Geology and Ground-Water Resources of Harper County, Kansas

By

CHARLES K. BAYNE

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

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GEOLOGY AND GROUND-WATER RESOURCES OF HARPER COUNTY, KANSAS

By Charles K. Bayne

ABSTRACT

This report describes the geography, geology, and ground-water resources of Harper County in south-central Kansas. The hydrologic and geologic information was obtained in the field during the summers of 1955 and 1956. The field data upon which this report is based are given in tables; they include records of 458 wells and test holes, chemical analyses of 32 water samples from wells and test holes, and 317 logs of wells and test holes.

Harper County lies partly in the Wellington Lowland minor division of the Arkansas River Lowland section of the Central Lowland province and partly in the Red Hills minor division of the Dissected High Plains section of the Great Plains province. A small area in northwestern Harper County lies in the High Plains section of the Great Plains province. The county is drained by Chikaskia River, Bluff Creek, Big and Little Sandy Creeks, and their tributaries. The topography in general slopes southeastward. The normal annual precipitation at Anthony, the county seat, is 27.41 inches. Wheat farming is the principal industry of the county, and oil is the chief natural resource.

The rocks that crop out in Harper County range in age from Paleozoic to Recent. The oldest of these are a part of the Ninnescah Shale of Permian age. Younger Permian rocks that crop out are the Harper Siltstone and the Salt Plain Siltstone. The Permian rocks in Harper County yield small quantities of hard water. Pleistocene deposits, ranging in age from Nebraskan to Recent, unconformably overlie the Permian rocks in the valleys and over much of the upland. These deposits consist of silt, sand, and gravel, and yield moderate supplies of water in parts of the county.

The report contains a map showing the areas of outcrop of the rock formations. The shape and slope of the water table are shown by means of contours, the locations of wells and test holes for which records are given also are shown on maps.

The ground-water reservoir is recharged principally from rain and snow that falls within the county, by percolation from streams and depressions, and by underflow from adjacent areas. Ground water is discharged from the ground-water reservoir by seepage into streams, by transpiration and evaporation, by movement into adjacent areas, and by wells. Water is pumped from wells in Harper County for domestic, stock, municipal, industrial, and irrigation use. Yields as great as 500 gpm can be obtained from wells located in the most productive areas. The results of aquifer tests are included in this report.

Chemical analyses of samples of water from Harper County indicate that the quality varies greatly from place to place. Strong concentrations of sulfate are common in water from the Permian rocks. Water from Pleistocene deposits, although fairly hard, generally is suitable for most uses.

INTRODUCTION

Purpose of Investigation

An investigation of the geology and ground-water resources in Harper County was begun in 1955 by the U. S. Geological Survey and the State Geological Survey of Kansas, with the cooperation of the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture. The investigation was made to determine the availability and quality of ground water for domestic, stock, industrial, and irrigation supplies and to determine the geologic and hydrologic factors that control the occurrence of ground water, which is one of the principal natural resources of the county. Although the danger of seriously depleting the ground-water supply, at the present rate of withdrawal, seems very slight, there still is a definite need for adequate understanding of the quantity and quality of the available supply, where additional supplies can be obtained, and what measures may be necessary to safeguard their continuance.

Location and Extent of Area

Harper County is in the south tier of counties about midway between the east and west borders of Kansas. It is bounded on the south by Grant and Alfalfa Counties, Okla., on the east by Sumner County, on the north by Kingman County, and on the west by Barber County. Harper County has an area of about 810 square miles and comprises 20 townships from T. 31 through T. 34 S., and R. 5 through R. 9 W. and the equivalent of about 2 townships in the north half of T. 35 S., from R. 5 through R. 9 W. (Fig. 1).

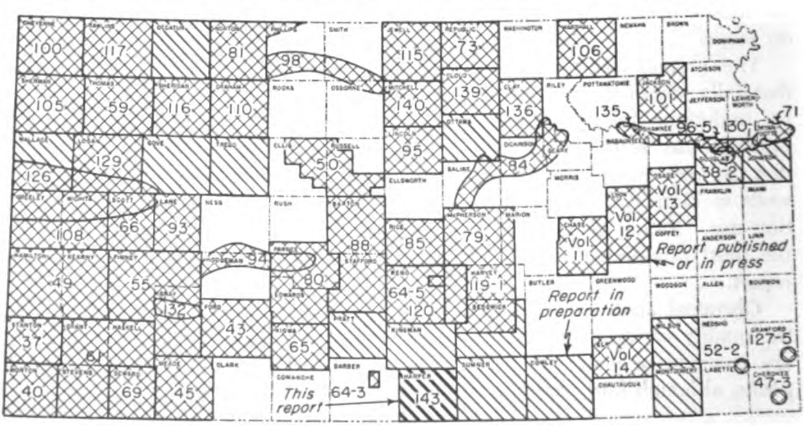

Fig. 1.—Map of Kansas showing area discussed in this report and other areas of ground-water investigations.

Previous Investigations

A detailed study of the geology and ground-water resources of Harper County has not been made previously. Several early reconnaissance reports included this part of the state and specific references were made to the county. The area was included during the preparation of the geologic map of Kansas in 1937. A report on the Pleistocene geology of Kansas by Frye and Leonard (1952) makes specific reference to this area, and a report by Swineford (1955) on the petrography of the upper Permian rocks in south-central Kansas includes this area. Studies have been made of the geology and ground-water resources of Sumner and Kingman Counties adjoining Harper County, and the reports are in press.

Methods of Investigation

Field work was begun in Harper County in June 1955 and was continued through October 1955. Additional field work was done from July 1956 to October 1956. Data were collected in the field on 142 wells including the depths to water and the depths of the wells (Pl. 3 and Table 10), and information on the yield of wells and the water-bearing materials was obtained from the owners.

A total of 213 test holes, drilled in the county to determine the thickness and character of the Quaternary deposits and the character of the Permian rocks, yielded drill cuttings that were studied in the field and in the laboratory by the author. Also, 103 drillers logs were used in preparing this report. Altitudes of the measuring points of the wells and test holes were determined by a planetable and alidade survey made under the direction of E. L. Reavis.

The geology of the area was studied and mapped in the field on areal photographs and later transferred to a base map modified from a map prepared by the Soil Conservation Service of the U. S. Department of Agriculture (Pl. 1).

Samples of water from 27 wells and test holes were collected by the author and were analyzed by Howard Stoltenberg, Chemist, Water and Sewage Laboratory, Kansas State Board of Health. In addition, the analyses of 5 samples of water from municipal wells obtained from files of the Kansas State Board of Health are included in this report (Table 6).

Well-Numbering System

The well and test-hole numbers in this report give the locations of the wells and test holes according to the system of subdivision of the public lands of the U. S. Bureau of Land Management. The first numeral of the well number indicates the township; the second, the range; and the third, the section. The quarter sections (160 acres), quarter-quarter sections (40 acres), and quarter-quarter-quarter sections (10 acres) are designated a, b, c, or d in a counter-clockwise direction beginning in the northeast quadrant, as shown in Figure 2. For example, well 34-9-18bcd is in the SE¼ SW¼ NW¼ sec. 18, T. 34 S., R. 9 W. If two or more wells are in a 10-acre tract, the location number is followed by serial numbers in the order in which the wells were inventoried.

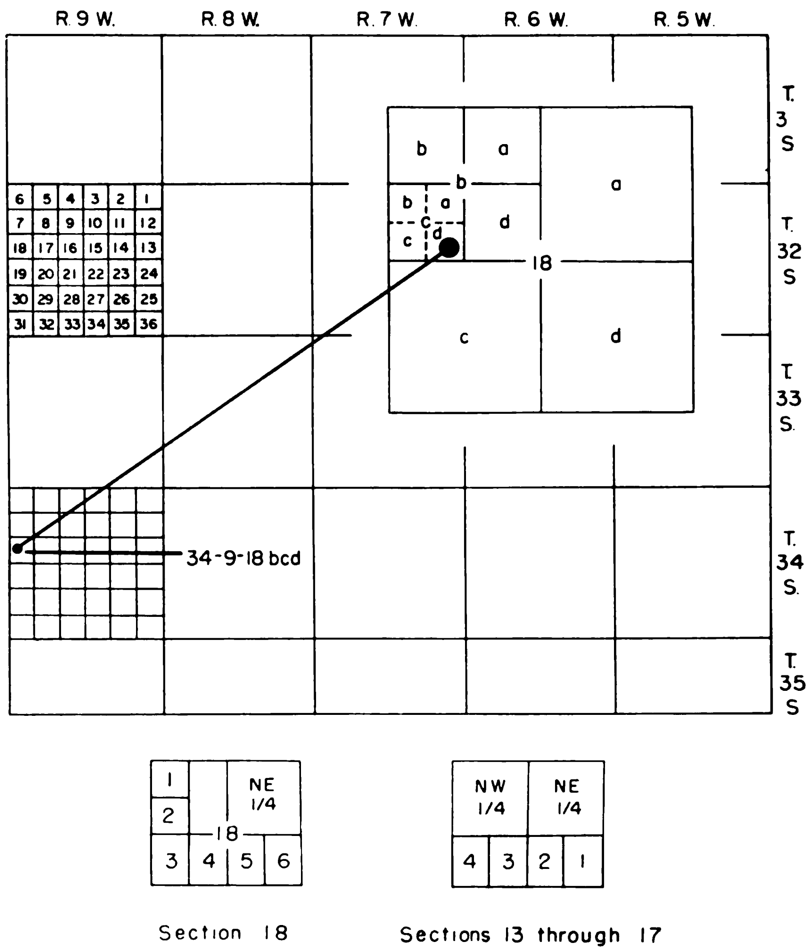

FIG. 2.—Map of Harper County illustrating well-numbering system used in this report.

When the General Land Office survey of the area along the Oklahoma border was made, T. 35 S. was found to be only about 2¾ miles from north to south. The north two rows of sections in T. 35 S. were laid out as full sections and the north part of the sections bordering Oklahoma were laid out as half sections. The remaining south part of each section bordering Oklahoma was divided into four lots and, in addition, the W½ NW¼ sec. 18 into two lots. These lots in sections 13 to 17, inclusive, are numbered serially 1 to 4 from east to west, as shown in Figure 2. Lots in section 18 are numbered serially 1 to 6 from the northwest corner counterclockwise around the west and south sides of the section (Fig. 2). Wells in these lots are not numbered according to the system described above, but are designated by township, range, section, and lot.

Acknowledgments

Appreciation is expressed to the many residents who supplied information on their wells and aided in collecting the field data. Special acknowledgment is made to the officials of the cities who furnished information regarding the municipal water supplies and to the drillers who supplied information and logs on wells and test holes in the county.

The manuscript of this report was reviewed by members of the U. S. Geological Survey and the State Geological Survey of Kansas; by R. V. Smrha, Chief Engineer, and George S. Knapp, Engineer, of the Division of Water Resources of the Kansas State Board of Agriculture; and Dwight F. Metzler, Director, and Willard O. Hilton, Geologist, of the Division of Sanitation of the Kansas State Board of Health.

GEOGRAPHY

Kansas lies in the Interior Plains major physiographic division. This major division is represented in Kansas by the Great Plains and Central Lowland provinces. The provinces are divided into sections, which in turn are divided into minor physiographic divisions according to the classification of Schoewe (1949) (Fig. 3).

Harper County lies partly in the Wellington Lowland minor division of the Arkansas River Lowland section of the Central Lowland province and partly in the Red Hills minor division of the Dissected High Plains section of the Great Plains province. A small area in northwestern Harper County lies in the High Plains section of the Great Plains province (Schoewe, 1949).

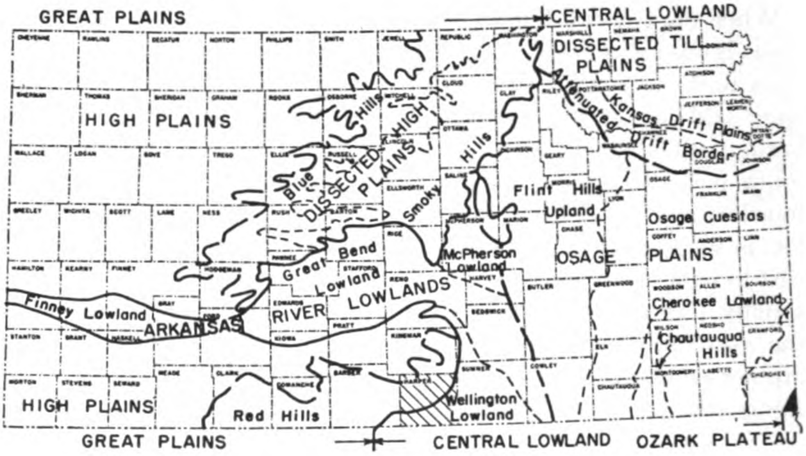

Fig. 3.—Map showing physiographic provinces in Kansas.

Topography and Drainage

The Wellington Lowlands are characterized by gently rolling hills covered with a reddish soil derived from the Permian bedrock underlying the surface.

The border between the Wellington Lowland division and the Red Hills division is sharply marked by a prominent escarpment at the eastern edge of the Dissected High Plains. The thin soils in this area are red, and the land surface has considerable local relief caused by the differential erosion of resistant sandstone and siltstone beds of the Permian bedrock.

An area of a few square miles in northwestern Harper County lies in the High Plains physiographic section. Here the topography is a very gently rolling, almost featureless upland plain.

The northeastern part of the county is drained by Chikaskia River and its principal tributaries, Spring and East Sand Creeks. The central and southeastern parts of the county are drained by Bluff Creek, and the southwestern part by Big and Little Sandy Creeks.

The surface of Harper County slopes from the northwest corner toward the southeast corner. The highest altitude, 1,700 feet, is just south of the northwest corner, and the lowest altitude, 1,180 feet, is just north of the southeast corner of the county in Bluff Creek valley.

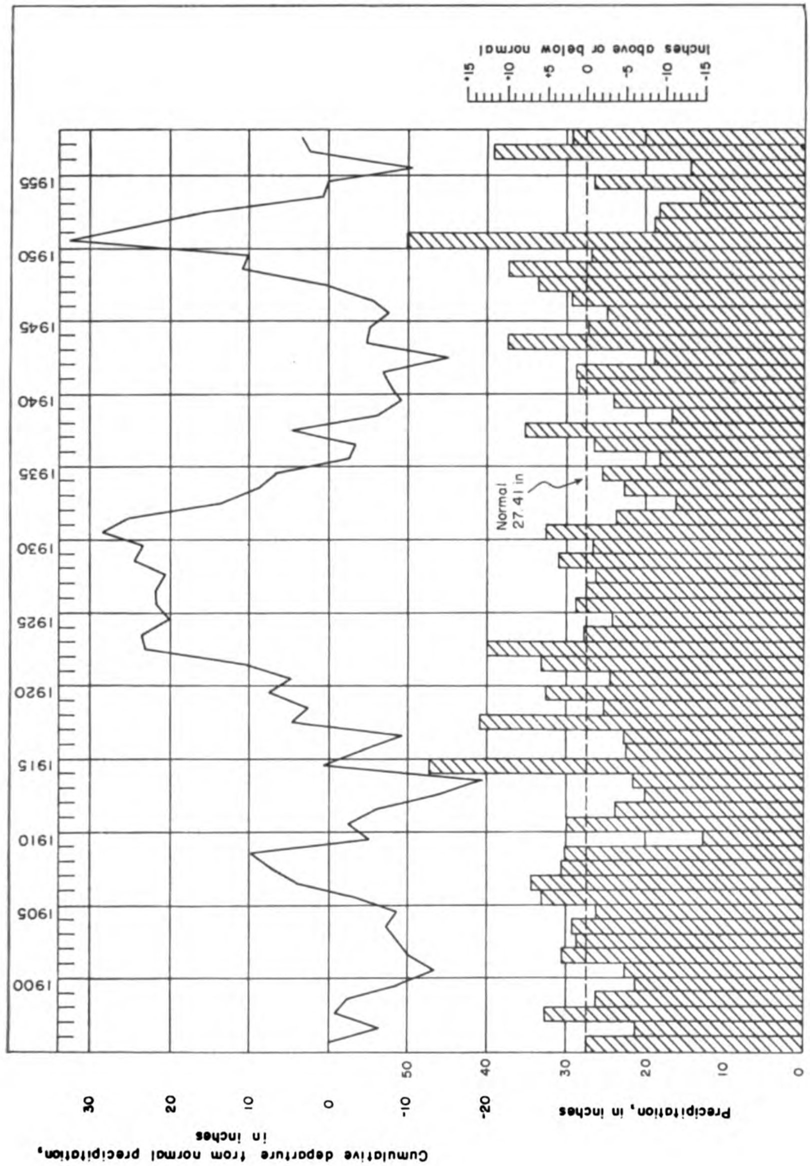

FIG. 4.—Annual precipitation and cumulative departure from normal at Anthony.

Climate

The climate of Harper County is subhumid and is characterized by moderate precipitation, a wide range of temperature, and a moderately high average wind velocity. In summer the days and many of the nights are generally hot; winters are moderately cold but generally are free from excessive snowfall.

The climatic data in this report were compiled from the records of the U. S. Weather Bureau. The normal monthly mean temperatures at Anthony range from 30.3° F for January to 80.6° F for July. The annual mean temperature is 56° F. The average annual number of days when the maximum temperature exceeds 100° F is 20 days and the average annual number of days when the minimum

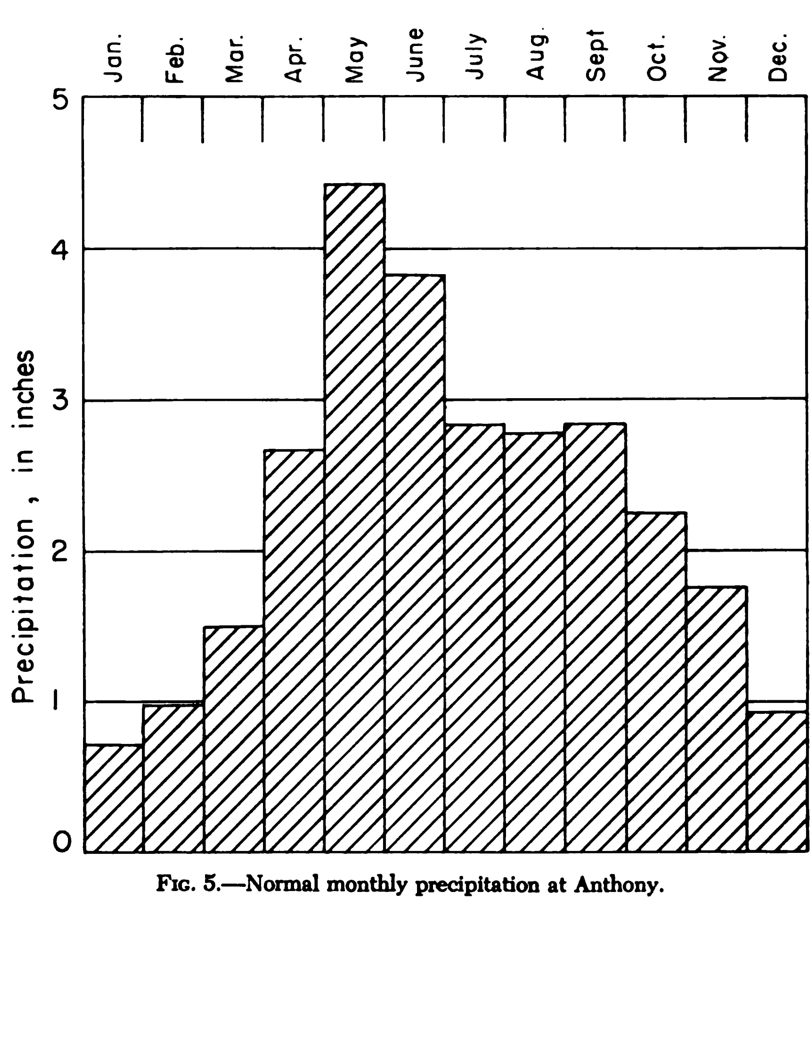

Fig. 5.—Normal monthly precipitation at Anthony.

temperature is 32° F or below is 110 days. The average date of the first killing frost in the fall is October 25 and the average date of the last killing frost in the spring is April 13. The earliest frost of record was September 26, 1912, and the latest killing frost of record was May 15, 1907. The average growing season is 195 days. The longest growing season of record was 225 days and the shortest was 154 days.

The normal annual precipitation at Anthony is 27.41 inches. The lowest annual precipitation of record was 12.54 inches in 1910 and the highest annual precipitation was 50.03 inches in 1951. The annual precipitation and cumulative departure from normal for the period of record (1896-1958) at Anthony are shown in Figure 4. About 72 percent of the annual precipitation falls during the growing season, from April through September. The lowest normal monthly precipitation is 0.70 inch, in January, and the highest normal monthly precipitation is 4.42 inches, in May. The normal monthly precipitation at Anthony is shown in Figure 5.

Population

The population of Harper county in 1955 was 10,195. The population in 1950 was 10,263, in 1940 was 12, 068, and in 1930 was 12,823. Thus a decrease of 15 percent occurred in the period 1940 to 1950 and a decrease of 20 percent in the period 1930 to 1950. In 1950 the population was about equally divided between those living in cities and towns and those living on farms; the urban population had decreased 6.8 percent and the rural population, 14.7 percent during the preceding decade.

The principal cities and towns and their 1955 populations were: Anthony, 2,799; Attica, 730; Bluff City, 161; Danville, 124; Freeport, 27; Harper, 1,829, and Waldron, 67.

Transportation

Harper County is served by a branch line of the Missouri Pacific Railroad Co., which enters on the east from Argonia in Sumner County and passes through Freeport, Anthony, and Corwin. The main line of the Atchison, Topeka, and Santa Fe Railway Co. serves Harper, Attica, and Danville. All other communities in the county, except Freeport and Waldron, are served by branch lines of the Atchison, Topeka, and Santa Fe.

Improved state and federal highways in Harper County total about 102 miles. U. S. Highway 160 crosses the county from east to west through Danville, Harper, and Attica. Kansas Highway 14 enters the county on the north side at Duquoin, runs south to Anthony, and thence west into Barber County. Kansas Highway 2 starts at Harper and runs northeast toward Wichita, Kansas Highway 44 runs east from Anthony into Sumner County, and Kansas Highway 179 runs south from Anthony to Manchester, Okla.

Agriculture

Harper County is primarily an agricultural county, there being 1,217 farms according to the 1955 farm census. In 1955 the total acreage of crops harvested was 236,345; the crops were valued at $3,869,000. Wheat is the principal crop, sorghums, oats, hay, and barley following in order of acreage harvested (Table 1).

Table 1.—*Acreages of principal crops harvested in Harper County in 1955 (From the biennial report of the Kansas State Board of Agriculture).*

Crop	*Acres*
Wheat	132,000
Sorghums	58,500
Oats	15,600
Alfalfa	15,400
Barley	8,500
Rye	2,000
Corn	330

The livestock industry is an important part of the economy of Harper County. In 1955, the number of livestock in Harper County was as follows: beef cattle, 36,850; milk cows, 4,650; sheep, 6,700; and hogs, 2,800. Their total value was $3,486,000.

Mineral Resources

The principal mineral resources of Harper County are oil, gas, sand, and gravel. Formerly, volcanic ash and salt were mined there, but the volcanic ash has been mined out and salt mining has been abandoned.

Oil and Gas

Exploratory wells for oil and gas had been drilled in Harper County at intervals for many years prior to the discovery of the first producing oil well in 1949. This well produced from Mississippian limestone at a depth of about 4,400 feet. Gas was first discovered in commercial quantity in 1950, also in Mississippian limestone.

The 1957 production of oil in Harper County was about 782,500 barrels from 164 wells in 12 fields. Oil was produced from Lansing-Kansas City rocks at a depth of about 3,900 feet, Mississippian limestone at about 4,400 feet, Viola Limestone at about 4,750 feet, and Viola Limestone and Simpson Group at about 4,850 feet. The cumulative production of oil at the end of 1957 was about 2,322,400 barrels.

Gas production in the county in 1957 was about 2,030,000 thousand cubic feet. Gas was produced from 30 wells in two fields from Mississippian limestone at a depth of about 4,400 feet. The cumulative production of gas at the end of 1957 was 6,170,000 thousand cubic feet.

Sand and Gravel

Sand and gravel is produced in considerable quantity in Harper County. One pit on Bluff Creek near Attica produces washed sand and gravel from the alluvium, and the material is used for concrete aggregate and road metal. Many small pits have been opened in the county. Sand and gravel from these pits is used principally for road metal.

GEOLOGY

Summary of Stratigraphy*

The rocks that crop out in Harper County are of sedimentary origin and range in age from Paleozoic to Cenozoic (Pl. 1). The oldest rocks are a part of the Ninnescah Shale of the Leonardian Series, Permian System. Nearly all outcrops of the Ninnescah Shale in the county are in the eastern tier of townships. The Harper Siltstone, also of Permian age, crops out in a belt about one township wide that roughly coincides with R. 6 W. through the county. The Harper Siltstone is composed of two members, the Chikaskia Siltstone (lower) and the Kingman Siltstone (upper). The upper limit of this formation is not clearly marked, but the Kingman Siltstone member seems to be more resistant to weathering than the overlying Salt Plain Siltstone. The outcrop line of contact can be drawn only approximately between the Ninnescah and Harper, but roughly parallels the west line of R. 6 W. The youngest Permian rocks exposed in the county are rocks of the Salt Plain Siltstone, which crop out in approximately the western half of the county. Cenozoic desposits of the Pleistocene Series ranging in age from Nebraskan to Recent unconformably overlie the Permian rocks in

* The geologic classification and nomenclature of this report follow the usage of the State Geological Survey of Kansas, which differs from that of the U. S. Geological Survey.

much of Harper County. These deposits consist chiefly of silt, sand, and gravel, and are widely distributed in the valleys and over much of the upland area of the county. A generalized section of the geologic formations exposed in Harper County is given in Table 2. Configuration of the pre-Pleistocene surface is shown in Plate 4, and geologic cross sections based on the test-hole information are shown in Plate 2.

Geologic History

The rocks exposed at the surface in Harper County total only a few hundred feet in thickness. From these surface exposures the geologic history of the near-surface deposits may be interpreted, but the history of the deeply buried rocks must be studied through the use of drill-hole logs and samples obtained during exploration for oil and gas. The geologic history of the Paleozoic Era as it is discussed here is based chiefly on a report by Lee, Leatherock, and Botinelly (1948).

Harper County, like the rest of Kansas, is underlain by a basement complex of crystalline rocks older than Paleozoic. The area that is now Harper County was invaded by the sea in Cambrian time and remained submerged most of the time until the end of the Mississippian deposition. Unconformities in the deposits older than Mississippian indicate that the area was probably a landmass for short intervals during pre-Mississippian time. Near the end of the Mississippian, the area became a landmass and remained so for a considerable time during which a large part of the Mississippian deposits was removed. Late in Mississippian time the Nemaha Anticline was formed. This major structural feature, which extends across Kansas from Nemaha County into Oklahoma, is east of Harper County, but the effects of the deformation were important in this area. The Sedgwick Basin to the west of the Nemaha Anticline was formed, and minor anticlinal ridges paralleling the Nemaha Anticline were formed in the basin. The Mississippian deposits were eroded to base level and the detritus was deposited in the Sedgwick Basin. These deposits are one of the most important oil producing zones in the Sedgwick Basin. After this period of erosion early in Pennsylvanian time, the area was again submerged and remained so until the end of Permian time. Rocks representing all the systems of the Paleozoic Era are present in Harper County, but the thinning of some units indicates that structural movements took place repeatedly throughout the Paleozoic Era.

The area that includes Harper County has remained above sea level since the emergence at the end of the Permian. Many of the late Permian deposits have been removed. During the Mesozoic Era, deposition was negligible, hence Cenozoic deposits rest directly on the remaining Permian deposits.

Tertiary System

During early Tertiary time, the landmass in Kansas continued to be eroded, and very little if any deposition took place.

During late Tertiary (Pliocene) time, western Kansas was covered by a thick mantle of alluvial deposits. Some alluvial material probably was deposited in Harper County but was removed by later erosion. It is possible that remnants of deposits in four small areas capping hills in southeast Harper County, which are unlike later Pleistocene deposits in western Kansas, may be Pliocene (Pl. 1). A thin veneer of gravel resembling these deposits was observed farther west and may be the same age, but some of this material seems to have been reworked and may be slope wash from a higher deposit that has been removed entirely.

Quaternary System—Pleistocene Series

Widespread deposition during late Pliocene time was followed by a period of stability marked by extremely arid conditions; only local erosion and deposition occurred during this arid period. An abrupt climatic change marked the end of the arid period and the beginning of Pleistocene time.

Beyond the glaciated areas in Kansas, Pleistocene deposits consist of fluvial and eolian deposits that were laid down in a cyclic pattern during alternating glacial and interglacial stages. Four main glacial stages and the intervening interglacial stages are represented in these cycles. The glacial stages—the Nebraskan, Kansan, Illinoisan, and Wisconsinan—represent the advance and early retreat of the continental glaciers; the interglacial stages—the Aftonian, Yarmouthian, and Sangamonian—represent periods of relative stability when the glaciers were remote or had disappeared completely. The Wisconsinan Stage was interrupted by a major retreat or recession of the glacier, therefore the Wisconsinan Stage has been divided into an early Wisconsinan substage, a Bradian interglacial substage, and a late Wisconsinan substage. Deposits of all the Pleistocene divisions are present in Harper County. Distribution of these deposits was controlled chiefly by the drainage patterns during the various stages.

TABLE 2.—*Generalized section of stratigraphic units exposed in Harper County* *

System	Series	Subseries	Stage	Stratigraphic unit	Member	Maximum thickness	Physical character	Water supply
Quaternary	Pleistocene	Upper Pleistocene	Recent	Alluvium		30	Silt, sand, and gravel in major valleys.	Moderate supplies adequate for domestic and stock use may be obtained in some areas.
			Recent	Dune sand		20	Medium and fine sand and some silt.	Generally above water table; yields little or no water to wells.
			Wisconsinan	Terrace deposits		40	Clay, silt, sand, and gravel beneath terraces along principal streams.	Moderate supplies of water available for domestic and stock use.
			Wisconsinan	Peoria Formation		10	Wind-deposited silt, locally clayey; in part composed of locally derived material.	Lies mostly above water table; yields no water to wells.
			Wisconsinan / Sangamonian and Illinoisan	Slope deposits (Recent to Illinoisan)		100	Silt, sand, and gravel; colluvium in part. Sand and gravel chiefly in deeper channels; water-laid silt and colluvium in upper part.	Wells that penetrate channel deposits yield moderate to large supplies of water. Wells in areas where channels are absent yield little or no water.
			Sangamonian and Illinoisan	Crete Formation		20	Silt, sand, and gravel; some caliche in highest upland position.	Lies above water table and yields no water to wells.
		Lower Pleistocene	Yarmouthian and Kansan	Sappa Formation	Pearlette Ash bed	25	Silt, sand, and gravel, and some volcanic ash. In upland position in northern part of area; in dissected terraces in southern part of area.	In northern part of area where there is sufficient thickness, water supplies adequate for industrial or irrigation use can be obtained. In southern part of area supplies adequate for domestic and stock use can be obtained.
				Grand Island Formation		45		
			Aftonian and Nebraskan	Fullerton Formation		20	Silt, clay, sand, and gravel underlying Kansan deposits in upland area.	Where sufficient thickness is penetrated, moderate to large quantities of water are obtained.
				Holdrege Formation		45		
Tertiary (?)	Pliocene (?)			Undifferentiated deposits		25	Sand and gravel, minor amounts of silt and clay. Gravel derived chiefly from local material.	Lies above water table; yields no water to wells.

Permian	Leonardian	(Group) Nippewalla	Salt Plain Siltstone	Crisfield Sandstone bed	265	Chiefly red silty shale. Contains thin sandstone and siltstone beds throughout.	Yields small quantities of water from weathered zones. Quality of water variable. In some areas water is unsuitable for domestic use and inadequate for stock use.
			Harper Siltstone	Kingman Siltstone	80	Red silty shale, thin sandstone, and siltstone beds in upper part; reddish-brown siltstone and silty shale and some sandstone in lower part.	Yields small quantities of water of good to poor quality from weathered zone and from sandstone. In much of the area supplies are inadequate for domestic or stock use.
				Chikaskia Siltstone	160		
		Sumner	Ninnescah Shale	Runnymede Siltstone	450	Varicolored calcareous, blocky clay shale, predominantly brownish red. Contains thin dolomitic and calcite-cemented zones of siltstone, limestone, and sandstone.	Yields small quantities of water of good to poor quality from weathered zone. In some areas supplies are inadequate for domestic or stock use.

* Classification of the State Geological Survey of Kansas. The Pleistocene stratigraphic nomenclature is that of the State Geological Survey as adopted in January, 1959.

Lower Pleistocene

Nebraskan and Aftonian Stages

The climatic change at the Pliocene-Pleistocene time boundary caused a rejuvenation of streams, and during the early Nebraskan Stage eastward-trending streams deepened their valleys, some to a considerable depth. Downcutting probably continued until the maximum advance of the glacier. After the glacial maximum and during the retreat of the glacier, the valleys or channels cut during the glacial advance were filled with coarse clastic deposits. This early valley-filling phase probably took place rapidly as the streams became overloaded and dropped their coarse load. As the glacier retreated farther, the load carried by the streams in Harper County decreased, and the materials carried were finer. These finer materials were deposited over the older coarse materials. During the late glacial and interglacial phases much eolian material probably was deposted, but eolian deposits of the Nebraskan and Aftonian Stages have not been recognized in Harper County. The Nebraskan deposits in Kansas are represented by the Holdredge and Fullerton Formations.

Nebraskan deposits occur along the northern border of Harper County, where they are overlain by younger deposits in much of the area. Beds in Kingman County that have been classified as Nebraskan or early Aftonian in age, on the basis of molluscan and vertebrate faunas, can be traced laterally into Harper County, where the deposits consist of sand and gravel in the basal part and mostly silt in the upper part. A caliche bed occurs in the top of the silt. Both the Holdrege and Fullerton Formations of the Lower Pleistocene presumably are represented in these deposits, and the caliche is believed to represent the remnants of the Afton soil. These deposits were not differentiated from the overlying Kansan deposits on Plate 1.

Kansan and Yarmouthian Stages

After the relatively stable conditions of the Aftonian Stage, climatic changes at the start of the Kansan Stage again caused rejuvenation of the streams in Harper County. In the upland area in northern Harper County where the Kansan deposits lie on Nebraskan deposits, there is little evidence of downcutting, but in southern Harper County considerable downcutting must have occurred; the Kansan deposits in this area form terraces along the present streams, are below older rocks bordering the valley, and lie directly on Permian rocks.

In Harper County the Kansan deposits are represented by the Grand Island and Sappa Formations. The lower unit, the Grand Island Formation, consists of sand and gravel and minor amounts of silt and clay; the Sappa Formation consists principally of silt and minor amounts of clay but locally may contain sand, some caliche, and volcanic ash. The caliche generally is near the top of the formation and probably represents the remnants of the Yarmouth soil. During deposition of the Sappa Formation or during Yarmouthian time, a volcanic ash (Pearlette Ash) bed was deposited in the area. Two deposits of the Pearlette Ash are present in Harper County. One deposit, in the NW¼ SW¼ sec. 18, T. 31 S., R. 7 W., is on the upland, and the other deposit, in the NW¼ NE¼ sec. 28, T. 33 S., R. 6 W., forms a terrace along Bluff Creek.

Upper Pleistocene

The Upper Pleistocene Subseries of the Pleistocene Series consists of the Illinoisan Stage, Sangamonian Interglacial Stage, early Wisconsinan glacial substage, Bradian interglacial substage, and late Wisconsinan glacial substage. Climate during these stages of the Pleistocene was more arid than that during the Nebraskan, Aftonian, Kansan, and Yarmouthian Stages of Lower Pleistocene. Therefore the character and mode of occurrence of the deposits also differ. In much of western and northern Kansas the Upper Pleistocene contains thick eolian deposits. In the Upper Pleistocene the coarser clastic materials are generally in terraces along the present streams, although there are some sheet deposits. Eolian deposits in the Lower Pleistocene are lacking, but they may have been deposited and later removed by erosion. The coarser clastic deposits of the Lower Pleistocene in many places are sheet deposits or lie in very broad, relatively shallow channels unlike those of the Upper Pleistocene.

Illinoisan and Sangamonian Stages

The best developed Illinoisan fluvial deposits (Crete Formation) are in central Kansas and along Smoky Hill River in central and western Kansas. In central Kansas many of these seem to be sheet deposits overlying older Pleistocene deposits along Smoky Hill River; in east-central Kansas the Illinoisan deposits are generally in terraces along the present streams. In northern and western Kansas thick eolian deposits (Loveland Formation) of Illinoisan and Sangamonian age occur. Thinner eolian deposits are widespread in south-central Kansas but are difficult to identify in many places, because they have been to some extent removed or reworked, and the distinctive Sangamon soil where present at the top of these deposits merges into the modern soil. During the early part of the Illinoisan Stage, there seems to have been a major shift or change in drainage over much of east-central Kansas, including the Harper County area. In north-central Kansas, Republican River is believed to have abandoned its ancestral "Belleville" channel and established its present drainage pattern. In McPherson and Harvey Counties the "McPherson" channel was abandoned and the drainage system of Smoky Hill River was diverted from the Arkansas River drainage system to the Kansas River drainage system.

In northwestern Harper County, deposits of sand and gravel overlying known Kansan deposits are thought to be Illinoisan in age. These deposits are present on the highest points along a part of the northern county boundary, but they have not been differentiated on Plate 1. Conditions seem to indicate that, after a short period of sheet deposition, structural movement or capture of an important trunk stream to the east and south caused an adjustment of drainage in this area. Sheet deposition ceased and a period of downcutting produced channels as much as 250 feet below Kansan deposits in the uplands area in central Harper County. The channel near the center of section B-B′ and the deepest channels in section E-E′, Plate 2, are believed to have been cut and at least partly filled during Illinoisan time.

The upper deposits in these channels and in adjacent areas differ from the lower deposits. These upper deposits are principally silt, but include sand and gravel at the top. This upper part is fairly widespread and is believed to be principally a slope-wash or colluvial material. The channels are not apparent from the surface, and all these deposits have been included in slope deposits of Illinoisan to Recent age on Plate 1.

Wisconsinan Stage

During early Wisconsinan time most of the present drainage system in the state was established. In Harper County the upper part of Bluff Creek established its present course, parts of the deep channel trending eastward through the city of Harper were abandoned, and new streams, which headed farther east than the Illinoisan streams, were established. During the Wisconsinan Stage extensive tracts of dunes were deposited. Most of the dunes are now stable, but a few are still active. Probably much loess was deposited in the upland areas of Harper County during the Wisconsinan Stage, but most was derived locally and was moved only relatively short distances, hence is not easily distinguished from the weathered silty shale that underlies it in much of the county.

GROUND WATER

Source

In Harper County, as well as in much of Kansas, ground water is derived almost entirely from precipitation. A part of the water that falls as precipitation becomes surface runoff, a part evaporates directly into the air, and a part is absorbed by plants and transpired into the air. The rest percolates downward through the soil and underlying strata until it reaches the water table, where it becomes ground water.

Occurrence

The rocks and surficial deposits that form the outer crust of the earth are not solid throughout, but contain numerous open spaces, called voids or interstices. It is in these spaces that water collects below the surface of the earth and from which it is recovered in part, through springs and wells. There are many types of rocks, and they differ greatly in the number, size, and arrangement of their interstices and, therefore, in their water-bearing properties. The occurrence of ground water in any region is thus determined by the geology of that region.

The interstices of rocks range from pores of miscroscopic dimensions to openings several feet wide. These interstices can be divided into two classes, primary interstices and secondary interstices. The primary or original interstices were formed during the formation of the rocks. Secondary interstices were developed by the different processes that affected the rocks after deposition. Several common types of interstices are shown in Figure 6. In Harper County all the water-bearing rocks are sedimentary in origin, and the openings that contain the water are either open spaces between the grains of rock (primary interstices) or joints, crevices, and open bedding planes that have resulted from deformation or solution of the rocks (secondary interstices).

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

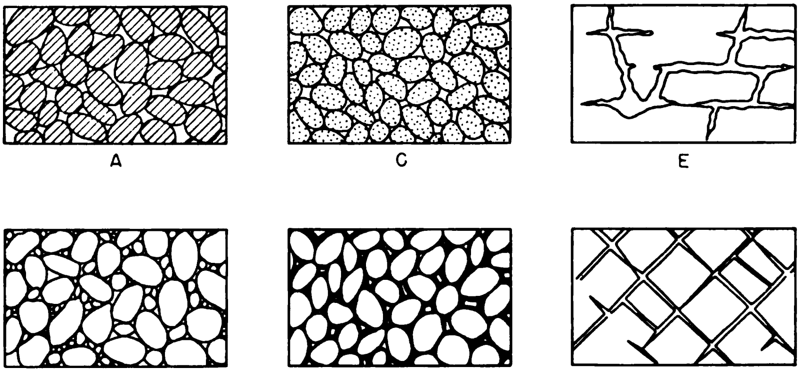

FIG. 6.—Diagram showing several types of rock interstices and the relation of rock texture to porosity. *A*, Well-sorted sedimentary deposit having high porosity; *B*, poorly sorted sedimentary deposit having low porosity; *C*, well-sorted sedimentary deposit consisting of pebbles that are themselves porous, so that the deposit as a whole has a very high porosity; *D*, well-sorted sedimentary deposit whose porosity has been diminished by the deposition of mineral matter in the interstices; *E*, rock rendered porous by solution; *F*, rock rendered porous by fracturing. (From Meinzer, 1923.)

the rock is said to be saturated. The amount of water that a saturated rock will yield to the pull of gravity is known as the specific yield. Although the amount of water a rock contains is determined by its porosity, the amount of water a rock will yield to wells is determined by its permeability. The permeability is its ability to transmit water under a hydraulic gradient; it is measured by the rate at which a rock will transmit water through a given cross section under a given loss of head per unit of distance. Some beds of clay or shale may have a high porosity, but because the pores or openings are small and poorly connected they transmit little or no water and may be regarded as virtually impermeable. Rocks differ greatly in their degree of permeability according to the number, size, and interconnection of their interstices.

Ground water may occur under artesian or water-table conditions in the aquifer.

Artesian Conditions

Artesian conditions are said to exist where a permeable bed or zone of considerable lateral extent is saturated and is overlain by a bed or beds of impermeable or relatively impermeable material. The beds must dip from the outcrop area toward the discharge area.

Water entering the water-bearing bed in the outcrop area percolates downward to the water table and moves downdip beneath the confining bed. The weight of the water at higher levels in the confined system creates a hydrostatic pressure in the ground-water reservoir. When the confining bed is penetrated, the water will rise in a drill hole to a level equal to the hydrostatic head in the aquifer at the point of discharge. If the head on the aquifer is sufficient to lift the column of water in the drill hole high enough to flow at the surface, the well is said to be a flowing artesian well.

Well 34-5-32abb (Table 10), which was drilled as a test hole for an oil-exploration survey, is an example of an artesian well. This well flowed when drilled but the head was sufficient to cause only a small surface flow. A pump was installed and the well then yielded enough water for stock use on several farms in the vicinity. The well is in a small valley at a low elevation in relation to the surrounding area. Other wells in the vicinity do not flow, although they probably obtain water from the same zone in the Permian rocks. Other flowing wells and test holes in this general area have been reported, but these wells either have been plugged or have stopped flowing. No flows of salt water have been reported in Harper County; all the well water is of a quality good enough for stock use.

Water-Table Conditions

Ground water may occur in an aquifer that is not overlain by a relatively impermeable bed. Under this condition the water is not confined, and the surface of the water within the aquifer is free to fluctuate up or down as water is added to or withdrawn from the aquifer. Ground water in such an aquifer is said to be under water-table conditions.

Harper County can be divided into six main areas as follows: The Upland area, which comprises somewhat less than three townships in the northwestern part of the county; the Bluff Creek area, which includes most of the drainage area of Bluff Creek, in which Pleistocene deposits occur; the Big Sandy Creek area in the western part of the county; the East Sand Creek area, which extends from a point west of Harper eastward to the edge of the county; the Chikaskia River area in northeast Harper County; and the Permian area, all the area in which Permian rocks crop out. These ground-water areas are shown in Figure 7.

Water Table and Movement of Ground Water

The upper surface of the zone of saturation in ordinary permeable soil or rock has been termed the ground-water table, or simply the water table. The water table is not a plane surface but has irregularities comparable with and related to those of the land surface although the water table generally is less rugged. Moreover, the water table does not remain in a stationary position, but fluctuates up and down. The irregularities are caused chiefly by local differences in geology and topography, and the fluctuations are due to additions of water to or withdrawals from the ground-water reservoir.

The shape of the water table in Harper County is indicated by contour lines on Plate 3. The contours were drawn for the Pleistocene deposits; the dashed lines show the inferred position of the water table in small areas of Permian deposits. No attempt was made to draw contours for the large areas of Permian deposits, as the water table probably is not continuous through these deposits. All points along a contour line have the same altitude, and the lines indicate the shape and slope of the water table just as similar lines on a topographic map show the land surface. The water moves downslope in a direction at right angles to the contours.

In the Upland area of Harper County (Fig. 7) the water moves south-southeast. Along the northern border of the county the water-table slope averages about 10 feet per mile and in the southern part about 40 feet per mile.

In the East Sand Creek area the water table slopes about 20 feet per mile in the western part and about 10 feet per mile in the eastern part. The water moves southeastward toward the edge of the county. The contours indicate that some water is being discharged from the aquifer into East Sand Creek east of Harper.

In the Bluff Creek and Chikaskia River areas the water-table contours bend sharply upstream near the streams, indicating discharge of ground water into these streams. In the Chikaskia River area the water table slopes toward the streams about 30 feet per mile or more; however, the slope of the stream is less than 10 feet per mile. In the Bluff Creek area the slope of the water table toward the stream is about 30 feet per mile above Anthony but only about 12 feet per mile below Anthony; however, the slope of the water table in the stream is about 12 feet per mile above Anthony and about 8 feet per mile below Anthony. In the Big Sandy Creek area the contours do not bend upstream as sharply as in the Bluff Creek

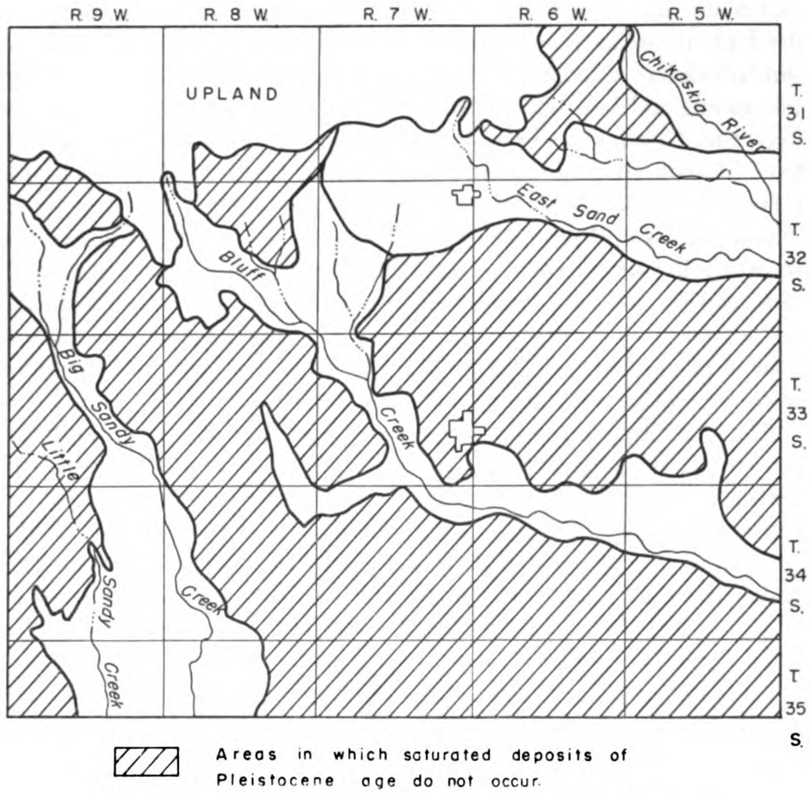

Fig. 7.—Ground-water areas in Harper County, Kans.

and Chikaskia River areas, indicating that less water from the aquifer is being discharged into Big Sandy Creek than into Bluff Creek and Chikaskia River. The slope of the water table adjacent to Big Sandy Creek is about 8 feet per mile parallel with the stream.

Ground-Water Recharge and Discharge

Precipitation is the principal source of recharge in Harper County. Only the Upland and Chikaskia areas (Fig. 7) receive recharge by subsurface inflow from outside the county. Along the north border of the Upland area some water probably moves into Harper County, but the quantity probably is small, as the ground-water divide is very near the county line. Some water moves from the northeast into the Chikaskia area.

In the upper reaches of the Big Sandy, Bluff Creek, and East Sand Creek areas, some recharge is derived from ground-water movement out of the Upland area. Along the southern border of the Upland area, many seeps and springs at the contact of the Kansan-Nebraskan deposits and the Permian rocks yield water during the spring and late fall. Water from these seeps and springs flows over the Permian rocks onto the permeable materials of the Big Sandy Creek, Bluff Creek, and East Sand Creek areas, and much of it returns to the ground-water reservoir in these areas.

Ground-water discharge is the water that leaves the ground-water reservoir through seeps and springs, by evaporation and transpiration, and by pumping from wells or infiltration galleries. Discharge by evaporation, transpiration, seeps, and springs is called natural discharge; discharge by pumping or natural flow from wells or infiltration galleries is artificial discharge.

Discharge by seeps and springs is most evident along the southern border of the Upland area, but water is discharged by seeps and springs into all the major streams in the ground-water areas except the Upland area. Flow is maintained in the lower reaches of the streams in years of normal precipitation by seepage from the ground-water reservoir. During the growing season most of the streams stop flowing because water moving toward them is evaporated or intercepted by plants.

Evaporation and transpiration are the principal means of discharge in Harper County. Locally, the water table is shallow enough to permit direct evaporation and transpiration; where the water table is too deep to permit evaporation and transpiration the water moves toward streams where the water table is shallow and much water can be evaporated and transpired.

The amount of ground water discharged by pumping in 1956 was small compared to the amount discharged by evaporation, transpiration, seepage, and springs. The use of ground water for municipalities, irrigation, industry, and rural domestic needs is increasing, however, and the amount discharged by pumping will become increasingly important. The total annual discharge by pumping was estimated to be about 3,000 acre-feet in 1956.

The recharge to and discharge from the ground-water reservoir can be shown by means of graphs of water levels in wells. Hydrographs of wells 32-7-11ccd and 32-7-12ccb1 and the monthly precipitation from 1954 through 1957 are shown in Figure 8. The water level in well 32-7-11cdd fluctuated in response to recharge from precipitation; the water level in well 32-7-12ccb1 fluctuated in response not only to recharge from precipitation, but also to a reduction of pumpage in the Harper and Anthony well fields.

Ground Water in Storage

The quantity of ground water in storage in the five ground-water areas in Harper County (Fig. 7) was determined by computing the volume of saturated material in these areas. This was computed by measuring the areas of equal saturated thickness shown in Plate 5 and multiplying the area by the thickness. A storage coefficient or specific yield of 15 percent was applied to the total volume of saturated material in each area to determine the quantity of water in storage. The quantity of water in storage in each area and the total quantity are given in Table 3.

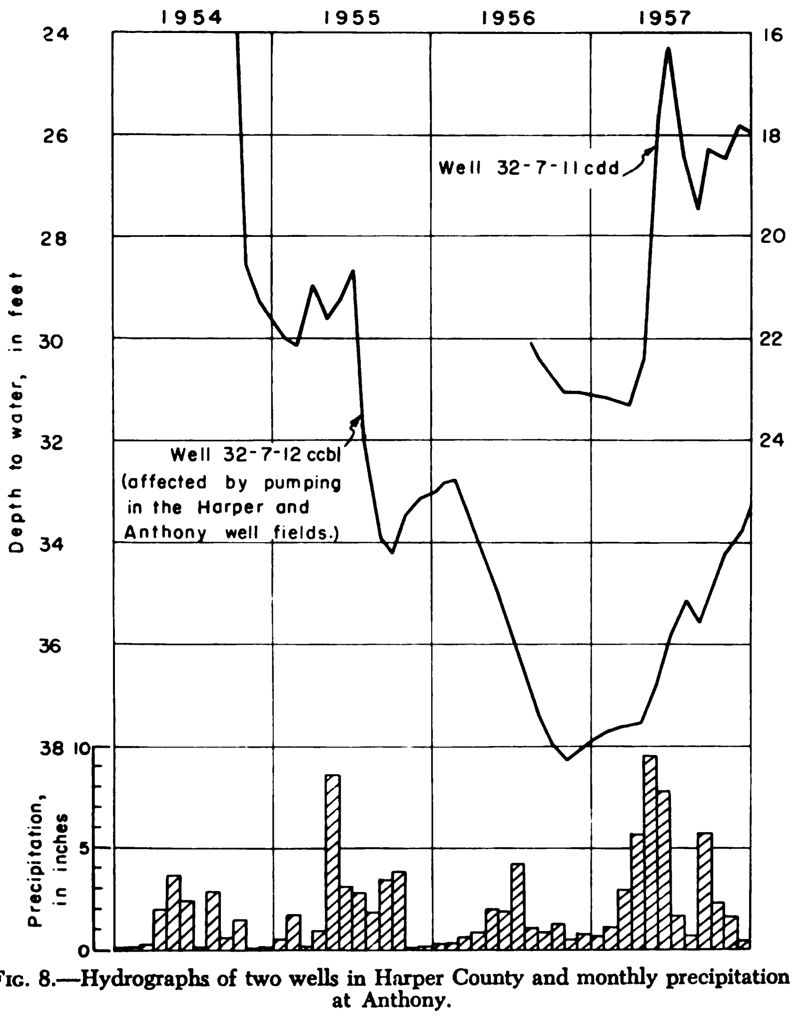

Fig. 8.—Hydrographs of two wells in Harper County and monthly precipitation at Anthony.

TABLE 3.—*Quantity of water in storage in the Pleistocene deposits of Harper County*

Ground-water area (Fig. 7)	Quantity of water (acre-feet)
Upland	365,000
Big Sandy Creek	140,000
Bluff Creek	137,000
East Sand Creek	104,000
Chikaskia	26,000
Total	772,000

RECOVERY

Principles of Recovery

When water is pumped from a well, the water level in and around the well is lowered, the greatest lowering being in the well. This lowering of the water level is called drawdown, and the area in which drawdown occurs is called the cone of depression. The greater the pumping rate in a well, the greater the drawdown. A diagrammatic section of an aquifer showing the water level when a well is being pumped is shown in Figure 9. The shape of the cone of depression is determined by the ease with which water flows

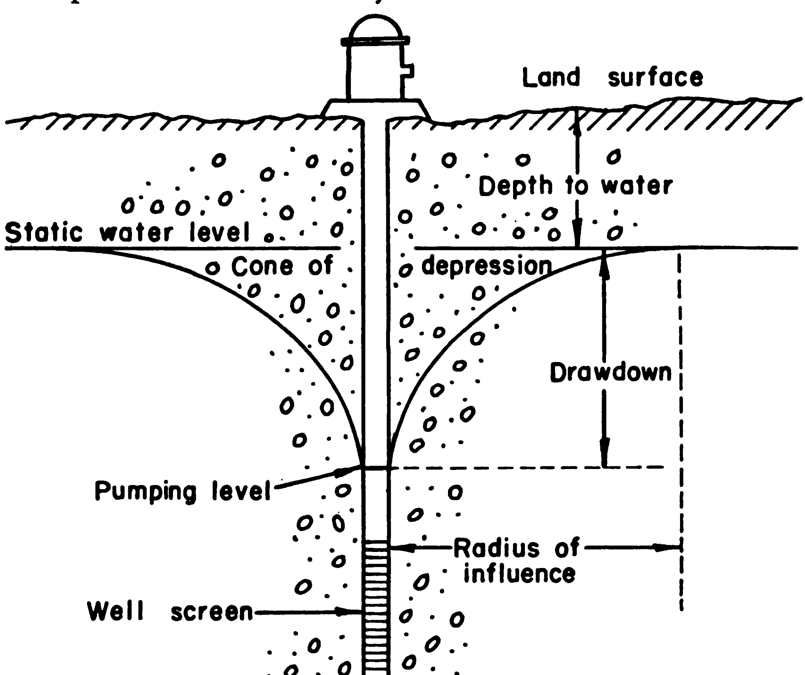

FIG. 9.—Diagrammatic section of an aquifer showing water level when well is being pumped.

through the water-bearing formation. A well producing a given quantity of water from a very permeable aquifer will have less drawdown than a well drawing from less permeable material. Continued pumping gradually lowers the water level and causes the cone of depression to expand. If water is being withdrawn from storage in the aquifer, the water level will decline steadily, though at a decreasing rate as a greater volume of material contributes to the flow. (Fig. 10). If the pumping rate is increased, the rate of decline also will increase. When pumping is stopped, water continues to move toward the well until the water level returns to its original, or to a new, static level. The recovery of the water level is rapid at first but progressively slower as the static water level is approached.

Types of Wells

In any particular locality, the type of well to be constructed depends on several related factors. The most important factors controlling the type of well construction are the intended use of the

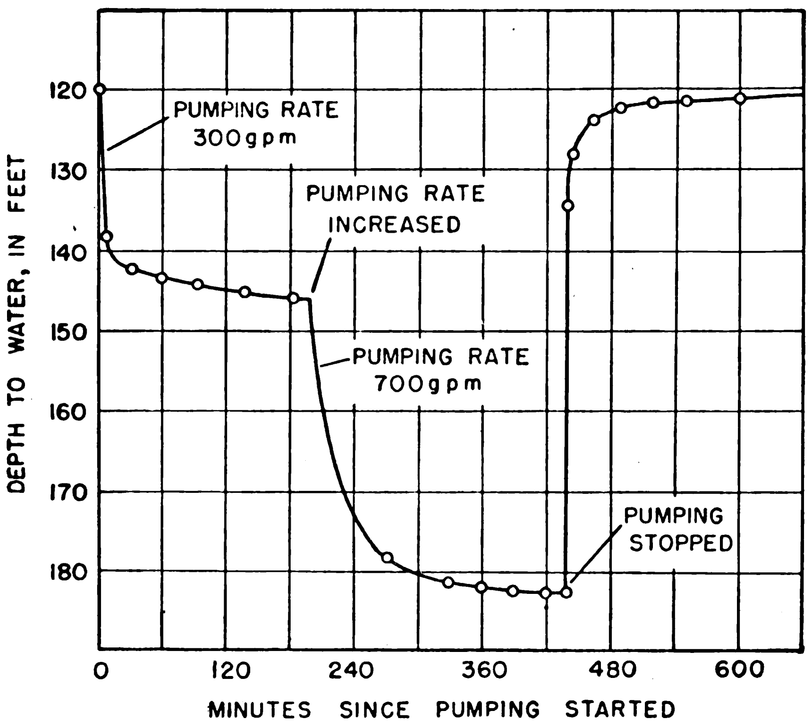

FIG. 10.—Drawdown and recovery of water level in pumped well.

water, the depth to the water, and the physical character of the water-bearing deposits. The relation of these factors to well construction is discussed below under the types of wells.

Dug wells.—Dug wells are excavated with pick and shovel or with machinery. They generally are 2 to 5 feet in diameter, are relatively shallow, and are cased with stone, brick, or concrete. Generally the wells are dug only a few feet deeper than the depth to water. Dug wells are most common in Harper County where the Permian rocks are at or near the surface, as these rocks are generally poor aquifers and do not yield water readily; the dug well of large diameter provides storage capacity.

Driven wells.—Driven wells are constructed in unconsolidated materials and consist of a small-diameter pipe, having a screen on the bottom, which is driven to a point a few feet below the water table. Driven wells can be constructed only where the water table is shallow, as the ability of pumps to lift the water is limited. Where the water table is deep a pit can be dug and the pump or cylinder can be installed in the pit so that the pumping lift will not be excessive. There are only a few driven wells in Harper County, and all of them are in unconsolidated materials in the valleys, where the water table is shallow.

Drilled wells.—Drilled wells are constructed with percussion or rotary machines. The diameter and depth of drilled wells generally depend on the use to be made of the water from the wells, and partly on the depth to water. Domestic wells drilled in Harper County generally are 4 to 6 inches in diameter and penetrate the aquifer only far enough to supply the needed quantity of water. Municipal or irrigation wells are larger and generally penetrate the entire aquifer. Most drilled wells are cased with steel or galvanized pipe. In consolidated rocks the casing may be extended to a depth of only a few feet below the surface, but in unconsolidated rocks the casing, with a screen on the bottom, must be extended through these materials to keep the well from collapsing.

Utilization of Water

During the investigation in Harper County, data were obtained on wells, test holes were drilled, and drillers logs were collected and studied. The well data given in Table 10 pertain to 100 domestic and stock wells, 19 public supply wells, 8 industrial wells, 5 irrigation wells, 8 oil wells, and 2 observation wells.

Domestic and Stock Supplies

Most domestic and stock water supplies in Harper County are obtained from wells, although stock supplies in increasing number are obtained from artificial ponds. The ground water generally is suitable for domestic and stock use; however, it is excessively hard in much of the area underlain by Permian rocks. Locally in that area the water contains much sulfate or chloride and is therefore undesirable for domestic use. In much of the area underlain by Permian rocks the supply of water is not adequate for domestic or stock use during periods of prolonged drought, and much water must be hauled for domestic use. In most of the area underlain by rocks of Pleistocene age, the supply of water is adequate for domestic and stock use; however, where these deposits are thin, some wells go dry during periods of prolonged drought, and water must be hauled. An estimated 750 to 1,000 acre-feet of water is used annually for domestic and stock supplies in Harper County.

Public Water Suplies

Three cities in Harper County, Anthony, Attica, and Harper, have public water supplies. The water systems and wells in these communities are described below, and additional information is given in Table 10 and in the logs of wells and test holes.

Anthony.—Anthony is the largest city in Harper County. Its first municipal water supply was built in 1885, but as this supply proved to be inadequate new wells were drilled in Bluff Creek Valley in sec. 33 and 34, T. 33 S., R. 7 W. Water was obtained from alluvium and Wisconsinan terrace deposits in a relatively narrow channel, and when there was water in Bluff Creek the supply from the wells was adequate. Nearly every year, however, Bluff Creek stopped flowing during the late summer and water was pumped from storage in the channel deposits. Pumping from storage quickly caused the water level in the wells to decline and the yields declined correspondingly. The water supply was operated in this manner until October 1954 when three new wells were drilled near Harper in sec. 12, T. 32 S., R. 7 W. The city of Anthony now has seven wells in the Bluff Creek area, only three of which are used. Water from these wells is used for cooling in the city's power-generating plant. The average daily pumpage from the Bluff Creek wells in 1956 was about 250,000 gallons.

The three new wells near Harper obtain water from deep channel deposits of Illinoisan and Wisconsinan age. The channel deposits in this area are relatively narrow, as indicated on geologic sections B-B′ and E-E′, Plate 2. The channel in section D-D′ seems to be wider, but this geologic section parallels the axis of the deepest part of the channel and does not give a true representation of the width. The new Anthony supply wells are equipped with turbine pumps powered by electricity. The yield from each of the two west wells is about 500 gpm and from the east well about 300 gpm. The average daily pumpage from the three wells is about 750,000 gallons. The annual pumpage from the well field near Harper is about 800 acre-feet and from the Bluff Creek well field, about 250 acre-feet. The water is chlorinated at the wells but receives no other treatment. An elevated steel tank in the city provides storage of 50,000 gallons, and a steel tank near the well field near Harper provides storage of 100,000 gallons.

Attica.—Prior to 1930 the public water supply for the city of Attica was obtained from shallow dug wells in the alluvium of Bluff Creek. These wells were not adequate, and in 1930 two wells were constructed in terrace deposits in a deep, narrow channel adjacent to Bluff Creek. These two wells are used as standby wells at present, but the dug wells have been abandoned. Late in the thirties two additional wells were constructed; the combined yield of all four wells when pumped by airlift was about 120 gpm. These wells were drilled to a depth of about 130 feet; although there is only about 50 feet of terrace material, the additional depth was necessary to obtain sufficient submergence for pumping by airlift.

In 1943 a well was drilled in thin Pleistocene deposits west of the city, but it was abandoned because it yielded only about 15 gpm. In 1944 another well was drilled 200 feet east of the old well field. This well, which was equipped with a turbine pump, yielded about 40 gpm. About 170,000 gpd (gallons per day) was pumped from this field when Bluff Creek was flowing, but when the creek stopped flowing, water levels declined rapidly and the yield declined correspondingly.

In 1956 four additional wells were drilled about 6 miles north of the city. These wells obtain water from Pleistocene deposits of Kansan and Nebraskan age. All the wells are 8 inches in diameter, 90 feet deep, and equipped with submersible turbine pumps. Their combined yield is about 200 gpm. Storage is provided by a 50,000-gallon elevated steel tank. The water is chlorinated at the wells and receives no further treatment. The water from the old well field contained much sulfate and had a hardness of 322 ppm. Water from the new wells has a hardness of 142 ppm, all of which is carbonated hardness. The average daily pumpage to supply Attica is about 200,000 gallons; the annual pumpage is about 220 acre-feet.

Harper.—The Harper water supply has been obtained from the same general area since 1907. The original supply was obtained from two wells drilled in a Pleistocene channel deposit of probable Illinoisan and Wisconsinan ages. One of these wells, about a mile west of the center of the city, is still in use. It is 54 feet deep and yields about 150 gpm. In 1940 the second of the original wells was abandoned and a new well (32-7-2dcb) was drilled in a deeper part of the channel. It is 80 feet deep and yields about 450 gpm. In 1954 another well was drilled in channel deposits about a mile south of the older wells. This well (32-7-11ad2) is 83 feet deep and yields 700 gpm. The water is chlorinated at the wells and receives no further treatment. Storage is provided by a 150,000-gallon elevated steel tank. The average daily pumpage is about 500,000 gallons, and the annual pumpage is about 550 acre-feet.

Industrial Supplies

Eight industrial wells, seven of which are being used, were canvassed during the investigation. Three wells, 31-8-5caa, 31-8-5ccc1, and 31-8-5ccc2, which yield 300, 150, and 120 gpm, supply water for the Magnolia Petroleum Co. extraction and compressor plant in northwest Harper County. They range in depth from 92 to 108 feet. The average daily pumpage is about 290,000 gallons, and the annual pumpage is about 325 acre-feet.

Phillips Petroleum Co. has one well (31-9-1ccc) that provides water for cooling at their compressor station about 2 miles west of the Magnolia Co. plant. This well is 102 feet deep, is equipped with a cylinder pump, and yields about 40 gpm. The average daily pumpage is about 50,000 gallons, and the annual pumpage is about 45 acre-feet.

Water for both the Magnolia Co. and Phillips Co. plants is obtained from Pleistocene deposits of Kansan and Nebraskan age in the Upland ground-water area (Fig. 7).

Cities Service Co. has three wells on the edge of the sand dunes in southwest Harper County, which provide water for cooling at a compressor plant. They are about 28 feet deep, are equipped with turbine pumps, and yield about 100 gpm each. The average daily pumpage from the three wells is about 80,000 gallons, and the annual pumpage is about 65 acre-feet. The water is obtained from Pleistocene deposits of Illinoisan and Wisconsinan age.

Irrigation Supplies

In the fall of 1956 only five irrigation wells were in operation in Harper County. One well was in the Upland ground-water area, three wells were in the East Sand Creek ground-water area, and one well was in the Big Sandy Creek ground-water area. (Fig. 7.)

Well 31-7-18bac, in the Upland area, is 83 feet deep, is equipped with a turbine pump, and yields about 300 gpm. It is used to irrigate about 80 acres of grain sorghums. The annual pumpage is about 100 acre-feet.

Three other irrigation wells, 32-6-4dcc, 32-6-9aac, and 32-7-12cda, are in the East Sand Creek area. Well 32-6-4dcc is 80 feet deep and yields 300 gpm. It is used to irrigate about 60 acres of feed crops, and the annual pumpage is about 100 acre-feet. Well 32-6-9aac is 67 feet deep and yields 560 gpm. The well is used to irrigate about 60 acres of feed crops, and the annual pumpage is about 80 acre-feet. Well 32-7-12cda, near the Anthony and Harper water-supply wells, is 100 feet deep, yields about 400 gpm, and is used to irrigate about 80 acres of wheat and maize. The annual pumpage is about 100 acre-feet.

Well 34-9-13cba, in the Big Sandy Creek area in southwestern Harper County, derives water from thin Pleistocene deposits. It consists of a battery of two wells 30 inches in diameter, 30 feet deep, and 20 feet apart. Both wells are connected to a single centrifugal pump driven by a natural-gas engine. The combined yield is about 400 gpm; the water is used to irrigate about 40 acres of alfalfa and 20 acres of maize. The annual pumpage is about 90 acre-feet.

Future development of irrigation supplies.—Additional irrigation supplies could be developed in parts of Harper County, but not on a large scale. Wells having large yields probably cannot be developed in the county, but wells yielding as much as 500 gpm probably can be developed.

In much of the Upland area in northwest Harper County, irrigation wells yielding 300 to 500 gpm probably could be developed. The thickness of the saturated material (Pl. 2, Pl. 5) is sufficient for the development of small-capacity irrigation wells in most places, but the lithology changes greatly from place to place. Test holes should be drilled at proposed well sites to locate the greatest saturated thickness and the most permeable gravels.

The northern part of the Big Sandy Creek area contains considerable saturated material (Pl. 5). The gravels are very permeable locally, and a few properly situated wells could be developed to yield as much as 500 gpm each. The channels containing the thickest and most permeable deposits are narrow, and test drilling would be necessary to locate the best well sites. For most efficient operation, wells should be spaced far enough apart to avoid excessive drawdown due to mutual interference.

A few irrigation wells could be drilled in the East Sand Creek area also, but they should be properly spaced so as not to interfere with the Anthony and Harper water supplies. In this area also the channels are narrow, and the deposits seem to be less permeable than those in the Upland or Big Sandy Creek areas. Test drilling would be advisable to locate the thickest permeable material in this area.

Irrigation supplies in either the Chikaskia or Bluff Creek areas could be developed only locally, for in these areas the thickness of the saturated deposits (Pl. 5) generally is not sufficient for the operation of irrigation wells. Locally, as in the Anthony well field adjacent to Bluff Creek in sec. 34 and 35, T. 33 S., R. 7 W., the aquifer is thick enough for development of irrigation wells of low yield, but this area already is overdeveloped. Moreover, excessive drawdowns occur when the stream ceases to flow, which generally is the time when irrigation is most needed.

Hydrologic Properties of Water-Bearing Materials

The quantity of water that a water-bearing formation will yield to wells depends upon the hydrologic properties of the material penetrated by the wells. The hydrologic properties of greatest significance are the coefficients of transmissibility (T) and storage (S). These factors are used in making estimates of the quantity of water available in an aquifer and of the water-level decline that will result from continued pumping. Controlled aquifer tests in the field can provide the data needed to compute these coefficients.

The coefficient of transmissibility (T) may be defined as the number of gallons of water, at the prevailing temperature, that will move in 1 day through a vertical strip of the aquifer 1 foot wide, having a height equal to the full saturated thickness of the aquifer, under a hydraulic gradient of 100 percent or 1 foot per foot.

The coefficient of storage (S) of an aquifer is the change in its stored volume of water per unit change in head per unit surface area of the aquifer. Under water-table conditions the coefficient of storage (S) is equal to the specific yield of the aquifer.

Aquifer Tests

Several aquifer tests have been made using wells in Harper County, but in only one test were observation wells used. The other tests were made by using measurements of the recovery of the water level in the wells after pumping stopped.

Table 4.—*Depth to water, drawdown, and values of t/r^2 for observation wells A and C during aquifer test using well 32-7-12cca2*

Time	Time since pumping started (minutes)	Depth to water (feet)		Draw-down (feet)	Corrected drawdown (feet)	t/r^2
		Obs. well A	Obs. well C			
11:00 a.m.	20 min. before pump started	25.58	22.17	0	0	0
11:20 a.m.	pump started					
12:32 p.m.	72	....	24.00	1.83	1.81	1.9×10^{-4}
12:38	78	29.00	....	3.42	3.36	1.2×10^{-3}
2:39	199	29.83	....	4.25	4.13	3.2×10^{-3}
3:15	235	....	24.67	2.50	2.46	6.3×10^{-4}
3:40	260	30.00	....	4.42	4.29	4.2×10^{-3}
3:52	272	....	24.67	2.50	2.46	7.3×10^{-4}
4:52	332	30.17	....	4.59	4.45	5.3×10^{-3}
5:00	340	....	24.83	2.66	2.61	9.1×10^{-4}
5:47	387	30.25	....	4.67	4.52	6.2×10^{-3}
6:00	400	....	24.92	2.75	2.70	1.1×10^{-3}
6:48	448	30.25	....	4.67	4.52	7.2×10^{-3}
7:00	460	....	24.92	2.75	2.70	1.2×10^{-3}
7:59	519	30.33	....	4.75	4.60	8.3×10^{-3}
8:00	520	....	25.00	2.83	2.77	1.4×10^{-3}
8:50	570	30.50	....	4.92	4.76	9.1×10^{-3}
9:00	580	....	25.17	3.00	2.94	1.6×10^{-3}
9:46	626	30.58	....	5.00	4.83	1.0×10^{-2}
9:58	638	....	25.25	3.08	3.02	1.7×10^{-3}
10:48	688	30.58	....	5.00	4.83	1.1×10^{-2}
10:57	697	....	25.25	3.08	3.02	1.9×10^{-3}
11:45	745	30.67	....	5.09	4.92	1.2×10^{-2}
11:55	755	....	25.33	3.16	3.08	2.0×10^{-3}
1:40 a.m.	860	30.67	....	5.09	4.92	1.4×10^{-2}
3:10	950	....	25.67	3.50	3.42	2.5×10^{-3}
4:00	1000	30.75	....	5.17	4.99	1.6×10^{-2}
4:10	1010	....	25.75	3.58	3.50	2.7×10^{-3}
5:45	1105	30.75	....	5.17	4.99	1.8×10^{-2}
6:05	1125	....	25.83	3.66	3.57	3.0×10^{-3}
6:42	1162	30.75	....	5.17	4.99	1.9×10^{-2}
7:10	1190	....	25.83	3.66	3.57	3.2×10^{-3}
7:50	1230	30.75	....	5.17	4.99	2.0×10^{-2}
8:08	1248	....	25.83	3.66	3.57	3.4×10^{-3}

The test using observation wells was made October 16 and 17, 1953. The well pumped was 32-7-12cca2, owned by the city of Anthony in the East Sand Creek ground-water area. The test was made by the Pate Engineering Co. and Layne-Western Co. Two observation wells were installed for the test as follows: observation well A, 250 feet northeast of the pumped well, and observation well C, 610 feet southwest of the pumped well. The depth of the two observation wells and the pumped well was 99 feet. Well 32-7-12cca2 is a gravel-envelope well, drilled 38 inches in diameter, and cased with 18-inch pipe that has 20 feet of slotted screen at the bottom. The well was pumped for 23 hours and 40 minutes at a rate of 503 gpm. Depth-to-water measurements made in observation wells A and C during the test are given in Table 4, and depth-to-water measurements in the pumped well during the test are given in Table 5.

TABLE 5.—*Depth to water and drawdown in well 32-7-12cca2 while pumping*

TIME	Time since pumping started (minutes)	Depth to water (feet)	Drawdown (feet)
11:20 a. m.	0	23.66	0
11:21	1	45.66	22.00
11:22	2	46.50	22.84
11:23	3	46.66	23.00
11:24	4	47.00	23.34
11:25	5	47.33	23.67
11:26	6	47.50	23.84
11:27	7	47.58	23.92
11:28	8	47.75	24.09
11:29	9	47.92	24.26
11:30	10	48.08	24.42
1:00 p. m.	100	51.83	28.17
1:30	130	51.83	28.17
2:30	190	51.83	28.17
3:30	250	51.83	28.17
4:30	310	52.00	28.34
5:30	370	52.33	28.67
6:30	430	52.33	28.67
7:30	490	52.42	28.76
8:30	550	52.50	28.84
9:30	610	52.67	29.01
10:30	670	53.00	29.34
11:30	730	53.00	29.34
12:30 a. m.	790	53.40	29.74
1:30	850	53.42	29.76
2:30	910	53.42	29.76
3:30	970	53.17	29.51
4:30	1,030	53.17	29.51
5:30	1,090	53.17	29.51
6:30	1,150	53.50	29.84
7:30	1,210	53.50	29.84
8:30	1,270	53.50	29.84

Cooper and Jacob (1946) devised three generalized graphical methods utilizing straight-line graphs for determining the coefficients of transmissibility and storage. The three types of graphs are referred to as the distance-drawdown graph, the time-drawdown graph, and the composite drawdown graph.

In Figure 11 the drawdowns in observation wells A and C are plotted against t/r^2 on semilogarithmic paper. By application of the generalized composite drawdown formula:

$$T = \frac{264Q}{\Delta s} \text{ in which}$$

T = coefficient of transmissibility
Q = discharge, in gallons a minute
Δs = drawdown over one log cycle
t = time since pumping started, in minutes
r = distance from pumped well, in feet

then $T = \frac{(264)\ (503)}{2.47} = 54{,}000$ gpd/ft.

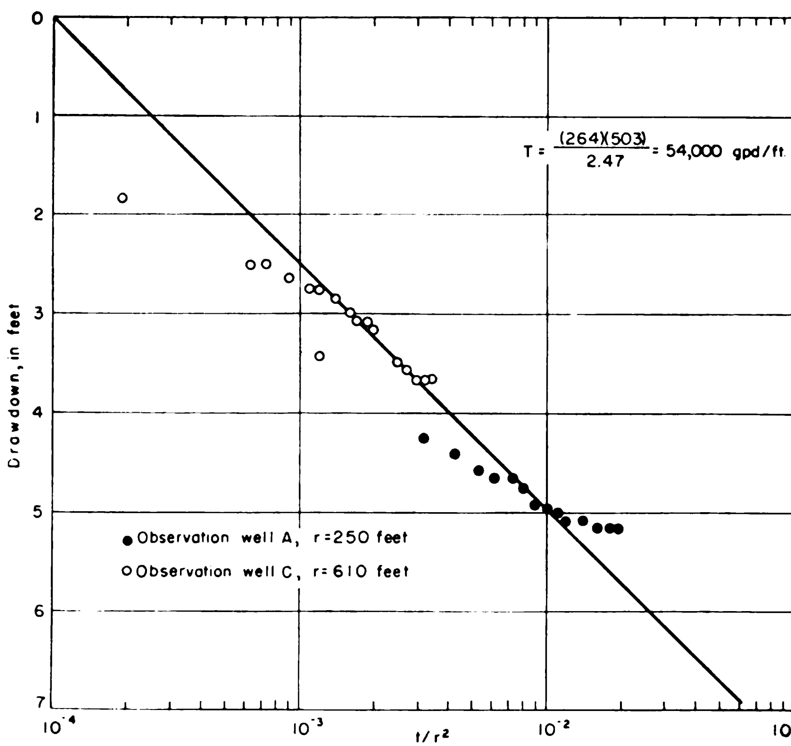

FIG. 11.—Generalized composite drawdown graph of water levels in observation wells A and C during aquifer test using well 32-7-12cca2.

In Fig. 12 the corrected drawdowns in wells A and C, 520 minutes after pumping started, are plotted on semilogarithmic paper against distance from the pumped well. By application of the Cooper-Jacob generalized distance-drawdown formula $T = \frac{528Q}{\Delta s}$

then $T = \frac{(528)\ (503)}{4.85} = 55{,}000$ gpd/ft.

Drawdown in the pumped well is plotted on semilogarithmic paper against time since pumping started (Fig. 13). By application of the Cooper-Jacob generalized time-drawdown formula $T = \frac{264Q}{\Delta s}$ then $T = \frac{(264)\ (503)}{2.6} = 51{,}000$ gpd/ft.

Because of the shortness of the test and the slow drainage of the aquifer, the coefficient of storage could not be determined.

The coefficient of transmissibility also was determined at well 32-6-4dcc, which also is in the East Sand Creek area. By measuring the recovery of the water level after pumping stopped, a value of

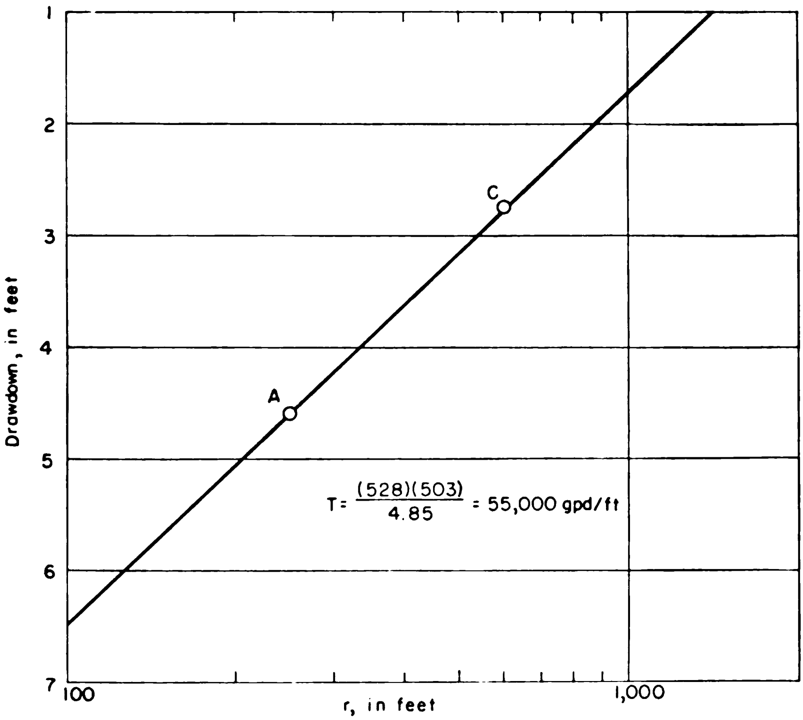

Fig. 12.—Generalized distance-drawdown graph of water levels in observation wells A and C, 520 minutes after pumping started.

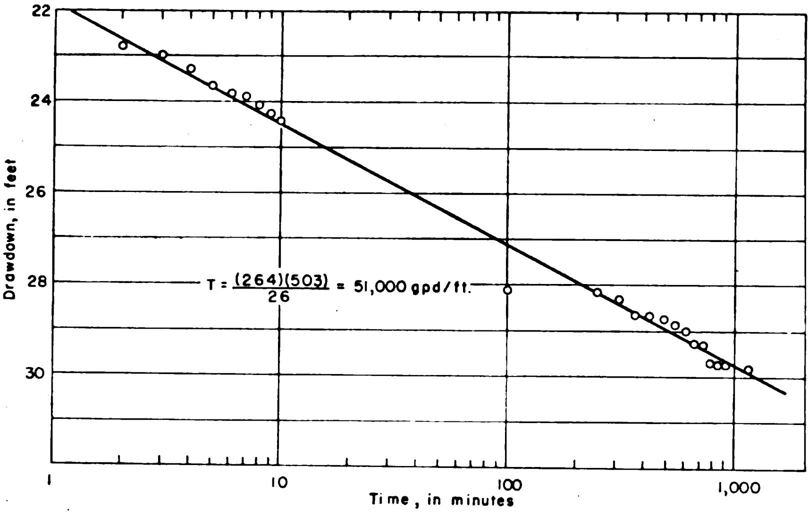

Fig. 13.—Generalized time-drawdown graph of water level in well 32-7-12cca2.

53,000 gpd per foot was obtained for the coefficient of transmissibility. A value of about 50,000 gpd per foot probably is near the true value for the water-bearing deposits in the East Sand Creek area.

Another aquifer test was made by the recovery method in well 31-7-18bac. The coefficient of transmissibility as determined by this test was 91,000 gpd per foot. This value may be considerably in error because measurements of the recovery of the water level were possible only in the well pumped. However, the well is located in the Upland area (Fig. 7), where generally the gravel is somewhat coarser than in the East Sand Creek area, and a higher value for the coefficient of transmissibility could be expected.

Chemical Character of Ground Water

The chemical character of the ground water in Harper County is shown by the analyses of 32 samples of water collected from wells and test holes (Table 6). Figures 14 and 15 show graphically the chemical character of typical water from the principal water-bearing formations in Harper County.

The concentrations of mineral constituents is given in ppm (parts per million) in Table 6. In order to show the constituents in terms of chemical equivalence, the analyses of Figures 14 and 15 have been expressed in epm (equivalents per million). To convert ppm to epm, the parts per million value is multiplied by the reciprocal of the combining weight of the appropriate ion (Table 7).

Table 6.—*Analyses of water from typical wells and test holes in Harper County*

Analyst, H. A. Stoltenberg, Kansas Board of Health. 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	Hardness as $CaCO_3$: Carbonate	Hardness as $CaCO_3$: Noncarbonate
31-5-10aaa	32.0	Slope deposits	8-22-56	56	386	12	1.3	48	16	74	305	33	32	0.2	21	186	186	0
31-5-25dcc	60.0	Permian	8-22-56	56	207	19	.1	29	12	20	122	21	11	.2	31	122	100	22
31-6-1cdd	50.0	do	8-22-56	56	597	23	.06	74	37	79	328	185	25	.2	13	336	269	67
31-6-5daa	34.0	Kansan and Nebraskan deposits	4-24-56	56	411	21	.11	80	16	20	132	23	44	.2	142	266	108	158
31-6-32aab	45.0	Permian	8-22-56	55	2,180	12	.09	333	88	227	168	1,240	164	.6	31	1,190	138	1,052
31-7-3cbb	28.0	Kansan and Nebraskan deposits	8-27-56	55	173	20	.18	34	6.6	14	124	11	12	.2	14	112	102	10
31-8-14cdd	65.0	do	4-25-56	56	244	20	.37	53	6.8	23	202	7	16	.2	18	160	160	0
31-8-19aaa1	90.0	do	10-27-55	55	215	....	.11	48	5.4	24	193	8.6	11	.2	14	142	142	0
31-9-16ddd	80	do	4-25-56	56	285	21	.11	64	4.5	34	264	10	14	.1	7.1	178	178	0
32-5-13cbb	56.0	Permian	8-22-56	56	507	19	.06	67	33	70	371	71	40	.2	24	302	302	0
32-6-4dcc	80.0	Slope deposits	4-21-56	56	371	18	.14	61	15	49	243	69	27	.3	12	214	199	15
32-6-35daa	26.5	Permian	4-24-56	56	602	12	.6	82	38	76	339	181	35	.8	10	360	278	82
32-7-4dcc	38.0	Slope deposits	8-27-56	56	308	20	.65	52	13	38	220	38	24	.2	15	183	180	3
32-7-11add2	83.0	do	7-27-56	56	346	....	.06	56	12	56	303	20	24	.3	8.9	189	189	0
32-7-12ccc1	93.0	do	12-13-54	56	465	....	.05	77	15	77	373	61	30	.4	9.3	254	254	0
32-7-21ccc	70	Permian	4-24-56	57	3,600	11	.15	499	116	478	120	2,070	356	.9	1.8	1,720	98	1,622
32-8-4ddd	40.0	do	8-22-56	56	1,140	18	.07	126	75	152	405	458	92	1.5	15	622	332	290
32-8-20bcd	30	Wisconsinan terrace deposits	1-7-44	56	420	....	.15	98	19	40	112	248	38	.3	6.6	322	92	230
32-8-32aba	20.0	Kansan deposits	4-25-56	56	585	12	.79	80	36	67	312	62	53	.9	120	348	256	92
32-9-17ccd	30	Slope deposits	4-25-56	56	498	13	.16	105	20	35	288	46	40	.3	97	344	236	108
32-9-19ccb	80.0	do	9-12-56	55	676	14	.47	67	38	129	420	92	97	.8	31	323	323	0
33-5-4ddd	40.0	Permian	8-22-56	57	770	13	2.0	72	57	124	276	25	251	.4	93	414	226	188
33-5-30ddd	69.0	do	8-23-56	55	485	16	.11	48	21	107	388	47	44	.2	11	206	206	0
33-7-34ccd2	40	Wisconsinan terrace deposits	8-21-41	56	730	....	.05	73	18	50	235	107	41	.3	3.2	256	193	63
33-8-13ddd	41.0	Permian	4-25-56	56	677	24	.9	113	45	52	351	36	109	.6	124	467	288	179
33-9-5baa	25	Slope deposits	4-25-56	55	419	18	.13	62	19	65	281	50	61	.5	5.3	232	230	2
34-5-29bbb	35.0	Permian	4-24-56	55	398	13	....	43	30	60	320	15	30	.5	49	231	231	0
34-6-16baa	70.0	do	8-23-56	55	552	17	.7	69	24	99	383	60	55	.2	39	270	270	0
34-6-32bcb	31.0	do	4-24-56	57	638	13	.09	43	26	162	444	84	67	.5	24	214	214	0
34-7-8aaa	35.0	Kansan deposits	8-25-56	56	1,190	16	.12	84	38	262	359	117	193	.2	305	366	294	72
34-9-18bbb	25.0	Permian	4-25-56	56	1,330	16	.05	81	91	269	659	174	232	.4	137	576	540	36
35-9-5bbb	30.0	do	4-25-56	56	5,040	12	1.4	256	146	1,308	487	1,525	1,400	1.7	146	1,240	400	840

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.

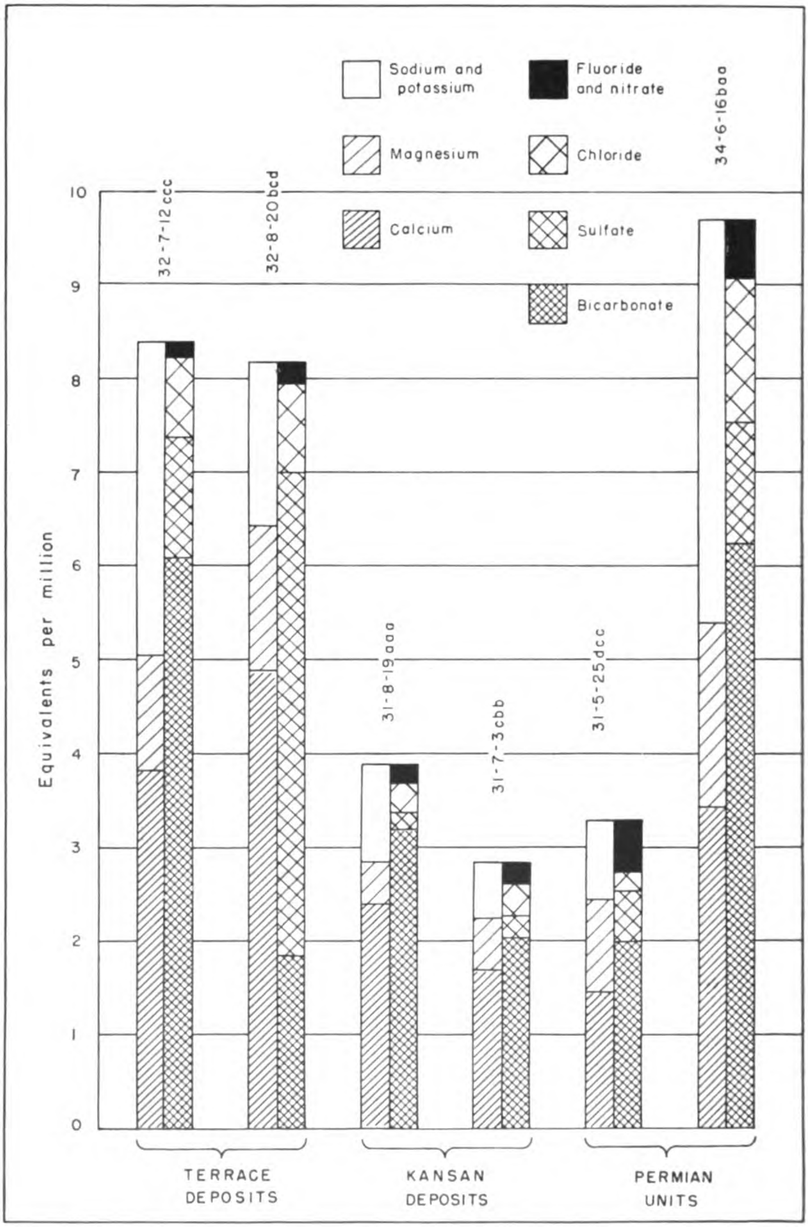

Fig. 14.—Graphic representation of chemical character of ground water in Harper County.

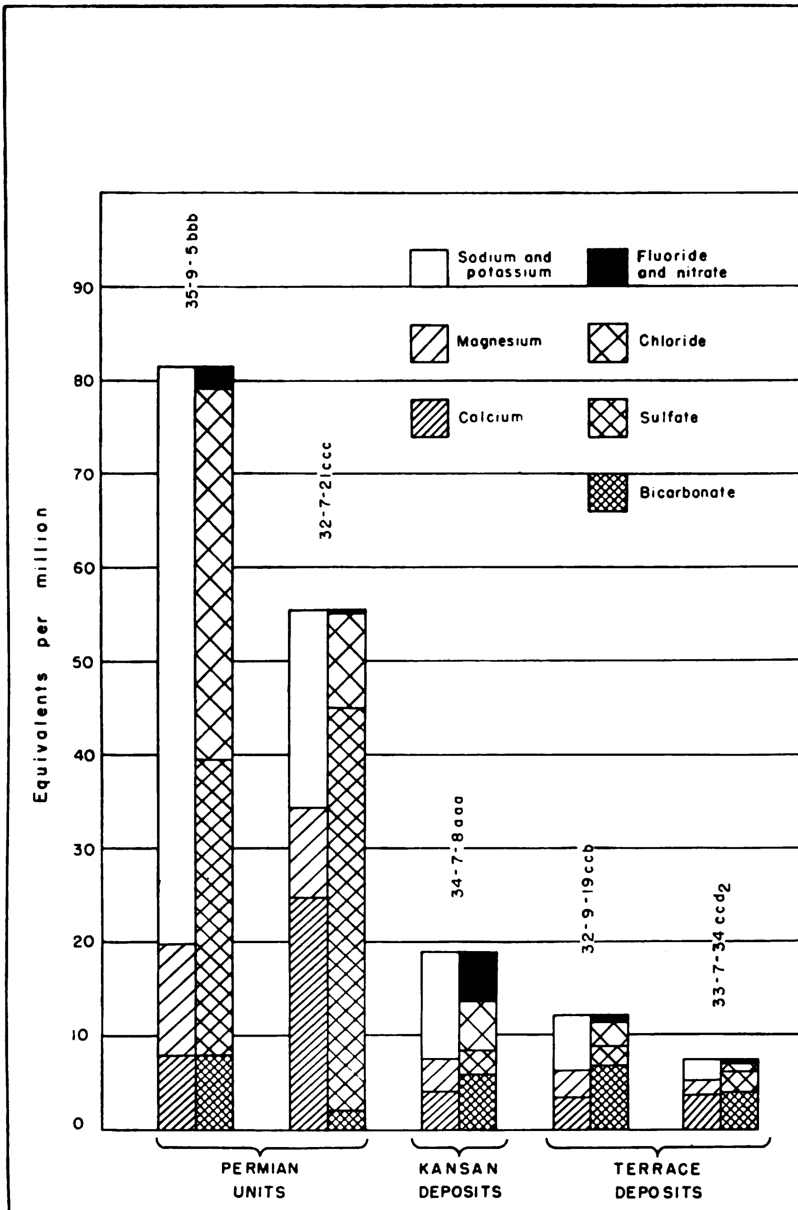

Fig. 15.—Graphic representation of chemical character of ground water in Harper County.

TABLE 7.—*Factors for converting parts per million to equivalents per million*

Ion	Chemical symbol	Multiply by
Calcium	Ca^{++}	0.0499
Magnesium	Mg^{++}	.0822
Sodium	Na^{+}	.0435
Carbonate	CO_3^{--}	.0333
Bicarbonate	HCO_3^{-}	.0164
Sulfate	SO_4^{--}	.0208
Chloride	Cl^{-}	.0282
Nitrate	NO_3^{-}	.0161
Fluoride	F^{-}	.0526

The samples of water from wells in Harper County were analyzed by Howard A. Stoltenberg, chemist, Water and Sewage Laboratory of the State Board of Health at Topeka. The analyses show only the dissolved mineral constituents of the water and do not indicate sanitary conditions.

Chemical Constituents in Relation to Use

Table 8 shows the concentration ranges of dissolved solids, hardness, iron, chloride, sulfate, fluoride, and nitrate in samples of water from typical wells in Harper County by geologic units.

Dissolved solids.—Ground water dissolves some of the rock materials with which it comes in contact. After a natural water has been evaporated, the residue consists of mineral matter, some organic matter, and water of crystallization. The kind and quantity of the minerals determine the suitability of the water for various uses. Water containing less than 500 ppm of dissolved solids generally is satisfactory for domestic use. Water containing more than 1,000 ppm of dissolved solids may include enough of certain constituents to cause a noticeable taste or to make the water unsuitable for use in some other respect.

Hardness.—Hardness, the property that in Harper County generally receives the most attention, is commonly recognized by the soap-consuming power of the water. Calcium and magnesium cause nearly all the hardness of ordinary water. These constituents also are the active agents in the formation of scale in steam boilers and other containers in which water is heated or evaporated.

The total hardness, the carbonate hardness, and the noncarbonate hardness of the water samples are given in Table 6. The carbonate hardness, or "temporary hardness", is caused by calcium and mag-

TABLE 8.—*Dissolved mineral constituents and hardness of water from aquifers in Harper County*

Range, in parts per million	Number of samples and aquifers		
	Permian	Lower Pleistocene	Upper Pleistocene
Dissolved solids			
Less than 250	1	3	0
250–500	2	2	8
501–1,000	8	1	1
More than 1,000	5	1	0
Total hardness			
Less than 150	1	2	0
150–300	4	3	7
301–500	5	2	3
More than 500	5	0	0
Iron			
Less than 0.1	6	0	3
0.1–0.3	3	5	4
0.31–1.0	3	2	2
More than 1.0	2	0	1
Chloride			
Less than 50	6	5	8
50–250	6	2	2
251–500	2	0	0
More than 500	1	0	0
Sulfate			
Less than 100	8	6	8
100–250	3	2	1
251–500	1	0	0
More than 500	3	0	0
Fluoride			
Less than 0.5	7	6	8
0.5–1.0	6	1	2
1.1–1.5	1	0	0
More than 1.5	1	0	0
Nitrate			
Less than 45	10	4	9
45–90	1	0	0
More than 90	4	3	1

nesium bicarbonates and can be almost entirely removed by boiling. The noncarbonate hardness, or "permanent hardness", is caused by sulfates and chlorides of calcium and magnesium and other salts and cannot be removed by boiling. Carbonate and noncarbonate hardness have the same effect in the consumption of soap.

Water having a hardness of less than 50 ppm is regarded as soft, and treatment for its removal under ordinary circumstances is not necessary. Hardness of 50 to 150 ppm does not seriously interfere with the use of water for most purposes but does increase the use of soap. Laundries or other industries using large quantities of soap, or to which hardness is objectionable in some way other than through excessive soap consumption, may profitably soften such water. A hardness of more than 150 ppm is easily noticeable and if it is much greater than 150 ppm softening generally is practical. When municipal supplies are softened, the hardness is generally reduced to about 100 ppm. The advantage of further softening of municipal supplies may not be economically justified. In most softening processes only the bicarbonate or "temporary" hardness is removed.

The hardness of samples of water from wells in Harper County ranged from 112 to 1,720 ppm. Table 8 gives the ranges of hardness in the 32 samples of water from the three chief aquifers in the county.

Iron.—Next to hardness, iron is the constituent in the water in Harper County that generally is most objectionable. Even in ground water from the same formation, the quantity of iron may differ greatly from place to place. If the water contains more than 0.3 ppm, the iron upon oxidation may settle out as a reddish sediment. Iron, present in sufficient quantity, gives a disagreeable taste to water, stains cooking utensils and plumbing fixtures, and is objectionable if used in the preparation of foods and beverages. Generally iron may be removed by aeration followed by settling or filtration, but some water requires treatment with chemicals.

Thirty-one samples of water from Harper County were analyzed for iron content, which ranged from 0.05 to 2.0 ppm (Table 8).

Chloride.—Chloride compounds are found in abundance in nature. They occur in sea water and in oil-field brines and are dissolved in widely varying quantities from many rock materials. Chloride has little effect on the suitability of water for ordinary use unless present in sufficient quantity to make the water unpotable.

Water containing excessive chloride may be corrosive if used in steam boilers. The removal of the chloride ions from water is difficult and expensive. The concentration of chloride in the 32 samples of water from Harper County ranged from 11 to 1,400 ppm (Table 6). Only one sample contained chloride in excess of 500 ppm, and all samples were suitable for stock use (Table 8).

Sulfate.—Sulfates of calcium or magnesium contribute most of the "permanent hardness" to a natural water, and the removal of these salts is both difficult and expensive. Sulfates in excessive amounts are undesirable in a domestic or stock water supply because of their laxative effect. A concentration limit of 250 ppm of sulfate is recommended for drinking water. Water containing more than 250 ppm if used for drinking may initially have a laxative effect. Sulfate concentrations as great as 2,000 ppm can be tolerated by man, and the tolerance by cattle is somewhat greater.

In Harper County the concentration of sulfate ranged from 7 to 2,070 ppm but only four samples had a concentration in excess of 250 ppm. Table 8 gives the number of samples in various ranges of concentration of sulfate from the three principal aquifers in Harper County.

Fluoride.—Although the quantites of fluoride are relatively small as compared with those of other common constituents of natural water, the amount of fluoride in drinking water that is used by children should be known. Fluoride is associated with the dental defect known as mottled enamel, which may appear on the teeth of children who, during the formation of their permanent teeth, habitually drink water containing amounts in excess of about 1.5 ppm (Dean, 1936). Small quantities of fluoride in the drinking water, about 1.0 ppm, are not sufficient to cause mottled enamel but are beneficial, by preventing or decreasing the incidence of caries in the permanent teeth of children (Dean and others, 1941). Fluoride has been added to many public water supplies in recent years, generally in concentration of about 1 ppm.

In Harper County only one sample of water contained fluoride in excess of 1.5 ppm. This water is strongly mineralized and is not used for domestic purposes. Table 8 gives the number of samples in various ranges of concentration of fluoride from the three chief aquifers in the county.

Nitrate.—Recent investigations have caused considerable interest in the amount of nitrate in drinking water. Large amounts of nitrate may cause cyanosis in infants if the water is used for drinking or in preparation of a formula. Infant cyanosis may be fatal if water containing much nitrate is used continually. Water containing more than 90 ppm of nitrate, if used continually, is regarded by the Kansas State Board of Health as likely to cause cyanosis (Metzler and Stoltenberg, 1950). In Harper County 23 samples of water had less than 45 ppm of nitrate, 1 sample contained between 45 and 90 ppm, and 8 samples had more than 90 ppm.

Chemical Constituents in Relation to Irrigation

This discussion of the suitability of water for irrigation is adapted from Agriculture Handbook 60 of the U. S. Department of Agriculture. (U. S. Salinity Laboratory Staff, 1954.)

The development and maintenance of successful irrigation projects involve not only supplying irrigation water to the land but also control of the salinity and alkalinity of the soil. The quality of irrigation water, irrigation practices, and drainage conditions affect salinity and alkali control. Soil that was originally nonsaline and nonalkali may become unproductive if excessive soluble salts or exchangeable sodium are allowed to accumulate because of improper irrigation and soil-management practices or inadequate drainage.

In areas of sufficient rainfall and ideal soil conditions the soluble salts originally present in the soil, or those added to the soil with water, are carried downward by the water and may ultimately reach the water table. The process of dissolving and transporting soluble salts by water moving through the soil is called leaching. If the amount of water applied to the soil is not in excess of the plant need, there will be no downward percolation of water below the root zone, and mineral matter will accumulate at the root zone. Likewise, impermeable soil zones near the surface can retard the downward movement of water and cause waterlogging of the soil and deposition of salts. Unless drainage is adequate, attempts at leaching may not be successful, because leaching requires the free passage of water through and away from the root zone.

The characteristics of an irrigation water that are most important in determining its quality are (1) the total concentration of soluble salts; (2) the relative proportion of sodium to the other principal cations (calcium, magnesium, and potassium); (3) the concentration of boron or other toxic elements; and (4) under some conditions, the concentration of bicarbonate as related to that of calcium and magnesium.

For diagnosis and classification of irrigation water the total concentration of soluble salts can be adequately expressed in terms of electrical conductivity, which is the measure of the ability of the ionized inorganic salts in solution to conduct an electrical current, and is usually expressed in terms of micromhos per centimeter at 25° C. The electrical conductivity can be determined accurately in the laboratory, or a rough approximation of the electrical conductivity can be obtained by multiplying by 100 the total content of calcium, sodium, magnesium, and potassium expressed as equivalents per million, or by dividing the dissolved solids expressed in parts per million by a factor of 0.6 to 0.7. In general, water having an electrical conductivity below 750 micromhos per centimeter is satisfactory for irrigation insofar as salt content is concerned, although salt-sensitive crops such as strawberries, green beans, and red clover may be adversely affected by irrigation water having an electrical conductivity in the range of 250 to 750 micromhos per centimeter. Water in the range of 750 to 2,250 micromhos per centimeter is 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 water having a conductivity of more than 2,250 micromhos per centimeter is not common, and very few instances can be cited where such waters have been used successfully.

In the past the relative proportion of sodium to other cations in irrigation water usually has been expressed simply as the percentage of sodium or percent sodium of the principal cations (expressed in equivalents). According to the U. S. Salinity Laboratory Staff (1954), the sodium-adsorption ratio (SAR), used to express the relative activity of sodium ions in exchange reactions with soil, is a better index of the suitability of water for irrigation with respect to the sodium (alkali) hazard. The sodium-adsorption ratio may be determined by the formula:

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

in which the ionic concentrations are expressed in equivalents per million (Table 7). The sodium-adsorption ratio may be determined also by use of the nomogram in Figure 16. In using this nomogram, the concentration of sodium expressed in equivalents per million is plotted on the left-hand scale and the concentration of calcium plus that of magnesium expressed in equivalents per million is plotted on the right-hand scale. The value at the point at which a line connecting these two points intersects the scale for the sodium-adsorption ratio is the sodium-adsorption ratio of the water. When the sodium-adsorption ratio and the electrical conductivity of the water are known, the classification of the water for irrigation can be determined by graphically plotting these values on the diagram

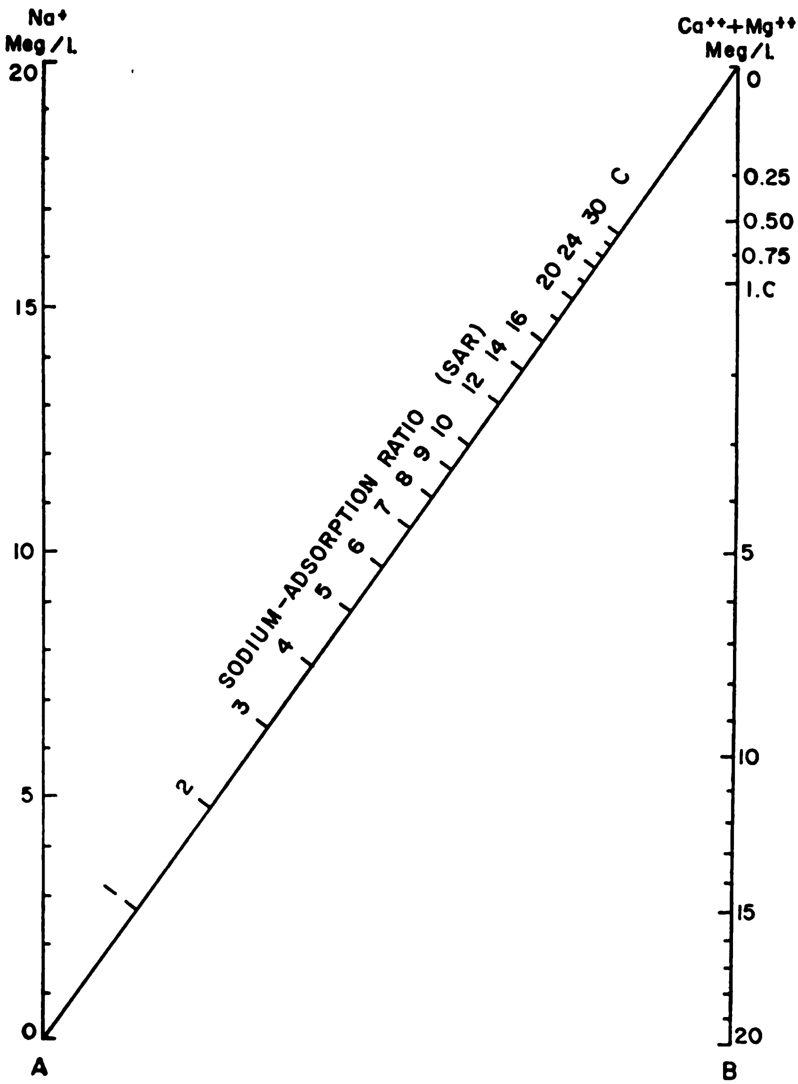

Fig. 16.—Nomogram used to compute sodium-adsorption ratio of water.

shown in Figure 17. Table 9 gives the sodium-adsorption ratio, the electrical conductivity, and the classification of the 32 samples of water from Harper County. Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of development of harmful levels of exchangeable sodium. Medium-sodium water (S2) will present an appreciable sodium hazard in certain fine-textured soils, especially poorly leached soils. Such water can be

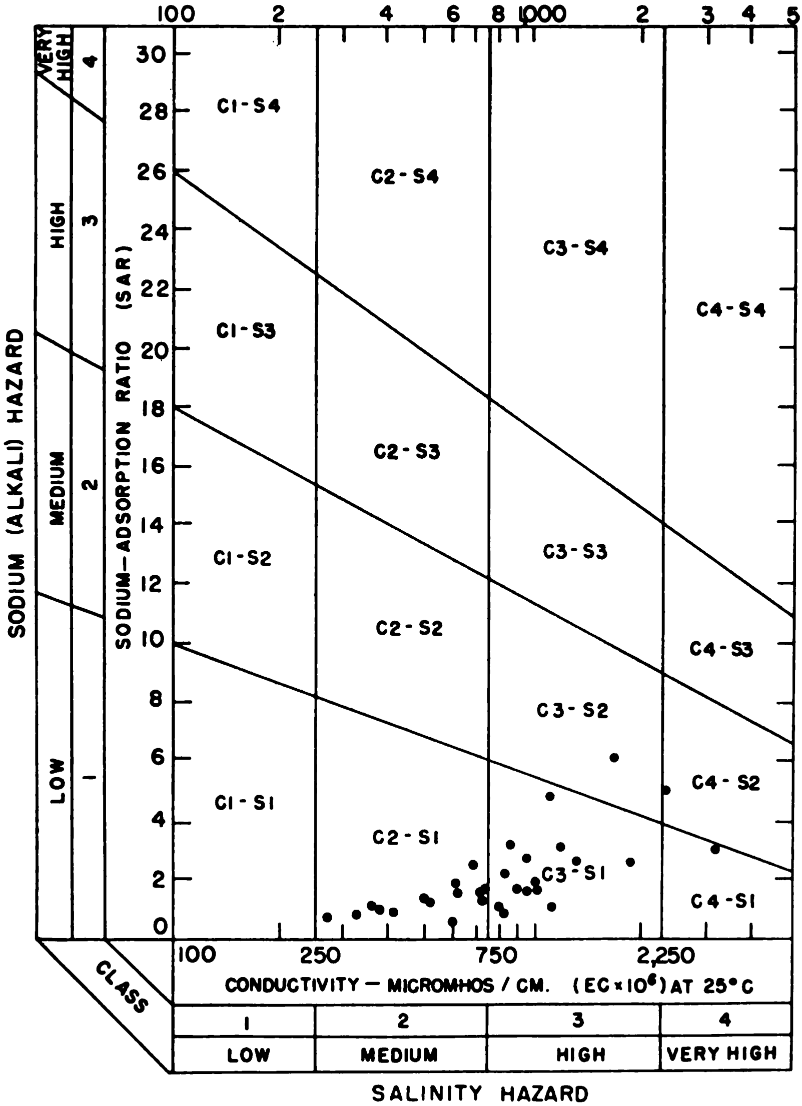

FIG. 17.—Classification of water for irrigation.

TABLE 9.—*Classification of water for irrigation*

Well number	Electrical conductivity	SAR	Classification
31–5–10aaa	690	2.4	C2–S1
31–5–25dcc	330	.8	C2–S1
31–6–1cdd	1,020	1.9	C3–S1
31–6–5daa	20	.5	C2–S1
31–6–32aab	3,370	2.9	C4–S1
31–7–3cbb	283	.8	C2–S1
31–8–14cdd	420	.8	C2–S1
31–8–19aaa	390	1.0	C2–S1
31–9–16ddd	510	1.0	C2–S1
32–5–13cbb	910	1.8	C3–S1
32–6–4dcc	640	1.5	C2–S1
32–6–35daa	1,050	1.8	C3–S1
32–7–4dcc	530	1.2	C2–S1
32–7–11add2	620	1.9	C2–S1
32–7–12ccc1	840	2.0	C3–S1
32–7–21ccc	5,520	5+	....
32–8–4ddd	1,900	2.8	C3–S1
32–8–20bcd	820	1.0	C3–S1
32–8–32aba	990	1.5	C3–S1
32–9–17ccd	840	1.0	C3–S1
32–9–19ccb	1,200	3.2	C3–S1
33–5–4ddd	1,370	2.7	C3–S1
33–5–30ddd	880	3.2	C3–S1
33–7–32ccd2	730	1.3	C2–S1
33–8–13ddd	1,160	1.0	C3–S1
33–9–5baa	750	1.8	C2–S1
34–5–29bbb	720	1.7	C2–S1
34–6–16baa	970	2.7	C3–S1
34–6–32bcd	1,130	5.0	C3–S1
34–7–8aaa	1,870	6.0	C3–S2
34–9–18bbb	2,320	4.9	C4–S2
35–9–5bbb	8,160	16+	....

used safely on coarse-textured or organic (permeable) soils. High-sodium water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management such as good drainage and leaching and the addition of organic matter. Very high sodium water (S4) is generally unsatisfactory for irrigation unless special precautions are taken, such as the 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 excessive salinity will develop. Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. Crops of moderate salt tolerance such as potatoes, corn, alfalfa, wheat, and oats can be irrigated with C2 water without special precautions. High-salinity water (C3) cannot be used on soils of restricted drainage, and very high salinity water (C4) is not suitable for irrigation under ordinary conditions. It can be used only on crops of extreme salt tolerance, and then only if much leaching takes place.

Boron is essential to plant growth but only in very small quantities; excessive quantities are harmful to most crops. Crops differ greatly in their boron tolerance, but in general the ordinary field crops common to Kansas are not adversely affected by boron concentrations of less than 1 ppm.

In water containing much bicarbonate, there is a tendency for calcium and magnesium to precipitate as the soil water becomes more concentrated because of evaporation and plant uptake. This reaction ordinarily does not go to completion, but insofar as it does proceed, there is a reduction in the concentration of calcium and magnesium in the water and therefore a relative increase in sodium. The calcium and magnesium are precipitated as carbonate and any residual carbonate or bicarbonate is left in solution as sodium carbonate. The potential amount of "residual sodium carbonate" may be computed as $(Na_2CO_3) = (CO_3^{--} + HCO_3^-) - (CA^{++} + Mg^{++})$, where the ionic concentrations are expressed as milliequivalents per liter or equivalents per million.

On the basis of limited data and using the "residual sodium carbonate" concept described above, the Department of Agriculture concluded that water having more than 2.5 epm or meq/l (milliequivalents per liter) of residual sodium carbonate is not suitable for irrigation. Water containing 1.25 to 2.50 epm of residual sodium carbonate is regarded as marginal, and water containing less than 1.25 epm is judged to be safe.

In appraising the quality of an irrigation water, first consideration must be given to the salinity and alkali hazards as classified in Figure 17. Then consideration should be given to other objectionable characteristics, such as boron and other toxic elements and bicarbonate, any one of which alters the quality rating.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING CHARACTERISTICS

Permian System—Leonardian Series

Sumner Group

The oldest rocks exposed at the surface in Harper County are rocks of the Sumner Group of Permian age. The Sumner Group is made up of rocks of the Wellington Formation, Ninnescah Shale, and Stone Corral Dolomite but only the Ninnescah Shale crops out in Harper County.

Ninnescah Shale

The Ninnescah Shale is predominantly a blocky brownish-red dolomitic or calcareous silty shale. Its maximum thickness is about 450 feet, but its average thickness is about 300 feet, and probably only about the upper 100 feet crops out in Harper County. The Ninnescah Shale is marked at the top by the Runnymede Siltstone member, which attains a maximum thickness of 8 feet in this area but averages 4 or 5 feet. North of Harper County the upper limit of the Ninnescah Shale is drawn at the base of the Stone Corral Dolomite, but in Harper County the Stone Corral is absent. The beds in the Ninnescah Shale range from chocolate brown to very light gray, but brownish red is their commonest color. The different colors of the beds give the outcrops a banded appearance.

The Ninnescah Shale yields small quantities of water of good to poor quality from the weathered zone near the surface and from fractures at greater depth. Generally, wells in the Ninnescah Shale are relatively shallow, and are dug to provide more storage. In some areas the Ninnescah Shale does not yield enough water for domestic or stock use.

Nippewalla Group

The Nippewalla Group consists of the upper part of the strata that are assigned to the Leonardian Series. It comprises all beds between the top of the Stone Corral Dolomite and the base of the Whitehorse Formation of Permian age and has a total thickness of about 930 feet. Only the Harper Siltstone and Salt Plain Siltstone, having a combined thickness of about 500 feet, crop out in Harper County.

Harper Siltstone

The Harper Siltstone consists of about 180 to 240 feet of reddish-brown argillaceous siltstone and silty shale and a few thin layers of silty sandstone. It has been subdivided into the Chikaskia Siltstone member below and the Kingman Siltstone member above.

The reddish-brown Chikaskia Siltstone member, in Harper County about 140 to 160 feet thick, consists principally of sandstone and siltstone in the lower two-thirds and silty shale in the upper third. Where the Stone Corral Dolomite is absent the base of the Chikaskia is difficult to identify, because of similarity between the lower Chikaskia and the Runnymede Siltstone member of the Ninnescah Shale.

The Kingman Siltstone member is composed of about 80 feet of reddish-brown thin slabby siltstone containing a few beds of silty shale and light-gray to white silty sandstone. The base of the member is marked by a white silty sandstone about 3 feet thick. The top of the member can not be clearly identified. Much of the Kingman Siltstone member is lithologically so nearly identical to the overlying Salt Plain Siltstone that differentiation is not possible or practical, although the Kingman Siltstone generally is more resistant to weathering, and in drill holes the unweathered material in the Kingman generally is slightly coarser and slightly darker than the Salt Plain.

The water-bearing characteristics of the Harper Siltstone are somewhat similar to those of the underlying Ninnescah Shale. Most of the water is obtained from the weathered portion of the formation, and where sandstone is penetrated in the weathered part of the formation good domestic or stock supplies can be obtained. Some wells do not provide adequate water supplies even for stock and domestic use. Many wells in the Harper Siltstone are dug wells, which utilize the added storage space afforded by the large-diameter well. The quality of the water ranges from good to very poor.

Salt Plain Siltstone

The Salt Plain Siltstone includes reddish-brown siltstone, thin sandy siltstone, silty shale, and fine silty sandstone between the Harper Siltstone and the Cedar Hills Sandstone. Its total thickness is about 265 feet, but probably somewhat less than 200 feet of the formation crops out in Harper County. The lower boundary is not clearly defined, whereas the upper boundary in other areas is marked by a white fine-grained sandstone at the base of the Cedar Hills Sandstone. Two prominent sandstones occur in the Salt Plain Siltstone, an unnamed one near the top and the Crisfield Sandstone bed about 100 feet below the top.

Ground water is obtained from the weathered portion of the formation, but generally is not adequate for stock and domestic wells. Dug wells are most common because of their greater storage. The quality of the water from the Salt Plain Siltstone ranges from good to unsuitable for domestic use.

TERTIARY(?) SYSTEM—PLIOCENE(?) SERIES

Deposits in four small areas that occupy the highest position on the divide that marks the south edge of the Bluff Creek drainage area in Southeast Harper County probably are remnants of Pliocene deposits. They are lithologically dissimilar to any of the Pleistocene deposits in this general area and resemble deposits of the Pliocene Delmore Formation of Williams and Lohman (1949) in McPherson County. These deposits probably do not exceed 25 feet in thickness in Harper County and generally are much thinner. They are not known to yield water to wells in Harper County.

Quaternary System—Pleistocene Series

Lower Pleistocene

The Pleistocene is divided into four main stages, which are related to continental glaciation, and three interglacial stages. Events in each of the periods of continental glaciation follow a cyclic pattern of repetition. Each cycle consists of a glacial and an interglacial interval. The typical cycle in the marginal belt of a glacial area is characterized by a period of downcutting and some local deposition of sediments while the glacier was advancing, then a period of deposition of coarse materials, deposition of progressively finer materials as the glacier retreated, and finally the development of a soil profile over large areas where surface conditions were relatively stable.

Unconsolidated deposits of Pleistocene age unconformably overlie older deposits of Permian age in a large part of Harper County (Pl. 1). The deposits represent all four glacial stages.

Although deposits that represent all the glacial stages are present in Harper County and can be identified locally in the field and in logs of test holes, it is difficult to map some of these units separately. Hence on the geologic map (Pl. 1), deposits of the Lower Pleistocene are not separated in the northern part of the area.

Holdrege Formation—Nebraskan Stage

Deposits of sand, gravel, silt, and some clay classified as Holdrege Formation occur in northern Harper County. Most of the Upland area is underlain by these deposits. The Holdrege Formation was deposited by an aggrading stream that shifted laterally on its alluvial fill. This stream filled its broad, shallow valley and deposited an almost coalescent sheet of sediment over former divides. The deposits range from clay-size particles to coarse gravel, and are as much as 45 feet thick.

The Holdrege Formation yields moderate to large quantities of water to wells in the area. The water is hard but otherwise is of good quality.

Fullerton Formation—Nebraskan and Aftonian Stages

The Fullerton Formation overlies the Holdrege Formation in northern Harper County. The formation is classified as late Nebraskan and Aftonian in age, and was laid down during the retreat of the Nebraskan glacier and, in part, during Aftonian interglacial time. In general the texture of the Fullerton Formation is finer than that of the underlying Holdrege Formation. Silt and clay are the predominant materials composing the deposits but there is also some sand and scattered gravel. The contact between the Fullerton Formation and the Holdrege Formation is placed where the material changes from predominantly coarse to predominantly fine clastic material. This contact is not everywhere clearly seen, for locally the change is gradational and there is interfingering of fine and coarse sediment. The top of the formation in this area is almost everywhere marked by an accumulation of caliche, which is suggestive of soil development during Aftonian time. The deposits of the Fullerton Formation in Harper County range in thickness from 0 to about 20 feet.

As the texture of the Fullerton is predominantly fine, the deposits yield only small quantities of water to wells. The water is hard but otherwise is of good quality.

Grand Island Formation—Kansan Stage

The Grand Island Formation is composed of sand and gravel and some silt. The gravel is principally granitic but in places includes considerable locally derived material. Deposits classified as Grand Island Formation occur in two general areas in Harper County. Those in the Upland area in northern Harper County were laid down by a laterally shifting stream or streams flowing from the west or northwest. Grand Island deposits in the Bluff Creek area in central and southern Harper County were laid down in a broad channel, which is believed to have headed a short distance southeast of the city of Attica. This channel trends south-southeast to about the south line of T. 33 S. and thence eastward, roughly parallel with the present position of Bluff Creek. The deposits range from silt to coarse gravel but contain more fine material than those in the Upland area. Locally a cemented zone occurs near the base of the gravel. In the Upland area the Grand Island Formation ranges in thickness from 0 to about 45 feet, and in the Bluff Creek area it ranges from 0 to about 10 feet.

In the Upland area much of the Grand Island Formation lies above the water table, but where it is below the water table it yields moderate quantities of water to wells. In the Bluff Creek area, it yields small to moderate quantities of water. The water is hard but otherwise of good quality.

Sappa Formation—Kansan and Yarmouthian Stages

Deposits of sand, silt, gravel, and locally, volcanic ash that overlie the Grand Island Formation in the Upland and Bluff Creek areas have been assigned to the Sappa Formation. They comprise the fine clastic deposits of the late glacial stage and the interglacial stage of the Kansan glacial cycle. The diagnostic Pearlette Ash bed was observed in two localities in the county. One deposit, in the NW¼ NE¼ sec. 29, T. 33 S., R. 6 W., in the Bluff Creek area, formerly was mined commercially. The other deposit, in the NW¼ SW¼ sec. 18, T. 31 S., R. 7 W., in the Upland area, is thin and is not of commercial value. The lower boundary of the formation is marked at the change from the coarse clastic material of the underlying Grand Island Formation to the finer texture of the Sappa Formation. At the upper boundary in many places the Sappa is indistinguishable from the present soil, but in extreme northwest Harper County the Sappa Formation is overlain by sand and gravel believed to be of Illinoisan age and here the upper boundary of the Sappa Formation is marked by caliche accumulation.

Most of the Sappa Formation lies above the water table and yields no water to wells. In areas where the formation lies below the water table, little water is obtained from it, because of the fine texture of the deposits.

Upper Pleistocene

The upper Pleistocene includes deposits of Illinoisan, Sangamonian, Wisconsinan, and Recent age. All deposits younger than Sappa Formation are included in this group.

Crete Formation—Illinoisan Stage

In extreme northwest Harper County, sand and gravel that lie above the caliche in the upper part of the Sappa Formation are believed to be early Illinoisan in age and are assigned to the Crete Formation. These deposits are small in areal extent and are probably not more than 10 feet thick, and they are not identified on the geologic map (Pl. 1). North and west of this area in central Kansas similar deposits underlie much of the surface but are generally thin.

In Harper County the Crete Formation lies above the water table and yields no water to wells.

Slope Deposits—Illinoisan to Recent Stages

A complex series of deposits lying topographically below deposits of Kansan and Nebraskan age are found in all the ground-water areas except the Upland area. These deposits, called slope deposits in this report, are shown on Plate 1 by the symbol Qsd. Locally they consist of channel deposits of sand and gravel overlain by thick silt, which in turn is locally overlain by silt containing imbedded gravel and sand. Logs record local accumulations of caliche at the top of the thick silt and below the silt containing imbedded gravel and sand. An age ranging from late Illinoisan to Recent is assigned these deposits. It is believed that the deeper channels were cut and at least partly filled during Illinoisan time, for two distinct lower terraces were observed locally in the area. The deposits beneath these terraces probably represent deposition during early and late Wisconsinan time. Also, in the upper part of the East Sand Creek area deep eastward-trending buried channels cross the present drainage system, which trends southward. The upper silt containing the imbedded sand and gravel is believed to be slope-wash material chiefly Recent in age. There is no surface expression of the deposits in the buried channels, which can be located only by test drilling. The sides of the channels are relatively steep, and although a test hole may penetrate only the thin upper silts at one place, another test hole only a very short distance away may penetrate as much as 100 feet of coarse channel deposits. The slope of the surface of these deposits is much steeper than that of the surface of areas underlain by deposits of Kansan or Nebraskan age or the terrace surfaces of Wisconsinan age, which border the present drainage. Moreover, the underlying Permian rocks generally have a much steeper slope than those beneath the deposits of Kansan and Nebraskan age (Pl. 2).

Wells that penetrate sand and gravel in the buried channels yield moderate to large quantities of water. Wells that do not penetrate channel deposits yield little or no water. The thickest channel deposits are in the East Sand Creek area near the city of Harper, and it is from these channel deposits that both Harper and Anthony obtain their water supplies. Three irrigation plants also obtain water from these deposits in the same general area. One irrigation well and three industrial wells obtain water from deposits of the same age in the Big Sandy Creek area in southwest Harper County. The water from the channel deposits is hard but otherwise is of good quality.

Peoria Formation—Wisconsinan Stage

Eolian silts classified as the Peoria Formation overlie older deposits in much of Harper County; where they overlie older Pleistocene deposits it is difficult to differentiate them. Also, in many areas it is difficult to differentiate the eolian silts from silts in underlying Permian "redbeds", and much of the material mapped as Peoria Formation probably is of local origin and has been moved only short distances. In few places does the thickness of the eolian deposits exceed 10 feet.

Wherever present, the Peoria Formation lies above the water table, hence yields no water to wells.

Terrace Deposits—Wisconsinan Stage

Deposits underlying prominent terraces bordering the principal streams in Harper County are assigned a Wisconsinan age (Table 2). Locally, two separate terrace levels probably represent early and late substages of Wisconsinan time, but such localities are few, and therefore the terraces have been mapped as a single unit (Pl. 1). These deposits are composed of clay, silt, sand, and gravel and probably do not exceed 40 feet in thickness.

In areas where a sufficient saturated thickness of sand and gravel is penetrated by a well, moderate supplies of water can be obtained. In areas where only the silt is penetrated, water supplies are inadequate. The old well fields of both Attica and Anthony obtained a part of their water from deposits of this age, but because the aquifer, being confined in a narrow channel, had little storage capacity and recharge was derived principally from the stream, these supplies proved inadequate when the stream ceased to flow. The water from Wisconsinan terrace deposits is hard but generally suitable for most uses.

Dune Sand—Wisconsinan and Recent Stages

Dune sand occurs in three of the ground-water areas in Harper County (Pl. 1). The most extensive deposits are in the Big Sandy Creek area in the western part of the county, where the dune sand overlies older deposits, which are probably of Illinoisan age. In a part of the area the dunes are well stabilized and are cultivated but in much of the area some of the dunes are still active, and the land is suitable only for grazing.

In an area on the east side of Bluff Creek northwest of Anthony, rocks of Permian age and early Pleistocene deposits are overlain by dunes. In general, this dune tract is better stabilized than that in the Big Sandy Creek area and nearly all of it is farmed. In the Chikaskia River area scattered dunes, now semiactive, overlie Wisconsinan terrace and older deposits.

The maximum thickness of the dune sand did not exceed 20 feet in any of the test holes, but a greater thickness probably occurs in the more inaccessible part of the Big Sandy Creek area.

Almost everywhere the dunes lie above the water table and yield little or no water to wells.

Alluvium—Recent Stage

Recent alluvium occurs in the modern channels of most of the principal streams in Harper County. It occupies only a narrow strip along these streams and, because of the scale, is not shown on the geologic map (Pl. 1) but is included in the area mapped as Wisconsinan terrace deposits. The alluvium is composed of silt, sand, and gravel and is relatively thin, probably not exceeding 30 feet in thickness. The water-bearing characteristics and yields of wells in the alluvium are similar to those of the Wisconsinan terrace deposits.

RECORDS OF WELLS AND TEST HOLES

Information pertaining to 458 wells and test holes is given in Table 10. The types of wells and test holes are summarized as follows:

Type of well or test hole	Number
Domestic and stock wells	100
Public supply wells	19
Industrial wells	8
Irrigation wells	5
Oil wells	8
Observation wells	2
Test holes drilled by private contractors	103
Auger holes drilled by the Geological Survey	199
Hydraulic rotary test holes drilled by the Geological Survey	14
Total number of wells	142
Total number of test holes	316
Total number of wells and test holes	458

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*

Well number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 30 S., R. 4 W.															
30-4-31ccc	SW cor. sec. 31		Ta	20.0	4	N	Silt	Slope deposits			Land surface	0.0	1,419.0	Dry	6-4-55	Test hole by U.S.G.S. and K.G.S.
	T. 30 S., R. 5 W.															
30-5-32cdd	SE SE SW sec. 32		Ta	46.0	4	N	Sand	do			do	0.0	1,342.7	10.60	6-4-55	Test hole by U.S.G.S. and K.G.S.
30-5-33ccd	SE SW SW sec. 33		Ta	15.0	4	N	do	do			do	0.0	1,352.0	10.70	6-5-55	do
30-5-34ccc	SW cor. sec. 34		Ta	25.0	4	N	do	do			do	0.0	1,365.8	19.20	6-5-55	do
30-5-36ccc	SW cor. sec. 36		Ta	7.0	4	N	Silt	do			do	0.0	1,398.7	Dry	6-5-55	Shale at 4 ft.
	T. 30 S., R. 6 W.															
30-6-33ccc	SW cor. sec. 33		Ta	50.0	4	N	Sand, gravel	Nebraskan-Kansan deposits			do	0.0	1,552.1	38.00	6-4-55	Test hole by U.S.G.S. and K.G.S.
30-6-34ccd	SE SW SW sec. 34		Ta	25.0	4	N	do	do			do	0.0	1,521.1		6-4-55	do
	T. 30 S., R. 7 W.															
30-7-34ccc	SW cor. sec. 34		T	80.0	4	N	do	do			do	0.0	1,604.1	49.10	7-26-55	do
30-7-35ccd	SE SW SW sec. 35		Ta	50.0	4	N	do	do			do	0.0	1,569.7		6-3-55	do
	T. 30 S., R. 9 W.															
30-9-31cbb	NW NW SW sec. 31		T	50.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,651.4		8-7-55	do
30-9-36ddd	SE cor. sec. 36		T	109.0	4	N	do	Nebraskan-Kansan deposits			do	0.0	1,683.3		7-26-55	do
	T. 31 S., R. 5 W.															
31-5-5aab	NW NE NE sec. 5		Ta	7.5	4	N	Silt	Slope deposits			do	0.0	1,343.0	Dry	6-5-55	do

31-5-5abb	NW NW NE sec. 5		Ta	7.5	4	N	do	Wisconsinan terrace deposits			do	0.0	1,340.0	Dry	6- 5-55	do
31-5-5caa	NE NE SW sec. 5		Ta	28.0	4	N	Sand, gravel	Slope deposits			do	0.0	1,333.7	15.90	6- 6-55	do
31-5-6ddd	SE cor. sec. 6		Ta	19.0	4	N	do	do			do	0.0	1,335.7	14.40	6- 6-55	do
31-5-7abd	SE NW NE sec. 7		Ta	27.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,327.7	3.10	6- 6-55	do
31-5-7cbb	NW NW SW sec. 7		Ta	13.0	4	N	do	do			do	0.0	1,325.6	Dry	6- 6-55	do
31-5-10aaa	NE cor. sec. 10	School district	D	32.0	6	GI	Sand, gravel	Slope deposits	Cy, H	D	Base of pump	0.3	1,367.4	19.32	8-22-56	
31-5-12aaa	NE cor. sec. 12	J. Holder	Du	36.0	48	R	Sandy shale	Permian rocks	Cy, W	S	do	0.2	1,355.1	18.40	8-22-56	
31-5-14ddd	SE cor. sec. 14		Ta	16.0	4	N	Sand	Slope deposits			Land surface	0.0	1,320.5	Dry	7-19-55	Test hole by U.S.G.S. and K.G.S.
31-5-16cdd	SE SE SW sec 16		Ta	35.0	4	N	Sand, gravel	Wisconsinan terrace deposits			do	0.0	1,295.6	6.00	7-19-55	do
31-5-18cdd	SE SE SW sec. 18	M. Poe	D	45.0	6	GI	Shale	Permian rocks	Cy, W	S	Base of pump	1.0	1,384.8	22.43	8-22-56	
31-5-20abb	NW NW NE sec. 20	H. Smithhisler	D	45.0	6	S	do	do	Cy, W	S	do	1.1	1,349.4	31.00	8-22-56	
31-5-21aaa	NE cor. sec. 21		Ta	25.0	4	N	Sand, gravel	Wisconsinan terrace deposits			Land surface	0.0	1,291.9	4.80	7-19-55	Test hole by U.S.G.S.
31-5-22aaa	NE cor. sec. 22		Ta	40.0	4	N	do	do			do	0.0	1,309.0	21.00	7-19-55	do
31-5-25dcc	SW SW SE sec. 25	J. Taton	D	60.0	6	GI	Sandy shale	Permian rocks	C, E	D, S	do	0.0	1,306.5	19.00	8-22-56	Permian rocks at 15 ft.
31-5-33aaa	NE cor. sec. 33		Ta	10.0	4	N	Sand, gravel	Slope deposits			do	0.0	1,331.9	Dry	7-19-55	Test hole by U.S.G.S. and K.G.S.
31-5-33dda	NE SE SE sec. 33		T	38.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,304.5	27.60	7-20-55	do
31-5-33ddb	NW SE SE sec. 33	C. P. Short	Tc	53.0	4	N	do	do			do	0.0		19	7- 6-53	Test hole.
	T. 31 S., R. 6 W.															
31-6-1baa	NE NE NW sec. 1		Ta	4	4	N	Shale	Permian rocks	N		do	0.0	1,341.1	Dry	6- 6-56	Shale at 3 ft.
31-6-1cdd	SE SE SW sec. 1	T. Newsum	D	50.0	4	GI	do	do	J, E	D, S	do	0.0	1,321.2	12.85	8-22-56	
31-6-2aab	NW NE NE sec. 2		Ta	9	4	N	Silt	Slope deposits	N		do	0.0	1,373.5	Dry	6- 6-56	Shale at 8 ft.
31-6-4ccd	SE SW SW sec. 4	A. Freeman	B	65.0	8	GI	Sand, gravel	Nebraskan-Kansan deposits	Cy, E	S	Top of casing	1.1	1,539.3	49.41	4-24-56	
31-6-5bbb	NW cor. sec. 5		Ta	33.0	4	N	do	do			Land surface	0.0	1,539.0	14.40	6- 6-55	Test hole by U.S.G.S. and K.G.S.
31-6-5daa	NE NE SE sec. 5	A. Freeman	Du	34.0	48	R	do	do	Cy, E	D, S	Base of pump	1.0	1,532.3	27.55	4-24-56	
31-6-6bbb	NW cor. sec. 6		Ta	50.0	4	N	do	do			Land surface	0.0	1,575.2	42.00	6- 6-56	Test hole by U.S.G.S. and K.G.S.
31-6-8aaa	NE cor. sec. 8		Ta	50.0	4	N	do	do			do	0.0	1,520.4		6- 6-56	do
31-6-8daa	NE NE SE sec. 8		Ta	45.0	4	N	do	do			do	0.0			6- 7-56	Test hole by U.S.G.S. and K.G.S.
31-6-9bcc	SW SW NW sec. 9	L. Bauer	Tc	28.0	4	N	Sand, gravel	Nebraskan-Kansan deposits			Land surface	0.0		17	7- 6-53	Test hole.

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*—*Continued*

Well number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 31 S., R. 6 W.															
31-6-14abd	SE NW NE sec. 14		Ta	20.0	4	N	Sand, gravel	Nebrasken-Kansan deposits			Land surface	0.0	1,421.2	Dry	6-10-55	Test hole by U.S.G.S. and K.G.S.
31-6-14ccc	SW cor. sec. 14	V. Bear	D	45.0	6	GI	Shale	Permian rocks	Cy, W	S	Base of pump	1.0	1,422.5	31.56	8-22-56	
31-6-17ddd	SE cor. sec. 17		Ta	11.0	4	N	do	do			Land surface	0.0	1,449.7	Dry	6- 7-55	Test hole by U.S.G.S. and K.G.S.
31-6-21ddd	SE cor. sec. 21		Ta	4.0	4	N	do	do			do	0.0	1,423.5	Dry	6- 7-55	Test hole by U.S.G.S. and K.G.S. Shale at 2 ft.
31-6-22aaa	NE cor. sec. 22		Ta	22.0	4	N	do	do			do	0.0	1,413.8	Dry	6- 7-55	Test hole by U.S.G.S. and K.G.S.
31-6-24aaa	NE cor. sec. 24		Ta	15.0	4	N	Sand, gravel	Slope deposits			do	0.0	1,382.8	Dry	7-10-56	do
31-6-24ddd	SE cor. sec. 24		Ta	22.0	4	N	do	do			do	0.0	1,365.6	Dry	7-10-56	do
31-6-25daa	NE NE SE sec. 25		Ta	16.0	4	N	do	do			do	0.0	1,355.9	Dry	7-10-56	do
31-6-28cca	NE SW SW sec. 28		Ta	17.0	4	N	do	Nebraskan-Kansan deposits			do	0.0	1,423.7	Dry	6- 8-55	do
31-6-31ccc	SW cor. sec. 31		Ta	20.0	4	N	do	Slope deposits			do	0.0	1,418.7	12.20	6- 8-55	do
31-6-32aab	NW NE NE sec. 32	A. R. King	D	45.0	6	S	Sandy shale	Permian rocks	J, E	D, S	Top of casing	0.3	1,419.0	25.95	8-22-56	
31-6-32aac	SW NE NE sec. 32		Ta	28.0	4	N	Sand, gravel	Slope deposits			Land surface	0.0	1,414.6	20.20	6- 9-55	Test hole by U.S.G.S. and K.G.S.
31-6-36aaa	NE cor. sec. 36		Ta	54.0	4	N	do	do			do	0.0	1,356.4	24.00	7-10-56	do
31-6-36daa	NE NE SE sec. 36		Ta	39.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,337.8	12.50	7-10-56	do
	T. 31 S., R. 7 W.															
31-7-1bbb	NW cor. sec. 1		Ta	45.0	4	N	do	Nebraskan-Kansan deposits			do	0.0	1,587.4		6- 3-55	Test hole by U.S.G.S. and K.G.S.

31-5-5abb	NW NW NE sec. 5		Ta	7.5	4	N	do	Wisconsinan terrace deposits			do	0.0	1,340.0	Dry	6- 5-55	do
31-5-5caa	NE NE SW sec. 5		Ta	28.0	4	N	Sand, gravel	Slope deposits			do	0.0	1,333.7	15.90	6- 6-55	do
31-5-6ddd	SE cor. sec. 6		Ta	19.0	4	N	do	do			do	0.0	1,335.7	14.40	6- 6-55	do
31-5-7abd	SE NW NE sec. 7		Ta	27.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,327.7	3.10	6- 6-55	do
31-5-7cbb	NW NW SW sec. 7		Ta	13.0	4	N	do	do			do	0.0	1,325.6	Dry	6- 6-55	do
31-5-10aaa	NE cor. sec. 10	School district	D	32.0	6	GI	Sand, gravel	Slope deposits	Cy, H	D	Base of pump	0.3	1,367.4	19.32	8-22-56	
31-5-12aaa	NE cor. sec. 12	J. Holder	Du	36.0	48	R	Sandy shale	Permian rocks	Cy, W	S	do	0.2	1,355.1	18.40	8-22-56	
31-5-14ddd	SE cor. sec. 14		Ta	16.0	4	N	Sand	Slope deposits			Land surface	0.0	1,320.5	Dry	7-19-55	Test hole by U.S.G.S. and K.G.S.
31-5-16cdd	SE SE SW sec 16		Ta	35.0	4	N	Sand, gravel	Wisconsinan terrace deposits			do	0.0	1,295.6	6.00	7-19-55	do
31-5-18cdd	SE SE SW sec. 18	M. Poe	D	45.0	6	GI	Shale	Permian rocks	Cy, W	S	Base of pump	1.0	1,384.8	22.43	8-22-56	
31-5-20abb	NW NW NE sec. 20	H. Smithhisler	D	45.0	6	S	do	do	Cy, W	S	do	1.1	1,349.4	31.00	8-22-56	
31-5-21aaa	NE cor. sec. 21		Ta	25.0	4	N	Sand, gravel	Wisconsinan terrace deposits			Land surface	0.0	1,291.9	4.80	7-19-55	Test hole by U.S.G.S.
31-5-22aaa	NE cor. sec. 22		Ta	40.0	4	N	do	do			do	0.0	1,309.0	21.00	7-19-55	do
31-5-25dcc	SW SW SE sec. 25	J. Taton	D	60.0	6	GI	Sandy shale	Permian rocks	C, E	D, S	do	0.0	1,306.5	19.00	8-22-56	Permian rocks at 15 ft.
31-5-33aaa	NE cor. sec. 33		Ta	10.0	4	N	Sand, gravel	Slope deposits			do	0.0	1,331.9	Dry	7-19-55	Test hole by U.S.G.S. and K.G.S.
31-5-33dda	NE SE SE sec. 33		T	38.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,304.5	27.60	7-20-55	do
31-5-33ddb	NW SE SE sec. 33	C. P. Short	Tc	53.0	4	N	do	do			do	0.0		19	7- 6-53	Test hole.
	T. 31 S., R. 6 W.															
31-6-1baa	NE NE NW sec. 1		Ta	4	4	N	Shale	Permian rocks	N		do	0.0	1,341.1	Dry	6- 6-56	Shale at 3 ft.
31-6-1cdd	SE SE SW sec. 1	T. Newsum	D	50.0	4	GI	do	do	J, E	D, S	do	0.0	1,321.2	12.85	8-22-56	
31-6-2aab	NW NE NE sec. 2		Ta	9	4	N	Silt	Slope deposits	N		do	0.0	1,373.5	Dry	6- 6-56	Shale at 8 ft.
31-6-4ccd	SE SW SW sec. 4	A. Freeman	B	65.0	8	GI	Sand, gravel	Nebraskan-Kansan deposits	Cy, E	S	Top of casing	1.1	1,539.3	49.41	4-24-56	
31-6-5bbb	NW cor. sec. 5		Ta	33.0	4	N	do	do			Land surface	0.0	1,539.0	14.40	6- 6-55	Test hole by U.S.G.S. and K.G.S.
31-6-5daa	NE NE SE sec. 5	A. Freeman	Du	34.0	48	R	do	do	Cy, E	D, S	Base of pump	1.0	1,532.3	27.55	4-24-56	
31-6-6bbb	NW cor. sec. 6		Ta	50.0	4	N	do	do			Land surface	0.0	1,575.2	42.00	6- 6-56	Test hole by U.S.G.S. and K.G.S.
31-6-8aaa	NE cor. sec. 8		Ta	50.0	4	N	do	do			do	0.0	1,520.4		6- 6-56	do
31-6-8daa	NE NE SE sec. 8		Ta	45.0	4	N	do	do			do	0.0			6- 7-56	Test hole by U.S.G.S. and K.G.S.
31-6-9bcc	SW SW NW sec. 9	L. Bauer	Tc	28.0	4	N	Sand, gravel	Nebraskan-Kansan deposits			Land surface	0.0		17	7- 6-53	Test hole.

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*—*Continued*

WELL NUMBER (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 31 S., R. 6 W.															
31-6-14abd	SE NW NE sec. 14	....	Ta	20.0	4	N	Sand, gravel	Nebrasken-Kansan deposits	....	......	Land surface	0.0	1,421.2	Dry	6-10-55	Test hole by U.S.G.S. and K.G.S.
31-6-14ccc	SW cor. sec. 14	V. Bear	D	45.0	6	GI	Shale	Permian rocks	Cy, W	S	Base of pump	1.0	1,422.5	31.56	8-22-56	
31-6-17ddd	SE cor. sec. 17	....	Ta	11.0	4	N	do	do	....	......	Land surface	0.0	1,449.7	Dry	6- 7-55	Test hole by U.S.G.S. and K.G.S.
31-6-21ddd	SE cor. sec. 21	....	Ta	4.0	4	N	do	do	....	......	do	0.0	1,423.5	Dry	6- 7-55	Test hole by U.S.G.S. and K.G.S. Shale at 2 ft.
31-6-22aaa	NE cor. sec. 22	....	Ta	22.0	4	N	do	do	....	......	do	0.0	1,413.8	Dry	6- 7-55	Test hole by U.S.G.S. and K.G.S.
31-6-24aaa	NE cor. sec. 24	....	Ta	15.0	4	N	Sand, gravel	Slope deposits	....	......	do	0.0	1,382.8	Dry	7-10-56	do
31-6-24ddd	SE cor. sec. 24	....	Ta	22.0	4	N	do	do	....	......	do	0.0	1,365.6	Dry	7-10-56	do
31-6-25daa	NE NE SE sec. 25	....	Ta	16.0	4	N	do	do	....	......	do	0.0	1,355.9	Dry	7-10-56	do
31-6-28cca	NE SW SW sec. 28	....	Ta	17.0	4	N	do	Nebraskan-Kansan deposits	....	......	do	0.0	1,423.7	Dry	6- 8-55	do
31-6-31ccc	SW cor. sec. 31	....	Ta	20.0	4	N	do	Slope deposits	....	......	do	0.0	1,418.7	12.20	6- 8-55	do
31-6-32aab	NW NE NE sec. 32	A. R. King	D	45.0	6	S	Sandy shale	Permian rocks	J, E	D, S	Top of casing	0.3	1,419.0	25.95	8-22-56	
31-6-32aac	SW NE NE sec. 32	....	Ta	28.0	4	N	Sand, gravel	Slope deposits	....	......	Land surface	0.0	1,414.6	20.20	6- 9-55	Test hole by U.S.G.S. and K.G.S.
31-6-36aaa	NE cor. sec. 36	....	Ta	54.0	4	N	do	do	....	......	do	0.0	1,356.4	24.00	7-10-56	do
31-6-36daa	NE NE SE sec. 36	....	Ta	39.0	4	N	do	Wisconsinan terrace deposits	....	......	do	0.0	1,337.8	12.50	7-10-56	do
	T. 31 S., R. 7 W.															
31-7-1bbb	NW cor. sec. 1	....	Ta	45.0	4	N	do	Nebraskan-Kansan deposits	....	......	do	0.0	1,587.4	....	6- 3-55	Test hole by U.S.G.S. and K.G.S.

31-7-1cdd	SE SE SW sec. 1		Ta	20.0	4	N	do.	do.			do.	0.0		6.70	7-12-56	do
31-7-3bbb	NW cor. sec. 3		Ta	50.0	4	N	do.	do.			do.	0.0	1,594.1	40.63	6-3-55	do
(31-7-3cbb)	NW NW SW sec. 3	F. Parsons	D	28.0	6	GI	do.	do.	C, E	D, S	do.	0.0	1,573.0	22.36	8-27-56	
31-7-6ada	NE SE NE sec. 6		Ta	40.0	4	N	do.	do.			do.	0.0	1,613.9	30.40	7-12-56	Test hole by U.S.G.S. and K.G.S.
31-7-13bdd	SE SE NW sec. 13		Ta	13.0	4	N	do.	do.			do.	0.0	1,478.7	Dry	7-13-56	Test hole by U.S.G.S. and K.G.S. Shale at 8 ft.
31-7-18bac	SW NE NW sec. 18	J. Hamilton	D	86.0	16	S	Sand, gravel	Nebraskan-Kansan deposits	T, B	Irr	Land surface	0.0	1,595.5	38.70	8-4-56	Estimated yield 300, log given.
31-7-18bca	NE SW NW sec. 18	do.	Tc	76.0	4	N	do.	do.			do.	0.0		33	6-7-53	Test hole.
31-7-20bba	NE NW NW sec. 20		Ta	17.0	4	N	do.	do.			do.	0.0	1,514.7	Dry	7-12-56	Test hole by U.S.G.S. and K.G.S.
31-7-20cdc	SW SE SW sec. 20		Ta	10.0	4	N	do.	Wisconsinan terrace deposits			do.	0.0	1,508.0	7.50	7-13-56	do
31-7-21ddc	SW SE SE sec. 21		Ta	13.0	4	N	do.	Slope deposits			do.	0.0	1,500.9	Dry	7-13-56	do
31-7-22bba	NE NW NW sec. 22		Ta	43.0	4	N	do.	do.			do.	0.0	1,540.9	16.80	7-12-56	Test hole by U.S.G.S. and K.G.S. Shale at 43 ft.
31-7-24cdd	SE SE SW sec. 24		Ta	36.0	4	N	do.	do.			do.	0.0	1,455.8	11.00	6-9-55	Test hole by U.S.G.S. and K.G.S.
31-7-25aab	NW NE NE sec. 25		Ta	26.0	4	N	do.	Wisconsinan terrace deposits			do.	0.0	1,443.3	6.80	6-9-55	do
31-7-25bbb	NW cor. sec. 25		Ta	15.0	4	N	do.	Slope deposits			do.	0.0	1,473.2	Dry	6-9-55	do
31-7-27baa	NE NE NW sec. 27		Ta	21.0	4	N	do.	do.			do.	0.0	1,494.3	14.80	6-9-55	do
31-7-28bab	NW NE NW sec. 28		Ta	12.0	4	N	do.	Wisconsinan terrace deposits			do.	0.0	1,505.8	Dry	7-15-56	do
31-7-29aaa	NE cor. sec. 29		Ta	27.0	4	N	do.	Nebraskan-Kansan deposits			do.	0.0	1,506.2	17.00	6-9-55	do
31-7-30aab	NW NE NE sec. 30		Ta	34.0	4	N	do.	do.			do.	0.0	1,550.6	20.80	6-9-55	do
31-7-30aba	NE NW NE sec. 30		Ta	17.0	4	N	do.	do.			do.	0.0	1,531.9	10.20	7-13-56	do
31-7-30baa	NE NE NW sec. 30		Ta	12.0	4	N	do.	Slope deposits			do.	0.0	1,525.9	Dry	7-13-56	do
31-7-31aab	NW NE NE sec. 31		Ta	17.0	4	N	do.	Wisconsinan terrace deposits			do.	0.0	1,482.7	4.50	7-14-56	do
31-7-31bba	NE NW NW sec. 31		Ta	17.0	4	N	do.	Slope deposits			do.	0.0	1,498.7	Dry	7-13-56	do
31-7-32aaa	NE cor. sec. 32		Ta	18.0	4	N	do.	Wisconsinan terrace deposits			do.	0.0	1,460.3	5.50	7-14-56	do
31-7-32baa	NE NE NW sec. 32		Ta	15.0	4	N	do.	Slope deposits			do.	0.0	1,473.1	Dry	8-1-56	do
31-7-32bbb	NW cor. sec. 32		Ta	15.0	4	N	do.	do.			do.	0.0	1,481.6	Dry	8-13-55	do
31-7-32ddd	SE cor. sec. 32		Ta	50.0	4	N	do.	do.			do.	0.0	1,450.7	6.70	7-16-55	do
31-7-33aaa	NE cor. sec. 33		Ta	30.0	4	N	do.	do.			do.	0.0	1,471.0	13.00	7-16-55	do

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*—*Continued*

WELL NUMBER (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 31 S., R. 7 W.															
31-7-33baa	NE NE NW sec. 33		Ta	29.0	4	N	Sand, gravel	Slope deposits			Land surface	0.0	1,466.1	9.80	7-14-56	Test hole by U.S.G.S. and K.G.S.
31-7-33dcc	SW SW SE sec. 33		Ta	40.0	4	N	do	do			do	0.0	1,454.3	22.80	7-16-55	do
31-7-33ddb	NW SE SE sec. 33	J. Parsons	Tc	65.0	4	N	do	do			do	0.0		21	7- 6-53	Test hole.
31-7-34baa	NE NE NW sec. 34		Ta	17.0	4	N	do	do			do	0.0	1,461.6	9.00	7-14-56	Test hole by U.S.G.S. and K.G.S.
31-7-34ccc	SW cor. sec. 34		Ta	37.0	4	N	do	do			do	0.0	1,453.5	22.00	7-16-55	do
31-7-34ddd	SE cor. sec. 34		T	80.0	4	N	do	do			do	0.0	1,441.4	27.10	8- 9-55	do
31-7-35aac	NW SE NE sec. 35	Gene Williams	Du	50	84	R	Shale	Permian rocks	J, E	D, S	do	0.0	1,464.2	46.50	4-25-56	Poor well.
31-7-35bbb	NW cor. sec. 35		Ta	9.0	4	N	Silt	Slope deposits			do	0.0	1,467.3	Dry	7-14-56	Test hole by U.S.G.S. and K.G.S.
31-7-35cdd	SE SE SW sec. 35		Ta	40.0	4	N	Shale	Permian rocks			do	0.0	1,440.1	24.90	7-16-55	do
31-7-36ccc	SW cor. sec. 36		Ta	12.0	4	N	Silt	Slope deposits			do	0.0	1,439.5	Dry	6- 9-55	do
	T. 31 S., R. 8 W.															
31-8-3cdd	SE SE SW sec. 3	Ted Troyer	D	70.0	2½	GIP	Sand, gravel	Nebraskan-Kansan deposits	Cy, E	D, S	Base of pump	0.5		68.45	8- 6-56	
31-8-5caa	NE NE SW sec. 5	Magnolia Petroleum Co.	D	103.0	10	S	do	do	T, E	Ind	Land surface	0.0	1,665.4	73	8- 6-56	Reported drawdown 17, yield 300. Log given.
31-8-5ccb	NW SW SW sec. 5	do	Tc	92.0	4	N	do	do			do	0.0	1,687.8	74	8- 6-56	Test hole.
31-8-5ccc1	SW SW SW sec. 5	do	D	92.0	10	S	do	do	T, E	Ind	do	0.0		74	8- 6-56	Reported drawdown 16, yield 150.
31-8-5ccc2	SW SW SW sec. 5	do	D	108.0	10	S	do	do	T, E	Ind	do	0.0		76	8- 6-56	Reported drawdown 15, yield 120. Log given.

31-8-7bab	NW NE NW sec. 7		Ta	55.0	4	N	do	do			do	0.0	1,654.4	47.40	7-11-56	Test hole by U.S.G.S. and K.G.S.
31-8-10bba	NE NW NW sec. 10		Ta	70.0	4	N	do	do			do	0.0	1,646.5	62.50	7-11-56	do
(31-8-14cdd)	SE SE SW sec. 14	M. R. Redford	D	65.0	6	GI	do	do	Cy, E	D, S	Base of pump	1.3	1,610.9	34.10	4-25-56	
31-8-17ccd	SE SW SW sec. 17	City of Attica	Tc	93.0	4	N	do	do			Land surface	0.0	1,624.8	49	1-15-55	Test hole.
(31-8-19aaa1)	NE cor. sec. 19	do	D	90	8	S	do	do	T, E	P	do	0.0	1,628.6		4-25-56	One of 4 identical wells at 300 foot spacing. Yield 50 each.
(31-8-19aaa2)	NE cor. sec. 19	do	Tc	103.0	4	N	do	do			do	0.0	1,628.6	52	1-14-55	Test hole.
31-8-19daa	NE NE SE sec. 19	do	Tc	75.0	4	N	do	do			do	0.0		35	1-14-55	do
31-8-19ddb	NW SE SE sec. 19	do	Tc	60.0	4	N	do	do			do	0.0	1,608.9	35	1-14-55	do
31-8-22aba	NE NW NE sec. 22		Ta	40.0	4	N	do	do			do	0.0	1,570.7	5.20	7-11-56	Test hole by U.S.G.S. and K.G.S. Shale at 40 ft.
31-8-29bbb	NW cor. sec. 29	City of Attica	Tc	62.0	4	N	do	do			do	0.0	1,591.6	33	1-14-55	Test hole.
31-8-29bcc	SW SW NW sec. 29	do	Tc	26.0	4	N	do	do			do	0.0	1,569.8		1-15-55	do
31-8-30aaa	NE cor. sec. 30		Ta	55.0	4	N	do	do			do	0.0	1,590.1	34.30	7-11-56	Test hole by U.S.G.S. and K.G.S.
	T. 31 S., R. 9 W.															
31-9-1ccc	SW cor. sec. 1	Phillips Petroleum Co.	D	102	8	S	do	do	Cy, E	Ind, D	Base of pump	1.0	1,693.4	64.00	7-18-56	Estimated yield 40.
31-9-2bdb	NW SE NW sec. 2		D				do	do	N	N			1,674.0			Oil well. Shale at 95 ft.
31-9-2ccc	SW cor. sec. 2		D				do	do	N	N			1,691			Oil well. Shale at 110 ft.
31-9-5ddd	SE cor. sec. 5		D				do	do	N	N			1,691			Oil well. Shale at 150 ft.
31-9-6aad	SE NE NE sec. 6		Ta	22.0	4	N	do	do			Land surface	0.0	1,679.7	15.60	7-11-56	Test hole by U.S.G.S. and K.G.S.
31-9-10aba	NE NW NE sec. 10		Ta	65.0	4	N	do	do			do	0.0	1,667.0	46.10	7-11-56	do
31-9-12aaa	NE cor. sec. 12		D				do	do	N	N			1,679			Oil well. Shale at 115 ft.
31-9-13dbb	NW NW SE sec. 13		D				do	do	N	N			1,640			Oil well. Shale at 85 ft.
(31-9-16ddd)	SE cor. sec. 16	M. Kernohan	D	80	2½	GIP	do	do	Cy, E	D, S	Land surface	0.0	1,671.2	35.00	4-25-56	
31-9-17abb	NW NW NE sec. 17		D				do	do	N	N			1,726			Oil well. Shale at 150 ft.
31-9-20bab	NW NE NW sec. 20		Ta	45.0	4	N	do	do			Land surface	0.0	1,649.2	32.60	7-11-56	Test hole by U.S.G.S. and K.G.S.

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*—*Continued*

WELL NUMBER (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	Geologic source of water	Method of lift (5)	Use of water (6)	Measuring point			Depth to water level below land surface, feet (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
											Description	Distance above land surface, feet	Height of land surface above mean sea level, feet			
	T. 31 S., R. 9 W.															
31-9-24cbb	NW NW SW sec. 24		D				Sand, gravel	Nebraskan-Kansan deposits	N	N			1,613			Oil well. Shale at 70 ft.
31-9-25ddd	SE SE SE sec. 25		D				do	do	N	N			1,574			Oil well. Shale at 60 ft.
31-9-27aaa	NE cor. sec. 27		Ta	40.0	4	N	do	do			Land surface	0.0	1,605.0	13.80	7-11-56	Test hole by U.S.G.S. and K.G.S.
	T. 32 S., R. 5 W.															
32-5-3bbb	NW cor. sec. 3		Ta	19.0	4	N	Sand, gravel	Wisconsinan terrace deposits			Land surface	0.0	1,294.5	8.20	7-19-55	Test hole by U.S.G.S. and K.G.S.
32-5-3bcc	SW SW NW sec. 3		Ta	19.0	4	N	do	Slope deposits			do	0.0	1,309.6	13.70	7-20-56	do
32-5-3ccc	SW cor. sec. 3		Ta	18.0	4	N	do	do			do	0.0	1,313.1	Dry	7-19-55	do
32-5-5aaa	NE cor. sec. 5		Ta	22.0	4	N	do	do			do	0.0	1,314.9	19.60	7-18-55	do
32-5-6aaa	NE cor. sec. 6		Ta	25.0	4	N	do	do			do	0.0	1,331.9		7-18-55	do
32-5-6cbb	NW NW SW sec. 6		Ta	70.0	4	N	do	do			do	0.0	1,354.4	29.60	7-10-56	do
32-5-6ccc	SW cor. sec. 6		Ta	58.0	4	N	do	do			do	0.0	1,358.0	31.00	7-10-56	do
32-5-9add	SE SE NE sec. 9		Ta	10.0	4	N	Silt	do			do	0.0	1,307.7	Dry	7-18-55	do
32-5-9ddd	SE cor. sec. 9		Ta	10.0	4	N	do	do			do	0.0	1,301.4	Dry	7-18-55	do
(32-5-13cbb)	NW NW SW sec. 13	John Sehon	D	56.0	6	GI	Shale	Permian rocks	Cy, W	S	Base of pump	1.3		29.94	8-22-56	
32-5-16add	SE SE NE sec. 16		Ta	10.0	4	N	Silt	Slope deposits			Land surface	0.0	1,299.8	Dry	7-18-55	Test hole by U.S.G.S. and K.G.S.
32-5-21ada	NE SE NE sec. 21		Ta	28.0	4	N	Sand, gravel	Wisconsinan terrace deposits			do	0.0	1,276.5	10.00	7-18-55	do
32-5-23cdc	SW SE SW sec. 23	Z. Strander	Du	20.0	40	R	Shale	Permian rocks	Cy, W	S	Base of pump	1.0		16.32	8- 4-56	
32-5-28aaa	NE cor. sec. 28		Ta	14.0	4	N	Silt	Slope deposits			Land surface	0.0	1,297.1	Dry	7-18-55	Test hole by U.S.G.S and K.G.S.
32-5-29aaa	NE cor. sec. 29	J. Blanchat	D	38.6	6	GI	Shale	Permian rocks	Cy, W	S	Base of pump	0.8		23.58	8- 4-56	
32-5-31dcd	SE SW SE sec. 31	W. Moger	Du	36.0	48	C	do	do	Cy, W	S	do	0.5		31.01	8- 4-56	

32-5-33aaa	NE cor. sec. 33		Ta	10.0	4	N	Silt	Slope deposits			Land surface	0.0	1,298.8	Dry	7-18-55	Test hole by U.S.G.S. and K.G.S.
	T. 32 S., R. 6 W.															
32-6-1aaa	NE cor. sec. 1		Ta	35.0	4	N	Sand, gravel	do			do	0.0	1,356.6	29.00	7-18-55	do
32-6-1bbb	NW cor. sec. 1		Ta	38.0	4	N	do	do			do	0.0	1,362.9	22.50	7-18-55	do
32-6-3aaa	NE cor. sec. 3		Ta	23.0	4	N	do	do			do	0.0	1,371.4		7-18-55	do
32-6-3cca	NE SW SW sec. 3	L. Hostetler	Tc	50.0	4	N	do	do			do	0.0	1,375.1	20	7- 6-53	Test hole.
32-6-4aaa	NE cor. sec. 4		Ta	25.0	4	N	Sand, gravel	Slope deposits			Land surface	0.0	1,384.2	24.20	7-18-55	Test hole by U.S.G.S. and K.G.S.
32-6-4bbb	NW cor. sec. 4		Ta	30.0	4	N	do	do			do	0.0	1,385.4	17.60	7-18-55	do
32-6-4dcc	SW SW SE sec. 4	C. P. Short	D	80.0	16	S	do	do	T, E	Irr	do	0.0	1,376.4	18	7- -53	Estimated yield 300. Log given.
32-6-6aaa	NE cor. sec. 6		Ta	40.0	4	N	do	do			do	0.0	1,406.7	16.80	7-18-55	Test hole by U.S.G.S. and K.G.S.
32-6-6aac	SW NE NE sec. 6		T	74.0	4	N	do	do			do	0.0	1,405.6	17.00	8-10-55	do
32-6-9aac	SW NE NE sec. 9	A. Hostetler	D	67.0	18	S	do	do	T, G	Irr	Base of pump	0.2	1,373.7	21.80	7- 1-55	Estimated yield 560.
32-6-9bad1	SE NE NW sec. 9	J. Zimmerman	Tc	50.0	4	N	do	Wisconsinan terrace deposits			Land surface	0.0		15	7- 6-53	Test hole.
32-6-9bad2	SE NE NW sec. 9	do	Tc	40.0	4	N	do	do			do	0.0		14	7- 6-53	do
32-6-9bbc	SW NW NW sec. 9		Ta	24.0	4	N	do	Slope deposits			do	0.0	1,378.0		7-18-55	Test hole by U.S.G.S. and K.G.S.
32-6-12daa	NE NE SE sec. 12		Ta	24.0	4	N	do	do			do	0.0	1,342.9	Dry	7-10-56	do
32-6-13aad	SE NE NE sec. 13		Ta	15.0	4	N	do	do			do	0.0	1,330.9	Dry	7-15-56	do
32-6-13daa	NE NE SE sec. 13		Ta	20.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,318.4	11.20	7-10-56	do
32-6-17bbb	NW cor. sec. 17		Ta	32.0	4	N	Silt	Slope deposits			do	0.0	1,405.3		7-10-55	do
32-6-21add	SE SE NE sec. 21	T. Sheriff	Du	22.0	40	R	Shale	Permian rocks	Cy, W	N	Base of pump	0.3		15.98	8- 4-56	Abandoned well.
32-6-24aac	SW NE NE sec. 24	J. Burke	Du	31.0	40	R	do	do	N	N	Top of curb	0.2		14.60	8- 4-56	do
32-6-35aaa	NE cor. sec. 35	P. Wedman	Du	22.6	30	R	do	do	Cy, H	S	Base of pump	0.0		18.62	4-24-56	
(32-6-35daa)	NE NE SE sec. 35	do	Du	26.5	36	R	do	do	Cy, W	D, S	do	1.0		20.30	4-24-56	
	T. 32 S., R. 7 W.															
32-7-2cac	SW NE SW sec. 2	City of Harper	D	54	18	S	Sand, gravel	Slope deposits	T, E	P	Land surface	0.0	1,428.8	27	7- -53	Reported yield 150. Log given.
32-7-2dcb	NW SW SE sec. 2	do	D	80.0	18	S	do	do	T, E	P	do	0.0	1,432.4	33.00	7-14-56	Reported draw-down 9 after pumping 450 for 24 hours.

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*—*Continued*

Well number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 32 S., R. 7 W.															
32-7-4bbb	NW cor. sec. 4		T	59.0	4	N	Sand, gravel	Wisconsinan terrace deposits			Land surface	0.0	1,451.3	8.40	8-10-55	Test hole by U.S.G.S. and K.G.S.
32-7-4cdd	SE SE SW sec. 4		Ta	44.0	4	N	do	Slope deposits			do	0.0	1,436.6	22.00	7-16-56	do
32-7-4daa	NE NE SE sec. 4		Ta	54.0	4	N	do	do			do	0.0	1,442.9	28.90	7-15-56	Test hole by U.S.G.S. and K.G.S.
32-7-4dcc	SW SW SE sec. 4	City of Harper	D	38.0	6	GI	do	do	J, E	D, S	Top of casing	0.0		25.80	8-27-56	Not a public-supply well.
32-7-4ddd	SE cor. sec. 4		Ta	40.0	4	N	do	do			Land surface	0.0	1,436.8	22.50	7-16-55	Test hole by U.S.G.S. and K.G.S. Did not reach shale.
32-7-5abb	NW NW NE sec. 5		Ta	34.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,454.8	5.40	7-16-55	Test hole by U.S.G.S. and K.G.S.
32-7-5bbb	NW cor. sec. 5		Ta	24.0	4	N	do	Slope deposits			do	0.0	1,463.3	10.60	7-16-55	do
32-7-6bbb	NW cor. sec. 6		Ta	39.0	4	N	do	do			do	0.0	1,473.1	21.70	7-10-55	do
32-7-7bba	NE NW NW sec. 7		Ta	28.0	4	N	do	Wisconsinan terrace deposits			do	0.0		8.10	7-18-56	do
32-7-8abb	NW NW NE sec. 8		Ta	19.0	4	N	do	do			do	0.0	1,436.5	12.30	7-16-56	do
32-7-8cbb	NW NW SW sec. 8		Ta	64.0	4	N	do	Slope deposits			do	0.0	1,439.4	23.80	7-16-56	do
32-7-9bbb	NW cor. sec. 9		Ta	39.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,429.3	20.50	7-16-56	do
32-7-9daa	NE NE SE sec. 9		Ta	70.0	4	N	do	Slope deposits			do	0.0	1,427.9	36.20	7-15-56	do. Did not reach shale.
32-7-11add1	SE SE NE sec. 11	City of Harper	D	60.0	6	GI	do	do	Cy, H	D	Base of pump	0.3	1,427.8	37.48	7-14-56	Well in roadside park.
(32-7-11add2)	SE SE NE sec. 11	do	D	83.0	18	S	do	do	T, E	P	do	0.6		37.36	7-14-56	Reported drawdown 19, yield 700.

32-7-11bcc	SW SW NW sec. 11		T	60.0	4	N	do	do			Land surface		1,427.1		8-10-55	Test hole by U.S.G.S. and K.G.S.
32-7-11cdd	SE SE SW sec. 11	City of Anthony	B	52.8	1¼	GIP	do	do	N	O	Top of pipe	1.2		22.20	8-15-56	Shale at 57 ft.
32-7-12cca1	NE SW SW sec. 12	do	Tc	100.0	4	N	do	do			Land surface	0.0	1,426.1	24	10- 6-53	Test hole.
32-7-12cca2	NE SW SW sec. 12	do	D	85	18	S	do	do	T, E	P	do	0.0	1,426.1		7-14-56	Reported yield 500.
32-7-12ccb1	NW SW SW sec. 12	do	D	60.0	2	GIP	do	do	N	O	Top of pipe	1.5	1,426.0	34.81	7- 8-56	Log given.
32-7-12ccb2	NW SW SW sec. 12	do	Tc	75.0	4	N	do	do			Land surface	0.0	1,423.6	22	10- 6-53	Test hole.
32-7-12ccb3	NW SW SW sec. 12	do	Tc	100.0	4	N	do	do			do	0.0	1,422.1	23	10- 6-53	do
32-7-12ccb4	NW SW SW sec. 12	do	Tc	101.0	4	N	do	do			do	0.0		23	10- 6-53	do
(32-7-12ccc1)	SW cor. sec. 12	do	D	93	18	S	do	do	T, E	P	Base of pump	1.0	1,423.6		7-14-56	Reported yield 500.
32-7-12ccc2	SW cor. sec. 12	do	Tc	97.0	4	N	do	do			Land surface	0.0	1,423.6	20	8- 7-53	Test hole.
32-7-12ccd1	SE SW SW sec. 12	do	Tc	80.0	4	N	do	do			do	0.0	1,425.5	24	10- 6-53	do
32-7-12ccd2	SE SW SW sec. 12	do	D	72	18	S	do	do	T, E	P	Base of pump	0.0	1,425.5		7-14-56	Reported yield 300.
32-7-12cda	NE SE SW sec. 12	I. A. Unruh	D	100.0	18	S	do	do	T, NG	Irr	Land surface	0.0	1,424.3	30.06	8-30-55	Reported drawdown 63 at 1,000, 10 at 400.
32-7-12cdb	NW SE SW sec. 12	City of Anthony	Tc	91.0	4	N	do	do			do	0.0		23	10- 7-53	Test hole.
32-7-12cdd	SE SE SW sec. 12	do	Tc	40.0	4	N	do	do			do	0.0			10- 5-53	Test hole. Shale at 40 ft.
32-7-13bcc	SW SW NW sec. 13	do	Tc	40.0	4	N	do	do			do	0.0	1,424.6		8- 8-53	Test hole.
32-7-14aaa	NE cor. sec. 14	do	Tc	97.0	4	N	do	do			do	0.0		20	8- 7-53	do
32-7-14bba	NE NW NW sec. 14	do	Tc	94.0	4	N	do	do			do	0.0	1,424.3	18	3- 4-52	do
32-7-14bcc	SW SW NW sec. 14	do	Tc	85.0	4	N	do	do			do	0.0	1,416.6	10	3- 4-52	do
32-7-14ccc	SW cor. sec. 14	do	Tc	27.0	4	N	do	do			do	0.0	1,408.7	6	3- 4-52	do
32-7-15baa	NE NE NW sec. 15	do	Tc	30.0	4	N	do	do			do	0.0	1,422.3	6	3- 4-52	do
32-7-15ccc	SW cor. sec. 15	do	Tc	27.0	4	N	do	do			do	0.0	1,399.8	2	3- 5-52	do
32-7-16aaa	NE cor. sec. 16	do	Tc	45.0	4	N	do	do			do	0.0	1,417.6	14	3- 4-52	do
32-7-17aad	SE NE NE sec. 17	do	Tc	31.0	4	N	do	do			do	0.0	1,414.2	4	3- 3-52	do
32-7-17bbb	NW cor. sec. 17		Ta	44.0	4	N	do	do			do	0.0	1,431.7	23.20	7-18-56	Test hole by U.S.G.S. and K.G.S.
32-7-17daa	NE NE SE sec. 17	City of Anthony	Tc	25.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,412.4	3	3- 2-52	Test hole.
32-7-18ddd	SE cor. sec. 18		Ta	58.0	4	N	do	Slope deposits			do	0.0	1,425.4	19.30	7-18-56	Test hole by U.S.G.S. and K.G.S.
32-7-19abb	NW NW NE sec. 19		Ta	22.0	4	N	do	do			do	0.0	1,414.0	7.80	8-16-56	do
32-7-19bbb	NW cor. sec. 19		Ta	20.0	4	N	do	do			do	0.0	1,419.4	7.30	8-16-56	do
32-7-20aaa	NE cor. sec. 20	City of Anthony	Tc	20.0	4	N	Sand	Wisconsinan terrace deposits			do	0.0	1,402.3	4	3- 2-52	Test hole.
32-7-20daa	NE NE SE sec. 20	do	Tc	26.0	4	N	Sand, gravel	do			do	0.0	1,395.5	8	3- 2-52	do
32-7-20ddd	SE cor. sec. 20	do	Tc	31.0	4	N	Sand	do			do	0.0	1,384.1	6	3- 2-52	do
(32-7-21ccc)	SW cor. sec. 21	L. Burkholder	D	70	6	GI	Shale	Permian rocks	Cy, E	D, S	do	0.0	1,384.1	15.00	4-24-56	

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*—*Continued*

WELL NUMBER (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 32 S., R. 7 W.															
32-7-25add	SE SE NE sec. 25	F. Coulson	D	48.0	6	GI	Shale	Permian rocks	Cy, W	S	Base of pump	1.1	....	28.77	8- 4-56	
32-7-27caa	NE NE SW sec. 27	H. Moldenhaur	Du	30.0	48	R	do	do	Cy, W	D	do	0.3	....	....	8- 3-56	Not adequate for domestic use; well used as cistern during drought.
32-7-29ada	NE SE NE sec. 29	City of Anthony	Tc	31.0	4	N	Sand	Wisconsinan terrace deposits	....	......	Land surface	0.0	....	10	3- 1-52	Test hole.
32-7-29ddd	SE cor. sec. 29	do	Tc	12.0	4	N	Shale	Permian rocks	....	......	do	0.0	....	Dry	3- 1-52	do
32-7-30bbb	NW cor. sec. 30	....	Ta	36.0	4	N	Sand, gravel	Slope deposits	....	......	do	0.0	1,400.8	18.80	8-16-56	Test hole by U.S.G.S. and K.G.S.
32-7-30dcc	SW SW SE sec. 30	....	Ta	45.0	4	N	do	do	....	......	do	0.0	1,365.4	9.60	8-16-56	do
32-7-32add	SE SE NE sec. 32	City of Anthony	Tc	18.0	4	N	Sand	do	....	......	do	0.0	....	Dry	3- 1-52	Test hole.
	T. 32 S., R. 8 W.															
32-8-2aaa	NE cor. sec. 2	....	Ta	20.0	4	N	Sand, gravel	Nebraskan-Kansan deposits	....	......	do	0.0	1,502.2	Dry	7-18-55	Test hole by U.S.G.S. and K.G.S.
(32-8-4ddd)	SE cor. sec. 4	School district	D	40.0	6	GI	Shale	Permian rocks	Cy, H	D	Base of pump	0.3	1,472.4	29.05	8-22-56	
32-8-6bbb	NW cor. sec. 6	City of Attica	Tc	48.0	4	N	Sand, gravel	Slope deposits	....	......	Land surface	0.0	1,514.0	....	1- 6-55	Test hole.
32-8-7bba	NE NW NW sec. 7	A. Prouse	D	18.6	6	GI	do	do	Cy, W	S	Top of casing	0.6	1,478.9	11.82	8-22-56	
32-8-13add	SE SE NE sec. 13	....	Ta	32.0	4	N	do	do	....	......	Land surface	0.0	1,434.8	19.60	7-18-56	Test hole by U.S.G.S. and K.G.S.
32-8-13daa	NE NE SE sec. 13	T. Carroll	D	50.0	6	GI	do	do	Cy, H	D, S	Base of pump	1.0	....	13.60	7-18-56	Shale at 50 ft.
32-8-14aaa	NE cor. sec. 14	....	Ta	15.0	4	N	do	do	....	......	Land surface	0.0	1,446.8	Dry	7-20-55	Test hole by U.S.G.S. and K.G.S.
32-8-14cba	NE NW SW sec. 14	City of Attica	Tc	23.0	4	N	do	Wisconsinan terrace deposits	....	......	do	0.0	....	....	1-16-55	Test hole.

32-8-20bcb1..	NW SW NW sec. 20	do.	D	132	8	S	do.	do.	A, E	P	do.	0.0	1,440.2	.	7-12-56	North air-lift well. Shale at 42 ft.
32-8-20bcb2..	NW SW NW sec. 20	do.	D	132	8	S	do.	do.	A, E	P	do.	0.0	.	.	7-12-56	Center air-lift well. Shale at 50 ft.
32-8-20bcb3..	NW SW NW sec. 20	do.	D	132	8	S	do.	do.	A, E	P	do.	0.0	1,443.3	.	7-12-56	South air-lift well. Shale at 50 ft.
32-8-20bcb4..	NW SW NW sec. 20	do.	D	132	8	S	do.	do.	A, E	P	do.	0.0	.	.	7-12-56	Southeast air-lift well. Shale at 48 ft.
(32-8-20bcd)..	SE SW NW sec. 20..	do.	D	30.0	12	S	do.	do.	T, E	P	do.	0.0	1,441.5	25.40	7-12-56	Shale at 49 ft.
32-8-20daa...	NE NE SE sec. 20..	do.	Tc	45.0	4	N	do.	do.	.	.	do.	0.0	1,422.8	.	1-13-55	Test hole.
32-8-21bbb..	NW cor. sec. 21.	do.	Tc	51.0	4	N	Sand.	Slope deposits.	.	.	do.	0.0	1,435.2	.	1-12-55	do
32-8-21bcc...	SW SW NW sec. 21	do.	Tc	22.0	4	N	Sand, gravel	Wisconsinan terrace deposits	.	.	do.	0.0	.	.	1-12-55	do
32-8-21cbb...	NW NW SW sec. 21	do.	Tc	25.0	4	N	do.	do.	.	.	do.	0.0	.	.	1-12-55	do
32-8-22dab...	NW NE SE sec. 22..	do.	Tc	31.0	4	N	do.	do.	.	.	do.	0.0	.	.	1-12-55	do
32-8-22dbb..	NW NW SE sec. 22	do.	Tc	60.0	4	N	do.	do.	.	.	do.	0.0	.	.	1-16-55	do
32-8-22ddd..	SE cor. sec. 22.	P. Allenbach.	Du	35.4	40	R	Shale.	Permian rocks.	N	S	Top of well curb	0.5	.	27.96	8-22-56	Abandoned well.
32-8-23add...	SE SE NE sec. 23.	.	Ta	32.0	4	N	Sand, silt.	Slope deposits.	.	.	Land surface..	0.0	1,397.0	22.10	8-16-56	Test hole by U.S.G.S. and K.G.S.
32-8-23ddd..	SE cor. sec. 23.	.	Ta	28.0	4	N	Sand.	do.	.	.	do.	0.0	1,384.2	9.40	8-16-56	do
32-8-24daa...	NE NE SE sec. 24..	.	Ta	31.0	4	N	Sand, gravel	do.	.	.	do.	0.0	1,411.8	23.00	8-16-56	do
(32-8-32aba)..	NE NW NE sec. 32	W. Hornahan.	Du	20.0	30	R	do.	Nebraskan-Kansan deposits	Cy, H	S	Base of pump	0.3	1,440.3	12.20	4-25-56	
	T. 32 S., R. 9 W.															
32-9-3bcc...	SW SW NW sec. 3..	J. Maroney.	Du	30.0	48	R	Shale.	Permian rocks.	Cy, H	S	Top of curb..	1.0	.	22.80	8-22-56	
32-9-6cbb...	NW NW SW sec. 6..	.	Ta	13.0	4	N	Silt.	Slope deposits.	.	.	Land surface..	0.0	1,497.9	Dry	8-16-56	Test hole by U.S.G.S. and K.G.S.
32-9-7bbb...	NW cor. sec. 7.	.	Ta	51.0	4	N	Sand, gravel	do.	.	.	do.	0.0	1,478.0	28.40	8-20-56	do
32-9-7cbb...	NW NW SW sec. 7..	.	Ta	36.0	4	N	do.	do.	.	.	do.	0.0	1,463.5	20.00	8-20-56	do
32-9-7ccc...	SW cor. sec. 7.	.	Ta	25.0	4	N	do.	do.	.	.	do.	0.0	1,451.6	12.30	8-20-56	do
32-9-13ccc...	SW cor. sec. 13.	.	D	25.0	6	S	do.	Kansan deposits.	Cy, H	N	Top of casing	0.0	1,495.0	12.75	8-20-56	Shale at 15 ft. Aband'd well.
32-9-16ccc...	SW cor. sec. 16.	.	Ta	19.0	4	N	do.	Slope deposits.	.	.	Land surface..	0.0	1,419.6	16.40	8-16-55	Test hole by U.S.G.S. and K.G.S.
(32-9-17ccd)..	SE SW SW sec. 17..	J. Davis.	B	30	6	GI	do.	do.	Cy, H	D, S	Base of pump	0.3	1,431.1	10.50	4-25-56	
32-9-18cbb...	NW NW SW sec. 18	.	Ta	39.0	4	N	do.	do.	.	.	Land surface..	0.0	1,442.6	10.20	8-20-56	Test hole by U.S.G.S. and K.G.S.

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*—*Continued*

Well number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 32 S., R. 9 W.															
32-9-18ddd	SE cor. sec. 18		T	99.0	4	N	Sand, gravel	Slope deposits			Land surface	0.0	1,428.9	16.08	8-25-55	Test hole by U.S.G.S. and K.G.S.
32-9-19aab	NW NE NE sec. 19		Ta	70.0	4	N	do	do			do	0.0	1,429.6	17.30	8-16-55	do
32-9-19bab	NW NE NW sec. 19		Ta	44.0	4	N	do	do			do	0.0	1,429.0	18.10	8-16-55	do
32-9-19bbb	NW cor. sec. 19		Ta	69.0	4	N	do	do			do	0.0	1,433.5	11.80	8-20-56	do
32-9-19cbb	NW NW SW sec. 19		Ta	70.0	4	N	do	do			do	0.0	1,420.7	11.20	8-20-56	do
(32-9-19ccb)	NW SW SW sec. 19		T	80.0	4	N	do	do			do	0.0	1,419.6	8.30	9-12-56	do
32-9-21aab	NW NE NE sec. 21		Ta	32.0	4	N	do	do			do	0.0	1,430.5	16.20	8-16-55	do
32-9-26cdd	SE SE SW sec. 26		Ta	10.0	4	N	Shale	Permian rocks			do	0.0	1,423.1	Dry	8-17-55	do
32-9-30bbb	NW cor. sec. 30		Ta	69.0	4	N	Sand, gravel	Slope deposits			do	0.0	1,419.0	6.50	8- 3-56	do
32-9-30bcb	NW SW NW sec. 30		Ta	16.0	4	N	do	do			do	0.0	1,415.5	4.00	8- 3-56	do
	T. 33 S., R. 5 W.															
33-5-1bcb	NW SW NW sec. 1	T. Story	Du	37.5	36	R	Shale	Permian rocks	Cy, H	N	Base of pump	1.0		30.36	8- 4-56	Abandoned well.
33-5-4aaa	NE cor. sec. 4		Ta	13.0	4	N	do	do			Land surface	0.0	1,333.1	Dry	7- 8-55	Test hole by U.S.G.S. and K.G.S.
33-5-4bab	NW NE NW sec. 4	M. Olmstead	Du	42.0	56	C	do	do	Cy, H	N	Base of pump	0.6		35.75	8- 4-56	Abandoned well.
(33-5-4ddd)	SE cor. sec. 4	Freeport Community	D	40.0	8	GI	do	do	Cy, H	D	do	0.8		32.41	8-22-56	
33-5-10bbb	NW cor. sec. 10		Ta	15.0	4	N	do	do			Land surface	0.0	1,337.6	Dry	7- 8-55	Test hole by U.S.G.S. and K.G.S.
33-5-14bbb	NW cor. sec. 14	O. Dickey	Du	38.0	40	R	do	do	Cy, W	S	Base of pump	1.8		27.92	8- 4-56	
33-5-18aab	NW NE NE sec. 18	A. Stewart	D	42.0	5	GI	do	do	Cy, W	S	do	1.2		30.43	8- 4-56	
33-5-21aaa	NE cor. sec. 21		Ta	10.0	4	N	do	do			Land surface	0.0	1,310.6	Dry	7- 8-55	Test hole by U.S.G.S. and K.G.S.
33-5-28aaa	NE cor. sec. 28		Ta	39.0	4	N	Sand, gravel	Kansan deposits			do	0.0	1,298.1	32.90	7- 8-55	do

(33-5-30ddd)	SE cor. sec. 30	D. E. Hoopes	Du	69.0	40	B	Shale	Permian rocks	Cy, W, E	D, S	Top of curb	1.0	1,290.7	36.51	8-23-56	
33-5-33aaa	NE cor. sec. 33		Ta	20.0	4	N	Silt	Kansan deposits			Land surface	0.0	1,280.9	Dry	7- 9-55	Test hole by U.S.G.S. and K.G.S.
33-5-33ddd	SE cor. sec. 33		Ta	40.0	4	N	Sand, gravel	Slope deposits			do	0.0	1,270.4	27.80	7- 9-55	do
33-5-36aaa	NE cor. sec. 36	L. Fowler	Du, D	60.0	48.8	R	Shale	Permian rocks	Cy, W	S	Base of pump	0.6		36.00	8- 1-56	
	T. 33 S., R. 6 W.															
33-6-3cdd	SE SE SW sec. 3	L. Smithhisler	Du	21.0	30	C	Shale	Permian rocks	Cy, W	S	Land surface	0.0		12.65	8- 4-56	
33-6-7baa	NE NE NW sec. 7	M. Potter	D	40.0	6	GI	do	do	N	N	Top of casing	0.6		38.60	8- 4-56	Abandoned well; not adequate.
33-6-11ddd	SE cor. sec. 11	L. Flinn	Du	26.5	48	R	do	do	Cy, W	S	Base of pump	1.0		19.30	8- 4-56	
33-6-17cdd	SE SE SW sec. 17		Ta	10.0	4	N	do	do			Land surface	0.0	1,318.7	Dry	7- 7-55	Test hole by U.S.G.S. and K.G.S.
33-6-18bcc	SW SW NW sec. 18	G. Truby	Du	23.0	48	R	do	do	Cy, W	S	Base of pump	0.9		16.48	8- 6-56	
33-6-19ccc	SW cor. sec. 19		D	1,125						Ind	Land surface	0.0			1888	Oyler Salt well, abandoned. Log given.
33-6-22ccc	SW cor. sec. 22	M. Harrison	D	26.0	10	T	Shale	Permian rocks	Cy, W	N	Base of pump	0.0		23.40	8- 3-56	Abandoned well.
33-6-27ccc	SW cor. sec. 27		Ta	11.0	4	N	do	do			Land surface	0.0	1,320.2	Dry	7- 8-55	Test hole by U.S.G.S. and K.G.S.
33-6-29ccc	SW cor. sec. 29		Ta	40.0	4	N	Sandy silt	Slope deposits			do	0.0	1,304.1	28.00	7- 8-55	do
33-6-29ddc	SW SE SE sec. 29		Ta	12.0	4	N	Silt	Kansan deposits			do	0.0	1,297.7	Dry	7- 8-55	do
33-6-30aaa	NE cor. sec. 30		Ta	10.0	4	N	Sand, gravel	do			do		1,308.5	Dry	7- 8-55	do
33-6-30cbb	NW NW SW sec. 30	City of Anthony	Tc	51.0	4	N	do	Slope deposits			do	0.0	1,322.7	13	3- 8-52	Test hole.
33-6-30cbc	SW NW SW sec. 30	do	Tc	25.0	4	N	do	do			do	0.0		13	3- 8-52	do
33-6-30ccc	SW cor. sec. 30	do	Tc	21.0	4	N	do	do			do	0.0	1,317.0	15	3- 8-52	do
33-6-31bbb	NW cor. sec. 31	do	Tc	21.0	4	N	do	do			do	0.0		15	3- 8-52	do
33-6-31bcb	NW SW NW sec. 31	do	Tc	28.0	4	N	Sand	do			do	0.0		20	3- 9-52	do
33-6-31bcc	SW SW NW sec. 31	do	Tc	21.0	4	N	Sand, gravel	do			do	0.0	1,302.1	16	3- 9-52	do
33-6-31cbc	SW NW SW sec. 31	do	Tc	25.0	4	N	do	do			do	0.0	1,311.2	26	3- 9-52	do
33-6-31ccb	NW SW SW sec. 31	do	Tc	40.0	4	N	do	do			do	0.0	1,299.3	17	3- 9-52	do
33-6-31ccd	SE SW SW sec. 31	do	Tc	31.0	4	N	do	do			do	0.0		13	3- 9-52	do
33-6-31cdc	SW SE SW sec. 31	do	Tc	31.0	4	N	do	do			do	0.0	1,295.8	20	3-12-52	do
33-6-31dcc	SW SW SE sec. 31	do	Tc	51.0	4	N	do	do			do	0.0	1,297.8	21	3-12-52	do
33-6-31ddc	SW SE SE sec. 31	do	Tc	35.0	4	N	Sand	do			do	0.0		20	3-12-52	do
33-6-31ddd	SE cor. sec. 31	do	Tc	58.0	4	N	Sand, gravel	do			do	0.0		22	3-12-52	do
33-6-32ddd	SE cor. sec. 32		Ta	40.0	4	N	do	Kansan deposits			do	0.0		18.00	7-15-55	Test hole by U.S.G.S. and K.G.S.
33-6-34ccc	SW cor. sec. 34		Ta	30.0	4	N	do	Slope deposits			do	0.0		Dry	7-15-55	do
33-6-34ddd	SE cor. sec. 34	L. Stewart	D	85.0	6	GI	Shale	Permian rocks	Cy, W	S	Base of pump	1.0		33.20	8- 3-56	
33-6-35cbb	NW NW SW sec. 35		Ta	17.0	4	N	Silt	Kansan deposits			Land surface	0.0		Dry	7-15-55	Test hole by U.S.G.S. and K.G.S.

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*—*Continued*

WELL NUMBER (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 33 S., R. 7 W.															
33-7-2cdc	SW SE SW sec. 2	K.E.R.C.	Du	31.0	120	R	Silt, sand	Wisconsinan terrace deposits	Cy, G	S	Base of pump	1.0		18.20	8- 3-56	Reported yield 10.
33-7-5aaa	NE cor. sec. 5		Ta	10.0	4	N	Sand	Slope deposits			Land surface	0.0		Dry	8- 5-55	Test hole by U.S.G.S. and K.G.S.
33-7-5baa	NE NE NW sec. 5		Ta	38.0	4	N	do	do			do	0.0		18.60	8- 5-55	do
33-7-5bba	NE NW NW sec. 5		Ta	12.0	4	N	do	do			do	0.0		Dry	8- 5-55	do
33-7-5bbb	NW cor. sec. 5		Ta	44.0	4	N	Sand, gravel	Wisconsinan terrace deposits			do	0.0		9.60	8- 5-55	do
33-7-5daa	NE NE SE sec. 5	City of Anthony	Tc	16.0	4	N	Sand	Slope deposits			do	0.0		Dry	3- 1-52	Test hole.
33-7-6abb	NW NW NE sec. 6		Ta	12.0	4	N	Silt, sand	do			do	0.0		Dry	8- 5-55	Test hole by U.S.G.S. and K.G.S.
33-7-6bbb	NW cor. sec. 6		Ta	58.0	4	N	Sand, gravel	do			do	0.0		11.60	8- 5-55	do
33-7-8aaa	NE cor. sec. 8	City of Anthony	Tc	16.0	4	N	Sand	do			do	0.0		Dry	3- 1-52	Test hole.
33-7-8daa	NE NE SE sec. 8	do	Tc	14.0	4	N	do	do			do	0.0		Dry	3- 1-52	do
33-7-11bab	NW NE NW sec. 11	do	Tc	31.0	4	N	do	Wisconsinan terrace deposits			do	0.0		7	3- 1-52	do
33-7-15cdc	SW SE SW sec. 15	do	Tc	37.0	4	N	Sand, gravel	Slope deposits			do	0.0	1,338.4	6	1- 8-52	do
33-7-17aaa	NE cor. sec. 17	do	Tc	15.0	4	N	Silt, sand	do			do	0.0		Dry	3- 1-52	do
33-7-17daa	NE NE SE sec. 17	do	Tc	15.0	4	N	Sand, gravel	Wisconsinan terrace deposits			do	0.0		4	3- 1-52	do
33-7-17ddd	SE cor. sec. 17	do	Tc	47.0	4	N	do	do			do	0.0	1,317.7	9	3- 1-52	do
33-7-20aad	SE NE NE sec. 20	do	Tc	50.0	4	N	do	do			do	0.0		8	3- 6-52	do
33-7-21aba	NE NW NE sec. 21	W. Boon	Du	29.6	48	R	Shale	Permian rocks	Cy, H	D, S	Base of pump	0.6		19.36	8- 3-56	
33-7-28cda	NE SE SW sec. 28	City of Anthony	D	40	12	S	Sand, gravel	Wisconsinan terrace deposits	T, E	P	Land surface	0.0			8- 3-56	Abandoned well.
33-7-32ddd	SE cor. sec. 32	do	Tc	27.0	4	N	Sand	Kansan deposits			do	0.0		10	3- 6-52	Test hole.

33-7-33baa	NE NE NW sec. 33	do	D	40	12	S	Sand, gravel	Wisconsinan terrace deposits	T, E	P	do	0.0			8- 3-56	Abandoned well.
33-7-33bdd	SE SE NW sec. 33	do	D	40	12	S	do	do	T, E	P	do	0.0			8- 3-56	do
33-7-33caa	NE NE SW sec. 33	do	D	40	12	S	do	do	T, E	P	do	0.0			8- 3-56	do
33-7-33ccc	SW cor. sec. 33	do	Tc	27.0	4	N	do	Kansan deposits			do	0.0		11	3- 6-52	Test hole.
33-7-33cdc	SW SE SW sec. 33	do	Tc	25.0	4	N	do	do			do	0.0	1,350.4	13	3- 6-52	do
33-7-33cdd	SE SE SW sec. 33	do	Tc	33.0	4	N	do	do			do	0.0	1,337.0	13	3- 6-52	do
33-7-33dac	SW NE SE sec. 33	do	D	40	12	S	do	do		P	do	0.0			8- 3-56	Abandoned well.
33-7-33dcd	SE SW SE sec. 33	do	Tc	22.0	4	N	do	do			do	0.0	1,322.7	14	3- 6-52	Test hole.
33-7-33ddc	SW SE SE sec. 33	do	Tc	22.0	4	N	do	do			do	0.0		15	3- 6-52	do
33-7-34cad	SE NE SW sec. 34	do	Tc	21.0	4	N	do	Wisconsinan terrace deposits			do	0.0	1,295.4		3- 6-52	do
33-7-34ccb	NW SW SW sec. 34	do	D	40	12	S	do	do	T, E	P	do	0.0			8- 3-52	Used as standby well.
33-7-34ccc	SW cor. sec. 34	do	Tc	22.0	4	N	do	Slope deposits			do	0.0	1,288.8	7	3- 6-52	Test hole.
33-7-34ccd1	SE SW SW sec. 34	do	Tc	45.0	4	N	do	do			do	0.0		26	3- 6-52	do
(33-7-34ccd2)	SE SW SW sec. 34	do	D	40	12	S	do	Wisconsinan terrace deposits	T, E	P	do	0.0			8- 3-52	2 wells used continuously for power plant.
33-7-34ccd3	SE SW SW sec. 34	do	Tc	37.0	4	N	do	Slope deposits			do	0.0		11	3- 6-52	Test hole.
33-7-34cdd	SE SE SW sec. 34	do	Tc	41.0	4	N	do	do			do	0.0	1,279.6	21	3- 6-52	do
33-7-34dcc	SW SW SE sec. 34	do	Tc	27.0	4	N	do	do			do	0.0		15	3- 6-52	do
33-7-34ddc	SW SE SE sec. 34	do	Tc	41.0	4	N	do	Wisconsinan terrace deposits			do	0.0			3- 6-52	do
33-7-34ddd	SE cor. sec. 34	do	Tc	41.0	4	N	do	do			do	0.0		13	3- 6-52	do
33-7-36daa	NE NE SE sec. 36	V. Hoopes	D	40.0	6	GI	do	do	Cy, H	N	Base of pump	0.6		19.72	8-23-56	Abandoned well.
	T. 33 S., R. 8 W.															
33-8-11bbc	SW NW NW sec. 11	K. E. R. C.	Du	36.0	96	C	do	Alluvium	C, N	S	Top of concrete cover	0.6		18.05	8- 3-56	
33-8-13ddc	SW SE SE sec. 13	L. Marts	D	55.0	10	GI	Shale	Permian rocks	B, H	D	Top of casing	1.3		48.75	4-25-56	
(33-8-13ddd)	SE cor. sec. 13	do	Du	41.0	36	R	do	do	Cy, W	S	Base of pump	0.5	1,395.6	18.12	4-25-56	
33-8-16ddd	SE cor. sec. 16	K. McKenny	Du	26.0	56	R	do	do	Cy, W	S	do	1.0		21.40	8- 3-56	Not adequate.
33-8-28acc	SW SW NE sec. 28	City of Anthony	Tc	110.0	4	N	do	do			Land surface	0.0			3- 8-52	Test hole.
33-8-31dcc	SW SW SE sec. 31		Ta	15.0	4	N	Sand, silt	Slope deposits			do	0.0	1,304.5	Dry	7-19-55	Test hole by U.S.G.S. and K.G.S.
33-8-33add	SE SE NE sec. 33	J. Hilts	D	40.0	8	S	Shale	Permian rocks	Cy, W	S	Top of casing	0.3		30.70	8- 3-56	
	T. 33 S., R. 9 W.															
33-9-1bbb	NW cor. sec. 9		Ta	15.0	4	N	Sand	Slope deposits			Land surface	0.0	1,384.0	Dry	7-18-55	Test hole by U.S.G.S. and K.G.S.
33-9-4abb	NW NW NE sec. 4		Ta	9.0	4	N	do	do			do	0.0	1,380.5	Dry	7-18-55	do
33-9-4bba	NE NW NW sec. 4		Ta	15.0	4	N	do	do			do	0.0	1,378.3	9.10	7-18-55	do
33-9-5aaa	NE cor. sec. 5		Ta	40.0	4	N	Sand, gravel	do			do	0.0	1,381.1	10.00	7-18-55	do
33-9-5aab	NW NE NE sec. 5		Ta	55.0	4	N	do	do			do	0.0	1,379.0	7.80	8- 4-56	do

TABLE 10.—*Records of wells and test holes in Harper County, Kansas*—*Continued*

Well number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 33 S., R. 9 W.															
33-9-5abb	NW NW NE sec. 5	....	Ta	40.0	4	N	Sand, gravel	Slope deposits	....	....	Land surface	0.0	1,380.3	8.20	7-18-55	Test hole. U.S.G.S. and K.G.S.
(33-9-5baa)	NE NE NW sec. 5	M. Blurton	D	25	6	GI	do	do	Cy, H	D	Base of pump	0.5	....	10.10	4-25-56	
33-9-5bab	NW NE NW sec. 5	....	Ta	7.0	4	N	do	do	....	....	Land surface	0.0	1,373.9	4.80	7-18-55	Test hole by U.S.G.S. and K.G.S.
33-9-5ddd	SE cor. sec. 5	H. Loesch	D	28.0	6	GI	do	do	C, E	S	Top of casing	0.4	1,367.2	14.46	8- 8-56	
33-9-6aaa	NE cor. sec. 6	....	Ta	5.0	4	N	Shale	Permian rocks	....	....	Land surface	0.0	1,384.3	Dry	7-18-55	Test hole by U.S.G.S. and K.G.S.
33-9-13bbb	NW cor. sec. 13	T. Hunt	D	21.0	5	GI	Sand	Dune sand	Cy, W	S	Top of casing	2.0	....	12.20	8- 8-56	
33-9-15dcc	SW SW SE sec. 15	....	T	41.0	4	N	Sand, gravel	Slope deposits	....	....	Land surface	0.0	1,331.1	7.50	7-19-55	Test hole by U.S.G.S. and K.G.S.
33-9-16ddd	SE cor. sec. 16	....	Ta	13.0	4	N	do	do	....	....	do	0.0	1,335.1	4.80	7-19-55	do
33-9-21abb	NW NW NE sec. 21	....	Ta	15.0	4	N	Silt	do	....	....	do	0.0	1,342.0	Dry	7-19-55	do
33-9-24dcc	SW SW SE sec. 24	K. E. R. C.	Du	27.0	96	C	Sand, gravel	do	N	S	Top of concrete cover	0.3	1,313.9	12.26	8- 8-56	Log given.
33-9-30daa	NE NE SE sec. 30	L. Albert	Du	18.6	48	GI	Shale	Permian rocks	Cy,H,W	S	Base of pump	1.0	....	14.80	8- 8-56	
33-9-34ddd	SE cor. sec. 34	....	Ta	39.0	4	N	Sand, gravel	Dune sand and slope deposits	....	....	Land surface	0.0	1,313.2	13.10	7-19-55	Test hole by U.S.G.S. and K.G.S.
	T. 34 S., R. 5 W.															
34-5-9aaa	NE cor. sec. 9	....	Ta	37.0	4	N	do	Slope deposits	....	....	do	0.0	1,244.2	26.50	7-20-55	do
34-5-10ccc	SW cor. sec. 10	....	T	46.0	4	N	do	do	....	....	do	0.0	1,233.0	20.04	7-19-55	do
34-5-13dcc1	SW SW SE sec. 13	K. Baker	Dn	28.0	1¼	GIP	do	Wisconsinan terrace deposits	C, E	D, S	do	0.0	....	19.60	8- 1-56	
34-5-13dcc2	SW SW SE sec. 13	do	D	75.0	6	GI	Shale	Permian rocks	Cy, H	N	Base of pump	0.5	....	41.80	8- 1-56	Water high in iron and sulfate; not used.

34-5-15daa	NE NE SE sec. 15	R. Misak	D	55.0	6	GI	do	do	Cy, H	S	do	0.3	....	31.02	8- 3-56	
34-5-20add	SE SE NE sec. 20	Mayo Service Sta.	D	44.0	6	GI	do	do	J, E	D	Land surface	0.0	....	36.00	8- 1-56	Poor yield.
34-5-26daa	NE NE SE sec. 26	C. Anton	D	50.0	6	GI	do	do	N	D, S	do	0.0	1,191.3	25.00	8- 1-56	New well.
(34-5-29bbb)	NW cor. sec. 29	J. Korbel	D	35.0	8	GI	do	do	Cy, H	D, S	Base of pump	0.2	1,259.8	25.16	4-24-56	Salty water at 50 ft.
34-5-32abb	NW NW NE sec. 32	G. Jess	D	50.0	4	S	do	do	C, E	S	Land surface	0.0	1,261.7	Flows	8- 1-56	Flowing core-drill hole.
	T. 34 S., R. 6 W.															
34-6-3ccc	SW cor. sec. 3	....	Ta	40.0	4	N	Sand, gravel	Slope deposits	....	......	do	0.0	1,279.8	14.60	7-20-55	Test hole by U.S.G.S. and K.G.S.
34-6-6aad	SE NE NE sec. 6	City of Anthony	Tc	47.0	4	N	do	do	....	......	do	0.0	1,289.5	16	3-12-52	Test hole.
34-6-6add	SE SE NE sec. 6	do	Tc	51.0	4	N	do	do	....	......	do	0.0	1,280.2	13	3-12-52	do
34-6-6bbb	NW cor. sec. 6	do	Tc	45.0	4	N	do	do	....	......	do	0.0	....	19	3-13-52	do
34-6-6bbc	SW NW NW sec. 6	do	Tc	65.0	4	N	do	do	....	......	do	0.0	....	15	3-13-52	do
34-6-6bcc	SW SW NW sec. 6	do	Tc	41.0	4	N	do	do	....	......	do	0.0	....	14	3-13-52	do
34-6-6bdc	SW SE NW sec. 6	do	Tc	39.0	4	N	do	do	....	......	do	0.0	....	16	3-13-52	do
34-6-6cac	SW NE SW sec. 6	do	Tc	48.0	4	N	do	do	....	......	do	0.0	....	16	3-13-52	do
34-6-6cbb	NW NW SW sec. 6	do	Tc	45.0	4	N	do	do	....	......	do	0.0	....	12	3-10-52	do
34-6-6ccb	NW SW SW sec. 6	do	Tc	47.0	4	N	do	do	....	......	do	0.0	....	8	3-10-52	do
34-6-6daa	NE NE SE sec. 6	do	Tc	40.0	4	N	Sandy silt	do	....	......	do	0.0	....	7	3-10-52	do
34-6-6dda	NE SE SE sec. 6	do	Tc	51.0	4	N	Sand, gravel	do	....	......	do	0.0	....	9	3-13-52	do
34-6-6ddd	SE cor. sec. 6	do	Tc	20.0	4	N	Shale	Permian rocks	....	......	do	0.0	1,272.5	11	3-13-52	do
34-6-7bbb	NW cor. sec. 7	do	Tc	45.0	4	N	Sand, gravel	Slope deposits	....	......	do	0.0	....	11	3-10-52	do
34-6-7bbc	SW NW NW sec. 7	do	Tc	44.0	4	N	do	Wisconsinan terrace deposits	....	......	do	0.0	1,268.7	15.60	3-10-56	Test hole. Did not reach shale.
34-6-8abb	NW NW NE sec. 8	....	Ta	12.0	4	N	Silt	Slope deposits	....	......	do	0.0	1,269.8	Dry	8-19-55	Test hole by U.S.G.S. and K.G.S.
34-6-8bbb	NW cor. sec. 8	....	Ta	15.0	4	N	Silt, sand	do	....	......	do	0.0	1,272.5	Dry	8-19-55	do
34-6-9add	SE SE NE sec. 9	....	Ta	30.0	4	N	Sandy silt	Wisconsinan terrace deposits	....	......	do	0.0	1,250.2	11.00	8-19-55	do
34-6-9baa	NE NE NW sec. 9	....	Ta	37.0	4	N	Sand, gravel	do	....	......	do	0.0	1,248.2	13.90	8-19-55	do
34-6-9daa	NE NE SE sec. 9	....	Ta	35.0	4	N	do	do	....	......	do	0.0	1,237.8	10.50	8-19-55	do
34-6-11aad	SE NE NE sec. 11	School district	D	45.0	5	GI	do	Slope deposits	N	N	Top of casing	0.1	1,252.2	29.62	8- 2-56	Abandoned well.
34-6-11bbb	NW cor. sec. 11	....	Ta	40.0	4	N	do	do	....	......	Land surface	0.0	1,258.4	15.90	8-20-55	Test hole by U.S.G.S. and K.G.S.
34-6-11cbc	SW NW SW sec. 11	....	Ta	33.0	4	N	do	Wisconsinan terrace deposits	....	......	do	0.0	1,225.9	6.00	8-20-55	do
(34-6-16baa)	NE NE NW sec. 16	C. Kaup	D	70.0	6	GI	Shale	Permian rocks	Cy, W	D, S	Base of pump	1.0	....	48.60	8-23-56	
34-6-24bbb	NW cor. sec. 24	L. Perry	D	56.0	5	GI	do	do	Cy, H	N	do	0.3	....	36.12	8- 2-56	Abandoned well.
34-6-25ddd	SE cor. sec. 25	F. Misak	D	35.0	8	GI	do	do	Cy, H	D, S	do	0.3	....	21.32	8- 1-56	
(34-6-32bcb)	NW SW NW sec. 32	L. Frazier	D	31.0	6	GI	do	do	Cy, W	S	do	1.3	....	12.62	4-24-56	
34-6-34bbb	NW cor. sec. 34	L. Reneau	Du	22.8	56	C	do	do	Cy, H	D, S	do	0.2	....	16.90	8- 1-56	

Table 10.—*Records of wells and test holes in Harper County, Kansas—Continued*

Well number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 34 S., R. 7 W.															
34-7-1aaa	NE cor. sec. 1	City of Anthony	Tc	33.0	4	N	Sand	Slope deposits			Land surface	0.0		17	3-11-52	Test hole.
34-7-1aac	SW NE NE sec. 1	do	Tc	60.0	4	N	Sand, gravel	do			do	0.0		13	3-11-52	do
34-7-1aba	NE NW NE sec. 1	do	Tc	60.0	4	N	do	do			do	0.0	1,302.1	22	3-11-52	do
34-7-1aca	NE SW NE sec. 1	do	Tc	50.0	4	N	do	do			do	0.0		6	3-11-52	do
34-7-1acc	SW SW NE sec. 1	do	Tc	17.0	4	N	do	do			do	0.0		5	3-11-52	do
34-7-2aba	NE NW NE sec. 2		Ta	30.0	4	N	do	Kansan deposits			do	0.0	1,301.0	26.20	8-20-55	Test hole by U.S.G.S. and K.G.S.
34-7-6cbb	NW NW SW sec. 6		Ta	34.0	4	N	do	do			do	0.0	1,363.0	25.00	8-20-55	do
34-7-6ccc	SW cor. sec. 6		Ta	35.0	4	N	do	do			do	0.0	1,343.6	17.10	8- 9-55	do
(34-7-8aaa)	NE cor. sec. 8	R. Gates	Du	35.0	48	R	do	do	J, E	D, S	Top of curb	0.6	1,341.4	29.46	8-25-56	
34-7-12abb	NW NW NE sec. 12	City of Anthony	Tc	45.0	4	N	do	Slope deposits			Land surface	0.0		20	3-12-52	Test hole.
34-7-23add	SE SE NE sec. 23	L. Orr	Du	42.0	40	R	Shale	Permian rocks	B, H	D, S	do	0.0		36.30	8-25-56	
34-7-26ddd	SE cor. sec. 26	K. E. R. C.	Du	32.0	108	C	Sand	Pleistocene deposits, undifferentiated	N	S	Top of cover	1.6	1,370.6	21.66	8- 2-56	Log given.
	T. 34 S., R. 8 W.															
34-8-1abb	NW NW NE sec. 1		Ta	50.0	4	N	Sandy silt	Kansan deposits			Land surface	0.0	1,360.7	20.10	8- 9-55	Test hole by U.S.G.S. and K.G.S.
34-8-6bba	NE NW NW sec. 6		Ta	20.0	4	N	Shale	Permian rocks			do	0.0	1,293.5	17.00	8- 3-55	do
34-8-10bcc	SW SW NW sec. 10	M. Lousenbury	D	38.0	8	GI	do	do	Cy, W	S	Base of pump	1.8		19.20	8- 3-56	
34-8-20ccc	SW cor. sec. 20		Ta	40.0	4	N	Sand, gravel	Slope deposits			Land surface	0.0	1,257.8	6.40	8- 3-55	Test hole by U.S.G.S. and K.G.S.
34-8-22ddd	SE cor. sec. 22	F. Moulton	Du	21.6	44	C	Shale	Permian rocks	Cy, H	D, S	Base of pump	0.2	1,312.9	16.40	8- 2-56	Abandoned well.
34-8-25daa	NE NE SE sec. 25	A. Cornick	Du	31.0	48	R	Sandy silt	Alluvium	Cy, W	D, S	do	0.8		19.06	8- 2-56	
34-8-29aaa	NE cor. sec. 29		Ta	30.0	4	N	Sand, gravel	Slope deposits			Land surface	0.0	1,264.7	12.40	8- 3-55	Test hole by U.S.G.S. and K.G.S.
34-8-29bab	NW NE NW sec. 29		T	45.0	4	N	do	do			do	0.0	1,260.5	9.40	8-10-55	do
34-8-30abb	NW NW NE sec. 30		T	40.0	4	N	do	do			do	0.0	1,268.1	18.60	8-10-55	do

34-8-33dda	NE SE SE sec. 33	L. Richardson	Du	22.0	48	C	Shale	Permian rocks	C, E	D, S	do	0.0	1,268.8	18.55	8- 2-56	Not adequate.
	T. 34 S., R. 9 W.															
34-9-1aab	NW NE NE sec. 1		Ta	25.0	4	N	Sand	Dune sand			do	0.0	1,295.1	2.00	7-19-55	Test hole by U.S.G.S. and K.G.S.
34-9-1baa	NE NE NW sec. 1		Ta	20.0	4	N	Sand, gravel	Slope deposits			do	0.0	1,307.8	12.00	7-19-55	do
34-9-1bbb	NW cor. sec. 1		Ta	35.0	4	N	do	do			do	0.0	1,315.9	10.40	7-19-55	do
34-9-3bbb	NW cor. sec. 3		Ta	10.0	4	N	Sand	Dune sand			do	0.0	1,298.7	Dry	7-19-55	do
34-9-9dcc	SW SW SE sec. 9	L. Anthony	D	28.0	6	GI	do	do	Cy, W	S	Base of pump	2.5		8.40	8- 8-56	
34-9-13cba	NE NW SW sec. 13	R. Stark	D	35.0	30	C	Sand, gravel	Slope deposits	C, NG	Irr	Top of well curb	1.0		11.00	7-17-56	Two identical wells connected to one pump; reported yield 500.
(34-9-18bbb)	NW cor. sec. 18	L. Bahr	Du	25.0	36	R	Shale	Permian rocks	Cy, E	D	Base of pump	1.0	1,302.0	18.30	4-25-56	Shale at 25 feet.
34-9-22dcc	SW SW SE sec. 22		Ta	35.0	4	N	Sand, gravel	Slope deposits			Land surface	0.0	1,262.8	4.60	8- 3-55	Test hole by U.S.G.S. and K.G.S.
34-9-22ddd	SE cor. sec. 22		Ta	15.0	4	N	Sand	Dune sand			do	0.0	1,274.3	Dry	8- 3-55	do
34-9-23ddd	SE cor. sec. 23		Ta	39.0	4	N	Sand, gravel	Dune sand and slope deposits			do	0.0	1,279.2	16.80	8- 3-55	do
34-9-24ddd	SE cor. sec. 24		Ta	40.0	4	N	do	do			do	0.0	1,279.4	13.80	8- 3-55	do
34-9-27dbb	NW NW SE sec. 27	Cities Service Co.	D	28.0	18	S	do	Slope deposits	T, E	Ind	do	0.0		7.50	7-17-56	Capacity 220; pumped at 100. Log given.
34-9-27dca	NE SW SE sec. 27	do	D	27.0	18	S	do	do	T, E	Ind	do	0.0		7.00	7-17-56	Pumped at 100. Log given.
34-9-27dcc	SW SW SE sec. 27	do	D	26.0	18	S	do	do	T, E	Ind	do	0.0	1,261.3	7.00	7-17-56	do
34-9-28aaa	NE cor. sec. 28		Ta	20.0	4	N	do	do			do	0.0	1,272.2	13.10	7-20-56	Test hole by U.S.G.S. and K.G.S.
34-9-30aaa	NE cor. sec. 30	J. Cummings	D	26.0	6	GI	Shale	Permian rocks	N	N	Top of casing	0.3		10.21	8- 8-56	Abandoned well.
34-9-36ddd	SE cor. sec. 36	T. Cantrell	D	68.0	6	GI	Sand, gravel	Slope deposits	J, E	D, S	Land surface	0.0		36.00	8- 8-56	Very good well; 8 feet coarse gravel above shale at 68 ft.
	T. 35 S., R. 5 W.															
35-5-5	Lot 4, sec. 5	School district	D	26.2	6	GI	Shale	Permian rocks	N	N	Top of casing	1.0		18.12	8- 1-56	Abandoned well.
35-5-11ccc1	SW cor. sec. 11	P. Shellhammer	D	90.0	6	GI	do	do	Cy, W	S	Base of pump	1.2		19.30	8- 1-56	Very good yield. Chloride about 195 ppm.

TABLE 10.—*Records of wells and test holes in Harper County, Kansas—Concluded*

Well number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet below land surface (3)	Diameter of well, inches	Type of casing (4)	Character of material	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. 35 S., R. 5 W.															
35-5-11ccc2	SW cor. sec. 11	P. Shellhammer	D	34.0	6	GI	Shale	Permian rocks	J, E	D	Top of casing	1.0	....	26.00	8- 1-56	Poor yield. Chloride about 60 ppm.
35-5-11ccc3	SW cor. sec. 11	do	D	32.0	6	GI	do	do	Cy, W	S	Base of pump	1.5	....	24.30	8- 1-56	Good yield. Chloride 750 ppm.
35-5-12add	SE SE NE sec. 12	F. Buersh	Du	26.0	48	R	do	do	C, E	D, S	do	1.0	....	20.01	8- 1-56	Good water.
35-5-17	Lot 4, sec. 17	G. Bush	D	50.0	6	GI	do	do	Cy, H	D	do	0.8	....	31.41	8- 2-56	
	T. 35 S., R. 6 W.															
35-6-1ccc	SW cor. sec. 1	C. Jelinek	Du	21.0	48	C	do	do	Cy, W	S	Top of cover	0.3	....	14.55	8- 1-56	
35-6-16	Lot 2, sec. 16	C. Williams	Du	23.0	48	C	do	do	Cy, W	S	Base of pump	0.6	....	17.33	8- 1-56	Not adequate.
	T. 35 S., R. 7 W.															
35-7-4cdc	SW SE SW sec. 4	L. Grubb	Du	26.0	48	R	do	do	Cy, W	S	do	1.5	....	18.36	8- 2-56	Water of poor quality.
35-7-12add	SE SE NE sec. 12	L. Jett	Du	21.0	48	C	do	do	Cy, G	S	do	0.4	....	13.42	8- 1-56	
35-7-18abb	NW NW NE sec. 18	W. Hent	Du	23.6	48	R	do	do	C, E	D, S	Land surface	0.0	....	19.40	8- 2-56	
	T. 35 S., R. 8 W.															
35-8-8dcc	SW SW SE sec. 8	....	Ta	47.0	4	N	Sand, gravel	Slope deposits	....	....	do	0.0	1,223.1	11.10	8-10-56	Test hole by U.S.G.S. and K.G.S.
35-8-11dcd	SE SW SE sec. 11	L. Washburn	D	28.5	5	GI	Shale	Permian rocks	Cy, W	S	Top of casing	0.0	....	16.50	8- 3-56	Abandoned well.
35-8-17aaa	NE cor. sec. 17	....	Ta	15.0	4	N	Sand, gravel	Slope deposits	....	....	Land surface	0.0	1,231.3	7.50	7- 6-55	Test hole by U.S.G.S. and K.G.S.
35-8-17abb	NW NW NE sec. 17	....	Ta	50.0	4	N	do	do	....	....	do	0.0	1,223.4	8.50	7- 6-55	do
35-8-17bba	NE NW NW sec. 17	....	Ta	42.0	4	N	do	do	....	....	do	0.0	1,220.5	8.30	7- 6-55	do

	T. 35 S., R. 9 W.														
35-9-3ccc....	SW cor. sec. 3......	R. Crittenden.....	D	32.0	8	GI	do.........	do...............	Cy, W	S	Base of pump	1.0	....	17.92	8- 8-56	
(35-9-5bbb)...	NW cor. sec. 5......	W. Wilson.......	Du	30.0	36	R	Shale......	Permian rocks....	Cy,E,W	S	do...........	0.9	....	13.60	4-25-56	Water of very poor quality.

1. Well number in parentheses indicates chemical analysis given in Table 6.
2. B, bored; D, drilled; Dn, driven; Du, dug well; T, rotary-drilled U. S. G. S. test hole; Ta, augered U. S. G. S. test hole; Tc, test hole by contract driller.
3. Reported depths are given in feet below land surface; measured depths are given in feet and tenths below land surface.
4. B, brick; C, concrete; GI, galvanized iron; GIP, galvanized iron pipe; N, none; R, rock; S, steel.
5. A, air lift; B, bucket; C, centrifugal; Cy, cylinder; J, jet; N, none; T, turbine. B, butane motor; E, electric motor; G, gasoline motor; H, hand; N, none; NG, natural-gas motor; W, wind.
6. D, domestic; Ind, industrial; Irr, irrigation; O, observation; N, none; P, public service; S, stock.
7. Measured depths to water are given in feet, tenths, and hundredths; reported depths are given in feet.

LOGS OF WELLS AND TEST HOLES

The logs of 317 wells and test holes are given on the following pages and are summarized as follows:

Logs of	Number
Test holes by private contractors (drillers logs)	103
Wells by private contractors (drillers logs)	12
Auger holes by Geological Surveys	188
Hydraulic-rotary test holes by Geological Surveys	14

30-4-31ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SW cor. sec. 31, T. 30 S., R. 4 W., on north road shoulder, 30 feet east of center of road. Surface altitude, 1,419.0 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	3	3
Silt, sandy, tan	2	5
Sand, clayey, red	4	9
PERMIAN—Leonardian		
Ninnescah Shale		
Clay shale, red	11	20

30-5-32cdd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SE¼ SE¼ SW¼ sec. 32, T. 30 S., R. 5 W., center of abandoned road 150 feet west of house. Surface altitude, 1,342.7 feet; depth to water, 10.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	2	2
Clay, silty, sandy, brown	3	5
Sand and gravel, coarse to fine, red	8	13
Sand and gravel, coarse to fine, brown	7	20
Sand and gravel, coarse to fine	15	35
Sand and gravel, coarse to fine (poor recovery of sample)	10	45
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	1	46

30-5-33ccd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SE¼ SW¼ SW¼ sec. 33, T. 30 S., R. 5 W., on north road shoulder at center of road to south. Surface altitude, 1,352.0 feet; depth to water, 10.70 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	2	2
Sand and gravel, coarse to fine	8	10
Clay, sandy, fine, red	2	12
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	3	15

30-5-34ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SW cor. sec. 34, T. 30 S., R. 5 W., on north road shoulder at center line of road to south. Surface altitude, 1,365.8 feet; depth to water, 19.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	2	2
Clay, sandy, some gravel, red	1	3
Clay, sandy, red	2	5
Sand and gravel, coarse to fine, red	4	9
Clay, pink	8	17
Sand, coarse to fine	6	23
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	2	25

30-5-36ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, June 5, 1955, in SW cor. sec. 36, T. 30 S., R. 5 W. Surface altitude, 1,398.7 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan to Recent Stages—Slope deposits		
Silt, fine sandy, red brown	4	4
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	3	7

30-6-33ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SW cor. sec. 33, T. 30 S., R. 6 W., 8 feet north of center of east-west road and in center of north-south road. Surface altitude, 1,552.1 feet; depth to water, 38.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, brown	2	2
Sand and gravel, coarse to fine, and silt, red brown	8	10
Sand, coarse to fine, silty, tan	15	25
Sand, coarse to fine, silty and clayey, tan	5	30
Clay, tan; sand streak at 33 ft.	5	35
Clay, tan	15	50

30-6-34ccd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SE¼ SW¼ SW¼ sec. 34, T. 30 S., R. 6 W., north road shoulder in line with center of road to south. Surface altitude, 1,521.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, sandy, brown	2	2
Silt, tan	2	4
Silt, brown	1	5
Sand, coarse to fine, some coarse gravel	5	10
Sand and gravel, coarse to fine	14	24
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	25

30-7-34ccc.—*Sample log of test hole drilled by Federal and State Geological Surveys, July 1955, in SW cor. sec. 34, T. 30 S., R. 7 W., on west road shoulder 100 feet north of sec. cor. Surface altitude, 1,604.1 feet; depth to water, 49.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, brown	2	2
Clay, sandy, brown	2	4
Sand and gravel, coarse to fine, clayey	6	10
Sand, coarse to fine, clayey	5	15
Nebraskan Stage		
Clay, tan	14	29
Sand and gravel, coarse to fine	1	30
Sand and gravel, coarse to fine, clay streaks	5	35
Sand and gravel, coarse to fine	15	50
Sand, coarse to fine	5	55
Sand and gravel, coarse to fine, clay streaks	5	60
Sand, coarse to fine, and fine gravel	4	64
Sand and gravel, coarse to fine, clay streaks at 64 to 66 ft.	6	70
Sand and gravel, coarse to fine, clayey	6	76
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	80

30-7-35ccd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SE¼ SW¼ SW¼ sec. 35, T. 30 S., R. 7 W., north road shoulder in line with center of north-south road. Surface altitude, 1,569.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, brown	3	3
Clay, red	2	5
Sand and gravel, fine to coarse, clayey, red	4	9
Clay, tan	1	10
Gravel, coarse	2	12
Sand, fine to coarse, clayey near bottom	5	17
Sand and gravel, fine to coarse	20	37
Clay, tan	8	45
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	5	50

30-9-31cbb.—*Sample log of test hole drilled by Federal and State Geological Surveys, August 1955, in NW¼ NW¼ SW¼ sec. 31, T. 30 S., R. 9 W., on east road shoulder 100 feet south of bridge. Surface altitude, 1,651.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand and gravel, fine to coarse, silty	10	10
Sand and gravel, fine to medium, and silt, black	10	20
Sand and gravel, medium	10	30

	Thickness, feet	Depth, feet
Sand, fine to coarse, and black silt	5	35
Sand and fine gravel, clayey	5	40
Gravel, fine to medium	7	47
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	3	50

30-9-36ddd.—*Sample log of test hole drilled by Federal and State Geological Surveys, July 1955, in SE cor. sec. 36, T. 30 S., R. 9 W., 35 feet north of east-west road and 75 feet west of end of road curve. Surface altitude, 1,683.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Clay, sandy, brown	8	8
Sand, fine to coarse, silty	2	10
Sand and gravel, fine to coarse, silty	7	17
Clay, gray, caliche	3	20
Clay, sandy, gray	16	36
Sand and gravel, fine to coarse	14	50
Sand, fine to coarse, clay streaks	5	55
Sand and gravel, coarse to fine	30	85
Nebraskan Stage		
Sand and clay, interbedded, caliche	5	90
Clay, gray; contains caliche	5	95
Clay and coarse sand, interbedded	5	100
Sand and gravel and pink clay	6	106
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	3	109

31-5-5aab.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NW¼ NE¼ NE¼ sec. 5, T. 31 S., R. 5 W., south road shoulder opposite 4th power pole west of RR. Surface altitude, 1,343.0 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, dark brown	2	2
Sand and gravel, fine to coarse, very silty	5	7
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	0	7

31-5-5abb.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NW¼ NW¼ NE¼ sec. 5, T. 31 S., R. 5 W., on south road shoulder at ½-mile line to south. Surface altitude, 1,340.0 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, dark brown	3	3
Silt, very sandy, tan	4	7

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	0	7

31-5-5caa.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NE¼ NE¼ SW¼ sec. 5, T. 31 S., R. 5 W., west road ditch opposite gate to pasture to east. Surface altitude, 1,333.7 feet; depth to water, 15.90 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, dark red	5	5
Silt, sandy, red brown	15	20
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	8	28

31-5-6ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SE cor. sec. 6, T. 31 S., R. 5 W., between highway and RR. in center of trail to west. Surface altitude, 1,335.7 feet; depth to water, 14.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, very sandy, black	2	2
Sand and gravel, fine to coarse, very silty, brown	3	5
Sand, fine to coarse, silty, tan	5	10
Sand, fine to coarse	4	14
Clay, red	1	15
Clay, sandy, red	2	17
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	2	19

31-5-7abd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SE¼ NW¼ NE¼ sec. 7, T. 31 S., R. 5 W., in borrow pit on north side of road opposite twin trees. Surface altitude, 1,327.7 feet; depth to water, 3.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage— Dune sand		
Sand, fine, red	4	4
Wisconsinan Stage—Terrace deposits		
Clay, sandy, gray brown	1	5
Clay, red	10	15
Sand and gravel, fine to coarse	11	26
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	27

31-5-7cbb.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NW¼ NW¼ SW¼ sec. 7, T. 31 S., R. 5 W., in north borrow pit 300 feet east of highway curve sign. Surface altitude, 1,325.6 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, red	3	3
Sand, fine to coarse, silty	4	7
Sand and gravel, fine to coarse	5	12
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	13

31-5-14ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE cor. sec. 14, T. 31 S., R. 5 W., west road shoulder 250 feet north of sec. cor. Surface altitude, 1,320.5 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	3	3
Silt, very sandy, tan	3	6
Sand, fine to coarse, silty	3	9
Silt, sandy, light gray	1	10
Silt, red brown	5	15
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	16

31-5-16cdd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE¼ SE¼ SW¼ sec. 16, T. 31 S., R. 5 W., on north road shoulder 0.4 mile east of corner and 300 feet west of bridge. Surface altitude, 1,295.6 feet; depth to water, 6.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt and sand, fine to medium, dark gray	3	3
Silt and clay, black	3	6
Sand, fine to coarse	9	15
Sand, fine to coarse, silty	15	30
Sand and silt	4	34
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	1	35

31-5-21aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 21, T. 31 S., R. 5 W., 300 feet west and 6 feet south of sec. cor. Surface altitude, 1,291.9 feet; depth to water, 4.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, dark gray	3	3
Sand, fine, silty, buff	2	5
Sand and gravel, fine to coarse	15	20

	Thickness, feet	Depth, feet
Silt, clayey, tan	3	23
Sand and gravel, fine to coarse	1	24
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	25

31-5-22aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 22, T. 31 S., R. 5 W., 150 feet west and 6 feet south of sec. cor. Surface altitude, 1,309.0 feet; depth to water, 21.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, red brown	5	5
Sand, fine, silty, brown	2	7
Sand, fine	1	8
Sand, fine to coarse, silty	2	10
Sand and gravel, fine to coarse	29	39
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	1	40

31-5-33aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 33, T. 31 S., R. 5 W., 100 feet west and 6 feet south of sec. cor. Surface altitude, 1,331.9 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, red brown	3	3
Sand and gravel, fine to coarse, silty, brown	3	6
Sand and gravel, fine to coarse	3	9
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	1	10

31-5-33dda.—*Sample log of test hole drilled by Federal and State Geological Surveys, July 1955, in NE¼ SE¼ SE¼ sec. 33, T. 31 S., R. 5 W., in field entrance to west, halfway between house and creek. Surface altitude, 1,304.5 feet; depth to water, 27.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, gray brown	4	4
Silt, sand, and gravel	6	10
Sand and gravel, fine to coarse, silty	10	20
Silt, sandy, tan, some gravel	10	30
Gravel and sand, fine to coarse	6	36
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	2	38

31-5-33ddb.—*Drillers log of test hole drilled by Layne-Western Co., July 1953, in NW¼ SE¼ SE¼ sec. 33, T. 31 S., R. 5 W.; depth to water, 19 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Loam	2	3
Clay, red	25	28
Sand, fine to coarse	12	40
Sand and gravel, medium to coarse	5	45
Clay	1	46
Sand and gravel, fine to coarse, clay streaks	4	50
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	3	53

31-6-1baa.—*Sample log of test hole augered by Federal and State Geological Surveys, June 6, 1956, in NE¼ NE¼ NW¼ sec. 1, T. 31 S., R. 6 W. Surface altitude, 1,341.1 feet; dry hole.*

	Thickness, feet	Depth, feet
Top soil	3	3
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	1	4

31-6-2aab.—*Sample log of test hole augered by Federal and State Geological Surveys, June 6, 1956, in NW¼ NE¼ NE¼ sec. 2, T. 31 S., R. 6 W. Surface altitude, 1,373.5 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan to Recent Stages—Slope deposits		
Silt, fine sandy, red brown	3	3
Silt, tan	3	6
Silt, very sandy, fine, tan	2	8
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty and sandy, red	1	9

31-6-5bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NW cor. sec. 5, T. 31 S., R. 6 W., at sec. line on south road shoulder 150 feet east of bridge. Surface altitude, 1,539.0 feet; depth to water, 14.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, black	2	2
Silt, red, contains sand and gravel	2	4
Sand and gravel, fine to coarse	2	6
Sand and gravel, fine to coarse, some silt	4	10
Clay, sandy, tan	5	15
Sand, fine to coarse	10	25
Sand and gravel, fine to coarse	7	32
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	33

31-6-6bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1956, in NW cor. sec. 6, T. 31 S., R. 6 W., on south road shoulder 280 feet east of sec. line fence. Surface altitude, 1,575.2 feet; depth to water, 42.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, brown	2	2
Gravel, clayey, brown	3	5
Gravel and sand, fine to coarse	4	9
Sand, fine to coarse	6	15
Sand and gravel, fine to coarse	9	24
Clay, sand, and gravel, interbedded	6	30
Sand and gravel, fine to coarse	20	50

31-6-8aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1956, in NE cor. sec. 8, T. 31 S., R. 6 W., west road shoulder 75 feet south of sec. cor. Surface altitude, 1,520.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, dark brown	5	5
Sand, gravel, and silt	5	10
Sand, fine to medium, silty	5	15
Sand and gravel, fine to coarse, silty	15	30
Sand and gravel, fine to medium	5	35
Sand and gravel, fine to medium, silty	15	50

31-6-8daa.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1956, in NE¼ NE¼ SE¼ sec. 8, T. 31 S., R. 6 W., 30 feet west of center of road in field entrance 0.45 mile north of cor.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, brown	3	3
Sand and silt, red brown	2	5
Silt, red brown	7	12
Sand, fine, red and tan	11	23
Clay, red	1	24
Sand and gravel, fine to coarse; contains clay streaks	6	30
Sand and gravel, fine to coarse	10	40
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	5	45

31-6-9bcc.—*Drillers log of test hole drilled by Layne-Western Co., July 1953, in SW¼ SW¼ NW¼ sec. 9, T. 31 S., R. 6 W.; depth to water, 17 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Soil	1	1
Sand, fine, cemented	4	5
Sand, fine to medium	5	10
Sand, fine to medium; contains clay streaks	9	19
Clay, soft	1	20
Sand, fine to medium; contains clay streaks	3	23

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	28

31-6-14abd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SE¼ NW¼ NE¼ sec. 14, T. 31 S., R. 6 W., in west road ditch opposite field entrance to east. Surface altitude, 1,421.2 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, brown	2	2
Silt, tan	4	6
Silt, red brown	6	12
Sand and gravel, fine to coarse, red	6	18
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	20

31-6-17ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SE cor. sec. 17, T. 31 S., R. 6 W., 6 feet west and 75 feet north of sec. cor. Surface altitude, 1,449.7 feet; dry hole.*

	Thickness, feet	Depth, feet
Soil, black	3	3
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	8	11

31-6-21ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 7, 1955, in SE cor. sec. 21, T. 31 S., R. 6 W. Surface altitude, 1,423.5 feet; dry hole.*

	Thickness, feet	Depth, feet
Topsoil	2	2
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red brown	2	4

31-6-22aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NE cor. sec. 22, T. 31 S., R. 6 W., on south road shoulder 30 feet east of center of highway. Surface altitude, 1,413.8 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, brown	5	5
Silt, red brown	5	10
Silt, tan	10	20
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	22

31-6-24aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE cor. sec. 24, T. 31 S., R. 6 W., 30 feet south and 6 feet west of sec. cor. Surface altitude, 1,382.8 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, red brown	3	3
Silt, clayey, tan	3	6
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, red, sand and gravel, fine to coarse	5	11
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	4	15

31-6-24ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in SE cor. sec. 24, T. 31 S., R. 6 W., 30 feet north and 6 feet west of sec. cor. Surface altitude, 1,365.6 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	2	2
Silt, sandy, brown	5	7
Sand and gravel, fine to coarse	2	9
Silt, red	5	14
Silt, sandy, red	7	21
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	1	22

31-6-25daa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NE¼ SE¼ sec. 25, T. 31 S., R. 6 W., on west road shoulder at ½-mile line. Surface altitude, 1,355.9 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sand, and gravel, red	8	8
Sand, fine to coarse, some fine to coarse gravel	3	11
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	5	16

31-6-28cca.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NE¼ SW¼ SW¼ sec. 28, T. 31 S., R. 6 W., in west borrow pit opposite fence to east. Surface altitude, 1,423.7 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, red brown	8	8
Silt, tan	3	11
Sand and gravel, fine to coarse	4	15
Silt, red	1	16
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	17

31-6-31ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SW cor. sec. 31, T. 31 S., R. 6 W., 50 feet north and 8 feet west of center of "T" road. Surface altitude, 1,418.7 feet; depth to water, 12.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	6	6
Silt, sandy, limy, gray	1	7
Sand and gravel, fine to coarse	5	12
Silt, fine sandy, red brown	6	18
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	20

31-6-32aac.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SW¼ NE¼ NE¼ sec. 32, T. 31 S., R. 6 W., at field entrance to west between RR. and highway. Surface altitude, 1,414.6 feet; depth to water, 20.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, tan	5	5
Silt, sand, and gravel, brown	2	7
Silt, red brown	6	13
Clay, red brown	2	15
Sand and gravel, silty, red	4	19
Silt, red	8	27
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	28

31-6-36aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE cor. sec. 36, T. 31 S., R. 6 W., 30 feet south and 6 feet west of sec. cor. Surface altitude, 1,356.4 feet; depth to water, 24.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, red	10	10
Silt, red brown	10	20
Silt, fine sandy, red brown	16	36
Silt, sand, and gravel, tan	11	47
Silt, sandy, tan	6	53
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	1	54

31-6-36daa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NE¼ SE¼ sec. 36, T. 31 S., R. 6 W., 700 feet south of creek on east road shoulder. Surface altitude, 1,337.8 feet; depth to water, 12.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, dark brown	4	4
Silt, fine sandy, red brown	8	12
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, fine sandy, gray	3	15
Sand and gravel, fine to coarse, very silty	15	30
Sand and gravel, fine to coarse; contains silt streaks near bottom	8	38
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red brown	1	39

31-7-1bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NW cor. sec. 1, T. 31 S., R. 7 W., at sec. cor. in south road ditch. Surface altitude, 1,587.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, brown	2	2
Clay and silt	3	5
Sand and gravel, fine to coarse, silty, brown	15	20
Sand and gravel, fine to coarse	15	35
Sand, fine to coarse	5	40
Sand and gravel, fine to coarse	5	45

31-7-1cdd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 12, 1956, in SE cor. SW¼ sec. 1, T. 31 S., R. 7 W.; depth to water, 6.70 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, fine sandy, red brown	5	5
Sand, fine to medium, silty	5	10
Sand, fine to coarse	7	17
Silt, fine sandy, red	2	19
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	20

31-7-3bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NW cor. sec. 3, T. 31 S., R. 7 W., in triangle formed by road curves in line with center of road to south. Surface altitude, 1,594.1 feet; depth to water, 40.63 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, brown	3	3
Sand and gravel, fine to coarse, clayey	2	5
Sand and gravel, fine to coarse	2	7
Silt, tan	3	10

Nebraskan Stage	Thickness, feet	Depth, feet
Clay, gray	8	18
Sand, fine to coarse	2	20
Clay, gray	3	23
Sand and clay, interbedded	2	25
Sand and gravel, fine to coarse	10	35
Sand and gravel, fine to coarse; contains clay streaks	15	50

31-7-18bac.—*Drillers log of test hole at site of irrigation well drilled by Layne-Western Co., July 1953, in SW¼ NE¼ NW¼ sec. 18, T. 31 S., R. 7 W. Surface altitude, 1,595.5 feet; depth to water, 36.70 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt	1	1
Clay, brown and yellow	5	6
Sand, medium, silty	7	13
Clay, tough, gray	3	16
Clay, soft, blue	9	25
Sand, medium to coarse	5	30
Sand, gravel, medium	10	40
Nebraskan Stage		
Clay, soft, brown	9	49
Clay, sandy	7	56
Clay	6	62
Sand, fine	3	65
Clay	5	70
Sand, fine to coarse, clay streaks	13	83
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	86

31-7-18bca.—*Drillers log of test hole drilled by Layne-Western Co., July 1953, in NE¼ SW¼ NW¼ sec. 18, T. 31 S., R. 7 W.; depth to water, 33 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Soil	1	1
Clay, hard, brown	1	2
Sand, cemented, brown	3	5
Clay, hard	7	12
Clay, sandy, red	1	13
Sand, fine, red	2	15
Gravel, medium to coarse	10	25
Sand, medium to coarse	5	30
Nebraskan Stage		
Sand, fine, clayey	5	35
Clay, hard, yellow	5	40
Sand, fine; contains clay streaks	19	59
Clay, soft	2	61
Sand, fine; contains clay streaks	8	69
Clay	1	70
Sand, fine; contains clay streaks	3	73

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	76

31-7-20cdc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in SW¼ SE¼ SW¼ sec. 20, T. 31 S., R. 7 W., 0.3 mile east of sec. cor. at curve and on north road shoulder. Surface altitude, 1,508.0 feet; depth to water, 7.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, black	2	2
Silt, sandy, red	4	6
Sand and gravel, fine to coarse	3	9
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	10

31-7-21ddc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in SW¼ SE¼ SE¼ sec 21, T. 31 S., R. 7 W., 0.2 mile west of sec. cor. on north road shoulder. Surface altitude, 1,500.9 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, black	2	2
Sand and gravel, fine to coarse, silty, red	6	8
Silt, clayey, red	3	11
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	13

31-7-24cdd.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SE¼ SE¼ SW¼ sec. 24, T. 31 S., R. 7 W., 8 feet north and 30 feet west of sec. cor. Surface altitude, 1,455.8 feet; depth to water, 11.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	5	5
Silt, tan	5	10
Silt, pink and tan	5	15
Silt, tan	15	30
Silt, very sandy, tan	5	35
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	36

31-7-25aab.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NW¼ NE¼ NE¼ sec. 25, T. 31 S., R. 7 W., on south road shoulder in field entrance 60 feet west of bridge. Surface altitude, 1,443.3 feet; depth to water, 6.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, black	3	3
Silt, sandy, fine, brown	2	5
Silt, tan	10	15
Silt, gray	5	20
Silt, sandy, fine, gray green	5	25
Silt, tan red	1	26

31-7-25bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NW cor. sec. 25, T. 31 S., R. 7 W., on east road shoulder 60 feet south of sec. cor. Surface altitude, 1,473.2 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	3	3
Silt, sandy, fine, brown	2	5
Silt, red	4	9
Gravel, fine to coarse, silty, red	1	10
Silt, red; contains sand and gravel	2	12
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	15

31-7-27baa.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NE¼ NE¼ NW¼ sec. 27, T. 31 S., R. 7 W., on south road shoulder 150 feet east of bridge. Surface altitude, 1,494.3 feet; depth to water, 14.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	3	3
Clay, fine sandy, tan	3	6
Sand and gravel, fine to coarse	3	9
Clay, red	6	15
Silt, red	5	20
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	21

31-7-28bab.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NW¼ NE¼ NW¼ sec. 28, T. 31 S., R. 7 W., on south road shoulder 70 feet west of bridge. Surface altitude, 1,505.8 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, brown	8	8
Sand and gravel, fine to coarse, silty	3	11
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	12

31-7-29aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NE cor. sec. 29, T. 31 S., R. 7 W., on south road shoulder 50 feet west of sec. cor. Surface altitude 1,506.2 feet; depth to water, 17.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, brown	4	4
Clay, sandy, tan	1	5
Sand and gravel, fine to coarse; contains clay streaks	5	10
Sand, fine to coarse; contains clay streaks	3	13
Clay, tan	2	15
Silt, red	11	26
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	27

31-7-30aab.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in NW¼ NE¼ NE¼ sec. 30, T. 31 S., R. 7 W., on south road shoulder by second power pole west of corner. Surface altitude, 1,550.6 feet; depth to water, 20.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, brown	4	4
Silt, sand, and gravel	1	5
Sand, fine to coarse	5	10
Sand, fine to coarse; contains clay streaks	10	20
Sand, fine to coarse, silty	5	25
Sand and gravel, coarse	8	33
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	34

31-7-30aba.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NW¼ NE¼ sec. 30, T. 31 S., R. 7 W., 0.3 mile west of corner in drive to house. Surface altitude, 1,531.9 feet; depth to water, 10.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, sandy, brown	7	7
Silt, gray to tan	2	9
Silt, red	2	11
Sand, fine to medium, silty	2	13
Silt, sandy, red	1	14
Sand and gravel, fine to coarse, silty	2	16
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	17

31-7-30baa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NE¼ NW¼ sec. 30, T. 31 S., R. 7 W., on south road shoulder 200 feet east of bridge. Surface altitude, 1,525.9 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, black	7	7
Sand and gravel, fine to coarse, silty	2	9
Silt, clayey, red	2	11
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	12

31-7-31aab.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NW¼ NE¼ NE¼ sec. 31, T. 31 S., R. 7 W., 0.25 mile west of corner on south road shoulder. Surface altitude, 1,482.7 feet; depth to water, 4.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, black	4	4
Sand, fine to medium	2	6
Sand and gravel, fine to coarse, silty	6	12
Silt, sandy, gray	4	16
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	17

31-7-31bba.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NW¼ NW¼ sec. 31, T. 31 S., R. 7 W., 0.25 mile east of sec. corner on south road shoulder. Surface altitude, 1,498.7 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	3	3
Sand and gravel, fine to coarse, silty, brown	5	8
Silt, red	8	16
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	17

31-7-32aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE cor. sec. 32, T. 31 S., R. 7 W., 100 feet west and 5 feet south of sec. cor. Surface altitude, 1,460.3 feet; depth to water, 5.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, dark brown	3	3
Silt, sandy, red	4	7
Sand and gravel, fine	4	11
Silt, tan; contains sand streaks	5	16
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	18

31-7-32baa.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NE¼ NE¼ NW¼ sec. 32, T. 31 S., R. 7 W., on south road shoulder 100 feet west of ½-mile line. Surface altitude, 1,473.1 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, black	6	6
Sand and gravel, fine, very silty	1	7
Silt, sandy, red brown	1	8
Sand and gravel, fine to coarse	1	9
Silt, sandy, light gray	1	10
Sand and gravel, fine to coarse	2	12
Silt, sandy, red	2	14
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	15

31-7-32bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW cor. sec. 32, T. 31 S., R. 7 W., 250 feet south and 6 feet east of sec. cor. Surface altitude, 1,481.6 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, very silty, brown	4	4
Sand, fine to coarse	2	6
Sand and gravel, fine to coarse	6	12
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	15

31-7-32ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE cor. sec. 32, T. 31 S., R. 7 W., in field entrance north side of road at sec. cor. Surface altitude, 1,450.7 feet; depth to water, 6.70 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	2	2
Clay, sandy, red	3	5
Sand, silty, red	2	7
Sand and gravel, coarse	8	15
Sand and gravel, fine to coarse; contains silt streaks	35	50

31-7-33aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 33, T. 31 S., R. 7 W., 70 feet west and 6 feet south of sec. cor. Surface altitude, 1,471.0 feet; depth to water, 13.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	5	5
Silt, sandy, brown	2	7
Silt, sandy, tan	2	9
Sand, fine, silty, tan	4	13

	Thickness, feet	Depth, feet
Silt, red	8	21
Silt, sandy, red	8	29
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	30

31-7-33baa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NE¼ NW¼ sec. 33, T. 31 S., R. 7 W., 200 feet west and 5 feet south of ½-mile line. Surface altitude, 1,466.1 feet; depth to water, 9.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, dark brown	6	6
Silt, red	2	8
Sand and gravel, fine to coarse; contains silt streaks	3	11
Silt, clayey and sandy, red	16	27
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	29

31-7-33dcc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW¼ SW¼ SE¼ sec. 33, T. 31 S., R. 7 W., on north road shoulder at ½-mile line. Surface altitude, 1,454.3 feet; depth to water, 22.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	3	3
Clay, sandy, coarse, red	4	7
Sand and gravel, coarse, silty, red	10	17
Sand and gravel, fine to coarse	13	30
Sand and gravel, coarse	9	39
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	40

31-7-33ddb.—*Drillers log of test hole drilled by Layne-Western Co., July 1953, in NW¼ SE¼ SE¼ sec. 33, T. 31 S., R. 7 W.; depth to water, 21 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Clay, gray	3	4
Clay, red	32	36
Sand, fine to medium, silty	4	40
Clay, red	8	48
Sand, fine to medium	7	55
Sand and gravel, fine to coarse	5	60
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	65

31-7-34baa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NE¼ NW¼ sec. 34, T. 31 S., R. 7 W., 100 feet west of bridge on south road shoulder. Surface altitude, 1,461.6 feet; depth to water, 9.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	4	4
Sand and gravel, fine to coarse, silty	3	7
Silt, red	5	12
Sand and gravel, fine to coarse	4	16
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	17

31-7-34ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW cor. sec. 34, T. 31 S., R. 7 W., 6 feet east and 50 feet north of sec. cor. Surface altitude, 1,453.5 feet; depth to water, 22.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	3	3
Clay, sandy, brown	2	5
Sand and gravel, fine to coarse, silty, tan	5	10
Silt, tan	10	20
Silt, tan, some medium gravel	5	25
Silt, pink	5	30
Silt, sandy, pink to tan	6	36
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	37

31-7-34ddd.—*Sample log of test hole drilled by Federal and State Geological Surveys, August 1955, in SE cor. sec. 34, T. 31 S., R. 7 W., 8 feet west and 30 feet north of sec. cor. Surface altitude, 1,441.4 feet; depth to water, 27.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	2	2
Silt, clayey, brown	3	5
Clay, brown, some coarse gravel	7	12
Silt, sandy, red brown, some gravel	8	20
Sand, silty, red brown	15	35
Sand and gravel, fine to medium, silty	15	50
Sand and gravel, fine to coarse	27	77
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	3	80

31-7-35bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NW cor. sec. 35, T. 31 S., R. 7 W., 50 feet east and 5 feet south of sec. cor. Surface altitude, 1,467.3 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and silt, red	6	6
Silt, red	2	8
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	9

31-7-35cdd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE¼ SE¼ SW¼ sec. 35, T. 31 S., R. 7 W., on north road shoulder 20 feet west of ½-mile line. Surface altitude, 1,440.1 feet; depth to water, 24.90 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	3	3
Clay, red brown; some coarse gravel	2	5
Silt, red brown; some coarse gravel	5	10
Silt, red	15	25
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	15	40

31-7-36ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, June 1955, in SW cor. sec. 36, T. 31 S., R. 7 W., north road shoulder 150 feet east of highway. Surface altitude, 1,439.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	4	4
Clay, brown	5	9
Silt, red	2	11
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	12

31-8-5caa.—*Drillers log of well drilled by Lyman Implement Co., January 1956, in NE¼ NE¼ SW¼ sec. 5, T. 31 S., R. 8 W. Surface altitude, 1,665.4 feet; depth to water, 73.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Soil	3	3
Sand, fine to coarse	18	21
Clay, gray white	6	27
Clay, reddish brown	3	30
Sand, fine to medium	31	61
Sand, fine to medium, and clay	19	80
Sand, fine to medium	22	102
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	103

31-8-5ccb.—*Drillers log of test hole drilled by Lyman Implement Co., January 1956, in NW¼ SW¼ SW¼ sec. 5, T. 31 S., R. 8 W. Surface altitude, 1,687.8 feet; depth to water, 74 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Soil	5	5
Sand, fine to coarse	26	31
Clay, sandy, yellow	2	33
Clay, sandy, white	3	36
Clay, sandy, yellow	5	41
Sand, fine to coarse	3	44
Clay, sandy, white	8	52
Sand, fine	6	58
Clay, sandy, red	2	60
Sand, medium	2	62
Clay, sandy, white	10	72
Sand, fine to coarse	14	86
Clay, hard, white	6	92

31-8-5ccc2.—*Drillers log of well drilled by Lyman Implement Co., January 1956, in SW¼ SW¼ SW¼ sec. 5, T. 31 S., R. 8 W.; depth to water, 76 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Soil	3	3
Sand and gravel, fine to coarse	15	18
Clay, sandy, white	16	34
Sand, medium to coarse, and white clay	8	42
Sand, fine to medium	6	48
Clay, sandy, yellow	8	56
Sand, medium to coarse, and clay	12	68
Clay, yellow	5	73
Sand, fine to coarse	23	96
Clay, sandy, white	9	105
Sand, fine	2	107
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, hard, red	1	108

31-8-17ccd.—*Sample log of test hole drilled by Air Made Well Co., January 15, 1955, in SE¼ SW¼ SW¼ sec. 17, T. 31 S., R. 8 W. Surface altitude, 1,624.8 feet; depth to water, 49 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, sandy, dark red brown	4	4
Clay, coarse sandy	36	40
Clay, yellow	3	43
Sand, medium and coarse	47	90
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	3	93

31-8-19aaa2.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NE cor. sec. 19, T. 31 S., R. 8 W. Surface altitude, 1,628.6 feet; depth to water, 52.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, sandy	4	4
Clay, sandy, white	33	37
Sand, fine	38	75
Sand, fine to coarse, streaks of yellow clay at 77 to 85 feet	22	97
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	6	103

31-8-19daa.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NE¼ NE¼ SE¼ sec. 19, T. 31 S., R. 8 W.; depth to water, 35 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Clay, sandy	3	3
Clay, sandy, yellow	9	12
Gravel, coarse, and clay	3	15
Clay, yellow	30	45
Sand, fine to medium coarse	22	67
Sand, medium to coarse	5	72
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	3	75

31-8-19ddb.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NW¼ SE¼ SE¼ sec. 19, T. 31 S., R. 8 W. Surface altitude, 1,608.9 feet; depth to water, 35.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, sandy	5	5
Sand, fine, and clay	10	15
Sand, some clay	17	32
Sand, fine and medium coarse	27	59
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	60

31-8-29bbb.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NW cor. sec. 29, T. 31 S., R. 8 W. Surface altitude, 1,591.6 feet; depth to water, 33 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, sandy, yellow	7	7
Clay, sandy, yellow	5	12
Clay, sandy	15	27
Sand, fine to coarse	32	59

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	3	62

31-8-29bcc.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in SW¼ SW¼ NW¼ sec. 29, T. 31 S., R. 8 W. Surface altitude, 1,569.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, sandy	4	4
Clay, reddish	7	11
Sand, medium to coarse	14	25
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	26

31-8-30aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 11, 1956, in NE cor. sec. 30, T. 31 S., R. 8 W. Surface altitude 1,590.1 feet; depth to water, 34.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, fine sandy, tan	10	10
Sand, fine to coarse, very silty, tan	15	25
Silt, tan	5	30
Sand, fine to coarse, and fine to medium gravel	15	45
Silt, fine sandy, tan	5	50
Gravel, fine to coarse, and fine to coarse sand	5	55

32-5-3bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 3, T. 32 S., R. 5 W., east road shoulder 150 feet south of bridge. Surface altitude, 1,294.5 feet; depth to water, 8.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, gray, and fine sand	3	3
Silt, sandy, black	5	8
Wisconsinan Stage—Slope deposits		
Silt, buff	2	10
Sand and gravel, fine to coarse	7	17
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	2	19

32-5-3bcc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in SW¼ SW¼ NW¼ sec. 3, T. 32 S., R. 5 W., east road shoulder at south end of row of trees. Surface altitude, 1,309.6 feet; depth to water, 13.70 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	5	5
Silt, red	5	10
Sand, fine, red	2	12
Sand, fine to coarse	3	15
Sand and gravel, fine to coarse	3	18
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	19

32-5-3ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW cor. sec. 3, T. 32 S., R. 5 W., 150 feet north and 6 feet east of sec. cor. Surface altitude, 1,313.1 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	2	2
Silt, sandy, tan	3	5
Sand, fine, very silty, buff	3	8
Sand, fine, well sorted	2	10
Sand and gravel, fine to coarse	3	13
Sand and gravel, fine to coarse, silty	2	15
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	3	18

32-5-5aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 5, T. 32 S., R. 5 W., 100 feet west and 6 feet south of center of "T" road. Surface altitude, 1,314.9 feet; depth to water, 19.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, gray brown	3	3
Silt, sandy, tan	4	7
Silt, sandy, light gray	2	9
Sand and gravel, fine to coarse	6	15
Sand and gravel, fine to coarse, silty	3	18
Sand and gravel, fine to coarse	3	21
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	22

32-5-6aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 6, T. 32 S., R. 5 W., 150 feet west and 8 feet south of sec. cor. Surface altitude, 1,331.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, gray	2	2
Silt, sandy, tan	1	3
Silt, tan	2	5
Sand, fine, very silty, red	2	7
Sand and gravel, fine to coarse, silty	2	9
Silt, sandy, brown	3	12
Sand, fine	5	17
Sand and gravel, fine to coarse	4	21
Sand and gravel, fine to coarse, silty	2	23
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	2	25

32-5-6cbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NW¼ NW¼ SW¼ sec. 6, T. 32 S., R. 5 W., east road shoulder at south RR. right of way fence. Surface altitude, 1,354.4 feet; depth to water, 29.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, dark brown to black	3	3
Silt, sandy, reddish brown	8	11
Silt, red	10	21
Silt, sandy, fine, red	9	30
Silt, sandy, brown	5	35
Sand and gravel, fine to coarse	34	69
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	70

32-5-6ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in SW cor. sec. 6, T. 32 S., R. 5 W., east road shoulder 100 feet north of highway. Surface altitude, 1,358.0 feet; depth to water, 31.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	7	7
Silt, red brown	14	21
Silt, sandy, buff	9	30
Sand and gravel, fine to coarse, silty	12	42
Silt, sandy, tan	4	46
Sand and gravel, fine to coarse	11	57
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, silty, red	1	58

32-5-9add.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE¼ SE¼ NE¼ sec. 9, T. 32 S., R. 5 W., 0.4 mile south of highway in drive to field to east. Surface altitude, 1,307.7 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	5	5
Silt, red	4	9
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, silty, red	1	10

32-5-9ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE cor. sec. 9, T. 32 S., R. 5 W., 100 feet north and 8 feet west of sec. cor. Surface altitude, 1,301.4 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	3	3
Silt, red	6	9
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	10

32-5-16add.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE¼ SE¼ NE¼ sec. 16, T. 32 S., R. 5 W., on west road shoulder 0.1 mile north of ½-mile line. Surface altitude, 1,299.8 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, gray, brown	3	3
Silt, red brown	1	4
Silt, clayey, black	1	5
Silt, red	3	8
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	2	10

32-5-21ada.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE¼ SE¼ NE¼ sec. 21, T. 32 S., R. 5 W., 150 feet north of bridge on west road shoulder. Surface altitude, 1,276.5 feet; depth to water, 10.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, black	5	5
Silt, sandy, dark brown	2	7
Sand, fine, very silty	4	11
Sand and gravel, fine to coarse, silty	9	20
Sand and gravel, fine to coarse, and cobbles; much locally derived gravel	6	26
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	2	28

32-5-28aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 28, T. 32 S., R. 5 W., 100 feet west and 8 feet south of sec. cor. Surface altitude, 1,297.1 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	5	5
Silt, tan	2	7
Sand, fine, silty	3	10
Sand and gravel, fine to coarse, silty	3	13
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	1	14

32-5-33aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 33, T. 32 S., R. 5 W., 100 feet west and 5 feet south of sec. cor. Surface altitude, 1,298.8 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, red brown	3	3
Silt, brown	5	8
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	2	10

32-6-1aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 1, T. 32 S., R. 6 W., 150 feet west and 6 feet south of sec. cor. Surface altitude, 1,356.6 feet; depth to water, 29.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, dark brown	3	3
Silt, brown	2	5
Silt, sandy, reddish brown	11	16
Sand, fine	7	23
Sand and gravel, fine to coarse	10	33
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red and gray	2	35

32-6-1bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 1, T. 32 S., R. 6 W., 100 feet east and 6 feet south of sec. cor. Surface altitude, 1,362.9 feet; depth to water, 22.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, gray brown	2	2
Silt, tan	14	16
Silt, sandy, brown	9	25
Silt, tan, and fine sand	10	35
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	3	38

32-6-3aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 3, T. 32 S., R. 6 W., 400 feet west and 8 feet south of sec. cor. Surface altitude, 1,371.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	7	7
Silt, tan	2	9
Silt, sandy, brown	12	21
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	23

32-6-3cca.—*Drillers log of test hole drilled by Layne-Western Co., July 1953, in NE¼ SW¼ SW¼ sec. 3, T. 32 S., R. 6 W. Surface altitude, 1,375.1 feet; depth to water, 20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	2	2
Clay, red	21	23
Clay, sandy, red	3	26
Sand, medium to coarse, brown	4	30
Sand and gravel, medium to coarse	10	40
Clay, red	3	43
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	50

32-6-4aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 4, T. 32 S., R. 6 W., 100 feet west and 6 feet south of sec. cor. Surface altitude, 1,384.2 feet; depth to water, 24.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	3	3
Silt, red brown	12	15
Silt, sandy, red brown	10	25

32-6-4bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 4, T. 32 S., R. 6 W., in center of trail 50 feet south of center of road. Surface altitude, 1,385.4 feet; depth to water, 17.60 feet.*

	Thickness, feet	Depth feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, gray brown	5	5
Silt, sandy, brown	10	15
Silt, sandy, tan	6	21
Sand and gravel, fine to coarse, silty	8	29
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	30

32-6-4dcc.—*Drillers log of irrigation well drilled by Layne-Western Co., July 1953, in SW¼ SW¼ SE¼ sec. 4, T. 32 S., R. 6 W. Surface altitude 1,376.4 feet; depth to water, 18 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Clay	2	3
Clay, red	14	17
Clay, red, soft	5	22
Sand, fine, cavey	3	25
Sand, medium fine to coarse	25	50
Sand, medium fine to coarse, some gravel	5	55
Clay, soft silt, and medium sand, interbedded	9	64
Sand, medium fine, some clay	6	70
PERMIAN—Leonardian		
Harper Siltstone		
Sandstone, shaly, red	10	80

32-6-6aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 6, T. 32 S., R. 6 W., 35 feet east of highway on south road shoulder. Surface altitude, 1,406.7 feet; depth to water, 16.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	2	2
Silt, tan (hard)	3	5
Silt, red tan	3	8
Sand and gravel, fine to coarse, silty	2	10
Silt, reddish tan	7	17
Sand, fine, red brown, and silt	3	20
Sand and gravel, fine to coarse, silty	20	40

32-6-6aac.—*Sample log of test hole drilled by Federal and State Geological Surveys, August 1955, in SW¼ NE¼ NE¼ sec. 6, T. 32 S., R. 6 W., east highway ditch at entrance to sand pit. Surface altitude, 1,405.6 feet; depth to water, 17.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, silty, tan	6	6
Silt, fine sandy, tan	6	12
Silt, sand, and gravel, interbedded	9	21
Sand and gravel, fine to coarse	8	29
Silt, tan	2	31
Sand and gravel, fine to coarse	9	40
Sand and gravel, fine to coarse, silty	10	50
Silt, sand, and gravel, interbedded	10	60
Sand and gravel, fine to coarse	12	72
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	74

32-6-9bad1—*Drillers log of test hole drilled by Layne-Western Co., July 1953, in SE¼ NE¼ NW¼ sec. 9, T. 32 S., R. 6 W.; depth to water, 15 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Soil	1	1
Clay, sandy	2	3
Clay, yellow	10	13
Clay, sandy	3	16
Sand, fine, and clay	4	20
Sand and gravel, coarse, clay streaks	5	25
Clay	2	27
Sand, medium coarse, clayey	3	30
Sand, clayey	7	37
Clay, sandy	3	40
Sand and gravel, coarse	6	46
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	50

32-6-9bad2.—*Drillers log of test hole drilled by Layne-Western Co., July 1953, in SE¼ NE¼ NW¼ sec. 9, T. 32 S., R. 6 W.; depth to water, 14 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Soil	1	1
Clay, yellow	11	12
Sand, fine to coarse, and clay	3	15
Clay, sandy	7	22
Sand and gravel, fine to medium; clay streaks	8	30
Clay	1	31
Sand and gravel, medium to coarse, cemented	5	36
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	40

32-6-9bbc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW¼ NW¼ NW¼ sec. 9, T. 32 S., R. 6 W., 0.15 mile south of highway on east road shoulder at south edge of old house. Surface altitude, 1,378.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	3	3
Silt, brown	2	5
Silt, tan	10	15
Silt, sandy and clayey, tan	8	23
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	24

32-6-12daa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NE¼ SE¼ sec. 12, T. 32 S., R. 6 W., 0.1 mile south of ½-mile line on west shoulder. Surface altitude, 1,342.9 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	3	3
Silt, sandy, red brown	7	10
Silt, brown	4	14
Sand, fine, very silty	8	22
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	2	24

32-6-13aad.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in SE¼ NE¼ NE¼ sec. 13, T. 32 S., R. 6 W., 0.15 mile south of sec. cor. on west road shoulder. Surface altitude, 1,330.9 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, dark brown	4	4
Sand and gravel, fine to coarse, silty	5	9
Silt, sandy, red	3	12
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, silty, red and gray	3	15

32-6-13daa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NE¼ SE¼ sec. 13, T. 32 S., R. 6 W., on west road shoulder 300 feet north of bridge. Surface altitude, 1,318.4 feet; depth to water, 11.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand, fine, and silt, brown	7	7
Sand, fine to coarse, silty	11	18
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	2	20

32-6-17bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 17, T. 32 S., R. 6 W., east road shoulder on east-west section line. Surface altitude, 1,405.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	2	2
Silt, red tan	16	18
Silt, sandy, red	7	25
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	7	32

32-7-2cac.—*Drillers log of test hole drilled at site of public-supply well by Layne-Western Co., July 1935, in SW¼ NE¼ SW¼ sec. 2, T. 32 S., R. 7 W. Surface altitude, 1,428.8 feet; depth to water, 27 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, red	15	15
Silt, sandy, caliche, red	2	17
Silt, sandy, red	18	35
Sand, fine	5	40
Gravel, coarse	14	54
Sand, fine	1	55
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	56

32-7-4bbb.—*Sample log of test hole drilled by Federal and State Geological Surveys, August 1955, in NW cor. sec. 4, T. 32 S., R. 7 W., 50 feet east and 6 feet south of sec. cor. Surface altitude, 1,451.3 feet; depth to water, 8.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, brown	4	4
Sand and gravel, fine to coarse, silt streaks	6	10
Sand and gravel, fine to coarse	16	26
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, clayey, sandy, brown	12	38
Sand and gravel, fine to coarse, cemented at top	16	54
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty and sandy, red	5	59

32-7-4cdd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in SE¼ SE¼ SW¼ sec. 4, T. 32 S., R. 7 W., north road shoulder 150 feet east of ½-mile line. Surface altitude, 1,436.6 feet; depth to water, 22.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	7	7
Silt, red brown	5	12
Silt, sandy, brown	4	16
Sand and gravel, fine to coarse, very silty	2	18
Silt, sandy, gray	5	23
Silt, red	7	30
Silt, red, and fine to coarse sand and gravel	12	42
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty and sandy, red	2	44

32-7-4daa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NE¼ SE¼ sec. 4, T. 32 S., R. 7 W., 5 feet west and 150 feet south of ¼-mile cor. Surface altitude, 1,442.9 feet; depth to water, 28.90 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	5	5
Silt, light brown	10	15
Silt, sandy, light tan	20	35
Silt, tan, and fine sand	17	52
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	54

32-7-4ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE cor. sec. 4, T. 32 S., R. 7 W., 50 feet north and 8 feet west of sec. cor. Surface altitude, 1,436.8 feet; depth to water, 22.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, gray brown	3	3
Silt, sandy, brown	3	6
Silt, sandy, reddish brown	26	32
Sand and gravel, fine to coarse, silty at top	8	40

32-7-5abb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW¼ NW¼ NE¼ sec. 5, T. 32 S., R. 7 W., in field entrance 15 feet south of center of road 15 feet west of bridge. Surface altitude, 1,454.8 feet; depth to water, 5.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand and gravel, fine to coarse, silty, tan	5	5
Sand and gravel, coarse	5	10
Sand and gravel, fine to coarse, silt streaks	10	20
Sand and gravel, fine to medium, silty	13	33
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	34

32-7-5bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 5, T. 32 S., R. 7 W., 50 feet south of center of east-west road on east road shoulder. Surface altitude, 1,463.3 feet; depth to water, 10.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	3	3
Silt, tan	2	5
Sand and gravel, fine to coarse, silty	5	10
Silt, fine sandy, gray	4	14
Silt, very fine sandy, red	6	20
Sand, fine to coarse, very silty	3	23

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	24

32-7-6bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 6, T. 32 S., R. 7 W., in triangle formed by road curve at east side of triangle. Surface altitude, 1,473.1 feet; depth to water, 21.70 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to coarse, silty	3	3
Sand, fine to coarse, silty	5	8
Sand and gravel, fine to coarse	8	16
Sand and gravel, fine to coarse, silty	2	18
Silt, clayey and sandy, buff	7	25
Sand and gravel, fine to coarse, silty	12	37
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	39

32-7-7bba.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NW¼ NW¼ sec. 7, T. 32 S., R. 7 W., on south road ditch 5 feet east of low water bridge; depth to water, 8.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand and gravel, fine to coarse, silty	3	3
Silt, sandy, red brown	8	11
Sand, fine to medium, silty	7	18
PERMIAN—Leonardian		
Harper Siltstone		
Shale, sandy, red	10	28

32-7-8abb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NW¼ NW¼ NE¼ sec. 8, T. 32 S., R. 7 W., on south road shoulder 200 feet east of bridge. Surface altitude, 1,436.5 feet; depth to water, 12.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, brown	6	6
Sand and gravel, fine to coarse, silty	3	9
Silt, sandy, brown	7	16
Sand and gravel, fine to coarse, very silty	2	18
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	19

32-7-8cbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NW¼ NW¼ SW¼ sec. 8, T. 32 S., R. 7 W., east road shoulder 100 feet south of ½-mile line. Surface altitude, 1,439.4 feet; depth to water, 23.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	4	4
Silt, brown	9	13
Sand and gravel, fine to coarse, silty	4	17
Sand and gravel, fine to coarse	9	26
Silt, soft, very sandy, tan	4	30
Sand, fine to medium, very silty, tan	20	50
Sand, fine, very silty, tan	12	62
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	64

32-7-9bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NW cor. sec. 9, T. 32 S., R. 7 W., on north road shoulder 100 feet west of bridge. Surface altitude, 1,429.3 feet; depth to water, 20.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, brown	3	3
Sand and gravel, fine to coarse	5	8
Silt, sandy, brown	4	12
Silt, brown	6	18
Sand and gravel, fine to coarse, silty	19	37
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	39

32-7-9daa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE¼ NE¼ SE¼ sec. 9, T. 32 S., R. 7 W., in drive to west at ½-mile line. Surface altitude, 1,427.9 feet; depth to water, 36.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, dark gray	2	2
Silt, sandy, brown	23	25
Silt, sandy, buff	10	35
Sand and gravel, fine to coarse, silt streaks	35	70

32-7-11bcc.—*Sample log of test hole drilled by Federal and State Geological Surveys, August 1955, in SW¼ SW¼ NW¼ sec. 11, T. 32 S., R. 7 W., on east road shoulder 100 feet north of ½-mile line. Surface altitude, 1,427.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, red brown	2	2
Silt, sandy, tan brown	5	7
Silt, sandy, tan	9	16
Silt, tan, some caliche at 19 to 20 ft.	5	21

	Thickness, feet	Depth, feet
Silt, very sandy, gray buff	5	26
Silt, red brown, some sand at top, more fine sand below 34 ft.	22	48
Sand and gravel, fine to coarse	9	57
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red and gray	3	60

32-7-12cca.—*Drillers log of test hole drilled by Layne-Western Co., October 1953, in NE¼ SW¼ SW¼ sec. 12, T. 32 S., R. 7 W. Surface altitude, 1,426.1 feet; depth to water, 24 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Clay, black and brown	4	5
Clay, red	10	15
Clay, brown and red	5	20
Clay, sandy	5	25
Clay, red and gray	15	40
Sand, fine, silty, and clay streaks	5	45
Clay and fine sand	7	52
Sand, fine to medium, clay streaks	4	56
Sand, medium to coarse, few clay streaks	16	72
Clay, interbedded fine sand	5	77
Sand, fine to medium	3	80
Sand and gravel, medium to coarse, clay streaks	11	91
Sand and gravel, fine to coarse, interbedded clay	5	96
Clay	3	99
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	100

32-7-12ccb.—*Drillers log of observation well drilled by Layne-Western Co., July 1953, in NW¼ SW¼ SW¼ sec. 12, T. 32 S., R. 7 W. Surface altitude, 1,426.0 feet; depth to water, 34.81 feet, July 18, 1956.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Clay, sandy, red	3	4
Clay, red and yellow	16	20
Clay, gray and red	10	30
Clay, soft, fine sandy, red	7	37
Sand, medium, clay streaks	3	40
Clay, soft, sandy, red	14	54
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	6	60

32-7-12ccb2.—*Drillers log of test hole drilled by Layne-Western Co., October 1953, in NW¼ SW¼ SW¼ sec. 12, T. 32 S., R. 7 W. Surface altitude, 1,423.6 feet; depth to water, 22 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Clay, red	19	20
Clay, sandy, red	6	26
Clay, caliche	4	30
Sand, fine, silty	6	36
Clay, soft, red	5	41
Clay, brown, tough	8	49
Clay, sandy, sand streaks	3	52
Sand and gravel, medium to coarse, clay streaks	8	60
Sand, medium to fine, clayey	5	65
Clay	2	67
Sand and gravel, fine to coarse, clay streaks	5	72
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	75

32-7-12ccb3.—*Drillers log of test hole drilled by Layne-Western Co., October 1953, in NW¼ SW¼ SW¼ sec. 12, T. 32 S., R. 7 W. Surface altitude, 1,422.1 feet; depth to water, 23 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Clay, brown	3	4
Clay, blue gray	9	13
Clay, brown	10	23
Clay, gray and brown, soft	5	28
Sand, fine, clayey	7	35
Clay	1	36
Sand, fine to medium, thick streaks of clay	9	45
Sand, fine to coarse, clay streaks	5	50
Sand, medium coarse	8	58
Clay	1	59
Sand, fine to coarse, some fine gravel	26	85
Sand and gravel, medium to coarse	12	97
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	100

32-7-12ccb4.—*Drillers log of test hole drilled by Layne-Western Co., October 1953, in NW¼ SW¼ SW¼ sec. 12, T. 32 S., R. 7 W.; depth to water, 23 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Clay, blue	4	5
Clay, brownish gray	5	10
Clay, brown	13	23

	Thickness, feet	Depth, feet
Clay, sandy, brown	18	41
Clay	10	51
Sand, medium	6	57
Sand, fine to coarse, few clay streaks	23	80
Clay, dark gray, soft	10	90
Sand and gravel, fine to coarse	9	99
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	101

32-7-12ccc2.—*Drillers log of test hole drilled by Layne-Western Co., August 1953, in SW cor. sec. 12, T. 32 S., R. 7 W. Surface altitude, 1,423.6 feet; depth to water, 20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, gray	5	5
Clay, red and gray, hard	10	15
Clay, sandy, gray	10	25
Clay, gray	5	30
Clay, sandy, red	7	37
Sand, fine to medium, clay streaks	9	46
Clay, sandy	4	50
Sand, fine, clay streaks	15	65
Sand, medium	5	70
Sand, fine, clay streaks	14	84
Clay, red	1	85
Sand and gravel, coarse, clay streaks	9	94
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	97

32-7-12ccd1.—*Drillers log of test hole drilled by Federal and State Geological Surveys, October 1953, in SE¼ SW¼ SW¼ sec. 12, T. 32 S., R. 7 W. Surface altitude, 1,425.5 feet; depth to water, 24 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Clay, sandy, brown	3	4
Clay, red, tough	16	20
Clay, red, soft	7	27
Clay, soft, sandy	10	37
Sand, fine	3	40
Sand, medium to coarse	6	46
Sand, fine to medium, clay streaks	4	50
Sand, fine to medium	5	55
Sand, medium to coarse, some gravel	5	60
Sand and gravel, fine to coarse	5	65
Sand and gravel, medium to coarse	5	70
Sand and gravel, coarse, cavey	5	75

PERMIAN—Leonardian	Thickness, feet	Depth, feet
Harper Siltstone		
Shale, red	5	80

32-7-12cdb.—*Drillers log of test hole drilled by Layne-Western Co., October 1953, in NW¼ SE¼ SW¼ sec. 12, T. 32 S., R. 7 W.; depth to water, 23 feet.*

QUATERNARY—Upper Pleistocene Illinoisan and Wisconsinan Stages—Slope deposits	Thickness, feet	Depth, feet
Soil	1	1
Clay	4	5
Clay, red	24	29
Sand and clay	4	33
Clay, caliche	4	37
Clay, sandy, and streaks of fine sand	11	48
Sand, fine	3	51
Clay, blue	3	54
Sand, fine to coarse	14	68
Sand, medium to coarse, clayey	15	83
Sand and gravel, fine to coarse, clayey, much locally derived gravel	4	87
Clay	2	89
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	91

32-7-12cdd.—*Drillers log of test hole drilled by Layne-Western Co., October 1953, in SE¼ SE¼ SW¼ sec. 12, T. 32 S., R. 7 W.*

QUATERNARY—Upper Pleistocene Illinoisan and Wisconsinan Stages—Slope deposits	Thickness, feet	Depth, feet
Soil	1	1
Clay, brown	3	4
Clay, gray	9	13
Clay, red	6	19
Clay, tough, red	2	21
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	19	40

32-7-13bcc.—*Drillers log of test hole drilled by Layne-Western Co., August 1953, in SW¼ SW¼ NW¼ sec. 13, T. 32 S., R. 7 W. Surface altitude, 1,424.6 feet.*

QUATERNARY—Upper Pleistocene Illinoisan and Wisconsinan Stages—Slope deposits	Thickness, feet	Depth, feet
Soil, black	1	1
Clay, red, soft	8	9
Clay, sandy, red	3	12
Clay, red, soft	13	25
PERMIAN—Leonardian		
Harper Siltstone		
Shale, sandy, platy, red	15	40

32-7-14aaa.—*Drillers log of test hole drilled by Layne-Western Co., August 1953, in NE cor. sec. 14, T. 32 S., R. 7 W., in west road ditch 600 feet south of sec. cor. Depth to water, 20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Soil	1	1
Clay, brown, soft	4	5
Clay, red brown, hard	5	10
Clay, red and gray	5	15
Clay, red	13	28
Clay, sandy	2	30
Clay, red	4	34
Sand, fine, silty	6	40
Sand, fine to medium, clay streaks	10	50
Sand, fine	10	60
Sand, fine to medium, clay streaks	20	80
Sand, fine	10	90
Gravel, coarse	5	95
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	97

32-7-14bba.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ NW¼ NW¼ sec. 14, T. 32 S., R. 7 W., 1000 feet east of sec. cor. on south road shoulder. Surface altitude, 1,424.3 feet; depth to water, 18 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Road fill	1	1
Clay, sandy	4	5
Clay, red	6	11
Clay, brown	2	13
Clay, red, caliche	7	20
Clay, brown	5	25
Clay, red and brown	6	31
Sand, fine, very silty	2	33
Clay, red, tough	7	40
Clay, red, soft	6	46
Sand, fine to coarse, clay streaks	12	58
Clay	2	60
Sand, fine	10	70
Sand, medium to fine, clay streaks near top	10	80
Sand, medium to coarse, some fine gravel	11	91
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	94

32-7-14bcc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SW¼ NW¼ sec. 14, T. 32 S., R. 7 W. Surface altitude, 1,416.6 feet; depth to water, 10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine	4	4
Clay, red, soft	11	15
Clay, brown, tough	5	20
Clay, blue, tough	5	25
Clay, sandy, red	21	46
Sand, fine to medium	7	53
Clay, red	5	58
Sand and gravel, medium to coarse	11	69
Sandstone, red, soft	3	72
Clay, sandy, blue	3	75
Sand and gravel, coarse	8	83
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	85

32-7-14ccc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW cor. sec. 14, T. 32 S., R. 7 W. Surface altitude, 1,408.7 feet; depth to water, 6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	2	2
Clay, sandy, gray	6	8
Clay, red	7	15
PERMIAN—Leonardian		
Harper Siltstone		
Sandstone, shaley, red	2	17
Shale, silty, sandy, red	10	27

32-7-15baa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ NE¼ NW¼ sec. 15, T. 32 S., R. 7 W. Surface altitude, 1,422.3 feet; depth to water, 6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine	3	3
Clay, sandy, brown	5	8
Clay, blue, tough	8	16
Clay, red	5	21
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	9	30

32-7-15ccc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW cor. sec. 15, T. 32 S., R. 7 W. Surface altitude, 1,399.8 feet; depth to water, 2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	1	1
Clay, gray, tough	9	10

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Harper Siltstone		
Sandstone, red	1	11
Shale, red	16	27

32-7-16aaa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE cor. sec. 16, T. 32 S., R. 7 W. Surface altitude, 1,417.6 feet; depth to water, 14 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	1	1
Clay, red, gyppy	5	6
Clay, sandy, red	6	12
Clay, red, tough	5	17
Clay, sandy	4	21
Sand, fine to medium, some clay	6	27
Sand, medium to coarse	6	33
Sand, fine, silty, red	2	35
Sand and gravel, medium to coarse	5	40
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	45

32-7-17aad.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ NE¼ NE¼ sec. 17, T. 32 S., R. 7 W. Surface altitude, 1,414.2 feet; depth to water, 4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, red	1	1
Clay, sandy	2	3
Clay, gyppy	4	7
Clay, red	6	13
Sand, medium, and red clay	3	16
Sand and gravel, coarse, few clay streaks	9	25
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	6	31

32-7-17bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NW cor. sec. 17, T. 32 S., R. 7 W., 200 feet south and 5 feet east of sec. cor. Surface altitude, 1,431.7 feet; depth to water, 23.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to coarse, very silty	8	8
Sand and gravel, fine to coarse, some silt	10	18
Silt, sandy, brown	4	22
Silt, brown, and medium sand	20	42
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	44

32-7-17daa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ NE¼ SE¼ sec. 17, T. 32 S., R. 7 W. Surface altitude, 1,412.4 feet; depth to water, 3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy	1	1
Clay, sandy	2	3
Clay	8	11
Sand and gravel	4	15
Clay, sandy	5	20
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	25

32-7-18ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in SE cor. sec. 18, T. 32 S., R. 7 W., 300 feet north and 5 feet west of sec. cor. Surface altitude, 1,425.4 feet; depth to water, 19.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	11	11
Silt, red brown	6	17
Silt, sandy, gray brown	10	27
Sand and gravel, fine to coarse, silty	30	57
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	58

32-7-19abb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW¼ NW¼ NE¼ sec. 19, T. 32 S., R. 7 W., in south road ditch at end of hedge row. Surface altitude, 1,414.0 feet; depth to water, 7.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	2	2
Silt, sandy, tan	5	7
Sand, fine to medium	14	21
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	22

32-7-19bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW cor. sec. 19, T. 32 S., R. 7 W., 30 feet south and 6 feet east of sec. cor. Surface altitude, 1,419.4 feet; depth to water, 7.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	5	5
Clay, silty, black	2	7
Sand, fine to medium, silty	5	12
Sand, fine, silty	7	19

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	20

32-7-20aaa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE cor. sec. 20, T. 32 S., R. 7 W. Surface altitude, 1,402.3 feet; depth to water, 4.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy	1	1
Clay, sandy	2	3
Sand, medium	4	7
Clay, red	6	13
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	20

32-7-20daa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ NE¼ SE¼ sec. 20, T. 32 S., R. 7 W. Surface altitude, 1,395.5 feet; depth to water, 8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt	1	1
Clay, sandy, silty	2	3
Sand and gravel, fine to coarse	6	9
Clay, red brown	12	21
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	26

32-7-20ddd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE cor. sec. 20, T. 32 S., R. 7 W. Surface altitude, 1,384.1 feet; depth to water, 6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand, silty	1	1
Clay, sandy, silty	2	3
Sand, fine to coarse, silty	6	9
Clay, brown and red	9	18
Clay, sandy	2	20
Sand, fine	4	24
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	31

32-7-29ada.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ SE¼ NE¼ sec. 29, T. 32 S., R. 7 W.; depth to water, 10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy	1	1
Sand, fine, silty	5	6
Clay, brown	9	15

	Thickness, feet	Depth, feet
Clay, sandy, brown	6	21
Sand, fine, and clay	3	24
Sand, fine to medium	3	27
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	31

32-7-29ddd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE cor. sec. 29, T. 32 S., R. 7 W.; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, sandy	1	1
Clay	4	5
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	12

32-7-30bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW cor. sec. 30, T. 32 S., R. 7 W., south road ditch 100 feet east of corner. Surface altitude, 1,400.8 feet; depth to water, 18.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	5	5
Silt, clayey, brown	5	10
Clay, brown	10	20
Sand, fine, silty	12	32
Sand and gravel, fine to medium	3	35
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	36

32-7-30dcc.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in SW¼ SW¼ SE¼ sec. 30, T. 32 S., R. 7 W., on south road shoulder 100 feet east of bridge 0.4 mile west of sec. cor. Surface altitude, 1,365.4 feet; depth to water, 9.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	5	5
Sand, medium to coarse	2	7
Sand, coarse, and fine gravel	3	10
Silt, sandy, clayey, tan	3	13
Sand, fine	12	25
Sand, fine, silty	19	44
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	45

32-7-32add.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ SE¼ NE¼ sec. 32, T. 32 S., R. 7 W.; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	1	1
Clay, sandy	3	4
Clay, red	11	15
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	18

32-8-2aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 2, T. 32 S., R. 8 W., 60 feet west and 6 feet south of sec. cor. Surface altitude, 1,502.2 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Nebraskan and Kansan Stages		
Silt, sandy, gray brown	5	5
Silt, tan brown	3	8
Sand, fine to coarse, and silt, tan	3	11
Silt, buff, and sand and gravel, fine to coarse	2	13
Silt, clayey, brown	5	18
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	20

32-8-6bbb.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NW cor. sec. 6, T. 32 S., R. 8 W. Surface altitude, 1,514.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine	4	4
Clay, sandy	7	11
Silt, black, soft	31	42
Gravel	4	46
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	2	48

32-8-13add.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in SE¼ SE¼ NE¼ sec. 13, T. 32 S., R. 8 W., at ½-mile line on south side of road. Surface altitude, 1,434.8 feet; depth to water, 19.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	6	6
Silt, sandy, red brown	5	11
Sand and gravel, fine to coarse, silty	6	17
Sand and gravel, fine to coarse	9	26
Silt, hard	2	28
PERMIAN—Leonardian		
Harper Siltstone		
Shale, sandy and silty, red	4	32

32-8-14aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 14, T. 32 S., R. 8 W., 300 feet west and 6 feet south of sec. cor. and 20 feet east of bridge. Surface altitude, 1,446.8 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, gray brown	2	2
Silt, brown	4	6
Sand, silty, fine	2	8
Sand and gravel, fine to coarse	4	12
Silt, sandy	2	14
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	15

32-8-14cba.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NE¼ NW¼ SW¼ sec. 14, T. 32 S., R. 8 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, black	3	3
Clay, yellow	3	6
Sand, coarse	13	19
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	23

32-8-20daa.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NE¼ NE¼ SE¼ sec. 20, T. 32 S., R. 8 W. Surface altitude, 1,422.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand, fine to coarse	17	17
Clay, blue, soft	18	35
Sand, fine, silty and clayey	2	37
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	8	45

32-8-21bbb.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NW cor. sec. 21, T. 32 S., R. 8 W. Surface altitude, 1,435.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	2	2
Sand, fine	7	9
Clay, blue, and fine sand	28	37
Sand, fine	12	49
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	2	51

32-8-21bcc.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in SW¼ SW¼ NW¼ sec. 21, T. 32 S., R. 8 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand	5	5
Clay, sandy	9	14
Sand, fine, and silty clay	4	18
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	4	22

32-8-21cbb.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NW¼ NW¼ SW¼ sec. 21, T. 32 S., R. 8 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy	7	7
Clay, sandy, red	10	17
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	8	25

32-8-22dab.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NW¼ NE¼ SE¼ sec. 22, T. 32 S., R. 8 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy	2	2
Sand, coarse	4	6
Clay, yellow	23	29
Sand, coarse	1	30
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	31

32-8-22dbb.—*Drillers log of test hole drilled by Air Made Well Co., January 1955, in NW¼ NW¼ SE¼ sec. 22, T. 32 S., R. 8 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace Deposits		
Sand, coarse	12	12
Silt and clay, black	43	55
Sand, coarse	2	57
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	3	60

32-8-23add.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in SE¼ SE¼ NE¼ sec. 23, T. 32 S., R. 8 W., at driveway into house on west side of road. Surface altitude, 1,397.0 feet; depth to water, 22 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	10	10
Clay, silty, brown	5	15
Clay, brown	12	27
Sand, fine, silty	3	30
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	32

32-8-23ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in SE cor. sec. 23, T. 32 S., R. 8 W., north road ditch 150 feet north of sec. cor. Surface altitude, 1,384.2 feet; depth to water, 9.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	10	10
Clay	3	13
Sand, medium to coarse	2	15
Sand, fine to medium	10	25
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	28

32-8-24daa.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NE¼ NE¼ SE¼ sec. 24, T. 32 S., R. 8 W., in east road ditch by cattle chute. Surface altitude, 1,411.8 feet; depth to water, 23 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, black	5	5
Sand, silty, red	2	7
Sand and gravel, coarse, silty	8	15
Sand, fine to medium	5	20
Sand, medium to coarse	10	30
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	31

32-9-6cbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW¼ NW¼ SW¼ sec. 6, T. 32 S., R. 9 W., at ½-mile line on east road shoulder. Surface altitude, 1,497.9 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	5	5
Silt, sandy, red	5	10
Silt, red	2	12

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	13

32-9-7bbb.—*Sample log of test hole drilled by Federal and State Geological Surveys, August 1956, in NW cor. sec. 7, T. 32 S., R. 9 W., south road shoulder 50 feet east of sec. cor. Surface altitude, 1,478.0 feet; depth to water, 28.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, tan	20	20
Silt, sandy, clayey, red	30	50
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	51

32-9-7cbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW¼ NW¼ SW¼ sec. 7, T. 32 S., R. 9 W., at ½-mile line on east road shoulder. Surface altitude, 1,463.5 feet; depth to water, 20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	5	5
Sand, fine to medium	5	10
Clay, sandy	10	20
Silt, fine sandy, red	15	35
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	36

32-9-7ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in SW cor. sec. 7, T. 32 S., R. 9 W., on west road shoulder 50 feet north of sec. cor. Surface altitude, 1,451.6 feet; depth to water, 12.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	5	5
Sand, medium to coarse	2	7
Clay, red	8	15
Silt, sandy, red	9	24
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	25

32-9-16ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SW cor. sec. 16, T. 32 S., R. 9 W., 100 feet north and 8 feet west of sec. cor. Surface altitude, 1,419.6 feet; depth to water, 16.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, gray	3	3
Sand, fine	3	6
Sand and gravel, fine to coarse, silty	3	9
Silt, sandy, brown	6	15
Sand and gravel, fine to coarse, silty	2	17
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	19

32-9-18cbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW¼ NW¼ SW¼ sec. 18, T. 32 S., R. 9 W., on east road shoulder 50 feet north of ½-mile line. Surface altitude, 1,442.6 feet; depth to water, 10.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	3	3
Silt, tan	2	5
Silt, tan, dark	5	10
Silt, sandy, red	28	38
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	39

32-9-18ddd.—*Sample log of test hole drilled by Federal and State Geological Surveys, August 1955, in SE cor. sec. 18, T. 32 S., R. 9 W., 100 feet west and 6 feet north of sec. cor. Surface altitude, 1,428.9 feet; depth to water, 16.08 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, silty	4	4
Silt, sandy, red brown	4	8
Sand and gravel, fine to coarse, silty	12	20
Silt, very sandy, tan	20	40
Sand and gravel, fine to coarse; much locally derived gravel	57	97
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, sandy and silty, red	2	99

32-9-19aab.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW¼ NE¼ NE¼ sec. 19, T. 32 S., R. 9 W., 0.2 mile west of sec. cor. on south road shoulder. Surface altitude, 1,429.6 feet; depth to water, 17.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	3	3
Silt, tan, hard	6	9
Silt, black	6	15
Silt, brown	7	22
Sand and gravel, fine to coarse, silty	18	40
Sand and gravel, fine to coarse, clay streaks	30	70

32-9-19bab.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW¼ NE¼ NW¼ sec. 19, T. 32 S., R. 9 W., 300 feet east of bridge on south road shoulder. Surface altitude, 1,429.0 feet; depth to water, 18.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine, silty, gray	4	4
Silt, sandy, brown	2	6
Sand and gravel, fine to coarse, silty, red	2	8
Silt, compact, sandy, red brown	7	15
Silt, red, and fine soft sand	20	35
Silt, sandy, red	7	42
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	44

32-9-19bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW cor. sec. 19, T. 32 S., R. 9 W., 20 feet south of sec. cor. on west shoulder. Surface altitude, 1,433.5 feet; depth to water, 11.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, tan	7	7
Silt, sandy, tan	3	10
Clay, sandy	3	13
Sand, medium to coarse	2	15
Sand, fine to medium, silty, some fine gravel	53	68
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	69

32-9-19cbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW¼ NW¼ SW¼ sec. 19, T. 32 S., R. 9 W., in west road ditch 100 feet north of ½-mile line. Surface altitude, 1,420.7 feet; depth to water, 11.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	5	5
Clay, sandy, red	20	25
Sand, fine, and fine to coarse gravel, silty	44	69
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	70

32-9-19ccb.—*Sample log of test hole drilled by Federal and State Geological Surveys, September 1956, in NW¼ SW¼ SW¼ sec. 19, T. 32 S., R. 9 W., on east road shoulder 150 feet south of RR. Surface altitude, 1,419.6 feet; depth to water, 8.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, clayey, brown	5	5
Silt, light gray, some red mottling	4	9
Silt, tan	4	13
Silt, sandy, red	2	15
Silt, sandy, brown, blocky	2	17
Silt, gray, clayey	3	20
Sand, fine to coarse, and sparse fine gravel	5	25
Sand and gravel, fine to coarse; interbedded brown clay streaks	5	30
Gravel, fine to coarse; interbedded tan silt streaks	10	40
Gravel, fine to coarse, a few cobbles	10	50
Gravel, fine to coarse	20	70
Gravel, fine to coarse, some very coarse	9	79
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	1	80

32-9-21aab.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW¼ NE¼ NE¼ sec. 21, T. 32 S., R. 9 W., on south road shoulder, 0.2 mile west of sec. cor. Surface altitude, 1,430.5 feet; depth to water, 16.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine, silty, brown gray	4	4
Sand and gravel, fine to coarse, very silty	2	6
Silt, tan, compact	4	10
Sand and gravel, fine to coarse, silty, brown	11	21
Silt, brown, and fine to coarse sand and gravel	10	31
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	1	32

32-9-26cdd.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SE¼ SE¼ SW¼ sec. 26, T. 32 S., R. 9 W., 100 feet west of ½-mile line on north road shoulder. Surface altitude, 1,423.1 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Soil and fine silty sand	3	3
PERMIAN—Leonardian		
Salt Plain Siltstone		
Silt, brown red	4	7
Shale, silty, red	3	10

32-9-30bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW cor. sec. 30, T. 32 S., R. 9 W., in south road ditch 100 feet east of sec. cor. Surface altitude, 1,419.0 feet; depth to water, 6.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	5	5
Silt, clayey, tan	5	10
Clay, white, limy	15	25
Silt, sandy, red	10	35
Silt, sandy, brown	15	50
Sand, medium to coarse, silty, some fine gravel	18	68
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	69

32-9-30bcb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW¼ SW¼ NW¼ sec. 30, T. 32 S., R. 9 W., on west road shoulder 30 feet north of bridge. Surface altitude, 1,415.5 feet; depth to water, 4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, brown	5	5
Silt, sandy, red	5	10
Silt, red	3	13
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	3	16

33-5-4aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 4, T. 33 S., R. 5 W., 50 feet west and 8 feet south of sec. cor. Surface altitude, 1,333.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, clayey, brown	3	3
Silt, red	6	9
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red	4	13

33-5-10bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 10, T. 33 S., R. 5 W., on road curve at NW corner of depot. Surface altitude, 1,337.6 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, clayey, red brown	2	2
Silt, red	8	10
Silt, red, contains caliche	2	12
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red and white	3	15

33-5-21aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 21, T. 33 S., R. 5 W., 50 feet west and 8 feet south of sec. cor. Surface altitude, 1,310.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, red brown	3	3
Silt, red	5	8
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, gray and red	2	10

33-5-28aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 28, T. 33 S., R. 5 W., 75 feet south and 8 feet west of sec. cor. Surface altitude, 1,298.1 feet; depth to water, 32.90 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, red brown	3	3
Silt, red	5	8
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, tan	7	15
Silt, sandy, red brown	15	30
Silt, clayey, sandy, brown	6	36
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, silty, red	3	39

33-5-33aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 33, T. 33 S., R. 5 W., 50 feet south and 8 feet west of sec. cor. Surface altitude, 1,280.9 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, gray, brown	3	3
Silt, gray	5	8
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, tan, contains caliche	7	15
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, silty, red	5	20

33-5-33ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE cor. sec. 33, T. 33 S., R. 5 W., 100 feet north and 8 feet west of sec. cor. Surface altitude, 1,270.4 feet; depth to water, 27.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, gray brown	2	2
Silt, red brown	5	7
Silt, buff	2	9
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, brown, compact	4	13
Silt, buff	7	20
Sand, fine to coarse, silty, some gravel	4	24
Clay, silty, sandy, tan	6	30
Silt, sandy, tan, compact	10	40

33-6-17cdd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE¼ SE¼ SW¼ sec. 17, T. 33 S., R. 6 W., 0.4 mile east of sec. cor. on north road shoulder 50 feet west of driveway. Surface altitude, 1,318.7 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, reddish brown	2	2
Silt, red, compact	4	6
Silt, red, very limy	2	8
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty and sandy, red	2	10

33-6-19ccc.—*Drillers log of test hole drilled for Oyler Salt Co., 1888, in SW cor. sec. 19, T. 33 S., R. 6 W.*

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Shale, sandy	30	30
Sandstone (water)	5	35
Red rock	3	38
Shale, white	2	40
Red rock	95	135
Shale, gray	15	150
Red rock	10	160
Shale, gray	10	170
Shale, red	25	195
Shale, gray	10	205
Shale, red	175	380
Shale, light	2	382
Shale, red	88	470
Shale, light	5	475
Shale, red	60	535
Shale, blue	35	570
Red rock	5	575
Shale, blue	125	700

	Thickness, feet	Depth, feet
Shale, gray (Salt 844-858)	158	858
Shale and limestone	2	860
Shale and salt	10	870
Shale, red	5	875
Shale, gray	5	880
Shale, red	5	885
Shale, red, and salt	5	890
Shale, red	10	900
Shale and gypsum	15	915
Shale, gray	15	930
Shale, salt	30	960
Salt	10	970
Shale	5	975
Salt	5	980
Shale, blue	65	1045
Shale, gypsum	10	1055
Salt, clean	5	1060
Salt and shale	5	1065
Salt, clean	60	1125

33-6-27ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW cor. sec. 27, T. 33 S., R. 6 W., 30 feet east and 8 feet north of sec. cor. Surface altitude, 1,320.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Silt, reddish brown	3	3
PERMIAN—Leonardian		
Harper Siltstone		
Silt, red	4	7
Shale, silty and sandy	4	11

33-6-29ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW cor. sec. 29, T. 33 S., R. 6 W., 50 feet east and 8 feet north of sec. cor. Surface altitude, 1,304.1 feet; depth to water, 28 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, reddish brown	2	2
Silt, pink, buff	10	12
Silt, buff, compact	10	22
Silt, sandy, soft, buff	18	40

33-6-29ddc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW¼ SE¼ SE¼ sec. 29, T. 33 S., R. 6 W., 1000 feet west of sec. cor. on north road shoulder opposite fence to south. Surface altitude, 1,297.7 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, reddish brown	2	2
Silt, red	6	8

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Harper Siltstone		
Shale and sandstone, red	4	12

33-6-30aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 8, 1955, in NE cor. sec. 30, T. 33 S., R. 6 W., 150 feet south and 6 feet west of center of road intersection. Surface altitude, 1,808.5 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, brown; caliche nodules	3	3
Silt, fine sandy, tan	2	5
Sand and gravel, fine to coarse, silty	4	9
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	10

33-6-30cbb.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW¼ NW¼ SW¼ sec. 30, T. 33 S., R. 6 W., 100 feet south of north railroad tracks. Surface altitude, 1,322.7 feet; depth to water, 13 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	1	1
Clay, sandy	2	3
Sand, medium, silty	3	6
Sand and gravel, coarse, few clay streaks	14	20
PERMIAN—Leonardian		
Harper Siltstone		
Shale, blue and red, hard; streaks of sandstone	10	30
Shale, red, soft	5	35
Shale, red, soft streaks	16	51

33-6-30cbc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ NW¼ SW¼ sec. 30, T. 33 S., R. 6 W.; depth to water, 13 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	1	1
Clay, sandy	2	3
Sand, coarse, silty	3	6
Clay, blue gray	4	10
Clay, sandy	3	13
Sand and gravel, fine to coarse	4	17
PERMIAN—Leonardian		
Harper Siltstone		
Shale, blue	3	20
Shale, red, hard	5	25

33-6-30ccc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW cor. sec. 30, T. 33 S., R. 6 W., 500 feet north of sec. cor. Surface altitude, 1,317.0 feet; depth to water, 15 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	1	1
Clay, sandy, red	4	5
Sand and gravel, fine to medium	9	14
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	21

33-6-31bbb.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW cor. sec. 31, T. 33 S., R. 6 W., 500 feet south of sec. cor. Depth to water, 15 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	1	1
Clay, sandy, red	3	4
Sand, fine, silty	3	7
Sand and gravel, coarse, silty	4	11
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	10	21

33-6-31bcb.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW¼ SW¼ NW¼ sec. 31, T. 33 S., R. 6 W.; depth to water, 20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	1	1
Clay, sandy, red	2	3
Clay, sandy, gray	4	7
Clay, sandy, red	4	11
Clay, sandy, red, very soft	4	15
Sand, fine, brown	5	20
Sand, medium to coarse, brown	3	23
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	28

33-6-31bcc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SW¼ NW¼ sec. 31, T. 33 S., R. 6 W. Surface altitude, 1,302.1 feet; depth to water, 16 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	1	1
Clay, sandy	3	4
Sand, fine, silty, brown	3	7
Sand and gravel, medium to coarse	9	16
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	21

33-6-31cbc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ NW¼ SW¼ sec. 31, T. 33 S., R. 6 W. Surface altitude, 1,311.2 feet; depth to water, 26 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown	1	1
Clay, red	2	3
Clay, sandy	4	7
Sand and gravel, silty	7	14
Sand and gravel, fine to coarse	6	20
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	25

33-6-31ccb.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW¼ SW¼ SW¼ sec. 31, T. 33 S., R. 6 W. Surface altitude, 1,299.3 feet; depth to water, 17 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, blue	6	7
Clay, red	4	11
Clay, sandy, red	4	15
Sand, fine, and clay	3	18
Sand and gravel, coarse	2	20
Clay, red	10	30
Sand, fine, silty	5	35
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	40

33-6-31ccd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ SW¼ SW¼ sec. 31, T. 33 S., R. 6 W., 880 feet east of sec. cor.; depth to water, 13 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, sandy, red	4	4
Sand, medium to coarse, brown	2	6
Sand and gravel, coarse	8	14
Sand and gravel, fine to coarse; clay streaks	5	19
Clay	3	22
Sand, medium; clay streaks	5	27
PERMIAN—Leonardian		
Harper Siltstone		
Shale	4	31

33-6-31cdc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SE¼ SW¼ sec. 31, T. 33 S., R. 6 W. Surface altitude, 1,295.8 feet; depth to water, 20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy	5	6
Sand and gravel, medium to coarse, silty, brown	4	10
Sand and gravel, medium to coarse	14	24
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	31

33-6-31dcc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SW¼ SE¼ sec. 31, T. 33 S., R. 6 W. Surface altitude, 1,297.8 feet; depth to water, 21 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, hard	6	6
Clay, sandy	5	11
Sand and gravel, coarse	14	25
Clay, red	10	35
Clay, red, and fine mucky sand	7	42
Sand and gravel, medium to coarse	6.5	48.5
PERMIAN—Leonardian		
Harper Siltstone		
Shale	2.5	51

33-6-31ddc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SE¼ SE¼ sec. 31, T. 33 S., R. 6 W., 150 feet east of railroad; depth to water, 20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, red, hard	4	4
Clay, sandy, soft	10	14
Clay and fine sand, interbedded	11	25
Clay and fine mucky sand	6	31
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	35

33-6-31ddd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE cor. sec. 31, T. 33 S., R. 6 W., 6 feet north and 30 feet west of sec. cor. Depth to water, 22 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, red	7	7
Sand, medium, silty	3	10
Sand and gravel	16	26
Sand, medium, silty	6	32
Clay, red	8	40

	Thickness, feet	Depth, feet
Clay, sandy, red	7	47
Sand, medium to coarse, silty	3	50
Sand and gravel, medium to coarse, silty	5	55
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	58

33-6-32ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE cor. sec. 32, T. 33 S., R. 6 W., 6 feet north and 50 feet west of sec. cor. Depth to water, 18 feet.*

QUATERNARY—Lower Pleistocene Kansan Stage	Thickness, feet	Depth, feet
Silt, sandy, brown	2	2
Sand, fine, very silty	3	5
Sand, fine to medium, trace of silt	5	10
Sand and gravel, fine to coarse	6	16
Gravel, fine to very coarse, sandy	4	20
Sand and gravel, fine to coarse	3	23
Silt, sandy, red brown	7	30
Silt, red, and fine sand	10	40

33-6-34ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW cor. sec. 34, T. 33 S., R. 6 W., 50 feet east and 8 feet north of sec. cor. Dry hole.*

QUATERNARY—Upper Pleistocene Illinoisan and Wisconsinan Stages—Slope deposits	Thickness, feet	Depth, feet
Silt, sandy, dark gray	5	5
Silt, tan	10	15
Silt, sandy, tan	5	20
Sand and gravel, fine to coarse	4	24
Gravel, fine to coarse, some very coarse gravel	4	28
Silt, very sandy, brown	2	30

33-6-35cbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW¼ NW¼ SW¼ sec. 35, T. 33 S., R. 6 W., 150 feet south and 8 feet east of ½-mile cor.*

QUATERNARY—Lower Pleistocene Kansan Stage	Thickness, feet	Depth, feet
Silt, brown	2	2
Silt, red	3	5
Silt, red grading to brown	5	10
Silt, brown, some coarse gravel	5	15
PERMIAN—Leonardian		
Harper Siltstone		
Shale, green and red	2	17

33-7-5aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NE cor. sec. 5, T. 33 S., R. 7 W., at sec. cor. 100 feet west of bridge. Dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, black	3	3
Sand, fine, silty, brown	3	6
PERMIAN—Leonardian		
Harper Siltstone		
Shale, sandy, red	4	10

33-7-5baa.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NE¼ NE¼ NW¼ sec. 5, T. 33 S., R. 7 W., 50 feet west and 8 feet south of ½-mile line. Depth to water, 18.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, brown, and fine sand	3	3
Silt, clayey, black	2	5
Silt, sandy, tan brown	5	10
Sand and gravel, fine to coarse, silty	6	16
Silt and clay, sandy, buff	5	21
Silt, sandy, fine, red brown	12	33
Sand and gravel, fine to medium, silty	4	37
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty and sandy, red	1	38

33-7-5bba.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NE¼ NW¼ NW¼ sec. 5, T. 33 S., R. 7 W., on terrace scarp, 0.1 mile east of bridge. Dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to medium, silty	3	3
Sand and gravel, fine to coarse	5	8
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty and sandy, red	4	12

33-7-5bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW cor. sec. 5, T. 33 S., R. 7 W., 50 feet east of bridge on south road shoulder. Depth to water, 9.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand and gravel, fine to coarse, silty	5	5
Sand and gravel, fine to coarse	20	25
Sand and gravel, fine to coarse, silty	16	41
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	3	44

33-7-5daa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ NE¼ SE¼ sec. 5, T. 33 S., R. 7 W., 600 feet south of ½-mile line.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	1	1
Sand and clay, silty	2	3
Sand, medium, silty	5	8
Sand, fine, and red clay	2	10
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	6	16

33-7-6abb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW¼ NW¼ NE¼ sec. 6, T. 33 S., R. 7 W., 50 feet east and 8 feet south of center of road crossing. Dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, red brown, and fine sand	5	5
Silt, tan	4	9
PERMIAN—Leonardian		
Harper Siltstone		
Shale, sandy, silty, red brown	3	12

33-7-6bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW cor. sec. 6, T. 33 S., R. 7 W., 0.1 mile east of sec. cor. on south road shoulder. Depth to water, 11.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, gray brown, and fine to coarse sand	5	5
Sand and gravel, fine to coarse	8	13
Silt, sandy, brown	3	16
Sand, fine, and red silt	14	30
Sand, fine to coarse, very silty, red, some fine gravel	26	56
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	58

33-7-8aaa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE cor. sec. 8, T. 33 S., R. 7 W., 50 feet west and 8 feet south of sec. cor.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	1	1
Sand, fine, silty	3	4
Clay, red	4	8
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	8	16

33-7-8daa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ NE¼ SE¼ sec. 8, T. 33 S., R. 7 W., 300 feet south of ½-mile line.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Sand, fine, silty	2	3
Clay, red	4	7
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	14

33-7-11bab.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW¼ NE¼ NW¼ sec. 11, T. 33 S., R. 7 W., across road from community well at north end of city lake. Depth to water, 7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt	1	1
Clay, sandy, black	3	4
Clay (tough)	4	8
Sand, fine to medium, white	3	11
Clay, sandy, blue	9	20
Clay, red and blue; sand streaks	7	27
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	31

33-7-15cdc.—*Drillers log of test hole drilled by Layne-Western Co., January 1952, in SW¼ SE¼ SW¼ sec. 15, T. 33 S., R. 7 W., 1,500 feet east of sec. cor., 20 feet south and 20 feet east of dug well. Surface altitude, 1,338.00 feet; depth to water, 6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Sand, fine	2	2
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, red	8	10
Clay, gray	3	13
Clay, red, sandy	3	16
Sand and gravel, coarse, brown	7.5	23.5
Clay, red	1.5	25
Sand and gravel, coarse, brown	7.5	32.5
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4.5	37

33-7-17aaa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE cor. sec. 17, T. 33 S., R. 7 W., 600 feet south of sec. cor.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	1	1
Sand, fine, silty	2	3
Sand and gravel, coarse	5	8

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	15

33-7-17daa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ NE¼ SE¼ sec. 17, T. 33 S., R. 7 W. Depth to water, 4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand, fine	1	1
Clay, red, and fine sand	4	5
Sand and gravel, coarse	4	9
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	6	15

33-7-17ddd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE cor. sec. 17, T. 33 S., R. 7 W. Surface altitude, 1,317.7 feet; depth to water, 8.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy	1	1
Sand, fine, and red silty clay	3	4
Sand, medium to coarse	4	8
Clay, gray, soft	8	16
Clay, brown	5	21
Clay, gray, soft	8	29
Sand, fine, silty, gray	2	31
Sand, fine, silty, and clay streaks	7	38
Sand and gravel, medium to coarse	6	44
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	47

33-7-20aad.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ NE¼ NE¼ sec. 20, T. 33 S., R. 7 W., 600 feet south of sec. cor. Depth to water, 8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy	1	1
Sand, medium, silty	2	3
Sand and gravel, medium to coarse	5	8
Sand and gravel, coarse	8	16
Clay, sandy, black	0.5	16.5
Sand and gravel, medium to coarse	26.5	43
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	50

33-7-32ddd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE cor. sec. 32, T. 33 S., R. 7 W., 400 feet west of sec. cor. Depth to water, 10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Clay, sandy	2	2
Clay, red	7	9
Clay, red; contains caliche and fine sand	7	16
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	11	27

33-7-33ccc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW cor. sec. 33, T. 33 S., R. 7 W., 600 feet east of sec. cor. Depth to water, 11 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, black	1	1
Clay, sandy, red	4	5
Clay, red	8	13
Sand, fine, silty, and red clay	3	16
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	11	27

33-7-33cdc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SE¼ SW¼ sec. 33, T. 33 S., R. 7 W. Surface altitude, 1,350.4 feet; depth to water, 13.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Clay, sandy	2	2
Clay, red	10	12
Sand, fine to coarse, and red clay and caliche	3	15
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red, and fine standstone	10	25

33-7-33cdd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ SE¼ SW¼ sec. 33, T. 33 S., R. 7 W., at ½-mile line. Surface altitude, 1,337.0 feet; depth to water, 13 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, sandy	1	1
Clay, sandy	8	9
Clay, red	9	18
Clay, sandy (gyppy)	2	20
Sand, fine, silty	5	25
Clay, red	3	28
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	33

33-7-33dcd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ SW¼ SE¼ sec. 33, T. 33 S., R. 7 W., 400 feet west of ¼-mile line. Surface altitude, 1,322.7 feet; depth to water, 14 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Clay, sandy	6	6
Clay, red (tough)	5	11
PERMIAN—Leonardian		
Harper Siltstone		
Shale and sandstone	5	16
Shale, red	6	22

33-7-33ddc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SE¼ SE¼ sec. 33, T. 33 S., R. 7 W., 700 feet west of sec. cor. Depth to water, 15 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Clay, sandy	5	5
Clay, red, and fine silty sand	5	10
Sand, medium to coarse, and some fine gravel	5	15
Clay, red	2	17
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	22

33-7-34cad.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ NE¼ SW¼ sec. 34, T. 33 S., R. 7 W., in creek bottom. Surface altitude, 1,295.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt,	1	1
Clay, sandy	2	3
Sand, medium, brown	7	10
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	11	21

33-7-34ccc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW cor. sec. 34, T. 33 S., R. 7 W., 300 feet east of sec. cor. Surface altitude, 1,288.8 feet; depth to water, 7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	1	1
Clay, caliche	2	3
Sand, medium to coarse	3	6
Clay, red	6	12
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	10	22

33-7-34ccd1.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ SW¼ SW¼ sec. 34, T. 33 S., R. 7 W., at ¼-mile line. Depth to water, 26 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine	1	1
Clay, sandy	4	5
Sand, medium, silty	4	9
Clay, red	9	18
Clay, sandy, red	2	20
Clay, tough, red	11	31
Sand, fine, silty	6	37
Sand and gravel, medium to coarse	2	39
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	6	45

33-7-34ccd3.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ SW¼ SW¼ sec. 34, T. 33 S., R. 7 W.; depth to water, 11 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	1	1
Clay, sandy	2	3
Sand and gravel, medium to coarse; clay streaks	7	10
Clay, few sand streaks	6	16
Clay, brown	9	25
Sand, medium to coarse	5	30
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	7	37

33-7-34cdd.—*Drillers log of test hole drilled by Layne-Western Co., March 1956, in SE¼ SE¼ SW¼ sec. 34, T. 33 S., R. 7 W., 400 feet west of ½-mile line. Surface altitude, 1,279.6 feet; depth to water, 21 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Clay, sandy	4	4
Sand, fine, silty	4	8
Sand, medium to coarse	7	15
Sand and gravel, medium to coarse	8	23
Clay, red	2	25
Sand, medium to coarse, some clay	6	31
Sand, fine, very silty, very soft	4	35
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	6	41

33-7-34dcc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SW¼ SE¼ sec. 34, T. 33 S., R. 7 W., 600 feet east of ½-mile line. Depth to water, 14.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Sand, fine	1	1
Clay, sandy	4	5
Sand, medium, silty	7	12
Sand and clay	3	15
Clay, red	6	21
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	6	27

33-7-34ddc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SE¼ SE¼ sec. 34, T. 33 S., R. 7 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Sand, fine	1	1
Sand, fine, and clay	4	5
Sand, medium to coarse, silty	6	11
Clay, sandy	4	15
Clay, red	12	27
Clay, red and blue	4	31
Sand and gravel, medium to coarse	2	33
PERMIAN—Leonardian		
Harper Siltstone		
Sandstone, fine, red	2	35
Shale, red	6	41

33-7-34ddd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE cor. sec. 34, T. 33 S., R. 7 W., at sec. cor. Depth to water, 13 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy	1	1
Clay, very sandy	4	5
Sand and gravel, medium to coarse, silty	5	10
Clay, red	11	21
Clay, very sandy, soft, red	5	26
Sand, fine, silty, clay streaks	7	33
Sand, medium fine to medium coarse	4	37
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	41

33-8-28acc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SW¼ NE¼ sec. 28, T. 33 S., R. 8 W.*

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Salt Plain Siltstone		
Clay, sandy	2	2
Shale, red	23	25
Shale, blue	2	27
Shale, red, soft	43	70
Shale, red, tough	40	110

33-8-31dcc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW¼ SW¼ SE¼ sec. 31, T. 33 S., R. 8 W., 0.1 mile east of ½-mile line. Surface altitude, 1,304.5 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Sand, fine, silty	3	3
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, tan	3	6
Silt, red	4	10
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	5	15

33-9-1bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 1, T. 33 S., R. 9 W., 30 feet south and 10 feet east of sec. cor. Surface altitude, 1,384.0 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine to coarse, silty	3	3
Sand and gravel, fine to coarse, silty, brown	3	6
Silt, brown, compact	2	8
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	7	15

33-9-4abb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW¼ NW¼ NE¼ sec. 4, T. 33 S., R. 9 W., in driveway at ½-mile line. Surface altitude, 1,380.5 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine, silty	5	5
Silt, sandy, red brown	1	6
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	3	9

33-9-4bba.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE¼ NW¼ NW¼ sec. 4, T. 33 S., R. 9 W., 0.25 mile east of sec. cor. on south road shoulder. Surface altitude, 1,378.3 feet; depth to water, 9.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine, silty, gray	7	7
Silt, fine sandy, tan	4	11
Silt, sandy, red	2	13
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	15

33-9-5aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 5, T. 33 S., R. 9 W., 150 feet west and 6 feet south of sec. cor. Surface altitude, 1,381.1 feet; depth to water, 10.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	3	3
Silt, sandy, brown	5	8
Sand, fine to coarse, silty	3	11
Silt, sandy, red brown	2	13
Silt, very sandy, light gray	3	16
Sand and gravel, fine to coarse, silty, tan	5	21
Sand and gravel, fine to coarse	19	40

33-9-5aab.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in NW¼ NE¼ NE¼ sec. 5, T. 33 S., R. 9 W., 50 feet east of bridge at entrance to pasture. Surface altitude, 1,379.0 feet; depth to water, 7.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	5	5
Clay, sandy, brown	5	10
Clay, sandy, black	5	15
Sand, fine, silty, black	35	50
Sand, fine to medium, red	4	54
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	55

33-9-5abb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW¼ NW¼ NE¼ sec. 5, T. 33 S., R. 9 W., on south road shoulder in line with center of road to north. Surface altitude, 1,380.3 feet; depth to water, 8.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine, silty, gray	5	5
Silt, fine sandy, gray brown	3	8
Silt, sandy, brown	8	16
Sand and gravel, fine to coarse, silty	5	21
Sand and gravel, fine to coarse	19	40

33-9-5bab.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW¼ NE¼ NW¼ sec. 5, T. 33 S., R. 9 W., 40 feet east of bridge in south road ditch. Surface altitude, 1,373.9 feet; depth to water, 4.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	3	3
Sand and gravel, fine to coarse	3	6
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	7

33-9-6aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 6, T. 33 S., R. 9 W., south road shoulder 75 feet west of sec. cor. Surface altitude, 1,384.3 feet.*

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Salt Plain Siltstone		
Silt, brown	4	4
Shale, silty, red	1	5

33-9-15dcc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW¼ SW¼ SE¼ sec. 15, T. 33 S., R. 9 W., on north road shoulder 100 feet east of ½-mile line. Surface altitude, 1,336.1 feet; depth to water, 7.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Sand, fine, silty	3	3
Silt, tan	4	7
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to coarse	33	40
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	1	41

33-9-16ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, March 1955, in SE cor. sec. 16, T. 33 S., R. 9 W., 130 feet west and 8 feet north of sec. cor. Surface altitude, 1,335.1 feet; depth to water, 4.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine, silty	6	6
Sand and gravel, fine to coarse	5	11
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	13

33-9-21abb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW¼ NW¼ NE¼ sec. 21, T. 33 S., R. 9 W., south road shoulder at ½-mile line. Surface altitude, 1,342.0 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, gray brown	6	6
Silt, sandy, clayey, gray	7	13

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty and sandy, red	2	15

33-9-24dcc.—*Drillers log of test hole drilled for Kansas Emergency Relief Corporation, 1934, in SW¼ SW¼ SE¼ sec. 24, T. 33 S., R. 9 W. Surface altitude, 1,313.9 feet; depth to water, 12.26 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Silt, sandy	4	4
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, sandy, some caliche, red	8	12
Sand, red	8	20
Silt, black	5	25
Sand, coarse, white	1.5	26.5
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	.5	27

33-9-34ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SE cor. sec. 34, T. 33 S., R. 9 W., in center of abandoned road at sec. cor. Surface altitude, 1,313.2 feet; depth to water, 13.10 feet*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Sand, fine, silty	2	2
Silt, sandy, tan	5	7
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to coarse	8	15
Sand and gravel, fine to medium	22	37
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	39

34-5-9aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 9, T. 34 S., R. 5 W., 60 feet south and 8 feet west of sec. cor. Surface altitude, 1,244.2 feet; depth to water, 26.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Peoria Formation		
Silt, brown	2	2
Silt, reddish brown	5	7
Illinoisan Stage—Slope deposits		
Silt, sandy, reddish brown	5	12
Sand, fine, silty	1	13
Sand and gravel, fine to medium	12	25
Sand and gravel, fine to coarse	11	36
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, silty, red	1	37

34-5-10ccc.—*Sample log of test hole drilled by Federal and State Geological Surveys, July 1955, in SW cor. sec. 10, T. 34 S., R. 5 W., 100 feet north and 6 feet east of sec. cor. Surface altitude, 1,233.00 feet; depth to water, 20.04 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Peoria Formation		
Silt, sandy, dark gray	3	3
Silt, sandy, tan	3	6
Illinoisan Stage—Slope deposits		
Sand and gravel, fine to coarse	3	9
Silt, tan	1	10
Sand and gravel, fine to coarse	7	17
Silt, reddish tan	1	18
Sand and gravel, fine to coarse	2	20
Sand and gravel, fine to coarse, much Permian-derived gravel	5	25
Silt, tan brown	3	28
Silt and clay, dark gray	6	34
Silt, dark brown	4	38
Silt, sand, and gravel, interbedded, mostly Permian-derived gravel	6	44
PERMIAN—Leonardian		
Ninnescah Shale		
Shale, red and gray green	2	46

34-6-3ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in SW cor. sec. 3, T. 34 S., R. 6 W., 50 feet north and 8 feet east of sec. cor. Surface altitude, 1,279.8 feet; depth to water, 14.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, tan	5	5
Silt, sandy, tan, some gravel	5	10
Sand and gravel, fine to coarse	5	15
Sand, fine to coarse, some fine gravel	3	18
Gravel, fine to coarse, silty	4	22
Gravel, fine to coarse	3	25
Sand and gravel, fine to coarse, silty	3	28
Silt and clay, tan, some coarse gravel	7	35
Silt, sandy, tan	4.5	39.5
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	0.5	40

34-6-6aad.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ NE¼ NE¼ sec. 6, T. 34 S., R. 6 W., 100 feet south of railroad. Surface altitude, 1,289.5 feet; depth to water, 16 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, sandy	3	3
Clay, red, compact	5	8
Clay, sandy, red	3	11
Sand and gravel, coarse	8	19
Clay, red	11	30
Silt and fine sand, tan, very soft, mucky	7	37
Sand, medium to coarse, silty	6	43
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	47

34-6-6add.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE¼ SE¼ NE¼ sec. 6, T. 34 S., R. 6 W. Surface altitude, 1,280.2 feet; depth to water, 13 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, sandy, red	3	3
Clay, red, tough	5	8
Clay, sandy, red	4	12
Clay, red	19	31
Clay, sandy	3	34
Sand, fine, and soft mucky clay	5	39
Clay, blue	3	42
Clay, red	2	44
Sand and gravel	5	49
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	51

34-6-6bbb.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW cor. sec. 6, T. 34 S., R. 6 W., 300 feet south of sec. cor. Depth to water, 19 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy, red	4	5
Clay, red, tough	15	20
Clay, sandy, brown	8	28
Sand, medium, silty	4	32
Sand and gravel, fine to coarse, silty and clayey	5	37
Clay, sandy, red	3	40
PERMIAN—Leonardian		
Harper Siltstone		
Shale	5	45

34-6-6bbc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ NW¼ NW¼ sec. 6, T. 34 S., R. 6 W., at ¼-mile line. Depth to water, 15 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy, red	4	5
Clay, red, tough	4	9
Clay, sandy	2	11
Clay, red	6	17
Clay, sandy, red	3	20
Sand and gravel	3	23
Sand, medium to coarse, silty, some fine gravel	15	38
Sand and gravel	7	45
Clay, blue	3	48
Sand, medium, clayey	7	55
Sand, medium to coarse, and clay	6	61
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	65

34-6-6bcc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SW¼ NW¼ sec. 6, T. 34 S., R. 6 W., 300 feet north of ¼-mile line. Depth to water, 14.21 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy	2	3
Clay, red	12	15
Sand, fine, mucky	2	17
Clay, brown, tough	8	25
Clay, sandy	5	30
Sand, medium to coarse, silty	6	36
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	41

34-6-6bdc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SE¼ NW¼ sec. 6, T. 34 S., R. 6 W. Depth to water, 16.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, red	13	14
Sand, medium to coarse, brown	4	18
Sand and gravel, coarse	7	25
Clay, red	3	28
Sand, medium to coarse, some fine gravel	7	35
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	39

34-6-6cac.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ NE¼ SW¼ sec. 6, T. 34 S., R. 6 W. Depth to water, 15.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy	2	3
Clay, red	2	5
Sand, medium, brown	5	10
Sand, medium coarse, brown	5	15
Clay, red	3	18
Sand and clay	3	21
Clay, red, sand streaks	14	35
Sand and clay	5	40
Sand and gravel, medium, Permian-derived gravel, and some clay	4	44
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	48

34-6-6cbb.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW¼ NW¼ SW¼ sec. 6, T. 34 S., R. 6 W., 700 feet south of ½-mile cor. Depth to water, 12 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy	2	3
Sand, fine, and clay	4	7
Clay, red, tough	10	17
Clay, sandy, red	8	25
Clay, sandy, blue	5	30
Sand, fine, very silty (mucky)	5	35
Sand, fine to medium coarse; interbedded clay streaks,	7	42
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	3	45

34-6-6ccb.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW¼ SW¼ SW¼ sec. 6, T. 34 S., R. 6 W., 400 feet south of ¼-mile line. Depth to water, 8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy	4	5
Clay, sandy, gray	5	10
Clay, gray, soft	5	15
Clay, brown	8	23
Clay, sandy, red	9	32
Sand, fine, very silty (mucky), and clay	3	35
Sand, fine, white	5	40
Sand and gravel, medium to coarse, some Permian-derived shale	3	43

	Thickness, feet	Depth, feet
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red, and sandstone	4	47

34-6-6daa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ NE¼ SE¼ sec. 6, T. 34 S., R. 6 W. Depth to water, 7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, sandy, red	5	5
Clay, red, tough	20	25
Clay, blue, tough	9	34
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red, soft	6	40

34-6-6dda.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ SE¼ SE¼ sec. 6, T. 34 S., R. 6 W. Depth to water, 9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy	6	6
Sand, medium, silty	2	8
Clay, sandy, red	13	21
Clay, gray, tough	9	30
Clay, sandy, red	8	38
Sand, fine, mucky	2	40
Sand and gravel, coarse, brown	8.5	48.5
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2.5	51

34-6-6ddd.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SE cor. sec. 6, T. 34 S., R. 6 W. Surface altitude, 1,272.5 feet; depth to water, 11.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, very sandy	1	1
Sand, fine, silty	10	11
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red (weathered)	6	17
Shale, red, hard	3	20

34-6-7bbb.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW cor. sec. 7, T. 34 S., R. 6 W., at sec. cor. Depth to water, 11 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, black	1	1
Clay, sandy, black	3	4
Clay, brown	11	15
Sand, fine, very silty (mucky)	10	25
Sand, silty	5	30

	Thickness, feet	Depth, feet
Clay, sandy, blue	5	35
Sand and gravel, medium to coarse	5	40
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	45

34-6-7bbc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ NW¼ NW¼ sec. 7, T. 34 S., R. 6 W., 350 feet north of north end of bridge. Surface altitude, 1,268.7 feet; depth to water, 15.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy	4	4
Clay, sandy	6	10
Clay and sand interbedded	6	16
Sand, medium, and clay	9	25
Sand, medium coarse	5	30
Sand, coarse, some fine gravel	5	35
Sand, medium to coarse, some fine gravel and clay streaks	5	40
Sand and gravel, coarse	4	44

34-6-8abb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW¼ NW¼ NE¼ sec. 8, T. 34 S., R. 6 W., 100 feet west of driveway to house on north side of road. Surface altitude, 1,269.8 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, reddish brown	3	3
Silt, red	4	7
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	5	12

34-6-8bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW cor. sec. 8, T. 34 S., R. 6 W., at sec. cor. west of road curve. Surface altitude, 1,272.5 feet; dry hole.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, sandy, tan	2	2
Silt, very sandy, red	3	5
Sand, fine to coarse	3	8
Sand and gravel, fine to coarse, grains stained with iron oxide	4	12
PERMIAN—Leonardian		
Harper Siltstone		
Shale, sandy and silty, red	3	15

34-6-9add.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SE¼ SE¼ NE¼ sec. 9, T. 34 S., R. 6 W., on west road shoulder 100 feet south of railroad. Surface altitude, 1,250.2 feet; depth to water, 11.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, gray	3	3
Silt, clayey, dark gray (soil zone)	3	6
Silt, tan	9	15
Silt, sandy, soft, buff	15	30

34-6-9baa.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NE¼ NE¼ NW¼ sec. 9, T. 34 S., R. 6 W., on south road shoulder 50 feet west of railroad. Surface altitude, 1,248.2 feet; depth to water, 13.90 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, dark gray	2	2
Silt, sandy, tan	5	7
Silt, sandy, gray	3	10
Silt, tan, some interbedded sand and gravel	3	13
Silt, brown, much medium gravel	2	15
Silt, brown, much fine to coarse sand and gravel	21	36
PERMIAN—Leonardian		
Harper Siltstone		
Shale, sandy, light gray	1	37

34-6-9daa.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NE¼ NE¼ SE¼ sec. 9, T. 34 S., R. 6 W., on west road shoulder 150 feet north of north end of bridge. Surface altitude, 1,237.8 feet; depth to water, 10.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, sandy, gray	3	3
Sand, fine	7	10
Sand and gravel, fine to coarse	5	15
Sand and gravel, fine to coarse, silty	18	33
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, gray green	2	35

34-6-11bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW cor. sec. 11, T. 34 S., R. 6 W., 50 feet south and 5 feet east of sec. cor. Surface altitude, 1,258.4 feet; depth to water, 15.90 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, gray	2	2
Silt, tan	5	7
Silt, sandy, tan	5	12
Silt, sandy, brown	8	20
Silt, sandy, tan, some gravel	18	38
Clay, black, compact	2	40

34-6-11cbc.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SW¼ NW¼ SW¼ sec. 11, T. 34 S., R. 6 W., 50 feet north of Bluff Creek bridge on west road shoulder. Surface altitude, 1,225.9 feet; depth to water, 6.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Terrace deposits		
Silt, gray	1	1
Sand and gravel, fine to coarse	4	5
Silt, sandy, dark gray	2	7
Sand and gravel, fine to coarse	8	15
Sand, fine, and gray silt	5	20
Clay, gray tan, gravel stringer at bottom	5	25
Silt, tan, and fine to coarse sand and gravel	7	32
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	33

34-7-1aaa.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE cor. sec. 1, T. 34 S., R. 7 W. Depth to water, 17 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy, red	11	12
Clay, red, tough	8	20
Clay and sand	5	25
Clay, red, tough	3	28
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	33

34-7-1aac.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ NE¼ NE¼ sec. 1, T. 34 S., R. 7 W. Depth to water, 12.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy	6	7
Clay, red	9	16
Clay, sandy, soft	11	27
Sand, medium to coarse, very silty, brown (mucky)	4	31
Clay, brown, soft	4	35
Sand and gravel, fine to coarse	5	40
Clay, blue	10	50
Sand and gravel, medium to coarse, very silty	6	56
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	60

34-7-1aba.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NE¼ NW¼ NE¼ sec. 1, T. 34 S., R. 7 W. Surface altitude, 1,302.1 feet; depth to water, 22 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy, red	5	6
Clay and sand	5	11
Sand, coarse, brown	4	15
Sand and gravel, coarse	14	29
Clay, brown	11	40
Clay, sandy	10	50
Sand and gravel, fine to medium, very silty, some Permian-derived gravel	5	55
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	5	60

34-7-1aca.—*Drillers log of test hole drilled by Layne-Western Co., March 1955, in NE¼ SW¼ NE¼ sec. 1, T. 34 S., R. 7 W. Depth to water, 6.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy	2	3
Sand, medium to coarse, silty	2	5
Sand, coarse	6	11
Clay, brown, hard	17	28
Clay, blue, soft	2	30
Clay, blue, hard	8	38
Clay, sandy, soft	5	43
Sand, silty, blue	1	44
PERMIAN—Leonardian		
Harper Siltstone		
Shale	6	50

34-7-1acc.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in SW¼ SW¼ NE¼ sec. 1, T. 34 S., R. 7 W. Depth to water, 4.70 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	1	1
Clay, sandy	2	3
Clay, gray	8	11
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	6	17

34-7-2aba.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NE¼ NW¼ NE¼ sec. 2, T. 34 S., R. 7 W. Depth to water, 26.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, tan brown	2	2
Sand and gravel, fine to coarse, silty, brown	4	6
Sand and gravel, fine to coarse	4	10
Sand and gravel, fine to coarse, silty	3	13
Silt, sandy, brown	2	15
Silt, tan	2	17
Silt, sandy, tan	6	23
Sand, fine to medium	2	25
Sand, fine to coarse, silty	3	28
Silt, tan brown	1	29
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	1	30

34-7-6cbb.—*Drillers log of test hole drilled by Federal and State Geological Surveys, August 1955, in NW¼ NW¼ SW¼ sec. 6, T. 34 S., R. 7 W. Depth to water, 25.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, red brown	3	3
Silt, tan red	3	6
Silt, sandy, brown	16	22
Sand and gravel, fine to coarse	10	32
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	2	34

34-7-6ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SW cor. sec. 6, T. 34 S., R. 7 W. Depth to water, 17.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, gray brown	2	2
Silt, sandy, black	2	4
Silt, gray, clayey	6	10
Silt, gray	15	25
Silt, clayey, gray black	8	33
Sand and gravel, fine to coarse	1	34
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	1	35

34-7-12abb.—*Drillers log of test hole drilled by Layne-Western Co., March 1952, in NW¼ NW¼ NE¼ sec. 12, T. 34 S., R. 7 W. Depth to water, 20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Clay, hard	4	4
Sand, medium, silty	3	7
Sand and gravel, coarse	16	23
Clay and sand	2	25
Clay, red, tough	5	30
Clay, sandy, red	11	41
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	4	45

34-7-26ddd.—*Drillers log of well drilled for Kansas Emergency Relief Committee, 1933, in SE cor. sec. 26, T. 34 S., R. 7 W. Surface altitude, 1,370.6 feet; depth to water, 21.66 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Undifferentiated Pleistocene deposits		
Silt, sandy, red	20	20
Silt, red, some caliche	4	24
Gravel, coarse, and some red clay	6	30
PERMIAN—Leonardian		
Harper Siltstone		
Shale, red	2	32

34-8-1abb.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NW¼ NW¼ NE¼ sec. 1, T. 34 S., R. 8 W. Depth to water, 20.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Lower Pleistocene		
Kansan Stage		
Silt, sandy, brown	3	3
Silt, tan	7	10
Silt, red brown	10	20
Silt, sandy, tan	6	26
Silt, tan	9	35
Silt, sandy, tan	7	42
PERMIAN—Leonardian		
Harper Siltstone		
Shale, silty, red	4	46
Sandstone, fine, red	4	50

34-8-6bba.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NE¼ NW¼ NW¼ sec. 6, T. 34 S., R. 8 W. Depth to water, 17.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt and fine sand	3	3
Silt, brown	7	10

PERMIAN—Leonardian

Salt Plain Siltstone	Thickness, feet	Depth, feet
Shale, tan brown (weathered)	2	12
Shale and sandstone, white	3	15
Shale, red	5	20

34-8-20ccc.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SW cor. sec. 20, T. 34 S., R. 8 W. Depth to water, 6.40 feet.*

QUATERNARY—Upper Pleistocene

Illinoisan and Wisconsinan Stages—Slope deposits	Thickness, feet	Depth, feet
Silt, sandy, gray brown	5	5
Sand and gravel, fine to coarse	10	15
Sand and gravel, fine to coarse, silty	6	21
Sand and gravel, very silty	14	35
Sand and gravel, fine to coarse	5	40

34-8-29aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in NE cor. sec. 29, T. 34 S., R. 8 W. Depth to water, 12.40 feet.*

QUATERNARY—Upper Pleistocene

Illinoisan and Wisconsinan Stages—Slope deposits	Thickness, feet	Depth, feet
Sand, fine, silty, brown	5	5
Sand, fine, silty, buff	3	8
Silt, tan	7	15
Sand and gravel, fine to coarse, very silty	12	27
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	3	30

34-8-29bab.—*Sample log of test hole drilled by Federal and State Geological Surveys, August 1955, in NW¼ NE¼ NW¼ sec. 29, T. 34 S., R. 8 W. Depth to water, 9.40 feet.*

QUATERNARY—Upper Pleistocene

Illinoisan and Wisconsinan Stages—Slope deposits	Thickness, feet	Depth, feet
Silt and fine sand	3	3
Silt, sandy, light gray	7	10
Silt, gray tan to black at bottom	13	23
Sand and gravel, fine to coarse, silty, black	8	31
Silt, red brown; contains many snails	9	40
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	5	45

34-8-30abb.—*Sample log of test hole drilled by Federal and State Geological Surveys, August 1955, in NW¼ NW¼ NE¼ sec. 30, T. 34 S., R. 8 W. Depth to water, 18.60 feet.*

QUATERNARY—Upper Pleistocene

Wisconsinan Stage—Dune sand	Thickness, feet	Depth, feet
Sand, fine, silty	3	3
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to coarse, silty	4	7

	Thickness, feet	Depth, feet
Silt, fine sandy, brown	2	9
Sand and gravel, fine to coarse, silt at 14 to 16 ft.	11	20
Sand and gravel, fine to coarse	17	37
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	3	40

34-9-1aab.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW¼ NE¼ NE¼ sec. 1, T. 34 S., R. 9 W. Depth to water, 2.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Silt and fine sand	5	5
Silt, sandy, brown	5	10
Silt and clay, gray	5	15
Sand, fine, silty	5	20
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to coarse	3	23
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	2	25

34-9-1baa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE¼ NE¼ NW¼ sec. 1, T. 34 S., R. 9 W. Depth to water, 12.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage		
Sand, fine, silty, gray brown	5	5
Silt, brown	7	12
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine to coarse, silty	4	16
Silt, red	2	18
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	20

34-9-1bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 1, T. 34 S., R. 9 W. Depth to water, 10.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Sand, fine, silty	2	2
Silt, very sandy, brown	2	4
Sand, fine	2	6
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine to coarse	6	12
Sand and gravel, fine to coarse	21	33
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	35

34-9-3bbb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW cor. sec. 3, T. 34 S., R. 9 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Sand, fine, silty	3	3
Sand, fine	4	7
Silt, sandy, red	2	9
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red, hard	1	10

34-9-22dcc.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SW¼ SW¼ SE¼ sec. 22, T. 34 S., R. 9 W. Depth to water, 4.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine, silty	3	3
Silt, sandy, brown	2	5
Silt, brown	3	8
Silt, very fine sandy, brown	5	13
Sand and gravel, fine to coarse, silty	20	33
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	35

34-9-22ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SE cor. sec. 22, T. 34 S., R. 9 W.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Sand, fine, some silt	7	7
Silt, reddish brown	5	12
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	3	15

34-9-23ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SE cor. sec. 23, T. 34 S., R. 9 W. Depth to water, 16.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Silt, brownish gray	2	2
Sand, fine, silty, tan	6	8
Sand, fine, silty, buff	5	13
Sand, fine	4	17
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to coarse	20	37
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	39

34-9-24ddd.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1955, in SE cor. sec. 24, T. 34 S., R. 9 W. Depth to water, 13.80 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Silt and sand, fine, dark gray	4	4
Silt, very sandy, tan	6	10
Sand, fine, some silt	3	13
Sand, fine	2	15
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to coarse, some silt	25	40

34-9-27dbb.—*Drillers log of well drilled by Layne-Western Co., July 1928, in NW¼ NW¼ SE¼ sec. 27, T. 34 S., R. 9 W. Depth to water, 7.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	2	2
Sand and gravel	9	11
Clay	8	19
Sand and gravel	8	27
Clay	1	28
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	2	30

34-9-27dca.—*Drillers log of well drilled by Layne-Western Co., July 1928, in NE¼ SW¼ SE¼ sec. 27, T. 34 S., R. 9 W. Depth to water, 7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	2	2
Sand and gravel	8	10
Clay	1	11
Sand and gravel	3	14
Sand, fine	1	15
Clay	3	18
Sand and gravel	9	27
Clay	2	29
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	30

34-9-27dcc.—*Drillers log of well drilled by Layne-Western Co., July 1928, in SW¼ SW¼ SE¼ sec. 27, T. 34 S., R. 9 W. Depth to water, 7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt	3	3
Sand, coarse	12	15
Sand and gravel	11	26
Clay	4	30
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale	1	31

34-9-28aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1956, in NE cor. sec. 28, T. 34 S., R. 9 W. Depth to water, 13.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt, very sandy, gray	3	3
Silt, gray to brown	4	7
Silt, brown	5	12
Sand and gravel, fine to coarse, silty	3	15
Sand and gravel, fine to coarse	3	18
Silt, brown	1	19
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	20

35-8-8dcc.—*Sample log of test hole augered by Federal and State Geological Surveys, August 1956, in SW¼ SW¼ SE¼ sec. 8, T. 35 S., R. 8 W. Depth to water, 11.10 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine to coarse, silty	5	5
Sand, fine to coarse	5	10
Silt, clayey and sandy	7	17
Sand and gravel, coarse	29	46
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, red	1	47

35-8-17aaa.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE cor. sec. 17, T. 35 S., R. 8 W. Depth to water, 7.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Wisconsinan Stage—Dune sand		
Sand, fine, silty	4	4
Silt, sandy, compact	2	6
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand and gravel, fine to coarse	6	12
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	3	15

35-8-17abb.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NW¼ NW¼ NE¼ sec. 17, T. 35 S., R. 8 W. Depth to water, 8.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Silt and sand, fine	2	2
Sand, fine	4	6
Silt, clayey, red brown	7	13
Sand, fine, silty, buff	4	17
Sand, fine to medium	3	20
Sand and gravel, fine to coarse, few clay streaks near bottom	30	50

35-8-17bba.—*Sample log of test hole augered by Federal and State Geological Surveys, July 1955, in NE¼ NW¼ NW¼ sec. 17, T. 35 S., R. 8 W. Depth to water, 8.30 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene		
Illinoisan and Wisconsinan Stages—Slope deposits		
Sand, fine, silty	3	3
Silt, gray	2	5
Sand, fine to coarse	7	12
Sand and gravel, fine to coarse, clay streaks near bottom	28	40
PERMIAN—Leonardian		
Salt Plain Siltstone		
Shale, silty, red	2	42

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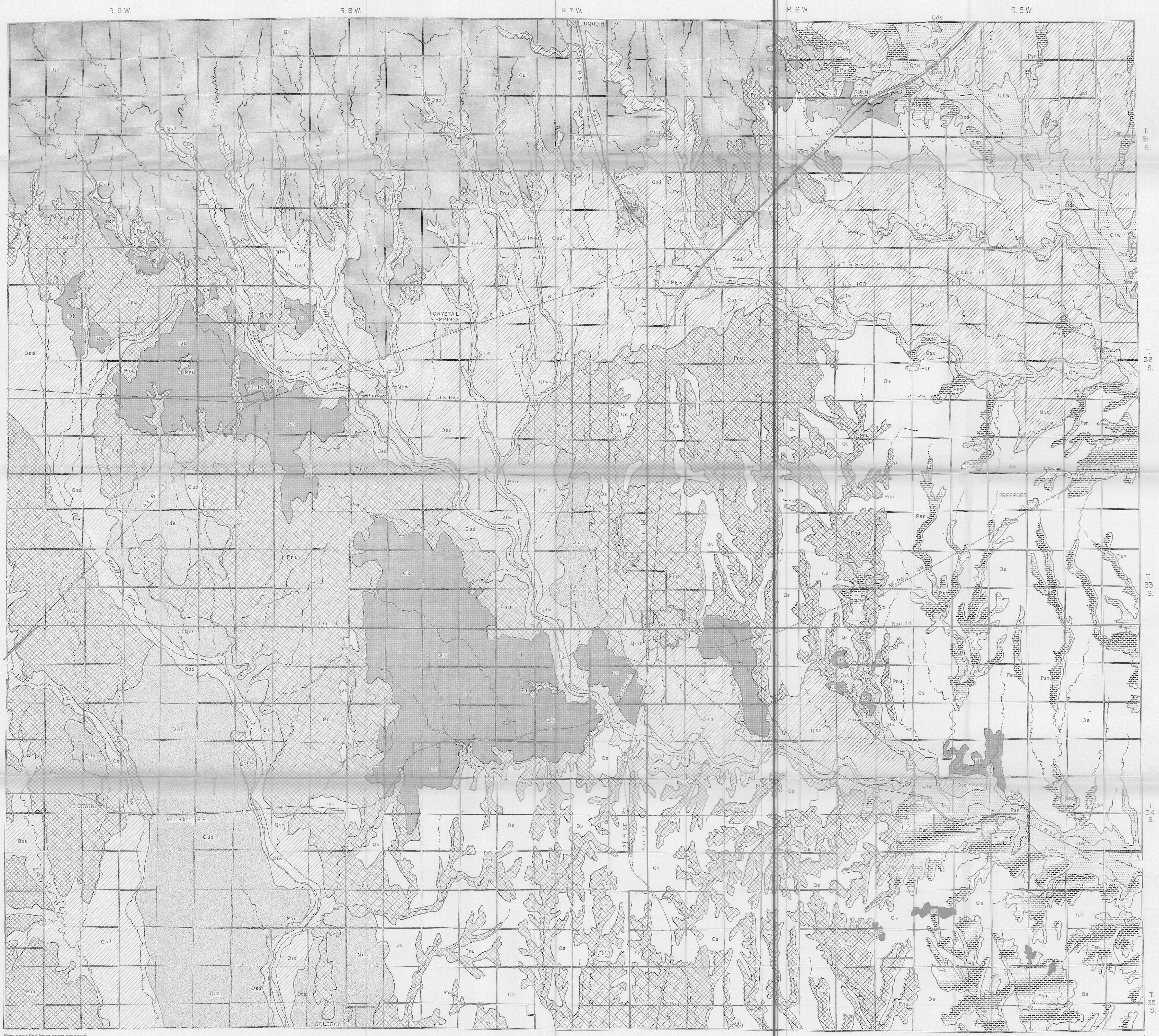
28-2123

AREAL GEOLOGY OF HARPER COUNTY, KANSAS

By Charles K. Bayne
1956

Bulletin 143
Plate 1

State Geological Survey
of Kansas



Base compiled from maps prepared
by the Soil Conservation Service

Drainage from map prepared
by U. S. Dept. of Agriculture

EXPLANATION

QUATERNARY

PLEISTOCENE

WISCONSINAN AND RECENT

Qds

Dune sand
Fine and medium eolian sand and silt. Yields small supplies of water to wells.

WISCONSINAN

Qtw

Terrace deposits
Fine to coarse sand and gravel and much silt and clay. Yields small to moderate supplies of water to wells. Includes recent alluvium along major streams.

Qs

Eolian silts
Wind-deposited silt. Principally derived locally.

ILLINOISAN TO RECENT

Qsd

Slope deposits
Silt, sand, and gravel the surface of which is a moderately steep slope locally underlain by narrow filled channels; upper part largely colluvium. Yields moderate to large supplies of water from channel deposits.

KANSAN

Qk

Kansan deposits
Silt, sand, gravel, and volcanic ash probably in terrace position to ancient streams. Sheet deposits in upland areas. Yields small supplies of water to wells.

NEBRASKAN AND KANSAN

Qu

Undifferentiated deposits
Silt, sand, gravel, and volcanic ash in upland position. Yields moderate to large supplies of water to wells.

TERTIARY (?)

PLIOCENE (?)

Tp

Undifferentiated deposits
Principally gravel derived from Permian units or from Dakota sandstone; some arkosic gravel. Lies above water table.

PERMIAN

LEONARDIAN

NIPPEWALA GROUP

Pnu

Harper Siltstone and Salt Plain Siltstone Undifferentiated
Silt, shale, siltstone, and sandstone. Yields small supplies of water of good to poor quality from upper weathered zone. In some areas yields no water to wells.

SUMNER GROUP

Psn

Ninnescah Shale
Blocky, clayey to silty shale, and thin limestone and siltstone beds. Yields small supplies of water of good to poor quality to wells from weathered part of formation.

Federal or state highway
Railroad
State line (no road)
County line (no road)
Township or county road
Section line (no road)
Perennial stream
Intermittent stream

0 1 2 3 4 5
Scale, in miles

State Geological Survey
of Kansas

GEOLOGIC CROSS SECTIONS IN HARPER COUNTY

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1956

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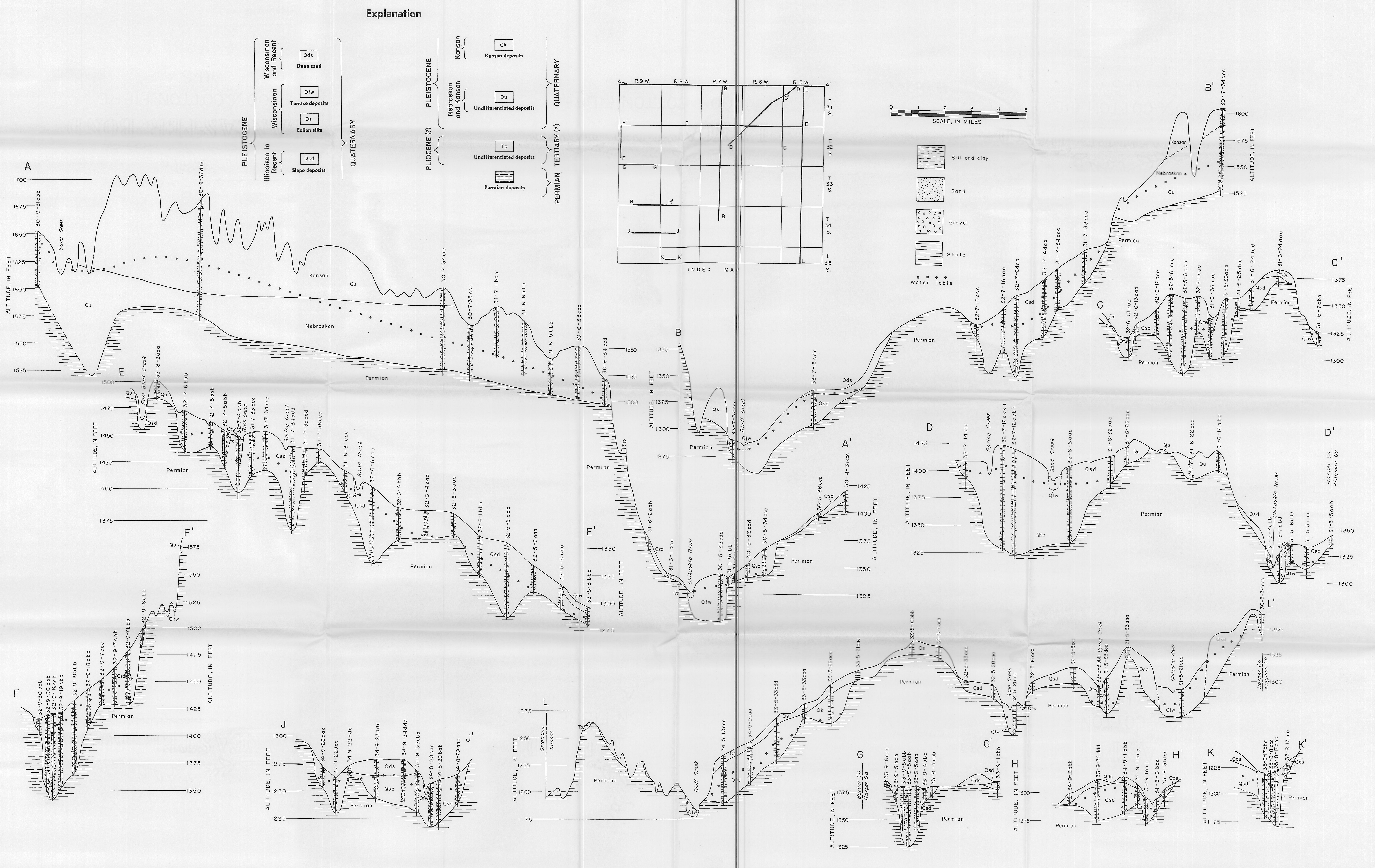
Plate 2



State Geological Survey
of Kansas

MAP OF HARPER COUNTY, KANSAS

showing water-table contours
and location of wells and test holes

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1956

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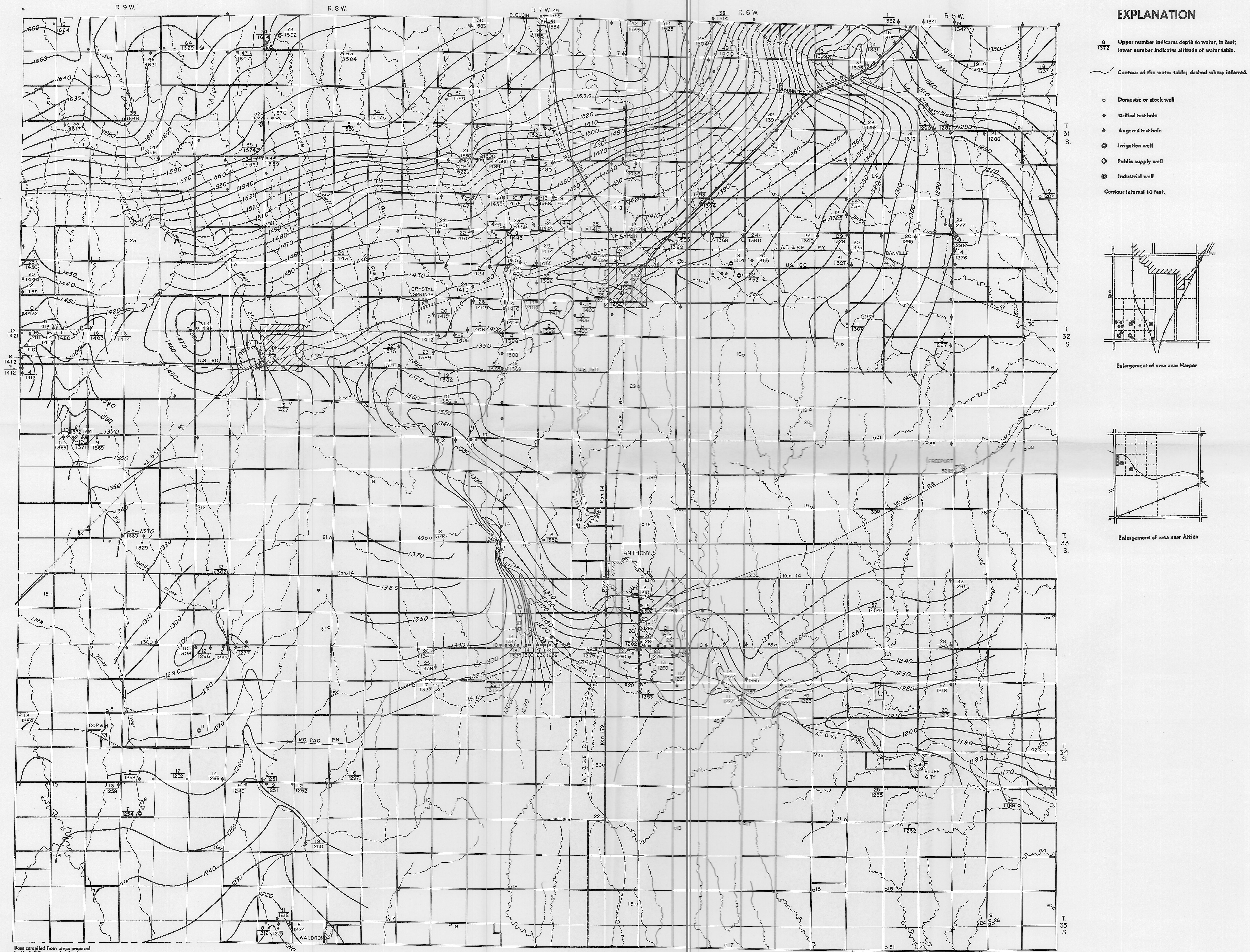
Plate 3



CONFIGURATION OF THE PRE-PLEISTOCENE SURFACE IN A PART OF HARPER COUNTY

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Plate 4

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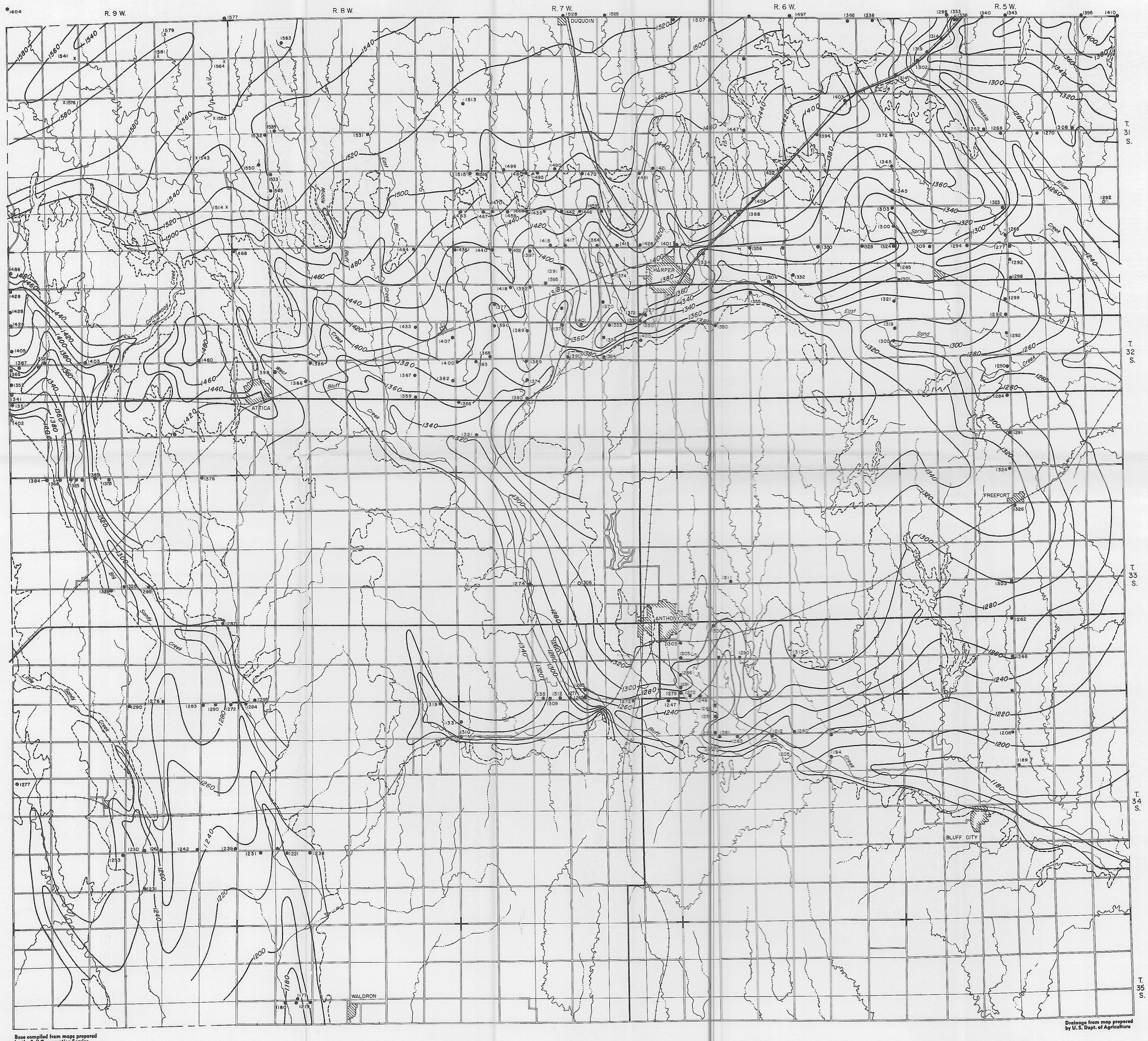
1956

State Geological Survey of Kansas



EXPLANATION

1563 — Test hole or well. Number indicates bedrock altitude

1500 — Bedrock contour. Contour interval 20 feet

Q/P — Permian-Pleistocene contact

Base compiled from maps prepared by the Soil Conservation Service

Drainage from map prepared by U. S. Dept. of Agriculture

MAP SHOWING SATURATED THICKNESS OF PLEISTOCENE DEPOSITS IN HARPER COUNTY

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1956

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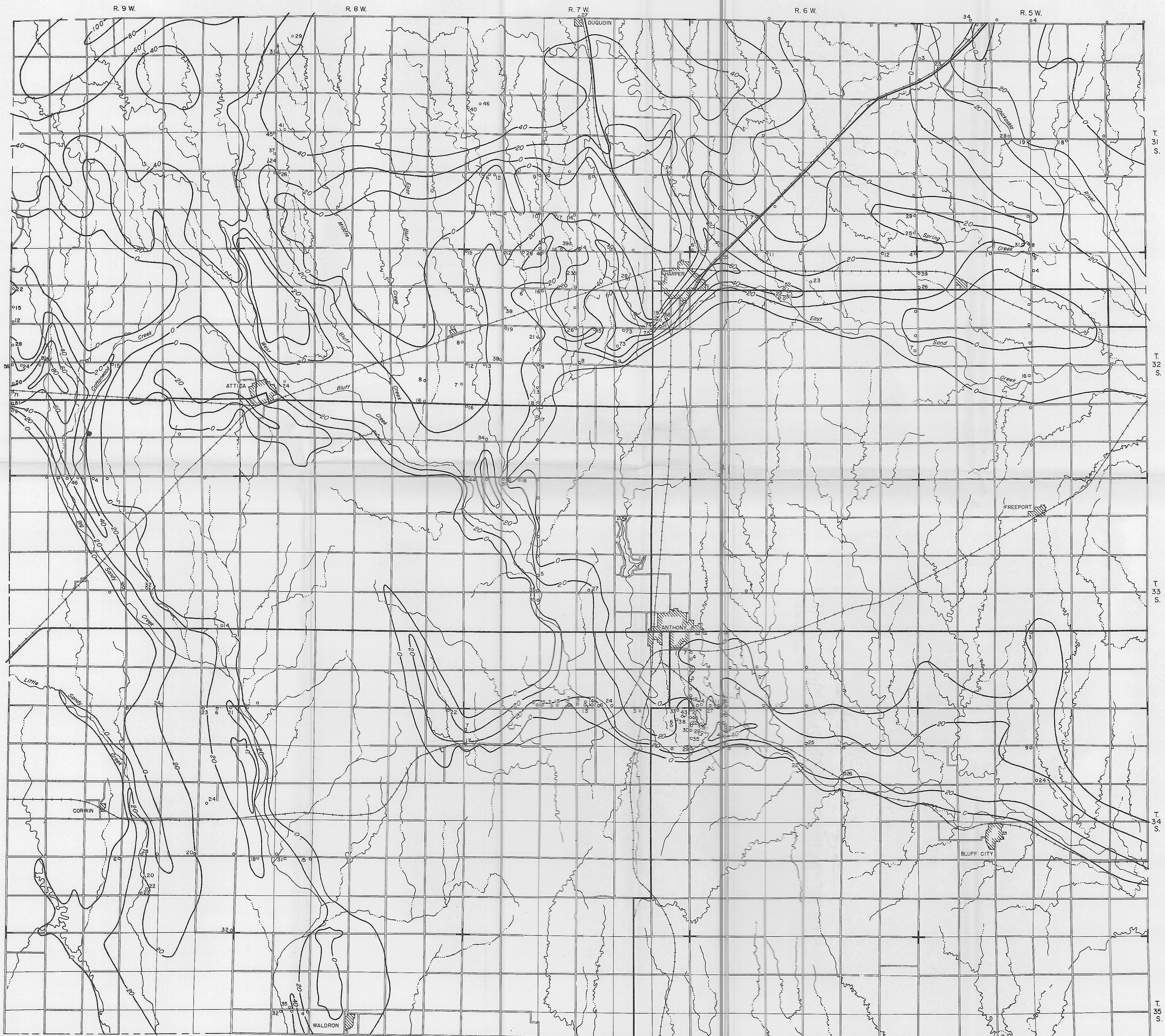
State Geological Survey
of Kansas



EXPLANATION

18 o
Test hole or well
Number indicates saturated thickness

20
Contours connect points of equal saturated thickness
Contour interval 20 feet

Base compiled from maps prepared by the Soil Conservation Service

Drainage from map prepared by U. S. Dept. of Agriculture