Characterization of Water Quality in Selected Tributaries of the Alamosa River, Southwestern Colorado, Including Comparisons to Instream Water-Quality Standards and Toxicological Reference Values, 1995–97

By Roderick F. Ortiz *and* Sheryl A. Ferguson

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CONVERSION FACTORS, ABBREVIATIONS, AND ACRONYMS

Multiply	By	To obtain
mile	1.609	kilometer
feet	0.3047	meter
inch	2.54	centimeter

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviations used in this report:

mg/L	milligram per liter
µg/L	microgram per liter
µS/cm	microsiemens per centimeter at 25 degrees Celsius
s.u.	standard units

Acronyms used in this report:

USEPA	U.S. Environmental Protection Agency
CDPHE	Colorado Department of Public Health and Environment
USGS	U.S. Geological Survey
TRV	Toxicological reference value
TVS	Table value standard
COC	Constituent of concern
MLE	Maximum likelihood estimation
ERA	Ecological risk assessment

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Abstract

A comprehensive water-quality sampling network was implemented by the U.S. Geological Survey from 1995 through 1997 at 12 tributary sites to the Alamosa River. The network was designed to address data gaps identified in the initial ecological risk assessment of the Summitville Superfund site. Tributaries draining hydrothermally altered areas had higher median values for nearly all measured properties and constituents than tributaries draining unaltered areas. Colorado instream standards for pH, copper, iron, and zinc were in attainment at most tributary sites. Instream standards for pH and chronic aquatic-life standards for iron were not attained in Jasper Creek. Toxicological reference values were most often exceeded at Iron Creek, Alum Creek, Bitter Creek, Wightman Fork, and Burnt Creek. These tributaries all drain hydrothermally altered areas.

INTRODUCTION

The upper Alamosa River Basin is a heavily mineralized area in the San Juan Mountains of southwestern Colorado (fig. 1). Metal contamination of streams has occurred for decades from the Summitville Mine site, from other smaller mines, and from natural metal-enriched acidic drainage in the basin (Walton-Day and others, 1995). Mining activities have occurred intermittently in the Summitville area since the late 1800's. Large-scale open-pit mining began at the Summitville Mine site in the mid-1980's and continued until the mine site was abandoned in late 1992 (Plumlee and Edelmann, 1995). As a result, the State of Colorado requested the U.S. Environmental Protection Agency (USEPA) to assume site-maintenance responsibilities under the emergency response provisions of Superfund. Since 1992, the site has undergone substantial waste-pile consolidation, runoff rerouting, water treatment, and reclamation. In 1998, the Colorado Department of Public Health and Environment (CDPHE) assumed shared site responsibility of the Summitville site with the USEPA (Plumlee and Edelmann, 1995).

In 1995, the initial ecological risk assessment of the Summitville Superfund site identified multiple data gaps in the available data for the site (Morrison-Knudsen Corp., 1995). The data gaps included, but were not restricted to, the characterization of background water-quality conditions in the basin, characterization of other stressors, such as storms, on the river, and characterization of exposure levels to aquatic and terrestrial biota. As a result, the U.S. Geological Survey (USGS) developed a comprehensive sampling analysis plan to help address some of the data gaps (Edelmann and Ortiz, U.S. Geological Survey, written commun., 1995 and 1997). Between 1995 and 1997, data collection included the operation of several instantaneous streamflow stations and water-quality monitors, and periodic water-quality sampling at several sites in the Alamosa River and Wightman Fork, including numerous tributaries to the

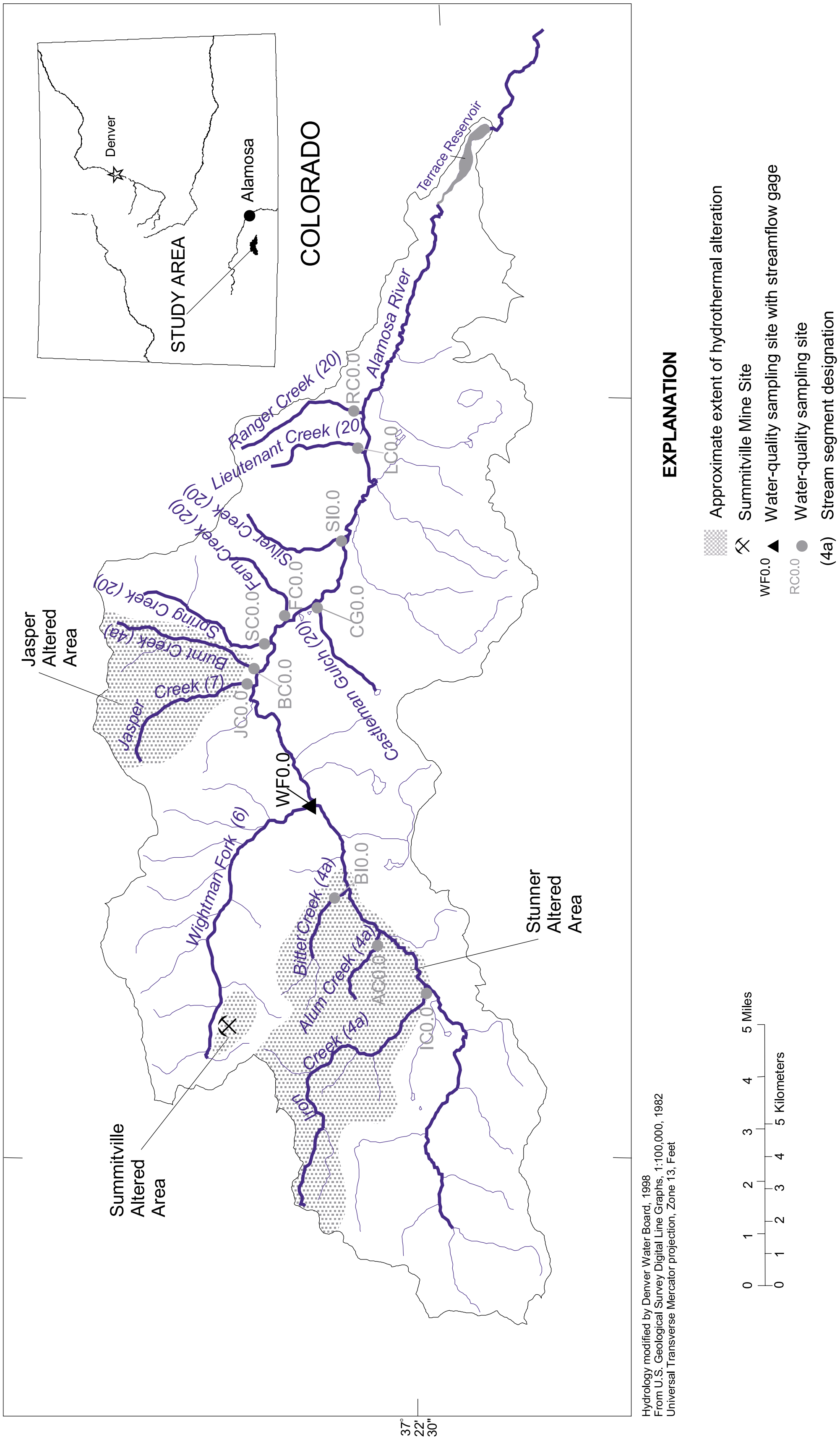

Figure 1. Location of study area and water-quality sampling sites in the Alamosa River Basin, 1995–97.

Alamosa River. These collected data were used to address the data gaps. Information in this report will be incorporated in the draft Tier II Summitville Ecological Risk Assessment (Camp Dresser and McKee Inc., 1999) to help address background water-quality conditions in the basin and exposure risk to aquatic biota.

Purpose and Scope

The purpose of this report is to characterize the water quality of selected tributaries to the Alamosa River. The available data are summarized to provide a general overview of the water quality at 12 tributary sites. The data also are compared to Colorado instream water-quality standards for pH, copper, iron, and zinc. In addition, the data are compared to toxicological reference values (TRVs) to determine if aquatic life is at risk from acute or chronic exposure to low-pH water or elevated concentrations of copper, iron, or zinc.

Description of the Study Area

The upper Alamosa River Basin is located in southwest Colorado (fig. 1). Elevations in the study area range from 8,400 feet to nearly 13,000 feet above sea level. Annual precipitation ranges from approximately 12 inches at the lower elevations to as much as 40 inches at the top of the highest peaks (Miller and McHugh, 1994). Most of the precipitation is in the form of snowfall.

The study area extends from the headwaters of the Alamosa River to just above Terrace Reservoir and has a drainage area of approximately 110 square miles (Stogner, 1996). Several areas in the basin are hydrothermally altered and contain sulfide minerals and precious metals. Runoff from mined areas and undisturbed altered areas can adversely affect the water quality in the basin.

Low-pH water with high concentrations of trace metals from the Summitville Mine site adversely affects Wightman Fork and the Alamosa River downstream from the confluence with Wightman Fork (Walton-Day and others, 1995). The Alamosa River also receives drainage from several tributaries draining the Stunner and the Jasper hydrothermally altered areas (fig. 1). Many other small tributaries flow into the Alamosa River along the 14-mile reach from the confluence of Wightman Fork to Terrace Reservoir. Most of these tributaries do not drain hydrothermally altered areas.

METHODS OF INVESTIGATION

Water-quality data were collected at selected tributary sites by the USGS from 1995 through 1997 (table 9, in the Appendix at the back of report). The samples were collected as described in the sample analysis plan for the study (Edelmann and Ortiz, U.S. Geological Survey, written commun., 1995 and 1997). Additional data collected by the USGS in October 1998 and June 1999 were used to support data-analysis approaches (Kirk Nordstrom, U.S. Geological Survey, written commun., 1998). These data were collected in conjunction with geochemical modeling efforts in the Alamosa River Basin. A description of the various approaches and uses of the data follows.

Data-Collection Methods

Water-quality samples were collected from 12 tributaries to the Alamosa River from April 1995 through October 1997. The tributaries (in downstream order) were Iron Creek, Alum Creek, Bitter Creek, Wightman Fork, Jasper Creek, Burnt Creek, Spring Creek, Fern Creek, Castleman Gulch, Silver Creek, Lieutenant Creek, and Ranger Creek (fig. 1). The level of sampling included various sampling frequencies and different constituent lists for many of the tributaries (table 1). Sites sampled at a frequency of seven to nine times per year were accessed throughout the year and represented all flow regimes in the basin; these sites drain hydrothermally altered areas and will be referred to as “Group 1 sites” (table 1). Sites sampled at a frequency of four to five times per year generally were sampled between May and September and drained unaltered areas; these sites will be referred to as “Group 2 sites” (table 1). Samples collected during storm events in the basin also are included in this report. Typically, the storm data are limited to total-recoverable metal analyses from Group 1 sites.

The analytes of concern in this report are pH, copper, iron, and zinc. These analytes are consistent with the constituents of concern (COC) described in the draft Tier II ecological risk assessment; cyanide

Table 1. Summary of water-quality data collected at tributary sites to the Alamosa River, southwestern Colorado, 1995–97

Site name	Site number	Group desig-nation	Hydro-thermal drainage area	Number of samples collected	Sampling frequency (per year)	Sampling method	Analyte group		
							Total-recoverable metals	Dissolved metals	Dissolved anions
Iron Creek	IC0.0	1	Altered	29	7-9	Grab	yes	yes	yes
Alum Creek	AC0.0	1	Altered	31	7-9	Grab	yes	yes	yes
Bitter Creek	BI0.0	1	Altered	29	7-9	Grab	yes	yes	yes
Wightman Fork	WF0.0	1	Altered	117	7-9	Grab or automatic[1]	yes	yes	yes
Jasper Creek	JC0.0	1	Altered	28	7-9	Grab	yes	yes	yes
Burnt Creek	BC0.0	1	Altered	17	7-9	Grab	yes	yes	yes
Spring Creek	SC0.0	2	Unaltered	12	4-5	Grab	yes	no	no
Fern Creek	FC0.0	2	Unaltered	13	4-5	Grab	yes	no	no
Castleman Gulch	CG0.0	2	Unaltered	16	4-5	Grab	yes	no	no
Silver Creek	SI0.0	2	Unaltered	13	4-5	Grab	yes	no	no
Lieutenant Creek	LC0.0	2	Unaltered	16	4-5	Grab	yes	no	no
Ranger Creek	RC0.0	2	Unaltered	15	4-5	Grab	yes	no	no

[1] Multiple samples per day were collected at WF0.0 using a programmable automatic sampler installed at the site.

was identified as a COC but no data were available for comparison (Camp Dresser and McKee Inc., 1999). In addition, aluminum is not addressed in this report because no instream standards are applicable. Dissolved calcium and magnesium data collected in 1998 and 1999 at selected tributary sites are used to estimate hardness at six of the sites sampled from 1995 to 1997.

Data-Analysis Methods

The availability of water-quality data differed from site to site. Dissolved metal and anion data were not collected at Spring Creek, Fern Creek, Castleman Gulch, Silver Creek, Lieutenant Creek, and Ranger Creek (table 1). In addition, a high percentage of the total-recoverable copper and zinc data for these Group 2 sites were reported as censored values (less than the analytical reporting limit). In addition, comparisons of water-quality data to instream standards and TRVs differ depending on the use of aggregated or instantaneous data, stream reach in question, and aquatic biota of concern. In many cases, comparisons were site specific and various assumptions were required to adequately address the comparisons to instream standards or TRVs. The following sections describe the methodology used to address the various data concerns.

Estimation of Hardness for Selected Sites

Hardness is an integral component of many instream water-quality standards and TRVs. Dissolved calcium and magnesium concentrations are needed to calculate hardness (Hem, 1985). These data were not available for Group 2 sites during 1995–97 (table 1). These sites were designated as miscellaneous water-quality sites and, as such, were sampled less often and only for total-recoverable metals (Edelmann and Ortiz, U.S. Geological Survey, written commun., 1995 and 1997). However, water-quality samples collected at these same sites in October 1998 and June 1999 included dissolved calcium and magnesium analyses (Kirk Nordstrom, U.S. Geological Survey, written commun., 1998). A comparison of the water-quality data collected from 1995 to 1997 and the data collected in 1998 and 1999 indicated that all six sites were similar in respect to pH, specific conductance, and metal concentrations. Since no substantial changes in land use had occurred along these six tributaries between 1995 and 1999, it was assumed that the hardness values in 1998 and 1999 are representative of hardness values from 1995 through 1997. Hardness values for Spring Creek, Fern Creek, Castleman Gulch, Silver Creek, Lieutenant Creek, and Ranger Creek in October 1998 and June 1999 were grouped, and a regression equation was developed using specific conductance to predict hardness (n=12, r^2=0.975). Available specific conductance data from 1995 to 1997 were used in the regression equation (hardness=0.374 × specific conductance + 4.66) to estimate hardness values at each of the Group 2 sites.

Lack of Dissolved-Metal Data for Selected Sites

Dissolved-metal data are commonly used to define instream standards and TRVs. As described in a previous section, dissolved-metal data were not available for Spring Creek, Fern Creek, Castleman Gulch, Silver Creek, Lieutenant Creek, and Ranger Creek (table 1). It was assumed, however, that dissolved copper and zinc concentrations would constitute a large percentage of the total-recoverable metal fraction in these near-neutral-pH waters with little or no observable suspended-solid material. As such, a decision was made to compare dissolved copper and zinc standards to total-recoverable copper and zinc concentrations when no dissolved-metal data were available. This approach provided a conservative (worst case) approximation of the dissolved-metal concentration at these six sites.

The assumption stated above is not valid for iron concentrations in near-neutral water because dissolved iron concentrations generally are a small percentage of the total-recoverable concentrations. Therefore, a decision was made to apply a conversion factor to the available total-recoverable iron data collected at all Group 2 sites during 1995–97. This was accomplished by computing dissolved to total-recoverable iron ratios for all paired data collected in 1998 and 1999 at each of the six sites. The computed ratios ranged from 0.05 to 0.39 with a median of 0.16. The median ratio was then used as the conversion factor and was applied to all total-recoverable iron data collected at the six sites during 1995–97. The estimated dissolved iron concentrations were only used for comparisons to standards.

Use of Censored Data

A large percentage of the total-recoverable copper and zinc data for Spring Creek, Fern Creek, Castleman Gulch, Silver Creek, Lieutenant Creek, and Ranger Creek were reported as less than the analytical reporting limit. Helsel and Hirsch (1992) describe several methods to estimate summary statistics when data include censored values. The approach used in this report was to compare censored water-quality data to instream standards and TRVs using the reporting limit as the estimated concentration. This methodology produced a conservative (worst case) estimate of the metal concentration.

Copper data collected during August and September 1995 at Group 2 sites (table 1) were not compared to instream standards and TRVs because the reporting limits were affected by multiple dilutions of sample aliquots in the laboratories. These data were reported as censored values with reporting limits as much as 10 times greater than expected. As such, these data values were removed from the data set.

Comparison of Aggregated Data to Instream Standards

Numeric standards have been set for the Rio Grande Basin including the Alamosa River and its tributaries (Colorado Department of Public Health and Environment, 1998). Acute and chronic numbers adopted as stream standards are not to be exceeded more than once every 3 years on the average. It is recognized, however, that measured instream parameter values might exceed the standard approximately 15 percent of the time (Colorado Department of Public Health and Environment, 1998). As such, an instream standard is exceeded if the 85th percentile value of the representative concentration data exceeds the instream standard value (P. Hegerman, Colorado Department of Public Health and Environment, oral commun., 2000). With respect to pH in the Alamosa River Basin, exceedance of the standard would require that the 15th percentile value was less than the standard value.

Not all instream standards are set as a single numeric value. In some instances, standards may be established by site-specific adoption of the hardness-dependent equations (Colorado Department of Public Health and Environment, 1995). This approach utilizes applicable mean hardness values to calculate table value standards (TVS) for metals. In this study, mean hardness values were calculated using available data or estimated values as described in an earlier section.

Comparison of Instantaneous Data to Instream Standards and Toxicological Reference Values

Exceedances of USEPA TRVs are determined by comparing instantaneous data to the TRVs. For the purposes of this report, a decision was made also to compare instantaneous data to CDPHE instream standards. This decision allowed for comparisons of the percent exceedances of the TRVs and instream standards. Exceedances of the instream standards were determined only where applicable standards existed. It is worth noting that the term "exceedance" does not mean that a value is greater than the standard, only that it does not meet the criteria of the standard. In particular, a pH value less than the specified acceptable range is not in compliance; it "exceeds" the standard.

SUMMARY STATISTICS FOR SELECTED TRIBUTARY SITES

Summary statistics for selected water-quality characteristics are shown in table 2. The calculated statistics include the minimum, 25th percentile, median, 75th percentile, 85th percentile, and maximum value. The number of samples collected and the percentage of censored (less than) values also are shown. Multiply censored data accounted for more than 50 percent of the total-recoverable copper and zinc data collected at Group 2 sites. Quantile statistics (25th percentile, median, and 75th percentile) for these data were generated using maximum likelihood estimation methods (MLE) as described in Helsel and Cohn (1988). If more than 85 percent of the data was reported as censored values, the MLE was not applicable, and only the minimum and maximum values are shown in table 2. Hardness values for Group 2 sites were estimated using regression analysis of data collected in 1998 and 1999.

The water-quality characteristics of tributaries to the Alamosa River can be grouped according to the geologic nature of the basin the tributary drains (fig. 1). Iron Creek, Alum Creek, Bitter Creek, Wightman Fork, Jasper Creek, and Burnt Creek (Group 1 sites) all drain hydrothermally altered areas. Spring Creek, Fern Creek, Castleman Gulch, Silver Creek, Lieutenant Creek, and Ranger Creek (Group 2 sites) all drain unaltered areas. Median values for nearly all measured characteristics at sites draining hydrothermally altered areas were higher than those from sites draining unaltered areas. The range of median values for Group 1 sites was 2.8 to 5.8 s.u. for pH; 172 to 1,560 μS/cm for specific conductance; 7.6 to 962 μg/L for total-recoverable copper; 1,560 to 163,000 μg/L for total-recoverable iron; and 11 to 766 μg/L of total-recoverable zinc. In contrast, the range of median values for Group 2 sites was 7.2 to 7.8 s.u. for pH; 71 to 115 μS/cm for specific conductance; and 136 to 516 μg/L for total-recoverable iron. Total-recoverable copper and zinc concentrations for Group 2 sites were generally reported as "less than" values. Alkalinity values for Group 1 sites were consistently less than the reporting limit of 5 mg/L whereas alkalinity for Group 2 sites ranged from 26 to 53 mg/L. For Group 1 sites, samples collected during storms invariably had the highest total-recoverable metal concentrations. Generally, a sample for dissolved metal analysis was not collected at these sites during storm events. No storm samples were collected at Group 2 sites.

COMPARISONS TO INSTREAM STANDARDS AND TOXICOLOGICAL REFERENCE VALUES

The CDPHE established instream water-quality standards for stream segments in the Rio Grande Basin, including tributaries to the Alamosa River (Colorado Department of Public Health and Environment, 1998). Similarly, the draft Tier II Summitville Ecological Risk Assessment has established acute and chronic TRVs for aquatic biota in the Alamosa River Basin (Camp Dresser and McKee Inc., 1999). Standards were either a numeric standard or a calculated value. The general form of the equation for a calculated standard (STD) was:

$$STD = (\exp^{a \times [\ln(\text{hardness})] \pm b}) \times m \qquad (1)$$

where

exp is the exponential e,
ln is the natural log,
hardness is the hardness value,
a is the slope of the log transformed data,
b is the adjusted intercept, and
m is the conversion factor from total recoverable to dissolved concentrations.

The conversion factor, m, was specific to the calculation of TRVs and was not used for CDPHE instream standards (A. Patterson, Camp Dresser and McKee Inc., written commun., 2000). Mean hardness data were used to determine attainment or nonattainment of Colorado instream standards, as described in a previous section of this report. Instantaneous hardness values were used to determine instantaneous exceedances of TRVs or instream standards.

Table 2. Summary statistics for selected tributary sites in the Alamosa River Basin, 1995–97

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; NA, not applicable; est, estimated;--, not reported]

Summary statistic	pH (s.u.)	Specific conductance (µS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
					Dissolved	Total recoverable	Dissolved	Total recoverable	Dissolved	Total recoverable
Iron Creek (IC0.0)[1]										
Minimum	3.3	52	16	0	2	<4	68	1,400	9	9
25th percentile	3.7	81	23	--	5	6	930	3,560	16	22
Median	4.2	172	35	--	11	12	2,460	5,550	39	38
75th percentile	5.1	236	43	--	15	19	3,770	9,120	48	59
85th percentile	5.3	331	52	--	18	21	5,290	11,200	62	84
Maximum	5.9	472	67	5	21	[3] 153	11,300	[3] 174,200	99	[3] 190
Number of samples	25	25	27	17	26	29	26	28	27	28
Percentage less than reporting limit	NA	NA	NA	100	12	7	0	0	0	4
Alum Creek (AC0.0)[1]										
Minimum	2.4	1,020	91	0	167	183	75,400	94,100	371	407
25th percentile	2.8	1,220	150	--	217	222	132,500	140,500	660	640
Median	2.8	1,560	184	--	250	257	148,000	163,000	815	766
75th percentile	2.9	1,730	239	--	300	314	180,000	210,000	941	897
85th percentile	3.0	1,760	247	--	327	375	195,200	244,700	970	961
Maximum	3.4	2,050	272	5	412	[3] 1,460	254,500	[3] 3,260,000	1,000	[3] 1,940
Number of samples	25	25	27	17	27	31	27	31	27	31
Percentage less than reporting limit	NA	NA	NA	100	0	0	0	0	0	0
Bitter Creek (BI0.0)[1]										
Minimum	3.2	70	18	0	3	<1	1,100	2,670	9	12
25th percentile	3.4	174	48	--	7	6	4,380	5,350	31	34
Median	3.6	374	86	--	12	12	7,690	12,300	80	91
75th percentile	4.2	530	115	--	17	21	12,700	14,100	118	120
85th percentile	4.6	558	126	--	21	29	14,300	16,600	135	130
Maximum	5.1	616	140	5	65	[3] 969	23,200	[3] 2,456,000	151	[3] 1,490
Number of samples	25	25	25	17	25	29	25	29	25	29
Percentage less than reporting limit	NA	NA	NA	100	8	14	0	0	0	0

Table 2. Summary statistics for selected tributary sites in the Alamosa River Basin, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; NA, not applicable; est, estimated;--, not reported]

Summary statistic	pH (s.u.)	Specific conductance (µS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
					Dissolved	Total recoverable	Dissolved	Total recoverable	Dissolved	Total recoverable
Wightman Fork (WF0.0)[1]										
Minimum	3.7	150	63	0	26	264	<4	635	129	190
25th percentile	4.5	313	105	--	476	712	340	1,600	460	485
Median	4.8	598	177	--	955	962	1,160	8,160	679	628
75th percentile	5.4	834	362	--	1,800	1,990	4,600	15,050	1,040	1,050
85th percentile	6.3	904	404	--	4,100	4,160	7,930	19,300	1,780	1,700
Maximum	7.8	2,470	840	24	8,410	[3] 10,700	17,600	[3] 301,000	3,180	[3] 3,600
Number of samples	100	99	113	47	113	117	112	116	113	116
Percentage less than reporting limit	NA	NA	NA	55	0	0	3	0	0	0
Jasper Creek (JC0.0)[1]										
Minimum	4.1	58	24	0	1	<1	11	316	<3	<3
25th percentile	5.3	88	40	5	4	5	104	639	4	5
Median	5.8	182	84	5	5	8	195	1,560	8	11
75th percentile	6.8	282	163	11	10	13	414	3,730	22	24
85th percentile	7.2	411	223	12	18	17	543	5,090	37	36
Maximum	7.7	616	266	18	[3] 56	[3] 1,000	[3] 2,800	[3] 1,420,000	[3] 78	[3] 1,400
Number of samples	25	25	26	19	26	28	26	28	26	28
Percentage less than reporting limit	NA	NA	NA	32	38	14	0	0	35	21
Burnt Creek (BC0.0)[1]										
Minimum	3.2	204	79	0	5	9	7	338	31	33
25th percentile	4.6	281	118	--	10	14	44	1,580	36	60
Median	4.8	452	203	--	14	20	135	3,400	70	91
75th percentile	5.1	540	291	--	17	46	327	23,800	93	121
85th percentile	5.3	577	363	--	19	336	354	184,700	97	466
Maximum	5.4	615	424	<5	[3] 96	[3] 3,020	624	[3] 2,137,000	[3] 157	[3] 4,430
Number of samples	12	12	14	7	13	17	14	17	14	17
Percentage less than reporting limit	NA	NA	NA	71	0	0	14	0	0	0

Table 2. Summary statistics for selected tributary sites in the Alamosa River Basin, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; NA, not applicable; est, estimated;--, not reported]

Summary statistic	pH (s.u.)	Specific conduct-ance (µS/cm)	Hard-ness (mg/L as $CaCO_3$)	Alka-linity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
					Dissolved	Total recov-erable	Dissolved	Total recov-erable	Dissolved	Total recov-erable
Spring Creek (SC0.0)[2,4]										
Minimum	6.8	64	est 29	29	--	--	--	72	--	--
25th percentile	7.6	78	est 34	31	--	.73	--	201	--	1.98
Median	7.7	88	est 38	37	--	1.31	--	516	--	3.04
75th percentile	8.0	127	est 52	46	--	2.34	--	820	--	4.66
85th percentile	8.2	135	est 55	47	--	--	--	1,110	--	--
Maximum	8.6	150	est 61	48	--	5	--	1,570	--	--
Number of samples	10	10	10	7	--	10	--	12	--	12
Percentage less than reporting limit	NA	NA	NA	0	--	70	--	8	--	67
Fern Creek (FC0.0)[2,4]										
Minimum	6.5	71	est 31	14	--	--	--	60	--	--
25th percentile	6.9	84	est 38	22	--	.95	--	237	--	2.13
Median	7.8	106	est 51	26	--	1.35	--	476	--	2.74
75th percentile	7.9	133	est 56	26	--	1.93	--	973	--	3.51
85th percentile	8.0	142	est 60	28	--	--	--	1,320	--	--
Maximum	8.2	191	est 76	30	--	--	--	1,690	--	--
Number of samples	11	11	11	9	--	11	--	13	--	13
Percentage less than reporting limit	NA	NA	NA	0	--	73	--	0	--	77
Castleman Gulch (CG0.0)[2]										
Minimum	6.6	48	est 23	21	--	<1	--	72	--	<3
25th percentile	6.9	64	est 29	27	--	--	--	101	--	--
Median	7.2	71	est 31	34	--	--	--	136	--	--
75th percentile	7.5	83	est 36	39	--	--	--	176	--	--
85th percentile	7.7	87	est 37	42	--	--	--	209	--	--
Maximum	7.8	98	est 41	48	--	6	--	354	--	<20
Number of samples	16	16	16	14	--	14	--	16	--	16
Percentage less than reporting limit	NA	NA	NA	0	--	86	--	0	--	87

Table 2. Summary statistics for selected tributary sites in the Alamosa River Basin, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; NA, not applicable; est, estimated;--, not reported]

Summary statistic	pH (s.u.)	Specific conduct-ance (µS/cm)	Hard-ness (mg/L as $CaCO_3$)	Alka-linity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
					Dissolved	Total recov-erable	Dissolved	Total recov-erable	Dissolved	Total recov-erable
Silver Creek (SI0.0)[2]										
Minimum	6.3	69	est 30	28	--	<1	--	25	--	<3
25th percentile	7.3	80	est 35	33	--	--	--	116	--	--
Median	7.8	104	est 44	38	--	--	--	227	--	--
75th percentile	8.0	122	est 50	50	--	--	--	428	--	--
85th percentile	8.1	124	est 51	53	--	--	--	446	--	--
Maximum	8.4	136	est 56	57	--	<4	--	725	--	<20
Number of samples	13	13	13	12	--	12	--	13	--	13
Percentage less than reporting limit	NA	NA	NA	0	--	92	--	0	--	100
Lieutenant Creek (LC0.0)[2,4]										
Minimum	6.8	94	est 40	35	--	<1	--	130	--	--
25th percentile	7.8	103	est 43	48	--	--	--	214	--	1.97
Median	7.8	115	est 48	53	--	--	--	344	--	2.56
75th percentile	8.1	118	est 49	56	--	--	--	521	--	3.32
85th percentile	8.2	121	est 50	59	--	--	--	565	--	--
Maximum	8.5	130	est 53	64	--	<5	--	801	--	--
Number of samples	16	16	16	13	--	14	--	16	--	16
Percentage less than reporting limit	NA	NA	NA	0	--	86	--	0	--	81
Ranger Creek (RC0.0)[2,4]										
Minimum	6.9	63	est 28	16	--	<1	--	61	--	--
25th percentile	7.5	71	est 31	31	--	--	--	114	--	1.10
Median	7.7	81	est 35	36	--	--	--	174	--	1.86
75th percentile	7.8	87	est 37	42	--	--	--	405	--	3.16
85th percentile	8.0	87	est 37	42	--	--	--	535	--	--
Maximum	8.1	91	est 39	44	--	<4	--	975	--	--
Number of samples	15	15	15	14	--	13	--	15	--	15
Percentage less than reporting limit	NA	NA	NA	0	--	92	--	7	--	80

[1] Site drains hydrothermally altered areas; referred to as "Group 1" site in report.
[2] Site drains unaltered areas; referred to as "Group 2" site in report.
[3] Samples were collected during a storm event.
[4] Maximum likelihood estimation methods used to estimate median, 25th percentile, and 75th percentile values for copper and zinc.

Tributaries in the Alamosa River Basin are classified by the CDPHE according to the beneficial use of the water, and classifications are assigned to specific stream segments. The 12 tributaries addressed in this report are included in either segment 4a, 6, 7, or 20 (table 3). Applicable instream standards for each analyte of concern differed depending on the stream segment. Attainment or nonattainment of the CDPHE standards were examined for pH, copper, iron, and zinc prior to comparisons using instantaneous data. TRVs (table 4) were applicable to all tributary sites and were compared to instantaneous data.

pH Comparisons

Comparisons of the 15th percentile pH values to instream standards indicated that pH standards were in attainment at all tributary sites except Jasper Creek, where applicable pH instream standards were in effect. The 15th percentile value of 25 pH values taken at Jasper Creek was 5.0 s.u. compared to the instream standard value of 5.5 s.u. (table 3). Wightman Fork did not have an applicable instream pH standard.

Instantaneous exceedances of pH standards set by the CDPHE were relatively uncommon with the exception of Jasper Creek (table 5). Instantaneous pH values were less than the designated standard in 35 percent of the Jasper Creek samples. Jasper Creek was the only tributary classified as “Aquatic Life—Coldwater Class 2” (table 3).

The chronic pH TRV for rainbow trout and the acute and chronic pH TRV for benthic macroinvertebrates were exceeded between 74 and 100 percent of the time at Iron Creek, Alum Creek, Bitter Creek, Wightman Fork, and Burnt Creek (table 5). The acute TRV for rainbow trout also was exceeded from 8 to

Table 3. Classifications and numeric standards for tributaries to the Alamosa River

[Colorado Department of Public Health and Environment, 1998; ln, natural log; e, exponential e; instream standards are shown as dissolved metal unless otherwise stated]

Site name	Stream segment	Stream classification	Applicable instream standard (in micrograms per liter)
Iron Creek, Alum Creek,	4a	[1]Recreation–Class 2	pH = 2.5–9.0 standard units
Bitter Creek, Burnt Creek		[2]Agriculture	
Wightman Fork	6	[1]Recreation–Class 2	No applicable standards
		[2]Agriculture	
Jasper Creek	7	[1]Recreation–Class 2	pH = 5.5 to 9.0 standard units
		[2]Agriculture	Chronic copper = 90 (as total recoverable)
		[3]Aquatic Life–Cold Water Class 2	Chronic iron = 3,400 (as total recoverable)
			Chronic zinc = 170 (as total recoverable)
Spring Creek, Fern Creek,	20	[1]Recreation–Class 2	pH = 6.5 to 9.0 standard units
Castleman Gulch,		[2]Agriculture	Acute copper = $e^{(0.9422 \times [\ln(\text{hardness})] - 1.4634)}$
Silver Creek,		[4]Aquatic Life–Cold Water Class 1	Chronic copper = $e^{(0.8545 \times [\ln(\text{hardness})] - 1.465)}$
Lieutenant Creek,			Chronic iron = 300
Ranger Creek			Chronic iron = 1,000 (as total recoverable)
			Acute zinc = $e^{(0.8473 \times [\ln(\text{hardness})] + 0.8604)}$
			Chronic zinc = $e^{(0.8473 \times [\ln(\text{hardness})] + 0.7614)}$

[1] These surface waters are suitable or intended to become suitable for recreational uses on or about the water included in secondary contact activities such as fishing and other streamside or lakeside recreation.

[2] These surface waters are suitable or intended to become suitable for irrigation of crops commonly grown in Colorado and are not hazardous as drinking water for livestock.

[3] These are waters that are not capable of sustaining a wide variety of cold- or warm-water biota due to physical habitat, water flows or levels, or uncorrectable water-quality conditions that result in substantial impairment of the abundance and diversity of species.

[4] These are waters that currently are capable of sustaining a wide variety of cold-water biota or could sustain such biota but for correctable water-quality conditions.

Table 4. Toxicological reference values for aquatic biota in the Alamosa River Basin

[modified from draft Tier II Summitville Ecological Risk Assessment (Camp Dresser and McKee Inc., written commun., 2000); ln, natural log; e, exponential e; toxicological reference values are shown as dissolved metal unless otherwise stated]

Aquatic receptor	Acute toxicological reference value (in micrograms per liter)	Chronic toxicological reference value (in micrograms per liter)
Rainbow trout	pH = 4.2 standard units copper = $e^{(0.9016 \times [\ln(\text{hardness})] - 0.562)} \times 0.960$ iron = 1000 (as total-recoverable) zinc = $e^{(0.8390 \times [\ln(\text{hardness})] + 2.6759)} \times 0.978$	pH = 5.6 standard units copper = $e^{(0.8545 \times [\ln(\text{hardness})] - 0.9895)} \times 0.960$ iron = 1000 (as total recoverable) zinc = $e^{(0.8390 \times [\ln(\text{hardness})] + 2.5710)} \times 0.986$
Benthic macroinvertebrates	pH = 5.38 standard units copper = $e^{(0.433 \times [\ln(\text{hardness})] + 0.6050)} \times 0.960$ iron = 320 zinc = $e^{(1.23 \times [\ln(\text{hardness})] + 1.039)} \times 0.978$	pH = 6.5 standard units copper = $e^{(0.433 \times [\ln(\text{hardness})] + 0.6050)} \times 0.960$ iron = 320 zinc = $e^{(0.6281 \times [\ln(\text{hardness})] + 0.8473)} \times 0.986$

100 percent of the time at these five sites; Iron Creek (48 percent), Alum Creek (100 percent), and Bitter Creek (72 percent) had the highest percent exceedances. Alum Creek was the only site to exceed all four TRVs all of the time. Including exceedances at Jasper Creek, nearly all the observed exceedances of the TRVs were associated with sites that drain hydrothermally altered areas in the basin (fig. 1 and table 5).

Copper Comparisons

Comparisons of the 85th percentile copper concentrations to acute and chronic instream standards indicated that the standards were in attainment at all tributary sites where applicable copper instream standards were in effect. No applicable instream copper standard was in effect for Iron Creek, Alum Creek,

Table 5. Percent instantaneous exceedance of instream pH standards and toxicological reference values for selected tributary sites in the Alamosa River Basin, 1995–97

[CDPHE, Colorado Department of Public Health and Environment; ERA, Ecological Risk Assessment; --, no applicable instream standard]

Site name	Stream segment (fig. 1)	Hydrothermal drainage area	Instantaneous exceedance of CDPHE instream standard	Summitville ERA toxicological reference value			
				Acute rainbow trout	Chronic rainbow trout	Acute benthic macroinvertebrate	Chronic benthic macroinvertebrate
Iron Creek	4a	Altered	0	48	92	84	100
Alum Creek	4a	Altered	8	100	100	100	100
Bitter Creek	4a	Altered	0	72	100	100	100
Wightman Fork	6	Altered	--	15	79	74	86
Jasper Creek	7	Altered	36	4	44	28	64
Burnt Creek	4a	Altered	0	8	100	83	100
Spring Creek	20	Unaltered	0	0	0	0	0
Fern Creek	20	Unaltered	0	0	0	0	0
Castleman Gulch	20	Unaltered	0	0	0	0	0
Silver Creek	20	Unaltered	8	0	0	0	8
Lieutenant Creek	20	Unaltered	0	0	0	0	0
Ranger Creek	20	Unaltered	0	0	0	0	0

Bitter Creek, Burnt Creek, and Wightman Fork (table 3). Instream copper standards for Jasper Creek were based on total-recoverable concentrations.

Instantaneous exceedances of applicable copper standards set by the CDPHE occurred infrequently. Jasper Creek, Spring Creek, and Castleman Gulch were the only sites where exceedances occurred. No more than 11 percent of the instantaneous concentrations at the three sites exceeded the chronic copper instream standard (table 6). No instantaneous exceedances of the acute standard were observed.

The chronic copper TRV for rainbow trout and the acute and chronic copper TRV for benthic macroinvertebrates were exceeded between 73 and 100 percent of the time at Iron Creek, Alum Creek, and Wightman Fork (table 6). In addition, the acute TRV for rainbow trout was exceeded 31 percent of the time at Iron Creek and 100 percent of the time at Alum Creek and Wightman Fork. Alum Creek and Wightman Fork were the only sites to exceed all four TRVs all of the time. Exceedances of the TRVs for copper were associated only with sites that drain hydrothermally altered areas in the basin (fig. 1 and table 6). Copper concentrations analyzed from samples collected during rainstorms tended to exceed acute TRVs. Two of the three exceedances of the acute TRV for benthic macroinvertebrates in Jasper Creek were associated with storm runoff events; the acute TRV for rainbow trout was not exceeded during these storm runoff events.

Iron Comparisons

Comparisons of the 85th percentile dissolved iron concentrations to chronic agriculture standards indicated that iron standards were in attainment at all tributary sites where applicable agriculture standards were in effect. Agricultural standards for dissolved iron were in effect at Spring Creek, Fern Creek, Castleman Gulch, Silver Creek, Lieutenant Creek, and Ranger Creek (table 3). Aquatic-life standards, however, were based on total-recoverable iron concentrations (table 3). Chronic aquatic-life standards were not attained in Jasper Creek, Spring Creek, and Fern Creek (table 7). The 85th percentile concentration for Jasper Creek exceeded the standard of 3,400 μg/L by nearly 1,700 μg/L. Spring Creek and Fern Creek exceeded the standard of 1,000 μg/L by 110 and 320 μg/L, respectively. No applicable instream

Table 6. Percent instantaneous exceedance of instream copper standards and toxicological reference values for selected tributary sites in the Alamosa River Basin, 1995–97

[CDPHE, Colorado Department of Public Health and Environment; ERA, Ecological Risk Assessment; --, no applicable instream standard; all instream standards and toxicological reference values are shown as dissolved copper unless otherwise stated]

Site name	Stream segment (fig. 1)	Hydrothermal drainage area	Instantaneous exceedance of CDPHE instream standard		Summitville ERA toxicological reference value			
			Acute	Chronic	Acute rainbow trout	Chronic rainbow trout	Acute benthic macroinvertebrate	Chronic benthic macroinvertebrate
Iron Creek	4a	Altered	--	--	31	85	73	73
Alum Creek	4a	Altered	--	--	100	100	100	100
Bitter Creek	4a	Altered	--	--	4	28	36	36
Wightman Fork	6	Altered	--	--	100	100	100	100
Jasper Creek	7	Altered	--	[1] 4	0	12	12	12
Burnt Creek	4a	Altered	--	--	8	15	23	23
Spring Creek	20	Unaltered	0	11	0	0	0	0
Fern Creek	20	Unaltered	0	0	0	0	0	0
Castleman Gulch	20	Unaltered	0	8	0	0	0	0
Silver Creek	20	Unaltered	0	0	0	0	0	0
Lieutenant Creek	20	Unaltered	0	0	0	0	0	0
Ranger Creek	20	Unaltered	0	0	0	0	0	0

[1] Instream copper standard was based on total-recoverable concentrations.

Table 7. Percent instantaneous exceedance of instream iron standards and toxicological reference values for selected tributary sites in the Alamosa River Basin, 1995–97

[CDPHE, Colorado Department of Public Health and Environment; ERA, Ecological Risk Assessment; --, no applicable instream standard; all instream standards and toxicological reference values are shown as dissolved iron unless otherwise stated]

Site name	Stream segment (fig. 1)	Hydrothermal drainage area	Instantaneous exceedance of CDPHE instream standard		Summitville ERA toxicological reference value			
			Chronic aquatic life[1]	Chronic agriculture	Acute rainbow trout[1]	Chronic rainbow trout[1]	Acute benthic macroinvertebrate	Chronic benthic macroinvertebrate
Iron Creek	4a	Altered	--	--	100	100	92	92
Alum Creek	4a	Altered	--	--	100	100	100	100
Bitter Creek	4a	Altered	--	--	100	100	100	100
Wightman Fork	6	Altered	--	--	89	89	75	75
Jasper Creek	7	Altered	29	--	57	57	38	38
Burnt Creek	4a	Altered	--	--	88	88	29	29
Spring Creek	20	Unaltered	17	0	17	17	0	0
Fern Creek	20	Unaltered	23	0	23	23	0	0
Castleman Gulch	20	Unaltered	0	0	0	0	0	0
Silver Creek	20	Unaltered	0	0	0	0	0	0
Lieutenant Creek	20	Unaltered	0	0	0	0	0	0
Ranger Creek	20	Unaltered	0	0	0	0	0	0

[1] Instream standard and toxicological reference values were based on total-recoverable concentrations.

standard for iron was in effect at Iron Creek, Alum Creek, Bitter Creek, Wightman Fork, and Burnt Creek (table 3).

Instantaneous exceedances of applicable iron standards set by the CDPHE occurred infrequently. Jasper Creek, Spring Creek, and Fern Creek were the only sites where exceedances occurred. Instantaneous concentrations measured at the three sites exceeded the chronic aquatic-life standard 17 to 29 percent of time (table 7). No instantaneous exceedances of the agriculture standard were observed.

The acute and chronic TRVs for rainbow trout and benthic macroinvertebrates were exceeded 75 percent or more of the time at Iron Creek, Alum Creek, Bitter Creek, and Wightman Fork (table 7). In addition, the acute and chronic TRVs for rainbow trout were exceeded 88 percent of the time at Burnt Creek. Alum Creek and Bitter Creek were the only sites to exceed all four TRVs all of the time.

Zinc Comparisons

Comparisons of the 85th percentile zinc concentrations to acute and chronic instream standards indicated that the standards were in attainment at all tributary sites where applicable zinc instream standards were in effect. No applicable instream zinc standard was in effect for Iron Creek, Alum Creek, Bitter Creek, Wightman Fork, and Burnt Creek (table 3). Instream zinc standards for Jasper Creek were based on total-recoverable concentrations.

Instantaneous exceedances of applicable zinc standards set by the CDPHE occurred only once at any tributary site. The chronic standard set for Jasper Creek (170 µg/L as total recoverable) was exceeded in a storm sample collected in August 1995; no acute standard is applicable at this site. No instantaneous exceedances of the acute standard were observed at any of the other sites.

The chronic zinc TRV for benthic macroinvertebrates was exceeded 50 percent or more of the time at Iron Creek, Alum Creek, Bitter Creek, Wightman Fork, and Burnt Creek (table 8). Wightman Fork was the only site to exceed all four TRVs. Acute rainbow trout TRVs were exceeded 34 percent of the time at Wightman Fork. Exceedances of the TRVs for zinc were generally associated with sites that drain hydrothermally altered areas (fig. 1 and table 8).

Table 8. Percent instantaneous exceedance of instream zinc standards and toxicological reference values for selected tributary sites in the Alamosa River Basin, 1995–97

[CDPHE, Colorado Department of Public Health and Environment; ERA, Ecological Risk Assessment; --, no applicable instream standard; all instream standards and toxicological reference values are shown as dissolved zinc unless otherwise stated]

Site name	Stream segment (table 1)	Hydro-thermal drainage area	Instantaneous exceedance of CDPHE instream standard		Summitville ERA toxicological reference value			
			Acute	Chronic	Acute rainbow trout	Chronic rainbow trout	Acute benthic macro-invertebrate	Chronic benthic macro-invertebrate
Iron Creek	4a	Altered	--	--	0	0	0	74
Alum Creek	4a	Altered	--	--	0	0	0	100
Bitter Creek	4a	Altered	--	--	0	0	0	92
Wightman Fork	6	Altered	--	--	34	4	22	100
Jasper Creek	7	Altered	--	[1] 4	0	0	0	4
Burnt Creek	4a	Altered	--	--	0	0	0	50
Spring Creek	20	Unaltered	0	0	0	0	0	0
Fern Creek	20	Unaltered	0	0	0	0	0	0
Castleman Gulch	20	Unaltered	0	0	0	0	0	0
Silver Creek	20	Unaltered	0	0	0	0	0	0
Lieutenant Creek	20	Unaltered	0	0	0	0	0	0
Ranger Creek	20	Unaltered	0	0	0	0	0	7

1 Instream standard was based on total-recoverable concentrations.

SUMMARY

The U.S. Geological Survey collected water-quality data from 1995 through 1997 at 12 tributary sites to the Alamosa River. These data were used to address the data gaps identified in the initial ecological risk assessment of the Summitville Superfund site. Selected data were summarized to provide a general overview of the water quality of the tributaries. Tributaries to the Alamosa River can be grouped according to the geology of the basin the tributaries drain. Tributaries draining hydrothermally altered areas generally had higher median values than tributaries draining unaltered areas. In addition, samples collected during storms invariably had the highest total-recoverable metal concentrations.

Copper, iron, zinc, and pH data were compared to Colorado instream water-quality standards to determine if attainment of the standards had been met. Instantaneous data comparisons also were made to U.S. Environmental Protection Agency toxicological reference values (TRV) and Colorado instream standards. Instantaneous comparisons provided a means to determine the frequency at which a standard or TRV was exceeded.

Instream pH standards were in attainment at all tributary sites except Jasper Creek. Most instantaneous exceedances were associated with Jasper Creek. Chronic TRVs for rainbow trout, and acute and chronic TRVs for benthic macroinvertebrates were exceeded more than 70 percent of the time at Iron Creek, Alum Creek, Bitter Creek, Wightman Fork, and Burnt Creek. The acute TRV for rainbow trout was exceeded from 8 to 100 percent of the time at these five sites.

Acute and chronic instream copper standards were in attainment at all tributary sites where applicable copper standards were in effect. Instantaneous exceedances of applicable instream standards occurred infrequently. Chronic TRVs for rainbow trout and acute and chronic TRVs for benthic macroinvertebrates were exceeded more than 70 percent of the time at Iron Creek, Alum Creek, and Wightman Fork. In addition, the acute TRV for rainbow trout was exceeded 31 percent of the time at Iron Creek and 100 percent of the time at Alum Creek and Wightman Fork.

Chronic agriculture standards for iron were in attainment at all tributary sites where applicable agri-

culture standards were in effect. Chronic aquatic-life standards for iron, however, were not attained at Jasper Creek, Spring Creek, and Fern Creek; instantaneous exceedances only occurred at these three sites. Acute and chronic TRVs for rainbow trout and benthic macroinvertebrates were exceeded 75 percent or more of the time at Iron Creek, Alum Creek, Bitter Creek, and Wightman Fork. In addition, the acute and chronic TRV for rainbow trout was exceeded 88 percent of the time at Burnt Creek.

Instream zinc standards were in attainment at all tributary sites where applicable zinc instream standards were in effect. Instantaneous exceedances of applicable zinc standards occurred only once at any tributary site (Jasper Creek). The chronic TRV for benthic macroinvertebrates was exceeded 50 percent or more of the time at Iron Creek, Alum Creek, Bitter Creek, Wightman Fork, and Burnt Creek.

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APPENDIX

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific conductance (µS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dissolved	Total recoverable	Dissolved	Total recoverable	Dissolved	Total recoverable
Iron Creek (IC0.0)											
05-25-95	1005	5.4	81	23.8	2.9	<4	<4	924	3,240	15	21
06-07-95	1800	5.3	63	18.7	--	<5	6	421	4,730	13	18
06-15-95	1610	4.8	56	16.0	--	<5	8	168	9,020	10	22
06-30-95	1340	4.8	52	17.0	--	2	4	520	1,400	11	11
07-25-95	1245	4.2	135	28.6	0	13	<5	--	--	31	--
08-22-95	1030	4.1	168	35.7	--	12	11	2,500	4,600	41	38
08-22-95[1]	1830	--	--	24.6	--	--	69	68	98,000	18	150
09-26-95	1030	4.1	202	35.0	5.0	8	12	3,400	5,500	43	42
10-23-95	1440	3.7	374	66.0	5.0	21	20	11,300	13,500	92	82
04-25-96	1025	5.0	137	41.3	0	8	10	1,650	8,080	28	27
05-18-96	1120	5.9	67	19.4	--	4	4	886	1,850	13	15
06-11-96	1250	4.7	175	36.1	--	9	10	2,690	3,600	40	37
07-16-96	1105	3.7	302	50.8	<5.0	12	12	4,090	5,230	59	49
07-25-96[1]	1430	--	--	--	--	--	153	--	174,200	--	190
07-25-96[1]	1555	--	--	--	--	--	63	--	18,600	--	64
08-12-96	1555	3.3	445	67.2	0	18	19	5,070	4,880	99	85
09-17-96	1040	3.5	425	63.7	0	18	16	7,990	8,170	90	85
10-16-96	1245	3.4	472	61.1	0	16	14	9,270	9,940	89	91
03-25-97	1430	3.6	280	50.4	<5.0	14	15	3,840	6,620	49	53
04-24-97	1220	4.4	172	41.9	--	10	12	2,990	6,250	42	40
05-14-97	1220	5.1	91	23.3	<5.0	4	10	1,050	11,300	16	25
05-28-97	1135	5.5	89	23.6	<5.0	4	6	1,317	3,090	21	22
06-05-97	1145	5.8	53	16.1	<5.0	4	5	431	2,100	9	9
06-17-97	1145	5.2	73	19.7	<5.0	5	4	949	1,640	16	13
07-15-97	1235	3.6	236	35.6	<5.0	13	14	2,420	3,420	44	38
07-21-97[1]	1610	--	--	32.9	--	16	19	1,110	4,560	30	33
08-13-97	1320	4.1	208	35.4	<5.0	14	16	3,420	5,600	39	38
09-10-97	1305	4.1	222	39.7	<5.0	20	21	3,560	6,550	46	40
10-22-97	1245	3.5	236	44.7	--	19	22	5,950	9,430	57	57

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific conductance (µS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dissolved	Total recoverable	Dissolved	Total recoverable	Dissolved	Total recoverable
Alum Creek (AC0.0)											
04-27-95	1330	2.8	1,130	--	--	--	369	--	235,400	--	827
05-25-95	0940	2.4	1,560	158	0	326	338	141,900	148,000	619	643
06-15-95	1420	3.0	1,100	91.0	--	196	226	75,600	132,000	392	438
06-30-95	1625	2.9	1,120	--	--	--	240	--	110,000	--	450
07-25-95	1230	2.7	1,450	142	0	260	237	129,000	124,000	700	638
08-22-95	1700	2.8	1,720	224	--	300	280	173,000	159,000	930	830
09-14-95[1]	1120	--	--	209	--	340	380	148,000	404,000	800	760
09-14-95[1]	1345	--	--	222	--	340	320	170,000	204,000	870	730
09-26-95	1100	2.4	1,780	236	5.0	290	270	186,000	186,000	1,000	1,000
10-23-95	1435	2.8	1,710	249	5.0	250	240	186,000	173,000	1,000	880
04-25-96	0915	2.8	1,520	180	0	247	257	134,800	144,300	676	697
05-18-96	1350	3.4	1,216	123	--	193	183	98,500	117,000	524	505
06-11-96	1510	2.9	1,470	179	--	223	211	147,000	142,000	774	702
07-15-96	1625	2.8	1,780	247	<5.0	257	270	201,200	214,600	965	963
07-25-96[1]	1420	--	--	--	--	--	1,460	--	3,260,000	--	1,940
07-25-96[1]	1605	--	--	--	--	--	581	--	484,000	--	961
08-13-96	1125	3.2	1,680	255	0	229	218	148,000	139,000	966	852
08-23-96[1]	1410	--	--	267	--	248	245	195,100	205,500	918	914
09-17-96	1040	2.9	1,730	272	0	236	208	164,000	150,000	1,000	937
10-16-96	1155	3.1	1,610	245	0	183	202	154,000	163,000	916	961
03-25-97	1700	2.8	2,050	170	<5.0	412	415	254,500	259,200	839	826
04-24-97	1015	2.7	1,760	184	--	354	380	202,800	226,000	815	836
05-14-97	1520	2.7	1,150	99.3	<5.0	212	299	75,400	254,000	397	510
05-28-97	1430	2.9	1,520	143	<5.0	307	308	145,800	151,600	644	610
06-05-97	1355	3.0	1,020	92.4	<5.0	167	187	84,500	109,900	371	407
06-17-97	1445	2.7	1,160	115	<5.0	209	198	94,900	94,100	522	468
07-15-97	1325	2.8	1,470	158	<5.0	222	219	130,200	130,200	730	646
07-21-97[1]	1620	--	--	167	--	203	225	147,500	163,800	715	743
08-13-97	1500	2.9	1,710	200	<5.0	269	269	154,100	151,700	834	766
09-10-97	1510	2.9	1,760	234	<5.0	266	253	174,000	165,000	952	851
10-22-97	1510	2.8	1,760	241	--	300	298	196,000	199,400	1,000	970

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific conductance (µS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dissolved	Total recoverable	Dissolved	Total recoverable	Dissolved	Total recoverable
Bitter Creek (BI0.0)											
04-27-95	1320	3.2	529	--	--	--	38	--	22,200	--	112
05-25-95	1045	4.5	198	47.7	0	9	6	5,880	4,980	30	33
06-15-95	1315	5.1	70	20.0	--	<5	<5	1,160	7,680	16	22
06-30-95	1700	4.5	85	--	--	--	<1	--	3,600	--	17
07-25-95	1330	3.7	252	56.0	0	7	<5	4,380	4,920	51	46
08-22-95	1805	3.2	470	116	--	33	30	12,700	12,300	110	98
09-26-95	1150	4.0	492	107	5.0	13	9	12,600	13,500	120	110
10-23-95	1620	3.4	548	138	5.0	12	12	14,600	14,100	140	120
04-25-96	1010	3.8	293	69.5	0	9	12	5,490	8,940	52	54
05-18-96	1515	4.7	99	25.0	--	5	<3	2,030	4,430	19	20
06-11-96	1610	3.5	333	75.9	--	6	7	6,770	6,790	77	70
07-15-96	1715	3.3	548	118	<5.0	20	21	7,690	8,590	118	112
07-25-96[1]	1410	--	--	--	--	--	969	--	2,456,000	--	1,490
07-25-96[1]	1610	--	--	--	--	--	126	--	189,800	--	242
08-13-96	1215	3.3	574	130	0	12	11	14,500	13,600	144	122
08-23-96[1]	1440	--	--	124	--	22	26	13,500	14,300	132	131
09-17-96	1135	3.4	605	140	<1.0	14	14	14,200	13,300	151	142
10-16-96	1310	3.4	616	129	0	13	12	15,700	16,800	147	151
03-25-97	1720	3.2	606	111	<5.0	65	71	23,200	25,500	109	127
04-24-97	1515	3.6	333	75.6	--	19	19	10,100	12,800	72	61
05-14-97	1615	3.9	174	39.7	<5.0	10	12	3,390	15,700	31	34
05-28-97	1540	4.2	138	33.2	<5.0	3	5	3,390	4,310	27	26
06-05-97	1450	4.9	140	18.2	<5.0	<4	5	1,110	5,350	9	12
06-17-97	1515	4.8	101	24.8	<5.0	4	3	2,010	2,670	17	15
07-15-97	1455	3.2	374	78.8	<5.0	7	6	4,740	4,920	79	70
07-21-97[1]	1630	--	--	85.6	--	9	13	5,530	6,420	80	82
08-13-97	1600	3.7	481	97.7	<5.0	28	27	12,600	13,900	97	91
09-10-97	1550	3.5	530	112	<5.0	17	17	12,200	11,800	114	116
10-22-97	1600	3.5	471	109	--	14	19	12,500	12,900	112	109

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific con-duct-ance (µS/cm)	Hard-ness (mg/L as $CaCO_3$)	Alka-linity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dis-solved	Total recover-able	Dis-solved	Total recover-able	Dis-solved	Total recover-able
Wightman Fork (WF0.0)											
02-23-95	1110	7.5	1,520	369	--	205	747	<15	1,000	386	411
03-15-95	1225	7.4	645	192	--	78	679	<5	2,670	344	418
04-27-95	1120	6.8	302	113	--	57	743	31	2,690	177	--
05-09-95	1310	7.8	298	113	--	51	634	49	2,910	146	237
05-24-95	1220	6.3	205	64.3	3.4	336	560	1,220	8,630	266	295
06-16-95	0610	4.8	283	64.8	--	841	875	2,100	9,260	502	499
06-29-95	1230	4.2	546	107	--	3,000	2,900	11,000	16,000	1,300	1,300
07-26-95	1200	--	--	162	0	5,970	5,620	12,600	20,000	2,440	2,270
07-26-95	1205	3.8	870	165	0	5,580	5,240	12,500	18,600	2,350	2,170
07-26-95	1620	3.8	869	162	0	5,330	5,000	12,100	17,700	2,280	2,140
07-26-95	2005	3.7	978	185	--	8,410	8,080	17,600	30,300	3,180	3,020
07-27-95	0005	3.7	882	164	0	6,380	6,190	14,600	20,900	2,610	2,340
07-27-95	0405	3.7	883	149	--	6,190	6,560	12,500	23,900	2,550	2,530
07-27-95	0805	3.8	861	154	0	5,330	5,320	10,500	19,900	2,270	2,280
08-21-95[1]	1630	4.1	512	127	--	1,800	3,500	620	301,000	1,100	1,600
08-21-95[1]	2359	4.1	668	141	--	4,100	4,000	6,500	34,700	1,800	1,600
08-23-95	1130	--	--	183	--	4,500	4,600	9,400	14,400	2,000	1,900
08-23-95	1135	4.4	726	171	--	4,300	4,200	7,500	12,100	1,900	1,700
08-23-95	1937	4.3	793	178	--	4,700	4,500	8,100	13,600	2,100	1,900
08-24-95	0337	4.3	791	177	--	4,800	4,900	7,500	12,600	2,000	1,900
09-14-95	1345	--	--	225	5.0	7,200	7,600	15,900	26,800	2,800	2,600
09-14-95[1]	1430	4.6	848	--	--	--	5,000	--	15,100	--	1,800
09-14-95[1]	1945	4.2	1,080	--	--	--	10,700	--	54,400	--	3,600
09-15-95[1]	0300	4.3	893	--	--	--	1,200	--	12,800	--	2,000
09-27-95	1030	--	--	207	1.1	4,100	4,300	10,400	12,900	1,600	1,600
09-27-95	1235	4.8	866	207	1.0	4,200	4,200	8,800	11,200	1,600	1,500
09-27-95	2045	4.7	985	251	1.2	4,700	4,400	14,800	15,800	2,000	1,700
09-28-95	0440	4.7	819	234	1.0	5,200	5,000	10,600	12,700	1,900	1,700
10-24-95	1030	5.1	1,160	303	1.2	4,100	4,100	7,700	8,200	1,800	1,600
11-21-95	1615	5.0	1,670	403	--	3,300	3,400	6,700	8,800	1,400	1,400
02-22-96	1335	5.8	2,470	541	--	942	1,224	1,900	3,260	771	789
03-27-96	1115	6.6	2,030	459	--	412	558	109	2,740	570	582

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific con-duct-ance (µS/cm)	Hard-ness (mg/L as $CaCO_3$)	Alka-linity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dis-solved	Total recover-able	Dis-solved	Total recover-able	Dis-solved	Total recover-able
Wightman Fork (WF0.0)—Continued											
04-24-96	1125	7.7	637	172	24.4	101	264	97	2,010	129	190
05-16-96	0900	--	--	96.1	2.2	322	397	1,380	11,700	343	341
05-16-96	1105	5.2	381	118	--	375	398	1,860	3,910	354	319
05-16-96	1505	4.9	381	115	--	492	540	2,850	12,000	482	460
05-16-96	1905	5.0	257	79.1	--	243	388	974	24,600	325	362
05-16-96	2305	5.2	273	81.9	--	276	327	888	7,200	290	296
05-17-96	0305	5.2	320	91.9	--	326	339	1,030	4,180	316	289
05-17-96	0705	5.2	354	106	2.2	355	383	1,310	4,320	339	326
06-10-96	1545	6.7	639	287	2.1	150	459	17	1,140	340	325
06-11-96	1400	--	--	272	1.8	203	438	44	951	349	318
06-11-96	1600	6.7	598	287	--	129	446	<4	1,020	329	331
06-11-96	2000	6.6	620	297	--	222	472	15	1,210	388	387
06-11-96	2359	6.4	554	265	--	263	502	143	1,290	367	364
06-12-96	0400	6.5	543	251	--	145	450	24	1,220	322	330
06-12-96	0800	6.6	584	272	--	188	468	56	989	338	346
06-12-96	1200	6.7	584	280	2.4	146	477	23	1,020	336	356
07-17-96	1430	--	--	362	<5.0	1,060	1,250	483	14,680	788	818
07-17-96	1630	5.2	801	366	--	645	712	644	1,580	615	547
07-17-96	2030	5.8	754	364	--	582	717	506	1,450	597	543
07-18-96	0030	6.0	788	377	--	521	775	403	1,850	589	558
07-18-96	0430	4.5	893	430	--	3,060	3,220	45	64,900	1,920	1,780
07-18-96	0830	4.8	801	393	--	1,090	1,070	922	4,910	888	776
07-18-96	1230	5.1	794	408	<5.0	862	830	871	2,160	735	634
07-25-96[1]	1630	--	--	--	--	--	917	--	2,260	--	595
08-13-96	1220	--	--	476	<1.0	981	973	536	1,080	710	599
08-13-96	1420	5.3	930	574	<1.0	863	921	507	1,010	625	562
08-13-96	2220	5.5	372	489	--	655	789	202	951	574	513
08-14-96	0220	5.4	345	446	--	1,740	1,700	1,120	1,650	971	852
08-14-96	1020	5.4	995	466	<1.0	1,370	1,300	801	1,430	894	749
08-22-96[1]	1330	4.5	661	250	--	1,950	1,990	1,140	8,120	1,250	1,260
08-22-96[1]	2130	4.7	582	227	--	1,490	1,560	1,090	8,680	1,040	1,070
08-23-96[1]	0130	4.4	683	256	<5.0	2,660	2,780	2,860	41,400	1,770	1,790

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific con-duct-ance (µS/cm)	Hard-ness (mg/L as $CaCO_3$)	Alka-linity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dis-solved	Total recover-able	Dis-solved	Total recover-able	Dis-solved	Total recover-able
					Wightman Fork (WF0.0—Continued						
08-23-96[1]	0930	4.2	642	235	--	1,840	1,880	1,050	17,400	1,310	1,310
08-23-96[1]	1730	4.5	610	249	<5.0	1,330	1,330	1,200	5,680	1,040	1,040
09-16-96	1425	5.6	1,570	834	<1.0	759	830	650	1,430	638	600
09-17-96	1215	--	--	800	<1.0	865	922	792	2,430	663	622
09-17-96	1415	5.3	1,330	676	<1.0	741	843	366	1,300	591	566
09-17-96	2215	5.4	1,620	840	--	715	807	694	1,270	575	548
09-18-96	1015	5.1	1,570	801	--	865	922	871	2,620	672	641
10-16-96	0920	4.6	1,640	739	<5.0	305	701	161	958	460	508
11-20-96	1120	6.6	523	218	14.0	162	913	7	1,610	451	520
02-19-97	1030	6.1	507	227	7.1	241	636	<10	635	532	553
03-26-97	1045	7.5	295	112	23.4	26	396	5	3,200	129	210
04-22-97	1140	4.9	356	118	--	1,220	1,270	3,390	16,900	716	689
05-13-97	1125	5.2	184	63.0	<5.0	290	417	844	8,270	271	293
05-14-97	1000	--	--	63.8	<5.0	476	577	754	17,400	349	364
05-14-97	1200	4.8	175	65.2	--	429	487	1,360	10,500	332	338
05-14-97	2000	4.6	165	65.1	--	468	621	741	24,600	359	376
05-14-97	2359	4.6	161	64.7	--	534	666	632	19,400	384	408
05-15-97	0800	4.8	150	64.2	<5.0	484	562	680	10,400	337	353
05-28-97	0945	--	--	86.4	<5.0	973	926	3,270	9,290	562	507
05-28-97	1145	4.5	306	101	--	1,190	1,150	4,580	9,560	660	597
05-28-97	1545	4.5	296	98.5	--	1,140	1,060	4,500	9,710	641	560
05-28-97	1945	4.6	241	76.9	--	806	776	2,460	10,800	488	442
05-28-97	2345	4.5	250	69.3	--	895	799	--	--	524	468
05-29-97	0345	4.5	262	84.2	--	922	895	2,960	8,360	546	496
05-29-97	0745	4.5	264	88.4	<5.0	1,020	964	3,430	8,510	576	515
06-03-97	0900	--	--	82.4	<5.0	1,420	1,600	4,680	26,300	686	761
06-03-97	1100	4.0	352	97.1	--	1,840	1,990	6,430	16,500	839	915
06-03-97	1500	4.0	329	85.3	--	1,450	1,580	5,330	32,400	704	764
06-03-97	1900	4.3	228	66.6	--	990	1,210	2,910	37,100	502	585
06-03-97	2300	4.1	250	74.8	--	1,270	1,410	3,870	19,100	612	670
06-04-97	0300	4.0	267	85.4	--	1,560	1,690	5,130	15,000	732	782
06-04-97	0700	4.0	286	92.2	<5.0	1,710	1,880	5,960	15,400	798	876

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific conductance (µS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dissolved	Total recoverable	Dissolved	Total recoverable	Dissolved	Total recoverable
Wightman Fork (WF0.0)—Continued											
06-16-97	1630	--	--	113	--	2,310	2,240	9,410	29,200	1,120	976
06-18-97	1000	--	--	107	<5.0	1,360	1,320	4,190	8,510	728	655
06-18-97	1200	4.1	442	134	--	2,270	2,190	8,280	13,300	1,120	1,020
06-18-97	1600	4.1	427	127	--	2,120	2,100	7,830	13,500	1,060	1,010
06-18-97	2000	4.5	279	91.7	--	922	891	2,130	6,550	531	490
06-18-97	2359	4.6	283	97.5	--	955	925	2,180	6,200	548	514
06-19-97	0800	4.7	296	105	<5.0	1,050	1,010	2,830	6,660	593	540
07-15-97	1130	--	--	378	<5.0	974	951	85	915	731	663
07-15-97	1330	4.8	753	359	--	885	923	151	998	718	616
07-15-97	1730	4.8	770	373	--	957	986	97	711	745	656
07-15-97	2130	4.9	798	390	--	949	962	58	817	732	640
07-16-97	0130	4.9	732	361	--	894	888	53	708	679	578
07-16-97	0530	5.0	742	363	--	885	904	54	884	699	610
07-16-97	0930	5.0	758	372	<5.0	908	933	114	982	716	663
08-13-97	1400	--	--	140	<5.0	1,390	1,390	1,520	4,040	968	992
08-13-97	1600	4.7	482	143	--	1,400	1,420	1,920	4,410	985	954
08-13-97	2359	4.7	408	142	--	1,400	1,400	1,460	4,160	988	953
08-14-97	0400	4.8	400	140	--	1,370	1,330	1,170	3,310	945	913
08-14-97	1200	4.8	394	137	<5.0	1,360	1,370	1,630	3,650	959	924
09-11-97	1005	5.2	1,010	557	<5.0	922	899	261	1,160	762	647
10-23-97	0930	5.7	850	434	<5.0	656	793	583	1,250	540	527
Jasper Creek (JC0.0)											
04-27-95	1315	5.4	182	--	--	--	13	--	4,640	--	16
05-25-95	1215	6.8	86	31.4	12.6	<4	4	148	1,850	<4	5
06-15-95	1145	7.5	61	23.5	--	<5	<5	100	2,230	<4	7
06-30-95	1743	5.4	71	--	--	--	<1	--	610	--	<5
07-25-95	1420	6.5	130	52.3	12.2	<5	<5	326	491	<4	<4
08-22-95[1]	1725	--	--	171	--	52	1,000	240	1,420,000	78	1,400
08-22-95	1905	4.2	260	103	--	29	28	1,000	6,000	21	22
09-26-95	1250	5.3	370	162	4.6	<30	5	1,100	1,700	24	28
10-23-95	1745	5.1	472	217	3.1	6	8	430	1,600	22	23
04-25-96	1230	7.5	137	56.1	18.4	5	7	133	3,500	<4	8

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific conductance (µS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dissolved	Total recoverable	Dissolved	Total recoverable	Dissolved	Total recoverable
Jasper Creek (JC0.0)—Continued											
05-18-96	1300	7.7	85	34.5	--	4	<3	169	756	4	4
06-11-96	1745	5.1	184	75.9	5.6	<3	3	11	433	<3	<3
07-15-96	1845	4.8	189	164	<5.0	9	16	488	1,620	17	12
08-13-96	1255	4.1	616	266	0	15	17	321	394	44	41
08-23-96[1]	1530	--	--	245	--	56	53	2,800	5,360	67	66
09-17-96	1240	5.6	571	254	<1.0	11	10	266	333	37	36
10-16-96	1605	4.8	587	244	<5.0	11	12	451	712	38	37
03-26-97	1415	5.5	223	83.6	<5.0	7	13	365	4,400	11	22
04-24-97	1715	5.6	140	53.7	--	<4	12	118	5,110	10	14
05-14-97	1715	7.1	91	33.2	6.6	5	27	190	18,900	<5	32
05-28-97	1630	6.6	74	29.8	10.4	2	4	152	649	3	<3
06-05-97	1600	7.4	58	24.3	13.2	4	7	96	818	<4	<4
06-17-97	1600	6.1	88	35.5	12.4	4	3	201	443	<3	<3
07-15-97	1555	5.8	157	63.3	<5.0	1	2	27	316	<3	4
07-21-97[1]	1900	--	--	83.7	--	<4	7	94	1,440	7	8
08-13-97	1655	7.0	204	84.5	5.0	<3	9	53	1,840	5	12
09-10-97	1635	6.1	309	131	<5.0	<3	5	19	917	9	12
10-22-97	1635	6.3	282	125	6.1	<4	13	710	1,510	13	17
Burnt Creek (BC0.0)											
04-27-95	1410	3.2	529	--	--	--	27	--	11,300	--	95
04-27-95	1830	--	--	--	--	--	46	--	23,800	--	103
05-25-95	1335	4.9	250	96.2	2.8	--	11	199	1,190	31	35
06-15-95	1010	5.4	204	78.6	--	5	12	378	5,330	32	42
06-30-95	1800	4.8	434	--	--	--	19	--	3,400	--	75
08-24-95[1]	1735	--	--	185	--	11	1,300	<40	890,000	47	1,700
04-25-96	1320	4.7	615	298	0	12	16	33	2,540	86	87
05-18-96	1225	4.5	580	271	--	16	14	260	338	96	91
08-23-96[1]	1555	--	--	424	--	17	19	26	1,240	115	121
08-23-96[1]	1840	--	--	363	--	20	3,020	7	2,137,000	96	4,430
03-26-97	1450	4.6	575	247	<5.0	17	39	55	19,500	73	113
04-24-97	1740	4.9	470	204	--	14	21	71	770	73	67
05-14-97	1810	5.3	274	105	<5.0	10	476	<60	290,000	35	648

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific conductance (µS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dissolved	Total recoverable	Dissolved	Total recoverable	Dissolved	Total recoverable
Burnt Creek (BC0.0)—Continued											
05-28-97	1700	5.1	284	118	<5.0	8	9	624	1,580	36	33
06-05-97	1645	5.4	285	118	<5.0	6	12	353	2,090	36	37
06-17-97	1630	4.5	476	203	<5.0	19	20	248	1,940	67	60
07-21-97[1]	1850	--	--	371	--	96	127	349	26,900	157	192
Spring Creek (SC0.0)											
04-27-95	1425	--	--	--	--	--	5	--	1,570	--	7
05-25-95	1240	7.5	64	est 28.6	--	--	<4	--	1,420	--	6
06-15-95	1645	--	--	--	--	--	<5	--	780	--	7
08-23-95	1700	8.3	150	est 60.8	45.0	--	--	--	96	--	4
09-27-95	1015	8.6	138	est 56.3	48.0	--	--	--	<90	--	<10
04-25-96	1400	7.6	64	est 28.6	--	--	<4	--	729	--	<4
05-13-97	1000	6.8	87	est 37.0	31.0	--	3	--	939	--	<20
05-27-97	1705	7.7	79	est 34.2	29.2	--	2	--	504	--	<3
06-05-97	1356	7.8	78	est 33.8	31.9	--	<4	--	528	--	<4
06-17-97	1440	7.3	90	est 38.3	36.7	--	<1	--	245	--	<3
07-14-97	1555	7.6	129	est 52.9	47.3	--	<1	--	72	--	<3
08-12-97	1325	8.0	122	est 50.3	--	--	<3	--	236	--	<4
Fern Creek (FC0.0)											
04-27-95	1435	--	--	est 42.1	--	--	<4	--	1,260	--	5
05-25-95	1330	--	--	est 32.7	--	--	<4	--	1,690	--	4
07-26-95	1511	6.8	139	est 56.6	--	--	<5	--	60	--	<4
08-23-95	1615	8.2	155	est 62.6	29.0	--	--	--	330	--	4
09-27-95	1110	7.9	191	est 76.1	26.0	--	--	--	94	--	<10
04-25-96	1410	6.5	106	est 44.3	17.0	--	<4	--	973	--	<4
05-16-96	1605	7.0	124	est 51.0	22.0	--	<3	--	156	--	<3
05-13-97	0930	6.6	92	est 39.1	30.0	--	3	--	1,540	--	<20
05-27-97	1815	7.2	71	est 31.2	14.0	--	2	--	596	--	<3
06-05-97	1330	7.8	75	est 32.7	24.0	--	<4	--	740	--	<4
06-17-97	1515	8.0	84	est 36.2	25.5	--	1	--	476	--	<3
07-14-97	1635	7.8	130	est 53.3	25.8	--	<1	--	237	--	<3
08-12-97	1245	7.8	133	est 54.4	--	--	<3	--	260	--	<4

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific conductance (µS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dissolved	Total recoverable	Dissolved	Total recoverable	Dissolved	Total recoverable
Castleman Gulch (CG0.0)											
06-29-95	1118	7.6	48	est 22.6	21.0	--	<1	--	120	--	<5
07-26-95	1430	6.8	66	est 29.3	--	--	<5	--	141	--	<4
08-23-95	1530	7.8	82	est 35.3	36.0	--	--	--	100	--	6
09-27-95	1155	7.7	85	est 36.4	36.0	--	--	--	98	--	<10
04-25-96	1440	6.6	98	est 41.3	42.0	--	<4	--	204	--	<4
05-16-96	1525	7.3	64	est 28.6	27.0	--	<3	--	101	--	<3
06-11-96	1045	7.1	66	est 29.3	38.0	--	<3	--	72	--	<3
07-16-96	1020	6.9	77	est 33.5	42.0	--	<4	--	116	--	<4
08-13-96	1330	6.6	87	est 37.2	48.0	--	6	--	141	--	5
09-16-96	1545	7.4	93	est 39.4	39.0	--	<3	--	75	--	<3
05-13-97	0835	7.0	71	est 31.3	33.0	--	<3	--	242	--	<20
05-27-97	1845	7.0	57	est 26.0	23.7	--	<1	--	167	--	<3
06-05-97	1255	7.8	63	est 28.2	26.6	--	<4	--	211	--	<4
06-16-97	1700	6.6	61	est 27.4	23.7	--	1	--	146	--	<3
07-14-97	1700	7.5	71	est 31.2	30.1	--	<1	--	354	--	<3
08-12-97	1200	7.3	75	est 32.7	--	--	<3	--	132	--	<4
Silver Creek (SI0.0)											
06-29-95	1030	8.3	80	est 34.6	34.0	--	<1	--	160	--	<5
09-27-95	1245	8.1	136	est 55.5	54.0	--	--	--	140	--	<10
04-25-96	1430	7.6	85	est 36.4	37.0	--	<4	--	227	--	<4
05-16-96	1750	7.1	113	est 46.9	38.0	--	<3	--	70	--	<3
06-11-96	1125	7.4	122	est 50.3	49.0	--	<3	--	25	--	<3
07-16-96	1200	6.3	122	est 50.3	52.0	--	<4	--	113	--	<4
09-17-96	1455	8.0	134	est 54.8	57.0	--	<3	--	374	--	<3
05-13-97	1255	7.0	79	est 34.4	30.0	--	<3	--	437	--	<20
05-28-97	1345	7.3	71	est 31.2	28.2	--	<1	--	243	--	<3
06-05-97	1225	7.8	69	est 30.5	27.6	--	<4	--	482	--	<4
06-16-97	1610	8.4	88	est 37.7	35.9	--	2	--	428	--	<3
07-14-97	1815	7.8	117	est 48.4	46.7	--	<1	--	725	--	<3
08-12-97	1105	7.9	104	est 43.6	--	--	<3	--	116	--	<4

Table 9. Instantaneous pH, specific conductance, and selected chemical data for selected tributary sites to the Alamosa River, 1995–97—Continued

[s.u., standard units; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; est, estimated]

Sample collection		pH (s.u.)	Specific con- duct- ance (µS/cm)	Hard- ness (mg/L as $CaCO_3$)	Alka- linity (mg/L)	Copper (µg/L)		Iron (µg/L)		Zinc (µg/L)	
Date	Time					Dis- solved	Total recover- able	Dis- solved	Total recover- able	Dis- solved	Total recover- able
					Lieutenant Creek (LC0.0)						
06-29-95	0915	8.4	100	est 42.1	--	--	<1	--	170	--	<5
07-26-95	1250	6.8	116	est 48.0	--	--	<5	--	138	--	<4
08-23-95	1440	8.2	116	est 48.0	54.0	--	--	--	220	--	5
09-27-95	0910	7.8	121	est 49.9	53.0	--	--	--	130	--	<10
04-25-96	1445	8.1	120	est 49.5	59.0	--	<4	--	398	--	<4
05-16-96	1445	7.8	130	est 53.3	64.0	--	<3	--	801	--	4
06-11-96	1155	8.5	114	est 47.3	54.0	--	<3	--	429	--	<3
07-16-96	1100	7.8	117	est 48.4	51.0	--	<4	--	518	--	<4
08-13-96	1405	7.4	114	est 47.3	59.0	--	<3	--	221	--	<3
09-17-96	1430	8.1	123	est 50.7	56.0	--	<3	--	289	--	<3
05-13-97	1340	7.8	96	est 40.5	45.0	--	<3	--	608	--	<20
05-28-97	1735	7.9	94	est 39.8	35.2	--	<1	--	577	--	<3
06-05-97	1145	7.6	102	est 42.8	47.8	--	4	--	421	--	<4
06-16-97	1540	7.2	103	est 43.2	48.0	--	1	--	530	--	4
07-14-97	1850	7.9	117	est 48.4	41.4	--	<1	--	194	--	<3
08-12-97	1015	8.0	110	est 45.8	--	--	<3	--	223	--	<4
					Ranger Creek (RC0.0)						
06-29-95	0825	7.6	75	est 32.7	31.0	--	<1	--	120	--	<5
08-23-95	1350	8.1	86	est 36.8	44.0	--	--	--	61	--	10
09-27-95	1320	8.1	89	est 38.0	41.0	--	--	--	<90	--	<10
04-25-96	1505	7.5	72	est 31.6	36.0	--	<4	--	468	--	<4
05-16-96	1350	7.7	91	est 38.7	37.0	--	<3	--	101	--	<3
06-11-96	1220	7.8	80	est 34.6	41.0	--	<3	--	113	--	<3
07-16-96	1125	6.9	85	est 36.4	44.0	--	<4	--	211	--	<4
08-13-96	1435	7.3	87	est 37.2	42.0	--	<3	--	117	--	4
09-17-96	1510	8.0	87	est 37.2	42.0	--	<3	--	199	--	<3
05-13-97	1415	7.7	63	est 28.3	28.0	--	<3	--	975	--	<20
05-28-97	1800	7.8	69	est 30.5	16.2	--	<1	--	561	--	<3
06-05-97	1115	7.5	67	est 29.7	32.6	--	<4	--	543	--	<4
06-16-97	1505	7.3	69	est 30.6	32.1	--	1	--	342	--	3
07-14-97	1935	7.8	86	est 36.8	27.8	--	<1	--	116	--	<3
08-12-97	0910	7.8	81	est 35.0	--	--	<3	--	174	--	<4

1 Storm sample collected on this date.