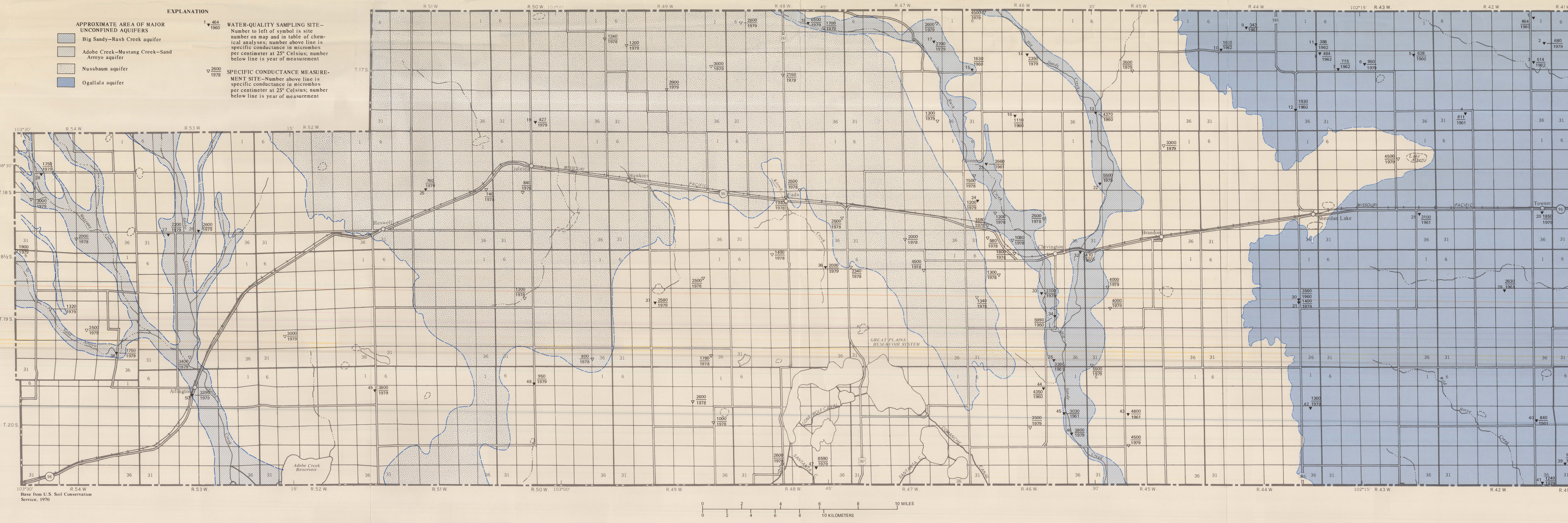
Prepared in cooperation with the
KIOWA COUNTY BOARD OF COMMISSIONERS

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 81-1023
SHEET 2 OF 2



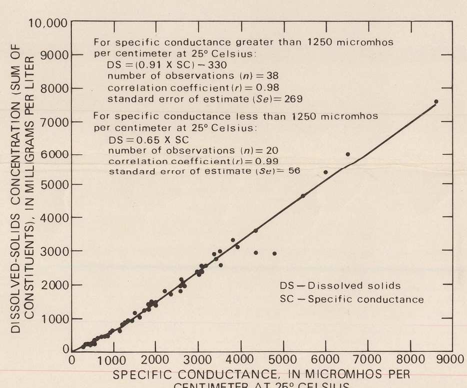
WATER QUALITY

CHEMICAL QUALITY OF GROUND WATER

Ground-water quality was evaluated by measuring specific conductance of water from pumping wells and springs and by analyzing water samples from selected wells and springs for chemical constituents. Specific-conductance data are plotted on the water-quality map, and chemical analyses are listed in the table. Also shown in the table of chemical analyses are drinking-water standards. Water-quality data are included from previous studies (Coffin, 1962; Boettcher, 1962) as well as the current study.

Specific conductance, measured in micromhos per centimeter (µmho/cm) 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 Kiowa 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 using the equations shown on the graph. For example, the specific conductance of water from well 7 in the chemical-analyses table is 715 µmho/cm. Since the specific conductance is less than 1,250 µmho/cm, the second equation should be used. Using the equation, an estimated dissolved-solids concentration of 465 mg/L results, which compares well with the actual value of 469 mg/L. Well 21 has a specific conductance of 3,100 µmho/cm so the first equation should be used. The estimated value of 2,491 mg/L compares well with the measured value of 2,440 mg/L. 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, 1976a) is summarized in the following table:

Suitability of water for irrigation	Dissolved-solids concentration (milligrams per liter)
No 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 sometimes is used for irrigation of tolerant crops in many areas of the Arkansas River valley of Colorado (Miles, 1977).

Stock generally can 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, 1976b). Based on dissolved-solids concentrations, water from all aquifers sampled during the study are suitable for stock watering.

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. Howver, 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 of water from the Big Sandy-Rush Creek aquifer ranged from 1,080 to 6,500 µmho/cm. Dissolved-solids concentrations were between 1,120 and 6,070 mg/L, exceeding the recommended limit for drinking water of 500 mg/L and indicating that careful management practices such as applying sufficient water to leach salts from the root zone or cultivating salt-tolerant crops may be necessary when using this water for irrigation. A further evaluation of water quality for irrigation use may be made on the basis of the sodium adsorption ratio (SAR) (U.S. Salinity Laboratory Staff, 1954). Most of the sampled wells tapping the aquifer produce water with the SAR indicating a medium to high sodium hazard, which is further indication that careful management practices may be required. Using the hardness classification below (Durfor and Becker, 1964), all of the waters analyzed from this aquifer would be considered very hard.

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

Sulfate concentrations of water produced from the aquifer exceeded the recommended limit of 250 mg/L (U.S. Environmental Protection Agency, 1977) in all samples analyzed. The high sulfate concentrations may cause a laxative effect in users unaccustomed to the water. Excessive concentrations of fluoride in drinking water can cause mottling of teeth, but an optimum concentration will help prevent dental cavities. The maximum allowable concentration and the optimum concentration are based on the average daily maximum air temperature. For Kiowa County the maximum allowable concentration is 1.8 mg/L and the optimum concentration is 0.9 mg/L. All water samples analyzed in 1979 from wells completed in this aquifer contained fluoride in concentrations greater than optimum and water from three wells contained fluoride at concentrations greater than the maximum allowable. Concentrations of nitrate or nitrite plus nitrate greater than 10 mg/L as nitrogen may cause methemoglobinemia (blue-baby disease) in infants under 3 months of age who ingest the water (U.S. Public Health Service, 1962; U.S. Environmental Protection Agency, 1976b). This concentration was exceeded in water from one well (site 35 in the table of chemical analyses) in the aquifer. Drinking-water standards for iron and manganese have been established because both of these constituents can cause staining of porcelain and laundry and may impart an objectionable taste to water. The standard of 300 µg/L for iron was exceeded in water samples obtained from two wells in the aquifer and the standard of 50 µg/L for manganese was exceeded in water from one well. Selenium concentrations in drinking water should not exceed 10 µg/L (U.S. Environmental Protection Agency, 1976a) due to possible toxic effects which may occur. Water samples collected during this study were analyzed for selenium because relatively high concentrations have been observed in ground water in Crowley County to the west (Colorado Department of Health, written commun., 1978; Tsongas and Ferguson, 1977). Of six samples analyzed for selenium from the Big Sandy-Rush Creek aquifer, three exceeded the drinking-water standard and one of the three exceeded the standard by more than a factor of 10. This information suggests that selenium should be evaluated when considering water from this aquifer as a source of domestic or municipal supply. Chemical analyses of water samples collected in 1960-61 and 1979 from three wells in the aquifer indicate that while water-quality conditions have been generally stable, local degradation has occurred, resulting in increases in dissolved solids and in most major anions and cations.

Water from the Adobe Creek-Mustang Creek-Sand Arroyo aquifer had specific-conductance values ranging from 1,320 to 3,400 µmho/cm, and dissolved-solids concentrations of four analyzed samples were between 1,300 and 1,890 mg/L. The water is very hard and sulfate concentrations exceed the drinking-water standard of 250 mg/L. Concentrations of fluoride locally exceed the maximum allowable limit for drinking water. Selenium was present in all four samples analyzed at concentrations greater than the drinking-water standard. Water from the Adobe Creek-Mustang Creek-Sand Arroyo aquifer generally should be suitable for irrigation use, although special management practices may be necessary. Municipal or domestic use of the water is limited by high dissolved-solids concentations, hardness, high sulfate and selenium concentrations, and locally high concentrations of fluoride.

Little water-quality data is available for the Nussbaum aquifer. Specific conductance ranged from 427 to 4,500 µmho/cm on 18 samples, with one-half the values below 1,500 µmho/cm. The results of two chemical analyses indicate that the water is hard, but it does not exceed drinking-water standards for dissolved solids, sulfate, chloride, fluoride, iron, or manganese. The maximum allowable drinking-water concentrations for selenium (10 µg/L) and fluoride (1.8 mg/L) were exceeded in one of the two samples, indicating these constituents could be a problem when considering water from this aquifer for domestic use. From a water-quality standpoint, the water is suitable for irrigation, but small well yields will limit this use.

Water produced from the Ogallala aquifer generally has the lowest specific conductance and dissolved-solids concentrations of any aquifer in the county. Specific conductances were between 343 and 3,560 µmho/cm, with an average value of 1,250 µmho/cm. Dissolved-solids concentrations determined on samples from 20 wells completed in the aquifer range from 256 to 2,560 mg/L. The smaller concentrations occur in the northern (T.17 S.) and southern (T.20 S.) parts of the aquifer while the larger concentrations are in the central part. Dissolved-solids concentrations and SAR indicate that the water generally is suitable for irrigation use, but careful management practices may be necessary in local areas. The water is hard to very hard, and sulfate concentrations exceed the drinking-water standard of 250 mg/L throughout most of the central and southern parts of the county and locally in the north. The mandatory limit of 1.8 mg/L for fluoride in drinking water was exceeded in only one water sample from the northern part of the county, but was commonly exceeded in the central and southern parts of the aquifer. Concentrations of nitrate or nitrite plus nitrate ranged from 0.88 to 22 mg/L, with an average value of 6.4 mg/L. Selenium was found at concentrations exceeding the drinking-water standard in four of six samples collected. These relatively high concentrations suggest that water from the Ogallala should be analyzed for nitrate and selenium before being used for domestic or municipal purposes. Iron may occur in ground water produced from the Ogallala aquifer at concentrations greater than the standard for drinking water (300 µg/L) locally, especially in the northern part of the county. Based on analyses of water samples collected from four wells in the aquifer in 1960-62 and again in 1979, it appears that there has been some degradation in water quality, especially in the more developed northern and southern parts of the aquifer. Marked increases in specific conductance, dissolved solids, calcium, magnesium, hardness, sulfate, chloride, fluoride, and nitrate were noted in three wells in these areas for which data are available. Less change in water quality was noted for the one well with data available in the central part of the county.

Water produced from the minor surficial aquifers (dune sand, slopewash, and loess) is variable in quality. Specific conductances range from 580 to 8,590 µmho/cm, and dissolved-solids concentrations range from 642 to 7,640 mg/L. Water produced from these aquifers is generally very hard, has sulfate concentrations greater than the standard for drinking water (250 mg/L), and is locally in excess of the maximum allowable drinking-water standards for selenium and fluoride. Where better quality water does not exist, water from these aquifers may be suitable locally for domestic use.

Little water-quality data are available for the Pierre Shale, the Smoky Hill Shale Member of the Niobrara Formation, the Fort Hays Limestone Member of the Niobrara Formation, or the Codell Sandstone Member of the Carlile Shale. The few available data indicate that water from these formations is generally high in specific conductance, dissolved solids, and hardness, and is likely to exceed drinking-water standards for sulfate and fluoride and possibly for selenium. One notable exception is well SC01704633ABC (site 16 in the table of chemical analyses), which is believed to be producing water from the Codell Sandstone Member of the Carlile Shale and possibly also from dune sand. Water from this well is relatively low in dissolved solids and sulfate and is the softest of any water analyzed in the county.

Water-quality data are available from only one well (SC01904414DDA2, site 31 in the table of chemical analyses) completed in the Dakota Sandstone in Kiowa County. Specific conductance of water from this well was 1,400 µmho/cm and dissolved-solids concentrations was 929 mg/L. Although water produced from this well is soft, it is softer than from all but 3 of 50 wells for which data are available in the county. This relatively soft water has been used extensively for municipal and domestic use to the south, west, and southwest of Kiowa County (Weist, 1963; Voegeli and Hershey, 1965). Water produced from the Dakota Sandstone is likely to exceed the water-quality standard for sulfate and can be expected locally to exceed the standard for fluoride and for iron (Cain and others, 1980; Weist, 1963; Voegeli and Hershey, 1960). Although water from the well sampled could be used for irrigation with careful management practices, data from south, west, and southwest indicate that water from the Dakota Sandstone often is not suitable for irrigation use because of high SAR. Although no wells are known to be completed in the Cheyenne Sandstone Member of the Purgatoire Formation in the county, information from Weist (1963) on nearby Crowley and Otero Counties indicates the quality of water in the aquifer is similar to that in the Dakota Sandstone.

CONCLUSIONS

Sufficient quantities of water for irrigation or municipal use are available from two aquifers in Kiowa County: The Big Sandy-Rush Creek alluvial aquifer in the east-central part of the county and the Ogallala aquifer in the eastern part of the county. Data from neighboring counties indicate that the Dakota Sandstone and Cheyenne Sandstone Member of the Purgatoire Formation, which underlie the entire county, may supply marginally adequate amounts for irrigation or municipal use.

Water from the Big Sandy-Rush Creek aquifer currently is used for both municipal and irrigation purposes, with about 30 wells yielding between 250 and 800 gal/min. Depths to water in the aquifer have changed little in the last 10 years. In contrast, depths to water in the Ogallala aquifer have fallen as much as 40 ft in the southeastern part of the county in the last 10 years. These water-level declines, which are caused by pumping water for irrigation faster than it is replaced by precipitation, can be expected to continue and to expand to the northern part of the aquifer in future years if pumping continues at current rates. The Dakota Sandstone and Cheyenne Sandstone Member of the Purgatoire Formation are currently almost undeveloped as water supplies in the county. Although they are relatively deeply buried (500 to 1,800 ft below land surface) throughout the county, these formations could become more important as sources of water supply in the future.

Where water is not available from the Big Sandy-Rush Creek or Ogallala aquifers, sufficient quantities for domestic and stock use generally are available from shallow wells. These wells produce water from the Adobe Creek-Mustang Creek-Sand Arroyo aquifer in the western part of the county, from the Nussbaum aquifer in the central part of the county, from dune sands, slopewash, and loess, from weathered or fractured zones in the Pierre Shale and Smoky Hill Shale Member of the Niobrara Formation, and from the Fort Hays Limestone Member of the Niobrara Formation and the Codell Sandstone Member of the Carlile Shale.

The quality of ground water in the county, as indicated by specific conductance or dissolved-solids concentration, varies widely, both from aquifer to aquifer and within single aquifers. Dissolved-solids concentrations are generally greater than 500 mg/L, the suggested limit for drinking water, except in the northern part of the Ogallala aquifer, where lower concentrations occur. Because of relatively high dissolved-solids concentrations in most of the county, careful management practices such as applying sufficient water to leach salts from the root zone or choosing salt-tolerant crops may be necessary when using ground water for irrigation. Ground water produced in the county is generally hard to very hard, but water from the Dakota Sandstone is soft. Sulfate concentrations generally are greater than the drinking-water standard (250 mg/L), except in the northern part of the Ogallala aquifer and in the Nussbaum aquifer. Concentrations of iron, manganese, fluoride, and nitrate exceed drinking-water standards for these constituents locally in the county. Selenium exceeded the drinking-water standard of 10 µg/L in 19 of 26 samples analyzed for this constituent. Because of the sometimes high concentrations of selenium, nitrate, and fluoride, it is suggested that ground water used for human consumption in the county be evaluated for these constituents to determine suitability for this use.

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CHEMICAL ANALYSES OF WATER FROM WELLS AND BIG SANDY CREEK

[ANALYSES BY U.S. GEOLOGICAL SURVEY; UMHO/CM=MICROMHOS PER CENTIMETER; °C=DEGREES CELSIUS; MG/L=MILLIGRAMS PER LITER; UG/L=MICROGRAM PER LITER]

SITE NUMBER ON WATER-QUALITY MAP	LOCAL IDENTIFIER	AQUIFER	DATE OF SAMPLE (Y-M-D)	SPECIFIC CONDUCTANCE (UMHO/CM AT 25°C)	PH (UNITS)	WATER TEMPERATURE (°C)	HARDNESS (AS CACO3) (MG/L)	NONCARBONATE HARDNESS AS CACO3 (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	SODIUM ADSORPTION RATIO (SAR)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	ALKALINITY AS CACO3 (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)	DISSOLVED SILICA (SIO_2) (MG/L)	DISSOLVED SOLIDS (SUM OF DETERMINED CONSTITUENTS) (MG/L)	DISSOLVED NITRATE (N) (MG/L)	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)	DISSOLVED PHOSPHORUS (P) (MG/L)	DISSOLVED ALUMINUM (AL) (UG/L)	DISSOLVED BORON (B) (UG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED MANGANESE (MN) (UG/L)	DISSOLVED SELENIUM (SE) (UG/L)
	DRINKING-WATER STANDARDS			NONE	[1]6.5-8.5	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	[1]250	[2]250	[1]1.8	NONE	[1]500	[2]10	[2]10	NONE	NONE	NONE	[1]300	[1]50	[2]10
1	SC01704201BCB	OGALLALA	60-10-17	464	8.2	15.0	180	35	46	16	38	1	6	180	0	150	110	8.0	0.5	----	320	2.0	-----	----	---	---	-----	-----	---
2	SC01704212DBB	OGALLALA	62-03-23	602	7.6	----	210	76	66	12	41	1	4	170	0	140	140	17	.7	26	[3]402	2.9	-----	----	0	---	100	0	---
			79-06-05	680	7.8	15.5	260	120	81	14	43	1	6	170	--	140	160	22	.8	24	[3]455	-----	4.7	0.01	---	---	40	0	11
3	SC01704213CBB	OGALLALA	62-03-23	514	7.7	14.0	210	39	62	14	24	.5	5	210	0	170	58	16	.8	29	[3]334	4.5	-----	----	20	---	0	0	---
4	SC01704232ABB	OGALLALA	61-05-16	811	7.7	14.5	310	120	95	18	48	1	3	240	0	200	170	24	.6	----	495	4.5	-----	----	---	190	520	-----	---
5	SC01704314AAD	OGALLALA	60-10-20	628	8.4	14.5	240	30	58	22	33	.9	9	230	10	190	32	25	2.4	----	348	10	-----	----	---	---	250	-----	---
6	SC01704316CAD1	OGALLALA	62-03-23	532	7.7	----	230	44	64	17	19	.5	7	230	0	180	46	10	.5	30	[3]339	8.2	-----	----	200	---	4,100	0	---
			79-06-05	950	7.6	14.0	400	190	120	24	53	1	10	260	--	210	180	41	.9	31	661	-----	17	.03	---	---	40	0	7
7	SC01704317CCC	OGALLALA	62-03-21	715	7.6	14.5	250	0	63	23	59	2	7	320	0	260	69	17	1.1	41	[3]469	9.5	-----	----	100	---	540	0	---
8	SC01704318BBA	OGALLALA	62-03-23	484	7.8	15.0	220	72	79	6.3	9.0	.3	4	180	0	150	45	7.8	.1	30	[3]326	10	-----	----	0	---	100	0	---
9	SC01704404CDA	OGALLALA	61-05-16	343	8.4	15.5	130	0	30	14	21	.8	2	160	6	130	23	4.0	1.2	----	187	1.0	-----	----	---	900	-----	-----	---
10	SC01704408CCC	OGALLALA	62-03-23	1,510	7.6	15.0	630	510	130	76	120	2	8	140	0	110	620	62	1.2	47	[3]1,230	8.2	-----	----	100	---	470	0	---
11	SC01704412DAD	OGALLALA	62-03-23	388	7.6	15.0	160	27	52	7.5	16	.6	4	160	0	130	50	5.3	.3	31	[3]256	5.0	-----	----	0	---	400	0	---
12	SC01704426DDD	OGALLALA	60-10-17	1,930	7.9	14.5	870	680	240	63	130	2	4	240	0	190	810	61	.6	----	1,530	22	-----	----	---	---	30	-----	---
13	SC01704531ABA	BIG SANDY-RUSH CREEK	60-09-21	4,370	7.9	15.5	1,100	870	270	120	730	9	10	330	--	270	2,200	140	1.3	----	3,640	.38	-----	----	---	80	-----	-----	110
14	SC01704615BBD	DUNE SAND	61-06-08	1,980	8.1	15.5	440	180	130	31	300	6	7	320	--	260	770	48	.8	----	1,450	.59	-----	----	---	---	-----	-----	---
			79-06-06	2,350	7.6	14.0	490	240	120	45	380	8	7	300	--	250	980	55	1.8	19	1,760	-----	1.1	.01	---	---	300	0	4
15	SC01704618CDD	BIG SANDY-RUSH CREEK	60-04-18	1,630	7.5	14.0	360	120	92	31	230	5	--	280	--	230	550	47	1.5	----	1,120	.02	-----	----	---	---	-----	-----	---
16	SC01704633ABC	DUNE SAND(?), CODELL SANDSTONE	60-09-26	1,110	7.9	15.5	20	0	8	1	270	25	3	580	--	470	5.8	90	1.6	----	672	1.2	-----	----	---	---	-----	-----	---
17	SC01704711BDD	BIG SANDY-RUSH CREEK	61-06-06	3,000	7.8	15.5	1,100	810	260	100	360	5	6	330	--	270	1,500	70	2.2	----	2,440	.29	-----	----	---	---	-----	-----	---
			79-06-06	2,700	7.6	15.0	680	440	150	75	400	7	7	290	--	240	1,100	65	1.6	18	2,010	-----	10	.02	---	---	50	10	32
18	SC01704802CBB1	BIG SANDY-RUSH CREEK	79-06-07	6,500	7.5	13.5	2,200	1,900	480	240	1,100	10	11	330	--	270	3,800	250	1.7	18	6,070	-----	.09	.01	---	---	3,600	1,600	1
19	SC01705033CBA1	NUSSBAUM	79-06-07	427	7.8	13.0	170	31	47	13	17	.6	4	170	--	140	42	11	.5	22	264	-----	5.3	.01	---	---	50	0	4
20	SC01804225BAA1	OGALLALA	60-08-22	1,870	7.3	16.5	710	570	140	85	170	3	--	170	0	140	740	110	3.3	36	1,390	4.5	-----	----	---	---	50	-----	---
			79-06-05	1,850	7.8	16.0	790	670	150	100	170	3	7	150	--	120	760	140	3.7	34	1,470	-----	6.5	.01	---	---	60	10	28
21	SC01804325BAC	OGALLALA	61-05-16	3,100	7.3	13.5	1,400	1,300	380	120	200	2	6	190	0	160	1,400	140	2.4	----	2,440	15	-----	----	---	---	140	-----	---
22	SC01804518DAC	BIG SANDY-RUSH CREEK	61-06-08	3,170	7.7	15.0	1,000	810	280	77	420	6	8	250	--	200	1,600	100	.9	----	2,570	.61	-----	----	---	---	-----	-----	---
			79-06-06	5,500	7.7	20.5	1,500	1,200	350	140	1,000	11	14	290	--	240	2,800	230	1.3	14	4,700	-----	1.2	.02	---	---	30	20	3
23	SC01804608CBC	BIG SANDY-RUSH CREEK	61-06-06	2,660	7.6	14.0	900	660	210	89	310	5	9	290	--	240	1,200	87	1.0	----	2,060	6.3	-----	----	---	---	-----	-----	---
24	SC01804619ACC1	DUNE SAND	79-06-06	1,200	7.8	16.0	390	230	82	45	110	2	8	200	--	160	320	74	2.7	26	808	-----	10	.01	---	---	50	10	22
25	SC01805116DCC1	NUSSBAUM	79-06-07	760	8.1	14.0	150	0	30	17	120	4	4	210	--	170	160	32	2.5	20	500	-----	2.8	.01	---	---	130	0	12
26	SC01805327CCC1	ADOBE CREEK-MUSTANG CREEK-SAND ARROYO	79-06-08	2,600	7.9	11.0	710	560	160	75	340	6	2	180	--	150	1,100	47	1.2	11	1,830	-----	.15	.01	---	---	30	10	12
27	SC01805332ABB1	ADOBE CREEK-MUSTANG CREEK-SAND ARROYO	79-06-08	2,200	8.0	12.0	550	320	130	55	400	7	.9	280	--	230	1,100	52	3.2	11	1,890	-----	.53	.03	---	---	100	10	34
28	SC01805417BAB1	ADOBE CREEK-MUSTANG CREEK-SAND ARROYO	79-06-08	1,750	7.9	13.5	610	470	150	56	180	3	4	170	--	140	780	16	1.1	11	1,300	-----	4.6	.01	---	---	20	10	25
29	SC01904215BAA	OGALLALA	61-05-16	2,630	7.7	14.5	1,000	890	230	110	220	3	4	180	0	150	1,200	140	4.0	22	[3]2,140	.88	-----	----	---	630	500	-----	---
30	SC01904414DDA1	OGALLALA	60-10-17	3,560	8.1	14.0	1,000	920	180	140	420	6	7	150	0	120	1,600	170	.3	----	2,560	2.1	-----	----	---	---	0	-----	---
31	SC01904414DDA2	DAKOTA SANDSTONE	79-06-05	1,400	7.7	22.0	150	0	36	15	260	9	7	370	--	300	360	58	2.1	9.8	929	-----	.12	.02	---	---	70	250	0
32	SC01904601AAB	BIG SANDY-RUSH CREEK	60-09-19	3,470	7.9	17.0	1,600	1,400	400	140	340	4	11	140	--	110	1,900	140	1.8	----	3,020	4.5	-----	----	---	---	-----	-----	---
33	SC01904615AAC1	BIG SANDY-RUSH CREEK	79-06-06	3,100	7.6	14.0	1,000	730	150	160	440	6	13	370	--	300	1,500	120	5.3	25	2,600	-----	1.0	.04	---	---	60	300	36
34	SC01904623BDD	BIG SANDY-RUSH CREEK	60-09-19	5,990	8.1	16.5	2,300	1,900	400	310	860	8	12	450	--	370	3,400	170	2.4	----	5,420	2.0	-----	----	---	---	-----	-----	---
35	SC01904635CAC	BIG SANDY-RUSH CREEK	61-06-08	3,360	7.9	15.0	1,600	1,400	380	170	280	3	13	260	--	210	1,800	80	3.0	----	2,930	16	-----	----	---	---	-----	-----	---
36	SC01904802DDC1	SLOPEWASH	79-06-08	2,000	7.8	12.0	670	410	140	77	250	4	7	320	--	260	730	96	4.0	32	1,500	-----	2.7	.02	---	---	60	10	41
37	SC01904916CBC1	SLOPEWASH	79-06-07	2,580	7.4	14.5	1,000	860	220	120	240	3	6	220	--	180	1,100	150	3.5	31	2,010	-----	6.4	.01	---	---	30	10	31
38	SC01905426DAA1	ADOBE CREEK-MUSTANG CREEK-SAND ARROYO	79-06-08	1,750	7.7	12.5	530	340	160	31	220	4	1	230	--	190	710	68	1.2	21	1,340	-----	1.9	.01	---	---	70	10	32
39	SC02004130CDD	OGALLALA	60-08-23	1,330	7.8	15.5	450	290	75	65	130	3	5	200	--	160	450	66	3.8	29	932	2.9	-----	----	---	---	10	-----	---
40	SC02004213CBC	OGALLALA	61-05-16	840	7.5	15.0	330	59	82	30	51	1	5	330	--	270	140	12	2.0	----	504	3.8	-----	----	---	200	20	-----	---
41	SC02004236CDC	OGALLALA	61-05-16	930	8.1	15.0	330	170	76	33	81	2	4	190	--	160	290	32	1.6	----	618	1.9	-----	----	---	300	110	-----	---
			79-06-05	1,240	7.6	23.0	450	300	98	51	110	2	5	180	--	150	420	59	1.8	24	877	-----	4.1	.01	---	---	20	0	17
42	SC02004413BAA2	OGALLALA	79-06-05	1,360	7.7	16.0	450	310	97	50	130	3	5	170	--	140	480	44	1.6	21	928	-----	3.5	.01	---	---	10	10	16
43	SC02004516BCC1	DUNE SAND, SMOKY HILL(?) SHALE	61-06-08	4,800	8.4	14.5	230	0	21	43	1,100	31	7	1,000	39	890	750	760	2.0	3.0	[3]2,920	.27	-----	----	---	---	-----	-----	---
44	SC02004610AAB	FORT HAYS LIMESTONE, CODELL SANDSTONE	60-09-19	4,350	8.2	17.0	550	190	63	96	850	16	11	540	--	440	1,100	550	1.8	----	2,940	.90	-----	----	---	---	-----	-----	---
45	SC02004614AD	([4])	61-06-08	3,030	7.9	20.0	830	610	180	90	440	7	8	270	--	220	1,400	75	1.5	----	2,370	.02	-----	----	---	---	-----	-----	---
46	SC02004624BCA	BIG SANDY-RUSH CREEK	60-09-19	3,960	7.8	15.5	1,000	800	220	120	630	9	10	280	--	230	2,000	110	1.4	----	3,210	.02	-----	----	---	---	-----	-----	---
			79-06-06	3,800	7.7	15.0	1,100	840	220	130	710	9	12	290	--	240	2,000	130	1.8	14	3,360	-----	.56	.02	---	---	40	10	3
47	SC02004835BBA1	SLOPEWASH	79-06-07	8,590	7.7	16.0	2,800	2,700	360	460	1,400	12	5	160	--	130	4,700	590	3.9	14	7,640	-----	5.4	.01	---	---	60	20	110
48	SC02005005DDA1	LOESS	79-06-07	950	8.1	16.0	240	100	49	29	120	3	5	170	--	140	250	47	2.8	22	642	-----	7.5	.02	---	---	20	0	19
49	SC02005212ADA1	DUNE SAND	79-06-08	3,800	7.8	15.0	1,900	1,900	500	170	280	3	5	110	--	87	2,200	110	2.6	18	3,380	-----	9.2	.01	---	---	50	20	47
50	SC02005309ACB1	SLOPEWASH, SMOKY HILL SHALE	79-06-08	3,390	7.6	13.0	1,100	920	260	110	500	7	1	220	--	180	1,600	150	2.5	14	2,750	-----	.16	.01	---	---	120	10	50

[1]Recommended standards for drinking water established by the U.S. Environmental Protection Agency (1977). [2]Mandatory standards for drinking water established by the Colorado Department of Health (1977). [3]Residue on evaporation at 180°C. [4]Big Sandy Creek; estimated flow 4.5 ft^3/s.

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

By
Martha H. Mustard and Doug Cain

1981