DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
STATE GEOLOGICAL SURVEY OF KANSAS
KANSAS STATE DEPARTMENT OF HEALTH
KANSAS STATE BOARD OF AGRICULTURE

HYDROLOGIC INVESTIGATIONS
ATLAS HA-462

TABLE 1.—*GENERALIZED COLUMNAR SECTION AND WATER-BEARING CHARACTERISTICS*

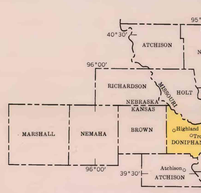
[The classification and nomenclature used in this report are those of the U.S. Geological Survey and differ somewhat from those of the State Geological Survey of Kansas]

System	Series	Group	Glaciation or formation	Rock unit or member	Thickness, in feet[1]	Physical character	Water supply[2]
Quaternary	Holocene and Pleistocene			Alluvium and terrace deposits in the valleys	0–120	Silt, clay, sand, and gravel underlying the active channels and flood plains of the major streams. These deposits in tributary streams contain a large percentage of fine-grained material	Large quantities of water are available to wells in the Missouri River valley. Only small quantities are available to wells in the tributary stream valleys.
	Pleistocene		Wisconsin and Illinoian	Loess	0–120	Silt and some clay, generally mantling the uplands. Two lenses of Wisconsin age and one lens of Illinoian age are locally present.	Although locally saturated in part, yields no water to wells in the area.
			Illinoian	Terrace deposits	0–20	Silt, clay, sand, and gravel present locally in terrace positions.	Small quantities of water are available to wells locally.
			Kansan and Nebraskan	Glacial drift	0–110	Two tills of Kansan age locally separated by lacustrine and outwash deposits that are locally underlain by a till of Nebraskan age. Outwash deposits of Nebraskan age consist of silty clay and fine sand underlain by chert. and limestone gravel are widespread.	Moderate quantities of water are available locally to wells in pre-glacial channel deposits. Small quantities generally are available to wells in outwash deposits.
Pennsylvanian	Upper Pennsylvanian	Wabaunsee	Seranton Shale	White Cloud Shale	50	Bluish-gray and yellowish-brown clayey sandy shale and locally sandstone.	Small quantities of water available in local areas to wells in sandstone.
			Howard Limestone	Utopia Limestone	0–3	Upper limestone member is composed of two or three gray to light-brown limestone beds separated by shale. Lower member is yellowish-gray and locally black in lower part. Lower limestone is bluish gray to dark blue, dense, and hard.	Little or no water is available to wells in this unit.
				Winzeler Shale	5		
				Church Limestone	1.5–2.0		
			Severy Shale		30–38	Gray and brownish-gray clay and sandy shale containing a thin coal bed in the upper part. Coal is overlain by a dark-bluish shale.	Little or no water is available to wells in this unit.
			Topeka Limestone	Coal Creek Limestone	30–35	Limestone members are hard gray and bluish-gray limestone beds separated by shale and clay members. Upper shale member is black and fossiliferous. Middle shale members are clayey and light gray, and the lower shale member is a gray clayey shale containing a persistent sandstone bed.	Small quantities of water are available to wells in the weathered upper part of the limestones and in the sandstone.
				Holt Shale			
				Du Bois Limestone			
				Turner Creek Shale			
				Sheldon Limestone			
				Jones Point Shale			
				Curson Limestone			
				Iowa Point Shale			
				Hartford Limestone			
			Calhoun Shale		8–17	Bluish-gray sandy shale in upper part and gray sandy shale in lower part.	Yields no water to wells in the area.
			Deer Creek Limestone	Ervine Creek Limestone	12–16	Upper limestone member is thick, irregular, wavy bedded, and gray. Underlying shale member is gray to the upper part and black in lower part. Middle limestone member is bluish gray, hard, and dense. Lower shale member is gray and blocky. Lower limestone member is a gray massive-bedded well-jointed limestone which weathers brown or brownish gray.	Small quantities of water are available locally to wells in the weathered part of the upper limestone.
				Burroak and Larsh Shale	3–5		
				Rock Bluff Limestone	1.5–2.5		
				Oskaloosa Shale	6–14		
				Ozawkie Limestone	3.5–7.0		
		Shawnee	Tecumseh Shale		60–65	Greenish-gray clay shale locally containing a thin limestone bed in the upper part. Elsewhere sandy shale occurs at this horizon.	Small quantities of water are available locally to wells in the sandy shale.
			Lecompton Limestone	Avoca Limestone	2.5–4.0	Consists of an upper thin-bedded hard gray limestone underlain by a dark-gray shale which is underlain by a limestone consisting of several thin beds of gray impure limestone separated by thin shale beds and a thin gray shale. Third limestone member from the top is a single bed of hard dense dark-gray limestone cut by many vertical joints. Lower shale member is a well-jointed gray to brown clayey shale, and the lower limestone is a fossiliferous light-gray limestone which weathers thick brown.	Yields no water to wells in this area.
				King Hill Shale	5		
				Bell Limestone	3–5		
				Queen Hill Shale	1.5–5.0		
				Big Springs Limestone	3–5		
				Doniphan Shale	2.5–6		
				Spring Branch Limestone	5–8		
			Kanwaka Shale	Stull Shale	25–40	Consists of two thick shale members and an intervening limestone member. Upper member is dark-gray shale with a few thin limestone beds and a persistent coaly sandstone. Limestone member is an impure bluish-gray limestone occurring in one or two beds. Lower shale member is bluish gray to dark gray and weathers light gray.	Small quantities of water are available to wells in the sandstone in this unit.
				Clay Creek Limestone	3.0–3.5		
				Jackson Park Shale	20–23		
			Oread Limestone	Kereford Limestone	3.5–6.5	Consists of an upper dark-gray microcrystalline oolitic and locally crossbedded limestone underlain by bluish-gray shale. Middle limestone member is a dark-gray limestone but next below consists of a thick wavy-bedded limestone containing thin chert horizons in the upper two-thirds of the member. Middle shale member is dark-gray in the upper part and black and fissile in the lower part. Lower limestone member is a dense hard bluish-gray, hard, and dense and is cut by numerous vertical joints. Lower shale member is ash gray to dark gray and weathers light gray. Lower limestone member consists of a massive and uniform brown limestone member with developed vertical joints.	Small quantities of water are available to wells in the upper, weathered part of the thick limestones.
				Heumader Shale	3–5		
				Leavenworth Limestone	27		
				Stoner Shale	4–7		
				Lecompton Limestone	1.5–2.0		
				Snyderville Shale	10–14		
				Toronto Limestone	4–5		
		Douglas	Lawrence Formation	Oread Limestone shale	15–22	Consists of an upper well-bedded and laminated clayey shale and sandy shale; red in upper part and greenish gray in lower part. Underlying limestone is a hard, irregular to wavy bedded, fine grained, brownish-yellow weathering, and has a speckled appearance. Underlying shale is gray to bluish gray and thinly laminated and weathers light gray.	Amazonia Limestone locally yields small quantities of water to wells.
				Amazonia Limestone	10–20		
				Unnamed Shale	70		

[1] Not to scale.
[2] In this report, "small supplies" refers to yields generally less than 10 gpm, "moderate supplies" to 10 to 100 gpm, and "large supplies" to greater than 100 gpm.

INTRODUCTION

This study is a part of a continuing program that was begun in Kansas in 1937 to evaluate the ground-water resources of the State. Doniphan County is the northeastern-most county in Kansas (see index map). Reports describing the water resources of area contiguous to Doniphan County are listed in the selected references. The locations of wells and test holes described in this report are identified according to the Federal system of land subdivision as shown by the well-numbering system diagram.



MAP LOCATION DIAGRAM

INDEX MAP SHOWING LOCATION OF STUDY AREA

GEOLOGY AND DRAINAGE

Eolian and glacial deposits of Pleistocene age (see geohydrologic map) underlie most of Doniphan County in the valleys, alluvial deposits of Pleistocene and Holocene age are present. Rocks of the Upper Pennsylvanian Series form the bedrock beneath the Pleistocene sediments and crop out in the valley walls along major streams.

PENNSYLVANIAN SYSTEM

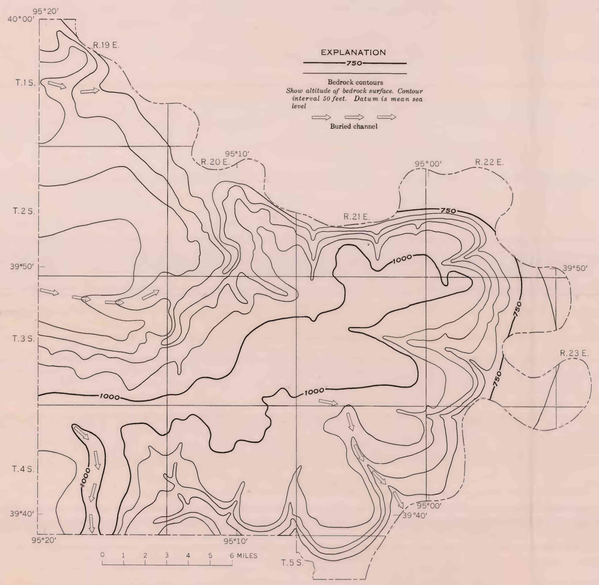
The Lawrence Formation of the Douglas Group (see generalized columnar section) crops out in the bluffs adjacent to the Missouri River in the eastern and southeastern parts of the county and comprises the oldest rocks exposed. Rocks which comprise the Shawnee Group overlie rocks of the Douglas Group and underlie rocks of the Wabaunsee Group. These rocks crop out in the bluffs adjacent to the Missouri River and in the valley walls of many of the principal tributaries to the Missouri River. The Seranton Shale of the Wabaunsee Group comprises the youngest rocks of Pennsylvanian age that crop out in the county. These rocks crop out in bluffs along the Missouri River in the northern part of Doniphan County and in Wolf Creek valley in the western part. Except in the valley walls along principal streams, Pennsylvanian rocks are everywhere overlain by deposits of Pleistocene age, as shown by the geohydrologic map and geologic section.

PRE-PLEISTOCENE DRAINAGE

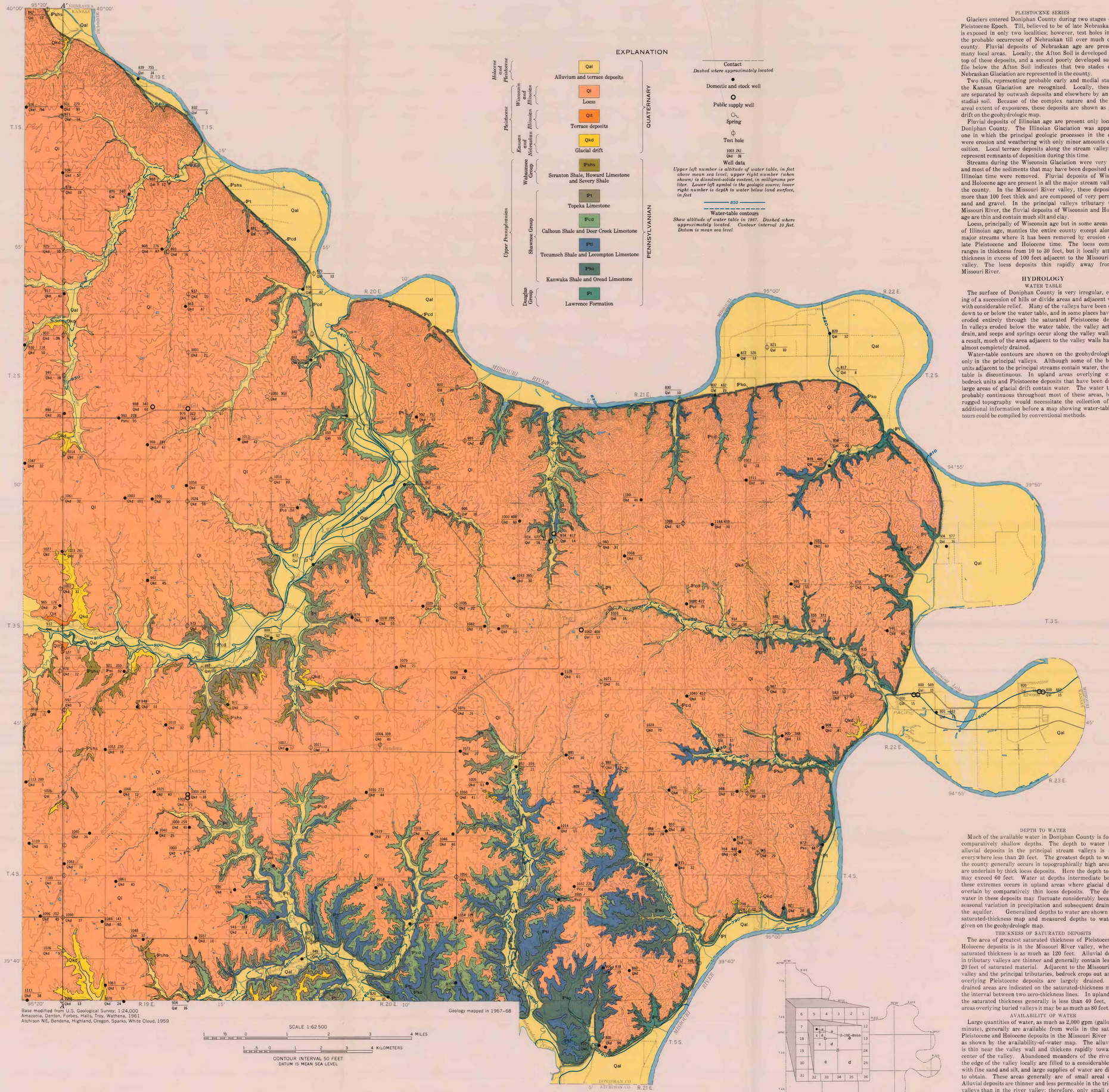
The Missouri River did not exist as a through-flowing stream in its present location before the close of the Kansan Glaciation of the Pleistocene Epoch. The trunk stream, which drained northeastern Kansas and northwestern Missouri during pre-Pleistocene time, entered Missouri near the northwest corner of Nodaway County, Mo., and flowed southeast for about 60 miles, and then south to the present Missouri River valley.

The northern part of Kansas was drained by a stream that headed in Marshall County, Kans., and flowed generally eastward to Atchison, then northeast along the present location of the Missouri River valley to St. Joseph, Mo. From St. Joseph the stream flowed eastward to join the trunk stream.

A topographic high on the bedrock surface in Doniphan County extends from the southwestern to the northeastern part of county (see map showing configuration of bedrock surface). Southeast of the divide, drainage was toward the ancient stream between Atchison, Kans., and St. Joseph, Mo. North and northwest of the divide, drainage was toward the trunk stream in northwestern Missouri. Four buried channels, incised into the bedrock surface prior to Nebraskan Glaciation, are indicated on the map.



MAP SHOWING GENERALIZED CONFIGURATION OF BEDROCK SURFACE AND LOCATION OF BURIED CHANNELS



GEOHYDROLOGIC MAP

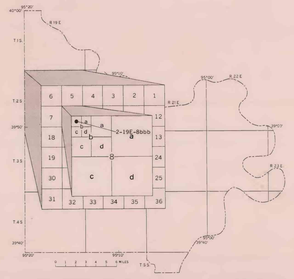
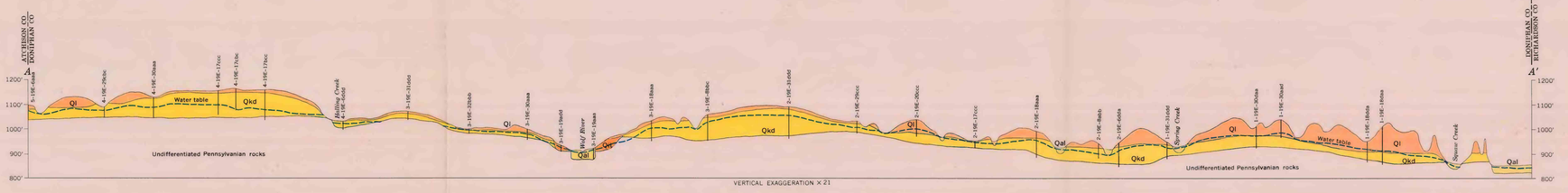


DIAGRAM ILLUSTRATING WELL-NUMBERING SYSTEM



GEOLOGIC SECTION

PLEISTOCENE SERIES

Glaciers entered Doniphan County during two stages of the Pleistocene Epoch. Till, believed to be of late Nebraskan age, is exposed in only two localities; however, test holes indicate the probable occurrence of Nebraskan till over much of the county. Fluvial deposits of Nebraskan age are present in many local areas. Locally, the Afton Soil is developed in the top of these deposits, and a second poorly developed soil profile below the Afton Soil indicates that two stades of the Nebraskan Glaciation are represented in the county.

Two tills, representing probable early and medial stades in the Kansan Glaciation are recognized. Locally, these tills are separated by outwash deposits and elsewhere by an interstadial soil. Because of the complex nature and the small areal extent of exposures, these deposits are shown as glacial drift on the geohydrologic map.

Fluvial deposits of Illinoian age are present only locally in Doniphan County. The Illinoian Glaciation was apparently one in which the principal geologic processes in the county were erosion and weathering with only minor amounts of deposition. Local terrace deposits along the stream valleys may represent remnants of deposition during this time.

Streams during the Wisconsin Glaciation were very active and most of the sediments that may have been deposited during Illinoian time were removed. Fluvial deposits of Wisconsin and Holocene age are present in all the major stream valleys in the county. In the Missouri River valley, these deposits are more than 100 feet thick and are composed of very permeable sand and gravel. In the principal valleys tributary to the Missouri River, the fluvial deposits of Wisconsin and Holocene age are thin and contain much silt and clay.

Loess, principally of Wisconsin age but in some areas partly of Illinoian age, mantles the entire county except along the major streams where it has been removed by erosion during late Pleistocene and Holocene time. The loess commonly ranges in thickness from 10 to 30 feet, but it locally attains a thickness in excess of 100 feet adjacent to the Missouri River valley. The loess deposits thin rapidly away from the Missouri River.

HYDROLOGY

WATER TABLE

The surface of Doniphan County is very irregular, consisting of a succession of hills or divide areas and adjacent valleys with considerable relief. Many of the valleys have been eroded down to or below the water table, and in some places have been eroded entirely through the saturated Pleistocene deposits. In valleys eroded below the water table, the valley acts as a drain, and seeps and springs occur along the valley walls. As a result, much of the area adjacent to the valley walls has been almost completely drained.

Water-table contours are shown on the geohydrologic map only in the principal valleys. Although some of the bedrock units adjacent to the principal streams contain water, the water table is discontinuous. In upland areas overlying exposed bedrock units and Pleistocene deposits that have been drained, large areas of glacial drift contain water. The water table is probably continuous throughout most of these areas, but the rugged topography would necessitate the collection of much additional information before a map showing water-table contours could be compiled by conventional methods.

DEPTH TO WATER

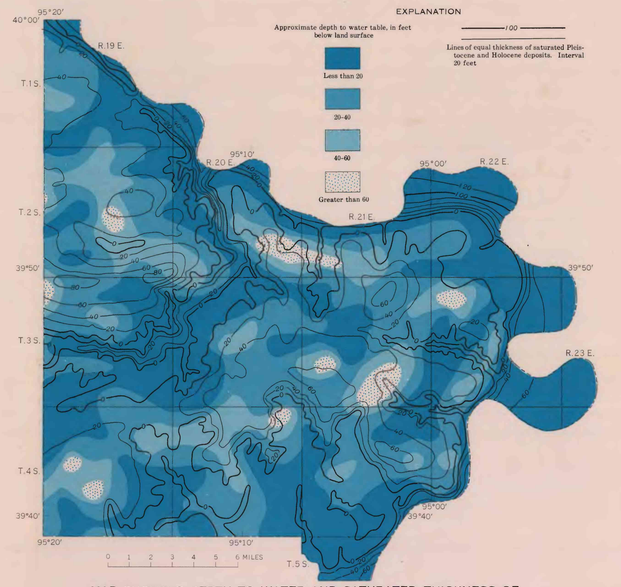
Much of the available water in Doniphan County is found at comparatively shallow depths. The depth to water in the alluvial deposits in the principal stream valleys is almost everywhere less than 20 feet. The greatest depth to water in the county generally occurs in topographically high areas that are underlain by thick loess deposits. Here the depth to water may exceed 60 feet. Water at depths intermediate between these extremes occurs in upland areas where glacial drift is overlain by comparatively thin loess deposits. The depth to water in these deposits may fluctuate considerably because of seasonal variation in precipitation and subsequent draining of the aquifer. Generalized depths to water are shown on the saturated-thickness map and measured depths to water are given on the geohydrologic map.

THICKNESS OF SATURATED DEPOSITS

The area of greatest saturated thickness of Pleistocene and Holocene deposits is in the Missouri River valley, where the saturated thickness is as much as 120 feet. Alluvial deposits in tributary valleys are thinner and generally contain less than 20 feet of saturated material. Adjacent to the Missouri River valley and the principal tributaries, bedrock crops out and the overlying Pleistocene deposits are largely drained. These drained areas are indicated on the saturated-thickness map by the interval between two zero-thickness lines. In upland areas the saturated thickness generally is less than 40 feet, but in areas overlying buried valleys it may be as much as 80 feet.

AVAILABILITY OF WATER

Large quantities of water, as much as 2,000 gpm (gallons per minute), generally are available from wells in the saturated Pleistocene and Holocene deposits in the Missouri River valley, as shown by the availability-of-water map. The alluvial fill is thin near the valley wall and thickens rapidly toward the center of the valley. Abandoned meanders of the river near the edge of the valley locally are filled to a considerable depth with fine sand and silt, and large supplies of water are difficult to obtain. These areas generally are of small areal extent. Alluvial deposits are thinner and less permeable in the tributary valleys than in the river valley; therefore, only small quantities of water (less than 10 gpm) generally are available to wells. Locally, moderate quantities of water (10 to 100 gpm) can be obtained.

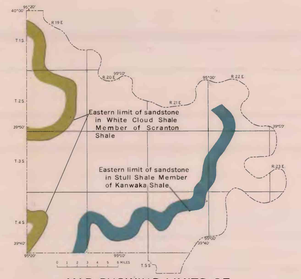


MAP SHOWING DEPTH TO WATER AND SATURATED THICKNESS OF PLEISTOCENE AND HOLOCENE DEPOSITS, 1967

In the uplands, the most productive aquifers do not necessarily occur in areas of greatest saturated thickness. The upland deposits composed of glacial till and outwash deposits generally are not homogeous. In areas underlain by buried channels, as shown on the bedrock-configuration map, moderate yelids of water generally can be obtained. In other upland areas, only small supplies generally are available. However, in almost any area having 30 to 40 feet of saturated Pleistocene deposits, wells completed in one or more thin sand and gravel beds should yield sufficient water for domestic and stock supplies.

In areas where Pennsylvanian rocks are not overlain by saturated Pleistocene deposits, domestic and stock ground-water supplies locally are difficult to obtain. Only a few gallons of water per hour generally are available from wells in the weathered upper part of the thick limestones. Locally thick beds of sandstone in the Stull Shale Member of the Kanwaka Shale and the White Cloud Shale Member of Seranton Shale yield water to wells (see map showing limits of sandstone aquifers). However, yields from these wells are almost everywhere less than 5 gpm.

The Pennsylvanian rocks in Doniphan County dip northwestward at about 25 feet per mile. The chemical quality of water in the sandstone aquifers deteriorates as the depth to the units increases. It is doubtful that potable water is present in the sandstone beds more than about 5 miles west of their outcrops or in areas where the sandstone beds are in direct contact with overlying glacial drift.



MAP SHOWING LIMITS OF SANDSTONE AQUIFERS

CHEMICAL QUALITY OF GROUND WATER

Chemical analyses of water from representative wells indicate that ground water in Doniphan County is of the calcium bicarbonate type. Calcium and magnesium are principal constituents producing hardness. Water from the wells sampled is classed as moderately hard to very hard, but it can be softened by simple treatment.

The concentration of dissolved solids in water from wells ranges from 114 to 767 mg/l (milligrams per liter), as shown on the geohydrologic map. Water containing dissolved solids in this range is generally satisfactory for domestic use; however, 500 mg/l is the maximum concentration recommended by the U.S. Public Health Service.

Concentrations of individual mineral constituents are below the recommended maximum, except those for nitrate and iron, which in some samples exceeded 45 mg/l and 0.3 mg/l, respectively.

Nine of the water samples from domestic and stock wells in Doniphan County had concentrations of nitrate above the recommended maximum limit, as did water from some of the municipal-supply wells in Highland and Troy. Water from the city supply wells west of Highland had nitrate concentrations ranging from 72 to 120 mg/l in six samples collected during 1957–67. Water from the Troy city well below the city lake had nitrate concentrations ranging from 44 to 106 mg/l in four samples collected during 1945–48, when the well was abandoned.

Excessive concentrations of nitrate in water used in infant feeding may cause cyanosis. Swine and cattle may be affected in the same way as humans, and dairy cattle drinking water high in nitrate content may produce milk that is high in nitrate. The cause of the high nitrate content of water in Doniphan County is not known. Pollution is thought to be the source in only one sample. In this sample the sulfate, chloride, and potassium concentrations exceeded those commonly found in water in the area. The occurrence of high nitrate content in other samples was random as to aquifer, well construction, and location. The ordinary treatment process for softening water does not change the nitrate concentration.

Iron in small concentrations occurs in ground water throughout the county. Concentrations in excess of 0.3 mg/l may cause staining of plumbing fixtures and give an unpleasant taste to the water. Water containing iron in concentrations in excess of 0.3 mg/l occurs locally in all aquifers in the county; however, water from alluvial aquifers generally contains more iron than water from the glacial drift or bedrock aquifers. Water from all wells sampled in the Missouri River valley contained total iron in concentrations ranging from 5 to 25 mg/l. Iron concentrations in ground water in stream valleys tributary to the Missouri River generally are less than 1.5 mg/l.

CONCLUSIONS

Adequate supplies of water for domestic and stock use generally are available from wells in the glacial deposits underlying the upland areas of Doniphan County. Adjacent to the major streams, the glacial deposits are thin or have been removed by erosion. In these localized areas, small supplies of water are available from wells drilled into bedrock aquifers. Large supplies of water are available only from wells in alluvial deposits in the Missouri River valley.

The ground water is hard or very hard but may be rendered soft by simple treatment. Water from wells in the Missouri River valley and in some tributary valleys is very high in iron content. Water containing excessive amounts of nitrate occurs locally in all the aquifers.

SELECTED REFERENCES

Bayne, C. K., 1967, Geology and ground-water resources of Brown County, Kansas: Kansas Geol. Survey Bull. 186, 68p.

———1968, Evidence of multiple stades in the lower Pleistocene of northeastern Kansas: Kansas Acad. Sci. Trans., v. 71, no. 3, p. 340–349.

Bayne, C. K., and O'Connor, H. G., 1968, Quaternary System, *in* Zeller, D. E., ed., The stratigraphic succession in Kansas: Kansas Geol. Survey Bull. 189, p. 59–67.

Condra, G. E., and Reed, E. C., 1959, The geological section of Nebraska: Nebraska Geol. Survey Bull. 14A, 82 p.

Emery, P. A., 1964, Geology and ground-water resources of Richardson County, Nebraska: U.S. Geol. Survey Water-Supply Paper 1779–W, p. W1–W23.

Emmett, L. F., and Jeffery, H. G., 1969, Reconnaissance of the ground-water resources of the Missouri River alluvium between Kansas City, Missouri and the Iowa Border: U.S. Geological Survey Hydrol. Inv. Atlas HA–336.

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

Heim, G. E., Jr., and Howe, W. B., 1963, Pleistocene drainage and depositional history in northwestern Missouri: Kansas Acad. Sci. Tran., v. 66, no. 3, p. 378–392.

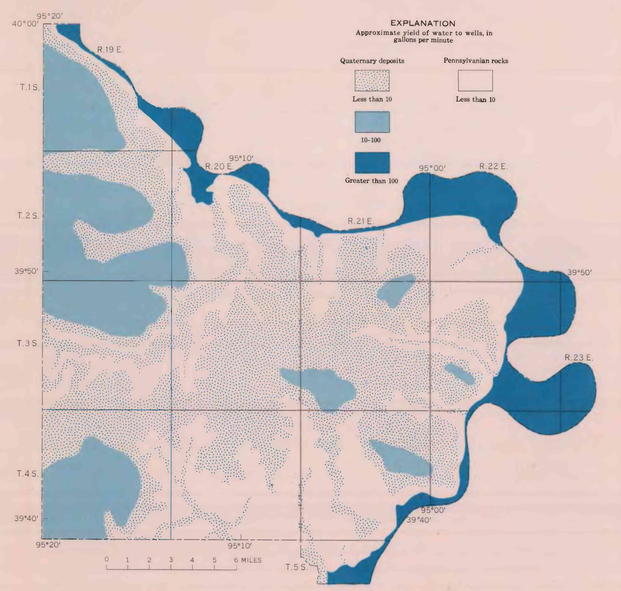
Jewett, J. M., O'Connor, H. G., and Zeller, D. E., 1968, Pennsylvanian System, *in* Zeller, D. E., ed., The stratigraphic succession in Kansas: Kansas Geol. Survey Bull. 189, p. 21–43.

Moore, R. C., 1949, Divisions of the Pennsylvanian System in Kansas: Kansas Geol. Survey Bull. 83, 203 p.

Reed, E. C., Dreesen, V. H., 1965, Revision of the classification of the Pleistocene deposits of Nebraska: Nebraska Geol. Survey Bull. 23, 65 p.

Reed, E. C., Dreesen, V. H., Bayne, C. K., and Schultz, C. B., 1965, The Pleistocene in Nebraska and northern Kansas; *in* Wright, H. E., Jr., and Frey, D. G., eds., The Quaternary of the United States: Princeton N. J., Princeton Univ. Press, p. 187–202.

U.S. Public Health Service, 1962, Drinking water standards: U.S. Public Health Service Pub. 956, 61 p.



MAP SHOWING AVAILABILITY OF WATER

GEOHYDROLOGY OF DONIPHAN COUNTY, NORTHEASTERN KANSAS

By
Charles K. Bayne
1973

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1973—W71332

For sale by U.S. Geological Survey, price 75 cents