

Colorado Abandoned Mines Water Quality Study

Data Report - June 2017



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Responsible agencies and contacts



Jeff Graves

Director Inactive Mine Reclamation Program
Division of Reclamation, Mining and Safety
jeff.graves@state.co.us
303-866-3567 xt. 8122



Andrew Ross

Environmental Data Unit Manager
Water Quality Control Division
andrew.ross@state.co.us
303-692-3395

Skip Feeney

Water quality scientist
Water Quality Control Division
skip.feeney@state.co.us
303-691-4928

Introduction

Abandoned mine sites are prevalent throughout the state of Colorado. Water quality impacts from these abandoned mines is a long-time concern. Efforts by federal, state, and local entities to assess and address pollution is an ongoing effort. This document describes the purpose and implementation of the Abandoned Mines Water Quality Study. This study was championed by Governor Hickenlooper in the 2016 State of the State address. The agencies leading this study surveyed and sampled 145 abandoned mines discharging water. The information collected through the study and the analytical results are presented through the environmental Resources Assessment and Management Systems (eRAMS), which was developed by Colorado State University.

Project background



Colorado and mining have a long history together. In the late 1850s, the Colorado gold rush brought an unprecedented number of people and mining operations into the region. Most of Colorado's mineral mining activity predates the passing of current environmental regulations in the 1970s and 1980s. Before this time, many mining companies did not sufficiently restore mined areas, leaving physical hazards and environmental impacts.

Colorado rivers and streams are negatively impacted by acid mine drainage. This occurs when oxygen from the air and water reacts with sulfide minerals exposed during past mining activities. Acid mine drainage, which often contains dissolved metals, flows into streams, lakes and groundwater.

High levels of metals in streams from acid mine drainage can harm fish and aquatic ecosystems. These contaminants may also impact drinking water and agricultural water sources. This problem is prevalent in Colorado. Most recent data reports there are over 23,000 abandoned mines across the state and 1,800 miles of streams impaired due to acid mine drainage related pollutants.

Following the Gold King mine release in August 2015, multiple federal, state, and local agencies believed it was important to identify inactive mine sites throughout the state that may pose a threat to water quality or physical and safety hazards. During this process, the Division of Reclamation, Mining and Safety (DRMS) and the Colorado Department of Public Health and Environment (CDPHE), in cooperation with

other participating agencies including Bureau of Land Management (BLM), United States Forest Service (USFS), and the Environmental Protection Agency (EPA) developed a list of draining mines.

These mines were classified into three categories:

- Green- Draining mines with partial to complete restoration (44 mines).
- Yellow- Draining mines with recent investigation or restoration project in process (32 mines).
- Red- Draining mines without recent investigations or restoration projects (148 mines).

A map and list of these mines and their classifications is available from the DRMS website: mining.state.co.us/Programs/Abandoned

To provide the most up-to-date and comprehensive data regarding draining mines throughout the state, DRMS and CDPHE partnered to visit and evaluate the abandoned mines (red sites) without recent investigations or restoration projects. The remaining 76 sites classified as having had recent investigations or restoration projects were not sampled as part of this study (green and yellow sites).

Goals and objectives

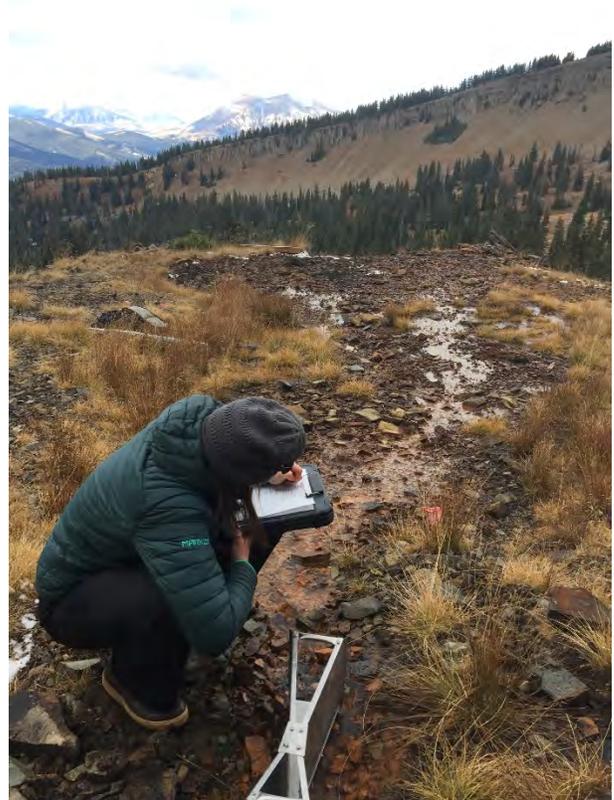
The goal of this study was to develop and share a dataset for the abandoned mines lacking current water quality data and/or documented field observations. This dataset will improve our understanding of water quality impacts associated with these mines. It is anticipated that many will use this data including federal and state agencies, watershed and environmental groups, mining companies, municipal water providers and the general public. Additionally, this information will be used to assist the decision making process of mine restoration agencies.

Scope of activities

A map of draining abandoned mines, displayed in this section, illustrates the initial scope of field efforts. Site visits to all draining mines were conducted within one field season, as close to low flow conditions as possible. Between initial project scope development and completion of field sampling in November, a number of additional sites were added to the draining mine inventory list. In total, field personnel visited 165 mine sites. Of those sites, 145 were draining at the time of the visit.

Visiting all sites in one field season provided a comparable snapshot of flow conditions, while low flow sampling provided data less influenced by annual snowpack fluctuations. A comprehensive sampling and analysis plan was developed to ensure data were collected in accordance with CDPHE quality assurance/quality control requirements.

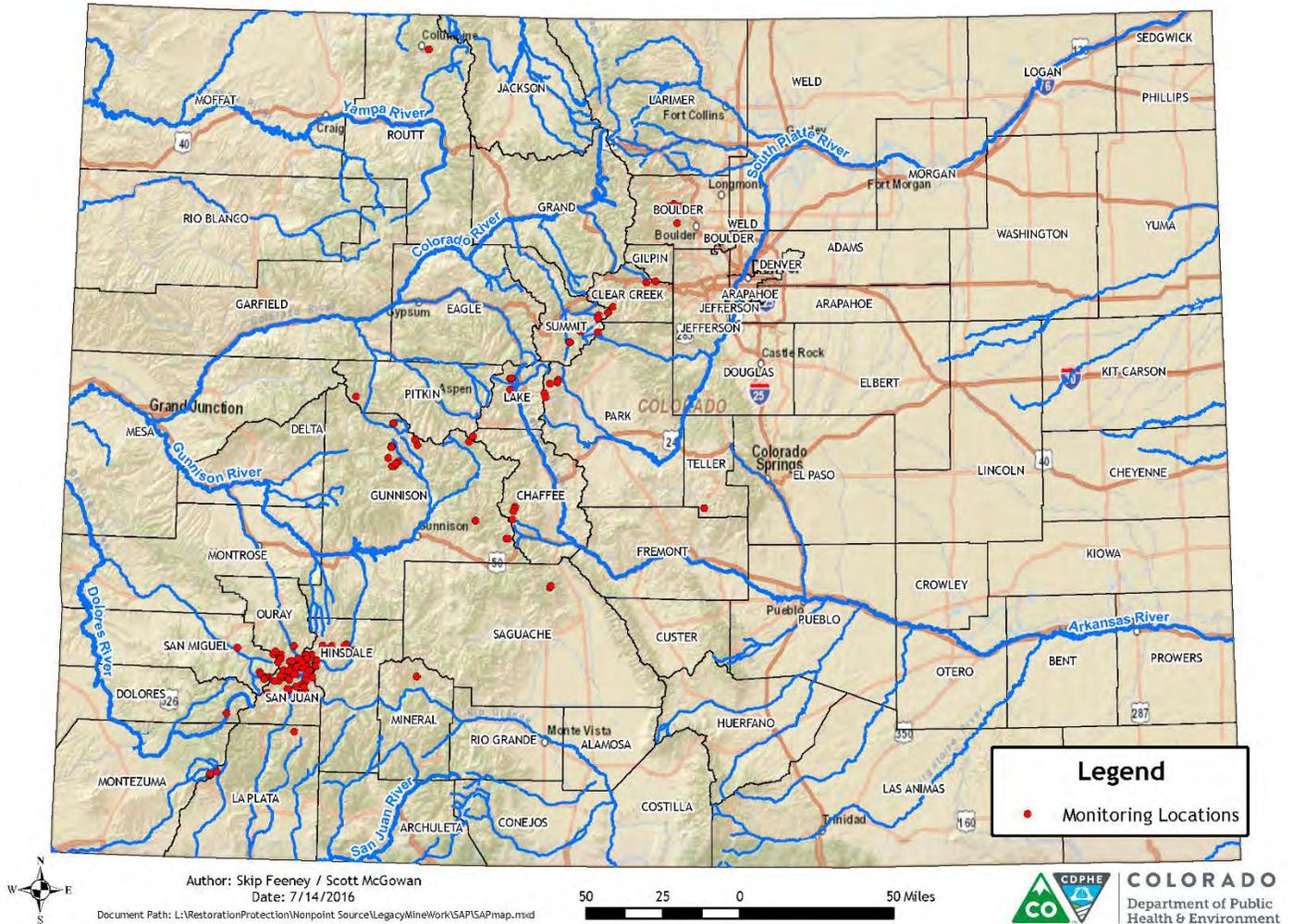
As part of each field visit, personnel documented existing site conditions on a standard DRMS draining mine inventory form, collected water samples for laboratory analysis, measured the quantity of water draining from the mine, recorded field parameters and took photographs of the site. Documentation of existing site conditions included physical condition of mine features, visual characteristics of the mine discharge, qualitative environmental impacts associated with the discharge, along with other various site observations. One water sample at each site was collected to analyze a suite of total



and dissolved metals. Flow measurements were made using cutthroat flumes.

A list of mines surveyed is displayed in Appendix A - Mine Visit Status. A map of mine sites from the sampling and analysis plan is displayed below in Figure 1 - Draining Mines Water Quality Study Map.

Figure 1 - Draining Mines Water Quality Study Map



Water quality data summary

As described previously, water quality samples were collected from 145 draining mines. This occurred from July 22 to November 16, 2016. Water quality impairments, predominantly attributed to abandoned mines, are associated with the following pollutants: pH, cadmium, zinc, copper and lead. A cursory review of water quality data was conducted. Table 1 - Draining mine water quality summary contains the minimum, median and maximum values of these pollutants across all mines. Additionally, the quantity of water exiting the mines is also displayed in the table. Measured concentrations for dissolved cadmium, zinc, copper and lead are represented in micrograms per liter (ug/l). Pollutant loadings are represented as pounds of pollutants per day.



Data generally indicates that the mines sampled in the study are less significant pollutant loaders than those abandoned mines being addressed through the Superfund program. For example, average loading values from the Nelson Tunnel Superfund site indicate a dissolved zinc load of nearly 178 pounds per day, while the dissolved zinc load from all 145 sampled draining mine sites combined as part of the inventory is 115 pounds per day. This suggests that the most significant draining abandoned mine problems have been or will be remediated through existing Superfund projects. While the 145 draining mines are not the largest sources of pollution, they may still contribute to water quality impairment.

Table 1 - Draining mine water quality summary

Parameter	Minimum value	Median value	Maximum value
Flow (gallons per minute)	0.05	13.4	1,497
Dissolved Cadmium (micrograms per liter)	Below detection	2.35	1,100
Dissolved Cadmium (pounds per day)	Below detection	0.00042	0.065
Dissolved Zinc (micrograms per liter)	Below detection	905	320,000
Dissolved Zinc (pounds per day)	Below detection	0.14	14.13
Dissolved Copper (micrograms per liter)	Below detection	Below detection	70,000
Dissolved Copper (pounds per day)	Below detection	Below detection	7.57
Dissolved Lead (micrograms per liter)	Below detection	0.23	2,100
Dissolved Lead (pounds per day)	Below detection	0.000014	0.62
pH (standard units)	2.21	6.55	8.66

How the data will be used

Data users are expected to be mine restoration specialists, watershed and environmental groups, policy makers and the general public. Each user may use data in different ways. For example, the general public may be interested in seeing draining mines near where they live. Restoration specialists may want to evaluate draining mines based on funding requirements and restoration goals. Policy makers may want information on mines in their counties/districts.

To meet the needs of expected users, data are shared through eRAMS - An interactive cloud-based spatial environmental data publisher. Mines are represented spatially, with access to water quality data, site visit photos and field survey information. Additionally, all water quality data and project summary information are provided.

Access to this information is available at:

<https://erams.com/co-abandoned-mines-water-quality>



Next steps

Reducing and eliminating pollution from abandoned mines is a complex process. Challenges hinge on cost, regulatory authority and liability. Because historic draining mines may continually discharge high concentrations of pollutants, perpetual treatment or long-term remedies are required. These can be very costly. It is a long standing policy of the Water Quality Control Division to not pursue discharge permits for mining features that are inactive with undetermined ownership. There are also liability concerns over the treatment of discharge from abandoned mines. Unless specifically protected by the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), most agencies have concerns about assuming liability to treat mine water discharge to Clean Water Act requirements for an indefinite period of time.



The state of Colorado is committed to reducing water pollution and improving water quality. In light of these challenges, we participate in and support a collaborative approach through the Colorado Mixed-Ownership Abandoned Mine Collaboration Group. This group is a forum for federal and state agencies as well as local organizations (when appropriate), to share expertise, combine staffing and pool resources (financial, services, technology, field support, etc.) to remediate lands and waters impacted by historic mining activities.

Participants

Federal participants - the Environmental Protection Agency (Region VIII), Department of Agriculture including the Forest Service, and the Department of Interior including the Bureau of Land Management, the US Geological Survey, the National Park Service and the US Fish and Wildlife Service.

State participants include the Colorado Department of Public Health and Environment, including the Hazardous Material and Waste Management Division along with the Water Quality Control Division, the Colorado Department of Natural Resources including the Division of Reclamation, Mining and Safety, and the Colorado Geological Survey.

Local participants include Trout Unlimited, the Coalition of the Upper South Platte, as well as numerous other non-governmental organizations and watershed groups.

Each agency, watershed group and program have different missions, restoration priorities and funding requirements. This study provides information that will be used across organizations as we continue to make restoration decisions. Next steps are to continue collaboratively and actively addressing abandoned mine impacts to streams.

This report and other information regarding ongoing efforts to diminish mining impacts to water quality can be found online at: www.colorado.gov/cdphe/wq-mining



Appendix A - Mine and visit status table

Site ID	Mine name	County	Visit date	Visit status	Comments
DRMS-1	Bueno	Boulder	8/10/2016	Sampled	
DRMS-2	Emmett	Boulder	8/10/2016	Sampled	
DRMS-3	Evening Star	Boulder		No discharge	
DRMS-4	Fairday	Boulder	9/30/2016	Sampled	
DRMS-5	Lily of the West	Boulder	8/17/2016	Sampled	
DRMS-6	Yellow Girl	Boulder	8/10/2016	Sampled	
DRMS-7	Dorothy H	Chaffee	8/24/2016	Sampled	
DRMS-8	Lady Murphy	Chaffee	8/24/2016	Sampled	
DRMS-9	Mary Murphy	Chaffee	8/24/2016	Sampled	
DRMS-10	Stonewall	Chaffee	8/24/2016	Sampled	
DRMS-11	Waldorf/Wilcox Tunnel	Clear Creek	9/4/2016	Sampled	
DRMS-12	Burleigh Tunnel	Clear Creek		Not sampled	
DRMS-13	Rockford	Clear Creek	8/11/2016	Sampled	
DRMS-14	Silver Age	Clear Creek	8/11/2016	Sampled	
DRMS-15	Rosebud Mine	Dolores	9/15/2016	Sampled	
DRMS-16	Perigo	Gilpin		Not sampled	Forest Service / EPA characterized
DRMS-17	Enterprise	Gunnison	10/3/2016	Sampled	
DRMS-18	Augusta complex 1	Gunnison	9/9/2016	No discharge	
DRMS-19	Augusta Mine	Gunnison	9/9/2016	Sampled	
DRMS-20	Baxter Basin Mines 2	Gunnison	9/9/2016	Sampled	
DRMS-21	Baxter Basin Mines 3	Gunnison	9/9/2016	Sampled	
DRMS-22	Copley Lake Mines	Gunnison	10/10/2016	Sampled	

Site ID	Mine name	County	Visit date	Visit status	Comments
DRMS-23	Daisy Mine Complex 1	Gunnison	10/5/2016	Sampled	
DRMS-24	Daisy Mine Main portal	Gunnison	10/5/2016	Sampled	
DRMS-25	Forest Queen	Gunnison	10/7/2016	Sampled	
DRMS-26	Lead King 1	Gunnison	10/10/2016	Sampled	
DRMS-27	Lead King 2	Gunnison	10/10/2016	Sampled	
DRMS-28	Queen Basin Mine	Gunnison	10/15/2016	Sampled	
DRMS-29	Robinson Basin Mine	Gunnison	10/7/2016	Sampled	
DRMS-30	Standard Mine Level 5	Gunnison	10/10/2016	Sampled	
DRMS-31	Standard Mine Level 98	Gunnison	10/10/2016	Sampled	
DRMS-32	Sylvanite Mine	Gunnison	10/15/2016	Sampled	
DRMS-33	Carter Raymond	Gunnison	10/14/2016	Sampled	
DRMS-34	Chicago Tunnel	Hinsdale	9/20/2016	Sampled	
DRMS-35	Cooper Creek Mines	Hinsdale	10/4/2016	No discharge	
DRMS-36	Dawn of Hope	Hinsdale	9/15/2016	No discharge	
DRMS-37	Fleece Ilma	Hinsdale	9/15/2016	Sampled	
DRMS-38	Gladiator	Hinsdale		Not sampled	
DRMS-39	GNOME	Hinsdale	9/15/2016	Sampled	
DRMS-40	Hough	Hinsdale	9/8/2016	Sampled	
DRMS-41	Lellie	Hinsdale	9/20/2016	No discharge	
DRMS-42	Pelican	Hinsdale	9/20/2016	Sampled	
DRMS-43	Pride of America	Hinsdale	9/20/2016	Sampled	
DRMS-44	Risorgimento	Hinsdale	9/20/2016	Sampled	

Site ID	Mine name	County	Visit date	Visit status	Comments
DRMS-45	Sarah Wood	Hinsdale	9/8/2016	No discharge	
DRMS-46	Vulcan	Hinsdale	9/20/2016	Sampled	
DRMS-47	Wyoming	Hinsdale	9/8/2016	Sampled	
DRMS-48	Allard Tunnel	La Plata	9/19/2016	Sampled	
DRMS-49	Griffin Tunnel	Lake	8/23/2016	Sampled	
DRMS-50	Rosse Tunnel	Lake	8/23/2016	Sampled	
DRMS-51	Sherman Mine	Lake	9/23/2016	Sampled	
DRMS-52	Siwatch Tunnel	Lake	9/23/2016	Sampled	
DRMS-53	Wilkesbarre #1	Lake	8/23/2016	Sampled	
DRMS-54	Wilkesbarre #2	Lake	8/23/2016	Sampled	
DRMS-55	Solomon	Mineral		Not sampled	
DRMS-56	Gold Dollar	Montezuma		No discharge	
DRMS-57	Thunder Mine	Montezuma	10/13/2016	Sampled	
DRMS-58	Atlas	Ouray	9/15/2016	Sampled	
DRMS-59	Auburn	Ouray	9/27/2016	Sampled	
DRMS-60	Camp Bird	Ouray		Not sampled	
DRMS-61	Grizzly Bear	Ouray	9/27/2016	Sampled	
DRMS-62	Hidden Treasure	Ouray	9/13/2016	Sampled	
DRMS-63	Larson Brothers	Ouray	9/18/2016	Sampled	
DRMS-64	Silver Mountain	Ouray	7/22/2016	Sampled	
DRMS-65	Terrible #3	Ouray	9/15/2016	Sampled	
DRMS-66	Upper Camp Bird #3	Ouray	9/13/2016	Sampled	
DRMS-67	Walker/Ruby Trust	Ouray		Not sampled	
DRMS-68	Jay Eye See Claim	Ouray	7/22/2016	Sampled	

Site ID	Mine name	County	Visit date	Visit status	Comments
DRMS-69	Buckskin Joe	Park	9/7/2016	Sampled	
DRMS-70	London Water Tunnel	Park		Not sampled	Removed from sampling list/ has active Permit
DRMS-71	Orphan Boy	Park	9/5/2016	Sampled	
DRMS-72	Dauntless	Park	11/15/2016	Sampled	
DRMS-73	Hall Valley - Missouri & Rosalie	Park	8/16/2016	Sampled	
DRMS-74	Coal Basin Rock Tunnel	Pitkin		No discharge	
DRMS-75	Hope	Pitkin	9/20/2016	Sampled	
DRMS-75	Hope	Pitkin	10/18/2016	Sampled	
DRMS-76	Ruby	Pitkin	9/21/2016	Sampled	
DRMS-76	Ruby	Pitkin	10/18/2016	Sampled	
DRMS-77	Iron Springs Mine	Routt	10/14/2016	Sampled	
DRMS-78	Minnie Lynch	Saguache	10/4/2016	Sampled	
DRMS-79	Whale	Saguache	10/4/2016	Sampled	
DRMS-80	Akron	Saguache	10/14/2016	Sampled	
DRMS-81	North Star	Saguache	10/14/2016	Sampled	
DRMS-82	Old Lout	San Juan	9/6/2016	Sampled	
DRMS-83	Anglo-Saxon*	San Juan	9/14/2016	Sampled	
DRMS-84	Aspen Mine	San Juan	9/28/2016	Sampled	
DRMS-85	Auburn Tunnel	San Juan	9/26/2016	Sampled	
DRMS-86	Bagley / Frisco Tunnel*	San Juan	9/28/2016	Sampled	
DRMS-87	Bandora Mine*	San Juan	9/29/2016	Sampled	
DRMS-88	Big Colorado*	San Juan	9/28/2016	Sampled	
DRMS-89	Black Hawk Mine	San Juan	9/21/2016	Sampled	

Site ID	Mine name	County	Visit date	Visit status	Comments
DRMS-90	Bonner*	San Juan	9/1/2016	Sampled	
DRMS-91	Bradley Tunnel	San Juan	9/25/2016	Sampled	
DRMS-92	Brooklyn Mine*	San Juan	9/1/2016	Sampled	
DRMS-93	Columbus*	San Juan	9/16/2016	Sampled	
DRMS-94	Eveline*	San Juan	9/29/2016	Sampled	
DRMS-95	Ferrocete Mine*	San Juan	9/1/2016	Sampled	
DRMS-96	Gold Point	San Juan	9/20/2016	No discharge	
DRMS-97	Golden Fleece	San Juan	9/26/2016	No discharge	
DRMS-98	Grand Mogul*	San Juan	9/20/2016	Sampled	
DRMS-99	Green Mountain Mine	San Juan	9/25/2016	Sampled	
DRMS-100	Hamlet Mine	San Juan	9/26/2016	Sampled	
DRMS-101	Henrietta 7	San Juan	9/29/2016	No discharge	
DRMS-102	Hidden Treasure	San Juan	9/25/2016	Sampled	
DRMS-103	Indian Chief	San Juan	9/28/2016	Sampled	
DRMS-104	Iowa Mine	San Juan	9/12/2016	No discharge	
DRMS-105	Iowa Mine Southern Adit	San Juan	9/12/2016	No discharge	
DRMS-106	Joe and Johns*	San Juan	9/29/2016	Sampled	
DRMS-107	Junction Mine*	San Juan	9/1/2016	Sampled	
DRMS-108	Kitti Mack	San Juan	9/26/2016	Sampled	
DRMS-109	Lark Mine	San Juan	9/29/2016	Sampled	
DRMS-110	Lewis Property*	San Juan	9/20/2016	No discharge	
DRMS-111	Little Dora*	San Juan	9/15/2016	Sampled	
DRMS-112	Little Nation*	San Juan	9/28/2016	Sampled	

Site ID	Mine name	County	Visit date	Visit status	Comments
DRMS-113	London	San Juan	9/16/2016	Sampled	
DRMS-114	Lucky Jack	San Juan	9/16/2016	Sampled	
DRMS-115	Mountain Queen*	San Juan	9/28/2016	Sampled	
DRMS-116	North Star*	San Juan	9/15/2016	Sampled	
DRMS-117	Old Hundred Mine	San Juan	9/25/2016	Sampled	
DRMS-118	Paradise*	San Juan	9/1/2016	Sampled	
DRMS-119	Porcupine*	San Juan	9/14/2016	Sampled	
DRMS-120	Pride of Bonita	San Juan	9/20/2016	Sampled	
DRMS-121	Queen Anne	San Juan	9/20/2016	Sampled	
DRMS-122	Royal Tiger*	San Juan	9/12/2016	Sampled	
DRMS-123	Senator*	San Juan	9/16/2016	Sampled	
DRMS-124	Silver Ledge*	San Juan	9/21/2016	Sampled	
DRMS-125	Silver Queen	San Juan	9/26/2016	No discharge	
DRMS-126	Silver Wing*	San Juan	9/28/2016	Sampled	
DRMS-127	Smuggler Mine	San Juan	9/25/2016	Sampled	
DRMS-128	Sound Democrat*	San Juan	9/26/2016	No discharge	
DRMS-129	Tom Moore	San Juan	9/28/2016	Sampled	
DRMS-130	Upper Vermillion	San Juan	9/28/2016	No discharge	
DRMS-131	Vermillion Mine*	San Juan	9/28/2016	Sampled	
DRMS-132	Yukon	San Juan	9/20/2016	Sampled	
DRMS-133	Black Hawk Adit	San Miguel	9/12/2016	Sampled	
DRMS-134	Calumet Mine	San Miguel	9/11/2016	Sampled	
DRMS-135	Game Bird Mine	San Miguel	9/11/2016	Sampled	
DRMS-136	Draining Mine A near Carbonero	San Miguel	9/9/2016	Sampled	

Site ID	Mine name	County	Visit date	Visit status	Comments
DRMS-137	Draining Mine B near Carbonero	San Miguel	9/9/2016	Sampled	
DRMS-139	New Dominion	San Miguel	9/9/2016	Sampled	
DRMS-141	Victor, AKA New American	San Miguel	9/9/2016	Sampled	
DRMS-142	Germania	Summit	9/3/2016	Sampled	
DRMS-143	Puzzle/Willard #2 Adit	Summit	9/1/2016	Sampled	
DRMS-144	Puzzle/Willard #1 Adit	Summit	9/1/2016	Sampled	
DRMS-145	Jumbo Mine	Summit	8/18/2016	Sampled	
DRMS-146	Morgan Mine	Summit	10/29/2016	No discharge	
DRMS-147	Shoebasin	Summit	8/18/2016	Sampled	
DRMS-148	Swan River Mine (Tiger Mine)	Summit	11/3/2016	Sampled	
DRMS-149	Roosevelt Tunnel	Teller		Not sampled	
DRMS-150	Sawthmore Mine	Boulder	8/17/2016	Sampled	New site added
DRMS-151	Delaware Mine	Summit	8/18/2016	Sampled	New site added
DRMS-152	Great Eastern Mine	Park	8/16/2016	Sampled	New site added
DRMS-153	McClelland Tunnel	Clear Creek	8/11/2016	Sampled	New site added
DRMS-154	Nelson Tunnel	Lake	8/23/2016	Sampled	New site added
DRMS-155	Tiger Tunnel	Lake	8/23/2016	Sampled	New site added
DRMS-156	Canterbury Tunnel	Lake	8/22/2016	Sampled	New site added
DRMS-157	Bartlet	Lake	8/23/2016	Sampled	New site added
DRMS-158	Greyhound	Ouray	9/27/2016	Sampled	New site added
DRMS-159	Blaine Mine	Ouray		Not sampled	New site added/no sample taken
DRMS-160	Mountain Top	Ouray	9/15/2016	Sampled	New site added

Site ID	Mine name	County	Visit date	Visit status	Comments
DRMS-161	Grey Burro	Ouray		Not sampled	New site added
DRMS-162	Caldwell	Ouray		No discharge	New site added - dry
DRMS-163	Saints John	Summit	10/30/2016	Sampled	New site added
DRMS-164	Ruby Trust	San Juan	9/1/2016	Sampled	New site added
DRMS-165	Bullion King	San Juan	9/1/2016	Sampled	New site added
DRMS-166	Lost Trail Mine 1	Gunnison	10/10/2016	Sampled	New site added
DRMS-167	Baxter Basin Mine 1	Gunnison	9/9/2016	No discharge	
DRMS-168	Silverspoon	Summit	10/5/2016	Sampled	
DRMS-169	Carson 1	Hinsdale	11/16/2016	Sampled	
DRMS-170	Carson 2	Hinsdale	11/16/2016	Sampled	
DRMS-171	Carson 3	Hinsdale	11/16/2016	Sampled	
DRMS-172	Carson 4	Hinsdale	11/16/2016	Sampled	
DRMS-173	Baxter Basin Draining Mine #1	Gunnison	9/9/2016	No discharge	
DRMS-174	Lower McIntyre	Ouray	1/15/2016	Sampled	New site added
DRMS-175	Pride of the West	San Juan	10/6/2016	Sampled	
DRMS-176	Mammoth	San Juan	10/20/2016	Sampled	New site added
DRMS-178	Forest Queen (San Juan)	San Juan	10/19/2016	Sampled	New site added
DRMS-179	Elk Tunnel	San Juan	10/20/2016	Sampled	New site added