T, E	RR						Reported yield 150, drawdown 17
80	SW SE sec. 18	John Hasz		Dr	86.8			do	do	T, G	I	Bottom edge of square pump base, south side	+1.5	2,968.7	54.94	9-12-40	———
81	SW SE sec. 18	J. E. Kirk	1936	Dr		18	GI	do	do	T, NG	I						Reported yield 900
82	NW NW sec. 19	Inland Utilities Co		Dr	79.2	24	C	do	do	T, E	PS						Municipal well under elevated tank
83	NW SW sec. 19	Jess Bright	1922	Dr	75.0	18	WI	do	do	T, E	I	Top of ½-inch hole in pump base	+1.0	2,960.0	41.97	2-18-41	Also used to fill swimming pool
84	SW SW sec. 20	American Life Ins. Co	1910	Dr	109.0	24	BS	do	do	T, G	I	Top of 2-inch slot in square base plate	.0	2,956.0	39.21	9-28-39	Reported yield 1,200
85	SE NW sec. 21	J. E. Kirk	1940	Dr	125.9	19	GI	do	Ogallala	T, NG	I	Top of casing			64.08	2- 7-41	Has only been test pumped
86	SE cor. NE sec. 24	R. D. Armstrong		Dr	73.6	5½	GI	do	do	N	N	Top of casing, north side	.0	2,964.4	69.49	10- 4-40	Unused stock well
87	NW NW sec. 27	Fred Strickert		Dr	68.9	5½	GI	do	do	Cy, W	D, S	Top of pump base, south side	+ .5	2,970.2	62.17	10- 5-40	See analysis

TABLE 19.—Records of wells and springs in Scott County—*Continued*

No. on Pl. 2	LOCATION	Owner or tenant	Date completed	Type of well (1)	Depth of well (feet) (2)	Diameter of well (in.)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic subdivision	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Height above (+) or below (—) land surface (feet)	Measuring point: Height above sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Remarks— (yield given in gallons a minute; drawdown in feet)
	T. 18 S., R. 32 W.																
88	NE NW sec. 29	V. M. Harris	1941	Dr	115.0	16	GI	Sand and gravel	Pleistocene and/or Ogallala	T, E	I	Top of hole in pump base	+ .4	2,953.0	35.72	2-14-41	Reported yield 725
89	NW cor. sec. 29	V. M. Harris	1943	Dr	122.8	16	I	do	do	T, E	I	Edge of rectangular hole in pumphead	+1.0	2,954.0 (7)	38.56	6-14-44	———
90	SE NW sec. 29	V. M. Harris	......	Dr	60.6	8	GI	do	Ogallala	N	N	Top of casing, north side	+1.5	2,949.5	32.50	9-28-39	Observation well
91	SE NW sec. 29	V. M. Harris	1940	Dr	70.0	18	GI	do	do	T, E	I	Top of casing, south side	+1.0	2,948.9	33.85	9- 3-40	Measured yield 668, drawdown 16
92	NE cor. NW sec. 30	Elvin Deng	1940	Dr	110.0	18	OW	do	do	T, E	I	....	....	....	....	....	Measured yield 1,210 drawdown 19 (10)
93	SW cor. NW sec. 30	Elvin Deng	......	Dr	65.7	6	GI	do	do	Cy, W	D, S	Top of casing, west side	+2.5	....	35.19	9-11-39	Pump and windmill installed in 1940; observation well
94	SW NW sec. 30	Elvin Deng	......	Dr	50.5	6	GI	do	do	N	S	Top of casing, north side	+ .1	....	31.25	9-11-39	Unused stock well
95	SE NE sec. 30	R. B. Christy	1940	Dr	123.0	18	GI	do	do	T, E	I	Top of ¾-inch hole in pump base	+1.0	2,947.9	34.37	9- 3-40	Reported yield 1,500, drawdown 22
96	NW SW sec. 30	Elvin Deng	1930	Dr	69.5	24	C	do	do	T, E	I	Top of casing, south side	+1.5	2,940.5	29.83	9-11-39	Reported yield 950
97	SW SW sec. 30	Elvin Deng	1930	Dr	78.1	24	C	do	do	T, E	I	Top of casing, southwest side	+ .7	2,941.2	20.41	9- 9-39	Measured yield 905; drawdown 23 (10)
98	SW SE sec. 31	Dick Armantrout	......	Dr	23.9	5	GI	do	do	Cy, W	S	Top of 2 x 4 pipe clamp, north side	+ .8	2,934.6	15.88	10- 7-40	———
99	SW SW sec. 34	Frank Brooks	......	Dr	53.5	5½	GI	do	do	Cy, W	S	Top of casing, west side	— .3	2,959.4	45.30	10- 7-40	Unused stock well
	T. 18 S., R. 33 W.																
100	NW cor. NE sec. 1	Wm. Mellson	1942	Dr	222.0	16	I	do	do	T, E	I	Edge of rectangular hole in pumphead	+1.0	2,985.0 (7)	65.48	6-16-44	———
101	SE NE sec. 4	J. Witt	......	Dr	95.2	5½	GI	do	do	N	S	Top of casing, south side	+ .6	3,010.1	72.49	10-24-40	Unused stock well
102	NE NW sec. 4	Geo. Mulch	1941	Dr	127.0	16	WI	do	do	T, G	I	Top of casing, south side	+ .3	3,017.0 (7)	72.10	5- 9-41	———
103	SW cor. sec. 5	Norman Buehler	1944	Dr	119.5	16	I	do	do	T, G	I	1-inch hole in pumpbase, south side	+ .3	3,042.0 (7)	75.45	6-16-44	———
104	SE cor. sec. 6	E. E. Dickhut	......	Dr	89.9	5½	GI	do	do	Cy, W	S	Top of 5½-inch hole in concrete base	+ .5	3,043.5	76.66	10-24-40	Unused stock well

105	SE SE sec. 11	Henry Parkinson	1942	Dr	180.0	16	I	Sand and gravel	Pleistocene and/or Ogallala	T, E	I			2,970.0 (7)			Well ended in Niobrara formation
106	NE cor. NW sec. 12	Frank Roark		Dr		12½	GI	do.	do.	T, E	I						
107	SE cor. NE sec. 12	Foquet	1931	Dr	83.0	12	OW	do.	do.	T, E	I	Top of ½-inch hole in pump base	+1.0	2,964.3	48.09	9-11-39	Reported yield 375, drawdown 24; see analysis; observation well
108	SE SW sec. 12	S. M. Lehman		Dr	64.4	5	GI	do.	do.	N	S	Top of casing, west side	+ .5	2,969.5	41.14	9-11-39	Unused stock well
109	NW NE sec. 13	S. W. Filson	1938	Dr	93.3	18	GI	do.	do.	T, E	I	Bottom edge of oval break in base of pumphead	+1.8	2,972.8	55.54	9-12-40	Measured yield 1,335, drawdown 14.4(10)
110	NW SE sec. 13	J. E. Kirk	1937	Dr	91.5	18	GI	do.	do.	T, NG	I	Top of square concrete block, southwest side		2,968.0	51.72	2- 7-41	Reported yield 1,100, drawdown 11.5
111	NE SE sec. 13	Inland Utilities Co.	1943	Dr	225.0	18	I	do.	do.	T, E	PS			2,972.0 (7)			Well ended in Niobrara formation
112	NE SE sec. 13	Inland Utilities Co.	1926	Dr	81.0	16	GI	do.	do.	T, E	PS	Top of casing, in concrete pit, east side	−5.7		53.76	11-22-40	Municipal well in power plant; see analysis
113	NE cor. SE sec. 13	Dr. G. A. Greene	1931	Dr	69.6	18	GI	do.	do.	T, E	I	Top of casing, south side	+1.0	2,959.0	41.36	9-29-39	Reported yield 900
114	NW NE sec. 14	V. M. Harris	1944	Dr	160.0	16	I	do.	do.	T, E	I	Edge of rectangular hole in pumphead	+1.2	2,972.0 (7)	55.30	6-16-44	Well ended in Niobrara formation
115	SE NW sec. 14	Henry Parkinson	1944	Dr	127.0	16	I	do.	do.	T, E	I	Top of casing, north side	+ .5	2,970.0 (7)	53.72	6-16-44	Test pump still on well
116	NE SE sec. 14	Fred W. Krause	1938	Dr	71.0	18	GI	do.	do.	T, G	I	Top of 1¼-inch threaded hole in side of pumphead	+1.5	2,965.9	42.28	9-10-40	Reported yield 800, drawdown 18
117	SE SE sec. 14	Harry Sharpe	1939	Dr	72.0	16	GI	do.	do.	T, G	I						Reported yield 875, drawdown 24
118	NE NW sec. 15	Anson Mark		Dr	90.2	5½	GI	do.	Ogallala	N	S	Top of casing, west side	+ .5	2,992.7	58.39	9-18-39	Unused stock well; observation well
119	SW cor. sec. 15	Clarence Luke	1944	Dr	91.0	16	I	do.	Pleistocene and/or Ogallala	T, E	I	Edge of rectangular hole in pumphead	+1.6	2,970.0 (7)	32.67	6-15-44	
120	NE NW sec. 19	Joe Knipp	1944	Dr	127.5	16	I	do.	Ogallala	T, E	I	½-inch oval opening in pumphead, south side	+1.3	3,057.0 (7)	79.89	6-15-44	Reported yield 800
121	SW SW sec. 20	Claude Hughes	1933	Dr	117.0	24	GI	do.	do.	T, NG	I	Top of ¾-inch hole in base of pumphead	+2.0	3,035.8	70.73	9- 6-39	Measured yield 1,700 (10)
122	SW SE sec. 20	Claude Hughes		Dr		16	I	do.	do.	T, NG	I	¾-inch hole in pump base, southeast side	+ .4	3,022.0 (7)	71.69	6-16-44	
123	SW SW sec. 21	Claude Hughes	1931	Dr	138.2	18	BS	do.	do.	T, NG	I	Top of ¾-inch hole in base of pumphead	+1.0		71.28	9- 6-39	Measured yield 1,380; drawdown 26.5, (10); see analysis, observation well
124	SW NE sec. 22	G. H. Cheney		Dr	123.5	24	BS	do.	Pleistocene and/or Ogallala	T, E	I	Bottom edge of rectangular opening in side of pumphead	+2.0	2,961.1	28.12	9-11-39	
125	SW NW sec. 23	Earl Brookover	1935	Dr	128.0	20	BS	do.	do.	T, NG	I	Top of ¾-inch hole in base of pump, north side	+ .2	2,959.3	30.56	2- 7-41	Measured yield 1,055; drawdown 50 (10)
126	SE NE sec. 23	C. L. Harpham	1930	Dr	104.0	18	GI	do.	do.	T, E	I	Top of 2-inch hole in base of pumphead	+2.0	2,961.0	38.32	9-10-40	

TABLE 19.—Records of wells and springs in Scott County—*Continued*

No. on Pl. 2	Location	Owner or tenant	Date completed	Type of well (1)	Depth of well (feet) (2)	Diameter of well (in.)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic subdivision	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Height above (+) or below (—) land surface (feet)	Measuring point: Height above sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Remarks—(yield given in gallons a minute; drawdown in feet)
	T. 18 S., R. 33 W. (Continued)																
127	NW SW sec. 33	Earl Brookover	......	Dr	....	16	I	Sand and gravel	Pleistocene and/or Ogallala	T, NG	I	....	....	2,966.0 (7)	....	....	Measurement not obtainable
128	SE cor. sec. 24	....	......	Dr	59.5	5½	GI	do.	do.	Cy, H	D, S	Top edge of break in pump base	+ .8	2,961.3	43.99	9-11-39	Unused domestic well; observation well
129	NE cor. NW sec. 25	Geo. Weishaar	1929	Dr	92.0	24	CR	do.	do.	T, E	I	Top of oblong slot in base plate	+ .5	2,962.4	46.36	9- 3-40	Measured yield 1,150 (10)
130	NE SE sec. 25	E. E. Coffin	......	Dr	44.0	18	GI	do.	do.	N	Obs	Top of casing, south side	+ .2	2,951.9	31.65	4-18-34	Equipped with recorder since April 18, 1934
131	NE SE sec. 26	Div. of Water Resources	1944	Dr	60.0	8	GI	do.	Pleistocene	N	Obs	Top of casing, west side	....	2,950.0 (7)	32.08	6-14-44	To be equipped with recorder
132	NW cor. NE sec. 29	J. M. Royer	1940	Dr	128.4	18	GI	do.	Ogallala	N	I	Top of 2-inch hole in barrel over casing	+ .5	3,023.6	66.67	9-12-40	Pump has not been installed
133	NW NW sec. 29	Ralph Taylor	......	Dr	....	16	GI	do.	do.	T, NG	I	....	....	3,040.0 (7)	....	....	Measurement not obtainable
134	NW SE sec. 34	Austin Been	1941	Dr	110.0	16	I	do.	do.	T, NG	I	....	....	2,950.0 (7)	....	....	Measurement not obtainable
135	NE NE sec. 35	Walter Proudfoot	1940	Dr	80.0	16	GI	do.	Pleistocene and/or Ogallala	T, E	I	Bottom edge of rectangular opening in side of pumphead	+1.5	2,940.5	18.20	2-14-41	Reported yield 850
136	NW SW sec. 35	C. T. Hutchins	1940	Dr	135.0	16	GI	do.	do.	T	I	Top of casing, south side	....	2,943.0	17.20	2-17-41	———
137	SE SE sec. 35	....	1912	Dr	112.0	18	BS	do.	do.	T, E	I	Top of 2-inch oblong hole in base of pumphead	+ .5	2,939.4	22.09	9- 4-40	Reported yield 500
138	NW NE sec. 36	M. K. Armantrout	1940	Dr	81.0	18	GI	do.	do.	T, E	I	Top of casing, south side	+1.0	2,938.0	20.45	9-16-40	Reported yield 1,350
139	NE NW sec. 36	M. K. Armantrout	1938	Dr	72.8	18	GI	do.	do.	T, E	I	Bottom edge of oval opening in side of pumphead	+1.5	2,938.5	21.17	8-31-40	Measured yield 725, drawdown 36.2 (10)
140	SE SW sec. 36	S. H. Hull	1940	Dr	74.0	18	GI	do.	do.	T, E	I	Bottom edge of rectangular opening in side of pumphead	+1.4	2,940.4	23.06	9- 4-40	Reported yield 900
	T. 18 S., R. 34 W.																
141	NW SW sec. 1	H. F. Mindrup	1944	Dr	160.7	19	I	do.	Ogallala	N	I	Top of casing, east side	+ .5	3,092.0 (7)	96.49	6-16-44	Pump to be installed soon

142	SE cor. sec. 2	R. B. Christy	......	Dr	100.2	5½	GI	Sand and gravel	Ogallala	Cy, W	D, S	Top of casing, north side	+1.2	3,092.9	93.19	10-24-40	See analysis
143	SW NW sec. 4	E. C. Douglass	......	Dr	112.0	5½	GI		do	Cy, W	D, S	Top of casing, north side	+ .5	3,137.9	94.70	10-19-40	———
144	SE SW sec. 16	......	......	Dr	97.9	8	GI	do	do	N	S	Top of 8-inch hole in concrete platform	+ .0	3,136.5	92.23	9-30-39	Unused stock well
145	SW SW sec. 19	H. M. A. Hess, et al	......	Dr	102.1	5½	GI	do	do	N	D, S	Top of casing, north side	+ .1	3,158.1	83.90	9-22-39	Observation well; unused stock well
146	NE SE sec. 21	M. E. Boulware	......	Dr	95.8	5½	GI	do	do	N	S	Top of 1¼-inch hole in floor flange	+ .4	3,122.5	84.17	9-12-40	Unused stock well
147	SW SW sec. 24	Claude Hughes	1938	Dr	144.0	18	GI	do	do	T, NG	I	Top of ½-inch hole in pump base	+ .5	3,098.6	95.63	2-14-41	Reported yield 670, drawdown 37
148	NW NW sec. 25	Claude Hughes	1938	Dr	141.5	18	BS	do	do	T, NG	I	Top of ½-inch hole in pump base	+1.3	3,092.0	91.94	9-12-40	Measured yield 452 (10)
149	SE cor. NW sec. 31	W. N. Robinson	1917	Dr	134.3	24	BS	do	do	T, E	I	Top of ½-inch hole in pump base	+1.7	3,165.7	91.48	9- 6-39	See analysis; observation well
150	NW NW sec. 34	Lewis Keyse	1944	Dr	160.0	16	I	do	do	T, G	I	Bottom edge of rectangular opening in side of pump ead	+ .9	3,131.0 (7)	88.84	6-15-44	Well ended in Niobrara formation
	T. 18 S., R. 35 W. (8)																
151	SE NE sec. 1	M. E. Bouleware	......	Dr	96.4	5½	GI	do	do	Cy, W	D, S	Top of casing, west side	+ .4	3,161.2	87.46	10-25-40	———
	T. 19 S., R. 31 W.																
152	NW cor. NE sec. 3	J. Kaufman	......	Dr	96.6	5½	GI	do	do	Cy, WH	D	Top of 2 x 8 plank under pump	+ .7	2,941.0	71.87	10- 9-40	Used only occasionally
153	SE SW sec. 4	J. A. Hollister	......	Dr	114.9	5½	GI	do	do	Cy, W	D, S	Top of casing, south side	+1.0	2,977.4	100.88	10- 4-40	Unused domestic well
154	NE NW sec. 17	James E. Ely	......	Dr	98.1	5½	GI	do	Niobrara	Cy, W	S	Top edge of round pump base	+ .3	2,971.6	88.21	10- 4-40	Unused stock well
155	NE NW sec. 32	James F. Storm	......	Dr	125.2	4½	GI	do	do	Cy, W	D, S	Top of 2 x 10 plank (2 feet long)	+1.6	2,981.8	86.39	10- 9-40	Unused domestic well
156	SW NE sec. 35	J. O. Rejsek	......	Dg	74.9	48	N	do	do	N	N	Top of 2-foot square opening, south side	+ .5	2,952.9	70.58	10- 9-40	Abandoned dug well. Fragments of Niobrara chalk on spoil pile
	T. 19 S., R. 32 W.																
157	NW cor. sec. 7	J. U. Hushaw	......	Dr	33.1	6	GI	do	Pleistocene	Cy, W	S	Top of casing, west side	+ .4	2,936.9	17.73	5-20-40	Observation well
158	SW SW sec. 7	M. E. Halley	......	Dr	30.4	4½	GI	do	do	Cy, G	S	Top of casing, west side	+ .8	2,936.0	21.53	9-27-39	Originally an observation well
159	NW NE sec. 11	Eliz. Strickert	......	Dg	85.9	48	R	do	Ogallala and/or Niobrara	N	S	Top of 6-inch hole in round concrete base	+ .3	2,971.1	65.22	9-17-40	Unused stock well
160	NW NW sec. 13	J. G. Edwards	......	Dr	94.5	5½	GI	do	Niobrara	N	S	Top of casing, north side	+ .3	2,973.3	68.19	10- 4-40	Unused stock well
161	NE NE sec. 17	F. W. and H. M. Starr	......	Dr	40.7	5½	GI	do	Pleistocene	Cy, W	S	Top of casing, south side	+ .5	2,949.7	33.42	10- 7-40	———
162	SE cor. SE sec. 28	F. M. Houstin	......	Dr	129.1	5½	GI	do	Niobrara	Cy, W	D, S	Top of casing, south side	+ .7	3,010.4	98.44	9-29-39	Unused domestic well; observation well
163	NE NW sec. 30	H. E. Trout	1914	Dr	81.0	24	BS	do	Pleistocene	T, NG	I	Bottom edge of rectangular opening in side of pumphead	+ .8	2,948.1	36.41	10-25-40	Reported yield 950, observation well
164	SW SW sec. 31	Leroy E. McKean	1942	Dr	79.2	16	I	do	Pleistocene and/or Ogallala	T, T	I	⅝-inch opening in pump-base, west side	+1.0	2,940.0 (7)	29.65	6-14-44	Replaces old well 165

TABLE 19.—Records of wells and springs in Scott County—*Continued*

No. on Pl. 2	Location	Owner or tenant	Date completed	Type of well (1)	Depth of well (feet) (2)	Diameter of well (in.)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic subdivision	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Height above (+) or below (—) land surface (feet)	Measuring point: Height above sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Remarks—(yield given in gallons a minute; drawdown in feet)
	T. 19 S., R. 32 W. (Continued)																
165	SW SW sec. 31	Leroy E. McKean	1916	Dr	56.0	72	C	Sand and gravel	Pleistocene and/or Ogallala	T, E	I	Top of wooden 2 x 24 inch plank, 48 inches long	+ .5	2,938.4	29.50	9- 9-39	Not used in 1940
166	NE NE sec. 35	H. E. Thiele	......	Dr	126.6	5½	GI	do	Niobrara	Cy, W	D, S	Top of 1x12 under pump base	+1.0	3,016.9	103.85	10-22-40	See analysis
	T. 19 S., R. 33 W.																
167	NW NE sec. 1	Roland Beach	1941	Dr	133.9	16	GI	do	Pleistocene and/or Ogallala	T, E	I	Bottom edge of rectangular opening in side of pumphead	+1.0	2,942.0 (7)	26.81	6-14-44	Well ended in Niobrara formation
168	SW NW sec. 1	Pete Hutchins	1943	Dr	158.0	16	I	do	do	T, E	I	Bottom edge of oval opening in side of pumphead	+1.0	2,948.0 (7)	31.04	6-14-44	Reported yield 1,500 when tested with two tractors
169	NE cor. NW sec. 7	A. Uppendahl	......	Dr	77.9	5½	GI	do	Ogallala	N	D, S	Top of casing, north side	+ .8	3,009.9	52.35	10-17-40	Unused domestic well
170	SW SE sec. 11	A. J. Collingwood	1940	Dr	110.0	18	CI	do	Pleistocene and/or Ogallala	T,E	I	......	......	......	......	......	Reported yield 1,100
171	NE NW sec. 12	J. E. Hushaw	1939	Dr	82.0	16	GI	do	Pleistocene	T, G	I	Bottom edge of oval opening in side of pumphead	+1.0	2,943.9	25.67	2-17-41	Reported yield 850
172	SW SW sec. 12	Geo. L. Duff	1940	Dr	......	19	GI	do	Pleistocene and/or Ogallala	T, E	I	Top of concrete platform	+2.0	......	26.94	2-17-41	Measured yield 567, drawdown 34.8
173	SW SW sec. 12	Geo. L. Duff	1935	Dr	83.8	18	GI	do	do	T, E	I	Top of 20-inch hole in concrete floor	+1.0	2,941.5	29.18	8-31-40	———
174	SE SE sec. 12	Geo. L. Duff	1937	Dr	76.0	16	GI	do	do	T, E	I	Bottom edge of rectangular opening in side of pumphead	+1.4	2,940.8	26.19	9-10-40	Reported yield 550; see analysis
175	SW SW sec. 13	Mrs. Maude Collingwood	......	Dr	70.7	24	BS	do	do	Cy, W	S	Top of 24-inch hole in square steel base plate	+1.2	2,953.2	45.55	9- 6-40	———
176	SW SW sec. 13	Mrs. Maude Collingwood	1940	Dr	......	18	GI	do	do	T, E	I	......	......	......	......	......	———
177	SW SE sec. 13	Fred Mahler	1939	Dr	71.0	19	GI	do	Pleistocene	T, E	I	......	......	......	......	......	West well, measured yield 340-475 (10)

178	SW SE sec. 13	Fred Mahler	1939	Dr	73.0	19	GI	Sand and gravel	Pleistocene	T, E	I	....	....	....	....	....	East well; measured yield 310–460
179	NW SE sec. 15	Otto Geeseka	1931	Dr	132.0	18	CI	do	Ogallala	T, E	I	Top of ½-inch hole in steel base, southwest side	+1.0	2,965.0	57.40	9–10–40	Measured yield 1,296 (10)
180	SE SW sec. 15	Estate of Lee Collingwood	1937	Dr	137.0	18	CI	do	do	T, E	I	Top of casing, west side	+2.0	2,970.0	62.25	9–10–40	Reported yield 1,600
181	SW SW sec. 19	Richard Deng	1944	Dr	120.0	16	I	do	do	T, NG	I	Bottom edge of rectangular hole in side of pumphead	+1.5	3,002.0 (7)	80.56	6–15–44	Reported yield 750; drawdown 14
182	SW NE sec. 20	J. A. Sweeney	1929	Dr	105.0	18	CI	do	do	T, E	I	Top of 1½-inch hole in pump base	+ .3	2,978.5	73.20	2–15–41	Reported yield 1,400
183	SW SW sec. 20	J. A. Sweeney	1942	Dr	138.0	16	I	do	do	T, E	I	Bottom edge of rectangular hole in side of pumphead	+2.4	2,992.0 (7)	82.03	6–15–44	Reported yield 800
184	SW SE sec. 20	Victory Life Ins. Co	1928	Dr	106.0	24	BS	do	do	T, NG	I	....	....	....	....	....	Plant No. 6
185	SW cor. SE sec. 20	Victory Life Ins. Co	1918	Dr	106.0	24	BS	do	do	T, NG	I	Bottom edge of rectangular opening in pumphead	+ .5	2,986.6	78.55	2–15–41	Plant No. 1; measured yield 845; drawdown 20.5 (10)
186	NW NE sec. 21	Victory Life Ins. Co	1938	Dr	107.4	16	GI	do	do	T, NG	I	Bottom edge of square opening in pumphead, east side	+ .8	2,966.8	62.68	9–18–39	Plant No. 5; reported yield 800
187	NW NE sec. 21	Victory Life Ins. Co	1912	Dr	92.0	24	BS	do	do	N	I	Top of casing, north side	+ .3	2,966.5	61.53	9–18–39	Abandoned; original depth, 102.5 feet
188	SW cor. NW sec. 21	Victory Life Ins. Co	......	Dr	94.0	16	OW	do	do	T, NG	I	Top of concrete platform under base of pumphead	.0	2,975.2	72.93	10–31–40	Plant No. 9; reported yield 600–650
189	NE SW sec. 21	Victory Life Ins. Co	1938	Dr	115.7	18	GI	do	do	T, NG	I	Top of 1-inch hole in base of pumphead	+ .7	2,973.7	69.67	9–18–39	Plant No. 4; measured yield 1,300; drawdown 24.5 (10)
190	SW NW sec. 22	Estate of Lee Collingwood	1937	Dr	132.0	18	CI	do	do	T, E	I	Bottom edge of rectangular opening in side of pumphead	+2.0	2,969.2	63.26	2–15–41	Reported yield 2,300
191	NW SE sec. 22	Estate of Lee Collingwood	1937	Dr	90.0	18	CI	do	do	T, E	I	....	....	....	....	....	Reported yield 900
192	SE SW sec. 23	A. J. Collingwood	......	Dr	55.3	24	BS	do	do	N	I	Top of square concrete curb, north side	+1.1	2,965.0	51.69	9–11–40	Abandoned
193	NW NE sec. 24	R. H. Teeter	1934	Dr	80.8	18	GI	do	do	T, E	I	Top of ½-inch hole in base of pump	+1.5	2,950.5	49.09	9– 7–40	Reported yield 800
194	SW NW sec. 24	Mrs. Maude Collingwood	1940	Dr	116.2	18	GI	do	do	T, E	I	Top of casing, south side	+ .3	2,955.5	46.22	10–31–40	———
195	SW cor. NW sec. 25	Mrs. Rosine Smith	1914	Dr	116.5	24	BS	do	Pleistocene and/or Ogallala	T, G	I	Top edge of square steel base plate	+1.5	2,957.0	43.13	9– 8–39	Seldom used; observation well
196	NW SE sec. 25	E. J. Roark	......	Dr	44.7	14	GI	do	Pleistocene	N	I	Top of casing, west side	.0	2,950.2	37.79	9–19–39	Equipped with recorder
197	SW SE sec. 25	Marvin Bastin	1940	Dr	106.7	19	GI	do	do	T, E	I	Top of 2-inch hole in round base	+1.0	2,953.1	42.64	11–15–40	———
198	SW cor. NW sec. 26	Mrs. Rosine Smith	......	Dr	115.1	24	BS	do	Pleistocene and/or Ogallala	T, T	I	Top of square steel pump base, north side	+1.8	2,966.3	53.02	9–27–39	Used occasionally. Reported yield 500–600; observation well
199	NE SW sec. 26	Mrs. Rosine Smith	1916	Dr	115.9	24	BS	do	do	T, N	I	Bottom edge of square steel base	+2.0	2,980.0	69.40	9–11–40	Abandoned

TABLE 19.—Records of wells and springs in Scott County—*Continued*

No. on Pl. 2	LOCATION	Owner or tenant	Date completed	Type of well (1)	Depth of well (feet) (2)	Diameter of well (in.)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic subdivision	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Height above (+) or below (—) land surface (feet)	Measuring point: Height above sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Remarks—(yield given in gallons a minute; drawdown in feet)
	T. 19 S., R. 33 W. (Continued)																
200	NW NE sec. 28	Victory Life Ins. Co.	1938	Dr	145.0	18	BS	Sand and gravel	Ogallala	T, NG	I	Top of 2-inch rectangular hole in pump base	+ .5	2,977.0	67.95	9–18 39	Plant No. 3; measured yield 1,850; drawdown 21.2 (10)
201	NW NW sec. 28	Victory Life Ins. Co.	1938	Dr	92.3	24	BS	do.	do.	T, NG	I	Top of square 1-inch hole in round base	+ .8	2,977.9	75.21	10–31–40	Plant No. 2; measured yield 690; drawdown 25 (10)
202	SW cor. NW sec. 28	Victory Life Ins. Co.	1940	Dr	127.0	16	BS	do.	do.	T, NG	I	Top of small rectangular hole in concrete floor	+ .3	2,980.7	71.12	2–15–41	Plant No. 8; reported yield 800
203	SE NW sec. 28	Victory Life Ins. Co.	1940	Dr	135.0	16	GI	do.	do.	T, NG	I	Top of ½-inch hole near airline opening	+1.0	2,979.7	77.56	9–11–40	Plant No. 7; reported yield 1,550, drawdown 18 (10)
204	NE NW sec. 29	American Life Ins. Co.	1930	Dr	112.0	26	BS	do.	do.	T, N	I	Top of 1½-inch hole in round pump base, north side	+1.0	2,985.0	75.45	9–11–40	Not used in 1940; casing collapsed
205	SW NW sec. 29	C. W. Umpleby	1914	Dr	105.7	24	BS	do.	do.	T, NG	I	Top of oblong hole in pump base	.0	2,991.4	78.50	2–15–41	Measured yield 1,030; drawdown 13 (10)
206	SW cor. NE sec. 29	American Life Ins. Co.	1942	Dr	127.0	16	GI	do.	do.	T, G	I	¾-inch hole in side of pumphead	+ .7	2,989.0 (7)	81.88	6–15–44	Well ended in Niobrara formation
207	NW SW sec. 29	American Life Ins. Co.	1910	Dr	110.7	24	BS	do.	do.	T, NG	I	Top of 6-inch slot in pump base	+1.2	2,994.8	79.71	9– 6–40	Reported yield 1,150; observation well
208	NW SW sec. 29	American Life Ins. Co.	1910	Dr	86.2	24	BS	do.	do.	N	I	Top of casing, north side	+ .5	....	79.90	9– 8–39	Abandoned; measured depth, 86.2 feet
209	NW SE sec. 29	Arthur Miller	1942	Dr	127.0	16	GI	do.	do.	T, NG	I	....	....	2,985.0 (7)	....	....	Measurement not obtainable; well ended in Niobrara formation
210	NE SE sec. 30	H. L. Fairleigh	1941	Dr	....	16	WI	do.	do.	T, NG	I	Bottom edge of rectangular hole in side of pumphead	+1.0	2,991.0 (7)	83.95	6–15–44	
211	NW cor. SE sec. 31	American Life Ins. Co.	......	Dr	104.2	24	BS	do.	do.	T	I	Top of casing, south side	+1.0	2,997.6	74.62	11–13–40	Not used in 1940
212	NE SW sec. 31	American Life Ins. Co.	......	Dr	78.2	24	BS	do.	do.	N	I	Top of casing, west side	+ .5	2,999.5	73.22	9–21–39	Equipped with recorder

213	NE SE sec. 31	American Life Ins. Co.	1942	Dr	132.0	16	I	Sand and gravel	Ogallala	T, NG	I	Bottom edge of rectangular hole in side of pump head	+1.3	2,989.0 (7)	74.95	6-15-44	Well ended in Niobrara formation
214	NW NE sec. 32	American Life Ins. Co.	1916	Dr	119.9	24	BS	do.	do.	T, NG	I	Top of 6-inch oblong slot in pump base	+ .5	2,988.6	75.70	9-14-40	Reported yield 1,500
215	SW NW sec. 33	Estate of Lee Collingwood	1940	Dr	135.0	18	CI	do.	do.	T, E	I	....	....	....	....	....	Measured yield 1,208 (10)
216	SW SW sec. 33	Estate of Lee Collingwood	1940	Dr	137.5	18	CI	do.	do.	T, E	I	....	....	....	....	....	Reported yield 1,500
217	NW NW sec. 35	Mrs. Rosine Smith	......	Dr	72.7	24	BS	do.	Pleistocene and/or Ogallala	N	I	Top of casing, southeast side	+1.5	2,962.9	49.42	9- 8-39	Abandoned; observation well
218	SW cor. sec. 35	Mrs. Rosine Smith	......	Dr	140.2	24	BS	do.	do.	N	I	Top of casing, north side	+ .3	2,960.0	48.07	9- 8-39	Abandoned; observation well
219	NW NE sec. 36	Ira C. Kerr	1937	Dr	65.0	18	GI	do.	do.	T, NG	I	Top of ½-inch hole in pump base	+1.0	2,950.1	40.28	9-11-40	Reported yield 800
220	SW NW sec. 36	Nancy D. Curtis	1937	Dr	57.0	18	GI	do.	do.	T, G	I	Top of oval hole in pump base	+1.0	2,952.8	43.73	9-16-40	Reported yield 600
	T. 19 S., R. 34 W.																
221	SE cor. sec. 5	F. L. Gritz	......	Dg	63.4	48	N	do.	Ogallala	Cy, W	D, S	Top of 2 x 6 plank under pump	+ .7	3,129.1	60.40	10-19-40	Unused domestic well
222	NE NW sec. 15	Mrs. Josephine Robinson	......	Dr	69.7	5½	GI	do.	do.	Cy, W	S	Top of casing, north side	.0	3,037.6	52.64	10-17-40	———
223	SE SW sec. 30	S. M. Lehman	......	Dr	96.3	5½	GI	do.	do.	Cy, W	S	Top of casing, west side	+ .8	3,091.9	81.18	10-19-40	See analysis
224	SW SE sec. 33	Mrs. Rosine Smith	......	Dr	91.4	5½	GI	do.	do.	Cy, W	S	Top of casing, north side	+ .5	3,046.4	72.38	10-18-40	———
	T. 19 S., R. 35 W. (8)																
225	SE cor. sec. 1	John Eder	......	Dr	21.9	5½	GI	do.	do.	Cy, WH	S	Top of casing, southeast side	+ .8	3,099.2	17.98	10-19-40	———
	T. 20 S., R. 30 W. (9)																
226	SW SE sec. 31	....	......	Dr	48.2	5½	GI	do.	do.	Cy, W	S	Top of round pump base, south side	+1.0	2,889.5	44.49	10- 8-40	Unused stock well
	T. 20 S., R. 31 W.																
227	SW SE sec. 4	Jas. E. Ely	......	Dr	50.5	5½	GI	do.	Ogallala and/or Niobrara	Cy, H	D	Top of 2-inch square hole in platform	.0	2,919.5	38.92	9-17-40	Unused domestic well
228	SE cor. sec. 10	B. B. Harkness	......	Dr	44.0	8	GI	do.	do.	N	N	Top of casing, north side	+ .5	2,876.6	38.59	5-20-40	Unused stock well; observation well
229	SW cor. SE sec. 12	Jas. E. Ely	......	Dr	....	5½	GI	do.	do.	Cy, H	D, S	Top of casing, south side	+ .6	2,870.3	33.79	9-14-40	Unused domestic well; see analysis
230	NW NE sec. 19	C. L. Davis	......	Dr	36.1	5½	GI	do.	do.	Cy, W	S	Top of casing, south side	+ .7	2,864.8	23.32	11-18-40	See analysis
231	SW SW sec. 21	J. K. and Jones Graber	......	Dr	31.9	6	GI	do.	do.	N	D, S	Top of casing, south side	+1.4	2,852.1	14.49	10- 8-40	Unused domestic well
232	SE NE sec. 22	Geo. M. Crofton	......	Dr	41.2	5½	GI	do.	do.	Cy, W	D, S	Top of casing, south side	.0	2,875.2	34.98	9-29-39	Unused domestic well; observation well
233	NW SW sec. 30	G. M. Jackman	......	Dg	63.7	48	N	do.	do.	N	D, S	Top of square wooden platform	+ .3	2,910.6	59.56	10- 8-40	Unused domestic well

TABLE 19.—Records of wells and springs in Scott County—*Continued*

No. on Pl. 2	LOCATION	Owner or tenant	Date completed	Type of well (1)	Depth of well (feet) (2)	Diameter of well (in.)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic subdivision	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Height above (+) or below (—) land surface (feet)	Measuring point: Height above sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Remarks—(yield given in gallons a minute; drawdown in feet)
	T. 20 S., R. 32 W.																
234	NW SW sec. 6	L. F. Roark	1918	Dr	89.0	24	BS	Sand and gravel	Pleistocene and/or Ogallala	T, D	I						———
235	NE NW sec. 7	L. F. Roark	1933	Dr	88.2	18	CI	do	do	T, E	I	Top of ¾-inch hole in pump base	+1.0	2,944.7	41.35	8-31-40	Reported yield 1,100, drawdown 23
236	SW SW sec. 8	E. Nevenschwander		Dr	44.2	5½	GI	do	do	Cy, WH	D, S	Top of casing, north side	+1.4	2,945.0	40.93	10- 7-40	See analysis
237	SE SW sec. 12	James Ely		Dr	93.6	5½	GI	do	Niobrara	Cy, W	S	Top of casing, south side	+ .5	2,985.9	88.60	10- 7-40	———
238	NW cor. NE sec. 22	R. Armantrout		Dg	77.9	48	BS	do	Ogallala	Cy, W	S	Top of square concrete opening, south side	+1.0	2,962.2	65.08	10- 8-40	Unused stock well
239	NW cor. SW sec. 27	C. Hollenbeck		Dr	49.2	8	GI	do	do	Cy, W	D, S	Top of casing, west side	+1.6	2,933.0	43.46	10- 8-40	Unused domestic well
	T. 20 S., R. 33 W.																
240	SW NW sec. 1	Irven Hinkle	1934	Dr	66.0	18	GI	do	Pleistocene and/or Ogallala	T, E	I	Top of casing, east side	+1.0	2,953.0	42.14	5-30-34	Estimated yield 400
241	NW NW sec. 2	Mrs. Rosine Smith	1939	Dr	104.6	20	GI	do	do	T, G	I	Top of ¾-inch hole in pump base	+ .5	2,960.8	50.64	9- 8-39	Measured yield 1,740, drawdown 12.5 (10)
242	NW NW sec. 2	Mrs. Rosine Smith		Dr	73.6	24	BS	do	do	N	I	Top of casing, southwest side	+ .4	2,961.4	51.00	9- 8-39	Abandoned
243	NW cor. SE sec. 2	A. J. Collingwood	1937	Dr	110.0	18	CI	do	do	T, E	I	Top of 2-inch square hole in base of pump	+1.5	2,956.5	50.73	2-17-41	Measured yield 1,320, drawdown 19 (10)
244	SW SW sec. 2	Mrs. Rosine Smith		Dr	99.7	24	BS	do	do	T, N	I	Top of casing, north side	—1.9	2,960.3	51.56	9- 9-39	Abandoned; observation well
245	NW SW sec. 3	Div. of Water Resources	1940	Dr	69.0	7	GI	do	do	N	Obs	Top of casing, south side	+ .8	2,965.4	54.25	9- 5-40	Equipped with continuous recorder
246	NW NW sec. 6	Ervin Gruben	1941	Dr	118.5	16	I	do	Ogallala	T, NG	I			3,001.0 (7)			Measurement not obtainable
247	NW SW sec. 8	Delmar C. Keyse	1918	Dr	119.0	24	BS	do	do	T, NG	I	Top of round steel base plate, northeast side	+ .2	2,978.9	66.14	9-17-40	Measured yield 1,000, draw-down 48.3 (10)
248	NW cor. sec. 9	Mrs. Rosine Smith		Dr	100.0+	26	BS	do	do	N	I	Top of circular edge of old pump base, west side	+ .8	2,974.3	60.40	12-31-39	Equipped with continuous recorder
249	NW NW sec. 9	Mrs. Rosine Smith	1940	Dr	103.0	18	CI	do	do	T, NG	I						Measured yield 1,346, drawdown 21 (10)

250	NW SE sec. 10	L. F. Roark	1934	Dr	102.0	18	CI	Sand and gravel	Pleistocene and/or Ogallala	T, E	I	Top of ¾-inch hole in pump base	+1.0	2,958.0	51.52	8-31-40	Reported yield 1,200
251	NE SW sec. 10	L. F. Roark	1931	Dr	104.0	18	CI	do.	do.	T, E	I	Top of ¾-inch hole in pump base	+ .5	2,961.2	57.42	9- 9-39	Reported yield 1,300
252	NE NW sec. 11	Estate of C. C. Hamlin	1939	Dr	107.5	19	GI	do.	do.	T, NG	I	Top of casing, northwest side	+ .3	2,952.9	45.61	9- 9-39	Reported yield 1,400; see analysis
253	NW NW sec. 11	Estate of C. C. Hamlin	1914	Dr	150.4	24	BS	do.	do.	N	I	Top of casing, north side	— .5	2,957.3	49.44	9- 9-39	Abandoned
254	NW cor. SE sec. 11	Estate of C. C. Hamlin	......	Dr	90.8	24	BS	do.	do.	T, N	I	Top of 1½-inch hole in pump base	+1.0	2,949.7	46.57	9- 7-40	Abandoned
255	SW NE sec. 12	Marvin Bastin	......	Dr	106.5	16	I	do.	do.	T, E	I	Bottom edge of rectangular hole in side of pump head	+1.0	2,944.0 (7)	42.23	6-14-44	———
256	NE NW sec. 13	Harold H. Crist	1942	Dr	147.0	16	I	do.	do.	T, NG	I	do.	+1.9	2,937.0 (7)	35.23	6-15-44	———
257	NW SE sec. 13	Shallow Water Oil Refin'y	1942	Dr	180.0	16	I	do.	do.	T, NG	In	....	....	2,929.0 (7)	....	....	Pumps continuously at rate of about 300; well ended in Niobrara formation
258	SE cor. NE sec. 14	Harvey Dague	1925	Dr	93.0	26	BS	do.	do.	T, NG	I	Top of 6-inch slot in base of pump, south side	+1.0	2,935.4	35.14	8-30-40	Reported yield 1,200
259	SW NE sec. 14	W. F. Pile	1934	Dr	104.0	18	GI	do.	do.	T, D	I	....	....	....	....	....	Reported yield 1,500
260	NE cor. NW sec. 15	Russell Drake	1937	Dr	89.0	18	GI	do.	do.	T, NG	I	....	....	....	....	....	Reported yield 800
261	NW NW sec. 16	L. F. Roark	1924	Dr	99.0	24	BS	do.	do.	T, E	I	Top of ¾-inch hole in pump base	+1.0	2,968.1	63.41	9- 7-40	Reported yield 900
262	NW SW sec. 16	L. F. Roark	1937	Dr	102.0	18	GI	do.	do.	T, E	I	Top of ¾-inch hole in pump base, east side	+1.0	2,964.6	58.88	9- 7-40	Reported yield 1,100; see analysis
263	SW SE sec. 16	L. F. Roark	1930	Dr	151.0	21	BS	do.	do.	T, D	I	Top of ¾-inch hole in pump base, northwest side	+ .6	2,959.5	54.92	9- 7-40	Reported yield 1,700
264	NE NW sec. 17	R. L. Crist	1918	Dr	132.0	24	BS	do.	Ogallala	T, NG	I	Top of round steel base plate	+ .8	2,975.0	62.82	9- 6-40	Reported yield 1,100
265	NW NE sec. 18	Foster Williams	1942	Dr	158.8	16	I	do.	do.	T, NG	I	Bottom edge of rectangular hole in side of pump head	+1.0	2,986.0 (7)	71.22	6-15-44	———
266	NW NE sec. 21	Marion Hutchins	1942	Dr	154.0	16	I	do.	Pleistocene and/or Ogallala	T, NG	I	2-inch hole in pump base, east side	+0.2	2,957.0 (7)	47.27	6-15-44	———
267	NE cor. sec. 25	P. Roark	......	Dr	34.9	5½	GI	do.	Pleistocene	....	D, S	Top of casing, north side	+2.0	2,929.1	32.52	9-28-39	Unused domestic well, observation well
268	SW NW sec. 28	Clayton and Anson Mark	......	Dr	56.9	5½	GI	do.	Pleistocene and/or Ogallala	Cy, W	S	Top of wooden 4 x 6 pipe clamp, west side	+ .7	2,956.7	50.51	9- 9-40	Unused stock well
269	NW SE sec. 35	Ralph Beach	1942	Dr	147.0	16	I	do.	do.	T, D	I	Bottom edge of rectangular hole in side of pump head	.0	2,929.0 (7)	34.02	6-15-44	———
	T. 20 S., R. 34 W.																
270	SW NE sec. 2	Melchior Lang	1937	Dr	92.1	18	CI	do.	Ogallala	N	I	Top of casing, north side	+ .5	3,013.8	68.87	9-27-39	Unsuccessful irrigation test
271	NW SE sec. 2	Melchior Lang	1937	Dr	109.1	16	GI	do.	do.	T, G	I	Top of 1-inch hole in pump base, east side	+1.2	3,015.9	72.20	9-27-39	Reported yield 1,200; see analysis; observation well
272	SE cor. sec. 8	Mrs. Rosine Smith	......	Dr	70.9	5½	GI	do.	do.	Cy, W	D, S	Top of casing, south side	+ .6	3,066.7	68.83	10-17-40	———

TABLE 19.—Records of wells and springs in Scott County—*Concluded*

No. on Pl. 2	LOCATION	Owner or tenant	Date completed	Type of well (1)	Depth of well (feet) (2)	Diameter of well (in.)	Type of casing (3)	Principal water-bearing bed		Method of lift (4)	Use of water (5)	Measuring point			Depth to water level below measuring point (feet)	Date of measurement	Remarks—(yield given in gallons a minute; draw-down in feet)
								Character of material	Geologic subdivision			Description	Height above (+) or below (—) land surface (feet)	Height above sea level (feet)			
	T. 20 S., R. 34 W. (Continued)																
273	SE NE sec. 11	John Lang	1942	Dr	136.0	16	I	Sand and gravel	Ogallala	T, NG	I	....	....	3,015.0 (7)	....	....	Measurement not obtainable
274	NW cor. SW sec. 12	Wayne Minnix	......	Dr	130.0	16	I	do	do	T, NG	I	Bottom edge of oval hole in side of pumphead	+ .9	3,015.0 (7)	79.15	6-15-44	———
275	NE cor. sec. 15	Prosper Minnix	......	Dr	91.9	5½	GI	do	do	Cy, W	D, S	Top of casing, north side	+1.0	3,041.5	88.97	10-17-40	———
276	SW SW sec. 16	J. B. Minnix	......	Dr	126.1	5½	GI	do	do	Cy, W	D, S	Top of casing, southwest side	+ .2	3,096.3	117.63	10-17-40	Unused domestic well; see analysis
277	SE SW sec. 21	E. C. Pollard	......	Dr	114.1	5½	GI	do	do	N	D	Top of 1¼-inch hole in tin cover plate	+ .2	3,089.0	112.55	10-17-40	Abandoned domestic well
278	NW cor. sec. 25	Clayton and Anson Mark	......	Dr	66.4	5½	GI	do	do	Cy, W	I	Top of casing, east side	+2.5	2,985.2	61.93	9-17-40	———
	T. 21 S., R. 31 W. (11)																
279	NE cor. NW sec. 8	F. L. Brayfogle	......	Dr	73.3	......	......	do	do	Cy, W	S	Top of tin plate covering casing	+ .8	2,903.4	57.39	9-13-40	———
	T. 21 S., R. 33 W. (11)																
280	SE SW sec. 1	E. F. Ware	1937	Dr	77.9	16	BS	do	Pleistocene and/or Ogallala	N	I	Top of casing, south side	+1.9	2,908.0	25.32	10- 8-40	Unused irrigation well; pump removed
281	NW SW NE sec. 2	Farm M. & H. Co.	......	Dr	125.0	16	BS	do	do	N	N	Top of board platform	.0	2,910.6	24.43	9-16-40	Unused irrigation well; pump removed
282	SW cor. NW sec. 5	G. W. Armantrout	......	Dr	62.0	6	GI	do	do	Cy, W	N	Top of casing, west side	—3.7	2,930.5	41.35	9-16-40	Unused domestic well

1. Dr, drilled; Dg, dug.
2. Reported depths below the land surface are given in feet; measured depths are given in feet and tenths below measuring points.
3. BS, boiler steel; C, concrete; CI, cast iron; CR, concrete rings; GI, galvanized iron I, iron; N, none; OW, oil well; R, rock; WI, wrought iron.
4. Method of lift: Cy, cylinder; N, none; T, turbine.
   Type of power: D, diesel; E, electric; G, gasoline engine; H, hand; NG, engine powered by natural gas; T, tractors; W, wind.
5. D, Domestic; I, irrigation; In, industrial; Obs, observation; PS, public supply; RR, railroad supply; S, stock.
6. Situated in Logan County.
7. Elevation estimated from topographic map.
8. Situated in Wichita County.
9. Situated in Lane County.
10. Pumping test conducted and results furnished by the Division of Water Resources, Kansas State Board of Agriculture.
11. Situated in Finney County.

LOGS OF TEST HOLES AND WELLS

Listed in the following pages are the logs of 76 wells and test holes in Scott County, including 23 test holes drilled by the State Geological Survey (1-23) and one log of a test hole in Wichita County (log 43). The locations of the test holes drilled by the State Geological Survey are shown in Figure 2 and many of the wells are shown on Plate 2. The samples from the test holes drilled by the State Geological Survey were studied in the field by Perry McNally and later in the office by me.

1. *Sample log of test hole 1, SW cor. sec. 18, T. 17 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude, 2988.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, dark	3	3
Silt and fine sand, yellow-tan; considerably harder near base	21	24
Sand, medium, to fine gravel, brown	4.5	28.5
Silt and fine sand, plastic, brown	2	30.5
Silt and fine sand, limy, grayish tan	1.5	32
Silt and fine sand, plastic, tan	2	34
Silt and fine sand, limy, grayish tan; darker near base; contains scattered caliche pebbles	12	48
Clay, silty, dark gray	3	51
Silt and fine sand, light gray; contains abundance of shell fragments	5	56
Silt and fine sand, medium gray; contains scattered caliche pebbles, sand, gravel, and shell fragments	8	64
Sand to fine gravel, light brown; contains abundance of light green-gray plastic silt and fine sand intermixed	4	68
Silt and fine sand, limy, light gray to tan	4	72
Clay, silty, tan	2	74
Sand, fine, plastic, brown	4	78
TERTIARY—Pliocene		
Ogallala formation		
Caliche, light gray, and clay, fine sandy, limy; hard beds 0.5 feet thick at top and at a depth of 81 feet	6	84
Silt and fine sand, pale green, limy, light gray; contains scattered sand, gravel, and caliche fragments	8	92
Sand and gravel, brown to gray; bottom part contains abundant caliche pebbles, plastic silt, and fine sand	6.5	98.5
Caliche, light gray, and clay, fine sandy, limy, white	5	103.5
Clay, fine, sandy, limy, light gray; contains lenses of sand and gravel	7.5	111
Sand, coarse, to coarse gravel, brown; contains abundant pink quartz and granite	9	120
Sand and gravel, semi-cemented	4	124

Caliche, hard, chertlike, light gray, and fine-grained interbedded mortar bed	6	130
Caliche, hard, chertlike, tan	5	135
Sand, fine, plastic, brown; contains lenses of sand and gravel, and chertlike caliche; 1½ foot caliche bed at depth of 145 feet	15	150
Silt and fine sand, plastic, limy, light gray; interbedded with hard caliche	22	172
Mortar bed, soft, tan	4	176
Silt and fine sand, plastic, limy, tan	6	182
Sand, fine to coarse, brown, partly cemented	16.5	198.5
Silt and fine sand, plastic, limy, light gray and tan	3.5	202
Sand, fine, to fine gravel, brown	20	222
Sand, medium, to coarse gravel	15	237
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Clay, silty, yellow	4	241
Shale, gray to black	4	245

2. *Sample log of test hole 2, SW cor. sec. 15, T. 18 S., R. 31 W., drilled by State Geological Survey, 1941, Surface altitude, 2,929.7 feet.*

QUATERNARY—Pleistocene	*Thickness, feet*	*Depth, feet*
Soil, dark, sandy	3	3
Silt and fine sand, soft, plastic, tan gray; contains abundant gastropod shells	11	14
Sand, fine, plastic, brown	2	16
Silt and fine sand, plastic, brown; contains streaks of lime and gastropod shells	2	18
Caliche and clay, fine-sandy, limy, light gray becoming more tan in color at base	18	36
Sand, fine, plastic, brown and lime, sand, gravel, and caliche intermixed	7	43
Sand to coarse gravel, cemented, brown	6.5	49.5
Sand, fine, plastic, brown and sand, gravel, caliche fragments, and pebbles; thin, hard beds at depths of 49½ and 51 feet	10.5	60
Mortar bed, tan	5	65
Silt and fine sand, plastic, limy, tan to brown	5	70
Sand and gravel, partially cemented, brown with some sandy clay intermixed	7.5	77.5
Caliche, hard, light gray	1.5	79
Mortar bed, fine-grained, light gray to tan, and caliche	7	86
Sand, fine, plastic, light gray, and gravel	8	94
Mortar bed, fine-grained, light gray to tan	10	104
Mortar bed, sand to coarse gravel, gray brown	7	111
Clay, limy, light gray, sand, and gravel	7.5	118.5
Sand and gravel, partially cemented	24.5	143
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Shale, clay, chalky, dull yellow	2	145
Shale, clay, dirty brown to black	5	150

3. *Sample log of test hole 3, SE cor. SW¼ sec. 17, T. 18 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude, 2,956.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, dark	1.5	1.5
Silt, sandy, tan	1.5	3
Soil, silty, black	3.5	6.5
Silt, limy, light gray to tan; contains lime-cemented nodules, snail shells, and shell fragments	4.5	11
Silt, clay, medium gray; contains shell fragments	17	28
Sand, fine, to fine gravel, brown gray	4	32
Sand, fine, to fine gravel and plastic silt, brown gray	6	38
Silt, fine sand, and limy clay, tan and gray	5	43
Silt and clay, limy, light gray	3	46
Silt and fine sand, plastic, limy, light gray; contains streaks of yellow-brown plastic sand, medium sand to fine gravel	8	54
Gravel, brown with few thin beds of gray silt and clay	6	60
Gravel, brown; contains abundance of water-worn caliche pebbles and some limy silt	7	67
TERTIARY—Pliocene		
Ogallala formation		
Caliche, light gray, and some tan to brown cemented sand fragments	8	75
Caliche, hard, light gray to white	5	80
Pebbles and fragments of mortar bed, fine-grained, unconsolidated, brown	4.5	84.5
Gravel, poorly sorted, brown, partly consolidated at base; contains abundance of mortar bed and caliche pebbles.	15.5	100
Mortar bed, gray	2	102
Sand, fine, to coarse gravel, brown	13	115
Sand and gravel, partly consolidated mortar bed, brown,	1.5	116.5
Mortar bed, fine-grained, light pink to tan	5.5	122
Sand and gravel, partly consolidated, brown; contains abundant caliche fragments	14	136
Clay, hard, blocky, chocolate brown	1.5	137.5
Sand, medium, to coarse gravel, brown	9.5	147
Mortar bed, fine-grained, partly consolidated, tan	11	158
Silt, light tan	3	161
Sand, coarse, to coarse gravel, glassy quartz	4.5	165.5
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Clay, silty, yellow tan and some light gray	6.5	172
Shale, clay, brownish black, becoming blue black	8	180

4. *Sample log of test hole 4, NE cor. sec. 20, T. 18 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude, 2,969.4 feet.*

QUATERNARY—Pleistocene	Thickness, feet	Depth, feet
Soil, silty, dark	2.5	2.5
Silt and sand, limy, light tan to light gray; contains few caliche pebbles	9	11.5
Caliche, gray to white, and light tan to light gray limy silt and sand	12.5	24
Mortar bed, brown and tan; some partly consolidated, and white limy material near base	36	60
Silt and sand, limy, tan; contains some gravel, and mortar bed fragments	6	66
Caliche, light gray to white and tan, and mortar bed, fine-grained	1.5	67.5
Sand, plastic, brown, and sand, gravel, and small mortar bed pebbles	8.5	76
Silt, plastic, brown	8.5	84.5
Silt and sand, plastic, light gray and green gray	7.5	92
Silt and sand, plastic, green gray, and sand, gravel, and small, white caliche pebbles	11.5	103.5
Sand, gravel, mortar bed, partly consolidated, brown	6.5	110
Sand, medium, to medium gravel and mortar bed pebbles, brown	5	115
Silt, and sand, brown	6	121
Silt, sand, and fine to medium gravel, brown	9	130
Sand, medium, to medium gravel; contains many white caliche pebbles	8	138
Silt and sand, limy, light gray	2	140
Sand, medium, to medium gravel, brown	5	145
Mortar bed, tan and light gray to white	6.5	151.5
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Shale, clay, cream-colored	4.5	156
Shale, clay, light yellow; 3-inch bed of yellow-tan to green blocky shale at a depth of 156 feet	4	160

5. *Sample log of test hole 5, NW cor. sec. 20, T. 18 S., R. 32 W., drilled by State Geological Survey, 1940. Surface altitude, 2,951.4 feet.*

QUATERNARY—Pleistocene	Thickness, feet	Depth, feet
Soil, sandy, limy, tan	1	1
Silt and clay, plastic, tan	15.5	16.5
Silt, clay, and scattered caliche, light gray	4.5	21
Sand, coarse, and fine gravel, brown	9	30
Clay, silty, pale green; contains abundant gastropod shells	3.5	33.5
Silt and clay, tan to brown	4.5	38
Silt, clay, brown, and some lime and loose sand	9	47
Sand, fine, silt, and clay, tan to brown	7	54

Sand, fine, silt, and clay, limy, light green	4	58
Sand, fine, silt, and clay, tan to brown	2	60
Sand, medium, to fine gravel, tan; contains mostly quartz and some caliche pebbles	11	71
Clay, silty, light gray	2	73
Sand, fine, silt, and clay, tan to brown	4	77
Sand and gravel, brown; contains some silt, clay, and abundant rounded, waterworn caliche pebbles	11	88
Sand, fine, silt, and clay, tan and light gray; contains abundant rounded, waterworn caliche pebbles	2	90
TERTIARY—Pliocene		
Ogallala formation		
Caliche, light gray; contains few thin, softer beds	8	98
Sand, fine, pink brown, and plastic silt	1.5	99.5
Caliche, light gray, and tan cemented fine sand	4.5	104
Sand and gravel, brown; contains abundant caliche pebbles and pink-brown silt and fine sand	14	118
Mortar bed, tan	3	121
Mortar bed, cemented fine sand, brown	2.5	123.5
Sand, medium, to medium gravel	12.5	136
Clay, limy, light gray, caliche, and cemented fine sand	7	143
Sand and gravel; contains few thin beds of caliche and mortar bed	7	150
Caliche, light gray and tan	7	157
Sand, fine, plastic; contains pink-brown and loose fine sand to coarse sand	3	160
Sand, medium, to medium gravel, brown	11	171
Caliche, hard, light gray and tan	7	178
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Clay, yellow	17.5	195.5
Clay, dirty gray brown	4.5	200

6. *Sample log of test hole 6, NE cor. NW¼ sec. 21, T. 18 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude, 2,975.0 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil, dark	5	5
Silt and clay, tan; contains few snail shells and shell fragments	10	15
TERTIARY—Pliocene		
Ogallala formation		
Caliche, light gray to white and tan	7	22
Mortar bed, fine-grained, tan	3	25
Sand, medium to coarse, cemented, green gray and brown; contains mortar bed and caliche pebbles	7	32
Mortar bed, brown	4.5	36.5
Sand, medium, to fine gravel, lime cemented, gray, brown, yellow tan	6.5	43

	Thickness, feet	Depth, feet
Mortar bed, hard, tan; contains fine to coarse sand	4	47
Sand, fine, to medium gravel, brown	3	50
Sand, coarse, to medium gravel, brown	7	57
Mortar bed, gray; contains coarse sand and fine gravel	6	63
Silt and sand, limy, light gray and light tan, and caliche	1.5	64.5
Sand, fine, to fine gravel, limy, light gray and brown	2	66.5
Clay, silty, blocky, hard, khaki-colored	6.5	73
Sand, fine, to fine gravel, brown	6	79
Silt and sand, lime-cemented, tan and gray	4	83
Sand, fine, to medium gravel, brown; contains mortar bed fragments	9	92
Mortar bed, tan	14.5	106.5
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, white to yellow	2.5	109

7. *Sample log of test hole 7, NW cor. sec. 22, T. 18 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude, 2,967.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, dark	5	5
Silt, tan	7	12
TERTIARY—Pliocene		
Ogallala formation		
Caliche, soft, light gray to pink tan	4	16
Caliche, hard, light gray to pink tan	9	25
Sand and gravel, partly cemented, brown	5	30
Mortar bed, tan	3	33
Sand, fine, to medium gravel, brown; contains abundant cement and mortar bed fragments	4	37
Mortar bed, brown	3	40
Sand, coarse, to medium gravel, brown; contains abundant cement and mortar bed	7	47
Mortar bed, brown	5	52
Sand, coarse, to coarse gravel, brown	7	59
Mortar bed, fine-grained, tan; contains some sand and gravel	11	70
Caliche, chertlike, hard, white and light tan	14	84
Mortar bed, tan; contains lime cement, sand, few fragments of Niobrara formation	12	96
Mortar bed, tan; contains coarse sand to medium gravel, abundant fragments of Niobrara formation	6	102
Mortar bed, soft, tan; contains fine to coarse sand	15	117
Mortar bed, hard, tan; contains lime cement, fine to coarse sand	6	123
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow and white	13	136

Shale, clay, silty, brown and black, soft; 3-inch coal bed at depth 139 feet	4	140
Shale, clay, silty, brown	7	147
Carlile formation—Blue Hill shale member (?)		
Shale and clay, dark gray to dark brown; contains fragments bright blue shale	3	150

8. *Sample log of test hole 8, NW cor. sec. 24, T. 18 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude, 2,969.3 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil, dark	4	4
Silt and fine sand, plastic, tan; contains fragments of gastropod shells	18	22
TERTIARY—Pliocene		
Ogallala formation		
Caliche, light gray to tan	3	25
Caliche and clay, fine, sandy, limy, light gray	8.5	33.5
Sand, fine, plastic, brown	2	35.5
Clay, limy, light gray; contains fine sand and thin caliche beds	5.5	41
Sand, fine, plastic, brown	2	43
Sand, medium, to medium gravel, brown	9	52
Mortar bed, tan	7	59
Sand, fine, plastic, brown	3	62
Sand, plastic, fine, and gravel, partly cemented, brown and tan, limy	8	70
Sand, coarse, to medium gravel, brown	15	85
Mortar bed, fine-grained, tan	2	87
Sand, fine, plastic, brown to tan	10	97
Caliche fragments, angular, hard	8	105
Caliche fragments, angular, hard, sand and gravel	2	107
Gravel, fine to coarse; contains abundant fragments of hard yellow-tan limestone	5	112
Sand, coarse, to fine gravel, partly cemeted, brown to light gray	12	124
Caliche, light gray, and tan fine-grained mortar bed	6	130
Caliche, hard, light gray	5	135
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Clay, chalky, yellow and white	12	147
Shale, clay, dark brown to black	13	160

9. *Sample log of test hole 9, NE cor. sec. 19, T. 18 S., R. 33 W., drilled by State Geological Survey, 1941. Surface altitude, 3,049.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, sandy, dark	1	1
Silt and sand, fine, plastic, tan	11	12
Silt, limy, gray to tan, and fine sandy clay; contains scattered caliche pebbles	12	24
TERTIARY—Pliocene		
Ogallala formation		
Caliche, hard, light gray to tan, and limy plastic silt and fine sand	9	33
Caliche, unconsolidated, and brown cemented fine to medium sand	7	40
Sand, fine to medium, partly cemented, brown, and scattered sand and gravel	6.5	46.5
Mortar bed, gray to tan	3.5	50
Sand and gravel, partly cemented, poorly sorted	2	52
Mortar bed and plastic fine sand	8	60
Mortar bed, contains some plastic fine sand	15	75
Mortar bed, brown and tan, and brown fine sandy clay	6	81
Mortar bed fragments, sand, gravel and some plastic silt and fine sand	9	90
Sand and gravel, brown; contains some sandy clay and mortar bed fragments	4	94
Mortar bed, brown; contains some sand, gravel, and fine sandy clay	10	104
Sand and gravel, partly cemented, brown; contains few yellow fragments of Niobrara formation	4	108
Silt and sand, fine, limy, plastic, light gray to tan	6	114
Mortar bed, gray and tan; contains abundant fragments of hard yellow Niobrara formation, sand, and gravel	6	120
Silt and sand, fine, plastic, tan	4	124
Sand and gravel, brown	4.5	128.5
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Clay, silty, dull yellow	5.5	134
Shale, clay, dirty gray to blue black	6	140

10. *Sample log of test hole 10 at the NE cor. sec. 23, T. 18 S., R. 33 W., drilled by State Geological Survey, 1941. Surface altitude, 2,956.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, sandy, dark	4	4
Clay, silty, gray; contains few scattered caliche pebbles,	4	8
Silt and sand, fine, plastic, light gray green; contains few scattered caliche pebbles	6	14
Clay, silty, dark gray to black	5	19
Sand and gravel, brown; contains some plastic silt and fine sand	3	22

	Thickness, feet	Depth, feet
Silt and fine sand, plastic, medium gray; contains scattered waterworn caliche pebbles and fragments of gastropod shells; from 40-48 feet contains thin lenses of small brown fragments of waterworn caliche	31	53
Sand and gravel, poorly-sorted, brown; contains abundance of waterworn caliche pebbles; predominantly fairly coarse	13	66
Silt and fine sand, limy, plastic; contains waterworn caliche	6	72
Sand, fine, plastic, brown; contains fragments of gastropod shell in upper 4 feet	7	79
TERTIARY—Pliocene		
Ogallala formation		
Caliche, light gray, and limy plastic silt and fine sand; drilled fairly hard	2	81
Sand, medium, to medium gravel, brown; contains abundance of caliche and lime fragments; thin lenses of tan fine-grained mortar bed at 91 and 93 feet	16	97
Mortar bed, tan to gray	4	101
Sand and gravel, brown; contains some fragments of mortar bed material	6	107
Silt and fine sand, limy, plastic, light gray to tan; contains a few thin hard lenses of mortar bed	4	111
Mortar bed; contains thin beds of plastic limy silt and fine sand	5	116
Sand and gravel, brown; contains limy plastic silt and fine sand and an abundance of caliche	10	126
Mortar bed, hard from 126 to 127.5, from 128.5 to 129.5, and from 132 to 133.5 feet; interbedded with softer material	8	134
Sand, brown, to fine gravel; contains a few thin lenses of mortar bed from 134 to 136 feet, and a thin bed at 139 feet	10	144
Mortar bed, tan; contains some sand and gravel intermixed	8	152
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Clay, silty, creamy-tan; thin bed of dark-gray clay shale at 154 feet; gradually becoming more yellow with depth	20	172
Shale, clay, dirty gray to blue black	8	180

11. *Sample log of test hole 11 at the NW cor. sec. 22, T. 18 S., R. 34 W., drilled by State Geological Survey, 1940. Surface altitude, 3,123.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, sandy, dark brown	1	1
Silt and fine sand, limy, light tan	3	4
Silt and fine sand, tan to brown; contains abundant gastropod shells	13	17
Silt and fine sand, limy, light gray to brown; plastic and sticky	8	25
TERTIARY—Pliocene		
Ogallala formation		
Caliche, light gray; hard from 25 to 27 feet	12	37
Sand, medium to coarse, brown; partly cemented	4	41
Sand, medium, to medium gravel, brown; partly cemented; contains abundance of black carbonaceous fragments	7	48
Mortar bed, hard, gray	5	53
Sand to medium gravel, poorly sorted, brown to gray; thin semicemented beds at 56 and 58 feet	7	60
Sand, coarse, to medium gravel, brown; contains thin semicemented beds; coarser from 70-98 feet	38	98
Sand, fine, limy, plastic, soft, light gray to tan	3	101
Sand and gravel, semiconsolidated; fairly hard caliche bed at 108 feet; gray, semicemented mortar bed from 116 to 120 feet	23	124
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Clay, yellowish gray; contains some white bentonite	3	127
Shale and clay, soft and sticky, dull brown to black	8	135

12. *Sample log of test hole 12 at the SE cor. sec. 27, T. 19 S., R. 31 W., drilled by State Geological Survey, 1940. Surface altitude, 2,958.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, sandy, dark brown	3	3
Silt and fine sand, tan; contains a few gastropod shells	11	14
TERTIARY—Pliocene		
Ogallala formation		
Clay, limy, light gray, caliche and fine to medium sand; predominantly hard caliche with some harder thin beds,	6	20
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Shale, clay, yellow; white chalky bed from 28 to 29 feet, harder	10	30

13. *Sample log of test hole 13 at the NW cor. sec. 7, T. 19 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude, 2,937.4 feet.*

QUATERNARY—Pleistocene	*Thickness, feet*	*Depth, feet*
Soil, sandy, brown	2	2
Clay, silty and fine sandy, dark brown; contains scattered sand and gravel from 10 to 21 feet	19	21
Clay, silty, sticky, tan	5	26
Clay, silty, black	2	28
Clay, silty and fine sandy, limy, light gray	2	30
Clay, limy, tan and some light gray; abundance of dull yellow iron-stain streaks; more lime from 30 to 32 feet; contains gastropod shells	12	42
Sand, medium, to medium gravel, brown; contains some sandy clay	6	48
Clay, fine sandy, soft, tan to yellow green	6	54
Silt, very soft, tan and medium gray; contains a few waterworn caliche pebbles	8	62
Clay, limy, fine sandy, and caliche; contains an abundance of sand and gravel intermixed, chiefly from 67 to 70 feet	9	71
Sand and gravel, gray and brown; contains many small caliche pebbles, dirty gravel, and has some sandy clay intermixed; includes an abundance of light green-gray plastic silt intermixed from 80 to 84 feet	13	84
Silt, plastic, light green gray; contains some sand and gravel intermixed	14	98
Silt and clay, limy, light gray, fine, sandy; contains some caliche pebbles and fragments	3	101
Silt, tan, fine, sandy; contains scattered sand and gravel and waterworn caliche pebbles	11	112
Silt and fine sand, plastic, grayish tan; contains sand and gravel and waterworn caliche pebbles	18	130
Clay, silty, soft, very sticky, light gray	27	157
Silt, plastic, tan, and fine sand; contains alternating beds of tan and light gray plastic silt and fine sand	13	170
Clay, silty, sticky, soft	8	178
Shale, clay, dirty brown to black; contains some gastropod fragments	12	190

14. *Sample log of test hole 14 at the SE cor. sec. 26, T. 19 S., R. 32 W., drilled by State Geological Survey, 1940. Surface altitude, 3,011.0 feet.*

QUATERNARY—Pleistocene	*Thickness, feet*	*Depth, feet*
Soil, sandy, dark brown	5	5
Sand, medium to coarse, tan; contains some lime and a thin mortar bed at 7 feet; contains some gastropods in lower part	11	16
Silt and fine sand, soft, tan; contains gastropods	5	21

TERTIARY—Pliocene		
Ogallala formation		
Caliche, light gray and tan, mortar bed; contains lime with plastic silt and fine sand intermixed	14	35
Caliche, light gray to white; contains a few hard yellow fragments near base	8	43
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Shale, clay, chalky, yellow; contains hard lenses of white chalk from 50 to 61 feet	18	61
Shale, clay, soft, sticky, reddish yellow	11	72
Shale, clay, chalky, yellow; thin white chalk beds at 74, 79, 83, and 86 feet	38	110

15. *Sample log of test hole 15 at the SE cor. SW¼ sec. 28, T. 19 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude, 3,009.7 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil, silty, brown	2	2
Clay, silty, tan; contains some gastropods	10	12
Silt and fine sand, plastic, tan	14	26
Medium sand to medium gravel, brown; mostly coarse sand and fine gravel; contains some gastropods	5	31
Silt and fine sand, plastic, tan; lower half contains few lime splotches; contains few caliche pebbles	18	49
TERTIARY—Pliocene		
Ogallala formation		
Silt and sand, limy, light gray to light tan	9	58
Clay and silt, limy, sandy, light gray	2	60
Silt and sand, limy, tan to light gray; lower two-thirds contains much sand and gravel intermixed, and scattered caliche pebbles	30	90
Silt, sandy, tan, light grayish; contains many limy fragments and caliche intermixed	6	96
CRETACEOUS (Upper)		
Niobrara formation		
Clay shale, yellow, some white chalky streaks; contains 3-foot layer of chalk at 98 feet and 1-foot layer at 118 feet	23	119
Shale, chalky, yellow and bright orange yellow; contains some red-brown concretionary material in lower half of layer; hard layer at 134 feet	34	153
Clay shale, dark brown to slightly black	3	156
Clay shale, blue black	4	160

16. *Sample log of test hole 16 at the SE cor. sec. 29, T. 19 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude 2,988.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, dark	2	2
Silt and sand, tan; contains many small white lime nodules	3	5
Sand, fine, to medium gravel, brown, mostly fine gravel; contains some plastic silt and fine sand intermixed	7	12
Silt, sandy, tan, intermixed with fine sand to medium gravel; contains some gastropod fragments	14	26
Sand, fine, to fine gravel, brown, more sandy silt and less sand and gravel in lower 5 feet; contains some gastropod fragments	9	35
Silt, sandy, tan to brown, harder near the base; contains a few gastropod fragments	17	52
Clay and silt, limy, light greenish gray, becoming sandy downward; contains a few waterworn caliche pebbles	18	70
Silt and sand, limy, plastic, light tan to light gray, intermixed with much sand and gravel; contains some small smooth waterworn caliche pebbles	68	138
Gravel, fine to coarse, brown; contains an abundance of yellow Niobrara fragments	3	141
Silt, limy, sandy, light gray to light tan, harder near base and intermixed with fine and medium gravel; contains waterworn Niobrara fragments	15	156
Clay, silt and sand, light gray to light tan intermixed with sand and gravel near base	12	168
CRETACEOUS (Upper)		
Niobrara formation		
Clay shale, gritty, pale yellow tan to cream	2	170
Shale, chalky, gritty, yellow and cream tan	6	176
Clay shale, silty, brown black to gray	4	180
Clay shale, slightly gritty, blue black	5	185

17. *Sample log of test hole 17 at the NW cor. sec. 32, T. 19 S., R. 32 W., 20 feet southwest of U. S. Geological Survey bench mark TT21B1938, drilled by State Geological Survey, 1941. Surface altitude, 2,941.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, sandy, dark	1	1
Sand, fine, limy, plastic, tan	3	4
Caliche, light gray	5	9
Sand, fine and medium, plastic, tan; contains gastropod fragments	9	18
Sand, fine and medium, plastic, brown, silt binder	12	30
Silt and sand, fine, limy, light gray to tan; contains some gastropod fragments	10	40

Clay, silty, tan	4	44
Silt and fine sand, limy, light gray to tan; contains some gastropod fragments	7	51
Sand, fine to coarse, brown, some lime intermixed; contains a few gastropod fragments	5	56
Sand, fine and medium, plastic, brown, silt binder; intermixed with an abundance of fine sand to fine gravel	11	67
Silt and fine sand, plastic, limy, tan and light green	6	73
Silt and fine sand, limy, plastic, light gray; contains an abundance of sand and gravel intermixed, more lime at the base	33	106
Clay, silt, and fine sand, limy, light gray; contains much sand and fine gravel intermixed	25	131
Clay, silt, and fine sand, plastic, tan and light gray, mortar beds at 156 and 167 feet; contains semiconsolidated sand and gravel lenses in the lower 10 feet	50	181
Sand, fine, to fine gravel, light tan; mostly clean quartz; contains a small amount of silty binder from 186 to 189 feet	15	196
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Clay shale, dark blue gray	14	210

18. *Sample log of test hole 18 at the NW cor. NE¼ sec. 34, T. 19 S., R. 32 W., drilled by State Geological Survey, 1941. Surface altitude, 3,008.5 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil, dark	5	5
Silt and clay, tan; contains gastropod fragments	11	16
TERTIARY—Pliocene		
Ogallala formation		
Mortar bed, tan, light gray; contains a few yellow Niobrara fragments	9	25
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Limestone, chalky, yellow orange; contains a few greenish yellow blocky clay fragments	16	41
Clay shale, chalky, yellow orange; contains some pink-tan-orange fragments	19	60
Clay shale, chalky, orange yellow; contains layers of white chalk from 61 to 62 feet, 77 to 78 feet, and 81 to 83 feet	30	90
Clay shale, white, chalky, cream yellow	47	137
Clay shale, chalky, yellow gray	6	143
Clay shale, sandy, brown black, some blue black	3	146
Shale, some gritty, blue black	4	150

19. *Sample log of test hole 19 in the SW cor. sec. 25, T. 19 S., R. 33 W., drilled by State Geological Survey, 1940. Surface altitude, 2,955.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, sandy, dark	1	1
Silt and fine sand, light tan	2	3
Silt and fine sand, dark tan; contains gastropods	13	16
Clay, silty, fine, sandy, yellow tan; contains abundant gastropods	6	22
Clay, silty, more fine sandy, yellow gray; contains abundant gastropods	4	26
Sand, medium, to fine gravel, brown; mostly coarse sand and fine gravel; contains some gastropods	11	37
Clay, silty, light gray and yellow gray	3	40
Silt and fine sand, plastic, tan to brown	6	46
Clay, silty, limy, hard, tan to brown; contains fine sand and a layer of black clay 46 to 47 feet	4	50
Clay, silt, and fine sand, limy, light tan; mostly lime and fine sand; contains some gatropod fragments	15	65
Sand, medium, to fine gravel, brown; mostly fine gravel; contains some small caliche pebbles	14	79
Clay, silt, and fine sand, limy, light gray, tan; contains an abundance of sand and gravel intermixed, and a few fragments of pale green material	11	90
Clay, silty, light gray to pale green	30	120
Clay, fine sandy, silty, tan to pale green; contains scattered sand and gravel	31	151
Sand, medium, to fine gravel, brown, mostly quartz and coarse sand	11	162
Caliche, light gray	5	167
Silt and clay; fine sandy, tan, pale green; probably contains a thin bed of bentonite	3	170
Sand, fine to coarse, brown; contains an abundance of soft caliche fragments and some light gray plastic limy fine sandy clay	9	179
Lime and caliche, light gray; intermixed with sand	17	196
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Clay, silty, yellow	5	201
Clay shale, dirty brown gray, becoming more blue gray from about 206 to 210 feet	9	210

20. *Log of test hole 20 in the NW cor. sec. 32, T. 19 S., R. 33 W., drilled by State Geological Survey, 1940. Surface altitude, 2,987.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, sandy, dark brown	1	1
Silt and fine sand, plastic, tan	11	12
Clay, silty, yellow tan	11	23
Sand and gravel, brown; intermixed with yellow-brown sandy clay from 23 to 25 feet; contains an abundance of large granite pebbles, but mostly subrounded quartz.	9	32
Silt and fine sand, dull gray brown; contains silt and clay binder making it plastic	6	38
Sand, medium, to medium gravel, tan, major grade is fine and medium gravel; contains many pink granite pebbles	15	53
Sand to coarse gravel, semiconsolidated; contains gastropod shells and some lenses of unconsolidated gravel.	17	70
Silt and fine sand, limy, plastic, tan	6	76
TERTIARY—Pliocene		
Ogallala formation		
Silt and fine sand, limy, plastic, tan, light gray	7	83
Sand, coarse, and fine gravel, tan	5	88
Sand, fine, plastic, reddish brown; contains a silty clay binder	9	97
Clay, silty, light gray, very sticky	11	108
Clay, silty, pink brown to tan	9	117
Clay, fine, sandy, silty, pink tan; mostly plastic fine sand	4	121
Sand, medium and coarse, light tan; contains an abundance of small caliche pebbles	7	128
Sand, fine, plastic, light yellow tan; contains some medium sand to fine gravel intermixed	10	138
Clay, silty, yellow, light gray streaks; contains some limy clay	4	142
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Shale, clay, dirty brown gray	4	146
Shale, clay, dark bluish gray	4	150

21. *Sample log of test hole 21 in the SW cor. sec. 27, T. 19 S., R. 34 W., drilled by State Geological Survey, 1940. Surface altitude, 3,089.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil, fine, sandy, dark brown	1	1
Silt and fine sand, limy, light tan	11	12
Clay, silty, tan; contains some gastropod fragments	3	15
Clay, light gray, and limy silt	2	17
Caliche, soft, tan to light gray, interbedded in plastic limy silt and clay	5	22
TERTIARY—Pliocene		
Ogallala formation		
Caliche, soft, tan to light gray	4	26
Caliche, tan to buff, and cemented fine sand	6	32
Mortar bed, brown; composed of fine sand to fine gravel, not much fine sand	7	39
Caliche, tan, and cemented fine sand	4	43
Clay, silty, tan; contains much fine to coarse sand	3	46
Sand, fine to coarse, brown	4	50
Silt, limy, plastic, pale green tan, and fine sand; contains scattered caliche pebbles	4	54
Sand, fine to coarse, brown; contains silt and clay binder intermixed	3	57
Mortar beds alternating with brown plastic fine to coarse sand	8	65
Mortar bed, hard, tan to gray brown; harder from 65 to 67 feet; composed largely of fine to coarse gravel	5	70
Gravel, fine to coarse, semiconsolidated; contains some hard limonite fragments and light gray caliche from 92 to 93 feet	30	100
Sand, medium, to fine gravel, semiconsolidated; contains scattered yellow-tan silty clay	20	120
Sand and gravel, semiconsolidated	18	138
Silt, plastic, soft, yellow tan, and fine sand	4	142
Sand, coarse, to fine gravel, rounded quartz; contains some angular chertlike caliche pebbles	3	145
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Shale, clay, dirty brown gray	5	150

22. *Sample log of test hole 22, in NE cor. sec. 24, T. 20 S., R. 33 W., drilled by State Geological Survey, 1941. Surface altitude, 2,925 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil, sandy, brown	2	2
Silt, light tan, and fine sand	5	7
Clay, silty, light greenish tan to gray; contains gastropods	5	12
Clay, silty, light greenish gray; contains gastropods, and a few yellow-green iron streaks	12	24
Clay, silty, fine sandy, light greenish gray; contains gastropods, scattered sand and gravel pebbles, and a few yellowish lime streaks	6	30
Clay, silt, pinkish gray tan	5	35
Clay, silty, fine sandy, black and gray	4	39
Silt, light green, and fine sand; contains gastropods	4	43
Sand, medium, to medium gravel, brown; contains some waterworn caliche pebbles; mostly quartz and granites.	13	56
Clay, silty, fine sandy, tan, light green tinge at base; contains gastropods	11	67
Sand, medium, to fine gravel, brown; major grade is quartz fine gravel; contains some plastic silt fragments intermixed	21	88
Clay, fine sandy, silty, light gray, lime intermixed	6	94
Caliche bed, light gray	1	95
Sand, fine and medium, plastic, pink tan; contains a few lime streaks	9	104
Caliche, light gray; contains some plastic limy silt and fine sand intermixed	8	112
TERTIARY—Pliocene		
Ogallala formation		
Caliche, light gray, tan; contains some limy silt and fine sand intermixed and a thin limestone bed at 111 feet.	8	120
Caliche, light gray, tan	16	136
Sand, fine to medium, tan to brown; contains some light gray limy silt and gravel intermixed at the base	7	143
Sand and gravel, poorly sorted; small amount of silt and fine sandy clay intermixed; thin bed of caliche at 146; drilled faster from 160 to 163 feet	20	163
Clay, fine sandy, silty, yellowish tan; contains a lens or two of sand and gravel	6	169
Sand, coarse, to coarse gravel, brown; contains a few caliche fragments; mostly pink quartz and granite	13	182
Clay, silty, faded yellow	3	185
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Shale, clay, dark gray to black	5	190

23. *Sample log of test hole 23 in the SE¼ SW¼ sec. 32, T. 20 S., R. 34 W., drilled by State Geological Survey, 1940. Surface altitude, 3,089.5 feet.*
(Samples studied by Perry McNally, H. A. Waite, Bruce F. Latta and Thad McLaughlin.)

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil, sandy, dark	1.5	1.5
Silt and sand, fine, limy, tan; contains gastropods	11	12.5
Silt and sand, fine, pinkish brown, with thin limy zones	5.5	18
Caliche, soft, tan to light gray	6	24
Sand, fine to medium, pinkish brown; contains some silt	2.5	26.5
Caliche, soft, tan gray, and clay, limy	6.5	33
Clay, tan gray	5	38
Sand, medium, to gravel, medium, brown	16.5	54.5
TERTIARY—Pliocene		
Ogallala formation		
Sand and gravel, lime-cemented, gray	4	58.5
Sand, medium, to gravel, coarse, brown; contains few lime-cemented zones	37	95.5
Silt, sandy, light gray yellow	7.5	103.5
Silt, sandy, lime-cemented, soft, light gray; contains lenses of brown, fine to medium sand; also contains fragments of *Celtis willistoni* (?) and *Biorbia fossilia* (?)	15.5	119
CRETACEOUS (Upper)		
Niobrara formation—Smoky Hill chalk member		
Chalk, silty, soft, light yellow to light gray	15	134
Shale, chalky, soft, dark blue gray; contains few fragments of white bentonite	6	140
Shale, chalky, dark blue gray; contains interbedded lighter gray hard sandy shale	14	154
Fort Hays limestone member		
Shale, chalky, dark gray to white	10	164
Chalk, light gray to white	3	167
Shale, chalky, light gray to dark gray	5	172
Chalk, light gray to white	12	184
Shale, chalky, dark gray	1	185
Chalk, light gray to white	15	200
Shale, chalky, light gray to white	19	219
Carlile shale—Codell sandstone and Blue Hill shale members		
Shale, sandy, noncalcareous, dark gray	33	252
Shale, sandy, light to dark gray	1.5	253.5
Shale, clayey, noncalcareous, dark gray to black	16.5	270

24. *Driller's log of test hole of W. D. Haston in the SW¼ sec. 3, T. 17 S., R. 31 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	15	15
TERTIARY—Pliocene		
Ogallala formation		
Gyp	60	75
Clay and gyp	43	118
Sand, fine	42	160
CRETACEOUS (Upper)		
Niobrara formation		
Shale	..	160

25. *Driller's log of irrigation well (37) of William Rodenburg in the SW¼ NW¼ sec. 25, T. 17 S., R. 31 W. Ben Hasz, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	3	3
Clay, brown	22	25
TERTIARY—Pliocene		
Ogallala formation		
Gyp rock	40	65
Sand rock	20	85
Clay, brown	10	95
Sand, fine	20	115
Sand and gravel	45	160
(Test did not reach shale)		

26. *Driller's log of irrigation well (44) of Ed Brookover in the NE¼ SE¼ sec. 22, T. 17 S., R. 32 W. Earl Brookover, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	30	30
TERTIARY—Pliocene		
Ogallala formation		
Gyp, soft white rock	16	46
Sand and clay streaks	12	58
Sand, cemented, hard	3	61
Sand, cemented, loose streaks	10	71
Sand, dry, loose	2	73
Sand, cemented, and gyp, fairly hard	5	78
Rock, hard, white	6	84
Gyp	7	91
Conglomerate, gyp, sand, and clay	4	95
Clay, sandy	6	101
Sand, medium	2	103

	Thickness, feet	Depth, feet
Sand, cemented, and clay streaks	7	110
Rock, hard, white	5	115
Clay, sandy	6	121
Sand, fine, muddy	4	125
Sand, fine, loose; casing settled in hole from own weight during drilling operations	20	145
Sand, fine, similar to above; necessary to drive casing in this interval	21	166
CRETACEOUS (Upper)		
Niobrara formation		
Shale, chalky, yellow	2	168
Chalk and shale, light blue gray	7	175

27. *Driller's log of test well (46) of L. A. Callen in the SE cor. SW¼ sec. 35, T. 17 S., R. 32 W. George Weishaar, driller.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil	30	30
TERTIARY—Pliocene		
Ogallala formation		
Gyp	13	43
Sand, dry	7	50
Gyp	20	70
Clay	10	80
Gyp	10	90
Clay	10	100
Gyp and clay	15	115
Sand, fine	8	123
Sand, dirty, fine	4	127

28. *Driller's log of test hole of Elmer Rudolph in the NW cor. SE¼ sec. 27, T. 17 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil	80	80
Sand	5	85
TERTIARY—Pliocene		
Ogallala formation		
Clay and gyp	15	100
Sand	5	105
Rock	8	113
Sand	7	120
Rock	13	133
CRETACEOUS (Upper)		
Niobrara formation		
Shale	0	133

29. *Driller's log of test hole of Ira Riney in the NW cor. NE¼ sec. 14, T. 18 S., R. 32 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	30	30
TERTIARY—Pliocene		
Ogallala formation		
Gyp and hard sand	36	66
Sand	10	76
Rock, hard	2	78
Sand	4	82
Clay	8	90
Sand, cemented	10	100
(Did not encounter shale.)		

30. *Driller's log of irrigation well (85) of J. E. Kirk in the SE¼ NW¼ sec. 21, T. 18 S., R. 32 W. Ted Guyer, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil and clay	20	20
TERTIARY—Pliocene		
Ogallala formation		
Gyp and boulder	18	38
Sand and rock (falls in hole)	10	48
Clay	10	58
Sand and gravel (core barrel used 65-71)	13	71
Sand	2	73
Rock, hard	1	74
Sand, fine (from 73-78 feet tough clay intermixed)	3	77
Rock	1	78
Sand	3	81
Sand and rock, intermixed with tough clay	6	87
Rock and sand	5	92
Rock, hard	19	111
Gravel, coarse	7	118
Sand and gravel, sticky	14	132
CRETACEOUS (Upper)		
Niobrara formation		
Shale, chalky, yellow	10	142
Shale, brownish-gray	59	201
Total depth of finished well, 125.9 feet.		

31. *Driller's log of irrigation well (95) of R. B. Christy in the NE¼ sec. 30, T. 18 S., R. 32 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	26	26
Sand	4	30
Clay	21	51
Sand	5	56
Clay	9	65
Sand	7	72
Clay	9	81
Sand	13	94
Clay	4	98
Sand, good	25	123
(Did not hit shale.)		

32. *Driller's log of domestic well of R. B. Christy in the SE¼ sec. 30, T. 18 S., R. 32 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	90	90
Clay, sandy	5	95
Clay	57	152
CRETACEOUS (Upper)		
Niobrara formation		
Shale		152
(This test was drilled to prospect for a soft-water supply just east of house, where present windmill is located.)		

33. *Driller's log of test hole of George Mulch in the NE cor. SW¼ sec. 4, T 18 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	Depth feet
QUATERNARY—Pleistocene		
Soil	57	57
Sand	8	65
TERTIARY—Pliocene		
Ogallala formation		
Rock	20	85
Sand, hard	14	99
Rock	2	101
Gyp and clay	19	120
Sand, fine	22	142
CRETACEOUS (Upper)		
Niobrara formation		
Shale	1	143

34. *Driller's log of test hole of W. D. Luke in the NW¼ SW¼ sec. 14, T. 18 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	47	47
Sand	7	54
TERTIARY—Pliocene		
Ogallala formation		
Gyp	6	60
Sand	7	67
Rock, very hard (glass rock)	9	76
Sand and gravel, good	55	131
CRETACEOUS (Upper)		
Niobrara formation		
Shale, blue	0	131

35. *Driller's log of test hole of Joe Knipp in the SW cor. NE¼ sec. 19, T. 18 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	55	55
TERTIARY—Pliocene		
Ogallala formation (?)		
Sand	35	90
Clay	5	95
Sand	26	121
CRETACEOUS (Upper)		
Niobrara formation		
Shale	0	121

36. *Driller's log of irrigation well (124) of G. H. Cheney in the SW¼ NE¼ sec. 22, T. 18 S., R. 33 W. Furnished by Mr. Cheney, owner, from memory.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil and clay	36	36
Sand	24	60
TERTIARY—Pliocene		
Ogallala formation		
Sand, cemented, and gravel	10	70
Gravel, coarse	20	90
Sand and gravel, coarse	33	123

37. *Driller's log of irrigation well (125) of Earl Brookover in the SW¼ NW¼ sec. 23, T. 18 S., R. 33 W. Furnished by Earl Brookover, owner.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	50	50
Sand	12	62
Clay	11	73
Sand	2	75
TERTIARY—Pliocene		
Ogallala formation (?)		
Clay	2	77
Sand and gravel	12	89
Clay with sand streaks	19	108
Sand and gravel	9	117
Clay	0.5	117.5
Sand	25.5	143
Clay	2	145

38. *Driller's log of test hole of Earl Brookover in the SW¼ sec. 23, T. 18 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	80	80
TERTIARY—Pliocene		
Ogallala formation		
Gyp	10	90
Clay	26	116
Sand	12	128
Rock	1	129
Sand	4	133
Clay	19	152
Sand, fine	10	162
Sand, hard	16	178
CRETACEOUS (Upper)		
Niobrara formation		
Shale	..	178

39. *Driller's log of test hole of Charles Harpham 500 feet south of his house. NE cor. SE¼ sec. 23, T. 18 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	35	35
Sand	5	40
Clay	60	100
Sand, fine	10	110
TERTIARY—Pliocene		
Ogallala formation		
Gyp and clay	35	145
CRETACEOUS (Upper)		
Niobrara formation		
Shale	..	145

40. *Driller's log of test hole of C. T. Hutchins in the SW cor. sec. 35, T. 18 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	60	60
TERTIARY—Pliocene		
Ogallala formation		
Gyp	10	70
Clay	55	125
CRETACEOUS (Upper)		
Niobrara formation		
Shale	..	125

41. *Driller's log of irrigation well (138) of M. K. Armantrout in the NE¼ NE¼ sec. 36, T. 18 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	16	16
Sand	7	23
Clay	23	46
Sand	35.5	81.5
(Wesley Weishaar reports the depth to shale at this site is about 116 feet.)		

42. *Driller's log of test hole near irrigation well (147) of Claude Hughes in the SW¼ SW¼ sec. 24, T. 18 S., R. 34 W. George Weishaar, driller*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	20	20
TERTIARY—Pliocene		
Ogallala formation		
Gyp	16	36
Sand and clay	24	60
Sand, hard	20	80
Gyp and clay	20	100
Sand, hard	23	123
Sand, good	3	126
Sand, hard	6	132
CRETACEOUS (Upper)		
Niobrara formation		
Shale, yellow	0	132

43. *Driller's log of test holes of Frank Robb in the NW cor. SW¼ sec. 13, T. 18 S., R. 35 W., Wichita County. Earl Brookover, driller. Surface altitude, 3,165.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil and clay	17	17
TERTIARY—Pliocene		
Ogallala formation		
Gyp	1	18
Clay and gyp	4	22
Gyp	8	30
Rock and gyp	4	34
Sand, fine, tight	10	44
Sand, coarse, slightly loose	3	47
Rock, hard, cemented sand and gyp	2	49
Sand	1	50
Rock, hard	3	53
Sand, fine	11	64
Rock	1	65
Clay, sandy	6	71
Rock	0.5	71.5
Sand, cemented, and gyp (mostly sand)	4.5	76
Rock, hard	1.5	77.5
Sand, cemented	1	78.5
Rock, hard	1	79.5
Sand, cemented	2.5	82
Rock, hard	1	83
Sand, cemented	1	84
Rock, hard	1	85
Sand, fair, somewhat tight	11	96
Clay, fine sandy	18	114
Sand, fair, somewhat tight	3	117
Sand, fine, tight	8	125
Clay	1	126
Sand, tight	9	135
CRETACEOUS (Upper)		
Niobrara formation		
Shale, chalky, yellow	3	138

44. *Driller's log of irrigation well (170) of A. J. Collingwood in the SW¼ SE¼ sec. 11, T. 19 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	74	74
Sand and clay	1	75
Sand	4	79
Clay	1	80
Sand, fine	5	85
Sand, fine, a little coarser	12	97
Clay	1	98

Sand	2	100
Clay	4	104
Sand	2	106
Clay	4	110

45. *Driller's log of irrigation well (172) of George L. Duff in the NW cor. SW¼ SW¼ sec. 12, T. 19 S., R. 33 W. Earl Brookover, driller*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil and clay	66	66
Sand, coarse, tight	3	69
Clay, sandy	3	72
Sand, loose, good	4	76
Clay streak	1	77
Sand, fine	5	82
Sand, loose, good	5	87
Clay, soft	4	91
Sand and clay streak	2	93
CRETACEOUS (Upper)		
Niobrara formation		
Shale, chalky, bluish gray	5	98

46. *Driller's log of irrigation well (180) of Otto Geeseka in the SE¼ SW¼ sec. 15, T. 19 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Clay	50	50
Sand, unconsolidated	8	58
Clay	35	93
Sand, fine	3	96
Sand, good	8	104
Sand, fine	6	110
Sand, fine, hard, or clay	1	111
Sand, fine	2	113
Sand	19	132
Clay	1	133
Sand	2	135
CRETACEOUS (Upper)		
Niobrara formation		
Shale, chalky, yellow	2	137

47. *Driller's log of irrigation well (179) of Otto Geeseka in the NW¼ SE¼ sec. 15, T. 19 S., R. 33 W. Ted Patton, driller.*

QUATERNARY—Pleistocene	*Thickness, feet*	*Depth, feet*
Clay	49	49
Sand	5	54
Clay, sandy	26	80
Sand	1	81
Clay	2	83
Sand	1	84
Sand and clay	2	86
Sand, fine	8	94
Sand and gravel	10	104
Clay and fine sand	5	109
Sand, coarse, good	11	120
Sand	12	132
Clay, brown	1	133

48. *Driller's log of test hole of Bert C. Deng in the NW cor. NE¼ sec. 19, T. 19 S., R. 33 W. George Weishaar, driller.*

QUATERNARY—Pleistocene	*Thickness, feet*	*Depth, feet*
Soil	78	78
TERTIARY—Pliocene		
Ogallala formation		
Rock	22	100
Sand, fine	6	106
Clay	14	120
CRETACEOUS (Upper)		
Niobrara formation		
Shale	0	120

49. *Driller's log of irrigation well (182) of J. A. Sweeney in the SW¼ NE¼ sec. 20, T. 19 S., R. 33 W. Ted Patton, driller.*

QUATERNARY—Pliestocene	*Thickness, feet*	*Depth, feet*
Clay	25	25
Sand	2	27
Clay, sandy	2	29
Clay	32	61
Clay, sandy	2	63
Sand and gravel	4	67
Clay	1.5	68.5
Sand, fine	1.5	70
Sand and gravel	9	79
Sand	3	82
Sand and gravel	18	100
Clay	1	101
Sand, fine	2	103
Clay, sandy	2	105

50. *Driller's log of irrigation well (190) of C. W. Flood in the SW¼ NW¼ sec. 22, T. 19 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	44	44
Sand and clay	4	48
Sand and gravel	10	58
Sand, fine	2	60
Clay	6	66
Sand	3	69
Clay	12	81
Sand	5	86
Sand, slightly coarser	2	88
Sand, fine	15	103
Sand and gravel	5	108
Sand and gravel, tight, interbedded clay, sandy brown	3	111
Sand and a little gravel	11	122
Sand, good, loose	6	128
Clay	3	131
CRETACEOUS (Upper)		
Niobrara formation		
Yellow clay, hard	1	132

51. *Driller's log of irrigation well (197) of Marvin Bastin in the SW¼ SE¼ sec. 25, T. 19 S., R. 33 W. Ted Guyer, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil and clay	25	25
Sand, dry	11	36
Clay	6	42
Sand	3	45
Gravel, medium	7	52
Gravel, coarse	8	60
Clay, sandy	12	72
Sand, water	5	77
Clay and "gyp"	4	81
Clay, sandy	6	87
Gravel, medium	12	99
Clay	5	104
Gravel; contained clay balls	4	108
Clay, yellow gray to rusty, intermixed with gravel	3	111

52. *Driller's log of irrigation well (216) of Lee Collingwood Estate in the SW¼ SW¼ sec. 33, T. 19 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	13	13
Sand	4	17
Clay	2	19
Sand	2	21
Clay	18	39
Sand	11	50
Clay	31	81
Sand, good	15	96
Sand, finer than above	15	111
Sand and some gravel; contains clay balls	7	118
Sand and gravel	10	128
TERTIARY—Pliocene		
Ogallala formation (?)		
Sand, fine, white, somewhat hard and tight	6	134
Clay	4	138

53. *Driller's log of irrigation well (220) of Nancy D. Curtis in the SW¼ NW¼ sec. 36, T. 19 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	24	24
Sand	10	34
Clay	12	46
Sand and gravel	13.5	59.5
Clay, brown	4.5	64

54. *Driller's log of irrigation well (235) of Frank Roark in the NE¼ NW¼ sec. 7, T. 20 S., R. 32 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	48	48
Clay, sandy	6	54
Sand	3	57
Sand, good	10	67
Clay	3	70
Sand, fine	17.5	87.5
Clay, brown	1	88.5

55. *Driller's log of test hole of W. R. E. Hall in the SW¼ SW¼ sec. 32, T. 30 S., R. 32 W. C. M. Waddell, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	25	25
Sand	23	48
Clay	32	80
Sand	2	82
Clay	18	100
Rock	15	115
Sand	5	120
Sand rock formation	10	130
Sand	5	135
Rock sand formation	15	150
Clay, yellow	15	165
CRETACEOUS (Upper)		
Niobrara formation		
Shale, blue gray	..	165

56. *Driller's log of irrigation well (241) of Mrs. Rosine Smith in the NW¼ NW¼ sec. 2, T. 20 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	12	12
Sand	23	35
Clay	9	44
Sand	6	50
Clay	5	55
Sand	11	66
Clay	3.5	69.5
Sand, good	31.5	101
Sand, fine	4	105

57. *Driller's log of irrigation well (243) of A. J. Collingwood in the NW cor. SE¼ sec. 2, T. 20 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	24	24
Sand	25	49
Sand and gravel, good	5	54
Sand	5	59
TERTIARY—Pliocene		
Ogallala formation		
Sand, gravel, and some rock, loose	2	61
Sand, fine	1	62
Sand	4	66
Clay, sandy	4	70
Clay	23	93
Sand, fine	6	99
Sand, good	6	105
Clay, brown	13	118

58. *Driller's log of irrigation well (249) of Ted Patton in the NW¼ NW¼ sec. 9, T. 20 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	30	30
Sand and clay streaks	5	35
Clay	25	60
Sand	14	74
Sand, fine, and clay	4	78
TERTIARY—Pliocene		
Ogallala formation		
Sand, hard, cemented streaks	5	83
Sand, good, and some gravel	14	97
Gravel, good	2	99
Clay	7	106

59. *Driller's log of irrigation well (251) of Earl Weisenberger in the NE¼ SW¼ sec. 10, T. 20 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	51	51
Sand and clay	7	58
Clay, little sand	8	66
Sand, fine	10	76
Clay and streaks of sand	5	81
Sand and gravel, good	23	104
Clay	2	106

60. *Driller's log of irrigation well (250) of Earl Weisenberger in the NW¼ SE¼ sec. 10, T. 20 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	43	43
Sand	3	46
Clay	16	62
Clay, white, hard	2	64
Clay	17	81
Sand, fine, and clay	2	83
Clay	6	89
Sand and gravel	13	102
Clay	1.5	103.5
Rock	0.5	104

61. *Driller's log of irrigation well (252) of C. C. Hamlin in the NE¼ NW¼ sec. 11, T. 20 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	15	15
Sand	3	18
Clay	13	31
Sand	6	37
Clay	13	50
Clay and sand	10	60
Clay	1	61
Sand	2	63
Clay	24	87
Sand and gravel	5	92
Sand, fine	1	93
Sand, good	14.5	107.5
Clay	7.5	115

62. *Driller's log of test hole of L. F. Roark drilled about 400 feet southeast of irrigation well 261 in the NW¼ NW¼ sec. 16, T. 20 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	57	57
Clay, sandy	3	60
Clay	2	62
Sand	6	68
Clay, sandy	6	74
TERTIARY—Pliocene		
Ogallala formation		
Rock, soft (sandrock)	1	75
Clay and rock	5	80
Clay	11	91
Sand	8	99
Rock	1	100
Sand	5	105
Sand, cemented, hard (sandrock)	9	114
Sand, fine, hard	3	117
Sand and gravel	7	124
Clay (bottom 4 or 5 feet yellow)	10	134
CRETACEOUS (Upper)		
Niobrara formation		
Shale, chalky, bluish gray	1	135

63. *Driller's log of irrigation well (263) of L. F. Roark in the SW¼ SE¼ sec. 16, T. 20 S., R. 33 W. Ted Patton, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	57	57
Gravel	6	63
Clay	14	76
TERTIARY—Pliocene		
Ogallala formation		
Rock and clay (almost entirely rock)	4	80
Sand, clay, and rock	10	90
Clay	5	95
Sand, fine, loose	10	105
Sand, cemented (hole would stand)	13	118
Sand, medium, loose	32	150
(Did not encounter shale)		

64. *Partial driller's log of oil test (Dague No. 3) of the Atlantic Refining Company in the Cen. NE¼ NW¼ sec. 14, T. 20 S., R. 33 W.*

QUATERNARY and TERTIARY	Thickness, feet	Depth, feet
Undifferentiated Pleistocene deposits and Ogallala formation		
Clay and sand	195	195
CRETACEOUS (?)		
Limestone	15	210
Shale	40	250
Shale, limy	65	315
Limestone	25	340
Shale	10	350
Shale, limy	40	390
Shale (?)	70	460
Sand and shale	30	490
Shale	50	540
Shale, limy	165	705
Limestone	15	720
Lime and sand	80	800
Sand	25	825
Shale, limy	45	870
Sand and shale	115	985
Shale, limy	25	1,010
Limestone	25	1,035
Sand	25	1,060
Sand and shale	20	1,080
Shale (?)	65	1,145
Shale, limy	35	1,180
PERMIAN (?)		
Top of redbeds		1,180

65. *Partial driller's log of oil test (Harvey Dague No. 1) of the Atlantic Refining Company in the Cen. SW¼ NW¼ sec. 14, T. 20 S., R. 33 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Undifferentiated Pleistocene deposits and Ogallala formation		
Clay	240	240
CRETACEOUS (?)		
Chalk, soft	60	300
No description	260	560
Limestone	40	600
Shale and shells	210	810
Sandstone	395	1,205
PERMIAN		
Redbeds	...	1,205

66. *Partial driller's log of oil test (Harvey Dague No. 2) of the Atlantic Refining Company in the Cen. SE¼ NW¼ sec. 14, T. 20 S., R. 33 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	35	35
TERTIARY—Pliocene		
Ogallala formation		
Sand and clay	150	185
CRETACEOUS (?)		
Limestone (Niobrara formation?)	25	210
No description	460	670
Sandstone	30	700
Shale, sandy, and lime	35	735
Shale, limy	120	855
Sand, and sandy shale	75	930
Lime and sand	30	960
Shale	40	1,000
Shale, limy	40	1,040
Sand	40	1,080
Shale, limy	130	1,210
PERMIAN		
Redbeds (top of redbeds)	..	1,210

67. *Partial driller's log of oil test (Pile No. 1) of the Atlantic Refining Company in the Cen. NE¼ SW¼ sec. 14, T. 20 S., R. 33 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Clay	65	65
TERTIARY—Pliocene		
Ogallala formation	115	180
CRETACEOUS (Upper)		
Niobrara formation	20	200
PERMIAN		
Top of redbeds	..	1,230

68. *Partial driller's log of oil test (Mark 1-B) of the Atlantic Refining Company in the Cen. NW¼ SW¼ sec. 14, T. 20 S., R. 33 W. Surface altitude, 2,945 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY and TERTIARY		
Undifferentiated Pleistocene deposits and Ogallala formation		
Clay	50	50
Sand and gravel	130	180
CRETACEOUS (?)	980	1,110
PERMIAN	..	1,160

69. *Partial driller's log of oil test (Mark No. 2B) of the Atlantic Refining Company in the Cen. W½ SW¼ sec. 14, T. 20 S., R. 33 W.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Clay	50	50
TERTIARY—Pliocene		
Ogallala (?) formation		
Sand	40	90
Gravel	30	125
CRETACEOUS (?)		
Niobrara formation (no description)	305	430
No description	110	540
Sand	60	600
Lime and shale, sandy	300	900
Shale, limy	130	1,030
Shale	160	1,190
PERMIAN		
Redbeds (top of redbeds)	..	1,190

70. *Partial driller's log of oil test (Pile No. 3) in the Cen. E½ SW¼ sec. 14, T. 20 S., R. 33 W.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Clay	40	40
Sand and clay	55	95
TERTIARY—Pliocene		
Ogallala formation		
Shale, limy	35	130
Sand and clay	105	180
CRETACEOUS (?)		
Shale, limy	100	205
Shale	35	240
Limestone	90	330
Shale (?)	170	500
Sand and shale	85	585
Shale, limy	140	725
Sand and shale	20	745
Lime, sandy, and shale	20	765
Shale	65	830

	Thickness, feet	Depth, feet
Shale, limy	40	870
Sand	20	890
Shale	5	895
Sand and shale	45	940
Sand	15	955
Shale, limy	115	1,070
Sand	35	1,105
Shale	10	1,115
Sand and shale	85	1,200
PERMIAN		
Top of redbeds	...	1,200

71. *Partial driller's log of oil test (Pile No. 2) of the Atlantic Refining Company in the Cen. NW¼ SE¼ sec. 14, T. 20 S., R. 33 W. Surface altitude, 2,940 feet.*

QUATERNARY and TERTIARY	Thickness, feet	Depth, feet
Undifferentiated Pleistocene deposits and Ogallala formation		
Clay	60	60
Sand and gravel	130	190
CRETACEOUS (?)		
Limestone	25	215
Shale	325	540
Limestone	50	590
Shale	75	665
Sandstone and interbedded shale	570	1,235
PERMIAN (?)		
Redbeds		

72. *Partial driller's log of oil test (Mark No. 1-C) of the Atlantic Refining Company in the Cen. NE¼ SE¼ sec. 15, T. 20 S., R. 33 W. Surface altitude, 2,951 feet.*

QUATERNARY and TERTIARY	Thickness, feet	Depth, feet
Undifferentiated Pleistocene deposits and Ogallala formation		
Soil and clay	65	65
Clay and sand	125	190
CRETACEOUS (?)		
Limestone	15	205
Shale	60	265
Shale, limy	55	320
Shale (?)	210	530
Shale, limy	210	740
Shale (?)	40	780
Shale, limy	120	900
Limestone	20	920
Shale (?)	190	1,110
Shale, limy	45	1,155
PERMIAN (?)		
Top of redbeds	..	1,155

73. *Driller's log of test hole of Marion Hutchins in the Cen. NE¼ sec. 21, T. 20 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil	74	74
TERTIARY—Pliocene		
Ogallala formation		
Rock	21	95
Clay	5	100
Sand	58	158
CRETACEOUS (Upper)		
Niobrara formation		
Shale	..	158

74. *Driller's log of test hole near irrigation well (266) of Marion Hutchins in the NW cor. SW¼ NE¼ sec. 21, T. 20 S., R. 33 W. George Weishaar, driller.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene		
Soil	14	14
TERTIARY—Pliocene		
Ogallala formation		
Gyp	71	85
Sand, fine	5	90
Gyp and fine sand	35	125
CRETACEOUS (Upper)		
Niobrara formation		
Shale	..	125

75. *Partial driller's log of oil test (Clayton Mark No. 1) of the Atlantic Refining Company in the Cen. SE¼ SE¼ sec. 28, T. 20 S., R. 33 W.*

	Thickness, feet	*Depth, feet*
QUATERNARY and TERTIARY		
Undifferentiated Pleistocene deposits and Ogallala formation		
Clay and sand	190	190
CRETACEOUS (?)		
No description	45	235
Shale and shells	15	250
No description	300	550
Limestone	35	585
Shale and shells	165	750
Shale and lime	100	850
Sandstone	35	885
Shale and lime	85	970
Shale	130	1,100
Sandstone	10	1,110
PERMIAN		
Redbeds (top of redbeds)	..	1,110

76. *Driller's log of test hole of M. Lang in the NE cor. sec. 8, T. 20 S., R. 34 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	26	26
Sand	32	58
Clay, yellow	36	94
Sand, fine	2	96
Clay	9	105
CRETACEOUS (Upper)		
Niobrara formation		
Shale	2	107

77. *Driller's log of test hole of Ruben Crist in the NW¼ SW¼ sec. 25, T. 20 S., R. 34 W. George Weishaar, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil	22	22
TERTIARY—Pliocene		
Ogallala formation		
Gyp	38	60
Clay	10	70
Sand, fine, hard	10	80
Clay	12	92
CRETACEOUS (Upper)		
Niobrara formation		
Shale	..	92

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INDEX

PAGE

21—6532

MAP OF SCOTT COUNTY

Showing the depths to Water Level and the Location of Wells for which Records are given

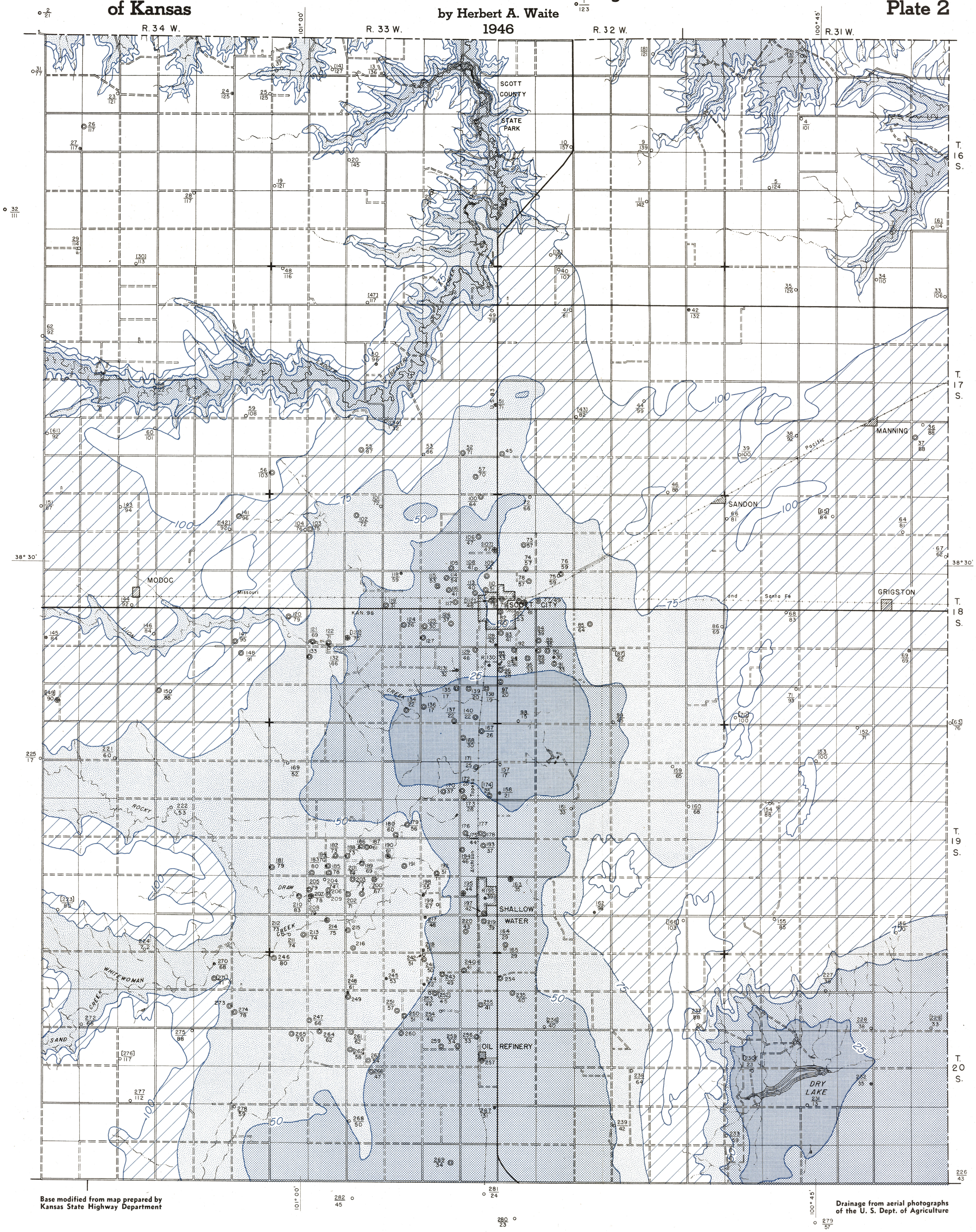
by Herbert A. Waite

1946

State Geological Survey of Kansas

Bulletin 66

Plate 2



EXPLANATION

- Less than 25
- 25-50
- 50-75
- 75-100
- More than 100

Depth to water level below land surface, in feet

- Domestic and stock wells
- Irrigation well
- Industrial well
- Public supply well
- Observation well
- Spring

(235) / 40

Upper number is well number used in well tables. Brackets around upper number, (235), indicate that analysis of water is given. Lower number is depth to water level below land surface, in feet.

- Federal or State highway
- Graded road
- Ungraded road
- Section line (no road)
- Railroad
- Perennial stream
- Intermittent stream

Base modified from map prepared by Kansas State Highway Department

Drainage from aerial photographs of the U. S. Dept. of Agriculture

0 1 2 3 4 5 6

scale in miles

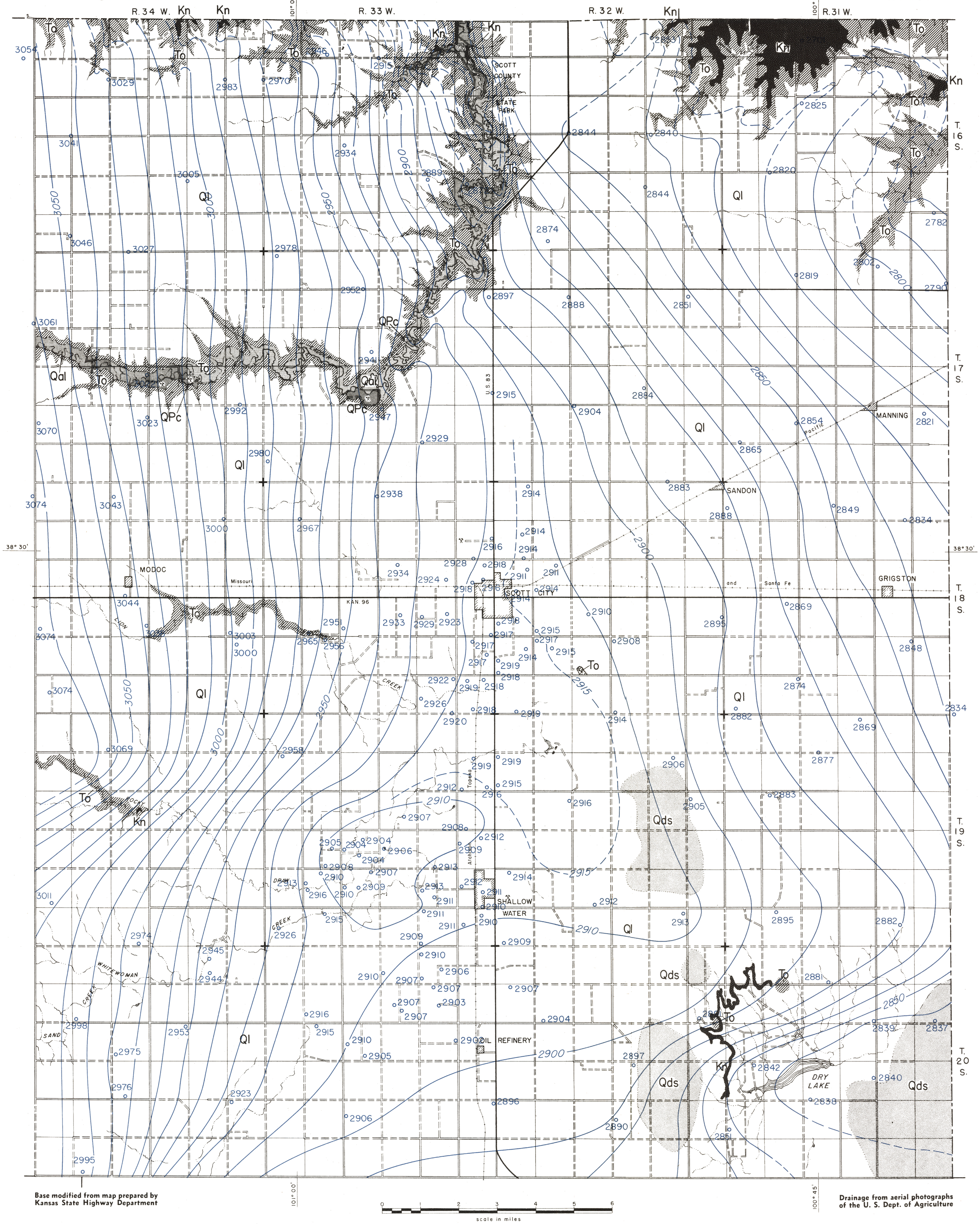
MAP OF SCOTT COUNTY

Showing Geology and Water-Table Contours, 1940

State Geological Survey of Kansas

Bulletin 66
Plate 1

by Herbert A. Waite



EXPLANATION

QUATERNARY

RECENT

Qal — Alluvium

Gravel, sand, silt, and clay comprising stream deposits in Ladder (Beaver) creek valley. The alluvium yields small supplies of relatively hard water to wells in Ladder creek valley.

Qds — Dune sand

Fine to medium eolian sand. Sand dunes do not supply water directly to wells but are important as favorable intake areas for ground-water recharge.

PLEISTOCENE

Ql — Loess

Light buff silt containing fine sand and some clay. Loess deposits occur mostly above the water table and are relatively impermeable.

QPc — Channel deposits

Gravel, sand, silt, and clay comprising isolated remnants of channel deposits along the valley sides of Ladder (Beaver) creek. Channel deposits are relatively permeable but generally occur above the water table.

TERTIARY

PLIOCENE

To — Ogallala formation

Gravel, sand, silt, caliche and some silty clay, contains hard and soft layers of sandstone and conglomerate, much of which is cross-bedded and cemented with lime. Constitutes the principal source of water for most of Scott county. Yields adequate supplies of moderately hard water to domestic, stock, industrial, and public supply wells. Yields large supplies of water to irrigation wells in the Scott basin.

CRETACEOUS

Kn — Niobrara formation

Alternating beds of soft chalk and chalky shale consisting of the Smoky Hill chalk member underlain by massive chalk beds separated by thin, soft, chalky shale comprising the Fort Hays limestone member. Not important as a water-bearing formation in Scott county. Yields limited supplies of hard to extremely hard water to wells in the southeastern quarter of the county where the overlying Ogallala formation is relatively thin. Water occurs principally along fractures and bedding planes.

Federal or State highway
Graded road
Ungraded road
Section line (no road)
Railroad
Perennial stream
Intermittent stream

Contour interval 10 feet

2850 — Water-table contours based on instrumental levels

○ 2882 — Well location. Number refers to altitude of water level