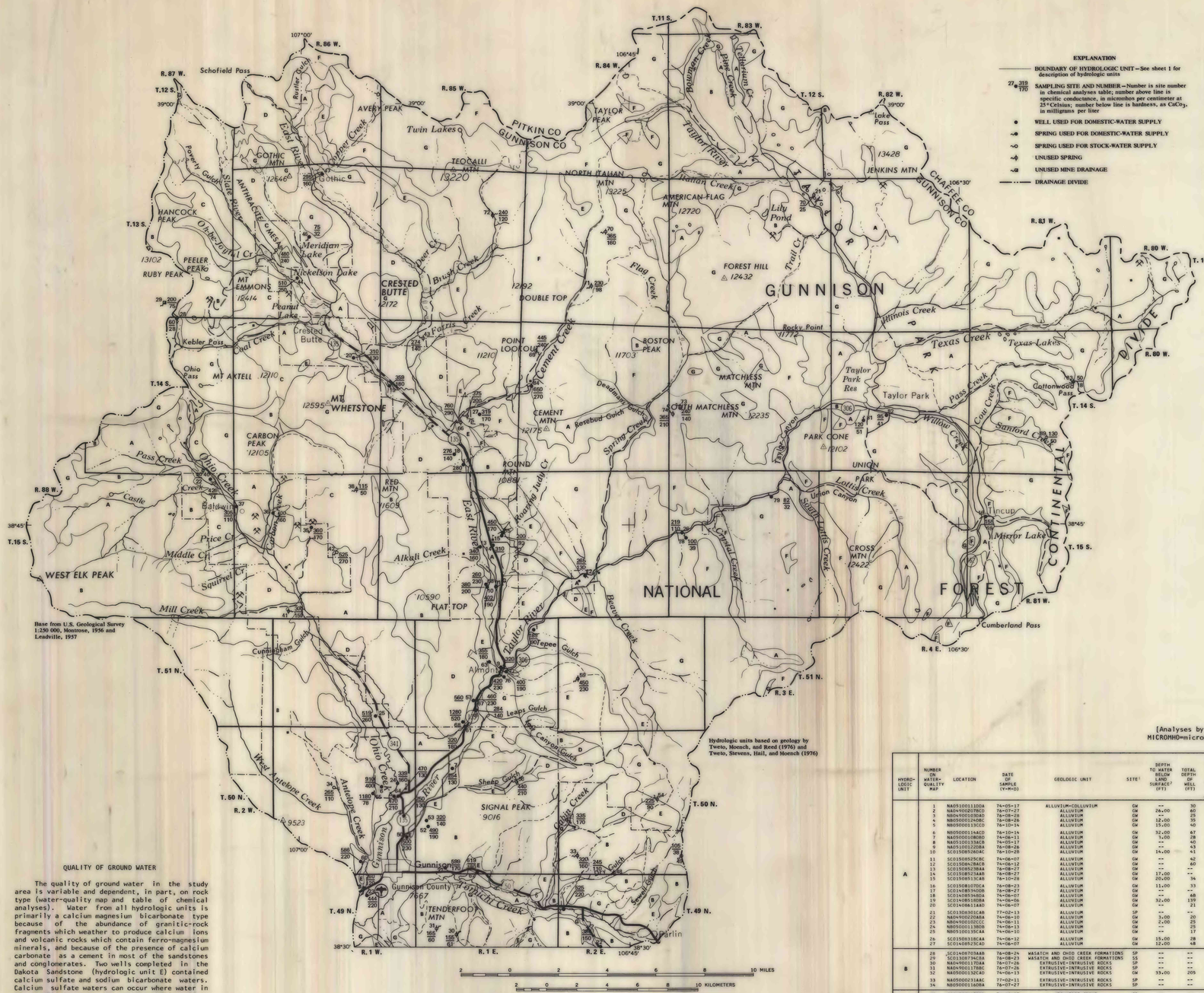
Prepared in cooperation with the
COLORADO DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER RESOURCES
OFFICE OF THE STATE ENGINEER



Base from U.S. Geological Survey 1:250 000, Montrose, 1956 and Leadville, 1957

Hydrologic units based on geology by Tweto, Moench, and Reed (1976) and Tweto, Stevens, Hail, and Moench (1976)

WATER-QUALITY MAP

EXPLANATION

- BOUNDARY OF HYDROLOGIC UNIT – See sheet 1 for description of hydrologic units
- 27 319/170 — SAMPLING SITE AND NUMBER – Number is site number in chemical analyses table; number above line is specific conductance, in micromhos per centimeter at 25°Celsius; number below line is hardness, as $CaCO_3$, in milligrams per liter
- WELL USED FOR DOMESTIC-WATER SUPPLY
- SPRING USED FOR DOMESTIC-WATER SUPPLY
- SPRING USED FOR STOCK-WATER SUPPLY
- UNUSED SPRING
- UNUSED MINE DRAINAGE
- DRAINAGE DIVIDE

QUALITY OF GROUND WATER

The quality of ground water in the study area is variable and dependent, in part, on rock type (water-quality map and table of chemical analyses). Water from all hydrologic units is primarily a calcium magnesium bicarbonate type because of the abundance of granitic-rock fragments which weather to produce calcium ions and volcanic rocks which contain ferro-magnesium minerals, and because of the presence of calcium carbonate as a cement in most of the sandstones and conglomerates. Two exceptions occur in the Dakota Sandstone (hydrologic unit E) contained calcium sulfate and sodium bicarbonate waters. Calcium sulfate waters can occur where water in the aquifer has been in contact with gypsum, organic materials, or coals. Calcium bicarbonate and calcium sulfate type waters are changed to sodium bicarbonate waters when they contact clays or weathered shales. Calcium ions readily exchange with sodium ions present in the clays and weathered shales.

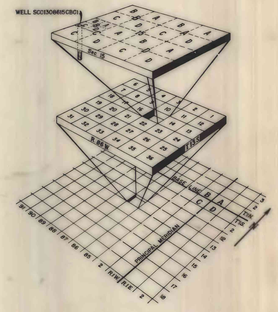
The quality of water in alluvial aquifers (hydrologic unit A) is dependent primarily on the type of material that was eroded and deposited as alluvium. Water quality is also affected by the underflow of ground water from adjacent bedrock aquifers. All samples collected from the alluvial aquifers are calcium bicarbonate waters and, for the most part, the alluvium is composed of material eroded from sandstones, granitic rocks, or reworked shale. Ground water discharged from hydrologic unit D to the alluvial aquifer also may produce this type of water. Dissolved-solids concentrations of the water sampled from hydrologic unit A ranged from 47 to 533 mg/L (milligrams per liter), and hardness from 25 to 400 mg/L. Concentrations of iron, manganese, and dissolved solids locally exceed recommended standards for drinking water (U.S. Environmental Protection Agency, 1977).

The bedrock aquifers (hydrologic units B to G) primarily contain calcium magnesium bicarbonate waters with a wide range of dissolved-solids concentration. Hydrologic unit E has the greatest diversity in quality with concentrations of dissolved solids ranging from 57 to 829 mg/L (water-quality map and table of chemical analyses). Percolation of water through the coal beds of the Dakota Sandstone, organic shales of the Morrison Formation, and the Entrada Sandstone contributes to the relatively large concentrations of iron and manganese in water from these aquifers.

Hardness values for all samples collected are presented on the water-quality map. The bedrock aquifers may contain concentrations of iron, manganese, and dissolved solids in excess of those recommended by the U.S. Environmental Protection Agency (1977) for drinking water. Locally, concentrations of fluoride and selenium may occur in excess of mandatory standards for drinking water established by the Colorado Department of Health (1977) and the U.S. Environmental Protection Agency (1976).

SYSTEM OF NUMBERING WELLS AND SPRINGS

The location numbers in the table of ground-water analyses indicate the well or spring location on the map. The numbers are 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. A graphic illustration of this method of well or spring location is shown below. The first letter "S" preceding the location number means that the site is located in the area governed by the sixth principal meridian; "N", the New Mexico 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 numbers indicate the township, the next three numbers indicate the range, and the last two numbers indicate the section in which the site 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 quarter. Letters are assigned within each quarter 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 wells or springs were inventoried. For example, SC01308615CBC1 indicates a well or spring in the southwest quarter of the northwest quarter of the southwest quarter of sec. 15, T. 13 S., R. 86 W.



GROUND-WATER MOVEMENT

Ground water in the study area occurs both under water-table (unconfined) and artesian (confined) conditions. Water-table conditions predominate in all the hydrologic units where they are exposed or crop out at the land surface. Artesian conditions occur where sandstones of hydrologic units C, E, and F are overlain and confined by shales, principally in the western one-third of the study area.

Ground-water movement in the aquifers under water-table conditions is controlled primarily by the geometry and permeability of the aquifers, by the amount of precipitation on the recharge areas, and by the degree of hydraulic connection with streams and underlying confined sandstone aquifers. Recharge to all the water-table aquifers occurs principally in the spring from infiltration of snowmelt, precipitation, and streamflow. Alluvium along Ohio Creek and the East and Gunnison Rivers also is recharged by leakage from irrigation canals and ditches, and along Ohio Creek and the East River by upward flow from the underlying hydrologic units B and D. In parts of the study area, underflow from sandstone aquifers in hydrologic units C, E, and F is an additional source of recharge to the alluvium.

Discharge from the alluvium is mainly to streams where the water table intersects the land surface and to underlying aquifers in hydrologic units B to E in the south-central part of the study area. Discharge from hydrologic units B and C is mainly underflow to stream valleys. Discharge from hydrologic unit D is principally to adjacent hydrologic units and is limited because a regional water table probably does not exist in the unit. The occurrence of ground water in hydrologic unit D is localized and restricted to shallow depths due to limited fracture porosity. Discharge from hydrologic units E and F in the outcrop areas and from hydrologic unit G also is mainly to stream valleys.

Ground water is discharged from numerous springs in the study area. The abundance of springs throughout the area indicates that, in many places, water-table aquifers consisting of coarse, relatively permeable material overlie relatively impermeable rocks, resulting in springs occurring at the contact. Springs also occur where the water-table aquifers are fractured, allowing water to flow to the land surface.

Ground water is under confined conditions in some of the sandstones of hydrologic units C, E, and F. The direction of ground-water flow is controlled primarily by the pattern of hydraulic gradients in the aquifer, which is, in turn, affected by the hydrogeologic characteristics of the aquifer, by the regional geologic structure, and by relative elevation differences between the recharge and discharge areas. In areas along the East and the Gunnison Rivers, the regional dip of the rock units and the regional ground-water flow is generally to the west and southwest.

In the southern part of the study area, recharge to the confined aquifers also is from leakage of water from the overlying volcanic material and, in the central and western parts, from leakage of water from hydrologic unit D.

Discharge from the confined aquifers principally occurs as underflow to the west and southwest out of the study area. Locally, in the southern part of the study area, discharge from the confined aquifers can occur where the sandstones of hydrologic unit E are faulted extensively--perennial springs flow in places where the faults extend to the land surface.

Gain-and-loss measurements conducted along the Taylor River indicate an infiltration loss of about 30 ft^3/s in a distance of about 1 mi where the Taylor River crosses dipping sandstones of hydrologic unit E. This represented 11 percent of the flow in the Taylor River at the time of the measurements. Cement and Copper Creeks, as well as other principal streams, are assumed to lose water where crossing dipping strata of hydrologic unit E.

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CHEMICAL ANALYSES OF WATER FROM WELLS AND SPRINGS

[Analyses by U.S. Geological Survey. Underlined concentration is in excess of standards for drinking water. FT=feet; MICROMHO=micromho per centimeter at 25 Celsius; DEG°C=degrees Celsius; MG/L=milligram per liter; UG/L=microgram per liter]

HYDROLOGIC UNIT	NUMBER ON WATER-QUALITY MAP	LOCATION	DATE OF SAMPLE (Y-M-D)	GEOLOGIC UNIT	SITE[1]	DEPTH TO WATER BELOW LAND SURFACE[2] (FT)	TOTAL DEPTH OF WELL (FT)	SPECIFIC CONDUCTANCE (MICROMHOS) (UNITS)	PH	TEMPERATURE (DEG C)	HARDNESS AS $CaCO_3$	NONCARBONATE HARDNESS (CA)	DISSOLVED CALCIUM (MG/L)	DISSOLVED MAGNESIUM (MG)	DISSOLVED SODIUM (NA) (MG/L)	PERCENT SODIUM	SODIUM ADSORPTION RATIO	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	ALKALINITY AS $CaCO_3$ (MG/L)	CARBON DIOXIDE (CO2) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L) [250]	DISSOLVED CHLORIDE (CL) (MG/L) [250]	DISSOLVED FLUORIDE (F) (MG/L) [1.4][3]	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L) [500]	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L) [10.0][3]	DISSOLVED ORTHO-PHOSPHORUS (P) (MG/L)	DISSOLVED ARSENIC (AS) (UG/L) [50]	DISSOLVED BORON (B) (UG/L) [1000]	DISSOLVED IRON (FE) (UG/L) [300]	DISSOLVED MANGANESE (MN) (UG/L) [50]	DISSOLVED SELENIUM (SE) (UG/L) [10]
A	1	NA051001110DDA	74-05-17	ALLUVIUM-COLLUVIUM	GW	--	30	189	7.7	5.0	90	3	25	6.8	2.4	5	0.1	1.0	107	0	88	3.4	8.6	1.4	0.7	8.0	108	0.23	0.01	--	40	40	20	--
	2	NA049002078CD	76-07-27	ALLUVIUM	GW	26.00	60	525	7.6	10.0	220	10	65	15	20	16	.6	1.0	281	0	214	10	29	9.9	.7	25	306	2.6	.05	3	--	0	0	2	--
	3	NA049001003AD	76-08-26	ALLUVIUM	GW	--	25	260	7.5	14.0	120	0	36	7.6	5.5	9	.2	1.6	140	0	115	7.1	21	1.4	.5	15	160	.18	.00	0	--	240	1300	0	0
	4	NB050001240BC	76-08-26	ALLUVIUM	GW	12.00	35	250	7.5	17.0	130	13	42	7.0	2.7	4	.1	1.1	147	0	121	7.4	13	.7	.2	13	151	.08	.02	0	--	0	0	0	--
	5	NB050001133CC	76-10-14	ALLUVIUM	GW	15.00	40	470	7.7	5.5	210	6	63	13	3.7	4	.1	1.7	244	0	200	7.8	15	.8	.3	12	251	.78	.01	1	--	60	0	0	--
B	6	NB050001144CD	76-10-14	ALLUVIUM	GW	32.00	67	910	7.7	6.0	400	180	110	30	12	6	3	3.5	262	0	215	8.4	210	1.3	.4	33	533	.72	.02	1	--	50	0	--	--
	7	NA050001803BD	77-05-17	ALLUVIUM	GW	1.00	28	254	7.9	7.0	130	17	40	7.2	3.0	5	.1	1.1	137	0	112	2.8	19	.8	.3	8	148	.17	.01	--	30	0	--	--	--
	8	NB051001133ACB	76-05-17	ALLUVIUM	GW	--	40	284	7.8	4.0	140	21	44	7.4	3.0	4	.1	.8	146	0	120	5.9	19	1.7	.2	7.9	163	1.3	.17	--	20	10	0	--	--
	9	NA051001220BA	76-08-26	ALLUVIUM	GW	14.00	40	380	7.6	10.0	200	0	53	13	4.0	5	.2	1.4	226	0	185	10	31	1.0	.4	13	214	.09	.01	0	--	0	0	0	--
	10	SC01508928DAC	76-08-27	ALLUVIUM	GW	14.00	41	380	7.5	11.0	200	17	63	11	5.0	5	.2	1.4	226	0	185	10	31	1.0	.4	9.4	214	.09	.01	0	--	0	0	0	--
A	11	SC01508928CBC	76-08-27	ALLUVIUM	GW	--	42	402	7.7	16.0	190	0	53	13	12	12	.4	2.3	232	0	190	7.4	15	4.7	.4	12	229	.36	.02	0	10	90	--	--	--
	12	SC01508428ACB	76-08-12	ALLUVIUM	GW	--	60	265	7.7	7.0	130	10	46	3.4	5.3	8	.2	2.7	145	0	119	4.6	5.3	1.0	.2	18	164	2.1	.02	--	30	30	20	--	--
	13	SC01508528BAA	76-08-27	ALLUVIUM	GW	--	--	340	8.4	11.0	160	25	50	8.6	4.8	6	.2	1.7	165	0	135	11	30	.8	.2	8.4	188	.13	.00	--	--	0	0	--	--
	14	SC01508523AAB	76-08-27	ALLUVIUM	GW	17.00	--	310	7.6	16.0	92	0	27	5.9	4.2	9	.2	.9	117	0	96	30	4.9	2.1	.2	14	119	.56	--	0	--	90	0	0	--
	15	SC01508353CAB	76-10-28	ALLUVIUM	GW	20.00	34	200	6.8	13.0	92	0	27	5.9	4.2	9	.2	.9	117	0	96	30	4.9	2.1	.2	14	119	.56	--	0	--	90	0	0	--
	16	SC01508107DCA	76-08-23	ALLUVIUM	GW	11.00	33	155	7.3	9.0	69	9	21	4.0	2.1	6	.1	1.4	73	0	60	5.9	8.2	.3	.1	11	84	.07	.00	0	--	20	0	0	--
	17	SC01508354DDB	76-08-27	ALLUVIUM	GW	--	--	280	7.3	12.0	120	0	36	7.3	3.0	5	.1	.9	146	0	120	4.9	19	1.0	.2	9.9	162	.04	--	0	--	0	0	--	--
	18	SC01408534BDA	76-06-07	ALLUVIUM	GW	--	68	276	8.0	9.0	160	18	46	6.2	3.3	4	.1	.9	160	0	132	2.4	19	1.6	.1	9.9	162	.04	--	0	0	0	40	--	--
	19	SC01408518BBA	76-06-07	ALLUVIUM	GW	32.00	139	510	7.9	8.0	230	29	59	8.8	5.1	6	.1	1.2	144	0	118	7.2	36	.9	.1	13	182	.40	.01	--	10	10	0	0	--
	20	SC01408611AAD	76-06-09	ALLUVIUM	GW	--	21	310	7.4	8.0	130	7	39	8.8	15	.0	.6	1.2	144	0	118	7.2	36	.9	.1	10	182	.40	.01	--	10	20	0	--	--
	21	SC01508360CAA	76-08-13	ALLUVIUM	GW	--	--	70	7.4	5.0	25	0	7.2	1.7	3.2	21	.3	.5	36	0	30	2.3	5.0	.5	.1	13	47	.11	.01	0	--	20	0	--	--
	22	NA050002020AA	76-06-10	ALLUVIUM	GW	3.00	20	390	7.2	7.0	150	25	47	9.0	24	25	.8	4.1	158	0	130	16	28	11	.3	37	263	5.1	.07	--	50	380	0	--	--
	23	NB050010202CC	76-06-11	ALLUVIUM	GW	2.00	25	444	7.2	6.0	220	0	66	19	5.1	5	.2	2.2	199	0	163	13	32	1.2	.2	17	255	.58	.00	--	30	3800	0	0	--
	24	NB050001138DB	76-08-13	ALLUVIUM	GW	--	29	339	7.2	7.0	160	0	46	12	3.9	7	.1	2.3	199	0	163	12	23	1.7	.3	12	214	.02	--	0	30	600	450	0	--
	25	NB050001353CAA	76-08-13	ALLUVIUM	GW	--	17	390	7.2	8.0	200	21	64	23	9.4	7	.3	2.6	295	0	242	5.4	26	3.1	.3	31	315	.69	--	0	50	50	0	--	--
B	26	SC01508138CAA	76-08-12	ALLUVIUM	GW	15.00	28	219	7.9	5.0	110	0	26	9.8	5.8	11	.2	.8	133	0	109	2.7	9.2	1.0	.1	11	132	.53	.01	--	9	30	0	--	--
	27	SC01408523CAD	76-10-07	ALLUVIUM	GW	12.00	48	315	8.0	3.0	170	22	48	12	2.2	3	.1	.7	140	0	115	2.9	18	1.5	.1	6.6	180	.41	.01	--	0	0	0	--	--
B	28	SC01408703AAB	76-08-24	WASATCH AND OHIO CREEK FORMATIONS	SP	--	--	60	6.2	15.0	28	5	9.4	1.2	1.5	10	.1	.7	28	0	23	28	5.1	.4	.0	5.7	39	.09	.00	1	--	280	240	0	--
	29	SC01408703AAA	76-08-24	WASATCH AND OHIO CREEK FORMATIONS	SS	--	--	200	7.3	12.0	80	17	21	5.1	2.1	4	.1	.8	71	0	58	33	7.5	.9	.1	7.5	115	.09	.00	1	--	80	50	0	--
	30	NA049001174BC	76-06-15	EXTRUSIVE-INTRUSIVE ROCKS	SP	--	--	155	9.1	24.0	61	0	20	2.7	6.2	18	.3	2.0	79	0	65	.1	9.6	2.4	.3	21	100	.00	.03	4	--	20	0	0	--
	31	NB050001178BC	76-07-29	EXTRUSIVE-INTRUSIVE ROCKS	SP	--	--	165	7.3	10.0	60	0	20	2.4	5.2	20	.3	1.8	68	0	56	2.5	8.0	2.5	.4	12	118	.18	.00	0	--	60	10	0	--
	32	NB050001322AD	76-06-13	EXTRUSIVE-INTRUSIVE ROCKS	GW	33.00	205	999	7.7	10.0	170	0	56	7.6	51	37	1.7	16	238	0	195	7.6	86	12	3.4	14	365	.04	.01	--	420	620	120	--	--
	33	NA050002171AD	76-06-17	EXTRUSIVE-INTRUSIVE ROCKS	SP	--	--	320	7.6	12.0	160	0	49	8.5	8.0	10	.3	3.0	208	0	171	.4	9.4	5.2	3.6	.3	27	211	.72	.04	1	--	10	30	0	--
	34	NB050001160BA	76-07-27	EXTRUSIVE-INTRUSIVE ROCKS	SP	--	--	265	7.5	11.0	160	0	34	6.5	8.8	14	.4	2.1	145	0	119	7.3	5.9	2.8	.3	49	182	.00	.00	3	--	40	20	1	--
C	35	SC01508615BDB	76-10-27	MESAVERDE GROUP	SP	--	--	380	7.6	6.0	170	0	45	15	7.0	8	.2	1.1	226	0	185	9.1	12	.9	.1	15	209	.33	.01	0	--	40	0	0	--
	36	SC01508608CCB	76-06-10	MESAVERDE GROUP	GW	28.70	200	400	7.4	10.0	160	0	43	12	21	22	.8	2.0	230	0	190	16	16	1.0	.1	15	225	.35	.01	0	--	20	30	0	--
	37	SC01508607BCD	76-10-13	MESAVERDE GROUP	GW	10.00	25	305	7.3	5.0	110	0	32	6.7	7.9	14	.3	1.6	148	0	120	12	5.2	3.3	.1	15	145	.34	.04	0	--	80	10	0	--
	38	SC01508608BCD	76-08-12	MESAVERDE GROUP	GW	--	--	115	6.7	6.0	50	0	15	2.7	1.0	3	.1	.6	58	0	56	12	2.7	1.5	.1	12	70	.08	.01	0	--	40	0	0	--
	39	SC01508701BCB	76-06-10	MESAVERDE GROUP	GW	--	72	426	7.4	9.0	74	0	25	2.7	58	63	2.9	.9	196	0	161	12	23	16	.4	10	235	.02	.01	--	60	2000	400	--	--
	40	SC01408730DCC	77-08-18	MESAVERDE GROUP	SP	--	--	50	7.5	5.0	22	2	6.9	10	3.5	26	.3	.2	24	0	20	1.2	4.0	.5	.1	11	41	.36	.01	0	--	40	1	0	--
D	41	SC01508633CAC	76-07-22	MANCOS SHALE	SP	--	--	300	7.2	5.0	150	7	37	14	8.1	10	.3	2.4	175	0	144	18	26	1.4	.2	22	198	.06	.05	1	--	60	10	1	--
	42	SC01508623BAC	76-07-26	MANCOS SHALE	SP	--	--	525	7.7	9.0	270	30	70	22	8.5	6	.2	.8	292	0	240	9.3	29	2.4	.2	16	291	.28	.02	1	--	10	0	0	--
	43	SC01508528CBB	76-04-06	MANCOS SHALE	SP	--	--	276	7.9	--	140	9	44	8.2	2.1	3	.0	.9	164	0	135	2.4	9.2	.8	.1	6.0	152	.00	.02	--	10	20	0	--	--
	44	SC01508628ACB1	77-04-29	MANCOS SHALE	GW	--	--	510	7.3	7.0	250	41	67	21	14	11	.4	1.3	260	0	213	23	58	1.0	.1	6.6	299	.00	.02	0	--	20	40	0	--
	45	SC01308628CAA	77-04-29	MANCOS SHALE	GW	--	--	480	8.1	7.0	240	60	67	18	14	11	.4	2.7	210	0	172	2.7	86	.4	.2	7.2	299	.11	.02	0	--	0	0	0	--
	46	SC01308615BCC1	77-04-29	MANCOS SHALE	SP	--	--	75	7.3	4.0	32	0	9.5	2.0	1.9	11	.1	1.0	42	0	34	3.4	7.3	.9	.1	7.5	52	.00	.02	0	--	260	0	0	--
	47	SC01308608BAC1	77-04-28	MANCOS SHALE	SP	--	--	299	7.5	13.0	160	18	58	5.0	2.6	3	.1	.7	170	0	139	13	12	1.2	.5	8.2	169	.13	.02	0	--	10	0	0	--
E	48	NA050002133CDC	76-07-28	DAKOTA SANDSTONE	GW	--	--	245	6.9	8.0	110	7	33	6.0	5.0	9	.2	1.4	120	0	100	25	11	2.9	.3	18	139	.10	.06	1	--	30	20	1	--
	49	NA050002368BC	76-07-28	DAKOTA SANDSTONE	GW	--	--	105	6.1	14.0	38	11	12	2.0	1.8	9	.1	1.0	33	0	27	4.5	6.0	3.0	.1	9.3	57	.71	.01	1	--	10	190	0	--
	50	NA050001133CCD1	76-10-14	DAKOTA SANDSTONE	GW	7.00	125	590	8.1	9.0	240	0	72	22	8.0	5	.2	1.8	292	0