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Methods and Basic Data from Mass-Loading Studies in American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000

Prepared in cooperation with the U.S. Forest Service

Data Series 443

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph of iron bog in upper American Fork Canyon, looking northeast toward Mineral Basin. American Fork runs to the left and receives drainage from the bog. Photo by Briant Kimball taken on July 26, 2005.

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KEN SALAZAR, Secretary

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Conversion Factors, Datums, and Abbreviated Water-Quality Units

Multiply	By	To obtain
	Length	
micrometer (µm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
	Flow rate	
liter per second (L/s)	15.85	gallon per minute (gal/min)
	Mass flow	
kilogram per day (kg/d)	1,233	pound per day (lb/d)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8.$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88); horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83). Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C). Concentrations of chemical constituents in water are reported either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Methods and Basic Data from Mass-Loading Studies in American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000

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Abstract

Land-management agencies are faced with decisions about remediation in streams affected by mine drainage. In support of the U.S. Forest Service, for the Uinta National Forest, the U.S. Geological Survey conducted mass-loading studies in American Fork and Mary Ellen Gulch, Utah. Synoptic samples were collected along a 10,000-meter study reach in American Fork and 4,500-meter reach in Mary Ellen Gulch. Tracer-injection methods were combined with synoptic sampling methods to evaluate discharge and mass loading. This data series report presents the results of chemical analyses of these samples and provides the equations used to calculate discharge from tracer concentrations and loads from discharge and concentrations of the constituents. The detailed information from these studies will facilitate the preparation of interpretive reports and discussions with stakeholder groups. Data presented include detailed locations of the sampling sites, results of chemical analyses, and graphs of mass-loading profiles for major and trace elements in American Fork and Mary Ellen Gulch. Ultrafiltration was used to define filtered concentrations, and total-recoverable concentrations were measured on unfiltered samples.

Introduction

Mass-loading studies were carried out by the U.S. Geological Survey to support the U.S. Forest Service in planning remediation in American Fork, Utah. The mass-loading studies combined two well-established techniques. First, a conservative tracer was injected to estimate discharge by dilution of the tracer along a 10,000-m study reach in American Fork and a 4,500-m study reach in Mary Ellen Gulch. Second, spatially detailed data derived from synoptic samples from the streams and inflows were used to complement the discharge data and provide the information to calculate changes in loading of major and trace elements in these streams.

The purpose of this data series report is to provide detailed information from these studies to facilitate the preparation of interpretive reports and discussions with stakeholder groups. It includes detailed locations of the sampling sites, results of chemical analyses, and graphs of mass-loading profiles for selected metals.

Methods

Tracer-injection studies have been used to provide a catchment-scale context for the quantification of metal loads from abandoned and inactive mines. Together with geologic and biologic studies, tracer-injection studies provide much of the information needed to make science-based decisions for a catchment (Buxton and others, 1997). The mass-loading approach used in this report addresses the problem of solute source determination (Kimball and others, 2002). The approach is based on two well-established techniques: the tracer-dilution method (Kilpatrick and Cobb, 1985) and synoptic sampling (Bencala and McKnight, 1987). The tracer-dilution method provides estimates of stream discharge that are in turn, used to quantify the amount of tributary and groundwater inflow entering the stream in a given stream segment. Synoptic sampling provides a spatially detailed profile of water chemistry along the study reach. It also defines the range of concentrations among inflows that influence the stream profile. When used together, these techniques provide a description of a catchment that quantifies stream discharge and concentrations of constituents that may then be used to determine mass loading of chemical constituents associated with various sources of surface and ground water. Methods used to support the mass-loading approach to catchment studies are detailed in several publications. Applying tracer-dilution methods to mine drainage was developed in studies of St. Kevin Gulch, Colorado (Broshears and others, 1993; Kimball and others, 1994). The general approach is described and applied to a heavily mined and altered catchment in Cement Creek, Colorado, by Kimball and others (2002). Equations to evaluate loading were used to contrast mined and unmined areas along the Red River, New Mexico (Kimball and others, 2006a). A much smaller-scale application identified particular hydrogeologic connections through fault shear zones between a stream and mine pit lakes near Strawberry Creek, South Dakota (Kimball and others, 2006b).

This study was undertaken during low-flow conditions in October 1999 and September 2000. Applying the tracer-dilution method to low-flow conditions provides a focus on metal sources that enter the stream continuously, but does not address transient, short-term loading that can result from storm or snowmelt runoff. A critical step in this approach was to walk the entire study reach and identify visible inflows and areas of likely ground-water inflow. Stream sampling sites were located upstream and downstream of these inflows and in locations that appeared to bracket areas of potential ground-water inflow (fig. 1). These areas were identified during the stream reconnaissance by observing changes in vegetation, geomorphologic controls, and geologic structure. The intent of placing stream-sampling sites downstream from visible inflows was to capture the visible tributary inflow and any additional subsurface inflow with the tracer dilution. At this level of spatial detail in a watershed, changes in stream chemistry and discharge between stream sampling sites reflect a net metal load for specific segments, but the loads cannot always be attributed to specific sources. Effects of sources on the stream, however, may be characterized by synoptic sampling. Distance along the study reach was measured from each tracer-injection site; both injection sites were assigned a distance of 0 m in the individual streams, providing an ordinate for the study. Each stream and inflow site is referred to by the downstream distance from the injection site in either American Fork or Mary Ellen Gulch (fig. 1).

Tracer Injections and Stream Discharge

Quantifying discharge in mountain streams by the traditional velocity-area method (Rantz, 1982) can be compromised by the roughness of the streambed and the variability caused by pools and riffles (Jarrett, 1992). Furthermore, a substantial percentage of stream water may flow through porous areas of the streambed as hyporheic flow (Zellweger and others, 1989). Measuring discharge using the velocity-area method does not account for flow through the hyporheic zone, and therefore, discharge estimates based on the velocity-area method may result in an underestimate of metal loads (Zellweger and others, 1989). Another limitation of the velocity-area method for the characterization of metal loads is the time limit it may place on the number of sites that can be measured in one day. In some studies, as many as 60 in-stream samples have been collected during a single day to characterize stream and inflow chemistry. Measuring velocity-area discharge in conjunction with collecting samples at so many sites can be problematic, if not impossible. An alternative means of estimating discharge used in our study is the tracer-dilution method (Bencala and others, 1990; Kilpatrick and Cobb, 1985). The focus of the present study was on metal loading; a detailed discussion of quantifying discharge, which is an important part of the mass-loading study, can be found in one of the studies cited above.

Synoptic Sampling and Analytical Methods

Instream concentrations of metals indicate where the stream and the aquatic ecosystem are most affected by metal sources, but those concentrations result from the greatest inflow loads, not necessarily from the highest inflow concentrations. Synoptic sampling gives a spatially intensive "snapshot" of chemistry and discharge so that instream loads can be quantified. Ideally, samples at all the sampling locations would be collected simultaneously, providing an instantaneous, truly synoptic description of stream water quality along the study reach. Personnel limitations generally preclude this, but samples were collected over a relatively short time period (less than 8 hours) to minimize the effect of transient conditions, such as diurnal flow variations.

Stream and inflow samples were collected at the predetermined locations, beginning at the downstream end of the study reach and ending upstream of the tracer-injection site (table 1). This downstream to upstream sampling order was followed in order to avoid disturbing the streambed before sampling. Inflow and stream sites that were considered well mixed were sampled using grab techniques. Sites that were not well mixed, particularly downstream from tributaries, were sampled by equal width integration (Ward and Harr, 1990). Water temperature was measured on site, and water samples were transported to a central field location for further processing. Samples were transported to the central location in dark plastic bags to keep out the sunlight and prevent changes in iron speciation. Samples were divided into several 125-mL bottles according to different treatments given at the central processing location: a raw (unfiltered) unacidified sample (RU), a raw acidified sample (RA), a filtered unacidified sample (FU), a 0.45-µm filtered acidified sample (FA), and an ultra-filtered, acidified (UFA) sample was obtained using a 10,000 Dalton tangential-flow filtration device. The UFA sample was used to measure a more truly dissolved concentration than the FA sample. The need for ultrafiltration comes from the nature of Al and Fe colloids that can range in size from a nanometer to tenths of micrometers. These colloids, and metals associated with them, can pass through a 0.45-µm filter (Kimball and others, 1995). When these samples are acidified, the Al and Fe colloidal material dissolves and is mistakenly measured as "dissolved" Al or Fe.

Anomalously high concentrations of Zn were noted in a few UFA samples. The high Zn concentration likely was a result of contamination caused by brass fittings contacting the tangential-flow filtration apparatus. The high Zn concentrations in UFA samples were replaced by the corresponding Zn concentrations in the FA sample.

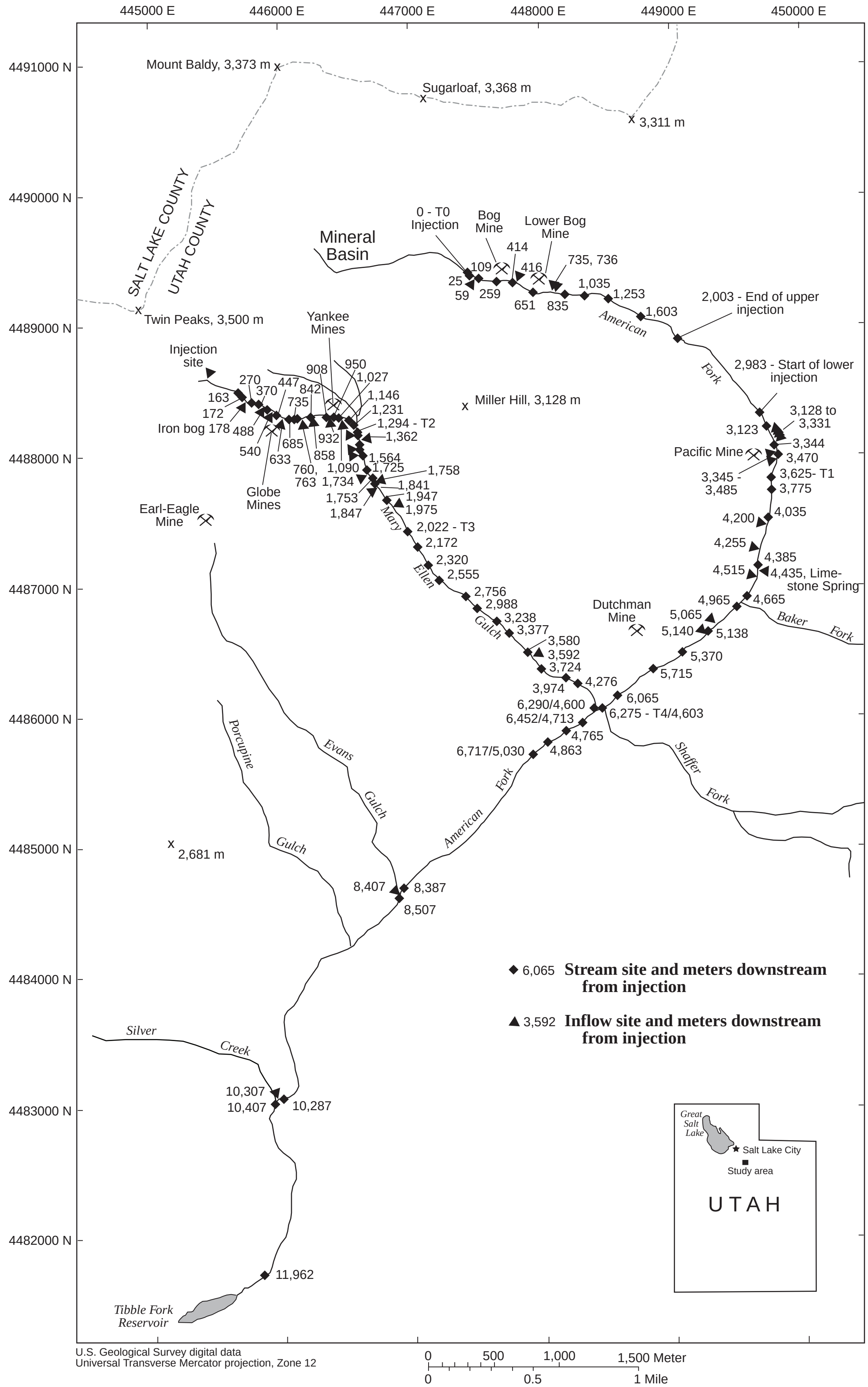

Figure 1. Locations of stream and inflow sampling sites and principal mines in American Fork and Mary Ellen Gulch, Utah.

Table 1. Source, site description, pH, calculated discharge, and tracer concentrations for synoptic samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.

[Distance is from tracer-injection point. Source: S, stream; RBI, right-bank inflow; LBI, left-bank inflow. Easting and Northing, all points Universal Transmercator, Zone 12 north. m, meter; L/s, liters per second; mg/L, milligram per liter; Cl, chloride; Br, bromide, <, less than; NM, not measured]

Distance (m)	Source	Site description	Easting (m)	Northing (m)	pH	Discharge (L/s)	Tracer (mg/L)	
							Cl	Br
		American Fork						
0	S	Transport site 0—Above injection site	447443	4489400	7.46	25.2	0.83	< 0.2
25	S	Upstream from first beaver pond	447457	4489390	7.91	25.2	27.5	< .2
59	RBI	Drains marsh with iron precipitate	447495	4489371	6.52	2.1	.91	< .2
109	S	Near beginning of Bog Mine waste area	447525	4489358	7.80	27.3	25.4	< .2
259	S	On bedrock downstream from Bog Mine influence	447666	4489337	8.07	29.2	23.8	< .2
414	S	At base of bedrock cascades upstream from left-bank inflow	447781	4489332	8.10	29.5	23.6	< .2
416	LBI	Cascades down bedrock	447839	4489345	7.09	4.1	.78	< .2
651	S	Upstream from Lower Bog mine	447944	4489246	7.56	33.6	20.9	< .2
735	LBI	Discharge from Lower Bog adit	448079	4489248	4.38	5.7	1.26	< .2
736	LBI	Spring draining from toe of mine dump	448083	4489252	5.42	5.7	1.33	< .2
835	S	Downstream from Lower Bog mine	448157	4489235	7.90	45.0	15.7	< .2
1,035	S	300 meters downstream from Lower Bog mine	448339	4489223	8.13	47.3	15.0	< .2
1,253	S	Upstream from left-bank inflow	448517	4489196	8.13	50.9	14.0	< .2
1,603	S	Upstream from start of rough road	448767	4489052	8.18	59.6	12.1	< .2
2,003	S	Above series of beaver ponds—end of upper reach	449056	4488891	8.19	62.0	7.15	< .2
2,983	S	T0 Site—Start of lower injection	449673	4488322	7.87	62.7	1.22	< .2
3,123	S	Upstream from pond inflows	449719	4488220	8.31	62.7	1.24	8.92
3,128	LBI	Draining left-bank ponds	449727	4488212	8.37	1.5	1.16	< .2
3,198	LBI	Channel draining pond with red precipitate on bed	449708	4488191	8.27	1.5	1.20	< .2
3,303	LBI	Also draining left-bank ponds	449767	4488127	8.08	1.5	1.31	< .2
3,331	LBI	Draining ponds, entering just above culvert	449781	4488089	8.26	1.5	1.43	< .2
3,344	S	Downstream from draining pond at end of culvert	449788	4488079	8.38	68.5	1.22	4.78
3,345	RBI	Draining beaver pond that receives adit flow	449778	4488078	7.62	2.9	1.48	< .2
3,385	LBI	Draining left-bank ponds—crosses road	449796	4488067	8.22	2.9	1.64	< .2
3,470	S	Downstream from first Pacific inflow	449810	4487993	8.27	74.4	1.26	4.40
3,475	RBI	Discharge draining Pacific tailings	449807	4487986	8.10	1.1	1.62	< .2
3,485	RBI	Drains from Pacific tailings pile	449803	4487971	8.38	1.1	1.47	< .2
3,625	S	Transport site 1—Downstream from Pacific tailings	449755	4487822	8.42	76.9	1.23	3.98
3,625	S	Transport site 1—Replicate	449755	4487822	8.41	76.9	1.37	4.27
3,775	S	Upstream from Dry Fork	449757	4487733	8.40	77.2	1.34	4.25
4,035	S	Below small beaver pond	449737	4487511	8.51	78.5	1.29	4.17
4,200	RBI	Flow from moss-covered rocks	449726	4487487	8.17	1.4	1.58	< .2
4,255	RBI	Seepage from mine waste at beaver pond	449681	4487273	8.74	1.4	1.46	< .2
4,385	S	Transport site 2—Downstream from beaver ponds at bedrock	449651	4487154	8.44	81.3	1.28	4.02
4,435	LBI	Spring from limestone	449658	4487097	7.92	15.1	1.34	.39

Table 1. Source, site description, pH, calculated discharge, and tracer concentrations for synoptic samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Site description	Easting (m)	Northing (m)	pH	Discharge (L/s)	Tracer (mg/L)	
							Cl	Br
4,515	RBI	Draining from right-bank flood plain—wider canyon	449639	4487056	8.29	15.1	1.35	3.00
4,665	S	Downstream from limestone spring	449577	4486916	8.34	112	1.31	2.80
4,965	S	Upstream from Baker Fork	449493	4486837	8.32	113	1.30	2.88
5,065	RBI	Discharge from base of hill	449337	4486700	7.98	0.1	1.57	< .2
5,138	S	Wide part of stream below small beaver dam	449270	4486646	8.43	113	1.39	2.90
5,140	RBI	Another discharge from base of hill	449263	4486645	8.17	4.1	1.57	< .2
5,370	S	Transport site 3—Upstream from Dutchman Flat culvert	449071	4486486	8.43	117	1.29	2.80
5,715	S	Downstream from larger beaver pond and culvert	448846	4486353	8.40	117	1.34	2.79
6,065	S	Downstream from Dutchman Flat	448576	4486153	8.34	117	1.42	2.79
6,275	S	Transport site 4—Upstream from Mary Ellen Gulch—Replicates	448413	4486038	8.27	120	1.31	2.63
6,275	S	Transport site 4—Replicate	448413	4486038	8.63	120	1.42	2.72
6,290	RBI	Mary Ellen Gulch	448398	4486047	8.33	34.3	1.05	< .2
6,452	S	Downstream from Mary Ellen Gulch	448309	4485951	8.13	154	1.26	2.10
6,717	S	Within canyon downstream from Mary Ellen Gulch	448038	4485801	7.97	154	1.34	2.12
8,387	S	Upstream from Major Evans Gulch	446919	4484682	8.62	164	1.27	2.00
8,407	RBI	Major Evans Gulch	446881	4484664	8.69	6.1	1.13	< .2
8,507	S	Downstream from Major Evans Gulch	446885	4484606	8.64	170	1.31	1.93
10,287	S	Upstream from Silver Creek	445986	4483075	8.47	254	1.54	1.29
10,307	RBI	Silver Creek	445938	4483079	7.95	5.8	2.25	< .2
10,407	S	Downstream from Silver Creek	445926	4483052	8.32	260	1.67	1.26
11,962	S	Upstream from Tibble Reservoir	445837	4481725	8.29	NM	2.13	.46
Mary Ellen Gulch								
163	S	T0 site—Injection point	445680	4488487	3.89	1.9	.75	< .2
172	S	Mixing point below injection	445699	4488473	4.04	1.9	.87	269.60
178	RBI	Iron bog draining from right bank	445703	4488458	4.02	0.1	.83	< .2
270	S	T1 site—Mixing site above dropoff	445737	4488418	3.96	2.0	.48	184.41
370	S	Upstream from right bank tributary	445776	4488414	4.15	2.1	.76	180.55
397	RBI	Draining from chute right bank	445789	4488404	8.23	0.1	.63	< .2
447	S	Below chute tributary	445853	4488397	4.57	2.2	.52	179.56
488	RBI	Downstream from second chute	445896	4488364	7.85	6.5	.78	4.17
540	S	Downstream from chute inflows	445935	4488358	8.03	8.7	.63	69.27
633	RBI	Within glacial gully cut	445977	4488324	7.93	1.1	.73	3.59
685	S	Downstream from falls	446021	4488299	8.20	9.7	.70	51.22
735	S	Upstream from Globe Mine	446079	4488281	8.31	9.9	.68	49.16
758	S	Upstream from right bank return flow	446109	4488279	8.34	9.9	.68	48.94
760	RBI	Return flow from road	446116	4488279	8.08	0.1	.71	10.97
763	RBI	Second return from road	446119	4488275	8.23	0.1	.70	13.99

Table 1. Source, site description, pH, calculated discharge, and tracer concentrations for synoptic samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Site description	Easting (m)	Northing (m)	pH	Discharge (L/s)	Tracer (mg/L)	
							Cl	Br
842	S	Downstream from right bank fracture seepage	446199	4488307	8.33	10.1	.70	45.23
858	RBI	Small inflow over rocks	446247	4488301	8.39	0.3	.85	42.30
908	S	Downstream from pyrite-rich piles	446334	4488318	8.27	10.4	.68	40.16
932	RBI	Seep from mine piles on right bank	446351	4488311	5.57	0.0	.90	< 0.2
950	S	Forest Service site between Globe and Yankee mines	446362	4488315	8.29	10.4	.68	39.89
950	S	Forest Service site between Globe and Yankee mines	446362	4488315	8.27	10.4	.68	39.89
1,027	S	Upstream from Yankee #1 inflow	446408	4488311	8.22	10.5	.68	38.59
1,090	RBI	Yankee #1 inflow	446454	4488301	5.95	1.1	.70	< 0.2
1,146	S	Downstream from Yankee #1 inflow	446533	4488276	7.82	11.6	.76	19.34
1,231	S	Second site downstream from Yankee	446570	4488238	8.09	11.6	.76	19.20
1,294	S	T2 site—Upstream from right bank marsh at foot of Yankee pile	446588	4488187	8.01	11.6	.75	19.06
1,312	RBI	Draining grassy marsh	446590	4488168	7.69	0.8	.95	< 0.2
1,354	S	Upstream from left bank inflow of Mary Ellen channel	446606	4488152	8.13	12.5	.83	18.20
1,362	LBI	East branch of Mary Ellen	446621	4488151	8.41	6.0	.73	< 0.2
1,438	S	Downstream from confluence of branches	446614	4488119	8.29	18.5	.75	12.03
1,462	RBI	Draining from tailings on right bank	446608	4488089	7.86	0.0	1.07	< 0.2
1,484	S	Upstream from split in channel	446615	4488064	8.36	18.5	.77	12.13
1,514	RBI	Draining tailings on right bank	446612	4488038	7.91	0.4	.97	< 0.2
1,564	S	Right branch downstream from right bank inflows	446629	4488007	8.31	18.9	.29	11.63
1,725	S	Right branch upstream from side canyon inflow	446661	4487889	8.24	19.4	.78	11.05
1,734	RBI	Drainage from side canyon right bank	446664	4487869	8.49	2.2	.74	< 0.2
1,753	S	Upstream from confluence with left branch	446693	4487835	8.37	21.6	.79	8.81
1,758	LBI	Return flow from left branch	446706	4487826	8.31	0.3	.78	11.19
1,841	S	Downstream from braid confluence	446723	4487791	8.29	21.9	.25	8.53
1,847	RBI	Right bank seep/spring for background	446730	4487768	7.76	1.0	.75	1.08
1,947	S	Downstream from gaining reach	446816	4487658	8.33	22.9	.80	7.49
1,975	LBI	Downstream from left bank inflows	446862	4487607	7.65	0.3	.99	7.22
2,022	S	T3 site—To evaluate inflows	446977	4487422	8.41	23.2	.82	7.08
2,022	S	T3 site—Replicates	446977	4487422	8.30	23.2	.80	7.19
2,172	S	Downstream from large right bank alluvial fan	447043	4487305	8.33	23.6	.79	7.11
2,320	S	At base of Chump slide	447126	4487160	8.42	24.5	.78	6.90
2,555	S	Near road before steep gradient	447213	4487046	8.49	26.1	.80	6.56
2,756	S	Stream within steep gradient—2 branches	447415	4486920	8.48	27.2	.79	6.34
2,988	S	On bedrock within steep gradient	447503	4486831	8.46	28.7	.83	6.01
3,238	S	Downstream from “20-foot dropoff”	447655	4486725	8.46	33.7	.84	4.93
3,377	S	Forest Service site “Mary Ellen at volunteer claims”	447744	4486639	8.18	35.2	.86	4.62
3,580	S	Upstream from left bank inflow	447890	4486484	8.32	37.3	.89	4.16

Table 1. Source, site description, pH, calculated discharge, and tracer concentrations for synoptic samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Site description	Easting (m)	Northing (m)	pH	Discharge (L/s)	Tracer (mg/L)	
							Cl	Br
3,592	LBI	Left bank inflow of clean water	447904	4486473	7.13	2.7	1.33	< 0.2
3,724	S	Downstream from clean left bank inflow	447996	4486359	8.35	40.1	.89	3.58
3,974	S	Within more chutes and pools	448181	4486291	8.38	42.5	.92	3.05
4,276	S	Site to check ground-water inflow	448266	4486249	8.34	43.4	.88	2.86
4,600	S	T4 site—Mary Ellen Gulch at mouth	448398	4486045	8.34	44.7	.95	2.59
4,603	LBI	Upper American Fork	448412	4486038	8.38	104	1.04	< 0.2
4,713	S	First site within narrows	448308	4485951	8.47	148	1.01	.55
4,765	S	Site to check ground-water inflow	448174	4485883	8.42	151	1.04	.54
4,863	S	Second site to check ground-water inflow	448038	4485800	8.50	154	1.09	.53
5,030	S	Last year's second site in canyon—End of synoptic	447922	4485707	8.47	154	.98	.54

Specific conductance and pH were determined from the RU sample shortly after it was collected. In-line 0.45-µm capsule filters were used to obtain the FU and FA samples. Metal concentrations in the RA, FA, and UFA samples were determined by using inductively coupled plasma-atomic emission spectrometry-mass spectrometry (Lichte and others, 1987). Anion concentrations in the FU samples were determined using ion chromatography (Brinton and others, 1996; Kimball and others, 1999). Total alkalinity in the FU sample was determined by using titration (Barringer and Johnsson, 1989).

Ultra-filtered and unfiltered treatments provided two operationally-defined concentrations of each metal. Metal concentration in the unfiltered sample (RA) was a measure of the total-recoverable concentration (dissolved + colloidal). In streams affected by mine drainage, this total-recoverable concentration accounted for Al and Fe colloids that will dissolve in the bottle after acidification. The ultra-filtered concentration (UFA) is an operational measure of the dissolved metal concentration. Colloidal metal concentrations are defined here as the difference between the total-recoverable (RA) and the ultra-filtered metal concentrations (UFA) in stream samples (Kimball and others, 1995). Aquatic standards for toxicity in Utah are based on 0.45-µm filtration.

Constituent Loads

Mass load was calculated for each stream sampling site along the study reach as:

$$M_A = C_A Q_A (0.0864) \quad (1)$$

where:

M_A is the constituent load, or mass flux, at location *A*, in kg/day,

C_A is the concentration of the selected constituent at location *A*, in mg/L,

Q_A is the discharge at location *A*, in L/s, and

0.0864 is the conversion factor for changing mg/s to kg/day.

The total sampled instream load was calculated from the total-recoverable concentration of the constituent, but the dissolved and the colloidal loads were calculated individually from the filtered and the total-recoverable concentrations. The longitudinal profiles of the sampled instream loads (total or dissolved plus colloidal) were derived from the basic data from the mass-loading study.

For each stream segment, the change in load between a pair of stream sites accounts for the gain or loss of constituent load for that segment. The change in load for the segment starting at site A and ending at site B is:

$$\Delta M_S = (M_B - M_A) \quad (2)$$

where:

M_S is the change in sampled in-stream load from site A to B, in kg/day,

M_B is the constituent load at site B, in kg/day, and

M_A is defined in equation 1.

Gains in constituent load (ΔM_S is greater than zero) imply that a source exists and that it contributes load to the stream between the two stream sites. However, instream processes that reduce the net gain may also exist; thus, the measured change may not indicate the total magnitude of the source. Instream load also can decrease within a stream segment (ΔM_S is less than zero), meaning that there is a net loss of the constituent as a result of physical, chemical, or biological processes. A net loss does not preclude the presence of a source of loading in a particular stream segment, but it does preclude quantifying the magnitude of that source. Summing all the increases in load between sampling sites along the study reach (positive values of ΔM_S) leads to the cumulative instream load. At the end of the study reach, the cumulative instream load is the best estimate of the total load added to the stream but is likely a minimum estimate because it measures only the net loading between sites and does not account for metal loads added to and then lost from the water column within individual stream segments.

For those segments that include one or more sampled inflows, it is possible to evaluate how well the sampled inflow accounts for the instream changes. If stream sites A and B bracket one inflow sample from site I,

$$\Delta M_I = C_I\,(Q_B - Q_A)(0.0864) \qquad (3)$$

where:

- M_I is the sampled inflow load from site A to B, in kg/day,
- C_I is the concentration of the selected constituent in inflow I, in mg/L,
- Q_B is the discharge at site B, in L/s, and
- Q_A and 0.0864 are defined in equation 1.

Equation 3 assumes that the entire increase in flow from site A to B was contributed by the sampled inflow and that C_I represents the concentration of the solute in all the water entering the stream from site A to B. Summing the calculated inflow loads along the study reach produced a longitudinal profile of the cumulative inflow load that can be compared with the cumulative instream load. Commonly in streams affected by mine drainage, the cumulative instream load is greater than the cumulative inflow load. This result can indicate important areas where the load is not sampled (unsampled inflow), defined as:

$$\Delta M_U = (M_S - M_I) \qquad (4)$$

where:

- M_U is the unsampled load from site A to B, in kg/day, and
- M_S and M_I are defined in equations 2 and 3.

If ΔM_I is greater than ΔM_S for a given stream segment, two explanations are possible, but they cannot be determined from the experimental data alone. First, the solute may be lost from the water column through chemical or biological processes, resulting in a smaller net value of ΔM_S. Second, the sampled inflow concentration may not represent all the water entering the stream segment. Despite these limitations, quantifying ΔM_S, ΔM_I, and ΔM_U provides useful information for understanding the dynamics of solute loading to the stream (Bencala and Ortiz, 1999). Unsampled inflow can be calculated for individual stream segments or for the entire study reach. A negative value for the entire study reach does not preclude positive values for some individual stream segments.

Because measurement error is inherent in discharge estimates and chemical analysis, a load error equation was used to constrain the changes of sampled in-stream load. The load error is calculated from an equation that accounts for these potential sources of error (McKinnon, 2002).

$$\text{Load error} = \left(\sqrt{Q_A^2 \Delta C_A^2 + C_A^2 \Delta Q_A^2}\right)(0.0864) \qquad (5)$$

where:

- ΔC_A is the precision of chemical analysis, in percent,
- ΔQ_A is the precision of discharge calculation, and
- Q_A, C_A, and 0.0864 are defined in equation 1.

The value of ΔC_A was calculated in a manner analogous to that used by Friedman and Erdman (1982) for single operator precision. The coefficient of variation (CV), representing precision, and the mean concentration were calculated for repeated analyses of a constituent in a set of standard reference samples that span a range of concentrations. Values for the CV were regressed as a power function of the mean concentrations to obtain an equation expressing analytical precision, ΔC_A, as a function of concentration.

$$\Delta C_A = a\,(C_A)^b \qquad (6)$$

where:

- ΔC_A is precision for the chemical analysis at site A, in percent,
- a is the coefficient derived from regression,
- C_A is the concentration of the constituent at site A, and
- b, is the exponent derived from regression.

The value of ΔQ_A is based on the CV for the plateau tracer concentration at the transport sites during the period of synoptic sampling. Similar to the procedure for analytical precision, the values of CV for each mean are used to develop a linear regression for ΔQ_A:

$$\Delta Q_A = mC_A^T + b \qquad (7)$$

where:

- ΔQ_A is the discharge error at site A,
- m is the slope derived from the linear regression,
- C_A^T is the tracer concentration at site A, and
- b, is the intercept derived from the linear regression.

Both ΔC_A and ΔQ_A give the percentage of C_A and Q_A to be substituted into equation 6 to calculate load error. The load error was compared to the change in load to the next site, ΔM_{B-A}. If the absolute value of ΔM_{B-A} was greater than the load error, then a measurable and significant change in load occurred. This error check was applied to values of ΔM_{B-A} that were used for the cumulative in-stream load only; sampled in-stream load is reported for all observed changes.

Results of Mass-Loading Studies

Chemical Analysis of Synoptic Samples

Results of chemical analyses of synoptic samples are presented in tables 2 and 3. Both stream and inflow samples are included and are listed in downstream order for the separate synoptic sampling days. These tables contain three rows of data for stream samples, including the analyses for the UFA, FA, and RA treatments. Most inflow samples have two rows, one to report results from the FA sample and another for results from the RA sample. Occasionally, concentrations from the UFA sample or the FA sample were greater than the concentrations from the RA sample for a given constituent, but the two concentrations usually were within analytical precision.

Analytical results indicate that some of the Cu and Zn concentrations from UFA and FA samples had been contaminated. The contamination was likely caused by the brass fittings contacting the tangential-filtration apparatus while the filters were being changed between the FA and UFA treatments. Samples considered to be contaminated are indicated in table 3. When the concentration from the RA sample was lower than the concentration from either the UFA or FA samples, the interpretation can become subjective. In this study, when this situation occurred because of contamination, we substituted the concentration from the RA sample for the filtered and the total-recoverable concentrations, and assigned a value to the colloidal concentration that was less than the detection limit. However, if upstream and downstream samples were not contaminated and substantial colloidal concentrations were present, we used the average of those colloidal percentages to calculate a colloidal concentration for the sample affected by contamination. This approach helped to avoid a zigzag pattern of colloidal concentrations.

Quality assurance results are given in table 4. These include the method detection limits (MDL) for each constituent and parameters derived from the application of equation 7, using the value of the relative standard deviation (RSD) and the mean concentration for various standard reference samples. The RSD and mean values were obtained by running standard reference samples after every group of 10 samples were analyzed. The RSD was used as the measure of precision for the chemical analyses.

Loading Profiles

Using the equations described in “Constituent Loads,” the mass-loading profiles for Al, Fe, Mn, and Zn are illustrated for American Fork (figs. 2–5) and Mary Ellen Gulch (figs. 6, 7, 9, and 10). The profile for Cu is shown for Mary Ellen Gulch only (fig. 8). Each figure indicates the longitudinal profile of load and the change in load for individual stream segments.

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Table 2. Chemical analyses for major ions in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.

[Distance, from injection, in meters (m). Source: S, stream; RBI, right-bank inflow; LBI, left-bank inflow. Filter: UFA, 10,000 Dalton ultra-filter; FA, 0.45-micrometer filter; RA, unfiltered; $CaCO_3$, calcium carbonate; <, less than; NM, not measured; all concentrations in milligrams per liter]

Distance (m)	Source	Sample time	Filter	Calcium	Magnesium	Potassium	Alkalinity as $CaCO_3$	Sulfate	Chloride	Silica
American Fork, Upper injection reach										
0	S	9:58	UFA	32.5	11.8	0.84				4.8
			FA	32.5	11.8	.84	86.9	39	.83	4.8
			RA	32.4	11.9	.83				4.7
25	S	14:00	UFA	32.2	11.7	.95				4.8
			FA	32.5	11.7	.94	87.1	39	28	4.8
			RA	33.0	11.9	.94				4.8
59	RBI	10:18	FA	11.6	4.49	1.0	19.0	42	.91	11
			RA	11.6	4.48	.99				13
109	S	14:15	UFA	31.0	11.2	.95				5.4
			FA	31.4	11.3	.96	84.3	40	25	5.5
			RA	32.0	11.7	.96				5.6
259	S	14:20	UFA	31.0	11.2	.99				5.4
			FA	31.2	11.3	.98	83.0	41	24	5.5
			RA	31.5	11.5	.99				6.0
414	S	14:35	UFA	31.0	11.2	1.0				5.6
			FA	31.3	11.3	.99	81.7	41	24	5.6
			RA	31.8	11.6	1.0				5.7
416	LBI	11:15	FA	4.52	1.48	.34	24.8	4.7	.78	6.9
			RA	4.64	1.55	.41				8.6
651	S	14:50	UFA	29.9	10.9	.96				5.5
			FA	30.1	10.9	.96	76.6	39	21	5.7
			RA	30.5	11.1	.96				5.6
735	LBI	11:35	FA	10.4	3.48	1.1	< 1	54	1.3	12
			RA	10.4	3.46	1.1				12
736	LBI	11:35	FA	10.0	3.28	1.1	< 1	54	1.3	11
			RA	10.3	3.34	1.2				11
835	S	15:05	UFA	25.2	9.12	1.0				7.2
			FA	25.3	9.16	1.0	76.6	42	16	7.3
			RA	26.1	9.44	1.0				7.3
1,035	S	13:45	UFA	25.0	9.10	.99				6.8
			FA	25.0	9.05	.98	67.5	40	15	7.0
			RA	25.5	9.25	.99				7.1
1,253	S	15:55	UFA	25.0	9.11	.98				6.8
			FA	24.9	9.04	.98	58.5	40	14	6.9
			RA	25.4	9.25	.98				7.2

Table 2. Chemical analyses for major ions in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Calcium	Magnesium	Potassium	Alkalinity as $CaCO_3$	Sulfate	Chloride	Silica
1,603	S	16:20	UFA	24.9	9.28	.95				6.7
			FA	25.2	9.33	.98	63.0	38	12	6.9
			RA	25.8	9.59	.99				7.2
2,003	S	16:35	UFA	28.2	11.1	.89				6.8
			FA	28.1	11.0	.88	80.2	32	7.2	6.7
			RA	28.3	11.1	.87				6.6
American Fork, Lower injection reach										
2,983	S	15:10	UFA	34.0	14.6	.71				5.7
			FA	34.8	15.0	.70	119	23	1.2	6.6
			RA	35.5	15.3	.71				6.8
3,123	S	15:05	UFA	33.8	14.6	.71				6.0
			FA	34.7	15.0	.70	119	24	1.2	6.5
			RA	34.8	15.0	.74				6.5
3,128	LBI	15:00	FA	29.9	15.4	.37		3.4	1.2	5.7
			RA	30.4	15.7	.34	128			5.3
3,198	LBI	14:55	FA	30.0	15.5	.39	128	3.2	1.2	5.7
			RA	30.2	15.6	.40				5.4
3,303	LBI	14:50	FA	30.9	15.8	.41	132	3.1	1.3	5.8
			RA	31.7	16.3	.41				6.0
3,331	LBI	14:45	FA	36.1	18.2	.48	155	3.2	1.4	6.3
			RA	36.2	18.2	.50	155			5.9
3,344	S	14:33	UFA	32.7	15.1	.59	119			5.6
			FA	33.3	15.4	.57	119	15	1.2	6.3
			RA	33.9	15.7	.56	119			6.4
3,345	RBI	14:35	FA	45.2	23.1	.72	173	25	1.5	7.6
			RA	46.1	23.5	.72	173			7.5
3,385	LBI	14:30	FA	38.8	19.5	.47	165	3.7	1.6	7.6
			RA	39.7	19.7	.53	165			6.6
3,470	S	14:20	UFA	33.2	15.4	.59	127			5.6
			FA	33.6	15.7	.57	127	14	1.3	7.4
			RA	34.0	15.9	.54	127			6.4
3,475	RBI	14:15	UFA	44.6	23.0	.84	172			6.4
			FA	45.7	23.5	.81	172	36	1.6	6.8
			RA	46.8	24.2	.86	172			8.1
3,485	RBI	14:10	FA	43.3	22.8	.80	158	NM	NM	7.6
			RA	43.9	23.2	.83	158			7.7
3,625	S	13:55	UFA	33.3	15.6	.61	128			5.8
			FA	34.0	15.9	.58	128	14	1.2	6.3
			RA	34.5	16.2	.56	128			6.3

Table 2. Chemical analyses for major ions in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Calcium	Magnesium	Potassium	Alkalinity as $CaCO_3$	Sulfate	Chloride	Silica
3,625	S	14:00	UFA	33.3	15.6	.59	128			5.6
			FA	34.3	16.0	.57	128	15	1.4	6.3
			RA	34.6	16.3	.56	128			6.3
3,775	S	13:56	UFA	33.4	15.6	.60	128			5.5
			FA	34.2	16.0	.59	128	15	1.3	7.7
			RA	34.3	16.1	.61	128			6.0
4,035	S	13:40	UFA	33.3	15.6	.61	128			5.5
			FA	33.9	15.9	.58	128	15	1.3	7.6
			RA	34.1	16.1	.60	128			5.9
4,200	RBI	13:25	FA	45.5	23.7	.50	168	4.3	1.6	8.0
			RA	45.8	23.7	.55	168			7.7
4,255	RBI	13:20	FA	29.6	18.8	1.7	139	7.7	1.5	6.3
			RA	48.7	19.8	2.0	139			8.0
4,385	S	13:10	UFA	33.9	16.0	.60	128			5.9
			FA	34.7	16.3	.56	128	15	1.3	6.4
			RA	34.6	16.3	.60	128			5.9
4,435	LBI	13:05	FA	43.4	20.1	.61	152	12	1.3	6.8
			RA	43.7	20.2	.64	152			6.3
4,515	RBI	13:00	RA	37.5	17.5	.63	145	14	1.4	6.0
4,665	S	12:50	UFA	36.3	17.0	.60	141			5.8
			FA	37.0	17.5	.58	141	13	1.3	6.6
			RA	37.8	17.8	.62	141			6.1
4,965	S	12:35	UFA	36.3	17.3	.60	143			5.0
			FA	37.5	17.6	.58	143	14	1.3	6.4
			RA	37.2	17.4	.61	143			6.1
5,065	RBI	12:10	FA	53.7	23.5	.58	153	4.9	1.6	7.8
			RA	53.8	23.5	.61	153			7.5
5,138	S	12:00	UFA	36.8	17.3	.61	142			6.0
			FA	37.6	17.6	.58	142	14	1.4	6.3
			RA	37.7	17.6	.60	142			6.1
5,140	RBI	11:55	FA	57.2	25.0	.55	142	2.9	1.6	8.2
			RA	57.4	24.9	.57	142			7.7
5,370	S	11:35	UFA	36.0	17.0	.59	144			4.9
			FA	37.8	17.7	.58	144	14	1.3	6.3
			RA	37.8	17.6	.60	144			5.9
5,715	S	11:25	UFA	37.4	17.4	.61	147			5.7
			FA	38.1	17.8	.58	147	14	1.3	6.4
			RA	37.9	17.7	.60	147			5.9

Table 2. Chemical analyses for major ions in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Calcium	Magnesium	Potassium	Alkalinity as $CaCO_3$	Sulfate	Chloride	Silica
6,065	S	11:05	UFA	36.7	17.7	.60	149			5.2
			FA	38.3	17.9	.59	149	14	1.4	6.3
			RA	38.4	17.9	.60	149			6.1
6,275	S	10:55	UFA	37.0	17.3	.60	150			5.1
			FA	37.9	17.7	.59	150	13	1.4	6.2
			RA	38.2	17.8	.61	150			6.1
6,275	S	17:15	UFA	36.8	17.7	.64	150			5.2
			FA	38.0	17.8	.62	150	13	1.4	6.3
			RA	38.0	17.6	.65	150			6.0
6,290	RBI	10:50	FA	35.2	13.3	.55	104	30	1.0	6.4
			RA	35.2	13.3	.57	104			6.0
6,452	S	10:40	UFA	37.0	16.8	.61	141			5.9
			FA	37.4	17.0	.57	141	16	1.3	6.1
			RA	37.8	17.1	.61	141			6.2
6,717	S	10:25	UFA	36.2	16.6	.85	141			5.1
			FA	37.7	17.0	.58	141	16	1.3	6.3
			RA	38.4	17.4	.65	141			6.8
8,387	S	16:25	UFA	37.3	17.1	.36	143			5.1
			FA	38.5	17.2	.61	143	16	1.3	6.5
			RA	38.9	17.4	.60	143			6.5
8,407	RBI	16:00	UFA	45.0	18.6	.58	137			5.5
			FA	45.7	19.0	.54	137	11	1.1	6.1
			RA	45.3	18.8	.57	137			5.6
8,507	S	15:45	UFA	37.9	16.8	.63	143			6.0
			FA	39.0	17.4	.61	143	16	1.3	7.6
			RA	38.9	17.5	.59	143			6.5
10,287	S	13:05	UFA	45.2	17.9	.61	118			6.2
			FA	47.1	18.7	.59	118	23	1.5	8.6
			RA	46.3	18.5	.55	118			6.6
10,307	RBI	12:45	UFA	64.1	7.59	.62	81.4			8.8
			FA	65.1	7.79	.60	81.4	41	2.3	12
			RA	65.4	7.83	.63	81.4			9.5
10,407	S	12:20	UFA	45.3	17.7	.60	159			6.2
			FA	45.5	17.7	.56	159	23	1.7	6.9
			RA	46.0	18.2	.54	159			7.0
11,962	S	11:10	UFA	83.1	26.2	.71	NM			10
			FA	84.4	26.6	.67	NM	140	2.1	11
			RA	84.7	26.7	.66	NM			11

Table 2. Chemical analyses for major ions in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Calcium	Magnesium	Potassium	Alkalinity as $CaCO_3$	Sulfate	Chloride	Silica
Mary Ellen Gulch										
163	S	16:12	UFA	6.40	2.00	.67	< 1			9.5
			FA	6.25	1.89	.75	< 1	44	.75	9.5
			RA	7.00	1.89	.63	< 1			9.9
172	S	16:10	UFA	6.40	1.82	1.5	< 1			9.1
			FA	6.30	1.78	1.4	< 1	40	.87	8.8
			RA	6.20	1.73	1.5	< 1			8.5
178	RBI	16:10	FA	6.50	2.35	.98	< 1	55	.83	12
			RA	6.90	2.42	.77	< 1			11
270	S	16:00	UFA	6.70	1.95	.69	< 1			10
			FA	6.35	1.99	1.4	< 1	44	.48	9.9
			RA	6.95	2.05	1.4	< 1			8.9
370	S	15:50	UFA	7.60	1.99	1.4	< 1			11
			FA	6.75	2.10	1.3	< 1	43	.76	9.7
			RA	7.45	2.08	1.3	< 1			9.9
397	RBI	15:50	FA	23.0	6.15	.60	63.7	23	.63	3.8
			RA	25.0	6.70	.74	63.7			4.2
447	S	15:42	UFA	7.85	2.38	1.4	< 1			10
			FA	8.00	2.25	1.1	< 1	43	.52	10
			RA	7.90	2.30	1.4	< 1			10
488	RBI	15:40	FA	32.0	14.2	.40	112	16	.78	3.5
			RA	32.5	14.5	.40	112			3.6
540	S	15:33	UFA	20.0	5.80	.39	40.0			6.2
			FA	19.0	6.00	.80	40.0	30	.63	5.9
			RA	20.0	6.15	.80	40.0			6.3
633	RBI	15:30	UFA	32.0	15.0	.38	104			3.8
			FA	31.0	14.7	.32	104	18	.73	3.6
633	RBI	15:30	RA	33.0	16.0	.37	104			3.6
685	S	15:23	FA	23.0	8.71	.70	60.0	27	.70	5.2
			RA	24.0	8.25	.68	60.0			4.7
735	S	15:20	UFA	21.5	8.40	.62	62.7			5.1
			FA	22.5	8.58	.79	62.7	27	.68	5.1
			RA	22.0	8.97	.61	62.7			4.9
758	S	15:12	UFA	24.0	9.35	.45	65.1			5.1
			FA	23.5	9.16	.69	65.1	27	.68	5.0
			RA	22.5	9.26	.68	65.1			4.8
760	RBI	15:10	FA	34.0	14.3	.26	96.1	27	.71	4.0
			RA	27.0	15.1	.18	96.1			3.6

Table 2. Chemical analyses for major ions in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Calcium	Magnesium	Potassium	Alkalinity as $CaCO_3$	Sulfate	Chloride	Silica
763	RBI	15:07	FA	28.0	13.4	.28	90.5	25	.70	3.8
			RA	28.0	13.0	.24	90.5			3.9
842	S	14:55	UFA	22.0	9.08	.56	65.9			5.1
			FA	24.0	9.42	.67	65.9	28	.70	4.8
			RA	26.0	9.15	.64	65.9			4.7
858	RBI	14:53	UFA	31.0	12.2	.50	76.0			4.4
			FA	30.5	11.5	.47	76.0	28	.85	4.3
			RA	27.0	12.5	.39	76.0			4.2
908	S	14:43	UFA	26.0	10.3	.67	67.3			4.8
			FA	25.0	10.1	.73	67.3	33	.68	4.7
			RA	25.0	10.2	.57	67.3			4.7
932	RBI	14:45	FA	78.0	39.0	.59	< 1	360	.90	10
			RA	77.0	38.0	.75	< 1			12
950	S	14:34	UFA	27.0	10.7	.67	68.7			4.8
			FA	25.0	9.85	.54	68.7	34	.68	4.5
			RA	27.0	11.0	.65	68.7			4.6
950	S	14:35	UFA	26.0	10.5	.67	67.3			4.7
			FA	26.0	10.2	.65	67.3	34	.68	4.6
			RA	27.0	10.0	.62	67.3			4.9
1,027	S	14:23	UFA	29.0	10.5	.67	68.5			4.8
			FA	27.0	10.4	.58	68.5	39	.68	4.5
			RA	27.5	11.0	.67	68.5			4.7
1,090	RBI	14:18	FA	30.0	12.0	1.2	24.6	100	.70	8.7
			RA	30.0	12.0	1.2	24.6			8.7
1,146	S	14:11	UFA	28.0	11.4	.42	64.0			6.8
			FA	28.0	11.0	.81	64.0	60	.76	7.0
			RA	28.0	11.5	.81	64.0			7.2
1,231	S	14:05	UFA	28.0	10.9	.73	52.3			6.7
			FA	28.0	11.0	.81	52.3	60	.76	7.0
			RA	28.5	11.0	.81	52.3			6.9
1,294	S	13:55	UFA	29.0	11.2	.81	54.4			6.8
			FA	28.0	11.4	.89	54.4	63	.75	6.6
			RA	27.0	11.5	.79	54.4			6.6
1,312	RBI	13:53	FA	45.0	23.4	.47	135	76	.95	5.2
			RA	52.0	23.7	1.1	135			9.6
1,354	S	13:43	UFA	25.0	11.9	.76	58.2			6.1
			FA	30.0	11.5	.74	58.2	64	.83	6.7
			RA	31.0	11.6	.78	58.2			7.2

Table 2. Chemical analyses for major ions in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Calcium	Magnesium	Potassium	Alkalinity as $CaCO_3$	Sulfate	Chloride	Silica
1,362	LBI	13:42	UFA	31.0	11.2	.39	42.3			3.6
			FA	33.0	11.4	.45	42.3	18	.73	3.8
			RA	36.0	10.7	.50	42.3			4.0
1,438	S	13:34	UFA	30.0	12.1	.67	72.6			5.6
			FA	29.0	12.0	.66	72.6	50	.75	5.6
			RA	27.0	12.5	.54	72.6			5.3
1,462	RBI	13:32	UFA	52.0	24.6	.47	154			6.1
			FA	49.0	23.9	.93	154	58	1.1	6.0
			RA	56.0	24.7	.87	154			6.3
1,484	S	13:15	UFA	28.0	11.4	.54	72.2			5.7
			FA	27.0	11.5	.52	72.2	51	.77	5.6
			RA	31.0	12.0	.59	72.2			5.7
1,514	RBI	13:08	UFA	47.0	23.9	.14	174			4.5
			FA	47.0	23.9	.26	174	27	.97	4.5
			RA	46.0	22.5	.21	174			4.4
1,564	S	12:56	UFA	33.0	12.1	.65	79.6			5.8
			FA	32.0	12.7	.65	79.6	50	.29	5.5
			RA	32.0	12.6	.67	79.6			5.3
1,725	S	12:49	UFA	29.0	12.3	.61	76.1			5.3
			FA	33.0	13.0	.58	76.1	50	.78	5.4
			RA	33.0	13.0	.61	76.1			5.5
1,734	RBI	12:47	FA	40.0	17.5	.33	136	12	.74	3.8
			RA	42.0	19.0	.33	136			3.9
1,753	S	12:43	UFA	32.0	13.6	.44	90.1			5.0
			FA	32.0	13.5	.57	90.1	43	.79	4.9
			RA	33.0	13.6	.54	90.1			5.3
1,758	LBI	12:40	UFA	29.0	11.3	.29	67.5			5.4
			FA	29.0	11.1	.59	67.5	46	.78	5.3
			RA	32.0	10.9	.56	67.5			5.1
1,841	S	12:30	UFA	32.0	13.3	.58	90.4			5.1
			FA	31.0	13.9	.52	90.4	42	.25	4.9
			RA	29.0	14.0	.48	90.4			5.0
1,847	RBI	12:25	FA	38.5	15.0	.29	133	18	.75	3.8
			RA	40.5	15.5	.39	133			3.9
1,947	S	12:17	UFA	34.0	14.2	.53	95.7			4.8
			FA	34.0	13.0	.49	95.7	39	.80	4.8
			RA	34.0	14.0	.50	95.7			4.9

Table 2. Chemical analyses for major ions in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Calcium	Magnesium	Potassium	Alkalinity as $CaCO_3$	Sulfate	Chloride	Silica
1,975	LBI	12:10	UFA	41.0	13.7	.34	114			5.0
			FA	38.0	14.8	.45	114	36	.99	4.6
			RA	44.0	13.7	.44	114			4.4
2,022	S	12:01	UFA	35.0	13.7	.53	95.5			4.9
			FA	34.0	13.3	.52	95.5	39	.80	4.8
			RA	35.0	14.0	.50	95.5			4.9
2,022	S	13:39	UFA	32.0	14.0	.49	94.5			4.7
			FA	32.0	14.0	.53	94.5	39	.82	4.8
			RA	32.0	14.2	.54	94.5			5.2
2,172	S	11:53	UFA	36.0	14.2	.53	96.7			4.9
			FA	30.0	13.1	.41	96.7	39	.79	4.8
			RA	36.0	13.5	.52	96.7			5.0
2,320	S	11:42	UFA	36.0	13.4	.50	98.1			4.8
			FA	33.0	13.5	.45	98.1	39	.78	4.7
			RA	39.0	14.3	.49	98.1			4.7
2,555	S	11:29	UFA	33.0	13.6	.50	94.5			4.7
			FA	33.0	13.9	.48	94.5	39	.80	4.7
			RA	30.0	13.9	.39	94.5			4.5
2,756	S	11:09	UFA	31.0	13.8	.30	96.8			4.6
			FA	32.0	14.0	.58	96.8	39	.79	4.6
			RA	34.0	14.6	.51	96.8			4.9
2,988	S	11:00	UFA	36.0	14.0	.49	100			4.7
			FA	35.0	13.5	.46	100	39	.83	4.7
			RA	32.0	14.4	.36	100			4.3
3,238	S	10:46	UFA	35.0	13.4	.48	104			4.7
			FA	34.5	13.5	.42	104	37	.84	4.6
			RA	37.0	13.6	.45	104			4.6
3,377	S	10:37	UFA	33.0	13.7	.40	103			4.6
			FA	34.0	13.9	.53	103	36	.86	4.6
			RA	35.0	13.6	.48	103			4.8
3,580	S	10:27	UFA	34.0	13.6	.43	103			4.5
			FA	35.0	13.7	.52	103	35	.89	4.5
			RA	34.0	13.9	.48	103			4.9
3,592	LBI	10:25	FA	15.0	4.44	.39	49.8	6.2	1.3	5.6
			RA	14.0	4.44	.32	49.8			5.6
3,724	S	10:12	UFA	35.0	13.7	.49	103			4.7
			FA	36.0	13.5	.47	103	34	.89	4.7
			RA	34.0	14.1	.43	103			4.3

Table 2. Chemical analyses for major ions in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Calcium	Magnesium	Potassium	Alkalinity as $CaCO_3$	Sulfate	Chloride	Silica
3,974	S	10:02	UFA	38.0	13.3	.52	104			4.9
			FA	34.0	13.0	.39	104	34	.92	4.4
			RA	31.0	13.1	.42	104			3.7
4,276	S	9:46	UFA	34.0	12.5	.38	106			4.4
			FA	34.0	13.7	.49	106	34	.88	4.6
			RA	37.0	13.2	.47	106			4.9
4,600	S	9:30	UFA	38.0	13.9	.48	104	34	.95	4.6
			FA	34.0	14.1	.46	104			4.5
			RA	37.0	13.7	.38	104			4.7
4,603	LBI	12:40	UFA	40.0	17.7	.55	147			4.5
			FA	39.0	18.0	.55	147	14	1.0	4.4
			RA	39.5	18.5	.53	147			4.4
4,713	S	12:55	UFA	38.5	17.0	.48	139			4.4
			FA	38.0	17.4	.55	139	18	1.0	4.4
			RA	38.0	17.1	.53	139			4.2
4,765	S	13:10	UFA	38.0	16.8	.55	140			4.5
			FA	36.0	16.6	.44	140	18	1.0	4.4
			RA	38.0	17.5	.59	140			4.2
4,863	S	13:25	UFA	36.0	16.6	.47	139			4.6
			FA	37.0	17.7	.52	139	18	1.1	4.4
			RA	36.0	17.8	.47	139			4.5
5,030	S	13:40	UFA	40.0	16.6	.57	140			4.6
			FA	38.0	16.7	.52	140	18	.98	4.4
			RA	34.0	17.0	.53	140			4.5

Table 3. Chemical analyses of trace elements in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.

[Distance from injection, in meters (m). Source: S, stream; RBI, right-bank inflow; LBI, left-bank inflow. Filter, UFA, 10,000 Dalton ultra-filter, FA, 0.45-micrometer; RA, unfiltered. Al, aluminum; As, arsenic; Ba, barium; Cd, cadmium; Cu, copper; Fe, iron; Pb, lead; Li, lithium; Mn, manganese; Ni, nickel; Sr, strontium; Zn, zinc; <, less than; MS, missing sample; NA, not analyzed; all concentrations in milligrams per liter]

Distance (m)	Source	Sample time	Filter	Al	As	Ba	Cd	Cu	Fe	Pb	Li	Mn	Ni	Sr	Zn
American Fork, Upper Injection Reach															
0	S	9:58	UFA	0.033	<0.107	0.040	<0.002	<0.001	0.021	<0.015	<0.001	0.022	<0.004	0.064	<0.001
			FA	.033	<.107	.040	<.002	<.001	.11	<.015	<.001	.022	<.004	.063	<.001
			RA	.037	<.107	.039	<.002	<.001	.18	<.015	<.001	.024	<.004	.064	.068
25	S	14:00	UFA	[2].044	<.107	.041	<.002	[1].006	.026	<.015	<.001	.024	<.004	.064	<.001
			FA	[2].042	<.107	.041	<.002	<.001	.15	<.015	<.001	.024	<.004	.064	<.001
			RA	.038	<.107	.042	<.002	<.001	.21	<.015	.001	.026	<.004	.065	.074
59	RBI	10:18	FA	.026	<.107	.041	<.002	<.001	.17	<.015	.004	.384	<.004	.034	<.001
			RA	.24	<.107	.046	.002	<.001	12.6	<.015	.012	.453	<.004	.034	.139
109	S	14:15	UFA	[2].042	<.107	.042	<.002	[1].004	.025	<.015	<.001	.045	<.004	.062	<.001
			FA	.035	<.107	.042	<.002	<.001	.18	<.015	<.001	.044	<.004	.062	<.001
			RA	.046	<.107	.044	<.002	<.001	.40	<.015	.001	.050	<.004	.064	.071
259	S	14:20	UFA	.070	<.107	.042	<.002	<.001	.023	<.015	<.001	.048	<.004	.062	<.001
			FA	.072	<.107	.043	<.002	<.001	.20	<.015	<.001	.048	<.004	.063	<.001
			RA	.15	<.107	.044	<.002	<.001	.85	<.015	.001	.056	<.004	.063	.166
414	S	14:35	UFA	.080	<.107	.043	<.002	[2].032	.049	<.015	<.001	.046	<.004	.063	[2].024
			FA	.085	<.107	.043	<.002	.002	.22	<.015	<.001	.045	<.004	.062	<.001
			RA	.10	<.107	.044	<.002	<.001	.52	<.015	.001	.048	<.004	.063	.088
416	LBI	11:15	FA	.14	<.107	.074	<.002	<.001	.12	<.015	<.001	<.001	<.004	.021	<.001
			RA	.46	<.107	.083	<.002	<.001	.34	<.015	<.001	.007	<.004	.021	.037
651	S	14:50	UFA	.056	<.107	.045	<.002	<.001	.023	<.015	<.001	.032	<.004	.060	[2].030
			FA	.071	<.107	.046	<.002	<.001	.19	<.015	<.001	.033	<.004	.061	<.001
			RA	.095	<.107	.046	<.002	<.001	.40	<.015	.001	.035	<.004	.060	.068
735	LBI	11:35	FA	1.2	<.107	.042	.013	.013	.039	<.015	<.001	.526	.011	.044	.558
			RA	1.2	<.107	.041	.015	.013	.041	<.015	.002	.519	.011	.045	.632
736	LBI	11:35	FA	.54	<.107	.031	.013	[1].014	4.43	<.015	<.001	.281	.011	.042	.457
			RA	.61	<.107	.033	.014	.011	4.84	<.015	.001	.288	.010	.043	.620
835	S	15:05	UFA	.042	<.107	.044	.002	[1].005	.031	<.015	<.001	.106	<.004	.056	[2].173
			FA	.12	<.107	.043	.003	.002	.12	<.015	<.001	.105	<.004	.056	.112
			RA	.21	<.107	.045	.003	.002	.97	<.015	.001	.100	<.004	.056	.193
1,035	S	13:45	UFA	.077	<.107	.044	<.002	<.001	.023	<.015	<.001	.087	<.004	.055	.010
			FA	.10	<.107	.044	.002	<.001	.14	<.015	<.001	.088	<.004	.055	.073
			RA	.18	<.107	.046	.003	.001	.81	<.015	.001	.091	<.004	.055	.144
1,253	S	15:55	UFA	.084	<.107	.044	<.002	<.001	.026	<.015	<.001	.072	<.004	.054	<.001
			FA	.099	<.107	.044	<.002	<.001	.14	<.015	<.001	.073	<.004	.055	<.001
			RA	.18	<.107	.046	.002	.001	.78	<.015	.001	.078	<.004	.055	.131

Table 3. Chemical analyses of trace elements in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Al	As	Ba	Cd	Cu	Fe	Pb	Li	Mn	Ni	Sr	Zn
1,603	S	16:20	UFA	.073	<.107	.047	<.002	<.001	.023	<.015	<.001	.050	<.004	.053	<.001
			FA	.093	<.107	.048	<.002	<.001	.18	<.015	<.001	.051	<.004	.054	.025
			RA	.16	<.107	.050	.002	.001	.66	<.015	.001	.057	<.004	.055	.163
2,003	S	16:35	UFA	.056	<.107	.050	<.002	[1].007	.025	<.015	<.001	.019	<.004	.054	[2].053
			FA	.072	<.107	.050	<.002	<.001	.13	<.015	<.001	.019	<.004	.054	<.001
			RA	.081	<.107	.049	<.002	<.001	.26	<.015	.001	.021	<.004	.053	.075
American Fork, Lower Injection Reach															
2,983	S	15:10	UFA	[2].042	<.107	.053	<.002	<.001	.024	<.015	<.001	.010	<.004	.046	[2].020
			FA	.031	<.107	.057	<.002	<.001	.053	<.015	.001	.011	<.004	.048	[2].034
			RA	.12	<.107	.060	<.002	<.001	.19	<.015	.001	.024	<.004	.048	.004
3,123	S	15:05	UFA	[2].037	<.107	.054	<.002	<.001	.025	<.015	.751	.008	<.004	.047	<.001
			FA	.030	<.107	.056	<.002	<.001	.052	<.015	.738	.008	<.004	.047	.035
			RA	.13	<.107	.057	<.002	<.001	.19	<.015	.742	.022	<.004	.048	.089
3,128	LBI	15:00	FA	<.021	<.107	.025	<.002	<.001	.016	<.015	<.001	<.001	<.004	.026	[2].026
			RA	<.021	<.107	.027	<.002	<.001	.013	<.015	<.001	<.001	<.004	.027	<.001
3,198	LBI	14:55	FA	.022	<.107	.025	<.002	<.001	.061	<.015	<.001	.005	<.004	.027	.048
			RA	.033	<.107	.023	<.002	<.001	.070	<.015	<.001	.005	<.004	.027	.057
3,303	LBI	14:50	FA	.023	<.107	.030	<.002	<.001	.22	<.015	<.001	.075	<.004	.028	[2].038
			RA	.063	<.107	.034	<.002	<.001	.46	<.015	<.001	.084	<.004	.028	<.001
3,331	LBI	14:45	FA	.025	<.107	.028	<.002	[1].003	.12	<.015	.001	.032	<.004	.032	[2].040
			RA	.047	<.107	.027	<.002	<.001	.20	<.015	.001	.039	<.004	.032	.069
3,344	S	14:33	UFA	[2].043	<.107	.042	<.002	<.001	.024	<.015	.405	.007	<.004	.039	[2].053
			FA	.022	<.107	.045	<.002	<.001	.046	<.015	.404	.008	<.004	.039	[2].040
			RA	.057	<.107	.048	<.002	.002	.10	<.015	.411	.009	<.004	.040	<.001
3,345	RBI	14:35	FA	<.021	<.107	.110	.004	.001	.093	<.015	.001	.241	<.004	.060	.747
			RA	.14	<.107	.115	.008	.023	4.30	.027	.001	.363	.004	.061	1.14
3,385	LBI	14:30	FA	.023	<.107	.031	<.002	<.001	.068	<.015	.001	.025	<.004	.035	.057
			RA	.12	<.107	.033	<.002	<.001	.23	<.015	.001	.047	<.004	.035	.076
3,470	S	14:20	UFA	[2].038	<.107	.042	<.002	<.001	.024	<.015	.365	.014	<.004	.039	<.001
			FA	.027	<.107	.044	<.002	<.001	.062	<.015	.359	.017	<.004	.039	[2].080
			RA	.071	<.107	.050	<.002	<.001	.14	<.015	.366	.019	<.004	.039	.003
3,475	RBI	14:15	UFA	[2].047	<.107	.126	.006	[2].037	[2].051	<.015	<.001	.124	<.004	.063	[2].640
			FA	.022	<.107	.125	.006	<.001	.022	<.015	.002	.119	<.004	.063	.687
			RA	.28	<.107	.193	.008	.016	1.66	.738	.001	.125	<.004	.065	1.02
3,485	RBI	14:10	FA	.030	<.107	.099	.006	.004	.017	<.015	.002	.008	<.004	.065	.521
			RA	.21	<.107	.865	.011	.041	3.01	1.88	.001	.010	<.004	.079	1.26
3,625	S	14:00	UFA	[2].036	<.107	.045	<.002	<.001	.022	<.015	.347	.014	<.004	.039	<.001
			FA	.024	<.107	.047	<.002	.003	.058	<.015	.349	.015	<.004	.040	[2].091
			RA	.056	<.107	.056	<.002	<.001	.18	.033	.351	.015	<.004	.040	.053

Table 3. Chemical analyses of trace elements in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Al	As	Ba	Cd	Cu	Fe	Pb	Li	Mn	Ni	Sr	Zn
3,625	S	13:55	UFA	[2].046	<.107	.046	<.002	[2].008	.033	<.015	.350	.016	<.004	.040	[2].068
			FA	.025	<.107	.047	<.002	<.001	.056	<.015	.353	.015	<.004	.040	[2].061
			RA	.056	<.107	.053	<.002	<.001	.17	.028	.350	.015	<.004	.040	.051
3,775	S	13:56	UFA	[2].035	<.107	.045	<.002	<.001	.023	<.015	.347	.014	<.004	.039	[2].078
			FA	.025	<.107	.048	<.002	.001	.058	<.015	.351	.015	<.004	.040	[2].108
			RA	.060	<.107	.053	<.002	<.001	.17	.038	.347	.017	<.004	.040	.096
4,035	S	13:40	UFA	[2].037	<.107	.046	<.002	.001	.023	<.015	.339	.014	<.004	.039	<.001
			FA	.024	<.107	.048	<.002	.001	.059	<.015	.343	.015	<.004	.040	[2].123
			RA	.057	<.107	.052	<.002	<.001	.17	.048	.341	.016	<.004	.040	.096
4,200	RBI	13:25	FA	<.021	<.107	.044	<.002	<.001	.017	<.015	.002	<.001	<.004	.045	.028
			RA	.12	<.107	.045	<.002	<.001	.12	<.015	.002	.007	<.004	.045	.048
4,255	RBI	13:20	FA	.022	<.107	.101	<.002	.001	.022	<.015	.005	.002	<.004	.048	.069
			RA	.57	<.117	.197	<.002	.005	1.47	.130	.006	.062	<.004	.058	.104
4,385	S	13:10	UFA	[2].041	<.107	.046	<.002	[2].003	.026	<.015	.335	.013	<.004	.040	<.001
			FA	.026	<.107	.048	<.002	<.001	.051	<.015	.333	.013	<.004	.040	[2].101
			RA	.047	<.107	.049	<.002	<.001	.14	.023	.328	.015	<.004	.040	.098
4,435	LBI	13:05	FA	<.021	<.107	.052	<.002	<.001	.015	<.015	.012	<.001	<.004	.047	.036
			RA	.030	<.107	.053	<.002	<.001	.032	<.015	.012	.001	<.004	.047	.066
4,515	RBI	13:00	RA	.051	<.107	.054	<.002	<.001	.20	.022	.237	.037	<.004	.043	.076
4,665	S	12:50	UFA	[2].034	<.107	.047	<.002	<.001	.023	<.015	.243	.009	<.004	.041	<.001
			FA	.024	<.107	.049	<.002	<.001	.043	<.015	.246	.010	<.004	.042	[2].106
			RA	.046	<.107	.051	<.002	<.001	.11	.022	.245	.011	<.004	.042	.080
4,965	S	12:35	UFA	<.021	<.107	.050	<.002	.001	.025	<.015	.252	.009	<.004	.043	[2].496
			FA	.024	<.107	.050	<.002	<.001	.041	<.015	.240	.009	<.004	.042	[2].083
			RA	.048	<.107	.052	<.002	<.001	.13	.028	.238	.012	<.004	.042	.079
5,065	RBI	12:10	FA	<.021	<.107	.042	<.002	<.001	.015	<.015	.002	<.001	<.004	.058	[2].047
			RA	.022	<.107	.042	<.002	<.001	.019	<.015	.002	<.001	<.004	.059	.045
5,138	S	12:00	UFA	[2].033	<.107	.049	<.002	<.001	.033	<.015	.228	.010	<.004	.042	.023
			FA	.025	<.107	.050	<.002	<.001	.036	<.015	.225	.009	<.004	.042	.065
			RA	.051	<.107	.053	<.002	<.001	.12	.025	.228	.012	<.004	.043	.121
5,140	RBI	11:55	FA	<.021	<.107	.046	<.002	<.001	.017	<.015	.002	<.001	<.004	.057	.033
			RA	.062	<.107	.046	<.002	<.001	.061	<.015	.002	.001	<.004	.058	.038
5,370	S	11:35	UFA	<.021	<.107	.049	<.002	[2].006	.027	<.015	.223	.007	<.004	.042	[2].599
			FA	.025	<.107	.050	<.002	<.001	.038	<.015	.222	.008	<.004	.043	.065
			RA	.052	<.107	.052	<.002	<.001	.10	.021	.220	.011	<.004	.042	.149
5,715	S	11:25	UFA	[2].038	<.107	.050	<.002	<.001	.024	<.015	.216	.009	<.004	.042	.014
			FA	.026	<.107	.052	<.002	<.001	.043	<.015	.212	.010	<.004	.042	.076
			RA	.051	<.107	.053	<.002	<.001	.11	.020	.212	.012	<.004	.042	.090

Table 3. Chemical analyses of trace elements in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Al	As	Ba	Cd	Cu	Fe	Pb	Li	Mn	Ni	Sr	Zn
6,065	S	11:05	UFA	<.021	<.107	.053	<.002	[2].007	.031	<.015	.217	.014	<.004	.043	[2].733
			FA	.029	<.107	.053	<.002	<.001	.042	<.015	.208	.012	<.004	.043	.060
			RA	.056	<.107	.055	<.002	<.001	.12	.029	.209	.015	<.004	.043	.100
6,275	S	17:15	UFA	<.021	<.107	.055	<.002	.001	.023	[2].020	.204	.008	<.004	.044	[2].540
			FA	.024	<.107	.056	<.002	<.001	.043	<.015	.202	.009	<.004	.043	.060
			RA	.052	<.107	.057	<.002	<.001	.11	.023	.198	.013	<.004	.043	.065
6,275	S	10:55	UFA	<.021	<.107	.052	<.002	.001	.022	<.015	.212	.010	<.004	.044	[2].464
			FA	.024	<.107	.052	<.002	<.001	.044	<.015	.203	.011	<.004	.043	.066
			RA	.059	<.107	.055	<.002	<.001	.14	.021	.204	.015	<.004	.043	.102
6,290	RBI	10:50	FA	.023	<.107	.046	<.002	<.001	.020	<.015	.001	<.001	<.004	.046	.099
			RA	.036	<.107	.046	<.002	.001	.059	<.015	.001	.002	<.004	.046	.129
6,452	S	10:40	UFA	[2].041	<.107	.051	<.002	<.001	.026	<.015	.171	.009	<.004	.044	.036
			FA	.024	<.107	.051	<.002	<.001	.041	<.015	.166	.009	<.004	.043	.075
			RA	.072	<.107	.055	<.002	<.001	.15	.030	.168	.014	<.004	.044	.136
6,717	S	10:25	UFA	<.021	<.107	.050	<.002	.001	.25	<.015	.167	.007	<.004	.044	[2].644
			FA	.026	<.107	.051	<.002	<.001	.035	<.015	.163	.008	<.004	.043	.073
			RA	.20	<.107	.064	<.002	.002	.36	.071	.165	.028	<.004	.044	.137
8,387	S	16:25	UFA	<.021	<.107	.535	<.002	[2].005	.024	<.015	.151	.003	<.004	.046	[2].343
			FA	.027	<.107	.054	<.002	[2].002	.032	<.015	.152	.004	<.004	.046	.091
			RA	.043	<.107	.059	<.002	<.001	.084	<.015	.156	.005	<.004	.046	.035
8,407	RBI	16:00	UFA	.038	<.107	.044	<.002	<.001	.022	<.015	<.001	<.001	<.004	.064	<.001
			FA	.021	<.107	.047	<.002	<.001	.016	<.015	.001	<.001	<.004	.065	[2].055
			RA	.040	<.107	.045	<.002	<.001	.038	<.015	.001	.003	<.004	.064	.030
8,507	S	15:45	UFA	.032	<.107	.052	<.002	<.001	.024	<.015	.143	.003	<.004	.045	<.001
			FA	.026	<.107	.055	<.002	<.001	.033	<.015	.150	.004	<.004	.047	[2].095
			RA	.047	<.107	.059	<.002	<.001	.092	<.015	.151	.005	<.004	.047	.036
10,287	S	13:05	UFA	.035	<.107	.048	<.002	<.001	.021	<.015	.085	<.001	<.004	.102	<.001
			FA	.035	<.107	.053	<.002	<.001	.055	<.015	.094	.002	<.004	.107	[2].071
			RA	.036	<.107	.052	<.002	<.001	.047	<.015	.090	<.001	<.004	.104	.024
10,307	RBI	12:45	UFA	.034	<.107	.044	<.002	[2].002	.024	<.015	<.001	<.001	<.004	.272	.032
			FA	<.021	<.107	.047	<.002	<.001	.019	<.015	.002	<.001	<.004	.279	[2].084
			RA	.033	<.107	.045	<.002	<.001	.053	<.015	.001	.001	<.004	.278	.040
10,407	S	12:20	UFA	.035	<.107	.048	<.002	<.001	.022	<.015	.082	<.001	<.004	.104	.031
			FA	.021	<.107	.049	<.002	<.001	.024	<.015	.087	.001	<.004	.105	.068
			RA	.031	<.107	.053	<.002	<.001	.045	<.015	.089	<.001	<.004	.106	.023
11,962	S	11:10	UFA	.030	<.107	.042	<.002	<.001	.027	<.015	.036	<.001	<.004	.981	<.001
			FA	.023	<.107	.043	<.002	<.001	.020	<.015	.037	<.001	<.004	.981	[2].059
			RA	.027	<.107	.045	<.002	<.001	.029	<.015	.036	<.001	<.004	.978	.008

Table 3. Chemical analyses of trace elements in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Al	As	Ba	Cd	Cu	Fe	Pb	Li	Mn	Ni	Sr	Zn
Mary Ellen Gulch															
163	S	16:12	UFA	1.7	<.03	.022	.002	.300	1.05	.019	<.001	.058	.013	.021	.235
			FA	1.8	<.03	.024	.003	.220	1.10	.016	<.001	.056	.015	.020	.200
			RA	1.8	<.03	.024	.002	.200	1.40	.009	<.001	.058	.016	.019	.200
172	S	16:10	UFA	1.6	<.03	.020	.002	.200	.910	.015	<.001	.050	.009	.020	[1].190
			FA	1.5	<.03	.018	<.001	.210	.920	<.006	<.001	.051	.010	.020	[1].180
			RA	1.5	<.03	.021	.002	.180	1.20	.012	<.001	.051	.011	.021	.150
178	RBI	16:10	FA	2.9	<.03	.019	.003	.033	3.60	.018	<.001	.074	.018	.023	.230
			RA	2.5	<.03	.018	.002	.029	4.15	.010	<.001	.075	.015	.023	.230
270	S	16:00	UFA	1.7	<.03	.020	.002	.180	.470	.012	<.001	.059	.011	.019	[2].215
			FA	1.6	<.03	.025	.002	.170	.465	.008	<.001	.056	.012	.020	[2].190
			RA	1.8	<.03	.022	.003	.150	.490	<.006	<.001	.047	.014	.020	.180
370	S	15:50	UFA	1.7	<.03	.031	.002	.210	.190	.014	<.001	.068	.012	.021	[2].195
			FA	1.5	<.03	.023	<.001	.200	.185	.013	<.001	.059	.014	.021	.165
			RA	1.7	<.03	.033	.003	.160	.185	<.006	<.001	.056	.013	.017	.190
397	RBI	15:50	FA	<.080	<.03	.026	<.001	.014	.014	<.006	<.001	.001	<.002	.044	.010
			RA	<.080	<.03	.032	<.001	.005	.061	<.006	<.001	.005	<.002	.046	.006
447	S	15:42	UFA	1.9	<.03	.026	.002	.200	.145	.012	<.001	.062	.012	.024	.180
			FA	1.7	<.03	.027	.002	.180	.165	.015	<.001	.060	.009	.022	.190
			RA	1.9	<.03	.026	.002	.190	.175	.016	<.001	.054	.011	.024	.170
488	RBI	15:40	FA	<.080	<.03	.027	<.001	.003	.013	<.006	<.001	<.001	<.002	.039	.012
			RA	.093	<.03	.022	<.001	.008	.083	<.006	<.001	.004	<.002	.039	.012
540	S	15:33	UFA	.160	<.03	.022	<.001	.030	.010	<.006	<.001	.022	.004	.033	[1].055
			FA	.220	<.03	.026	<.001	.021	.009	<.006	<.001	.020	.003	.034	.039
			RA	.620	<.03	.026	<.001	.064	.061	<.006	<.001	.021	.004	.035	.055
633	RBI	15:30	UFA	<.080	<.03	.029	<.001	.015	.008	<.006	<.001	.001	<.002	.040	[2].020
			FA	<.080	<.03	.030	<.001	<.001	.015	<.006	<.001	<.001	<.002	.037	[2].019
633	RBI	15:30	RA	<.080	<.03	.028	<.001	.002	<.008	<.006	<.001	<.001	<.002	.041	.010
685	S	15:23	UFA	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
			FA	.240	<.03	.026	<.001	.013	<.008	<.006	<.001	.011	<.002	.036	.018
			RA	.350	<.03	.021	<.001	.026	.032	<.006	<.001	.010	.002	.035	.028
735	S	15:20	UFA	.190	<.03	.027	<.001	<.001	.013	<.006	<.001	.010	<.002	.033	.028
			FA	.190	<.03	.027	<.001	.017	.010	.009	<.001	.010	.003	.035	.021
			RA	.320	<.03	.028	<.001	.008	.029	<.006	<.001	.009	<.002	.031	.027
758	S	15:12	UFA	.160	<.03	.028	.001	.008	<.008	<.006	<.001	.008	.002	.035	.057
			FA	.180	<.03	.028	<.001	.010	.020	<.006	<.001	.008	<.002	.036	.048
			RA	.280	<.03	.028	<.001	.017	.026	<.006	<.001	.007	<.002	.034	.054
760	RBI	15:10	FA	<.080	<.03	.061	<.001	.004	.010	<.006	<.001	<.001	<.002	.035	.009
			RA	<.080	<.03	.050	<.001	<.001	.031	<.006	<.001	.002	<.002	.030	.006

Table 3. Chemical analyses of trace elements in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Al	As	Ba	Cd	Cu	Fe	Pb	Li	Mn	Ni	Sr	Zn
763	RBI	15:07	FA	.090	<.03	.053	<.001	.010	.009	<.006	<.001	<.001	<.002	.029	.010
			RA	<.080	<.03	.056	<.001	<.001	.042	<.006	<.001	.004	<.002	.030	.007
842	S	14:55	UFA	.120	<.03	.029	<.001	.014	.014	.009	<.001	.006	<.002	.036	.051
			FA	.170	<.03	.036	.002	.012	.019	<.006	<.001	.004	<.002	.034	[1].058
			RA	.180	<.03	.030	<.001	.011	.025	<.006	<.001	.005	<.002	.037	.047
858	RBI	14:53	UFA	<.080	<.03	.035	<.001	.010	.008	<.006	<.001	.001	<.002	.047	.019
			FA	<.080	<.03	.028	<.001	.010	.009	<.006	<.001	<.001	<.002	.042	.018
			RA	<.080	<.03	.029	<.001	<.001	.021	<.006	<.001	.001	<.002	.040	.014
908	S	14:43	UFA	.110	<.03	.029	.001	.017	<.008	<.006	<.001	.011	.003	.038	.099
			FA	.120	<.03	.037	.003	.015	.023	<.006	<.001	.017	<.002	.035	.125
			RA	.140	<.03	.034	.002	.002	.030	<.006	<.001	.010	<.002	.034	.120
932	RBI	14:45	FA	.110	<.03	.021	.043	.011	9.30	.019	<.001	.250	.046	.063	7.4
			RA	.890	.040	.051	.046	.058	22	.960	<.001	.250	.046	.063	7.6
950	S	14:35	UFA	.120	<.03	.032	.001	.008	<.008	<.006	<.001	.010	.003	.038	.105
			FA	.140	<.03	.033	.001	.005	.014	.006	<.001	.010	<.002	.036	.115
			RA	.140	<.03	.038	.002	<.001	.052	.007	<.001	.011	.002	.035	.135
950	S	14:34	UFA	.110	<.03	.032	.001	.010	<.008	<.006	<.001	.010	<.002	.037	.099
			FA	.120	<.03	.031	<.001	.004	.015	<.006	<.001	.010	<.002	.037	.099
			RA	.160	<.03	.034	.001	.011	.150	.021	<.001	.011	.002	.037	.125
1,027	S	14:23	UFA	.100	<.03	.035	.001	.008	<.008	<.006	<.001	.018	<.002	.037	.105
			FA	.100	<.03	.030	.002	.004	.047	<.006	<.001	.016	<.002	.034	.120
			RA	.150	<.03	.036	<.001	.010	.255	.015	<.001	.017	<.002	.037	.150
[3]1,090	RBI	14:18	FA	NA	.070	.014	.001	.015	7.80	<.006	NA	.210	NA	NA	.800
1,146	S	14:11	UFA	<.080	<.03	.010	<.001	.002	<.008	<.006	<.001	.066	.005	.028	.110
			FA	.081	<.03	.025	<.001	<.001	.016	<.006	<.001	.070	.007	.053	.120
			RA	.130	.035	.022	.001	.013	2.05	.010	<.001	.064	.005	.051	.280
1,231	S	14:05	UFA	<.080	<.03	.023	.001	.007	.008	<.006	<.001	.061	.004	.052	.062
			FA	<.080	<.03	.024	.001	<.001	.059	<.006	<.001	.067	.005	.054	.092
			RA	.100	.032	.023	<.001	.006	1.65	.012	<.001	.066	.004	.054	.260
1,294	S	13:55	UFA	.088	<.03	.019	<.001	.007	<.008	<.006	<.001	.067	.004	.053	.092
			FA	.086	<.03	.021	<.001	.002	.027	<.006	<.001	.066	.004	.051	.115
			RA	.170	<.03	.022	.001	.026	1.45	.009	<.001	.065	.004	.049	.240
1,312	RBI	13:53	FA	<.080	<.03	.059	.006	.052	.020	<.006	<.001	.054	.005	.039	.370
			RA	3.2	.050	.180	.014	.950	9.90	.890	<.001	.065	.016	.045	1.8
1,354	S	13:43	UFA	.100	<.03	.022	.001	.016	.013	<.006	<.001	.059	.003	.047	.087
			FA	.120	<.03	.020	<.001	.009	.049	<.006	<.001	.064	.005	.051	.120
			RA	.170	<.03	.028	.002	.043	1.50	.013	<.001	.073	.004	.053	.350
1,362	LBI	13:42	UFA	<.080	<.03	.041	<.001	<.001	.021	<.006	<.001	.002	.002	.045	.002
			FA	<.080	<.03	.041	<.001	.007	<.008	<.006	<.001	.003	<.002	.046	.003
			RA	.150	<.03	.043	<.001	.004	.037	<.006	<.001	.005	.002	.049	.003

Table 3. Chemical analyses of trace elements in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Al	As	Ba	Cd	Cu	Fe	Pb	Li	Mn	Ni	Sr	Zn
1,438	S	13:34	UFA	.091	<.03	.027	<.001	.009	<.008	<.006	<.001	.041	<.002	.048	.091
			FA	.110	<.03	.034	.001	<.001	.027	<.006	<.001	.039	<.002	.047	.097
			RA	.150	<.03	.029	<.001	.015	.685	<.006	<.001	.040	.003	.046	.160
1,462	RBI	13:32	UFA	<.080	<.03	.130	.002	.005	.010	<.006	<.001	.180	.002	.065	.290
			FA	<.080	<.03	.120	.002	<.001	.019	<.006	<.001	.170	<.002	.062	.260
			RA	<.080	<.03	.130	.008	.022	6.80	.011	<.001	.190	<.002	.065	.820
1,484	S	13:15	UFA	<.080	.032	.028	<.001	.019	.016	<.006	<.001	.042	<.002	.047	.093
			FA	<.080	.043	.025	<.001	.018	.035	<.006	<.001	.041	<.002	.049	.090
			RA	.130	<.03	.034	.002	.023	.680	.009	<.001	.042	.003	.047	.165
1,514	RBI	13:08	UFA	<.080	<.03	.110	<.001	.003	<.008	<.006	<.001	.042	<.002	.057	.031
			FA	<.080	<.03	.120	<.001	.001	.050	<.006	<.001	.044	<.002	.059	.034
			RA	<.080	<.03	.130	<.001	<.001	.565	<.006	<.001	.043	<.002	.055	.041
1,564	S	12:56	UFA	.086	<.03	.032	<.001	.012	<.008	<.006	<.001	.040	.002	.050	.084
			FA	<.080	<.03	.034	<.001	.006	.021	<.006	<.001	.040	.002	.049	.086
			RA	.140	<.03	.031	.001	.033	.510	<.006	<.001	.035	.006	.049	.150
1,725	S	12:49	UFA	<.080	<.03	.032	.001	.012	.013	<.006	<.001	.032	<.002	.047	.070
			FA	.110	<.03	.031	<.001	.006	.036	<.006	<.001	.031	.003	.047	.088
			RA	.120	<.03	.036	<.001	.012	.430	.007	<.001	.036	.003	.051	.140
1,734	RBI	12:47	FA	<.080	<.03	.053	<.001	<.001	.011	.008	<.001	<.001	<.002	.042	.009
			RA	<.080	<.03	.057	<.001	<.001	.010	<.006	<.001	<.001	<.002	.043	.011
1,753	S	12:43	UFA	<.080	<.03	.033	<.001	.009	<.008	<.006	<.001	.025	.003	.047	.070
			FA	<.080	<.03	.038	<.001	.014	.022	.010	<.001	.026	.003	.047	.079
			RA	<.080	<.03	.043	.002	.007	.385	.013	<.001	.030	.004	.046	.125
1,758	LBI	12:40	UFA	.082	<.03	.011	<.001	.014	.012	<.006	<.001	.025	.003	.029	.052
			FA	.081	<.03	.028	<.001	.005	.028	<.006	<.001	.026	<.002	.045	.062
			RA	.120	<.03	.028	<.001	.011	.365	.010	<.001	.027	.003	.045	.097
1,841	S	12:30	UFA	<.080	<.03	.041	<.001	.005	<.008	<.006	<.001	.024	<.002	.049	.079
			FA	.120	<.03	.037	<.001	.007	.024	<.006	<.001	.022	<.002	.047	.076
			RA	.093	.035	.037	<.001	.008	.255	<.006	<.001	.024	<.002	.048	.110
1,847	RBI	12:25	FA	<.080	<.03	.059	<.001	.002	<.008	<.006	<.001	<.001	<.002	.039	.052
			RA	<.080	<.03	.065	<.001	<.001	<.008	<.006	<.001	<.001	<.002	.045	.050
1,947	S	12:17	UFA	<.080	<.03	.039	<.001	.005	<.008	<.006	<.001	.017	<.002	.047	.079
			FA	<.080	<.03	.041	<.001	.004	.021	<.006	<.001	.018	<.002	.045	.087
			RA	<.080	<.03	.042	<.001	.007	.160	.007	<.001	.019	<.002	.047	.099
1,975	LBI	12:10	UFA	<.080	<.03	.056	.002	[2].005	<.008	<.006	<.001	.002	<.002	.049	[1].240
			FA	.085	<.03	.054	.002	[2].005	<.008	<.006	<.001	<.001	<.002	.047	.210
			RA	<.080	<.03	.046	.002	.002	.070	<.006	<.001	.010	<.002	.047	.205
2,022	S	13:39	UFA	<.080	<.03	.040	.001	.003	.009	<.006	<.001	.014	<.002	.048	.080
			FA	.091	<.03	.046	.002	<.001	.017	<.006	<.001	.012	<.002	.045	.089
			RA	<.080	<.03	.047	<.001	.002	.225	.007	<.001	.016	<.002	.048	.115

Table 3. Chemical analyses of trace elements in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Al	As	Ba	Cd	Cu	Fe	Pb	Li	Mn	Ni	Sr	Zn
2,022	S	12:01	UFA	<.080	<.03	.046	<.001	.004	<.008	<.006	<.001	.017	<.002	.048	.086
			FA	<.080	<.03	.041	<.001	.004	.022	<.006	<.001	.016	<.002	.046	.090
			RA	<.080	<.03	.044	.001	.007	.180	<.006	<.001	.018	.004	.048	.105
2,172	S	11:53	UFA	<.080	<.03	.042	<.001	[2].009	.013	<.006	<.001	.015	.003	.048	.081
			FA	<.080	.031	.038	<.001	.005	.024	<.006	<.001	.015	<.002	.046	.100
			RA	<.080	<.03	.043	<.001	.005	.150	<.006	<.001	.016	<.002	.050	.110
2,320	S	11:42	UFA	<.080	<.03	.042	.002	[2].014	.015	<.006	<.001	.013	<.002	.045	.093
			FA	<.080	<.03	.041	<.001	.006	.021	<.006	<.001	.014	<.002	.043	.091
			RA	<.080	<.03	.036	<.001	.010	.180	.008	<.001	.014	<.002	.049	.098
2,555	S	11:29	UFA	<.080	<.03	.042	.001	<.001	.014	<.006	<.001	.010	<.002	.044	.100
			FA	<.080	<.03	.043	<.001	<.001	.016	.007	<.001	.009	.003	.046	.090
			RA	.097	<.03	.040	<.001	.003	.130	<.006	<.001	.010	<.002	.044	.110
2,756	S	11:09	UFA	<.080	<.03	.042	.001	<.001	.014	<.006	<.001	.007	<.002	.042	.071
			FA	<.080	<.03	.043	<.001	<.001	.013	.008	<.001	.007	.004	.046	.082
			RA	.086	<.03	.049	<.001	<.001	.245	.007	<.001	.012	<.002	.042	.125
2,988	S	11:00	UFA	<.080	<.03	.043	<.001	.002	<.008	<.006	<.001	.005	<.002	.046	.076
			FA	<.080	<.03	.041	.001	.007	.013	<.006	<.001	.006	.002	.047	.084
			RA	.081	<.03	.044	<.001	<.001	.150	.012	<.001	.007	<.002	.039	.110
3,238	S	10:46	UFA	<.080	<.03	.043	<.001	[2].006	<.008	<.006	<.001	.004	<.002	.047	.064
			FA	<.080	<.03	.037	.001	[2].008	.017	<.006	<.001	.004	<.002	.043	.079
			RA	.097	<.03	.043	.001	.004	.125	<.006	<.001	.005	.003	.045	.100
3,377	S	10:37	UFA	<.080	<.03	.045	.001	<.001	.014	<.006	<.001	.003	<.002	.044	.125
			FA	<.080	<.03	.046	<.001	.001	.015	.014	<.001	.003	<.002	.047	.105
			RA	<.080	<.03	.051	.001	<.001	.115	<.006	<.001	.005	.002	.045	.110
3,580	S	10:27	UFA	<.080	<.03	.044	<.001	<.001	.014	<.006	<.001	.002	<.002	.043	[2].160
			FA	<.080	<.03	.046	<.001	<.001	.010	.008	<.001	.002	<.002	.047	.135
			RA	<.080	<.03	.048	.001	.011	.130	.011	<.001	.005	<.002	.046	.098
3,592	LBI	10:25	FA	.099	<.03	.058	<.001	.005	.039	<.006	<.001	.001	<.002	.037	[2].036
			RA	<.080	<.03	.059	<.001	<.001	.185	<.006	<.001	.012	<.002	.034	.013
3,724	S	10:12	UFA	<.080	<.03	.047	<.001	[2].007	.009	<.006	<.001	.002	<.002	.049	.076
			FA	<.080	<.03	.049	<.001	.002	.010	<.006	<.001	.001	<.002	.048	.080
			RA	<.080	<.03	.044	.001	<.001	.063	<.006	<.001	.002	<.002	.042	.085
3,974	S	10:02	UFA	<.080	<.03	.051	.001	[2].009	.011	<.006	<.001	.002	<.002	.049	[2].160
			FA	<.080	<.03	.045	<.001	[2].004	.018	<.006	<.001	.001	<.002	.048	.096
			RA	<.080	<.03	.039	.001	<.001	.049	<.006	<.001	<.001	<.002	.037	.081
4,276	S	9:46	UFA	<.080	<.03	.045	<.001	<.001	.013	<.006	<.001	<.001	<.002	.046	.067
			FA	<.080	<.03	.050	.001	<.001	.021	<.006	<.001	<.001	<.002	.046	.084
			RA	<.080	<.03	.052	.002	<.001	.052	<.006	<.001	.002	.002	.048	.081

Table 3. Chemical analyses of trace elements in water samples from American Fork, October 1999, and Mary Ellen Gulch, Utah, September 2000.—Continued

Distance (m)	Source	Sample time	Filter	Al	As	Ba	Cd	Cu	Fe	Pb	Li	Mn	Ni	Sr	Zn
4,600	S	9:30	UFA	<.080	<.03	.045	<.001	[2].006	<.008	<.006	<.001	<.001	<.002	.050	.090
			FA	.089	<.03	.046	<.001	[2].006	<.008	<.006	<.001	<.001	<.002	.048	.085
			RA	.088	<.03	.056	<.001	<.001	.051	<.006	<.001	<.001	.003	.045	.092
4,603	LBI	12:40	UFA	<.080	<.03	.059	<.001	[2].005	.008	<.006	<.001	.017	<.002	.043	.026
			FA	<.080	<.03	.059	<.001	<.001	.047	<.006	<.001	.016	<.002	.045	.027
			RA	<.080	<.03	.066	<.001	<.001	.080	.010	<.001	.019	<.002	.046	.030
4,713	S	12:55	UFA	<.080	<.03	.057	<.001	<.001	.011	<.006	<.001	.013	<.002	.046	.028
			FA	<.080	<.03	.064	<.001	<.001	.031	<.006	<.001	.013	<.002	.046	.028
			RA	<.080	<.03	.054	<.001	<.001	.080	<.006	<.001	.014	<.002	.043	.034
4,765	S	13:10	UFA	<.080	<.03	.052	<.001	.004	<.008	<.006	<.001	.012	<.002	.047	.026
			FA	<.080	<.03	.055	<.001	.004	.042	.008	<.001	.012	<.002	.044	.037
			RA	.096	<.03	.055	<.001	.007	.115	.010	<.001	.015	<.002	.045	.039
4,863	S	13:25	UFA	<.080	<.03	.055	<.001	[2].003	.013	<.006	<.001	.011	<.002	.047	.021
			FA	.084	<.03	.058	<.001	[2].004	.031	<.006	<.001	.010	<.002	.046	.027
			RA	<.080	<.03	.063	<.001	<.001	.145	.008	<.001	.019	<.002	.044	.033
5,030	S	13:40	UFA	<.080	<.03	.059	<.001	[2].011	.008	<.006	<.001	.011	<.002	.047	.028
			FA	<.080	<.03	.056	<.001	<.001	.036	.007	<.001	.010	.004	.047	.026
			RA	<.080	<.03	.059	.002	.003	.125	.014	<.001	.015	.003	.042	.044

[1] Possible contamination

[2] Contamination, the sample was not used

[3] USGS sample lost in field, used results from a U.S. Forest Service sample

Table 4. Method detection limits and relative standard deviation of quality-assurance samples.

[MDL, method detection limit, in micrograms per liter; $CaCO_3$, calcium carbonate; NE, no equation]

Constituent	MDL	Relative standard deviation	
		Coefficient	Exponent
Calcium	416	7.7586	-.2861
Magnesium	101	2.4179	-.3756
Sodium	302	3.7271	-.2209
Potassium	36	2.2376	.1502
Alkalinity as $CaCO_3$	500	NE	NE
Sulfate	1,760	6.6228	-.3185
Chloride	480	3.7271	-.2209
Bromide	80	5.7087	-.3406
Silica, as Si	309	3.0626	.0624
Aluminum	.2	1.6461	-.4146
Arsenic	.01	3.6077	-.176
Barium	.1	1.2463	-.1304
Cadmium	.09	.6576	-.3452
Cobalt	.01	.1594	-.57
Chromium	.05	.8397	-.305
Copper	.04	3.7668	.0892
Iron	.3	1.3058	-.2804
Lead	.01	.7153	-.1152
Lithium	.5	1.0295	-.3813
Manganese	5	1.249	-.0496
Molybdenum	.04	.8158	-.2531
Nickel	.37	1.3722	-.4094
Silver	.01	3.2254	-.2851
Strontium	2	11.556	.0854
Uranium	.003	1.0411	-.0962
Vanadium	.01	.08742	-.2047
Zinc	22	.8362	-.7002

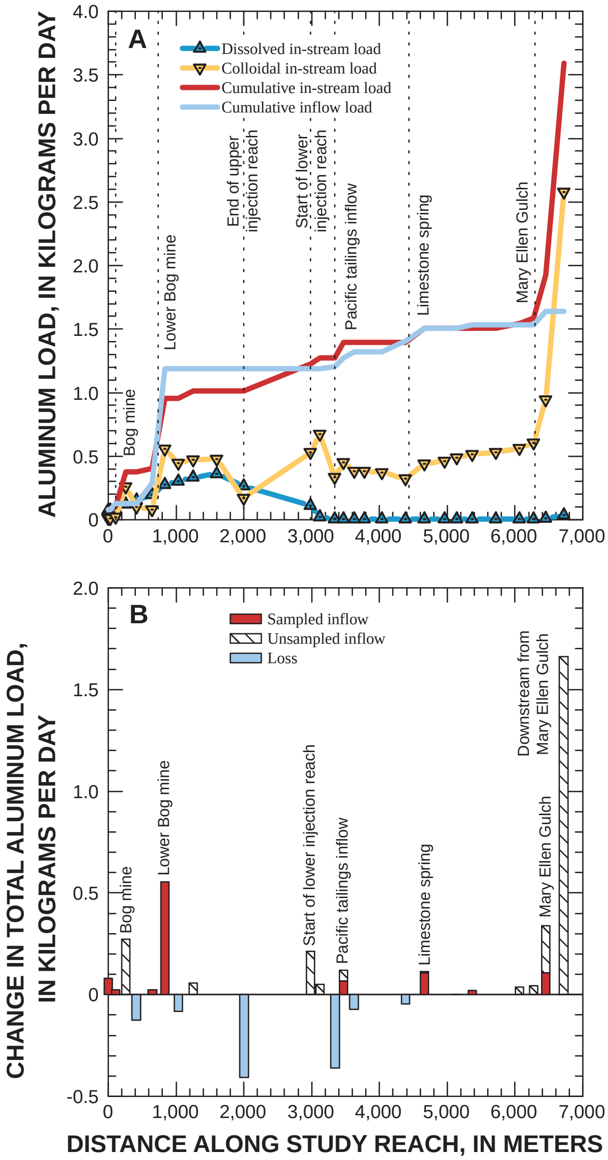

Figure 2. (A) Mass-loading profiles for aluminum and (B) change in aluminum load for individual stream segments, including unsampled inflow load, American Fork, Utah, October 1999.

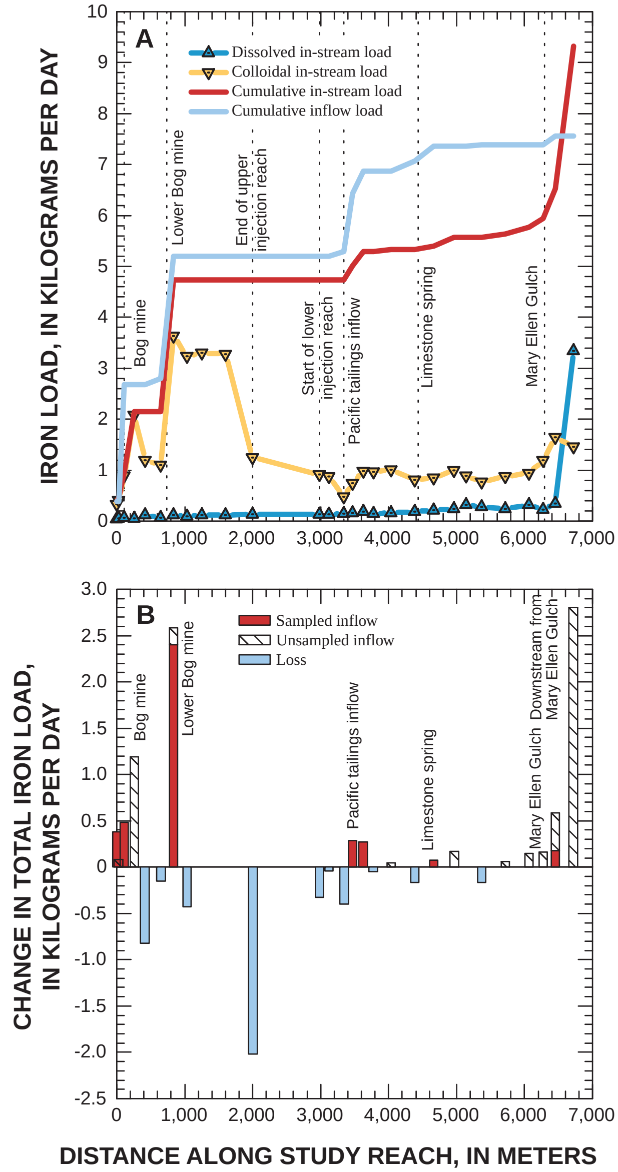

Figure 3. (A) Mass-loading profiles for iron and (B) change in iron load for individual stream segments, including unsampled inflow load, American Fork, Utah, October 1999.

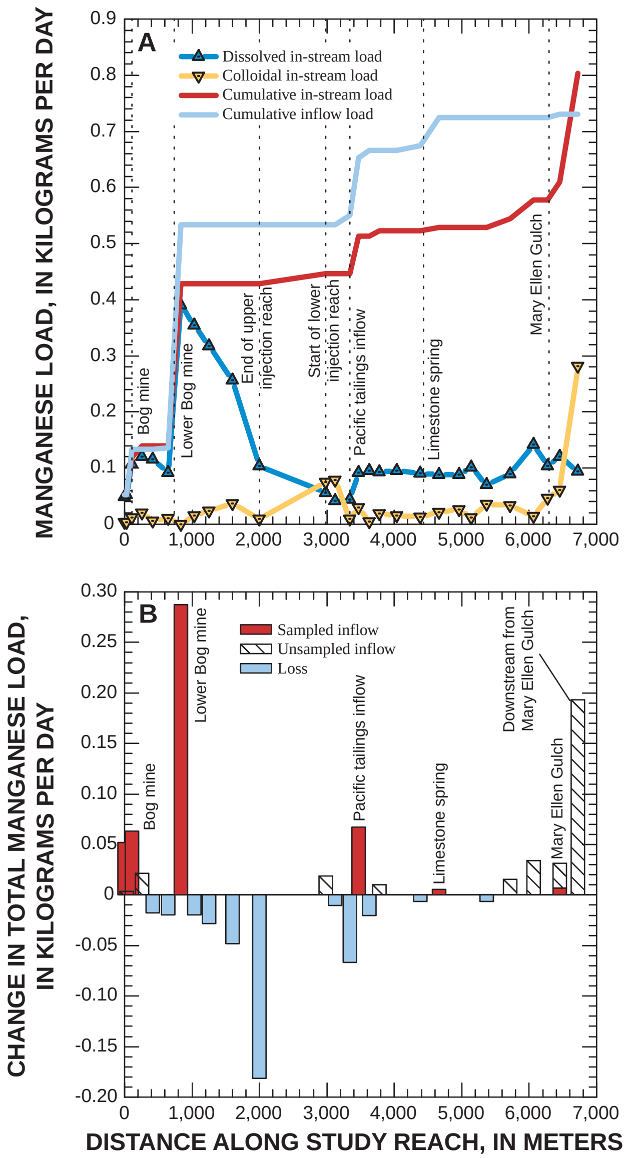

Figure 4. (A) Mass-loading profiles for manganese and (B) change in manganese load for individual stream segments, including unsampled inflow load, American Fork, Utah, October 1999.

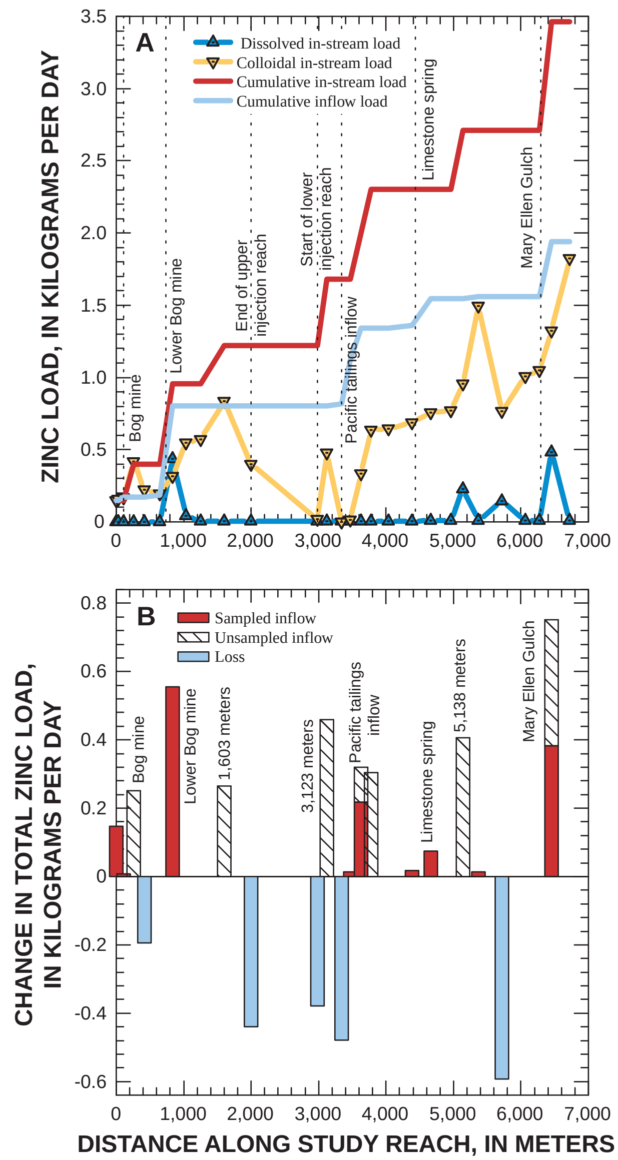

Figure 5. (A) Mass-loading profiles for zinc and (B) change in zinc load for individual stream segments, including unsampled inflow load, American Fork, Utah, October 1999.

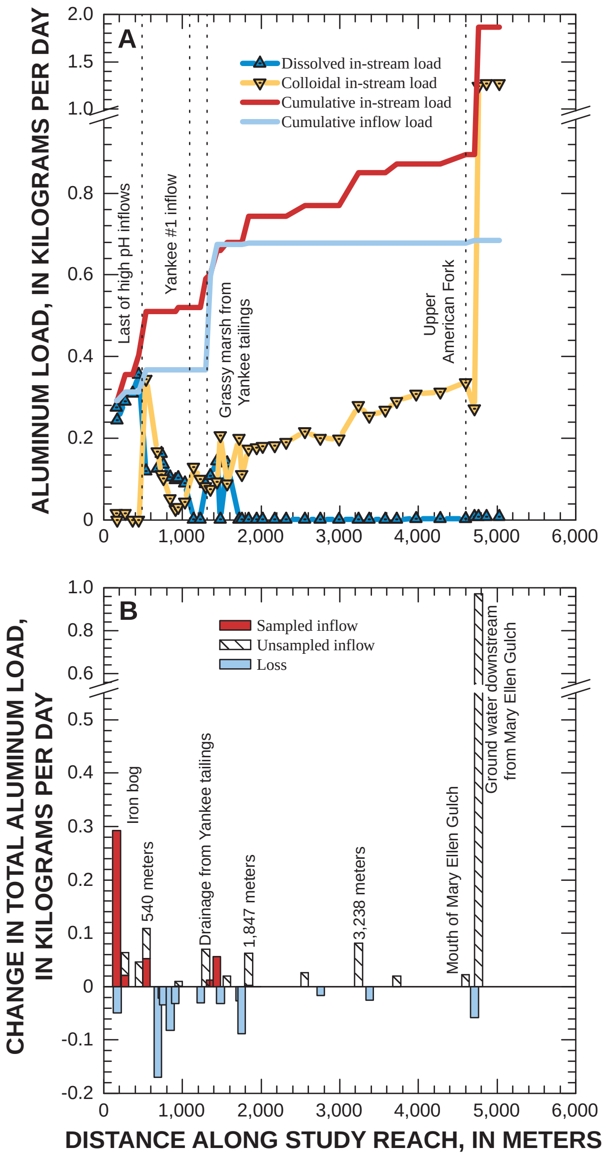

Figure 6. (A) Mass-loading profiles for aluminum and (B) change in aluminum load for individual stream segments, including unsampled inflow load, Mary Ellen Gulch, Utah, September 2000.

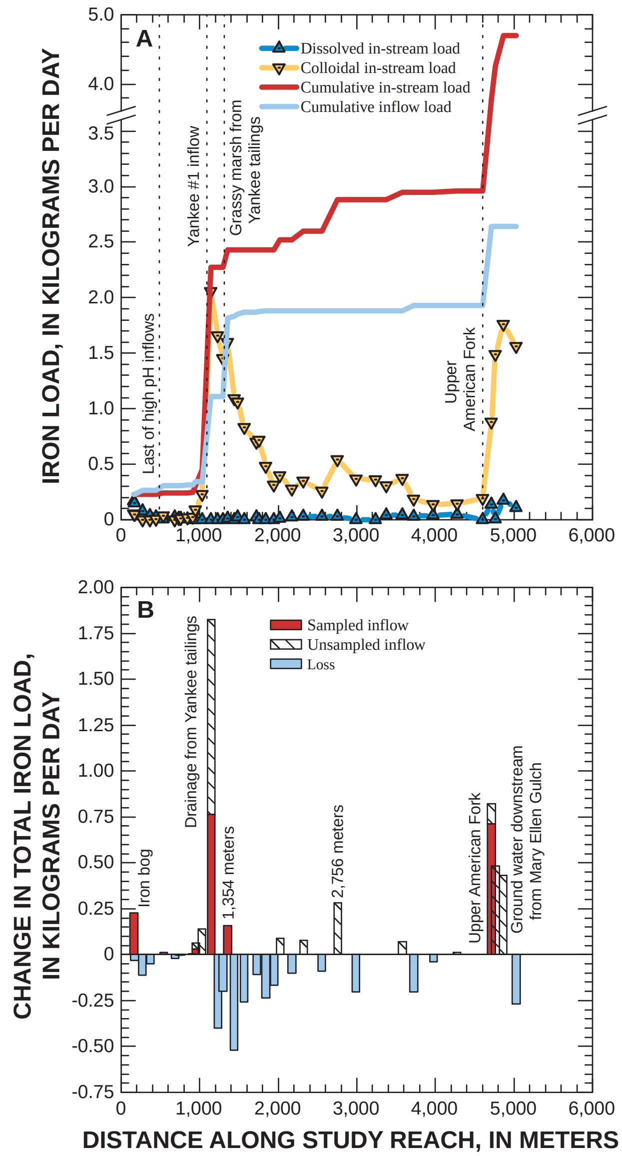

Figure 7. (A) Mass-loading profiles for iron and (B) change in iron load for individual stream segments, including unsampled inflow load, Mary Ellen Gulch, Utah, September 2000.

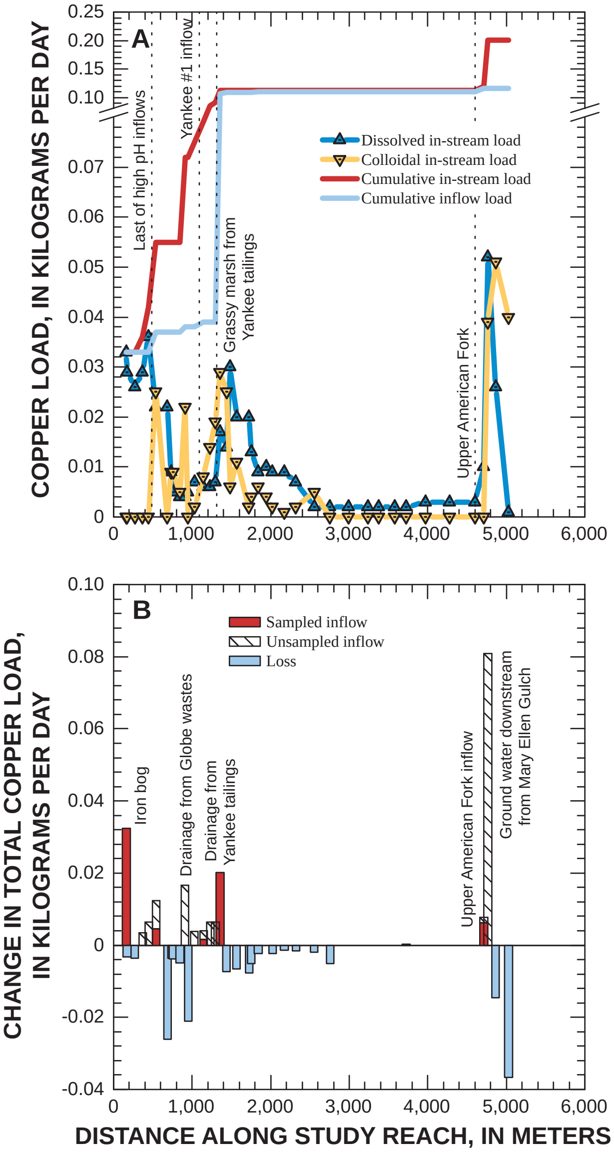

Figure 8. (A) Mass-loading profiles for copper and (B) change in copper load for individual stream segments, including unsampled inflow load, Mary Ellen Gulch, Utah, September 2000.

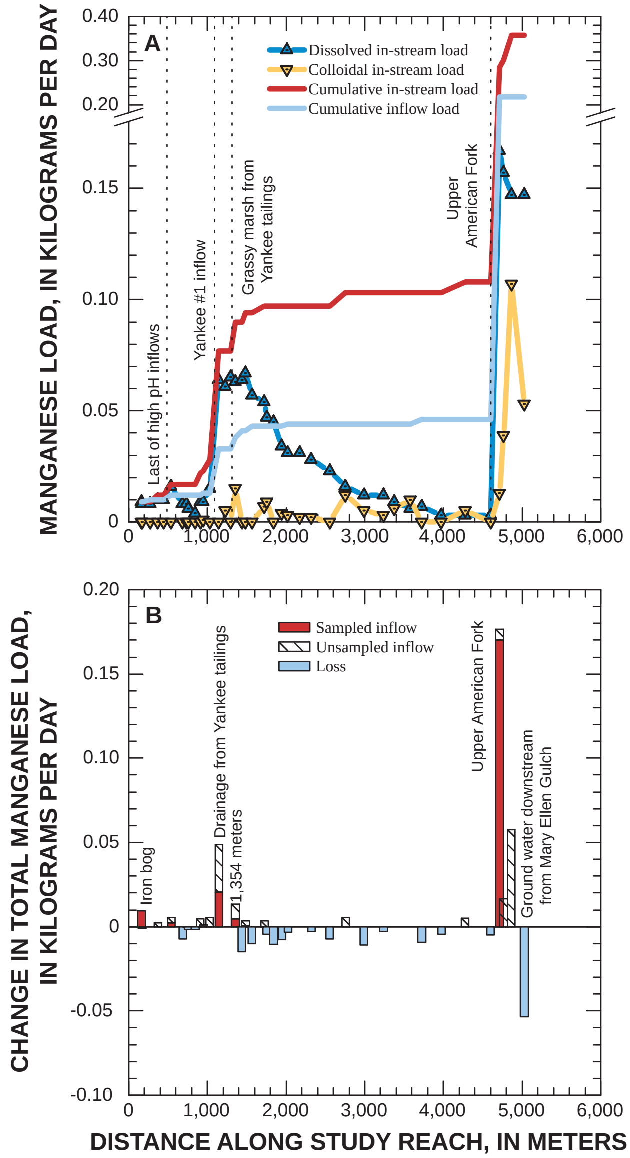

Figure 9. (A) Mass-loading profiles for manganese and (B) change in manganese load for individual stream segments, including unsampled inflow load, Mary Ellen Gulch, Utah, September 2000.

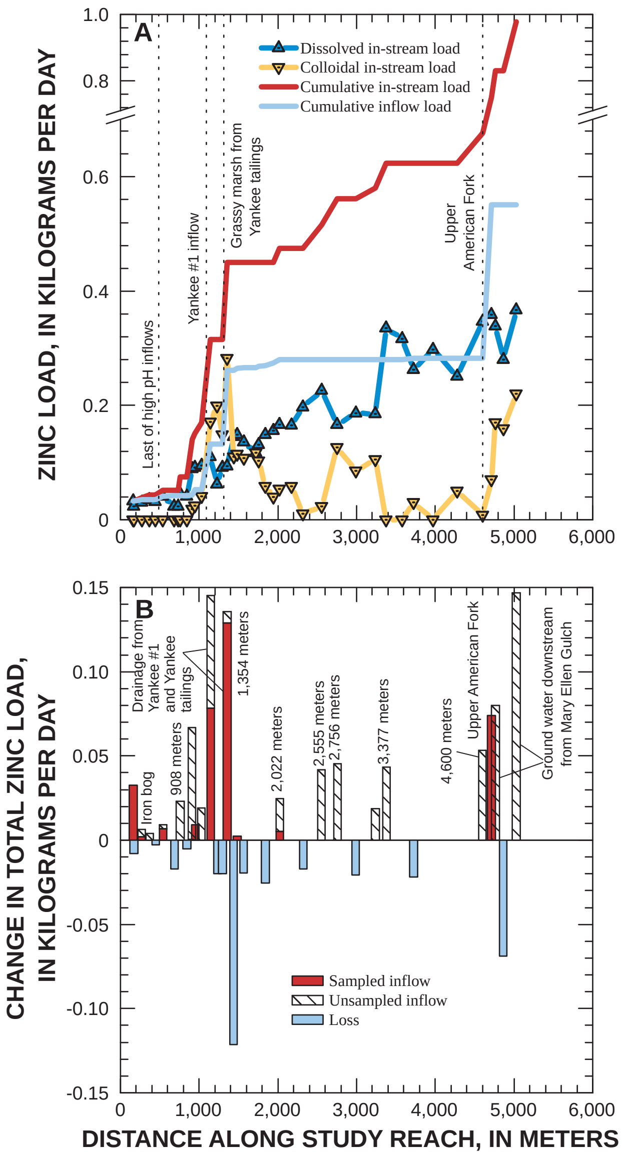

Figure 10. (A) Mass-loading profiles for zinc and (B) change in zinc load for individual stream segments, including unsampled inflow load, Mary Ellen Gulch, Utah, September 2000.

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