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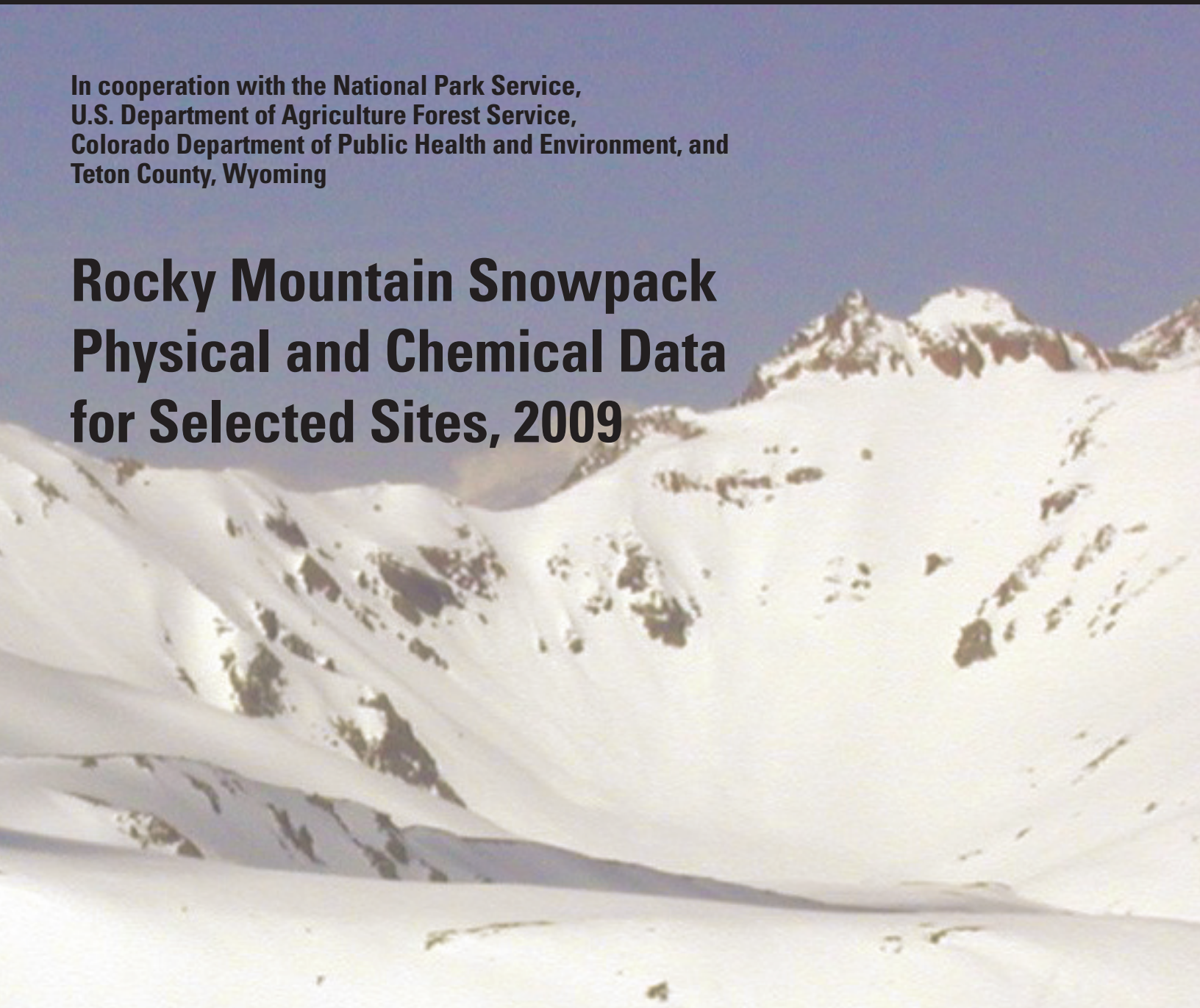
In cooperation with the National Park Service,
U.S. Department of Agriculture Forest Service,
Colorado Department of Public Health and Environment, and
Teton County, Wyoming

Rocky Mountain Snowpack Physical and Chemical Data for Selected Sites, 2009



Data Series 498

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

Cover photograph: The Continental Divide near Loveland Pass, Colorado.
Photograph by George P. Ingersoll, U.S. Geological Survey.

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U.S. Department of the Interior
KEN SALAZAR, Secretary

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
	Volume	
liter (L)	33.82	ounce, fluid
	Mass	
Nanogram (ng)	$3.53x10^{-11}$	ounce

µS/cm, microsiemens per centimeter
µeq/L, microequivalents per liter

To convert microequivalents per liter (µeq/L) to milligrams per liter for major ions, divide microequivalents by factors indicated for each ion:

To obtain milligrams per liter for	divide by
H^+	1,000
Ca^{2+}	49.90
Mg^{2+}	82.26
K^+	25.57
Na^+	43.50
NH_4^+	55.44
SO_4^{2-}	20.83
NO_3^-	16.13
Cl^-	28.21

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

$$°F=(1.8×°C)+32$$

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.

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Abstract

The Rocky Mountain Snowpack program established a network of snowpack-sampling sites in the Rocky Mountain region from New Mexico to Montana to monitor the chemical content of snow and to understand the effects of regional atmospheric deposition. The U.S. Geological Survey, in cooperation with the National Park Service; the U.S. Department of Agriculture Forest Service; the Colorado Department of Public Health and Environment; Teton County, Wyoming; and others, collected and analyzed snowpack samples annually for 48 or more sites in the Rocky Mountain region during 1993–2009. Sixty-three snowpack-sampling sites were sampled once each in 2009 and data are presented in this report. Data include acid-neutralization capacity, specific conductance, pH, hydrogen ion concentrations, dissolved concentrations of major constituents (calcium, magnesium, sodium, potassium, ammonium, chloride, sulfate, and nitrate), dissolved organic carbon concentrations, snow-water equivalent, snow depth, total mercury concentrations, and ionic charge balance. Quality-assurance data for field and laboratory blanks and field replicates for 2009 also are included.

Introduction

The U.S. Geological Survey (USGS), in cooperation with the National Park Service; the U.S. Department of Agriculture Forest Service; the Colorado Department of Public Health and Environment; Teton County, Wyoming; and others, has been collecting and analyzing snowpack samples from a network of 48 or more sites in the Rocky Mountain region since 1993 (Ingersoll and others, 2009). Because snowmelt supplies most of the freshwater in mountain lakes, streams, and wetlands in the Rocky Mountain region, monitoring the chemical content of snow is critical to understanding the effects of atmospheric deposition to these systems. As part of this cooperative program methods for measuring physical and chemical properties of seasonal snowpacks were developed for the purpose of determining atmospheric deposition in many areas of the region where no other monitoring has been done. Forty-eight of these snowpack sites have been sampled annually since 1993. In 2009, 63 snowpack-sampling sites were sampled once each. More details about the history of the program can be found in Ingersoll and others (2002; 2009). Results of the monitoring program can be found in other reports and publications (Ingersoll and others, 2002; Mast and others, 2005).

Purpose and Scope

The purpose of this report is to publish the 2009 Rocky Mountain snowpack physical and chemical data in an easily accessible document. This report contains tables listing site information, physical and chemical data, and quality-assurance data from snowpack samples collected and analyzed for 63 snowpack sites during 2009. These tables include location information, acid-neutralization capacity, specific conductance, pH, hydrogen ion concentrations, dissolved concentrations of major constituents (calcium, magnesium, sodium, potassium, ammonium, chloride, sulfate, and nitrate), dissolved organic carbon concentrations, snow-water equivalent, snow depth, total mercury concentrations, and ionic charge balance. These data are available with other similar snowpack data from earlier years at the USGS Web site: http://co.water.usgs.gov/projects/CO53100/data/index.html.

Study Area

To identify regional emission signals in atmospheric deposition of nitrogen, sulfur, and mercury, the snowpack-sampling sites were selected primarily along the Continental Divide in Montana, Idaho, Wyoming, Utah, Colorado, and New Mexico, in areas that are exposed to limited atmospheric emissions from local residential, commercial, or industrial activities (fig. 1). Snow-sampling sites were located at least 30 meters (m) away from plowed roadways to minimize contamination from vehicular traffic. Colorado and New Mexico sites range in elevations from about 2,500 to 3,600 m; sites in Idaho, Utah, Wyoming, and Montana typically are at lower elevations at about 1,500 to 3,300 m (table 1).

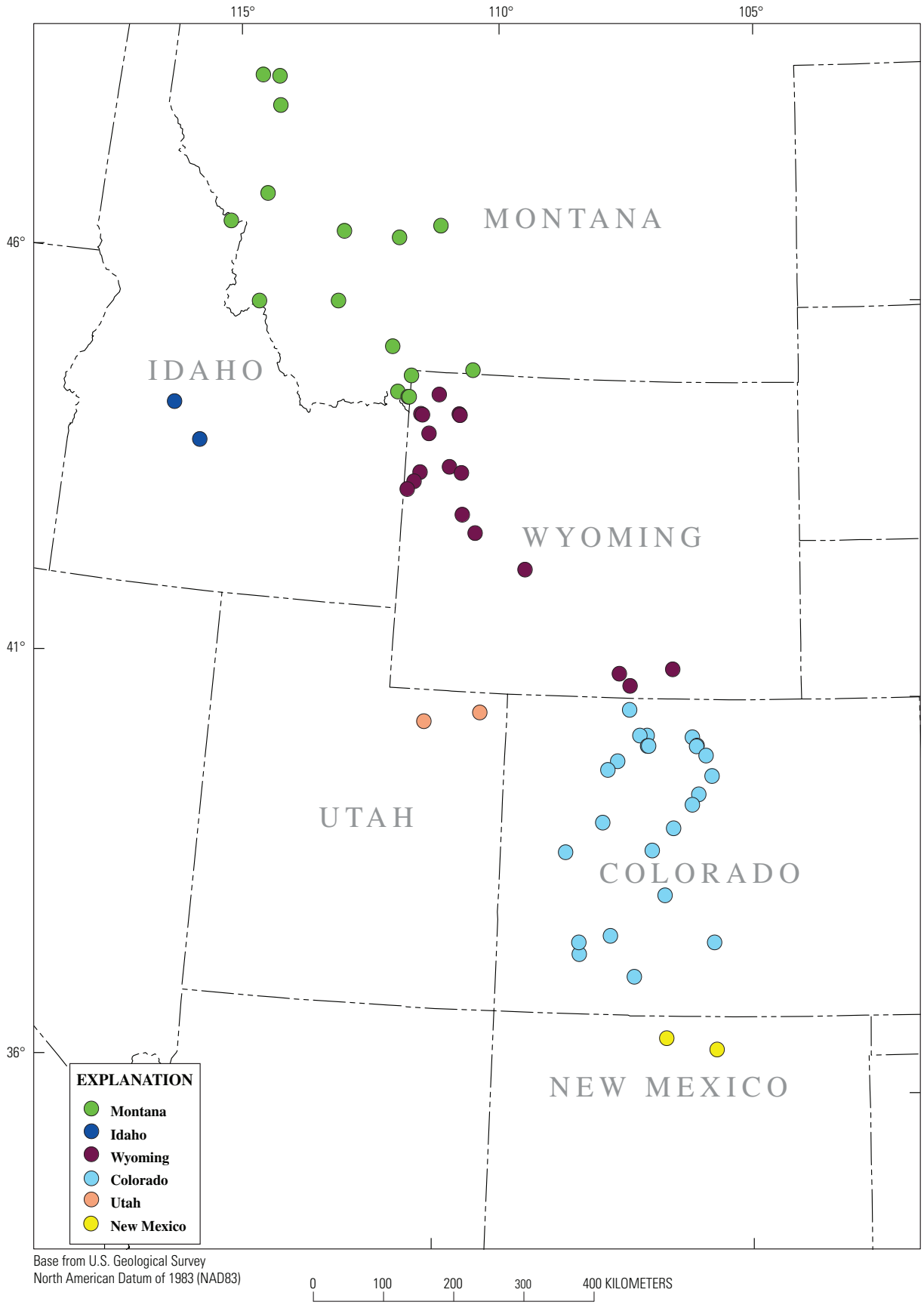

Figure 1. Study area and snowpack-sampling sites in Rocky Mountain region of the United States, 2009.

Sampling Methods and Analyses

Snowpacks were sampled annually from late February through early April according to field methods described in Ingersoll and others (2005). Snow depth was measured at all sites and snow-water equivalent (SWE) was measured at selected sites during the period. Snow samples from 63 sites were selected for this report. Analytical laboratory methods and quality-assurance procedures for analyses of major-ion and mercury concentrations are described in Turk and others (2001) and Ingersoll and others (2005). Laboratory reporting levels (LRL) are based on long-term method detection limits (LT-MDL) and are calculated as two times the LT-MDL (for details see Childress and others, 1999). LRLs shown in tables 2–4 are 1.0 microsiemens per centimeter (µS/cm) at 25° Celsius for specific conductance, 0.4 to 3.1 microequivalents per liter (µeq/L) for major dissolved constituents and nutrients (calcium, 3.1; magnesium, 1.7; sodium, 1.0; potassium, 0.4; ammonium, 1.0; chloride, 1.0; sulfate, 0.6; nitrate, 0.4), 0.4 milligram per liter (mg/L) for dissolved organic carbon (DOC), and 0.7 nanogram per liter (ng/L) for total (whole-water) mercury. Censored values (preceded by "<") in this report reflect non-detection based on the LRL. Ammonium and nitrate concentrations are reported as NH_4^+ and NO_3^-, respectively (and not as N); sulfate concentrations are reported as SO_4^{2-} (and not as S). Negative acid neutralization capacity (ANC) values shown in this report reflect the absence of bicarbonate ion at the typically low pH levels, although for many samples positive ANC was detected.

Quality-assurance data for field and laboratory blanks and field replicates were collected and analyzed (tables 3 and 4). Ultra-pure (18 megohm resistance) de-ionized water was used for all blanks. Quality-assurance data for field and laboratory blanks show no contamination; all major-ion- and mercury-blank concentrations were below LRL. Additional information including interlaboratory comparisons of USGS standard reference samples can be found at http://bqs.usgs.gov/srs.

As a quality-control measure, ionic charge balances of each major-ion analysis were calculated by dividing the sum of cations (hydrogen ion, calcium, magnesium, sodium, potassium, and ammonium) minus the sum of anions (ANC [> 0.0], chloride, nitrate, and sulfate) by the total cations and anions in solution. Censored values were not included in ionic balances. In general, ionic balances of results of chemical analyses for many samples included in this report had a positive bias believed to be because of organic acids that were not analyzed (Turk and others, 2001). This positive bias indicating an excess of cations also has been found in other precipitation work in the Western United States (National Atmospheric Deposition Program, 2001, 2005). In this report the same criteria were used to identify the maximum acceptable ion percent difference as applied by the National Atmospheric Deposition Program (2006). Ion percent differences were considered suspect if they met one of the following three criteria: (1) for total anions plus cations less than 50 µeq/L, the ionic balance exceeds plus or minus 60 percent; (2) for total anions plus cations greater than or equal to 50 µeq/L and less than 100 µeq/L, the ionic balance exceeds plus or minus 30 percent; and (3) for total anions plus cations greater than or equal to 100 µeq/L, the ionic balance exceeds plus or minus 15 percent. No suspect ion percent differences were identified in table 2 using these criteria.

To quantify comparisons of concentrations of selected major constituents between environmental samples and field replicate samples, relative percent differences (RPD) were calculated. The RPD (expressed as a percentage in this report) is the absolute value of the difference of depth-integrated environmental sample concentration (E) minus the field replicate sample concentration (FR), divided by the average of the environmental sample concentration and the field replicate sample concentration, and multiplied by 100: (|E-FR|/[(E+FR)/2]) * 100. It is important to realize that as dilute concentrations approach detection limits, relative percent differences between environmental sample concentrations and replicate sample concentrations appear to be substantial whereas absolute differences are small. For example, the RPD for two chloride samples of 0.5 and 0.7 µeq/L is 33.3 percent. The median RPD values for the 10 constituents ranged from 0 to 66.7 percent with a median of 11.6 (table 4). Magnesium, potassium, and DOC showed the greatest variation in RPD (66.7, 46.2, and 40.0 percent, respectively), typical of concentrations near detection limits. Overall, the replicate samples show good precision.

Snowpack Physical and Chemical Data

Site information, including location and elevation, is listed in table 1. Physical and chemical data are listed in table 2. Quality-assurance data for chemical analyses of blank and replicate snow samples are listed in tables 3 and 4.

Table 1. Station identification and snow-sampling-site location information, 2009.

[dd, decimal degrees; m, meters above the North American Vertical Datum of 1988; FIPS, Federal Information Processing Standards; NADP, National Atmospheric Deposition Program].

Station identification	Site name	Latitude (dd)	Longitude (dd)	Elevation (m)	FIPS county code	FIPS State code
		Colorado				
394800105470000	Berthoud Pass, Colo.	39.80588	105.77862	3,466	049	8
390500106323000	Brumley, Colo.	39.08693	106.54060	3,231	065	8
403200106400000	Buffalo Pass, Colo.	40.54654	106.67788	3,139	107	8
403100105540000	Cameron Pass, Colo.	40.52185	105.89403	3,132	057	8
403200106470000	Dry Lake, Colo.	40.53528	106.78027	2,526	107	8
401200107090000	Dunckley Pass, Colo.	40.20170	107.15635	2,987	103	8
405100106580000	Elk River, Colo.	40.84795	106.96992	2,636	107	8
392200106120000	Fremont Pass, Colo.	39.36419	106.21523	3,440	065	8
390158107583900	Grand Mesa, Colo.	39.03278	107.97750	3,158	029	8
402440105484700	Lake Irene, Colo.	40.41508	105.81925	3,256	049	8
401722105400301	Loch Vale Forest, Colo.	40.28944	105.66750	3,216	069	8
401726105395801	Loch Vale Meadow, Colo.	40.29028	105.66667	3,215	069	8
394000105533000	Loveland Pass, Colo.	39.66667	105.89167	3,615	019	8
374500107420000	Molas Lake, Colo.	37.74953	107.69560	3,307	111	8
383100106193000	Monarch Pass, Colo.	38.51333	106.32666	3,223	015	8
375542105301800	Music Pass, Colo.	37.92861	105.50530	3,474	027	8
402355106392400	Rabbit Ears 1, Colo.	40.39882	106.65656	2,986	049	8
402354106392500	Rabbit Ears 2, Colo.	40.39890	106.65657	2,986	049	8
375400107430000	Red Mountain Pass, Colo.	37.89055	107.71351	3,396	111	8
400507107184501	Ripple Creek NADP, Colo.	40.08610	107.31194	2,938	045	8
375930107120000	Slumgullion Pass, Colo.	37.99003	107.20441	3,537	053	8
392516107223000	Sunlight Peak, Colo.	39.42646	107.37952	3,226	045	8
400200105340000	University Camp, Colo.	40.03284	105.57601	3,149	013	8
372900106470000	Wolf Creek Pass, Colo.	37.48196	106.79252	3,339	079	8
		Idaho				
441812115140400	Banner Summit, Idaho	44.30333	115.23444	2,147	015	16
435228114425200	Galena Summit, Idaho	43.87444	114.71444	2,686	013	16
		Montana				
483105114011200	Apgar Lookout, Mont.	48.51806	114.02000	1,579	035	30
483029114204200	Big Mountain, Mont.	48.50806	114.34500	1,959	029	30
451630111260000	Big Sky, Mont.	45.27722	111.43304	2,772	057	30
454113113555600	Chief Joseph Pass, Mont.	45.69638	113.93597	2,228	081	30
450300109570000	Daisy Pass, Mont.	45.05087	109.95293	2,987	067	30
463823114364100	Granite Pass, Mont.	46.64117	114.61275	1,994	063	30
465100110420000	Kings Hill, Mont.	46.83824	110.71883	2,361	013	30
444300111170000	Lionshead, Mont.	44.69500	111.29640	2,459	031	30
464000112300000	Mount Belmont, Mont.	46.74992	112.33111	2,134	049	30
480919113563600	Noisy Basin, Mont.	48.15700	113.94577	1,845	029	30
454730112293000	Red Mountain, Mont.	45.77219	112.49197	2,717	053	30

Table 1. Station identification and snow-sampling-site location information, 2009.—Continued

[dd, decimal degrees; m, meters above the North American Vertical Datum of 1988; FIPS, Federal Information Processing Standards; NADP, National Atmospheric Deposition Program].

Station identification	Site name	Latitude (dd)	Longitude (dd)	Elevation (m)	FIPS county code	FIPS State code
		Montana (cont.)				
470211113594300	Snow Bowl, Mont.	47.03397	113.98955	2,262	063	30
463900111280000	Spring Gulch, Mont.	46.65000	111.46667	1,826	007	30
445400111030000	Twenty-one Mile, Mont.	44.93013	111.05616	2,209	031	30
444000111060000	West Yellowstone, Mont.	44.65845	111.09061	2,035	031	30
443900111050000	West Yellowstone (in road), Mont.	44.65716	111.09086	2,032	031	30
		New Mexico				
364300106160000	Hopewell, N. Mex.	36.70930	106.24763	3,036	039	35
363429105273000	Taos Ski Valley, N. Mex.	36.57286	105.44525	3,320	055	35
		Utah				
404456109301800	Grizzly Ridge, Utah	40.74886	109.50513	2,914	047	49
403544110260200	Lake Fork, Utah	40.59556	110.43389	3,094	013	49
		Wyoming				
412200106140000	Brooklyn Lake, Wyo.	41.37472	106.24472	3,231	001	56
444300110320000	Canyon, Wyo.	44.71743	110.51329	2,416	029	56
411800107100000	Divide Peak, Wyo.	41.30472	107.15972	2,634	007	56
430000109450000	Elkhart Park, Wyo.	43.00265	109.75698	2,865	035	56
434900110160000	Four Mile Meadow, Wyo.	43.82363	110.26472	2,406	039	56
434326110465900	Garnet Canyon, Wyo.	43.71003	110.75360	2,174	039	56
431322109592700	Gypsum Creek, Wyo.	43.22925	109.99613	2,516	035	56
441300110400000	Lewis Lake Divide, Wyo.	44.19934	110.66045	2,363	039	56
410900106580000	Old Battle, Wyo.	41.15464	106.97577	3,024	007	56
442640110503300	Old Faithful (in road), Wyo.	44.45586	110.83376	2,250	039	56
442721110500300	Old Faithful Fire Road, Wyo.	44.45603	110.83458	2,246	039	56
433606110522200	Rendezvous Mountain, Wyo.	43.60080	110.87263	3,040	039	56
423420108503200	South Pass, Wyo.	42.57230	108.84272	2,755	013	56
442900110090000	Sylvan Lake, Wyo.	44.47436	110.15481	2,566	029	56
442900110090100	Sylvan Lake (in road), Wyo.	44.47364	110.15485	2,572	029	56
433000110590000	Teton Pass, Wyo.	43.50175	110.96583	2,480	039	56
434500110030000	Togwotee Pass, Wyo.	43.74767	110.05362	2,926	039	56

Table 2. Selected physical and chemical data for Rocky Mountain snowpack samples collected in 2009.

[All concentrations are dissolved (filtered) except for mercury which are total (unfiltered). ANC, acid neutralization capacity; µeq/L, microequivalent per liter; µS/cm, microsiemens per centimeter; SC, specific conductance at 25°C; pH values in standard units; H, hydrogen; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; NH_4, ammonium; Cl, chloride; SO_4, sulfate; NO_3, nitrate; DOC, dissolved organic carbon; mg/L, milligram per liter; SWE, snow-water equivalent; cm, centimeter; Hg, mercury; ng/L, nanogram per liter; na, not analyzed; <, below reporting limit; %, percent; E, depth-integrated environmental; NADP, National Atmospheric Deposition Program].

Site name	Sample date	Sample type	ANC (µeq/L)	SC (µS/cm)	pH	H (µeq/L)	Ca (µeq/L)	Mg (µeq/L)	Na (µeq/L)	K (µeq/L)	NH_4 (µeq/L)	Cl (µeq/L)	SO_4 (µeq/L)	NO_3 (µeq/L)	DOC (mg/L)	SWE (cm)	Snow depth (cm)	Hg (ng/L)	Ionic balance (%)
Apgar Lookout, Mont.	3/18/2009	E	–3.3	3.8	5.48	3.3	<3.1	<1.7	<1.0	0.4	3.2	<1.0	2.4	4.7	0.8	57.1	170	3.1	–1.0
Banner Summit, Idaho	3/5/2009	E	9.1	3.7	6.14	0.7	10.5	<1.7	9.6	0.6	3.0	4.3	5.3	2.6	<0.4	50.3	186	4.5	6.9
Berthoud Pass, Colo.	4/8/2009	E	22.0	6.8	6.42	0.4	31.9	2.5	3.2	2.7	<1.0	2.6	7.0	7.5	1.1	65.8	188	9.6	2.0
Big Mountain, Mont.	2/27/2009	E	–6.8	3.0	5.31	4.9	<3.1	<1.7	<1.0	<0.4	2.4	<1.0	2.3	3.1	<0.4	67.1	238	2.2	15.4
Big Sky, Mont.	3/4/2009	E	–0.3	2.8	5.66	2.2	4.5	<1.7	2.2	0.7	4.2	1.0	2.8	4.7	0.7	30.5	101	2.9	24.0
Brooklyn Lake, Wyo.	3/26/2009	E	3.4	3.7	5.97	1.1	13.0	2.5	2.6	1.2	5.4	1.0	6.3	7.0	0.8	74.4	243	4.0	18.4
Brumley, Colo.	3/17/2009	E	12.8	4.3	6.22	0.6	20.0	2.5	2.2	1.2	2.9	1.1	4.7	7.3	0.7	35.0	124	4.8	6.4
Buffalo Pass, Colo.	3/31/2009	E	10.6	4.8	6.11	0.8	19.5	<1.7	2.1	0.7	4.9	1.1	6.9	8.5	0.6	131.3	428	4.0	1.5
Cameron Pass, Colo.	3/22/2009	E	–0.7	4.0	5.84	1.4	11.0	<1.7	5.2	1.3	4.7	4.4	5.7	6.8	0.6	50.0	148	6.2	16.9
Canyon, Wyo.	2/18/2009	E	–0.1	3.3	5.62	2.4	<3.1	<1.7	1.2	1.1	7.1	1.0	2.8	5.7	0.5	25.9	110	3.4	11.0
Chief Joseph Pass, Mont.	2/28/2009	E	–2.6	2.7	5.45	3.5	<3.1	<1.7	<1.0	0.9	2.3	<1.0	1.6	2.3	0.6	41.5	136	4.7	27.0
Daisy Pass, Mont.	2/24/2009	E	–0.9	2.8	5.56	2.8	<3.1	<1.7	<1.0	<0.4	5.6	<1.0	2.5	4.1	<0.4	77.1	236	3.1	12.0
Divide Peak, Wyo.	3/25/2009	E	16.3	6.2	6.41	0.4	26.9	4.9	6.1	1.5	na	2.1	10.1	12.4	0.8	74.4	215	7.5	na
Dry Lake, Colo.	3/13/2009	E	–1.1	4.0	5.52	3.0	8.5	<1.7	1.5	0.6	3.8	<1.0	5.7	10.5	<0.4	48.8	149	1.5	3.7
Dunckley Pass, Colo.	4/3/2009	E	32.0	6.7	6.57	0.3	35.4	3.3	3.8	1.2	4.6	1.4	6.9	7.1	0.5	69.7	231	4.0	1.2
Elk River, Colo.	3/13/2009	E	10.0	4.9	6.07	0.9	16.5	2.5	3.1	3.0	4.8	1.5	6.9	9.9	1.2	39.1	131	4.2	4.0
Elkhart Park, Wyo.	3/11/2009	E	5.0	3.7	5.87	1.3	8.0	<1.7	3.9	1.2	4.1	3.2	4.7	6.3	0.6	27.2	107	5.5	–1.5
Four Mile Meadow, Wyo.	3/19/2009	E	54.2	12.2	6.84	0.1	50.9	7.4	36.2	1.0	6.5	31.2	10.6	6.0	0.4	29.3	102	2.5	0.1
Fremont Pass, Colo.	4/6/2009	E	29.5	6.1	6.48	0.3	32.4	2.5	1.6	1.8	1.9	1.0	5.3	5.7	0.7	38.2	160	11.2	–1.0
Galena Summit, Idaho	3/5/2009	E	5.0	3.9	6.03	0.9	9.0	<1.7	8.8	0.8	3.3	4.5	5.2	3.0	0.4	40.1	172	5.6	12.7
Garnet Canyon, Wyo.	3/9/2009	E	3.1	4.0	5.95	1.1	10.5	2.5	4.7	1.2	6.3	3.9	5.2	6.9	0.6	60.0	188	7.3	15.8
Grand Mesa, Colo.	3/16/2009	E	31.9	6.5	6.59	0.3	35.9	4.9	2.5	1.7	5.6	1.6	7.1	8.8	0.7	45.9	141	8.6	1.5
Granite Pass, Mont.	3/2/2009	E	–5.8	2.8	5.41	3.9	<3.1	<1.7	<1.0	1.2	1.7	<1.0	1.8	2.6	0.4	40.6	140	13.7	21.0
Grizzly Ridge, Utah	3/24/2009	E	25.1	6.6	6.47	0.3	31.4	5.8	3.5	2.6	5.7	2.0	7.9	12.1	1.3	16.8	91	9.6	2.4
Gypsum Creek, Wyo.	3/11/2009	E	5.2	4.2	5.90	1.3	10.0	2.5	4.9	1.9	4.3	4.5	4.5	7.0	0.8	27.1	103	7.6	7.8
Hopewell, N. Mex.	3/20/2009	E	0.7	4.0	5.74	1.8	11.0	<1.7	1.4	2.4	4.1	1.2	7.2	7.6	0.9	44.2	135	11.2	10.5
Kings Hill, Mont.	2/21/2009	E	–4.6	4.0	5.34	4.6	4.0	<1.7	<1.0	1.2	4.7	<1.0	4.6	5.9	0.8	30.7	110	14.3	16.0
Lake Fork, Utah	3/23/2009	E	34.4	8.5	6.49	0.3	39.4	5.8	16.3	1.8	4.9	5.2	14.7	8.2	0.6	25.3	88	4.3	4.5
Lake Irene, Colo.	4/10/2009	E	11.1	4.1	6.15	0.7	20.5	2.5	1.4	2.1	3.6	<1.0	5.9	7.1	1.0	68.5	208	3.8	12.1
Lewis Lake Divide, Wyo.	2/16/2009	E	0.2	3.8	5.72	1.9	<3.1	<1.7	1.7	<0.4	7.6	<1.0	3.2	5.3	<0.4	58.8	194	2.9	12.6
Lionshead, Mont.	2/23/2009	E	2.3	3.8	5.78	1.7	4.0	<1.7	1.2	1.5	11.0	1.3	4.5	8.9	0.7	41.8	147	9.1	6.3
Loch Vale Forest, Colo.	4/9/2009	E	9.0	3.9	6.11	0.8	17.0	<1.7	1.5	1.0	2.9	<1.0	5.7	7.5	0.7	85.4	251	3.7	2.0

Table 2. Selected physical and chemical data for Rocky Mountain snowpack samples collected in 2009.—Continued

[All concentrations are dissolved (filtered) except for mercury which are total (unfiltered). ANC, acid neutralization capacity; µeq/L, microequivalent per liter; µS/cm, microsiemens per centimeter; SC, specific conductance at 25°C; pH values in standard units; H, hydrogen; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; NH_4, ammonium; Cl, chloride; SO_4, sulfate; NO_3, nitrate; DOC, dissolved organic carbon; mg/L, milligram per liter; SWE, snow-water equivalent; cm, centimeter; Hg, mercury; ng/L, nanogram per liter; na, not analyzed; <, below reporting limit; %, percent; E, depth-integrated environmental; NADP, National Atmospheric Deposition Program].

Site name	Sample date	Sample type	ANC (µeq/L)	SC (µS/cm)	pH	H (µeq/L)	Ca (µeq/L)	Mg (µeq/L)	Na (µeq/L)	K (µeq/L)	NH_4 (µeq/L)	Cl (µeq/L)	SO_4 (µeq/L)	NO_3 (µeq/L)	DOC (mg/L)	SWE (cm)	Snow depth (cm)	Hg (ng/L)	Ionic balance (%)
Loch Vale Meadow, Colo.	4/9/2009	E	10.4	3.6	6.21	0.6	15.0	<1.7	<1.0	<0.4	3.3	<1.0	4.2	5.7	<0.4	63.1	185	2.2	–3.7
Loveland Pass, Colo.	4/11/2009	E	24.2	4.9	6.50	0.3	28.9	2.5	2.1	0.7	3.2	2.2	4.8	6.0	0.5	48.0	161	1.9	0.6
Molas Lake, Colo.	3/17/2009	E	22.1	4.9	6.48	0.3	27.9	3.3	1.2	0.7	3.5	<1.0	4.4	7.4	<0.4	57.8	160	2.9	4.4
Monarch Pass, Colo.	3/17/2009	E	19.3	4.8	6.36	0.4	19.0	2.5	2.4	2.3	5.0	2.5	4.4	6.8	0.6	31.8	111	6.3	–2.3
Mount Belmont, Mont.	2/20/2009	E	–0.2	4.0	5.55	2.8	4.0	<1.7	1.2	8.3	1.6	1.5	4.6	4.8	1.6	22.2	70	20.3	24.1
Music Pass, Colo.	3/19/2009	E	2.6	3.7	5.78	1.7	11.0	<1.7	1.5	1.7	6.1	<1.0	6.7	7.7	0.8	57.6	160	8.5	12.6
Noisy Basin, Mont.	2/26/2009	E	–5.5	3.4	5.31	4.9	<3.1	<1.7	<1.0	<0.4	3.2	<1.0	3.4	4.1	<0.4	79.6	299	1.5	4.0
Old Battle, Wyo.	3/24/2009	E	4.9	4.5	6.09	0.8	16.5	3.3	3.8	1.5	6.5	1.3	8.2	10.2	0.7	74.2	223	5.7	13.8
Old Faithful Fire Road, Wyo.	2/18/2009	E	–2.2	3.0	5.67	2.1	<3.1	<1.7	1.7	0.5	6.8	1.3	3.0	6.2	<0.4	24.7	90	2.3	3.2
Old Faithful (in road), Wyo.	2/18/2009	E	9.2	4.4	6.04	0.9	11.5	2.5	3.6	2.6	8.9	4.1	3.6	5.8	1.9	na	56	12.8	13.7
Rabbit Ears 1, Colo.	3/27/2009	E	16.9	5.4	6.41	0.4	26.9	2.5	2.7	1.1	6.2	<1.0	8.6	8.4	0.5	92.6	291	3.8	7.9
Rabbit Ears 2, Colo.	3/27/2009	E	27.3	6.4	6.60	0.3	37.4	4.1	2.6	1.1	6.8	0.9	9.1	8.3	0.6	87.7	281	4.2	7.0
Red Mountain, Mont.	3/3/2009	E	–3.8	3.1	5.41	3.9	<3.1	<1.7	<1.0	0.8	3.6	<1.0	3.4	3.7	0.7	40.8	138	4.8	8.6
Red Mountain Pass, Colo.	3/17/2009	E	25.5	5.2	6.54	0.3	30.9	3.3	1.3	1.4	3.7	<1.0	4.2	6.4	0.6	57.1	177	4.9	6.2
Rendezvous Mountain, Wyo.	3/10/2009	E	12.9	4.4	6.24	0.6	13.0	2.5	8.3	0.4	5.5	6.0	5.7	4.4	<0.4	64.9	231	3.2	2.1
Ripple Creek NADP, Colo.	4/1/2009	E	52.4	7.7	6.78	0.2	48.9	3.3	3.0	0.8	3.9	1.5	5.2	6.6	0.4	60.0	199	3.8	–4.6
Slumgullion Pass, Colo.	3/18/2009	E	19.2	4.4	6.37	0.4	20.5	2.5	1.5	2.5	1.6	1.4	3.3	5.4	1.2	24.7	85	31.3	–0.4
Snow Bowl, Mont.	3/1/2009	E	–5.0	3.1	5.34	4.6	<3.1	<1.7	<1.0	0.5	1.8	<1.0	2.2	2.8	0.4	66.7	222	7.7	16.4
South Pass, Wyo.	3/16/2009	E	4.9	4.7	6.03	0.9	17.0	3.3	4.7	2.7	2.1	2.4	9.4	8.6	1.5	22.7	92	5.7	9.7
Spring Gulch, Mont.	2/20/2009	E	–0.5	4.4	5.47	3.4	7.0	2.5	<1.0	3.9	4.2	<1.0	4.1	7.5	2.0	10.6	44	5.5	28.8
Sunlight Peak, Colo.	4/2/2009	E	43.5	7.7	6.72	0.2	43.9	2.5	3.8	2.4	4.2	1.4	6.1	7.2	0.5	70.4	220	7.2	–1.1
Sylvan Lake, Wyo.	2/17/2009	E		3.0	5.56	2.8	<3.1	<1.7	<1.0	1.0	6.0	<1.0	3.1	5.1	0.7	41.9	140	3.9	8.5
Sylvan Lake (in road), Wyo.	2/17/2009	E	–2.0	2.8	5.51	3.1	<3.1	<1.7	<1.0	0.4	4.7	<1.0	1.9	4.7	<0.4	na	90	2.2	10.6
Taos Ski Valley, N. Mex.	3/21/2009	E	4.1	5.2	5.81	1.5	15.5	<1.7	2.1	2.5	6.9	1.8	11.5	9.2	1.6	55.3	160	15.7	3.2
Teton Pass, Wyo.	3/9/2009	E	21.6	5.9	6.44	0.4	17.5	4.1	9.3	2.6	6.4	7.3	5.7	5.7	0.9	53.9	176	7.5	–0.1
Togwotee Pass, Wyo.	3/19/2009	E	8.1	3.8	6.16	0.7	10.5	<1.7	6.8	0.6	4.2	4.6	4.6	4.2	0.4	83.5	259	3.1	3.1
Twenty-one Mile, Mont.	2/19/2009	E	–0.4	3.6	5.59	2.6	<3.1	<1.7	1.6	1.0	7.6	2.2	2.7	7.2	1.0	24.0	83	4.9	3.1
University Camp, Colo.	4/7/2009	E	20.9	5.7	6.47	0.3	27.9	2.5	3.4	1.4	6.3	1.3	8.8	8.6	0.8	44.2	163	5.3	2.7
West Yellowstone, Mont.	2/19/2009	E	–1.7	3.6	5.55	2.8	<3.1	<1.7	1.3	0.7	7.8	1.1	2.8	7.9	0.7	18.4	68	4.1	3.1
West Yellowstone (in road), Mont.	2/19/2009	E	3.4	4.0	5.87	1.3	4.5	<1.7	2.2	0.7	14.5	2.5	3.9	8.3	0.8	na	48	3.4	11.9
Wolf Creek Pass, Colo.	3/18/2009	E	12.7	4.9	6.29	0.5	25.0	2.5	2.2	1.5	5.0	1.6	8.3	9.3	0.7	52.8	179	11.1	7.1

Table 3. Quality-assurance data: selected chemical concentrations in blank samples collected in 2009.

[All concentrations are dissolved (filtered) except for mercury which are total (unfiltered). ANC, acid neutralization capacity; µeq/L, microequivalent per liter; SC, specific conductance at 25°C; µS/cm, microsiemens per centimeter; pH values in standard units; H, hydrogen; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; NH_4, ammonium; Cl, chloride; SO_4, sulfate; NO_3, nitrate; DOC, dissolved organic carbon; mg/L, milligram per liter; Hg, mercury; ng/L, nanogram per liter; FB, field blank; LB, laboratory blank; <, below reporting limit.]

Site name	Sample date	Sample type	ANC (µeq/L)	SC (µS/cm)	pH	H (µeq/L)	Ca (µeq/L)	Mg (µeq/L)	Na (µeq/L)	K (µeq/L)	NH_4 (µeq/L)	Cl (µeq/L)	SO_4 (µeq/L)	NO_3 (µeq/L)	DOC (mg/L)	Hg (ng/L)
Banner Summit, Idaho	3/5/2009	FB	–3.3	1.6	5.57	2.7	<3.1	<1.7	<1.0	<0.4	<1.0	<1.0	<0.6	<0.4	<0.4	<0.7
South Pass, Wyo.	3/16/2009	FB	–4.8	1.6	5.52	3.0	<3.1	<1.7	<1.0	<0.4	<1.0	<1.0	<0.6	<0.4	<0.4	<0.7
Laboratory blank	5/1/2009	LB	–3.5	1.5	5.52	3.0	<3.1	<1.7	<1.0	<0.4	<1.0	<1.0	<0.6	<0.4	<0.4	<0.7
Laboratory blank	5/6/2009	LB	–4.6	1.6	5.56	2.8	<3.1	<1.7	<1.0	<0.4	<1.0	<1.0	<0.6	<0.4	<0.4	<0.7

Table 4. Quality-assurance data: relative percent differences in concentrations between selected environmental and replicate samples collected in 2009.

[All concentrations are dissolved (filtered) except for mercury which are total (unfiltered). µeq/L, microequivalent per liter; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; NH_4, ammonium; Cl, chloride; SO_4, sulfate; NO_3, nitrate; DOC, dissolved organic carbon; mg/L, milligram per liter; Hg, mercury; ng/L, nanogram per liter; E, depth-integrated environmental; FR, field replicate; RPD, relative percent difference as: [(|E-FR| / [(E+FR)/2]) * 100]

Site name	Sample date	Sample type	Ca (µeq/L)	Mg (µeq/L)	Na (µeq/L)	K (µeq/L)	NH_4 (µeq/L)	Cl (µeq/L)	SO_4 (µeq/L)	NO_3 (µeq/L)	DOC (mg/L)	Hg (ng/L)
Buffalo Pass, Colo.	3/31/2009	E	19.5	1.6	2.1	0.7	4.9	1.1	6.9	8.5	0.6	4.0
Buffalo Pass, Colo.	3/31/2009	FR	18.0	1.6	2.4	0.6	5.8	0.9	7.5	8.6	0.4	3.4
		RPD	**8.0**	**0.0**	**13.3**	**15.4**	**16.8**	**20.0**	**8.3**	**1.2**	**40.0**	**16.2**
Galena Summit, Idaho	3/5/2009	E	9.0	1.6	8.8	0.8	3.3	4.5	5.2	3.0	0.4	5.6
Galena Summit, Idaho	3/5/2009	FR	8.0	0.8	8.5	0.5	3.5	3.9	4.9	2.6	0.4	5.0
		RPD	**11.8**	**66.7**	**3.5**	**46.2**	**5.9**	**14.3**	**5.9**	**14.3**	**0.0**	**11.3**
Hopewell, N. Mex.	3/20/2009	E	11.0	1.6	1.4	2.4	4.1	1.2	7.2	7.6	0.9	11.2
Hopewell, N. Mex.	3/20/2009	FR	11.0	1.6	1.4	2.6	4.6	1.1	7.2	8.0	0.8	13.4
		RPD	**0.0**	**0.0**	**0.0**	**8.0**	**11.5**	**8.7**	**0.0**	**5.1**	**11.8**	**17.9**
Lake Fork, Utah	3/23/2009	E	39.4	5.8	16.3	1.8	4.9	5.2	14.7	8.2	0.6	4.3
Lake Fork, Utah	3/23/2009	FR	32.9	4.9	14.4	2.3	4.1	5.0	12.5	7.4	0.6	4.4
		RPD	**18.0**	**16.8**	**12.4**	**24.4**	**17.8**	**3.9**	**16.2**	**10.3**	**0.0**	**2.3**
Music Pass, Colo.	3/19/2009	E	11.0	1.6	1.5	1.7	6.1	0.7	6.7	7.7	0.8	8.5
Music Pass, Colo.	3/19/2009	FR	10.5	1.6	1.5	2.0	6.8	0.5	6.5	7.3	1.1	6.9
		RPD	**4.7**	**0.0**	**0.0**	**16.2**	**10.9**	**33.3**	**3.0**	**5.3**	**31.6**	**20.8**
Taos Ski Valley, N. Mex.	3/21/2009	E	15.5	1.6	2.1	2.5	6.9	1.8	11.5	9.2	1.6	15.7
Taos Ski Valley, N. Mex.	3/21/2009	FR	19.0	2.5	2.4	4.0	7.1	2.1	12.9	10.2	1.3	16.2
		RPD	**20.3**	**43.9**	**13.3**	**46.2**	**2.9**	**15.4**	**11.5**	**10.3**	**20.7**	**3.1**
West Yellowstone (in road), Mont.	2/19/2009	E	4.5	0.8	2.2	0.7	14.5	2.5	3.9	8.3	0.8	3.4
West Yellowstone (in road), Mont.	2/19/2009	FR	5.5	0.8	2.6	0.8	15.6	2.9	4.0	8.3	0.9	2.9
		RPD	**20.0**	**0.0**	**16.7**	**13.3**	**7.3**	**14.8**	**2.5**	**0.0**	**11.8**	**15.9**

RPD statistics

minimum	0.0
median	11.6
maximum	66.7

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