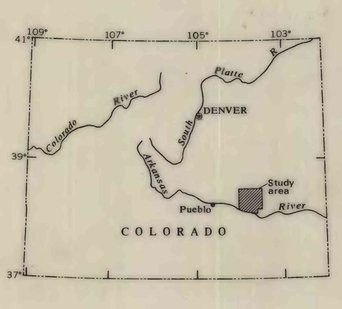
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with the
CROWLEY COUNTY BOARD OF COMMISSIONERS

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 80-681
SHEET 1 OF 2



INTRODUCTION

Crowley County, on the semiarid plains of southeastern Colorado (index map), has had water-supply problems in recent years. Ground-water supplies in the northern one-half of the county are sufficient only for domestic and stock wells. Ground water and water diverted from the Arkansas River through the Colorado Canal generally have been sufficient for municipal and agricultural needs in the southern one-half of the county. In recent years, much of the water diverted through the Colorado Canal has been purchased for use outside the county. Because of the changes in canal-diversion practices and a need for additional reliable sources of municipal water, in 1977 the U.S. Geological Survey entered into a cooperative agreement with the Crowley County Board of Commissioners to determine current ground-water conditions and areas with the potential for increased ground-water development in the county.

The investigation included reviewing existing hydrologic and geologic data, measuring water levels in wells, and measuring specific conductance of water from springs and pumping wells. Water samples for chemical analyses were collected from selected wells. An aquifer test was conducted using a well completed in the Dakota Sandstone.

Appreciation is extended to the Crowley County Board of Commissioners for providing access to municipal wells, to the Lower Arkansas Valley Council of Governments for coordination between the Crowley County Board of Commissioners and the U.S. Geological Survey, and to well owners for granting permission to measure water levels and to collect water samples from their wells.

GROUND-WATER HYDROLOGY

Significant quantities of ground water in Crowley County occur in several shallow water-table aquifers and in two deep confined aquifers (hydrologic map). Water-table conditions exist in the unconsolidated alluvial deposits. These alluvial deposits overlie the Pierre Shale in all but the southeastern corner of the county, where the alluvial deposits overlie the Niobrara Formation. (See generalized bedrock geology table.) Water-table aquifers are located in the alluvium of the Arkansas River valley, in the alluvium in the Horse Creek drainage basin, in the lower part of the dune sand and in the alluvium underlying the dune sand in the western one-fourth of the county, in the alluvium in the Bob Creek drainage basin, in the alluvium in the Sand Arroyo drainage basin, and in the loess southwest of Sand Arroyo. The confined aquifers are the Dakota Sandstone and the Cheyenne Sandstone Member of the Purgatoire Formation. The geologic formations which occur between the bedrock surface and these two aquifers are summarized in the generalized bedrock geology table. Although zones in the bedrock formations overlying the Dakota Sandstone may yield small quantities of water to wells, no wells in Crowley County are known to be completed in these zones. The Graneros Shale overlying the Dakota Sandstone and the Kiowa Shale Member overlying the Cheyenne Sandstone Member of the Purgatoire Formation act as confining beds.

The principal source of ground water in Crowley County is the alluvium in the Arkansas River valley, which ranges in thickness from zero to 80 ft and consists of material ranging in size from clay to boulders. The alluvium tends to be coarser and contains a higher percentage of gravel near the Arkansas River. Away from the river channel, the alluvium tends to contain more sand and clay, and, thus, is less permeable.

Principal sources of inflow to the Arkansas River alluvial aquifer are underflow from the west and underflow from the alluvium in the Bob Creek drainage basin. Principal sources of local recharge to the aquifer are seepage from the Arkansas River, Colorado Canal, and to some degree the southwest end of Lake Meredith; irrigation return flows; and, to a lesser extent, infiltration of precipitation. Depths to water in the alluvium range from land surface to about 55 ft below land surface. Generally, the depth to water in most of the alluvium ranges from 10 to 30 ft below land surface. According to Weist (1965), annual water-level fluctuations in the area between Olney Springs and Sugar City correlate closely with diversions in the Colorado Canal and indicate significant recharge to the aquifer by canal seepage. In May or June, when diversions are greatest, water levels rise significantly. Water levels begin to decline during August or September when diversions are infrequent, and are lowest during the late winter and early spring. Examination of records collected since 1959 indicates no apparent long-term water-level changes. The direction of ground-water movement, which is perpendicular to the water-table contours (hydrologic map), is generally south to southeast. The saturated thickness of the alluvium varies from less than 10 to approximately 32 ft with an average saturated thickness of about 25 ft. Outflow from the Arkansas River alluvial aquifer occurs primarily as underflow out of the county to the east. Discharge is by wells, evapotranspiration from areas where the water table is less than 10 ft below land surface, and seepage into Lake Meredith.

Maximum reported yields of wells located in the flood plain of the Arkansas River and completed in the alluvium exceed 2,000 gal/min. Well yields between 500 and 1,000 gal/min are typical. Well yields in areas other than the flood plain generally range from 100 to 200 gal/min. In the vicinity of Ordway, well yields are generally less than 35 gal/min--probably because of decreased saturated thickness and permeability caused by an increase in clay and a decrease in gravel in the aquifer.

The Horse Creek alluvial aquifer includes all of the saturated alluvium in the Horse Creek drainage basin. The alluvium consists primarily of silt and sand with some gravel; the gravel is located primarily in the present stream channels. The thickness of the alluvium ranges from zero to 50 ft with an average thickness of about 30 ft. Inflow to the aquifer occurs as underflow into the county from the north. The principal source of local recharge is infiltration of precipitation. The configuration of the water-table contours shown on the hydrologic map indicates that the aquifer also is recharged by application and return flow of irrigation water from the Colorado Canal. The direction of ground-water movement is south to southeast, generally paralleling surface drainage. Depth to water in the aquifer varies from less than 10 to nearly 40 ft below land surface. Typically the depth to water is 15 to 23 ft below land surface. The saturated thickness of the alluvium in the upper reaches of the basin is generally less than 10 ft. In the area south of Lake Henry, saturated thickness generally ranges from 10 to 20 ft. Outflow from the aquifer occurs as underflow to the southeast, and discharge is by wells. In the area affected by recharge from surface-water irrigation, reported yields range from about 10 to 650 gal/min; large-capacity wells in this area generally have reported well yields of 150 to 200 gal/min. North of the area affected by irrigation, reported well yields generally range from about 5 to 15 gal/min. However, reported yields of several public-supply wells located in sec. 33, T. 19 S., R. 56 W., and in sec. 4, T. 20 S., R. 56 W., are as much as 90 gal/min.

The thickness of the dune sand in the western one-fourth of the county, north of Olney Springs, ranges from less than 10 ft along the eastern and southern limits of the aquifer to about 80 ft in the northwest corner of the county. Only the lower part of the dune sand is saturated. The saturated alluvium underlying the dune sand consists of cobbly gravel and silty sand (Sharps, 1976). The alluvium ranges from 20 to 30 ft in thickness.

Inflow to the dune sand and the underlying alluvium occurs as underflow into the county from the west and north. Recharge is by infiltration of precipitation. The configuration of the water-table contours on the hydrologic map indicates the direction of ground-water movement is south to southeast. Depth to water in the lower part of the dune sand and the underlying alluvium ranges from land surface along parts of the eastern and southern limits of the aquifer, where contact springs occur, to about 100 ft below land surface along the western edge of the county. The saturated thickness of the lower part of the dune sand and the alluvium generally varies from less than 10 ft in the eastern and southern parts of the aquifer to more than 40 ft in the northwest corner of the county. The saturated thickness is generally between 10 and 20 ft. Discharge from the aquifer occurs at contact springs, as evapotranspiration, and as discharge from wells. Several contact springs located in secs. 34 and 35, T. 21 S., R. 59 W., used for a public-water supply, have a combined yield of about 20 gal/min. Reported well yields, generally less than 10 gal/min, restrict water use to domestic and stock purposes.

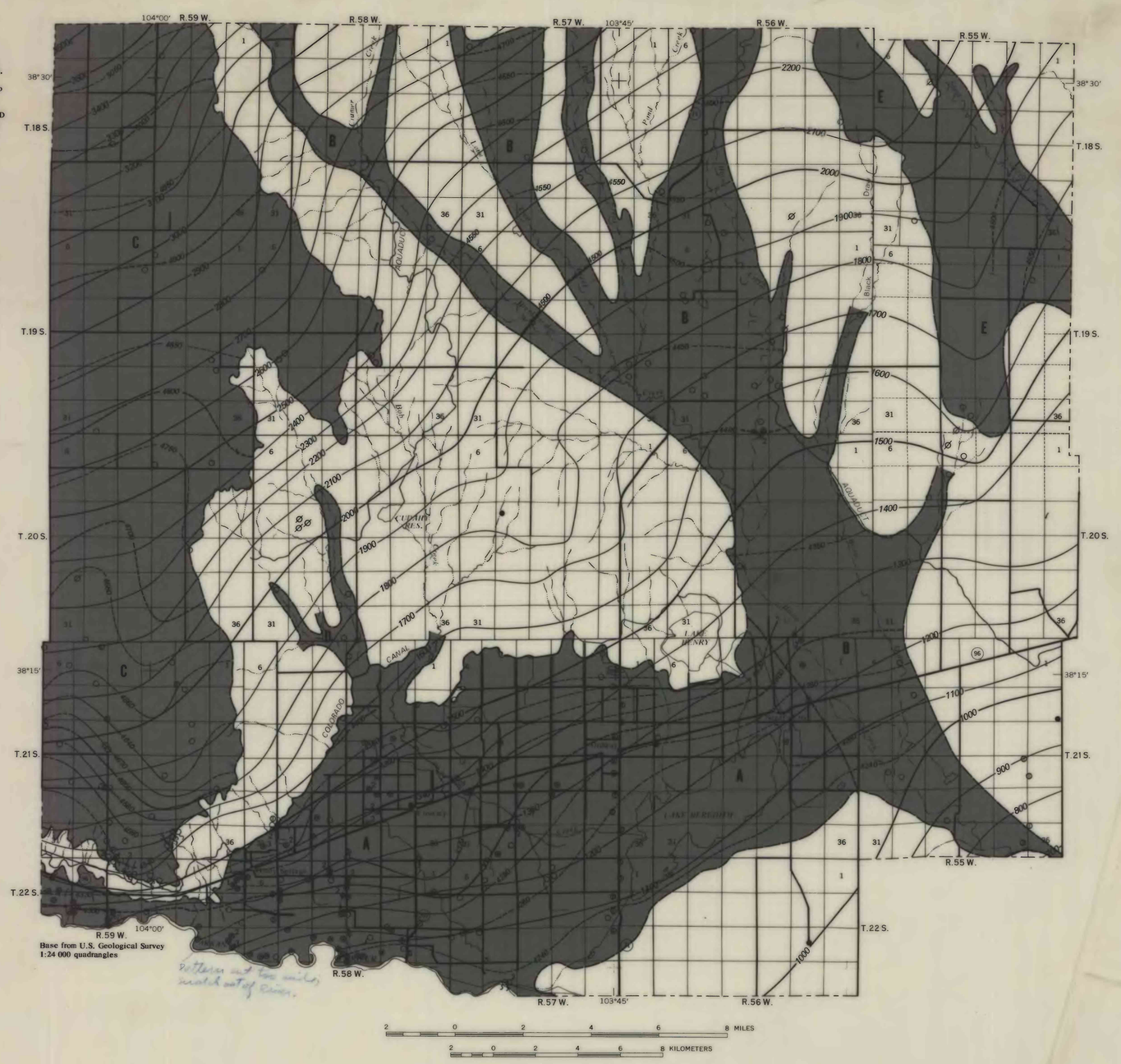
The alluvium in the Bob Creek drainage basin north of the Colorado Canal consists of sandy silt but may include some gravel or chips of shale (Sharps, 1976). The thickness of the alluvium ranges from zero to about 30 ft. Recharge to this aquifer is mostly from infiltration of precipitation. The direction of ground-water movement is generally south, paralleling the surface drainage. Insufficient hydrologic data are available to determine depth to water; based on data from one well, the saturated thickness is estimated to be less than 10 ft. Outflow from the aquifer occurs as underflow to the Arkansas River alluvial aquifer. Discharge is by wells. Reported well yields are generally less than 5 gal/min.

The alluvium in the Sand Arroyo drainage basin consists of silty sand and some gravel and chips of shale. The alluvium underlying the loess southwest of Sand Arroyo consists of cobbly gravel and silty sand (Sharps, 1976). Ground-water data are available from only five wells in this area. The limited data indicate the thickness of the alluvium in Sand Arroyo and the combined thickness of the loess and underlying alluvium probably is less than 30 ft. Inflow to the alluvium occurs as underflow from the north. Recharge is by infiltration of precipitation. Ground-water movement is generally to the southeast, paralleling surface drainage. The limited data also indicate that the depth to water ranges from about 15 to 25 ft below land surface. The saturated thickness of the alluvium is less than 10 ft and possibly less than 5 ft. Outflow from the aquifer occurs as underflow out of the county to the southeast. Discharge is by wells. Reported well yields are generally about 5 gal/min.

The Dakota Sandstone and the Cheyenne Sandstone Member of the Purgatoire Formation are the only known bedrock aquifers in Crowley County. The top of the Dakota Sandstone ranges from about 700 ft below land surface in the southeastern part of the county to about 3,600 ft below land surface in the northwest. (See hydrologic map.) The Dakota Sandstone ranges in thickness from about 75 to 140 ft, and the Cheyenne Sandstone Member ranges in thickness from about 70 to 110 ft. The two sandstone units are separated by the 50- to 130-ft thick Kiowa Shale Member of the Purgatoire Formation (Weist, 1963).

The Dakota Sandstone and the Cheyenne Sandstone Member of the Purgatoire Formation are artesian aquifers; water in the aquifers is confined by overlying shale units. Water levels in tightly cased wells penetrating these aquifers are above the top of the sandstones. Because both of these aquifers are confined, the complete thickness of the units is saturated, although not all the thickness may be water yielding, due to interbedded shale. Because of the overlying shale, no recharge occurs to the Dakota Sandstone or the Cheyenne Sandstone Member in Crowley County. The nearest recharge area is about 25 to 30 mi south to southeast of the county where the sandstones crop out. According to Weist (1965), the direction of water movement is toward the northeast in the Dakota Sandstone in southern Crowley County. No data are available on the direction of water movement in the Cheyenne Sandstone Member or for the Dakota Sandstone in the northern part of the county. Reported depths to water in wells completed in the Dakota Sandstone range from above land surface (flowing) in the southwest corner of the county (Weist, 1962) to 406 ft below land surface in a well located in sec. 17, T. 20 S., R. 57 W. No water-level data are available for the Cheyenne Sandstone Member.

Outflow from the Dakota Sandstone occurs primarily as underflow. Discharge is by wells. Outflow from the Cheyenne Sandstone Member probably occurs primarily as underflow. Reported yields from wells completed in the Dakota Sandstone in Crowley County range from 4 to 25 gal/min.



HYDROLOGIC MAP

GENERALIZED BEDROCK GEOLOGY

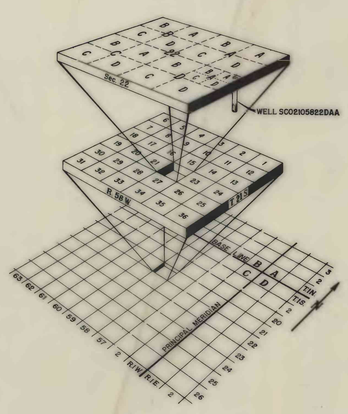
[After Sharps (1976) and Weist (1963)]

Age	Formation	Description
Late Cretaceous	Pierre Shale	Brownish-gray to dark-gray shale. About 2,500 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 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; 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.

SYSTEM OF NUMBERING WELLS AND SPRINGS

The well and spring locations in this report are 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 the wells or springs were collected. For example, well SC02105815DBB is located in the NW¼NW¼SE¼ sec. 15, T. 21 S., R. 58 W., southwest quadrant of the area governed by the Sixth Principal Meridian.



METRIC CONVERSION TABLE

Multiply inch-pound unit	*By*	*To obtain metric unit*
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
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 CROWLEY COUNTY, COLORADO

Doug Cain, Barbara J. Ryan, and Patrick J. Emmons

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