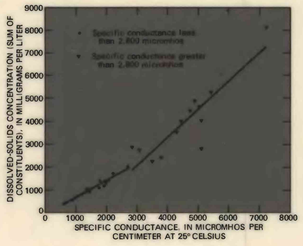
Prepared in cooperation with the
CROWLEY COUNTY BOARD OF COMMISSIONERS

CHEMICAL QUALITY OF GROUND WATER

The chemical quality of ground water was evaluated by measuring the specific conductance of water from springs and pumping wells and by analyzing water samples from selected wells and springs for selected chemical constituents. Specific-conductance data are plotted on the water-quality map and results of the chemical analyses are shown in the table of chemical analyses. The table includes data collected during this study and during previous studies (Weist, 1962; Major, Hurr, and Moore, 1970).

Specific conductance, measured in micromhos per centimeter at 25°C (degrees Celsius), is the ability of water to conduct an electrical current. Specific conductance is a useful indicator of ground-water quality because it is related to the dissolved-solids concentration of the water, measured in milligrams per liter (mg/L). The relationship between specific conductance and dissolved-solids concentration for ground-water samples collected in Crowley County is shown in the graph.



If the specific conductance is known, the approximate dissolved-solids concentration can be determined using the graph, or can be calculated for the lines shown on the graph by using one of the two equations given below:

$$DS = SC \times 0.75 - 83 \text{ mg/L}, \quad (1)$$

for specific conductance less than 2,800 micromhos; or

$$DS = SC \times 1.22 - 1{,}620 \text{ mg/L}, \quad (2)$$

for specific conductances greater than 2,800 micromhos,

where:

DS = dissolved solids, in milligrams per liter; and
SC = specific conductance, in micromhos per centimeter at 25°C.

For example, the specific conductance of water from well 5 in the chemical-analyses table is 690 micromhos. Using equation 1, an estimated dissolved-solids concentration of 435 mg/L results, which compares well with the actual value of 448 mg/L. Using equation 2 to estimate the dissolved-solids concentration of water from well 3 in the chemical-analyses table gives a value of 4,600 mg/L; the actual value is 4,050 mg/L. Examination of the graph relating specific conductance to dissolved solids shows more points further from the line at specific-conductance values greater than 2,800 micromhos. This will result in a larger expected error in estimated dissolved-solids concentrations when using equation 2 than when using equation 1. The standard error of estimate is 770 mg/L for equation 2 as compared with 70 mg/L for equation 1. This same type of calculation can be made for any of the specific-conductance data on the water-quality map or for any specific conductances measured in the future.

The dissolved-solids concentration may be used to make an initial evaluation of the suitability of a water supply for a specific use. Water with dissolved-solids concentrations greater than 500 mg/L are considered to be esthetically unacceptable for drinking (U.S. Environmental Protection Agency, 1977), although waters with larger concentrations are commonly used without obvious ill effects on human health (U.S. Public Health Service, 1962).

The suitability of water in different ranges of dissolved solids for irrigation use (U.S. Environmental Protection Agency, 1976) is summarized below:

Suitability of water for irrigation	Dissolved-solids concentration (milligrams per liter)
Detrimental effects will usually be noticed---------	0-500
Can have detrimental effects on sensitive crops---------	500-1,000
May have adverse effects on many crops; requires careful management practices---	1,000-2,000
Can be used for tolerant plants in permeable soils with careful management practices----------	2,000-5,000

Although this classification does not consider water with dissolved-solids concentrations greater than 5,000 mg/L, water of this quality is sometimes used for irrigation of tolerant crops in many areas of the Arkansas River valley of Colorado (Miles, 1977).

Stock can generally tolerate very large concentrations of dissolved solids. Studies have shown that chickens, swine, cattle, and sheep can tolerate waters with dissolved-solids concentrations as large as 15,000 mg/L (U.S. Environmental Protection Agency, 1976).

In addition to specific conductance and dissolved solids, other water-quality constituents need to be determined when evaluating the suitability of water for a specific use. However, specific-conductance and dissolved-solids determinations may be used to provide a quick and inexpensive means of determining if further water-quality evaluations need to be made.

The specific-conductance data on the water-quality map indicate that the quality of ground water varies widely in the county. Much of the variation is related to different conditions in each aquifer, such as chemical composition of the aquifer materials and quality of water which recharges the aquifer.

Specific conductance in water from the Arkansas River alluvial aquifer ranged from 1,000 to 9,000 micromhos, with most values between 1,000 and 5,000 micromhos. Dissolved-solids concentrations ranged from about 700 to 4,500 mg/L. Using the following hardness classification (Durfor and Becker, 1964), all of the waters analyzed from this aquifer would be considered very hard.

Hardness, as calcium carbonate (milligrams per liter)	Description
0-60	Soft
61-120	Moderately hard
121-180	Hard
More than 180	Very hard

Sulfate concentrations of water produced from the Arkansas River alluvial aquifer exceeded the recommended limit of 250 mg/L for drinking water (U.S. Environmental Protection Agency, 1977) in all samples analyzed. A laxative effect may be noticed by users unaccustomed to drinking this water (U.S. Public Health Service, 1962). Fluoride locally exceeded the mandatory limit of 1.8 mg/L for drinking water (Colorado Department of Health, 1977). Concentrations greater than 1.8 mg/L may cause mottling of teeth, especially children's teeth (U.S. Public Health Service, 1962).

Water from the Arkansas River alluvial aquifer generally is suitable for irrigation, but special irrigation-management practices, such as applying sufficient water to leach salts from the root zone or cultivating crops tolerant to large dissolved-solids concentration, may be required locally. The water should be suitable for stock use. Chemical analyses of water collected from well SC02205818CBD in 1960, 1964, and 1978 indicate only minor changes in the concentrations of the analyzed constituents, indicating relatively stable water-quality conditions in the alluvial aquifer.

Water from alluvium in the Horse Creek drainage basin had specific-conductance values ranging from 690 to 5,100 micromhos, and dissolved-solids concentrations between 448 and 4,050 mg/L. Water from the alluvium along the mainstem of Horse Creek in the southern two-thirds of the county may be suitable locally for use as a domestic supply. The smallest specific-conductance values and dissolved-solids concentrations occurred in water samples collected from wells in this part of the aquifer. Sulfate and hardness concentrations also tend to be smaller in this part of the aquifer. However, water from only well SC01905627CAB had a sulfate concentration less than 250 mg/L, and water from only this well and well SC02105528DCD had hardness concentrations less than 120 mg/L. Fluoride locally exceeded 1.8 mg/L.

The water is generally suitable for irrigation and stock purposes but special irrigation-management practices such as previously mentioned may be required locally. Chemical analyses of water collected from well SC02105602BAA in 1960 and 1978 show a decrease in concentrations of dissolved solids, sulfate, and sodium, and an increase in hardness.

Water from wells and springs in the dune sand and the underlying alluvium in western Crowley County generally had the smallest specific-conductance values and dissolved-solids concentrations of any aquifer in the county. These small dissolved-solids concentrations probably result from a combination of recharge, primarily from precipitation that contains few dissolved solids, and little increase of dissolved solids as the recharging water percolates to the water table through the relatively insoluble dune sand. Specific conductance ranged from 620 to 4,400 micromhos but generally was less than 2,000 micromhos. Dissolved-solids concentrations were between 394 and 2,270 mg/L. None of the water sampled from this aquifer was classified as soft; water from three samples, collected in different areas of the aquifer, was classified as moderately hard to hard; and water from five samples was classified as very hard. Sulfate and fluoride concentrations locally exceeded drinking-water limits. Concentrations of nitrite plus nitrate were generally greater in water from this aquifer than from any other, and the mandatory limit of 10 mg/L as nitrogen for drinking water (Colorado Department of Health, 1977) was exceeded in three of eight samples collected. Concentrations of nitrate as nitrogen greater than 10 mg/L as nitrogen may cause methomoglobinemia (blue-baby disease) in infants ingesting the water (U.S. Public Health Service, 1962).

While not analyzed as part of this study, other data (Colorado Department of Health, written commun., 1978) indicate that concentrations of selenium in excess of the mandatory limit for drinking water of 10 µg/L (micrograms per liter) (Colorado Department of Health, 1977) may occur in water from this aquifer. The limit of 10 µg/L is set to protect users from selenium toxicity (U.S. Public Health Service, 1962). Selenium concentrations as much as 124 µg/L have been reported; however, most concentrations ranged from 0 to 30 µg/L. The water from this aquifer generally is suitable for stock and irrigation use.

Water-quality data were obtained from only two wells completed in the alluvium of Bob Creek. Specific conductances of 3,800 and 4,400 micromhos were measured. The results of a chemical analysis of a single water sample indicated that the water was very hard and that concentrations of dissolved solids, sulfate, fluoride, and nitrite plus nitrate exceeded the limits for drinking water. The limited data indicate that the water may be suitable for stock or irrigation uses, but not for domestic purposes.

Specific conductance was measured in water from two wells completed in the alluvium of Sand Arroyo and from one well completed in the alluvium underlying the loess west of Sand Arroyo. The specific-conductance values ranged from 550 to 2,500 micromhos, indicating dissolved-solids concentrations from 330 to 1,800 mg/L. No samples were analyzed for chemical constituents. The water probably is suitable for irrigation and stock purposes, but without additional data, suitability of the water for domestic use cannot be evaluated.

Specific conductance of water samples collected from four wells completed in the Dakota Sandstone ranged from 1,450 to 2,260 micromhos and the dissolved-solids concentrations in three samples were 944, 1,200, and 1,430 mg/L. Water from this aquifer is generally the softest in the county; hardness was less than 140 mg/L in all four samples. Sulfate concentrations, however, are likely to exceed the limit for drinking water of 250 mg/L; fluoride locally may exceed the limit of 1.8 mg/L. Two of the four samples analyzed contained iron in excess of the recommended limit for drinking water of 300 µg/L (U.S. Environmental Protection Agency, 1977). Concentrations in excess of 300 µg/L may cause staining of porcelain and laundry (U.S. Public Health Service, 1962). The water is suitable for stock use, but may not be suitable for irrigation because of a large sodium-adsorption ratio. Although no wells are completed in the Cheyenne Sandstone Member in the county, Weist (1963) reported that, on the basis of chemical analyses from other localities, the quality of water in the aquifer was similar to that in the Dakota Sandstone.

POTENTIAL FOR DEVELOPMENT OF ADDITIONAL MUNICIPAL WATER SUPPLIES

When evaluating an aquifer for use as a source of municipal water supplies, factors to be considered include availability and quality of water that will be available for an extended period of time, and the costs of (1) well construction and (2) production and distribution of the water.

On the basis of the hydrologic data in this report, aquifers with potential for development as sources of municipal water supplies are the Arkansas River alluvial aquifer, the Horse Creek alluvial aquifer, the Dakota Sandstone, and the Cheyenne Sandstone Member of the Purgatoire Formation. Although the alluvial aquifer underlying the dune sand in western Crowley County is presently being used as a source for municipal supplies, it is doubtful that adequate additional supplies could be developed, due to limited saturated thickness and reported relatively small well yields. The alluvial aquifer in the Bob Creek drainage basin, the alluvial aquifer in the Sand Arroyo drainage basin, and the alluvial aquifer underlying the loess southwest of Sand Arroyo have insufficient saturated thickness to warrant consideration for future development.

The Arkansas River alluvial aquifer in Crowley County has the greatest potential to supply an adequate amount of water for an extended period of time. This aquifer is capable of supplying large quantities of water to wells, and records indicate there have been no significant long-term water-level changes. Recent changes in diversions through the Colorado Canal and subsequent reduction in surface-water irrigation may result in water-level declines in the aquifer in areas near the canal and in areas previously irrigated with canal water. Because the area near the river will be least affected by these changes and because the largest yields occur there, that area has the greatest potential for future development. The quality of water produced from this aquifer is somewhat variable. Locally, excessive concentrations of dissolved solids, hardness, or sulfate would affect the esthetic characteristics of the water. Excessive concentrations of fluoride locally could limit use of the water for municipal purposes. Specific-conductance measurements and results of chemical analyses indicate the most chemically suitable water for use as municipal supplies was obtained from the aquifer in secs. 11 and 13, T. 22 S., R. 59 W., and secs. 14, 16, and 18, T. 22 S., R. 58 W.

The Horse Creek alluvial aquifer from the southern end of T. 19 S. to about 2 mi south of State Highway 96 has potential for limited additional ground-water development. The area southeast of Lake Henry is partly recharged by seepage from Lake Henry and Lake Meredith, and irrigation water from the Colorado Canal. As a result of decreased diversions in the Colorado Canal, some water-level declines and subsequent reduction in well yield may occur, reducing the potential for additional development in this area. Even with the limited saturated thickness and relatively small well yields, a properly constructed well field in the area could possibly supply additional quantities of water for municipal use. On the basis of chemical analyses of water from four wells in the general area, the water probably would be hard to very hard, and would contain excessive concentrations of dissolved solids and sulfate, which would affect the esthetic characteristics of the water.

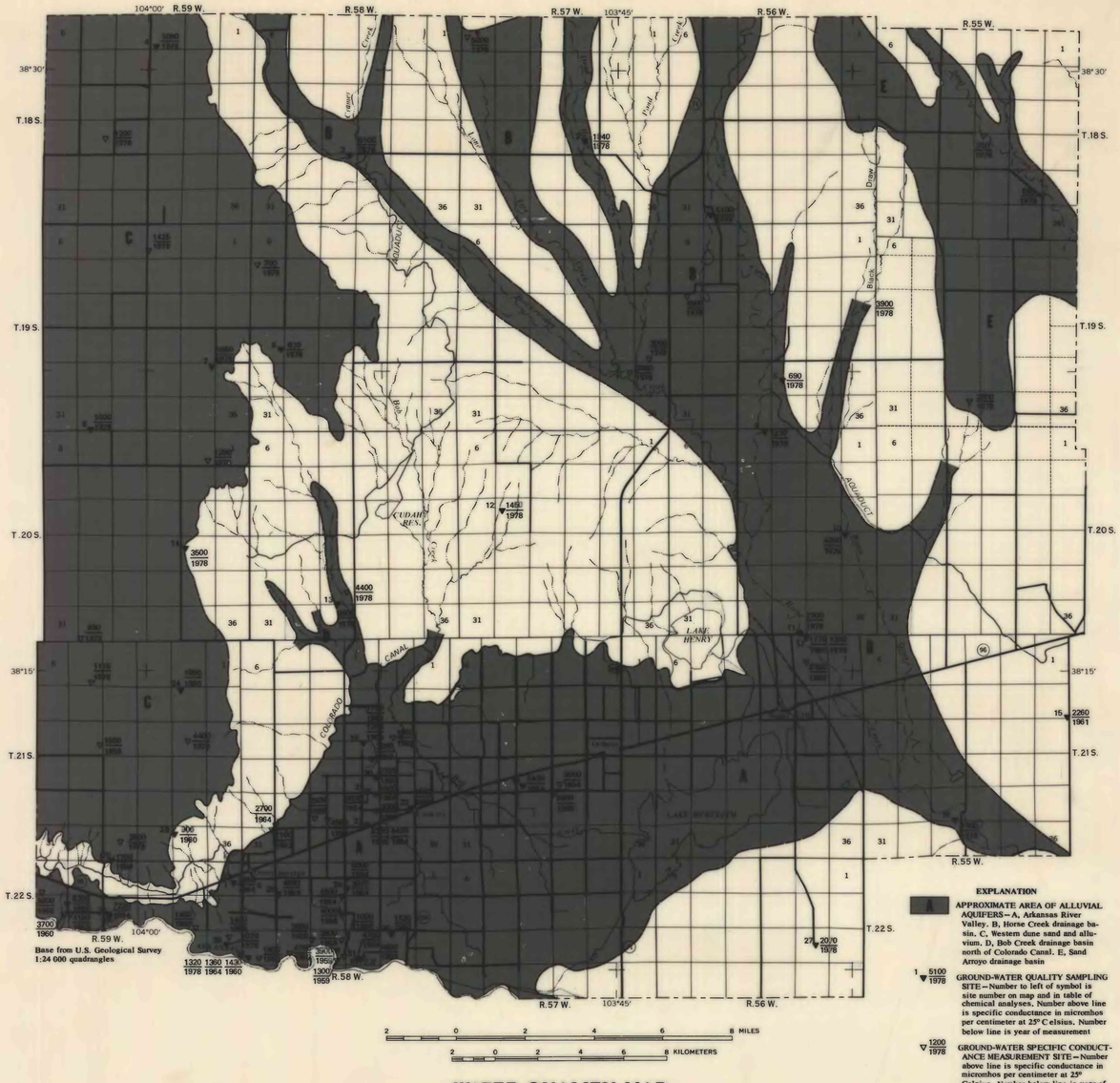
Thus far the great depth, costs of drilling and production, and relatively small yields have discouraged widespread development of the Dakota Sandstone and the Cheyenne Sandstone Member of the Purgatoire Formation in Crowley County. An aquifer test using well SC02005717BCA made in 1978 indicated that locally the Dakota Sandstone may be capable of producing greater yields than previously reported. The specific capacity (the quantity of water the well will yield per foot of drawdown) was 0.36 (gal/min)/ft at a discharge of 14.6 gal/min. The specific-capacity value may decrease somewhat if a larger pumping rate is used. The total reported depth of the well was 1,937 ft and the static water level in the well was 406 ft below land surface. Assuming a 50-percent drawdown, yield from the well may be as much as 275 gal/min. This is more than three times the maximum yield for wells completed in the Dakota Sandstone reported by Weist (1963). Yields from wells completed in both the Dakota and the Cheyenne Sandstones may be larger than from the Dakota Sandstone alone. However, the potential sustained yield is unknown. Locally, the relatively soft water from the Dakota Sandstone may contain excessive concentrations of dissolved solids, iron, sulfate, and fluoride.

Before proceeding with any of the ground-water-development possibilities indicated above, it would be necessary to thoroughly evaluate the specific situation with regard to possibly depleting streamflow especially along the Arkansas River. This might involve drilling of test holes, aquifer testing, and other hydrologic testing and evaluation.

Ground water containing excessive concentrations of dissolved solids, hardness, iron, or sulfate may be used for municipal supplies if water with more suitable quality is not available (U.S. Environmental Protection Agency, 1977). Various methods could be used to reduce the excessive concentrations of constituents in the ground water. Relatively simple ion-exchange processes could be used to reduce the hardness while aeration and filtration could be used to reduce concentrations of iron. However, these methods would not significantly reduce excessive concentrations of dissolved solids and fluoride. Dilution, by mixing the ground water with water containing relatively small concentrations of chemical constituents or removal of dissolved constituents by desalinization methods, would be required to reduce excessive concentrations of dissolved solids and fluoride.

SELECTED REFERENCES

Colorado Department of Health, 1977, Primary drinking water regulations for the State of Colorado: Denver, 56 p.
Darton, N. H., 1906, Geology and underground waters of the Arkansas Valley in Eastern Colorado: U.S. Geological Survey Professional Paper 52, 90 p., 28 plates.
Durfor, C. N., and Becker, Edith, 1964, Public water supplies of the 100 largest cities in the United States, 1962: U.S. Geological Survey Water-Supply Paper 1812, 364 p.
Finley, E. A., Dobbin, C. E., and Richardson, E. E., 1955, Preliminary structure contour map of the Colorado plains: U.S. Geological Survey Oil and Gas Investigations Map OM-176.
Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 1473, 363 p.
Johnson Division, Universal Oil Products Co., 1972, Ground water and wells: St. Paul, Minn., Johnson Division, Universal Oil Products Co., 440 p.
Major, T. J., Hurr, R. T., and Moore, J. E., 1970, Hydrogeologic data for the lower Arkansas River valley, Colorado: Colorado Water Conservation Board, Water Resources Basic-Data Release 21, 125 p.
Major, T. J., Kerbs, L. L., and Penley, R. D., compilers, 1974, Selected water-level records for Colorado, 1970-74: Colorado Water Conservation Board, Water Resources Basic-Data Release 34, 104 p.
_____1975, Water-level records for Colorado, 1971-75: Colorado Water Conservation Board, Water Resources Basic-Data Release 37, 356 p.
Miles, D. L., 1977, Salinity in the Arkansas Valley of Colorado: U.S. Environmental Protection Agency, Interagency Agreement, Colorado State University, EPA-IAG-D4-0544, 80 p.
Penley, R. D., 1977, Water-level records for the lower Arkansas River valley of Colorado, 1973-77: U.S. Geological Survey Open-File Report 77-560, 49 p.
Scott, G. R., 1976, Geologic map of the Pueblo 1° x 2° quadrangle, south-central Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-775.
Scott, G. R., Taylor, R. B., Epis, R. C., and Wobus, R. A., 1978, Geologic map of the Pueblo 1° x 2° quadrangle, south-central Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-1022.
Scott, R. C., and Voegeli, P. T., Sr., 1961, Radiochemical analyses of ground and surface water in Colorado, 1954-61: Colorado Water Conservation Board, Basic-Data Report 7, 27 p.
Sharps, J. A., 1976, Geologic map of the Lamar quadrangle, Colorado and Kansas: U.S. Geological Survey Miscellaneous Investigations Map I-944.
Tsongas, T. A., and Ferguson, S. W., 1977, Human health effects of selenium in a rural Colorado drinking supply, *in* Proceedings, Trace Substances and Environmental Health, 11th Conference: Columbia, University of Missouri, p. 30-35.
U.S. Department of Agriculture, 1968, Soil survey, Crowley County, Colorado: U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, 70 p.
U.S. Environmental Protection Agency, 1976 [1977], Quality criteria for water: Washington, D.C., U.S. Government Printing Office, 256 p.
_____1977, National secondary drinking water regulations: Federal Register, vol. 42, no. 62, p. 17144-17146.
Weist, W. G., Jr., 1962, Records, logs, and water-level measurements of selected wells, springs and test holes, and chemical analyses of ground water in Otero and the southern part of Crowley Counties, Colorado: Colorado Water Conservation Board, Basic-Data Report 11, 54 p.
_____1963, Water in the Dakota and Purgatoire Formations in Otero County and the southern part of Crowley County, Colorado: U.S. Geological Survey Water-Supply Paper 1669-P, 17 p.
_____1965, Geology and occurrence of ground water in Otero County and the southern part of Crowley County, Colorado: U.S. Geological Survey Water-Supply Paper 1799, 90 p.



WATER-QUALITY MAP

CHEMICAL ANALYSES OF WATER FROM SELECTED WELLS AND SPRINGS

[Analyses by U.S. Geological Survey; MG/L=milligram per liter; UG/L=microgram per liter; °C=degrees Celsius. Maximum concentrations for public-water supplies (Colorado Department of Health, 1977, and U.S. Environmental Protection Agency, 1977) are indicated below column headings; underlined values are mandatory standards; all others are recommended standards]

SITE NUMBER ON WATER-QUALITY MAP	LOCATION[1]	AQUIFER	DATE OF SAMPLE (Y-M-D)	DIS-SOLVED SILICA (SiO_2) (MG/L)	DIS-SOLVED IRON (FE) (UG/L)	DIS-SOLVED MANGA-NESE (MN) (UG/L)	DIS-SOLVED CALCIUM (CA) (MG/L)	DIS-SOLVED MAGNE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	DIS-SOLVED POTAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO_3) (MG/L)	ALKA-LINITY AS ($CaCO_3$) (MG/L)	DIS-SOLVED SULFATE (SO_4) (MG/L)	DIS-SOLVED CHLORIDE (CL) (MG/L)	DIS-SOLVED FLUORIDE (F) (MG/L)	DIS-SOLVED NITRITE PLUS NITRATE (NO_2 + NO_3 AS N) (MG/L)	DIS-SOLVED ORTHO-PHOS-PHATE (PO_4 AS P) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTIT-UENTS) (MG/L)	HARD-NESS (CA,MG) (MG/L)	NON-CARBON-ATE HARD-NESS (MG/L)	SODIUM ADSORB-TION RATIO	SPECIFIC CONDUCT-ANCE (MICRO-MHOS)	pH (UNITS)	TEMPERA-TURE (°C)
				NONE	300	50	NONE	NONE	NONE	NONE	NONE	NONE	250	250	1.8	10	NONE	500	NONE[2]	NONE	NONE	NONE	6.5-8.5	NONE
1	SC01805632CBD	ALLUVIUM, HORSE CREEK BASIN	78-06-29	28	380	20	110	190	740	6.8	450	370	1,200	140	3.0	1.7	0.01	2,850	1,600	1,200	8.2	5,100	---	13.0
2	SC01805722DBB	ALLUVIUM, HORSE CREEK BASIN	78-06-29	19	100	0	67	35	350	2.2	340	280	660	41	1.6	7.0	.08	1,370	310	33	8.6	1,940	---	15.0
3	SC01805828AAB	ALLUVIUM, HORSE CREEK BASIN	78-06-29	20	210	10	150	180	900	3.1	410	340	2,400	190	2.4	1.2	.01	4,050	1,100	780	12	5,100	---	16.0
4	SC01805903CCD	ALLUVIUM UNDERLYING DUNE SAND	78-06-30	28	90	10	70	26	130	3.1	190	160	230	89	.9	1.2	.01	724	280	130	3.4	1,090	---	17.5
5	SC01905627CAB	ALLUVIUM, HORSE CREEK BASIN	78-06-30	14	40	0	28	10	110	3.4	210	170	160	9.8	.9	1.9	.01	448	110	0	4.5	690	---	15.0
6	SC01905819DAA	ALLUVIUM UNDERLYING DUNE SAND	78-06-29	23	110	0	34	8.8	95	1.8	220	180	72	32	1.2	3.9	.01	394	120	0	3.8	620	---	15.0
7	SC01905926AAA	ALLUVIUM UNDERLYING DUNE SAND	78-06-30	16	40	10	85	37	300	1.9	200	160	610	120	1.4	6.7	.01	1,300	360	200	6.8	1,860	---	17.5
8	SC01905932CDD	ALLUVIUM UNDERLYING DUNE SAND	78-06-30	16	1,100	40	40	11	170	2.4	180	150	230	87	1.2	4.3	.00	667	150	0	6.1	1,000	---	15.5
9	SC02005604AAB	ALLUVIUM UNDERLYING DUNE SAND	78-06-30	16	20	0	59	20	190	4.2	240	200	360	33	.9	2.5	.01	813	230	33	5.5	1,210	---	15.5
10	SC02005624BBB	ALLUVIUM, HORSE CREEK BASIN	78-06-29	17	130	10	250	140	650	2.0	190	160	2,300	98	2.1	1.5	.00	3,560	1,200	1,000	8.2	4,300	7.6	13.0
11	SC02005634DDC	ALLUVIUM, HORSE CREEK BASIN	78-06-30	16	30	10	140	53	440	6.2	280	230	1,100	79	1.0	.97	.01	1,980	570	340	8.0	2,700	---	14.5
12	SC02005717BCA	DAKOTA SANDSTONE	78-11-01	15	1,500	30	22	.5	330	2.1	380	310	390	13	2.7	.01	----	944	8	0	52	1,450	7.9	31.0
13	SC02005828DCC	ALLUVIUM, BOB CREEK BASIN	78-06-29	18	110	20	120	83	700	2.7	230	190	1,200	130	2.5	11	.01	2,420	640	450	12	3,800	---	17.0
14	SC02005923BCA	ALLUVIUM UNDERLYING DUNE SAND	78-06-30	17	1,300	60	180	76	490	2.2	170	140	1,100	250	3.9	15	.00	2,270	760	620	7.7	3,500	---	15.0
15	SC02105512DDD	DAKOTA SANDSTONE	61-07-17	--	7,000	-----	5.6	8.8	495	5.5	273	---	830	23	1.2	.09	----	------	51	0	30.4	2,260	7.0	21.5
16	SC02105528DCD	ALLUVIUM, HORSE CREEK BASIN	78-06-29	12	60	20	11	3.6	350	6.0	270	220	490	40	1.7	.54	.00	1,050	42	0	23	1,500	---	22.5
17	SC02105602BAA	ALLUVIUM, HORSE CREEK BASIN	60-07-27	25	30	-----	46	20	324	2.8	412	---	476	46	1.6	.4	.01	1,150	197	0	10	1,770	7.7	14.5
			78-06-30	17	20	5	62	24	210	3.6	290	240	400	31	1.3	1.3	.01	898	250	16	5.7	1,320	---	14.5
18	SC02105721CCB	ALLUVIUM, ARKANSAS RIVER VALLEY	64-09-02	--	-----	-----	-----	-----	759	----	184	---	3,220	204	---	-----	.00	[5]5,260	2,060	1,910	7.3	5,430	7.7	14.0
19	SC02105815DBB	ALLUVIUM, ARKANSAS RIVER VALLEY	64-09-02	--	-----	-----	-----	-----	254	.6	314	---	728	36	---	-----	.00	[5]1,370	500	243	4.8	1,790	7.8	15.0
20	SC02105822DAA	ALLUVIUM, ARKANSAS RIVER VALLEY	60-08-30	16	-----	-----	117	98	301	1.6	320	---	947	48	3.5	3.5	----	[5]1,710	694	432	5.0	2,220	7.6	14.5
21	SC02105822DCD2	ALLUVIUM, ARKANSAS RIVER VALLEY	64-09-02	--	-----	-----	-----	-----	772	----	360	---	2,750	172	---	-----	.00	[5]4,640	1,620	1,320	8.3	5,030	8.0	15.0
22	SC02105826ADD	DAKOTA SANDSTONE	60-08-30	12	0	-----	4.8	4.4	408	3.2	301	---	508	110	.8	.7	.05	1,200	30	0	32	1,920	7.4	24.0
23	SC02105827DCC	ALLUVIUM, ARKANSAS RIVER VALLEY	64-09-02	--	-----	-----	-----	-----	775	2.0	394	---	2,310	103	---	-----	----	[5]3,970	1,180	857	9.8	4,430	7.9	15.0
24	SC02105911BAB	ALLUVIUM UNDERLYING DUNE SAND	60-08-30	17	-----	-----	44	27	386	.8	427	---	503	106	2.5	12	----	1,350	220	0	11	1,990	8.0	14.5
25	SC02105933CDC[6]	ALLUVIUM UNDERLYING DUNE SAND	60-07-28	25	0	-----	74	29	264	1.6	182	---	432	180	1.6	6.2	.00	1,120	304	154	6.6	1,760	7.7	19.0
26	SC02105935BBC[6]	ALLUVIUM UNDERLYING DUNE SAND	60-08-05	17	40	-----	25	8.8	173	1.4	350	---	112	45	3.1	2.4	2.1	[5]566	98	0	7.6	906	8.1	25.5
27	SC02205614ACC	DAKOTA SANDSTONE	78-06-29	12	50	30	25	18	430	10	310	250	750	32	1.5	.66	.00	4,430	140	0	16	2,070	7.2	23.0
28	SC02205803CCB	ALLUVIUM, ARKANSAS RIVER VALLEY	64-09-02	--	-----	-----	-----	-----	428	----	296	---	1,540	87	---	-----	.00	[5]2,690	1,060	817	5.7	3,070	7.9	14.0
29	SC02205805CCC	ALLUVIUM, ARKANSAS RIVER VALLEY	64-09-02	20	-----	-----	-----	-----	661	----	266	---	2,910	123	---	-----	.00	[5]4,880	1,970	1,750	6.5	4,890	7.9	16.0
30	SC02205814BAB	ALLUVIUM, ARKANSAS RIVER VALLEY	60-09-17	--	-----	-----	81	48	186	1.4	309	---	451	21	4.0	6.2	----	------	400	146	4.0	1,430	7.8	15.5
31	SC02205815CDA	ALLUVIUM, ARKANSAS RIVER VALLEY	64-09-02	--	-----	-----	-----	-----	701	----	354	---	2,630	174	---	-----	.00	4,460	1,690	1,400	7.4	4,750	7.9	14.0
32	SC02205818CBD	ALLUVIUM, ARKANSAS RIVER VALLEY	60-09-17	--	-----	-----	163	49	101	3.6	212	---	556	26	.9	.44	----	------	608	435	1.8	1,430	7.4	14.5
			64-09-02	19	-----	-----	156	55	90	----	244	---	560	29	---	-----	.00	1,030	615	415	1.6	1,360	7.8	15.0
			78-06-29	13	70	1,000	160	47	86	5.4	220	180	500	33	.9	2.0	.01	964	590	410	1.5	1,320	8.2	14.0
33	SC02205901DAB	ALLUVIUM, ARKANSAS RIVER VALLEY	64-09-02	--	-----	-----	329	195	212	----	248	---	1,710	33	---	-----	.00	[5]2,860	1,620	1,420	2.3	2,860	8.0	14.0
34	SC02205909CBA	ALLUVIUM, ARKANSAS RIVER VALLEY	64-09-02	--	-----	-----	-----	-----	745	----	394	---	5,420	74	---	-----	.00	[5]8,150	4,410	4,090	4.9	7,220	7.8	14.0
35	SC02205913ACB	ALLUVIUM, ARKANSAS RIVER VALLEY	78-06-29	12	20	10	120	39	66	3.4	170	140	360	34	1.1	1.6	.01	726	460	320	1.3	1,070	8.3	13.5

[1]See system of numbering wells and springs. [2]There is no standard for hardness. See text for hardness classification. [3]Residue on evaporation at 180°C. [4]Spring.

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

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

1980