Geology and Ground-Water Resources of Gove County, Kansas

By

WARREN G. HODSON and KENNETH D. WAHL

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FRANKLIN D. MURPHY, M. D.,
Chancellor of the University, and ex efficio Director of the Survey

FRANK C. FOLEY, Ph. D.,
State Geologist and Director

Division of Ground Water

V. C. FISHEL, B. S.
Engineer in Charge

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By WARREN G. HODSON and KENNETH D. WAHL
(U. S. Geological Survey)

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WARREN G. HODSON and KENNETH D. WAHL

ABSTRACT

This report describes the geography, geology, and ground-water resources of Gove County, in west-central Kansas in the High Plains physiographic section. The county has an area of approximately 1,070 square miles and had a population of about 4,200 in 1957.

The rocks that crop out in Gove County are sedimentary and range in age from Cretaceous to Recent. Chalk beds of the Fort Hays Chalk member of the Niobrara Chalk are the oldest rocks exposed in the county. They are overlain by the Smoky Hill Chalk, upper member of the Niobrara Chalk; the Smoky Hill crops out in much of the southern part of the county. It is overlain by the Pierre Shale, of Late Cretaceous age, which is exposed in a faulted area in the southwestern part of the county but in the northwestern part is found only in the subsurface. Fluviatile deposits of the Ogallala Formation, of Pliocene age, cover most of the northern part of Gove County. Unconsolidated continental deposits of fluviatile and eolian origin represent four stages of the Pleistocene Epoch. Loess classified as Loveland and Peoria Formations, of late Pleistocene age, mantles much of the interstream areas, particularly in the northern part of the county. Alluvium of Wisconsinan and Recent age fills the inner valleys of Smoky Hill River, Hackberry Creek, and Big Creek. Older alluvial deposits, of Illinoisan and Kansan age, dissected and in a high terrace position, occur along the larger streams in the county, chiefly along Smoky Hill River. The surface geology of Gove County is shown by a geologic map; cross sections illustrate the stratigraphic relations of the geologic formations.

Ground water is one of the principal natural resources of the county; most water supplies are obtained from wells. Moderate quantities of ground water are available from the Ogallala Formation and from alluvial deposits in Hackberry Creek and Big Creek valleys. About 1.2 million acre-feet of ground water is in storage in the Ogallala Formation in the northern two-fifths of Gove County. In the southern part, ground water is almost restricted to alluvial valleys. Moderate to large quantities of water are available from alluvial deposits in the Smoky Hill River valley. Only meager quantities, derived mostly from colluvial materials, are available in the interstream areas in the southern part of the county. A few wells in the southeastern part obtain water from the deeper-lying Dakota Formation.

The chemical quality of the ground water is closely related to geologic source, and distinctive types of water are characteristic of each water-bearing formation in the county. Ground water from the Ogallala Formation is fair to good. Water from the alluvium is generally very hard but otherwise suitable for most purposes.

Ground-water pumped for domestic and stock use in Gove County is estimated to be about 800 acre-feet per year. Approximately 500 acre-feet is pumped annually by municipal wells, and an estimated 6,000 acre-feet for irrigation.

Ground-water in the Ogallala Formation in the northern upland moves eastward down an average gradient of about 11 feet per mile. The rate of movement was calculated to be about 0.3 foot per day. The amount of ground water leaving the county underground is believed to be less than that entering the county; much of the difference is accounted for by seepage of ground water from the Ogallala Formation at the contact of the Ogallala on Cretaceous bedrock along Hackberry Creek and Big Creek valleys.

The field data upon which this report is based are given in tables. They include records of 309 wells and test holes, logs of 83 wells and test holes, and chemical analyses of water from 52 representative wells, 4 municipal supplies, and 1 sample from Smoky Hill River.

INTRODUCTION

Purpose and Scope of Investigation

This report gives the results of a study of the geology and ground-water resources of Gove County, Kansas. The study was designed to determine the availability and quantity of ground water in the county, to learn the geologic factors that control the occurrence of ground water, to determine the chemical characteristics of ground water in relation to geologic formations, and to serve as a guide to future ground-water development.

An investigation of the geology and ground-water resources of Gove County was begun by Willis D. Waterman, Geologist, U. S. Geological Survey, in the summer of 1952 and was continued during the spring of 1953. Owing to the resignation of Mr. Waterman, the project was reassigned in the summer of 1956 to the authors, who spent 2½ months during the summer and fall of 1956 and 2 weeks during the fall of 1957 in the field gathering most of the data upon which this report is based.

Nearly all water supplies in Gove County are obtained from wells. Irrigation has been practiced in the larger valleys for several years, but drought in recent years has increased the interest in irrigation. Interest has also turned to the upland areas, and in the fall of 1956 seven irrigation wells were obtaining ground water from the Ogallala Formation in the northern part of the county. Most of the irrigation wells in the county have been drilled since 1950, and an additional increase in the use of ground water for irrigation can be expected. At the present rate of withdrawal, the danger of seriously depleting the ground-water supply seems slight, but there is a definite need for adequate understanding of the quantity and quality of water available from sources now being used, of possible additional sources, and of measures that may be necessary to safeguard their continuance.

This study was made as a part of the co-operative ground-water program begun in 1937 by the State Geological Survey of Kansas and the United States Geological Survey, in co-operation 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.

Location and Extent of Area

Gove County is in the third tier of counties south of the Nebraska border and the third county east of the Colorado border. It contains 30 townships, from T. 11 S. to T. 15 S. and from R. 26 W. to R. 31 W.; it extends approximately 36 miles east and west and 30 miles north and south. Gove County and other areas in which co-operative ground-water investigations have been made are shown in Figure 1.

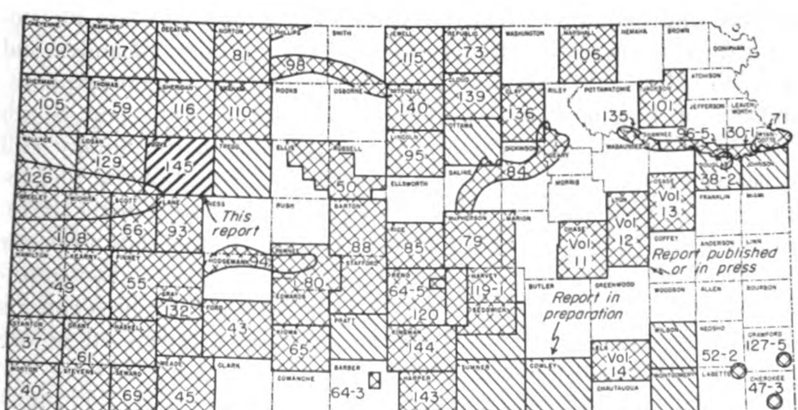

Fig. 1.—Map of Kansas showing area discussed in this report and other areas for which ground-water investigations have been reported or are in progress.

Previous Investigations

No detailed studies of the areal geology and ground-water resources of Gove County have been published, but specific reference to the county has been made in several earlier geological and hydrological reports.

Haworth (1897, 1897a) described the physiography of western Kansas and discussed the physical properties of the Tertiary rocks. Logan (1897) in a report on the Upper Cretaceous of Kansas discussed the occurrence of rocks of that age in Gove County. Williston (1897) described the Niobrara Chalk in western Kansas and discussed the Pleistocene deposits of Kansas (1897a). In his report on the utilization of the High Plains, Johnson (1901, 1902) referred to the source, availability, and use of ground water in western Kansas. In 1905 Darton reported on the geology and ground-water resources of the central Great Plains. A report by Parker (1911, p. 96) on the quality of water supplies in Kansas contained a brief description of the geologic setting of Gove County and analyses of samples of ground water. In a special report on well waters in Kansas, Haworth (1913) discussed the Tertiary of western Kansas and its water-bearing characteristics. Russell (1929) studied the stratigraphy and structure of the Smoky Hill Chalk in Logan, Gove, and Trego Counties and reported on the usefulness of bentonite layers in interpreting the stratigraphy. The work of Elias (1931) was an important contribution to the geology of western Kansas, and his studies of the Ogallala Formation and late Pleistocene deposits were the foundation for later studies. Landes and Keroher (1939) briefly described the geology and petroleum resources of Logan, Gove, and Trego Counties. Frye and Smith (1942) discussed graded valley slopes peculiar to the Smoky Hill River valley in Logan and Gove Counties. A study of the Pleistocene geology of Kansas was made by Frye and Leonard (1952). Bradley and Johnson (1957) made a study of the ground-water resources of the Ladder Creek area in Kansas, including the southwestern corner of Gove County. Areas in Kansas for which reports of geology and ground-water studies have been published or are in preparation are shown in Figure 1.

Methods of Investigation

During the summer of 1952, 25 test holes were drilled through the Pleistocene and Tertiary deposits to Cretaceous bedrock by a hydraulic-rotary drilling machine owned by the State Geological Survey of Kansas. During the summer and fall of 1952 and the summer of 1953, the depth to water and the depth of the well were measured in 80 wells by steel tape from a fixed measuring point near the land surface, and 15 samples of water were collected from representative wells in the county and were analyzed by Howard Stoltenberg, chemist, in the Sanitary Engineering Laboratory of the Kansas State Board of Health. Altitudes of the wells and test holes were determined by plane table and alidade.

During the summer and fall of 1956 the authors inventoried additional wells and collected additional water samples. Well drillers were visited and logs of test holes and wells were collected. During this time the areal geology was mapped from field observations and from stereoscopic study of aerial photographs obtained from the U. S. Department of Agriculture. County maps prepared by the State Highway Commission of Kansas at a scale of 1 inch to the mile were used to record field data. In September 1957, 17 additional test holes were drilled in the county by the State Geological Survey.

Well-Numbering System

The location of wells, test holes, and local features in this report are designated according to General Land Office surveys in the following sequence: township, range, section, quarter section or 160-acre tract, and quarter-quarter section or 40-acre tract. The 160-acre and 40-acre tracts are designated a, b, c, or d in a counter-clockwise direction beginning in the northeast quarter. For example, well 14-26-30da is in the NE¼ SE¼ sec. 30, T. 14 S., R. 26 W. (Fig. 2). If two or more wells are within a 40-acre tract the location number is followed by serial numbers in the order in which the wells were inventoried.

Acknowledgments

Appreciation is expressed to the residents and municipal officials of Gove County who supplied information and gave assistance during the course of the field work. Wilbur White, County Agent of Gove County, and Howard Chaney of the Soil Conservation Service of the U. S. Department of Agriculture gave valuable aid in the collection of ground-water data. Thanks are given to Page Campbell, Robert Dickman, and Melvin Denlinger who permitted use of their wells for aquifer tests and to the Struckhoff brothers, drillers at Grinnell, Harry Coberly and James Tuttle, drillers at Gove, and Vern Litton, driller at Scott City, who provided logs of wells and test holes and other information on wells in the county.

The manuscript of this report has been reviewed critically by several members of the Federal and State Geological Surveys; by Robert V. Smrha, Chief Engineer, and George S. Knapp, Engineer, of the Division of Water Resources of the Kansas State Board of Agriculture; by Dwight F. Metzler, Chief Engineer, and Willard O.

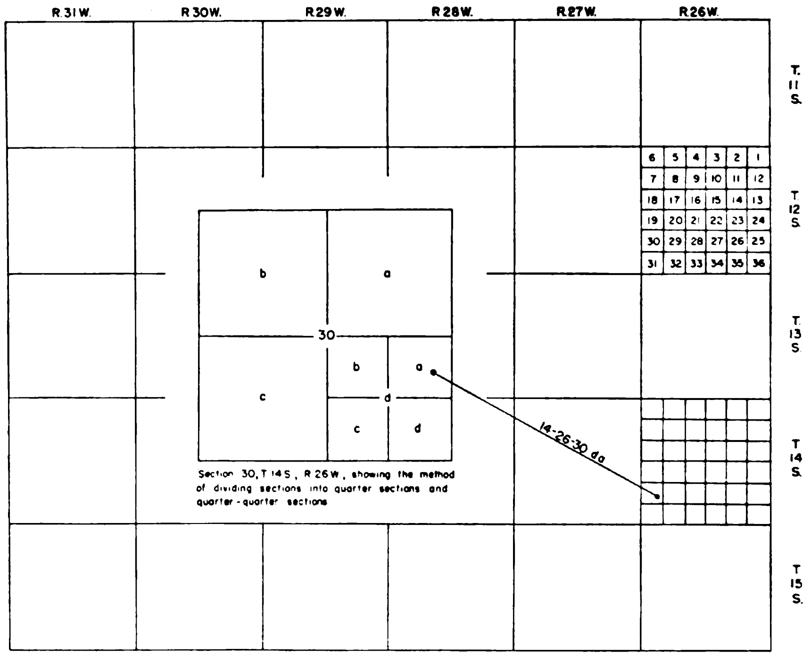

Fig. 2.—Diagram illustrating well-numbering system used in this report.

Hilton, Geologist, of the Division of Sanitation of the Kansas State Board of Health; and by Robert L. Smith, Executive Secretary, of the Kansas Water Resources Board.

GEOGRAPHY

Drainage and Topography

The principal streams in Gove County are Smoky Hill River, Hackberry Creek, and Big Creek. Smoky Hill River heads in eastern Colorado and flows across the southern part of Gove County, draining most of the southern half of the county. Hackberry Creek heads in Logan County and flows eastward across the central part of Gove County. Big Creek heads in the northwestern corner of Gove County and its course is approximately parallel to Hackberry Creek across the county. The extreme north-central and northeastern parts of Gove County are drained by tributaries to Saline River, which flows across the northeast corner of the county.

The total topographic relief in Gove County is about 700 feet. The highest elevation, about 3,000 feet, is in the northwestern part

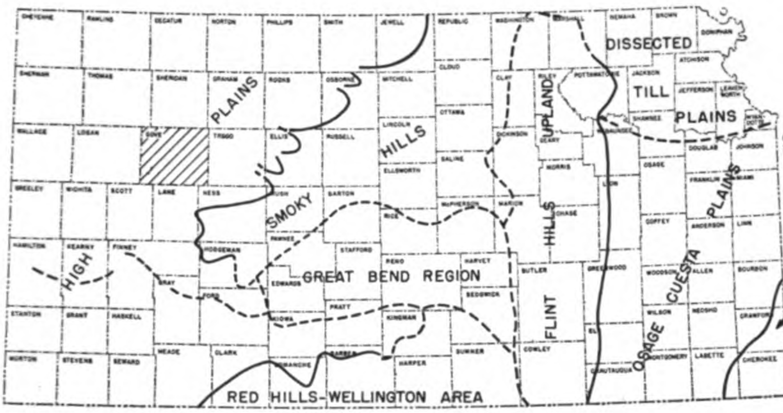

FIG. 3.—Physiographic regions of Kansas, showing areas of topographic homogeneity (after Frye and Schoewe, 1953).

of the county; the lowest elevation, about 2,300 feet, is in the Smoky Hill valley on the eastern county line.

Gove County is in the High Plains section (Fig. 3) of the Great Plains physiographic province (Schoewe, 1949). The county differs from much of the High Plains of Kansas, however, in that in most of the southern half, the Tertiary capping of unconsolidated sand, gravel, and silt (Ogallala Formation) has been eroded away by Smoky Hill River and its tributaries, exposing the older underlying soft chalk beds, of Cretaceous age. The Smoky Hill valley in Gove County is about 15 to 20 miles wide and includes approximately the southern two-fifths of the county. The break from the High Plains into the valley is generally abrupt, but between the break and the narrow inner valley of Smoky Hill River the slope is relatively gentle. At places on this slope, badland topography is formed by erosion of the soft Cretaceous chalk beds. Rain wash, running water, and wind have carved the chalk beds into small buttes and bizarre pinnacles and spires such as Castle Rock in southeastern Gove County and Monument Rocks in southwestern Gove County (Pl. 4).

Flanking pediments, erosional surfaces thinly veneered with local rock debris, are characteristic of much of the Smoky Hill valley. In their streamward part, the flanking pediments approach a horizontal attitude, and in places the pediments blend into the terrace surfaces so imperceptibly that delineation of the upland edge of the terrace deposits is arbitrary. Eolian silts have further masked the slopes, hence areal mapping and correct interpretation of valley

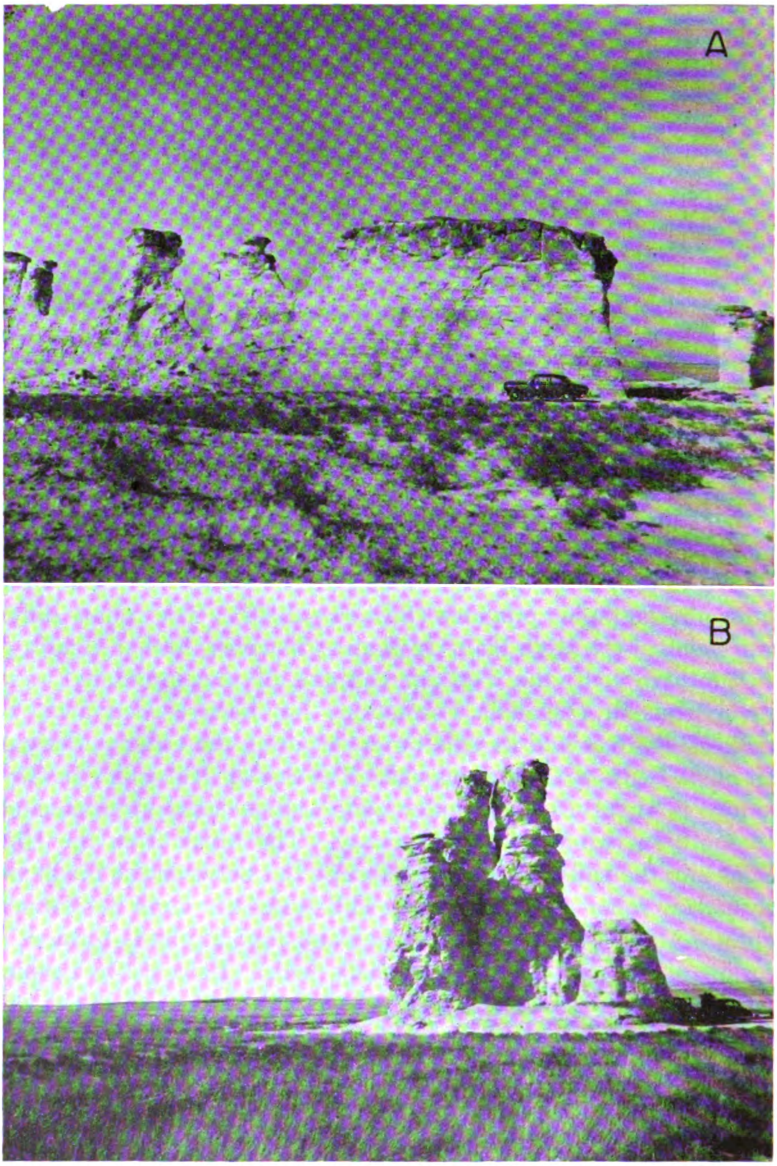

PLATE 4.—Erosional features of Smoky Hill Chalk in Gove County. **A,** Monument Rocks, near center of west line of sec. 34, T. 14 S., R. 31 W. **B,** Castle Rock, in NW¼ SW¼ sec. 1, T. 14 S., R. 26 W.

history is difficult in many places without subsurface information.

In contrast to the gentle slopes and flanking pediments of most of the Smoky Hill valley is the area between Smoky Hill River and Hackberry Creek in south-central Gove County, known locally as the "Missouri Flats", a flat fertile strip 10 to 12 miles long and 6 to 8 miles wide along the north side of the Smoky Hill valley in T. 14 S., R. 27 and 28 W., and the northern part of T. 15 S., R. 27 and 28 W. The "Missouri Flats" is underlain by about 40 to 100 feet of unconsolidated material, the lower part of which is believed to be fluviatile. Logs of test holes indicate that thin sand and gravel beds are characteristic of the lower part, but that the beds are lenticular and are separated by thin silt and clay layers. Only the lower part is below the water table, hence the total volume of ground water available is not large, although supplies adequate for stock and domestic use are available in most of this area. The "Missouri Flats" area seems to be a segment of an old channel of Smoky Hill River that was cut off and abandoned during Kansan or Illinoisan time, later to be masked by eolian silts (Pl. 3, B-B′ and D-D′).

The inner valley of Smoky Hill River, ¼ to ½ mile wide, is filled with alluvium believed to be of late Wisconsinan and Recent age. The alluvium is about 100 feet thick in the deepest part of the valley fill. Adjacent to the inner valley but generally separated from it by Cretaceous bedrock bluffs are deeply dissected terrace deposits consisting chiefly of unconsolidated sand and gravel of middle Pleistocene age. The terraces have an upland appearance in many places because of thorough dissection by small tributary streams.

The northern two-fifths of Gove County consists of nearly flat, gently rolling uplands mantled by eolian silts of late Pleistocene age and underlain by the Ogallala Formation. Small streams have dissected the surface moderately and in places have exposed the underlying rocks. The upland surface declines eastward at an average rate of about 15 feet per mile. Most of this area is drained by Big Creek and by tributaries to Hackberry Creek.

Climate

The climate of Gove County is semiarid and is characterized by abundant sunshine, low to moderate precipitation, moderate wind velocity, and a high rate of evaporation. During the summer the days are hot, but the nights are generally cool. The hot weather in summer is moderated by brisk wind movement and low humidity. The winters are moderate and generally have little snowfall and only short periods of severe cold weather.

In Gove County the amount of precipitation and its seasonal distribution are the chief factors controlling crop growth. According to records of the U. S. Weather Bureau, 67 percent of the annual precipitation in Gove County falls during the growing season of

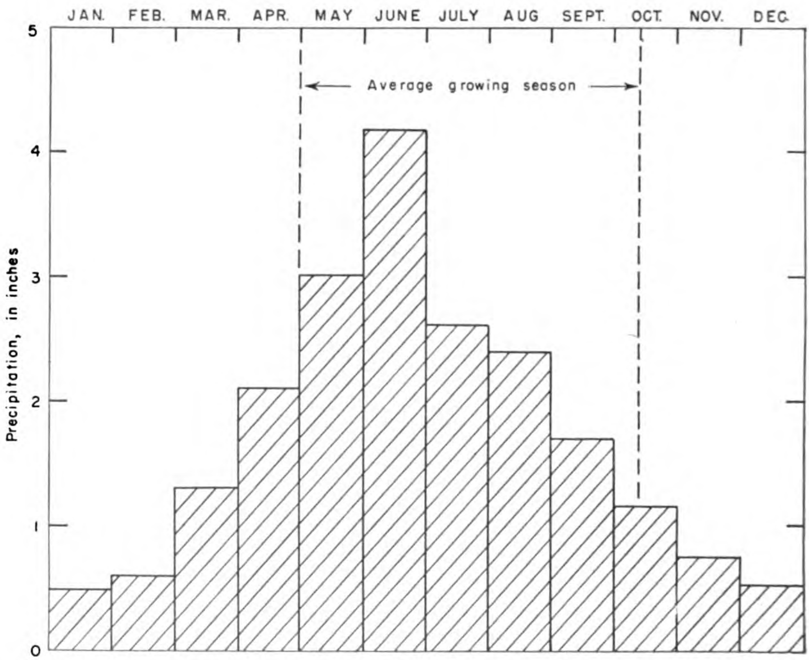

Fig. 4.—Normal monthly precipitation and average growing season in Gove County.

about five months (Fig. 4). The normal annual precipitation at Quinter is 20.89 inches. The greatest annual precipitation was 35.38 inches in 1957; the least was 7.97 inches in 1910. A weather Bureau precipitation gage was maintained at Gove from 1889 to 1930 and one has been maintained at Quinter since 1930. The annual precipitation and the cumulative departure from normal precipitation for the period of record are shown in Figure 5.

The annual mean temperature at Quinter is 53.2° F. July generally is the hottest month and has an average temperature of 79.4° F. January generally is the coldest month and has an average temperature of 28.7° F. The average length of the growing season is 167

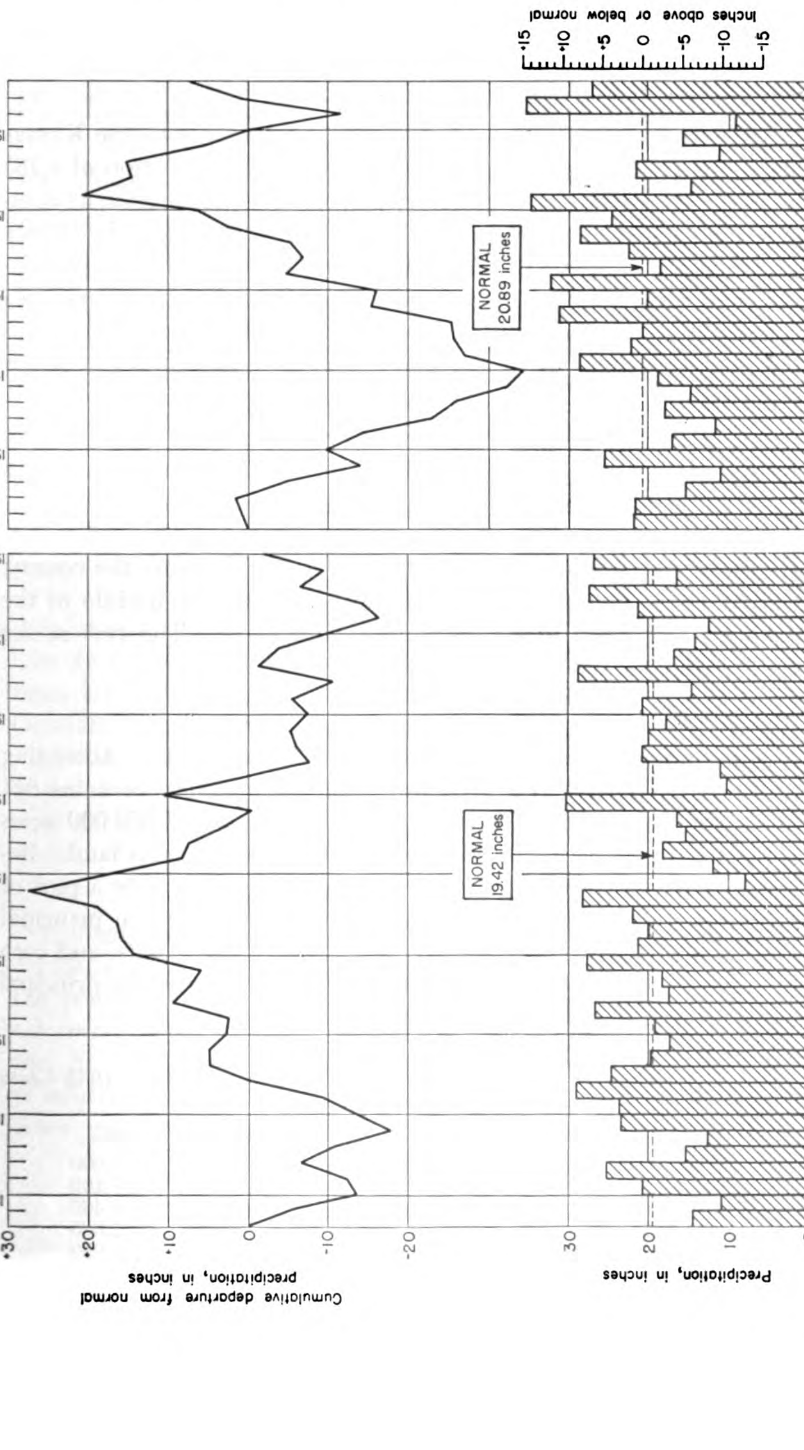

Fig. 5.—Annual precipitation and cumulative departure from normal precipitation at Gove from 1889 to 1930 and at Quinter from 1931 to 1958.

days; the average date of the last killing frost is April 28; and the average date of the first killing frost is October 12.

Population

According to figures reported by county assessors to the Kansas State Board of Agriculture, Gove County had a population of 4,185 in 1957. This is an average of 3.9 persons per square mile as compared to 23.2 persons per square mile for the state. Gove, the county seat, had a population of 197. Other towns and their 1957 populations are Quinter, 726; Grinnell, 388; Grainfield, 369; and Park, 243. Although the population of the county has declined since 1930 when the population was 5,643, the population of most of the towns has increased.

Transportation

Gove County is served by the Union Pacific Railroad, which crosses east-west near the northern edge of the county and passes through the towns of Quinter, Park, Grainfield, and Grinnell. U. S. Highway 40 parallels the Union Pacific Railroad across the county. Kansas Highway 23 crosses north-south through the middle of the county and passes through Grainfield and Gove. The rest of the county is served by county and township roads.

Agriculture

Agriculture is the chief occupation in Gove County. According to the State Board of Agriculture (1956), the county contains 644 farms comprising about 684,000 acres of which about 320,000 acres is pasture or range land and about 364,000 acres is crop land. Because of the practice of summer fallowing, however, only a part of the crop land is in cultivation each year. Wheat is the principal crop in the county, and sorghums, alfalfa, barley, rye, oats, and corn follow in order of acreage harvested. The acreages of the principal crops grown in 1955 are given in Table 1.

Table 1.—*Acreage of principal crops grown in Gove County in 1955 (data from Kansas State Board of Agriculture).*

Crop	*Acres*
Wheat	98,000
Sorghums	65,100
Alfalfa	4,430
Barley	2,000
Rye	950
Oats	400
Corn	220
Total	171,100

Mineral Resources

Mineral resources of Gove County other than soil and ground water include oil and gas, construction materials, and volcanic ash.

Oil and Gas

The first producing oil well in Gove County was drilled in 1951, although several dry holes were drilled prior to that time. The first production was in the Coberly field from rocks of the Marmaton Group of Pennsylvanian age. The Gove and Jasper pools also were discovered in 1951 and the Beougher, Lundgren, Lundgren South, and Pyramids pools were discovered in 1952. Production of oil in Gove County in 1958 was 18,902 barrels from 7 wells. At the end of 1958 the cumulative production of oil in Gove County was 205,446 barrels. Three zones, at depths ranging from 3,670 to 4,547 feet have produced oil in Gove County. These zones are in the Lansing-Kansas City and Marmaton Groups, of Pennsylvanian age, and in Mississippian rocks.

Construction Material

Sand and gravel from terrace deposits have been used in Gove County for road construction and road surfacing and large quantities are available. Sand and gravel are also available from the Ogallala Formation and from alluvium along the principal streams.

Chalk layers within the Smoky Hill Chalk in Gove County were quarried at one time for building stone but little chalk if any is now quarried for this purpose. Chalk is still used for road fill on county roads, however.

Volcanic Ash

Volcanic ash consists of fine glass-like shards ejected during the explosive phase of a volcanic eruption. Six deposits of ash within the county were examined and discussed in a report on Kansas ash resources (Carey and others, 1952). A deposit in the NE¼ SW¼ sec. 21, T. 13 S., R. 26 W., is reported to be 17 feet thick and of relatively good quality. This deposit had been mined earlier but when visited in 1956 showed no evidence of recent operation.

Table 2.—*Generalized section of geologic rock units and their water-bearing properties*

System	Series	Rock unit	Thickness, feet	Physical character	Water supply in Gove County
Quaternary	Pleistocene	Alluvium (Recent and late Wisconsinan Stages)	0–100	Stream-laid deposits ranging from clay to coarse sand and gravel; thick, coarse deposits in major valleys, finer deposits in smaller valleys.	Yields moderate to large quantities of water to wells along Smoky Hill River valley, moderate quantities along Hackberry Creek and Big Creek valleys, and lesser amounts in smaller tributary valleys.
		Peoria and Loveland Formations (Early Wisconsinan and late Illinoisan Stages)	0–50	Silt, mostly eolian, sandy in lower part. Mantles most of the uplands and masks much of the valley walls. Locally includes slope deposits.	Yield little or no water to wells.
		Terrace Deposits (Early Illinoisan and Kansan Stages)	0–65	Stream-deposited sand, gravel, and silt, dissected or continuous, chiefly along Smoky Hill valley. Locally includes volcanic ash deposits (Pearlette Ash).	Yield small quantities of water to wells, chiefly along Smoky Hill valley, and to springs.
Tertiary	Pliocene	Ogallala Formation	0–150	Consists chiefly of sand, gravel, silt, and clay; unconsolidated except in places cemented by calcium carbonate and silica.	Yields moderate to small quantities of water to wells. Principal aquifer in northern and much of west-central Gove County.
Cretaceous	Gulfian	Pierre Shale	0–150	Fissile dark-gray shale; weathers to coffee brown. Contains abundant selenite crystals.	Yields no water to wells.
		Niobrara Chalk: Smoky Hill Chalk (member)	0–600	Light- to dark-gray chalk and chalky shale, thin bedded and platy. Bentonite beds throughout. Locally contains silicified zones in upper part.	Yields no water to wells except in local silicified zones or fractured zones from which small quantities of water may be available.
		Niobrara Chalk: Fort Hays Chalk (member)	65±	Grayish-white massive chalk beds separated by thin chalky shale partings.	Yields little or no water to wells.
		Carlile Shale	250±	Lower part consists of gray calcareous shale and thin beds of chalky limestone; upper part consists of dark-gray clayey shale and contains a few feet of silty fine-grained sandstone at top (Codell Sandstone zone).	Yields very small quantities of water to wells from Codell Sandstone zone.
		Greenhorn Limestone	100±	Alternating beds of chalky limestone and chalky shale.	Yields no water to wells.
		Graneros Shale	45±	Noncalcareous dark-gray shale. Contains persistent bentonite bed in upper part.	Do.
		Dakota Formation	250±	Clay, shale, siltstone, and sandstone, interbedded and varicolored. Sandstone is fine to medium grained, lenticular, and soft. Lignite and "ironstone" common.	Yields small quantities of water to wells.

GEOLOGY

Summary of Stratigraphy *

The areal distribution of rocks that crop out in Gove County is shown on Plate 1. The rocks are sedimentary in origin and range in age from Cretaceous through Quaternary. A generalized section of the rock units is given in Table 2. Their stratigraphic relation is shown by cross sections on Plate 3.

The Fort Hays Chalk, lower member of the Niobrara Chalk, is the oldest geologic rock unit exposed in Gove County. It is exposed in the southeastern part of the county along the edges of the inner valley of Smoky Hill River but is buried beneath younger rocks in the rest of the county. The Smoky Hill Chalk, upper member of the Niobrara Chalk, crops out in much of the southern part of the county, chiefly along the valleys of Smoky Hill River, Hackberry Creek, and their tributaries. It is conformably overlain by the Pierre Shale, which was eroded from almost all of Gove County by pre-Pliocene erosion and is found in the subsurface in only the northwestern part of the county, although it crops out in the southwestern part of Gove County in a small down-faulted area in T. 13 and 14 S., R. 31 W. (Pl. 1).

The Ogallala Formation, of Pliocene age, unconformably overlies Pierre Shale and Niobrara Chalk and occurs mostly in the west-central and northern parts of the county. The Ogallala crops out in much of this area and is best exposed along stream valleys and at the edge of the upland plain.

Sand and gravel deposits of middle Pleistocene age border the larger valleys as terrace deposits, and become extensive in places along the Smoky Hill valley. Eolian silts of late Pleistocene age mantle the upland and valley walls in much of Gove County, especially the northern part, and are shown on the geologic map (Pl. 1) as the Loveland and Peoria Formations. Slope deposits, derived chiefly from loess but also containing local bedrock fragments, are extensive on the steeper slopes in the Smoky Hill valley and tributary valleys and are mapped in this report with the Loveland and Peoria Formations. Recent alluvium along the principal streams is the youngest geologic deposit in the county.

Rocks Not Exposed

The Niobrara Chalk in Gove County is underlain by approximately 400 feet of shale and limestone including the Carlile Shale,

* The classification and nomenclature of the rocks described in this report follow the usage of the State Geological Survey of Kansas. They differ somewhat from the classification and nomenclature given in formal reports of the U. S. Geological Survey.

Greenhorn Limestone, and Graneros Shale. In Gove County, the Codell Sandstone zone at the top of the Carlile Shale yields water to a few wells, but other strata in this section are believed to yield little or no water to wells. Beneath the Graneros Shale is the Dakota Formation, which is an important aquifer in some areas of Kansas and which is thought to be a potential source of small amounts of ground water in Gove County in certain areas where shallow ground water is scarce. The Dakota Formation and the overlying rock units are discussed in more detail in the section on geologic formations and their water-bearing properties.

Summary of Geologic History and Geomorphology

The oldest rock exposed in Gove County is the Fort Hays Chalk member of the Niobrara Chalk of Cretaceous (Gulfian) age. The history of geologic events that preceded deposition of the Fort Hays Chalk is deduced partly from logs of oil and gas test wells and partly from surface exposures of rocks that, although deeply buried in Gove County, crop out to the east of the county.

The oldest rocks beneath Gove County are the Precambrian crystalline rocks, the basement rocks upon which later sedimentary rocks have been deposited. The Precambrian rocks were subjected to long exposure and erosion, which resulted in a relatively level plain.

Paleozoic Era

Throughout the Paleozoic Era, Gove County was alternately inundated by epicontinental seas and subjected to subaerial erosion, resulting in the deposition of sequences of limestone, dolomite, sandstone, and shale separated by many hiatuses. Much of the sediment that was deposited during the early part of the Paleozoic Era was eroded during times of emergence and only about 700 to 800 feet of Paleozoic rocks older than Pennsylvanian are reported in the subsurface of Gove County. Most of these rocks belong to the Arbuckle Group of Late Cambrian and Early Ordovician age. In a test well drilled in the NW¼ NW¼ sec. 36, T. 13 S., R. 30 W., the top of the Arbuckle was reached at a depth of 4,615 feet; the Precambrian at 5,160 feet. Rocks of Silurian and Devonian age are not known to underlie Gove County; if sediments were deposited during this interval, they were subsequently eroded.

Mississippian, Pennsylvanian, and lower Permian rocks in Gove County are mostly of marine origin. Mississippian rocks consist chiefly of dolomitic limestone deposited during the early part of the period. During most of Pennsylvanian and early Permian time, cyclical deposits of alternating beds of limestone and shale were deposited in shallow and fluctuating seas. Toward the end of the Paleozoic Era, evaporites and nonmarine deposits attest a progressive emergence of the area, and shallow basins and low plains became areas of continental deposition. Shale, siltstone, and sandstone are the predominant rocks of middle and late Permian age, although extensive deposits of salt, anhydrite, and gypsum, suggesting a climate of rapid evaporation, are characteristic upper Permian strata.

Mesozoic Era

In the subsurface of northwestern Kansas no deposits of Triassic age are known, but deposits of Jurassic age have been correlated with the Morrison Formation. In Gove County, thickness of Jurassic deposits ranges from a feather edge to 150 feet (Merriam, 1955).

During late Comanchean time (Early Cretaceous), a shallow sea advanced northward across central and western Kansas, and the Cheyenne Sandstone was deposited near the shores of this advancing sea. The overlying Kiowa Shale was deposited in the deeper water that subsequently covered the area. Overlying the Kiowa Shale are clay shale and sandstone beds of the Dakota Formation that represent a return of continental and littoral deposition. The Cretaceous sea again advanced, and while marine conditions prevailed, thick layers of shale, limestone, and chalk were deposited. These rock layers constitute the Graneros Shale, Greenhorn Limestone, Carlile Shale, Niobrara Chalk, and Pierre Shale. The upper of these rock layers (Niobrara Chalk and Pierre Shale) form much of the outcropping rocks in the southern part of Gove County. At the close of Cretaceous time, the sea had withdrawn from this area, and a continental environment has existed since that time.

Cenozoic Era

The principal topographic features of Gove County are those formed as a result of events that happened during the Pliocene and Pleistocene Epochs.

Tertiary Period.—In early Tertiary time, uplift in the Rocky Mountain province tilted the rocks underlying the Great Plains and increased the gradient of eastward-flowing streams that crossed the High Plains of Kansas. These streams stripped off a considerable thickness of Upper Cretaceous rocks. The Pierre Shale was eroded from all of Gove County except the northwestern part and a small downfaulted area in the southwestern part. Various thicknesses of the underlying Niobrara Chalk were also removed. Because of accelerated uplift in the Rocky Mountains during the Pliocene Epoch, stream gradients and the competence of the streams increased in their upper reaches. Gradients downstream remained essentially unchanged and hence stream deposition occurred in these lower reaches. Streams from the Rocky Mountains that crossed western and central Kansas aggraded their channels and deposited large quantities of alluvial material. As the stream valleys became filled, the streams spread laterally across the bedrock divides and developed an extensive alluvial plain of sand, gravel, silt, and clay (Ogallala Formation). This deposit underlies nearly all the northern half of the county and is nearly 150 feet thick in places.

Quaternary Period.—Climatic changes that resulted in the formation of great ice sheets characterize the Pleistocene Epoch. Although none of the continental ice sheets that advanced toward the central United States during the Pleistocene Epoch reached Gove County, the development of the present landscape of the county was influenced greatly by the associated climatic fluctuations.

The Pleistocene is divided into four glacial stages, each followed by an interglacial stage. The Nebraskan (glacial) Stage was followed by the Aftonian (interglacial) Stage, the Kansan (glacial) Stage was followed by the Yarmouthian (interglacial) Stage, the Illinoisan (glacial) Stage was followed by the Sangamonian (interglacial) Stage, and the Wisconsinan (glacial) Stage was followed by the Recent Stage, which may be an interglacial stage.

Deposits of Nebraskan age are not known to be present in Gove County; thus, the events that took place during Nebraskan and Aftonian time are deduced from early Pleistocene deposits in nearby areas.

Shortly before the beginning of the Pleistocene Epoch there was either uplift of the land or a climatic change that caused streams to deepen their valleys and entrench their channels through former deposits. The major streams of this part of Kansas probably essentially paralleled the present streams but flowed at a higher elevation. In Gove County, Smoky Hill River is believed to run near and approximately parallel to a pre-Ogallala divide, or bedrock high, were Ogallala deposits were either thin or missing. Thus, Smoky Hill River probably was cutting into bedrock in Gove County by the end of the Nebraskan Stage. During the Nebraskan Stage the streams deepened their channels, and seemingly only a minor amount of alluvial material was deposited, later to be removed by erosion.

Scattered terrace remnants of Kansan and Yarmouthian age indicate that by Kansan time the major streams in Gove County had be-

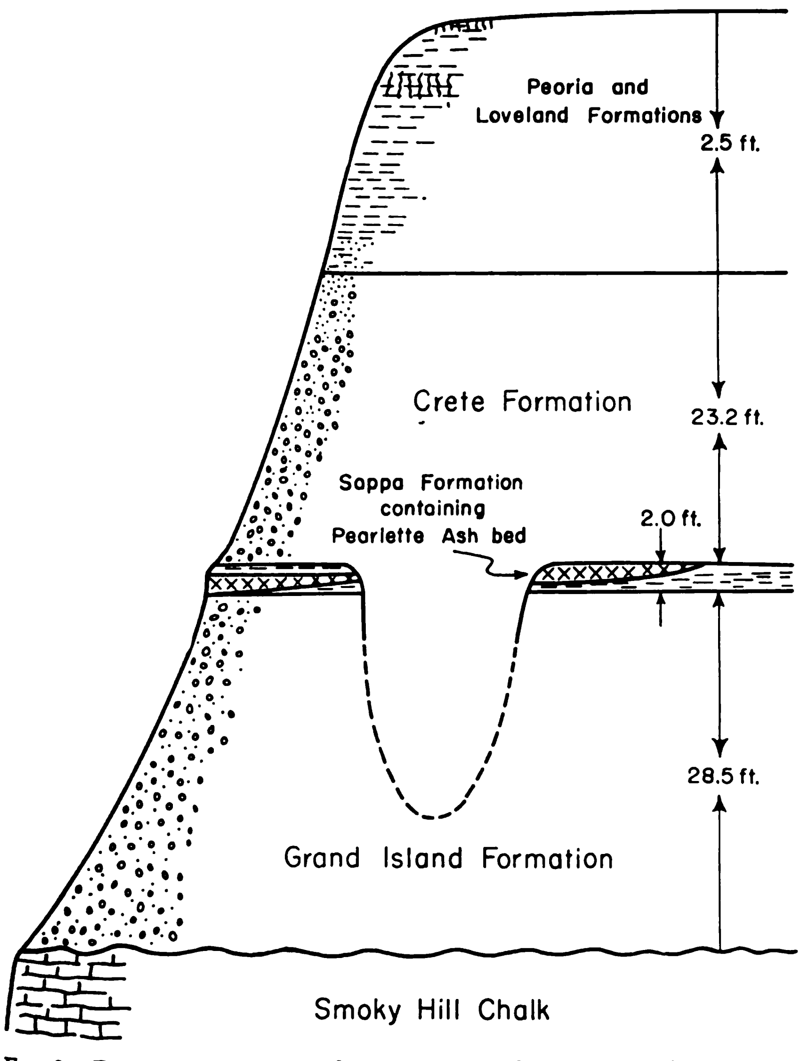

FIG. 6.—Diagrammatic section showing stratigraphic relations of Pleistocene deposits in SE¼ SW¼ sec. 20, T. 15 S., R. 28 W.

come entrenched in approximately the present geographic position. Small dissected terrace deposits of sand and gravel represent the Grand Island Formation, of Kansan age. The Grand Island is generally identified by its association with the overlying Pearlette Ash bed within the Sappa Formation of late Kansan and early Yarmouthian age (Fig. 6). Several Pearlette Ash deposits are present in Gove County; but the Sappa Formation where present generally consists of only a thin silty zone at the base of the ash. In most places, the underlying Grand Island was absent and only the Pearlette Ash bed was present. The Pearlette Ash, although of small areal extent in Gove County, is as much as 17 feet thick in the NE¼ SW¼ sec. 21, T. 13 S., R. 26 W. (Pl. 5).

The Crete Formation, of Illinoisan age, consists of deposits of sand and gravel as terraces along the principal streams. Lithologically, the Crete and the Grand Island are very similar in Gove County, both being composed chiefly of coarse arkosic sand and gravel. Stratigraphically, the Crete Formation overlies the Sappa Formation and the Grand Island Formation in Gove County, although locally the Crete is channeled into the Grand Island (Fig. 6). Characteristically, much of the Crete Formation is of relatively wide areal extent; small thin deposits of arkosic sand and gravel are scattered over much of the southern half of Gove County. Where these deposits are not associated with the Pearlette Ash they are shown as the Crete Formation on Plate 1. Because they are relatively thin and laterally extensive, they have the appearance in many places of being pediment-type deposits. Thicker channel deposits are found along the principal streams, and are most extensive and thickest along Smoky Hill River.

Sand, gravel, and silt constitute the alluvial fill within the inner valleys of the principal streams in the county. The alluvium is believed to be of late Wisconsinan and Recent age. Along Smoky Hill River, low terraces of late Wisconsinan age border the narrow floodplain. Lithologically, the alluvial deposits underlying the flood plain are indistinguishable from the slightly older alluvial deposits underlying the low terraces, which were deposited before the Recent cycle of down cutting and alluviation began.

Fine silt and sandy silt, mostly eolian, mantles much of Gove County, particularly the upland in the northern part of the county, and is classified as the Loveland Formation of late Illinoisan age and the Peoria Formation of early Wisconsinan age. A few feet of

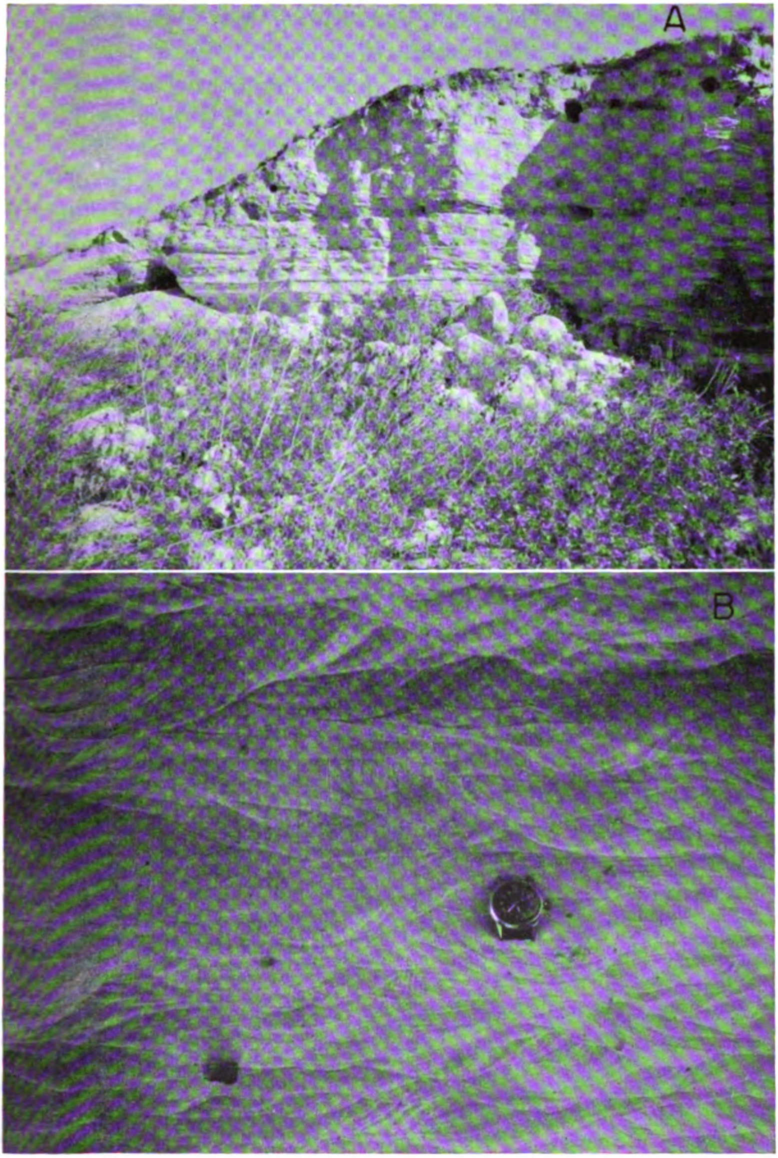

PLATE 5.—Volcanic ash deposit in Gove County. **A,** Pearlette Ash bed in NE¼ SW¼ sec. 21, T. 13 S., R. 26 W. **B,** Bedding detail of Pearlette Ash, same locality.

silt representing the Bignell Formation of late Wisconsinan and Recent age was recognized locally in the northwestern part of Gove County. Where the Bignell was present it did not exceed 2 feet in thickness, and much of it was incorporated within the modern soil profile. Because it was not possible to map the eolian silt formations separately at the scale at which the geology of Gove County was mapped, and because the formations are lithologically and hydrologically similar, the eolian silts are shown together on Plate 1 as the Peoria and Loveland Formations (undifferentiated).

GROUND WATER

Principles of Occurrence

The following discussion of the occurrence of ground water is adapted largely from Meinzer (1923). Moore and others (1940) discussed the principles of ground-water occurrence with special reference to Kansas.

The rocks that form the crust of the earth are rarely, if ever, solid throughout but contain many open spaces called interstices or pores. These open spaces range in size from minute openings between particles of silt or clay through larger openings between grains or pebbles in sandstone, sand, or gravel to open channels formed by fractures and solution. The percentage of the total volume of material that consists of open spaces is termed the porosity. A formation in which the openings are interconnected and large enough to allow water to move to a well is called an aquifer. Although the amount of water that can be stored in an aquifer depends on the porosity, it is the permeability of an aquifer that determines the rate at which ground water can move. The permeability of an aquifer depends upon the number and size of its open spaces, or interstices, and the extent to which these interstices are interconnected.

All the water below the surface of the earth is called subsurface water to distinguish it from surface water and from atmospheric water. Water percolating from the surface into the rocks of the earth is drawn downward by gravity and capillarity. Some of this water will reach a zone where all the open spaces are filled with water under hydrostatic pressure. This zone is called the zone of saturation. A part of the water percolating downward will not reach the zone of saturation, but will be held by molecular attraction, or surface tension, to the walls of the open spaces through which the water passes in its descent. This zone of suspended water above the water table is termed the zone of aeration. The zone of aeration consists of three parts: the belt of soil water, the intermediate belt, and the capillary fringe. The belt of soil water, lying just below the land surface, consists of soil and loose materials from which water may be discharged into the atmosphere by plant transpiration or by direct evaporation. The open spaces of the intermediate belt below the belt of soil water are usually filled with air and water and may at times contain appreciable amounts of water in transit to the water table. The intermediate belt may be absent, however, where the water table is near the surface. The capillary fringe lies directly above the water table and contains water drawn up by capillary action from the zone of saturation and water in transit downward to this zone. In general, the thickness of the capillary fringe varies inversely with the size of the interstices. In clean gravel, the capillary fringe almost disappears; in silt or clay, the fringe may be several feet thick. Figure 7 shows, in general, the divisions of subsurface water.

Under water-table conditions, the term water table designates the surface between that part of the zone of saturation where water is free to move by gravity and the zone of aeration. Where a water-bearing formation is confined between relatively impermeable beds and water is supplied to it from an adjacent area of higher altitude, the water table is absent and the water is said to be confined or under artesian pressure. Under artesian conditions, water enters the water-bearing formation at the intake area, percolates downdip, and exerts pressure on the confining layers. Under these conditions, water is confined under hydraulic pressure similar to water in a pipe connected to a reservoir at a higher altitude. When an aquifer under artesian pressure is penetrated by a well, water will rise in the well to a height equal to the hydraulic head. The imaginary surface connecting this level in wells is called the piezometric surface. For an artesian well to flow the piezometric surface must be at a higher altitude than the land surface.

Ground water in Gove County occurs under both water-table and artesian conditions. Water-table conditions are present in shallow aquifers such as alluvial deposits in the valleys. Most of the ground water in the Ogallala Formation is under water-table conditions although some is confined under silt and clay beds at least locally. Ground water in the Dakota Formation in Gove County is under artesian pressure.

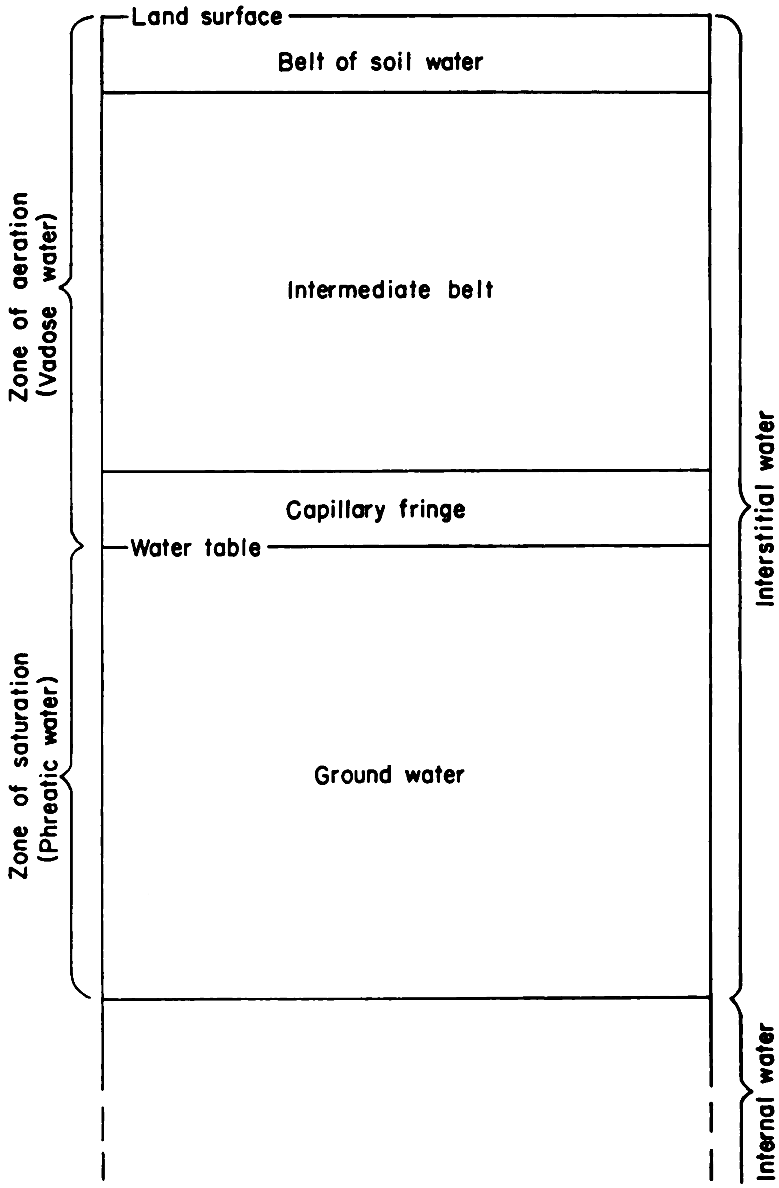

FIG. 7.—Diagram showing generalized divisions of subsurface water (after Meinzer, 1923a, fig. 2).

The Water Table and Movement of Ground Water

The water table has been defined as the upper surface of that part of the zone of saturation where water is free to move by gravity. The water table is not a static, level surface, but is generally a sloping surface having many irregularities in the form of mounds, depressions, and ridges caused by differences in permeability of the water-bearing material and by unequal additions or withdrawals of ground water. Where recharge to an aquifer is exceptionally great because of very permeable overlying material, the water table may build up a low mound from which water slowly spreads out. Depressions in the water table are formed where ground water is discharging, generally where water is withdrawn by wells or along streams that are below the level of the water table. Streams that gain water from the flow of ground water are said to be gaining or effluent streams. Conversely, streams that are above the water table and contribute water to the ground-water reservoir are said to be losing or influent streams (Fig. 8).

In central and west-central Gove County, a considerable amount of ground water moves from the Ogallala Formation into Hackberry

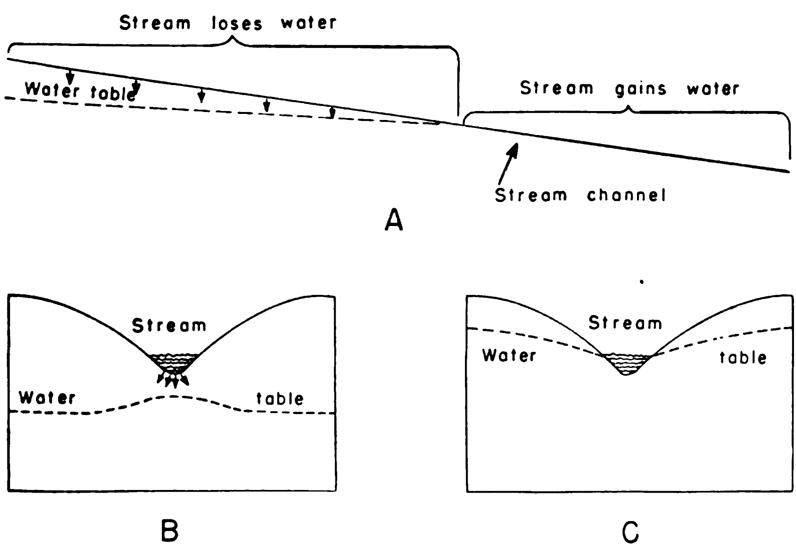

Fig. 8.—Diagrammatic sections showing influent and effluent streams. A, Longitudinal section showing (right) how river gains water and (left) how it loses water. B, Transverse section across influent part of river. C, Transverse section across effluent part of river. (After Meinzer, 1923a, fig. 26).

Creek and its tributaries. In extreme north-central and northeastern Gove County, ground water moves from the Ogallala Formation toward Saline River. Some ground water moves from the Ogallala into the alluvium of Big Creek and then discharges from the alluvium into Big Creek as effluent seepage. In the Smoky Hill valley, the water table in the alluvium is separated from the water table in the Ogallala Formation by the relatively impervious Cretaceous bedrock. Although the Smoky Hill alluvial valley is small in areal extent, some ground water discharges into the river from the alluvium. During extended periods of below-normal precipitation, however, the amount of such discharge is negligible.

The configuration of the water table in the northern part of Gove County is shown on Plate 2 by means of water-table contours. The direction of ground-water movement is at right angles to the contours and in a down-slope direction. This movement is very slow because of frictional resistance of the small interstices through which the water must pass. The slope of the water table varies inversely with the permeability of the aquifer. In areas where the water-bearing beds are less permeable, the slope of the water table steepens and the water-table contours are closely spaced; in areas of greater permeability, the slope of the water table flattens and the water-table contours are spaced farther apart. The water-table contours across Gove County indicate an average gradient of about 11 feet per mile.

Fluctuations of Water Table

The water table does not remain stationary but fluctuates up and down in response to recharge and discharge of ground water. A rise of the water level indicates that recharge exceeds discharge; a decline indicates that discharge exceeds recharge. Thus, changes in water level indicate to what extent the ground-water reservoir is being replenished or depleted.

Hydrographs showing the fluctuations of the water level in two observation wells and graphs showing precipitation data are given in Figure 9. The graphs show the normal monthly precipitation in the area of the wells, the monthly precipitation, and the cumulative departure from normal monthly precipitation. The hydrographs indicate that precipitation and fluctuations of the water levels correlate in a general way. Records of these water levels are published by the U. S. Geological Survey (1935-56) and by the State Geological Survey of Kansas.

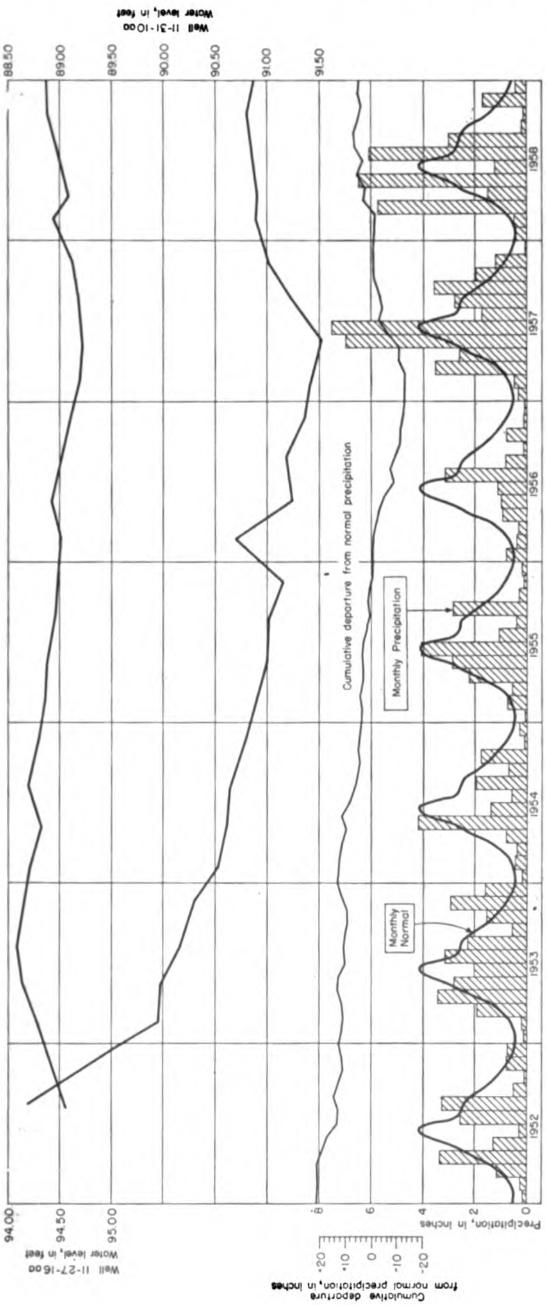

FIG. 9.—Hydrographs showing fluctuations of water levels in two wells in Ogallala Formation, and graphs showing monthly precipitation, normal precipitation, and cumulative departure from normal precipitation in Gove County.

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Ground-Water Recharge

Ground water in Gove County, as in other parts of the Great Plains, is derived almost entirely from local precipitation in the form of rain or snow. One inch of water falling on 1 square mile amounts to more than 17 million gallons. Thus, the normal annual precipitation of 20.89 inches amounts to approximately 360 million gallons per square mile. Only a small part of the annual precipitation, however, reaches the ground-water reservoir. Part of the water that falls as precipitation is carried away as surface runoff by streams; part is evaporated into the atmosphere; part is absorbed by vegetation and later transpired to the atmosphere. Water that is not discharged by these processes percolates downward to the zone of saturation. After the water reaches the water table, it moves slowly toward points of discharge such as wells, springs, effluent streams, or points of evaporation and transpiration.

About 77 percent of the normal annual precipitation in Gove County falls during the months of April through September when the climate is characterized by strong wind movement, high temperatures, and relatively low humidity. Consequently, evaporation is rapid, and much of the annual precipitation returns to the atmosphere. Because much of the rain falls during the growing season, a large part of the annual precipitation is returned to the atmosphere through transpiration by plants. In Gove County, the amount of annual precipitation that is discharged through evaporation and transpiration is estimated to be about 20 inches (Fig. 10), but

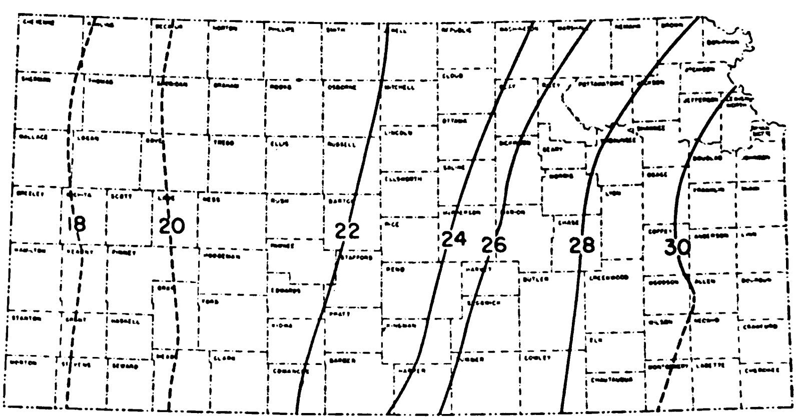

Fig. 10.—Map of Kansas showing lines of mean annual water loss, in inches (precipitation minus runoff) adapted from Williams and others (1940, pl. 2).

the normal annual precipitation of Gove County is only 20.89 inches, and hence the amount of runoff, including both surface and ground-water runoff, is less than 1 inch per year and probably is not more than 0.3 inch per year.

Ground-Water Discharge

Ground-water discharge is the release of water from the zone of saturation. In Gove County, ground-water is discharged by evaporation and transpiration, by springs and seepage into streams, by discharge from wells, and by subsurface movement to adjacent areas.

Evaporation and Transpiration

Evaporation to the atmosphere from the zone of saturation is limited to areas where the water table is near the land surface, such as along beds and banks of the larger streams. As these conditions are restricted to a small part of Gove County, discharge by evaporation is not large. After floods or after long periods of exceptionally heavy rainfall, when the water table is nearer the surface in many areas, appreciable amounts of ground water may be evaporated from lowland areas into the atmosphere.

Water may be taken into the roots of plants directly from the capillary fringe or from the zone of saturation, as well as from the soil zone, and discharged from the plants by evaporation from the leaves (transpiration). The depth to which plant roots will grow varies with different plant species and with the type of material the roots penetrate. Common field crops and grasses do not draw water from depths of more than a few feet, but certain plants called phreatophytes are capable of sending their roots deep in search of water. Alfalfa roots may reach the water table where it is as much as 30 feet below the surface, and certain desert plants send their roots to depths of 50 or 60 feet. In Gove County, phreatophytes capable of obtaining ground water at considerable depths include alfalfa, cottonwood and hackberry trees, yucca, and certain weeds.

The measurements of water level in observation wells show that the water level in the Ogallala Formation of Gove County has not fluctuated significantly in recent years, that is, ground-water discharge has been in approximate equilibrium with recharge to the ground-water reservoir. Although discharge of ground water by transpiration is not significant in the upland of the northern part of the county where the water table is fairly deep, it is of importance in stream valleys and in much of the southern part of the county where the water table is shallow.

Springs

Small springs are common in Gove County, especially in draws, and characteristically emerge at or near the contact between the Ogallala Formation or unconsolidated Pleistocene deposits and the underlying relatively impermeable Cretaceous bedrock. The outcropping contact of the Ogallala Formation on Cretaceous bedrock represents a hydrologic boundary of the upland along which ground water is discharged in springs. Seepage at the base of the Ogallala Formation along Hackberry Creek and its tributaries provides considerable recharge to the alluvial fill of these valleys and to the colluvial fill in the upland draws in the central and west-central parts of the county. Seepage also occurs along Big Creek in the eastern part of the county. Springs are common along the Smoky Hill valley near the contact between the high terrace sand and gravel deposits and the underlying Cretaceous bedrock; several of these springs provide water for domestic and livestock supplies.

Ground-Water Pumpage

Most rural residents obtain water for domestic and livestock supplies from small-diameter drilled wells equipped with cylinder pumps powered by windmills. The yields of these wells are small and probably average about one gallon a minute. Because of their great number and long pumping periods, however, such wells represent an important withdrawal from the ground-water reservoir, estimated to be about 800 acre-feet per year in Gove County. Municipal wells at Quinter, Grainfield, Grinnell, and Gove yield a total of approximately 500 acre-feet per year. Irrigation wells in the valleys of Smoky Hill River, Big Creek, and Hackberry Creek and in the upland of Gove County add an estimated 6,000 acre-feet per year. The irrigation season generally lasts about 60 days but may vary according to rainfall distribution.

Subsurface Movement

Water-table contours (Pl. 2) show that ground water in the Ogallala Formation in the northern part of the county moves eastward. Thus, some ground water within the Ogallala in Logan County moves into Gove County from the west; likewise, some ground water leaves Gove County toward the east. The amount leaving the county underground is believed to be less than that entering, much of the difference being accounted for by seepage and springs along the edge of the upland plain and by discharge from the Ogallala along Hackberry Creek valley and its tributaries.

A small amount of ground water moves out of Gove County through the alluvial fill of Smoky Hill River, Hackberry Creek, and Big Creek valleys, but because of the small cross-sectional area of the alluvial fill of the valleys, the amount of ground water that leaves the county through these aquifers is relatively small. Much of the streamflow derived from ground water in the valleys is dissipated by evaporation and transpiration, hence very little ground water is discharged as stream flow into Trego County.

The approximate rate of movement of ground water through the Ogallala Formation can be obtained by application of the following formula: $v = \frac{PI}{395p}$ where v is the average velocity of the ground water, in feet per day; P is the coefficient of permeability, defined in Meinzer's units (gallons per day per square foot under a hydraulic gradient of 1 foot per foot and a temperature of 60° F); I is the hydraulic gradient, in feet per mile; and p is the porosity, as a percentage. On the basis of an average coefficient of permeability of the water-bearing material of 325 gallons a day per square foot, a hydraulic gradient of 11 feet per mile, and porosity of 30 percent (assumed on the basis of data on similar sediments elsewhere in Kansas), the average velocity of the ground water can be computed by the above formula as follows: $v = \frac{325 \times 11}{395 \times 30} = 0.3$ foot per day.

Recovery of Ground Water

When a water-table well is not pumped, the head of water inside the well is in equilibrium with that of water outside the well. When pumping is started, water is discharged from the well, and a difference in head is established between the water inside the well and water in the surrounding aquifer. As a result of this differential head, water moves from the aquifer toward the well, and a depression in the form of an inverted cone forms in the water table (Fig. 11). The lateral extent of this cone of depression is called the area of influence, and the vertical distance that the water level is lowered is called the drawdown. When pumping stops, the cone of depression gradually fills with water from the surrounding area until equilibrium is again reached between the water level in the well and the surrounding aquifer. An increased pumping rate in

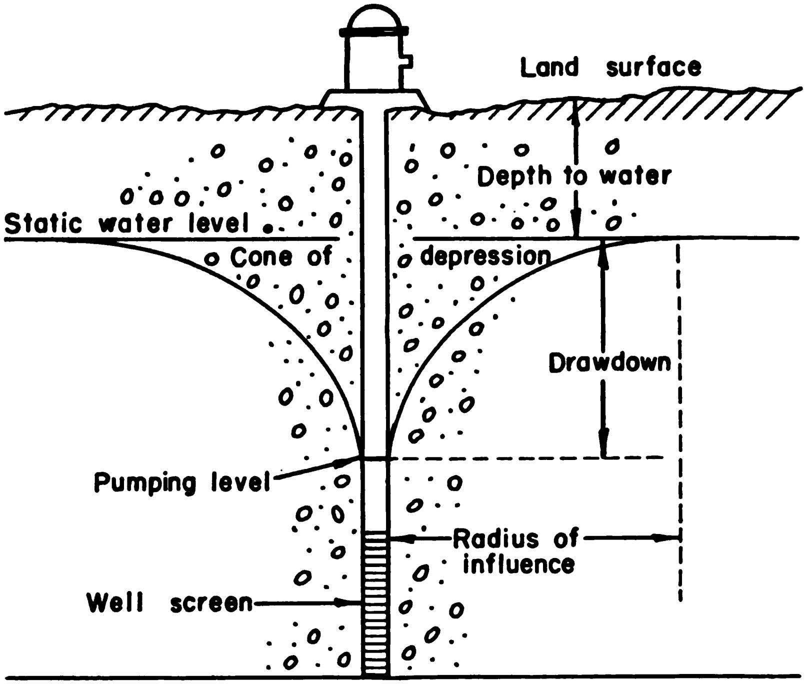

Fig. 11.—Diagrammatic section of well that is being pumped, showing drawdown, cone of depression, and radius of influence.

a well produces a greater drawdown; water moves toward the well under a steeper gradient and at a greater rate. When large quantities of water are withdrawn from a well, the water level drops rapidly at first but gradually drops more slowly until it becomes almost stationary. When pumping stops, the water level rises rapidly at first, gradually rising more slowly until it finally reaches approximately its original position. A recovery curve of irrigation well 11-30-27dc1 is shown in Figure 12.

The character, thickness, and extent of the water-bearing material as well as the construction and condition of the well determine the yield and resultant drawdown of a well. If the water-bearing material is coarse, well rounded, and uniform in size, it will readily yield large quantities of water at relatively slight drawdown. If the water-bearing material is fine or poorly sorted, offering more resistance to the flow of water toward the well, it will decrease the yield and increase the drawdown.

Hydrologic Properties of Water-Bearing Materials

Porosity and specific yield.—The amount of water that can be stored in an aquifer depends upon the porosity of the aquifer. Porosity is expressed quantitatively as the percentage of the total volume of material that consists of open spaces. An aquifer is said to be saturated when all its open spaces are filled with water.

Not all the water will drain from an aquifer when the water table is lowered, some being held by molecular attraction. The volume that drains from a unit volume of the aquifer is called the specific yield, and the volume that is retained in a unit volume is called the specific retention. The specific yield of a water-bearing formation is defined by Meinzer (1923a, p. 28) as the ratio of the volume of water that a saturated sample of the formation will yield by gravity, divided by the volume of the sample. The specific yield of an unconfined aquifer is practically identical to the coefficient of storage, which is a measure of the quantity of water that the aquifer will yield when it is drained by a lowering of the water table. The specific yield is usually stated as a percentage.

Permeability and transmissibility.—The coefficient of permeability of an aquifer is defined as the rate of flow of water, in gallons per day, through a square foot of its cross section, under a hydraulic gradient of 1 foot per foot, at a temperature of 60° F. The field coefficient of permeability is the same, except that it is measured at the prevailing temperature rather than at 60° F. The coefficient of permeability can be conveniently expressed for field use as the flow in gallons per day, across a section 1 mile wide and 1 foot thick under a hydraulic gradient of 1 foot per mile, rather than a section 1 foot wide under a gradient of 1 foot per foot.

The coefficient of transmissibility may be expressed as the rate of flow of water, in gallons per day, through a vertical strip of the aquifer 1 foot wide, under a hydraulic gradient of 1 foot per foot, at the prevailing temperature. The coefficient of transmissibility is equal to the field coefficient of permeability multiplied by the saturated thickness of the aquifer, in feet.

Aquifer tests.—The permeability and transmissibility of the Ogallala Formation in Gove County were calculated, from aquifer tests, by the recovery method developed by Theis (1935, p. 522) and described also by Wenzel (1942, p. 94). According to the recovery formula:

$$T = \frac{264Q \log_{10} t/t'}{s'}$$

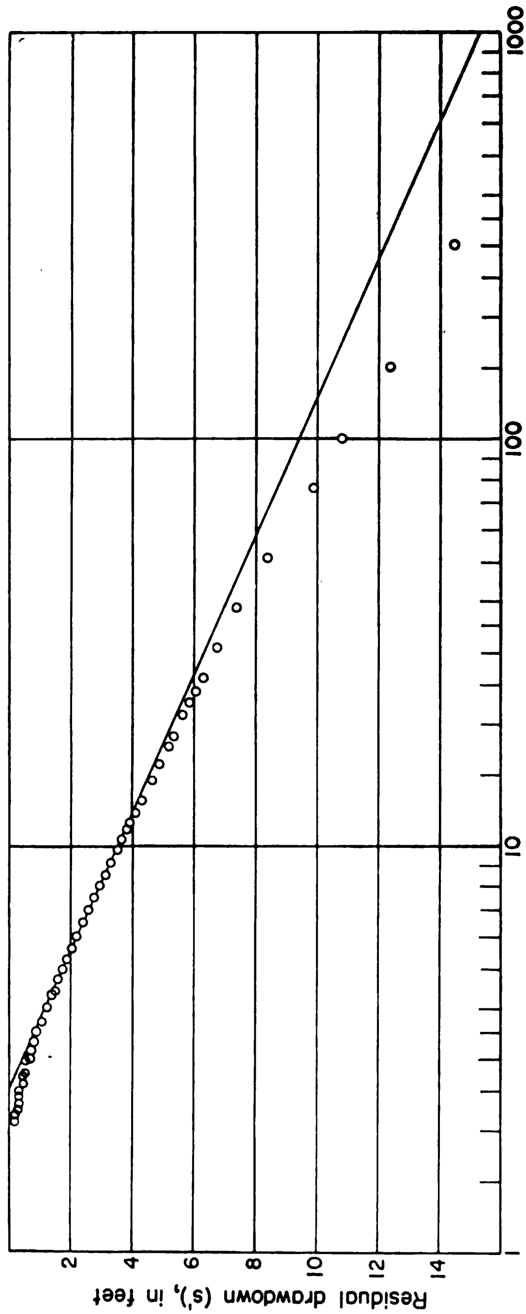

FIG. 12.—Curve obtained by plotting *s'* against *t/t'* for aquifer test using well 11-30-27dc1.

in which T is the coefficient of transmissibility, in gallons per day per foot

Q is the pumping rate, in gallons per minute
t is the time since pumping began, in minutes
t′ is the time since pumping stopped, in minutes, and
s′ is the residual drawdown at the pumped well at time t′, in feet.

The residual drawdown (s′) at any time after pumping ceases (t′) is computed by subtracting the static water-level measurement before pumping began from the water-level measurement made at time t′. The ratio of $\log_{10} t/t'$ to s′ may be determined graphically by plotting $\log_{10} t/t'$ against corresponding values of s′. This procedure is simplified by plotting t/t′ on the logarithmic co-ordinate and s′ on the arithmetic co-ordinate of semilogarithmic paper (Fig. 12). If $\log_{10} t/t'$ is taken over one log cycle, it will become unity and s′ will be the difference in drawdown over one log cycle. The above formula then reduces to: $T = \frac{264Q}{\Delta s'}$ in which $\Delta s'$ is the change in residual drawdown for one log cycle.

An aquifer test using irrigation well 11-30-27dc1, owned by Page Campbell, was made on October 11, 1956. The well was pumped 5 hours at a rate of approximately 400 gallons per minute and the depth to water was measured frequently. Depth-to-water measurements were made during the recovery period for 4½ hours after pumping ceased. Measurements were made with an electric water-level gage, which was checked periodically with a chalked steel tape. The data used in the calculation of the coefficients of transmissibility and permeability are given in Table 3. The time-versus-drawdown curve is shown in Figure 12.

The computations are as follows:

$$T = \frac{(264)\ (400)}{6} = 18{,}000 \text{ gpd/ft.}$$

$$P = \frac{18{,}000}{55\ 4} = 325 \text{ gpd/ft.}^2$$

The coefficient of transmissibility is computed to be about 18,000 gallons per day per foot. The coefficient of permeability, which is obtained by dividing the coefficient of transmissibility by the thickness of the saturated material, 55.4 feet, is about 325 gallons per

TABLE 3.—*Data on aquifer test using well 11-30-27dc1 in Gove County, October 11, 1956. Average yield during pumping was 400 gpm measured by Hoff flow gage. Water-level measurements were made by electric water-level gage.*

Time since pumping started, minutes (t)	Time since pumping stopped, minutes (t′)	t/t′	Depth to water level (feet)	Drawdown below static water level (feet)
0	Pumping started		100.60 static water level	
5	....	....	124	23.40
10	....	....	126	25.40
15	....	....	128	27.40
60	....	....	132	31.40
120	....	....	134.10	33.50
180	....	....	134.28	33.68
240	....	....	134.40	33.80
300	0 Pumping stopped		134.45	33.85
301	1	301	115.1	14.50
302	2	151	113	12.40
303	3	101	111.4	10.80
304	4	76	110.49	9.89
306	6	51	109.00	8.40
308	8	38.5	108.00	7.40
310	10	31	107.35	6.75
312	12	26	106.90	6.30
313	13	24	106.66	6.06
314	14	22.4	106.45	5.85
315	15	21	106.25	5.65
317	17	18.7	105.92	5.32
318	18	17.7	105.74	5.14
320	20	16	105.42	4.82
322	22	14.6	105.22	4.62
325	25	13	104.88	4.28
327	27	12.1	104.68	4.08
329	29	11.3	104.50	3.90
330	30	11	104.41	3.81
332	32	10.4	104.24	3.64
334	34	9.8	104.10	3.50
337	37	9.1	103.88	3.28
340	40	8.5	103.71	3.11
343	43	8.0	103.53	2.93
346	46	7.5	103.37	2.77
350	50	7.0	103.19	2.59
355	55	6.5	102.97	2.37
360	60	6.0	102.78	2.18
365	65	5.6	102.61	2.01
370	70	5.3	102.46	1.86
375	75	5.0	102.32	1.72

TABLE 3.—*Data on aquifer test using well 11-30-27dc1 in Gove County, October 11, 1956. Average yield during pumping was 400 gpm measured by Hoff flow gage. Water-level measurements were made by electric water-level gage.—Concluded*

Time since pumping started, minutes (t)	Time since pumping stopped, minutes (t')	t/t'	Depth to water level (feet)	Drawdown below static water level (feet)
381	81	4.7	102.18	1.58
385	85	4.4	102.10	1.50
390	90	4.3	101.98	1.38
400	100	4.0	101.80	1.20
410	110	3.7	101.65	1.05
420	120	3.5	101.53	.93
430	130	3.3	101.40	.80
440	140	3.14	101.31	.71
450	150	3.0	101.23	.63
460	160	2.87	101.16	.56
470	170	2.76	101.10	.50
480	180	2.7	101.05	.45
490	190	2.6	101.00	.40
500	200	2.5	100.95	.35
510	210	2.43	100.91	.31
525	225	2.33	100.87	.27
540	240	2.25	100.83	.23
555	255	2.19	100.79	.19
570	270	2.11	100.76	.16

day per square foot. The specific capacity of this well is obtained by dividing the discharge in gallons per minute by the drawdown. After 5 hours of pumping at a rate of 400 gpm the well had a drawdown of about 34 feet, giving a specific capacity of about 12 gallons per minute per foot of drawdown.

Recovery measurements also were obtained on irrigation wells 11-30-25cc and 12-26-11bb1. Because the coefficients of transmissibility computed from these data were inconclusive and seemingly could be in error by as much as 50 percent, they have been omitted from this report, but the data are given to show that the local transmissibility of the water-bearing materials is moderately high (Tables 4 and 5).

UTILIZATION

Data on 242 wells in Gove County were obtained during the course of this investigation. Only part of the domestic and stock wells were visited but records were made for all municipal and irrigation wells known to exist in the county at the time of this in-

TABLE 4.—*Data on aquifer test using well 11-30-25cc in Gove County, October 3, 1956. Average yield during pumping was 420 gpm measured by Hoff flow gage. Water-level measurements were made by electric water-level gage.*

Time since pumping started, minutes (t)	Time since pumping stopped, minutes (t′)	t/t′	Depth to water level (feet)	Drawdown below static water level (feet)
0	Pumping started		104.02 static water level	
390	Pumping stopped		.....	.....
391½	1½	261.0	143.98	39.96
394½	4½	87.7	109.00	4.98
395½	5½	71.9	107.95	3.93
398	8	49.8	106.93	2.91
400	10	40.0	106.50	2.48
402	12	33.5	106.15	2.13
404	14	28.9	105.93	1.91
410	20	20.5	105.43	1.41
417	27	15.4	105.16	1.14
420	30	14.0	105.08	1.06
425	35	12.1	104.97	.95
430	40	10.8	104.90	.88
435	45	9.7	104.82	.80
440	50	8.8	104.78	.76
445	55	8.1	104.72	.70
450	60	7.5	104.68	.66
455	65	7.0	104.67	.65
460	70	6.6	104.65	.63
465	75	6.2	104.62	.60
470	80	5.9	104.60	.58
475	85	5.6	104.57	.55
480	90	5.3	104.55	.53
490	100	4.9	104.53	.51
500	110	4.5	104.51	.49
510	120	4.2	104.50	.48
520	130	4.0	104.48	.46
530	140	3.8	104.47	.45
540	150	3.6	104.46	.44
550	160	3.4	104.45	.43
560	170	3.3	104.44	.42
570	180	3.2	104.43	.41
585	195	3.0	104.42	.40
600	210	2.9	104.41	.39
615	225	2.7	104.40	.38
630	240	2.6	104.39	.37
645	255	2.5	104.38	.36
660	270	2.44	104.37	.35
675	285	2.37	104.36	.34
690	300	2.30	104.35	.33
720	330	2.20	104.34	.32
750	360	2.10	104.33	.31
1350	960	1.40	104.26	.24

TABLE 5.—*Data on aquifer test using well 12-26-11bb1 in Gove County, October 16, 1956. Average yield during pumping was 250 gpm measured by Hoff flow gage. Water-level measurements were made by electric water-level gage.*

Time since pumping started, minutes (t)	Time since pumping stopped, minutes (t′)	t/t′	Depth to water level (feet)	Drawdown below static water level (feet)
0	Pumping started		72.37 static water level	
2	....	....	73.85	1.48
3	....	....	74.35	1.98
4	....	....	74.70	2.33
8	....	....	75.35	2.98
10	....	....	75.60	3.23
12	....	....	76.00	3.63
15	....	....	76.40	4.03
19	....	....	76.85	4.48
23	....	....	77.20	4.83
29	....	....	77.70	5.33
33	....	....	77.92	5.55
36	....	....	78.10	5.73
62	....	....	80.31	7.94
72	....	....	81.18	8.81
80	....	....	81.70	9.33
90	....	....	82.30	9.93
100	....	....	82.85	10.48
110	....	....	83.20	10.83
120	....	....	83.62	11.25
130	....	....	83.95	11.58
140	....	....	84.30	11.93
150	....	....	84.57	12.20
160	....	....	84.95	12.58
183	....	....	85.15	12.78
190	....	....	85.15	12.78
215	....	....	85.10	12.73
260	....	....	85.10	12.73
275	....	....	84.48	12.11
320	Pumping stopped		84.75	12.38
321	1	321.0	84.50	12.13
322	2	161.0	84.15	11.78
323	3	107.7	83.97	11.60
324	4	81.0	83.80	11.43
325	5	65.0	83.70	11.33
326	6	54.3	83.55	11.18
327	7	46.7	83.45	11.08
328	8	41.0	83.35	10.98
329	9	36.6	83.26	10.89
330	10	33.0	83.17	10.80

Table 5.—*Data on aquifer test using well 12-26-11bb1 in Gove County, October 16, 1956. Average yield during pumping was 250 gpm measured by Hoff flow gage. Water-level measurements were made by electric water-level gage.—Concluded*

Time since pumping started, minutes (t)	Time since pumping stopped, minutes (t′)	t/t′	Depth to water level (feet)	Drawdown below static water level (feet)
331	11	30.1	83.12	10.75
333	13	25.6	83.00	10.63
335	15	22.3	82.87	10.50
337	17	19.8	82.77	10.40
340	20	17.0	82.63	10.26
345	25	13.8	82.44	10.07
350	30	11.7	82.27	9.90
355	35	10.2	82.11	9.74
360	40	9.0	81.97	9.60
365	45	8.1	81.84	9.47
370	50	7.4	81.71	9.34
375	55	6.8	81.58	9.21
380	60	6.3	81.47	9.10
390	70	5.6	81.25	8.88
400	80	5.0	81.05	8.68
410	90	4.6	80.87	8.50
420	100	4.2	80.70	8.33
430	110	3.9	80.53	8.16
440	120	3.7	80.37	8.00
455	135	3.4	80.16	7.79
470	150	3.1	79.94	7.57
490	170	2.9	79.72	7.35
510	190	2.7	79.53	7.16
530	210	2.5	79.35	6.98
550	230	2.4	79.19	6.82
575	255	2.3	79.02	6.65
605	285	2.1	78.83	6.46
650	330	2.0	78.60	6.23
710	390	1.8	78.34	5.97
770	450	1.7	78.10	5.73
890	570	1.6	77.70	5.33
1040	720	1.44	77.27	4.90
1220	900	1.37	76.85	4.48
1400	1080	1.3	76.51	4.14
1785	1465	1.2	75.67	3.30
2765	2445	1.1	73.97	1.60

vestigation in the summer of 1956. Information regarding these wells is listed in Table 11. The principal uses of ground water in the county are listed below.

Domestic and Stock Supplies

One of the chief uses of ground water in Gove County is for domestic and stock purposes, for which a total of about 800 acre-feet of ground water is pumped annually. Nearly all domestic and stock supplies in the rural part of Gove County are obtained from wells, although in southern Gove County where in many places ground water is difficult to obtain, ponds made by the construction of dams across hillside watercourses provide water for some stock supplies. Most domestic and stock wells in the county are drilled wells in which standard-size galvanized casing has been set and are equipped with displacement-type pumps in which the cylinder is below the water level. Most pumps are operated by windmills; others are operated by electric motors, by gasoline engines, or by hand.

Municipal Supplies

Brief descriptions of cities in Gove County and their water supplies are given below; details of well construction are given in the table of wells and logs at the end of the report. Analyses of water from municipal wells are given in Table 7. Privately owned wells, most of which have individual pressure systems, are used for businesses, homes, and grade and high schools in Park, which has no municipal water supply.

Quinter.—Quinter (population about 730) obtains its water supply from eight drilled wells deriving water from the Ogallala Formation. Most of the wells are southwest of the city, where the saturated thickness of the Ogallala Formation is greater (Fig. 18). Pertinent remarks regarding individual wells and details of well construction are given in Table 11. The wells are equipped with electrically driven turbine pumps. Water is pumped directly into the mains, the excess going into an elevated 50,000-gallon tank. An average daily use of about 300,000 gallons of water was reported by the city engineer.

Grainfield.—Grainfield (population about 370) obtains its water supply from two drilled wells deriving water from the Ogallala Formation. The wells have 12-inch steel casings and are equipped with electrically driven turbine pumps. Water is pumped directly into the mains, the excess going into an elevated 50,000-gallon tank.

An average daily use of 75,000 gallons of water was reported by the city engineer.

Gove.—Gove (population about 200) obtains its water supply from a drilled well in Hackberry Creek alluvium at the south edge of town. The well has a 16-inch steel casing and is equipped with an electrically driven turbine pump, which pumps water into a 750-gallon pressure tank from which the water flows into the mains. An average daily use of 20,000 gallons of water was reported by the city engineer.

Grinnell.—Grinnell (population about 390) obtains its water supply from two drilled wells deriving water from the Ogallala Formation. The wells are at the north edge of town in the SW¼ SW¼ sec. 36, T. 10 S., R. 30 W., in Sheridan County. Electrically driven deep-well turbines pump water directly into the mains, the excess going into an elevated 50,000-gallon tank. An average daily use of 60,000 gallons of water was reported by the city engineer.

Irrigation Supplies

There were 43 irrigation plants pumping ground water in Gove County in the summer of 1956. Most were single irrigation wells but a few plants in the valley of Hackberry Creek were pumping from batteries of two to ten wells.

Nearly half of the irrigation plants in Gove County are in Hackberry Creek valley. Pumping rates of these plants average about 325 gpm each. An estimated 2,000 acre-feet of ground water is pumped annually from this valley, which is relatively narrow. The alluvial fill is about one-third mile wide and contains 50 to 60 feet of alluvial deposits in the deepest part. Water-table contours on Plate 1 show that ground water is draining from the Ogallala Formation into the valley, especially in the western part of the county.

Although only seven irrigation wells in Gove County were obtaining ground water from the Ogallala Formation at the time of this investigation, further development of irrigation in the Ogallala is anticipated. The volume of ground water in storage in the Ogallala Formation in the northern two-fifths of the county was estimated by use of a saturated-thickness map prepared by superimposing a contour map of the water table upon a contour map of the bedrock surface and drawing contours through points of equal saturated thickness. On the basis of an effective porosity of 15 per cent for the saturated deposits, approximately 1.2 million acre-feet of ground water would be in storage in this part of Gove County. Of this volume only a small part could be withdrawn economically by wells, however. Because saturated thickness in the Ogallala is not great in much of this area and because transmissibility is only moderate, ground-water yields can not be expected to exceed 500 gpm and in many places yields will be much less. In addition, depth to water in the Ogallala is greater than in the valley alluvium, hence pumping costs are greater.

Irrigation wells in the Smoky Hill valley are considerably larger than those in other parts of Gove County, yielding as much as 2,000 gpm and averaging about 800 gpm. The relatively small amount of tillable land in the valley has restricted development of irrigation in this part of Gove County, however.

Quality of Ground Water

The chemical character of ground water in Gove County is indicated in Table 6 by analyses of water from the principal aquifers. Also included in the table is an analysis of water from Smoky Hill River. Because most of the samples from municipal supplies are composite samples of water from more than one well, analyses of municipal supplies are given in a separate table (Table 7). The analyses of water samples were made by H. A. Stoltenberg, Chemist, in the Sanitary Engineering Laboratory of the Kansas State Board of Health. The analyses show only the dissolved mineral contents and do not indicate the sanitary conditions of the water. The concentration of mineral constituents is given in parts per million in Table 6 and 7, and in equivalents per million in Figure 13. To convert parts per million to equivalents per million, the valence of each mineral constituent is divided by its atomic weight; then this factor (listed in Table 8) is multiplied by the parts per million for each mineral constituent. A summary of the chemical character of samples of water from wells in Gove County is given in Table 9.

Chemical Constituents in Relation to Use

The following discussion of the chemical constituents of ground water in relation to use has been adapted in part from publications of the U. S. Geological Survey and the State Geological Survey of Kansas.

Dissolved solids.—The residue left after a natural water has

TABLE 6.—*Analyses of water from typical wells in Gove County, Kansas*

Analyzed by H. A. Stoltenberg. Dissolved constituents given in parts per million [a]

WELL NUMBER	Depth, feet	Geologic source	Date of collection	Temperature (°F)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$		
																Total	Carbonate	Noncarbonate
11-26-12cc	75	Ogallala Formation	3-19-56	57	306	34	0.25	65	16	17	254	26	16	0.7	6.2	228	208	20
11-26-33bb	73.4	do	7-21-53	59	319	25	.36	72	16	17	270	18	17	.6	20	246	222	24
11-27-7ca	108.1	do	7-21-53	65	314	28	.05	65	18	17	249	31	19	.6	12	236	204	32
11-28-29da	94	do	7-21-53	65	285	23	.37	60	16	19	257	15	15	.7	9.3	216	210	6
11-29-11dd	101.9	do	7-21-53	60	311	27	.29	58	18	24	239	32	20	1.0	13	218	196	22
11-30-7cb	100	do	3-19-56	57	301	30	12	44	21	30	244	28	14	1.0	13	196	196	0
11-30-27dc1	156	do	10-1-56		283	17	.07	50	18	28	249	23	15	1.1	8.4	199	199	0
11-30-28da	124.3	do	3-18-56	58	302	33	1.1	46	21	28	249	28	14	1.1	8.4	202	202	0
11-31-27ad	69.7	do	7-21-53	58	375	24	4.0	70	21	36	317	36	25	.8	5.8	261	260	1.0
12-26-10cc	48	Alluvium	7-21-53	55	426	33	.13	101	19	24	366	39	26	.5	4.0	330	300	30
12-26-11bb1	92	Ogallala Formation	10-4-56		286	38	.09	58	15	18	251	19	11	.6	3.0	206	206	0
12-26-33bb	74.0	do	7-21-53	59	305	31	.08	70	15	14	244	22	25	.4	8.0	236	200	36
12-27-7bb	105	do	3-18-56	58	246	36	.87	55	12	10	227	7.4	6.0	.5	7.1	186	186	0
12-27-10da	74.0	do	3-19-56	57	332	42	5.0	70	16	18	256	37	19	.8	2.8	240	210	30
12-28-34dd	43.0	Terrace deposits	3-19-56	55	939	34	.09	225	23	39	293	397	40	.7	36	656	240	416
12-29-24da	60.0	Ogallala Formation	3-19-56	56	240	18	18	35	16	28	189	24	18	.9	7.1	154	154	0
12-30-1bb	103.5	do	7-21-53	58	393	29	.89	67	26	28	238	54	40	1.2	31	274	195	79
12-30-14db	35	Alluvium	10-2-56		700	44	1.1	111	42	66	378	190	59	1.0	1.1	450	310	140
12-30-27dd1	39	do	10-2-56		737	40	1.1	137	26	65	294	293	29	1.1	1.3	449	241	208
12-31-13ab	84.2	Ogallala Formation	3-18-56	56	306	27	2.5	49	23	26	259	21	20	1.0	11	216	212	4
13-26-29ab	50	Terrace deposits	7-20-53	70	989	39	.16	196	36	72	329	425	56	.5	2.4	637	270	367
13-27-4ab	11.9	Alluvium	3-19-56		493	24	.12	97	21	40	294	119	20	.9	26	328	241	87
13-27-16ca2	64	do	10-4-56		527	39	.11	119	15	30	271	140	23	.5	27	358	222	136
13-27-27bb	51.0	do	3-19-56	56	428	28	2.7	121	13	11	383	26	9.0	.3	31	356	314	42
13-29-4ba	65	do	10-2-56		752	41	2.8	124	36	78	354	228	68	.8	1.7	458	290	168
13-29-14dd	79.0	Ogallala Formation	3-19-56	57	320	28	.32	73	15	16	266	25	14	.7	17	244	218	26
13-30-2bd	68	do	3-18-56	57	400	45	.22	76	17	31	257	69	23	.8	12	260	210	50
13-30-8ab2	80	Terrace deposits	10-2-56		353	39	.08	69	18	24	254	51	22	.7	4.1	246	208	38
13-30-35ca	54.5	Colluvium	3-18-56	58	2,290	16	8.4	504	63	115	314	1,390	38	2.0	5.8	1,520	260	1,260
13-31-2dd		Terrace deposits	7-21-53	65	968	28	.22	227	16	57	261	459	35	1.0	17	632	214	418
14-26-7cd	18.0	Colluvium	3-19-56	54	352	20	.36	93	9.7	17	278	58	7.0	.7	10	272	228	44
14-26-14dc	696	Dakota Formation	7-20-53	65	1,130	10	.20	4.5	2.2	434	562	176	213	5.6	4.4	20	20	0
14-26-29cc	64	Terrace deposits	7-20-53	61	303	31	2.5	57	16	27	264	24	16	1.0	.7	208	208	0

14-26-30dd2	64.0	do	7-20-53	63	422	46	.15	80	22	27	288	41	29	.8	34	290	236	54
14-26-35dc	70	Alluvium	10- 2-56	....	1,310	32	6.2	242	54	86	220	772	18	1.1	1.6	826	180	646
14-27-7cc	47	Terrace deposits	3-19-56	56	427	32	.76	97	14	26	242	95	35	.4	8.4	300	198	102
14-27-11dc	717	Dakota Formation	10- 1-56	....	923	10	1.6	2.4	.5	370	620	86	137	7.5	4.0	8.0	8.0	0
14-27-12cd	340	Codell Sandstone	10- 1-56	....	409	23	2.1	99	14	21	288	48	20	.5	42	304	236	68
14-29-26da	43.5	Colluvium	3-17-56	57	1,950	13	15	519	36	24	254	1,220	10	1.0	7.1	1,440	210	1,230
14-29-29bb	17.1	do	3-18-56	56	1,430	37	.08	286	42	104	292	765	52	.6	1.2	886	240	646
14-31-27cc	47.5	do	3-18-56	57	2,870	32	.18	599	120	99	298	1,830	32	1.2	8.8	1,990	240	1,750
15-26-32cd	68.0	Terrace deposits	3-19-56	57	411	31	.42	123	10	8.0	384	17	9.0	.3	24	348	315	33
15-26-36ba2	400	Codell Sandstone	10- 4-56	....	898	7.0	2.9	15	8.9	316	495	221	81	4.0	1.3	74	74	0
15-28-2bc	45	Terrace deposits	7-20-53	55	601	22	.18	146	25	25	396	129	24	.6	34	467	324	143
15-28-24aa	98	Alluvium	7-20-53	59	1,240	27	2.9	239	49	77	205	716	34	1.2	1.3	798	168	630
15-29-11ad	22.5	do	3-17-56	53	2,740	31	.16	455	140	181	242	1,760	47	1.0	3.5	1,710	200	1,510
15-29-14da	....	Smoky Hill River	3-19-56	52	1,150	15	.26	237	43	57	188	678	21	1.0	1.3	768	154	614
15-29-18db	90	Alluvium	10- 4-56	....	7,180	27	36	319	614	1,030	329	4,860	162	2.6	3.6	3,320	270	3,050
15-30-9cb	16.3	do	3-18-56	56	1,970	24	5.0	338	98	136	302	1,190	37	1.3	2.5	1,250	250	1,000

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.

TABLE 7.—*Analyses of composite samples of water from municipal supplies in Gove County, Kansas*

Analyzed by H. A. Stoltenberg. Dissolved constituents given in parts per million[a]

MUNICIPAL SUPPLY	Geologic source	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$		
														Total	Carbonate	Noncarbonate
Quinter	Ogallala Formation	2-18-55	281	30	.05	59	14	23	244	28	12	0.8	9.3	204	200	4
Grainfield	do	9-12-55	318	33	.11	54	19	25	238	31	18	1.1	13	212	195	17
Grinnell	do	9-12-55	271	28	.12	46	18	22	239	16	12	1.0	7.5	189	189	0
Gove	Alluvium	3-14-55	674	32	5.3	120	30	65	361	200	41	.6	1.5	423	296	127

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.

TABLE 8.—*Factors for converting parts per million to equivalents per million*

Mineral constituent	Chemical symbol	Factor
Calcium	Ca^{++}	0.0499
Magnesium	Mg^{++}	.0822
Sodium	Na^{+}	.0435
Potassium	K^{+}	.0256
Carbonate	CO_3^{--}	.0333
Bicarbonate	HCO_3^{-}	.0164
Sulfate	SO_4^{--}	.0208
Chloride	Cl^{-}	.0282
Fluoride	F^{-}	.0526
Nitrate	NO_3^{-}	.0161

evaporated consists mainly of the mineral constituents but may also include some organic material and water of crystallization. Water containing less than 500 ppm (parts per million) of dissolved solids generally is satisfactory for domestic and many industrial purposes. Water containing more than 1,000 ppm of dissolved solids generally has enough of certain constituents to produce a disagreeable taste and to make the water unsuitable in other respects.

The dissolved solids in samples of water from wells in Gove County ranged from 240 to 7,180 ppm; 31 samples contained less than 500 ppm but 10 samples contained more than 1,000 ppm (Table 9). Water from the Ogallala Formation characteristically contains only a small amount of dissolved solids; that from the alluvium characteristically contains appreciably more.

Hardness.—Hardness of water is indicated most commonly by the amount of soap needed to produce a lather or suds and by an insoluble scum that forms during washing processes. Calcium and magnesium cause almost all the hardness of water and are the constituents that form most of the scale in steam boilers and other containers in which water is heated or evaporated. The tables of analyses (Tables 6 and 7) show carbonate hardness and noncarbonate hardness in addition to total hardness. Calcium and magnesium bicarbonates cause carbonate hardness, which is sometimes called temporary hardness because the hardness can be virtually removed by boiling the water. Noncarbonate hardness, which is sometimes called permanent hardness because it cannot be removed by boiling, is caused by calcium and magnesium salts of sulfate, chloride, nitrate, and fluoride. Both types of hardness react similarly with soap.

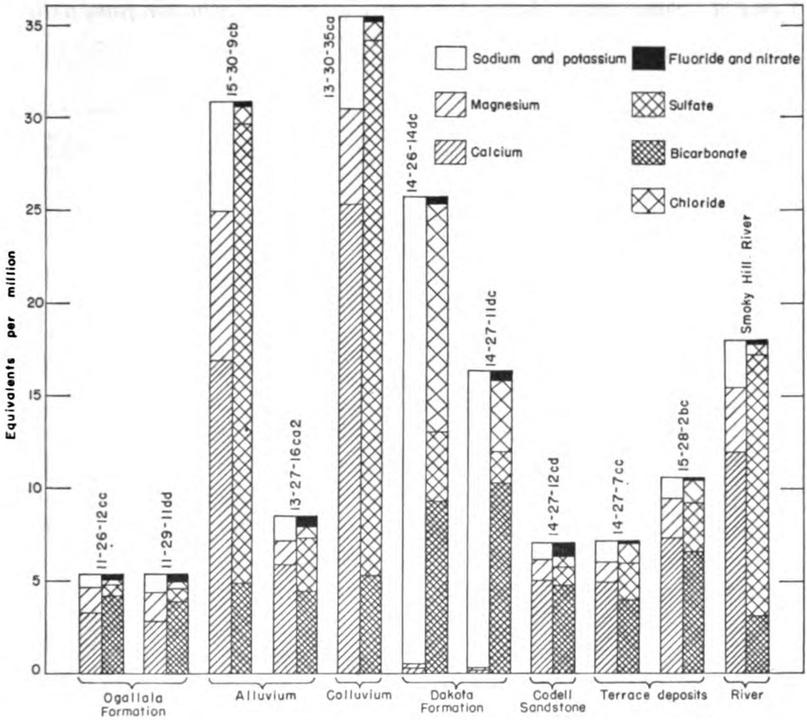

FIG. 13.—Graphic representation of chemical analyses of samples of water from wells in principal aquifers and from Smoky Hill River.

Water that has a hardness of 50 ppm or less is regarded as soft. Water that has a hardness of 50 to 150 ppm is satisfactory for most purposes, but the hardness does increase the amount of soap needed, and treatment of such water by a softening process generally is essential for laundries. Water having a hardness in the upper part of this range will cause scale in steam boilers. Hardness of more than 150 ppm is generally obvious, and water that has a hardness of 200 or 300 ppm is undesirable for household use unless it is treated by a softening process. Where municipal water supplies are softened, the hardness generally is reduced to about 100 ppm.

Total hardness (carbonate and noncarbonate) in samples of water from wells in Gove County ranged from 8 to 3,320 ppm. Only 3 samples had a hardness of less than 150 ppm, and 23 samples had a hardness of more than 300 ppm (Table 9). Water from the Dakota Formation is characteristically soft because of a natural

TABLE 9.—*Summary of chemical character of samples of water from wells in Gove County.*

Range in parts per million	Geologic source and number of samples					
	Ogallala Formation	Alluvium	Terrace deposits	Colluvium	Dakota Formation	Codell Sandstone zone
Dissolved solids						
200-300	7	...	...	...	...	...
301-400	14	...	2	1	...	...
401-500	...	3	3	...	...	1
501-1,000	...	5	4	...	1	1
1,001-5,000	...	4	...	4	1	...
More than 5,000	...	1	...	...	...	...
Hardness						
0-50	...	...	...	...	2	...
51-150	...	...	...	...	...	1
151-200	5	...	...	...	...	...
201-300	16	...	4	1	...	...
301-500	...	8	2	...	...	1
501-1,000	...	2	3	1	...	...
More than 1,000	...	3	...	3	...	...
Nitrate						
0- 5.0	2	10	3	1	2	1
5.1-10	10	...	1	4	...	...
11 -20	8	...	1	...	...	...
21 -40	1	3	4	...	...	...
More than 40	...	...	...	...	...	1
Fluoride						
0-0.5	2	3	3	...	...	1
0.6-1.0	15	5	6	3	...	...
1.1-1.5	4	4	...	1	...	...
More than 1.5	...	1	...	1	2	1
Chloride						
0-10	1	1	1	2	...	...
11-15	8	...	...	...	...	...
16-25	11	3	3	...	...	1
26-35	...	3	3	1	...	...
36-50	1	3	1	1	...	...
More than 50	...	3	1	1	2	1
Iron						
0-0.30	10	4	6	2	1	...
0.31-1.0	5	...	2	1	...	...
1.1-2.0	1	2	...	...	1	...
2.1-4.0	2	3	1	...	...	2
4.1-10	1	3	...	1	...	...
11 -20	2	...	...	1	...	...
More than 20	...	1	...	...	...	...
Sulfate						
0-25	10	...	2	...	...	...
26-50	9	2	1	...	...	1
51-100	2	...	2	1	1	...
101-200	...	4	1	...	1	...
201-300	...	2	...	...	...	1
301-500	...	...	3	...	...	...
501-800	...	2	...	1	...	...
More than 800	...	3	...	3	...	...

softening process that it undergoes in this formation. Water from the Ogallala Formation is moderately hard, the hardness ranging from 154 to 274 ppm. Water from the alluvium in Gove County is hard, and water from the alluvium of the Smoky Hill valley is very hard.

Nitrate.—The nitrate content of different waters differs greatly and in many waters seemingly is not related to the geologic formation. Although some nitrate may be derived from nitrate-bearing rocks and minerals in the water-bearing formation, strong concentrations of nitrate probably are due to other sources. Nitrates are dissolved readily from soils that contain concentrations of nitrate derived from plants, animal waste, or nitrifying action. Because privies, cesspools, and barnyards are sources of organic nitrogen, a large amount of nitrate in well water may indicate the presence of harmful bacteria or prior pollution.

Nitrate in concentrations greater than about 45 ppm is undesirable because of the possible toxic effect that it may have on infants (Metzler and Stoltenberg, 1950). This effect, known as cyanosis, may result when water containing excessive nitrate is used in the preparation of the baby's formula. The Kansas State Board of Health regards 45 ppm as the safe limit of nitrate (as NO_3). This is equivalent to 10 ppm of nitrate nitrogen. Water containing as much as 90 ppm of nitrate generally is regarded as very dangerous to infants, and water containing as much as 150 ppm may cause severe cyanosis. Nitrate in drinking water does not cause cyanosis in older children or adults but may be responsible for certain digestive disorders. Nitrate cannot be removed from water by boiling.

The nitrate content of samples of water from wells in Gove County ranged from 0.7 to 42 ppm. All samples contained less than the 45 ppm limit set by the State Board of Health.

Fluoride.—Fluoride generally is present only in small concentrations in ground water, but it is important to know the amount of fluoride in water used by children. Too much fluoride in water has been shown to be associated with the dental defect known as mottled enamel, which may appear on the teeth of children who, during the period when permanent teeth are forming, drink water containing too much fluoride (Dean, 1936, p. 1270). Although too much fluoride may have a detrimental effect, later studies have shown that moderate concentrations of fluoride (1.0 to 1.5 ppm) too small to cause objectionable mottling of tooth enamel, help to prevent tooth decay. The United States Public Health Service (1946) has published standards that set or recommend the maximum concentrations of mineral constituents permissible in drinking water that is used on interstate carriers. The maximum amount of fluoride permissible is 1.5 ppm.

The fluoride content of water samples from wells in Gove County ranged from 0.3 to 7.5 ppm. Five samples contained fluoride in excess of 1.5 ppm (Table 9).

Chloride.—Chloride is abundant in nature, and many rocks contain small to large amounts of chloride salts that may be dissolved by ground water. Water that contains less than 250 ppm of chloride is satisfactory for most purposes. Water containing more than 250 ppm of chloride generally is objectionable for municipal supplies, and water containing more than 350 ppm can be objectionable for irrigation or industrial use. Water containing as much as 500 ppm of chloride has a salty taste. The upper limit of chloride in water permissible for cattle is believed to be about 4,000 or 5,000 ppm.

Chloride content of water samples from wells in Gove County ranged from 6 to 213 ppm, but only eight samples contained more than 50 ppm (Table 9). Samples from the Dakota Formation contained more chloride than samples from other aquifers, and all but one sample from the Ogallala Formation contained less than 25 ppm.

Iron.—Iron and manganese in quantities that exceed a few tenths of a part per million are undesirable, as they stain fabrics and plumbing fixtures and produce an objectionable precipitate in the water. The limit generally specified is 0.3 ppm. Water in the ground may contain considerable iron but upon exposure to air most of the iron is oxidized and precipitated as a reddish sediment, only a few tenths of a part per million of the iron remaining in solution. Iron may be removed from most water by aeration and filtration, but some water requires additional treatment.

The iron content of water samples from wells in Gove County ranged from 0.05 to 36 ppm; 23 samples contained less than 0.3 ppm and only 9 samples contained more than 4 ppm (Table 9).

Sulfate.—Sulfate (SO_4) in ground water is derived principally from gypsum or anhydrite (calcium sulfate) and from the oxidation of pyrite (iron disulfide). Magnesium sulfate (Epsom salt) and sodium sulfate (Glauber's salt), if present in sufficient quantities, will impart a bitter taste to the water and the water may act as a laxative for people not accustomed to drinking it. More than 250 ppm of sulfate in drinking water generally is undesirable (U. S. Public Health Service, 1946).

Most water samples from wells in Gove County contained only a small amount of sulfate, but some contained nearly 5,000 ppm. Ground water from the Ogallala Formation characteristically contained a very small amount of sulfate, whereas ground water from alluvial deposits in the Smoky Hill valley contained a large amount of sulfate (Table 6).

Sanitary Considerations

The analyses of water in Tables 6 and 7 give only the amount of dissolved mineral matter in the water and do not indicate the sanitary quality of the water, although a large amount of certain mineral constituents such as nitrate or chloride may indicate pollution. Water containing mineral matter that imparts an objectionable taste or odor may be free from harmful bacteria and safe for drinking. Conversely, water clear and pleasant to the taste may contain harmful bacteria. Great care should be taken to protect domestic and public water supplies from pollution. To guard against contamination of a ground-water supply, a well must be properly sealed in order to keep out dust, insects, vermin, debris, and surface water. Wells should not be placed where barnyards, privies, or cesspools are possible sources of pollution.

Suitability of Water for Irrigation

This discussion of the suitability of water for irrigation is based on methods outlined in Agriculture Handbook Number 60, U. S. Department of Agriculture (U. S. Salinity Laboratory Staff, 1954).

In areas of sufficient rainfall and ideal soil conditions, soluble salts originally present in the soil or added to the soil with water are carried downward by percolation and ultimately reach the water table. Soil that was originally nonsaline and nonalkali may become unproductive if excessive soluble salts or exchangeable sodium are allowed to accumulate as a result of improper irrigation and soil management or inadequate drainage. If the amount of water applied to the soil is not in excess of the amount needed by plants, water will not percolate downward below the root zone, and mineral matter will accumulate at that point. Likewise, impermeable soil zones near the surface can retard the downward movement of water and cause waterlogging of the soil and deposition of salts.

The characteristics of an irrigation water that seem to be most important in determining its suitability are the total concentration of soluble salts and the relative activity of sodium ions in exchange reactions. For diagnosis and classification, the total concentration of soluble salts in irrigation water can be expressed in terms of electrical conductivity, which is a measure of the capacity of the inorganic salts in solution to conduct an electrical current. The electrical conductivity can be determined accurately in the laboratory, or an approximation of the electrical conductivity can be obtained by multiplying the total equivalents per million of cations (calcium, magnesium, sodium, and potassium) by 100 or by dividing the total dissolved solids in parts per million by 0.64.

Salt-sensitive crops such as strawberries, green beans, and red clover may be affected adversely by irrigation water having an electrical conductivity exceeding 250 micromhos per centimeter, but waters having electrical-conductivity values below 750 micromhos per centimeter are generally satisfactory for irrigation insofar as salt content is concerned. Waters in the range of 750 to 2,250 micromhos per centimeter are widely used, and satisfactory crop growth is obtained under good management and favorable drainage conditions, but saline conditions will develop if leaching and drainage are inadequate. Use of waters having conductivities of more than 2,250 micromhos per centimeter is the exception, and few instances can be cited where such waters have been used successfully.

The sodium-adsorption ratio may be determined by the formula

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

where the ionic concentrations are expressed in equivalents per million. The sodium-adsorption ratio may also be determined by use of the nomogram shown in Figure 14. In using the nomogram to determine the sodium-adsorption ratio of a water, the concentration of sodium expressed in equivalents per million is plotted on the left scale (A), and the concentration of calcium plus magnesium expressed in equivalents per million is plotted on the right scale (B). In this report the concentrations of sodium and potassium are given together as sodium, but the amount of potassium is negligible. The point at which a line connecting these two points intersects the sodium-adsorption-ratio scale (C) determines the sodium-adsorption ratio of the water. Table 10 gives the well numbers and index numbers of samples for which analyses are plotted on Figures 14 and 15, sodium-adsorption ratios, and approximate electrical conductivities.

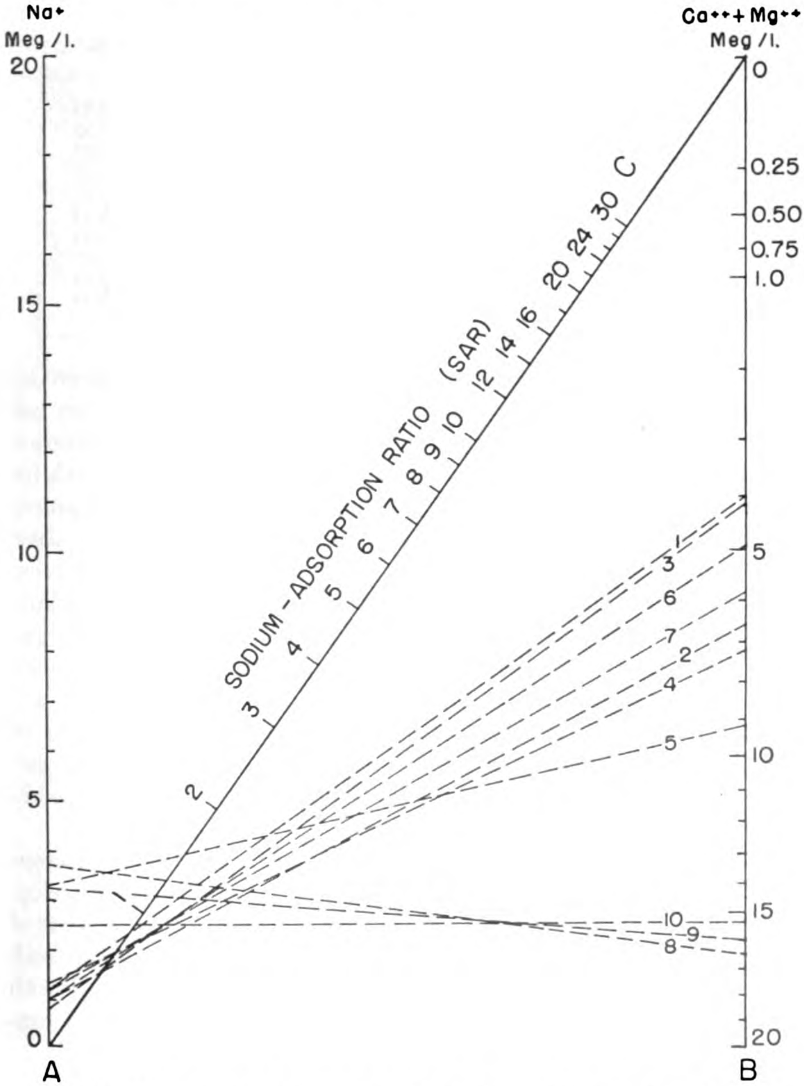

Fig. 14.—Nomogram for determining the sodium-adsorption ratio of water.

TABLE 10.—*Index numbers of samples shown in Figures 14 and 15, and sodium-adsorption ratio (SAR) and conductivity of samples for which analyses are given in Table 6.*

Well number	Number used in Figures 14 and 15	SAR	Approximate conductivity micromhos/cm at 25° C
11-30-27dc1	1	0.90	480
12-26-10cc	2	.60	720
12-26-11bb1	3	.60	470
13-27-16ca1	4	.70	840
13-29-4ba	5	1.60	1,220
13-30-8ab2	6	.70	580
14-26-30dd	7	.70	680
14-26-35dc	8	1.30	2,040
15-28-24aa	9	1.20	1,940
15-29-14da	10	.90	1,890

When the sodium-adsorption ratio and the electrical conductivity of a water are known, the suitability of the water for irrigation can be determined graphically by plotting these values on the diagram shown in Figure 15. Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. Medium-sodium water (S2) may be used safely on coarse-textured or organic soils having good permeability, but S2 water will present an appreciable sodium hazard in certain fine-textured soils, especially under low-leaching conditions. High-sodium water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management such as good drainage, leaching, and addition of organic matter. Very high sodium water (S4) generally is unsatisfactory for irrigation unless special action is taken, such as addition of gypsum to the soil.

Low-salinity water (C1) can be used for irrigation of most crops on most soils with little likelihood that soil salinity will develop. Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. Crops that tolerate moderate amounts of salt such as potatoes, corn, wheat, oats, and alfalfa, can be irrigated with C2 water without special practices. High-salinity water (C3) cannot be used on soils having restricted drainage. Very high salinity water (C4) can be used only on certain crops and then only if special practices are followed.

Ten representative analyses of water samples from irrigation systems were selected for determining the suitability of water in

Gove County for irrigation; also included is an analysis of water from Smoky Hill River (Table 10). Electrical-conductivity values ranged from 470 to 2,040. In Figure 15, all the waters were classified as low-sodium water (S1), and as either medium-salinity water (C2) or high-salinity water (C3).

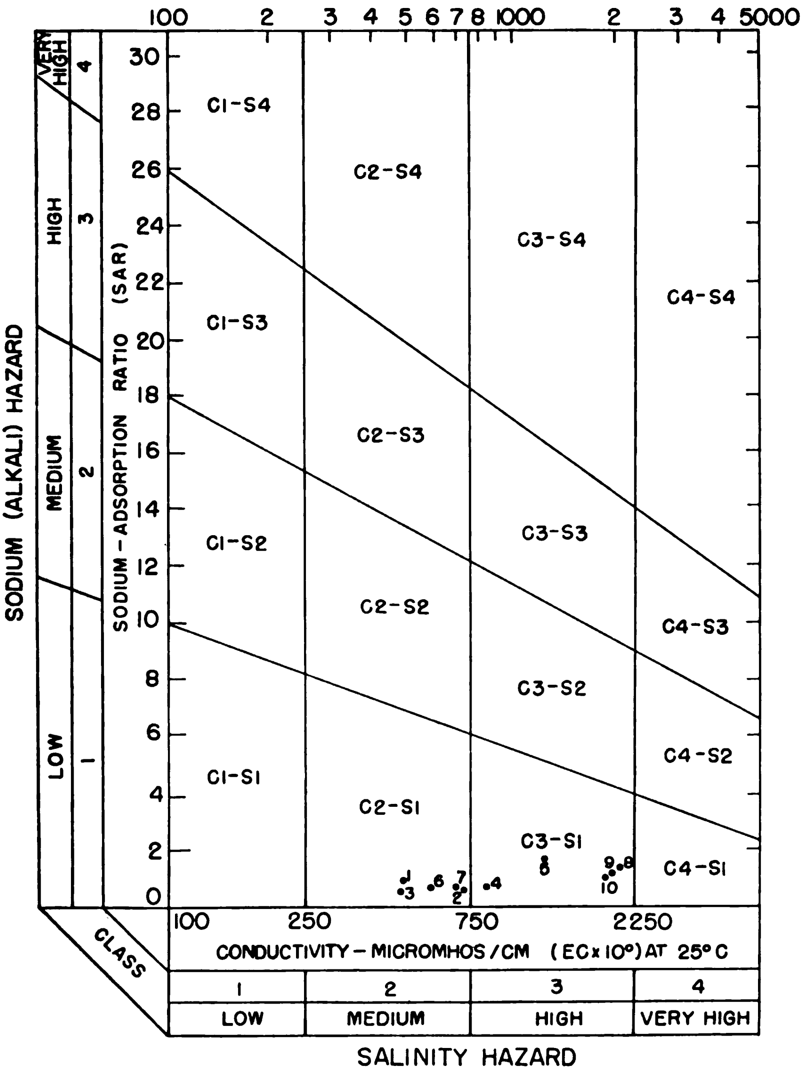

FIG. 15.—Classification of waters being used for irrigation in Gove County.

GEOLOGIC FORMATIONS IN RELATION TO GROUND WATER

Cretaceous System (Gulfian Series)

Dakota Formation

The Dakota Formation does not crop out in Gove County but it contains ground water within a practical drilling depth and should be considered in a discussion of the aquifers of the county. In nearby Trego and Rooks Counties the Dakota is an important source of ground water in certain areas where shallow ground water is scarce, and in Logan County a well in the NW¼ sec. 6, T. 13 S., R. 33 W., obtains water from the Dakota Formation for stock use (Johnson, 1958). Data were obtained on six water wells in Gove County that were drilled to the Dakota Formation, mostly in the southeastern part of the county. At the time of this investigation, four of the wells were being used and two were abandoned because of pumping difficulties.

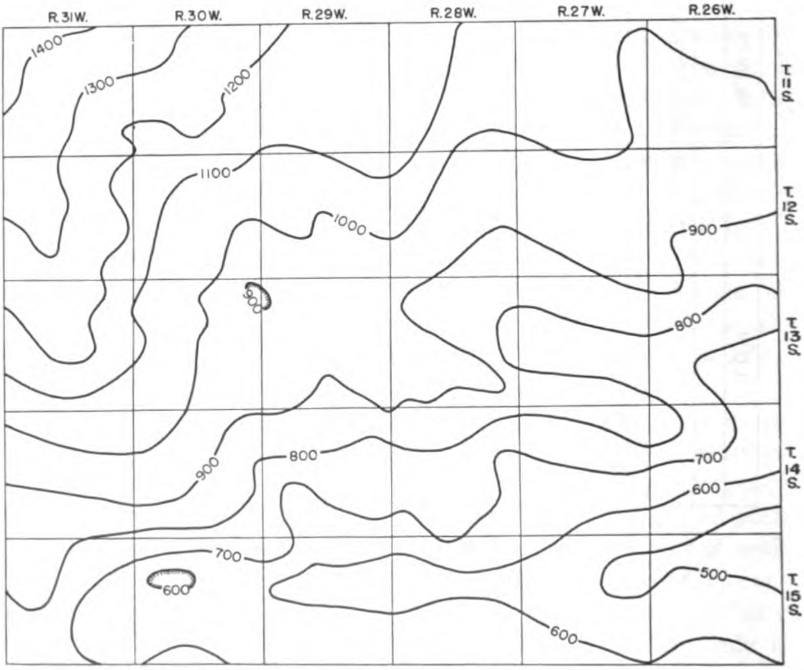

Fig. 16.—Generalized contours showing depth of Dakota Formation below land surface. Interpolated from structure and convergence maps by Merriam and Frye (1954) and from logs of oil and gas test wells. Contour interval 100 feet.

The Dakota Formation in Kansas consists predominantly of clay, shale, siltstone, and lenses of fine- to medium-grained sandstone. Although the Dakota is predominantly clay (Plummer and Romary, 1942), sandstone lenses occur throughout the formation, and water-bearing sandstone can be expected at any locality. The thickness of the Dakota Formation is about 250 feet in Gove County. The depth below land surface to the top of the Dakota ranges from about 500 feet in the southeastern part of the county to about 1,400 feet in the northwestern part (Fig. 16). Water within the Dakota Formation is under artesian pressure in Gove County and although the water does not flow at the surface the water level rises considerably in the wells. In a well in the SE¼ sec. 14, T. 14 S., R. 26 W., water from the Dakota rises to 276 feet below the land surface and in the NW¼ sec. 21, T. 13 S., R. 30 W., water rises within 445 feet of the surface. Because of the discontinuity of sandstone lenses in the Dakota, wells fairly close together may differ in depth to water, artesian head, and quality of water.

Analyses of water samples from two wells deriving water from the Dakota Formation in Gove County indicate that water from the Dakota contains more than 350 ppm of sodium but is suitable for domestic and stock use.

Graneros Shale

The Graneros Shale overlies the Dakota Formation and is about 45 feet thick in Gove County. The Graneros Shale consists principally of dark blue-gray shale; thin layers of bentonite are characteristic, and locally it contains thin lenses of ferruginous sandstone. The Graneros Shale is not known to yield water to any wells in Gove County.

Greenhorn Limestone

The Greenhorn Limestone overlies the Graneros Shale and is about 100 feet thick in Gove County. The Greenhorn Limestone consists chiefly of alternating beds of chalky limestone and calcareous shale. The Greenhorn is not known to yield water to any wells in Gove County.

Carlile Shale

The Carlile Shale overlies the Greenhorn Limestone and is about 250 feet thick in Gove County. The lower two-thirds (Fairport Shale member) consists chiefly of gray to blue-gray calcareous shale and thin beds of chalky limestone. The upper one-third

(Blue Hill Shale member) consists of dark-gray clayey shale, at the top of which is silty, fine-grained sandstone a few feet thick called the Codell Sandstone zone. The Codell Sandstone zone is typically variable in both thickness and lithology. It is reported in the subsurface in Gove County by drillers as a thin sandy zone at the "between the shales" break. Wells 14-27-12cd and 15-26-36ba2 are believed to derive water from the Codell, although it is possible that some water also comes from the overlying Fort Hays Chalk member of the Niobrara Chalk. Reported yields from these wells are low; the quality is poor but the water is useable.

Niobrara Chalk

The Niobrara Chalk, chiefly the Smoky Hill Chalk member, crops out in much of the southern and east-central part of Gove County along the valleys of Smoky Hill River and Hackberry Creek and their tributaries. The Niobrara consists of about 700 feet of beds of light-gray chalk, chalky limestsone, and chalky shale, the lower part of which (Fort Hays Chalk member) is massive chalk or chalky limestone about 65 feet thick. Many thin beds of bentonite occur throughout the Niobrara; neither sand nor noncalcareous shale is present. A pair of bentonite seams near the top of the uppermost thick chalk bed marks the boundary between the Fort Hays Chalk member and the overlying Smoky Hill Chalk member.

Fort Hays Chalk member.—The oldest rocks that crop out in Gove County consist of massive chalk beds of the Fort Hays Chalk member, of which only the uppermost part is exposed in the county. The Fort Hays crops out in the extreme eastern part of the county along the edges of the inner valley of Smoky Hill River and is buried beneath the Smoky Hill Chalk, upper member of the Niobrara Chalk, in the rest of the county. The Fort Hays is distinguished from the overlying Smoky Hill by the predominance of massive beds of chalk and chalky limestone characteristic of the Fort Hays. These beds generally are about 3 to 6 feet thick and are separated by thin chalky shale partings. The Fort Hays is grayish white but generally weathers yellow or light brown. Because the Fort Hays is more resistant to erosion than the overlying Smoky Hill Chalk member or the underlying Carlile Shale it generally forms cliffs.

The Fort Hays Chalk Member is not known to yield water to wells in Gove County although some of the water from wells

14-27-12cd and 15-26-36ba2 may be derived from fractures or bedding planes within the Fort Hays rather than from the underlying Codell Sandstone zone.

Smoky Hill Chalk member.—The Smoky Hill Chalk member consists principally of chalky shale and chalk. It is characteristically thin bedded and platy in structure although massive beds occur locally. The Smoky Hill Chalk member is light to dark gray but weathers colorfully to white, yellow, pink, and brown. Concretions of limonite and pyrite and veins of gypsum are common, and thin beds of bentonite occur throughout. Locally, chalk of sufficient porosity has been replaced by chert to form silicified zones. The chert has been precipitated from silica dissolved from the overlying Ogallala Formation by ground water.

The Smoky Hill Chalk member is notable for its effect on topography. Soil is thin or absent, vegetation is sparse, and rain wash and gully erosion have produced winding canyons and barren rocky ridges in much of the outcrop area.

The Smoky Hill Chalk member has long been famous for the abundant vertebrate and invertebrate fossils it contains. Vertebrate fossils include aquatic reptiles, such as mosasaurs and plesiosaurs, and many genera and species of fish. The Smoky Hill also contains abundant invertebrate fossils. Minute shells of foraminifera belonging mainly to the families Globigerinidae and Textularidae compose much of the chalk. Most larger invertebrates belong to the Mollusca and Echinodermata, the most numerous of which are the clams *Inoceramus platinus* and *Ostrea larva.*

The Smoky Hill Chalk member is more than 600 feet thick in northwestern Gove County but thins toward the east, owing to pre-Pliocene erosion. Smoky Hill River and its tributaries have stripped off a considerable part of the Smoky Hill Chalk member in the southern part of Gove County, and along the inner valley, in southeastern Gove County, the whole member has been removed, exposing the underlying Fort Hays.

The Smoky Hill Chalk member is a poor aquifer in Kansas and yields very little water to wells in Gove County. It is relatively impervious except in small local silicified zones and along fractures. A few wells may obtain some ground water from fractured zones in the faulted area in the southwestern part of Gove County, although most of the water is obtained from colluvium. The driller of irrigation well 12-26-11bb2 reported a cavernous siliceous zone in the lower 3 feet of this well, in the upper part of the member.

Because the silicified zones are generally thin and of small lateral extent, only small water yields should be expected.

Pierre Shale

The Pierre Shale conformably overlies the Niobrara Chalk and consists chiefly of dark-gray to black, thin-bedded shale that weathers gray and coffee brown. Thin beds of bentonite are scattered throughout the formation, selenite crystals are abundant, and thin chalk beds occur locally. The Pierre Shale crops out in a downfaulted area in T. 13 and 14 S., R. 31 W., but is restricted to the subsurface in the northwestern part of Gove County where its thickness ranges from a feather edge at its eastern limit to about 150 feet at the west county line (Pl. 3, A-A′). The Pierre Shale is relatively impervious and is of no consequence as an aquifer in Gove County. Where overlain by unconsolidated Tertiary deposits as in northwestern Gove County, the Pierre Shale, like the Smoky Hill Chalk, serves as an impervious layer underlying water-bearing sediments and retards or prevents the downward percolation of ground water.

Tertiary System (Pliocene Series)

Ogallala Formation

The Ogallala Formation was named by Darton (1899) from exposures in southwestern Nebraska. In 1920 Darton designated the type locality as being near Ogallala Station in western Nebraska. Since the work of Darton, the most significant studies of the Ogallala in western Kansas have been by Elias (1931), Smith (1940), and Frye, Leonard, and Swineford (1956). The Ogallala Formation is believed by the State Geological Survey of Kansas to range from early Pliocene, or possibly late Miocene, to late Pliocene in age. It is subdivided into three members—in ascending order, the Valentine, Ash Hollow, and Kimball. A thin discontinuous bed of pisolitic limestone, commonly 1 to 3 feet thick, forms the top of the Ogallala. No attempt was made to subdivide the Ogallala Formation in Gove County.

Character.—The Ogallala was deposited chiefly by eastward-trending streams whose source areas were underlain by igneous rocks of the Rocky Mountains and sedimentary rocks of eastern Colorado. The Ogallala Formation constitutes a widespread mantle of fluviatile deposits consisting predominantly of unconsolidated sand, gravel, silt, and clay but also containing thin beds of volcanic ash, fresh-water limestone, and bentonitic clay. Calcium carbonate is a common constituent as a cementing material in hard gritty beds called "mortar beds" or as caliche beds and nodules. Silica also serves as a cementing material in beds of opaline sandstone and forms chert deposits. Sand is the principal constituent throughout the Ogallala Formation. Beds of sand may be uniform but generally the sand ranges from fine to coarse and commonly is mixed with gravel, silt, or clay. Gravel beds containing lenses of sand, silt, and clay are common but thick beds of uniform gravel are scarce. Silt, sandy silt, and clay beds occur throughout the Ogallala and are greenish gray, pink, tan, and gray, or if the beds contain a large amount of calcium carbonate, they are light gray or white.

Despite the diversity of deposits, the outcrop pattern of the Ogallala presents a uniformity of aspect that makes the formation readily identifiable. Many beds in the Ogallala are cemented or partly cemented with calcium carbonate. Ogallala "quartzite" is another distinctive type of rock in the formation. The "quartzite" consists of sand and gravel beds cemented with opaline silica into a very hard rock. Where the sand is fine or medium, the interstices are almost filled with cement and the rock resembles true quartzite. Where the rock contains coarse sand or gravel it has little resemblance to quartzite except in respect to hardness. The quartzite occurs close to the base of the Ogallala. The siliceous cementing material of the quartzite is believed to have been leached from overlying volcanic ash beds. Because the cemented beds are more resistant to erosion, most outcrops of the Ogallala form rough benches, hard ledges, and cliffs; exposed surfaces commonly have a knobby, irregular aspect (Pl. 6A).

Distribution and thickness.—The Ogallala Formation rests on an erosional topography developed on Cretaceous bedrock; relief is about 500 feet in Gove County (Fig. 17). The Ogallala is thickest in the northern part of the county; it becomes thin and discontinuous in the central part of the county and is missing in almost all the southern part. It caps a few high interstream areas in the extreme southeastern and southwestern parts of the county and caps isolated buttes in sec. 28, T. 14 S., R. 30 W., and in sec. 33, T. 13 S., R. 31 W. (Pl. 1). The Ogallala, although generally mantled with eolian silts, underlies the upland plain in the northern part of Gove County and crops out along the valleys of Hackberry Creek

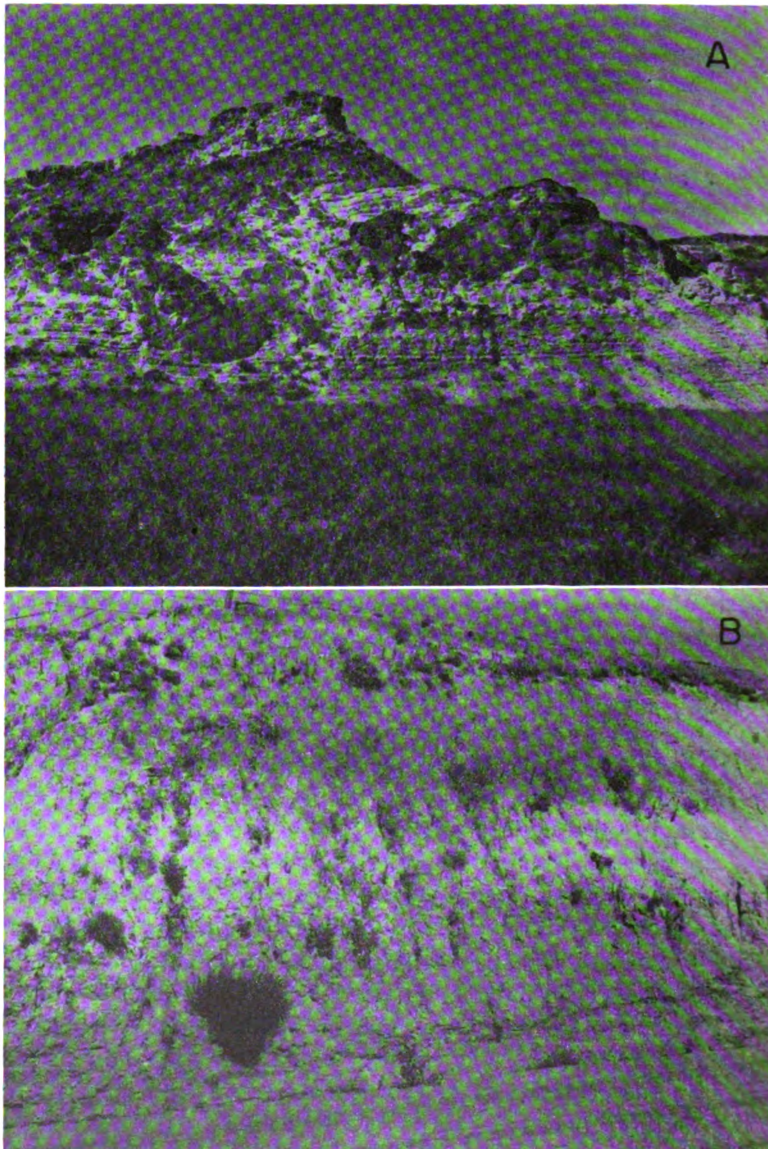

PLATE 6.—Tertiary and Quaternary deposits in Gove County. A, Outcrop of Ogallala Formation in NW¼ NW¼ sec. 12, T. 14 S., R. 26 W. B, Eolian silts, classified as Peoria and Loveland Formations, in SE¼ SW¼ sec. 35, T. 15 S., R. 29 W.

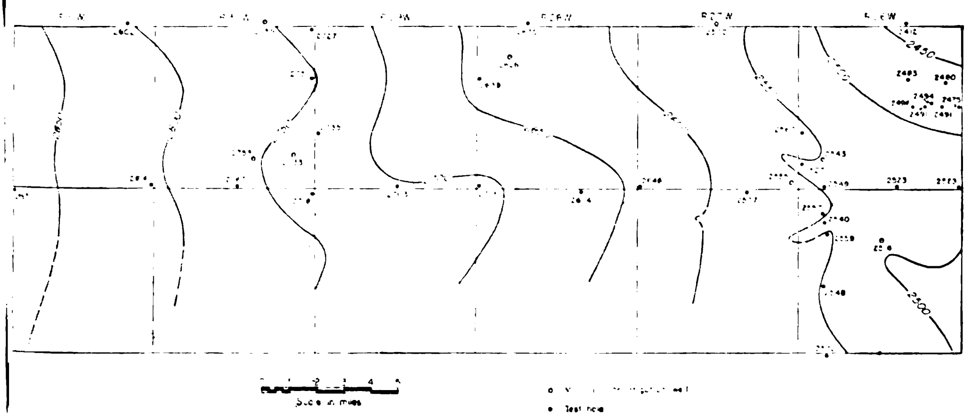

FIG. 17.—Map of northern part of Gove County showing configuration of Cretaceous bedrock surface beneath unconsolidated Tertiary and Quaternary deposits. Contour interval 50 feet.

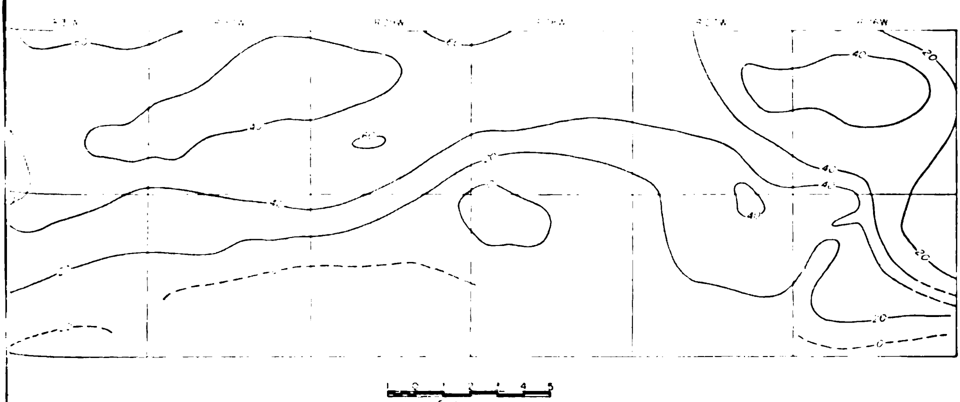

FIG. 18.—Saturated thickness of Tertiary and Quaternary deposits in Gove County. Contour interval 20 feet.

and Big Creek and their tributaries. Tributaries of Saline River have exposed the Ogallala at places along the northern edge of the county.

Smoky Hill River in Gove County runs near and approximately parallel to a pre-Ogallala divide, or bedrock high. The bedrock slopes downward from each side of this divide, hence deposits of the Ogallala become increasingly thicker to the north and south. Wichita, Lane, and Scott Counties to the south of Gove County, and Sheridan and Thomas Counties to the north are underlain by thick deposits of the Ogallala Formation, but in Gove County the thickness does not exceed 150 feet and is not uniform, because of unconformable contacts at the top and bottom. Over most of the northern upland the Ogallala is mantled by loess, which is locally 50 feet thick. The thickness and character of the Ogallala are given in the logs of test holes at the back of this report and are illustrated in the cross sections on Plate 3.

Water supply.—The Ogallala Formation is the most widespread water-bearing formation in Gove County. It supplies water to nearly all domestic and stock wells in the northern part of the county, and at the time of this investigation seven irrigation wells were obtaining water from the Ogallala. The yields of the wells range from a few gallons per minute for domestic and stock wells to about 400 gpm for irrigation well 11-30-25cc. In much of the Ogallala Formation in Gove County, the water-bearing beds are too thin and the transmissibility too low to permit the pumping of large amounts of water. Logs of test holes, however, indicate that parts of the Ogallala Formation consist of sand and gravel beds in which relatively large amounts of water are in storage and from which moderate yields of water can be expected.

Analyses of water samples from wells that derive water from the Ogallala Formation indicate that the water is almost uniform and good. Although moderately hard, the water is suitable for most purposes.

Quaternary System (Pleistocene Series)

Deposits of Quaternary age, although relatively thin in most of Gove County, are surficial materials in much of the county as shown by the geologic map (Pl. 1) and cross sections (Pl. 3). Quaternary deposits are both fluviatile and eolian in origin and are assigned to the Pleistocene Series. The deposits are composed chiefly of silt, sand, and gravel. Fluviatile deposits are associated either with the present drainage system or with older drainage systems. Eolian deposits generally blanket the upland but locally extend into the valleys and rest on older fluviatile deposits.

Terrace Deposits

Character and distribution.—Stream-deposited sand, gravel, and silt in a terrace position overlying Cretaceous bedrock represent alluvial deposits classified as Illinoisan and Kansan in age. The deposits are more extensive along the Smoky Hill River valley but also occur along Hackberry Creek and Big Creek valleys. The terrace deposits are dissected and discontinuous and lie considerably above the surface of the alluvial fill of the inner valleys. In Gove County, terrace deposits attain their maximum thickness in the "Missouri Flats" area, where they are as much as 65 feet thick. Arkosic sand and gravel classified as the Crete Formation, of Illinoisan age, constitute the greater part of the terrace deposits in the county. Small isolated volcanic ash deposits at scattered localities, mostly along Smoky Hill River, are identified as the Pearlette Ash bed of the Sappa Formation, of late Kansan and early Yarmouthian age. Small deposits of sand and gravel along Smoky Hill River are classified as the Grand Island Formation, of Kansan age. Lithologically, the Grand Island is very similar to the Crete Formation. Stratigraphically, the Grand Island underlies the Sappa Formation and is generally identified by its association with the Pearlette Ash bed. Most of the sand and gravel deposits mapped as Terrace deposits on Plate 1 probably belong to the Crete Formation, but it is possible that the Grand Island underlies much of the more extensive terrace deposits, particularly those along the south side of Smoky Hill River. The basal deposits underlying the "Missouri Flats" area may also belong to the Grand Island Formation.

Water supply.—Much of the material classified as Terrace deposits in this report forms only small isolated deposits containing little or no ground water. In such places as the "Missouri Flats" area in south-central Gove County and other small areas along Smoky Hill River, however, the terrace deposits are the principal source of ground water. Springs are common along the contact of terrace deposits on Cretaceous bedrock and in places the water is diverted for domestic and stock use.

Loveland and Peoria Formations

Eolian silts form the most extensive outcrops in Gove County, blanketing much of the county with a cover of loess ranging in thickness from a featheredge to as much as 50 feet. The loess caps the rolling topography of the upland and also masks the valley walls of the larger streams. Eolian silts in Gove County represent the Loveland Formation of Illinoisan age and the Peoria Formation of early Wisconsinan age. In the northwestern part of the county the Bignell Formation, of late Wisconsinan and Recent age, locally overlies the Peoria. Where the Bignell was recognized it was generally about 1 or 2 feet thick and most of it was incorporated within the modern soil profile.

The Loveland Formation is a reddish-tan silt, mostly eolian, which characteristically grades into sand in the lower part. At the top of the Loveland and separating it from the Peoria Formation is the Sangamon buried soil. The Peoria Formation is a massive, eolian, tan to gray silt, which extends in an almost unbroken blanket over the upland of Gove County and also masks the valley slopes in much of the county. Colluvium, material deposited by slope wash and consisting of reworked loess and Cretaceous bedrock fragments, mantles many slopes; where it is thick enough to conceal the underlying bedrock it has been mapped with the Peoria and Loveland Formations. Plate 6B shows the Peoria and Loveland Formations resting on the Smoky Hill Chalk member of the Niobrara Chalk, where the following section was measured.

Section of Peoria and Loveland Formations measured in road cut in SE¼ SW¼ sec. 35, T. 15 S., R. 29 W.

	Thickness, feet
PEORIA FORMATION	
6. Silt, eolian, massive, gray to yellowish tan, contains modern soil profile at top	8.8
LOVELAND FORMATION	
5. Silt, eolian, reddish brown, leached but containing a few caliche nodules and streaks	5.6
4. Silt, eolian, calcareous, light gray to white	1.8
3. Silt, eolian, sandy, light tan to brown; sand is fine at top and grades to coarse at base	16.6
2. Sand, silty, tan; sand becomes very coarse at base	10.0
SMOKY HILL CHALK MEMBER OF NIOBRARA CHALK	
1. Shale, chalky, dark gray	
Total thickness of Pleistocene deposits	42.8

The deposits mapped as Peoria and Loveland Formations in this report consist mostly of relatively thin, wind-deposited silt generally well above the water table. In the southern part of Gove County, where in most places ground-water supplies are meager, shallow domestic and stock wells obtain small amounts of ground water from colluvium and slope deposits that in this report are included with the Peoria and Loveland Formations. Because ground water in these deposits is generally in contact with the underlying Cretaceous bedrock and with bedrock fragments that are incorporated within the colluvium, the water obtained from these wells is generally very poor (Fig. 13).

Alluvium (Late Wisconsinan and Recent Stages)

Character.—Alluvial deposits along the streams in Gove County range in composition from clay to coarse sand and gravel. Thick coarse deposits of sand and gravel are restricted to the larger valleys and are derived by erosion from older alluvial deposits and from the Ogallala Formation. Thin deposits of alluvium lie in the smaller valleys and contain more fine sand and silt; they grade headward into colluvium and slope deposits. The lithology of these deposits depends upon the rock into which the valley has been incised.

In the Smoky Hill valley, the alluvium that underlies the braided stream channel and the narrow floodplain is Recent in age. Low, relatively narrow terraces thought to be of late Wisconsinan age border the floodplain. The alluvium of Recent age and the alluvial deposits underlying the low terraces of late Wisconsinan age are lithologically indistinguishable and are shown together as Alluvium on Plate 1.

Distribution and thickness.—Alluvium occurs in narrow belts along the principal streams. It attains its greatest width, almost a mile in some places, in the valleys of Smoky Hill River and Hackberry Creek. The thickest alluvium is that in the Smoky Hill valley, where it is approximately 100 feet thick in the deepest part of the valley fill. Alluvium in the Hackberry Creek valley is as much as 60 feet thick. Alluvium in the small tributary valleys is thin or absent.

Water supply.—Alluvial deposits constitute one of the principal aquifers in Gove County. Many domestic and stock wells obtain water from them, and in much of the southern part of the county the small alluvial deposits are the principal source of ground water. Several irrigation wells have been developed in alluvium in the valleys of Smoky Hill River, Hackberry Creek, and Big Creek.

Large to moderate yields of water can be expected from wells in alluvium of the Smoky Hill valley. Areal extent of the alluvium is small, however, averaging only a half mile in width. In addition, most of the soil in the inner valley is poor, very sandy, and subject to floods, and soil in the outer valley is very thin and subject to rapid erosion. The amount of tillable land in the Smoky Hill valley is therefore small, hence a relatively small amount of the ground-water potential is utilized. Contrarily, soil in the Hackberry Creek valley is fertile, and although only small to moderate amounts of ground water are available from wells in the alluvium, irrigation has been developed much more extensively. An estimated 2,000 acre-feet of ground water is pumped annually from alluvium in Hackberry Creek valley.

Although ground-water yields from alluvium in the larger stream valleys are moderate to large, yields from alluvium in the smaller valleys can be expected to be considerably smaller. Material penetrated by wells in the smaller valleys has small cross-sectional area and less permeability. Consequently, yields from wells in the smaller valleys can be expected to diminish during extended periods of pumping, especially during low rainfall periods. Declining water levels and diminishing yields after several weeks of pumping were reported in the Hackberry Creek valley by local irrigators.

Depth to water below the surface in the alluvium of Gove County is generally less than 20 feet. The water table can be expected to fluctuate, however, in response to evapotranspiration and to local precipitation as well as to ground-water pumpage. Much of the water in the alluvium is transpired by deep-rooted plants, often resulting in a seasonal decline in the summer when water use by plants is greatest.

RECORDS OF WELLS AND TEST HOLES

Information pertaining to 242 wells, 45 test holes drilled by the State Geological Survey, and 22 drillers logs in Gove County is given in Table 11. Measured well depths are given to the nearest tenth of a foot; reported well depths are given in feet. Measured depths to water are given to the nearest tenth or hundredth of a foot; reported depths to water are given in feet. The well-numbering system used in this table is illustrated in Figure 2 and described on page 11.

TABLE 11.—*Records of wells and test holes in Gove County, Kansas*

Well number	Location (1)	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, inches	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source of water	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height of land surface above mean sea level, feet	Depth to water level below land surface, feet (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 10 S., R. 26 W.															
10-26-35dd	SE SE sec. 35		T	59.0	4	N					Land surface	0	2467.4	19.80	8-28-52	Located in Sheridan County.
	T. 10 S., R. 27 W.															
10-27-34dd	SE SE sec. 34		T	108.0	4	N					do	0	2672.8	71.80	9-8-52	do
10-27-36dd	SE SE sec. 36	C. W. Woodward	Dr	51.0	5	GI	Sand and gravel	Ogallala Formation	N	N	Top of concrete walk	0.1	2598.0	38.00	8-20-52	do
	T. 10 S., R. 28 W.															
10-28-33dd	SE SE sec. 33		T	113.0	4	N					Land surface	0	2741.2		9-12-52	do
10-28-34dd	SE SE sec. 34	A. Selenke	Dr	75.6	6	GI	Sand, gravel	Ogallala Formation	Cy, W	S	Base of pump	0.6	2743.3	61.66	9-17-52	do
	T. 10 S., R. 29 W.															
10-29-32dc	SW SE sec. 32	O. B. Jones	Dr	128.0	5	GI	do	do	Cy, W	S	do	1.5	2874.0	110.90	9-16-52	do
	T. 10 S., R. 30 W.															
10-30-31cc	SW SW sec. 31		T	138.0	4	N					Land surface	0	2924.6	52.40	9-12-52	do
10-30-36cc1	SW SW sec. 36	City of Grinnell	Dr	150	12	S	Sand, gravel	Ogallala Formation	T, E	PS	do	0	2909.2	112	9-27-56	do
10-30-36cc2	SW SW sec. 36	do	Dr	150	10	S	do	do	T, E	PS	do	0	2909.2	112	9-27-56	do
	T. 11 S., R. 26 W.															
11-26-4cc	SW SW sec. 4	R. B. Sterrett	Dr	60.5	5	GI	do	do	Cy, W	S	Base of pump	1.3	2581.9		7-30-56	Well caved; weight muddy at 60.5 ft.
11-26-6bd	SE NW sec. 6	John D. Owens	Dr	32.0	5	GI	do	do	Cy, W	S	do	1.0	2567.6	27.65	8-31-56	
11-26-8cc	SW SW sec. 8	C. Starkey	Dr	105.0	5	GI	do	do	Cy, W	N	Top of platform	0.4	2645.8	90.55	7-30-56	Abandoned.
11-26-11cc1	SW SW sec. 11		Dr	70	3	N					Land surface	0	2537.3	10	6-20-52	Schaeffer Geophysics shot hole. Drillers log.
11-26-11cc2	SW SW sec. 11		Dr	110	3	N					do	0	2581.9		6-20-52	do

11-26-11cd	SE SW sec. 11		Dr	107.5	3	N					do	0		60 27	6-12-52	Schaeffer Geophysics shot hole.
•11-26-12cc	SW SW sec. 12	J. Walsh	Dr	75 8	5	GI	Sand, gravel	Ogallala Formation	Cy, W	S	Base of pump	1.2	2563.7	60 00	7-30-56	
11-26-13ba1	NE NW sec. 13		Dr	70.0	3	N					Land surface	0		66.16	6-11-52	Schaeffer Geophysics shot hole.
11-26-13ba2	NE NW sec. 13		Dr	125 0	3	N					do	0	2569.8		6-20-52	Schaeffer Geophysics shot hole. Drillers log.
11-26-13cd	SE SW sec. 13		Dr	115.0	3	N					do	0	2571.0	54.80	6-20-52	do
11-26-13dd	SE SE sec. 13		Dr	95.0	3	N					do	0	2540.3	37.80	6-20-52	do
11-26-14cc	SW SW sec. 14	School district	Dr	93 5	5	GI	Sand, gravel	Ogallala Formation	Cy, W	D	Top of casing	0.2		83.47	7-30-56	
11-26-14cd	SE SW sec. 14		Dr	120.0	3	N					Land surface	0	2609.1	73.97	6-20-52	Schaeffer Geophysics shot hole. Drillers log.
11-26-14dc	SW SE sec. 14		Dr	125 0	3	N					do	0	2594 2	69.34	6-20-52	do
11-26-14dd	SE SE sec. 14		Dr	100.0	3	N					do	0	2558.6	38.40	6-20-52	do
11-26-16cc	SW SW sec. 16	W Ulrich	Dr	95.5	5	GI	Sand, gravel	Ogallala Formation	N	N	Top of casing	0.6	2647.4		7-30-56	Well caved; weight muddy at 95.50 ft.
11-26-19cc	SW SW sec. 19		T	105 5	4	N					Land surface	0	2664.0		9-19-52	
11-26-25ab	NW NE sec. 25	L. H. Weins	Dr	64.0	5½	GI	Sand, gravel	Ogallala Formation	Cy, W	D, S	Concrete curb	0.5	2579.8	56.45	9- 7-56	
11-26-27dd	SE SE sec. 27	M. E. Neher	Dr	138	4	N								85		Irrigation test hole. Drillers log.
11-26-29ba	NE NW sec. 29	City of Quinter	Dr	110	36	S	Sand, gravel	Ogallala Formation	T, E	PS					10- 4-56	Reported yield 50.
11-26-29cc	SW SW sec. 29	do	Dr	121	12	S	do	do	T, E	PS	Land surface	0		117	10- 4-56	do
11-26-30dd	SE SE sec. 30	do	Dr	123	12	S	do	do	T, E	PS	Base of pump	0.6	2666.2		7-30-56	Reported yield 50; drawdown 27.
11-26-31bb	NW NW sec. 31		T	140 0	4	N					Land surface	0	2664.9		9-18-52	
11-26-31dd	SE SE sec. 31		T	92 0	4	N					do	0	2638.2		9- 2-52	
•11-26-33bb	NW NW sec. 33	S. B. Bowman	Dr	73.4	5	GI	Sand, gravel	Ogallala Formation	Cy, W	D	Top of platform	0.3	2636 7	69 98	7-30-56	
11-26-34bc	SW NW sec. 34	J. C. Boone	Dr	97 5	5	GI	do	do	N	N	Top of casing	2.2	2626.8	74.10	7-30-56	
11-26-34dc	SW SE sec. 34		T	91.0	4	N					Land surface	0	2613.6	62.50	9- 7-57	
11-26-36dd	SE SE sec. 36		T	63.5	4	N					do	0	2584.4		9-19-52	
	T. 11 S., R. 27 W.															
11-27-4dd	SE SE sec. 4	J. P. Geotz	Dr	83 3	5	GI	Sand, gravel	Ogallala Formation	Cy, W	S	Base of pump	1.3	2683.8	79.20	8-31-56	
11-27-5ab	NW NE sec. 5	J. Schoenfeldt	Dr	82 0	5	GI	do	do	Cy, W	S	do	0.6	2696.2	74.30	9- 4-52	
•11-27-7ca	NE SW sec. 7	U. P. Railroad	Du	108 1	180	R	do	do	T, E	D	Top of rail	3.3	2715.7	101.10	8- 5-52	
11-27-12bb	NW NW sec. 12	R. B. Sterrett	Dr	23 0	6	GI	do	do	Cy, W	S	Base of pump	0.8	2594.8	18.00	8-31-56	
11-27-16aa	NE NE sec. 16	M. E. Neher	Dr	132	5	GI	do	do	Cy, W	N	do	0	2712.9	94.57	8- 2-56	Abandoned domestic well used as observation well.
11-27-19ad	SE NE sec. 19	R. Waldman	Dr	112 0	4	GI	do	do	Cy, W	D, S	do	0.5	2736.3	89.07	10-15-56	
11-27-22bb	NW NW sec. 22	J. C. Richmeier	Dr	78 2	5	GI	do	do	Cy, W	S	do	0 9	2687.5	64.40	8- 2-56	
11-27-25ba	NE NW sec. 25	F. Reinecker	Dr	87 5	6	GI	do	do	Cy, W	S	do	0.2	2653.6	53.82	10-15-56	
11-27-27cc	SW SW sec. 27	H. A. Steinle	Dr	128.0	5	GI	do	do	Cy, W	N	Top of platform	0.5	2722.8	98.40	8- 2-56	

Table 11.—*Records of wells and test holes in Gove County, Kansas—Continued*

Well number	Location (1)	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, inches	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source of water	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height of land surface above mean sea level, feet	Depth to water level below land surface, feet (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 11 S., R. 27 W.															
11-27-29bc	SW NW sec. 29	P. Waldman	Dr	96.0	5	GI	Sand, gravel	Ogallala Formation	Cy, W	S	Base of pump	1.8	2723.1	74.40	7-31-56	
11-27-30cc	SW SW sec. 30	School district	Dr	89.0	5	GI	do	do	Cy, W	D	Top of platform	1.2	2726.9	66.00	7-31-56	
11-27-31cc	SW SW sec. 31	....	T	49.5	4	N	....	....	....	....	Land surface	0	2691.3	....	9-18-52	
11-27-31dd	SE SE sec. 31	Mrs. G. G. Waldman	Dr	45.5	5	GI	Sand and gravel	Ogallala Formation	Cy, W	S	Base of pump	0.7	2696.0	43.05	7-31-56	
11-27-36ca1	NE SW sec. 36	City of Quinter	Dr	85	12	S	do	do	N	PS	Land surface	0	....	20	10-4-56	New well; not in use. Reported test yield 100.
11-27-36ca2	NE SW sec. 36	do	Dr	62	12	S	do	do	T, E	PS	do	0	....	20	10-4-56	Reported yield 200.
11-27-36cb	NW SW sec. 36	do	Dr	62	12	S	do	do	T, E	PS	do	0	....	20	10-4-56	do
11-27-36da	NE SE sec. 36	do	Dr	74.2	12	S	do	do	N	PS	Top of casing	4.2	....	46.67	9-11-56	New well; not in use.
11-27-36dc	SW SE sec. 36	do	Dr	58.0	16	GI	do	do	T, E	PS	do	0	2613.4	13.94	6-12-52	
	T. 11 S., R. 28 W.															
11-28-3bc	SW NW sec. 3	Dorothy Van Marter	Dr	87.5	6	GI	do	do	Cy, W	S	Base of pump	0.4	2750.8	82.40	9-7-56	
11-28-7aa1	NE NE sec. 7	City of Grainfield	Dr	150	12	S	do	do	T, E	PS	Land surface	0	2807.5	112	9-27-52	
11-28-7aa2	NE NE sec. 7	do	Dr	150	12	S	do	do	T, E	PS	do	0	....	115	9-27-56	
11-28-7cc	SW SW sec. 7	....	T	187	4	N	....	....	....	....	do	0	2825.4	....	9-16-52	
11-28-8bb	NW NW sec. 8	F. S. Osborn	Dr	178	18	S	Sand, gravel	Ogallala Formation	T, B	I	Base of pump	0.6	2801.1	119.50	9-13-56	Reported yield 280.
11-28-10dd	SE SE sec. 10	O. Hartman	Dr	120	5½	GI	do	do	N	N	Top of casing	0.5	....	80	9-26-56	New well; not in use. Drillers log.
11-28-11ad	SE NE sec. 11	K. Truethin	Dr	110	5½	GI	do	do	Cy,W,E	D, S	Land surface	0	....	100	8-31-56	
11-28-16dc	SW SE sec. 16	R. Zimmerman Est.	Dr	......	5	GI	do	do	Cy, W	S	Base of pump	0.4	2770.8	87.72	9-10-56	
11-28-18aa	NE NE sec. 18	Ernie Hauser	Dr	114.0	5	GI	do	do	Cy, N	N	Top of platform	0.2	2808.0	111.10	7-31-56	
11-28-19bb	NW NW sec. 19	J. Wolf	Dr	87.0	5	GI	do	do	Cy, W	N	do	1.0	2777.7	75.29	7-31-56	
11-28-22dd	SE SE sec. 22	J. Heier	Dr	110.0	5	GI	do	do	Cy, W	S	Base of pump	1.1	2756.1	83.00	7-31-56	
11-28-25aa	NE NE sec. 25	M. D. Zimmerman	Dr	......	5	GI	do	do	Cy, W	S	do	0.5	....	75.30	9-10-56	

11-28-26bb	NW NW sec. 26	J. Heier	Dr	108.0	5½	GI	do	do	N	N	Top of casing	0.1	....	83.10	9-30-56	New well; not in use. Drillers log.
11-28-28da	NE SE sec. 28	S. V. Crider	Dr	94.2	5	GI	do	do	N	N	do	1.4	2756.1	75.60	7-31-56	
•11-28-29da	NE SE sec. 29	C. A. Zerr	Dr	94.0	5	GI	do	do	Cy, W	S	Base of pump	0	2771.6	81.02	7-31-56	
11-28-31bb	NW NW sec. 31	A. Selensky	Dr	78.0	5	GI	do	do	Cy, W	S	do	0.2	2765.7	57.35	9-12-56	
11-28-31cc	SW SW sec. 31	....	T	104.0	4	N	....	....	....	....	Land surface	0	2810.8	....	9-18-52	
11-28-32dd	SE SE sec. 32	School district	Dr	....	6	GI	Sand, gravel	Ogallala Formation	Cy, W	D	Base of pump	0.3	2754.3	66.22	10- 9-56	
11-28-33dd	SE SE sec. 33	....	T	50.0	4	N	....	....	....	....	Land surface	0	2738.4	....	8-10-56	
11-28-36cc	SW SW sec. 36	A. Delensky	Dr	41.0	5	GI	Sand, gravel	Alluvium	Cy, N	N	Base of pump	0	2682.9	20.10	7-31-56	
	T. 11 S., R. 29 W.															
11-29-2ab	NW NE sec. 2	J. Gassman	Dr	80.0	6	GI	do	Ogallala Formation	Cy, W	S	do	0.5	....	62.30	9-10-56	
11-29-8dd	SE SE sec. 8	School district	Dr	112.0	4	GI	do	do	Cy, W	D	Top of platform	0.3	2846.7	100.12	7-31-56	Used as observation well.
11-29-9ab	NW NE sec. 9	L. Boxberger	Dr	130.0	5	GI	do	do	Cy, H	N	Base of pump	1.0	2859.2	124.00	7-31-56	
•11-29-11dd	SE SE sec. 11	C. B. Greer	Dr	104.9	5	GI	do	do	Cy, W	S	do	0.4	2786.1	82.74	7-31-56	
11-29-14cc	SW SW sec. 14	D. Gillespie	Dr	120.0	6	GI	do	do	Cy, E	D, S	do	0.6	2818.2	92.82	10-15-56	
11-29-19cb	NW SW sec. 19	G. McNitt	Dr	83.0	5	GI	do	do	Cy, W	S	do	0.3	2850.3	63.50	9- 4-56	
11-29-19cc1	SW SW sec. 19	....	T	87.0	4	N	....	....	N	N	Land surface	0	2833.5	....	9-12-57	
11-29-19cc2	SW SW sec. 19	....	T	130.0	4	N	....	....	....	....	do	0	2860.6	74.20	9-16-57	
11-29-27da	NE SE sec. 27	M. A. Gillespie	Dr	78.9	6	GI	Sand, gravel	Ogallala Formation	N	N	Top of casing	0	2801.1	69.18	7-31-56	
11-29-29aa	NE NE sec. 29	Elmo Cooper	Dr	....	5	GI	do	do	Cy, W	S	Base of pump	1.4	2826.9	65.40	9- 4-56	
11-29-34cc	SW SW sec. 34	....	T	150.0	4	N	....	....	....	....	Land surface	0	2828.6	....	9-10-57	
	T. 11 S., R. 30 W.															
11-30-1aa	NE NE sec. 1	....	T	210	4	N	....	....	....	....	do	0	2889.5	....	5-24-52	
11-30-4ba	NE NW sec. 4	J. Nollette	Dr	120.0	5	GI	Sand, gravel	Ogallala Formation	Cy, G	S	Base of pump	1.0	2938.3	112.14	9-16-52	
•11-30-7cb	NW SW sec. 7	Wm. Friend	Dr	100.0	6	GI	do	do	Cy, W	S	do	0.5	2940.6	82.50	8- 1-56	
11-30-12bb	NW NW sec. 12	F. E. Karlin	Dr	148.7	6	GI	do	do	Cy, W	S	do	0.7	2906.6	122.80	7-31-56	
11-30-12dd	SE SE sec. 12	....	T	150.0	4	N	....	....	....	....	Land surface	0	2892.2	....	9-17-57	
11-30-15dd	SE SE sec. 15	A. Geist	Dr	100.0	5	GI	Sand, gravel	Ogallala Formation	Cy, W	S	Base of pump	1.2	2875.4	70.75	9- 4-56	
11-30-16db	NW SE sec. 16	E. C. Beougher	Dr	123.0	5½	GI	do	do	N	N	....	....	....	....	Aug. 56	New well; not in use. Drillers log.
11-30-17da	NE SE sec. 17	R. M. Thomas	Dr	86.0	5½	GI	do	do	Cy, N	N	Base of pump	0.1	2910.4	82.50	9- 6-56	
11-30-25cc	SW SW sec. 25	Bob Dickman	Dr	161.0	16	S	do	do	T, D	I	do	1.0	2894.4	104.02	10- 1-56	Measured yield 420. Drillers log.
11-30-27c	SW sec. 27	Loyd Swart	Dr	166	4	N	....	....	....	....	....	....	....	....	....	Irrigation test hole. Drillers log.
•11-30-27dc1	SW SE sec. 27	Page Campbell	Dr	156	16	S	Sand, gravel	Ogallala Formation	T, B	I	Base of pump	0.2	2906.0	100.40	9-12-56	Measured yield 400 Drillers log.
11-30-27dc2	SW SE sec. 27	do	Dr	156	16	S	do	do	T, B	I	Land surface	0	....	101	9-12-56	Reported yield 170
•11-30-28da	NE SE sec. 28	G. M. Swart	Dr	124.3	6	GI	do	do	Cy, W	S	Base of pump	0.7	....	102.88	7-31-56	
11-30-29cd	SE SW sec. 29	L. Meuse	Dr	92.0	6	GI	do	do	Cy, W	S	do	0.6	....	71.30	9- 4-56	
11-30-34cc	SW SW sec. 34	....	T	110.0	4	N	....	....	....	....	Land surface	0	2870.6	....	9-11-57	
	T. 11 S., R. 31 W.															
11-31-9cb	NW SW sec. 9	M. W. Swart	Dr	102.1	5	GI	Sand, gravel	Ogallala Formation	Cy, H	N	Base of pump	0.3	3009.8	99.96	8- 1-56	

TABLE 11.—*Records of wells and test holes in Gove County, Kansas*—*Continued*

Well number	Location (1)	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, inches	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source of water	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height of land surface above mean sea level, feet	Depth to water level below land surface, feet (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 11 S., R. 31 W.															
11-31-10aa	NE NE sec. 10	Thos. P. Johnstone	Dr	97.3	5½	GI	Sand, gravel	Ogallala Formation	N	N	Top of casing	0.8	2980.1	91.20	8-1-56	Abandoned domestic well; used as observation well.
11-31-14ad	SE NE sec. 14	School district	Dr	99.5	5	GI	do	do	Cy, H	D	Base of pump	0	2958.1	85.82	8-1-56	
11-31-18cb	NW SW sec. 18	H. Tinsley	Dr	81.0	5	GI	do	do	Cy,G,W	S	do	0.7	......	67.95	8-1-56	
11-31-19dc	SW SE sec. 19	B. F. Tinsley	Dr	36.5	6	GI	do	do	Cy, W	S	do	0.3	2948.0	28.12	10-17-56	
11-31-20ab	NW NE sec. 20	E. P. Wieland	Dr	47.0	6	GI	do	do	Cy, W	S	do	1.0	2936.0	27.05	9-6-56	
11-31-24dc	SW SE sec. 24	M. R. Trueman	Dr	94	5½	GI	do	do	Cy, W	S	Land surface	0	......	86	9-6-56	
*11-31-27ad	SE NE sec. 27	School district	Dr	69.7	5	GI	do	do	Cy, H	D	Base of pump	0.2	2916.3	44.84	8-1-56	
11-31-30bc	SW NW sec. 30	B. F. Tinsley	Dr	39.0	5½	GI	do	do	Cy, W	S	Top of casing	0.5	2958.8	31.54	6-25-54	
11-31-32da	NE SE sec. 32	J. J. Redfern	Dr	69.0	4	GI	do	do	Cy, W	S	Base of pump	0.4	2969.4	66.73	8-1-56	
11-31-36dd	SE SE sec. 36	......	T	36.0	4	N	......	......	......	......	Land surface	0	2846.2	......	9-16-52	
	T. 11 S., R. 32 W.															
11-32-24aa	NE NE sec. 24	Cleal M. Harrison	Dr	81.0	5½	GI	Sand, gravel	Ogallala Formation	Cy, W	S	Top of casing	0.5	2990.1	58.50	6-26-54	Located in Logan County.
	T. 12 S., R. 26 W.															
12-26-4dc	SW SE sec. 4	Jesse Long	Dr	40.0	5	GI	do	do	Cy, H	S	Base of pump	0.8	2595.9	39.40	7-30-56	
12-26-6dd	SE SE sec. 6	......	T	36.6	4	N	......	......	......	......	Land surface	0	2593.2	15.20	9-3-52	
12-26-7aa	NE NE sec. 7	......	T	50.0	4	N	......	......	......	......	do	0	2587.0	......	9-3-52	
12-26-8aa	NE NE sec. 8	S. S. Ebbert	Dr	53	18	S	Sand, gravel	Alluvium	T, B	I	Base of pump	0.3	......	18.10	9-14-56	Reported yield 350; drawdown 30.
12-26-8cb	NW SW sec. 8	......	T	37.0	4	N	......	......	......	......	Land surface	0	2587.8	11.90	9-4-52	
12-26-10aa	NE NE sec. 10	......	Dr	75	10	S	Sand, gravel	Ogallala Formation	T, E	I	do	0	......	55	9-14-56	Reported yield 50.
*12-26-10cc	SW SW sec. 10	W. R. Jamison	Dr	48.0	12	S	do	Alluvium	T, G	I	Base of pump	0.4	2564.1	18.10	9-14-56	
*12-26-11bb1	NW NW sec. 11	Z. Z. Oenlinger	Dr	92.0	16	S	do	Ogallala Formation	T, D	I	do	0.3	2612.2	72.67	10-10-56	Measured yield 250.
12-26-11bb2	NW NW sec. 11	do	Dr	90.0	10	S	do	do	T, B	I	do	0.3	......	70.30	9-11-56	
12-26-11cd	SE SW sec. 11	W. C. Jamison	Dr	65.5	6	GI	do	do	Cy, W	D	do	0.2	2586.3	52.87	10-12-56	
12-26-15bb	NW NW sec. 15	Dale Jamison	Dr	59.0	18	S	do	Alluvium	N	I	Top of casing	3.2	......	19.00	9-14-56	New well; not in use.

12-26-10da	NE SE sec. 19		T	130.0	4	N					Land surface	0	2650.3	80.30	9-17-57	
12-26-24ca	NE SW sec. 24	George Walz	Dr	38	18	S	Sand, gravel	Alluvium	T, B	I	do	0		18	9-11-56	Reported yield 400; drawdown 20.
12-26-26aa	NE NE sec. 26	A. Schwarzenberger	Dr	98.0	5	GI	do	Ogallala Formation	Cy, W	S	Base of pump	1.0	2576.8	57.01	7-30-56	
12-26-29aa	NE NE sec. 29	J. C. Blackwell	Dr	50.2	5	GI	do	do	Cy, W	S	do	0.4	2608.8	46.30	9- 7-56	
•12-26-33bb	NW NW sec. 33	H. Jamison	Dr	74.0	5	GI	do	do	Cy, W	S	do	0.4	2606.5	57.00	7-30-56	
12-26-35cc	SW SW sec. 35	A. T. Ziegler	Dr	78.7	6	GI	do	do	Cy, W	S	Top of casing	0.3	2576.1	68.22	10-12-56	
	T. 12 S., R. 27 W.															
12-27-2bb	NW NW sec. 2		T	97.3	4	N					Land surface	0	2673.7	54.90	9- 9-57	
12-27-2dd	SE SE sec. 2	J. L. Mann	Dr	31.5	5	GI	Sand, gravel	Ogallala Formation	Cy, W	N	Top of platform	2.0	2624.6	22.30	7-30-56	
12-27-4aa	NE NE sec. 4	H. Lines	Dr	70.0	6	GI	do	do	Cy, W	S	Base of pump	0.6	2664.5	36.50	9-10-56	
•12-27-7bb	NW NW sec. 7	J. Zerr	Dr	105.0	5	GI	do	do	Cy, W	S	do	0.8	2736.7	86.50	7-31-56	
•12-27-10da	NE SE sec. 10	J. L. Jamison	Dr	74.0	6	GI	do	do	Cy, W	S	Top of platform	0.1	2673.5	61.67	7-30-56	
12-27-15bc	SW NW sec. 15	do	Dr	90.0	5	GI	do	do	Cy, W	S	Base of pump	1.2	2697.8	76.50	7-30-56	
12-27-17bb	NW NW sec. 17	P. Dreher	Dr	76.0	5	GI	do	do	Cy, W	D, S	do	0.9	2707.2	67.18	10-15-56	
12-27-22da	NE SE sec. 22	Ed. Fink	Dr		5	GI	do	do	Cy, W	S	do	0.5	2668.8	65.73	9-10-56	
12-27-24bd	SE NW sec. 24	H. D. Wertz	Dr		6	GI	do	do	Cy, W	S	do	0.6		92.87	9-10-56	
12-27-25bb	NW NW sec. 25	W. D. Jamison	Dr	43.0	5	GI	do	do	Cy, W	S	do	1.4	2620.3	29.30	9-10-52	
12-27-29bb	NW NW sec. 29	A. Zerr	Dr	55.0	5	GI	do	do	Cy, W	S	do	1.0	2665.8	48.05	9- 7-56	
12-27-36bb	NW NW sec. 36	E. Graham	Dr	82.0	5	GI	do	do	Cy, W	N	do	0.3	2653.9	68.50	7-30-56	
	T. 12 S., R. 28 W.															
12-28-3aa	NE NE sec. 3		T	67.0	4	N					Land surface	0	2717.0		9-10-57	
12-28-3db	NW SE sec. 3	Mrs. J. Ochs	Dr	97.0	6	GI	Sand, gravel	Ogallala Formation	Cy, W	S	Base of pump	0.5		73.10	9- 7-56	
12-28-8bb	NW NW sec. 8	R. Ochs	Dr	90.0	5	GI	do	do	Cy, W	S	do	2.1	2776.0	79.60	7-31-56	
12-28-9cb	NW SW sec. 9	Earnest Katt	Dr	77.0	5	GI	do	do	Cy, W	S	do	0.5	2751.5	67.00	7-31-56	
12-28-13cc	SW SW sec. 13	Sutcliffe Est.	Dr	35.6	6	GI	do	Ogallala Formation and alluvium	Cy, W	N	do	0.1		32.50	9- 7-56	
12-28-14bb	NW NW sec. 14	A. Selensky	Dr	56.0	5	GI	do	Ogallala Formation	Cy, W	S	do	2.0	2717.4	51.58	10-15-56	
12-28 21cb	NW SW sec. 21	H. E. Hetzel	Dr	71.0	5	GI	do	do	Cy, W	N	do	0.3	2744.2	63.10	7-31-56	
12-28-22bb	NW NW sec. 22	A. E. Graham	Du		40	R	do	do	Cy, W	N	Top of platform	1.5	2698.2	30.35	7-31-56	
12-28-25dd	SE SE sec. 25	Dale Roberts	Dr	45	18	GI	do	Alluvium	T, G	I	Land surface	0		12	9-15-56	
•12-28-34dd	SE SE sec. 34	G. D. Royer	Du	43.0	58	R	do	Terrace deposits	Cy, W	S	Base of pump	0.3		32.30	9- 4-56	
	T. 12 S., R. 29 W.															
12-29-3da	NE SE sec. 3	B. J. Weber	Dr		5	GI	do	Ogallala Formation	Cy, W	S	do	0.6	2803.3	75.70	9-10-56	
12-29-5bc	SW NW sec. 5	A. Yale	Dr	117.9	4	GI	do	do	Cy, H	N	do	0.2	2862.1	99.89	7-31-56	
12-29-6cc	SW SW sec. 6		T	80.0	4	N					Land surface	0	2798.0	28.80	9-12-57	
12-29-12ba	NE NW sec. 12	M. E. Campbell	Dr	120.0	5	GI	Sand, gravel	Ogallala Formation	Cy, W	D, S	Base of Pump	0.3	2813.1	100.40	10-15-56	
12-29-13cc	SW SW sec. 13	G. Maurath	Dr	79.6	5	GI	do	do	Cy, W	S	do	1.0	2767.4	61.70	9-21-56	
12-29-16aa	NE NE sec. 16	B. Heier	Dr	69.7	5	GI	do	do	Cy, G	S	do	0.7	2787.3	49.23	9-21-56	
12-29-17bb	NW NW sec. 17		Dr	27.0	6	GI	do	do	Cy, W	S	do	0.5	2770.9	20.14	10-15-56	
•12-29-24da	NE SE sec. 24	G. Heier	Dr	60.0	5	GI	do	do	Cy, W	D, S	do	1.6	2752.1	55.10	9-19-56	

TABLE 11.—*Records of wells and test holes in Gove County, Kansas*—*Continued*

Well number	Location (1)	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, inches	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source of water	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height of land surface above mean sea level, feet	Depth to water level below land surface, feet (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 12 S., R. 29 W.															
12-29-30aa	NE NE sec. 30	G. D. Tustin	Dr	54.1	5	GI	Sand, gravel	Ogallala Formation	Cy, H	D	Top of platform	0.4	2742.4	49.19	9-21-56	
12-29-30dd	SE SE sec. 30	do	Dr	56	16	S	do	Alluvium	T, P	I	Base of pump	0.5		22.48	9-13-56	Reported yield 140; drawdown 33.
	T. 12 S., R. 30 W.															
12-30-1aa	NE NE sec. 1		T	170.0	4	N					Land surface	0	2880.6	111.00	5-21-52	
•12-30-1bb	NW NW sec. 1	Russell Sites	Dr	103.5	5	GI	Sand, gravel	Ogallala Formation	Cy, W	D, S	Top of casing	0.1		90.10	7-31-56	
12-30-7ab	NW NE sec. 7	A. H. Ottken	Dr	73.0	6	GI	do	Alluvium	Cy, W	S	Base of pump	0.2		47.59	10-17-56	
12-30-7ad	SE NE sec. 7	School district	Dr	86.2	5	GI	do	Ogallala Formation	N	N	Top of platform	0.4	2897.0	73.75	9-25-52	Abandoned.
12-30-9ab	NW NE sec. 9	D. Hood	Dr	37.5	5½	GI	do	Alluvium	Cy, W	S	Base of pump	0.5		18.10	9-4-56	
12-30-13cb	NW SW sec. 13	B. Zimmerman	Dr	28.0	5½	GI	do	Ogallala Formation	Cy, W	N				17.58	9-4-56	
12-30-14cc	SW SW sec. 14	Grant Dohm	Dr	40	24	S	do	Alluvium	T, P	I	Land surface	0		12	9-12-56	Reported yield 200; drawdown 25.
•12-30-14db	NW SE sec. 14	do	Dr	35	5½	GI	do	do	C, P	I	do	0		8	9-12-56	Reported yield 330. Battery of ten wells 20 ft. apart.
12-30-16cb	NW SW sec. 16	E. C. Beougher	Dr	78.2	5	GI	do	Ogallala Formation	Cy, H	N	Base of pump	0.2	2876.6	67.76	8-1-56	
12-30-20da	NE SE sec. 20	Dorothy Van Marter	Dr	16.2	6	GI	do	do	Cy, W	N	Top of casing	0.3		16.10	9-6-56	
12-30-26dd	SE SE sec. 26	Walter Dohm	Dr	57	12	S	do	Alluvium	T, B	I	Land surface	0		14	9-12-56	Measured yield 350.
•12-30-27dd1	SE SE sec. 27	Lubbers Bros.	Dr	39	16	S	do	do	T, E	I	do	0		13	9-12-56	Reported yield 100. Drillers log.
12-30-27dd2	SE SE sec. 27	do	Dr	39	16	S	do	do	T, D	I	do	0		13	9-12-56	Reported yield 200.
12-30-28db	NW SE sec. 28	Guy Van Marter	Dr	34	14	S	do	do	T, D	I	do	0		14	9-12-56	Reported yield 150. Drillers log.
	T. 12 S., R. 31 W.															
12-31-3aa	NE NE sec. 3	Jane Buist	Du	36.8	30	GI	do	Ogallala Formation	Cy, G	S	Top of platform	0.2	2909.0	28.72	8-1-56	

12-31-6bb	NW NW sec. 6		T	120.0	4	N					Land surface	0	3014.3	89.35	9-15-52	
12-31-8aa	NE NE sec. 8	R. Vavrioka	Dr	41.6	5½	GI	Sand, gravel	Ogallala Formation	Cy, H	N	do	0		28.55	9- 6-56	
•12-31-13ab	NW NE sec. 31	L. Brungardt	Dr	84.2	7	GI	do	do	Cy, W	S	Base of pump	0.6	2905.0	70.55	8- 1-56	
12-31-14aa	NE NE sec. 14		Dr	83.3	6	GI	do	do	Cy, H	N	do	0.3			9- 6-56	Well dry; weight muddy at 83.3.
12-31-17cd	SE SW sec. 17	H. A. Hauschild	Dr	22.0	5½	GI	do	do	Cy, W	S	Top of casing	0.2		14.70	9- 6-56	
12-31-26ba	NE NW sec. 26	H. J. Wolf	Dr	25.0	6	GI	do	Alluvium	Cy, W	S	Base of pump	0.5		10.80	9- 6-56	
12-31-30cd	SE SW sec. 30	R. S. Coberly	Dr	81.5	5½	GI	do	Ogallala Formation	Cy, W	N	Hole in pump	1.0	2939.9	67.70	6-23-54	
12-31-33dd	SE SE sec. 33	School district	Dr	79.0	6	GI	do	do	J, E	D	Top of platform	0.3	2944.5	68.30	8- 1-56	
12-31-34d	SE sec. 34	Mads Anderson	Dr	161.0	4	N									9-22-55	Irrigation test well. Drillers log.
	T. 13 S., R. 26 W.															
13-26-5bb	NW NW sec. 5		T	36.0	4	N					Land surface	0	2607.6		9- 4-56	
13-26-20bc	SW NW sec. 20		T	57.0	4	N					do	0	2425.0		9- 4-52	
13-26-23bb	NW NW sec. 23	M. E. Dohm	Dr		6	GI	Sand, gravel	Alluvium	Cy, W	S	Base of pump	0.3		15.50	8- 6-56	
•13-26-29ab	NW NE sec. 29	H. T. Courtney	Dr	50.0	8	S	do	Terrace deposits	N	N	Top of board	0.1		13.09	6-12-52	
13-26-29ac	SW NE sec. 29	do	Dr	405	7½	S	Sand	Dakota Formation	Cy, N	N	Top of casing	0.5	2457.5	324.00	7-17-52	
13-26-29dd	SE SE sec. 29	do	Dr	50	10	S	Sand, gravel	Alluvium	C, E	I	Land surface	0		18	9-19-56	Reported yield 200; drawdown 7.
13-26-30aa	NE NE sec. 30		T	58.0	4	N					do	0	2464.6		9- 4-52	
13-26-32ab	NW NE sec. 32	Albert Tuttle	Dr	42.7	6	GI	Sand, gravel	Terrace deposits	N	N	Top of casing	0.5		26.42	8- 2-56	
	T. 13 S., R. 27 W.															
•13-27-4ab	NW NE sec. 4	E. L. Norton	Du	11.9	48	R	do	Alluvium	Cy, W	N	Top of platform	2.2		11.30	9- 7-56	
13-27-16ca1	NE SW sec. 16	Charles Pierano	Dr	60	18	S	do	do	T, B	I	Land surface	0		14	9-11-56	Reported yield 400; drawdown 40. Drillers log.
•13-27-16ca2	NE SW sec. 16	do	Dr	64	18	S	do	do	T, B	I	do	0		14	9-11-56	Reported yield 1000; drawdown 28 at 830.
•13-27-27bb	NW NW sec. 27	V. E. Kyser	Dr	51.0	6	GI	do	do	Cy, W	S	Top of casing	0.1		34.10	8-28-56	
13-27-30cc	SW SW sec. 30		T	25	4	N					Land surface	0	2637.9		9-17-57	
	T. 13 S., R. 28 W.															
13-28-13aa	NE NE sec. 13	E. G. Smith	Dr	370	6	N									9-14-56	Central Exploration test hole. Drillers log.
13-28-14ac	SW NE sec. 14	Charles Hockersmith	Dr	56	20	GI	Sand, gravel	Alluvium	T, B	I	Land surface	0		17	9-11-56	Reported yield 400; drawdown 30.
13-28-15aa1	NE NE sec. 15	Leslie Mendenhall	Dr	50	18	GI	do	do	T, B	I	do	0		21	9-11-56	Reported yield 200; drawdown 26.
13-28-15aa2	NW NE sec. 15	do	Dr	50	16	S	do	do	T, B	I	do	0		21	9-11-56	do
13-28-15ac	SW NE sec. 15	do	Dr	50	16	S	do	do	T, B	I	do	0		21	9-11-56	do
13-28-27dc	SW SE sec. 27	Wendall Roberts	Dr	58.0	6	GI	do	Ogallala Formation	Cy, W	S	Top of casing	0.5		53.85	8-28-56	
13-28-36dd	SE SE sec. 36		T	25	4	N					Land surface	0	2599.6		9-17-57	

TABLE 11.—*Records of wells and test holes in Gove County, Kansas—Continued*

Well number	Location (1)	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, inches	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source of water	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height of land surface above mean sea level, feet	Depth to water level below land surface, feet (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 13 S., R. 29 W.															
13-29-1ad	SE NE sec. 1	City of Gove	Dr	53	16	S	Sand and gravel	Alluvium	T, E	PS	Land surface	0	....	30	9-28-56	Reported yield 250. Drillers log.
13-29-1d	SE sec. 1	Louie Anglin	Dr	46	4	N	....	....	....	....	....	....	....	....	....	Irrigation test hole. Drillers log.
13-29-3ac	SW NE sec. 3	Richard Roemer	Dr	33	24	S	Sand and gravel	Alluvium	T, B	I	Land surface	0	....	8	9-12-56	Reported yield 200; drawdown 21.
13-29-3bb	NW NW sec. 3	do	Dr	40	12	S	do	do	C, B	I	do	0	....	8	9-12-56	Measured yield 400; drawdown 28. Battery of three wells.
*13-29-4ba	NE NW sec. 4	Raymond Roemer	Dr	65	24	S	do	do	T, B	I	do	0	....	30	9-13-56	Reported yield 400.
13-29-4ca	NE SW sec. 4	do	Dr	38	12	S	do	do	C, B	I	do	0	....	18	9-13-56	Reported yield 250; battery of two wells.
*13-29-14dd	SE SE sec. 14	E. R. Slawson	Dr	79.0	5	GI	do	Ogallala Formation	Cy, W	S	Top of casing	0.3	....	58.15	9-18-56	
	T. 13 S., R. 30 W.															
13-30-1ad	SE NE sec. 1	Anna Howard Est.	Dr	......	5½	GI	do	do	Cy, W	S	Base of pump	0	....	58.60	9- 4-56	
*13-30-2bd	SE NW sec. 2	Ludwig Zerr	Dr	68	6	GI	do	do	Cy, W	S	Land surface	0	....	40	9-17-56	
13-30-3dd	SE SE sec. 3	J. L. Kruger	Dr	45.3	5	GI	do	do	Cy, N	N	Top of platform	0	....	43.25	8- 1-56	
13-30-8ab1	NW NE sec. 8	Halbert Litton	Dr	52.6	5	GI	do	do	Cy, W	S	do	1.3	....	47.63	8- 1-56	
*13-30-8ab2	NW NE sec. 8	do	Dr	80	16	S	do	Terrace deposits	T, P	I	do	0.3	....	43.50	9-13-56	Reported yield 175; drawdown 34.
13-30-21bb	NW NW sec. 21	E. L. Downard	Dr	1100	8	S	Sand	Dakota Formation	N	N	Top of casing	0.9	....	445.76	9-25-52	
*13-30-35ca	NE SW sec. 35	R. Weber	Dr	54.5	6	GI	do	Colluvium	Cy, W	S	do	0.3	....	51.10	9-17-56	
	T. 13 S., R. 31 W.															
*13-31-2dd	SE SE sec. 2	E. J. Hogan	Dr	......	......	......	Sand, gravel	Terrace deposits	....	D, S	Land surface	0	....	65	7-21-53	
13-31-4c	SW sec. 4	Bob Parsons	Dr	64	4	N	....	....	....	....	....	....	....	....	....	Irrigation test hole. Drillers log.
13-31-6da	NE SE sec. 6	Mrs. F. E. Vans	Dr	42.2	5	GI	Sand, gravel	Terrace deposits	Cy, N	N	Base of pump	1.3	....	36.88	8- 1-56	

13-31-21cd	SE SW sec. 21	Nora Hockersmith	Dr	49.2	5	GI	do	Ogallala Formation	Cy, W	S	do	1.5		34.45	8- 1-56	
	T. 13 S., R. 32 W.															
13-32-1aa	NE NE sec. 1	M. P. Cook et al.	Dr	44.0	5½	GI	do	do	Cy, W	S	Top of casing	0.5	2917.3	32.27	6-21-54	Located in Logan County.
13-32-24dc	SW SE sec. 24	Miles Collins	Du	16.5		R	Sand	Colluvium	Cy, W	S	do	1.0	2880.3	15.50	9- 7-54	do
	T. 14 S., R. 26 W.															
14-26-3dd	SE SE sec. 3	Wilford Myers	Dr	890	6	S	do	Dakota Formation	Cy, W	S	do	3.8		445.20	7-23-52	Dakota at 855 ft.
*14-26-7cd	SE SW sec. 7	J. Sutcliffe	Dr	18.0	6	GI	do	Colluvium	Cy, W	S	Top of platform	1.0		15.10	8-27-56	
*14-26-14dc	SW SE sec. 14	Ward Jacka	Dr	696	7¼	S	do	Dakota Formation	Cy, W	D, S	Top of well curb	0		276	7-17-52	
14-26-19dc	SW SE sec. 19	Delaine Jacka	Dr	82.0	6	GI	Sand, gravel	Terrace deposits	Cy, W	S	Top of casing	0.2		63.90	8-28-56	
*14-26-29cc	SW SW sec. 29	School district	Dr	64	6	GI	do	do	J, E	D	Land surface	0		40	7-20-53	
14-26-30ad	SE NE sec. 30	Delaine Jacka	Dr	74.0	6	GI	do	do	J, E	D	Base of pump	0.2		44.75	8-28-56	
14-26-30db1	NW SE sec. 30	L. W. Miller	Dr	51	4	N					Land surface	0		44	11-27-55	Irrigation test No. 5. Drillers log.
14-26-30db2	NW SE sec. 30	do	Dr	78	4	N					do	0		48	11-27-55	Irrigation test No. 4. Drillers log.
14-26-30dc1	SW SE sec. 30	do	Dr	82	4	N					do	0		43	11-22-55	Irrigation test No. 3. Drillers log.
14-26-30dc2	SW SE sec. 30	do	Dr	105	4	N					do	0		45	11-22-55	Irrigation test No. 2. Drillers log.
14-26-30dd1	SE SE sec. 30	do	Dr	95	4	N					do	0		42	11-22-55	Irrigation test No. 1. Drillers log.
*14-26-30dd2	SE SE sec. 30	do	Dr	64	5½	GI	Sand, gravel	Terrace deposits	J, E	D, S	Top of casing	0.2		41	9-18-56	
14-26-31aa	NE NE sec. 31		T	80.0	4	N					Land surface	0	2431.8	41.00	9- 4-52	
14-26-32cc	SW SW sec. 32		T	47.0	4	N					do	0	2412.0		9- 5-52	
14-26-35cc	SW SW sec. 35	Marvin Albin	Dr	40		S	Sand and gravel	Alluvium	T, B	I	do	0		12	8-28-56	Reported yield 750; battery of two wells 40 ft. apart; 18- and 20-inch casing.
*14-26-35dc	SW SE sec. 35	do	Dr	70	12	S	do	do	T, B	I	do	0		10	8-28-56	Reported yield 1000.
	T. 14 S., R. 27 W.															
14-27-6cc	SW SW sec. 6		T	30	4	N					do	0	2569.3		9-18-57	
*14-27-7cc	SW SW sec. 7	R. D. Adams	Dr	47	5	GI	Sand, gravel	Terrace deposits	Cy, W	S	do	0		40	8-28-56	
14-27-9ab	NW NE sec. 9	do	Dr	12.5	5	GI	Sand	Colluvium	Cy, W	D, S	Base of pump	0.5		6.15	8-28-56	
14-27-9db	NW SE sec. 9	do	Dr	46	5	GI	Sand, gravel	Terrace deposits	Cy, W	S	Land surface	0		33	8-28-56	
*14-27-11dc	SW SE sec. 11	Horace Puthoff	Dr	717	8	S	Sand	Dakota Formation	Cy, E	D, S	do	0		300	8-28-56	
*14-27-12cd	SE SW sec. 12	John Sutcliffe	Dr	340	6	GI	do	Codell Sandstone	Cy, W	D, S	do	0		100	8-26-56	
14-27-16cd	SE SW sec. 16	D. and E. Albin	Dr	64.5	6	GI	Sand, gravel	Terrace deposits	Cy, E	D, S	Base of pump	0.6		49.59	8-28-56	
14-27-20bb	NW NW sec. 20	Joe Jacobs	Dr	83.5	5½	GI	do	do	N	N	Top of casing	0.3		52.10	July, 56	Drillers log.
14-27-22aa	NE NE sec. 22	Glen Albin	Dr	61.0	5	GI	do	do	Cy, W	S	do	0.5		46.12	8-28-56	

TABLE 11.—*Records of wells and test holes in Gove County, Kansas*—*Continued*

Well number	Location (1)	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, inches	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source of water	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height of land surface above mean sea level, feet	Depth to water level below land surface, feet (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 14 S., R. 28 W.															
14-28-3b	NW sec. 3	Harry Coberly	Dr	29.5	4	N	...	...	...	...	...	...	...	...	...	Irrigation test hole. Drillers log.
14-28-11ab	NW NE sec. 11	C. Hefner	Dr	11.6	5	GI	Sand	Colluvium	N	N	Top of casing	0.2	...	8.88	9-24-56	
14-28-13aa	NE NE sec. 13	...	T	44.0	4	N	Sand, gravel	Terrace deposits	N	N	Land surface	0	2532.5	35.40	9-18-57	
14-28-13dd	SE SE sec. 13	...	T	26.0	4	N	...	...	...	...	do	0	2490.8	10.70	9-19-57	
14-28-24dd	SE SE sec. 24	...	T	70.0	4	N	...	...	...	...	do	0	2512.4	44.00	9-19-57	
14-28-25dd	SE SE sec. 25	...	T	44.0	4	N	...	...	...	...	do	0	2496.1	...	9-19-57	
14-28-26dd	SE SE sec. 26	J. W. Coberly	Dr	26.2	7	GI	Sand, gravel	Terrace deposits	Cy, W	S	do	0	...	21.66	8-27-56	
14-28-28cc	SW SW sec. 28	School district	Dr	46.4	5	GI	do	do	J, E	D	Top of casing	0.1	...	41.40	8-28-56	
14-28-29cc	SW SW sec. 29	Edith Webb	Dr	44.0	6	GI	do	do	Cy, N	N	do	0.3	...	36.13	8-28-56	Used as observation well.
14-28-36dd	SE SE sec. 36	...	T	20.0	4	N	...	...	...	...	Land surface	0	2532.0	...	9-19-57	
	T. 14 S., R. 29 W.															
14-29-16db	NW SE sec. 16	H. W. Coberly	Dr	75	5½	GI	do	do	N	S	do	0	...	49	June, 56	New well. Drillers log.
14-29-17ac	SW NE sec. 17	Leonard Lundgren	Dr	56	6	N	...	...	...	...	...	...	...	...	June, 56	Test hole; dry. Drillers log.
•14-29-26da	NE SE sec. 26	W. Evans	Dr	43.5	6	GI	Sand	Colluvium	Cy, W	S	Top of casing	0.2	...	41.76	9-19-56	
•14-29-29bb	NW NW sec. 29	L. R. Lundgren	Du	17.1	20	OB	do	do	Cy, W	S	Top of platform	0.5	...	13.87	9-21-56	
	T. 14 S., R. 30 W.															
14-30-5aa	NE NE sec. 5	School district	Dr	48.0	5	GI	do	do	N	D	Top of casing	1.20	...	35.02	5- 3-56	To be used for school supply; used as observation well.
14-30-13ab	NW NE sec. 13	Jack Hemmert	Dr	30	44	S	Sand, gravel	Alluvium	T, G	I	Land surface	0	...	18	9-17-56	
14-30-16ad	SE NE sec. 16	S. Benson	Dr	27.8	6	GI	Sand	Colluvium	N	N	Top of casing	0.6	...	13.60	7-18-52	Well has been destroyed.
	T. 14 S., R. 31 W.															
•14-31-27cc	SW SW sec. 27	H. P. Thies	Dr	47.5	5	GI	do	do	Cy, W	S	Base of pump	0.8	...	44.50	8- 1-56	

	T. 15 S., R. 26 W.													
15-26-1da...	NE SE sec. 1.......	W. V. Stuts......	Dr	108	16	S	Sand, gravel	Alluvium.........	T, B	I	Land surface..	0	....	20	9-14-56	Reported yield 2000; drawdown 50.
15-26-7aa...	NE NE sec. 7......	....	T	100.0	4	N	....	....	....	.....	do..........	0	2317.3	8.90	9- 5-52	
15-26-7dd...	SE SE sec. 7......	....	T	28	4	N	....	....	....	.....	do..........	0	2411.4	....	9- 5-52	
15-26-8bc...	SW NW sec. 8......	....	T	32.0	4	N	....	....	....	.....	do..........	0	2353.0	27.60	9- 5-52	
15-26-10dc..	SW SE sec. 10.....	S. J. Bollinger.....	Du	9.5	30	S	Sand......	Colluvium........	Cy, E	D, S	Base of pump	0.2	....	8.15	8-27-56	
15-26-22ca..	NE SW sec. 22.....	H. L. Babcock....	Du	28.5	48	OB	do.........	do..............	Cy, E	D, S	do..........	0	....	24.17	8-27-56	
*15-26-32cd..	SE SW sec. 32.....	Darrell Cheney....	Dr	68.0	6	GI	Sand, gravel	Terrace deposits...	Cy, W	D, S	Top of casing	0.1	....	60.15	8-27-56	
15-26-34cd..	SE SW sec. 34.....	C. West..........	Du	37.5	36	R	do.........	do..............	Cy, W	S	Base of pump	0.2	....	31.25	8-27-56	
15-26-36ba1	NE NW sec. 36.....	Nora Bollinger....	Dr	700	7	S	Sand......	Dakota Formation	Cy, W	D, S	Land surface..	0	....	360	8-27-56	
*15-26-36ba2	NE NW sec. 36.....	do..............	Dr	400	6	GI	do.........	Codell Sandstone..	Cy, W	D, S	do..........	0	....	300	10- 4-56	
	T. 15 S., R. 27 W.															
15-27-9dc...	SW SE sec. 9......	R. L. Miller......	Dr	65.5	8	S	Sand, gravel	Terrace deposits...	Cy, W	S	Base of pump	0.9	....	55.20	8-27-56	
15-27-15cc..	SW SW sec. 15.....	Dale Bernbeck....	Dr	32.7	19	GI	do.........	Alluvium.........	C, G	I	Top of well curb	1.3	....	10.05	10-13-52	
15-27-18cd..	SE SW sec. 18.....	Rod Bently.......	Dr	81	4	N	....	....	....	.....	....	......	....	....	....	Irrigation test hole. Drillers log.
15-27-21bb..	NW NW sec. 21.....	Loyd Nilhas......	Dr	100	16	S	Sand, gravel	Alluvium.........	T, P	I	Land surface..	0	....	12	8-10-56	Reported yield 1000.
15-27-21bd..	SE NW sec. 21.....	W. D. Owens.....	Dr	30.7	5	GI	do.........	Terrace deposits...	Cy, W	S	Top of casing	0.3	....	23.80	8-27-56	
	T. 15 S., R. 28 W.															
15-28-2bb...	NW NW sec. 2.....	J. M. Coberly.....	Dr	28.0	6	GI	do.........	do..............	Cy, E	D, S	Base of pump	0.4	....	25.40	8-28-56	
*15-28-2bc...	SW NW sec. 2.....	do..............	Dr	45	6	GI	do.........	do..............	Cy, E	D, S	Land surface..	0	....	33	7-20-53	
15-28-17ad..	SE NE sec. 17.....	Roscoe Coberly...	Dr	92	16	S	do.........	Alluvium.........	T, Ng	I	do..........	0	....	8	8-30-56	Reported yield 1500. Drillers log.
15-28-23da..	NE SE sec. 23.....	Ross Bentley.....	Dr	90	18	S	do.........	do..............	T, P	I	Base of pump	0.3	....	12.20	8-13-56	Reported yield 900.
15-28-23db..	NW SE sec. 23.....	do..............	Dr	50	18	S	do.........	do..............	T, P	I	Land surface..	0	....	17	8-13-56	Reported yield 500.
*15-28-24aa..	NE NE sec. 24.....	F. D. Munsell....	Dr	98	16	S	do.........	do..............	T, P	I	do..........	0	....	18	8-13-56	Reported yield 600; drawdown 20. Drillers log.
15-28-27dd..	SE SE sec. 27......	Don Davis.......	Dr	20	5½	GI	do.........	Terrace deposits...	N	N	....	......	....	....	9- 2-56	New farm well. Drillers log.
15-28-29aa...	NE NE sec. 29.....	W. F. Davis......	Dr	43	5½	GI	do.........	do..............	N	N	Top of casing	0	....	33.20	9- 2-56	do
	T. 15 S., R. 29 W.															
*15-29-11ad..	SE NE sec. 11.....	W. J. Madden....	Dr	22.5	6	GI	do.........	Alluvium.........	Cy, W	S	Top of casing	0.4	....	18.50	8-27-56	
15-29-18ca..	NE SW sec. 18.....	York and Sons....	Dr	90	18	S	do.........	do..............	T, E	I	Land surface..	0	....	20	9-17-56	Reported yield 300.
*15-29-18db..	NW SE sec. 18.....	do..............	Dr	90	18	S	do.........	do..............	T, E	I	do..........	0	....	20	9-17-56	do
15-29-25ab..	NW NE sec. 25.....	R. S. Coberly....	Dr	56	5½	GI	do.........	Terrace deposits...	N	N	Top of casing	0.3	....	38.40	8-13-56	New farm well. Drillers log.
15-29-27ad..	SE NE sec. 27.....	Lee Miller........	Dr	80	6	GI	do.........	do..............	Cy, H	D, S	Land surface..	0	....	70	8-27-56	
15-29-30cb..	NW SW sec. 30.....	Henry York......	Dr	26.0	5	GI	Sand......	Colluvium........	Cy,H,W	D	Top of casing, west side	0	....	21.21	5- 3-56	Used as observation well.

TABLE 11.—*Records of wells and test holes in Gove County, Kansas—Concluded*

Well number	Location (1)	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, inches	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source of water	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height of land surface above mean sea level, feet	Depth to water level below land surface, feet (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 15 S., R. 30 W.															
*15-30-9cb	NW SW sec. 9	G. Fleming	Dr	16.3	6	GI	Sand, gravel	Alluvium	Cy, W	S	Base of pump	0.3	....	9.20	8-24-56	
15-30-26bc	SW NW sec. 26	Anne Hoffman	Dr	56.8	6	GI	do	Terrace deposits	Cy, W	S	Top of casing	0.5	....	50.26	8-24-56	
15-30-26dd	SE SE sec. 26	F. A. Lewis	Dr	56.5	6	GI	do	do	J, E	D	Top of curb	0.3	....	50.64	12-18-51	
	T. 15 S., R. 31 W.															
15-31-4ad	SE NE sec. 4	H. P. Thies	Dr	21.0	5	GI	do	Alluvium	C, G	S	Base of pump	0.6	....	13.80	8-23-56	
15-31-9dd	SE SE sec. 9	Elmer Russell	Dr	22.0	8	S	Sand	Colluvium	Cy, W	D, S	do	0.2	....	8.70	8-23-56	
15-31-11ca	NE SW sec. 11	R. D. Miller	Dr	38.5	6	GI	Sand, gravel	Terrace deposits	Cy, N	N	Top of casing	0	....	23.34	7- 5-51	
15-31-16aa	NE NE sec. 16	Mrs. H. L. Bartlett	Du	8.0	24	R	Sand	Colluvium	Cy, W	S	Land surface	0	....	5.20	8-23-56	
15-31-18ba	NE NW sec. 18	J. E. Ely	Dr	13.0	5½	GI	do	do	Cy, W	S	Top of casing	2.0	....	7.34	7- 5-51	
15-31-26ba	NE NW sec. 26	Fick Bros	Dr	23.5	5½	GI	do	do	N	N	do	1.5	....	7.02	7- 5-51	
15-31-31ac	SW NE sec. 31	T. G. Russell	Dr	13.0	6	GI	do	do	Cy, G	S	Base of pump	0.4	....	7.30	8-23-56	
15-31-32cc	SW SW sec. 32	O. Hamit	Du	17.8	36	R	do	do	Cy, W	S	do	0.2	....	12.30	8-23-56	

* Chemical analysis included in Table 6 or 7.

1. Well number indicates, in the following order, township, range, section, quarter section, and quarter quarter section.
2. Dr, drilled well; Du, dug well; T, test hole drilled by the U. S. Geological Survey and the State Geological Survey; logs are given in table.
3. Reported depths below land surface are given in feet; measured depths are given in feet and tenths below land surface.
4. GI, galvanized iron; N, none; OB, oil barrel; R, rock; S, steel.
5. Method of lift: C, centrifugal; Cy, cylinder; J, jet; N, none; T, turbine.
   Type of power: B, butane; D, diesel; E, electric; G, gasoline engine; H, hand operated; N, none; Ng, natural gas; P, propane; W, windmill.
6. D, domestic; I, irrigation; N, none; PS, public supply; S, stock.
7. Measured depths to water are given in feet, tenths, and hundredths; reported depths are given in feet.

LOGS OF TEST HOLES AND WELLS

Listed on the following pages are the logs of 83 wells and test holes in Gove County. Of these, 45 are logs of test holes drilled by the State Geological Survey of Kansas, and 38 are drillers logs, which include logs of 16 wells, 14 test holes, and 8 shot holes. Logs entitled "sample logs" are logs of test holes drilled by the State Geological Survey for which samples were collected. The logs are numbered according to the system illustrated in Figure 2. Locations of wells and test holes are shown on Plate 2. Plate 3 illustrates the character of material penetrated by the test holes. Water-level measurements are in feet below land surface.

10-26-35dd.—*Sample log of test hole in SE cor. sec. 35, T. 10 S., R. 26 W., on terrace flat, 40 feet west of center line of road and 40 feet south of private road. Drilled by State Geological Survey August 28, 1952. Surface altitude, 2,467.4 feet; depth to water, 19.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt	5	5
Clay, silty, tan brown	6	11
Clay, compact, brown to gray brown	6	17
Clay, compact, tan brown	4	21
Clay, silty to sandy, gray brown; contains embedded fine to coarse gravel	14	35
Clay, silty, blocky, light brown	7	42
Clay, sandy, blue black	3	45
Sand, fine to coarse, clayey, black; contains fossil clam shells	7	52
Sand and gravel, fine to coarse	3.5	55.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, dark gray	3.5	59

10-27-34dd.—*Sample log of test hole in SE cor. sec. 34, T. 10 S., R. 27 W., 6 feet west and 80 feet north of intersection. Drilled by State Geological Survey September 8, 1952. Surface altitude, 2,672.8 feet; depth to water, 71.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, tan gray	10	10
Silt, tan to brown	2	12
Clay, dark brown	3	15
Clay, limy, light tan	3	18
TERTIARY—Pliocene		
Ogallala Formation		
Sand, fine to coarse, clayey, tan brown	8	26
Sand, fine to coarse, silty	2	28

	Thickness, feet	Depth, feet
Clay, very sandy, tan brown; contains embedded fine to medium gravel	9	37
Sand, fine to coarse	2	39
Clay, sandy, tan brown	5	44
Sand and gravel, fine to coarse; contains cemented stringers	15	59
Clay, sandy to very sandy, light tan	15	74
Sand and gravel, fine to medium, silty	2	76
Clay, sandy, limy, light tan	3	79
Sand, fine to medium, silty, cemented	2	81
Clay, very sandy, brown	10	91
Clay, tan brown; contains interbedded stringers of sand,	8	99
Clay, tan brown; contains interbedded stringers of sand, gravel, and chalk fragments	4	103
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, weathered, white	3	106
Chalk, silicified, brown, white, and yellow	2	108

10-28-33dd.—*Sample log of test hole in SE cor. sec. 33, T. 10 S., R. 28 W., at county line on north road shoulder, 170 feet west of center of highway. Drilled by State Geological Survey September 12, 1952. Surface altitude, 2,741.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, clayey, tan gray	6	6
TERTIARY—Pliocene		
Ogallala Formation		
Sand, clayey, red brown	3.5	9.5
Clay, limy, tan to white	1.5	11
Sand and gravel, coarse to fine, silty	11	22
Sand, coarse to fine; contains coarse to fine gravel, cemented; silty, tan brown	5	27
Sand, fine to coarse	5	32
Sand, fine to coarse, and fine to coarse gravel; contains interbedded stringers of sandy clay	6	38
Clay, mottled gray brown; contains embedded gravel	9	47
Clay, sandy to very sandy, red brown	3	50
Sand, fine to coarse	5	55
Clay, sandy, brown; contains embedded gravel	9.5	64.5
Sand, fine to coarse; contains fine to coarse gravel	7.5	72
Clay, gray; contains interbedded coarse to fine sand and gravel	6	78
Sand, fine to coarse	5	83
Clay, gray, and interbedded fine to coarse sand	7	90
Sand and gravel, fine to coarse	8	98

	Thickness, feet	Depth, feet
Sand and gravel, fine to coarse, clayey	2	100
Clay, tan gray, and interbedded fine to coarse sand and gravel	6.5	106.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, yellow orange; silicified at top	6.5	113

10-30-31cc.—*Sample log of test hole in SW cor. sec. 31, T. 10 S., R. 30 W., 60 feet north of county line and 5 feet west of right-of-way fence on east side of road. Drilled by State Geological Survey September 12, 1952. Surface altitude, 2,924.6 feet; depth to water, 52.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, tan gray	10	10
TERTIARY—Pliocene		
Ogallala Formation		
Sand and gravel, coarse to fine, cemented, silty, red brown	8.5	18.5
Sand and gravel, fine to coarse	10.5	29
Clay, sandy to very sandy, light tan	7	36
Silt, sandy, very limy, white	1	37
Clay, sandy, tan to tan brown; contains embedded gravel	18	55
Sand, fine to coarse; contains fine to coarse gravel	31.5	86.5
Clay, compact, brown	4.5	91
Sand, silty to clayey	20	111
Sand and gravel, fine to coarse	12	123
CRETACEOUS—Gulfian		
Pierre Shale		
Shale, bentonitic, gray white	9	132
Shale, yellow to orange	6	138

11-26-11cc1.—*Drillers log of shot hole in SW¼ SW¼ sec. 11, T. 11 S., R. 26 W. Drilled by Schaeffer Geophysics June 20, 1952. Surface altitude, 2,537.3 feet; depth to water, 10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	11	11
Clay, sandy	23	34
TERTIARY—Pliocene		
Ogallala Formation		
Caliche, sandy	21	55
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow	7	62
Shale, brown	4	66
Shale, blue	4	70

11-26-11cc2.—*Drillers log of shot hole in SW¼ SW¼ sec. 11, T. 11 S., R. 26 W. Drilled by Schaeffer Geophysics June 20, 1952. Surface altitude, 2,581.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	10	10
Clay, sandy	15	25
TERTIARY—Pliocene		
Ogallala Formation		
Caliche, sandy	25	50
Clay, sandy	30	80
Sand	21	101
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow	8	109
Shale, brown	1	110

11-26-13ba2.—*Drillers log of shot hole in NE¼ NW¼ sec. 13, T. 11 S., R. 26 W. Drilled by Schaeffer Geophysics June 20, 1952. Surface altitude, 2,569.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	15	15
Clay, sandy	11	26
TERTIARY—Pliocene		
Ogallala Formation		
Sand	10	36
Caliche, sandy	24	60
Sand	20	80
Limestone, hard; contains flint layers	10	90
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow	7	97
Shale, brown	28	125

11-26-13cd.—*Drillers log of shot hole in SE¼ SW¼ sec. 13, T. 11 S., R. 26 W. Drilled by Schaeffer Geophysics June 20, 1952. Surface altitude, 2,571.0 feet; depth to water, 54.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	10	10
TERTIARY—Pliocene		
Ogallala Formation		
Sand, clayey	34	44
Caliche	21	65
Clay, sticky	7	72
Limestone, hard; contains flint layers	8	80
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow	19	99
Shale, brown	16	115

11-26-13dd.—*Drillers log of shot hole in SE¼ SE¼ sec. 13, T. 11 S., R. 26 W. Drilled by Schaeffer Geophysics June 20, 1952. Surface altitude, 2,540.3 feet; depth to water, 37.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	8	8
TERTIARY—Pliocene		
Ogallala Formation		
Sand	12	20
Sand, clayey	29	49
Caliche	3	52
Limestone, hard; contains flint layers	13	65
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow	25	90
Shale, brown	5	95

11-26-14cd.—*Drillers log of shot hole in SE¼ SW¼ sec. 14, T. 11 S., R. 26 W. Drilled by Schaeffer Geophysics June 20, 1952. Surface altitude, 2,609.1 feet; depth to water, 73.97 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	11	11
TERTIARY—Pliocene		
Ogallala Formation		
Sand	9	20
Clay, sandy	80	100
Sand and gravel, cemented	13	113
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow	6	119
Shale, brown	1	120

11-26-14dc.—*Drillers log of shot hole in SW¼ SE¼ sec. 14, T. 11 S., R. 26 W. Drilled by Schaeffer Geophysics June 20, 1952. Surface altitude, 2,594.2 feet; depth to water, 69.34 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	10	10
Clay	11	21
TERTIARY—Pliocene		
Ogallala Formation		
Caliche, sandy	30	51
Sand	9	60
Caliche	1	61
Clay, sandy	27	88
Limestone, hard; contains flint layers	15	103
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow	18	121
Shale, brown	4	125

11-26-14dd.—*Drillers log of shot hole in SE¼ SE¼ sec. 14, T. 11 S., R. 26 W. Drilled by Schaeffer Geophysics June 20, 1952. Surface altitude, 2,558.6 feet; depth to water, 38.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	11	11
TERTIARY—Pliocene		
Ogallala Formation		
Sand	9	20
Clay, sandy	35	55
Sand and gravel, cemented	10	65
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow	27	92
Shale, brown	4	96
Shale, blue	4	100

11-26-19cc—*Sample log of test hole in SW¼ SW¼ sec. 19, T. 11 S., R. 26 W., 45 feet north of intersection and 20 feet east of center line of north-south road. Drilled by State Geological Survey, September 19, 1952. Surface altitude, 2,664.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Clay, silty, blocky, dark brown	6.5	6.5
Clay, silty, compact, tan gray	4.5	11
Clay, compact, light gray	12	23
Clay, soft, tan; contains gravel in lower part	4	27
TERTIARY—Pliocene		
Ogallala Formation		
Clay, very sandy, tan	2	29
Sand, fine to coarse; contains some clay	7.5	36.5
Sand, fine to coarse, and fine gravel	6.5	43
Clay, sandy, tan brown; contains caliche	14	57
Sand, fine to coarse, and fine to medium gravel, clayey,	2	59
Clay, sandy, tan brown to light tan; contains cemented sand at 67 feet	14	73
Sand and gravel, fine to coarse	4	77
Clay, sandy to compact, tan brown	17	94
Sand, gravel, and pebbles, clayey, gray; contains tan silt and chalk fragments	10.5	104.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, silicified, hard, yellow brown	1	105.5

11-26-27dd.—*Drillers log of test hole in SE¼ SE¼ sec. 27, T. 11 S., R. 26 W. Drilled on Mark Neher farm. Depth to water 85 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt and clay, sandy at base	20	20
TERTIARY—Pliocene		
Ogallala Formation		
Sand, cemented	15	35
Sand, loose	8	43
Clay	1	44
Sand, clayey	3	47
Clay	3	50
Sand	6	56
Sand, clayey	21	77
Sand, coarse	9	86
Sand and gravel, cemented	3	89
Clay	6	95
Sand	6	101
Sand, clayey	6	107
Sand, cemented	8	115
Sand, loose, coarse	2	117
Sand and gravel, cemented	8	125
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, weathered, yellow	13	138

11-26-31bb.—*Sample log of test hole in NW¼ NW¼ sec. 31, T. 11 S., R. 26 W., 40 feet south of intersection and 10 feet east of center line of road. Drilled by State Geological Survey September 18, 1952. Surface altitude, 2,664.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, buff	14.5	14.5
Clay, compact, dark brown	1	15.5
Clay, silty to sandy in lower part, tan	6.5	22
TERTIARY—Pliocene		
Ogallala Formation		
Sand and gravel, fine to coarse, silty, cemented in part,	6	28
Sand, fine to medium, cemented with light-gray limy silt; very clayey in part	9	37
Sand and gravel, fine to coarse, clean	5	42
Sand, fine to coarse, clayey, tan to brown	15	57
Sand, fine to coarse, loosely cemented	8	65
Clay, compact to silty, tan to brown	8	73
Sand and gravel, fine to coarse, silty in part	15	88
Clay, very sandy, tan brown; contains chalk fragments in lower part	19	107

	Thickness, feet	Depth, feet
Sand, fine to coarse, clayey; contains chalk fragments and clay below 117 feet	31	138
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, chalky, white and yellow	2	140

11-26-31dd.—*Sample log of test hole in SE¼ SE¼ sec. 31, T. 11 S., R. 26 W., 100 feet west of road intersection and 10 feet north of center line of road. Drilled by State Geological Survey September 2, 1952. Surface altitude, 2,638.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Clay, silty, brown	3	3
Silt, gray green to tan brown	6.5	9.5
Clay, silty, brown	5.5	15
Clay, silty, tan to white; contains gravel in lower part,	4	19
TERTIARY—Pliocene		
Ogallala Formation		
Sand and gravel, fine to coarse, silty to clayey above 27 feet	10	29
Sand, fine to coarse, and fine to medium gravel, silty; limy cement	3	32
Sand, fine to medium, clayey, tan	6	38
Clay, sandy, gray brown; contains some gravel	8.5	46.5
Sand and gravel, fine to coarse, clayey to silty, gray brown	12.5	59
Clay, sandy and limy, tan gray	3	62
Sand, fine to coarse, clayey	11	73
Clay, sandy, tan brown	14	87
Sand and gravel, fine to coarse, clayey	2.5	89.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, silicified, hard, yellow, white, and brown	2.5	92

11-26-34dc.—*Sample log of test hole in SW¼ SE¼ sec. 34, T. 11 S., R. 26 W., 100 feet east of ½-mile line and 8 feet north of center line of road. Drilled by State Geological Survey September 7, 1957. Surface altitude, 2,613.6 feet; depth to water, 62.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, light brown; contains snail shells	18	18
TERTIARY—Pliocene		
Ogallala Formation		
Sand, fine, and caliche, light gray	10	28
Sand, fine	1	29
Sand, fine to medium, cemented	1	30
Sand, medium to coarse, cemented, light gray	7	37
Sand, medium to coarse, cemented, pink	13	50

	Thickness, feet	Depth, feet
Sand, fine to medium	4	54
Sand, medium, cemented	6	60
Sand, fine, silty; contains thin cemented zones	23	83
Sand, clean, white	7.5	90.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, silicified, hard	0.5	91

11-26-36dd.—*Sample log of test hole in SE¼ SE¼ sec. 36, T. 11 S., R. 26 W., 40 feet west of road intersection and 11 feet north of center line of road. Drilled by State Geological Survey September 19, 1952. Surface altitude, 2,584.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, clayey, tan gray; contains gravel in lower part	7	7
TERTIARY—Pliocene		
Ogallala Formation		
Clay, very sandy, tan to tan white	3	10
Sand and gravel, fine to coarse, silty to clayey, red brown; loosely cemented sand below 27 feet	18	28
Clay, sandy, tan to light tan	4	32
Sand and gravel, fine to coarse, silty	10.5	42.5
Clay, sandy and limy, light tan to white	2.5	45
Sand and gravel, fine to coarse, clayey	3.5	48.5
Clay, sandy, tan gray to gray brown	12.5	61
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, silicified, yellow to white	2.5	63.5

11-27-31cc.—*Sample log of test hole in SW¼ SW¼ sec. 31, T. 11 S., R. 27 W., 20 feet north of road intersection and 22 feet east of center line of road. Drilled by State Geological Survey September 18, 1952. Surface altitude, 2,694.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, tan gray to tan brown	9	9
Clay, tan gray to gray	5	14
Clay, silty, tan to tan brown; contains some gravel in lower part	14	28
TERTIARY—Pliocene		
Ogallala Formation		
Clay, sandy, light gray	1	29
Sand, fine to coarse, and fine to medium gravel	12	41
Sand, fine to coarse; contains tan to white silt	5	46
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, very chalky, yellow and white; contains silicified zone at 49.5 feet	3.5	49.5

11-28-7cc.—*Sample log of test hole in SW cor. sec. 7, T. 11 S., R. 28 W., 60 feet east of road intersection and 33 feet south of fence line. Drilled by State Geological Survey September 16, 1952. Surface altitude, 2,825.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Soil, silty and clayey, dark brown	1.5	1.5
Silt, tan gray; contains many snail shells	10.5	12
Clay, silty to blocky, limy, tan white	22	34
TERTIARY—Pliocene		
Ogallala Formation		
Gravel, fine to coarse; contains some sand and clay	15	49
Clay, sandy, gray to tan gray	2	51
Sand and gravel; contains some pebbles throughout and is silty in lower part	18.5	69.5
Sand, fine to medium, silty	3.5	73
Sand, fine to coarse, and fine gravel, clayey above and silty below 80 feet	10	83
Clay, sandy, tan and tan red	19	102
Sand and gravel, fine to coarse, silty	12	114
Clay, very sandy, tan brown	4	118
Sand, fine to coarse, and clay, interbedded, limy, light tan	60	178
Sand, fine to coarse, limy cement, tan	8.5	186.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, chalky, yellow; silicified at 187 feet	0.5	187

11-28-10dd.—*Drillers log of well in SE¼ SE¼ sec. 10, T. 11 S., R. 28 W. Drilled by Aqua Drillers September 26, 1956. Depth to water, 80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Clay, yellow	20	20
Clay, pink	15	35
TERTIARY—Pliocene		
Ogallala Formation		
Sand	15	50
Clay, sandy	25	75
Clay, sandy cemented layers	15	90
Clay, blue	1	91
Sand, thin flint zone	4	95
Sand	22	117
Clay, sandy	3	120

11-28-26bb.—*Drillers log of well in NW¼ NW¼ sec. 26, T. 11 S., R. 28 W. Drilled by Aqua Drillers September 30, 1956. Depth to water, 83.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Clay	25	25
TERTIARY—Pliocene		
Ogallala Formation		
Caliche, hard	.5	25.5
Clay, sandy	18.5	44
Caliche, hard	1	45
Clay, red, sandy	20	65
Sand	20	85
Clay, sandy	18	103
Caliche, hard	5	108
Lost circulation	..	108

11-28-31cc.—*Sample log of test hole in SW cor. sec. 31, T. 11 S., R. 28 W., 20 feet north of section line and 6 feet east of fence line on edge of field. Drilled by State Geological Survey September 18, 1952. Surface altitude, 2,810.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Soil, silty and clayey, dark brown	1.5	1.5
Clay, silty, light gray	1.5	3
Silt, tan gray	11	14
Clay, silty, light tan	11	25
TERTIARY—Pliocene		
Ogallala Formation		
Sand, fine, clean	2	27
Sand, fine to coarse, loose to cemented	27	54
Clay, sandy, tan to tan brown	8	62
Sand, gravel, and pebbles, silty	8	70
Clay, sandy and gravelly, tan brown	7	77
Sand and gravel, fine to coarse, clayey, tan brown	13	90
Sand, gravel, and pebbles, silty to clayey, tan yellow	8	98
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow and white; contains a thin bed of silicified chalk in upper part	6	104

11-28-33dd.—*Sample log of test hole in SE¼ SE¼ sec. 33, T. 11 S., R. 28 W., ¼ mile north of sec. cor. on west side of road by cornerpost. Drilled by State Geological Survey August 10, 1957. Surface altitude, 2,738.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Top soil, brown	2	2
Silt, clayey, yellow brown	7.5	9.5
Silt, red brown, sandy	2.5	12
Silt, tan; contains some caliche	1.5	13.5
Silt, white to tan, sandy; contains abundant caliche,	9.5	23

	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala Formation		
Sand, fine to medium, tan	2	25
Sand, medium to very coarse; contains thin cemented layer at 28 feet	8	33
Silt, sandy, tan	10	43
Sand, fine to medium; contains thin silt layers	5	48
Gravel, coarse	2	50
(Lost circulation at 50 feet)		

11-29-19cc1.—*Sample log of test hole in SW¼ SW¼ sec. 19, T. 11 S., R. 29 W., 200 feet north of bridge and 5 feet east of center line of road. Drilled by State Geological Survey September 12, 1957. Surface altitude, 2,833.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, brown	3	3
Silt, black	9	12
Silt, brown	6	18
Silt, gray	4	22
TERTIARY—Pliocene		
Ogallala Formation		
Sand, fine to coarse	8	30
Sand, fine to coarse; contains some gravel	3	33
Sand, medium to coarse, silty, gray	5	38
Sand and gravel, silty	9	47
Sand and gravel, cemented	2	49
Sand and gravel	2	51
Sand, coarse, silty, gray	11	62
Silt, white; contains some gravel	23	85
Sand, fine to medium, clean	2	87
(Lost circulation at 87 feet)		

11-29-19cc2.—*Sample log of test hole in SW cor. sec. 19, T. 11 S., R. 29 W., 50 feet east of sec. cor. and 10 feet north of center line of road. Drilled by State Geological Survey September 16, 1957. Surface altitude, 2,860.6 feet; depth to water, 74.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, brown	12	12
Caliche, soft, white	1	13
TERTIARY—Pliocene		
Ogallala Formation		
Sand and gravel, coarse	6	19
Silt, light tan, sandy; contains cemented sand layers	11	30
Silt, sandy, light gray to white	7	37
Sand, fine to coarse	1	38
Sand, coarse, silty, pink	9	47
Silt, sandy, tan to gray	2	49
Sand, fine to coarse, silty	17	66

	Thickness, feet	Depth, feet
Silt, pink and white; contains thin beds of coarse sand and gravel	8	74
Sand, fine to coarse, clean; contains some gravel	11	85
Silt, white; contains thin beds of sand and gravel	15	100
Silt, white	6	106
Sand, fine; cemented layer at about 109 feet	9	115
Silt, sandy, gray green	2	117
Sand, gray	7	124
Silt, gray green	2	126
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, dark gray	4	130

11-29-34cc.—*Sample log of test hole in SW cor. sec. 34, T. 11 S., R. 29 W., 120 feet east of intersection and 15 feet north of center line of road. Drilled by State Geological Survey September 10, 1957. Surface altitude, 2,828.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, light tan to brown	19	19
TERTIARY—Pliocene		
Ogallala Formation		
Silt, white; contains thin beds of sand and gravel	14	33
Silt, light tan to pink	2	35
Silt, white, sandy	3	38
Sand; contains some pink silt in top part	17	55
Sand, coarse, silty, pink	11	66
Sand, medium to coarse	14	80
Sand, cemented	5	85
Silt, pink to white; contains layers of cemented sand	20	105
Silt, white, sandy	3	108
Sand, medium to coarse	8	116
Sand, cemented	3	119
Sand and gravel, clean	1	120
Sand, cemented	6	126
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, white to yellow	19	145
Shale, black	5	150

11-30-1aa.—*Sample log of test hole in NE cor. sec. 1, T. 11 S., R. 30 W., 200 feet south of road intersection and 15 feet west of center line of road. Drilled by State Geological Survey May 24, 1952. Surface altitude, 2,889.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Soil, silty and clayey, dark gray	1	1
Silt, clayey to fine sandy, gray green	10	11
Clay, silty to fine sandy, tan	13	24

	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala Formation		
Clay, silty, tan brown grading to tan white	4	28
Sand, coarse, and fine to coarse gravel, cemented with limy silt; clayey in lower part	4	32
Sand, gravel, and pebbles, clayey at 46 feet	16	48
Sand, fine to coarse, and fine gravel; contains embedded clay	3	51
Clay, very sandy, red brown; contains some gravel at 55 and 58 feet	24	75
Sand, medium to coarse, and fine to coarse gravel, clayey in part	23	98
Clay, compact to sandy, gray brown and red brown	5	103
Clay, tan brown; contains some light-gray limy silt	5	108
Sand and gravel, fine to coarse	5	113
Clay, sandy, gray brown	8	121
Sand, fine to coarse	17	138
Clay, gray brown; contains red-brown sand	18	156
Clay, silty, limy, white to tan white	7	163
CRETACEOUS—Gulfian		
Pierre Shale		
Shale, bentonitic, noncalcareous, mottled yellow brown and yellow gray	14	177
Niobrara Chalk—Smoky Hill Chalk member		
Shale, clayey, calcareous, dark gray	33	210

11-30-12dd.—*Sample log of test hole in SE cor. sec. 12, T. 11 S., R. 30 W., 70 feet west of sec. cor. in middle of east-west road. Drilled by State Geological Survey September 16, 1957. Surface altitude, 2,892.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, tan to brown; contains some caliche	10	10
Silt, sandy, reddish brown; contains some caliche	12	22
TERTIARY—Pliocene		
Ogallala Formation		
Silt, white; contains some caliche	10	32
Silt, sandy, limy, light gray	3	35
Sand, silty	13	48
Silt, sandy, limy, pink to white	19	67
Sand and gravel	4	71
Sand and gravel, silty	2	73
Sand and gravel	5	78
Silt, pink to white; contains some gravel	9	87
Sand, medium to coarse	2	89
Silt, sandy, pink; contains some gravel	2	91
Sand and gravel	4	95
Silt, sandy, limy, gray to pink	6	101
Sand and gravel	15	116
Silt, gray; contains some sand and gravel	11	127

	Thickness, feet	Depth, feet
Sand and gravel	6	133
Silt, white; contains hard limy layers	8	141
CRETACEOUS—Gulfian		
Pierre Shale		
Shale, very tight, yellow	9	150

11-30-16db.—*Drillers log of well in NW¼ SE¼ sec. 16, T. 11 S., R. 30 W. Drilled by H. W. Coberly August 1956.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Clay, yellow	10	10
TERTIARY—Pliocene		
Ogallala Formation		
Sand	5	15
Clay, white	12	27
Gravel	18	45
Clay, red, sandy	19	64
Gravel; contains clay layers	21	85
Gravel	15	100
Clay, tight, yellow	2	102
Sand, clayey	3	105
Sand and gravel	5	110
Sand, clayey	13	123

11-30-25cc.—*Drillers log of irrigation well in SW¼ SW¼ sec. 25, T. 11 S., R. 30 W. Drilled by Struckhoff Bros. September 25, 1956. Depth to water, 104.02 feet.*

	Thickness, feet	Depth, feet
QUATERNARY and TERTIARY undifferentiated		
Top	75	75
TERTIARY—Pliocene		
Ogallala Formation		
Gravel	7	82
Clay	4	86
Gravel	26	112
Clay; contains some gravel	11	123
Sand; contains cemented layers	2	125
Gravel	3	128
Sand and gravel	7	135
Clay, sandy; contains layers of fine sand	4	139
Clay	3	142
Gravel	18	160
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow, weathered	1	161

11-30-27c—*Drillers log of test hole in SW¼ sec. 27, T. 11 S., R. 30 W. Drilled by Struckhoff Bros.*

	Thickness, feet	Depth, feet
QUATERNARY and TERTIARY undifferentiated		
Top	100	100
TERTIARY—Pliocene		
Ogallala Formation		
Sand, cemented; contains clay layers	5	105
Gravel	3	108
Clay	22	130
Gravel	7	137
Clay	1	138
Sand, cemented; contains some gravel	2	140
Sand, cemented	2	142
Clay	4	146
Gravel	16	162
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, weathered, yellow	3	165
Shale	1	166

11-30-27dc1.—*Drillers log of irrigation well in SW¼ SE¼ sec. 27, T. 11 S., R. 30 W. Drilled by Struckhoff Bros. Surface altitude, 2,906.0 feet; depth to water, 100.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY and TERTIARY undifferentiated		
Top	95	95
TERTIARY—Pliocene		
Ogallala Formation		
Clay	8	103
Gravel	2	105
Clay	5	110
Sand, cemented	1	111
Sand, cemented; contains clay layers	19	130
Sand, clayey	7	137
Sand, fine	3	140
Gravel	13	153
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	3	156

11-30-34cc.—*Sample log of test hole in SW cor. sec. 34, T. 11 S., R. 30 W., 100 feet north of sec. cor. and 5 feet east of center line of road. Drilled by State Geological Survey September 11, 1957. Surface altitude, 2,870.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, reddish tan; contains some caliche	11	11
TERTIARY—Pliocene		
Ogallala Formation		
Sand, medium to coarse; contains caliche	14	25
Sand, silty; contains cemented layers	4	29

	Thickness, feet	Depth, feet
Sand; contains some tan silt in middle part	18	47
Sand and gravel, coarse; contains cemented layers	5	52
Sand, silty, pink to white	24	76
Silt, sandy, limy, white	11	87
Sand, coarse; contains some white and green silt	4	91
Sand; contains cemented layers	6	97
Sand, coarse; contains sandy silt layers	7	104
CRETACEOUS—Gulfian		
Pierre Shale		
Shale, clayey, yellow	4	108
Shale, black	2	110

11-31-36dd.—*Sample log of test hole in SE cor. sec. 36, T. 11 S., R. 31 W., 60 feet north of road intersection and 8 feet west of center line of road. Drilled by State Geological Survey September 16, 1952. Surface altitude, 2,846.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Clay, silty, dark brown	1	1
Silt, clayey, tan gray	5	6
TERTIARY—Pliocene		
Ogallala Formation		
Sand, fine to coarse; contains some gravel and pebbles	10	16
Sand, gravel, and pebbles	11	27
Sand and gravel, fine to coarse, well cemented with limy silt; contains some pebbles	1.5	28.5
Sand, gravel, and pebbles; contains weathered chalk fragments	2	30.5
CRETACEOUS—Gulfian		
Pierre Shale		
Shale, bentonitic, noncalcareous, yellow, gray, and white	5.5	36

12-26-6dd.—*Sample log of test hole in SE cor. sec. 6, T. 12 S., R. 26 W., 20 feet south of bridge and 10 feet west of center line of road. Drilled by State Geological Survey September 3, 1952. Surface altitude, 2,593.2 feet; depth to water, 15.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, sandy, tan	5	5
Clay, silty, dark gray	3	8
Clay, compact, tan gray; contains some gray-green sandy clay	9	17
TERTIARY—Pliocene		
Ogallala Formation		
Sand, fine to coarse, silty; contains clay at 19 and 25 feet	11	28
Sand and gravel, fine to coarse, silty to clayey	8.5	36.5

CRETACEOUS—Gulfian	Thickness, feet	Depth, feet
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, silicified, yellow brown	0.1	36.6

12-26-7aa.—*Sample log of test hole in NE¼ NE¼ sec. 7, T. 12 S., R. 26 W., 0.2 mile south of road intersection and 12 feet west of center line of road. Drilled by State Geological Survey September 3, 1952. Surface altitude, 2,587.0 feet.*

QUATERNARY—Pleistocene	Thickness, feet	Depth, feet
Alluvium		
Clay, silty, dark gray to tan brown	5	5
Clay, fine, sandy to silty, tan	2	7
Clay, compact, blue gray	2	9
Clay, compact, light gray; contains some sand	3	12
Clay, sandy, tan	9.5	21.5
Sand, fine to coarse, and some fine to coarse gravel	10.5	32
Clay, compact, dark gray, sandy in part	7	39
Sand, gravel, and pebbles, clayey	8	47
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale and siltstone, calcareous, dark gray	3	50

12-26-8cb.—*Sample log of test hole in NW¼ SW¼ sec. 8, T. 12 S., R. 26 W., 0.35 mile north of sec. cor. and 80 feet east of center line of road. Drilled by State Geological Survey September 4, 1952. Surface altitude, 2,587.8 feet; depth to water, 11.90 feet.*

QUATERNARY—Pleistocene	Thickness, feet	Depth, feet
Alluvium		
Clay, silty, dark gray	0.5	0.5
Clay, silty to sandy, dark brown	6.5	7
Sand, fine to coarse, silty	2	9
Sand and gravel, fine to coarse; contains pebbles throughout and clay at 10 feet	10	19
Sand and gravel, fine to coarse, silty; contains chalk fragments in lower part	10	29
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, pink, yellow, and white; silicified at 36.5 feet	8	37

12-26-19da.—*Sample log of test hole in NE¼ SE¼ sec. 19, T. 12 S., R. 26 W., on west edge of road at ¼-mile line. Drilled by State Geological Survey September 17, 1957. Surface altitude, 2,650.3 feet; depth to water 80.30 feet.*

QUATERNARY—Pleistocene	Thickness, feet	Depth, feet
Peoria and Loveland Formations		
Silt, light tan	5	5
TERTIARY—Pliocene		
Ogallala Formation		
Sand; contains some caliche	3	8
Sand, medium to coarse, cemented	22	30
Sand	6	36

	Thickness, feet	Depth, feet
Sand; contains cemented layers	2	38
Sand	9	47
Sand, silty; contains cemented layers	12	59
Sand and gravel	10	69
Sand and gravel, silty, tan	2	71
Silt, sandy, tan to brown	5	76
Sand and gravel	3	79
Silt, sandy, tan	15	94
Sand and gravel, cemented	8	102
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, weathered, yellow	15	117
Shale, black	13	130

12-27-2bb.—*Sample log of test hole in NW cor. sec. 2, T. 12 S., R. 27 W., 50 feet east of sec. cor. and 10 feet south of center line of road. Drilled by State Geological Survey September 9, 1957. Surface altitude, 2,673.7 feet; depth to water, 54.90 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, light brown; contains snail shells	16	16
Silt, light brown; contains caliche	3	19
TERTIARY—Pliocene		
Ogallala Formation		
Caliche, sandy, pink to gray	9	28
Sand, fine, cemented, white to light gray	27	55
Sand and gravel	11	66
Sand; contains cemented layers	11	77
Sand; contains silty layers	2	79
Silt, sandy	9	88
Sand and gravel, silty; contains cemented layers	7	95
Sand, silty, silicified, very hard	0.5	95.5
Sand	0.5	96
Sand, cemented	1	97
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, silicified, very hard	0.3	97.3

12-28-3aa.—*Sample log of test hole in NE cor. sec. 3, T. 12 S., R. 28 W., 500 feet south of sec. cor. and 5 feet west of center line of road. Drilled by State Geological Survey September 10, 1957. Surface altitude, 2,717.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, sandy at base	5	5
Silt, light tan to brown	9	14
TERTIARY—Pliocene		
Ogallala Formation		
Sand, coarse	3	17
Silt, light gray	10	27

	Thickness, feet	Depth, feet
Silt, light gray; contains some coarse sand	2	29
Sand, coarse; contains caliche	6	35
Silt, yellow; contains some gravel	8	43
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow to white; contains limy layers	20	63
Shale, weathered, black	4	67

12-29-6cc.—*Sample log of test hole in SW cor. sec. 6, T. 12 S., R. 29 W., 100 feet north of sec. cor. and 5 feet east of center line of road. Drilled by State Geological Survey September 12, 1957. Surface altitude, 2,798.0 feet; depth to water, 28.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, tan	5	5
TERTIARY—Pliocene		
Ogallala Formation		
Sand, fine to medium	3	8
Caliche; contains cemented fine sand layers	4	12
Silt, pink; contains cemented sand layers	11	23
Silt, pink	4	27
Silt, pink; contains cemented sand layers	10.5	37.5
Silt, cemented, very hard	0.5	38
Sand	3	41
Silt, sandy, limy, white	16	57
Sand, fine, tan to brown	5	62
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, silicified, green	1	63
Shale, brown to black	7	70
Shale, black	10	80

12-30-1aa.—*Sample log of test hole in NE¼ NE¼ sec. 1, T. 12 S., R. 30 W., 700 feet south of road intersection and 10 feet west of center line of road. Drilled by State Geological Survey May 21, 1952. Surface altitude, 2,880.6 feet; depth to water, 111.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, fine sandy, tan gray to gray green; contains many snails in upper part and some sand in lower part	16.5	16.5
TERTIARY—Pliocene		
Ogallala Formation		
Clay, sandy, limy, light gray	4	20.5
Clay, limy, soft, light tan	1.5	22
Clay, very sandy, tan brown; contains some gravel	4	26
Sand and gravel, fine to coarse, clayey to silty; contains clay at 28 feet and coarse gravel in lower part	16.5	42.5

	Thickness, feet	Depth, feet
Sand, fine to coarse, silty, cemented, tan brown	13.5	56
Sand and gravel, fine to coarse, silty, light gray; contains some pebbles	18	74
Clay, sandy, noncalcareous, light red to tan brown	22	96
Clay, sandy and limy, gray to tan gray	11	107
Sand, fine to very fine, limy, silty, light gray; opaline cemented at 108 feet	21	128
Sand and gravel, fine to coarse, clayey, yellow tan	3	131
Clay, tan gray to gray brown; contains embedded gravel throughout and silty limestone at 131 feet	7	138
Sand and gravel, fine to coarse, clayey; contains some weathered chalk fragments of pebble size in lower part	25	163
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, chalky, yellow and white	2	165
Shale, silty, calcareous, dark gray	5	170

12-30-27dd1.—*Drillers log of irrigation well in SE¼ SE¼ sec. 27, T. 12 S., R. 30 W. Drilled by Struckhoff Bros. Depth to water, 13 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Clay	15	15
Clay, blue	1	16
Gravel, good	21	37
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	2	39

12-30-28db.—*Drillers log of irrigation well in NW¼ SE¼ sec. 28, T. 12 S., R. 30 W. Drilled by Struckhoff Bros. Depth to water, 14 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Clay	15	15
Gravel, good	13	28
Silt, blue	3	31
Gravel	1	32
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	2	34

12-31-6bb.—*Sample log of test hole in NW cor. sec. 6, T. 12 S., R. 31 W., 90 feet south of road intersection and 35 feet east of center line of road. Drilled by State Geological Survey September 15, 1952. Surface altitude, 3,014.3 feet; depth to water, 89.35 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Clay, silty, dark brown	1	1
Clay, gray; contains some gravel	2	3

	Thickness, feet	Depth, feet
Silt, tan gray to tan brown	14	17
Clay, silty to very limy, tan to tan white	13	30
TERTIARY—Pliocene		
Ogallala Formation		
Clay, limy, tan to white; contains embedded sand and gravel	17	47
Sand, gravel, and pebbles, clayey, cemented in part	11	58
Clay, compact to sandy in the lower part, light gray to red brown	22	80
Sand, gravel, and pebbles, silty, loosely cemented	10	90
Sand, fine, silty to limy, cemented	8	98
Sand, fine to medium, clayey to cemented, dark gray,	8	106
Clay, sandy, light gray; contains weathered shale fragments	11	117
CRETACEOUS—Gulfian		
Pierre Shale		
Shale, bentonitic, yellow and yellow brown	3	120

12-31-34d—*Drillers log of test hole in SE¼ sec. 34, T. 12 S., R. 31 W. Drilled by Struckhoff Bros.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt and clay	15	15
TERTIARY—Pliocene		
Ogallala Formation		
Sand, clayey; contains some gravel	15	30
Gravel	17	47
Clay, sandy; contains some gravel	7	54
Sand, fine; contains some gravel	11	65
Sand, cemented	1	66
Clay, white	2	68
Sand, fine	7	75
Sand and gravel	4	79
Sand, cemented	2	81
Clay, sandy	5	86
Sand, cemented	1	87
Sand and gravel; contains cemented layers	9	96
Clay	2	98
Gravel	39	137
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	24	161

13-26-5bb.—*Sample log of test hole in NW¼ NW¼ sec. 5, T. 13 S., R. 26 W., 30 feet south of sec. line and 20 feet east of center line of road. Drilled by State Geological Survey September 4, 1952. Surface altitude, 2,607.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Clay, silty, dark brown	1	1
Silt, clayey, tan gray	5	6
Silt, brown to red brown	2.5	8.5

	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala Formation		
Clay, silty to sandy, red brown; contains some gravel	2.5	11
Sand, loose to cemented, light red to tan brown	8	19
Sand, gravel, and pebbles, fine to coarse, silty, red brown; contains clay and chalk fragments in lower part	15	34
Gravel, coarse, silty to cemented; contains many chalk fragments	1.5	35.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Chalk, silicified, yellow and yellow brown	.5	36

13-26-20bc.—*Sample log of test hole in SW¼ NW¼ sec. 20, T. 13 S., R. 26 W., 35 feet south of bridge and 15 feet east of center line of road. Drilled by State Geological Survey September 4, 1952. Surface altitude, 2,425.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Sand, fine to medium, silty, dark gray	2.5	2.5
Sand, fine to medium, clean	4.5	7
Clay, sandy, gray; contains siltstone fragments	2	9
Sand, gravel, and pebbles, silty, gray	20	29
Sand and gravel, fine to coarse, silty to clayey below 36 feet, dark gray	23.5	52.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, dark gray; contains silt and siltstone	4.5	57

13-26-30aa.—*Sample log of test hole in NE cor. sec. 30, T. 13 S., R. 26 W., 0.1 mile south of road intersection and 11 feet west of center line of road. Drilled by State Geological Survey September 4, 1952. Surface altitude, 2,464.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, tan gray	9	9
Silt, sandy, tan to tan yellow	11	20
Terrace deposits		
Sand, fine to medium, very clayey, tan brown	17	37
Clay, sandy, brown to tan	12.5	49.5
Sand and gravel, fine to coarse, clayey	2	51.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, clayey, yellow to light gray	1.5	53
Shale, clayey, calcareous, dark gray	5	58

13-27-16ca1.—*Drillers log of irrigation well in NE¼ SW¼ sec. 16, T. 13 S., R. 27 W. Drilled by Struckhoff Bros. Depth to water, 14 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt and clay	22	22
Gravel, good	17.5	39.5

	Thickness, feet	Depth, feet
Clay, blue	7.5	47
Gravel, good	13	60
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	.5	60.5

13-27-30cc.—*Sample log of test hole in SW cor. sec. 30, T. 13 S., R. 27 W., 100 feet east of sec. cor. and 10 feet north of center line of road. Drilled by State Geological Survey September 17, 1957. Surface altitude, 2,637.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, brown	5	5
Silt, black	2	7
Silt, brown to tan	10	17
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, weathered, yellow	2	19
Chalk, white	1	20
Shale, hard, yellow	5	25

13-28-13aa.—*Drillers log of test hole in NE¼ NE¼ sec. 13, T. 13 S., R. 28 W. Drilled by Central Exploration Company.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt and sand	64	64
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, blue	231	295
Niobrara Chalk—Fort Hays Chalk member		
Chalk and limestone	65	360
Carlile Shale		
Shale, sandy at top	10	370

13-28-36dd.—*Sample log of test hole in SE cor. sec. 36, T. 13 S., R. 28 W., 30 feet west of sec. cor. and 5 feet north of center line of road. Drilled by State Geological Survey September 17, 1957. Surface altitude, 2,599.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, brown to tan	8	8
Silt, red to brown	10	18
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, weathered, yellow	4	22
Chalk, hard, white	3	25

13-29-1ad.—*Drillers log of well in SE¼ NE¼ sec. 1, T. 13 S., R. 29 W. Drilled by Struckhoff Bros. Depth to water, 30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt and fine to medium sand	36	36
Sand, fine	4	40
Clay, sandy	2	42
Sand, fine	4	46
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	7	53

13-29-1d.—*Drillers log of test hole in SE¼ sec. 1, T. 13 S., R. 29 W. Drilled by Struckhoff Bros.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt and clay, sandy	35	35
Gravel, coarse	10	45
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	1	46

13-31-4c.—*Drillers log of test hole in SW¼ sec. 4, T. 13 S., R. 31 W. Drilled by Struckhoff Bros.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt and sand	29	29
Gravel, coarse	5	34
Clay	22	56
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, weathered; contains blue-gray clay in top part,	8	64

14-26-30db1.—*Drillers log of test hole in NW¼ SE¼ sec. 30, T. 14 S., R. 26 W. Drilled by Vern Litton November 22, 1955. Depth to water, 44 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, sandy	20	20
Terrace deposits		
Sand and gravel	10	30
Clay	9	39
Sand and gravel	1	40
Sand, clayey; contains cemented layers	5	45
Gravel	2	47
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	4	51

14-26-30db2.—*Drillers log of test hole in NW¼ SE¼ sec. 30, T. 14 S., R. 26 W. Drilled by Vern Litton November 22, 1955. Depth to water, 48 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, sandy at base	29	29
Terrace deposits		
Sand and gravel	3	32
Clay, sandy; contains some gravel	18	50
Clay	27	77
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	1	78

14-26-30dc1.—*Drillers log of test hole in SW¼ SE¼ sec. 30, T. 14 S., R. 26 W. Drilled by Vern Litton November 22, 1955. Depth to water, 43 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, sandy at base	22	22
Terrace deposits		
Sand and gravel	13	35
Clay	10	45
Sand and gravel	1	46
Clay; contains some gravel	5	51
Clay, sandy	24	75
Sand and gravel	4	79
Clay	2	81
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	1	82

14-26-30dc2.—*Drillers log of test hole in SW¼ SE¼ sec. 30, T. 14 S., R. 26 W. Drilled by Vern Litton November 22, 1955. Depth to water, 45 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, sandy	21	21
Terrace deposits		
Sand and gravel	9	30
Clay, sandy	57	87
Sand and gravel; contains shale pebbles	17	104
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	1	105

14-26-30dd1.—*Drillers log of test hole in SE¼ SE¼ sec. 30, T. 14 S., R. 26 W. Drilled by Vern Litton November 22, 1955. Depth to water, 42 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, sandy	20	20
Terrace deposits		
Clay, sandy	55	75
Sand and gravel	19	94
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	1	95

14-26-31aa.—*Sample log of test hole in NE¼ NE¼ sec. 31, T. 14 S., R. 26 W., 300 feet south of sec. cor. and 14 feet west of center line of road. Drilled by State Geological Survey September 4, 1952. Surface altitude, 2,434.8 feet; depth to water, 41.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, tan gray	7	7
Silt, compact to sandy, light tan	4	11
Silt, tan yellow	1	12
Terrace deposits		
Sand, fine to coarse, silty	3	15
Clay, silty, tan yellow; contains some sand	34	49
Clay, light gray to tan gray; contains some sand	20	69
Clay, sandy, light gray; contains gravel and chalk fragments in lower part	6	75
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, compact, clayey, calcareous, dark gray to blue gray	5	80

14-26-32cc.—*Sample log of test hole in SW¼ SW¼ sec. 32, T. 14 S., R. 26 W., 15 feet north of intersection and 13 feet east of center line of road. Drilled by State Geological Survey September 5, 1952. Surface altitude, 2,412.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, sandy, dark brown	1	1
Silt, tan gray	8	9
Silt, fine, sandy, light tan	6	15
Terrace deposits		
Silt, compact, tan yellow	17	32
Sand, fine to coarse; contains clay layer at 35 feet	11	43
Gravel and pebbles, predominantly chalk fragments; contains some silt	1	44
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, clayey, yellow gray	1	45
Shale, clayey, calcareous, blue gray	2	47

14-27-6cc.—*Sample log of test hole in SW cor. sec. 6, T. 14 S., R. 27 W., 30 feet east of sec. cor. and 5 feet north of center line of road. Drilled by State Geological Survey September 18, 1957. Surface altitude, 2,569.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, tan to brown	5	5
Silt, sandy, reddish brown	4	9
Silt, sandy, white to tan	8	17
Silt, soft, yellow	3	20
Silt, sandy, yellow	6	26
Sand; contains chalk pebbles	2	28
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, yellow	2	30

14-27-20bb.—*Drillers log of well in NW¼ NW¼ sec. 20, T. 14 S., R. 27 W. Drilled by H. W. Coberly. Depth to water, 52.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	10	10
Terrace deposits		
Clay, sandy, brown	5	15
Clay, sandy, white	5	20
Sand and gravel	12	32
Gravel	6	38
Clay, white	14	52
Clay, sandy	9	61
Sand	4	65
Sand; contains clay streaks	10	75
Gravel	8	83
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	.5	83.5

14-28-3b.—*Drillers log of test hole in NW¼ sec. 3, T. 14 S., R. 28 W. Drilled by Struckhoff Bros.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	6	6
Terrace deposits		
Gravel, coarse	5	11
Clay, blue; contains some gravel	1.5	12.5
Gravel, coarse	3.5	16
Clay	10	26
Gravel, coarse	3	29
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	.5	29.5

14-28-13aa.—*Sample log of test hole in NE cor. sec. 13, T. 14 S., R. 28 W., 500 feet south of sec. cor. and 5 feet west of center line of road. Drilled by State Geological Survey September 18, 1957. Surface altitude, 2,532.5 feet; depth to water, 35.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, light brown	5	5
Silt, sandy, reddish brown	3	8
Silt, reddish brown; contains caliche and sand layers near base	6	14
Sand, silty, light tan	3	17
Terrace deposits		
Silt, sandy, light tan; contains some gravel	14	31
Sand, medium to coarse, silty	5	36
Silt, sandy, gray; contains some gravel	3	39
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Silt, clayey, yellow	2	41
Shale, blue gray	3	44

14-28-13dd.—*Sample log of test hole in SE cor. sec. 13, T. 14 S., R. 28 W., 50 feet north of sec. cor. and 8 feet west of center line of road. Drilled by State Geological Survey September 19, 1957. Surface altitude, 2,490.8 feet; depth to water, 10.70 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, soft, tan	10	10
Terrace deposits		
Silt, sandy, tan	5	15
Sand, clean	2.5	17.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, hard, dark blue gray	8.5	26

14-28-24dd.—*Sample log of test hole in SE cor. sec. 24, T. 14 S., R. 28 W., 20 feet north of sec. cor. and 5 feet west of center line of road. Drilled by State Geological Survey September 19, 1957. Surface altitude, 2,512.4 feet; depth to water, 44.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, gray	6	6
Silt, reddish tan	9	15
Terrace deposits		
Silt, light tan; contains some caliche	3	18
Silt, yellow	8	26
Silt, sandy, tan	11	37
Sand	8	45
Sand, silty, tan	2	47
Sand and gravel, clean; contains chalk gravel	8	55

	Thickness, feet	Depth, feet
Sand and gravel, silty; contains chalk gravel in lower part	5	60
Silt, yellow to gray; contains gravel in lower part	8	68
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, blue gray	2	70

14-28-25dd.—*Sample log of test hole in SE cor. sec. 25, T. 14 S., R. 28 W., 80 feet north of sec. cor. and 5 feet west of center line of road. Drilled by State Geological Survey September 19, 1957. Surface altitude, 2,496.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, tan	8	8
Silt, reddish brown	6	14
Terrace deposits		
Silt, light tan, sandy in lower part	13	27
Silt, light brown; contains some sand and gravel	5	32
Silt, brown	2	34
Silt, sandy, gray	4	38
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Silt, clayey, yellow	4	42
Shale, hard, blue gray	2	44

14-28-36dd.—*Sample log of test hole in SE cor. sec. 36, T. 14 S., R. 28 W., 50 feet west of sec. cor. and 5 feet north of center line of road. Drilled by State Geological Survey September 19, 1957. Surface altitude, 2,532.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Soil and road fill	3	3
Silt, tan	2	5
Silt, sandy, reddish tan	2	7
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, soft, weathered, yellow; contains limonite layer at 12 feet	13	20

14-29-16db.—*Drillers log of well in NW¼ SE¼ sec. 16, T. 14 S., R. 29 W. Drilled by H. W. Coberly June 1956. Depth to water, 49 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, sandy	20	20
Terrace deposits		
Clay	30	50
Clay, sandy	10	60
Clay; contains thin sand layers	10	70
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	5	75

14-29-17ac.—*Drillers log of test hole in SW¼ NE¼ sec. 17, T. 14 S., R. 29 W. Drilled by H. W. Coberly June 1956.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	10	10
Terrace deposits		
Clay, yellow	15	25
Sand	5	30
Clay, tight, white	4	34
Clay, sandy	2	36
Clay, yellow	2	38
Clay; contains thin sand layers	4	42
Clay, blue green	10	52
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	4	56

15-26-7aa.—*Sample log of test hole in NE¼ NE¼ sec. 7, T. 15 S., R. 26 W., 12 feet south of sec. line and 11 feet west of center line of road. Drilled by State Geological Survey September 5, 1952. Surface altitude, 2,317.3 feet; depth to water, 8.90 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt and sand, fine, dark gray	1	1
Silt, clayey, tan to tan gray	3	4
Clay, very sandy, light tan; contains gravel in lower part	2	6
Sand, gravel, and pebbles, clean	4	10
Sand and gravel, fine to coarse, silty, dark gray	4	14
Sand and gravel, fine to coarse, clean	10	24
Sand and gravel, fine to coarse, silty, dark gray; contains gray clay	61	85
Sand and gravel, fine to coarse, clean in upper part, silty below 95 feet	13	98
CRETACEOUS—Gulfian		
Carlile Shale		
Shale and siltstone, calcareous, dark gray	2	100

15-26-7dd.—*Sample log of test hole in SE¼ SE¼ sec. 7, T. 15 S., R. 26 W., 0.1 mile north of road intersection and 12 feet west of center line of road. Drilled by State Geological Survey September 5, 1952. Surface altitude, 2,411.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Terrace deposits		
Sand, fine to coarse, and fine gravel, silty; contains clay at 7 feet	10	10
Clay, sandy, tan to yellow tan	3	13
Sand and gravel, fine to coarse, silty, yellow	5	18
Pebbles and gravel, coarse; contains thin layers of sandy clay	5.5	23.5

	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, clayey, calcareous, yellow gray	1	24.5
Shale, clayey, calcareous, dark gray	3.5	28

15-26-8bc.—*Sample log of test hole in SW¼ NW¼ sec. 8, T. 15 S., R. 26 W., 120 feet north of sec. line and 14 feet east of center line of road. Drilled by State Geological Survey September 5, 1952. Surface altitude, 2,353.0 feet; depth to water, 27.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Sand, fine to medium, silty to clayey, brown to dark gray; contains coarse sand and fine gravel in lower part	16	16
Sand, fine to coarse, clean	10	26
Clay (weathered shale), yellow gray	2.5	28.5
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale, clayey, calcareous, dark gray to blue gray	1.5	30

15-27-18cd.—*Drillers log of test hole in SE¼ SW¼ sec. 18, T. 15 S., R. 27 W. Drilled by Struckhoff Bros.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, sandy	11	11
Gravel	10	21
Sand, fine	2	23
Clay, blue	4	27
Gravel, medium	3	30
Sand, fine	2	32
Gravel, medium	6	38
Gravel, coarse	9	47
Clay, blue	27	74
Clay and weathered shale	5	79
Gravel	2	81

15-28-17ad.—*Drillers log of irrigation well in SE¼ NE¼ sec. 17, T. 15 S., R. 28 W. Drilled by Struckhoff Bros. Depth to water, 8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, sandy	7	7
Gravel, medium	8	15
Clay, sandy	7	22
Clay, blue; contains some gravel	12	34
Sand, fine	5	39
Gravel, coarse	9	48
Clay, blue; contains some gravel	12	60
Gravel, coarse	28	88
CRETACEOUS—Gulfian		
Niobrara Chalk—Fort Hays Chalk member		
Chalk	4	92

15-28-24aa.—*Drillers log of irrigation well in NE¼ NE¼ sec. 24, T. 15 S., R. 28 W. Drilled by Struckhoff Bros. Depth to water, 18 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, sandy	8	8
Gravel	4	12
Clay	4	16
Gravel	8	24
Sand, fine	5	29
Gravel	3	32
Clay, blue	2	34
Gravel	5	39
Clay, blue	2	41
Gravel	6	47
Clay, blue	24	71
Gravel	22	93
CRETACEOUS—Gulfian		
Niobrara Chalk—Fort Hays Chalk member		
Chalk	5	98

15-28-27dd.—*Drillers log of well in SE¼ SE¼ sec. 27, T. 15 S., R. 28 W. Drilled by H. W. Coberly September 2, 1956.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	8	8
Terrace deposits		
Sand; contains limestone gravel	7	15
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	5	20

15-28-29aa.—*Drillers log of well in NE¼ NE¼ sec. 29, T. 15 S., R. 28 W. Drilled by H. W. Coberly September 2, 1956. Depth to water, 33.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt	10	10
Terrace deposits		
Sand	32	42
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	1	43

15-29-25ab.—*Drillers log of well in NW¼ NE¼ sec. 25, T. 15 S., R. 29 W. Drilled by H. W. Coberly July 1956. Depth to water, 38.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Peoria and Loveland Formations		
Silt, sandy	12	12
Terrace deposits		
Sand	8	20
Clay, sandy, green	15	35
Clay, blue	5	40
Sand, fine	7	47
Sand	3	50
Gravel	6	56
CRETACEOUS—Gulfian		
Niobrara Chalk—Smoky Hill Chalk member		
Shale	.5	56.5

REFERENCES

Bradley, Edward, and Johnson, C. R. (1957) Ground-water resources of the Ladder Creek area in Kansas: Kansas Geol. Survey Bull. 126, p. 1-194.

Carey, J. S., and others (1952) Kansas volcanic ash resources: Kansas Geol. Survey Bull. 96, pt. 1, p. 1-68.

Darton, N. H. (1899) Preliminary report on the geology and water resources of Nebraska west of the 103d meridian: U. S. Geol. Survey 19th Ann. Rept., pt. 4, p. 719-785.

——— (1905) Preliminary report on the geology and underground water resources of the central Great Plains: U. S. Geol. Survey Prof. Paper 32, p. 1-433.

——— (1920) Description of the Syracuse and Lakin quadrangles: U. S. Geol. Survey Geol. Atlas, Syracuse-Lakin folio (No. 212), p. 1-10.

Dean, H. T. (1936) Chronic endemic dental fluorosis: Am. Med. Assoc. Jour., v. 107, p. 1269-1272.

Elias, M. K. (1931) The geology of Wallace County, Kansas: Kansas Geol. Survey Bull. 18, p. 1-254.

Frye, J. C., and Leonard, A. B. (1952) Pleistocene geology of Kansas: Kansas Geol. Survey Bull. 99, p. 1-230.

Frye, J. C., Leonard, A. B., and Swineford, Ada (1956) Stratigraphy of the Ogallala Formation (Neogene) of northern Kansas: Kansas Geol. Survey Bull. 118, p. 1-92.

Frye, J. C., and Schoewe, W. H. (1953) The basis of physiographic subdivision of Kansas: Kansas Acad. Sci. Trans., v. 56, no. 2, p. 246-252.

Frye, J. C., and Smith, H. T. U. (1942) Preliminary observations on pediment-like slopes in the central High Plains: Jour. Geomorphology, v. 5, no. 3, p. 215-221.

Haworth, Erasmus (1897) Physiography of western Kansas: Kansas Univ. Geol. Survey, v. 2, p. 11-49.

——— (1897a) Physical properties of the Tertiary: Kansas Univ. Geol. Survey, v. 2, p. 247-284.

——— (1913) Special report on well waters in Kansas: Kansas Univ. Geol. Survey Bull. 1, p. 1-110.

Johnson, C. R. (1958) Geology and ground-water resources of Logan County, Kansas: Kansas Geol. Survey Bull. 129, p. 1-175.

Johnson, W. D. (1901) The High Plains and their utilization: U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 601-741.

——— (1902) The High Plains and their utilization (sequel): U. S. Geol. Survey 22nd Ann. Rept., pt. 4, p. 631-669.

Kansas State Board of Agriculture (1956) Summary of Kansas crop and livestock information for 1955 with preliminary estimates for 1956: Reprinted from Kansas Agriculture 1953-56, 39th rept. Kansas State Board of Agri., p. 1-87.

Landes, K. K., and Keroher, R. P. (1939) Geology and oil and gas resources of Logan, Gove, and Trego Counties, Kansas: Kansas Geol. Survey Min. Res. Circ. 11, p. 1-45.

Logan, W. N. (1897) Upper Cretaceous of Kansas: Kansas Univ. Geol. Survey, v. 2, p. 195-234.

MEINZER, O. E. (1923) The occurrence of ground water in the United States with a discussion of principles: U. S. Geol. Survey Water-Supply Paper 489, p. 1-321.

——— (1923a) Outline of ground-water hydrology with definitions: U. S. Geol. Survey Water-Supply Paper 494, p. 1-71.

MERRIAM, D. F. (1955) Jurassic rocks in Kansas: Am. Assoc. Petrol. Geol. Bull., v. 39, p. 31-46.

——— and FRYE, J. C. (1954) Additional studies of the Cenozoic of western Kansas: Kansas Geol. Survey Bull. 109, pt. 4, p. 49-64.

METZLER, D. F., and STOLTENBERG, H. A. (1950) The public health significance of high nitrate waters as a cause of infant cyanosis and methods of control: Kansas Acad. Sci. Trans., v. 53, no. 2, p. 194-211.

MOORE, R. C., and others (1940) Ground-water resources of Kansas: Kansas Geol. Survey Bull. 27, p. 1-112.

PARKER, H. N. (1911) Quality of water supplies of Kansas: U. S. Geol. Survey Water-Supply Paper 273, p. 1-375.

PLUMMER, NORMAN, and ROMARY, J. F. (1942) Stratigraphy of the pre-Greenhorn Cretaceous beds of Kansas: Kansas Geol. Survey Bull. 41, pt. 9, p. 313-348.

RUSSELL, W. L. (1929) Stratigraphy and structure of the Smoky Hill Chalk in western Kansas: Am. Assoc. Petrol. Geol. Bull., v. 13, p. 595-604.

SCHOEWE, W. H. (1949) The geography of Kansas, part II, Physical geography: Kansas Acad. Sci. Trans., v. 52, no. 3, p. 261-333.

SMITH, H. T. U. (1940) Geologic studies in southwestern Kansas: Kansas Geol. Survey Bull. 34, p. 1-244.

THEIS, C. V. (1935) The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophysical Union Trans. 16th Ann. Meeting, pt. 2, p. 519-524.

U. S. GEOLOGICAL SURVEY (1935-1956) Water levels and artesian pressure in observation wells in the United States, pt. 3, North-central States: Issued annually as water-supply papers.

U. S. PUBLIC HEALTH SERVICE (1946) Drinking water standards: Public Health Rept., v. 61, no. 11, p. 371-384.

U. S. SALINITY LABORATORY STAFF (1954) Diagnosis and improvement of saline and alkali soils: U. S. Dept. of Agri., Agriculture Handbook No. 60, p. 1-160.

WENZEL, L. K. (1942) Methods for determining permeability of water-bearing materials with special reference to discharging well methods: U. S. Geol. Survey Water-Supply Paper 887, p. 1-192.

WILLIAMS, G. R., and others (1940) Natural water loss in selected drainage basins: U. S. Geol. Survey Water-Supply Paper 846, p. 1-62.

WILLISTON, S. W. (1897) The Kansas Niobrara Cretaceous: Kansas Univ. Geol. Survey, v. 2, p. 235-246.

——— (1897a) The Pleistocene of Kansas: Kansas Univ. Geol. Survey, v. 2, p. 297-308.

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Plate 1

State Geological Survey
of Kansas

AREAL GEOLOGY OF GOVE COUNTY, KANSAS

By Warren G. Hodson and Kenneth D. Wahl

1956

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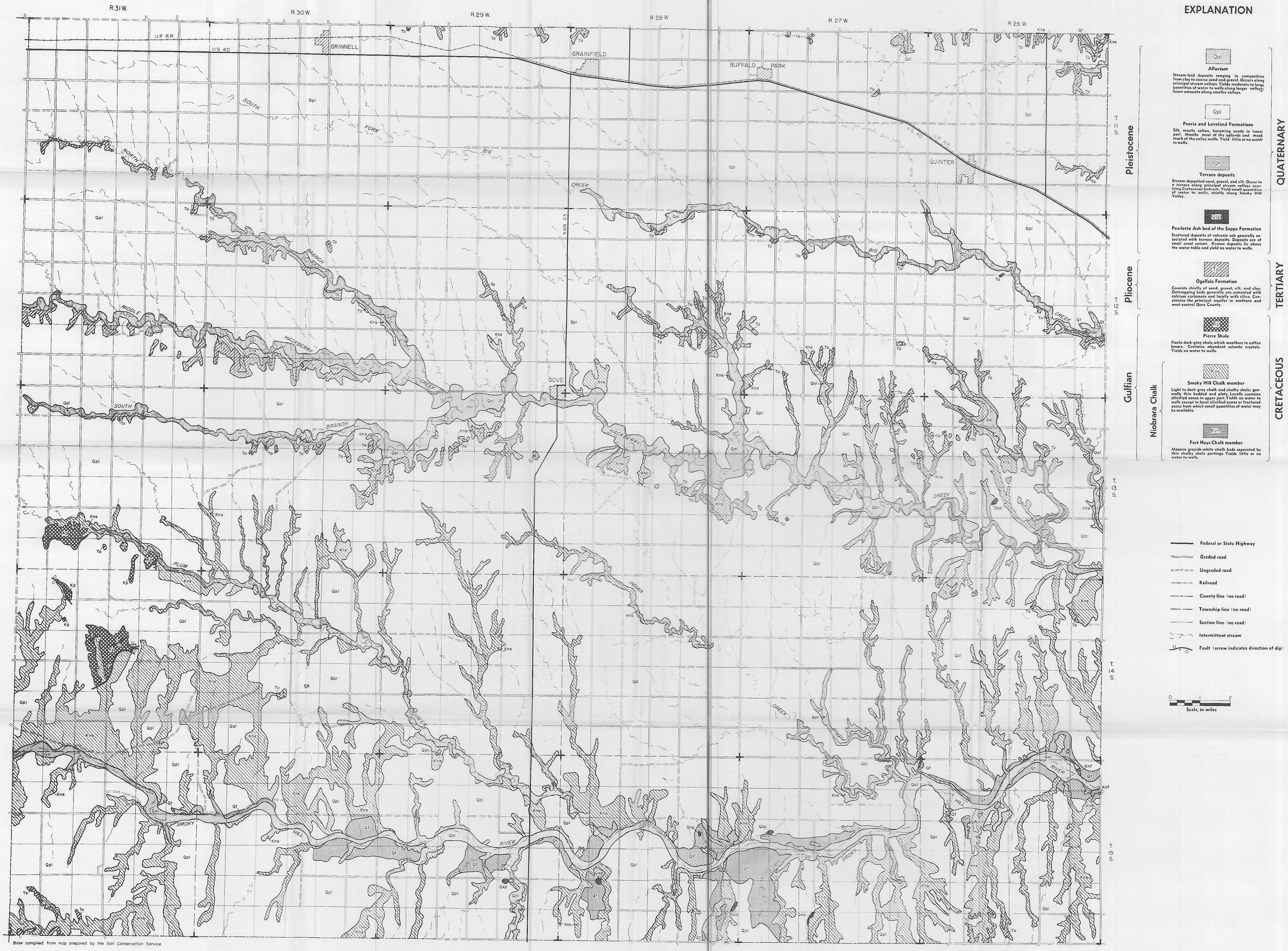
Plate 1



MAP OF GOVE COUNTY

showing the depths to water level, the location of wells and test holes for which records are given, and water-table contours

By Warren G. Hodson and Kenneth D. Wahl

1956

State Geological Survey of Kansas

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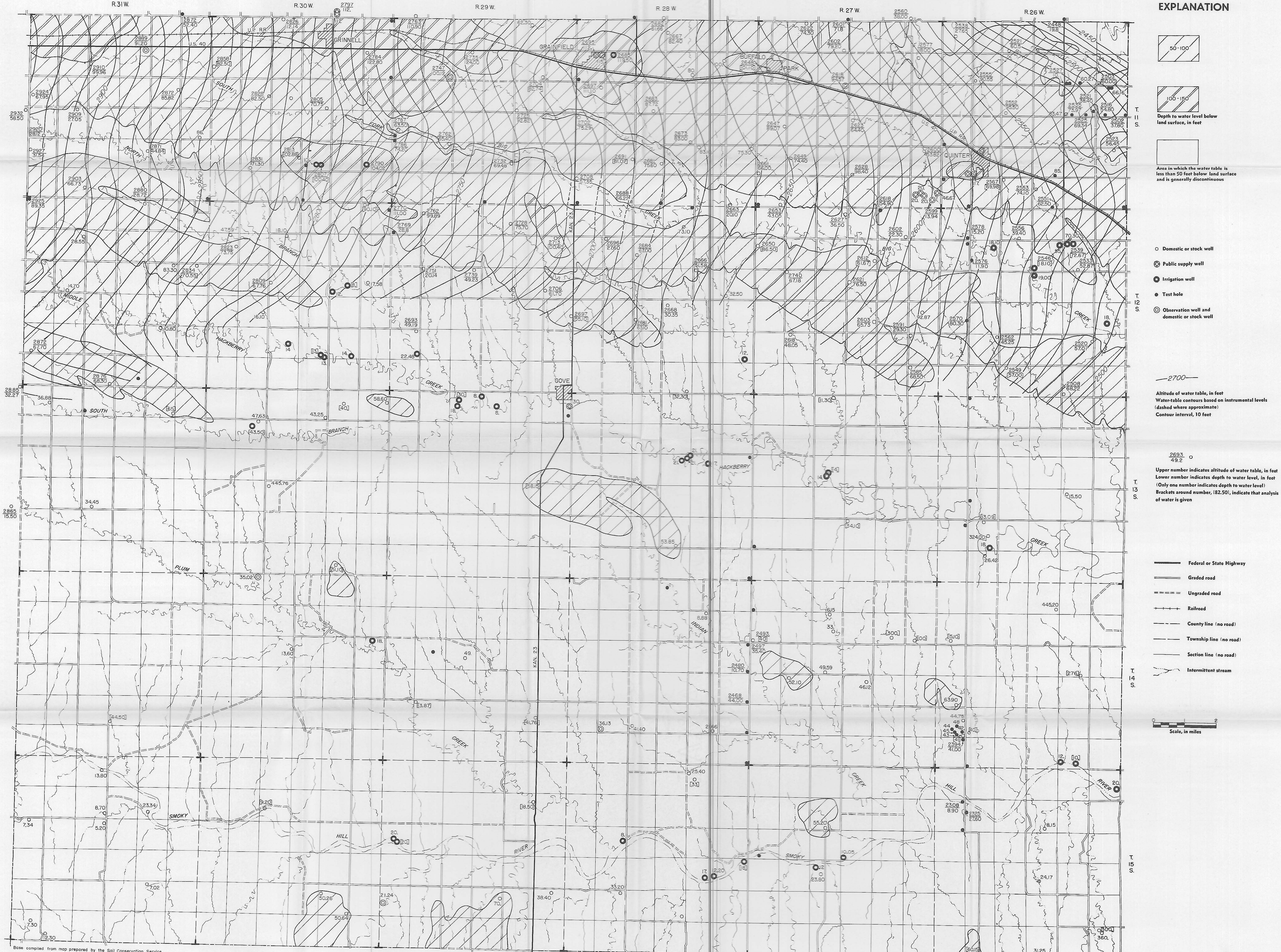
Plate 2



Base compiled from map prepared by the Soil Conservation Service

State Geological Survey of Kansas

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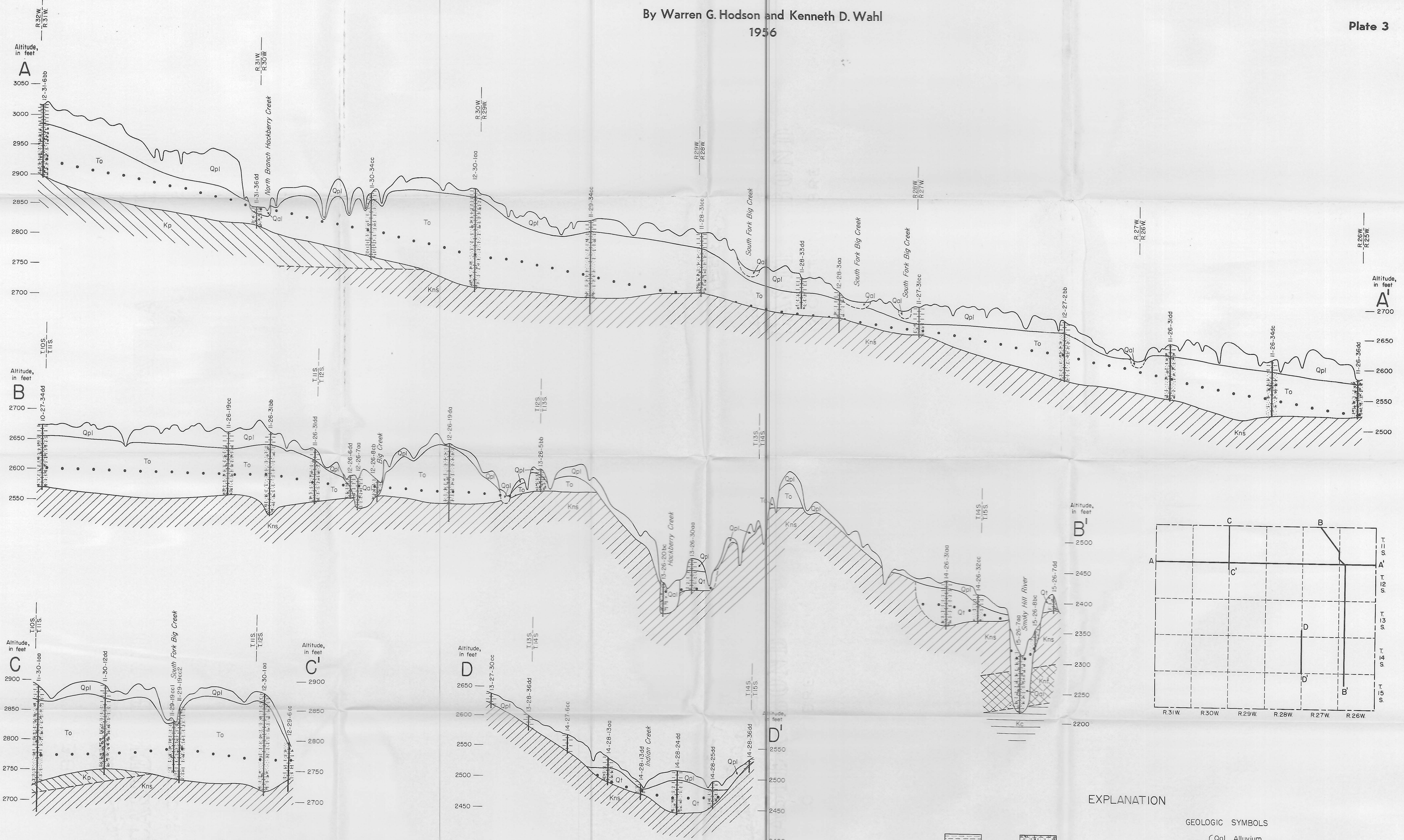
Plate 3

GEOLOGIC CROSS SECTIONS IN GOVE COUNTY, KANSAS

By Warren G. Hodson and Kenneth D. Wahl

1956



EXPLANATION

GEOLOGIC SYMBOLS

Silt and clay

Cemented sand and gravel

Sand and gravel

Cretaceous rocks

Quaternary-Pleistocene	Qal	Alluvium
	Qt	Terrace deposits
	Qpl	Peoria and Loveland Formations
Tertiary-Pliocene	To	Ogallala Formation
Cretaceous-Gulfian	Kp	Pierre Shale
	Kns	Smoky Hill Chalk member-Niobrara Chalk
	Knf	Fort Hays Chalk member-Niobrara Chalk
	Kc	Carlile Shale

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SCALE IN MILES