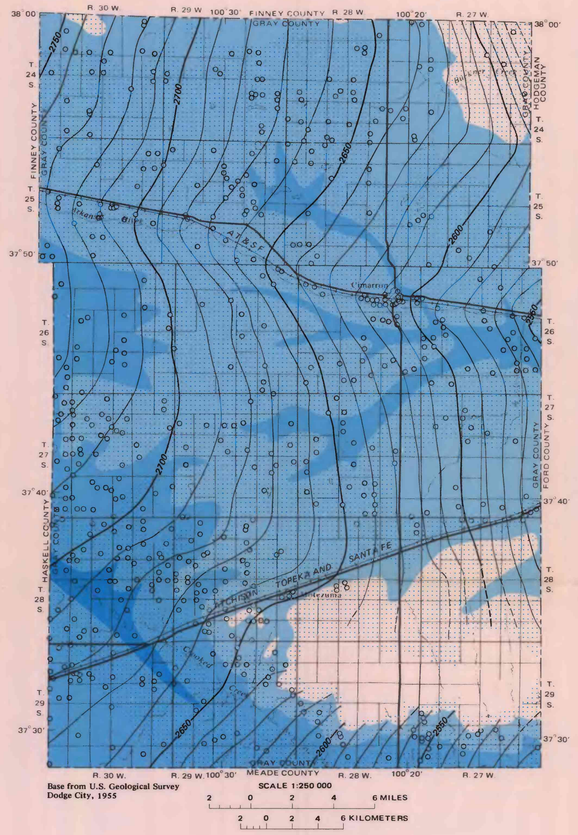
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

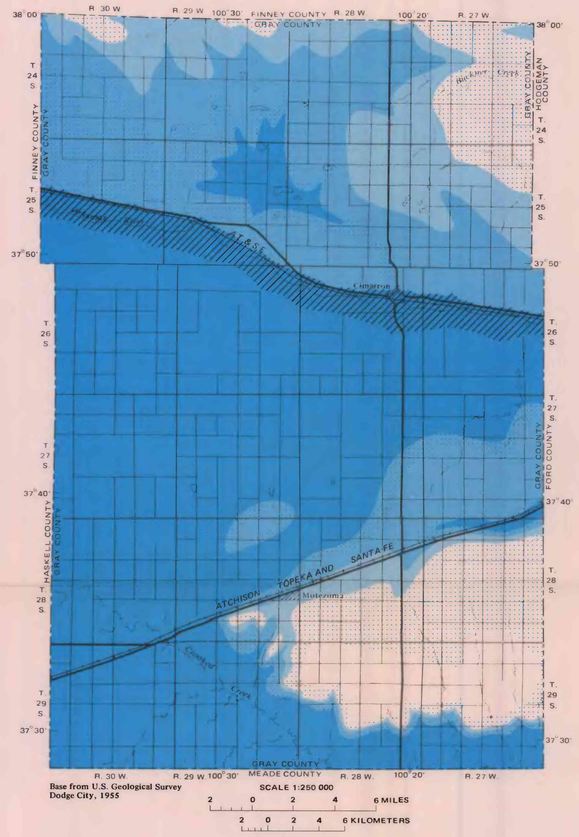
Prepared in cooperation with the
STATE GEOLOGICAL SURVEY OF KANSAS
KANSAS STATE DEPARTMENT OF HEALTH
KANSAS STATE BOARD OF AGRICULTURE

HYDROLOGIC INVESTIGATIONS
ATLAS HA-517 (SHEET 2 OF 2)

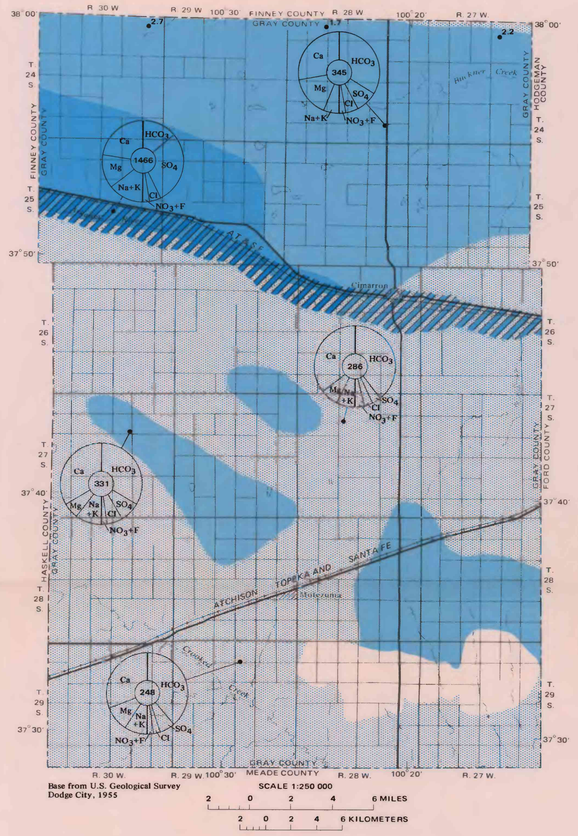
HYDROLOGY OF UNCONSOLIDATED AQUIFER



MAP SHOWING SATURATED THICKNESS, LOCATION OF LARGE CAPACITY WELLS, AND WATER-LEVEL CONTOURS (JANUARY 1970)



MAP SHOWING POTENTIAL GROUND-WATER YIELD TO WELLS

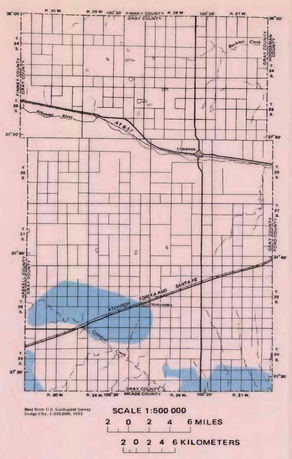


MAP SHOWING CHEMICAL QUALITY OF GROUND WATER

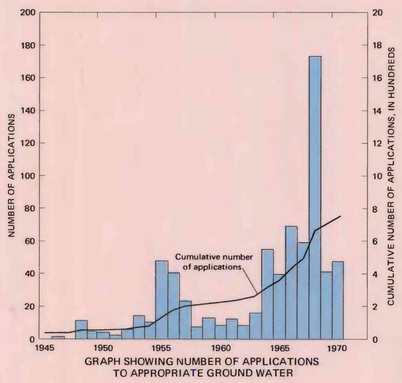
Summary of aquifer tests[1]

Geologic source	Well location	Effective thickness (ft)	Hydraulic conductivity (ft per day)	Transmissivity (ft^2 per day)	Storage coefficient	Vertical permeability (ft per day)
Alluvium	SW¼NE¼ sec. 22, T. 25 S., R. 30 W.	22	580	13,000	0.13	----------
	NE¼SE¼ sec. 25, T. 25 S., R. 30 W.		670	24,000	.17	----------
Undifferentiated Pleistocene deposits (Arkansas River valley)	SE¼NW¼ sec. 21, T. 25 S., R. 30 W.	60	26	1,600	.0002	0.016
	SE¼NW¼ sec. 28, T. 25 S., R. 29 W.	53	29	1,600	.0003	.026
Undifferentiated Pleistocene deposits (upland area)	NE¼SW¼ sec. 32, T. 24 S., R. 30 W.	100	39	3,900	----------	----------
	NW¼NE¼ sec. 14, T. 25 S., R. 29 W.	120	68	8,200	----------	----------

[1]Data from Stramel, Lane, and Hodson (1958).



MAP SHOWING WATER-LEVEL DECLINE, 1940-70



GRAPH SHOWING NUMBER OF APPLICATIONS TO APPROPRIATE GROUND WATER

GENERAL HYDROLOGY

Unconsolidated deposits of Tertiary and Quaternary age form the principal aquifer of Gray County. The water-yielding characteristics of the aquifer differ greatly from one area to another, and the ground water may occur under unconfined (water table) or semiconfined (semiartesian) conditions.

Ground-water movement generally is to the east and southeast, as shown by water-level contours on the hydrologic map. Water enters the aquifer by underflow from the west and northwest, by infiltration from precipitation, by percolation from applied irrigation water, and by infiltration from the river during periods of above-normal flow. Ground water is discharged from the aquifer by underflow to the east and south, by evapotranspiration where the water table is shallow, by inflow to the river, and by pumping from wells. Based on historic records at Garden City and Dodge City, the flow of the Arkansas River gains about 11,000 acre-feet per year across Gray County.

The saturated thickness of unconsolidated deposits, shown on the hydrologic map, ranges from zero in the southeastern part of the county to about 400 feet in the southwestern part. The depth to water at a selected site may be approximated by subtracting saturated thickness from the thickness of unconsolidated deposits. Also shown on the hydrologic map is the location of about 600 wells, most of which were used for irrigation as of January 1, 1970.

The relationship between well yield and saturated thickness differs greatly from one area to another within the county. The yield to wells penetrating coarse-grained material will greatly exceed the yield to wells penetrating mostly fine-grained material. Many wells, which partly penetrate the aquifer, obtain large yields from very coarse grained material at shallow depths. Other wells obtain large yields from coarse gravels in the deep channel deposits near the bottom of the aquifer. Wells that penetrate mostly fine-grained deposits must utilize the total saturated thickness of the aquifer to obtain an adequate quantity of water for irrigation.

On the basis of numerous drillers' logs and well-performance tests, the specific capacities of wells (gallons per minute per foot of drawdown), effective thickness of the aquifer (principal water-yielding deposits), and potential well yield were determined in different areas. Then, the potential yields of other wells were calculated by extrapolation of specific capacity and effective thickness values indicated by drillers' logs. Data from these tests were made comparable by calculating specific capacity and potential yield for an assumed drawdown in the pumped well equal to 70 percent of the effective thickness. The range of potential yield from fully penetrating wells, based on well-performance tests and extrapolated data, is shown on the map of potential ground-water yield to wells. The actual yield to an individual well, however, depends on well construction, method of completion, and density of wells in the surrounding area, as well as the saturated thickness and lithology of sediments at the selected site. Because wells are normally designed for irrigation requirements and pump efficiency rather than aquifer efficiency, the ranges shown on the map should be used primarily as a guide in planning. Test drilling is recommended for locating a site for a large-capacity well to insure the greatest yield for the least pumping lift.

AQUIFER AND WELL CHARACTERISTICS

Units of the unconsolidated aquifer have different hydrologic characteristics in different parts of the county. The units and their characteristics are described as follows:

A. Alluvium—ground water is unconfined in very coarse to medium- grained sediments. Specific capacities range from 50 to 200 gpm per foot.
B. Undifferentiated Pleistocene deposits.
   1. North of the Arkansas River—ground water is semiconfined to unconfined in medium- to coarse-grained sediments. Specific capacities range from 25 to 50 gpm per foot.
   2. South of the Arkansas River—ground water is semiconfined in fine- to medium-grained sediments. Specific capacities range from 20 to 40 gpm per foot.
      a. Shallow channel deposits—ground water is unconfined in very coarse to medium- grained sediments. Specific capacities range from 70 to 200 gpm per foot.
      b. Deep channel deposits—ground water is semiconfined in coarse-grained sediments. Specific capacities range from 40 to 80 gpm per foot.
C. Ogallala Formation—ground water is unconfined to semiconfined in fine- to coarse-grained sediments. Specific capacities range from 20 to 40 gpm per foot.

The hydraulic characteristics of the unconsolidated aquifer have been determined from the aquifer tests that are summarized in the table. Hydraulic conductivity is defined as the volume of water transmitted per unit of time through 1 square foot of aquifer under unit gradient. Transmissivity is the rate at which water is transmitted through a vertical strip of the aquifer 1 foot wide under unit gradient. The storage coefficient is a measure of the volume of water that is released from or taken into storage from 1 square foot of the aquifer surface per foot of water-level change. Vertical permeability is the volume of water transmitted per unit of time through 1 square foot of a semiconfining-bed surface at unit gradient.

GROWTH AND EFFECT OF IRRIGATION DEVELOPMENT

The increasing use of ground water for irrigation has caused a decline in water levels and an accompanying loss of water from storage. The historical development of irrigation with ground water in Gray County is illustrated by the graph showing the number of applications to appropriate ground water. Data on the graph, which are from the records of the Division of Water Resources of the Kansas State Board of Agriculture, show the increasing use of ground water for irrigation since the enactment of the Kansas Water Appropriations Act (June 28,1945). The cumulative total and number of applications to appropriate water per year may differ from the actual number of wells because the wells may not be completed in the year the applications were filed.

Water-level changes are not uniform in rate or amount, but reflect the response of the aquifer to climate, hydrologic conditions, and irrigation development. To evaluate the change in the aquifer, water-level data collected during 1940 (Latta, 1944) are compared with measurements made in 1970. Because irrigation with ground water before 1940 was insignificant, the 1940 data are considered to be representative of natural, or equilibrium, conditions (recharge equal to discharge). In 1970, water levels were measured in January when the effects of seasonal pumping were at a minimum. A decline of more than 10 feet has occurred only in the southern part of the county, as shown on the water-level-decline map. This decline is attributed to large withdrawals of ground water for irrigation in an area where the aquifer is semiconfined in part. Water levels have declined less than 10 feet in most of the upland part of the county and have remained almost unchanged in the valley of the Arkansas River.

During the irrigation season, water levels decline at different rates locally because of areal differences in transmissivity of the aquifer, the extent that water in the aquifer is under artesian pressure, and the amount of pumping from nearby wells. Some deep wells in the Arkansas River valley flow during the winter months after water levels have recovered from the effects of pumping.

CHEMICAL QUALITY OF GROUND WATER

Ground water in the unconsolidated aquifer ranges from the calcium bicarbonate type to the calcium magnesium sulfate type. The water, which has a hardness of more than 180 mg/l (milligrams per liter), is classed as very hard. The chemical quality map shows the range in concentrations of dissolved solids and a few representative diagrams that indicate the proportion of selected chemical constituents.

As shown on the map, water having concentrations of dissolved solids less than 500 mg/l is available in most of the county. Water having concentrations of 500 to 1,000 mg/l occurs in an area north of the river valley in the western part of the county. In the Arkansas River valley, concentrations of dissolved solids in water from the alluvium decrease from 1,600 mg/l at the western county line to about 500 mg/l at the eastern county line. In the same reach of the river valley, concentrations in water from the undifferentiated Pleistocene deposits decrease from 800 to about 200 mg/l. Concentrations of more than 500 mg/l of dissolved solids generally are associated with evapotranspiration from a shallow water table and with infiltration from applied irrigation water. The largest concentrations in the western part reflect underflow of highly mineralized water from Finney County. Because the Arkansas River functions as a natural drain in Gray County, ground water moving toward the valley improves the chemical quality by dilution of both surface and ground water eastward across the county.

Ground water of suitable quality for domestic and stock use is available in most of the county. Locally, concentrations of some chemical constituents exceed the limits recommended by the U.S. Public Health Service (1962) for drinking water standards. In Gray County, high concentrations of nitrate (more than 45 mg/l) and iron (more than 0.3 mg/l) generally can be prevented by proper well construction. A fluoride concentration of more than 1.5 mg/l may cause fluorosis in the formation of permanent teeth; however, a concentration of at least 1.0 mg/l is desirable to inhibit dental caries. Water samples containing high fluoride concentrations were obtained only from a few wells where chalky shales underlie a thin zone of saturated deposits. High concentrations of dissolved solids (more than 500 mg/l) are undesirable in drinking water, especially when high sulfate concentrations may cause the water to have a laxative effect.

The chemical quality of ground water is suitable for irrigation in most of the county. In areas where the concentration of dissolved solids exceeds 500 mg/l, special irrigation practices may be necessary if the soils have low permeability and poor drainage.

SELECTED REFERENCES

Frye, J. C., 1942, Geology and ground-water resources of Meade County, Kansas: Kansas Geol. Survey Bull. 45, 152 p.

Gutentag, E. D., Lobmeyer, D. H., McGovern, H. E., and Long, W. A., 1974, Ground water in Finney County, southwestern Kansas: U.S. Geol. Survey Hydrol. Inv. Atlas HA-442.

Gutentag, E. D., and Stullken, L. E., 1974, Ground water in Haskell County, southwestern Kansas: U.S. Geol. Survey Hydrol. Inv. Atlas (in press).

Hem, J. D., 1959, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 269 p.

Latta, B. F., 1944, Geology and ground-water resources of Finney and Gray Counties, Kansas: Kansas Geol. Survey Bull. 55, 272 p.

McGovern, H. E., 1970, Geology and ground water in the Ogallala Formation and undifferentiated Pleistocene deposits, southwestern Kansas, *in* Ogallala Aquifer Symposium: International Center for Arid and Semiarid Land Studies, Texas Tech Univ. Special Report No. 39, p. 15–29.

McLaughlin, T. G., 1946, Geology and ground-water resources of Grant, Haskell, and Stevens Counties, Kansas: Kansas Geol. Survey Bull. 61, 221 p.

Merriam, D. F., 1957, Preliminary regional structural contour map on top of the Dakota Formation (Cretaceous) in Kansas: Kansas Geol. Survey Oil and Gas Inv. No. 15.

Meyer, W. R., Gutentag, E. D., and Lobmeyer, D. H., 1970, Geohydrology of Finney County, southwestern Kansas: U.S. Geol. Survey Water-Supply Paper 1891, 117 p.

Moss, R. G., 1932, The geology of Ness and Hodgeman Counties, Kansas: Kansas Geol. Survey Bull. 19, 48 p.

Stramel, G. J., Lane, C. W., and Hodson, W. G., 1958, Geology and ground-water hydrology of the Ingalls area, Kansas: Kansas Geol. Survey Bull. 132, 154 p.

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

Waite, H. A., 1942, Geology and ground-water resources of Ford County, Kansas: Kansas Geol. Survey Bull. 43, 250 p.

Walton, W. C., 1962, Selected analytical methods for well and aquifer evaluation: Illinois Water Survey Bull. 49, 81 p.

Additional information on drillers' logs, well production, and water quality is available in the office of the U.S. Geological Survey, Garden City, Kans., and may be examined there.

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GROUND WATER IN GRAY COUNTY, SOUTHWESTERN KANSAS

By
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