Ground-Water Conditions in the Smoky Hill Valley in Saline, Dickinson, and Geary Counties, Kansas

By

BRUCE F. LATTA

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By BRUCE F. LATTA

with analyses by

H. A. STOLTENBERG

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

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GROUND-WATER CONDITIONS IN THE SMOKY HILL VALLEY IN SALINE, DICKINSON, AND GEARY COUNTIES, KANSAS

By Bruce F. Latta

ABSTRACT

This report gives the results of an investigation of ground water in the Smoky Hill Valley and its major tributary valleys in Saline, Dickinson, and Geary Counties, in central Kansas. Situated in this area are the cities of Salina, the chief distribution center for the central Kansas area, Abilene, Junction City, and numerous smaller towns, the cantonment areas of the Fort Riley Military Reservation and Camp Phillips, and the Smoky Hill Army Air Base. Agriculture is the dominant enterprise of the area and most urban industries are related to the agriculture.

The strata in the central Kansas region dip gently to the west, but have been beveled by an erosional plain that slopes eastward. Smoky Hill River and its major tributaries have cut below this old plain and are now flowing in rather wide, flat-bottomed valleys that are underlain by thick unconsolidated alluvial deposits of Quaternary age. These deposits are the most important source of water in the area.

The bedrock formations that underlie the unconsolidated alluvial deposits and form the uplands bordering the valleys include sedimentary rocks of Permian and Cretaceous age. East of Abilene the bedrock consists of alternating beds of limestone and shale of the Wolfcampian Series (Permian). West of Abilene the Wellington formation (Permian) underlies the alluvial deposits and forms the uplands. The Wellington formation consists chiefly of shale, but includes also thick beds of gypsum and thin beds of impure limestone. Clay, shale, and thick lenticular beds of sandstone of the Kiowa shale (Cretaceous) unconformably overlie the Wellington formation along parts of the Smoky Hill and Saline Valleys in Saline County.

Dune sand, ranging from a featheredge to about 40 feet in thickness, covers an area of about 20 square miles along the north side of Smoky Hill Valley between Abilene and Solomon. Stream-laid terrace deposits of Pleistocene age underlie the dune sand and rest unconformably on shale, limestone, and gypsum of the Wellington formation and the upper part of the Wolfcampian Series. The terrace deposits are 50 to 65 feet thick near the valley and thin to a featheredge at the north. They consist principally of overlapping lenses of unconsolidated silt, sand, and gravel. Domestic and stock wells derive water of excellent quality from the terrace deposits. There are no large wells in this area, but test drilling indicates that in some places the sands and gravels are sufficiently thick and coarse to supply several hundred gallons of water a minute to properly constructed wells.

The only spring (Sand Springs) of importance in the Smoky Hill Valley

area is on the north bank of Smoky Hill River about 2.5 miles west of Abilene and is the source of the Abilene water supply. Water is discharged at the spring from a solution opening between bedding planes in Permian limestone (Herington limestone member of the Nolans limestone). The limestone through which the water issues is about 7 feet thick and extends only a short distance northward beneath the water-bearing terrace deposits. Water moves from the terrace deposits into fractures and solution openings in the limestone and is discharged at the spring. The flow of the spring ranges from less than 900 gallons a minute during periods of low rainfall to about 1,200 gallons a minute during wet periods.

All large water supplies in this area, with the exception of the Abilene supply, are obtained from wells that tap the Quaternary alluvial deposits beneath the valley plains. The logs of 93 test holes drilled by the State Geological Survey in Smoky Hill Valley and its tributary valleys and the logs of 30 test holes and 23 wells obtained from city officials and private drilling companies are included in this report. These data are shown graphically by 14 cross sections, nine of which are of Smoky Hill Valley and one each of Republican, Solomon, Saline, Mulberry, and Dry Creek Valleys. The alluvium in these valleys consists of unconsolidated clay, silt, sand, and gravel. The finer materials commonly occur in the upper part and the coarser materials in the lower part. Most of the large wells penetrate the entire thickness of alluvium.

Smoky Hill Valley in the area considered is about 72 miles long and 1 to 5 miles wide. It is underlain by alluvium ranging in thickness from less than 30 to more than 90 feet. The greatest thickness of alluvium, 94 feet, was encountered about 1 mile southeast of Mentor in southern Saline County. The yields of wells that tap alluvium in Smoky Hill Valley range from a few gallons a minute for small domestic and stock wells to 1,500 gallons a minute for larger wells. Moderate to large supplies of water are available from wells in most places in Smoky Hill Valley in this area. The Cities of Assaria, Salina, Solomon, Enterprise, and Chapman obtain their water supplies from wells in Smoky Hill Valley.

Alluvium in the part of the Republican Valley in Geary County ranges in thickness from a few feet to 82 feet, the average being about 45 feet. The sands and gravels in the lower part of the alluvium furnish large supplies of water to wells that tap them. The Cities of Milford and Junction City, the Cavalry Replacement Training Center of the Fort Riley Military Reservation, and Fort Riley obtain water from these deposits. The yields of the wells range from 150 to 1,200 gallons a minute.

Nine test holes drilled in Solomon Valley in Saline County penetrated 44 to 65 feet of alluvium. No large wells have been drilled in Solomon Valley in this area, but the test drilling indicates that wells having moderate to large yields could be developed here. In places, however, the water in the alluvial deposits is too highly mineralized for ordinary uses.

In Saline Valley in Saline County the thickness of alluvium in six test holes ranges from 20 to 92 feet and averages 64 feet. The thickness of alluvium in five test holes drilled in Mulberry Valley, a tributary of Saline Valley, ranges from 36 to 66 feet. No large wells have been drilled in either Saline or Mulberry Valley but the test drilling indicates that moderate to large supplies are available in these valleys.

The alluvium in the valley of Dry Creek, which flows northward along the west edge of Smoky Hill Valley and is tributary to Mulberry Creek, is a few feet to more than 50 feet thick. It consists principally of silt and clay with thin lenses of sand and gravel at the base. Small supplies of very hard water are obtained from these deposits for farm use.

The use of ground water for irrigation is not extensive in the Smoky Hill Valley area. In 1943 there were only seven irrigation wells in this entire area. Five of these wells were in the vicinity of Abilene and two were in the vicinity of Salina.

Ground waters from the alluvial deposits in the Smoky Hill Valley area are hard to very hard. The hardness of 61 samples analyzed ranged from 274 to 1,980 parts per million. Many of the samples contained undesirable concentrations of iron. Of 64 samples analyzed for iron, 51 contained more than 0.1 part per million and 32 contained more than 1 part. Some ground waters in the alluvium of Solomon and Smoky Hill Valleys in the vicinity of Solomon are unfit for most uses because of the high concentrations of chloride. Concentrations of chloride in excess of 10,000 parts per million were found in some samples of water taken from the lower part of the alluvium in this area. However, in places the upper waters in the Solomon area are relatively low in chloride.

INTRODUCTION

Purpose and Scope of the Investigation

In 1937 the Geological Survey, United States Department of the Interior, and the State Geological Survey of Kansas, with the coöperation of the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture, started an extensive program of ground-water investigations in the State. Prior to the war most of the studies were of counties in the western part of the State where irrigation from wells was being carried on or was potentially important. During the war, however, emphasis was placed on studying the ground-water conditions in those areas of the State in which the demand for water for military, industrial, and municipal use was greatly increased as a result of the war. Such studies furnished the basic data needed to answer many of the inquiries received from the War and Navy Departments, the War Production Board, other agencies, and industries regarding the availability and quality of ground water in specific localities. Special studies were made in response to the more important inquiries or for those concerning areas in which data on the gound-water conditions were inadequate or lacking.

This report presents the results of a brief study of ground-water conditions in Smoky Hill River Valley and valleys tributary to it in central Kansas made during the summer of 1943. Two important military centers are located in this area as well as several important cities, many of which became greatly overcrowded during the war owing to their proximity to near-by military establishments. All municipal and military water supplies in the area are obtained from wells except the supply at Abilene, which is obtained from a spring. The chief purpose of the investigation was to collect the information necessary to answer inquiries relating to the availability and quality of ground water in this area. Specific problems concerning ground water which will require more detailed studies in particular areas, may arise in the future.

The field work on which this report is based was done during the period from June 1 to August 15, 1943. Information concerning the nature and thickness of the water-bearing material, construction details, yield, the use and general character of the water, and the amount of pumpage was obtained for one spring, 55 domestic and stock wells, and 43 municipal, irrigation, and industrial wells. Samples of water from 55 wells were collected and sent to the Water and Sewage Laboratory of the Kansas State Board of Health at Lawrence, where they were analyzed by Howard Stoltenberg, chemist. All the important mineral constituents in 48 of the samples were determined, but only the chloride content of the other 7 samples was determined.

During the winter of 1943-1944, 109 test holes were drilled in the Smoky Hill Valley area by O. S. Fent, Milford Klingaman, and Harold Rector, using a portable hydraulic-rotary drilling rig owned by the State Geological Survey. Results of this test drilling are given in logs at the back of this report. Most of the test holes were drilled in valley areas to determine the character and thickness of the alluvium. Of the 109 test holes, 69 were drilled in Saline County, 28 in Dickinson County, and 12 in Geary County.

The analyses of the water samples collected from wells during the summer of 1943 indicated that ground waters in parts of the area, especially in the Solomon area, contained excessive amounts of chloride. To obtain additional data on the distribution of chloride waters, samples of water from 22 test holes were collected by the drilling crew and sent to Lawrence, where Mr. Stoltenberg determined their chloride content.

During March and April, 1946 the U. S. Geological Survey, coöperating with the U. S. Bureau of Reclamation in connection with the Kanopolis dam project, put down 11 small-diameter observation wells in Smoky Hill Valley in southern Saline County. This work was done by John Sears. Periodic measurements of the water levels in these wells are being made to obtain information concerning the fluctuations of the water table in the alluvium in this part of the valley. The altitudes of the measuring points of the observation wells and of the test-hole locations were determined with an alidade and plane table by Charles K. Bayne and Norbert Riebel. The investigation was made under the general supervision of O. E. Meinzer and A. N. Sayre, successive geologists in charge, Ground-Water Branch, U. S. Geological Survey.

Location and General Features of the Area

The area covered by this report includes Smoky Hill Valley in Saline, Dickinson, and Geary Counties, in central Kansas; those parts of Mulberry, Saline, Solomon, and Republican Valleys just above their confluence with Smoky Hill Valley; and that part of Kansas River Valley in Geary County (Fig. 1). For convenience the entire area is referred to in this report as the Smoky Hill Valley

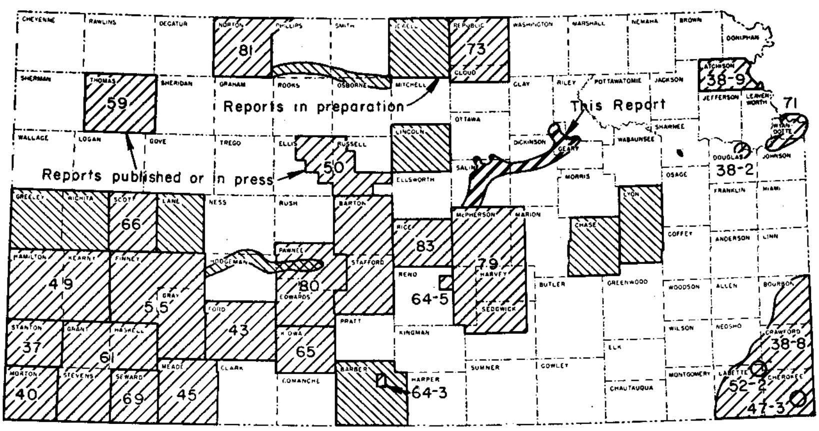

Fig. 1.—Area covered by this report and other areas in Kansas for which coöperative ground-water reports have been published or are in preparation.

area. The segment of Smoky Hill Valley studied is about 72 miles long and 1 to 5 miles wide.

Several important cities and military bases are located in this area. Salina, the county seat of Saline County and largest city in the area, had a population of 24,001 in 1943; Abilene, the county seat of Dickinson County, had a population of 5,539; and Junction City, the county seat of Geary County, had a population of 9,524. Other cities and their 1943 populations include Milford (258) in Geary County; Chapman (873), Enterprise (706), and Solomon (811) in Dickinson

County; and New Cambria (132) and Assaria (211) in Saline County. Milford is in Republican Valley; the other cities are in Smoky Hill Valley. The southern part of the Fort Riley Military Reservation is in Republican and Kansas Valleys north and east of Junction City. The reservation, which was established in 1852, comprises 22,000 acres and includes Fort Riley, one of the nation's large army posts and site of the Cavalry School, Camp Funston, Camp Whitside, and Marshall Flying Field. Two military bases were constructed southwest of Salina in 1942. Smoky Hill Army Air Field, comprising 2.5 square miles, is in Smoky Hill Valley 2 miles southwest of Salina. Camp Phillips, an infantry training base, covers a roughly triangular area of 70 square miles in southwestern Saline County. The cantonment at Camp Phillips is in the northeastern part of the camp area about 5 miles southwest of Salina.

Transportation facilities in the Smoky Hill Valley area are excellent. The main line of the Union Pacific Railroad from Kansas City to Denver follows Smoky Hill Valley between Junction City and Salina. Branch lines of the Union Pacific Railroad run from Junction City to Concordia, from Solomon to Beloit, from Salina to Colby, and from Salina to McPherson. A branch line of the Rock Island Railroad follows Smoky Hill Valley from Salina to Enterprise, where it turns south and joins the main line at Herington in southeastern Dickinson County. A branch of the Atchison, Topeka, and Santa Fe Railway that leaves the main line at Neva in northern Chase County enters this area at Enterprise and follows the Smoky Hill Valley to Abilene, thence turning north to Manchester, where it splits—one branch running north to Superior, Nebraska, and one northwest to Osborne, Kansas. The main line of the Missouri Pacific Railroad between St. Louis and Pueblo passes through the southeastern part of Saline County. A branch line of the Missouri Pacific leaves the main line at Gypsum in southeastern Saline County, passes through Salina, and rejoins the main line at Marquette in northwestern McPherson County.

Federal and State highways connect the Smoky Hill Valley area with all parts of the state. U. S. Highway 40, a main east-west highway, passes through all the towns in the valley between Junction City and Salina. The area is traversed by north-south highways U. S. 77 at Junction City, Kan., 43 at Enterprise, Kan., 15 at Abilene, and U. S. 81 at Salina. In addition to the Federal and State highways there are many county roads that are graveled and kept in excellent condition throughout the year.

Agriculture is the dominant industry in the Smoky Hill Valley area. The principal crops grown in the valley proper are wheat, corn, alfalfa, kaffir corn, and sorphum. Watermelons, cantaloupes, and some truck crops are grown in the sand-hills area that borders the north side of Smoky Hill Valley between Solomon and Abilene. Cattle raising is an important phase of the agriculture on the rough uplands that border the valley, particularly in the eastern part of the area. The urban industries are primarily related to the agriculture and particularly to wheat production. These industries include flour milling, wheat storage, and the distribution of farm machinery and supplies. Salina, the chief distribution center in north-central Kansas, has five large mills and ranks fourth in the nation in the production of flour. Abilene and Junction City also have flour mills, and every town in the area, regardless of size, has one or more wheat elevators.

Previous Investigations

No investigations dealing primarily with the geology and ground-water resources of Smoky Hill Valley in the central Kansas area, have been made previously. Brief references to the geology or ground water of parts of this area have been made in numerous reports, however. The more important of these are cited below.

In a report published in 1883 describing the geology of Kansas, St. John (1883, p. 591) included a description of brine wells of the National Solar Salt Company near Solomon. In a report on the physiography of western Kansas, Haworth (1897, pp. 35-41) includes brief physiographic descriptions of Smoky Hill, Saline, Solomon, and Republican Valleys. The brine wells near Solomon were again referred to by Bailey (pp. 72, 74-76) in 1902. In this same report, (p. 319) Bailey gave a brief discussion of the quality of the water from Sand Springs, the source of Abilene's water supply. Analyses of samples of water from wells at Salina, Chapman, Enterprise, Solomon, and Junction City and river samples from Smoky Hill River at Lindsborg and Republican River at Junction City were tabulated in 1911 by Parker (pp. 78, 96, 178, 217, and 233).

During the first World War, Moore (1918, pp. 39-81) published a popular description of the geology and physiography of the area about Camp Funston for the use of the soldiers in training there. A general discussion of ground-water conditions in the Camp Funston area and a description of the water supply at the camp are included in the report (pp. 57, 58, 76-78). Another report by Moore

(1940) describes the ground-water resources of Kansas. In 1941 Jewett's excellent report on the geology of Riley and Geary Counties was published. Although emphasis was placed on the bedrock geology of this area, brief descriptions were given of the alluvial deposits in Republican and Smoky Hill Valleys and of the water resources of the area (Jewett, 1941, pp. 96, 112-115).

A report published in 1942 on the availability of ground-water supplies for national defense industries in Kansas includes descriptions of the availability of ground-water supplies in Smoky Hill, Saline, Solomon, and Republican Valleys (Lohman et al., 1942, pp. 31-35, 45, 46).

Acknowledgments

Thanks and appreciation are expressed to the many residents of the Smoky Hill Valley area who kindly supplied information regarding ground-water conditions in this area. Special acknowledgment is due the officials of the many cities who willingly furnished information about their respective city water supplies. I also wish to acknowledge the help and information received from the Quartermaster Corps, U. S. Army, at Fort Riley and the Corps of Engineers at Camp Phillips. The Layne-Western Company; Paulette and Wilson, Engineers; and the Widmer Engineering Company furnished many well records, well and test-hole logs, and water-level measurements which have been invaluable in this study.

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

CLIMATE

The climate of the Smoky Hill Valley area is of the subhumid type and is marked by extremes of precipitation and temperature. The normal mean annual temperature at Salina, Chapman, and Junction City is 55.9° F., 55.4° F., and 55.3° F., respectively. The highest temperatures occur during the three summer months, the monthly mean being about 74° F. in June; 80° F. in July; and 78° F. in August. December, January, and February are generally the

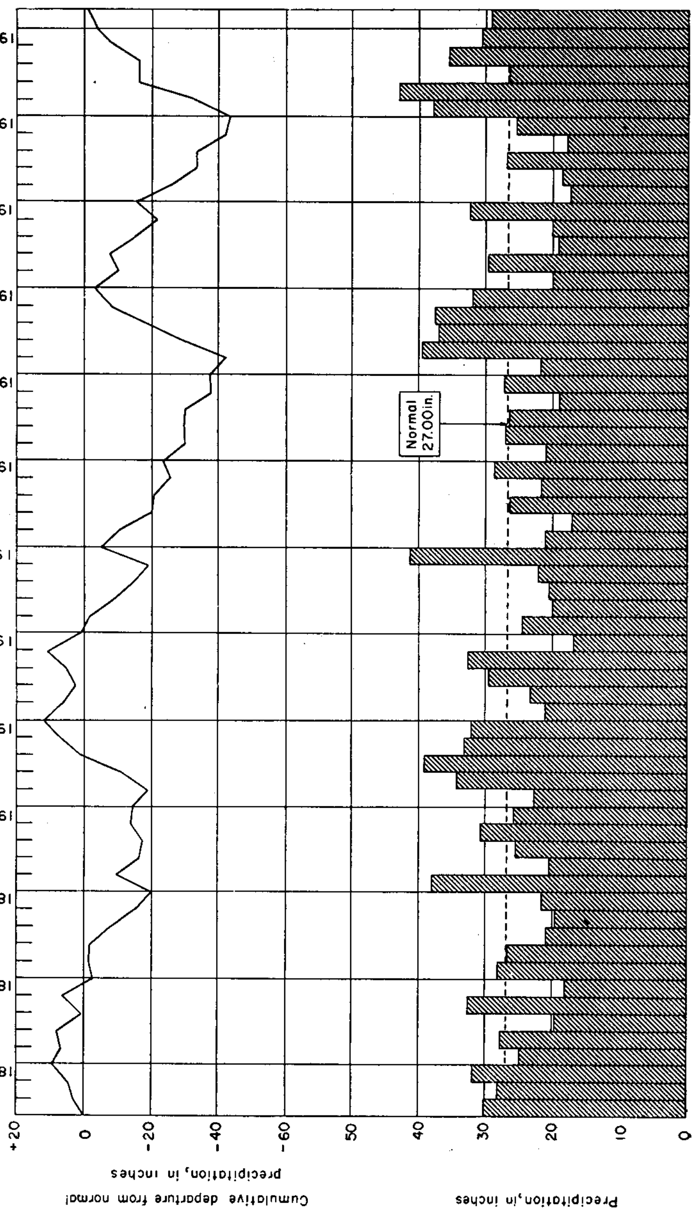

FIG. 2.—Annual precipitation and cumulative departure from normal precipitation at Salina.

coldest months, the mean monthly temperature being about 32° F. in December; 29° F. in January; and 32° F. in February.

The average growing season in the western part of the area is about 175 days, and has ranged from about 140 to about 200 days. In the eastern part of the area the average growing season is about 185 days and has ranged from about 160 to about 207 days.

Records of the U. S. Weather Bureau show that the normal annual precipitation increases from west to east in this area. The normal annual precipitation at Salina is 27.00 inches, at Chapman it is 29.22 inches, and at Junction City it is 31.55 inches. Deviations from the normal are frequent, however. At Salina the recorded annual precipitation has ranged from a minimum of 16.89 inches in 1910 to a maximum of 43.19 inches in 1942; at Chapman it has ranged from 18.93 inches in 1917 to 47.13 inches in 1944; and at Junction City it has ranged from 21.56 inches in 1934 to 53.28 inches in 1944. The annual precipitation and the cumulative departure from normal precipitation at Salina, Chapman, and Junction City are shown graphically in Figures 2, 3, and 4.

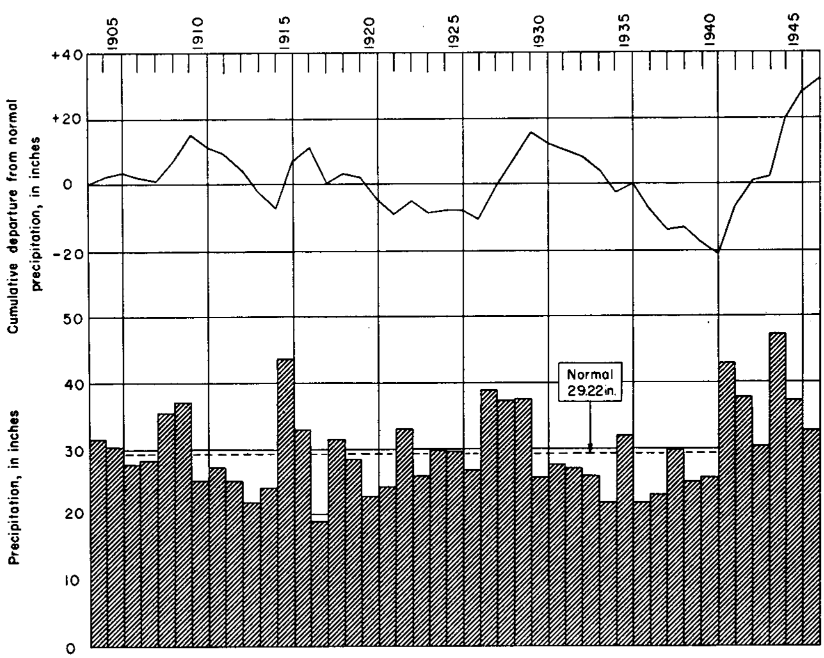

FIG. 3.—Annual precipitation and cumulative departure from normal precipitation at Chapman.

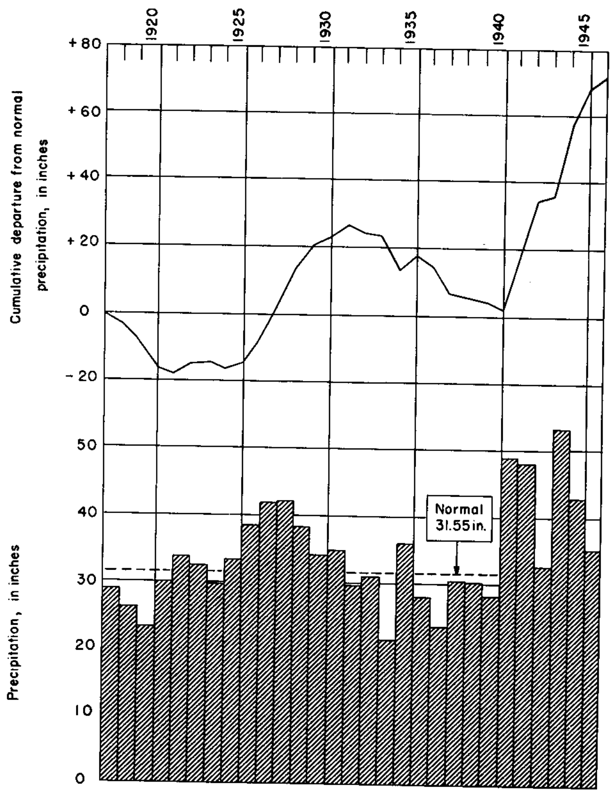

FIG. 4.—Annual precipitation and cumulative departure from normal precipitation at Junction City.

PHYSIOGRAPHY

GENERAL FEATURES

The Smoky Hill Valley area lies within two major physiographic provinces—the Central Lowlands province and the Great Plains province. The area east of a north-south line drawn approximately through Solomon lies in the Osage Plains section of the Central Lowlands province, and the area west of this line lies in the Plains Border section of the Great Plains province. The strata in the central Kansas region dip gently to the west, but have been beveled by an erosional plain that slopes eastward. The Osage Plains are distinguished by many east-facing escarpments that trend roughly north-south. The edges of westward-dipping hard limestones form the escarpments, between which are gently rolling plains underlain

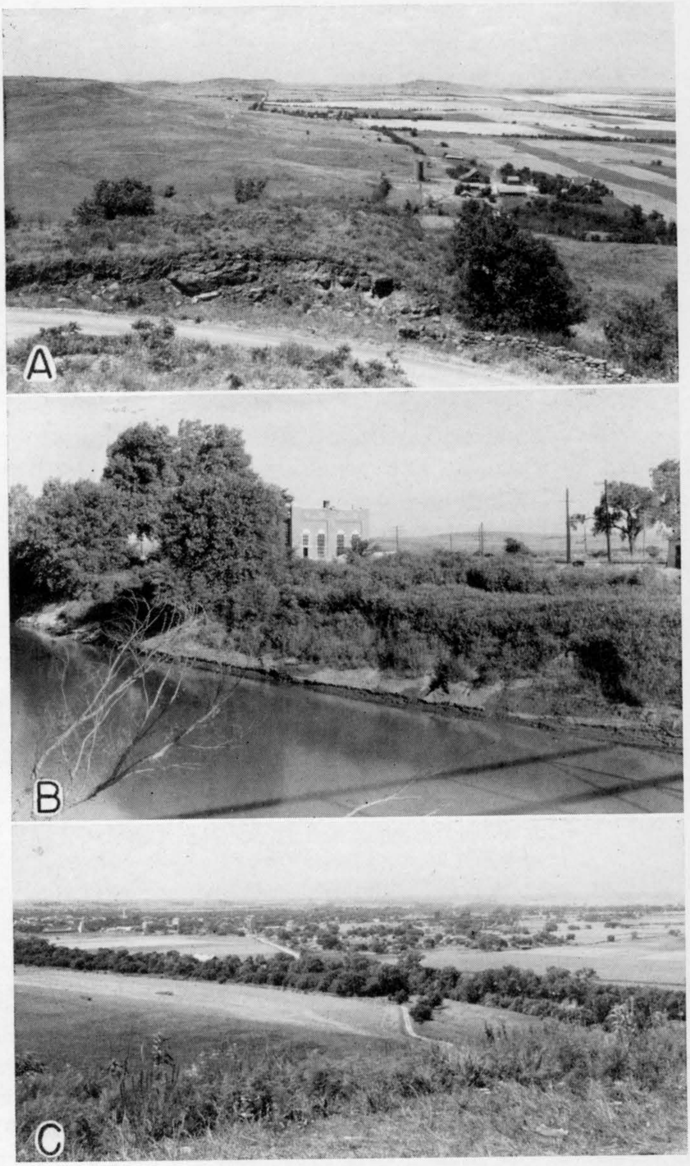

PLATE 2.—*A,* View looking north along the Smoky Hill Buttes from the top of Coronado Hill (sec. 31, T. 16 S., R. 3 W.). The hills are capped by hard brown Cretaceous sandstone (Kiowa shale) and the gentle slope at the right is underlain by soft Permian shale (Wellington formation). *B,* Abilene pumping station on the north bank of Smoky Hill River, about 3 miles west of Abilene. Sand Springs (No. 73) is hidden by trees at the right of the buildings. Sand hills form the bluff in the distance. *C,* Confluence of Smoky Hill and Republican Valleys. Looking northwest from top of bluff southeast of Junction City. Junction City is in middle distance.

by the softer shales of this region. Immediately west of the Osage Plains is an area in which moderately hard thick sandstones, clays, and shales of Cretaceous age overlap the beveled Permian strata. This area has been called the Smoky Hill Upland and is the eastern part of the larger Plains Border section. The hard sandstones exposed in the Smoky Hill Upland form an east-facing escarpment somewhat similar to the limestone escarpments of the Osage Plains, although it is less regular and there are numerous outlying hills. A line of such hills on the west side of Smoky Hill Valley in south-central Saline County is known as the Smoky Hill Buttes (Pl. 2A). Other prominent outlying sandstone-capped hills in this area are Iron Mound southeast of Salina and North Pole Mound north of Salina. Coronado Hill northwest of Lindsborg is the southernmost prominence of the Smoky Hill Buttes.

This area is part of an older erosional plain that is now being dissected. Major streams have cut below the old plain and are now flowing in rather wide, flat-bottomed valleys. The topography of the intervalley areas is gently rolling to semirugged. The larger streams are obsequent to the rock structure and were probably superimposed upon a plain of deposition (Jewett, 1941, p. 14).

Smoky Hill Valley

Smoky Hill River heads on the High Plains in eastern Colorado, about 40 miles west of the Kansas-Colorado State line, and flows in a general easterly direction until it reaches a point near Ellsworth in central Kansas. Here its direction changes and it flows east-southeast to the northwestern part of McPherson County. An anomalous condition is presented by the river's course from this point to Salina, for it makes a broad sweeping curve to the northeast and finally flows nearly due north from Bridgeport in southern Saline County to Salina. At Salina the river makes a sharp turn and follows a seemingly normal easterly course to a point just east of Junction City, where it joins Republican River to form Kansas River (Pl. 2C).

Smoky Hill River is a freely meandering mature stream whose low gradient in this area is less than half the gradient of its valley floor. It enters Saline County at an altitude of 1,280 feet and joins Republican River at an altitude of about 1,045 feet, the average gradient of the river in this part of its course being 1.5 feet to the mile. The average gradient of the valley floor through this area is 3.6 feet to the mile. The average gradient of the river above Salina is 2 feet to the mile, whereas below Salina it is somewhat less, averaging 1.4 feet to the mile. The extent of the meandering is indicated by the fact that the river travels about 150 miles in its course from the McPherson-Saline County line to Junction City, whereas the airline or valley distance between the two points is less than half this distance, or about 65 miles. Above Solomon the meander belt in most places is less than a mile wide and occupies the right side of the valley. Below Solomon the width of the meander belt increases to about 2 miles and occupies nearly the full width of the valley. Old meander scars, cut-off meanders, oxbow lakes, and slip-off slopes are common features that modify the otherwise flat flood plain. These features are well shown on aerial photographs of the valley (Pls. 3 and 4).

Smoky Hill River flows in a relatively flat valley that exhibits differences in width and in the character of its bluffs as a result of the differences in the character of the rocks in which it has been cut. South of Salina the valley proper is 2 to 3 miles wide. The bluffs on the west side of this part of the valley in most places are formed by soft Permian shale (Wellington formation) and are low and inconspicuous. The slope produced by erosion of the soft shale joins the valley floor at such a low angle that in places it is difficult to determine the western border of the valley by surface inspection. The shale slope rises toward the west and merges with the Smoky Hill Buttes (Pl. 2A). The bluffs on the east side of the valley above Salina are low and have gentle slopes, but are more distinct than those on the west side. The bluffs here are formed by shale of the Wellington formation overlain near the valley edge by Cretaceous sandstone and shale (Kiowa shale).

The valley from Salina to Solomon is 3 to 4 miles wide. The bluffs are composed of shale of the Wellington formation and, although distinct, are not prominent because of the gentle slopes produced by the soft shale (Pl. 5A). Between Solomon and Abilene the valley is bordered on the north by sand hills, which form low bluffs with gentle slopes (Pl. 2B).

Below Abilene the valley has been cut into alternating beds of Permian shale and hard limestone (Wolfcampian Series), and as a result the valley becomes narrower and the bluffs become higher and more prominent (Pl. 5B). The width of the valley just below Abilene is about 2.5 miles and below Chapman it ranges from 1 to a little less than 2 miles. The presence of the massive beds of hard limestone has resulted in the formation of steep and rugged bluffs

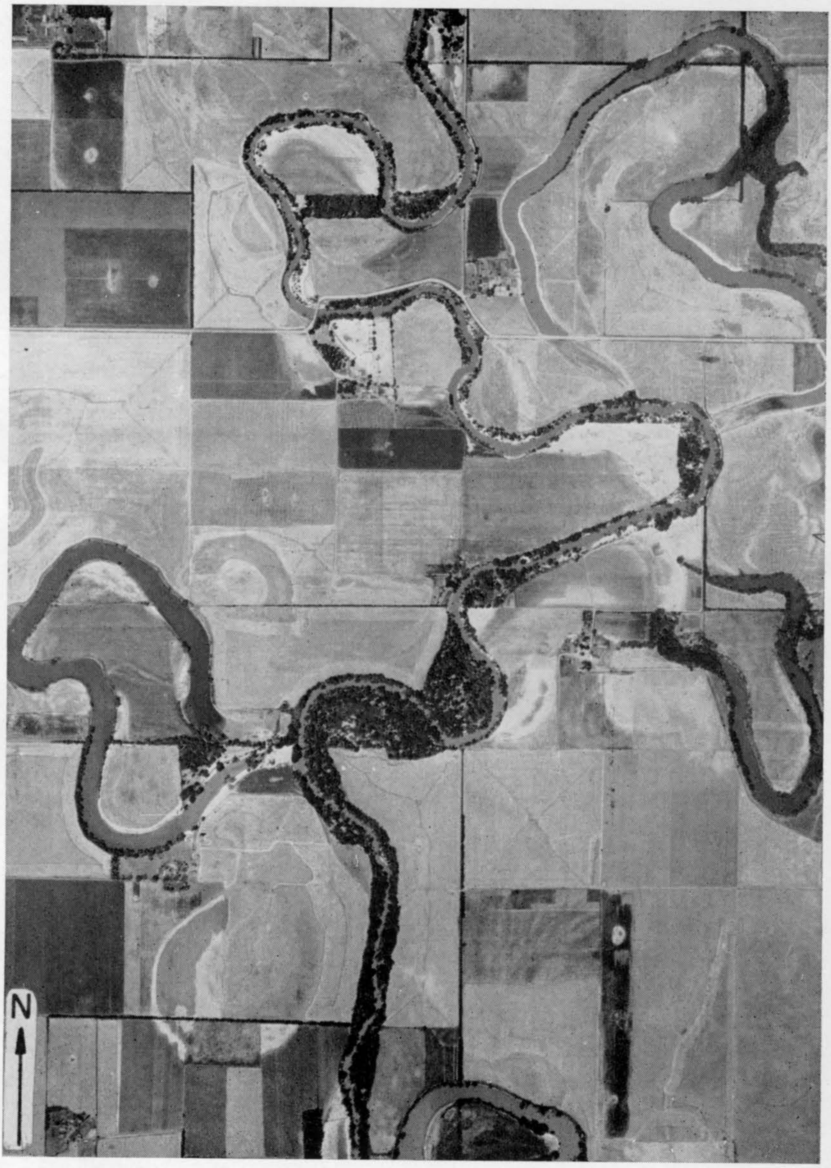

PLATE 3.—Aerial photograph of part of Smoky Hill Valley east of Mentor, southern Saline County, showing the meandering character of the river, old meander scars, and cut-off meanders. The arrow points north and is approximately 0.5 mile long. U. S. Department of Agriculture photograph.

PLATE 4.—Aerial photograph of part of Smoky Hill Valley between Solomon and Abilene, Dickinson county, showing the meandering character of Smoky Hill River. Note the old meander scars, cut-off meanders, and slip-off slopes on the inside of the present meanders. The arrow points north and is approximately 0.5 mile long. U. S. Department of Agriculture photograph.

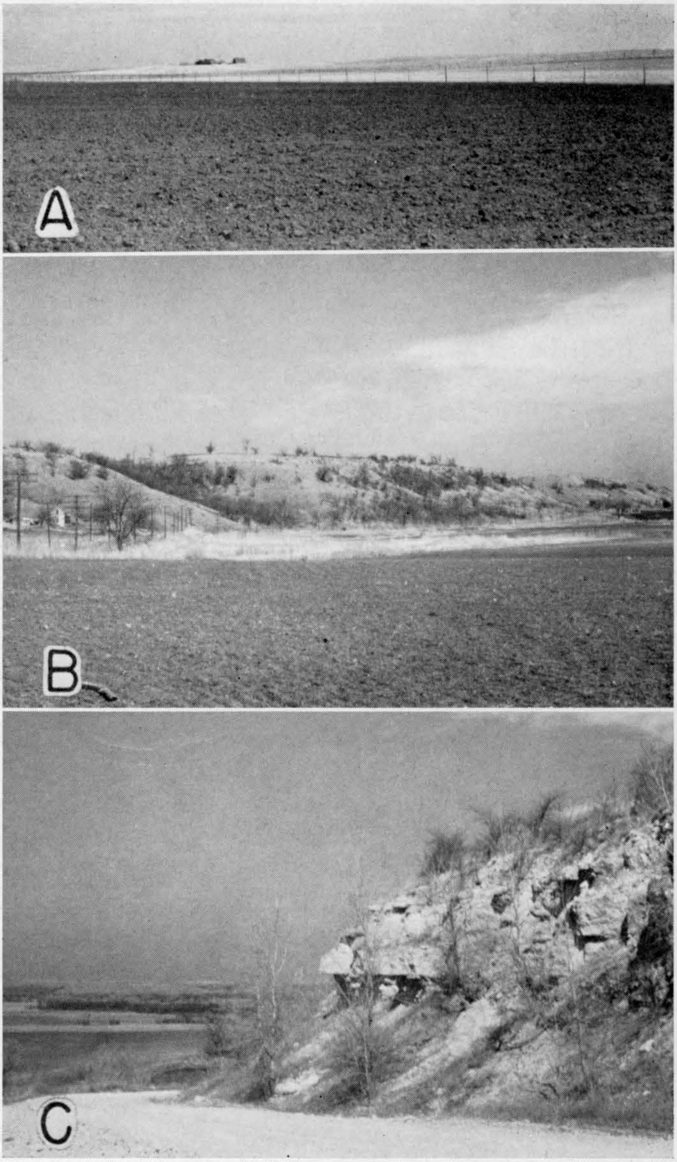

PLATE 5.—Character of the bluffs of Smoky Hill Valley. *A*, Low, gently sloping bluff formed by the Wellington shale along the south side of the valley, about 3 miles below Solomon. *B*, High, prominent bluff formed by limestones and shales of the Wolfcampian Series (Permian) along north side of valley, 1 mile west of Junction City. Note bench formed by bed of limestone near top of bluff. *C*, Massive limestone capping bluff on east side of valley, about 1 mile east of Junction City.

50 to 200 feet high. Prominent benches are formed by the limestones at or near the top of the bluffs (Pl. 5B and C).

At least one terrace occurs along Smoky Hill Valley in the area south of Salina. It is a wide terrace and lies about 10 feet above the flood plain. In many places the river is flowing against and is cutting into the edge of this terrace.

Tributary Valleys

Three major rivers join Smoky Hill River in this area—Saline, Solomon, and Republican. All three rivers originate on the High Plains to the west and join Smoky Hill River from the northwest.

Saline River heads in southern Thomas County and follows an easterly course to its junction with Smoky Hill River a few miles east of Salina. Its valley in Saline County is 2.5 to 3.5 miles wide and has been cut through Cretaceous sandstone and clay (Kiowa shale) into Permian shale (Wellington formation). The valley has a relatively flat floor bordered by rather high, distinct bluffs having moderate slopes. The Cretaceous hills a few miles back from the river rise nearly 200 feet above the valley floor.

Solomon River in western Kansas consists of two forks that head within 10 miles of each other in Thomas and Sherman Counties. They follow general easterly courses to their junction in northwestern Mitchell County. From here Solomon River flows in a southeasterly direction and joins Smoky Hill River south of Solomon. Only about the lower 4 miles of Solomon Valley is in the area studied. Here, the valley is 3 to 3.5 miles in width and its character is similar to that of Saline Valley, although the bluffs, which are developed entirely in the shale of the Wellington formation are somewhat lower and the slopes more gentle.

Republican River originates in eastern Colorado and flows across the northwestern corner of Kansas into Nebraska. It re-enters Kansas near the northwestern corner of Republic County and flows in a southeasterly direction to its junction with Smoky Hill River east of Junction City. In Geary County Republican River has a relatively narrow, flat-bottomed valley that ranges from 0.5 to 1.5 miles in width. The stream in this part of its course has cut through beds of massive limestone (Permian) and as a result the valley has high prominent bluffs with steep slopes.

Several smaller streams join Smoky Hill River in Saline, Dickinson, and Geary Counties. They are short local streams that range in length from 20 to 40 miles. Their valley floors are flat to gently rolling and are from less than 0.5 mile to 1.5 miles wide. Those entering from the south include Gypsum Creek southwest of Solomon, Holland Creek southwest of Abilene, Turkey Creek south of Abilene, and Lyons Creek southwest of Junction City. On the north, Mud Creek joins Smoky Hill River at Abilene and Chapman Creek joins it at Chapman.

Mulberry Creek heads in the Cretaceous hills about 25 miles west of Salina and joins Saline River north of Salina. Spring Creek, which is comparable in size to Mulberry Creek, enters Mulberry Creek from the southwest at a point about 4 miles west of Salina. At and below the confluence of these two streams the valley is unusually wide, considering the length of the streams. The valley in the area studied west of Salina is from 2 to 3.5 miles wide and is bordered by relatively high, prominent bluffs. Dry Creek, an ephemeral stream, joins Mulberry Creek about 1.5 miles above its mouth. The main branch of Dry Creek heads northwest of Lindsborg, in northern McPherson County, and follows a course nearly parallel to Smoky Hill River. A tributary branch heads in southwestern Saline and northwestern McPherson Counties and after following a northeasterly course joins the main branch about 5 miles south of Salina.

Sand Hills

Bordering the north side of Smoky Hill Valley between Solomon and Abilene is an area of about 20 square miles covered by sand hills (Pl. 1). This area is characterized by typical sand-dune topography, having moderate slopes and hills separated by small basins (Pls. 2B and 6C). Most of the area is covered by vegetation, but there are a few bare areas where the sand is being continually shifted by the wind (Pl. 6C). Parts of the sand hills are drained by small intermittent streams that flow into Smoky Hill River, but in other parts there is no surface drainage. Water from precipitation on the undrained areas collects in basins and hollows, where a part seeps into the ground to replenish the underground reservoir and part is evaporated. The sandy soils of the sand hills are especially well suited to the growing of watermelons and cantaloupes. Because of the large number of melons grown in this area, it is known locally as the Sand Springs melon district.

A smaller area of sand hills covering about 1½ square miles occurs northwest of Detroit (Pl. 1).

GEOLOGY IN RELATION TO GROUND WATER[1]

The Smoky Hill Valley area is underlain in part by Permian shale, limestone, and gypsum and Cretaceous clay, shale, and sandstone, and in part by clay, silt, sand, and gravel representing slope, terrace, dune, and alluvial deposits of Tertiary to Recent age. Smoky Hill River and its major tributaries have cut deep valleys in the Permian bedrock and have later partly filled them with Pleistocene and Recent clay, silt, sand, and gravel. This report is concerned mainly with these alluvial deposits because they are the most important sources of ground water in the area. Rocks other than alluvium and certain terrace deposits were not studied in detail. A geologic map of the area and geologic sections are shown on Plate 1.

PERMIAN ROCKS

The upland surface on both sides of Smoky Hill Valley in Saline, Dickinson, and Geary Counties, except for the relatively small area of sand hills near Abilene and parts of northern and southern Saline County, is underlain by Permian rocks belonging to the upper part of the Wolfcampian Series and the lower part of the Leonardian Series (Pl. 1). Permian rocks are also found beneath the alluvial deposits everywhere in this area.

About 350 feet of rocks of the Wolfcampian Series, including all of the Chase group and the upper part of the Council Grove group, are exposed along the valley from Abilene eastward (Pl. 1). They consist of alternating beds of limestone and shale. The limestone beds are from a few inches to about 40 feet thick and the shale beds are from a few feet to about 50 feet thick. The thickest limestones are exposed in the eastern part of the area in the vicinity of Junction City. Hard flint-bearing limestones that form prominent benches and escarpments along their outcrop are the most conspicuous features of this series of rocks. The shale beds are poor sources of water supply, but some of the limestones, especially those which contain an abundance of flint, yield rather large supplies of water of good quality to shallow farm wells and springs (Moore, 1940, p. 43). During years of low precipitation many of these wells go dry or yield inadequate supplies of water for ordinary farm use. The chief water-bearing limestones are those of the Winfield formation, Fort Riley limestone, Florence flint, and Wreford limestone.

1. The terminology used in this paper is that of the State Geological Survey of Kansas and differs in some respects from that of the United State Geological Survey.

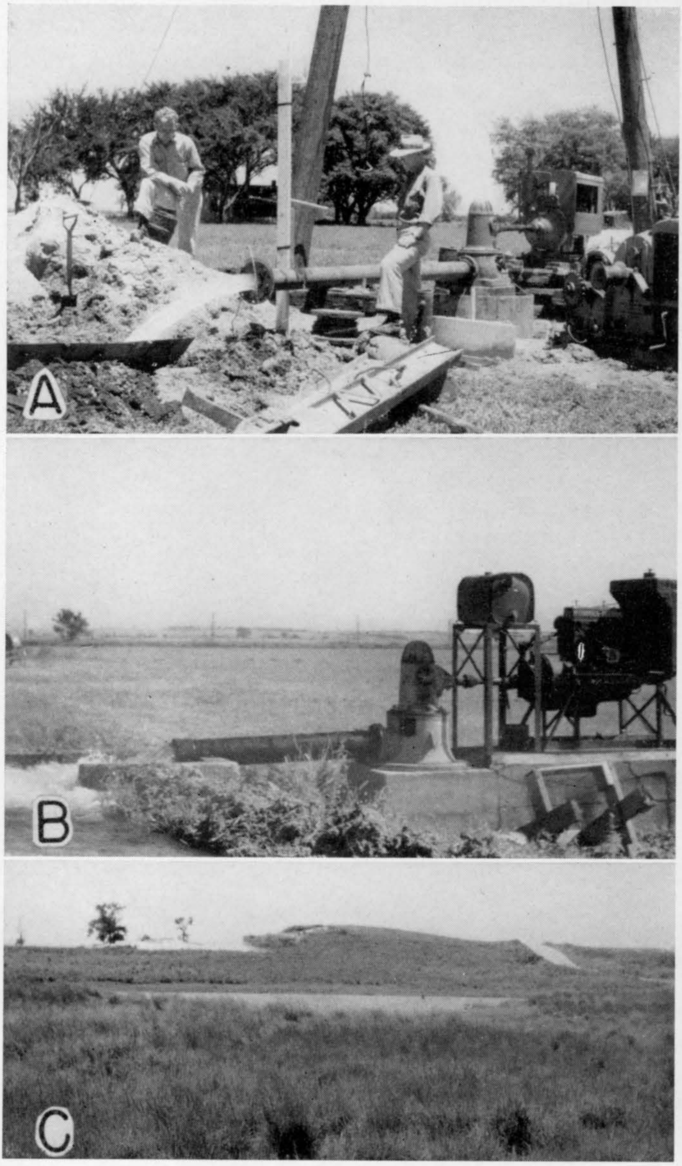

PLATE 6.—*A*, Well 200 (camp well 5) south of Salina, Saline county, which furnishes part of Camp Phillips and Smoky Hill Army Air Base water supply. *B*, Irrigation well 60, east of Abilene, Dickinson county. *C*, Small water-filled basin in sand hills, in SW¼ sec. 11, T. 13 S., R. 1 E., Dickinson county. Note small area of bare sand in the upper left part of photograph.

The Wellington formation of the Sumner group, Leonardian Series, underlies the alluvial deposits and forms the bluffs and upland surface in most of the area west of Abilene. It uncomformably underlies the Kiowa shale (Cretaceous) in parts of Saline County. The Wellington formation has a total thickness of about 700 feet and consists chiefly of gray shale, but it contains some red and green shale in the lower part. Discontinuous beds of gypsum and impure limestone are found at the outcrops, and thick beds of salt (Hutchinson salt member) occur near the middle of the formation in the subsurface. The Wellington is a poor water-bearing formation, for it consists largely of shale of low permeability. Shallow wells that tap the shale have small yields and are subject to failure during periods of drought. Somewhat larger yields are obtained from wells that penetrate the thin beds of limestone in the formation. Water in the Wellington formation generally is excessively hard and highly mineralized, owing to the large amount of soluble minerals in the formation. A former salt company obtained brine from three or four wells that tapped the Wellington formation west of Solomon.

Cretaceous Rocks

KIOWA SHALE

Overlying the Wellington formation along parts of Smoky Hill Valley in Saline County are Cretaceous rocks belonging to the Kiowa shale (Comanchean Series). The Kiowa shale has a maximum thickness of about 200 feet in this area and consists of light to dark-gray and black clay and shale and thick lenticular beds of dark-brown iron-rich sandstone. Selenite is common in the shale and locally there are thin beds of limestone composed largely of fossil oyster shells. Owing to their greater resistance to erosion, the sandstone beds are the most conspicuous feature of the formation, even though shale is more abundant. Sandstone beds of the Kiowa shale cap all the high hills bordering Smoky Hill and Saline Valleys in Saline County.

The Kiowa shale is relatively impervious and is a poor source of water. The sandstone lenses, however, are good sources of water. Wells that penetrate them generally yield adequate supplies of water for stock and domestic use, and in some localities adequate water is available to supply the needs of small towns. The City of Gypsum, in southeastern Saline County, obtains its supply from wells that tap sandstone of the Kiowa shale. The wells are situated on the divide between Smoky Hill River and Gypsum Creek, about

6 miles southeast of Mentor. The City of Lindsborg, in northern McPherson County, prospected for a new water supply in these sandstones east of Lindsborg, but the quantity of water available was inadequate to supply the need.

Tertiary and Quaternary Slope Deposits

Relatively thin deposits of silt, sand, gravel, and conglomerate unconformably overlie the Permian rocks in places in the western part of the Smoky Hill Valley area. They are irreguarly distributed on the upland surface in Dickinson and eastern Saline Counties and on the slopes that separate Smoky Hill Valley and the Cretaceous hills west of the valley in southern Saline County. In places in southern Saline County these deposits cap small hills or ridges along the west edge of the valley. The materials comprising these deposits are of local origin and probably represent slope deposits that were laid down by sheet wash and soil creep at and for a short distance beyond the base of the westward-retreating Cretaceous hills. Some of the material probably was deposited by small, short streams that headed in the Cretaceous hills or by larger streams that headed in areas of Cretaceous rocks farther away. In places, especially in the area south of Salina, some of this material seems to be the remnant of a once more extensive terrace deposit (see cross sections N—N′ and O—O′ on Pl. 1).

The lower part of these slope deposits and related terrace deposits generally consists of poorly sorted clayey sand and gravel composed of grains, pebbles, and cobbles of sandstone, ironstone, shale, and caliche nodules. The sand and gravel locally contains one or more irregular layers, ranging from a few inches to about 4 feet in thickness, which have been firmly cemented to form conglomerate. Gray and light-tan to brown sandy silt generally is found above the beds of sand and gravel. Pebbles and cobbles of sandstone, ironstone, shale, and caliche are irregularly distributed in the silt, especially in the lower part. Although they range in thickness from a few feet to about 40 feet, these deposits in most places are less than 10 feet thick.

In 1895, Prosser (p. 786) gave the name "Abilene conglomerate" to certain of these deposits in western Dickinson County and placed them in the Permian. Moore (1920, p. 63) later recognized the fallacy of this correlation and stated that the formation seemed to be a Tertiary deposit. Although no detailed study of the slope and terrace deposits was made during the course of the present investigation, available data indicate that they are of different ages in different places. The deposition of these sediments probably started in the Tertiary Period, when erosion of the Cretaceous rocks began, and has been more or less continuous to the present time.

The Tertiary and Quaternary slope deposits and related terrace deposits are unimportant as sources of water in the area studied. They are above the water table everywhere in this area. Because they are unimportant as a source of ground water and because of their irregular distribution and thinness, no attempt has been made to map these sediments.

Quaternary Deposits

TERRACE DEPOSITS

Stream-laid terrace deposits of Pleistocene age underlie the dune sand in the area north of Smoky Hill Valley between Solomon and Abilene. They unconformably overlie shale, limestone, and gypsum belonging to the Wellington formation and the upper part of the Wolfcampian Series of Permian age. The character of the terrace deposits is shown by logs 66-69, 71, 72, 89, and 90, and their relation to the underlying Permian rocks and to the alluvium in Smoky Hill Valley is shown by cross section E—E′ on Plate 1. The materials making up the terrace deposits probably were deposited by Smoky Hill River at a time when it was flowing at a higher level than at present. The conditions that caused the river to swing widely to the north and deposit these materials are not known. The presence of the resistant Herington limestone in this area, the first limestone bed of any consequence encountered by the river, probably was partly responsible. The lowest part of the terrace deposits is 10 to 15 feet below the present flood plain of Smoky Hill River and the highest part is more than 100 feet above the flood plain.

The terrace deposits are 50 to 65 feet thick near the valley and thin to a featheredge at the north. They consist principally of unconsolidated silts, sands, and gravels that are poorly sorted. These materials form lenses that overlap one another irregularly. The finer materials, which consist of sandy silt and sand, are more common in the middle and upper parts. Sand is abundant in the lenses of silt or gravel but is uncommon in beds by itself. The coarser materials are composed of fine to very coarse gravel that generally contains much silt and sand. Lenses of sand and gravel, from a few inches to about 15 feet thick, occur throughout these deposits but are thickest and most common in the lower part. A thin bed composed of pebbles of ironstone and sandstone occurs at the base of the terrace deposits in most places. Test holes 66 and 69 encountered thin beds of conglomerate at or near the base of these deposits. The conglomerate is composed of lime-cemented sand and gravel containing pebbles of sandstone and ironstone.

The sands and gravels of the terrace deposits are the principal source of water in the sand-hills area and yield abundant supplies of water to stock and domestic wells. These deposits are also the source of the water that supplies Sand Springs. At present there are no large wells in this area. The test drilling indicates, however, that in some places the sands and gravels are sufficiently thick and coarse to supply several hundred gallons of water a minute to properly constructed wells. Furthermore, the cover of permeable dune sand affords excellent opportunity for a high rate of recharge from local precipitation. Analyses of samples of water from well 70 and spring 73 (Sand Springs) indicate that the water from the terrace deposits is softer and is less mineralized than any of the samples collected from the alluvium in the Smoky Hill Valley area. The samples from well 70 and spring 73 had, respectively, 239 and 265 parts per million of dissolved solids and hardness of 168 and 184 parts. Complete analyses for these samples are given in Table 9.

The material that forms the low terrace along the west side of Smoky Hill River south of Salina is mapped and described with the alluvium of Smoky Hill Valley.

DUNE SAND

Dune sand underlies a large area north of Smoky Hill Valley between Solomon and Abilene and a smaller area near Detroit (Pl. 1). The material consists of tan to light-gray fine to medium quartz sand that locally contains considerable silt. The thickness of dune sand encountered by test holes in the Solomon-Abilene area ranges from 3 feet in test hole 90 to 20 feet in test hole 72. The thickness of the dune sand beneath the higher dunes probably exceeds 40 feet. The dune sand in the Detroit area is much thinner and probably is not more than 15 feet thick anywhere in the area.

The dune sand lies above the water table and so does not supply water to wells. Because the sand is loose and highly permeable, it provides excellent recharge facilities for the underlying water-bearing beds.

ALLUVIUM

Alluvium of Pleistocene and Recent age occurs in Smoky Hill Valley and its tributary valleys in the area studied. The alluvium is the most important source of water in the Smoky Hill Valley area and furnishes water to stock, domestic, irrigation, industrial, and public-supply wells. All the large wells in the area derive water from alluvium. Most of the rest of this report describes the source, occurrence, availability, utilization, and chemical character of the ground water in these deposits.

The State Geological Survey drilled 93 test holes in Smoky Hill Valley and its tributary valleys to determine the character and thickness of the alluvium. In addition, the logs of 30 test holes and 23 wells were obtained from city officials and private drilling companies. These data are shown graphically by 14 cross sections, nine of which are of Smoky Hill Valley and one each of Republican, Solomon, Saline, Mulberry, and Dry Creek Valleys. The cross sections and locations of the cross sections are shown on Plate 1, and the logs of the test holes and wells are given at the end of this report.

The alluvium consists of stream-laid deposits of clay, silt, sand, and gravel, the character and proportions of which differ from one place to another. The finer materials of the alluvium commonly occur in the upper part and the coarser materials in the lower part. The thickness of the alluvium, as shown by the logs of test holes and wells, ranges from a few feet to more than 90 feet and averages about 55 feet. Water from the alluvium is hard to very hard and in some localities contains excessive iron or chloride.

The thickness and character of the alluvium are described by areas on the pages that follow.

Smoky Hill Valley.—The character and thickness of the alluvium in Smoky Hill Valley in Saline, Dickinson, and Geary Counties are indicated by the logs of 93 test holes and wells, including 56 logs of test holes drilled by the State Geological Survey. The thickness of the alluvium in Smoky Hill Valley ranges from less than 30 feet to more than 90 feet. The maximum thickness encountered was 94 feet in test hole 223, 1 mile southeast of Mentor. The thickness of the alluvium and shape of the bedrock floor at nine places in the valley are shown by cross sections on Plate 1. The maximum and average thickness of the alluvium and width of the valley at each cross section are given in Table 1. It is not possible to predict at what point along a given line across the valley the greatest thickness of alluvium will be found. There seems to be no definite relationship between the position of the present stream channel and the greatest depth to bedrock, where the alluvium is thickest. In some places (cross sections N—N′ and O—O′) the channel of the river nearly coincides with the deepest place in the bedrock floor. In other places the deepest part of the bedrock floor is on the opposite side of the valley from the present stream channel (cross section E—E′). At Enterprise the river is at the south edge of the valley, whereas the deepest part of the bedrock floor is near the middle of the valley (cross section D—D′).

TABLE 1.—*Maximum and average thickness of the alluvium and width of the valley for nine cross sections in Smoky Hill Valley*

Cross section	LOCATION	Number of test holes	Width of valley, miles	Thickness of alluvium, feet	
				Maximum	Average
B—B′	3 mi. above Junction City	5	1.7	61	50
C—C′	At Chapman	4	1.5	64	43
D—D′	At Enterprise	7	2.0	68	50
E—E′	3 mi. above Abilene	5	2.8	65	53
G—G′	3 mi. below Salina	9	4.0	69	61
K—K′	South edge of Salina	10	3.2	76	55
L—L′	3 mi. above Salina	9	3.5	72	53
N—N′	1 mi. above Mentor	6	2.4	94	64
O—O′	2 mi. above Assaria	5	1.8	90	75

In some places the alluvium has a relatively uniform thickness across the valley (cross sections D—D′ and G—G′), but elsewhere it varies considerably. South of Junction City, at cross section B—B′, the alluvium is thickest in the middle of the valley and thins toward the edges of the valley. At Chapman (cross section C—C′), the thickest alluvium is found near the north edge of the valley and it gradually thins to the south. Three miles above Abilene (cross section E—E′) the alluvium is thickest near the south edge of the valley and gradually thins to the north.

The upper 8 to 45 feet of material in the alluvium in Smoky Hill Valley consists of silt, sandy silt, and fine sand. This finer material is underlain by coarse sand and gravel that ranges in thickness from less than 5 feet to about 70 feet. The sand and gravel in most places is poorly sorted and contains thin lenses of silt and sandy silt. Locally derived cobbles of sandstone, ironstone, and limestone which measure as much as 10 inches in their greatest dimension, are commonly found in coarse gravel at or near the base of the alluvium. The sand and gravel are made up principally of rounded and subrounded grains of quartz, feldspar, and other material derived from igneous rocks. Where small tributaries enter Smoky Hill Valley the alluvium may be composed almost entirely of clay, silt, and sand. This is true south of Salina where the alluvium along the west edge of the valley consists mostly of fine material deposited by Dry Creek (see cross sections K—K′ and L—L′). The fine material in the alluvium at the south edge of the valley 3 miles below Salina probably was brought in by the unnamed tributary that enters the valley at that point (cross section G—G′).

Republican Valley.—The character and thickness of the alluvium in the lower part of Republican Valley are indicated by cross section A—A′ on Plate 1 and by the logs of 19 test holes and wells (logs 5-15, 18-24). The alluvium here is similar in character to the alluvium in Smoky Hill Valley. Its thickness ranges from less than 30 feet to 82 feet and averages about 45 feet. The greatest thicknesses of alluvium were encountered along the northeast side of the valley. The upper 3 to 40 feet consists of silt, sandy silt, and sand. From 17 to 57 feet of water-bearing sand and gravel occurs below the finer material.

The cities of Milford and Junction City, the Cavalry Replacement Training Center at Fort Riley, and Fort Riley obtain water supplies from wells (1, 14, 15, 16-19, 21-24) that tap the alluvium in Republican Valley. The yields of these wells range from 150 to 1,200 gallons a minute.

Solomon Valley.—Nine test holes drilled by the State Geological Survey in the Solomon Valley in Saline County penetrated 44 to 65 feet of alluvium (logs 102-107, 109, 112, and 113). Peat, clay, silt, sandy silt, and sand constitute the upper 20 to 40 feet and coarse water-bearing sand and gravel comprises the lower 15 to 25 feet. In general, the proportion of coarse material to fine material is lower here than in Smoky Hill Valley and more silt and clay are mixed with the sand and gravel. There are no large wells in this part of Solomon Valley. In some places the water from the alluvium in Solomon Valley has such a high concentration of chloride that it is unfit for ordinary uses.

Saline Valley.—Six test holes were drilled in a line across Saline Valley just above its confluence with Smoky Hill Valley, and a cross section (H—H′) was prepared. The width of the valley at this point is 3.2 miles. The alluvium in these test holes ranged from 20 to 92 feet in thickness and averaged about 64 feet. Test hole 129, at the southwest edge of the valley, did not encounter any sand or gravel, but it penetrated 20 feet of silt and clay above the bedrock. The other test holes encountered 14.5 to 42 feet of sand and gravel in the lower part of the alluvium at depths ranging from 23 to 76 feet. The sand and gravel is overlain by clay and silt that contains small lenses of peat. It is poorly sorted and ranges in texture from fine sand to very coarse gravel. Limestone, sandstone, and shale fragments are abundant in the coarse gravels.

The recovery of ground water from the alluvium in Saline Valley is limited at present to small farm wells, although larger-yielding wells could be developed in this valley. Analyses indicate that the water is hard to very hard and locally is high in chloride and iron.

Mulberry Creek Valley.—The character and thickness of the alluvium in Mulberry Creek Valley near its confluence with Smoky Hill Valley are shown by cross section J—J′ and the logs of test holes 148-152, which were used to prepare this cross section. The valley is 2 miles wide at the location of the cross section. The five test holes encountered 36 to 66 feet of alluvium here. Clay and silt comprise the upper 20 to 38 feet, and fine sand to coarse gravel comprises the lower 10 to 28 feet. The materials of the alluvium in Mulberry Creek Valley were derived locally from Cretaceous rocks to the west. The coarser materials are composed of fragments of sandstone and ironstone from the Kiowa shale and Dakota formation.

There are no large wells in this part of Mulberry Creek Valley. Two samples of water from farm wells in this area contained 846 and 1,499 parts of total solids and had a hardness of 487 and 838 parts respectively (see analyses 146 and 147).

Dry Creek Valley.—Test holes 209 and 211-218 were drilled in Dry Creek Valley to determine the character and thickness of the alluvium in that area. The results of the test drilling are shown graphically by cross sections M—M′ and N—N′. The alluvium in Dry Creek Valley is 17 to 53.5 feet thick and is composed principally of material derived locally from Cretaceous and Permian rocks. It consists chiefly of silt and clay but contains some sand and gravel which occurs in lenses from a few inches to 10 feet thick. The sand and gravel is poorly sorted and generally is intermixed with much silt and clay. The gravels are composed entirely of fragments and pebbles of shale, sandstone, ironstone, and "mortar beds."

The lenses of sand and gravel in the alluvium of Dry Creek Valley yield small supplies of water to farm wells for domestic and stock use. A sample of water collected from well 210 in this area was very hard and contained 380 parts per million of chloride (see analysis 210).

GROUND WATER

Occurrence, Source, and Movement of Water

Ground water in Smoky Hill Valley occurs in the pore spaces of the gravel, sand, silt, and clay of the valley fill and terrace deposits. The depth below which these materials are saturated in the valley areas—that is, the depth to the water table—ranges from a few feet to about 40 feet below the land surface, but in most places it is between 20 and 30 feet. The rate at which water moves through these materials depends largely on the size and shape of the pore spaces and on the slope of the water table. The sand and gravel deposits of the alluvium generally contain relatively large, interconnecting pore spaces through which water moves freely under low water-table gradiants. All the recorded wells in the Smoky Hill Valley area derive water from sand and gravel under water-table conditions. The high permeability of the sand and gravel in parts of the area is indicated by the large yields of some of the wells.

Beds and lenses of silt and clay are associated with the sand and gravel in the alluvium and in some places make up a large part of the alluvium. Clay and silt may contain large quantities of water where they occur below the water table, but because of the minute size of their pore spaces the water moves through them with extreme slowness even under high water-table gradients. Compact clay is essentially impervious.

The ultimate source of all ground water in the Smoky Hill Valley area is the precipitation upon this and near-by areas. A part of the water from rain and snow that falls on the valley floor, or falls on the valley sides and deploys on the valley floor, is carried off by streams, a part evaporates, and the remainder percolates directly into the ground. Part of the water that enters the ground is used by plants, but some eventually reaches the ground-water body in the alluvium. A part of the runoff from drainage areas tributary to the main valleys probably reaches the ground-water body in the alluvium through the channels of the small creeks and ravines that cross the valley to reach the large rivers. The large through-flowing rivers also furnish water to the ground-water reservoir in the alluvium. A discussion of the relation of Smoky Hill River to the water table is given later in this section.

Some water also percolates into the alluvium from adjacent formations. The slope of the water table in the sand hills area between Abilene and Solomon (Pl. 1, section E—E′) indicates that water moves from the terrace deposits into the alluvium in this area. Further evidence of this is furnished by a study of the analyses of samples of water from the terrace deposits, from alluvium near the sand hills, and from alluvium farther out in the valley. The analyses indicate that the water in alluvium near the edge of the sand hills is a mixture of relatively soft water of low mineralization from the terrace deposits and hard, more highly mineralized water from other parts of the alluvium. At places where Permian water-bearing beds are in contact with alluvium, and where the pressure head of water in the Permian beds is greater than the head in the overlying alluvium, water can move from the Permian beds into the alluvium. Such movement is known to take place near Solomon, where water in alluvium of Smoky Hill and Solomon Valleys has been contaminated by highly mineralized water from the underlying Wellington formation.

Ground water in the terrace deposits is derived from precipitation on the surface of the dune area—an area that offers unusually good opportunities for recharge from precipitation as much of the rain that falls on the dune-covered area is absorbed by the sand. Part of the water that falls in the dune area during heavy rains gathers in shallow undrained depressions and forms temporary ponds (Pl. 6C). Part of this water evaporates but a part seeps downward and eventually reaches the ground-water body in the terrace deposits.

The available data indicate that the general movement of ground water in this area is down the valley and that the average slope of the water table is about 4 feet to the mile. The altitude of the water table is about 1,255 feet at Assaria, 1,240 feet at Mentor, 1,205 feet at Salina, 1,105 feet at Enterprise, and 1,050 feet at Junction City.

The relation of the water table to Smoky Hill River at Assaria, Mentor, Salina, and Enterprise is shown by profiles in Figure 5, and the relation of the water table to Smoky Hill, Republican, and Kansas Rivers in the vicinity of Junction City is shown by water-table contours in Figure 6. It will be noted that at Assaria and Mentor the water table is higher than the stream surface. Under these con-

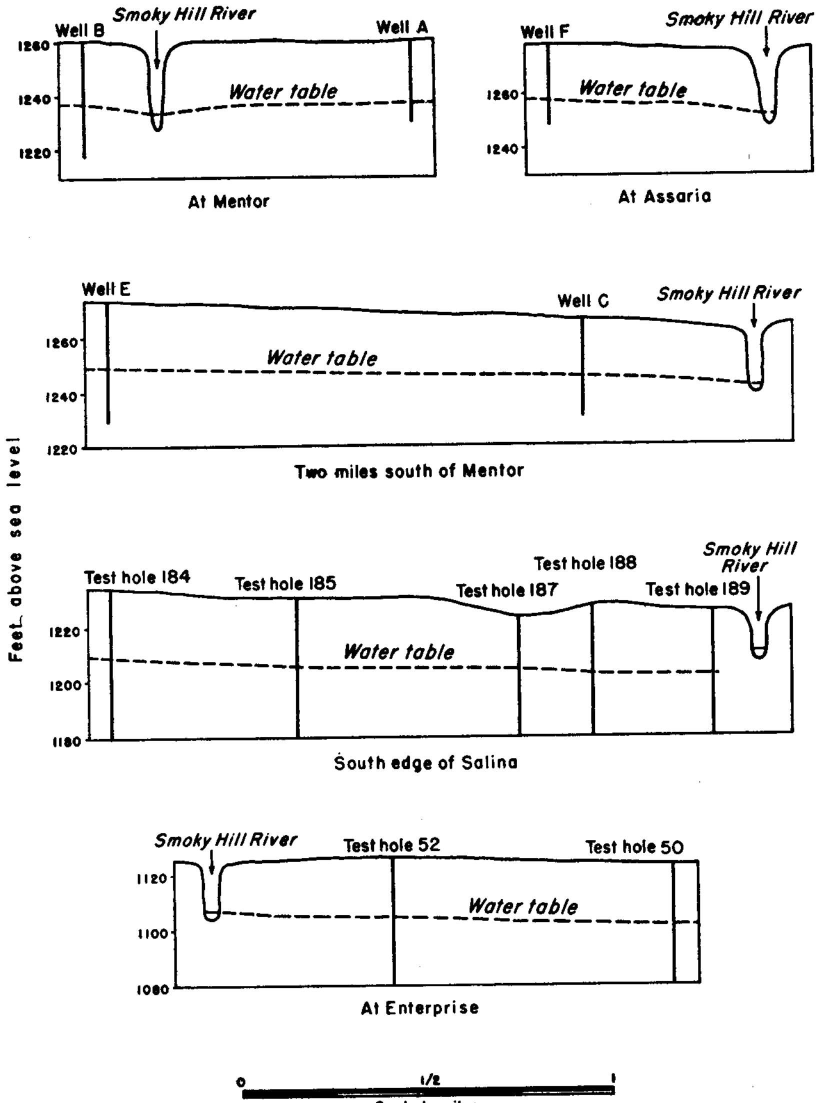

FIG. 5.—Relation of the water table to Smoky Hill River at Enterprise, Salina, Mentor, 2 miles south of Mentor, and Assaria. Based on July 1946 measurements.

ditions ground water moves toward the river. At Enterprise the water table is slightly below the stream surface and at Salina it is several feet below the stream surface. This condition at Salina probably is caused by the heavy withdrawals of water from the Salina city wells. Under these conditions water will tend to move outward from the river to an extent governed by the available head and the permeability of the materials underlying the river bottom.

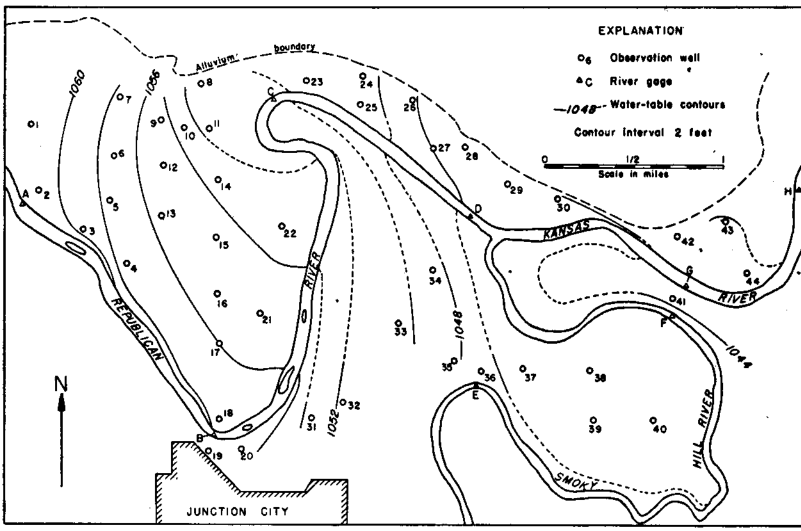

Fig. 6.—Water-table contours in the vicinity of Junction City. Based on water-level measurements and gauge readings made April 18-22, 1941, and furnished by the Quartermaster Corps, U. S. Army.

The amount of water percolating from the river during periods of normal or low flow probably is comparatively small because of the deposition of silt in the bottom of the channel. During high stages of the river the available head is increased, and in most or all sections of the river there is movement of water from the river toward the water table.

The measurements upon which the contours in Figure 6 are based were made during the period April 18-22, 1941, when the river flow was about normal. At this time Republican River above river guage C was a losing stream, as indicated by the downstream flexure of the contours. Below river gauge C the ground water was moving obliquely across Republican River with very little change in direction at the river. Smoky Hill and Kansas Rivers during this period were both above the water table and losing water to the ground-water reservoir in this area. The water table does not remain as it is shown in Figure 6 but changes shape as water is added to or taken from the ground-water body. During periods of high water, the movement of water is everywhere away from the rivers at steeper slopes than is shown in Figure 6. During periods of low river flow, there may be a reversal of the water-table gradient near the streams, in which case water will move toward and into the rivers.

Fluctuations of Water Level in Wells

As was pointed out above, the water table does not remain in a stationary position but fluctuates up and down as water is added to or taken from the ground-water reservoir. Fluctuation of the water table is recorded by the change in the water level in wells. A well that is measured periodically to observe the change in the height of its water level is called an observation well.

In January 1941 the Quartermaster Corps, U. S. Army, authorized the Widmer Engineering Company to make a study of the ground-water conditions in the valley areas of the Fort Riley Military Reservation. During January, February, and March 1941 a large number of observation wells were put down in Smoky Hill, Republican, and Kansas Valleys north and northeast of Junction City, and gauges were established on the rivers. Each observation well consisted of a 1¼-inch galvanized-iron pipe on the lower end of which was a screened drive point. A hole was first augered by hand to the water table, then the 1¼-inch pipe and drive point were placed in the hole and driven several feet below the water table. Measurements of the water levels in these observation wells and readings of the river gauges were made weekly from April 18 to June 4, 1941, by personnel of the Quartermaster Corps. A flood early in June destroyed the river gauges and filled most of the wells with sand and debris. Personnel was not available at that time to repair the damage done by the flood, and therefore the program was discontinued.

The locations of 44 of the observation wells and 8 river gauges are shown in Figure 6. Table 2 lists the depths and altitudes of the observation wells and Table 3 lists the available water-level

TABLE 2.—*Depths and altitudes of driven observation wells put down by the Widmer Engineering Company for the Quartermaster Corps, U. S. Army, at the Fort Riley Military Reservation, Kansas* [a]

Well number on Fig. 6	Depth of well, feet	Altitude of measuring point, feet	Well number on Fig. 6	Depth of well, feet	Altitude of measuring point, feet
1	23	1,078.9	23	43	1,080.3
2	23	1,077.6	24	38	1,079.6
3	28	1,076.4	25	48	1,081.2
4	23	1,073.9	26	38	1,068.5
5	28	1,074.1	27	28	1,065.1
6	28	1,079.9	28	28	1,065.0
7	28	1,077.4	29	23	1,060.6
8	43	1,081.8	30	18	1,055.8
9	33	1,076.9	31	....	1,065.4
10	28	1,073.2	32	18	1,069.7
11	28	1,074.7	33	23	1,069.3
12	28	1,074.3	34	23	1,064.0
13	28	1,075.1	35	....	1,061.7
14	23	1,069.7	36	28	1,066.6
15	23	1,070.6	37	23	1,068.1
16	23	1,071.1	38	28	1,064.2
17	28	1,072.7	39	18	1,057.7
18	23	1,071.7	40	33	1,067.8
19	38	1,082.8	41	28	1,063.8
20	28	1,077.9	42	28	1,062.0
21	23	1,070.3	43	23	1,059.1
22	23	1,067.3	44	18	1,053.9

a. Wells put down in January-March 1941 and abandoned in July 1941. Each consisted of a 1¼-inch galvanized-iron pipe with a screened sand point at the lower end. Measuring point of each well was at the top edge of the pipe.

TABLE 3.—*Water levels in observation wells at the Fort Riley Military Reservation, in feet below the measuring point, 1941*
(For location of wells refer to Plate 1; for descriptions refer to Table 15)

Well number	April						May										June		
	18	21	22	24	25	30	1	7	8	14	15	20	21	26	27	28	2	3	4
1	......	17.01	......	......	16.78	......	16.61	......	16.68	......	16.80	......	16.81	......	16.60	......	......	......	16.52
2	......	16.55	......	......	16.23	......	16.30	......	16.35	......	16.32	......	16.51	......	15.74	......	......	......	16.12
3	......	16.86	......	......	16.61	......	16.59	......	16.62	......	16.49	......	16.59	......	16.09	......	......	......	16.38
4	......	16.51	......	......	16.34	......	16.28	......	16.29	......	16.26	......	16.44	......	15.98	......	......	......	16.06
5	......	16.80	......	......	16.81	......	16.74	......	16.67	......	16.67	......	16.65	......	16.56	......	......	......	16.41
6	......	22.82	......	......	22.81	......	22.57	......	22.68	......	22.69	......	22.70	......	22.66	......	......	......	22.56
7	......	19.67	......	......	19.52	......	19.43	......	19.38	......	19.40	......	19.36	......	20.51	......	......	......	19.50
8	......	31.07	......	......	30.81	......	30.76	......	30.94	......	31.16	......	31.23	......	31.09	......	......	30.99	......
9	22.55	......	......	......	23.12	......	......	......	23.11	......	23.23	......	23.22	......	23.24	......	......	......	23.00
10	......	20.39	......	......	20.57	......	20.60	......	20.60	......	20.70	......	......	......	20.48	......	......	20.45	......
11	......	23.75	......	......	23.48	......	23.56	......	23.20	......	24.02	......	23.51	......	23.87	......	......	22.87	......
12	......	19.90	......	......	19.95	......	19.85	......	19.45	......	19.87	......	19.91	......	......	19.91	......	......	19.74
13	......	19.63	......	......	19.61	......	19.48	......	19.47	......	19.46	......	19.47	......	19.37	......	......	......	19.26
14	......	15.94	......	......	15.92	......	15.82	......	15.77	......	15.78	......	......	......	......	15.64	......	......	15.55
15	......	15.69	......	......	15.69	......	15.57	......	15.50	......	15.43	......	15.49	......	15.23	......	......	......	15.25
16	......	15.59	......	......	15.56	......	15.47	......	15.69	......	15.29	......	15.34	......	15.23	......	......	......	15.12
17	......	16.72	......	......	16.66	......	16.51	......	16.49	......	16.20	......	16.44	......	16.24	......	......	......	16.21
18	......	15.62	......	......	15.34	......	15.30	......	15.35	......	15.27	......	15.62	......	......	14.84	......	......	15.23
19	......	29.75	......	......	29.65	......	29.31	......	29.58	......	29.04	......	28.64	......	28.00	......	......	28.75	......
20	......	21.67	......	20.45	......	......	21.42	......	22.37	......	21.55	......	21.80	......	......	......	......	21.39	......
21	......	15.30	......	......	15.23	......	15.10	......	15.07	......	14.90	......	15.03	......	14.86	......	......	......	14.77
22	......	13.81	......	......	13.75	......	13.60	13.58	......	......	13.57	......	13.55	......	13.24	......	......	......	13.21
23	......	......	30.90	......	30.69	......	30.47	......	30.37	......	30.35	......	30.36	......	29.90	......	......	29.84	......
24	......	......	30.78	......	30.53	......	30.61	......	30.79	......	30.85	......	31.07	......	29.82	......	......	30.54	......
25	......	......	31.75	......	31.76	......	31.94	......	32.01	......	32.14	......	33.36	......	31.23	......	......	31.75	......

26			22.15		21.87		21.47		21.78		21.95		22.13		20.84			21.72	
27			19.14		19.02		18.80		19.02		18.93		19.76		17.53			18.03	
28			19.80		19.78		19.38		19.64		19.46		19.24		18.38			18.62	
29		15.29		15.15			14.85	14.91			14.61	15.04			14.08			13.99	
30		10.97		10.68			10.53	10.67											
31		11.95		11.80			11.60		11.66		11.58		11.73	11.23				11.31	
32		17.86		17.81			17.62		17.46		17.34		18.32	17.25				17.01	
33		18.62		18.60		18.76		18.47			18.37		18.33		19.32			18.26	
34		15.39		15.36		15.29		15.25			15.16		15.07		15.08			14.96	
35		13.23		13.19			12.85	13.09			13.03		13.01		12.93			12.77	
36		20.28		20.22			20.02	20.01			20.02		19.80		19.30			19.15	
37		22.71		22.65			21.35		22.37		22.38		22.42		22.04			21.89	
38		19.70		19.63			19.44		19.46		19.33		19.44		19.08			18.94	
39		13.22		13.18			12.60		12.93		12.83		11.70		12.78			12.57	
40		23.64		23.70			23.41		23.39		22.33		23.27		23.19			22.96	
41	20.30			19.83		19.74		20.25		19.83		20.10		18.26			18.55		
42	19.12			18.99		18.64		18.59		18.63		18.94		17.96			17.57		
43	17.05			16.98		16.79		16.55		16.48		16.58		16.39			15.87		
44	11.40			11.75		11.40		11.49		11.49		11.66		10.42			10.30		

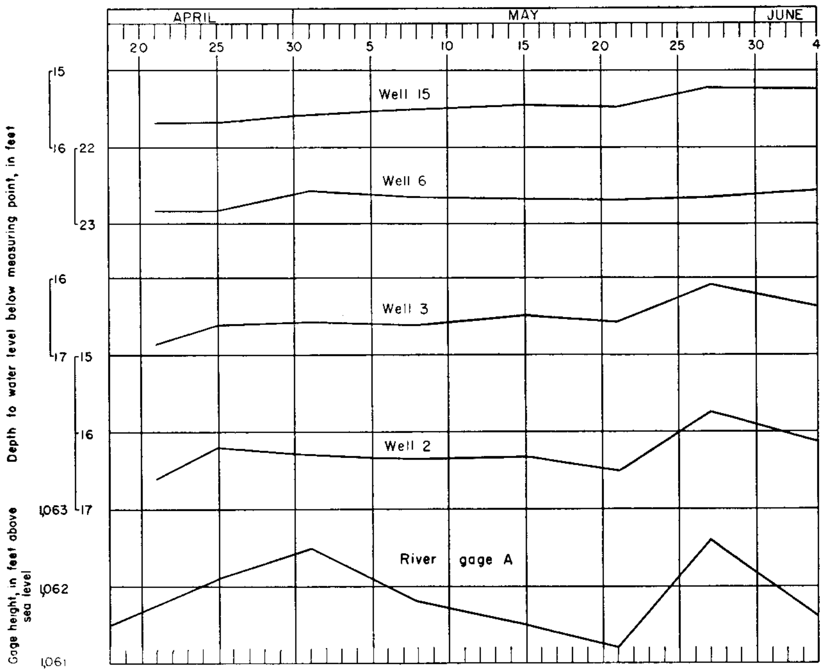

FIG. 7.—Hydrographs showing the weekly water levels in observation wells 2, 3, 6, and 15 at the Fort Riley Military Reservation and the weekly stages of Republican River at gauge A. Location of the observation wells and river gauge are shown in Figure 6.

measurements. Altitudes of the water surface at the 8 river gauges are given in Table 4.

The period of observation of the water levels in these wells was too short to permit drawing any conclusions regarding the general trend of the water-table fluctuations. The weekly water levels in observation wells 2, 3, 6, and 15 are plotted in comparison with the weekly stage of Republican River at river gauge A in Figure 7. Wells 2 and 3 are within 500 feet of the river and wells 6 and 15 are about 2,700 and 3,300 feet from the river, respectively (Fig. 6). Wells 2 and 3 are close enough to the river that the fluctuations in their water levels follow very closely fluctuations of the water surface in the river. The water levels in wells 6 and 15 are also affected by the fluctuations of the water surface in the river, but the fluctuations of the water levels in these wells are of a smaller magnitude because they are farther from the river. Because water is trans-

TABLE 4.—*Height of gauges on Smoky Hill, Republican, and Kansas Rivers at the Fort Riley Military Reservation, from April 18 to June 4, 1941, in feet above sea level* *

Date, 1941	River gauge†							
	A	B	C	D	E	F	G	H
April 18	...	...	...	...	...	1,045.7	1,043.7	1,040.6
21	1,061.5	1,057.8	...	1,045.8	1,046.5	...	...	...
22	...	...	1,050.3	...	...	...	...	...
24	...	...	...	1,046.5	1,046.8	1,046.6	1,048.8	1,042.0
25	1,062.1	1,058.1	1,050.6	...	...	...	...	...
30	...	...	...	...	1,046.7	1,046.1	1,043.6	1,041.2
May 1	1,062.5	1,057.6	1,050.2	1,045.9	...	...	...	...
7	...	...	...	1,045.5	1,046.9	1,045.9	1,043.2	1,041.0
8	1,061.8	1,058.0	1,050.4	...	...	...	...	...
14	...	...	...	...	...	1,046.5	1,043.5	1,041.5
15	1,061.5	1,057.9	1,050.0	1,045.7	1,046.6	...	...	...
20	...	...	...	...	...	1,045.7	1,042.9	1,040.7
21	1,061.2	1,057.8	1,049.1	1,045.4	1,046.5	...	...	...
26	...	...	...	...	...	1,049.8	1,046.6	1,045.0
27	1,062.6	...	1,050.0	...	1,050.0	...	...	...
28	...	1,058.5	...	...	...	...	...	...
June 2	...	...	...	...	...	1,049.0	1,045.9	...
3	...	1,057.5	...	...	1,048.7	...	...	...
4	1,061.6	...	...	...	...	...	...	...

* Furnished by the Quartermaster Corps, U. S. Army.
† Locations of gauges shown on Figure 6.

mitted through the ground very slowly there is generally some lag between the fluctuations of the river and fluctuations of the adjacent water table. The longer the river maintains a high stage, the farther from the river will the water table be affected. The high stages caused by floods are usually of short duration and, therefore, probably do not affect the ground-water levels very far back from the river.

In March 1946 the United States Geological Survey, coöperating with the United States Bureau of Reclamation, started an observation-well program in Smoky Hill Valley below the Kanopolis dam, which is situated on Smoky Hill River in eastern Ellsworth County, Kansas. As a part of this program, 11 observation wells were put down in Smoky Hill Valley in southern Saline County during March and April 1946, and monthly measurements of the water levels in them were begun in July. The location of these observation wells are shown on Plate 1 and descriptions of them are given in Table 5. The wells consist of 1¼-inch galvanized-iron pipe with screened drive points and were put down by John Sears, who used a hand auger and driving block. The water-level measurements for 1946, which were made with a steel tape by Mr. Sears, are given in Table 6. These and subsequent water-level measurements will be published in the annual water-level reports of the Federal Geological Survey.

Sand Springs

The only spring of importance in the Smoky Hill Valley area is situated on the north bank of Smoky Hill River about 2.5 miles west of Abilene (No. 73, Pl. 1). About 300 feet north of the spring is the edge of the sand hills. Before any improvements were made this was a seepage area in which water issued from many small openings in the sandy alluvial deposits and discharged into the river. This seepage area was called Sand Springs and was an important watering point for early travelers and cattlemen.

Table 5.—*Records of driven observation wells in Smoky Hill Valley in southern Saline County, Kansas*

No. on Plate 1	Location	Date constructed, 1946	Depth, feet	Measuring point [1]		Depth to water level below measuring point,[2] feet	Date of measurement, 1946
				Distance above land surface, feet	Height above aea level, feet		
	T. 15 S., R. 2 W.						
A	SE SW sec. 17......	Mar. 27	30.7	0.35	1,261.6	24.13	Mar. 28
B	SE cor. SW sec. 18...	Mar. 28	43.7	1.35	1,262.7	25.52	Mar. 29
C	SE SW SE sec. 30...	Mar. 26	37	1.0	1,267.8	22.38	Mar. 27
	T. 15 S., R. 3 W.						
D	SE cor. sec. 24......	Mar. 27	36.8	1.23	1,264.9	20.1	do
E	NW cor. NE sec. 36	Mar. 26	45.9	1.1	1,275.4	26.4	Mar. 26
	T. 16 S., R. 2 W.						
F	NW cor. sec. 7......	Mar. 15	31.2	.8	1,279.6	21	Mar. 21
G	SW cor. sec. 18......	Mar. 21	38.1	.9	1,284.2	26.7	do
H	NW NE sec. 19.....	do	38	1.0	1,279.8	24.9	do
	T. 16 S., R. 3 W.						
J	SE SW sec. 13......	April 1	47.4	1.3	1,283.9	22.0	April 1
K	SW SE sec. 26......	April 9	27.8	1.25	1,304.3	21.9	April 9
L	SE SE sec. 34.......	April 10	45.9	1.13	1,311.2	23	April 10

1. Top edge of 1¼-inch pipe at each well.
2. Subsequent water-level measurements are given in Table 6.

In 1881 the Sand Springs area was developed as a source of water supply for the City of Abilene. The water plant, which was rebuilt by a private company in 1890, was purchased by the city in 1907. A pit about 30 feet deep and 30 feet in diameter was dug at the site of the springs and cased with stone. The water issues from a solution opening along a bedding plane in Permian limestone (Herington limestone member of the Nolans limestone) at the bottom of the pit. A number of residents of this area expressed the belief that the water at Sand Springs had traveled a great distance before being discharged at the spring. Contrary to this belief, the present study shows that the water is of local origin. The limestone through

TABLE 6.—*Water levels in observation wells in Smoky Hill Valley in southern Saline County, Kansas, in feet below the measuring point*
(For descriptions of wells, see Table 5)

Well number	1946				
	July 3	Aug. 1	Sept. 5	Oct. 1	Nov. 4
A	24.96	25.15	24.89	24.32	23.19
B	26.13	26.22	26.38	25.65	24.30
C	23.05	23.35	23.42	22.89	21.99
D	20.68	21.08	20.95	21.70	20.96
E	27.80	28.22	28.26	28.06	27.91
F	21.64	22.88	22.05	21.64	21.02
G	27.20	27.08	27.25	26.22	24.29
H	24.38	25.18	25.35	24.18	22.00
J	25.26	25.47	25.63	25.22	24.44
K	22.43	22.57	22.69	21.87	20.36
L	23.66	23.84	24.08	23.41	22.24

which the water issues is about 7 feet thick and extends only a short distance northward beneath the sand hills, where it is overlain by water-bearing terrace deposits. Water from the terrace deposits enters the limestone through fractures and solution openings and after traveling a short distance through the limestone (probably less than a quarter of a mile) is discharged at the spring. The relation between the terrace deposits and the spring is well shown by cross section E—E′ on Plate 1.

The flow of Sand Springs is reported to fluctuate with the rainfall and ranges from less than 900 gallons a minute during periods of deficient rainfall to about 1,200 gallons a minute during periods of excessive rainfall. The water, although somewhat hard, is of unusually good quality as compared with the waters from alluvium in this area. An analysis (No. 73) of a sample of water from Sand Springs is given in Table 9.

WELLS IN ALLUVIUM

Most water supplies in the area studied are obtained from wells in the Quaternary alluvium that fills the valleys. Records of 97 wells in the Smoky Hill Valley area that derive water from these alluvial deposits for domestic, stock, public-supply, industrial, and irrigation use were obtained. Descriptions of these wells are given in Table 15 and their locations are shown on Plate 1.

CONSTRUCTION OF WELLS

The most common type of domestic and stock well in this area is constructed of 1¼-inch or 2¼-inch galvanized-iron pipe on the lower end of which is a screened drive point (sometimes called "sand point"). These are generally put down by first augering a hole to water-bearing sand or gravel, using a hand augur, then placing the pipe with the drive point in the hole and driving it several feet into the water-bearing material. In some cases, especially for the deeper wells, the hole is drilled to the desired depth, then the pipe and screened point are placed in it. In this type of well the small-diameter pipe acts both as a discharge pipe and a casing. Some of the stock and domestic wells are drilled wells that have separate galvanized-iron or steel casings, which range from 5 to 10 inches in diameter. The depths of 54 domestic and stock wells on which information was obtained range from 14 to 84 feet. Of these wells, 10 are less than 30 feet deep, 34 are between 30 and 50 feet deep, and 9 are between 50 and 84 feet deep. Most of these wells are equipped with cylinder pumps operated by windmill or hand, or by both. Five of the wells are equipped with electrically operated cylinder pumps and one has a small gasoline engine.

All the public-supply, industrial, and irrigation wells are drilled wells and most of them penetrate the entire thickness of alluvium. The depths of 43 wells of this type for which records were obtained range from 38 to 86 feet. Of these wells, 7 are between 38 and 50 feet deep, 8 are between 50 and 60 feet deep, 16 are between 60 and 70 feet deep, and 11 are between 70 and 86 feet deep. The diameters of these wells range from 6 to 26 inches, but about two-thirds of them are 16, 18, 24, or 26 inches in diameter. Steel or concrete casings are most common, although a few wells have iron casings. Thirty-five of the 43 wells, including all the wells drilled in recent years, are gravel packed. All but one of the public-supply, industrial, and irrigation wells are equipped with turbine pumps, and of these, 37 are powered by electric motors, 4 by stationary gasoline engines, and 1 by a tractor. Well 40 at Chapman is equipped with a plunger pump and gasoline engine.

Although most of the public-supply, industrial, and irrigation wells are single wells, Nos. 40 and 57 are battery-well units consisting of three and four wells, respectively, each group connected to a single pump. Well 57 was abandoned in 1943 and well 40 is operated only during periods of emergency.

YIELDS OF WELLS

The yields of wells in the Smoky Hill Valley area vary widely. Important factors that determine the yield of a well are the construction, the diameter of the well casing, the type of casing and perforations, the development and finishing of the well—whether gravel-packed or not—the age of the well, and the character and thickness of the water-bearing material. The quality of water may also be an important factor, for water that readily forms incrustations may eventually fill the perforations in the well casing, thus causing a decrease in the yield of the well. The water-bearing sands and gravels in the alluvial deposits of Smoky Hill, Kansas, Republican, Solomon, Saline, and Mulberry Valleys in this area are in most places highly permeable and sufficiently thick to furnish moderate to large quantities of water to properly constructed wells. In the smaller tributary valleys the alluvial deposits are thinner and consist mostly of fine material having low permeability. Therefore, wells in these areas can be expected to have relatively low yields.

Farm wells that supply water for domestic and stock purposes generally yield only a few gallons a minute and are pumped only when the water is needed. Public-supply, industrial, and irrigation water is derived from wells that are constructed to yield larger quantities of water. The reported operating yields of 39 wells of this type ranged from 50 to 1,500 gallons a minute. Of these wells, 6 yielded less than 250 gallons a minute, 5 between 250 and 500 gallons a minute, 12 between 500 and 1,000 gallons a minute, and 16 between 1,000 and 1,500 gallons a minute.

Data on the measured yield and drawdown for 31 public-supply and irrigation wells were obtained from the Layne-Western Company, Paulette and Wilson, Engineers (now Wilson and Company), and the Division of Water Resources of the Kansas State Board of Agriculture, and are given in Table 7. For most wells these measurements were made during pumping tests conducted at the time the wells were drilled. The measured yields of the wells tested ranged from 50 gallons a minute to 1,700 gallons a minute and averaged about 860 gallons a minute. The drawdowns ranged from 3 feet to 25.3 feet. Also given in Table 7 is the specific capacity for each well. The specific capacity of a well is its rate of yield per unit of drawdown and in this report it is given in gallons a minute per foot of drawdown. The specific capacities for the 31 wells tested ranged from 16.7 to 185.4 and averaged 81.5. Of the 31 wells, 6 had specific capacities of less than 50, 19 had specific capacities between 50 and 100, and 6 had specific capacities of more than 100.

Utilization of Ground Water

During the course of the investigation information on 98 wells and one spring in the Smoky Hill Valley area was obtained. Of the 98 wells, 55 are domestic and stock wells, 35 are public-supply wells, 7 are irrigation wells, and 1 is an industrial well. The principal uses of ground water in this area are described below.

DOMESTIC AND STOCK SUPPLIES

Most of the farms in the Smoky Hill Valley area have one or more small-diameter wells that supply water for domestic or stock use. At some farms one well supplies water for both purposes, but many have separate wells—one for domestic use near the house and one for stock use near the barn or in a pasture. Domestic and stock wells generally do not extend through the entire thickness of alluvium but penetrate only a few feet into the water-bearing sand and gravel. Although the chief reason for this is the lower construction cost, in some areas, especially in the vicinity of Solomon, it is because the deeper waters are harder and more highly mineralized than the shallow waters.

No attempt was made to obtain information on all domestic and stock wells in this area. The 55 wells of this type for which records were obtained represent only a small percentage of the total number of such wells. These wells were visited primarily to collect samples of water for chemical analyses. The water in the Smoky Hill Valley area is hard, but generally is satisfactory for domestic and stock use. In the Solomon area some of the ground waters contain undesirable quantities of chloride or sulfate and in other places the ground waters locally contain undesirable amounts of iron (see chemical character of ground water).

PUBLIC SUPPLIES

The cities of Milford, Junction City, Chapman, Enterprise, Solomon, Salina, and Assaria have public water systems supplied by ground water pumped from wells, and Abilene has a public water system supplied by ground water from a spring. Smaller communities in the Smoky Hill Valley area are supplied from private wells, each family having a well of its own. In addition to the cities, each of the following military centers have public water systems: Fort

TABLE 7.—*Yield, drawdown, and specific capacity of 31 public-supply and irrigation wells in the Smoky Hill Valley area* [1]

Well number (Pl. 1, Table 15)	LOCATION	Discharge, gallons a minute[2]	Draw-down, feet	Specific capacity, gallons a minute per foot of draw-down
14	Republican Valley, Geary Co.	980	25.3	38.7
15	do	1,000	18	55.5
18	do	1,000	11.5	86.9
19	do	1,025	16.7	61.4
21	do	500	8	62.5
22	do	500	6	83.3
23	do	500	5	100
24	do	1,700	15.7	108.2
25	Kansas Valley, Geary Co.	1,000	6	166.7
26	do	1,020	6.2	164.5
27	do	1,020	7.2	141.7
28	do	1,020	5.5	185.4
41	Smoky Hill Valley, Dickinson Co.	200	8	25
56	do	305	17.5	17.6
60	do	1,360	16.02	85
91	do	50	3	16.7
92	do	50	3	16.7
127	Smoky Hill Valley, Saline Co.	1,500	19	78.9
168	do	1,090	11	99.1
169	do	850	16.9	50.4
170	do	1,020	11.7	87.1
171	do	900	14.5	62
172	do	1,120	10	112
173	do	1,040	13.5	77
174	do	1,090	20	54.5
175	do	1,040	13.5	77
200	do	750	7.5	100
201	do	776	9.5	81.7
202	do	781	8.8	88.8
203	do	830	8.3	100
204	do	750	16.9	44.4

1. Well 60 tested by Division of Water Resources, Kansas State Board of Agriculture; wells 91 and 92 by Paulette and Wilson, Engineers; all others by the Layne-Western Company.
2. Average rate of discharge during test.

Riley, the Cavalry Replacement Training Center near Fort Riley, Camp Funston, and Camp Phillips. The Smoky Hill Army Air Base receives its water from the Camp Phillips system. Descriptions of the public water supplies follow.

Milford.—Milford (population 258) is supplied by one well (No. 1 in Table 15) situated at the southwest edge of town that taps alluvium in Republican Valley. The well is 38 feet deep and 18 inches in diameter, and is gravel-packed. It has a reported yield of 150 gallons a minute. Water is pumped from the well directly into the mains, the excess water going to a 50,000-gallon elevated steel storage tank located on a high bluff in the northeast part of town. The average daily consumption of water at Milford is reported to be about 15,000 gallons. The water is hard, but otherwise it is of good quality and is not treated (see analysis 1, Table 9).

Junction City.—Junction City (population 9,524) is supplied by four wells (16-19) located on the south side of Republican River at the north edge of town that tap alluvium in the Republican Valley (see logs 18 and 19). Wells 16 and 17 are, respectively, 67 and 54 feet deep and pump 400 and 500 gallons a minute. The diameter and type of casing in these wells are not known. Wells 18 and 19 are, respectively, 54 and 52 feet deep, pump 700 and 850 gallons a minute, and are cased with 19-inch concrete casing. Both are gravel-packed. These two wells (city wells 4 and 5) furnish most of the supply and are pumped directly into the city mains, the excess water going to two steel storage tanks on a high bluff at the southwest edge of town. Wells 16 and 17 (city wells 2 and 3) are used only in emergencies. Water is pumped from these wells to a small sunken reservoir nearby and from there to the two tanks at the southwest edge of town. The total storage capacity of the three reservoirs is about 250,000 gallons.

The monthly consumption of water at Junction City for the 5-year period from January 1938 to December 1942 ranged from 20,772,000 to 58,934,000 gallons and averaged 30,750,000 gallons. Approximately 95 percent of the water consumed is used by the inhabitants and 5 percent is furnished to manufacturing plants and the railroad. An analysis (19) of a sample of water from well 19 is given in Table 9. The water is moderately hard and, except for being disinfected by chlorine, is not treated.

Fort Riley Military Reservation.—The Cavalry Replacement Training Center, Fort Riley, and Camp Funston on the Fort Riley Military Reservation, each have a separate water-supply system.

The Cavalry Replacement Training Center obtains its water from two gravel-packed wells (14 and 15) that tap alluvium in Republican Valley 1.75 miles north of Junction City (see logs 14 and 15). These wells are 26 inches in diameter and are 81 and 74 feet deep, respectively. Each well has a reported yield of 1,200 gallons a minute. The water is reported to be moderately hard and is treated with chlorine and sodium hexametaphosphate (Calgon).

Fort Riley is supplied by four gravel-packed wells (21-24) on the northeast side of Republican River about 0.75 mile above its confluence with Smoky Hill River. The wells are 66 to 70 feet deep and derive water from alluvium (see logs 21-24). Wells 21-23 were drilled in 1928 and have 18-inch concrete casings. Well 24 was drilled in 1937 and has a 26-inch steel casing. The wells are only 300 to 500 feet apart, and because of the close spacing there is interference between wells, which decreases the yield of each well when the others are pumping. The yields of the wells range from 200 to 1,100 gallons a minute when all wells are pumping, the aggregate yield being about 2,800 gallons a mintue. The yields are somewhat greater when the wells are pumped individually. According to partial analyses furnished by Army engineers, the waters from the four wells at Fort Riley contain 0.5 to 3.4 parts per million of iron and have hardnesses of 283 to 481 parts.

Four gravel-packed wells (25-28) were constructed during the winter of 1940-41 in Kansas Valley about 6 miles below Junction City to supply water to Camp Funston. Logs (25-28) of these wells are given at the back of this report. The wells are 61 to 64 feet deep and 26 inches in diameter, and have steel casings. They are reported to yield 1,200 gallons a minute each when pumped separately. The water is reported to be hard and to contain undesirable amounts of iron. Wells 27 and 28, nearest the river, are seldom used because of the high iron content of the water.

Chapman.—Chapman (population 873) obtains most of its water supply from one gravel-packed well (41) in the western part of town. This is an old railroad well that was reconstructed by the city in 1939. It is 68 feet deep, is cased with 19-inch concrete casing, and taps alluvium in Smoky Hill Valley (see log 41). The well is reported to yield 200 gallons a minute with a drawdown of 8 feet. The supply at Chapman was formerly derived from a pumping unit constructed in 1912. This unit is situated at the west edge of town and consists of three drilled wells (40) connected to one plunger pump driven by a gasoline engine. These wells, which are spaced about 15 feet apart, are 68 feet deep and are cased with 10-inch iron casing. They have a reported aggregate yield of 225 gallons a minute. This well unit is kept in operating condition for emergency use only.

Water is pumped from the wells directly into the mains, the excess water going to a 100,000-gallon concrete standpipe on a bluff at the northwest edge of town. The daily capacity of the system is about 400,000 gallons, and the average daily consumption is about 70,000 gallons. The water is very hard, as shown by analyses 40 and 41 in Table 9. It is chlorinated but receives no other treatment.

Enterprise.—Until recently Enterprise (population 706) was supplied by four wells (57) about 250 feet north of Smoky Hill River north of town. The wells, which are spaced 25 feet apart at the corners of a square, are 38 feet deep and 8 inches in diameter, and have iron casings. They are connnected to one turbine pump having a capacity of 500 gallons a minute. Decrease in the aggregate yield of these wells caused by packing of fine sand around the casings or by incrustation of the well casings resulted in their being abandoned in 1943, and a new well was drilled. The new well (56) is about 75 feet west of the old wells, is 41.5 feet deep, has 19-inch concrete casing, and is gravel-packed (see log 56). During a pumping test conducted at the time the well was constructed it had a yield of 305 gallons a minute with a drawdown of 17.5 feet after pumping 8 hours. The capacity of this well is reported to have declined considerably since it was drilled.

Water is pumped directly from the well into the distribution mains, the excess water going to a 300,000-gallon elevated steel storage tank near the center of town. Figures on the consumption of water at Enterprise are not available. The water is very hard, as indicated by analysis 56 in Table 9, but otherwise it is of good chemical quality and is not treated.

Abilene.—Abilene (population 5,539) obtains its water supply from Sand Springs (73), located on the north bank of Smoky Hill River 2.5 miles west of town. A detailed description of the spring is given on pages 46-47. The reported capacity of the spring ranges from 900 gallons a minute during prolonged dry periods to 1,200 gallons a minute during periods having normal or excessive precipitation. Three plunger pumps at the spring pump the water through a 12-inch pipe line to two elevated steel storage tanks at the west edge of Abilene. The total storage capacity of the two tanks is 750,000 gallons. Distribution to the consumers is by gravity. The monthly consumption of water at Abilene ranges from 17,000,000 to about 33,000,000 gallons and averages about 21,000,000 gallons, of which about 2,400,000 gallons is supplied to railroads. The water is moderately hard, as indicated by analysis 73 in Table 9, but otherwise it is of excellent chemical quality and, except for intermittent chlorination, it is not treated.

Abilene plans to supplement its present water supply by constructing one or more wells in the sand hills area north of the spring.

Solomon.—The water supply at Solomon (population 811) was formerly obtained from two wells that tapped alluvium of Smoky Hill Valley in the southeastern part of town. These wells, drilled in 1930 and 1931, were 46 and 49.5 feet deep and were reported to yield about 200 gallons a minute each, with relatively small drawdowns. The water was hard, but otherwise it was of satisfactory quality. During the next 10 years the water gradually increased in mineral content and by 1941 had become too salty for public supply use. From 1931 to 1941 the chloride content of the water increased from 50 to 1,690 parts per million, the sodium content increased from 41 to 758 parts per million, and the hardness increased from 323 to 1,474 parts per million (Table 8). The old wells were abandoned and new wells were drilled early in 1942.

Solomon is now supplied by two wells (91 and 92), which derive water from alluvium (see log 92) and which are situated near the edge of the sand hills at the east edge of town. Wells 91 and 92 are gravel-packed, have 6-inch iron casings, and are 50.5 and 44.8 feet deep, respectively. Each well is reported to yield 50 gallons a minute with a drawdown of 3 feet. The water is moderately hard and has a low chloride content (analysis 91, Table 9). Water is pumped from the wells directly into the mains, the excess water going to a 40,000-gallon elevated steel storage tank on a bluff in the northern part of town. The average daily consumption of water at Solomon is reported to be about 30,000 gallons.

Salina.—Salina (population 24,001) has had a public water supply since 1883. The original system was constructed by a private company which operated it until 1926, when it was purchased by the city. Although the type of well construction has changed, the general location of the wells and the source of supply has been the same since the first supply was developed. The original supply was derived from one dug well 27 feet in diameter that extended about 15 feet below the water table. Fifty sand points, 1.5 inches in diameter, were driven in the bottom of the dug well and derived water from sand and gravel at the base of the alluvium. This system of wells furnished the supply until 1898, when the well points became clogged and it was necessary to construct new wells. The new system consisted of 12 sand points located along the bank of Smoky Hill River. They were connected to a common suction line, laid

TABLE 8.—*Changes in the total hardness and the content of chloride and sodium in waters from the old city wells at Solomon, Kansas, from 1931 to 1941*
(Analyzed by the Division of Sanitation, Kansas State Board of Health. Constituents given in parts per million)

DATE	Source	Chloride (Cl)	Sodium (Na)	Total hardness as $CaCO_3$
April 29, 1931	South well	50	41	323
April 15, 1932	do	56	54	302
May 10, 1933	do	51	25	296
May 16, 1934	do	61	69	315
May 9, 1935	do	72	58	343
May 7, 1936	do	88	69	330
April 13, 1937	do	94	71	370
April 13, 1938	do	100	79	414
May 8, 1939	Park tap	139	112	423
May 6, 1940	do	206	124	561
January 20, 1941	North well	450	....	....
January 20, 1941	South well	855	....	....
March 26, 1941	South well	1,690	758	1,474

about 15 feet below the ground surface, that led to steam pumps in the pump house. This supply was later supplemented by drilling four wells, 6 inches in diameter, in the bottom of the original dug well. This arrangement supplied the needs of the city for the next 15 years, during which time clogging of the sand points caused a great deal of trouble and finally reduced the capacity of the wells below the requirements of the city.

In 1913, 12 gravel-packed wells spaced at intervals of about 70 feet were constructed south and west of the present pumping station. These first gravel-packed wells were 6 inches in diameter and the gravel wall surrounding the well screen was only 3 inches thick. The 12 wells were connected directly to the steam pumps by a common suction line and, for this reason, certain operating difficulties were encountered when the water levels in the wells were lowered. Beginning in 1916 high-capacity wells equipped with individual pumps were constructed to replace the other wells. The first two wells of this type were drilled in 1916 and a third in 1919. These three wells have since been abandoned and replaced with newer wells of the same type.

The present supply at Salina is obtained from eight gravel-packed wells (168-175) located on both sides of Smoky Hill River south, southeast, and east of the pumping station in the east-central part of the city. The wells are 70 to 85 feet deep, have

24-inch steel or concrete casings, and tap alluvium (see logs 168-170). They are equipped with electrically driven turbine pumps. The yields of the wells range from 850 to 1,120 gallons a minute and average 1,000 gallons a minute. Water is pumped from the wells into two underground reservoirs at the pumping station, having capacities of 325,000 and 1,000,000 gallons, respectively. From here the water is pumped into the mains by five high-service centrifugal pumps having a total capacity of 15,000 gallons a minute, the excess water going to two elevated steel storage tanks—one in the north-central part of town, holding 1,000,000 gallons, and one in the eastern part of town, holding 265,000 gallons.

The monthly consumption of water at Salina for the 4-year period from 1939 through 1942 ranged from 41,940,000 to 177,345,000 gallons and averaged 77,400,000 gallons. Analyses (Nos. 168, 171-175, Table 9) of samples of water from five of the eight wells show that they are hard calcium bicarbonate waters. The five samples contained 649 to 836 parts per million of dissolved solids and ranged in hardness from 354 to 402 parts per million. The samples of water from wells 168 and 171 near the river contained 2.5 and 0.85 parts per million of iron, respectively, whereas those collected from wells back from the river contained 0.1 part or less. The water is not treated.

Camp Phillips and Smoky Hill Army Air Base.—Camp Phillips and the Smoky Hill Army Air Base are supplied by five gravel-packed drilled wells (200-204) that are situated in Smoky Hill Valley about 3 miles south of Salina and derive water from alluvium (see logs 200-204). Wells 201-204 were drilled in 1942 and well 200 (Pl. 6A) was drilled in 1943. They are 48 to 61.5 feet deep and 19 inches in diameter, have concrete casings, and yield 750 to 830 gallons a minute each. An average of 66,000,000 gallons a month was pumped from these wells during 1943 and 1944. The waters from all five wells are hard, and the waters from wells 203 and 204, which are nearest the river, are reported to contain excessive amounts of iron. The water is treated with chlorine and sodium hexametaphosphate (Calgon).

Assaria.—Assaria (population 211) obtains its water supply from one drilled well (227) situated in town, which derives water from sand and gravel in the alluvium of Smoky Hill Valley. The well is 86 feet deep and 10 inches in diameter, and is equipped with an electrically driven turbine pump. During a pumping test conducted when the well was drilled in 1937, it discharged 400 to 600 gallons a minute, but it is now operated at only 100 gallons a minute. The water is pumped from the well into a concrete standpipe holding 50,000 gallons, and from there it enters the distribution mains by gravity.

The average daily consumption of water at Assaria is about 30,000 gallons, all of which is used by the inhabitants. The water is hard and contains an excessive amount of iron, as indicated by analysis 227 in Table 9, but it is not treated.

IRRIGATION SUPPLIES

The use of ground water for irrigation has not been extensive in the Smoky Hill Valley area. In 1943 there were only seven irrigation wells in this area which supplied water to less than 400 acres of land. Five of these wells (53, 58-60, and 63) are in Dickinson County within 5 miles of Abilene and two (127 and 160) are in Saline County near Salina (Pl. 1). In 1940 an irrigation well was drilled about 3 miles south-southeast of Solomon, in the NW¼ sec. 32, T. 13 S., R. 1 E. This well reportedly encountered a "hard layer" at a depth of 30 feet, below which was good water-bearing sand and gravel. The water was unsatisfactory for irrigation use, however, because of the high concentration of chloride, and the well was abandoned. A detailed discussion of the chemcial character of the ground water in the Solomon area is given elsewhere in this report.

Records of existing irrigation wells are given in Table 15, and they are described in more detail in the following paragraphs. All the irrigation wells are gravel packed and derive water from sand and gravel in alluvium.

Abilene area.—Five irrigation wells are located in Smoky Hill Valley between Abilene and Enterprise. Well 53, belonging to the Enterprise Academy, is about 0.5 mile north of Enterprise. It was drilled in 1934, is 43 feet deep and 18 inches in diameter, and is equipped with a gasoline-powered turbine pump. The measured depth to water level in this well on August 11, 1943, was 15.91 feet below ground surface. The yield is not known, but it is reported to irrigate 35 acres. An objectionable amount of fine sand entering the well has resulted in considerable operating difficulty and has caused the ground to cave in around the well casing.

In 1939, a well (63) was drilled 0.75 mile south of Abilene by the U. S. Department of Agriculture to irrigate trees in a shelter belt.

This well is now being used occasionally to irrigate about 80 acres of crops. It is 70 feet deep and 18 inches in diameter, and is equipped wth a turbine pump operated by a tractor. The measured depth to water level on August 12, 1943, was 19.32 feet below ground surface. The yield of the well is not known.

Three irrigation wells (58-60) were drilled in the area between Abilene and Enterprise in 1940. Well 58, which is owned by T. L. Welch, is in the SW¼ SW¼ sec. 7, T. 13 S., R. 3 E., is 86 feet deep and 18 inches in diameter, and is equipped with a gasoline-powered turbine pump. The water level in this well is reported to be 28 feet below land surface. Well 58 is reported to have yielded 1,500 gallons a minute with a drawdown of 10 feet during a pumping test conducted at the time the well was drilled. Its operating yield in 1943 was reported to be between 1,000 and 1,200 gallons a minute.

Well 59, of C. W. Whitehair, is in the NW¼ NW¼ sec. 13, T. 13 S., R. 2 E., about 2 miles east of Abilene. It is 42 feet deep and 18 inches in diameter, and is equipped with an electrically driven turbine pump. The well is reported to yield 350 gallons a minute and supplies water to about 40 acres of land.

Well 60 (Pl. 6B), belonging to H. H. Hoffman, is about a mile south of the Whitehair well in the NW¼ NW¼ sec. 24, T. 13 S., R. 2 E. It is 63 feet deep and 18 inches in diameter, and is equipped with a turbine pump and stationary gasoline engine. Water-bearing sand and gravel was penetrated in the well at a depth of 23 to 60 feet and shale was encountered at 63 feet. The water level on October 13, 1943, was 23.22 feet below land surface. During a pumping test conducted in 1943 by K. D. McCall of the Division of Water Resources, Kansas State Board of Agriculture, the well yielded 1,360 gallons a minute with a drawdown of 16.02 feet after pumping 3 hours.

Salina area.—Wells 127 and 160 near Salina supply water for irrigation use. Well 127, of M. A. Hensley, is in the SW¼ NW¼ sec. 31, T. 13 S., R. 2 W., about 2 miles northeast of Salina. It is 70 feet deep and 24 inches in diameter, and is equipped with a turbine pump and gasoline engine. The water level in the well is reported to be 25 feet below land surface. According to the owner, it yields 1,500 gallons a minute with a drawdown of 19 feet. About 40 acres of crops is irrigated with water from well 127.

Well 160 is in the SW¼ NW¼ sec. 8, T. 14 S., R. 2 W., about 1 mile east of Salina. It is 54 feet deep and 24 inches in diameter,

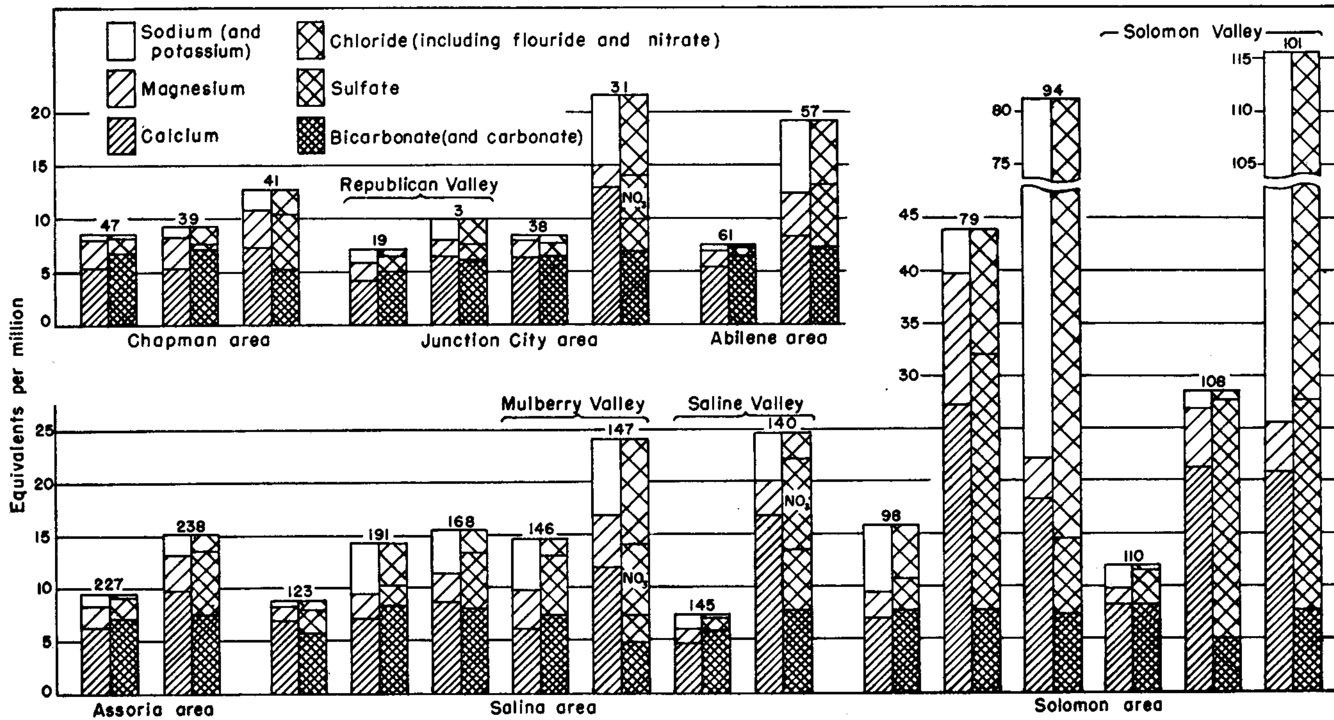

FIG. 8.—Chemical character of waters from 15 wells in Smoky Hill Valley and 9 wells in valleys tributary to Smoky Hill Valley in Saline, Dickinson and Geary Counties, Kansas. Numbers refer to wells described in text. Unless otherwise indicated, samples are from wells in Smoky Hill Valley.

and the water level is about 28 feet below land surface. Equipped with an electrically driven turbine pump, the well is reported to yield 800 to 1,000 gallons a minute. Crops on 57 acres of land are irrigated with water from well 160.

INDUSTRIAL SUPPLIES

Most industrial water in this area is obtained from the public water systems. The Banfield Brothers Packing Company well (163) at Salina is the only industrial well for which a record was obtained. This well is 84 feet deep and 10 inches in diameter, and is equipped with a turbine pump and electric motor. It is reported to yield 65 gallons a minute and is pumped continuously. The water, which is reported to be very hard, is used in the processing of meat. Water purchased from the City of Salina is also used at the packing plant.

Moderate to large quantities of water are available for industrial use in most parts of the Smoky Hill Valley area, but the poor quality of the ground waters in some areas makes it unsuited for many industrial uses. The chemical character of the ground water is discussed in the following section.

Chemical Character of Ground Water

The chemical character of the ground water in the Smoky Hill Valley area is shown by the analyses of 63 representative samples of the water given in Table 9. Of these, 61 samples were taken from wells in alluvium, one from a well (70) in the terrace deposits west of Abilene, and one from spring 73, which derives its water indirectly from the terrace deposits. Of the 61 samples collected from wells in alluvium, 41 are from wells in Smoky Hill Valley and 20 are from wells in valleys tributary to the Smoky Hill, including five each from Saline, Solomon, and Republican Valleys, two from Mulberry Valley, and one each from the valleys of Dry Creek, Clarke Creek, and an unnamed tributary south of Solomon. Figure 8 shows graphically the chemical character of typical waters from the alluvium in the major valleys by areas. Table 10 gives the chloride content of 29 additional samples of water collected from wells and test holes in alluvium. Of these, 14 samples were taken from test holes in Smoky Hill Valley between Abilene and Salina, 7 from test holes in Solomon Valley, 1 from a test hole in the valley of Gypsum Creek, and 7 from wells in Saline Valley.

TABLE 9.—*Analyses of water from typical wells and spring in Smoky Hill Valley area in Saline, Dickinson, and Geary Counties, Kansas*

Dissolved constituents given in parts per million[a], and in equivalents per million[b] (in italics)

Analyzed by H. A. Stoltenberg.

No. on Plate 1	Location	Depth, feet	Geologic source	Date of collection, 1943	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
	GEARY COUNTY																		
	T. 10 S., R. 5 E.																		
1c	SW SE sec. 19	38	Alluvium	Nov., 1939	......	507	......	1.8	106 *5.29*	17 *1.40*	32 *1.41*	338 *5.53*	52 *1.08*	33 *0.93*	0.3 *0.01*	34 *0.55*	335	277	58
	T. 11 S., R. 5 E.																		
2	SW NW sec. 7	24	do	July 20	59	342	......	2.9	101 *5.04*	19 *1.56*	5.1 *0.22*	390 *6.40*	13 *0.27*	3 *0.08*	0.5 *0.03*	2.2 *0.04*	330	320	10
3	NE SW sec. 18	14	do	do	59	570	......	.4	130 *6.49*	19 *1.56*	43 *1.89*	373 *6.12*	76 *1.58*	31 *0.87*	0.4 *0.02*	84 *1.35*	402	306	96
4	SW NW sec. 27	20	do	do	59	405	......	.2	102 *5.09*	26 *2.14*	15 *0.67*	417 *6.84*	35 *0.73*	10 *0.28*	.2 *0.01*	2.6 *0.04*	362	342	20
19d	SW SW sec. 36	52	do	Mar. 15	......	433	......	1.3	85 *4.24*	19 *1.56*	32 *1.38*	305 *5.00*	69 *1.44*	24 *0.68*	0.5 *0.03*	1.8 *0.03*	290	250	40
	T. 11 S., R. 6 E.																		
29	SW SE sec. 35	35	do	July 31	59	586	......	.28	151 *7.53*	32 *2.63*	12 *0.51*	459 *7.53*	68 *1.41*	18 *0.51*	0.1 *0.01*	75 *1.21*	508	376	132
	T. 12 S., R. 6 E.																		
30	NE SE sec. 5	60	do	Aug. 4	58	444	......	.48	122 *6.09*	28 *2.30*	7.6 *0.33*	440 *7.22*	38 *0.79*	22 *0.62*	0.1 *0.01*	5.3 *0.08*	420	361	59
	T. 12 S., R. 5 E.																		
31	NE SW sec. 13	45	do	Aug. 5	58	1,319	......	.18	257 *12.82*	28 *2.30*	151 *6.55*	417 *6.84*	154 *3.20*	268 *7.56*	0.2 *0.01*	252 *4.06*	756	342	414
36	SE NE sec. 27	33	do	July 20	59	584	......	0	167 *8.33*	21 *1.73*	18 *0.80*	476 *7.81*	71 *1.48*	37 *1.04*	0.1 *0.01*	32 *0.52*	503	390	113
38	NW NW sec. 32	20	do	Aug. 4	59	451	......	9.1	126 *6.29*	18 *1.48*	15 *0.66*	395 *6.48*	58 *1.21*	25 *0.70*	0.1 *0.01*	2 *0.03*	388	324	64
	DICKINSON COUNTY																		
	T. 13 S., R. 4 E.																		
39	NE NE sec. 4	40	do	July 20	58	498	......	.04	106 *5.29*	36 *2.96*	25 *1.09*	427 *7.00*	29 *0.60*	26 *0.73*	0.2 *0.01*	62 *1.00*	412	350	62
	T. 12 S., R. 4 E.																		
40e	NW NE sec. 31	68	do	Aug., 1937	......	1,006	......	.8	164 *8.21*	50 *4.13*	58 *2.51*	312 *5.12*	346 *7.20*	85 *2.39*	....	8.8 *0.14*	617	256	361
41e	NW NE sec. 31	68	do	June 23	......	841	......	.04	146 *7.28*	43 *3.53*	46 *2.01*	312 *5.12*	253 *5.26*	71 *2.00*	0.3 *0.02*	26 *0.42*	540	256	284

	T. 13 S., R. 4 E.																		
45	NW NW sec. 6	32	do	Aug. 5	59	493	......	7.0	151 *7.53*	15 *1.23*	12 *0.54*	466 *7.64*	57 *1.18*	16 *0.45*	0.2 *0.01*	1.5 *0.02*	438	382	56
	T. 13 S., R. 3 E.																		
46	NW NW sec. 10	35	do	July 20	58	585	......	.24	154 *7.68*	26 *2.14*	16 *0.70*	388 *6.36*	159 *3.31*	22 *0.52*	0.2 *0.01*	14 *0.22*	491	318	173
47	SE SE sec. 16	60	do	do	60	448	......	2.4	109 *5.44*	32 *2.63*	13 *0.58*	415 *6.81*	70 *1.46*	11 *0.31*	0.3 *0.02*	2.9 *0.05*	404	340	64
56f	SW SW NE sec. 20	41.5	do	Aug. 11, 1944	......	1,134	......	0	162 *8.08*	47 *3.86*	145 *6.29*	410 *6.72*	243 *5.05*	216 *6.09*	0.3 *0.02*	22 *0.35*	597	336	261
57f	SW SW NE sec. 20	38	do	Jan. 12	......	1,203	......	0	167 *8.33*	50 *4.11*	158 *6.89*	437 *7.17*	296 *6.16*	187 *5.27*	0.3 *0.02*	44 *0.71*	622	358	264
	T. 13 S., R. 2 E.																		
61	SW SE sec. 14	40	do	July 21	59	391	......	4.5	108 *5.39*	19 *1.56*	14 *0.61*	399 *6.54*	34 *0.71*	10 *0.28*	0.2 *0.01*	1.5 *0.02*	348	327	21
62	SW SE SE sec. 21	63	do	July 30	58	528	......	1.9	130 *6.49*	28 *2.30*	22 *0.97*	401 *6.58*	125 *2.60*	19 *0.54*	0.2 *0.01*	1.8 *0.03*	440	329	111
65	SW SW SE sec. 19	32	do	July 20	58	335	......	.19	89 *4.44*	17 *1.40*	8 *0.35*	277 *4.54*	36 *0.75*	12 *0.34*	0.2 *0.01*	34 *0.55*	292	227	65
	T. 13 S., R. 1 E.																		
70	NE SE SE sec. 15	48	Terrace deposits	May 27, 1944	59	239	......	2.0	51 *2.54*	10 *0.82*	12 *0.52*	120 *1.97*	30 *0.62*	8 *0.22*	0.1 *0.01*	66 *1.06*	168	98	70
73g	SE NW SE sec. 23	Spring	Herington limestone member.	Nov. —	......	265	......	.05	54 *2.69*	12 *0.99*	8.5 *0.37*	159 *2.61*	34 *0.71*	13 *0.37*	0.1 *0.01*	22 *0.35*	184	130	54
76	NW SE sec. 26	35	Alluvium	May 27, 1944	58	495	......	.16	146 *7.28*	14 *1.15*	17 *0.76*	403 *6.61*	90 *1.87*	23 *0.65*	0.2 *0.01*	3 *0.05*	422	330	92
79	SW SE sec. 36	40	do	July 30	59	2,771	......	11	545 *27.20*	151 *12.41*	103 *4.46*	478 *7.84*	1,162 *24.17*	250 *7.05*	0.4 *0.02*	310 *4.99*	1,980	392	1,588
	T. 14 S., R. 1 E.																		
81	NE cor. sec. 3	20	do	July 15	59	1,253	......	2.6	218 *10.88*	38 *3.12*	169 *7.36*	356 *5.84*	367 *7.63*	278 *7.84*	0.3 *0.02*	1.8 *0.03*	700	292	408
85	NW SW SW sec. 17	30.5	do	July 30	58	2,514	......	3.0	611 *30.49*	73 *6.00*	60 *2.61*	321 *5.26*	1,320 *27.46*	144 *4.06*	0.5 *0.03*	142 *2.29*	1,824	263	1,561
	T. 13 S., R. 1 E.																		
86	NE cor. sec. 31	26	do	July 15	58	1,990	......	1.2	437 *21.81*	58 *4.77*	95 *4.14*	429 *7.04*	519 *10.80*	178 *5.02*	0.4 *0.02*	487 *7.84*	1,329	352	977
87	SW SE SE sec. 21	29.5	do	July 30	59	290	......	.48	87 *4.34*	14 *1.15*	2.5 *0.11*	282 *4.62*	34 *0.71*	8 *0.22*	0.2 *0.01*	2.6 *0.04*	274	231	43
91h	NW SW SE sec. 18	50.5	do	Nov. —	......	394	......	.18	84 *4.19*	17 *1.40*	13 *0.56*	260 *4.26*	49 *1.02*	10 *0.28*	0.2 *0.01*	36 *0.58*	280	213	67
93	SE SW NW sec. 19	30	do	May 27, 1944	59	695	......	4	123 *6.14*	21 *1.73*	111 *4.83*	458 *7.51*	85 *1.77*	119 *3.36*	0.3 *0.02*	2.6 *0.04*	394	376	18
	SALINE COUNTY *T. 13 S., R. 1 W.*																		
94	SW SE sec. 24	32	do	Aug. 4	59	4,770	......	1.4	365 *18.21*	48 *3.94*	1,356 *58.98*	446 *7.31*	351 *7.30*	2,270 *64.01*	0.2 *0.01*	155 *2.50*	1,108	366	742

TABLE 9.—*Analyses of water from typical wells and spring in Smoky Hill Valley area in Saline, Dickinson, and Geary Counties, Kansas—Concluded*

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

No. on Plate 1	LOCATION	Depth, feet	Geologic source	Date of collection, 1943	Temperature (°F.)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$ Total	Carbonate	Noncarbonate
95	*T. 14 S., R. 1 W.* NW SW NW sec. 2	35	Alluvium	July 21	58	3,404	......	.08	217 *10.83*	40 *3.29*	1,006 *43.77*	556 *9.12*	364 *7.57*	1,410 *39.76*	0.4 *0.02*	88 *1.42*	706	456	250
98	*T. 13 S., R. 1 W.* NW SW NW sec. 32	36	do	do	58	884	......	.49	139 *6.94*	30 *2.47*	148 *6.45*	471 *7.72*	141 *2.93*	175 *4.94*	0.5 *0.03*	15 *0.24*	470	386	84
100	SE NE sec. 15	40	do	do	59	2,150	......	3.4	503 *25.10*	79 *6.49*	54 *2.36*	366 *6.00*	1,280 *26.62*	45 *1.27*	0.6 *0.03*	2 *0.03*	1,580	300	1,280
101	SW SE sec. 16	40	do	July 15	58	6,848	......	3.6	418 *20.86*	56 *4.60*	2,065 *89.81*	468 *7.68*	962 *20.01*	3,100 *87.42*	0.4 *0.02*	8.8 *0.14*	1,273	384	889
108	NW NW NE sec. 9	40	do	July 21	60	1,813	......	.46	425 *21.21*	68 *5.59*	42 *1.83*	307 *5.03*	1,089 *22.65*	30 *0.85*	0.5 *0.03*	4.4 *0.07*	1,340	252	1,088
110	NE cor. sec. 7	34	do	July 15	58	662	......	2.2	166 *8.28*	19 *1.56*	49 *2.15*	506 *8.30*	157 *3.26*	14 *0.39*	0.2 *0.01*	1.7 *0.03*	492	415	77
111	SW SW NW sec. 7	44.5	do	do	58	1,786	......	9.5	365 *18.21*	48 *3.94*	133 *5.78*	383 *6.28*	1,024 *21.30*	8 *0.22*	0.4 *0.02*	6.6 *0.11*	1,108	314	794
118	*T. 13 S., R. 2 W.* SE SE sec. 28	44	do	July 21	59	583	......	1.1	146 *7.28*	22 *1.81*	36 *1.58*	409 *6.71*	123 *2.56*	48 *1.35*	0.3 *0.02*	2 *0.03*	454	336	118
123	*T. 14 S., R. 2 W.* NE NW NW sec. 10	40	do	do	59	498	......	2.5	137 *6.84*	16 *1.32*	16 *0.69*	345 *5.66*	106 *2.20*	16 *0.45*	0.4 *0.02*	32 *0.52*	408	283	125
126	*T. 13 S., R. 2 W.* SE SE SW sec. 31	50	do	July 30	58	712	......	.19	159 *7.93*	31 *2.55*	54 *2.34*	410 *6.72*	177 *3.68*	84 *2.37*	0.3 *0.02*	1.8 *0.03*	524	336	188
139	*T. 13 S., R. 3 W.* SE SW SE sec. 27	68.7	do	July 19	57	3,681	......	6.2	513 *25.60*	103 *8.47*	434 *18.90*	605 *9.92*	174 *3.62*	400 *11.28*	0.1 *0.01*	1,748 *28.14*	1,704	496	1,208
140	SE SW SE sec. 27	30	do	May 27, 1944	55	1,626	......	1.4	335 *16.72*	41 *3.37*	107 *4.64*	470 *7.71*	279 *5.80*	91 *2.57*	0.3 *0.02*	536 *8.63*	1,004	386	618
143	SE SW SE sec. 17	42	do	July 19	59	578	......	.2	134 *6.69*	22 *1.81*	34 *1.49*	400 *6.56*	43 *0.89*	24 *0.68*	0.2 *0.01*	115 *1.85*	425	328	97
144	NE SE sec. 9	50	do	do	59	462	......	......	110 *5.49*	17 *1.40*	36 *1.57*	72 *6.10*	85 *1.77*	20 *0.56*	0.1 *0.01*	1.5 *0.02*	344	305	39
145	NE NE sec. 6	45	do	do	58	395	......	2.2	93 *4.64*	15 *1.23*	36 *1.59*	359 *5.89*	51 *1.06*	17 *0.48*	0.2 *0.01*	1.4 *0.02*	294	294	0
146	*T. 14 S., R. 4 W.* SE SE SE sec. 13	45	do	July 29	65	846	......	5.0	121 *6.04*	45 *3.70*	115 *5.01*	446 *7.31*	272 *5.66*	60 *1.69*	0.4 *0.02*	4.4 *0.07*	487	366	121

147	*T. 14 S., R. 3 W.* SW NW sec. 8	42	do.	do.	58	1,499	......	.52	237 *11.83*	60 *4.93*	166 *7.21*	293 *4.80*	118 *2.45*	355 *10.01*	0.1 *0.01*	416 *6.70*	838	240	598
168i	NW SE NE sec. 13	72	do.	Oct. 19, 1938	......	830	......	2.5	173 *8.63*	32 *2.63*	95 *4.13*	490 *8.03*	247 *5.14*	76 *2.14*	0.6 *0.03*	3.3 *0.05*	563	402	161
171i	NE NW SE sec. 13	74	do.	do.	......	771	......	.85	174 *8.68*	26 *2.14*	58 *2.53*	469 *7.67*	184 *3.82*	63 *1.78*	0.5 *0.03*	3.3 *0.05*	541	384	157
172i	SW NW SE sec. 13	81	do.	May 16, 1939	......	810	......	.1	176 *8.78*	27 *2.22*	49 *2.12*	459 *7.52*	194 *4.03*	53 *1.49*	0.3 *0.02*	3.5 *0.06*	550	376	174
173i	NW SE SW sec. 13	84	do.	do.	......	836	......	0	174 *8.68*	30 *2.47*	52 *2.26*	449 *7.35*	216 *4.49*	48 *1.35*	0.2 *0.01*	13 *0.21*	558	368	190
174i	SE SE SW sec. 13	81	do.	do.	......	740	......	0	160 *7.98*	28 *2.30*	38 *1.64*	432 *7.07*	180 *3.74*	34 *0.96*	0.2 *0.01*	8.8 *0.14*	514	354	160
175i	NE NW sec. 24	....	do.	do.	......	649	......	0	144 *7.19*	28 *2.30*	29 *1.28*	450 *7.37*	137 *2.85*	16 *0.45*	0.2 *0.01*	5.8 *0.09*	475	369	106
190	SE SE SE sec. 28	51.5	do.	July 30	59	1,202	......	6.4	204 *10.18*	64 *5.26*	134 *5.84*	405 *6.64*	211 *4.39*	340 *9.59*	0.3 *0.02*	40 *0.64*	772	332	440
191	SE SE SW sec. 26	80	do.	May 27, 1944	60	843	......	.06	140 *6.99*	28 *2.30*	113 *4.90*	503 *8.25*	90 *1.87*	43 *1.21*	0.2 *0.01*	177 *2.85*	464	412	52
192	*T. 14 S., R. 2 W.* SE SW SE sec. 30	60	do.	do.	57	622	......	1.2	144 *7.18*	24 *1.97*	42 *1.82*	311 *5.10*	180 *3.74*	74 *2.09*	0.3 *0.02*	1.4 *0.02*	458	255	203
210	*T. 15 S., R. 3 W.* SW NW SW sec. 16	41	do.	July 29	59	1,362	......	.76	255 *12.72*	61 *5.01*	125 *5.45*	424 *6.95*	45 *0.94*	380 *10.72*	0.1 *0.01*	283 *4.56*	886	348	538
226	*T. 15 S., R. 2 W.* SW NE SE sec. 30	50	do.	July 29	59	588	......	3.1	148 *7.38*	27 *2.22*	29 *1.28*	470 *7.71*	123 *2.56*	20 *0.56*	0.4 *0.02*	2.1 *0.03*	480	386	94
227j	*T. 16 S., R. 3 W.* NW SE NW sec. 12	86	do.	Oct. —	......	569	......	3.4	126 *6.29*	23 *1.89*	32 *1.38*	431 *7.07*	94 *1.96*	17 *0.48*	0.3 *0.02*	2 *0.03*	409	353	56
237	NW NW NE sec. 25	45	do.	July 29	59	566	......	.25	116 *5.79*	21 *1.73*	61 *2.66*	334 *5.48*	126 *2.62*	72 *2.03*	0.4 *0.02*	2.1 *0.03*	376	274	102
238	SE SE SW sec. 34	50	do.	do.	59	876	......	1.7	195 *9.73*	41 *3.37*	44 *1.91*	449 *7.36*	288 *5.99*	28 *0.79*	0.4 *0.02*	53 *0.85*	655	368	287

a. One part per million is equivalent to one pound of substance per million pounds of water or 8.33 pounds per million gallons of water.
b. An equivalent per million is a unit chemical equivalent weight of solute per million unit weights of solution. Concentration in equivalents per million is calculated by dividing the concentraton in parts per million by the chemical combining weight of the substance or ion.
c. Sample collected from well at Milford by city engineer.
d. Sample collected from well at Junction City by water superintendent.
e. Sample collected from wells at Chapman by city engineer.
f. Sample collected from well at Enterprise by city engineer.
g. Sample collected from hydrant at Abilene pumping station by city engineer.
h. Sample collected from well at Solomon by city engineer.
i. Sample collected from city well at Salina by water superintendent.
j. Sample collected from water tower hydrant at Assaria by water superintendent.

TABLE 10.—*Chloride content of water from wells and test holes in the Smoky Hill Valley area in Saline and Dickinson Counties, Kansas*

Analyzed by H. A. Stoltenberg

No. on Plate 1	LOCATION	Depth, feet	Source (1)	Valley	Date of collection, 1944	Temperature (°F.)	Chloride (Cl) (parts per million)
	DICKINSON COUNTY						
	T. 13 S., R. 2 E.						
64	SE cor. SW sec. 20	53–58	TH	Smoky Hill	Mar. 13	....	19
	T. 13 S.. R. 1 E.						
75	SE SW NE sec. 26	42–47	TH	do.	Feb. 24	....	32
78	NW NE SE sec. 35	62–67	TH	do.	Feb. 25	....	4,950
80	SE SW SE sec. 35	62–67	TH	do.	do.	....	1,940
82	NW cor. SW sec. 35	61–66	TH	do.	Feb. 26	....	4,750
83	SW cor. NW sec. 34	62–67	TH	do.	do.	....	8,400
84	SE cor. NE NE sec. 32	55–60	TH	do.	Feb. 27	....	5,475
88	NW SW sec. 21	38–43	TH	do.	Feb. 23	....	9
	SALINE COUNTY						
	T. 14 S., R. 1 W.						
96	NW NE NW sec. 15	43–48	TH	Gypsum Creek	Mar. 11	....	12
	T. 13 S., R. 1 W.						
97	NE cor. sec. 33	54–59	TH	Smoky Hill	do.	....	2,900
99	SW cor. sec. 29	46–51	TH	do.	Mar. 6	....	10,000
102	SE SE NE sec. 19	55–60	TH	Solomon	Mar. 7	....	47,000
104	SW SW NW sec. 16	52–57	TH	do.	Mar. 8	....	15,100
105	NE NE NW sec. 16	52–57	TH	do.	do.	....	580
106	SE SE NE sec. 9	42–47	TH	do.	Mar. 9	....	21
109	NW SW SW sec. 4	47–52	TH	do.	do.	....	47
112	SW cor. sec. 6	47–52	TH	do.	Mar. 10	....	9
	T. 13 S., R. 2 W.						
113	NE cor. sec. 2	42.5-47.5	TH	do.	do.	....	5.5
114	SW cor. sec. 25	57–62	TH	Smoky Hill	Mar. 4	....	780
117	SW cor. sec. 27	57–62	TH	do.	Mar. 2	....	69
	T. 14 S., R. 2 W.						
120	NE cor. sec. 4	67–72	TH	do.	do.	....	54
122	SE cor. sec. 4	55–60	TH	do.	Mar. 3	....	69
	T. 13 S., R. 3 W.						
128	SE SW sec. 34	20	D, S	Saline	May 24	58	35
131	SW NW sec. 35	80	D	do.	May 25	58	27
133	NE NW SW sec. 25	50	D	do.	May 24	60	50
136	NW cor. NE sec. 25	35	D	do.	do.	59	13
138	Center sec. 24	40	S	do.	do.	59	29
141	SE SE SE sec. 28	84	D, S	do.	do.	58	108
142	NE NW sec. 27	50	D	do.	May 25	59	230

1. D, domestic well; S, stock well; TH, test hole.

All the samples of water from wells were collected by me except those from public-supply wells, which were collected by the city engineers or water superintendents. The samples from test holes were collected by O. S. Fent. The analyses, which were made by Howard A. Stoltenberg in the Water and Sewage Laboratory of the Kansas State Board of Health, show only the dissolved mineral content of the water and do not in general indicate the sanitary condition. The suitability of the waters for the common industrial or commercial uses and for irrigation can be determined from the analyses, but not their suitability for human consumption. The constituents given were determined by the methods used by the United States Geological Survey.

CHEMICAL CONSTITUENTS IN RELATION TO USE

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

The residue left after a natural water has evaporated consists of rock materials, with which may be included some organic material and some water of crystalization. Waters that contain less than 500 parts per million of dissolved solids ordinarily are suitable for domestic purposes and for many industrial and commercial uses, except for the difficulties resulting from their hardness and, in some areas, excessive iron corrosiveness. Waters having more than 1,000 parts per million of dissolved solids are generally not satisfactory, for they are likely to contain enough of certain constituents to produce a noticeable taste or to make the water unsuitable in some other respects. According to these limits, the waters in the terrace deposits west of Abilene are satisfactory for most ordinary uses, but some of the waters from alluvium are unsatisfactory. Of the 61 samples collected from wells in alluvium, 16 contained between 290 and 500 parts per million of dissolved solids, 26 contained between 500 and 1,000 parts, 12 contained between 1,000 and 2,000 parts, and seven (79, 85, 94, 95, 100, 101, and 139) contained more than 2,000 parts. The greatest concentration of dissolved solids—6,848 parts per million—was found in the water from well 101.

With respect to ordinary uses, the hardness of a water is important and is the property that generally receives the most attention. A hard water requires more soap to be used in laundering; it forms scale in steam boilers, hot-water tanks, and other receptacles in which water is heated; and it must be treated to make it suitable for certain industrial uses. Water having a hardness of less than 50 parts per million is generally rated as soft, and its treatment for the removal of hardness under ordinary circumstances is not necessary. Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most purposes, but it does slightly increase the consumption of soap, and its removal by a softening process is profitable for laundries or other industries using large quantities of soap. Waters in the upper part of this range of hardness will cause considerable scale in steam boilers. Hardness above 150 parts per million can be noticed by anyone and if the hardness is 200 or 300 parts per million it is common practice to soften the water for household use or to install cisterns to collect soft rain water. Where municipal water supplies are softened, an attempt is generally made to reduce the hardness to 60 or 80 parts per million. The additional improvement from further softening of a whole public supply is not deemed worth the increase in cost.

The ground waters in the Smoky Hill Valley area are hard to very hard. Only two samples (70 and 73), both from the terrace deposits west of Abilene, had less than 200 parts per million of hardness. The 61 samples from alluvium ranged in hardness from 274 to 1,980 parts per million. Of these, 32 samples had between 274 and 500 parts per million of hardness, 19 had between 500 and 1,000 parts, and 10 had more than 1,000 parts. The areal distribution of waters in the different ranges of hardness in this area is shown in Figure 9.

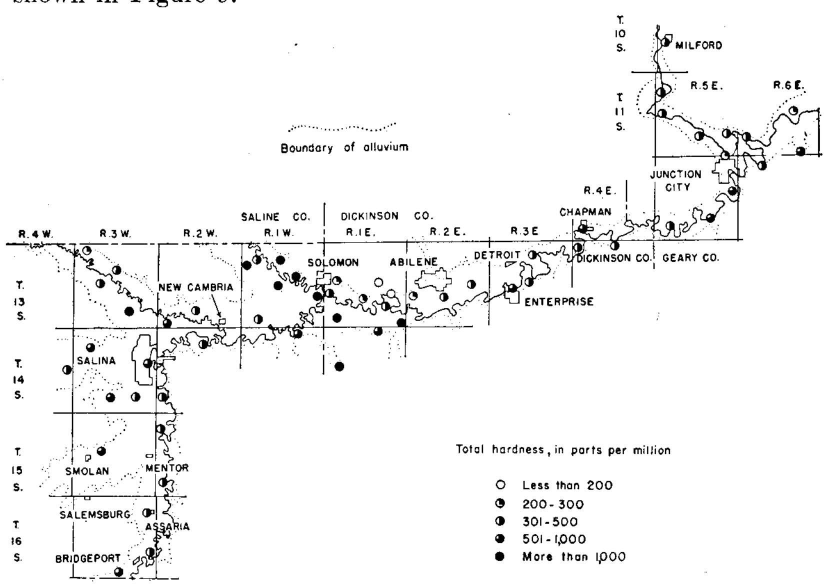

FIG. 9.—Total hardness of ground waters in the Smoky Hill Valley area.

In addition to the total hardness, the table of analyses shows the carbonate hardness and the noncarbonate hardness. The carbonate hardness is that due to the presence of calcium and magnesium bicarbonates. It is almost completely removed by boiling. In some reports this type of hardness is called temporary hardness. The noncarbonate hardness is due to the presence of sulfates or chlorides of calcium and magnesium. It cannot be removed by boiling and has sometimes been called permanent hardness. With reference to use with soaps, there is no difference between carbonate and noncarbonate hardness. In general, the noncarbonate hardness forms harder scale in steam boilers. The noncarbonate hardness was greater than the carbonate hardness in only 17 of the samples analyzed. The concentration of sulfate or chloride was exceptionally high in each of these 17 samples.

Iron, which is dissolved from many rock materials and may be dissolved from water pipes, is found in objectionable amounts in many waters in this area. If a water contains much more than 0.1 part per million of iron, the excess may separate out and settle as a reddish sediment. A water high in iron is not suited for use in laundries or breweries or for making ice or carbonated beverages unless the excess iron is removed. In the manufacture of high-quality papers and textiles, the upper limit of dissolved iron that can be tolerated in the water is even less than 0.1 part per million. Iron, which may be present in sufficient quantity to give a disagreeable taste and to stain cooking utensils, can be removed from most waters by simple aeration and filtration, but a few waters require the addition of lime or some other substance. Only 12 of the samples of water analyzed contained 0.1 part per million or less of iron, 19 contained between 0.1 and 1 part, 25 contained between 1.1 and 5 parts, and 7 contained more than 5 parts. The sample from well 79 had the greatest concentration of iron—11 parts per million. The areal distribution of iron in the ground waters of this area is shown in Figure 10.

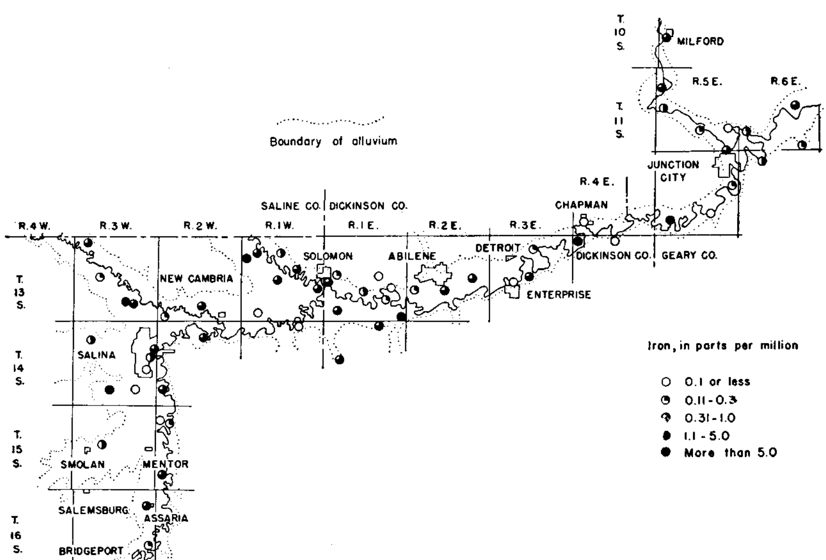

FIG. 10.—Iron contained in ground waters in the Smoky Hill Valley area.

In parts of the Smoky Hill Valley area, waters in alluvium contain undesirable amounts of chloride. Chlorine combined as chloride is widely distributed in nature; it is an abundant constituent of sea water and is dissolved in small quantities from many rock materials. Chloride has little effect on the suitability of water for ordinary use, unless enough is present to impart a salty taste and render the water unpalatable. Waters high in chloride are not suited for use in irrigation and may be corrosive if used in steam boilers. Chlorides of calcium and magnesium contribute to the hardness of a water in a manner similar to the sulfates and carbonates of these elements. The removal of chloride from water supplies is difficult and expensive, and is seldom done. The areal distribution of chloride in the ground waters of the Smoky Hill Valley area is shown in Figure 11. Samples 70 and 73 from the terrace deposits contained 8 and 13 parts per million of chloride, respectively. Of 90 samples collected from alluvium, 48 samples contained less than 50 parts per million of chloride, 64 contained less than 150 parts, and 12 contained more than 1,000 parts (Table 11). All the samples that had exceptionally high concentrations of chloride were collected from wells and test holes in the Solomon area.

TABLE 11.—*Range in chloride content of water samples from wells and test holes in alluvium in the Smoky Hill Valley area*

Chloride (parts per million)	Number of samples	Chloride (parts per million)	Number of samples
Less than 50	48	751- 1,000	1
50–150	16	1,001- 5,000	7
151–250	6	5,001–10,000	3
251–500	6	More than 10,000	2
501–750	1	Total	90

Reference has been made previously to the high sulfate content of some of the water samples from alluvium in this area. Sulfate in ground water in large quantities is generally derived from gypsum and from deposits of sodium sulfate. The areal distribution of sulfate in ground waters in the Smoky Hill Valley area is shown in Figure 12. The sulfate in samples of water collected ranged from 13 parts per million in the sample from well 2 to 1,320 parts in the sample from well 85. Samples from alluvium in the Solomon area had the greatest concentration of sulfate. Gypsum in the Wellington formation (Permian), which forms the uplands and underlies the alluvium in the Solomon area, is undoubtedly the source of most of the sulfate.

The amount of fluoride in waters that are to be used by children is important. It has been stated that waters containing 1.5 parts per million, or more, of fluoride are likely to produce mottled enamel on the teeth of children who drink the water during the formation of the permanent teeth. Smaller quantities of fluoride are thought to inhibit tooth decay. The analyses given in Table 9 show that ground water in this area is low in fluoride content. All the samples analyzed had 0.6 part per million or less of fluoride.

The suitability of water for use in irrigation is commonly believed to depend mainly on the total quantity of soluble salts and the ratio of the quantity of sodium to the total quantity of sodium, calcium, and magnesium. The quantity of chloride may be large enough to affect the use of the water, and in some areas other constituents, such as boron, may be present in sufficient quantity to cause difficulty. In a discussion of the interpretation of analyses with reference to irrigation in southern California, Scofield (1933) suggests that if the total concentration of dissolved salts is less than 700 parts per million there is not much probability of harmful effects in irrigation use, but if it exceeds 2,100 parts per million there is a strong probability of damage to either the crops or the land, or both. Water containing less than 50 percent sodium (the percentage being caculated as 100 times the ratio of the total bases, in equivalents) is not likely to be injurious, but if it contains more than 60 percent its use is inadvisable. Similarly, a chloride content of less than 142 parts per million is not objectionable, but more than 355 parts per million is undesirable. It is recognized that the harmfulness of irrigation water is so dependent on the nature of the land and the crops, on the manner of use, and on the drainage that no hard and fast limits can be adopted.

The analyses in Table 9 indicate that the ground waters in parts of this area are unsatisfactory for use in irrigation. The waters from 30 of the wells sampled contained more than 700 parts per million of dissolved solids, and the waters from seven wells (79, 85, 94, 95, 100, 101, and 139) contained more than 2,100 parts per million. The dissolved solids in these seven wells ranged from 2,150 to 6,848 parts per million. All but three of the samples contained less than 50 percent sodium (including potassium); these three (wells 94, 95, and 101) contained more than 60 percent. Of the samples analyzed for

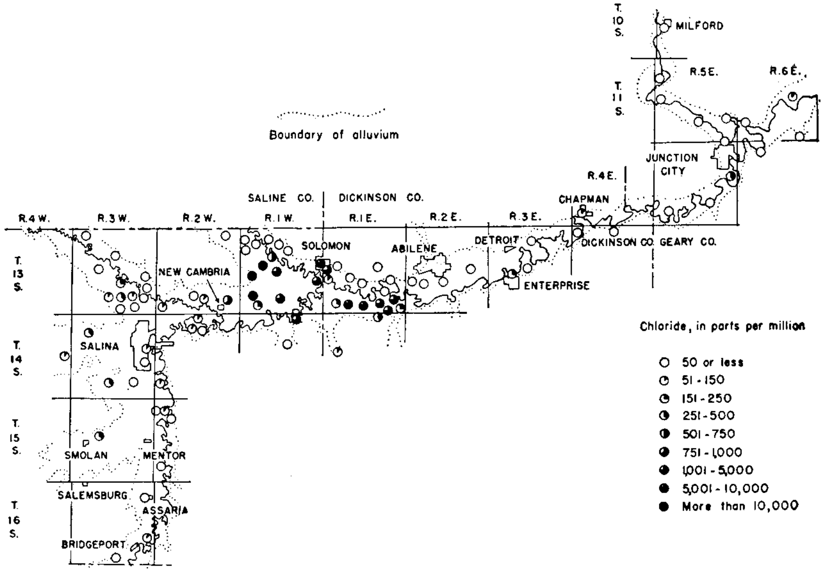

FIG. 11.—Chloride contained in ground waters in the Smoky Hill Valley area.

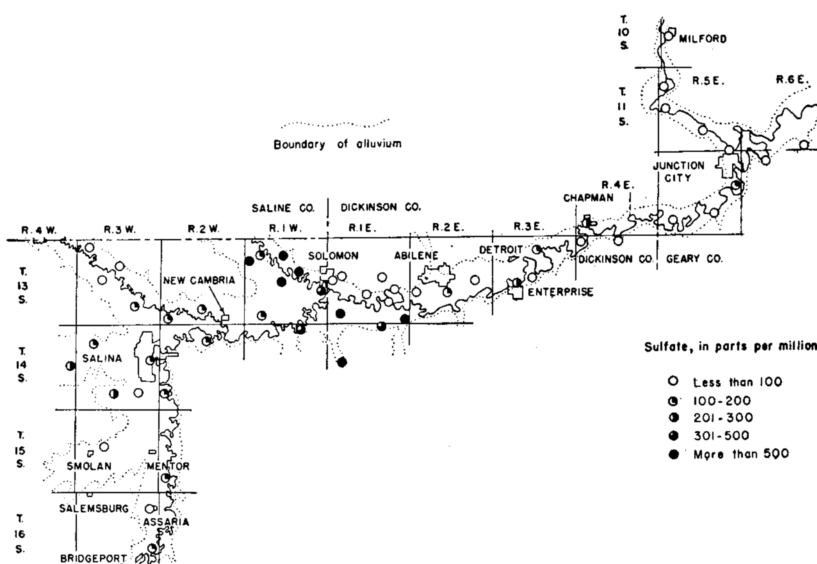

FIG. 12.—Sulfate contained in ground waters in the Smoky Hill Valley area.

chloride, 27 samples contained more than 142 parts per million of chloride and 16 samples contained more than 355 parts per million. Fourteen of the 16 samples that contained more than 355 parts per million of chloride were collected from wells and test holes in the Solomon area, one was collected from a well (139) in Saline Valley northwest of Salina, and one was collected from a well (210) in the valley of Dry Creek, about a mile northeast of Smolan.

CHEMICAL CHARACTER OF GROUND WATER DESCRIBED BY AREAS

The discussion given in the preceding section indicates the wide range in the amount of mineral matter in the samples from the Smoky Hill Valley area. In places the ground waters are highly mineralized, in other places the ground waters are only moderately mineralized, and in still other places the ground waters are comparatively low in mineral content. For convenience of description, the Smoky Hill Valley area has been divided into seven smaller areas. The chemical character of the ground waters in each of these areas is described on the following pages, and the average composition of the samples collected from each area is given in Table 12. As only a few samples were collected from some areas, the analyses given in the table are possibly not representative of the waters in those particular areas. In general, however, the analyses are believed to be representative of the waters from the areas to which they are ascribed. The analyses of typical waters from five of the areas described are shown graphically in Figure 8.

Junction City area.—The Junction City area includes the valleys of Smoky Hill, Republican, and Kansas Rivers in Geary County. The analyses of nine samples of water from alluvium in this area are given in Table 9, five of which were collected from wells (1-4, and 19) in Republican Valley and four from wells (30, 31, 36, and 38) in Smoky Hill Valley. Analyses of waters from wells at the Cavalry Replacement Training Center and Fort Riley in Republican Valley and Camp Funston in Kansas Valley are given in Table 13. These analyses were made at the Station Hospital, Camp Whitside, and are of composite samples taken from each of the three well fields.

TABLE 12.—*Average composition of ground waters from different parts of the Smoky Hill Valley area, in parts per million*

Source *a*	No. of analyses	Dissolved solids	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Total hardness as $CaCO_3$	Analyses used in averages *b*
Junction City area:											
Smoky Hill River Valley	4	670	2.44	168	24	48	432	80	88	517	30, 31, 36, 38
Republican River Valley	5	451	1.32	105	20	25	365	49	20	344	1–4, 19
Abilene-Chapman area—Smoky Hill Valley	10	713	1.69	140	35	51	397	161	66	491	39, 40, 41, 45–47, 56, 57, 61, 62
Sand hills area	2	252	1.03	53	11	10	140	32	11	176	70, 73
Solomon area:											
Smoky Hill River Valley	8	2,033	2.61	274	50	376	450	385	2,584*c*	889	76, 79, 81, 86, 93–95, 98 (75, 78, 80, 82–84, 97, 99, 114)
Smoky Hill Valley near edge of sand hills	3	340	.28	87	16	7.8	273	40	12*d*	282	65, 87, 91, (64, 88)
Solomon River Valley	5	2,652	3.83	375	54	469	406	902	5,496*e*	1,159	100, 101, 108, 110, 111, (102, 104–106, 109, 112, 113)
Unnamed tributary valley south of Solomon	1	2,514	3.0	611	73	60	321	1,320	144	1,824	85
Salina area:											
Smoky Hill River Valley	12	758	1.24	161	30	60	428	170	73*f*	523	118, 123, 126, 168, 171–175, 190–192 (117, 120, 122)
Saline River Valley	5	1,348	2.5*g*	237	40	129	441	126	87*e*	754	139, 140, 143–145 (128, 131, 133, 136, 138, 141, 142)
Mulberry Creek Valley	2	1,173	2.76	179	53	141	370	195	208	663	146, 147
Assaria area—Smoky Hill Valley	4	650	2.11	146	28	42	421	158	34	480	226, 227, 237, 238
Smolan area—Dry Creek Valley	1	1,362	.76	255	61	125	424	45	380	886	210

a Samples from sand hills area are from terrace deposits; all others are from alluvium.
b Numbers within parentheses are of samples for which the chloride content only was determined.
c Seventeen analyses.
d Five analyses.
e Twelve analyses.
f Fifteen analyses.
g Four analyses.

TABLE 13.—*Analyses of composite samples of water from wells at the Fort Riley Military Reservation*[1]

(Constituents given in parts per million)

Numbers on Plate 1	Wells 14 and 15 at the Cavalry Replacement Training Center	Wells 21–24 at Fort Riley	Wells 25–28 at Camp Funston
Total solids	450	469	875
Iron	.08	.62	2.1
Calcium	87	98	92
Magnesium	27	33	12
Silica	13	13	13
Bicarbonate alkalinity as $CaCO_3$	298	240	252
Sulfate	80	84	180
Chloride	18	25	99
Total hardness	340	360	279
Total alkalinity	285	300	392

1. Analyzed at Station Hospital, Camp Whitside, March, 1943. Analyses furnished by Mr. Eglelston, water superintendent, Fort Riley Military Reservation.

All the samples from wells in the Junction City area were hard calcium bicarbonate waters in which the hardness ranged from 279 to 756 parts per million. The hardest waters were taken from wells in Smoky Hill Valley. The five samples (1-4, and 19) from Republican Valley had 290 to 402 parts per million of hardness, whereas the four samples (30, 31, 36, and 38) from Smoky Hill Valley had 388 to 756 parts of hardness. A composite sample from the four wells (25-28) at Camp Funston in Kansas River Valley had 279 parts per million of hardness (Table 13).

The chloride content of most of the waters from the Junction City area was relatively low (Fig. 11). The largest concentration of chloride—268 parts per million—was found in the water from well 31, which is a farm well in Smoky Hill Valley south of Junction City.

Five of the samples (analyses 1, 2, 19, 25, and 38) contained more than 1 part per million of iron. Water from well 38 had 9.1 parts per million of iron—the largest concentration of iron found in the Junction City area. Of the four wells (25-28) at Camp Funston, those (wells 27 and 28) nearest the river are reported to yield waters having undesirable amounts of iron. For this reason, wells 27 and 28 are used only when wells 25 and 26 are unable to supply the demand.

Abilene-Chapman area.—Waters from 10 wells (39, 40, 41, 45, 46, 47, 56, 57, 61, and 62) that tap alluvium in Smoky Hill Valley between Abilene and the Dickinson-Geary County line, the area which is here referred to as the Abilene-Chapman area, were analyzed. Most of the waters in this area are hard calcium bicarbonate waters similar in chemical character to those in the Junction City area. The hardness of the samples analyzed ranged from 348 to 622 parts per million and averaged 491 parts. Calcium is the predominant basic constituent in all the waters, and bicarbonate is the predominant acidic constituent in all but the waters from wells 40 and 41 at Chapman. Sulfate exceeds bicarbonate in the water from well 40 and is nearly equal to the bicarbonate in the water from well 41.

Chloride in 8 of the 10 samples amounted to less than 100 parts per million, and in 6 samples it was less than 30 parts per million. Samples from the city wells (56 and 57) at Enterprise contained 187 and 216 parts of chloride. The iron content of the samples ranged from less than 0.1 to 7 parts per million. Four (45, 47, 61, and 62) of the waters contained more than 1 part per million of iron.

Sand hills area.—Ground waters in the terrace deposits that underlie the dune sand in the area north of Smoky Hill Valley between Abilene and Solomon, although moderately hard, are the least mineralized of any of the waters sampled in the entire Smoky Hill Valley area. Samples 70 and 73, of waters from the terrace deposits, contained 239 and 265 parts per million of dissolved solids, had hardnesses of 168 and 184 parts, and 2.0 and .05 parts of iron, respectively. In both of these samples, calcium and bicarbonate were the predominant basic and acidic constituents, respectively. Analyses of samples 70 and 73 are shown graphically in Figure 13. Sand Springs (73), which derives water indirectly from the terrace deposits, is the source of the Abilene water supply.

Solomon area.—This area takes its name from the City of Solomon in western Dickinson County, and includes Smoky Hill Valley between Abilene and New Cambria and the lower part of Solomon Valley. Analyses of 17 samples of water collected from wells in the Solomon area are given in Table 9. In addition to these, Table 10 gives the chloride content of 19 samples taken from test holes. Ground waters in the Solomon area differ greatly in content of dissolved mineral matter.

Samples from wells 65, 87, and 91, in alluvium near the edge of the sand hills between Abilene and Solomon, had the lowest concentrations of dissolved mineral matter of any of the samples collected from alluvium in the entire Smoky Hill Valley area. Samples 65, 87, and 91 were calcium bicarbonate waters and contained 335, 290, and 394 parts per million of dissolved solids and had hardness of 292, 274, and 280 parts, respectively. The iron and chloride concentrations were relatively low in all three samples. These samples doubtless represent waters of mixed origin—waters of low mineralization from the terrace deposits mixed with more highly mineralized waters from other parts of the alluvium. Analyses of two samples from the terrace deposits, three samples from alluvium back from the sand hills, and two samples of mixed water from alluvium near the sand hills are shown graphically in Figure 13.

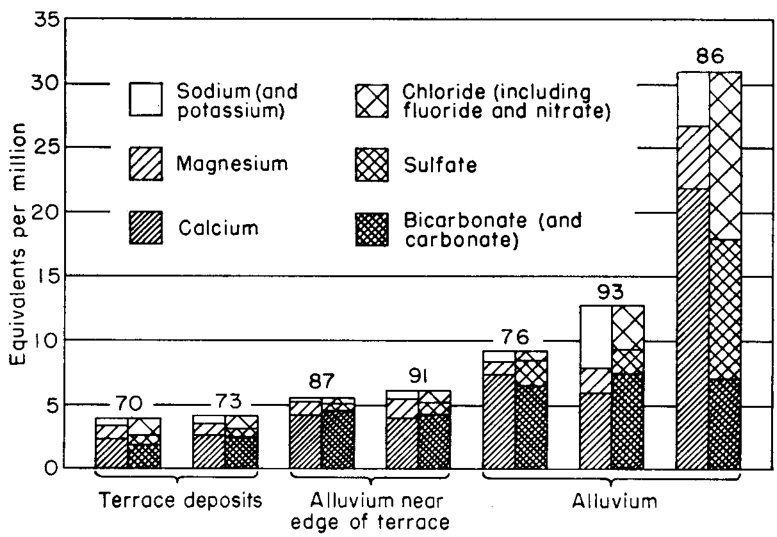

FIG. 13.—Analyses of waters from six wells and one spring (73) illustrating the mixing of slightly mineralized water from terrace deposits with more highly mineralized water from alluvium. Numbers refer to wells and spring described in text. Numbers 87 and 91 are mixed waters from alluvium near the edge of the sand hills.

Waters from alluvium in other parts of the Solomon area are in general of very poor quality, as indicated by the analyses of waters from 13 wells (76, 79, 81, 86, 93, 94, 95, and 98 in Smoky Hill Valley and 100, 101, 108, 110, and 111 in Solomon Valley). In addition to these analyses, chloride determinations for 16 other samples taken from test holes drilled in the Solomon area were made. All test hole samples were taken from the base of the alluvium. The distribution of the waters with respect to total hardness and their content of dissolved solids, chloride, and sulfate is shown in Table 14. Although they differ in content of dissolved mineral matter, most of the waters are highly mineralized. About two-thirds of the waters had more than 1,000 parts per million of dissolved solids. All the waters are very hard, about 90 percent having a hardness of more than 400 parts per million and about 50 percent a hardness of more than 1,000 parts. Although the waters in the Solomon area are similar with respect to hardness, they differ greatly in composition. The predominant basic and acidic constituents were, respectively, calcium and bicarbonate in samples 76, 93, and 110; calcium and sulfate in samples 79, 86, 100, 108, and 111; and sodium and chloride in samples 94, 95, and 101. In sample 81 calcium was the predominant basic constituent and bicarbonate and sulfate, which were present in about equal amounts, were the predominant acidic

TABLE 14.—*Number of samples according to ranges, in parts per million, of dissolved solids, total hardness, sulfate, and chloride in waters from wells and test holes in alluvium in the Solomon area*

Constituents, parts per million	Number of samples
Dissolved solids:	
Less than 500	1
500–1,000	3
1,001–3,000	6
3,001–5,000	2
More than 5,000	1
Total hardness:	
Less than 400	1
400–500	3
501–1,000	2
More than 1,000	7
Sulfate:	
Less than 100	2
100–300	2
301–500	3
501–1,000	2
More than 1,000	4
Chloride:	
Less than 100	10
100–250	4
251–500	1
501–1,000	2
1,001–5,000	7
More than 5,000	5

constituents. In sample 98 the concentrations of calcium and sodium were about equal and bicarbonate was present in the greatest concentration of the acidic constituents. The poor quality of the waters in alluvium in the Solomon area probably is the result of contamination by highly mineralized waters from the underlying Wellington formation (Permian). Gypsum and salt, both of which are easily dissolved in water, occur in the Wellington formation. The gypsum is undoubtedly the source for the high sulfate concentrations found in some of the waters from alluvium in this area. The sulfate content of nine waters was more than 300 parts per million and four had more than 1,000 parts of sulfate. A sample of water from well 85, which is in an unnamed tributary valley south of Solomon that drains an area of gypsum-bearing rocks, contained 1,320 parts per million of sulfate.

Of the 29 samples for which chloride determinations were made, 14 contained more than 500 parts per million of chloride, 12 contained more than 2,000 parts, and 5 contained more than 5,000 parts. The distribution of chloride in the Solomon area is shown in Figure 11. The greatest concentration of chloride—47,000 parts per million—was found in the sample from test hole 102, which was drilled in Solomon Valley near the tip of the divide that separates Solomon Valley from Smoky Hill Valley (Pl. 1). Samples from test holes 104 and 105 and well 101, northeast of test hole 102, had 15, 100, 580, and 3,100 parts of chloride, respectively. Samples from wells (100, 108, 110, and 111) and test holes (106, 107, 109, 112, and 113) in other parts of Solomon Valley were relatively low in chloride. Because of a higher specific gravity, waters high in chloride tend to concentrate in the lower part of the alluvium. In places in the Solomon area shallow wells may yield waters low in chloride, whereas deeper wells in the same vicinity may yield waters high in chloride. Water from well 98, a shallow well east of New Cambria, contained only 175 parts per million of chloride. Samples 97, 99, and 114 from test holes that tapped the lower part of the alluvium in the same area had 2,900, 10,000, and 780 parts of chloride. The chloride content of waters from four shallow wells (76, 79, 81, and 86) in that part of Smoky Hill Valley south of the river between Solomon and Abilene ranged from 23 to 278 parts per million. Of six samples collected from the lower part of the alluvium in this same area, one (75) contained 32 parts per million of chloride and five (78, 80, 82, 83, and 84) contained from 1,940 to 8,400 parts of chloride.

The City of Solomon formerly obtained its water supply from two wells in the southeastern part of town. These wells were abandoned in 1942, however, because the water had become excessively salty. In an effort to determine the limits of the salty water, the Division of Sanitation of the Kansas State Board of Health in 1940 collected samples from 22 private wells in Solomon and analyzed them for chloride. Samples from wells in the northern and northeastern parts of town contained relatively small amounts of chloride. Waters low in chloride from terrace deposits to the north probably migrate into the alluvium in these areas. Most of the waters from wells in the southern and western parts of Solomon were salty. Abandoned brine wells on the west side of Solomon River about 1 mile west of Solomon, which were used about 40 years ago by a salt company, are believed by many residents of Solomon to be the source of the salt water. The land on which the salt company was located is now farmed and there remains no evidence of the factory or the wells. The distribution of waters high in chloride, as shown in Figure 11, indicates that the occurrence of salty water in the Solomon area is a natural condition and cannot be attributed to the abandoned brine wells. Furthermore, the brine wells were drilled here because of the occurrence of a salt-water spring west of Solomon (Bailey, 1902, p. 72). The exact location of the salt-water spring is not known, but residents of Solomon report that it was in the bank of Solomon River near the site of the brine wells.

Most of the samples from the Solomon area, other than those from wells near the sand hills, contained excessive iron. Of the 13 samples analyzed, only one (95) had less than 0.1 part per million of iron, three (76, 98, and 108) had between 0.1 and 1.0 part, seven (81, 86, 93, 94, 100, 101, and 110) had between 1.1 and 5 parts, and two (79 and 111) had more than 5 parts.

Salina area.—The Salina area includes Smoky Hill Valley from a point about 3 miles above Salina to New Cambria, the part of Saline Valley in Saline County, and the lower part of Mulberry Creek Valley. Nearly all the samples from wells in this area were very hard calcium bicarbonate waters. Analyses of six representative samples are shown graphically in Figure 8.

Of twelve samples collected from wells in Smoky Hill Valley in the Salina area (118, 123, 126, 168, 171-175, 190-192), 11 contained 498 to 843 parts per million of dissolved solids and had 408 to 563 parts of hardness. The chloride content of these waters was relatively low and the iron content ranged from less than 0.1 to 2.5 parts per million. The water from well 190, which is situated in a short, broad reëntrant of Smoky Hill Valley southwest of Salina, was somewhat harder and more mineralized than other waters from Smoky Hill Valley. It (sample 190) contained 1,202 parts per million of dissolved solids, 340 parts of chloride, and 6.4 parts of iron, and had a hardness of 772 parts.

Waters from wells tapping alluvium in Saline Valley ranged from hard, moderately mineralized waters (samples 143, 144, and 145) to very hard, highly mineralized waters (samples 139 and 140). Samples 143, 144, and 145 were of calcium bicarbonate waters that contained, respectively, 578, 462, and 395 parts per million of dissolved solids and had 425, 344, and 294 parts of hardness. Samples 139 and 140 were collected from two wells about 200 feet apart, one 68.7 feet deep and the other 30 feet deep. Both wells yield very hard, highly mineralized waters. Water (sample 140) from the shallow well contained 1,626 parts per million of dissolved solids, 91 parts of chloride, 1.4 parts of iron, and had 1,004 parts of hardness. Water (sample 139) from the deep well contained 3,681 parts of dissolved solids, 400 parts of chloride, and 6.2 parts of iron, and had 1,704 parts of hardness.

Most of the waters from Saline Valley had relatively low amounts of chloride. Of 12 waters analyzed for chloride, eight had 50 parts per million, or less, of chloride and four (samples 139-142) had 91 to 400 parts. The four waters having the highest concentrations of chloride were all from wells and test holes in secs. 27 and 28, T. 13 S., R. 3 W.

Samples of water were collected from two wells (146 and 147) in Mulberry Creek Valley, the analyses of which are shown graphically in Figure 8. One sample (146) was a hard calcium bicarbonate water that contained 846 parts per million of dissolved solids and had 487 parts of hardness. The other sample (147) was of a very hard, highly mineralized water, in which calcium was the predominant basic constituent and chloride was the predominant acidic constituent. This sample (147) contained 1,499 parts per million of dissolved solids and 355 parts of chloride, and had 838 parts of hardness.

Assaria area.—The Assaria area includes Smoky Hill Valley in Saline County above the Salina area. Samples from four wells (226, 227, 237, and 238) in this area were of hard to very hard calcium bicarbonate waters that contained 566 to 876 parts per million of dissolved solids and 0.25 to 3.4 parts of iron, and had 376 to 655 parts of hardness.

Dry Creek Valley.—Only one sample of water was collected from Dry Creek Valley. This sample, which was collected from a farm well (210) about 1 mile east of Smolan, may or may not be representative of waters in alluvium of Dry Creek Valley. It was a very hard, highly mineralized water that contained 1,362 parts per million of dissolved solids, 380 parts of chloride and 0.76 part of iron, and had 886 parts of hardness.

WELL AND TEST-HOLE RECORDS

Descriptions of wells and test holes in the Smoky Hill Valley area in Saline, Dickinson, and Geary Counties are given in Table 15. The wells and test holes are listed in order from east to west beginning at Milford in Republican Valley. The locations of all wells and test holes listed in this table are shown on Plate 1. All information classed as "reported" was obtained from the owner or driller. Depths of wells not classed as "reported" are measured and given to the nearest tenth of a foot below the measuring point described in the table, and depths to water level not classed as "reported" are measured and given to the nearest hundredth of a foot.

TABLE 15.—*Records of wells, spring, and test holes in the Smoky Hill Valley area in Saline, Dickinson, and Geary Counties, Kansas*

No. on Plate 1 (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Year drilled	Drilled by	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement, 1943	REMARKS (Yield given in gallons a minute; drawdown in feet)
	GEARY COUNTY *T. 10 S., R. 5 E.*															
[1]	SW SE sec. 19	City of Milford	Dr	38	18	Bs	1933	Layne-Western Co.	T, E	P				31		Reported yield 150.
	T. 11 S., R. 5 E.															
[2]	SW NW sec. 7	Fred Schweitzer	Dn	24	2¼	GP			Cy, H	D				5–8		
[3]	NE SW sec. 18	Ralph White	Dn	14	2¼	GP			P, H	D				7		
[4]	SW NW sec. 27	Mrs. McKiney	Dn	20	2¼	GP			Cy, H	D				6		
5	NW SE sec. 22		TH	73			1944	State Geological Survey.					1,101.1			
6	SW SE sec. 22		TH	64			1944	do.					1,082.9			
7	NE NW sec. 27		TH	44			1944	do.					1,076.4			
8	SE NW sec. 27		TH	36.6			1944	do.					1,077.5			
9	Center SW sec. 27		TH	32			1944	do.					1,073.4			
10	SW SW sec. 27		TH	28			1944	do.					1,078.0			
11	NW NW sec. 34		TH	35			1944	do.					1,079.6			
	FORT RILEY MILITARY RESERVATION															
12	Cavalry Replacement Training Center.		TH	51			1940	Layne-Western Co.						19		Water level measured by driller December, 1940.
13	do.		TH	40			1940	do.						13.2		do.
14	Cavalry Replacement Training Center. Well 2	U. S. Army	Dr	81	26	Bs	1941	do.	T, E	P				24.7		Gravel-packed well; operating yield 1,200; measured yield during 8-hour test 980; drawdown 25.3 (8).
15	Cavalry Replacement Training Center. Well 1	do.	Dr	74	26	Bs	1941	do.	T, E	P				20.5		Gravel-packed well; operating yield 1,200; measured yield during 8 hour test 1,000: drawdown 18 (8).
	T. 11 S., R. 5 E.															
16	SW SW sec. 36	City of Junction City. Well 2.	Dr	67				do.	T, E	P				20		Reported yield during original test 870; reported yield in 1943, 400.

17	do.	City of Junction City. Well 3.	Dr	54	......	......	......	do.	T, E	P	....	....	....	9	....	Reported yield during original test 710; reported yield in 1943, 500.
18	do.	City of Junction City. Well 4.	Dr	54	19	C	1937	do.	T, E	P	....	....	....	11	....	Operating yield 700; measured yield during 6-hour test 1,000; drawdown 11.5 (8).
[19]	SW SW sec. 36.	City of Junction City. Well 5.	Dr	52	19	C	1943	Layne-Western Co.	T, E	P	....	....	....	8	....	Gravel-packed well; operating yield 850; measured yield 1,025; drawdown 16.7 after pumping 8 hours (8).
20	Hippodrome area.	....	TH	73	......	......	......	do.	......	......	....	....	....	23	....	
21	Fort Riley. Well 3.	U. S. Army.	Dr	68	18	C	1928	do.	T, E	P	....	....	....	24	....	Gravel-packed well; operating yield 750; measured yield 500; drawdown 8 after pumping 10 hours (8).
22	Fort Riley. Well 2.	do.	Dr	67	18	C	1928	do.	T, E	P	....	....	....	22	....	Gravel-packed well; reported yield 200 when wells 21, 23, and 24 are pumping and 400 when pumped alone; measured yield 500; drawdown 6 after pumping 10 hours (8).
23	Fort Riley. Well 1.	do.	Dr	66	18	C	1928	do.	T, E	P	....	....	....	21	....	Gravel-packed well; operating yield 750; measured yield 500; drawdown 5 after pumping 10 hours (8).
24	Fort Riley. Well 4.	do.	Dr	70	26	Bs	1937	do.	T, E	P	....	....	....	19	....	Gravel-packed well; operating yield 1,100; measured yield 1,700; drawdown 15.7 after pumping 8 hours (8).
25	Camp Funston. Well 1.	do.	Dr	63	26	Bs	1940	do.	T, E	P	....	....	....	18	....	Gravel-packed well; operating yield 1,200; measured yield 1,000; drawdown 6 after pumping 6 hours (8).
26	Camp Funston. Well 2.	do.	Dr	64	26	Bs	1940	do.	T, E	P	....	....	....	16	....	Gravel-packed well; operating yield 1,200; measured yield 1,020; drawdown 6.2 after pumping 8 hours (8).
27	Camp Funston. Well 3.	do.	Dr	61	26	Bs	1941	do.	T, E	P	....	....	....	18	....	Gravel-packed well; operating yield 1,200; measured yield 1,020; drawdown 7.2 after pumping 8 hours (8).
28	Camp Funston. Well 4.	do.	Dr	64	26	Bs	1941	do.	T, E	P	....	....	....	19	....	Gravel-packed well; operating yield 1,200; measured yield 1,020; drawdown 5.5 after pumping 8 hours (8).

TABLE 15.—*Records of wells, spring, and test holes in the Smoky Hill Valley area in Saline, Dickinson, and Geary Counties, Kansas*—*Continued*

No. on Plate 1 (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Year drilled	Drilled by	Method of lift (5)	Use of water (6)	Measuring point		Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement, 1943	REMARKS (Yield given in gallons a minute; drawdown in feet)
											Description	Distance above land surface (feet)				
	T. 11 S., R. 6 E.															
[29]	SW SE sec. 35	William Smiterman	Dn	35	2¼	GP			Cy, W	D, S				18		
	T. 12 S., R. 6 E.															
[30]	NE SE sec. 5		Dr	60	2¼	GP			Cy, W, E	D, S				26		Tubular well.
	T. 12 S., R. 5 E.															
[31]	NE SW sec. 13	Charles Fish	Dn	45	2¼	GP			Cy, H	D				15		
32	NE SE sec. 22		TH	53			1944	State Geological Survey.					1,079.8			
33	SE SE sec. 22		TH	63			1944	do.					1,067.7			
34	NE NE sec. 27		TH	61			1944	do.					1,061.6			
35	SE NE sec. 27		TH	57			1944	do.					1,064.4			
[36]	do.	Joe A. Brown	Dn	33	2¼	GP			Cy, W, H	D				15		
37	SE SE sec. 27		TH	27			1944	State Geological Survey.					1,083.5			
[38]	NW NW sec. 32	George Britt	Dn	20	2¼	GP			Cy, H	D				15		
	DICKINSON COUNTY *T. 13 S., R. 4 E.*															
[39]	NE NE sec. 4	Harold McLaughlin	Dn	40	2¼	GP			Cy, H, G	D				12-15		
	T. 12 S., R. 4 E.															
[40]	NW NE sec. 31	City of Chapman	3 Dr	68	8	I			PI, G	P				38		Battery of 3 wells; reported aggregate yield 225; used only in emergencies; see well 41.
[41]	NW NE sec. 31	do.	Dr	68	19	C	1939	Layne-Western Co.	T, E	P	Opening, east side of pump base.	+1.5		38.58	June 5	Gravel-packed well; reported yield 200; drawdown (8).
42	NE SE sec. 31		TH	50			1944	State Geological Survey.					1,108.1			

	T. 13 S., R. 4 E.															
43	NW cor. sec. 5	...	TH	33	...	...	1944	do.	...	...	...	...	1,111.4	...	...	
44	SE NE sec. 6	...	TH	30	...	...	1944	do.	...	...	...	...	1,115.9	...	...	
[45]	NW NW sec. 6	...	Dn	32	2¼	GP	...	...	Cy, H	D	...	...	...	...	...	
	T. 13 S., R. 3 E.															
[46]	NW NW sec. 10	...	Dn	35	2¼	GP	...	...	Cy, H	D	...	...	...	20	...	
[47]	SE SE sec. 16	D. W. Shrader	Dn	60	2¼	GP	...	...	Cy, W, H	D, S	...	...	...	20	...	
48	NE SW sec. 8	...	TH	14	...	...	1944	State Geological Survey.	...	...	...	...	1,139.1	...	...	
49	NW cor. NE sec. 17	...	TH	60	...	...	1944	do.	...	...	...	...	1,126.8	...	...	
50	SW NE sec. 17	...	TH	70	...	...	1944	do.	...	...	Land surface	0	1,125.1	22	Sep. 1945	
51	NW SE sec. 17	...	TH	68	...	...	1944	do.	...	...	...	...	1,124.5	...	...	
52	NW cor. NE sec. 20	...	TH	68.1	...	...	1944	do.	...	...	Land surface	0	1,127.6	22.5	Sep. 1945	
53	NW NE sec. 20	Enterprise Academy	Dr	43	18	Bs	1934	...	T, G	I	Top of pump-house floor.	+1.5	...	17.41	Aug. 11	Gravel-packed well; ground caving in beneath pump-house.
54	NW SW NE sec. 20	...	TH	60	...	...	1944	State Geological Survey.	...	...	...	...	1,127.8	...	...	
55	SW SW NE sec. 20	...	TH	47	...	...	1944	do.	...	...	...	...	1,129.0	...	...	
[56]	do.	City of Enterprise	Dr	41	19	C	1943	Layne-Western Co.	T, E	P	...	...	...	18.5	...	Gravel-packed well; measured yield 305; drawdown 17.5 after pumping 8 hours (8).
[57]	do.	do.	4 Dr	38	8	I	1923 (?)	...	T, E	P	Top edge of manhole.	0	...	19.93	June 1	Battery of 4 wells; measured southeast well; reported aggregate yield 500; abandoned in 1943; see well 56.
58	SW SW sec. 7	T. L. Welch	Dr	86	18	Bs	1940	...	T, G	I	...	...	...	28	...	Gravel-packed well; operating yield 1,000-1,200; reported drawdown 10 when pumping 1,500.
	T. 13 S., R. 2 E.															
59	NW NW sec. 13	C. W. Whitehair	Dr	42	18	Bs	1940	...	T, E	I	...	...	...	15	...	Gravel-packed well; reported yield 350.
60	NW NW sec. 24	H. H. Hoffman	Dr	63	18	Bs	1940	Hockinstein	T, G	I	Opening in pump base.	+3.0	...	20.22	Oct. 13	Gravel-packed well; measured yield 1,360; drawdown 16.02 after pumping 3 hours (9).
[61]	SW SE sec. 14	A. S. Blair	Dn	40	...	...	...	...	Cy, W, H	D, S	...	...	...	20	...	
[62]	SW SE SE sec. 21	Karl Hansen	Dr	63	6	Bs	...	...	Cy, W, H	S	...	...	...	21	...	
63	NW NE sec. 28	Mr. Wilson	Dr	70	18	Bs	1939	...	T, T	I	Opening, north side of pump base.	+3.0	...	20.32	Aug. 12	Gravel-packed well; originally drilled to irrigate trees in shelter belt.
(64)	SE cor. SW sec. 20	...	TH	58	...	...	1944	State Geological Survey.	...	...	...	...	1,147.6	...	...	
[65]	SW SW SE sec. 19	Newland	Dr	32	10	Bs	...	...	Cy, W, H	D, S	Top edge of manhole.	0	...	14.83	July 21	
66	NW cor. sec. 18	...	TH	34.5	...	...	1944	State Geological Survey.	...	...	...	...	1,227.9	...	...	

TABLE 15.—*Records of wells, spring, and test holes in the Smoky Hill Valley area in Saline, Dickinson, and Geary Counties, Kansas—Continued*

No. on Plate 1 (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Year drilled	Drilled by	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement, 1943	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 12 S., R. 1 E.															
67	SE cor. sec. 34		TH	120			1944	do.					1,310.3			
	T. 13 S., R. 1 E.															
68	SW cor. sec. 2		TH	100			1944	do.					1,302.7			
69	SW cor. sec. 11		TH	100			1944	do.					1,258.8			
[70]	NE SE SE sec. 15	Bob Akers	Dr	48	8	T			Cy, H	D	Top of wooden platform.	+1.8		45.62	May 26, 1944	
71	SW cor. sec. 14		TH	80			1944	State Geological Survey.					1,201.2			
72	NW NE SW sec. 23		TH	54			1944	do.					1,174.8			
[73]	SE NW SE sec. 23	City of Abilene	Sp						F	P						Water issues from bedding plane in limestone; yield reported to range from 900 to 1,200.
74	SE SW SE sec. 23		TH	38			1944	State Geological Survey.					1,150.4			
(75)	SE SW NE sec. 26		TH	50			1944	do.					1,152.5			
[76]	NW SE sec. 26	Roy Clemence	Dn	35	1¼	GP			Cy, H	D				20		
77	NE NW NE sec. 35		TH	60			1944	State Geological Survey.					1,156.6			
(78)	NW NE SE sec. 35		TH	69			1944	do.					1,155.4			
[79]	SW SE sec. 36	Charles Shannon	Dn	40	2¼	GP			Cy, H	D, S				20		
(80)	SE SW SE sec. 35		TH	70			1944	State Geological Survey.					1,155.1			
[81]	NE cor. sec. 3	John Scott	Dn	20	2¼	GP			Cy, W, H	D, S				15		
	T. 13 S., R. 1 E.															
(82)	NW cor. SW sec. 35		TH	68			1944	State Geological Survey.					1,158.5			
(83)	SW cor. NW sec. 34		TH	67			1944	do.					1,160.3			
(84)	SE cor. NE NE sec. 32		TH	62			1944	do.					1,164.6			

	T. 14 S., R. 1 E.															
[85]	NW SW SW sec. 17	R. T. Fair	Dr	30.5	5	GI			Cy, H	S	Top of casing	+ .5		12.18	July 30	
	T. 13 S., R. 1 E.															
[86]	NE cor. sec. 31	Floyd Shepard	B	26	6	GI			Cy, W, H	D, S				12		Well originally drilled to 45 feet; water was salty so casing was pulled back to 26 feet.
[87]	SW SE SE sec. 21	Lawrence Clemence	Dr	29.5	10	C			Cy, W, H	D	Top of casing	0		11.27	July 30	
(88)	NW SW sec. 21		TH	48			1944	State Geological Survey.					1,169.5			
89	NW cor. sec. 15		TH	173			1944	do.					1,245.2			
90	NE cor. sec. 18		TH	192.5			1944	do.					1,234.8			
[91]	NW SW SE sec. 18	City of Solomon	Dr	50	6	I	1942		T, E	P						Gravel-packed well; reported yield 50; drawdown 3.
92	NE SW SE sec. 18	do.	Dr	45	6	OW	1942		T, E	P						Gravel-packed well; reported yield 50; drawdown 3.
[93]	SE SW NW sec. 19		Dn	30	1¼	GP			Cy, W, H	D				12		
	SALINE COUNTY *T. 13 S., R. 1 W.*															
[94]	SW SE sec. 24		Dr	32	5	GI			Cy, W	S				18		Water contains 2,270 ppm of chloride; first water encountered at 26 feet was reported to be fresher.
	T. 14 S., R. 1 W.															
[95]	NW SW NW sec. 2	Charles Dunmire	Dn	35	2¼	GP			Cy, E	S				18		
(96)	NW NE NW sec. 15		TH	50			1944	State Geological Survey.					1,181.2			
	T. 13 S., R. 1 W.															
(97)	NE cor. sec. 33		TH	60			1944	do.					1,176.4			
[98]	NW SW NW sec. 32	School District	Dn	36	2¼	GP			Cy, H	D				15		School well.
(99)	SW cor. sec. 29		TH	60			1944	State Geological Survey.					1,181.2			
[100]	SE NE sec. 15	Charles Cruse	Dn	40	2¼	GP			Cy, W, H	D, S				18		
[101]	SW SE sec. 16	Axel Swenson	Dr	40	6	GI			Cy, W	D, S				20		
(102)	SE SE NE sec. 19		TH	70			1944	State Geological Survey.					1,180.1			
103	SE SE SW sec. 17		TH	73			1944	do.					1,178.2			
(104)	SW SW NW sec. 16		TH	68			1944	do.					1,179.6			
(105)	NE NE NW sec. 16		TH	60			1944	do.					1,177.0			
(106)	SE SE NE sec. 9		TH	50			1944	do.					1,177.2			
107	NW NE NW sec. 10		TH	60			1944	do.					1,180.8			
[108]	NW NW NE sec. 9	Breneman	Dn	40	2¼	GP			Cy, W	D, S				15		
(109)	NW SW SW sec. 4		TH	60			1944	State Geological Survey.					1,182.4			
[110]	NE cor. sec. 7	Phillip Nelson	Dn	34	2¼	GP	1936		Cy, W, H	D, S				28		Water reported to have "irony" taste.

TABLE 15.—*Records of wells, spring, and test holes in the Smoky Hill Valley area in Saline, Dickinson, and Geary Counties, Kansas—Continued*

No. on Plate 1 (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Year drilled	Drilled by	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement, 1943	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 13 S., R. 2 E.—Cont.															
[111]	SW SW NW sec. 7	School District	Dr	44.5	5	GI			Cy, H	D	Top of casing	+ .3		11.50	July 15	School well.
(112)	SW cor. sec. 6		TH	53			1944	State Geological Survey.					1,183.0			
	T. 13 S., R. 2 W.															
(113)	NE cor. sec. 2		TH	50			1944	do.					1,188.1			
(114)	SW cor. sec. 25		TH	80			1944	do.					1,190.5			
115	NW cor. sec. 27		TH	62			1944	do.					1,222.0			
116	SE cor. NE sec. 28		TH	70			1944	do.					1,208.9			
(117)	SW cor. sec. 27		TH	70			1944	do.					1,206.3			
[118]	SE SE sec. 28	Leon Schipple	Dn	44	2¼	GP			Cy, H	D				17		
119	SW cor. NW sec. 34		TH	68			1944	State Geological Survey.					1,203.1			
	T. 14 S., R. 2 W.															
(120)	NE cor. sec. 4		TH	73			1944	do.					1,202.5			
121	NW cor. SW sec. 3		TH	70			1944	do.					1,201.5			
(122)	SE cor. sec. 4		TH	70			1944	do.					1,199.7			
[123]	NE NW NW sec. 10	William Gustafson	Dr	40	5	GI			Cy, W, H	D, S	Top of casing	+0.8		19.19	July 21	
124	SW SW NW sec. 10		TH	70			1944	State Geological Survey.					1,200.1			
125	NW SW SW sec. 10		TH	70			1944	do.					1,206.7			
	T. 13 S., R. 2 W.															
[126]	SE SE SW sec. 31	Crowthers Estate	Dn	50	2¼	GP			Cy, W, H	D, S				25		
127	NE SW NW sec. 31	Dr. M. A. Hensley	Dr	70	24	GI			T, G	I				25		Gravel-packed well; reported yield 1,500; drawdown 19; encountered shale at 70 feet.
	T. 13 S., R. 3 W.															
(128)	SE SW sec. 34		Dn	20	1¼	GP			Cy, W, H	D, S				15		
129	SE SW SE sec. 34		TH	30			1943	State Geological Survey.					1,220.7			
130	SW NW SW sec. 35		TH	95			1943	do.					1,220.4			
(131)	SW NW sec. 35	Robert Fetterhoof	Dn	80	1½	GP			Cy, H	D				12		
132	SW SW SE sec. 26		TH	110			1943	State Geological Survey.					1,218.8			

(133)	NE NW SW sec. 25		Dn	50	1¼	GP			Cy, H	D						
134	NE cor. SE sec. 26		TH	80			1943	State Geological Survey.					1,217.1			
135	SE NW NW sec. 25		TH	50			1943	do.					1,221.3			
(136)	NW cor. NE sec. 25		Dn	35	1¼	GP			Cy, H	D						
137	NE SW SE sec. 24		TH	60			1943	State Geological Survey.					1,226.6			
(138)	Center sec. 24		Dn	40	1¼	GP			Cy, E	S						
[139]	SE SW SE sec. 27	Mrs. John W. Carney	Dr	68.7	5	GI			Cy, W, H	S	Top of casing	0.7		10.50	July 19	
[140]	SE SW SE sec. 27	do	Dn	30	1¼	GP			Cy, H	D				11		Well 140 is about 300 feet southeast of well 139.
(141)	SE SE SE sec. 28	F. W. Pfeifer	Dr	84	5	GI			Cy, H	D, S				18		
(142)	NE NW sec. 27	Art Nelson	Dn	50					Cy, W, H	D						
[143]	SE SW SE sec. 17	G. W. Came	Dn	42	2¼	GP			Cy, H	D				12		
[144]	NE SE sec. 9	Fred W. Lockard	Dn	50	2¼	GP			C, E	D				18		Pumps into pressure tank.
[145]	NE NE sec. 6	John White	Dn	45	2¼	GP			Cy, W, H	D, S				18		
	T. 14 S., R. 4 W.															
[146]	SE SE SE sec. 13	C. Schneider	Dn	45	2¼	GP			C, E	D, S				18		Pumps into pressure tank; water reported to be corrosive.
	T. 14 S., R. 3 W.															
[147]	SW NW sec. 8	J. L. Struble	Dr	42	5	GI			Cy, E	D				15		
148	SE cor. sec. 17		TH	45			1943	State Geological Survey.					1,231.8			
149	SW SW NW sec. 16		TH	67			1943	do.					1,232.7			
150	NE cor. sec. 17		TH	70			1943	do.					1,232.8			
151	NE cor. SE sec. 8		TH	60			1943	do.					1,232.6			
152	SW NW NW sec. 9		TH	38			1943	do.					1,233.9			
153	SW cor. sec. 2		TH	74			1939	Layne-Western Co.					1,221.0	19		
154	SE cor. SW sec. 2		TH	74			1939	do.					1,221.0	22		
155	NE NW NE sec. 11		TH	59			1939	do.					1,221.0	24		
156	SW SW SE sec. 1		TH	88			1939	do.					1,218.0	26		
	T. 14 S., R. 2 W.															
157	SE SW SW sec. 6		TH	90			1939	do.					1,217.0	27		
158	SW NW SE sec. 6		TH	69			1939	do.					1,217.0	27		
159	NE cor. sec. 7		TH	72			1939	do.					1,213.0	23		
160	SW NW sec. 8	Vanier	Dr	54	24	C	1938	Kelly Well Co.	T, E	I				28		Gravel-packed well; reported yield 800-1,000.
161	SW SE sec. 7		TH	57			1939	Layne-Western Co.					1,219.0	29		
	T. 14 S., R. 3 W.															
162	NW NW SE sec. 12		TH	77			1939	do.					1,219.0	28		
163	NE SW SW sec. 11	Banfield Bros. Packing Co.	Dr	84	10	OW	1938	do.	T, E	In						Reported yield 65; shale encountered at 84 feet.

TABLE 15.—*Records of wells, spring, and test holes in the Smoky Hill Valley area in Saline, Dickinson, and Geary Counties, Kansas—Continued*

No. on Plate 1 (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Year drilled	Drilled by	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement, 1943	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 14 S., R. 3 W.—Cont.															
164	NW NW NW sec. 14		TH	97			1939	Layne-Western Co.					1,223.0	21		
165	NE NE NW sec. 14		TH	91			1939	do.					1,225.0	25		
166	SE SE sec. 12		TH	72			1939	do.					1,220.0	27		
167	NE NE NE sec. 13		TH	61			1939	do.					1,222.0	28		
[168]	NW SE NE sec. 13	City of Salina. Well 7	Dr	72	24	C	1938	do.	T, E	P				32		Gravel-packed well; measured yield 1,090; drawdown 11 after pumping 3 hours (10).
169	NW NE SW sec. 13	City of Salina. Well 3	Dr	85	24	C	1941	do.	T, E	P	Top of opening in pump base.	2.0		34.15	Aug. 6	Gravel-packed well; measured yield 850; drawdown 16.9 after pumping 8 hours (8).
170	SE SE NW sec. 13	City of Salina. Well 8	Dr	71	24	C	1940	do.	T, E	P	do.	2.0		32.64	Aug. 6	Gravel-packed well; measured yield 1,020; drawdown 11.7 after pumping 36 hours (8).
[171]	NE NW SE sec. 13	City of Salina. Well 2	Dr	74	24	C	1938	do.	T, E	P	do.	2.0		29.96	Aug. 6	Gravel-packed well; measured yield 900; drawdown 14.5 after pumping 7 hours (10).
[172]	SW NW SE sec. 13	City of Salina. Well 6	Dr	81	24	Bs	1932	do.	T, E	P				32		Gravel-packed well; measured yield 1,120; drawdown 10 after pumping 10 hours (10).
[173]	NW SE SW sec. 13	City of Salina. Well 1	Dr	84	24	C	1935	do.	T, E	P	do.	1.5		34.19	Aug. 6	Gravel-packed well; measured yield 1,040; drawdown 13.5 after pumping 8 hours (10).
[174]	SE SE SW sec. 13	City of Salina. Well 4	Dr	81	24	Bs	1924		T, E	P				35		Gravel-packed well; measured yield 1,090; drawdown 20 after pumping 8 hours (10).
[175]	NE NW sec. 24	City of Salina. Well 5	Dr		24	C	1930		T, E	P	do.	2.0		29.56	Aug. 6	Gravel-packed well; measured yield 1,040; drawdown 13.5 after pumping 8 hours (10).
176	SW cor. sec. 14		TH	72			1939	Layne-Western Co.					1,228.0	27		
177	NE cor. sec. 24		TH	53			1939	do.					1,229.0	33		

	T. 14 S., R. 2 W.															
178	SE SE SW sec. 18		TH	58			1939	do.					1,229.0	29		
	T. 14 S., R. 3 W.															
179	SE cor. NE sec. 24		TH	53			1939	do.					1,231.0	33		
180	SW SE SE sec. 22		TH	40			1943	State Geological Survey.					1,232.2			
181	SW cor. sec. 23		TH	46				Layne-Western Co.					1,234.0	19		
182	SE SW SW sec. 23		TH	76				do.					1,230.0	23		
183	SE cor. SW sec. 23		TH	42				do.					1,234.0	24		
184	NE NE sec. 26		TH	62				do.					1,235.0	26		
185	NE NW sec. 25		TH	72				do.					1,232.0	26		
186	SE SW SE sec. 24		TH	57			1943	State Geological Survey.					1,232.0			
	T. 14 S., R. 2 W.															
187	NW cor. sec. 30		TH	55				Layne-Western Co.					1,225.0	20		
188	SE SW SW sec. 19		TH	49				do.					1,229.0	26		
189	NW NW NE sec. 30		TH	55				do.					1,227.0	24		
	T. 14 S., R. 3 W.															
[190]	SE SE SE sec. 28		Dr	51.5	5	GI			Cy, W	D, S	Top of casing	−5.0		19.90	July 30	
[191]	SE SE SW sec. 26	Nordball	Dn	80	2¼	GP			Cy, W	S				24		
	T. 14 S., R. 2 W.															
[192]	SE SW SE sec. 30	George Whelchel	Dn	60	1¼	GP			Cy, H	D				25		
	T. 15 S., R. 3 W.															
193	NW cor. NE sec. 10		TH	30			1943	State Geological Survey.					1,299.1			
194	NE cor. sec. 10		TH	40			1943	do.					1,266.4			
195	NW cor. NE sec. 11		TH	37			1943	do.					1,250.7			
196	NE cor. sec. 11		TH	60			1943	do.					1,248.6			
197	NW cor. NE sec. 12		TH	70			1943	do.					1,247.1			
198	NE NW NE sec. 12		TH	90			1943	do.					1,247.7			
	T. 15 S., R. 2 W.															
199	NW cor. SW sec. 6		TH	61			1942	Layne-Western Co.						16.8		
200	NW SW SW sec. 6	U. S. Army. Camp Phillips; well 5.	Dr	61.5	19	C	1943	do.	T, E	P	Top of opening in pump base.	+1.7		24.45	June 17	Gravel-packed well; measured yield 750; drawdown 7.45 after pumping 24 hours (8).
201	NW cor. sec. 7	U. S. Army. Camp Phillips; well 1.	Dr	59.5	19	C	1942	do.	T, E	P				16.5		Gravel-packed well; measured yield 776; drawdown 9.5 after pumping 12 hours (8); depth to water level is for July, 1942.

TABLE 15.—*Records of wells, spring, and test holes in the Smoky Hill Valley area in Saline, Dickinson, and Geary Counties, Kansas—Concluded*

No. on Plate 1 (1)	LOCATION	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Year drilled	Drilled by	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement, 1943	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 15 S., R. 2 W.—Cond.															
202	NE NE NW sec. 7	U. S. Army. Camp Phillips; well 2.	Dr	55.5	19	C	1942	Layne-Western Co.	T, E	P	Top of ¾-inch pipe in pump base.	+3.8		24.80	Oct. 30	Gravel-packed well; measured yield 781; drawdown 8.8 after pumping 24 hours (8); water level 12.5 feet below land surface on July 21, 1942 before well was pumped.
203	NE NE NE sec. 7	U. S. Army. Camp Phillips; well 3.	Dr	59.5	19	C	1942	do.	T, E	P	do.	+4.8		24.07	Oct. 30	Gravel-packed well; measured yield 830; drawdown 8.3 after pumping 12 hours (8); water level 14.5 feet below land surface on July 26, 1942, before well was pumped.
204	NW NW sec. 8	U. S. Army. Camp Phillips; well 4.	Dr	48	19	C	1942	do.	T, E	P	do.	+4.8		24.64	Oct. 30	Gravel-packed well; measured yield 750; drawdown 16.9 after pumping 12 hours (8); water level 17 feet below land surface on Aug. 1, 1942, before well was pumped.
205	NE NE NW sec. 8		TH	20			1943	State Geological Survey.					1,301.9			
206	NW SW NW sec. 7		TH	60			1942	Layne-Western Co.						16		
	T. 15 S., R. 3 W.															
207	SW SW SW sec. 9		TH	30			1943	State Geological Survey.					1,296.8			
208	NW cor. sec. 16		TH	35			1943	do.					1,287.2			
209	SW NW NW sec. 16		TH	60			1943	do.					1,277.2			
[210]	SW NW SW sec. 16	John Nelson	Dr	41	5	GI			Cy, H	D				33		
211	SW cor. sec. 16		TH	40			1943	State Geological Survey.					1,269.1			
	T. 15 S., R. 4 W.															
212	NW NE NW sec. 25		TH	56			1943	do.					1,292.6			
213	NE cor. sec. 25		TH	53			1943	do.					1,280.1			

	T. 15 S., R. 3 W.															
214	NE cor. sec. 30		TH	50			1943	do.					1,273.6			
215	NW cor. sec. 28		TH	56			1943	do.					1,267.0			
216	NE cor. sec. 32		TH	30			1943	do.					1,277.7			
217	SW cor. sec. 22		TH	20			1943	do.					1,264.2			
218	SW cor. sec. 23		TH	60			1943	do.					1,266.6			
219	SE cor. sec. 23		TH	45			1943	do.					1,277.7			
220	SE SW SW sec. 24		TH	60			1943	do.					1,256.5			
221	SW cor. SE sec. 24		TH	70			1943	do.					1,267.7			
222	NE cor. sec. 25		TH	65			1943	do.					1,263.4			
	T. 15 S., R. 2 W.															
223	SE cor. SW sec. 19		TH	100			1943	do.					1,266.0			
224	SE SE SE sec. 19		TH	58			1943	do.					1,268.4			
225	SE SW SW sec. 20		TH	55			1943	do.					1,263.3			
[226]	SW NE SE sec. 30	Elmer Anderson	Dn	50	2¼	GP			Cy, W, H	D, S				25		Well is about 200 feet west of river.
	T. 16 S., R. 3 W.															
[227]	NW SE NW sec. 12	City of Assaria	Dr	86	10	I	1937	Scott Montgomery.	T, E	P						Reported operating yield 100; reported yield during test 400-600.
228	NE NE NW sec. 23		TH	40			1943	State Geological Survey.					1,320.2			
229	NE NW NE sec. 23		TH	24			1943	do.					1,287.7			
230	NE NE NE sec. 23		TH	20			1943	do.					1,271.6			
231	NW NW NW sec. 24		TH	20			1943	do.					1,286.9			
232	SW SE SW sec. 13		TH	78			1943	do.					1,282.0			
233	SE SE SE sec. 13		TH	70			1943	do.					1,282.1			
	T. 16 S., R. 2 W.															
234	SW SE SW sec. 18		TH	94			1943	do.					1,279.6			
235	NW cor. NE sec. 19		TH	90			1943	do.					1,279.9			
236	SE NE NE sec. 19		TH	60			1943	do.					1,287.9			
	T. 16 S., R. 3 W.															
[237]	NW NW NE sec. 25	Arnold Gilberg	Dn	45	2¼	GP			Cy, H	D						
[238]	SE SE SW sec. 34	W. R. Carlson	Dn	50	2¼	GP			Cy, W, H	D, S				30		

1. Well number in brackets indicates that analysis of water is given in table 9; parentheses indicate that chloride content of water is given in table 10.
2. B, bored well; Dn, driven well; Dr, drilled well; Sp, spring; TH, test hole.
3. Reported depths below the land surface are given in feet; measured depths are given in feet and tenths below measuring points.
4. Bs, boiler steel; C, concrete; GI, galvanized sheet iron; GP, galvanzed-iron pipe; I, iron; OW, oil-well casing; T, tile.
5. Method of lift: CY, cylinder; F, natural flow; P, pitcher pump; Pl, plunger; T, turbine.
Type of power: E, Electric; G, gas engine; H, hand operated; T, tractor; W, windmill.
6. D, domestic; I, irrigation; In, industrial; P, public supply; S, stock.
7. Measured depths to water level are given in feet, tenths, and hundredths; reported depths to water level are given in feet and tenths below land surface.
8. Pumping test conducted at time well was drilled and results furnished by Layne-Western Company.
9. Pumping test conducted and results furnished by Division of Water Resources, Kansas State Board of Agriculture.
10. Pumping test conducted by Paulette and Wilson Company and results given in report to the City of Salina.

LOGS OF WELLS AND TEST HOLES

In the following pages are listed the logs of 109 test holes drilled by the State Geological Survey, 30 test holes drilled by the Layne-Western Company, and 23 public-supply wells. Samples from test holes drilled by the Geological Survey were studied by O. S. Fent and me. The numbers assigned to the logs are the same as well and test-hole numbers used in the text, in Table 15, and on Plate 1.

5. *Sample log of test hole in the NW¼ SE¼ sec. 22, T. 11 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,101.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, gray black and gray	5	5
Silt, sandy, yellow gray to gray	25	30
Silt, yellow gray and blue gray	5	35
Sand, fine to coarse, brown; contains some fine to medium gravel	5	40
Gravel, fine to coarse; contains some silt and sand; partly cemented in lower part	32	72
PERMIAN—Wolfcampian		
Limestone, hard, white	1	73

6. *Sample log of test hole in the SW¼ SE¼ sec. 22, T. 11 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,082.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, gray brown to gray green	8	8
Sand, fine, to medium gravel	12	20
Gravel, fine to coarse; contains some sand	20	40
Sand, fine, to medium gravel	21	61
PERMIAN—Wolfcampian		
Shale, dark red and gray green	3	64

7. *Sample log of test hole in the NE¼ NW¼ sec. 27, T. 11 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,076.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Soil, sandy, dark gray	3	3
Sand, fine to coarse, brown; contains some fine to medium gravel	10	13
Gravel, fine to coarse, and some sand; light green	7	20
Gravel, fine to medium, brown; fine to medium sand	22	42
PERMIAN—Wolfcampian		
Limestone, hard, white, and some blue-gray chert	2	44

8. *Sample log of test hole in the SE¼ NW¼ sec. 27, T. 11 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,077.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Sand, fine, and silt; buff and gray	8	8
Sand, fine to coarse, brown	5	13
Sand, fine to coarse, and fine to medium gravel	23.5	36.5
PERMIAN—Wolfcampian		
Chert, blue gray; contains some hard white limestone	.1	36.6

9. *Sample log of test hole in the cen. SW¼ sec. 27, T. 11 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,073.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, sandy, light to dark gray	5	5
Sand, fine to coarse; contains some fine to medium gravel	5	10
Sand, fine to coarse	10	20
Sand, fine to coarse; contains some fine to medium gravel	10	30
PERMIAN—Wolfcampian		
Shale, gray green and yellow green	2	32

10. *Sample log of test hole in the SW¼ SW¼ sec. 27, T. 11 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,078.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Sand, fine to coarse, and silt, soft, buff and gray	10	10
Gravel, fine to medium, and sand	17	27
PERMIAN—Wolfcampian		
Shale, gray green, yellow green, and gray	1	28

11. *Sample log of test hole in the NW¼ NW¼ sec. 34, T. 11 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,079.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Sand, fine to medium, silty, gray and buff	10	10
Sand, fine to coarse, brown to gray green	10	20
Sand, fine to coarse; contains little fine gravel	11	31
PERMIAN—Wolfcampian		
Shale, silty, yellow buff; contains thin bed of hard, light blue-gray limestone at 34 feet	4	35

12. *Driller's log of test hole at the Cavalry Replacement Training Center, Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1940.*

	Thickness, feet	Depth, feet
Soil, sandy	10	10
QUATERNARY		
Alluvium		
Sand, very fine	8	18
Sand, coarse, and some gravel	8	26
Sand, blue; contains some clay	5	31
Sand, coarse, and gravel	16	47
Clay, blue	3	50
PERMIAN—Wolfcampian		
Shale	1	51

13. *Driller's log of test hole at the Cavalry Replacement Training Center, Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1940.*

	Thickness, feet	Depth, feet
Soil, sandy	2	2
QUATERNARY		
Alluvium		
Sand, very fine	9	11
Sand, coarse; contains few streaks of clay	5	16
Sand, coarse, and gravel	24	40
PERMIAN—Wolfcampian		
Shale	1	41

14. *Driller's log of well at the Cavalry Replacement Training Center (well 2), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1941.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Clay, yellow	12	14
Sand, fine	12	26
Clay, soft, blue	5	31
Sand, coarse	15	46
Clay and rocks	4	50
Sand, fine	8	58
Sand, coarse	24	82

15. *Driller's log of well at the Cavalry Replacement Training Center (well 1), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1941.*

	Thickness, feet	Depth, feet
Soil, black	3	3
QUATERNARY		
Alluvium		
Soil, sandy	6	9
Sand, silty	5	14
Clay	4	18
Sand, fine	16	34
Sand, coarse	30	64
Sand, fine	1	65
Sand, coarse	6	71
Sand, fine	1	72
Sand, coarse	3	75

18. *Driller's log of well in the SW¼ SW¼ sec. 36, T. 11 S., R. 5 E., Geary County; drilled by the Layne-Western Company for the City of Junction City (well 4,) 1937.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Clay	8	8
Clay, sandy	8	16
Sand	4	20
Sand, coarse	8	28
Quicksand	9	37
Sand and gravel	17	54

19. *Driller's log of well in the SW¼ SW¼ sec. 36, T. 11 S., R. 5 E., Geary County; drilled by the Layne-Western Company for the City of Junction City (well 5), 1943.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Sand, fine	8	10
Sand, coarse, and gravel	8	18
Sand, fine	7	25
Sand, coarse, and gravel; contains clay balls	10	35
Sand, coarse, and gravel	18	53
PERMIAN—Wolfcampian		
Shale	1	54

20. *Driller's log of test hole in the Hippodrome area, Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Clay	13	15
Sand, fine	3	18
Sand, coarse	10	28
Sand and gravel	9	37
Clay	1	38
Sand, coarse	2	40
Sand and gravel	15	55
Sand, fine	18	73
PERMIAN—Wolfcampian		
Rock	1	74

21. *Driller's log of well at Fort Riley (well 3), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U.S. Army, 1928.*

	Thickness, feet	Depth, feet
Soil	5	5
QUATERNARY		
Alluvium		
Clay, sandy	7	12
Sand, fine	6	18
Clay	7	25
Clay, sandy	3	28
Sand, fine	12	40
Sand and gravel	30	70

22. *Driller's log of well at Fort Riley (well 2), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1928.*

	Thickness, feet	Depth, feet
Soil, sandy	8	8
QUATERNARY		
Alluvium		
Clay	5	13
Clay, sandy	12	25
Sand, fine	15	40
Sand and gravel	9	49
Clay	1	50
Sand	5	55
Sand and gravel	12	67

23. *Driller's log of well at Fort Riley (well 1), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1928.*

	Thickness, feet	Depth, feet
Soil, sandy	5	5
QUATERNARY		
Alluvium		
Clay	17	22
Sand, coarse	7	29
Clay	1	30
Sand, fine	10	40
Sand and gravel	28	68
PERMIAN—Wolfcampian		
Rock	1	69

24. *Driller's log of well at Fort Riley (well 4), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1937.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Clay, sandy	8	10
Sand	15	25
Clay, sandy	5	30
Sand and gravel	40	70

25. *Driller's log of well at Camp Funston (well 1), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1940.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Sand, silty	5	5
Sand, packed	4	9
Sand, silty	14	23
Sand, coarse	9	32
Sand, coarse, and gravel; gray	13	45
Sand, coarse, and gravel; brown	19	64

26. *Driller's log of well at Camp Funston (well 2), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1940.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Sand, silty	16	16
Sand, fine	8	24
Sand, coarse	21	45
Sand, coarse, and gravel	20	65
PERMIAN—Wolfcampian		
Rock	1	66

27. *Driller's log of well at Camp Funston (well 3), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1941.*

	Thickness, feet	Depth, feet
Soil, sandy	2	2
QUATERNARY		
Alluvium		
Sand, silty	16	18
Sand, fine	6	24
Sand, coarse, and clay balls	7	31
Sand, coarse, and gravel	31	62
PERMIAN—Wolfcampian		
Rock	1	63

28. *Driller's log of well at Camp Funston (well 4), Fort Riley Military Reservation; drilled by the Layne-Western Company for the U. S. Army, 1941.*

	Thickness, feet	Depth, feet
Soil, sandy	2	2
QUATERNARY		
Alluvium		
Sand, silty	17	19
Sand, medium coarse	13	32
Sand, coarse	12	44
Sand, coarse, and gravel	20.3	64.3
PERMIAN—Wolfcampian		
Rock	1	65.3

32. *Sample log of test hole in the NE¼ SE¼ sec. 22, T. 12 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,079.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Soil, sandy, gray black	2	2
Sand, fine to medium, and some fine to medium gravel,	14	16
Clay, silty, buff; contains some fine to coarse sand and a few pebbles	5	21
Sand, medium to coarse	30	51
PERMIAN—Wolfcampian		
Shale, hard	2	53

33. *Sample log of test hole in the SE¼ SE¼ sec. 22, T. 12 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,067.7 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Silt, clayey, yellow gray; contains some fine to coarse sand between depths of 10 and 15 feet	16	18
Silt, clayey, gray	2	20

	Thickness, feet	Depth, feet
Silt, yellow gray, and fine to coarse sand	8	28
Gravel, fine, and sand; contains some medium to coarse gravel	12	40
Sand, fine to coarse	10	50
Gravel, fine to medium, and sand	11	61
PERMIAN—Wolfcampian		
Shale, calcareous, hard, white and light gray green; contains thin bed of limestone at 62 feet	2	63

34. *Sample log of test hole in the NE¼ NE¼ sec. 27, T. 12 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,061.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, sandy, yellow gray	20	20
Sand, fine to medium, grading downward to fine to medium gravel and sand; contains some silty blue-gray clay	20	40
Gravel, fine to coarse, and sand	20	60
PERMIAN—Wolfcampian		
Limestone, very hard, white and blue gray	1	61

35. *Sample log of test hole in the SE¼ NE¼ sec. 27, T. 12 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,064.4 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	4	4
QUATERNARY		
Alluvium		
Sand, fine to medium	4	8
Silt, clayey, gray, interbedded with fine to medium sand	10	18
Silt, clayey, blue gray	3	21
Gravel, fine to coarse; contains some sand	29	50
Gravel, fine to medium	6	56
PERMIAN—Wolfcampian		
Limestone, hard, white	1	57

37. *Sample log of test hole in the SE¼ SE¼ sec. 27, T. 12 S., R. 5 E., Geary County; drilled by the State Geological Survey, 1944. Surface altitude, 1,083.5 feet.*

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY		
Alluvium		
Sand, fine, and soft gray-buff silt	19	23
PERMIAN—Wolfcampian		
Shale, red and gray green	4	27

41. *Driller's log of city well at Chapman, Kansas, in the NE¼ NW¼ NE¼ sec. 31, T. 12 S., R. 4 E., Dickinson County; drilled by the Layne-Western Company, 1939.*

	Thickness, feet	Depth, feet
Soil	8	8
QUATERNARY		
Alluvium		
Clay, sandy	7	15
Sand	5	20
Clay, sandy	8	28
Clay	14	42
Sand, medium fine	3	45
Sand, coarse, and gravel	14	59
Clay	2	61
Sand and gravel	4	65
PERMIAN—Wolfcampian		
Rock	1	66

42. *Sample log of test hole in the NE¼ SE¼ sec. 31, T. 12 S., R. 4 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,108.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, dark gray brown	4	4
Silt, soft gray buff; contains some fine sand	11	15
Silt, soft, dark blue gray	4	19
Gravel, fine to coarse, and sand; contains little dark blue-gray silt	21	40
Gravel, fine to medium	8	48
PERMIAN—Wolfcampian		
Limestone, fairly soft, light buff	2	50

43. *Sample log of test hole at the NW cor. sec. 5, T. 13 S., R. 4 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,111.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, light gray to dark gray	5	5
Sand, fine to coarse	1	6
Silt, sandy, gray buff	8	14
Sand, fine to medium	6	20
Sand, fine to coarse; contains some fine to coarse gravel between 25 and 31 feet	11	31
PERMIAN—Wolfcampian		
Shale, calcareous, gray green	2	33
Limestone, hard, gray buff	.1	33.1

44. *Sample log of test hole in the SE¼ NE¼ sec. 6, T. 13 S., R. 4 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,115.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, dark gray brown	3	3
Silt, soft, yellow gray; contains some fine sand	20	23
Silt, soft, buff gray to dark gray	4.5	27.5
Gravel, fine to coarse	.5	28
PERMIAN—Wolfcampian		
Shale, calcareous, hard, buff and light gray	2	30

48. *Sample log of test hole in the NE¼ SW¼ sec. 8, T. 13 S., R. 3 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,139.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, sandy, brown	3	3
Silt, clayey, dark gray	3	6
Silt, sandy, buff and tan	3	9
PERMIAN—Wolfcampian		
Shale, gray green; contains thin beds of limestone	5	14

49. *Sample log of test hole at the NW cor. NE¼ sec. 17, T. 13 S., R. 3 E., Dickinson County; drilled by the State and Federal Geological Surveys, 1944. Surface altitude, 1,126.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, gray black	3	3
Silt, gray brown and buff	5	8
Clay, silty, dark buff and light blue gray	14	22
Gravel, fine to coarse; contains some sand	36	58
PERMIAN—Wolfcampian		
Shale, red brown and gray green	2	60

50. *Sample log of test hole in the SW¼ NE¼ sec. 17, T. 13 S., R. 3 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,125.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, soft, yellow gray; contains fine to medium sand in lower part	20	20
Sand, fine to medium; grades downward to fine to coarse, sandy and silty gravel	10	30
Silt, clayey, blue gray	3	33
Gravel, fine to coarse; contains some sand	27	60
PERMIAN—Wolfcampian		
Shale, clayey, red brown and blue gray	10	70

51. *Sample log of test hole at the NW¼ SE¼ sec. 17, T. 13 S., R. 3 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,124.5 feet.*

	Thickness, feet	Depth, feet
Soil, dark gray	3	3
QUATERNARY		
Alluvium		
Silt, soft, sandy, yellow gray	7	10
Sand, fine to coarse, and yellow-gray silt; contains some fine to coarse gravel in lower part	10	20
Gravel, fine to coarse, and some sand	30	50
Gravel, fine to coarse, partly cemented	12	62
PERMIAN—Wolfcampian		
Shale, red brown and gray green, and hard, gray-white limestone containing a little chert	6	68

52. *Sample log of test hole at the NW cor. NE¼ sec. 20, T. 13 S., R. 3 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,127.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, partly clayey, sandy, yellow gray; contains a little fine gravel	7	7
Gravel, fine to coarse, and sand	28	35
Silt, sandy, light blue gray, gray, and buff; grades downward to fine to medium gravel and sand	15	50
Gravel, fine to coarse, and sand	18	68
PERMIAN—Wolfcampian		
Limestone, very hard, gray white	.1	68.1

54. *Sample log of test hole in the NW¼ SW¼ NE¼ sec. 20, T. 13 S., R. 3 E., Dickinson County; drilled by the State Geolgical Survey, 1944. Surface altitude, 1,127.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, dark yellow gray, and fine to medium sand	19	19
Gravel, fine to coarse, and sand; contains little blue-gray silt near 35 feet	34	53
PERMIAN—Wolfcampian		
Shale, clayey, red brown, blue gray, and yellow green,	7	60

55. *Sample log of test hole in the SW¼ SW¼ NE¼ sec. 20, T. 13 S., R. 3 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,129.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, yellow gray; and fine to medium sand; interbedded,	17	17
Gravel, fine to coarse, and sand	11	28
Silt, gray buff and blue gray	3	31
Gravel, fine to medium, and sand; partly cemented	9	40
Gravel, fine to medium, and sand; tightly cemented	3	43
PERMIAN—Wolfcampian		
Shale, gray green and light brown	4	47

56. *Driller's log of city well at Enterprise, Kansas, in the SW¼ SW¼ NE¼ sec. 20, T. 13 S., R. 3 E., Dickinson County; drilled by the Layne-Western Company, 1943.*

	Thickness, feet	Depth, feet
Soil, black	2	2
QUATERNARY		
Alluvium		
Loam, sandy	6	8
Sand, coarse, dry	6	14
Sand and clay, mucky	2	16
Sand and gravel	17	33
Clay and gravel	4	37
Sand and gravel	5	42
PERMIAN—Wolfcampian		
Clay, red	1	43

64. *Sample log of test hole at the SE cor. SW¼ sec. 20, T. 13 S., R. 2 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,147.6 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	2	2
QUATERNARY		
Alluvium		
Silt, clayey, gray to yellow buff; contains few caliche nodules	8	10
Sand, fine to medium, and yellow-buff silt; contains much caliche and a little fine to medium gravel	28	38
Silt, dark blue gray; contains some fine to coarse gravel,	2	40
Sand, fine to coarse; contains some fine to coarse gravel,	10	50
Gravel, fine to medium, and sand. See analysis 64, Table 10	6	56
PERMIAN—Wolfcampian		
Shale, silty, dull red and light gray green	2	58

66. *Sample log of test hole at the NW cor. sec. 18, T. 13 S., R. 2 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,227.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand		
Sand, fine to coarse	5	5
Terrace deposits (Pleistocene)		
Clay, sandy, gray green	7	12
Sand, fine to coarse, and fine to medium gravel	4	16
Sand, fine to coarse, lime-cemented	4	20
PERMIAN—Leonardian		
Wellington formation		
Shale, silty, red brown and gray green	5	25
Limestone, hard, white	.5	25.5
Shale, silty, red brown and gray green	6.5	32
Limestone, hard, white	2.5	34.5

67. *Sample log of test hole at the SE cor. sec. 34, T. 12 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,310.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand		
Sand, fine to medium; contains some gray-brown silt..	14	14
Terrace deposits (Pleistocene)		
Silt, sandy, mottled tan and gray green; contains some fine gravel in lower part	10	24
PERMIAN—Leonardian		
Wellington formation		
Shale, soft, gray green, yellow buff, and gray white....	23	47
Shale, soft, dark gray, and blocky, light-gray and green-gray shale	23	70
Shale, soft, light green gray	10	80
Clay, soft, green gray, and light- to dark-gray shale....	10	90
Shale, partly calcareous, light to dark gray and red brown	10	100
Gypsum, massive to crystalline, white to transparent, and some gray and red-brown shale	20	120

68. *Sample log of test hole at the SW cor. sec. 2, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,302.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand		
Sand, fine to medium, silty, tan and gray	15	15
Terrace deposits (Pleistocene)		
Sand, fine to coarse, and brown silt; contains some fine to medium gravel	6	21
PERMIAN—Leonardian		
Wellington formation		
Shale, blue gray, gray green, and cream; contains few thin veins of calcite	59	80
Shale, dark blue gray	18	98
Gypsum (?). No sample, due to loss of circulation. Possibly a solution channel in gypsum	2	100

69. *Sample log of test hole in the SW cor. sec. 11, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,258.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand		
Sand, fine to medium, and light-brown silt	6	6
Terrace deposits (Pleistocene)		
Silt, sandy, tan and light gray to gray black	14	20
Sand, fine to medium, and clayey gray-green and tan silt	9	29

	Thickness, feet	Depth, feet
Clay, silty, soft, gray brown to tan; contains some fine to medium sand	17	46
Sand, fine to coarse, and fine to medium gravel; contains caliche and many pebbles of sandstone and ironstone in lower part. Thin cemented zones at 56 and 58 feet	14	60
PERMIAN—Leonardian		
Wellington formation		
Shale, gray green, and soft blue-gray clay	16	76
Clay, blue gray and brown, and some blue-gray shale	12	88
Gypsum, massive, white and gray, and thin beds of hard, partly calcareous, gray shale	12	100

71. *Sample log of test hole at the SW cor. sec. 14, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,201.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand		
Sand, fine to coarse; contains some dark-gray to light tan silt	10	10
Terrace deposits (Pleistocene)		
Silt, sandy, light tan, yellow brown, and light gray	10	20
Sand, medium to coarse	12	32
Silt, sandy and clayey, light tan and light gray	6	38
Sand, fine to coarse, and fine gravel	8	46
Silt, clayey, sandy, gray and light gray brown	6	52
Sand, medium to coarse, and fine to coarse gravel; contains few pebbles of Dakota sandstone and ironstone	21	73
PERMIAN—Wolfcampian		
Shale, hard, light gray	3.5	76.5
Limestone, hard, white, and hard, light-gray shale. Solution opening at 80 feet	3.5	80

72. *Sample log of test hole in the NW¼ NE¼ SW¼ sec. 23, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,174.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand		
Sand, fine to medium, silty	20	20
Terrace deposits (Pleistocene)		
Silt, sandy, clayey, light brown to light gray	7	27
Sand, fine, to medium gravel	9	36
PERMIAN—Wolfcampian		
Shale, red and bright gray green	4	40
Shale, red, gray green, and blue gray; containing thin beds of limestone and gypsum	8	48
Limestone, hard, white, and hard, white to gray-white shale	6	54

74. *Sample log of test hole in the SE¼ SW¼ SE¼ sec. 23, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,150.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, light to dark gray	10	10
Silt, soft, sandy, buff and gray	8	18
Gravel, fine, and sand	8	26
Silt, soft, dark blue gray	1	27
Gravel, fine to coarse, and sand	6	33
PERMIAN—Wolfcampian		
Shale, hard, gray green, red brown, and blue gray	2	35
Limestone, white	2	37
Shale, very hard, light gray	1	38

75. *Sample log of test hole in the SE¼ SW¼ NE¼ sec. 26, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,152.5 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Silt, sandy, gray brown to yellow gray	15	17
Gravel, fine to coarse; contains some sand. See analysis 75, Table 10	29	46
PERMIAN—Wolfcampian		
Shale, gray green and red brown; contains some gypsum between 48 and 50 feet	4	50

77. *Sample log of test hole in the NE¼ NW¼ NE¼ sec. 35, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,156.6 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY		
Alluvium		
Silt, clayey, gray and gray buff	17	20
Silt, yellow gray, grading downward to fine to coarse sand	6	26
Gravel, fine to coarse, and sand	31	57
PERMIAN—Wolfcampian		
Shale, red brown and gray green	3	60

78. *Sample log of test hole at the NW cor. NE¼ SE¼ sec. 35, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,155.4 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Silt, clayey, compact, dark gray	2	4
Silt, sandy, yellow gray	9	13
Silt, clayey, gray	7	20
Clay, silty, light blue gray and buff	9	29
Gravel, fine to coarse, and sand. See analysis 78, Table 10	36	65
PERMIAN—Wolfcampian		
Shale, light brown and light gray	4	69

80. *Sample log of test hole at the SE cor. SW¼ SE¼ sec. 35, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,155.1 feet.*

	Thickness, feet	Depth, feet
Soil, gray black	2	2
QUATERNARY		
Alluvium		
Silt, yellow clay	10	12
Silt and clay, gray, light blue gray, and buff	18	30
Sand, fine to coarse, and fine to medium gravel	20	50
Gravel, fine to coarse; contains some sand. See analysis 80, Table 10	15	65
PERMIAN—Wolfcampian		
Shale, red brown and gray green	5	70

82. *Sample log of test hole at the NW cor. SW¼ sec. 35, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,158.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Clay, silty, light brown to yellow gray; contains a few caliche nodules	14	14
Clay, silty, gray and buff	16	30
Sand, fine to coarse; contains some gray-green silt and a little fine to medium gravel	8	38
Gravel, fine to coarse; contains some sand. See analysis 82, Table 10	22	60
Clay, silty, gray	4	64
PERMIAN—Wolfcampian		
Shale, silty, red brown and light gray	4	68

83. *Sample log of test hole at the SW cor. NW¼ sec. 34, T. 13 S., R. 1 E., Dickinson County; drilled by the state Geological Survey, 1944. Surface altitude, 1,160.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Clay, silty, gray brown	3	3
Silt and clay, yellow gray and dark blue gray	27	30
Gravel, fine to coarse; contains some sand	28	58
Clay, yellow green to light blue	5	63
Gravel, fine to coarse, and sand; loosely cemented. See analysis 83, Table 10	2	65
PERMIAN—Wolfcampian		
Shale, hard, light gray to gray	2	67

84. *Sample log of test hole at the SE cor. NE¼ NE¼ sec. 32, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,164.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, buff	18	18
Gravel, fine to coarse, and sand. See analysis 84, Table 10	40	58
PERMIAN—Wolfcampian		
Shale, clayey, light blue gray, and hard light-buff shale,	4	62

88. *Sample log of test hole in the NW¼ SW¼ sec. 21, T. 13 S., R. 1 E., drilled by the State Geological Survey, 1944. Surface altitude, 1,169.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, gray to buff gray	17	17
Sand, fine to coarse, and some fine to coarse gravel	23	40
Gravel, fine, and sand. See analysis 88, Table 10	3	43
PERMIAN—Wolfcampian		
Shale, hard, light gray	5	48

89. *Sample log of test hole at the NW cor. sec. 15, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,245.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand		
Sand, fine to medium, silty, tan	10	10
Terrace deposits (Pleistocene)		
Silt, clayey, light gray and light tan	8	18
Sand, fine to coarse, yellow	3	21
Silt, clayey, sandy, soft, light tan and light gray; contains much fine to medium gravel in lower part	17	38
PERMIAN—Leonardian		
Wellington formation		
Shale, partly calcareous, gray green and blue gray	10	48
Shale, hard, light to dark gray	22	70

	Thickness, feet	Depth, feet
Shale, clayey, gray green and red brown	30	100
Shale, calcareous, gray	16	116
Shale, very hard, gray and green gray	4	120
Shale, gray green and red brown	14	134
Gypsum, white, translucent	10	144
Shale, calcareous, gray to dark gray; hard in upper part and interbedded hard and soft beds in lower part	28.5	172.5
Chert, fossiliferous, blue gray	.5	173

90. *Sample log of test hole at the NE cor. sec. 18, T. 13 S., R. 1 E., Dickinson County; drilled by the State Geological Survey, 1944. Surface altitude, 1,234.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Dune sand		
Sand, fine to coarse	3	3
Terrace deposits (Pleistocene)		
Sand and gravel, fine to medium; contains some tan silt,	2	5
Silt, sandy, yellow tan	4	9
Sand and gravel, fine to medium; silty	9	18
Silt, clayey, yellow gray	2	20
Sand, fine, to coarse gravel; interbedded with yellow-gray and green-gray clay	12	32
Clay, compact, gray green; contains some caliche	6	38
Sand, fine, to coarse gravel	2	40
Sand, fine to coarse, interbedded with buff silt; contains some fine to coarse gravel. Gravels derived from the Dakota formation	14	54
PERMIAN—Leonardian		
Wellington formation		
Shale, calcareous, gray green; contains some calcite in upper part	35	89
Shale, calcareous, light gray and brown; contains thin bed of limestone near top	5	94
Gypsum, white, and hard gray shale	2	96
Shale, gray green and brown	2	98
Gypsum, white, interbedded with some dark-gray shale,	7	105
Shale, gray	3	108
Gypsum, interbedded with light-gray and brown shale,	17	125
Shale, light gray	6	131
Gypsum and shale, gray	13	144
Shale, calcareous, hard, light gray to gray	21	165
Shale, gray green and red brown	17	182
Gypsum	8	190
Limestone, hard, gray white, and gray shale	2.5	192.5

92. *Driller's log of well at Solomon, Kansas, in the NE¼ NW¼ SE¼ sec. 18, T. 13 S., R. 1 E., Dickinson County; drilled by local driller, 1942.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Loam, sandy	4	4
Clay and sand	16	20
Clay, brown	15	35
Quicksand	3	38
Sand, fine	3	41
Sand, medium	2	43
Sand, coarse, to fine gravel	1	44
PERMIAN—Leonardian		
Wellington formation		
Shale	4	48

96. *Sample log of test hole in the NW¼ NE¼ NW¼ sec. 15, T. 14 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,181.2 feet.*

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY		
Alluvium		
Silt and clay, dark buff, gray, and gray green; contains some fine to medium sand in lower part	30	34
Gravel, fine to coarse; contains some light-gray sand and silt. See analysis 96, Table 10	12	46
PERMIAN—Leonardian		
Wellington formation		
Shale, blue gray and yellow	4	50

97. *Sample log of test hole at the NE cor. sec. 33, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,176.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay, buff and light to dark gray	22	22
Sand, fine to coarse gravel	18	40
Gravel, fine; contains some sand, a little medium to coarse gravel, and blue-gray silt. See sample 97, Table 10	17	57
PERMIAN—Leonardian		
Wellington formation		
Shale, gray and gray green	3	60

99. *Sample log of test hole at the SW cor. sec. 29, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,181.2 feet.*

	Thickness, feet	Depth, feet
Road fill	2.5	2.5
QUATERNARY		
Alluvium		
Silt, clayey, gray and yellow gray	15.5	18
Gravel, fine to coarse, and sand. See analysis 99, Table 10	31	49
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray, alternating hard and soft beds,	11	60

102. *Sample log of test hole in the SE¼ SE¼ NE¼ sec. 19, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,180.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, gray, gray black, and yellow gray; contains few caliche nodules	10	10
Silt and clay, gray, green gray, and brown	15	25
Sand, fine to coarse	3	28
Silt, clayey, blue gray	2	30
Sand, fine to coarse, and soft gray silt; contains some fine to medium gravel between 40 and 50 feet	20	50
Sand, fine to coarse, and much fine to medium gravel; cemented by lime between 52 and 53 feet. See analysis 102, Table 10	6	56
PERMIAN—Leonardian		
Wellington formation		
Shale, laminated, light and dark gray	14	70

103. *Sample log of test hole in the SE¼ SE¼ SW¼ sec. 17, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,178.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, dark gray to yellow gray	24	24
Clay, silty, gray green to gray brown; contains many snails	6	30
Peat, brown	4	34
Sand, fine to coarse, and fine to coarse gravel	22	56
PERMIAN—Leonardian		
Wellington formation		
Shale, soft, light gray and gray	17	73

104. *Sample log of test hole in the SW¼ SW¼ NW¼ sec. 16, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,179.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay; gray black, yellow gray, and brown; contains few caliche nodules between 4 and 10 feet	20	20
Clay, light gray green, blue green, and dark gray	10	30
Sand, fine to coarse, and light-gray clay; contains some fine to medium gravel	14	44
Silt, gray and brown, and brown peat; contains much fine to coarse sand	6	50
Clay, sandy, light blue gray	5	55
Sand, fine to coarse, and fine to medium gravel. See analysis 104, Table 10	10	65
PERMIAN—Leonardian		
Wellington formation		
Shale, hard, light gray	3	68

105. *Sample log of test hole in the NE¼ NE¼ NW¼ sec. 16, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,177.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, sandy, yellow gray	19	19
Sand, fine, to medium gravel	8	27
Clay, silty, blue gray	3	30
Gravel, fine to medium; contains much sand and a little coarse gravel	7	37
Clay, silty, blue gray	2	39
Gravel, fine to coarse, and sand. See analysis 105, Table 10	17	56
PERMIAN—Leonardian		
Wellington formation		
Shale, alternating hard and soft beds	4	60

106. *Sample log of test hole in the SE¼ SE¼ NE¼ sec. 9, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,177.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay; gray and yellow gray; contains caliche nodules and some sand	20	20
Silt, clayey, buff and dark blue gray	3	23
Sand, fine, to coarse gravel. See analysis 106, Table 10,	21	44
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray	6	50

107. *Sample log of test hole in the NW¼ NE¼ NW¼ sec. 10, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,180.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, dark gray brown	4	4
Sand, fine to coarse, and buff silt; contains a little fine gravel	5	9
Silt, soft, gray and yellow gray	11	20
Silt, clayey, sandy, gray to gray green	10	30
Sand, fine, to coarse gravel	8	38
Silt, soft, gray and gray green	2	40
Sand, fine, to fine gravel	6	46
Silt, sandy, dark gray	4	50
PERMIAN—Leonardian		
Shale, hard, porous, gray white, and soft dark-gray and gray-green shale	10	60

109. *Sample log of test hole at the NW cor. SW¼ SW¼ sec. 4, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,182.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, dark gray to brown	3	3
Sand, fine, and silt, yellow gray	22	25
Clay, silty, blue gray	9	34
Gravel, fine to medium, and sand; partly cemented between 43 and 49 feet. See analysis 109, Table 10	15	49
PERMIAN—Leonardian		
Wellington formation		
Shale, gray white to gray green	11	60

112. *Sample log of test hole at the SW cor. sec. 6, T. 13 S., R. 1 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,183.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay; tan, buff, gray, and gray green	25	25
Silt and clay; sandy, blue gray	4	29
Sand, fine, to coarse gravel. See analysis 112, Table 10,	20	49
PERMIAN—Leonardian		
Wellington formation		
Shale, gray white and gray	4	53

113. *Sample log of test hole at the NE cor. sec. 2, T. 13 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,188.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay, gray, dark gray, buff, and gray green	25	25
Clay, silty, sandy, gray green	2.5	27.5

	Thickness, feet	Depth, feet
Silt, gray, and brown peat	1.5	29
Sand, fine, to medium gravel	10	39
Gravel, fine to medium, and sand; lime-cemented	2	41
Gravel, fine to coarse, and sand; in part loosely cemented. See analysis 113, Table 10	5	46
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray	4	50

114. *Sample log of test hole at the SW cor. sec. 25, T. 13 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,190.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, sandy, yellow gray	17	17
Sand and gravel, fine to coarse; partly cemented	13	30
Gravel, fine to coarse, and sand. See analysis 114, Table 10	30	60
PERMIAN—Leonardian		
Wellington formation		
Shale, soft, gray, gray green, and white	20	80

115. *Sample log of test hole at the NW cor. sec. 27, T. 13 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,222.0 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Sand, fine to medium	3	5
Silt, sandy, gray buff; contains some fine gravel in lower part	15	20
Sand, fine to medium, and some fine to medium gravel,	4	24
Silt, sandy, gray buff	6	30
Silt, clayey, gray	22	52
Gravel, fine to coarse, and much sand	7	59
PERMIAN—Leonardian		
Wellington formation		
Shale, light and dark blue gray	3	62

116. *Sample log of test hole at the SE cor. NE¼ sec 28, T. 13 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,208.9 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Sand, fine to coarse	2	4
Silt, dark gray to buff gray	21	25

	Thickness, feet	Depth, feet
Silt, sandy, soft, yellow gray	10	35
Silt, soft, blue gray	2	37
Gravel, fine to coarse; contains some sand	24	61
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray	9	70

117. *Sample log of test hole at the SW cor. sec. 27, T. 13 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,206.3 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	2	2
QUATERNARY		
Alluvium		
Silt, clayey, buff	23	25
Silt, sandy, yellow to tan buff	11	36
Sand and gravel, fine to coarse; contains little blue-gray silt. See analysis 117, Table 10	24	60
PERMIAN—Leonardian		
Wellington formation		
Shale, blue gray and gray white	10	70

119. *Sample log of test hole at the SW cor. NW¼ sec. 34, T. 13 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,203.1 feet.*

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY		
Alluvium		
Silt, sandy, soft, yellow gray	21	25
Silt, clayey, blue gray and buff; contains some sand and fine gravel	8	33
Gravel, fine to medium, and sand	2	35
Silt, blue gray; contains some sand and fine to coarse gravel	7	42
Sand and gravel, fine to coarse; contains a few pebbles in lower part	16	58
PERMIAN—Leonardian		
Wellington formation		
Shale, gray white to blue gray	10	68

120. *Sample log of test hole at the NE cor. sec. 4, T. 14 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,202.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay; yellow buff, light gray, and blue gray; contains caliche nodules in upper 10 feet and a little sand in lower part	32	32
Silt, soft, yellow	4	36
Sand and gravel, fine to coarse	24	60
Gravel, fine to very coarse; contains thin beds of clayey blue-gray silt. See analysis 120, Table 10	9	69
PERMIAN—Leonardian		
Wellington formation		
Shale, hard, gray white	1	70
Shale, light gray to blue gray	3	73

121. *Sample log of test hole at the NW cor. SW¼ sec. 3, T. 14 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,201.5 feet.*

	Thickness, feet	Depth, feet
Road fill and soil	3	3
QUATERNARY		
Alluvium		
Silt, soft, yellow gray	7	10
Silt, soft, yellow gray; contains a little fine to medium gravel and sand	7	17
Silt, carbonaceous, blue gray	10	27
Sand and gravel, fine to coarse; contains a little light-gray clay in lower part	38	65
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray	5	70

122. *Sample log of test hole at SE cor. sec. 4, T. 14 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,199.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay, gray, yellow gray, and blue gray	22	22
Sand and gravel, fine to medium	3	25
Silt, clayey, blue gray	1	26
Sand, fine, to coarse gravel. See analysis 122, Table 10,	31	57
PERMIAN—Leonardian		
Wellington formation		
Shale, soft, blue gray to gray white	13	70

124. *Sample log of test hole in the SW¼ SW¼ NW¼ sec. 10, T. 14 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,200.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, yellow gray	7	7
Sand, fine to medium, silty; contains some fine to medium gravel from 18 to 20 feet	13	20
Sand and gravel, fine	6	26
Silt, light tan	33	59
Sand, fine to coarse, a little fine gravel and caliche; hard, lime-cemented bed from 62.5 to 63 feet	6	65
PERMIAN—Leonardian		
Wellington formation		
Shale, light blue gray	5	70

125. *Sample log of test hole in the NW¼ SW¼ SW¼ sec. 10, T. 14 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1944. Surface altitude, 1,206.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, sandy, dark gray brown	4	4
Silt, clayey, gray to buff	16	20
Silt, sandy, light gray and buff	6	26
Sand, fine, to coarse gravel	7	33
Silt, yellow gray to light blue gray; contains some sand and gravel. Many fragments of limestone from 50 to 59 feet	26	59
PERMIAN—Leonardian		
Wellington formation		
Shale, silty, brown, blue gray, and gray	11	70

129. *Sample log of test hole in the SE¼ SW¼ SE¼ sec. 34, T. 13 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,220.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, light to dark gray and gray black	12	12
Clay, silty, light gray	2	14
Silt, blocky, light brown	6	20
PERMIAN—Leonardian		
Wellington formation		
Shale, clayey, light gray	10	30

130. *Sample log of test hole in the SW¼ NW¼ SW¼ sec. 35, T. 13 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,220.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, gray, gray black, and light brown	28	28
Clay, blue gray and green	14	42
Peat, brown	5	47
Sand, fine to medium, silty, brown	13	60
Silt, clayey, yellow gray to blue gray	16	76
Sand and gravel, fine to coarse; coarse gravel composed of limestone and siltstone pebbles	14.5	90.5
PERMIAN—Leonardian		
Wellington formation		
Shale, blue gray	4.5	95

132. *Sample log of test hole in the SW¼ SW¼ SE¼ sec. 26, T. 13 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,218.8 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY		
Alluvium		
Clay, silty, dark buff and blue gray to dark gray	35	36
Peat, sandy, brown	2.5	38.5
Clay, blue green and gray brown	1.5	40
Silt, sandy, light green	10	50
Sand, fine to coarse, some fine to medium gravel, and little light-gray silt; contains caliche and many limestone pebbles	30	80
Sand and gravel, fine to coarse; partly lime-cemented; gravels are composed chiefly of limestone, sandstone, and shale	12	92
PERMIAN—Leonardian		
Wellington formation		
Shale, sandy, light gray to blue gray	8	100
Shale, clayey, blue green, gray, and red brown	10	110

134. *Sample log of test hole at the NE cor. SE¼ sec. 26, T. 13 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,217.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, blocky, dark gray and yellow gray	10	10
Silt, sandy, gray to light brown gray	15	25
Silt, clayey, dark blue gray	3.5	28.5
Sand and gravel, fine to medium	2.5	31
Silt, clayey, gray green and gray	9	40

	Thickness, feet	Depth, feet
Sand and gravel, fine to coarse; gravel contains many limestone fragments	34.5	74.5
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray	5.5	80

135. *Sample log of test hole in the SE¼ NW¼ NW¼ sec. 25, T. 13 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,221.3 feet.*

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY		
Alluvium		
Silt, clayey, buff gray	23	27
Sand and gravel, fine; contains a little medium to coarse limestone gravel	20	47
PERMIAN—Leonardian		
Wellington formation		
Shale, hard, gray; contains a little pyrite	3	50

137. *Sample log of test hole in the NE¼ SW¼ SE¼ sec. 24, T. 13 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,226.6 feet.*

	Thickness, feet	Depth, feet
Soil, gray black	4	4
QUATERNARY		
Alluvium		
Silt, clayey, light to dark gray and yellow buff; contains a little sand and few fragments of sandstone and shale in lower part	14	18
Sand, fine, to coarse gravel	2	20
Silt and clay; yellow buff and dark blue gray; contains little sand	16	36
Sand, fine to coarse, brown, and yellow-gray silt	4	40
Gravel, fine to coarse, and a little gray sand; contains many pebbles of limestone and a few snails	17	57
PERMIAN—Leonardian		
Wellington formation		
Shale, light and dark gray	3	60

148. *Sample log of test hole at the SE cor. sec. 17, T. 14 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,231.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, light to dark gray, dark gray brown, tan, and yellow buff; contains sand near top and bottom,	19	19
Gravel, fine to medium, silty	1	20
Silt, clayey, sandy, yellow buff	10	30
Gravel, fine to very coarse; contains some sand and buff silt; gravel composed of Cretaceous sandstone and ironstone	10	40
PERMIAN—Leonardian		
Wellington formation		
Shale, red brown and gray green	5	45

149. *Sample log of test hole in the SW¼ SW¼ NW¼ sec. 16, T. 14 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,232.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, tan, light brown, and light gray; contains some sand in lower 10 feet	20	20
Sand and gravel, fine to coarse; composed of sandstone and ironstone grains and pebbles	25	45
Silt, clayey, buff to blue gray	9	54
Sand and gravel, fine to coarse, brown	10.5	64.5
PERMIAN—Leonardian		
Wellington formation		
Shale, light and dark blue gray	2.5	67

150. *Sample log of test hole at the NE cor. sec. 17, T. 14 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,232.8 feet.*

	Thickness, feet	Depth, feet
Soil, gray black	2	2
QUATERNARY		
Alluvium		
Silt, gray and brown	8	10
Silt, sandy, buff and gray	10	20
Silt, clayey, light to dark blue gray and buff gray	15	35
Silt and clay, sandy, blue green	3	38
Sand, fine, to very coarse gravel; contains thin lime-cemented layers; composed of Cretaceous sandstone and ironstone	28	66
PERMIAN—Leonardian		
Wellington formation		
Shale, laminated, blue gray	4	70

151. *Sample log of test hole at the NE cor. SE¼ sec. 8 T. 14 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,232.6 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Silt, sandy, light brown	3	5
Silt, clayey, light gray	15	20
Silt, clayey, sandy, blue gray	10	30
Clay, silty, green	5	35
Sand, fine, to coarse gravel, brown; composed of Cretaceous sandstone and ironstone grains and pebbles,	21	56
PERMIAN—Leonardian		
Wellington formation		
Shale, laminated, dark blue gray	4	60

152. *Sample log of test hole, in the SW¼ NW¼ NW¼ sec. 9, T. 14 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,233.9 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Silt, clayey, brown and light gray	6	8
Silt, sandy, yellow tan and light gray	15.5	23.5
Sand, fine, to coarse gravel, brown; composed of Cretaceous sandstone and ironstone grains and pebbles; contains a little yellow-tan silt in upper part	12.5	36
PERMIAN—Leonardian		
Wellington formation		
Shale, laminated, red brown	2	38

153. *Driller's log of test hole at the SW cor. sec. 2, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,221 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Clay	22	25
Sand and gravel	49	74
PERMIAN—Leonardian		
Wellington formation		
Shale	1	75

154. *Driller's log of test hole at the SE cor. SW¼ sec. 2, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,221 feet.*

	Thickness, feet	Depth, feet
Soil	3.5	3.5
QUATERNARY		
Alluvium		
Clay	22.5	26
Sand and gravel	39	65
Gravel	9	74
PERMIAN—Leonardian		
Wellington formation		
Shale	1	75

155. *Driller's log of test hole in the NE¼ NW¼ NE¼ sec. 11, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,221 feet.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Shale, soft (probably clay)	29	31
Sand and gravel	28	59
PERMIAN—Leonardian		
Wellington formation		
Shale	1	60

156. *Driller's log of test hole in the SW¼ SW¼ SE¼ sec. 1, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,218 feet.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Shale, soft	19	21
Sand and gravel	31	52
Shale	9	61
Gravel	6	67
Shale, blue	11	78
Gravel	10	88
PERMIAN—Leonardian		
Wellington formation		
Shale	1	89

157. *Driller's log of test hole in the SE¼ SW¼ SW¼ sec. 6, T. 14 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,217 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Shale, soft	2.5	2.5
Sand and gravel	87.5	90
PERMIAN—Leonardian		
Wellington formation		
Shale	1	91

158. *Driller's log of test hole in the SW¼ NW¼ SE¼ sec. 6, T. 14 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,217 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Sand	48	51
Gravel	18	69
PERMIAN—Leonardian		
Wellington formation		
Shale	1	70

159 *Driller's log of test hole at the NE cor. sec. 7, T. 14 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,213 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Shale, soft	24	27
Sand	24	51
Gravel	21	72
PERMIAN—Leonardian		
Wellington formation		
Shale	1	73

161. *Driller's log of test hole in the SW¼ SE¼ sec. 7, T. 14 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,219 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Shale, soft	14	17
Sand	5	22
Shale, soft	15	37

	Thickness, feet	Depth, feet
Sand	9	46
Gravel	11	57
PERMIAN—Leonardian		
Wellington formation		
Shale	1	58

162. *Driller's log of test hole in the NW¼ NW¼ SE¼ sec. 12, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,219 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Clay	19	22
Sand and gravel	55	77
PERMIAN—Leonardian		
Wellington formation		
Shale	1	78

164. *Driller's log of test hole in the NW¼ NW¼ NW¼ sec. 14, T. 14 S. R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,223 feet.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Shale, soft	51	53
Sand and gravel	44	97
PERMIAN—Leonardian		
Wellington formation		
Shale	1	98

165. *Driller's log of test hole in the NE¼ NE¼ NW¼ sec. 14, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,225 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Clay	15	18
Sand	62	80
Gravel	11	91
PERMIAN—Leonardian		
Wellington formation		
Shale	1	92

166. *Driller's log of test hole in the SE¼ SE¼ sec. 12, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,220 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Clay	14	14
Sand, fine	4	18
Sand, coarse	6	24
Clay	6	30
Clay and gravel	3	33
Sand and gravel	39	72
PERMIAN—Leonardian		
Wellington formation		
Shale	1	73

167. *Driller's log of test hole in the NE¼ NE¼ NE¼ sec. 13, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,222 feet.*

	Thickness, feet	Depth, feet
Soil	4	4
QUATERNARY		
Alluvium		
Clay	14	18
Sand, fine	7	25
Sand and gravel	15	40
Clay, blue	2	42
Sand and gravel	19	61
PERMIAN—Leonardian		
Wellington formation		
Shale	1	62

168. *Driller's log of well (city well 7) at Salina, Kansas, in the NW¼ SE¼ NE¼ sec. 13, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company, 1938.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Clay, sandy	3	5
Clay	6	11
Clay, sandy	5	16
Sand, coarse	9	25
Sand and gravel	5	30
Sand, coarse, and gravel	7	37
Sand, coarse, and gravel; contains clay balls	3	40
Sand, coarse, and gravel	29	69
Clay	?	

169. *Driller's log of well (city well 3) at Salina, Kansas, in the NW¼ NE¼ SW¼ sec. 13, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company, 1941.*

	Thickness, feet	Depth, feet
Soil, black	3	3
QUATERNARY		
Alluvium		
Clay	11	14
Clay, sandy	7	21
Sand, fine	7	28
Sand, coarse	2	30
Sand and gravel	11	41
Clay and fine sand	3	44
Sand and gravel	11	55
Clay, yellow, tough	5	60
Sand and gravel; contains much clay	5	65
Sand and gravel; clean	11	76
Clay, yellow	1	77
Sand and gravel	2	79
Clay, yellow and blue	3	82
Sand, fine	2	84
Sand, coarse	1	85
PERMIAN—Leonardian		
Wellington formation		
Clay (probably shale)	0.5	85.5

170. *Driller's log of well (city well 8) at Salina, Kansas, in the SE cor. SE¼ NW¼ sec. 13, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company, 1940.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Clay, sandy	16	19
Sand, fine	13	32
Sand, coarse, and gravel; contains little clay	4	36
Sand, coarse, and gravel	22	58
Sand, coarse, and gravel; contains clay balls	13	71
PERMIAN—Leonardian		
Wellington formation		
Shale	1	72

176. *Driller's log of test hole at the SW cor. sec. 14, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,228 feet.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Shale, soft	28	30
Sand and gravel	16	46
Shale, soft	17	63
Sand and gravel	9	72
PERMIAN—Leonardian		
Wellington formation		
Shale	1	73

177. *Driller's log of test hole at the NE cor. sec. 24, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,229 feet.*

	Thickness, feet	Depth, feet
Soil	4	4
QUATERNARY		
Alluvium		
Shale, soft	18	22
Sand and gravel	31	53
PERMIAN—Leonardian		
Wellington formation		
Shale	1	54

178. *Driller's log of test hole in the SE¼ SE¼ SW¼ sec. 18, T. 14 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,229 feet.*

	Thickness, feet	Depth, feet
Soil	4	4
QUATERNARY		
Alluvium		
Shale, soft	13	17
Sand and gravel	39	56
PERMIAN—Leonardian		
Wellington formation		
Limestone	2	58
Shale	1	59

179. *Driller's log of test hole at the SE cor. NE¼ sec. 24, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,231 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Clay	23	26
Sand, fine	4	30
Sand, coarse	10	40
Sand and gravel	8	48
Sand, coarse	4	52
Clay	1	53
PERMIAN—Leonardian		
Wellington formation		
Rock	1	54

180. *Sample log of test hole at the SW cor. SE¼ SE¼ sec. 22, T. 14 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,232.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, gray, gray black, and brown	10	10
Silt, light buff and light gray	18	28
Sand and gravel, fine to coarse; gravels derived from sandstone and shale	7	35
PERMIAN—Leonardian		
Wellington formation		
Shale, laminated, gray to blue gray	5	40

181. *Driller's log of test hole at the SW cor. sec. 23, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,234 feet.*

	Thickness, feet	Depth, feet
Soil	4	4
QUATERNARY		
Alluvium		
Clay	42	46
PERMIAN—Leonardian		
Wellington formation		
Shale	1	47

182. *Driller's log of test hole in the SE¼ SW¼ SW¼ sec. 23, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,230 feet.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Clay	33	35
Sand, fine	8	43
Clay, sandy	2	45
Sand, fine	3	48
Sand, coarse	8	56
Clay	15	71
Sand, coarse	5	76
PERMIAN—Leonardian		
Wellington formation		
Shale	1	77

183. *Driller's log of test hole at the SE cor. SW¼ sec. 23, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,234 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Shale, soft	35	38
Sand and gravel	4	42
PERMIAN—Leonardian		
Wellington formation		
Shale	1	43

184. *Driller's log of test hole in the NE¼ NE¼ sec. 26, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,235 feet.*

	Thickness, feet	Depth, feet
Soil	5	5
QUATERNARY		
Alluvium		
Shale, soft	19	24
Shale, sandy	18	42
Sand and gravel	20	62
PERMIAN—Leonardian		
Wellington formation		
Shale	1	63

185. *Driller's log of test hole in the NE¼ NW¼ sec. 25, T. 14 S., R. 3 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,232 feet.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Shale, soft	39	41
Sand and gravel	31	72
PERMIAN—Leonardian		
Wellington formation		
Shale	1	73

186. *Sample log of test hole at the SE cor. SW¼ SE¼ sec. 24, T. 14 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,232.0 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY		
Alluvium		
Silt, clayey, buff and brown; contains few caliche nodules	9	10
Silt, sandy, buff and gray; contains a little fine to medium gravel	17	27
Sand and gravel, fine to coarse	19	46
Silt, gray	8	54
PERMIAN—Leonardian		
Wellington formation		
Shale, green and gray	3	57

187. *Driller's log of test hole at the NW cor. sec. 30, T. 14 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,225 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Clay	30	33
Sand and gravel	22	55
PERMIAN—Leonardian		
Wellington formation		
Shale	1	56

188. *Driller's log of test hole in the SE¼ SW¼ SW¼ sec. 19, T. 14 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,229 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Clay	21	24
Sand, fine	5	29
Sand, coarse, and gravel	19	48
Clay	1	49
PERMIAN—Leonardian		
Wellington formation		
Rock	1	50

189. *Driller's log of test hole in the NW¼ NW¼ NE¼ sec. 30, T. 14 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the City of Salina. Surface altitude, 1,227 feet.*

	Thickness, feet	Depth, feet
Soil	3	3
QUATERNARY		
Alluvium		
Clay	12	15
Sand and gravel	40	55
PERMIAN—Leonardian		
Wellington formation		
Shale	1	56

193. *Sample log of test hole at the NW cor. NE¼ sec. 10, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,299.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Slope deposit		
Silt, clayey, light gray to gray	3	3
Silt, clayey, dark brown to red	5	8
PERMIAN—Leonardian		
Wellington formation		
Shale, yellow green, blue gray, and red brown	22	30

194. *Sample log of test hole at the NE cor. sec. 10, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,266.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, partly clayey, gray, yellow brown, dark brown, and tan	20	20
Silt, sandy, yellow buff	5	25

	Thickness, feet	Depth, feet
Sand and gravel, fine to very coarse; composed of sandstone and shale fragments	5	30
PERMIAN—Leonardian		
Wellington formation		
Shale, gray green and red brown	10	40

195. *Sample log of test hole at the NW cor. NE¼ sec. 11, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,250.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, gray black	3	3
Silt, clayey, light gray to gray, brown, and buff	23	26
Sand and gravel, fine to medium	2	28
PERMIAN—Leonardian		
Wellington formation		
Shale, light gray to gray	9	37

196. *Sample log of test hole at the NE cor. sec. 11, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,248.6 feet.*

	Thickness, feet	Depth, feet
Road fill and soil, gray black	2	2
QUATERNARY		
Alluvium		
Silt and clay; tan, brown, and gray	25.5	27.5
Sand, fine to coarse; contains some fine to medium gravel	2.5	30
Sand and gravel, fine to coarse	25.5	55.5
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray	4.5	60

197. *Sample log of test hole at the NW cor. NE¼ sec. 12, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,247.1 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Silt, clayey, gray	8	10
Sand, fine to coarse, soft gray silt, a little fine gravel,	7	17
Silt, soft, gray	5	22
Sand and gravel, fine	2	24
Silt, gray	6	30
Sand, fine to coarse	7.5	37.5
Silt, sandy, dark blue gray	14.5	52

	Thickness, feet	Depth, feet
Gravel, fine to very coarse; composed largely of sandstone, shale, and ironstone fragments; contains a little sand	6	58
PERMIAN—Leonardian		
Wellington formation		
Shale, silty, blue gray	12	70

198. *Sample log of test hole in the NE¼ NW¼ NE¼ sec. 12, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,247.7 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Silt, clayey, brown and brown gray	13	15
Sand, fine to medium, silty; contains many shells	14	29
Silt, gray	3	32
Sand and gravel, fine to coarse; contains some silty dark blue-gray clay	18	50
Gravel, fine to coarse, brown; contains many sandstone and ironstone fragments	10	60
Gravel, medium to very coarse; composed mostly of Cretaceous-derived material; contains some fine gravel, sand, and silt	11.5	71.5
PERMIAN—Leonardian		
Wellington formation		
Shale, blue gray, gray green, and brown	18.5	90

199. *Driller's log of test hole at the NW cor. SW¼ sec. 6, T. 15 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the U. S. Army, 1942.*

	Thickness, feet	Depth, feet
Soil	1	1
QUATERNARY		
Alluvium		
Clay, sandy	17	18
Clay, brown	10	28
Sand, medium coarse	2	30
Sand, coarse, and gravel	21	51
Sand, gravel, and clay balls	2	53
Clay, sandy, blue	5	58
Sand, silty, and brown chipped rocks (sandstone and ironstone)	2	60
PERMIAN—Leonardian		
Wellington formation		
Shale, blue	1	61

200. *Driller's log of well (camp well 5) at Camp Phillips, Kansas, in the NW¼ SW¼ SW¼ sec. 6, T. 15 S., R. 2 W., Saline County; drilled by the Layne-Western Company, 1943.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Clay, sandy	10	12
Sand, silty	11	23
Sand, fine to medium	7	30
Sand, medium to coarse, and gravel	15	45
Sand, coarse, and gravel; contains clay balls	13	58
Gravel, very coarse	2.5	60.5
PERMIAN—Leonardian		
Wellington formation		
Shale	?	

201. *Driller's log of well (camp well 1) at Camp Phillips, Kansas, at the NW cor. sec. 7, T. 15 S., R. 2 W., Saline County; drilled by the Layne-Western Company, 1942.*

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY		
Alluvium		
Clay	29	31
Sand, coarse, and gravel; contains clay balls	6	37
Sand, coarse, and gravel; contains a few boulders at base	22	59
Rock, chipped, brown, and streaks of yellow clay	4	63
PERMIAN—Leonardian		
Wellington formation		
Shale	2	65
Rock	?	

202. *Driller's log of well (camp well 2) at Camp Phillips, Kansas, in the NE¼ NE¼ NW¼ sec. 7, T. 15 S., R. 2 W., Saline County; drilled by the Layne-Western Company, 1942.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Clay, brown	19	19
Sand, coarse; contains clay streaks	6	25
Sand, coarse, and gravel	3	28
Clay, soft, blue	3	31
Sand and gravel	19	50
Sand, coarse, and gravel	7.5	57.5
PERMIAN—Leonardian		
Wellington formation		
Shale	3.5	61

203. *Driller's log of well (camp well 3) at Camp Phillips, Kansas, in the NE¼ NE¼ NE¼ sec. 7, T. 15 S., R. 2 W., Saline County; drilled by the Layne-Western Company, 1942.*

	Thickness, feet	Depth, feet
Soil	1	1
QUATERNARY		
Alluvium		
Clay	20	21
Sand, fine	5	26
Sand, gravel, and clay balls	3	29
Sand, gravel, and a few boulders	31	60
PERMIAN—Leonardian		
Wellington formation		
Shale	2	62

204. *Driller's log of well (camp well 4) at Camp Phillips, Kansas, in the NW¼ NW¼ sec. 8, T. 15 S., R. 2 W., Saline County; drilled by the Layne-Western Company, 1942.*

	Thickness, feet	Depth, feet
Soil	1	1
QUATERNARY		
Alluvium		
Clay	18	19
Sand, fine, clayey	3	22
Sand, gravel, and clay balls	11	33
Sand and gravel	17	50
PERMIAN—Leonardian		
Wellington formation		
Shale	5	55
Rock	?	

205. *Sample log of test hole in the NE¼ NE¼ NW¼ sec. 8, T. 15 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,301.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Slope deposits		
Silt, clayey, brown	3.5	3.5
Gravel, medium to very coarse; derived from Cretaceous material; contains silt, some fine gravel and sand	4.5	8
PERMIAN—Leonardian		
Wellington formation		
Shale, gray green and yellow green	4	12
Shale, red brown, yellow green, and blue gray; contains a little calcite	8	20

206. *Driller's log of test hole in the NW¼ SW¼ NW¼ sec. 7, T. 15 S., R. 2 W., Saline County; drilled by the Layne-Western Company for the U. S. Army, 1942.*

	Thickness, feet	Depth, feet
Soil	1	1
QUATERNARY		
Alluvium		
Clay, sandy	12	13
Clay, blue	12	25
Clay, brown	10	35
Clay and sand	5	40
Sand and gravel	18	58
Clay, sandy	1	59
PERMIAN—Leonardian		
Wellington formation		
Shale, blue	1	60

207. *Sample log of test hole in the SW¼ SW¼ SW¼ sec. 9, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,296.8 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Slope deposits		
Silt, clayey, light gray green; contains few caliche nodules	2	4
Silt, clayey, brown and yellow buff	6	10
Volcanic ash, white	2	12
Clay, silty, yellow and dark gray	15	27
PERMIAN—Leonardian		
Wellington formation		
Shale, red brown and gray green	3	30

208. *Sample log of test hole at the NW cor. sec. 16, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,287.2 feet.*

	Thickness, feet	Depth, feet
Road fill	1.5	1.5
QUATERNARY		
Slope deposits		
Silt, gray, brown, and yellow tan; contains few limonite nodules	13.5	15
Silt, yellow gray; contains some sand and a little gravel	12	27
Gravel, fine to coarse; derived from sandstone and shale	4	31
PERMIAN—Leonardian		
Wellington formation		
Shale, red brown and gray green	4	35

209. *Sample log of test hole in the SW¼ NW¼ NW¼ sec. 16, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,277.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, dark gray; contains some fine to coarse gravel and sand	5	5
Silt, clayey, blue gray, green gray, and yellow brown,	7	12
Silt, sandy, limonitic, yellow brown	3	15
Sand, fine to medium, and yellow-buff silt	5	20
Silt, sandy, yellow buff	5.5	25.5
Sand, fine, to very coarse brown gravel	9.5	35
Silt, sandy, buff	4	39
Silt, sandy, and gravel, fine to medium; grades downward to sandy blue-gray silt, interbedded with sand and fine to medium gravel	14	53
PERMIAN—Leonardian		
Wellington formation		
Shale, blue green and red brown	7	60

211. *Sample log of test hole at the SW cor. sec. 16, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,269.1 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY		
Alluvium		
Silt and clay; tan, gray brown, and yellow buff; contains some fine sand in lower part	16	17
Sand, fine, to very coarse gravel; derived from Creaceous and Permian rocks; contains yellow and light-gray silt	14	31
PERMIAN—Leonardian		
Wellington formation		
Shale, red brown and gray green	9	40

212. *Sample log of test hole in the NW¼ NE¼ NW¼ sec. 25, T. 15 S., R. 4 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,292.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, gray and gray black	6	6
Silt, clayey, yellow and yellow tan; contains sand, a few caliche nodules and some medium to coarse gravel	19	25
Gravel, fine to coarse, silty	2.5	27.5
Silt, clayey, sandy, yellow gray and gray	10.5	38

	Thickness, feet	Depth, feet
Sand and gravel, fine to coarse; contains few soft limonitic concretions	5	43
Silt, yellow buff and gray	7	50
Silt and sand, medium, yellow-buff; contains a little medium to coarse gravel	3.5	53.5
PERMIAN—Leonardian		
Wellington formation		
Shale, gray green and purple	2.5	56

213. *Sample log of test hole at the NE cor. sec. 25, T. 15 S., R. 4 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,280.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, tan and light to dark gray	20	20
Silt and clay, sandy, tan gray; contains some caliche,	14.5	34.5
Sand, fine to very coarse gravel	3	37.5
Silt, sandy, buff and gray	9.5	47
Sand, fine, to very coarse brown gravel; composed of shale and sandstone fragments	3	50
PERMIAN—Leonardian		
Wellington formation		
Shale, red brown	3	53

214. *Sample log of test hole at the NE cor. sec. 30, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,273.6 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY		
Alluvium		
Silt, light gray, gray and yellow brown	13	15
Silt, sandy, yellow buff	18.5	33.5
Sand and gravel, medium to coarse; composed of sandstone, ironstone, and "mortar bed" pebbles	5.5	39
Silt, buff	5	44
Sand and gravel, fine to coarse; composed of sandstone, ironstone, and "mortar bed" pebbles	3	47
PERMIAN—Leonardian		
Wellington formation		
Shale, red and gray green	3	50

215. *Sample log of test hole at the NW cor. sec. 28, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,267.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay, light to dark gray and blue gray	17	17
Silt, tan; contains a little medium to coarse gravel between 18 and 20 feet	13	30
Silt, dark buff; contains some sand and fine to coarse gravel	8	38
Clay, silty, blue gray, interbedded with some fine to coarse sand and fine to medium gravel	16	54
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark blue gray	2	56

216. *Sample log of test hole at the NE cor. sec. 32, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,277.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, light to dark gray, tan, and brown; contains caliche	25	25
Sand, fine to coarse gravel; brown; composed of material derived from the Cretaceous and Permian	3	28
PERMIAN—Leonardian		
Wellington formation		
Shale, green and red brown	2	30

217. *Sample log of test hole at the SW cor. sec. 22, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,264.2 feet.*

	Thickness, feet	Depth, feet
Soil, dark gray-brown	2	2
QUATERNARY		
Alluvium		
Silt and clay; green gray, yellow brown, and gray brown	8	10
Silt, light yellow tan	6	16
Gravel, coarse; composed of shale, sandstone, and caliche pebbles; contains much yellow-tan silt	1	17
PERMIAN—Leonardian		
Wellington formation		
Shale, blocky, gray green	3	20

218. *Sample log of test hole at the SW cor. sec. 23, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,266.6 feet.*

	Thickness, feet	Depth, feet
Soil, gray brown	1.5	1.5
QUATERNARY		
Alluvium		
Silt and clay, tan and light gray	18.5	20
Clay, silty, tan; contains a little fine to medium gravel, and caliche nodules	10	30
Silt, greenish tan; contains sand, gravel and fragments of snails	10	40
Sand, fine, to medium gravel; composed of Permian and Cretaceous fragments	2	42
PERMIAN—Leonardian		
Wellington formation		
Shale, light green, gray, and blue gray	14	56
Shale, light to dark gray, and thin beds of hard limestone	4	60

219. *Sample log of test hole at the SE cor. sec. 23, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,277.7 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
TERTIARY AND/OR QUATERNARY		
Slope and terrace deposits		
Silt, clayey, tan brown and yellow gray; contains fine sand in lower part	4	5
Gravel, fine to coarse, silty, sandy; derived from Permian and Cretaceous material; hard, lime-cemented beds occur between 8 and 10 feet and 14 and 15 feet	10	15
Clay, silty, sandy, yellow gray; contains a little fine to coarse gravel	11	26
Gravel, fine to coarse; composed of material derived from Permian and Cretaceous rocks; contains some sand and silt	4	30
Clay, light gray to blue gray	10	40
PERMIAN—Leonardian		
Wellington formation		
Shale, blue green and red brown	5	45

220. *Sample log of test hole in the SE¼ SW¼ SW¼ sec. 24, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,256.5 feet.*

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY		
Alluvium		
Silt, sandy, buff; contains caliche	6	10
Silt and clay, gray, gray buff, and blue gray	20	30
Silt and clay, sandy, blue gray	7	37
Sand, fine, to gravel, coarse	20	57
PERMIAN—Leonardian		
Wellington formation		
Shale, hard, light to dark gray	3	60

221. *Sample log of test hole at the SW cor. SE¼ sec. 24, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,267.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay; gray, blue green, and green gray; contains a few snails near base	40	40
Sand, fine, to coarse gravel; contains a little clay in upper part	22	62
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark blue gray; contains much gypsum between 66 and 70 feet	8	70

222. *Sample log of test hole at the NE cor. sec. 25, T. 15 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,263.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, clayey, brown gray to gray buff	10	10
Silt, sandy, gray buff; contains caliche	16	26
Silt and clay, light green gray mottled yellow brown,	5	31
Sand, fine, to gravel, coarse; contains a little silt in upper part	26	57
Gravel, fine to very coarse; composed of limestone, sandstone, and shale fragments; contains some sand and silt	5	62
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark blue gray	3	65

223. *Sample log of test hole at the SE cor. SW¼ sec. 19, T. 15 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,266.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, light gray	10	10
Silt, sandy, light gray to gray	15	25
Sand, fine, to coarse gravel; gravel composed mostly of shale fragments	10	35
Sand, fine, to very coarse granitic gravel	19.5	54.5
Silt and clay; sandy, yellow gray	8.5	63
Gravel, fine to very coarse; composed of shale, limestone, and sandstone fragments; contains some sand and clay	4.5	67.5
Clay, silty, blue gray	10.5	78
Sand, fine, to coarse gravel	7	85
Silt and clay; dark gray to blue gray	9	94
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark blue gray	6	100

224. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 19, T. 15 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,268.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, sandy, yellow gray; contains much fine to medium gravel at bottom	30	30
Sand, fine, to coarse gravel; mostly granitic gravel	8	38
Silt, clayey, blue gray	2.5	40.5
Sand, fine, to coarse gravel	13.5	54
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray	4	58

225. *Sample log of test hole in the SE¼ SW¼ SW¼ sec. 20, T. 15 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,263.3 feet.*

	Thickness, feet	Depth, feet
Soil, dark gray brown	2	2
QUATERNARY		
Alluvium		
Silt, clayey, gray	8	10
Silt, sandy, yellow gray and gray; contains some gravel,	10	20
Silt, sand, and gravel	10	30
Sand and gravel, fine; contains a little medium to coarse gravel; composed partly of material derived from Cretaceous and Permian rocks	13	43

	Thickness, feet	Depth, feet
Silt, sandy, buff and gray	3	46
Sand, fine, to gravel, coarse; mostly granitic	6.5	52.5
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray	2.5	55

228. *Sample log of test hole in the NE¼ NE¼ NW¼ sec. 23, T. 16 S., R. 3 W., drilled by the State Geological Survey, 1943. Surface altitude, 1,320.2 feet.*

	Thickness, feet	Depth, feet
TERTIARY AND/OR QUATERNARY		
Slope and terrace deposits		
Clay, silty, red brown, gray, and yellow buff; contains ironstone pebbles in upper part	7	7
Silt, clayey, yellow buff	6	13
Gravel, fine to coarse, silty, brown; composed of angular sandstone and ironstone fragments; contains some fine sand	6	19
Silt, sand, and fine to coarse gravel	7	26
PERMIAN—Leonardian		
Wellington formation		
Shale, gray, blue gray, green gray, and red brown	14	40

229. *Sample log of test hole in the NE¼ NW¼ NE¼ sec. 23, T. 16 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,287.7 feet.*

	Thickness, feet	Depth, feet
TERTIARY AND/OR QUATERNARY		
Slope and terrace deposits		
Silt, sandy, gray and red brown	11	11
Clay, silty, sandy, yellow tan	4.5	15.5
Gravel, fine to coarse, silty; composed of material derived from Permian and Cretaceous rocks	5.5	21
PERMIAN—Leonardian		
Wellington formation		
Shale, red brown and gray green	3	24

230. *Sample log of test hole in the NE¼ NE¼ sec. 23, T. 16 S., R. 3 W., drilled by the State Geological Survey, 1943. Surface altitude, 1,271.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, sandy, gray	1.5	1.5
Silt, clayey, gray black	5.5	7
Silt, sandy, gray	9.5	16.5
PERMIAN—Leonardian		
Wellington formation		
Shale, gray, yellow brown, blue gray, and red brown	3.5	20

231. *Sample log of test hole in the NW¼ NW¼ NW¼ sec. 24, T. 16 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,286.9 feet.*

	Thickness, feet	Depth, feet
Road fill	1.5	1.5
TERTIARY AND/OR QUATERNARY		
Slope and terrace deposits		
Sand, fine to medium, yellow gray	2.5	4
Silt, sandy, gray; contains a little fine to medium gravel	6	10
Sand, fine, to coarse gravel; silty; gravel composed of materials derived from Permian and Cretaceous rocks	6	16
PERMIAN—Leonardian		
Wellington formation		
Shale, red and green gray	4	20

232. *Sample log of test hole in the SW¼ SE¼ SW¼ sec. 13, T. 16 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,282.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay; tan to gray	5	5
Clay, silty, sandy, light to dark gray	5	10
Silt, clayey, gray	10	20
Silt, sandy, gray and blue gray; contains few snail shells	14	34
Sand and gravel, fine to coarse; light gray	13	47
Silt, sandy, gray and blue gray	5	52
Sand and gravel, fine to coarse; light gray	21.5	73.5
PERMIAN—Leonardian		
Wellington formation		
Shale, dark blue gray	4.5	78

233. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 13, T. 16 S., R. 3 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,282.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt and clay; gray, gray brown and blue gray	35	35
Sand, fine, to gravel, coarse; silty	24	59
Silt, sandy, gray	3	62
Gravel, fine to coarse; contains a little sand; gravel contains many Permian and Cretaceous fragments,	6	68
PERMIAN—Leonardian		
Wellington formation		
Shale, dark gray	2	70

234. *Sample log of test hole in the SW¼ SE¼ SW¼ sec. 18, T. 16 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,279.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY		
Alluvium		
Silt, sandy, gray brown to yellow gray	10	10
Silt, sandy, gray; contains sand and gravel in lower part,	10	20
Sand, fine to medium gravel; silty; contains a few pebbles	16	36
Clay, sandy, blue gray; contains a few pebbles	4	40
Sand, fine, to coarse gravel	49.5	89.5
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark gray	4.5	94

235. *Sample log of test hole at the NW cor. NE¼ sec. 19, T. 16 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,279.9 feet.*

	Thickness, feet	Depth, feet
Soil, gray black	3	3
QUATERNARY		
Alluvium		
Silt and clay; yellow gray	13	16
Sand and gravel, fine	2	18
Silt, sandy, light brown	4	22
Sand, fine to coarse, grading downward to fine to coarse gravel	8	30
Sand, fine, to coarse gravel; silty; contains a few lenses of clay	56	86
PERMIAN—Leonardian		
Wellington formation		
Shale, light to dark blue gray	4	90

236. *Sample log of test hole in the SE¼ NE¼ NE¼ sec. 19, T. 16 S., R. 2 W., Saline County; drilled by the State Geological Survey, 1943. Surface altitude, 1,287.9 feet.*

	Thickness, feet	Depth, feet
Soil, gray brown	2	2
QUATERNARY		
Alluvium		
Silt and clay; light to dark gray and light brown	36	38
Sand, fine, to coarse gravel	18	56
PERMIAN—Leonardian		
Wellington formation		
Shale, hard, light and dark blue gray	4	60

REFERENCES

BAILEY, E. H. S., *1902*, Special report on mineral waters: Kansas Univ. Geol. Survey, vol. 7, pp. 1-343, pls. 1-38.

HAWORTH, ERASMUS, *1897*, Physiography of western Kansas: Kansas Univ. Geol. Survey, vol. 2, pp. 11-49, fig. 1, pls. 1-8.

JEWETT, JOHN M., *1941*, The geology of Riley and Geary Counties, Kansas: Kansas Geol. Survey, Bull. 39, pp. 1-164, figs. 1, 2, pls. 1-17.

LOHMAN, S. W., ET AL., *1942*, Ground-water supplies in Kansas available for national defense industries: Kansas Geol. Survey, Bull. 41, pt. 2, pp. 21-68, figs. 1-3, pls. 1-4.

MOORE, R. C., *1918*, The environment of Camp Funston: Kansas Geol. Survey, Bull. 4, pp. 1-81, figs. 1-37, pls. 1-11.

———, *1920*, Oil and gas resources of Kansas: Kansas Geol. Survey, Bull. 6, pt. 2, pp. 1-98, figs. 1-12, pls. 1-17.

———, *1940*, Ground-water resources of Kansas: Kansas Geol. Survey, Bull. 27, pp. 1-112, figs. 1-28, pls. 1-34.

PARKER, H. N., *1911*, Quality of the water supplies of Kansas; U. S. Geol. Survey Water-Supply Paper 273, pp. 1-375, map.

PROSSER, C. S., *1895*, Classification of the Upper Paleozoic rocks of central Kansas: Jour. Geol., vol. 3, pp. 682-705, 764-800.

ST. JOHN, O. H., *1883*, Sketch of the geology of Kansas: Kansas State Board of Agriculture, 3d Bienn. Rept., vol. 8, pp. 571-599.

SCOFIELD, C. S., *1933*, Quality of irrigation waters: California Dept. of Public Works, Div. of Water Resources, Bull. 40, pp. 1-95, pls. 1, 2.

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