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Characterization of Seepage in the Exploratory Studies Facility, Yucca Mountain, Nevada

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Abstract – Following a 5-month period of above-average precipitation during the winter of 2004-2005, water was observed seeping into the South Ramp section of the Exploratory Studies Facility of the proposed repository for high-level radioactive waste at Yucca Mountain, Nevada. Samples of the seepage were collected and analyzed for major ions, trace metals, and delta deuterium and delta oxygen-18 values in an effort to characterize the water and assess the interaction of seepage with anthropogenic materials used in the construction of the proposed repository. As demonstrated by the changes in the chemistry of water dripping from a rock bolt, interaction of seepage with construction materials can alter solution chemistry and oxidation state.

I. INTRODUCTION

On February 28, 2005, water was first observed seeping into the South Ramp section of the Exploratory Studies Facility (ESF) at Yucca Mountain, Nevada, site of the proposed repository for high-level radioactive waste (Fig. 1). The water seeped from the Tiva Canyon welded (TCw) tuff hydrogeologic unit,¹ which overlies the Paintbrush tuff nonwelded hydrogeologic unit, both of Miocene age. Following a 5-month period of above-average precipitation from October 2004 through February 2005, several seeps occurred between ESF Centerline Station (CS) 75+62 and CS 77+52 (ESF locations are defined by stations at 100-meter (m) intervals, beginning near the north portal; for example, CS 75+62 is 7,562 m from the reference point near the north portal of the ESF). About 32.4 centimeters (cm) of precipitation was measured during these 5 months at meteorological monitoring station Site 1, located about 1.9 km north of the South Ramp (Fig. 1), substantially greater than the station's 1995 to 2004 average of 9.25 cm for the same 5-month period from October to February.¹ The U.S. Geological Survey (USGS) collected samples of seepage to characterize the seepage and assess its interaction with anthropogenic materials used in the construction of the ESF.

II. SAMPLE COLLECTION AND ANALYSIS METHODS

Samples were collected from seepage dripping from the overhead ventilation tube, seepage dripping directly from

fractures in the rock walls, seepage dripping from a steel rock bolt, and a pool of seepage on the concrete invert. The samples were collected either by placing sample containers below drips or by using funnels to direct the flow into the sample containers. From March 2, 2005, to April 28, 2005, thirty-five samples were collected into

Fig. 1. Shaded relief map of Yucca Mountain, Nevada, showing the location of seeps in the Exploratory Studies Facility, meteorological monitoring station Site 1, and borehole UE-29 a#2.

plastic bottles and 15 samples were collected into glass vacutainers™. Unfiltered aliquots of the 35 samples were transferred to 2-milliliter (mL) sample vials for pH and specific conductance measurements, and additional 3.5-mL aliquots from the 35 samples were filtered through a 0.1-micrometer (μm) filter and split for major ion, alkalinity, and trace metal analyses. The trace metal samples then were preserved with ultra-pure nitric acid. The delta deuterium ($\delta^2\text{H}$) and delta oxygen-18 ($\delta^{18}\text{O}$) values of water were determined for the 15 samples collected directly into glass vacutainers™ and an additional 15 samples that were split from the samples collected into plastic bottles. Due to the possibility of air-water interaction prior to collection, the pH measurements may not reflect the original seepage pH values.

Specific conductance and pH were measured using miniature Cardy® meters. Alkalinity was measured using a low-volume colorimetric titration. Major cations and anions were analyzed by ion chromatography, trace metals were analyzed by inductively coupled-plasma mass spectrometry, and $\delta^2\text{H}$ and $\delta^{18}\text{O}$ values were determined by thermal ionization mass spectrometry and reported relative to Vienna Standard Mean Ocean Water (VSMOW).²

III. RESULTS

Stable isotope data for $\delta^2\text{H}$ and $\delta^{18}\text{O}$ are reported in Table I. Major ion and trace metal data for each of the seeps are reported in Table II.

Table I: Composition of delta deuterium ($\delta^2\text{H}$) and delta oxygen-18 ($\delta^{18}\text{O}$) in seepage samples collected from the South Ramp of the Exploratory Studies Facility, Yucca Mountain, Nevada.

[Sample names with an *overnight* indicate that the samples were collected over one or more days. Permil values of deuterium and oxygen-18 are reported relative to VSMOW. Abbreviation : **, field replicates]

Sample Name	Date of Collection	$\delta^{18}\text{O}$ permil	$\delta^2\text{H}$ permil	Sample Name	Date of Collection	$\delta^{18}\text{O}$ permil	$\delta^2\text{H}$ permil
CS 75+73 Fracture	03/02/05	-7.1	-68.5	CS 75+95 Vent	04/14/05	-5.8	-67.8
CS 75+73 Fracture	03/08/05	-0.8	-45.1	CS 75+95 Vent (overnight)	04/18/05	-4.4	-60.4
CS 75+76 Fracture	03/08/05	-8.1	-74.1	CS 75+99 Vent	03/02/05	-10.8	-86.4
CS 75+94 Fracture	03/08/05	-10.2	-82.6	CS 75+99 Fracture (overnight) **	03/29/05	-9.8	-83.1
CS 75+94 Fracture	03/15/05	-9.8	-80.7	CS 75+99 Fracture (overnight) **	03/29/05	-9.9	-83.5
CS 75+94 Fracture (overnight)	03/15/05	-10.6	-82.8	CS 75+99 Fracture	04/05/05	-7.9	-72.3
CS 75+94 Fracture	03/29/05	-10.9	-85.2	CS 76+00 Fracture	03/29/05	-9.9	-81.2
CS 75+94 Fracture	04/05/05	-10.6	-85.0	CS 76+00 Fracture	03/08/05	-7.9	-72.6
CS 75+94 Fracture	04/14/05	-10.3	-83.5	CS 76+00 Pool on Concrete Invert	03/02/05	-5.8	-62.8
CS 75+94 Fracture (overnight)	04/18/05	-10.0	-82.1	CS 76+00.5 Rock Bolt	03/02/05	-11.2	-87.2
CS 75+94 Fracture	04/28/05	-10.4	-82.2	CS 76+00.5 Rock Bolt	03/08/05	-10.8	-84.3
CS 75+95 Vent	03/15/05	-8.3	-74.6	CS 76+00.5 Rock Bolt	03/15/05	-8.2	-74.0
CS 75+95 Vent	03/29/05	-9.8	-81.8	CS 76+00.5 Rock Bolt (overnight)	03/15/05	-11.2	-82.6
CS 75+95 Vent (overnight)	03/29/05	-9.8	-83.2	CS 76+00.5 Rock Bolt	03/29/05	-7.4	-70.4
CS 75+95 Vent	04/05/05	-8.5	-77.8	CS 77+52 Fracture	03/08/05	-6.4	-67.0

The graph of $\delta^2\text{H}$ plotted against $\delta^{18}\text{O}$ shows that the seepage samples define a line with a slope of 3.99 and a correlation coefficient (r^2) of 0.976 (Fig. 2), consistent with heavy isotope enrichment by evaporation.³ This seepage line intercepts the Yucca Mountain precipitation line⁴ at values of about -12.7 ± 0.3 permil (‰) for $\delta^{18}\text{O}$ and -92.6 ± 2.1 ‰ for $\delta^2\text{H}$ (2-sigma), in agreement with values for samples of young shallow ground water in borehole UE-29 a#2, located 14 km northeast of the South Ramp.⁴

Fig. 2. Delta deuterium ($\delta^2\text{H}$) plotted against delta oxygen-18 ($\delta^{18}\text{O}$) for samples of seepage from the South Ramp of the Exploratory Studies Facility (ESF), Yucca Mountain, Nevada. Yucca Mountain precipitation line from Benson and Klieforth (1989).⁴

Fig. 3. Spatial variability of the major ion compositions in the seepage samples from the South Ramp of the Exploratory Studies Facility, Yucca Mountain, Nevada.

Spatial variability in the chemistry of the seepage samples is shown in Figure 3. Overall, the seepage is a calcium-sulfate-chloride type water. With the exception of a higher bicarbonate concentration in the seepage water, the seepage water has a composition similar to pore water from the overlying TCw units [USGS unpub. data]. Mineral saturation indices and equilibrium gas pressures were calculated for seepage samples using PHREEQC (WATEQ4F database).³ All of the seepage samples are undersaturated with respect to anhydrite, gypsum, and amorphous silica and oversaturated with respect to quartz and chalcedony. Most of the samples are saturated with respect to calcite and near or at saturation with respect to silica gel and fluorite. The log of the equilibrium gas pressures for carbon dioxide ($p\text{CO}_2$) ranged from 2.7 to 3.2, which is greater than the log of the atmospheric $p\text{CO}_2$ value of 3.6 for Yucca Mountain, Nevada.⁶ The greater $p\text{CO}_2$ in the seepage samples could be due to the samples

having equilibrated with rock gas that contains more CO_2 than the atmosphere or due to dissolution of calcite from the overlying tuff units.

IV. DISCUSSION AND CONCLUSIONS

Despite the numerous precipitation events that occurred from October 2004 through February 2005 at Yucca Mountain, Nevada, the co-variation of the $\delta^2\text{H}$ and $\delta^{18}\text{O}$ values in the seepage (Fig. 2) indicates that the precipitation events either had unexpectedly constant isotopic compositions over time, or that the precipitation inputs were mixed during infiltration or as they percolated through the welded tuffs overlying the seepage sites. This cannot be determined without data from the individual precipitation events, which are unavailable. Mixing, however, is a more likely explanation for the apparent constancy of the initial $\delta^2\text{H}$ and $\delta^{18}\text{O}$ values of the

seepage. The linear distribution of these isotopic compositions below the Yucca Mountain precipitation line⁴ (Fig. 2) is consistent with evaporation of the seepage. Whether this evaporation occurred during infiltration and percolation or after the water entered the tunnel is not known.

At each seep location, the differences in the major ion chemistry of the seepage over time are mostly due to evaporation. However, among the seeps, the major ion chemistry of the seepage shows a general decrease in calcium, chloride, and sulfate relative to the other major ions progressing from CS 75+73 to CS 77+52 (Fig. 3). This spatial variability most likely is due to a change in lithology and a decrease in the thickness of the overlying tuff units progressing toward the south portal of the ESF. One exception to the fairly homogeneous composition of the individual seeps is the high variability of the chemistry from the seepage dripping from the rock bolt at CS 76+00.5.

With the exception of manganese, the first sample collected from the rock bolt is chemically similar to the chemistry of water dripping directly from fractures. Over time, the concentrations of most of the major ions in the seepage dripping from the rock bolt increased (Fig. 4). This increase is consistent with changes from evaporation; however, several ions including calcium, bicarbonate, silicon dioxide, arsenic, molybdenum, and uranium, decreased over time. One possible explanation is microbial-induced calcite and silica deposition on the rock bolt surface coupled with localized reduction of uranium, molybdenum, and arsenic in the seepage and oxidation of the manganese in the rock bolt. An increase in the nitrite and ammonium concentrations over time supports localized reduction.

Fig. 4. Spider diagram showing the relative changes in chemistry over time for samples of seepage dripping from the rock bolt at CS 76+00.5 in the South Ramp of the Exploratory Studies Facility, Yucca Mountain, Nevada. The data are normalized to the water chemistry of the March 2, 2005, sample.

Changes over time in the chemistry of water dripping from the rock bolt indicate that interaction of seepage with anthropogenic materials used in the construction of the ESF can alter solution chemistry and oxidation state.

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Table II: Chemical composition of water samples collected from the South Ramp of the Exploratory Studies Facility, Yucca Mountain, Nevada.

[Sample names with an *overnight* indicate that the samples were collected over one or more days. Abbreviations: $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25° Celsius;

mg/L , milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; —, no data; **, field replicate]

Sample Name	Date of Collection	pH	Specific Conductance ($\mu\text{S}/\text{cm}$)	Sodium (mg/L)	Potassium (mg/L)	Magnesium (mg/L)	Calcium (mg/L)	Ammonium as NH_4 (mg/L)	Fluoride (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Bicarbonate (mg/L)	Nitrite as NO_2 (mg/L)	Nitrate as NO_3 (mg/L)
Minimum Reporting Limit				0.002	0.005	0.045	0.039	0.002	0.005	0.012	0.008	1.18	0.009	0.018
CS 75+73 Fracture	03/02/05	7.8	1620	62.0	9.65	32.0	234	0.723	3.52	236	379	129	0.192	78.6
CS 75+76 Fracture	03/08/05	8.2	1240	42.2	7.67	22.8	171	<.008	3.44	149	258	146	.099	49.3
CS 75+77 Vent	03/08/05	8.0	1360	51.9	8.76	22.5	192	<.008	3.81	165	314	139	.178	59.2
CS 75+77 Vent	03/15/05	8.2	1570	65.8	11.0	28.0	226	<.009	4.45	209	358	128	.870	72.8
CS 75+94 Fracture	03/08/05	8.0	820	28.5	6.82	15.2	102	2.17	3.22	75.2	154	115	.193	37.5
CS 75+94 Fracture	03/15/05	8.1	850	26.8	4.42	13.4	106	<.006	2.91	72.1	157	106	<.026	35.6
CS 75+94 Fracture (overnight)**	03/15/05	8.1	800	26.0	4.25	13.0	95.9	<.004	2.73	69.4	139	101	<.019	34.4
CS 75+94 Fracture (overnight)**	03/15/05	8.1	800	26.0	4.25	13.0	95.5	<.004	2.75	69.5	139	109	<.019	34.6
CS 75+94 Fracture (overnight)**	03/15/05	8.1	800	26.0	4.25	13.0	95.7	<.004	2.75	69.7	139	111	<.019	34.8
CS 75+94 Fracture (overnight)	03/29/05	7.9	770	22.9	3.54	11.7	84.8	<.004	2.58	62.7	123	98.4	.022	30.8
CS 75+94 Fracture (overnight)	04/05/05	7.8	790	27.1	4.22	13.9	94.2	<.005	2.74	72.0	139	98.5	.057	35.0
CS 75+94 Fracture (overnight)	04/18/05	8.1	840	28.9	4.63	14.3	100	<.005	2.92	76.8	147	107	<.024	37.7
CS 75+94 Fracture (overnight)	04/28/05	7.9	780	27.4	4.22	12.8	93.4	<.006	2.78	70.4	141	95.2	.031	35.6
CS 75+95 Vent	03/08/05	7.9	710	30.0	4.81	12.2	78.9	.194	3.11	54.2	115	131	.058	36.3
CS 75+95 Vent	03/15/05	8.0	760	30.7	5.14	12.7	82.0	.132	3.04	54.6	118	126	.037	36.1
CS 75+95 Vent	03/29/05	8.2	700	28.0	4.45	12.1	77.7	.169	2.85	51.3	111	130	<.019	33.6
CS 75+95 Vent (overnight)	03/29/05	8.1	690	27.8	4.41	12.0	77.1	.147	2.83	51.6	111	119	<.018	33.9
CS 75+95 Vent (overnight)	04/05/05	8.0	670	26.8	4.26	11.5	74.1	.181	2.73	49.3	106	99.5	.021	31.7
CS 75+95 Vent (overnight)	04/05/05	8.1	770	32.0	5.08	13.6	84.3	.178	3.10	58.7	123	122	.038	38.0
CS 75+95 Vent (overnight)	04/14/05	8.2	790	33.2	9.56	14.2	87.3	.188	3.29	64.2	131	122	.086	38.7
CS 75+95 Vent (overnight)	04/18/05	8.1	870	39.3	6.57	16.4	96.4	.208	3.71	71.9	147	140	.122	45.7
CS 75+99 Fracture (overnight)**	03/29/05	8.2	740	31.7	4.77	13.8	82.3	.104	3.13	60.9	123	113	.050	40.8
CS 75+99 Fracture (overnight)**	03/29/05	8.2	750	32.0	4.81	13.9	82.4	.105	3.14	61.4	124	114	.049	41.2
CS 75+99 Fracture (overnight)	04/05/05	8.0	800	34.1	5.27	14.7	85.9	.473	3.39	66.0	127	112	.293	42.7
CS 75+99 Vent	03/02/05	7.9	650	26.6	4.44	11.3	68.4	.087	2.80	44.0	98.4	126	.048	31.6
CS 76+00 Fracture	03/08/05	8.2	770	33.3	5.03	14.7	88.9	<.006	3.60	55.7	132	144	.107	40.1
CS 76+00 Pool on Concrete Invert	03/02/05	7.9	950	46.8	27.3	15.3	86.5	.420	4.01	71.3	157	167	2.33	48.4
CS 76+00 Vent	03/08/05	8.2	960	46.2	6.80	19.1	115	.173	4.54	77.9	173	182	.313	55.2
CS 76+00.5 Rock Bolt	03/02/05	7.9	640	23.6	4.49	12.6	67.1	.098	2.79	48.0	102	124	.026	30.9
CS 76+00.5 Rock Bolt	03/08/05	8.0	660	25.1	4.50	13.4	67.8	.220	2.93	51.9	111	96.3	.071	32.5
CS 76+00.5 Rock Bolt	03/15/05	8.1	680	28.5	5.29	14.3	63.4	.591	3.16	52.1	113	86.2	.130	32.3
CS 76+00.5 Rock Bolt (overnight)	03/15/05	7.7	640	26.3	4.79	13.0	57.9	.555	2.91	49.2	107	70.0	.059	30.5
CS 76+00.5 Rock Bolt (overnight)	03/29/05	7.8	680	30.8	5.23	15.2	58.0	.967	3.22	64.5	120	59.2	.159	34.1
CS 77+52 Fracture	03/08/05	8.3	800	55.9	12.2	14.0	72.9	.182	5.92	46.2	110	189	.215	57.0
CS 77+52 Fracture	03/15/05	8.4	800	49.3	11.0	15.2	73.2	<.005	5.33	41.6	88.1	213	.232	52.5

Table II: Chemical composition of water samples collected from the South Ramp of the Exploratory Studies Facility, Yucca Mountain, Nevada-- Continued.

[Sample names with an *overnight* indicate that the samples were collected over one or more days. Abbreviations: µg/cm, microsiemens per centimeter at 25° Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; **, field replicates]

Sample Name	Date of Collection	Phosphate as PO4 (mg/L)	Lithium (µg/L)	Beryllium (µg/L)	Boron (µg/L)	Aluminum (µg/L)	Vanadium (µg/L)	Chromium (µg/L)	Manganese (µg/L)	Iron (µg/L)	Cobalt (µg/L)	Nickel (µg/L)	Copper (µg/L)
Minimum Reporting Limit		0.015	0.10	0.50	10	5	0.20	0.90	0.15	10	0.25	1.0	0.50
CS 75+73 Fracture	03/02/05	<0.059	70	52	2,510	<26	10	<4.6	5.7	<41	<1.3	<5.2	4.0
CS 75+76 Fracture	03/08/05	<0.059	72	41	1,910	<26	12	<4.8	2.1	<65	<1.3	<5.3	<2.6
CS 75+77 Vent	03/08/05	<0.059	72	51	2,480	<26	11	<4.7	2.4	<59	<1.3	<5.2	<2.6
CS 75+77 Vent	03/15/05	1.09	74	89	2,880	<26	12	<4.7	2.6	<54	<1.3	<5.2	4.0
CS 75+94 Fracture	03/08/05	.681	58	30	1,680	<26	12	<4.7	.90	<49	<1.3	<5.3	21
CS 75+94 Fracture	03/15/05	<0.044	55	32	1,650	<26	9.6	<4.7	<.79	<61	<1.3	<5.3	<2.6
CS 75+94 Fracture (overnight)**	03/15/05	<0.032	52	29	1,540	<26	9.3	<4.7	2.0	<57	<1.3	<5.2	<2.6
CS 75+94 Fracture (overnight)**	03/15/05	<0.032	52	27	1,510	<26	9.3	<4.7	2.1	<58	<1.3	<5.2	<2.6
CS 75+94 Fracture (overnight)**	03/15/05	<0.032	53	30	1,590	<26	9.4	<4.7	2.1	<41	<1.3	<5.2	<2.6
CS 75+94 Fracture (overnight)	03/29/05	.305	46	28	1,500	<25	9.8	<4.4	<.74	<42	<1.2	<4.9	<2.5
CS 75+94 Fracture (overnight)	04/05/05	<0.036	47	30	1,510	<25	10	<4.5	1.4	<42	<1.2	<5.0	<2.5
CS 75+94 Fracture (overnight)	04/18/05	<0.040	49	32	1,630	<25	11	<4.5	.86	<46	<1.3	<5.0	<2.5
CS 75+94 Fracture (overnight)	04/28/05	<0.045	50	24	1,230	<25	8.6	<4.5	<.75	--	<1.3	<5.0	<2.5
CS 75+95 Vent	03/08/05	.361	59	33	1,780	<26	7.1	<4.7	57	<42	<1.3	<5.2	<2.6
CS 75+95 Vent	03/15/05	<0.031	54	35	1,750	<26	6.5	<4.7	79	<57	<1.3	<5.2	7.6
CS 75+95 Vent	03/29/05	<0.031	45	31	1,520	<25	6.5	<4.4	47	<42	<1.2	<4.9	<2.5
CS 75+95 Vent (overnight)	03/29/05	<0.029	45	32	1,540	<25	6.6	<4.6	47	<42	<1.3	<5.1	<2.5
CS 75+95 Vent (overnight)	04/05/05	<0.030	43	30	1,490	<25	5.9	<4.5	54	<42	<1.3	<5.0	<2.5
CS 75+95 Vent (overnight)	04/05/05	<0.036	48	36	1,690	<25	7.1	<4.5	59	<42	<1.3	<5.0	<2.5
CS 75+95 Vent (overnight)	04/14/05	<0.036	47	37	1,770	<25	6.5	<4.4	61	<42	<1.2	45	<2.5
CS 75+95 Vent (overnight)	04/18/05	<0.040	53	46	2,110	<25	7.5	<4.5	69	<41	<1.2	<5.0	<2.5
CS 75+99 Fracture (overnight)**	03/29/05	<0.031	49	31	1,610	<24	13	<4.4	<.73	<42	<1.2	<4.9	<2.4
CS 75+99 Fracture (overnight)**	03/29/05	<0.031	47	31	1,600	<25	13	<4.5	<.74	<41	<1.2	<5.0	<2.5
CS 75+99 Fracture (overnight)	04/05/05	<0.036	50	33	1,650	<25	14	<4.5	<.75	<42	<1.2	<5.0	<2.5
CS 75+99 Vent	03/02/05	<0.030	55	26	1,480	<26	8.7	<4.7	17	<41	<1.3	<5.2	<2.6
CS 76+00 Fracture	03/08/05	<0.048	68	34	1,850	<26	13	<4.7	2.9	<48	<1.3	<5.3	<2.6
CS 76+00 Pool on Concrete Invert	03/02/05	.505	64	96	2,160	<26	7.4	<4.7	154	<41	<1.3	7.3	<2.6
CS 76+00 Vent	03/08/05	<0.049	80	45	2,470	<26	16	<4.7	1.2	<40	<1.3	<5.2	<2.6
CS 76+00.5 Rock Bolt	03/02/05	<0.030	46	33	1,400	<26	4.2	<4.7	94	<42	<1.3	<5.2	<2.6
CS 76+00.5 Rock Bolt	03/08/05	<0.030	46	35	1,520	<26	2.1	<4.7	172	<41	1.8	<5.3	<2.6
CS 76+00.5 Rock Bolt	03/15/05	<0.030	33	42	1,440	<26	<1.0	<4.7	275	<69	2.7	9.5	<2.6
CS 76+00.5 Rock Bolt (overnight)	03/15/05	.344	31	39	1,440	<26	<1.1	<4.8	251	<60	2.4	8.9	<2.6
CS 76+00.5 Rock Bolt (overnight)	03/29/05	<0.031	19	43	1,490	<25	<1.0	<4.4	174	<41	2.0	9.0	<2.5
CS 77+52 Fracture	03/08/05	<0.048	79	68	1,090	<26	27	<4.7	1.1	<45	<1.3	<5.3	<2.6
CS 77+52 Fracture	03/15/05	<0.031	74	59	1,060	<26	25	<4.7	3.5	<58	<1.3	<5.2	<2.6

Table II: Chemical composition of water samples collected from the South Ramp of the Exploratory Studies Facility, Yucca Mountain, Nevada-- Continued.

[Sample names with an *overnight* indicate that the samples were collected over one or more days. Abbreviations: $\mu\text{S/cm}$, microsiemens per centimeter at 25° Celsius; mg/L , milligrams per liter; $\mu\text{g/L}$, micrograms per liter; --, no data; **, field replicates]

Sample Name	Date of Collection	Zinc ($\mu\text{g/L}$)	Arsenic ($\mu\text{g/L}$)	Selenium ($\mu\text{g/L}$)	Strontium ($\mu\text{g/L}$)	Rubidium ($\mu\text{g/L}$)	Molybdenum ($\mu\text{g/L}$)	Silver (mg/L)	Cadmium ($\mu\text{g/L}$)	Antimony ($\mu\text{g/L}$)	Barium ($\mu\text{g/L}$)	Lead ($\mu\text{g/L}$)	Thorium ($\mu\text{g/L}$)	Uranium ($\mu\text{g/L}$)
Minimum Reporting Limit		3.0	0.60	1.0	1.0	0.10	0.10	0.70	0.20	0.20	3.0	0.18	0.03	0.03
CS 75+73 Fracture	03/02/05	<15	10	15	1,670	9.4	6.1	<3.6	1.7	<1.0	<15	<0.93	<0.15	1.04
CS 75+76 Fracture	03/08/05	<16	11	9.5	1,140	6.2	4.3	<3.7	<1.1	<1.1	<16	<.95	<.16	.96
CS 75+77 Vent	03/08/05	708	8.1	11	1,280	6.8	4.9	<3.7	<1.0	<1.0	<16	<.94	<.16	1.00
CS 75+77 Vent	03/15/05	534	7.2	12	1,580	8.0	5.6	<3.6	<1.0	<1.0	<16	<.94	<.16	1.10
CS 75+94 Fracture	03/08/05	<16	13	5.4	738	4.0	5.2	<3.7	<1.1	<1.1	<16	<.95	<.16	1.02
CS 75+94 Fracture	03/15/05	<16	11	<5.3	736	3.2	4.9	<3.7	<1.1	<1.1	<16	<.95	<.16	1.00
CS 75+94 Fracture (overnight)**	03/15/05	73	10	<5.2	688	3.2	4.7	<3.7	<1.0	<1.0	<16	<.94	<.16	.95
CS 75+94 Fracture (overnight)**	03/15/05	71	10	<5.2	679	3.1	4.6	<3.6	<1.0	<1.0	<16	<.94	<.16	.96
CS 75+94 Fracture (overnight)**	03/15/05	78	11	<5.2	683	3.2	4.7	<3.7	<1.0	<1.0	<16	<.94	<.16	.97
CS 75+94 Fracture (overnight)	03/29/05	<15	10	<4.9	684	2.5	4.5	<3.4	<1.0	<1.0	<15	<.88	<.15	.97
CS 75+94 Fracture (overnight)	04/05/05	29	11	<5.0	721	3.1	4.6	<3.5	<1.0	<1.0	<15	<.90	<.15	.95
CS 75+94 Fracture (overnight)	04/18/05	30	12	<5.0	768	3.3	5.4	<3.5	<1.0	<1.0	<15	<.91	<.15	1.11
CS 75+94 Fracture (overnight)	04/28/05	20	9.6	<5.0	582	2.4	4.2	<3.5	<1.0	<1.0	<15	<.90	<.15	.83
CS 75+95 Vent	03/08/05	405	5.6	<5.2	566	3.7	4.4	<3.6	<1.0	<1.0	<16	<.94	<.16	.78
CS 75+95 Vent	03/15/05	435	4.7	<5.2	602	3.9	4.5	<3.6	4.7	<1.0	<16	<.94	<.16	.89
CS 75+95 Vent	03/29/05	407	4.8	<4.9	583	3.4	4.0	<3.4	<1.0	<1.0	<15	<.88	<.15	.80
CS 75+95 Vent (overnight)	03/29/05	458	4.9	<5.1	592	3.5	4.2	<3.6	<1.0	<1.0	<15	<.92	<.15	.82
CS 75+95 Vent (overnight)	04/05/05	470	4.2	<5.0	557	3.3	3.8	<3.5	<1.0	<1.0	<15	<.90	<.15	.75
CS 75+95 Vent (overnight)	04/05/05	434	4.9	<5.0	654	3.9	4.6	<3.5	<1.0	<1.0	<15	<.91	<.15	.89
CS 75+95 Vent (overnight)	04/14/05	432	4.1	<4.9	649	3.9	4.6	<3.5	<1.0	<1.0	<15	<.89	<.15	.84
CS 75+95 Vent (overnight)	04/18/05	472	4.4	<5.0	761	4.9	5.2	<3.5	<1.0	<1.0	<15	<.90	<.15	.93
CS 75+99 Fracture (overnight)**	03/29/05	<15	13	<4.9	620	3.6	6.9	<3.4	<1.0	<1.0	<15	<.88	<.15	.83
CS 75+99 Fracture (overnight)**	03/29/05	<15	13	<5.0	620	3.6	6.8	<3.5	<1.0	<1.0	<15	<.89	<.15	.83
CS 75+99 Fracture (overnight)	04/05/05	<15	14	<5.0	656	3.9	7.3	<3.5	<1.0	<1.0	<15	<.89	<.15	.87
CS 75+99 Vent	03/02/05	442	7.1	<5.2	457	3.0	4.7	<3.6	<1.0	<1.0	<16	<.93	<.16	.69
CS 76+00 Fracture	03/08/05	<16	13	<5.3	622	4.0	6.5	<3.7	<1.1	<1.1	<16	<.95	<.16	.93
CS 76+00 Pool on Concrete Invert	03/02/05	21	5.2	6.6	616	51.3	12	<3.7	<1.0	1.1	<16	<.94	<.16	1.01
CS 76+00 Vent	03/08/05	261	13	6.1	805	5.1	8.0	<3.6	<1.0	<1.0	<16	<.93	<.16	1.08
CS 76+00.5 Rock Bolt	03/02/05	<16	3.6	<5.2	423	3.6	4.8	<3.7	<1.0	<1.0	<16	<.94	<.16	.55
CS 76+00.5 Rock Bolt	03/08/05	<16	<3.2	<5.3	485	3.6	4.3	<3.7	<1.1	<1.1	<16	<.95	<.16	.50
CS 76+00.5 Rock Bolt	03/15/05	<16	<3.1	<5.2	481	4.3	3.7	<3.6	<1.0	<1.0	<16	<.94	<.16	.37
CS 76+00.5 Rock Bolt (overnight)	03/15/05	<16	<3.2	<5.3	434	3.9	3.6	<3.7	<1.1	<1.1	<16	<.95	<.16	.26
CS 76+00.5 Rock Bolt (overnight)	03/29/05	<15	<2.9	<4.9	481	4.2	1.6	<3.4	<1.0	<1.0	<15	<.88	<.15	<.15
CS 77+52 Fracture	03/08/05	<16	25	<5.3	611	6.1	16	<3.7	<1.1	<1.1	<16	<.95	<.16	1.22
CS 77+52 Fracture	03/15/05	<16	26	<5.2	609	5.9	12	<3.6	<1.0	<1.0	<16	<.93	<.16	1.47