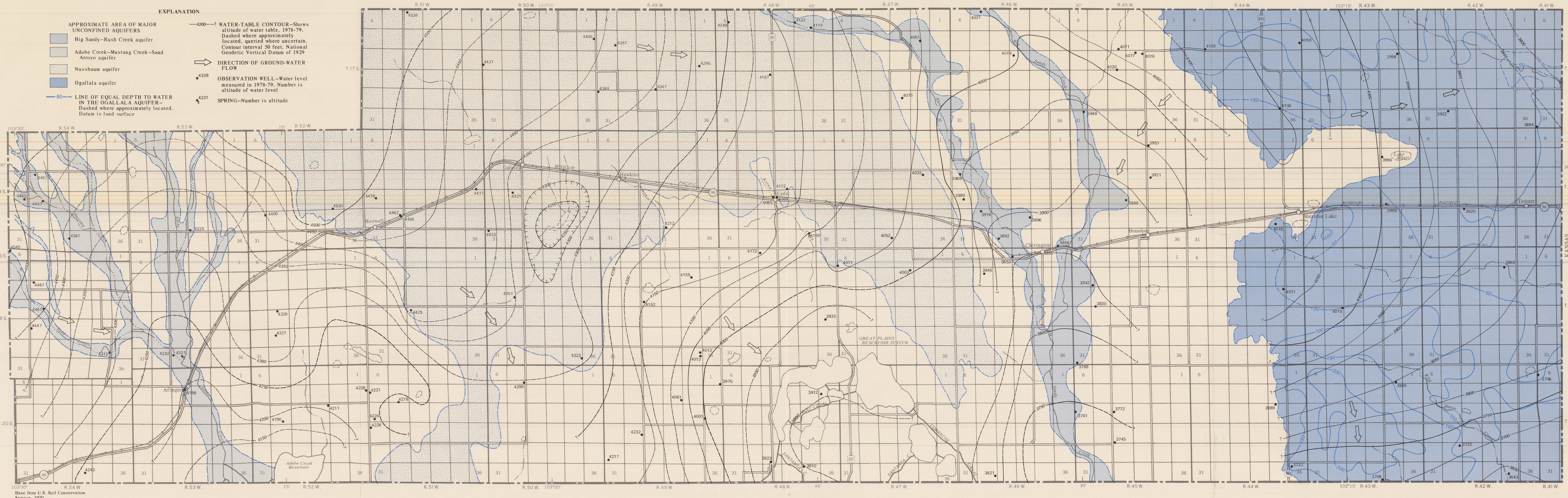
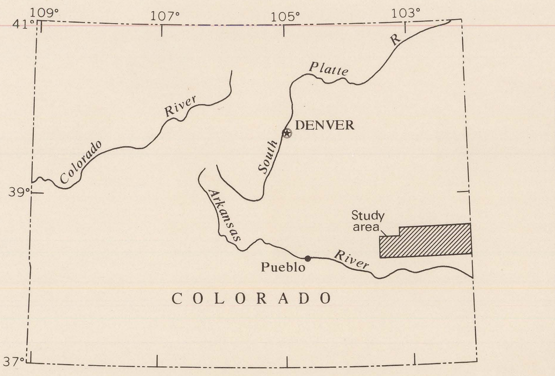
Prepared in cooperation with the
KIOWA COUNTY BOARD OF COMMISSIONERS



HYDROLOGY



INTRODUCTION

Kiowa County is a sparsely populated, semiarid, farming and ranching area in southeastern Colorado (index map). Ground water is the major source of water supply for irrigation, stock, municipal, and domestic needs. Because of concerns about drought conditions in the late 1970's and changes in canal-diversion practices to the Great Plains reservoirs, in 1978 the U.S. Geological Survey entered into a cooperative agreement with the Kiowa County Board of Commissioners to describe the hydrology and chemical quality of ground water in the county.

The investigation included reviewing existing hydrologic and geologic data and reports, measuring water levels in 114 wells, measuring specific conductance of water samples from 50 wells, and collecting and analyzing water samples from 25 additional wells. The data were interpreted to indicate the availability of ground water and suitability for specific uses. Appreciation is extended to the Lower Arkansas Valley Council of Governments for coordination between the Kiowa County Board of Commissioners and the U.S. Geological Survey and to well owners for permitting access to wells for measurement of water levels and collection of water samples.

HYDROLOGY

Ground water in Kiowa County is obtained largely from four unconfined aquifers: The Big Sandy-Rush Creek aquifer, the Adobe Creek-Mustang Creek-Sand Arroyo aquifer, the Nussbaum aquifer, and the Ogallala aquifer (see hydrology map). Where these aquifers are thin or absent, water may be available from surficial deposits, including dune sand, slopewash, and loess, and from the following bedrock formations: The Pierre Shale, the Smoky Hill Shale Member of the Niobrara Formation, the Fort Hays Limestone Member of the Niobrara Formation, the Codell Sandstone Member of the Carlile Shale, the Dakota Sandstone, and the Cheyenne Sandstone Member of the Purgatoire Formation (see generalized bedrock geology).

The Big Sandy-Rush Creek aquifer consists of unconsolidated alluvial deposits of sand, gravel, silt, and clay in the flood plains and streambeds of Big Sandy and Rush Creeks (Coffin, 1967). The alluvial deposits, averaging 25 ft in thickness, are underlain by the Smoky Hill Shale Member of the Niobrara Formation, except in T. 20 S., Rs. 45 and 46 W., where the Fort Hays Limestone Member of the Niobrara Formation and the Codell Sandstone Member of the Carlile Shale form the bedrock surface. In some places the alluvial deposits are overlain by dune sand. Depths to water in wells finished in the aquifer are less than 70 ft, with most water levels between 15 and 35 ft. Water levels in five wells measured in 1959 and again during the current study indicate no consistent, long-term changes in water level. Thickness of water-saturated material in the Big Sandy-Rush Creek aquifer ranges from 6 to 50 ft with the average about 25 ft. Well yields range from 6 to 1,200 gal/min. Most of the approximately 30 irrigation and municipal supply wells tapping the aquifer have yields between 250 and 800 gal/min. In addition to providing water for irrigation and municipal supply for the town of Eads, water pumped from the aquifer is used for stock and domestic needs Ground-water movement in the aquifer is to the south, generally paralleling the surface drainage. Water moves into the aquifer in three ways: as ground water from Cheyenne County to the north, as infiltration of precipitation, and as flood water. Water moves out of the aquifer by ground-water outflow to the south (underflow), by evapotranspiration, and by well pumpage.

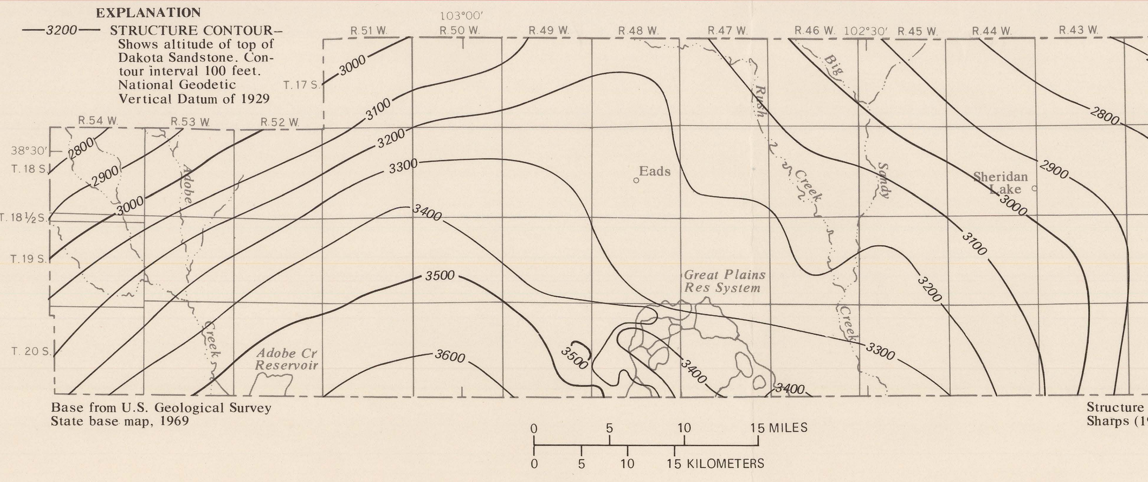
GENERALIZED BEDROCK GEOLOGY

[Modified from Sharps (1976) and Weist (1963)]

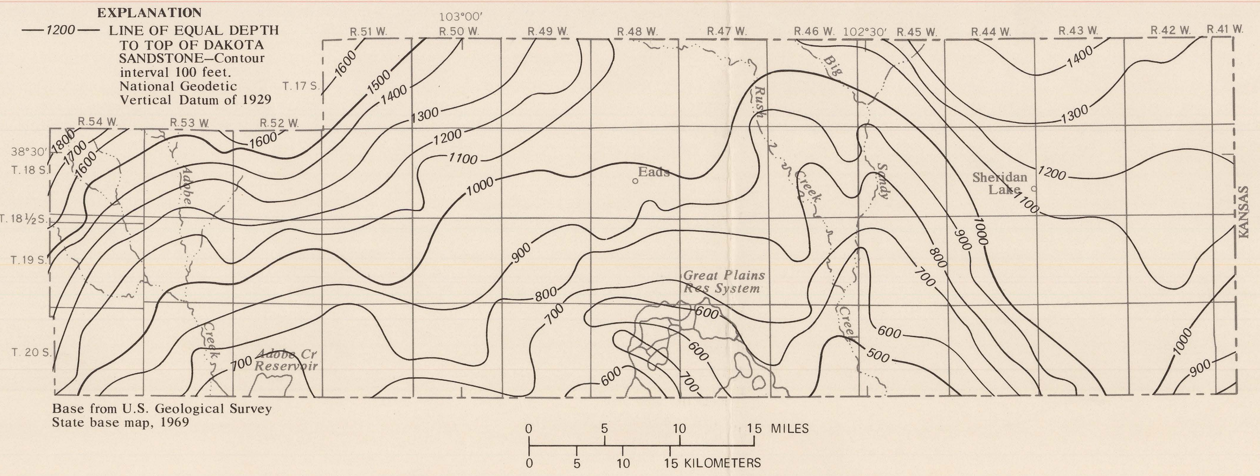
Age	Formation	Description
Late Cretaceous	Pierre Shale	Brownish-gray to dark-gray shale. About 750 ft thick in northwest corner of county, beveled by erosion southeastward to zero thickness.
	Niobrara Formation	Consists of Smoky Hill Shale Member, 500 to 700 ft of yellowish-orange, chalky fissile shale; and Fort Hays Limestone Member, 75 to 100 ft of fractured, hard yellowish-gray, massive bedded limestone.
	Carlile Shale	Consists of Juana Lopez Member, a calcarenite bed; Codell Sandstone Member, a silty sandstone and sandy shale about 25 ft thick; Blue Hill Shale Member, a black fissile shale; and Fairport Chalky Shale Member, a calcareous shale. Total thickness, 125 to 200 ft.
	Greenhorn Formation	Consists of Bridge Creek Limestone Member, an interbedded limestone and shale; Hartland Shale Member, a calcareous shale; and Lincoln Limestone Member, a calcareous shale with thin limestone beds. Total thickness, about 135 ft.
	Graneros Shale	Dark gray to black fissile shale. About 125 ft thick.
Early Cretaceous	Dakota Sandstone	Yellowish-brown, cross-bedded, resistant quartz sandstone with beds of shale. Total thickness 75 to 140 ft.
	Purgatoire Formation	Consists of Kiowa Shale Member, 50 to 130 ft of yellowish-brown to black calcareous shale; and Cheyenne Sandstone Member, 70 to 110 ft of white to buff, fine- to coarse-grained massive sandstone. In places, Cheyenne Sandstone Member consists primarily of varicolored shales.

The Adobe Creek-Mustang Creek-Sand Arroyo aquifer includes all of the saturated alluvial material in the flood plains and streambeds of Adobe Creek, Mustang Creek, and Sand Arroyo. The alluvial deposits, which consist of silty sand with some gravel and chips of shale, are probably less than 30 ft thick in most places and are underlain by Pierre Shale in the north and the Smoky Hill Shale Member of the Niobrara Formation in the south. Depths to water in wells completed in the aquifer range from 12 to 25 ft, and saturated thickness in the aquifer, based on available logs, ranges from 5 to 12 ft. Reported yields of wells completed in this aquifer, which were located during the study, range from 8 to 15 gal/min. Records of registered wells on file with the Colorado Department of Natural Resources indicate that 10 irrigation wells with yields up to 4,000 gal/min are present in the aquifer. These wells were not located during this study. Well yields of this magnitude are not likely to occur in this aquifer due to the nature of the aquifer materials and small saturated thickness. Water pumped from the aquifer is used primarily for stock watering and domestic purposes. Ground-water movement is generally to the south, paralleling the surface drainage. Water enters the aquifer as ground-water inflow from the north and west and as infiltration of precipitation and flood water. Water leaves the aquifer by underflow to the south, by evapotranspiration, and by pumping of wells.

The Nussbaum aquifer, which is the major unconfined aquifer in much of central Kiowa County, consists of cobbly gravel and silty sand deposited during the Pleistocene age as an alluvial fan unrelated to present drainage patterns



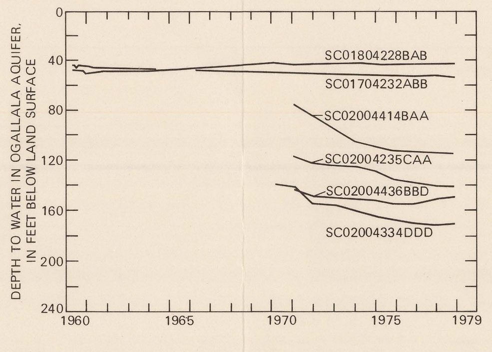
ALTITUDE AND CONFIGURATION OF TOP OF DAKOTA SANDSTONE



DEPTH TO TOP OF DAKOTA SANDSTONE

(Sharps, 1976). The alluvial deposits vary in thickness from 15 to 150 ft, with the average thickness about 100 ft. The Pierre Shale forms the bedrock surface under the Nussbaum aquifer in the northern one-third of the county and the Smoky Hill Shale Member of the Niobrara Formation comprises the bedrock in the south. Throughout most of the county, the Nussbaum alluvial deposits are covered by slopewash, dune sand, and loess. Depths to water in wells tapping the aquifer range from 23 to 58 ft and saturated thickness ranges from about 1 to 50 ft. Reported well yields range from 2 to 450 gal/min but most wells yield between 10 and 20 gal/min. The small yields limit the use of water from the aquifer primarily to domestic and stock use. Ground water in the aquifer moves primarily to the southeast. Closed water-level contours on the altitude and the configuration of the water-table map shown southeast of Galatea result from ground-water flow into a topographic depression. Inflow to the aquifer is as infiltration of precipitation and as ground-water inflow from the north and west. Water moves out of the aquifer primarily by well pumpage, ground-water outflow into minor unconfined aquifers such as dune sand, slopewash, and loess, and by ground-water outflow to the south in R. 51 W. Little water moves out of the aquifer by evapotranspiration due to the relatively large depth to water.

The Ogallala aquifer in the eastern part of the county consists of sand and gravel with interbedded silt, cemented with caliche in part, and capped with thin hard limestone in places. Thickness varies from a few feet east of Lake Albert to approximately 200 ft in the southeastern and northeastern corners of the county. The aquifer is underlain by the Smoky Hill Shale Member of the Niobrara Formation in all but the most northerly 2 to 3 mi of the county, where the aquifer lies on Pierre Shale (Boettcher, 1964). The deposits are poorly exposed at the surface, generally being covered by loess or slopewash. Depths to water of wells completed in the aquifer range from 13 ft to greater than 200 ft (see depth to water table in the Ogallala aquifer). Depths to water in wells in T. 20 S., Rs. 42, 43, and 44 W., have declined significantly in the last 10 years (see graph below). Although depths to water in wells in the northern part of the county have been fairly stable, water-level declines of about 10 ft from the 1964 level are predicted by the year 2000 (Kapple and others, 1977). Declines in water level are primarily the result of water for irrigation being pumped faster than the aquifer is being recharged by precipitation. Saturated thickness ranges from a few feet to more than 100 ft with the greatest saturated thickness found in the southeastern part of the county. Well yields range from 1 to 3,000 gal/min, with about one-third equal to or exceeding 100 gal/min. Well yields can be expected to decrease in areas of water-level declines as the thickness of saturated material decreases. Water from the aquifer is used primarily for irrigation, stock, and domestic purposes. Water movement in the aquifer is to the northeast, east, and southeast. Water moves into the aquifer primarily as infiltration from precipitation and flows out as ground-water underflow to the northeast, east, and southeast, and as well pumpage.



Dune sands, which consist primarily of very fine to medium sand and silt, cover large areas of the county to depths as great as 70 ft, but average 15 ft (Coffin, 1967; Sharps, 1976). Where dune sands overlie the Big Sandy-Rush Creek and Nussbaum aquifers, they act as a catchment for recharge to these aquifers by absorbing much of the incident precipitation which might otherwise run off. Depths to water in wells tapping the aquifer range from 10 to 40 ft, depending primarily on the thickness of the sands. Because of small saturated thicknesses (generally less than 5 ft) and low permeability of the sand, well yields are only 1 to 10 gal/min, and wells may go dry during periods of below-normal precipitation. The small yields limit the water use to domestic or stock purposes. Dune sands are considered a minor aquifer in the county because of the small yields and discontinuous distribution of saturated material.

Other minor unconfined surficial aquifers in the county are in slopewash and loess deposits. Slopewash is material deposited on slopes by water and consists mostly of sandy silt but may include gravel or chips of limestone or shale. Loess consists of silt, sandy silt, and very fine sand deposited primarily by wind. These deposits overlie the Nussbaum and Ogallala aquifers in places but generally contain thin saturated material only where they directly overlie the Pierre Shale or the Smoky Hill Shale Member of the Niobrara Formation. Depths to water in wells tapping these aquifers are usually between 20 and 60 ft. Because of the small saturated thicknesses and low permeability of the deposits, well yields are sufficient only for stock or domestic use.

The Pierre Shale and the Smoky Hill Shale Member of the Niobrara Formation form the bedrock surface throughout most of the county. Both of these formations are relatively impermeable and can be expected to yield only small quantities of water (less than about 2 gal/min) to wells from weathered or fractured zones. Because of poor quality, the water is likely to be suitable only for stock watering.

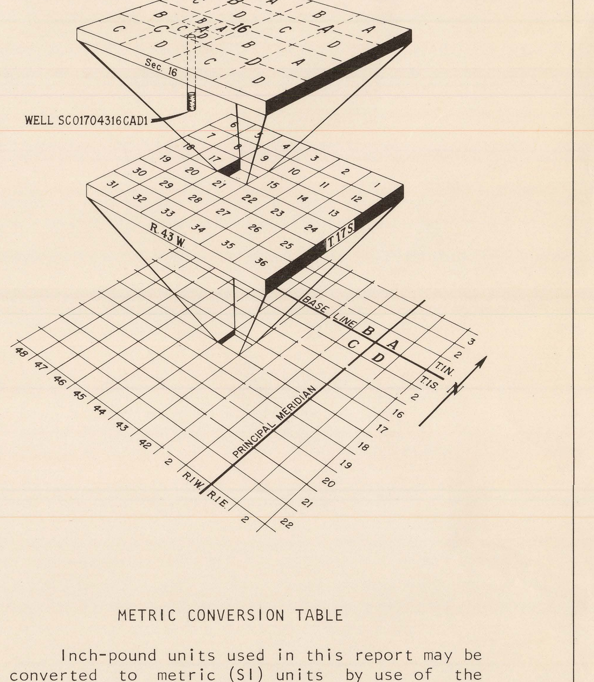
The Fort Hays Limestone Member of the Niobrara Formation and the Codell Sandstone Member of the Carlile Shale both provide water to wells near their outcrops. The wells are primarily located in Tps. 7-20 S., Rs. 45 and 46 W. (Coffin, 1967). Yields of water from both formations are small (less than 10 gal/min) and except near the outcrops, both formations are too deeply buried to be a feasible source of water supply. Because of small yields and generally poor quality, the water is used primarily for stock watering.

The Dakota Sandstone and the Cheyenne Sandstone Member of the Purgatoire Formation are two deep, confined aquifers underlying the entire county. Water in the two formations is confined by overlying shale units (see table of generalized bedrock geology) resulting in artesian pressure; that is, water in wells in the formations will rise above the top of the formation. Depth to the top of the Dakota Sandstone is less than 500 ft in the south-central part of the county and increases to over 1,800 ft in the northwestern part of the county (see maps showing altitude and configuration of top of Dakota Sandstone and depth to top of Dakota Sandstone). These relatively large depths have discouraged widespread development of the aquifers to date. No current information is available on depth to water in wells completed in these formations because of a lack of wells currently in use. Only one well tapping the Dakota Sandstone (site 31 in the table of chemical analyses) was located during the study, and it was not possible to measure a water level in this well. Some indication of probable depths to water is available, however. Darton (1906, plate XVIII) reported the altitude of the potentiometric surface of water in the Dakota Sandstone to range from 3,000 ft in the eastern part of the county to 4,000 ft in the west. This range of depth to water likely still exists, because water levels in Prowers County to the immediate south measured in the early 1970's (Major and others, 1974, p. 289-291) are within 100 ft of Darton's potentiometric contours. Information on yields of wells completed in the Dakota Sandstone and the Cheyenne Sandstone Member of the Purgatoire Formation are not available in Kiowa County. However, wells completed in the Dakota Sandstone or in both formations to the south, west, and southwest are commonly used for domestic, stock, and municipal purposes (Weist, 1963; Voegeli and Hershey, 1965) with reported yields ranging from 4 to 85 gal/min. A recent pumping test (Cain and others, 1980) of a 1,937-ft deep well completed in the Dakota Sandstone in Crowley County to the west had a discharge of 14.6 gal/min and a specific capacity of 0.36 gal/min/ft of drawdown. Assuming a 50-percent drawdown, the yield would be 275 gal/min. This yield is three times as large as most reported previously in the area. Yields of wells completed in both aquifers can be expected to be larger. Water movement in the Dakota Sandstone and Cheyenne Sandstone Member of the Purgatoire Formation in the county is from the west-southwest to the east-northeast. Recharge to the aquifers does not occur in the county but does occur in outcrop areas to the south and west. Underflow to the east and northeast is the primary way water from these aquifers leaves the county.

SYSTEM OF NUMBERING WELLS AND SPRINGS

The well and spring locations in this report were given numbers based on the U.S. Bureau of Land Management system of land subdivision and show the location of the well by quadrant, township, range, section, and position within the section. (See diagram showing system of numbering wells and springs.) The first letter "S" preceding the location number indicates that the well or spring is located in the area governed by the Sixth Principal Meridian. The second letter indicates the quadrant in which the well or spring is located. Four quadrants are formed by the intersection of the base line and the principal meridian--A indicates the northeast quadrant, B the northwest, C the southwest, and D the southeast.

The first three digits of the number indicate the township, the next three digits the range, and the last two digits the section in which the well or spring is located. The letters following the section number locate the well or spring within the section. The first letter denotes the quarter section, the second the quarter-quarter section, and the third the quarter-quarter-quarter section. The letters are assigned within the section in a counterclockwise direction, beginning with (A) in the northeast section and within each quarter-quarter section in the same manner. Where two or more locations are within the smallest subdivision, consecutive numbers beginning with 1 are added in the order in which the data from wells or springs were collected. For example, well SC01704316CAD1 is located in the SE¼NE¼SW¼ sec. 16, T. 17 S., R. 43 W., southwest quadrant of the area governed by the Sixth Principal Meridian.



METRIC CONVERSION TABLE

Inch-pound units used in this report may be converted to metric (SI) units by use of the following conversion factors:

Multiply	*By*	*To obtain*
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
cubic foot per second (ft^3/s)	28.32	liter per second
gallon per minute (gal/min)	0.06309	liter per second
gallon per minute per foot (gal/min/ft)	0.2070	liter per second per meter

HYDROLOGY AND CHEMICAL QUALITY OF GROUND WATER IN KIOWA COUNTY, COLORADO

By
Martha H. Mustard and Doug Cain

1981

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