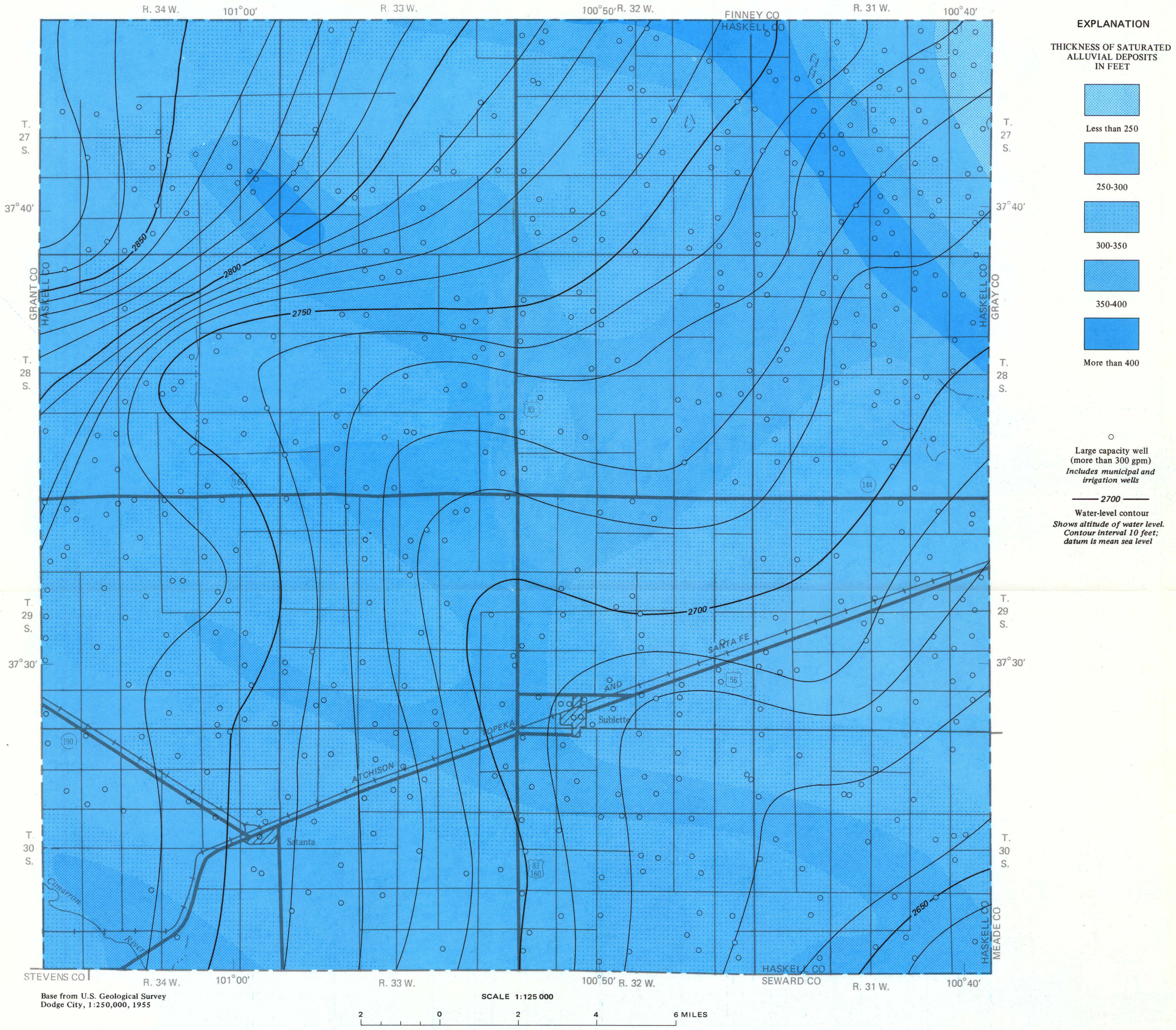
Prepared in cooperation with the
STATE GEOLOGICAL SURVEY OF KANSAS
KANSAS STATE DEPARTMENT OF HEALTH
KANSAS STATE BOARD OF AGRICULTURE

HYDROLOGY OF UNCONSOLIDATED AQUIFER



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

OCCURRENCE AND THICKNESS

Unconsolidated alluvial deposits of Tertiary and Quaternary age are the principal aquifer in most of Haskell County. These deposits consist of lenses of clay, silt, sand, and gravel that affect the water-yielding capacity and degree of confinement (artesian pressure) within the aquifer.

Ground-water movement is east-southeastward, as shown by the water-level contours on the hydrologic map. Water enters the aquifer by underflow from the west and north, by infiltration of precipitation on the county, by percolation of water applied for irrigation, and by infiltration from the Cimarron River. Ground water is discharged primarily by pumping from wells, and by underflow to the southeast. The closely spaced water-level contours in the northwestern part of the county indicate restricted ground-water flow, probably due to a greater percentage of clayey deposits than elsewhere.

The thickness of saturated deposits, shown by pattern on the hydrologic map, ranges from about 250 to 400 feet with an average thickness in the county of 330 feet. Many irrigation wells do not penetrate the total saturated thickness, but penetrate only enough water-yielding material to satisfy the production requirements of the irrigator. As shown on the hydrologic map, about 500 wells, most of which were used for irrigation, were in use in January 1970.

AQUIFER CHARACTERISTICS

The principal characteristics of an aquifer are its ability to store and transmit water. The ability to store water is expressed by the storage coefficient, and the ability to transmit water is expressed by the transmissivity.

The storage coefficient is a measure of the volume of water that an aquifer releases from or takes into storage from 1 square foot of the aquifer surface per foot of water-level change. If water in the aquifer is unconfined, the storage coefficient approaches the value obtained from gravity drainage of the interstices in the dewatered part of the aquifer.

Transmissivity is the rate at which water is transmitted through a column of the aquifer 1 foot wide under a hydraulic gradient of 1 foot per foot. Hydraulic conductivity is defined as the volume of water, in cubic feet per day, that passes through 1 square foot of the aquifer under a hydraulic gradient of 1 foot per foot. Hydraulic conductivity, as used in this study, is transmissivity divided by the thickness of water-yielding materials.

The transmissivity and the storage coefficient can be determined by several types of aquifer-test analyses using the discharge of a well and the related changes of water levels in the pumped well and in nearby observation wells. During this investigation five aquifer tests were made to determine the aquifer characteristics. Data from these tests are tabulated in the summary of aquifer tests. Storage coefficients that range from 0.15 to 0.22 indicate unconfined conditions in the principal water-yielding deposits. A storage coefficient of 0.01 reflects the influence of semiconfinement in the water-yielding deposits at that site.

Summary of aquifer tests

Well location	Effective thickness (feet)	Hydraulic conductivity (ft per day)	Transmissivity (ft^2 per day)	Storage coefficient
SE¼SE¼SE¼ sec. 31, T. 26 S., R. 32 W. (Finney County)	139	87	12,000	0.22
NW¼NW¼SW¼ sec. 2, T. 28 S., R. 31 W.	155	220	35,000	.20
SE¼SE¼SE¼ sec. 16, T. 27 S., R. 34 W.	142	180	26,000	.18
NW¼NW¼NW¼ sec. 18, T. 28 S., R. 32 W.	200	200	40,000	.15
NE¼NE¼SE¼ sec. 28, T. 27 S., R. 34 W.	130	70	9,000	.01

POTENTIAL YIELD TO WELLS

Analysis of drillers' well-performance tests from a sampling of 125 of the existing irrigation wells indicates a general correlation between percentage penetration of total saturated thickness, effective thickness (water-yielding material, in both feet and percent) of total saturated deposits, and calculated specific capacity of the well (in gallons per minute per foot of drawdown). The summary table of well-performance tests lists these factors by townships.

Percentage penetration is calculated from the ratio of saturated materials penetrated by an irrigation well to the total saturated thickness of aquifer at that site. The effective thickness is that part of the saturated material that yields most of the water to well. Specific capacity, as determined from drillers' tests, is the ability of the well to obtain water from the aquifer when the well is pumped at a rate sufficient to produce a drawdown equivalent to 70 percent of the effective thickness.

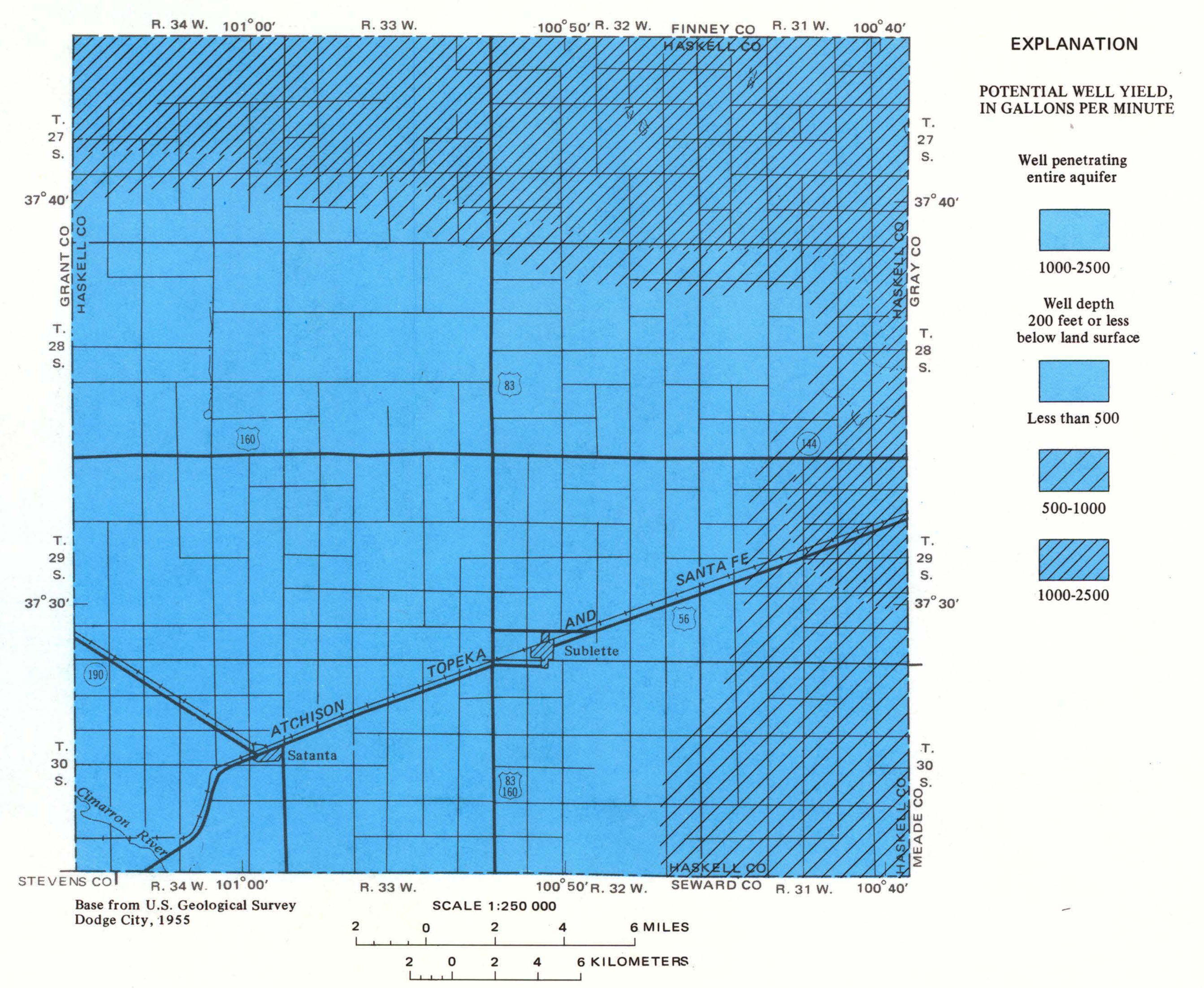
The specific capacities of wells penetrating coarse-grained deposits greatly exceed those of wells penetrating fine-grained deposits. In areas of loose coarse-grained deposits in the upper part of the aquifer many wells with a low percent penetration obtain large yields, whereas in areas of fine-grained material wells must penetrate most of the aquifer to obtain a yield adequate for irrigation.

Data from the summary table of well-performance tests were used in preparation of the potential yield map. The map shows that well yields of 1,000 to 2,500 gpm are available everywhere in the county if the full saturated thickness of the unconsolidated deposits is penetrated. Locally, however, test drilling may be required to locate a thickness of water-yielding material adequate for such large yields. The map also shows that well yields of 500 to 2,500 gpm are available from depths of 200 feet or less in the northern and eastern parts of the county.

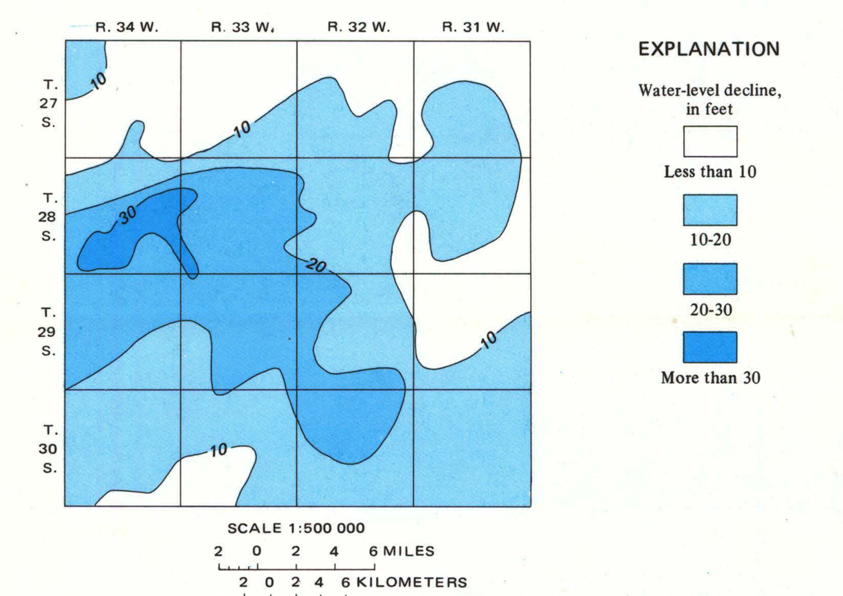
Additional information on drillers' logs and well production is available in the office of the U.S. Geological Survey, Garden City, Kans., and may be examined there.

Summary of well-performance tests of producing wells

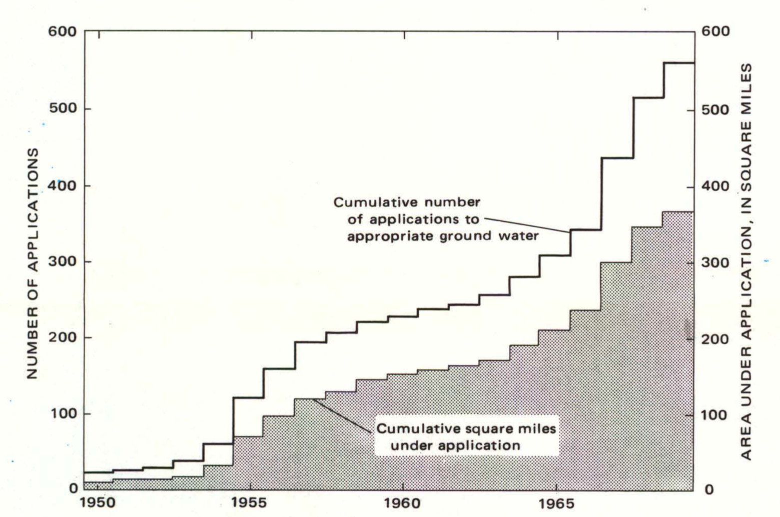
Township and range	Percentage penetration of saturated deposit	Effective thickness (percent)	Effective thickness (feet)	Specific capacity (gpm per ft drawdown)
27 S., 31 W.	26– 77 51 avg.	46– 92 75 avg.	61–226 122 avg.	30–105 72 avg.
27 S., 32 W.	28–100 68 avg.	42– 96 70 avg.	84–231 154 avg.	33–123 78 avg.
27 S., 33 W.	29– 75 55 avg.	39– 94 70 avg.	89–242 148 avg.	30–121 84 avg.
27 S., 34 W.	39–100 64 avg.	41– 75 65 avg.	82–146 118 avg.	30– 77 54 avg.
28 S., 31 W.	33–100 62 avg.	43–100 66 avg.	93–180 143 avg.	26–135 65 avg.
28 S., 32 W.	66–100 83 avg.	43– 78 52 avg.	112–200 147 avg.	29–125 59 avg.
28 S., 33 W.	88–100 98 avg.	39– 50 45 avg.	151–177 164 avg.	16– 65 41 avg.
28 S., 34 W.	48–100 81 avg.	44– 75 57 avg.	108–159 132 avg.	32– 46 41 avg.
29 S., 31 W.	35–100 73 avg.	32– 92 70 avg.	80–218 149 avg.	40–104 72 avg.
29 S., 32 W.	53– 80 66 avg.	33– 93 67 avg.	80–168 145 avg.	31– 53 39 avg.
29 S., 33 W.	50–100 73 avg.	34– 58 47 avg.	103–142 116 avg.	37– 53 46 avg.
29 S., 34 W.	60–100 93 avg.	32– 79 47 avg.	100–168 122 avg.	28–120 56 avg.
30 S., 31 W.	62– 80 70 avg.	39– 81 56 avg.	75–170 125 avg.	50–100 69 avg.
30 S., 32 W.	57–100 79 avg.	29– 80 58 avg.	114–189 140 avg.	20– 67 49 avg.
30 S., 33 W.	58–100 71 avg.	51– 69 61 avg.	117–134 126 avg.	41– 70 56 avg.
30 S., 34 W.	85–100 91 avg.	37– 70 56 avg.	100–170 140 avg.	62– 92 74 avg.



MAP SHOWING POTENTIAL YIELD TO WELLS



MAP SHOWING WATER-LEVEL DECLINE, 1941-70



GRAPH SHOWING CUMULATIVE NUMBER OF APPLICATIONS TO APPROPRIATE GROUND-WATER

WATER-LEVEL CHANGES

Ground-water withdrawals for irrigation have removed water from storage and caused a decline in water levels. Changes in water level reflect the response of the aquifer to changes in recharge and discharge rates. To evaluate the water-level change in the unconsolidated aquifer, data collected during 1941 (McLaughlin, 1946) are compared with measurements made in 1970. Ground-water pumpage prior to 1941 was insignificant and the measurements made in 1941 are considered to be representative of equilibrium conditions (recharge equal to discharge). Water levels in 1970 were measured in January when the effects of seasonal pumping are at a minimum.

Water-level declines from 1941 to 1970 (map of water-level decline) range from less than 10 feet to more than 30 feet, with an average decline of 15 feet. The greatest decline is in T. 28 S., R. 34 W., where recharge by lateral flow into the area of pumping is retarded by clayey deposits to the northwest.

IRRIGATION DEVELOPMENT

The period from June 28, 1945 (effective date of the Kansas Water Appropriation Act), through 1952 was one of little irrigation development. Development proceeded from 1953 through 1969 at an average rate of about 30 applications per year to appropriate water. Data on the number of applications to appropriate ground water and the number of square miles under application as shown on the graph, are from the records of the Division of Water Resources of the Kansas State Board of Agriculture. The cumulative number of applications to appropriate ground water differs from the number of wells in use in January 1970 because the wells may not be completed in the year the applications were filed.

CHEMICAL QUALITY OF GROUND WATER

Selected chemical analyses

[Chemical constituents in milligrams per liter; analyses by Kansas State Department of Health]

Well location	Date sampled	Depth (feet)	Temperature (°C)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness: Total	Hardness: Noncarbonate
SW¼SW¼ sec. 2, T. 28 S., R. 31 W.	5–05–64	200	16.0	199	17	0.00	0.00	47	7.6	13	176	12	9.0	0.2	6.6	150	4
SE¼SW¼ sec. 33, T. 29 S., R. 33 W.	5–03–66	360	17.0	265	17	.00	.00	50	10	29	198	44	11	.9	6.2	170	4
SE¼SE¼ sec. 36, T. 28 S., R. 33 W.	4–03–70	590	17.0	245	18	.09	.00	43	11	27	185	36	8.0	.6	6.2	150	0
NW¼SW¼ sec. 30, T. 30 S., R. 33 W.	5–03–66	415	17.5	482	28	.00	.00	70	26	52	212	167	20	1.0	13	280	110
NW¼NE¼ sec. 28, T. 30 S., R. 34 W.	7–30–69	532	17.5	465	25	.13	.00	62	30	46	210	154	20	1.1	9.7	280	110

CHEMICAL QUALITY OF GROUND WATER

Water in the unconsolidated aquifer is of the calcium bicarbonate type and is suitable for domestic, stock, and irrigation use. The water, which generally has a hardness of 150 to 280 mg/l (milligrams per liter), is classed as hard to very hard. Hardness of water is classified by the U.S. Geological Survey as follows: 0–60 mg/l, soft; 61–120 mg/l, moderately hard; 121–180 mg/l, hard; and more than 180 mg/l, very hard.

The selected chemical analyses table indicates that depth generally has little effect on water quality where the unconsolidated deposits are underlain by Jurassic or Cretaceous rocks. The higher sulfate concentration in water from wells in the southern part of the county indicates that the water in the lower part of the unconsolidated aquifer has dissolved gypsum that was derived from Permian rocks.

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GROUND WATER IN HASKELL COUNTY, SOUTHWESTERN KANSAS

By
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