STATE GEOLOGICAL SURVEY OF KANSAS, BULLETIN 38
1941 REPORTS OF STUDIES, PART 9, PAGES 237-260, PLS. 1-3, FIGS. 1-6
SEPTEMBER, 10, 1941

RECONNAISSANCE OF GROUND-WATER RESOURCES IN ATCHISON COUNTY, KANSAS

By JOHN C. FRYE

CONTENTS

ILLUSTRATIONS

Abstract

A severe drought during the fall and winter of 1939-40 gave rise to a shortage of water supplies in parts of eastern Kansas. In an attempt to locate areas in which additional supplies could be obtained from wells, a brief investigation was undertaken in Atchison county by the Federal and State geological surveys in cooperation with the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture.

The bedrock of the county consists of shale, limestone, sandstone, and a few thin coal beds. It is Carboniferous in age, and is all included within the Virgil series of the Pennsylvanian. The bedrock yields small supplies of ground water locally. Pleistocene deposits are widespread in this area and include Nebraskan and Kansan till, Aftonian interglacial deposits, and loess. These deposits are the most widely used source of ground water in Atchison county. Although most of the wells in the county are relatively shallow nonartesian wells, a few flowing artesian wells have been obtained in the Pleistocene deposits along the Delaware valley. As a result of this brief investigation certain areas are here designated in which additional ground-water supplies probably can be obtained, and the construction of additional stock ponds is recommended in other parts of the county.

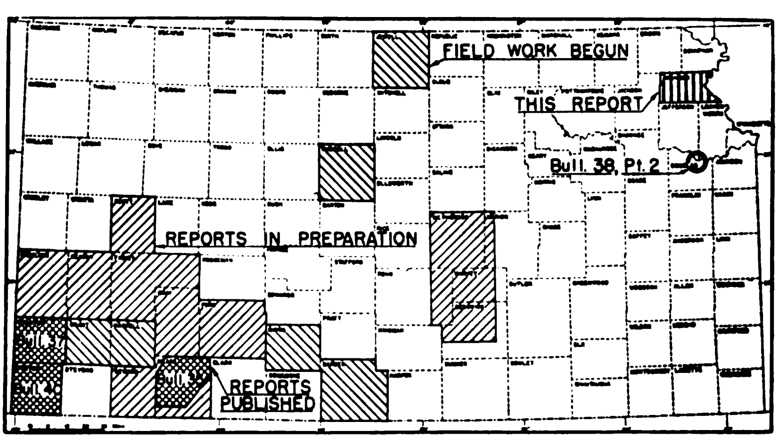

Figure 1. Map of Kansas showing area discussed in this report, and other areas for which cooperative ground-water reports have been published or are in preparation.

INTRODUCTION

A period of prolonged drought during the winter and spring of 1939-40 gave rise to a serious deficiency in the water supplies in parts of eastern Kansas. As a result of this shortage of domestic and stock water, W. A. Meyle, the agricultural agent of Atchison county, requested of the State Geologist that an investigation be made in Atchison county in an attempt to locate areas in which additional ground-water supplies could be obtained. In June, 1940, a brief investigation was undertaken jointly by the Geological Survey, United States Department of the Interior, and the State Geological Survey of Kansas, with the cooperation of the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture. This work was done under the general administration of R. C. Moore and K. K. Landes, State geologists, and O. E. Meinzer, geologist in charge of the Division of Ground Water of the Federal survey; and under the direct supervision of S. W. Lohman, Federal geologist in charge of ground-water investigations in Kansas. Approximately one week was spent by the writer in Atchison county in June, 1940, and an additional three days in April, 1941. The area studied is shown in figure 1.

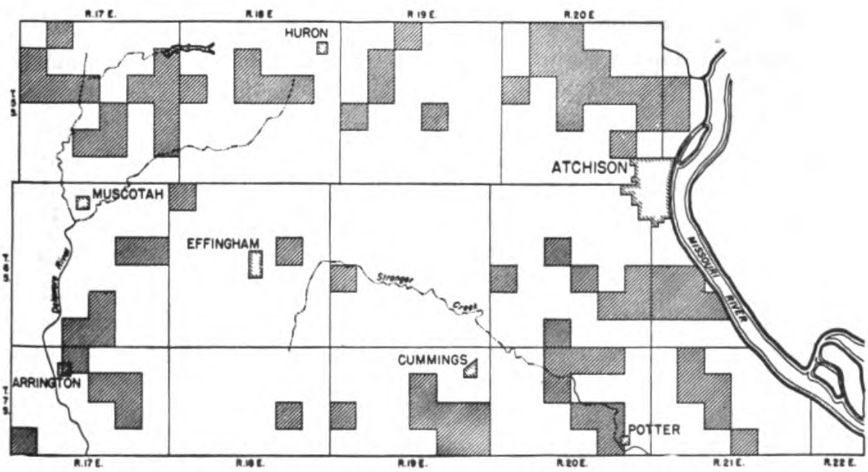

Figure 2. Map of Atchison county showing sections in which it was necessary to haul water during the spring of 1940.

A map of the county (fig. 2) showing the sections in which it was necessary for the residents to haul some water for domestic or stock use during the spring of 1940 was compiled by W. A. Meyle on the basis of questionnaires and personal interviews. Although the immediate problem of water supply in the county has been alleviated by precipitation, which was greater than normal during the fall and winter of 1940-41, it is believed that the following data will be of use to the residents of the county by indicating those areas in which additional ground-water supplies are most readily obtainable for use in future need.

In 1934 a period of severe drought affected this area, and at that time the Kansas Emergency Relief Committee made a brief investigation of the ground-water resources of Atchison and other counties under the direction of Ogden S. Jones, geologist. During the course of that work there were fourteen construction projects in this county, comprising nine dug wells, one of which is shown in plate 3B, and five developed springs. The wells were all 15 feet in diameter and were dug in the alluvium of small streams. The development of the springs consisted of building basins at the spring sites and piping the water from these basins to stock tanks situated along roads. At the completion of this work a typewritten report for each county was prepared that contained some reported data on the fluctuations of the water table in addition to a stratigraphic section for the county, logs of test holes, and descriptions of the wells that were constructed.

The field work for the present report consisted of the examination of existing wells and springs and conversations with well owners; the study of exposures of Pennsylvanian, Tertiary (?), and Pleistocene rocks; and observations of the topography and surficial materials in areas suitable for the construction of stock ponds. W. A. Meyle, R. P. Keroher, C. W. Hibbard, and H. T. U. Smith each spent one or more days in the field with me. Four test holes were drilled in Atchison county in July, 1940, by Ellis D. Gordon, driller, Perry McNally, sampler, and Laurence P. Buck, helper, using a rotary drilling machine owned by the State and Federal Geological Surveys. Mechanical analyses of samples from the test holes were made in the laboratory by Charles C. Williams.

Thanks and appreciation are expressed to the many residents of Atchison county who supplied information and aided in the collection of field data. Special thanks are due W. A. Meyle, county agent; and Tom Lockwood, driller, who supplied many logs of water wells and drilling information in the county. The manu-

script for this report has been reviewed critically by S. W. Lohman, O. E. Meinzer, R. C. Cady, George S. Knapp, and R. C. Moore.

GEOLOGIC FORMATIONS

Rocks exposed in Atchison county consist of Carboniferous limestone, shale, and sandstone; Tertiary(?) stream gravels; Pleistocene till, outwash, lacustrine silts, and loess; and Recent alluvium. The physical character and water supply of these various rocks are discussed briefly.

PENNSYLVANIAN ROCKS

Character and subdivisions.—Pennsylvanian rocks underlie all of Atchison county and either crop out at the surface or are buried beneath a thin cover of Pleistocene deposits. These rocks are all included within the Virgil series, as classified by the Kansas Geological Survey, and comprise the upper part of the Douglas group, the Shawnee group, and the lower part of the Wabaunsee group. The rocks dip gently westward although there are local deviations from this regional dip. The stratigraphy of these beds has been described in detail by Moore (1936), and much of the following discussion is quoted from that report.

The Douglas group crops out only along the eastern edge of the county and is especially well exposed along the west bluff of Missouri river. It underlies the surface of the eastern part of the county at depths of 300 feet or less. The rocks of this group have been described by Moore (1936, p. 145) as follows:

> The Douglas group comprises the lowermost part of the Virgil series, extending from the disconformity that marks the lower boundary of the series to the base of the Oread limestone. . . .
>
> As thus defined, the Douglas group consists primarily of clastic deposits in which fairly thick bodies of massive or crossbedded sandstone, shaly sandstone, and sandy shale are prominent. The group contains two persistent, though rather thin limestone beds, the Haskell and Westphalia limestones, in the middle or lower part, and there are some coal beds. Locally, especially at the base of the group, there are deposits of conglomerate.

The thickness of this group in Atchison county is 150 to 200 feet.

The Shawnee group, which overlies the Douglas group, crops out in the eastern third of the county and underlies the central part of the county at depths of only a few hundred feet. The rocks of this group have been described by Moore (1936, pp. 159-160) as follows:

The Shawnee group is now redefined to include the beds from the base of the Oread limestone to the top of the Topeka limestone. Thus limited, the group is a very well differentiated segregation of beds in which thick limestones and a distinctive type of cyclic sedimentation are prominent features. In tracing these beds underground it is found that the limestones converge to form a thick body of nearly solid limestone that is readily separated from the clastic Douglas beds below and from the shaly strata and thin limestones of the Wabaunsee group above. . . .

The Shawnee group contains the following formations, named in upward order: Oread limestone [pl. 1A], Kanwaka shale, Lecompton limestone, Tecumseh shale, Deer Creek limestone, Calhoun shale, and Topeka limestone.

The maximum thickness of the Shawnee group in Atchison county probably does not exceed 300 feet.

Rocks of the Wabaunsee group crop out or underlie the surface at depths of 150 feet or less over the western two-thirds of Atchison county. The rocks comprising this group have been described by Moore (1936, pp. 200-202) as follows:

The Wabaunsee group . . . . comprises the beds above the top of the Topeka limestone and below the unconformity at the base of the Towle shale, which is regarded as marking the boundary between rocks classed as Pennsylvanian and Permian in the northern Mid-Continent region. . . . . Shale is relatively much more prominent in the Wabaunsee group than in adjoining parts of the geologic section. Much of the shale is sandy and at several horizons there are extensive sandstones. The Wabaunsee limestones are very persistent but are uniformly thin, the average thickness of individual members being about 2 feet. A distinctive feature of the Wabaunsee group is the character of the cyclic sedimentary succession, which shows regularly alternating nonmarine and marine units in which a grouping of cyclothems in megacyclothems is not evident. This serves especially to set the Wabaunsee beds apart from those of the Shawnee group. . . .

The thickness of the Wabaunsee group in Kansas shows little variation although the thickness of several of its contained formations shows a considerable range. Excepting places where the Indian Cave sandstone at the base of the Big Blue series cuts out the upper beds, the thickness of the Wabaunsee group is about 500 feet. Where the channel sandstone just mentioned occurs, the thickness of the group is reduced 80 to 125 feet. . . .

As here classified, the Wabaunsee group contains the following formations, named in upward order: Severy shale, Howard limestone, White Cloud shale, Happy Hollow limestone, Cedar Vale shale, Rulo limestone, Silver Lake shale, Burlingame limestone, Soldier Creek shale, Wakarusa limestone, Auburn shale, Reading limestone, Harveyville shale, Elmont limestone, Willard shale, Tarkio limestone, Pierson Point shale, Maple Hill limestone, Table Creek shale, Dover limestone, Dry shale, Grandhaven limestone, Freidrich shale, Jim Creek limestone, French Creek shale, Caneyville limestone, Pony Creek shale, and Brownville limestone.

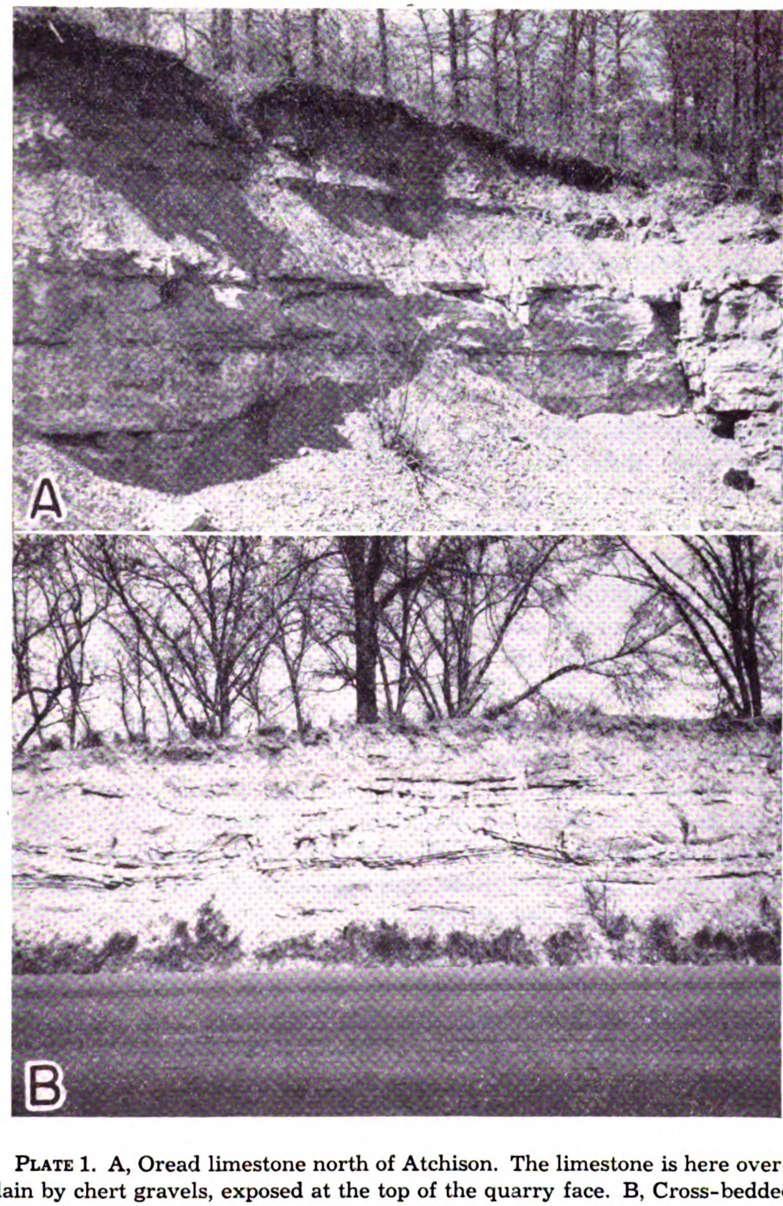

Plate 1. A, Oread limestone north of Atchison. The limestone is here overlain by chert gravels, exposed at the top of the quarry face. B, Cross-bedded Pennsylvanian sandstone 3 miles north of Muscotah.

Only the lower part of this group, up to and including the Tarkio limestone, occurs in Atchison county.

Water supply.—The various lithologic types included within the Pennsylvanian rocks of this county contrast markedly in their ability to transmit and yield water to wells. The most abundant bedrock supplies in the county are obtained from sandstone (pl. 1B). As stated above, sandstone occurs in the lower part of the Douglas group, particularly in the Stranger formation; in the middle part of the Shawnee group; and at several stratigraphic positions in the Wabaunsee group. Although the sandstone of the Stranger formation is the thickest and most persistent of the sandstones of the Virgil series underlying Atchison county, it is of very little value as a source of domestic and stock water because it is deeply buried in most places. Except along the valleys of some of the streams in the extreme eastern part of the county, it is necessary to drill through 200 feet or more of shale and limestone in order to penetrate this water-bearing sandstone, and in the central and western parts of the county it is much deeper. The quality of the water contained in it probably becomes progressively poorer westward, moreover, and even if a deep well were drilled into the Stranger sandstone, the water obtained probably would be too salty for ordinary use. The sandstones of the Shawnee and Wabaunsee groups, although thinner and much less persistent than the Stranger, may be encountered at shallower depths in central and western Atchison county, and in most places where penetrated they contain water of much better quality. These upper sandstones are in large part channel sandstones, however, so that their lateral extent, thickness, and permeability generally can be determined only by test drilling.

Limestone is next in importance as a water producer among the Pennsylvanian rocks of Atchison county. Limestone is composed dominantly of calcium carbonate, a substance that is soluble even in very weak acid solutions, and in many places percolating waters containing carbonic acid have dissolved passageways along joints, bedding planes, and fractures in this rock. The occurrence of water in the limestones of Kansas has been summarized by Moore (1940, p. 18) as follows:

> In limestone, the water is mostly confined to certain passageways that have been dissolved along joint cracks and bedding planes. A limestone well may obtain little water if it happens to be drilled in a part of the rock that lacks

these crevices, whereas a nearby well in the same rock may yield abundant water because it intersects water-bearing channels [fig. 3]. Water production from some wells penetrating limestone has been greatly increased by treating the well with hydrochloric acid (30 or more gallons), so as to open or enlarge the passageways for water leading into the well.

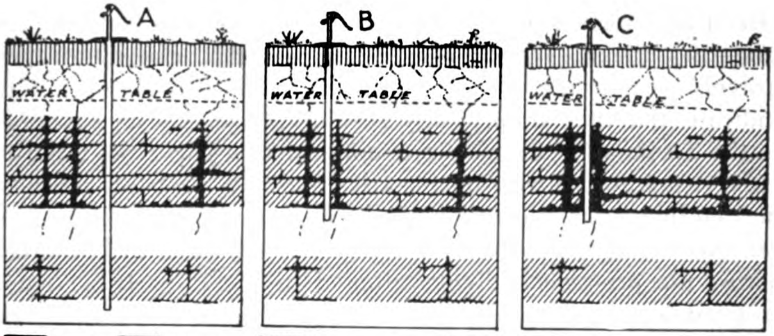

FIGURE 3. Wells drilled to obtain water from limestone. A, The well shown in the diagram at left happened to miss water-filled openings in the upper limestone and was drilled into a lower bed, but was unsuccessful in obtaining a good supply of water. B, The well shown in the middle diagram was located in a fortunate manner to intersect good water-bearing fissures in the limestone; this well has a fairly satisfactory yield. C, The right-hand figure shows the effect of acidizing the well represented in the middle diagram; the openings in the limestone have been enlarged by the acid and admit water to the well much more freely. (After Moore).

Water is obtained from limestone in Atchison county by many wells and springs. The most prevalent type of spring occurs where weathered and fractured limestone underlies the Pleistocene deposits and serves as a natural infiltration gallery. Water from the glacial deposits percolates slowly into the crevices in the limestone over a large area and moves by gravity through these small channelways until it emerges at the surface along a hillside or creek bank. Water obtained from limestone generally is hard and somewhat mineralized.

Shale is the most abundant rock in the county and is also the poorest water bearer. Although a few wells may obtain very meager supplies from shale, for the most part the shale does not yield water to wells.

Locally a few thin coal beds within the Pennsylvanian may yield meager supplies of water of poor quality.

Tertiary (?) Rocks

Character.—At many places in Atchison county poorly sorted gravel, composed predominantly of chert pebbles, overlies the bedrock. Todd (1920) referred to these gravels as preglacial and described a section north of Atchison in which this chert overlies the Oread limestone of the Shawnee group, as shown in plate 1A, and underlies Pleistocene deposits. The fact that elsewhere these gravels are overlain by early Pleistocene blue-gray Nebraskan till indicates that they are probably Tertiary in age. The chert pebbles in the Tertiary (?) deposits probably came in part from the Flint Hills region to the west of this area, and they probably were deposited by streams flowing toward the east at a time before Kansas river had developed a through-flowing eastward drainage across the pre-glacial divide situated in the Flint Hills region. Isolated deposits of similar gravels occur at many places in eastern Kansas (Todd, 1918, pp. 190-191) and may be contemporary with similar beds in the Emma Creek formation of central Kansas (Lohman and Frye, 1940, pp. 849-851).

Water supply.—The Tertiary (?) gravels occur only as thin local deposits and hence are not an important source of ground water. Several springs in the eastern part of the county issue from the base of these gravels where they overlie impervious shales of the Shawnee group. A few wells obtain moderate supplies of water of good quality from these gravels.

Quaternary Rocks

Deposits of Quaternary age mantle the Pennsylvanian rocks over most of Atchison county. These deposits have a maximum thickness of nearly 200 feet and consist of till, interglacial deposits, loess, and alluvium. The most widespread surficial deposits in the county are of Pleistocene age and contain the most extensively used ground-water supplies.

PLEISTOCENE DEPOSITS

Character and subdivisions.—The Pleistocene deposits of this area consist principally of sediments that were spread over northeastern Kansas by the continental ice sheets of the Pleistocene epoch, and of the water-laid materials associated with the glaciation. On the basis of detailed studies of the Pleistocene deposits of northeastern Kansas made early in the present century, Todd (1909, 1918, 1918a, 1920) believed that only one glacier, the Kansan, had invaded this county and that the Pleistocene deposits consisted of Kansan till, some outwash sands and gravels and lacustrine sands and silts below, and locally loess above the till. Recently Schoewe (1938) has described a section of Pleistocene deposits on the west edge of the city of Atchison in which are exposed two distinct tills separated by stratified sand (pl. 2A). There is a striking contrast in the lithology of the two tills exposed in this section. The lower till is blue gray and is composed of clay and silt; there are only a few pebbles and cobbles, consisting chiefly of limestone, scattered throughout. Some of the granite pebbles are rotten and can be crushed in the hand. The upper till is red brown to tan and is much coarser than the lower till. It contains blocks of quartzite, limestone, and other rocks, some of which are several feet in diameter. Irregular masses of the lower blue-gray till and stratified sand are incorporated in the lower part of the upper till, suggesting that the lower till was plowed up by the next overriding glacier.

In addition to the section west of Atchison described by Schoewe, these two tills were observed by me in contact, or separated by stratified sand, at several other localities from the southern part of Doniphan county to Cummings, in southern Atchison county. In Atchison county, exposures of the lower blue-gray till are rare, but the logs of wells and test holes indicate that its areal extent is considerably greater than was believed formerly.

The upper brown and tan till is well exposed over much of northeastern Kansas, including Atchison county. From place to place it varies considerably both in color and texture. The upper till is red brown, brown, tan, and gray tan, and is sandy and moderately well sorted in some localities, but very heterogeneous in others.

At several places stratified deposits occur between the two tills or, in areas where the lower till is absent, below the upper till and above the bedrock or Tertiary (?) gravels. In some localities the interglacial sediment consists of well-sorted cross-bedded outwash sand, and at others (pl. 2B) there is thin-bedded silt and fine sand, suggesting lacustrine deposition (Todd, 1920).

There seems to be sufficient evidence in this area for correlating the several stratigraphic units included within the Pleistocene with

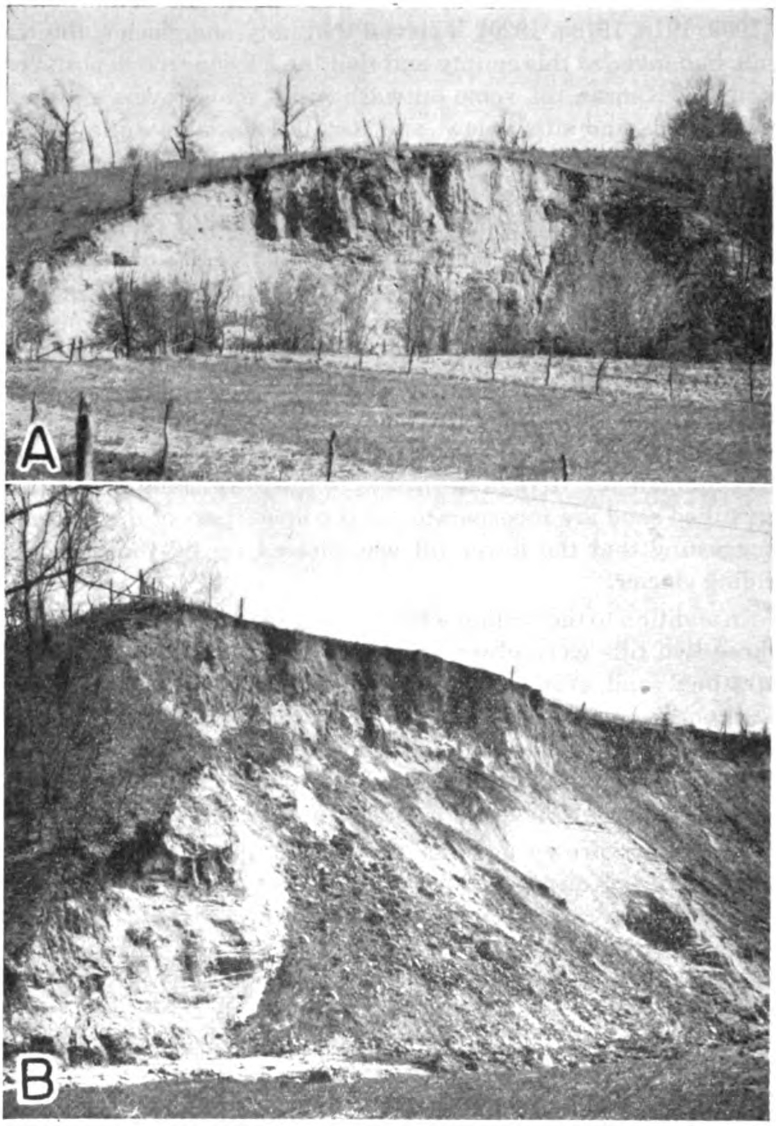

PLATE 2. Pleistocene deposits west of Atchison. A, Glacial till 1.5 miles west of Atchison city limit along Kansas highway 4. B, Interglacial beds overlain by till 0.5 mile west of Atchison city limit, south of Kansas highway 4.

similar deposits in adjacent areas where they have been studied in more detail (Kay and Apfel, 1928). The lower till is here regarded as Nebraskan, the interglacial material as Aftonian, and the upper till as Kansan in age. The two tills have been mapped in southwestern Iowa (Kay and Apfel, 1928, pl. 2), and no terminal morains or other definite evidence of a southern termination of either glaciation is evident in that area. Furthermore, the areal distribution of glacial deposits north of Atchison county virtually precludes the possibility of any glaciation other than the Nebraskan and Kansan having reached Kansas. The fact that the two tills described here do not represent two minor advances of the same ice sheet is indicated by contrast in color and lithology, and by the presence of intervening water-laid deposits that are known to attain a thickness of 70 feet or more.

The maximum known thickness of the Nebraskan till in Atchison county is 80 feet. Although at one time this till may have covered the entire county, it is now confined to isolated patches in the eastern two-thirds of the county. The fact that Nebraskan till has not been observed south of Cummings seems to indicate that the first ice sheet did not reach as far into the state as did the Kansan, although it is possible that subsequent detailed work may discover exposures of Nebraskan till south of Atchison county. The Kansan till in this county is known to exceed 50 feet in thickness, and locally it may be much thicker.

Eolian loess overlies the Kansan till locally in the eastern part of the county. Wherever observed by me the loess is tan and is less than 20 feet thick; however, its maximum thickness may be somewhat greater. As shown by its stratigraphic position, the loess in this area is post-Kansan in age.

Water supply.—Because the Pleistocene deposits are widespread and constitute the material near the surface over most of Atchison county, they have been widely used as a source of ground water. Of the Pleistocene deposits described above, loess is the poorest source of ground water, and outwash or interglacial sand is the best source. Loess is very fine grained and so yields water to wells very slowly or not at all. Much of the loess in Atchison county occurs in topographically high positions and is above the water table.

Many dug wells in the county obtain small supplies of water from the Kansan till. Although till generally has slight permeability, in many places some water can be obtained from it, particularly where the texture is coarse. In some places where the Kansan till is thin, a small amount of poorly sorted sand and gravel occurs at the base. Some of the wells dug in these areas extend downward into the shale, as shown in figure 4, and the lower part of the well serves merely as a reservoir. Such a well supplies a relatively large quantity of water for a short period of use and fills slowly when it is not being pumped.

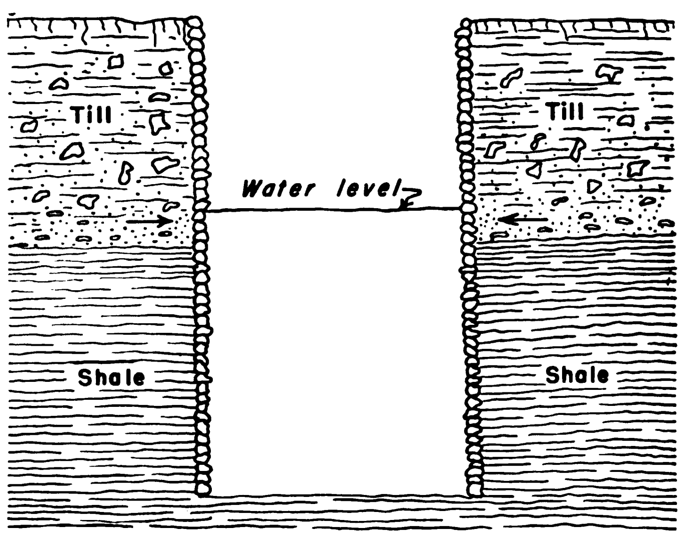

FIGURE 4. Diagram of a typical dug well in thin till overlying shale. Water comes from the sand and gravel at the base of the till and fills the reservoir in the shale, thus a relatively large supply of water is available when needed, although the flow of water into the well is small.

Outwash and interglacial sands are the most prolific sources of ground water in the county. As pointed out above, interglacial sands occur only locally and differ considerably in thickness and texture from place to place. For the most part these sands are overlain by Kansan till and so can be discovered only by test drilling. The following table shows the mechanical composition and coefficient of permeability of some typical samples of interglacial sands in Atchison county. Although the permeability of these sands is low compared to that of coarse gravel, it must be remem-

Physical properties of interglacial sands in Atchison county, Kansas
(Collected by Perry McNally; analyzed by Charles C. Williams)

Test hole no. (fig. 5)	Depth of sample, feet	Mechanical analysis (percent by weight)							Coefficient of permeability[1]
		Medium and coarse gravel (larger than 2.0 mm)	Fine gravel (2.0-1.0 mm)	Coarse sand (1.0-0.5 mm)	Medium sand (0.5-0.25 mm)	Fine sand (0.25-0.125 mm)	Very fine sand (0.125-0.062 mm)	Silt and clay (less than 0.062 mm)	
1	68-70	22.6	44.8	19.8	6.8	2.3	1.1	2.6	49
2	20	0	0	5.0	91.8	2.2	0.5	0.5	48
2	74-88	25.8	22.5	24.0	16.3	4.2	2.1	5.1	7.5
3	31-34	1.4	7.6	23.9	52.5	8.3	2.1	4.1	2.9

1 Number of gallons of water a day, at 60° F., that is conducted laterally through each mile of water-bearing beds under investigation (measured at right angles to the direction of flow), for each foot of thickness of the bed and for each foot per mile of hydraulic gradient.

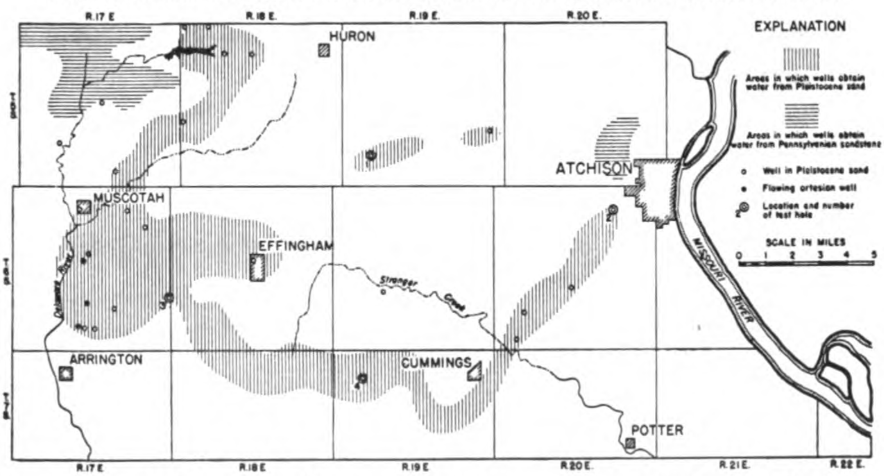

Figure 5. Map of Atchison county showing areas in which wells obtain water from Pleistocene and Pennsylvanian sands and the location of test holes.

bered that the sand is much more permeable than the glacial till into which many wells in the county have been dug. Some of the areas in which water can be obtained from interglacial sands, and areas in which wells are known to obtain water from Pennsylvanian sandstones are shown in figure 5. The data from which the map in figure 5 was compiled are not complete and probably other areas can be found in the county in which wells would produce water from sandstone.

RECENT ALLUVIUM

Character.—Some alluvium occurs along most of the valleys in the county, and thick, pervious alluvium occurs below most of the valley flat of Missouri river (pl. 3A). Few data are available concerning these deposits in Atchison county, but they have been studied in some detail at Lansing, Kans., in adjacent Leavenworth county (Unpublished report, "Memorandum in regard to prospecting for a softer water supply for the Kansas State Penitentiary at Lansing, Kansas", by S. W. Lohman and Alexander Mitchell). In test holes drilled in the Missouri valley near Lansing, the maximum recorded thickness of alluvium was 81 feet. The alluvium along Missouri river consists mostly of sand and gravel, but contains a few beds of silt and clay.

Thin deposits of alluvium occur along most of the minor valleys in the county. Although some of the small valleys contain very permeable material, it is generally much more poorly sorted than the alluvium in the Missouri valley.

Water supply.—Alluvium along the valleys constitutes one of the most dependable sources of shallow ground water in the county. All the community wells constructed by the Kansas Emergency Relief Committee in 1934 were dug in alluvium along the smaller streams of the county, and many domestic and stock wells obtain water from these deposits.

The quality of water obtained from alluvium varies greatly, but in most places is somewhat poor. Samples collected from alluvium in the Missouri valley near Lansing, Leavenworth county, ranged in total hardness from 252 to 851 parts per million, and contained as much as 27 parts per million of iron. It is probably true, however, that much of the water obtained from alluvium along the smaller streams in the county is of better quality, though locally this water may be polluted by organic material.

ARTESIAN WATER

In order to understand the features that produce artesian conditions, the occurrence of nonartesian ground water in the county will be summarized briefly. A detailed discussion of the occurrence of ground water in the United States has been given by Meinzer (1923, 1923a), and in Kansas by Moore (1940).

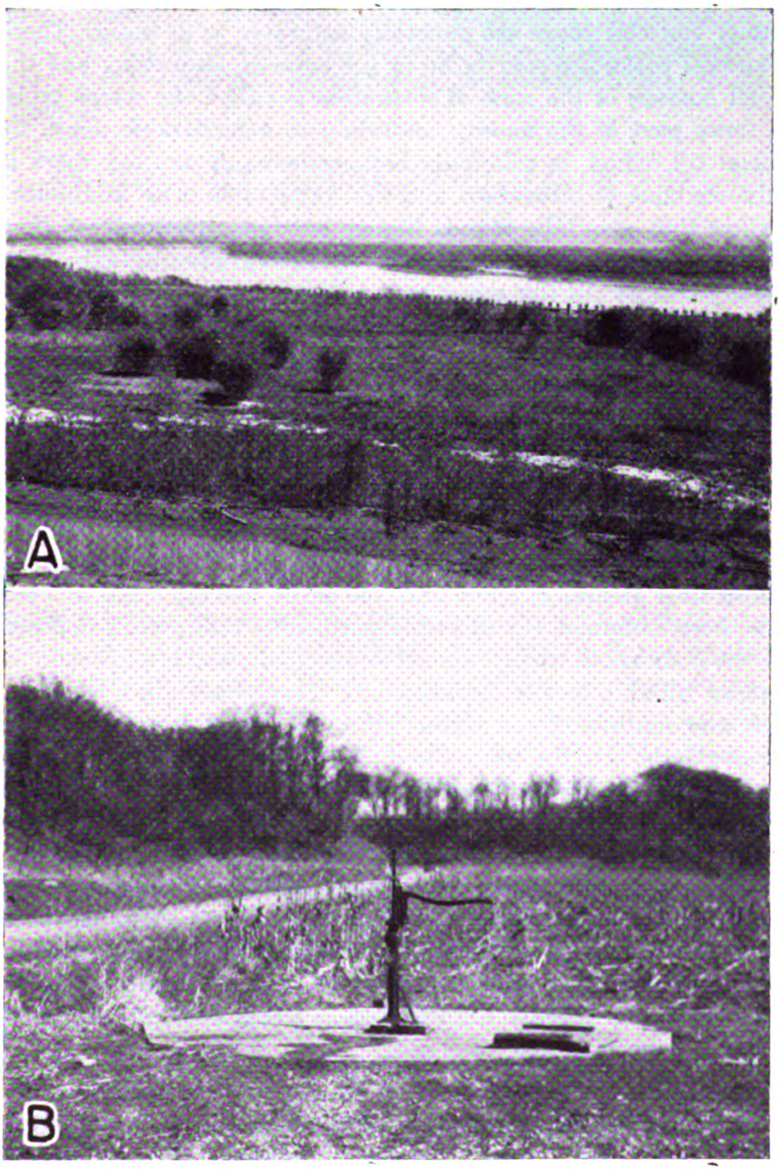

PLATE 3. A, Missouri valley north of Oak Mills. B, Community well near Cummings.

The permeable rocks that lie below a certain level in Atchison county and elsewhere are generally saturated with water. These saturated rocks are said to be in the zone of saturation, and the upper surface of the zone of saturation is called the water table. In those part of the county underlain to considerable depth by glacial till, which is relatively homogeneous in texture, there is only one zone of saturation, and the water table is an undulating surface that generally stands higher beneath upland areas than beneath the adjacent valley areas, and slopes gradually to the level of the streams. In the areas between the streams the supply of ground water is replenished from the rain and snow, and hence the water table is built up above the level of the streams. The ground water moves in the direction of the slope of the water table toward the discharge areas along the streams. Thus, except at flood stages, the streams are commonly gaining water from the zone of saturation.

A notable exception to these general conditions occurs along the valley of Delaware river between Muscotah and Arrington, where, over an area of a few hundred acres, flowing artesian wells have been obtained. In this area permeable interglacial deposits overlie Nebraskan till or Pennsylvanian shale, and are overlain by Kansan till and, locally, by alluvium. These beds dip toward the west and southwest, and water falling on the outcrop area of the permeable beds in the central and north-central part of the county moves down the dip between the confining layers of relatively impermeable material and saturates the beds of sand and gravel nearly to the surface. Under these conditions wells drilled into the water-bearing beds may encounter water that is under artesian pressure, that is, water that rises above the local water table. If the water rises high enough to flow at the surface, the well is a flowing artesian well. Two generalized sections through this artesian area (fig. 6) show the Pleistocene strata from which the artesian water is obtained.

H. M. Rice reports that the first flowing well in the valley was drilled in 1900 on his farm in the SW¼ NW¼ sec. 15, T. 6 S., R. 17 E., and that at the time of completing the well the water flowed over the top of the casing when it was extended 20 feet above the land surface. The initial flow is reported to have been 55 gallons a minute. At the present time there are several flowing wells and several artesian springs in this area. That the upper confining beds probably do not constitute a perfect seal is suggested by the fact that the water table stands very close to the surface in this part of the valley flat, necessitating the construction of drainage ditches.

AVAILABILITY OF ADDITIONAL WATER SUPPLIES

From the foregoing discussion it is evident that in certain parts of Atchison county, proper prospecting and development will produce additional ground-water supplies, whereas in other parts of the county adequate ground-water supplies will be difficult or impossible to obtain. The upper part of the Pleistocene deposits, particularly the Kansan till, seems to have been explored extensively throughout the county by numerous dug wells, as has much of the alluvium along the smaller streams. The interglacial beds that locally occur some distance below the surface, however, have been utilized as a source of ground water in only a few places. Areas in the county that contain some interglacial sand below the surface are indicated in a general way in figure 5. Deeper drilling into these interglacial sands probably will produce supplies of ground water. It should be remembered that the map in figure 5 is based upon inadequate data. At some places within the areas shown by cross-ruling, the interglacial sands may be too thin or too poorly sorted to yield adequate supplies; on the other hand, prospecting outside the areas indicated may disclose ample supplies in this material in some places.

Although it is probable that future drilling in the western part of the county will find some additional water supplies in the sandstones of the Wabaunsee group, the lenticular nature of these rocks and the inadequacy of the data on hand make it impracticable to delineate the areas in which wells drilled to moderate depths will encounter water-bearing sandstone.

As pointed out above, it seems probable that locally the quantity of water obtainable from wells in limestone may be increased somewhat by treating the wells with acid.

From the foregoing it becomes evident that there are certain areas in the county in which the likelihood of obtaining additional supplies of potable water by deeper drilling is very slight. In these areas the only method of assuring adequate supplies of stock water may be by the construction of dams along water courses for

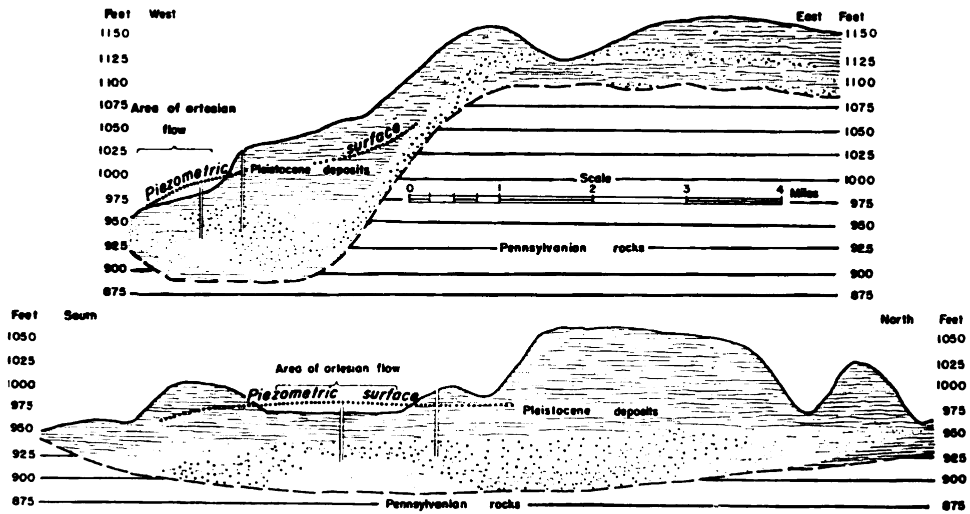

FIGURE 6. Generalized sections through the Delaware valley artesian area. These sections are based on surface data, drillers' logs, and one test hole.

the impounding of water. For details concerning the proper method of constructing farm ponds, the reader is referred to a report published by the Kansas State Board of Agriculture (vol. 58, no. 230-C, March, 1939). The essential requirements for a successful stock pond consist of topography suitable for the construction of a dam, an adequate drainage basin, and surficial material that is impervious enough to hold impounded water. Most of the western two-thirds of the county contains suitable sites for farm ponds, and certain locations in the eastern third probably would prove satisfactory.

If additional dug wells are constructed in Atchison county, it is believed that they would be less likely to fail if they were dug during the dryest time of year when the water table is lowest, and also if they were dug as far as possible below the water table in order to provide additional reservoir capacity and to anticipate excessive lowering of the water table during periods of drought.

References

KAY, G. E., and APFEL, E. T., *1928,* The pre-Illinoian Pleistocene geology of Iowa: Iowa Geol. Survey, Ann. Rept., vol. 34, pp. 1-304, figs. 1-63, plates 1-3.

LOHMAN, S. W., and FRYE, J. C., *1940,* Geology and ground-water resources of the "Equus beds" area in south-central Kansas: Econ. Geology, vol. 35, pp. 839-866, 5 figs.

MEINZER, O. E., *1923,* The occurrence of ground water in the United States, with a discussion of principles: U. S. Geol. Survey, Water-Supply Paper 489, pp. 1-321, figs. 1-110, pls. 1-31 (including maps).

———, *1923a,* Outline of ground-water hydrology, with definitions: U. S. Geol. Survey, Water-Supply Paper 494, pp. 1-71, figs. 1-35.

MOORE, R. C., *1936,* Stratigraphic classification of the Pennsylvanian rocks of Kansas: Kansas Geol. Survey, Bull. 22, pp. 1-256, figs. 1-12.

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

SCHOEWE, W. H., *1922,* Southernmost extension of Kansas tills: Pan-Am. Geologist ,vol. 38, pp. 378-382.

———, *1923,* Glacial geology of Kansas: Pan-Am. Geologist, vol. 40, pp. 102-110.

———, *1930,* Evidence for a relocation of the drift border in eastern Kansas: Jour. Geology, vol. 38, pp. 67-74.

———, *1938,* The west Atchison glacial section (abstract): Kansas Acad. Sci., Trans., vol. 41, p. 227.

TODD, J. E., *1909,* Drainage of the Kansas ice sheet: Kansas Acad. Sci., Trans., vol. 22, pp. 107-112.

———, *1918,* Kansas during the ice age: Kansas Acad. Sci., Trans., vol. 28, pp. 33-47.

———, *1918a,* History of Kaw Lake: Kansas Acad. Sci., Trans., vol. 29, pp. 187-199, 3 figs.

———, *1920,* Lacustrine beds near Atchison (abstract): Kansas Acad. Sci., Trans., vol. 29, pp. 116-117.

Logs of Test Holes

(Samples studied by J. C. Frye and Perry McNally)

Test hole 1. SW corner sec. 29, T. 5 S., R. 19 E.

	Thickness (feet)	Depth (feet)
Quaternary (Recent)		
Soil	2	2
Quaternary (Pleistocene)		
Kansan till		
Clay and silt, yellow brown to light gray	14	16
Sand, silt, and clay, yellow brown	15	31
Aftonian deposits		
Sand, fine to coarse, brown	3	34
Silt, and fine sand, some gravel at base, yellow brown and gray	24	58
Nebraskan till		
Clay, silt, and sand, blue gray, sticky when wet, contains some gravel	17	75
Sand and gravel, some silt and clay, blue gray	6	81
Clay, silt, and sand, blue gray, sticky when wet, contains some gravel	50	131

Test hole 2. SE¼ SW¼ sec. 2, T. 6 S., R. 20 E.

(Upper part is measured section along creek bank, lower part drilled section)

	Thickness (feet)	Depth (feet)
Quaternary (Pleistocene)		
Kansan till		
Till, heterogeneous, contains cobbles and boulders, tan	8	8
Aftonian deposits		
Sand, fine to very fine, light tan, thin bedded and locally cross bedded	47	55
Sand, coarse, orange brown, locally cross bedded	19	74
Sand and gravel, poorly sorted	14	88
Nebraskan till		
Clay and silt, some gravel, blue gray	4	92
Carboniferous (Pennsylvanian, Virgil series)		
Lawrence shale		
Shale, hard, gray	1	93

Test hole 4. NW¼ NW¼ sec. 8, T. 7 S., R. 19 E.

	Thickness (feet)	Depth (feet)
Quaternary (Recent)		
Soil	3	3
Quaternary (Pleistocene)		
Kansan till		
Clay and silt, sticky when wet, gray to yellow brown	14	17
Clay and silt, some gravel, yellow to yellow tan, some gray and red-brown zones	51	68
Aftonian deposits		
Gravel, fine, yellow brown	2	70
Sand, fine, some silt and coarse sand, yellow, some gray and red-brown zones	22	92
Nebraskan till		
Clay, silt, and sand, some gravel, dark gray to blue gray	16	108

Test hole 3. NE¼ NE¼ sec. 25, T. 6 S., R. 17 E.

	Thickness (feet)	Depth (feet)
Quaternary (Recent)		
Soil	10	10
Quaternary (Pleistocene)		
Kansan till		
Clay, silt, and sand, tan and gray	13	23
Aftonian deposits		
Sand, fine, some silt and coarse sand, light gray to blue green	9	32
Gravel	5	37
Nebraskan till		
Clay, silt, and sand, dark gray	29	66
Carboniferous (Pennsylvanian, Virgil series)		
Wabaunsee group		
Limestone, light gray	0.5	66.5

PRINTED BY
THE UNIVERSITY OF KANSAS PRESS
LAWRENCE