

SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM

WATERSHED PROJECT FINAL REPORT

Upper Uncompahgre Watershed Mine Remediation Project

by

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This project was conducted in cooperation with the State of Colorado and the United States Environmental Protection Agency, Region 8.

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EXECUTIVE SUMMARY

PROJECT TITLE: Upper Uncompahgre Watershed Mine Remediation Project

PROJECT START DATE: May 14, 2014 PROJECT COMPLETION DATE: Feb. 14, 2018

FUNDING:	TOTAL BUDGET	\$365,231.30
	TOTAL EPA GRANT	\$163,125.00
	TOTAL EXPENDITURES OF EPA FUNDS	\$151,766.03
	TOTAL SECTION 319 MATCH ACCRUED	\$185,178.92
	BUDGET REVISIONS	1) \$78,187.79 EPA funds after 2/28/2017 2) \$59,588.19 EPA funds after 8/31/2017
	TOTAL EXPENDITURES	\$285,649.84 (EPA funds + cash match) \$336,944.95 (EPA funds + all match)

SUMMARY ACCOMPLISHMENTS

1. BMPs were installed at three locations in the Upper Uncompahgre Watershed to reduce metals loading to the Upper Uncompahgre River, Gray Copper Gulch and Sneffels Creek. This project in combination with other mine remediation actions taking place in the watershed should help to make progress in reducing metal loads and implementing TMDLs in the watershed.

2. A sampling and analysis plan (SAP) was developed and implemented to characterize surface water chemistry and macroinvertebrate communities before and after BMP implementation. These data were used to estimate load reductions and downstream water quality improvements from the BMPs. Results are summarized Section 4.3 and provided in Appendix A.

3. The sampling and analysis plan (SAP) also included additional sites in the headwaters of the Uncompahgre Watershed which were sampled in 2016 and 2017 to evaluate potential metals impairments to water quality. Analysis included water standards evaluation, metal loading, and identification of pollution sources. Results are summarized Section 4.3 and provided in Appendix B.

Data generated from this project were uploaded to WQX/STORET.

4. Water quality data collected by UWP and others were evaluated to characterize spatial patterns in water quality in the Upper Uncompahgre Watershed. Metal loading patterns and potential load reductions were assessed to prioritize future clean-up work. Results are provided in Appendix C.

5. The UWP provided multiple opportunities for public education on this project and the issue of water quality impacts from abandoned mines in general. This included press reports, community presentations, e-newsletters, field trips to the sites, presentation at and organization of the annual San Juan Mining and Reclamation Conference, and interpretive signs at project sites.

6. NPS semi-annual reports and reimbursement requests were provided regularly.

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1.0 INTRODUCTION

The Uncompahgre River Watershed (HUC 14020006) drains 1,115 square miles (713,876 acres) of the Gunnison Basin in southwestern Colorado. The Uncompahgre River originates in Lake Como at 12,215 ft. in the Uncompahgre National Forest and flows approximately 75 miles to Confluence Park, Delta where it joins the Gunnison River at an elevation of 4,915 ft. The seasonal flow patterns of the Uncompahgre River and tributaries are comprised of a low, base-flow period that generally runs from August through April followed by a high flow period that runs from May through July. Typical peak flows occur in late May through late June from snowmelt runoff. In recent years, however, peak snowmelt has often occurred earlier and over a shorter duration than the historical average. Numerous high runoff periods occur during the monsoon season of July and August from strong thunderstorms. The upper watershed (south and upstream of City of Ouray) is characterized by the San Juan Mountains which are a mixture of pre-Cambrian metamorphics with mid-Tertiary Andesitic volcanic intrusions that have deposited several minerals in extractable quantities, including gold, lead, silver, and copper. The upper watershed is characterized by steep, glacial valleys and confined stream channels. The lower watershed of the Uncompahgre River Valley (downstream and north of City of Ouray) is characterized by sedimentary rocks, low gradient streams, and wide alluvial valley floors. Approximately half of the land in the Uncompahgre River Watershed is managed for conservation and recreation by the federal government. The rest of the lands are private: residential, commercial, and agricultural (Fig. 1). Approximately 11% of the watershed is irrigated agriculture. The primary past and present land uses in the watershed include mining, production agriculture, residential and commercial development, recreation, and tourism.

Natural mineralization rates of the ore-rich Red Mountain Massif and high mining activity in the late 1800s to mid-20th century have resulted in high heavy metal loading in Uncompahgre's headwaters (Upper Uncompahgre Watershed). One of the largest mining operations in the watershed was the Idarado Mine (now part of Newmont Mining Corporation) which was operational on Red Mountain Creek, Uncompahgre River's main headwater tributary, until 1979. In 1983, the State of Colorado filed a lawsuit against Idarado using the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The lawsuit was settled in 1992 and Idarado implemented a remediation plan as required by a Consent Decree resulting from Natural Resource Damage Claims brought forth by the state. Because impacts from Idarado's sites are being mitigated with oversight from CDPHE, the goal of this project was to address acid mine drainage and heavy metals loading from other legacy mines in the watershed. Improving water quality by reducing heavy metals and meeting Total Maximum Daily Loads (TMDLs) for water bodies in the upper Uncompahgre watershed is the primary goal of the Uncompahgre Watershed Plan (UWP 2018).

According to the 2012 Nonpoint Source Management Plan, addressing pollution from legacy mining was the top priority. Consequently, waterbodies on the 303(d) List of Impaired Waters and outside of Idarado's Consent Decree were considered for this project. The Water Quality Control Division Environmental Data Unit Staff investigations of restoration potential further refined priorities to a few key water bodies or stream segments based on a statewide assessment of waters impaired by heavy metals. Staff considered several factors including, the degree of impairment (i.e. not far from meeting standards), low concentration of mines, existing data,

accessibility, and partner remediation support. By applying this filter and commencing field investigations in 2012, partners were able to facilitate and expedite restoration planning within the Uncompahgre watershed.

Three waterbodies and associated legacy mine sites were selected for this project (Fig. 1): Upper Uncompahgre River (Michael Breen Mine), Gray Copper Gulch (Vernon Mine) and Sneffels Creek (Atlas Mill). Their beneficial uses and impairments per CDPHE-WQCD Regulation 35 and 93 are summarized in Table 1.

Table 1. Waterbodies included in this project: beneficial uses classification under Regulation 35 (effective 12/31/17) and Regulation 93 (effective 3/2/18). Regulation 93 effective Mar. 30, 2012 was used to develop the original Project Implementation Plan.

Waterbody ID	Beneficial Uses	303(d) list	TMDL Status	Colorado M&E
COGUUN02 (Uncompahgre River)	Agriculture, Aquatic Life Cold 1*, Recreation P, Water Supply‡	pH*, Mn‡	Cd, Cu, Zn (2010); Cd revision in progress	Pb*
COGUUN07 (Gray Copper Gulch)	Agriculture, Aquatic Life Cold 2*, Recreation P, Water Supply	Cu*, Pb*, Zn*, pH*	In Progress	
COGUUN05 (Sneffels Creek)	Agriculture, Aquatic Life Cold 2*, Recreation E, Water Supply‡	Sneffels Creek downstream of Governor Basin: Cd*, Pb*, Mn‡, Zn*, and Macroinvertebrates*	In Progress	
COGUUN09	Agriculture, Aquatic Life Cold 2*, Recreation P	Sneffels Cr: Cd*, Pb*, Zn*; Imogene Cr: Cd*, Cu*, Zn*; Canyon Cr: Zn*	In Progress	Sneffels Cr: Macroinvertebrates*

Pre- and post-implementation surface water and macroinvertebrate samples were collected at the site scale within the respective waterbodies to evaluate implementation of Best Management Practices (BMPs) at each project site. Additionally, samples were collected at other sites in the Upper Uncompahgre Watershed (part of Headwaters Assessment of this project) to characterize heavy metal loading from other features to the waterbodies included in this project. These data will inform future restoration planning in the watershed. BMPs for each project were informed by Best Practices in Abandoned Mine Land Reclamation (CDNR 2002) and discussions with project partners.

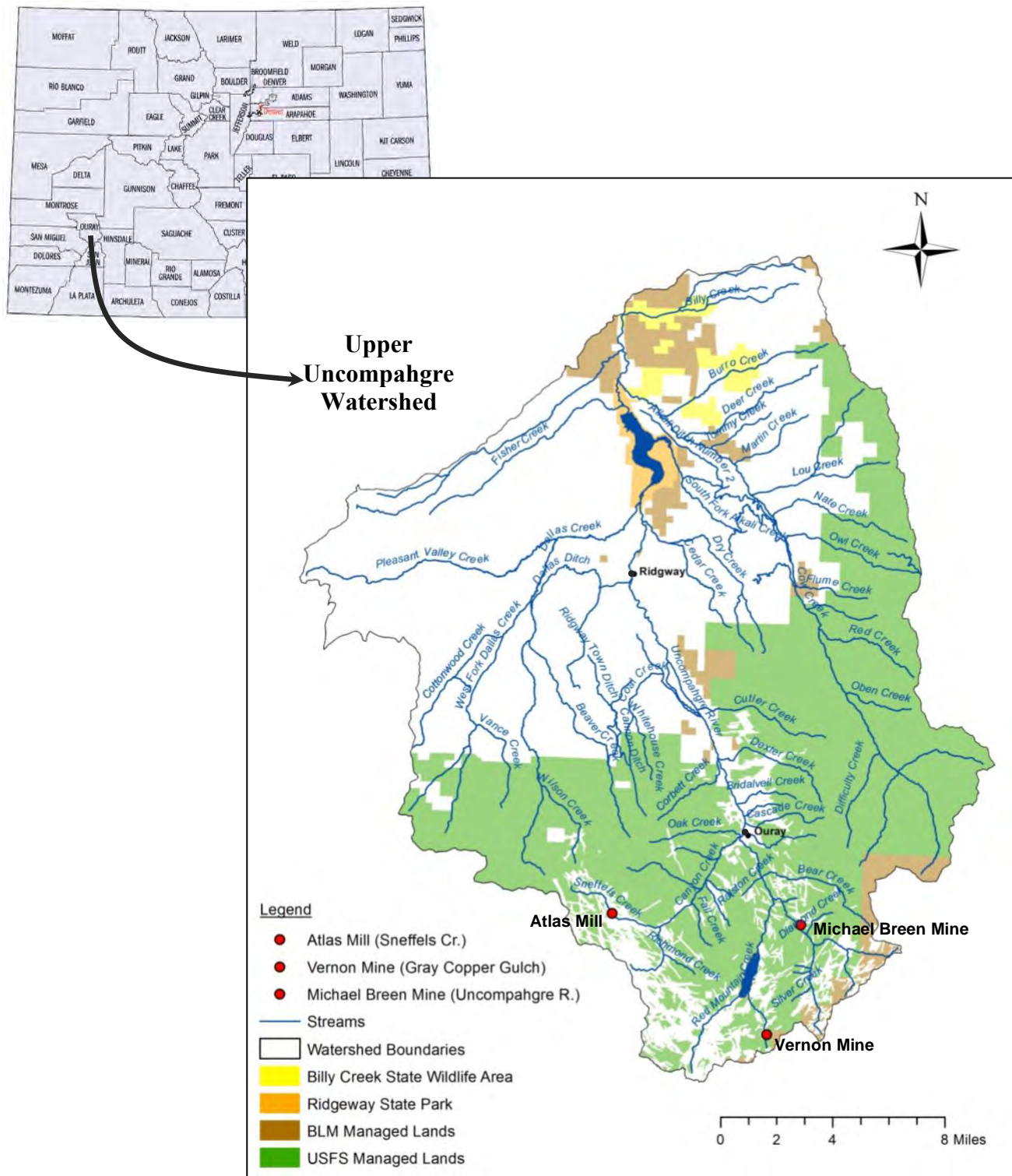


Figure 1. Map of the Upper Uncompahgre Watershed showing land ownership and location of the three project sites: Atlas Mill, Vernon Mine, and Michael Breen Mine.

2.0 PROJECT GOALS, OBJECTIVES AND ACTIVITIES

The following goals and objectives were outlined in the Project Implementation Plan (PIP). The tasks that were completed to implement these goals are described with each objective.

GOAL 1. Improve water quality of the Upper Uncompahgre River watershed by reducing the level of heavy metal loading or acid mine drainage from three legacy mining sites: Atlas Mill to Sneffels Creek, Vernon Mine to Gray Copper Gulch, and Michael Breen to the upper Uncompahgre River.

Objective 1. Reduce metals loading to Sneffels Creek by addressing sources from Atlas Mill.

Problem: Based on 2012 data collected by the Water Quality Control Division (WQCD), Sneffels Creek reference site above the Atlas Mill was in attainment of state water quality standards for cadmium and zinc, while the segment below the mill failed to attain dissolved chronic and acute zinc and chronic cadmium standards at high flows. This indicated that the tailings might be a source of metals to the creek. Furthermore, before the project there was evidence of erosion of the tailings by 1) the stream's main channel and 2) a secondary channel that flowed through the tailings and reentered the stream at the project "below Atlas Mill sampling site."

Task 1.

A) Complete site investigation, cost estimate, permitting and design of remediation approach of tailings deposited along Sneffels Creek from the abandoned Atlas Mill. Determine boundaries of tailing deposits, evaluate tailings removal and repository protocols, as well as re-vegetation, streambank stabilization and possible wetland creation methods.

B) Implement site remediation as determined by efforts in Task 1A.

Products.

A) Army Corps of Engineers Nationwide Permit for stream channel augmentation and stabilization. This included consultation with State Historical Preservation Office as the site had been previously recorded for cultural resources. Construction bid, channel and revegetation design were completed by Western Stream Works.

Original remedial actions considered for the NPS project included 1) removal of the Atlas Mill tailings (estimated at 7 acres, 20,000 cubic yards), their re-milling and reprocessing in the mill of the adjacent Revenue Mine, vegetation of the area and stabilization of Sneffels Creek streambanks or 2) capping and vegetation of the tailings and stabilization of Sneffels Creek. Because of mixed ownership challenges (private and USFS) and grant timeline constraints, the final approach was to mitigate metal loading to the stream by reducing erosion of the mine tailings into the stream by re-aligning the main channel, closing off the secondary channel that crossed the

tailings, and stabilizing the new channel's streambanks with physical in-stream structures and riparian vegetation.

- B) A 450' reach of Sneffels Creek was mitigated. The braided section of the reach was removed by excavating a new, three-stage single channel to prevent the stream from flowing through the tailings area. Streambanks were stabilized with vane arms, willow transplants, willow bundles, and willow stakes. Four acres of disturbed areas were seeded with an herbaceous seed mix.

Objective 2. Reduce metals loading and improve pH of mine drainage from Vernon Mine to Gray Copper Gulch.

Problem: The Vernon mine consists of a draining adit discharging a constant small volume of water that before project implementation flowed through the existing waste rock pile and into Gray Copper Gulch. In addition, a large waste rock pile was located in the drainage. The metal loads from the draining adit and those leached from the metal laden waste rock pile were entering Gray Copper Gulch. In addition, the waste rock pile was eroding directly in to Gray Copper Gulch during periods of high flows.

Task 2.

- A) Complete site investigation, cost estimate, permitting and design of remediation approach at the Vernon Mine. Determine appropriate diversion of drainage waters, waste rock removal and repository, and possible revegetation approach.
- B) Implement site remediation as determined by efforts in Task 2A.

Products.

- A) The Cultural Resource Survey was completed by Division of Reclamation, Mining, and Safety (DRMS). DRMS also prepared design for project construction, bid and contract for the construction team. Revegetation approach was designed by DRMS and UWP.
- B) The water from the draining adit was diverted from flowing through the waste rock pile. The waste rock pile (1,500 cubic yards) lower in the drainage was excavated and hauled up on to the mining claim in to a repository area. The excavated 1-acre area was treated with soil amendments, seeded and mulched.

Objective 3. Reduce metals loading from Michael Breen Mine to the Uncompahgre River.

Problem: The Michael Breen mine consists of a draining adit that before the project discharged a constant small volume of water that flowed through a waste rock pile and into the Uncompahgre River. The metal loads from the draining adit and the additional metals associated with the interaction of the adit water and the metal laden waste rock pile were a source of contaminants to the river. In addition, the draining adit water ponded underneath a historic loadout structure causing issues with the foundation's structural integrity.

Task 3.

- A) Complete site investigation, cost estimate, permitting and design of remediation approach at the Michael Breen Mine. Determine appropriate diversion of drainage waters, drainage design across Ouray County Road 17, potential removal of waste rock near load-out structure, and hillslope stabilization/vegetation.
- B) Implement site remediation as determined by efforts in Task 3A.

Products.

- A) The Cultural Resource Survey and SHPO consultation was completed by Alpine Archaeological Consultants. Per its recommendations, DRMS prepared the design for project construction, bid and contract for construction team (Mountain Region Corporation). Revegetation approach was designed by Research Services, LLC.
- B) A drainage ditch was excavated to divert approximately 1 cfs of draining adit water away from waste rock and loadout structure. The associated drainage across county road was improved with installation of a culvert, 1 acre of waste rock and diversion ditch were amended and seeded, and the historic loadout structure was stabilized.

GOAL 2: Monitor and report the effectiveness of BMPs implemented at Atlas Mill, Vernon Mine, and Michael Breen Mine. And, expand or refine water quality sampling at abandoned mine nonpoint sources to prioritize remediation sites for future restoration efforts in Upper Uncompahgre River Headwaters

Objective 4. Collect pre- and post-project water quality to document and evaluate the effectiveness of mine remediation efforts. And, assess water quality at other abandoned mine sites in Uncompahgre River headwaters to prioritize future remediation efforts.

Task 4.

- A) Develop a Sampling Analysis Plan (SAP) for pre- and post-project monitoring and evaluation of remediation efforts at the three project sites (Atlas Mill, Vernon Mine, Michael Breen Mine) as well as for collection of baseline data at other sites in the Uncompahgre River headwaters (i.e. Headwaters Assessment).
- B) Collect water quality data, vegetation cover and channel geometry data where appropriate. Analyze and document results in final project report. Upload data for storage in EPA WQX/STORET database.

Products.

- A) SAP(s) were prepared in collaboration with CDPHW-WQCD TMDL Bridge to Restoration Program. The original SAP was amended as needed for each sampling campaign and included site specific sampling information, field and laboratory methods, and QA/QC programs.

- B) Pre-and post-project surface water and macroinvertebrate samples were collected at the three project sites at high and low flows at locations in corresponding streams that bracketed the sites. Results, load reductions and evaluation of BMPs at the three project sites are detailed in Measurable Results Assessment for the Atlas Mill, Michael Breen, and Vernon Abandoned Mine Sites in the Uncompahgre River Watershed (AEC 2018a; Appendix A). 101 samples were collected from 42 locations for the Headwater Assessment during high and low flow sample events in 2016 and 2017 (AEC 2018b; Appendix B). Water quality data were compiled, mapped, and assessed to identify future reclamation projects in the Upper Uncompahgre River Watershed Data Compilation and GIS Analysis (AEC 2018c; Appendix C). All data collected for this NPS project have been uploaded to EPAWQX/STORET database via Colorado Data Sharing Network (CDSN).

GOAL 3: Conduct effective project administration and outreach. Inform and educate the public on the need for and progress of mine remediation projects in the Uncompahgre watershed through effective outreach and education activities.

Objective 5. Communicate project implementation plan and outcomes with the public through community outreach and education activities. Enhance understanding of mine remediation by installing interpretive signs at two remediated sites.

Task 5.

- A) Organize community presentations and site tours to inform the public on project goals and mine remediation approaches. Build an informed UWP stakeholder group on abandoned mine issues and mine remediation needs for improved water quality in the Uncompahgre watershed.
- B) Install interpretive signs at Atlas Mill and Michael Breen Mine to enhance public awareness of abandoned mine reclamation.

Products.

A) Public Events:

- Community presentation about need and plans for the project at Ridgway State Park (8/16/2014).
- Community presentation at the Sherbino Theatre in Ridgway, CO on legacy of mining in the region, water quality impairments, need for remediation, this project and work to date at Michael Breen Mine (3/6/2015).
- Community presentation in collaboration with Ridgway-Ouray Community Council at the Wright Opera House in Ouray, CO. Content included historic mining, re-opening of local silver mine, watershed water quality status and need for remediation, highlights of this project (6/17/2015).
- Project presentations at San Juan Mining and Reclamation Conferences: review of 3 projects (May 2015), Atlas Mill-Sneffels Creek Bank Stabilization Project (May 2016), heavy metals impairments in the Uncompahgre Watershed and how UWP's projects are making a difference in water quality (May 2017).

- Public Field Tour: the tour of project at Atlas Mill was organized in conjunction with the 2017 San Juan Mining and Reclamation conference and was attended by 40 people.

San Juan Mining and Reclamation Conference:

- Collaboration with partner organizations (DRMS, watershed groups, CDPHE-NPS) to organize the annual San Juan Mining and Reclamation Conference (2015, 2016, 2017, 2018) to educate public on impacts of legacy mining, remediation approaches, and contemporary mining approaches to water quality impacts, and to build networks among diverse stakeholders.

Media:

- Articles in Ouray County Plaindealer: 11/13/2014, 3/5/2015, 7/14/2016
- Articles in Montrose Mirror: 10/12/2015 and Montrose Daily Press: 10/22/2015
- Article in The Watch: 12/21/2016
- Uncompahgre Watershed Annual Reports 2016, 2017 (electronic and print)
- Website updates: www.uncompahgrewatershed.org
- Electronic e-mails on project updates to UWP's stakeholders.

B) Two 30" x 48" weather proof interpretive signs were installed at the Michael Breen project site. One sign is an overview of historic mining at the site and the San Juan Mountains, while the second sign depicts this remediation project and importance of mine remediation to improve water quality in the Uncompahgre Watershed. An interpretive sign was not fabricated and installed at the Atlas Mill site because of uncertainty of project completion and delayed change in project timeline. Instead, a 24" x 36" Keep Off sign with before and after project pictures and informative text was installed at the Atlas Mill.

Objective 6. Conduct effective project administration and evaluation. (Programmatic Goal 3)

Task 6.

Project administration (contracts, budgeting, invoicing) and reporting.

Products. Reimbursement invoices, match reporting, progress, semi-annual and final reports.

2.1 PLANNED AND ACTUAL MILESTONES, PRODUCTS, AND COMPLETION DATES

Planned and actual milestones and product completion dates for the six project tasks are summarized in Table 2. Dotted cells indicate planned completion dates while filled cells indicate actual completion dates. This project's primary tasks were Implementation Task 1, 2, 3 and Evaluation Task 4. These, and major deviations from planned timeline, are summarized in detail below Table 2.

Table 2. Project tasks, products, actual (filled cells) and planned (dotted cells) timelines.

Task	Partners*	Products & Outcomes	2014				2015				2016				2017				2018
			Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar
1. Atlas Mill (Sneffels Cr.)	UWP, OSM, WSW, DRMS, USFS	Army Corps of Engineers Nationwide Permit, design and bid, 450 ft of stabilized streambank, 5 acres seeded, minor improvement in water quality.																	
2. Vernon Mine (Gray Copper Gulch)	UWP, DRMS, Private Landowner	Design and bid, Cultural Resource Survey, 1,500 cu yd of waste rock removed, diverted draining adit, 1 acre seeded, water quality improvements not quantifiable because of flow variations.																	
3. Michael Breen Mine (Uncompahgre R.)	UWP, DRMS, AAC, OCRB, OCHS	Design and bid, Cultural Resource Survey, 1 cfs of adit drainage diverted, stabilized historic loadout structure, 1 acre seeded, small improvement in water quality.																	
4. Evaluation	UWP, DRMS, WQCD	Sampling Analysis Plan (SAP), pre- & post-project and headwaters sites; surface water and macroinvertebrate data sets, report on water quality trends, load reductions and prioritization of future projects; data storage in EPA WQX/STORET.																	
5. Community Outreach	UWP, DRMS, AAC, OSM, WSW	Stakeholder media updates (press reports, website, e-mails, FaceBook), community and conference presentations, San Juan Mining & Reclamation Conference (2015-2017), field two to two interpretive signs at Michael Breen site, Keep Off informative sign at Atlas Mill site.																	
6. Project Administration	UWP	Contracts, invoices, match reporting, progress, semi-annual and final reports.																	

*Partners:

AAC: Alpine Archaeological Consultants, LLC
 DRMS: Division of Reclamation, Mining and Safety
 OCHS: Ouray County Historical Society
 OCRB: Ouray County Road and Bridge Department

OSM: Ouray Silver Mines, Inc.
 USFS: United States Forest Service
 UWP: Uncompahgre Watershed Partnership
 WSW: Western Stream Works
 WQCD: Water Quality Control Division

Task 1. Atlas Mill.

Original remedial actions considered for the NPS project included 1) removal of the Atlas Mill tailings (estimated at 7 acres, 20,000 cubic yards), their re-milling and reprocessing in the mill of the adjacent Revenue Mine, vegetation of the area and stabilization of Sneffels Creek streambanks or 2) capping and vegetation of the tailings and stabilization of Sneffels Creek. Because of mixed ownership challenges (private and USFS) and grant timeline constraints, the final approach was to mitigate metal loading to the stream by reducing erosion of the mine tailings into the stream by re-aligning the main channel, closing off the secondary channel that crossed the tailings, and stabilizing the new channel's streambanks with physical in-stream structures and riparian vegetation.

Jun. 11, 2014 Pre-project Surface Water Sampling – High Flow

Sampling was led by Skip Feeney of CDPHE-WQCD and collected per 2014 SAP. A reference site was sampled in Sneffels Creek headwaters, **Sneffels Creek above and below Atlas Mill**, Sneffels Creek above Canyon Creek at Camp Bird, Sneffels Creek above Canyon Creek at Camp Bird ~30 ft downstream of bridge by Ruby Mine, Sneffels Creek above Canyon Creek at Camp ~30 ft Bird upstream of bridge to Imogene Pass. Additionally, a sample was collected at the Atlas Mine adit and seep below Atlas Mine waste rock pile, Governors Basin at mouth and Governors Basin at road. Samples in bold are most relevant to this project, the other samples were collected as part of a broader WQCD assessment. All surface water samples were analyzed by CDPHE-WQCD.

Sept. 10, 2014 Pre-project Surface Water & Macroinvertebrate Sampling – Low Flow

Sampling was led by Skip Feeney of CDPHE-WQCD and collected per 2014 SAP. A reference site was sampled in Sneffels Creek headwaters, Sneffels Creek above and below Atlas Mill, Sneffels Creek above Canyon Creek at Camp Bird, Sneffels Creek above Governor Basin (in June 2014 it was: Sneffels Creek above Canyon Creek at Camp Bird about 30 ft downstream of bridge by Ruby Mine), Sneffels Creek above Canyon Creek at Camp Bird about 30 ft Bird upstream of bridge to Imogene Pass. Additionally, a sample was collected at the Atlas Mine adit and seep below Atlas Mine waste rock pile, Governors Basin at mouth and Governors Basin at road. Samples in bold are most relevant to this project, the other samples were collected as part of a broader WQCD assessment. All surface water samples were analyzed by CDPHE-WQCD.

WQCD also collected surface water samples in Sneffels, Imogene, and Canyon Creeks on Oct. 18, 2013.

UWP volunteers Scott and Jenny Williams and Agnieszka Przeszlowska collected macroinvertebrate samples from Sneffels Creek above and below Atlas Mill and from Sneffels Creek above Canyon Creek at Camp Bird. Samples were analyzed by Timberline Aquatics.

May 6, 2016 Design and Permitting.

UWP contracted Western Stream Works to design and obtain an Army Corps of Engineers (ACOE) Nationwide Permit for project construction within approximately a 0.5-acre area. This included consultation with State Historic

Preservation Office (SHPO). Details of design and approach are detailed in the permit application and are summarized here:

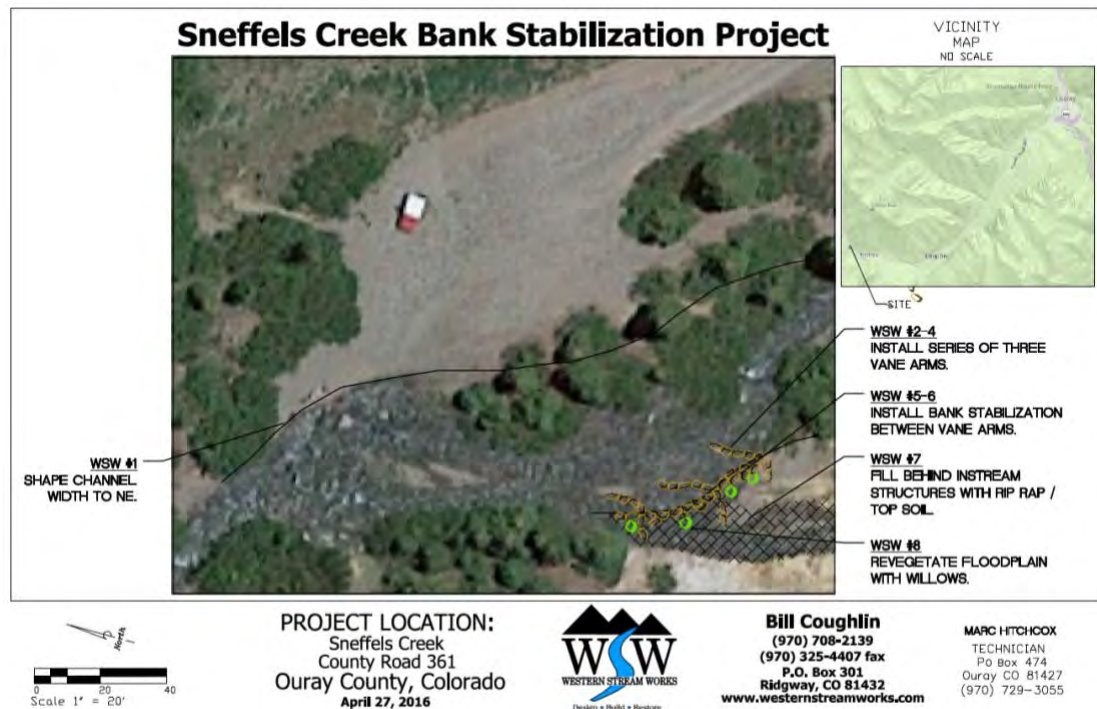


Figure 2. Schematic of design for Sneffels Creek Bank Stabilization Project.

Jun. 13, 2016 ACOE issued the Nationwide Permit for bank stabilization.

May-June 2016 Pre-project Evaluation.

WSW conducted pre-project channel stability and vegetation surveys.

Jun. 10 – Jul. 11, 2016 Construction

Aug. 25-27 & Oct. 7-26, 2016 Vegetation

WSW mobilized a trackhoe excavator and front-endloader to the project site on June 10, 2016 to shape a new channel, transport large boulders and materials for vane arms and transplant willows. A 450 ft reach of Sneffels Creek was mitigated. The braided section of the reach was removed by excavating a new, three-stage single channel to prevent the stream from flowing through the tailings area. A large depositional island was removed and the channel and floodplain was also widened (slightly increased width:depth ratio relative to upstream and downstream reference reaches) to accommodate bed load transfer and alleviate erosion of the western bank where tailings are deposited. The new channel was shaped to replicate sinuosity of reference reaches in order to dissipate sheer stresses. Excavation activities were managed with coffer dams to reduce downstream sediment transport. Large boulders (3.5-6 ft diameter) and rip-rap materials (1-2.5 ft diameter) were excavated from the nearby Potosi slide (3/4 mile away) and transported by front-end loader to the project site. The boulders and log cribbing were utilized in construction of three vane arms on the west

bank. Willows were harvested with the excavator and transplanted on top of the vane arms to further stabilize the structures and western streambank.

Established willows were harvested on-site from areas of the excavated new channel and transplanted to disturbed areas along stream banks to promote revegetation and bank stabilization. Three willow transplant techniques were used: 1) live willows with root-balls were transplanted by trackhoe, 2) willow bundles (long pole cuttings with leaves) were harvested and planted within water table, and 3) 150 live willow stakes were augured into the depth of water table. Live transplants and bundles were planted in July 2016. In August and October 2016, disturbed areas within the second stage were seeded with native, herbaceous riparian species while areas within the third stage were seeded with herbaceous upland species. A total of three acres was seeded. The riparian seeds were covered with wood straw and the upland seeds were covered with conventional straw. The wood straw remained in place after several high-altitude wind storms while the wood straw was blown against and trapped by willow transplants. The riparian seed mix comprised of bullrush, Nebraska sedge, Baltic rush, streambank wheatgrass, blue wildrye, tufted hairgrass, slender wheatgrass, mountain brome, Rocky Mountain fescue, and fowl bluegrass. The upland seed mix comprised of red top, big bluegrass, streambank wheatgrass, hard fescue, western yarrow, Kentucky bluegrass, smooth brome, slender wheatgrass, mountain brome, and Lewis flax.

Jul. 25, 2017 Post-project Surface Water Sampling – High Flow

Surface water samples were collected per 2017 SAP by WQCD (Skip Feeney, Ian C.) UWP (Agnieszka Przeszlowska, Ashley Bembenek, Julia Nave), DRMS (Jeff Litteral, Kirstin Brown, Paul Landahl, Mark Mikos) at Sneffels Creek above and below Atlas Mill, Sneffels Creek above Canyon Creek at Camp Bird, Sneffels Creek above Imogene Pass bridge and Canyon Creek below Sneffels and Imogene Creeks confluence. Samples were analyzed by CDPHE-WQCD.

August 2017 Evaluation.

WSW conducted post-project channel and vegetation surveys and recommended the following project improvements:

- 1) Remove obstacles within project channel. Logs get deposited and deposition increases, water slows and channel widens over time.
- 2) Plant additional willow stakes along meanders, to further stabilize slopes.
- 3) Remove deposition islands and deposited logs.
- 4) Build Lateral Deposition Wings, from placed rip rap and backfilled by alluvium, downstream of meanders to further mitigate sheer stress on banks.

Sept. 10, 2017 Post-project Surface Water & Macroinvertebrate Sampling – Low Flow

Surface water samples were collected per 2017 SAP by WQCD (Skip Feeney) UWP (Agnieszka Przeszlowska, Julia Nave, Elizabeth Stuffings, Justin Pomeranz) at Sneffels Creek above and below Atlas Mill, Sneffels Creek above Canyon Creek at Camp Bird, Sneffels Creek above Imogene Pass bridge and

Canyon Creek below Sneffels and Imogene Creeks confluence. Surface water samples were analyzed by CDPHE-WQCD. UWP (Agnieszka Przeszlowska, Elizabeth Stuffings, Justin Pomeranz) also collected macroinvertebrate samples from Sneffels Creek above and below Atlas Mill. Macroinvertebrate samples were analyzed by Timerline Aquatics.

Oct.10-Nov.3, 2017 Project Improvements.

WSW mobilized an excavator to the site on October 10, 2017 and over the next couple of days removed logs, debris, and small depositional islands in the channel and constructed lateral deposition wings. In late October to early November, additional willow stakes were planted along meanders with a hand auger, the third-stage upland area seeded in fall 2016 was reseeded and mulched, this time with wood straw. The seeding and mulching was extended across an upland area which had been utilized for camping and stream access by visitors. This area was first tilled and closed off to access with large boulders. All seeds were broadcast over a 1-acre area on Oct. 30 and Nov. 1, 2017 before some snowfall and mulched with wood straw on Nov. 2, 2017 after a few inches of snowfall. A Keep Off sign, which includes some project information, was installed at the boulders. A simple post and rope fence was also installed along the county road to further deter trespassers from the restoration site.

Nov. 2017 – Feb. 2018 Evaluation.

Pre- and post-project surface water and macroinvertebrate data were analyzed and BMPs were evaluated for efficacy and heavy metal load reductions.

Task 2. Vernon Mine.

The water from the draining adit was diverted from flowing through the waste rock pile in Gray Copper Gulch. The waste rock pile lower in the drainage was excavated and hauled up on to the mining claim in to a repository area.

July 2, 2014 Pre-project Surface Water Sampling – High Flow

Samples were collected by Jeff Litteral (Division of Reclamation, Mining and Safety, DRMS), Agnieszka Przeszlowska and Walter Wright (UWP) per 2014 SAP at the upper mine adit, at a small seep below the adit and waste rock, in Gray Copper Gulch above and below the mine site, and at mouth of Gray Copper Gulch. Lab analyses were completed by ACZ Laboratories.

Aug. 8, 2014 Cultural Resource Survey.

Survey of the site was completed by James Herron and Sarah Russell of Colorado DRMS. It concluded that there would be no adverse effects to historic resources from the project.

Sept. 25, 2014 Pre-project Surface Water & Macroinvertebrate Sampling – Low Flow

Surface water samples were collected by Jeff Litteral (DRMS) and Walter Wright (UWP) per 2014 Sampling Analysis Plan (SAP) at the upper mine adit, in Gray Copper Gulch above and below the mine site, and at mouth of Gray Copper

Gulch. Sample was not collected at the seep below the adit and waste rock as it was dry. Lab analyses were completed by ACZ Laboratories. A macroinvertebrate sample was collected at the below site as the flow was very low at above site and adequate sample area with flow was not located. Timberline Aquatics enumerated the sample.

May 19, 2015 Design & Bid.

Jeff Litteral of DRMS initiated contractor bidding process. Project design and implementation steps were outlined in the bid document. Construction and most vegetation work was contracted through DRMS.

Sept. 8-29, 2015 Construction, Vegetation, and Monitoring.

Construction was completed by Colorado West Contracting of Grand Junction, CO and supervised by Jeff Litteral of DRMS. A Caterpillar 966C rubber tired front end loader was used to remove approximately 1,500 cubic yards of waste rock from Gray Copper Gulch (the waste rock had been piled between a hillslope below the mine and the stream bank). The materials were removed and stockpiled up out of the drainage on to the existing mining claim; a flat area upslope and away from the waterbody. The waste rock immediately below the draining Vernon mine adit was also excavated and the drainage diverted directly to the stream and away from the waste rock excavated area below. Sediment runoff controls consisting of straw bales and Ertec S-fence were installed prior to excavation of the waste rock pile. A DRMS mine safety closure project occurred simultaneously as the non-point source project and the contractors were able to assist each other with equipment work.

The area excavated of the waste rock was amended with 10.5 cubic yards of woody compost, delivered to the site in super sacks and spread manually across the area. The woody compost was a by-product from manufacturing aspen excelsior erosion control blankets; its breakdown produces calcium carbonate which helps to neutralize acidic soil conditions. The entire area was broadcast seeded with a native seed mix comprised of Rock Mountain fescue, columbine, slender wheatgrass, American vetch, Lewis flax, blue wildrye, western yarrow, tufted hairgrass, Rocky Mountain penstemon, chick starter, aspen daisy and fringed brome. Excelsior aspen bales, blankets and mulch were used to cover the seeded areas. The repository area was left in a roughened state at the surface to prevent potential runoff. On Sept. 29, 2015, Jeff Litteral (DRMS), Agnieszka Przeszlowska and Dennis Murphy (UWP) seeded the repository with the same native seed mix used in the excavated area. It was covered with excelsior aspen bales and straw leftover from erosion bales.

Nine photo-points were established after construction to evaluate change in vegetation over time. Seven, 1-m² plots were GPS-ed and marked with flagging for vegetative cover monitoring. All cover consisted of waste rock before construction and aspen blankets construction.

July 15, 2016 Site Evaluation.

The small diversion that was constructed in fall 2015 to route adit drainage to stream and away from area that contained waste rock was functioning properly and there was no evidence of other seeps. The landscape blankets that covered the excavated waste rock were not secured to the ground in fall 2015 and some drifted with snowmelt or were blown off by wind. Regardless, some plants established in covered as well as exposed areas, especially in areas where woody compost was thicker. Nine established photo-points were photographed.

July 26, 2017 Post-project Surface Water Sampling – High Flow.

Samples were collected by Jeff Litteral (DRMS) and Julia Nave (UWP) per 2017 SAP at the upper mine adit, in Gray Copper Gulch above and below the mine site, and at mouth of Gray Copper Gulch. Lab analyses were completed by CDPHE-WQCD.

Aug. 25, 2017 Vegetation Monitoring.

Agnieszka photographed nine established photo-points and estimated relative cover by main functional group at the previously established seven, 1-m² plots.

Sept. 26, 2017 Post-project Surface Water & Macroinvertebrate Sampling – Low Flow.

Samples were collected by Jeff Litteral (DRMS) and Julia Nave (UWP) per 2017 SAP at the upper mine adit, in Gray Copper Gulch above and below the mine site, and at mouth of Gray Copper Gulch. Lab analyses were completed by CDPHE-WQCD. Macroinvertebrate samples were collected in Gray Copper Gulch above and below the mine and sent to Timberline Aquatics for analysis.

Oct. 4, 2017 Additional Vegetation Seeding.

Horizon Environmental Services incorporated additional amendments, seed and mulch to the area cleared of waste rock and seeded along Gray Copper Gulch. The remaining aspen fiber from 2015 vegetation was left in place and the following amendments were applied on top: fine-particle biochar, slow release N-P-K fertilizer (4-6-4) and mycorrhizal amendment (AM120 Mycorrhizal Inoculum with 100% *Glomus intraradice*). The native seed mix detailed above was broadcast along with another seed mix comprised of tufted hairgrass, mountain brome, alpine bluegrass, yarrow and a sterile Triticale hybrid (QuickGuard). The fast germinating hybrid should facilitate soil microbial activity and stabilize soil to promote establishment of other perennial species. The seed and amendments were mixed with rakes and the treated area was covered with wood fiber hydraulic mulch that was wetted to tack it to the ground. Snowfall a few days after vegetation should have further stabilized the mulch and will provide good moisture for the next growing season.

Nov. 2017 – Feb. 2018 Evaluation.

Pre- and post-project surface water and macroinvertebrate data were analyzed and BMPs were evaluated for efficacy: heavy metal load reductions and pH improvements.

Task 3. Michael Breen Mine

A drainage ditch was excavated to divert the draining adit water away from waste rock pile and offsite to reduce its seepage through the waste rock pile and under the loadout structure. The loadout structure was inventoried by Alpine Archaeological Consultants and included a consultation with SHPO. This outlined historically acceptable structural improvements that were installed to stabilize the loadout structure.

July 7, 2014 Pre-project Surface Water Sampling – High Flow

Samples were collected by Jeff Litteral (DRMS), Agnieszka Przeszlowska and Walter Wright (UWP) per 2014 Sampling Analysis Plan (SAP) at the mine adit, discharge of mine adit water below waste rock, on the Uncompahgre River above and below the Michael Breen. Lab analyses were completed by ACZ Laboratories.

Aug. 14, 2014 Design and Bid.

Jeff Litteral of DRMS initiated contractor bidding process. Project design and implementation steps were outlined in the bid document. Construction and most vegetation work was contracted through DRMS.

Oct. 1, 2014 Cultural Resource Inventory.

The inventory was completed by Jack E. Pfertsh of Alpine Archaeological Consultants, Montrose CO. It focused on the loadout structure and included subsequent consultation with the State Historic Preservation Office (SHPO). Recommendations included:

1. Divert adit water away from eastern foundation of structure: deepen an existing channel that drains westward from the mine and northward of the structure.
2. Place a rigid, steel I-beam parallel to the wooden-post piers supporting the southern side of the structure.
3. Clear fallen building materials along the northern, southern, and eastern sides of the structure to decrease trapping of moisture against structure.
4. Once the building materials are removed, excavate excess waste rock and soil that have sloughed in around the base of the structure. Once removed, contour the slopes to deter future sloughing or build retaining walls.
5. Re-channel a drainage path that had deposited waste rock in the load-out area, into the load-out structure's interior, and against the base of its western foundation wall.
6. Remove the fallen and partly standing roof and wall remnants that once enclosed the top of the structure. This is taxing the original outer beams of the structure and should be removed. The remaining portion of the western wall should also be removed to avoid damage to the original outer beams in the event of strong winds.

Oct. 9, 2014 Pre-project Surface Water & Macroinvertebrate Sampling – Low Flow
Surface water samples were collected by Jeff Litteral (DRMS), Judi Chamberlin and Dave Jones (UWP) per 2014 SAP at the mine adit, discharge of mine adit water below waste rock, on the Uncompahgre River above and below the Michael Breen. Lab analyses were completed by ACZ Laboratories. The team also collected macroinvertebrates at the above and below sites on the Uncompahgre River. These samples were enumerated by Timberline Aquatics in Fort Collins, CO.

Oct. 10, 2014 Holly Norton, Section 106 Compliance Manager for SHPO, responded with evaluation of loadout stabilization recommendations. See #2 below.

Oct. 20-Nov. 3, 2014 Construction Phase.

Jul. 27-29, 2015 Construction Continued

Work was completed by Mountain Region Corporation of Grand Junction, CO and supervised by Jeff Litteral of DRMS. The main goal was to divert adit waters around the waste rock and load out structure. Specific steps aligned with Cultural Resource Inventory recommendations above and most of the following were completed between Oct. 20 and Nov. 3, 2014:

1. Diversion Ditch: This was mitigated by cleaning and re-contouring a small drainage path was cleaned and re-contoured on northern side of the structure, along the base of a hillside using a mini excavator. Sediment runoff controls consisted of straw bales and Ertec S-fence which were installed prior to excavation of the diversion ditch. The 150-foot diversion ditch was constructed approximately 3 feet wide at bottom and 12 inches deep with side slope angles of 2:1. This measure allowed the water to drain away from the structure and into an existing drainage on the structure's western side. This, coupled with the placement of an 18" diameter HDPE culvert (donated by Ouray County Road & Bridge Department) across County Road 18, allows for proper shedding of water.
2. Per SHPO evaluation, no steel I-beam was used to support the southern side of the ore bin. Instead, 8-x-8-in. timber support walls were constructed using treated railroad ties. The footing for the wall was excavated to solid ground and the header beam was jacked up to get a snug fit to the existing joist. Additionally, diagonal beams were installed on the exterior of the structure to enhance support.
3. Fallen building materials along the northern, southern, and eastern sides were removed.
4. Waste rock and soil that sloughed around the building were not removed because underground timbered footings were found to be present beneath the waste rock. Overburden was not removed because the slope on the northern side of the site was too steep for an excavator to be used safely.
5. A berm was created along the drainage's eastern edge to shield the structure but no waste rock was removed as it would have destabilized the adjacent slope.

6. The southern section of the roof that was overhanging the top of the wall and roof remnants from the catwalk area on the top of the structure were removed. The framed, gable end on the western side of the bin was found to be structurally sound and was not removed because the sill of the wall extended downward into the structure's timber wall supports. Removing the wall would have required extensive cutting, and may have weakened the external frame on the western side of the structure.

The contractor returned to the site next summer (Jul. 27-29, 2015) to install additional lag bolts in timber supports, stain the supporting diagonal beams, and stockpile fallen building debris and sheet metal away from the loadout structure.

Oct. 30, 2014 Pre-project Surface Water Sampling – Low Flow.

Additional sample was collected by Jeff and Agnieszka at MB-Adt-03 (Michael Breen seep below the mine). It was analyzed by ACZ.

Feb. 2015 Cultural Resource Inventory Report completed.

The inventory identified adits, structure locations, features, and mining-related items associated with the Michael Breen mine group originally located by William F. Sherman and Fredrick W. Pitkin between 1874 and 1885. Because the mining elements documented represented a consolidated ownership, all were recorded as a single site under the previously recorded site number 5OR984.

Aug. 25, 2015 Seeding & Vegetation Monitoring.

Areas adjacent to the diversion ditch (150-ft length) and waste rock pile (approximately 2,000 square feet on primarily a 2:1 slope) were re-vegetated by UWP volunteers, Jeff Litteral, Agnieszka Przeszlowska and Chris Peltz of Research Services, LLC who also assisted with design of re-vegetation. Total area treated was approximately 1 acre. Biochar amendment was distributed first, followed by a mix of native seeds and sterile Triticale hybrid, and finally aspen mulch. The native seed mix included tufted hair grass, alpine bluegrass, mountain brome and yarrow. The sterile Triticale hybrid (QuickGuard) was applied as it is a fast germinating species that helps to initially stabilize soils by quickly developing a dense fibrous root system while allowing perennial species to establish. Before implementation, Agnieszka also established and photographed 10 photo-points and estimated relative cover by main functional group (i.e. vegetation vs. ground cover type) within six, 1-m² plots.

July 20, 2016 Post-project Surface Water Sampling – High Flow.

Surface water samples were per 2016 Sampling Analysis Plan (SAP) at the mine adit, discharge of mine adit water below waste rock, on the Uncompahgre River above and below the Michael Breen by Agnieszka Przeszlowska and UWP volunteers. UNR-05 (Uncompahgre River above Red Mountain Creek) was sampled by Paul Landahl (DRMS) and Jaqueline K. (CDPHE-WQCD). Lab analyses were completed by CDPHE-WQCD.

Aug. 17, 2016 Additional Seeding.

Areas seeded, amended, and mulched in August 2015 were spot treated with same prescriptions to enhance plant growth.

Sept. 14, 2016 Post-project Surface Water & Macroinvertebrate Sampling – Low Flow.

Surface water samples were collected per 2016 Sampling Analysis Plan (SAP) at the mine adit, discharge of mine adit water below waste rock (MB-Adt-02 the sample was actually collected at the culvert below county road), on the Uncompahgre River above and below the Michael Breen by Agnieszka Przeszlowska, Dennis Murphy, Dudley Case (UWP) and Chris Peltz (Research Services, LLC). UNR-05 (Uncompahgre River above Red Mountain Creek) was sampled by Paul Landahl and Mark Mikos (DRMS). Lab analyses were completed by CDPHE-WQCD. The UWP team also collected macroinvertebrates at the above and below sites on Uncompahgre River. These were analyzed by Timberline Aquatics.

Sept. 16, 2016 Interpretive Signs.

Two signs were fabricated and installed on site by Rocky Mountain Aluminum. The signs were designed by Alpine Archaeological Consultants. One sign is an overview of historic mining at the site and the San Juan Mountains, while the second sign depicts this remediation project and importance of mine remediation to improve water quality in the Uncompahgre Watershed.

July 26, 2017 Post-project Surface Water Sampling – High Flow.

Surface water samples were collected per 2017 SAP at the mine adit, on the Uncompahgre River above and below the Michael Breen, and Uncompahgre River above Red Mountain Creek by Agnieszka Przeszlowska and Ashley Bembenek (UWP). Lab analyses were completed by CDPHE-WQCD. MB-Adt-02 Michael Breen adit below waste rock was not sampled (culvert was plugged and most flow was not entering it or the drainage below county road).

Aug. 16, 2017 Vegetation Monitoring.

Agnieszka photographed the 10 photo-points established in August 2015 and estimated relative cover by main functional group at the previously established six, 1-m² plots.

Sept. 26, 2017 Post-project Surface Water & Macroinvertebrate Sampling – Low Flow.

Surface water samples were collected per 2017 SAP at the mine adit, on the Uncompahgre River above and below the Michael Breen, and Uncompahgre River above Red Mountain Creek by Agnieszka Przeszlowska, Ashley Bembenek, Dennis Murphy, Scott Williams (UWP) and Mark Mikos (DRMS). MB-Adt-02 Michael Breen adit below waste rock was not sampled because most of low flow was bypassing culvert. Lab analyses were completed by CDPHE-WQCD. Dennis Murphy and Scott Williams (UWP) collected macroinvertebrate samples above and below that Michael Breen site on the Uncompahgre River. Samples were sent for enumeration and identification to Timberline Aquatics.

Nov. 2017 – Feb. 2018 Evaluation.

Pre- and post-project surface water and macroinvertebrate data were analyzed and BMPs were evaluated for efficacy and heavy metal load reductions.

Task 4. Evaluation.

Pre-project sampling was completed as planned. Post-project sampling at the three sites was adjusted from original timeline because order of implantation was altered: Michael Breen work was advanced to 2014. and Atlas Mill was delayed to 2016.

2014 Sampling Analysis Plan.

The original SAP was prepared in collaboration with CDPHW-WQCD TMDL Bridge to Restoration Program. It was amended as needed for each annual sampling campaign and included WQCD sampling protocols for surface waters. All macroinvertebrate samples were collected per WQCD Standard Operation Procedure WQCD SOP-001.

2014 Pre-project Surface Water & Macroinvertebrate Sampling.

Pre-project surface water and macroinvertebrate samples for all three projects were collected in 2014 during high and low flows. Macroinvertebrates were collected during low flows only. Exact sampling dates are above in Task 1, 2, 3 details.

2014 Pre-project Surface Water & Macroinvertebrate Sampling.

Pre-project surface water and macroinvertebrate samples for all three projects were collected in 2014 during high and low flows. Macroinvertebrates were collected during low flows only. Exact sampling dates are above in Task 1, 2, 3 details.

2016 & 2017 Post-project Surface Water & Macroinvertebrate Sampling.

Post-project surface water and macroinvertebrate samples were collected during high and low flows in 2016 and 2017 at the Michael Breen site and in 2017 at the Vernon Mine and Atlas Mill sites. Macroinvertebrates were collected during low flows only. Exact sampling dates are above in Task 1, 2, 3 details.

2016 & 2017 Headwaters Assessment.

101 surface water samples were collected over two years during high and low flows at non-project locations to evaluate their water quality and inform future mine remediation projects. Sampling sites in 2016 were located in Imogene Creek and Mineral Creek drainages and in 2017 were located in Imogene Creek, Sneffels Creek, Governor Basin.

Nov. 2017 – Feb. 2018 Evaluation.

Pre- and post-project surface water and macroinvertebrate data were analyzed and BMPs were evaluated for efficacy and heavy metal load reductions. Data from headwaters sampling were analyzed and evaluated for possible water quality impairments and future projects.

2.2 EVALUATION OF GOAL ACHIEVEMENT AND RELATIONSHIP TO THE STATE NPS MANAGEMENT PLAN

Atlas Mill - Sneffels Creek Bank Stabilization

During high flow, post-project cadmium, lead, and zinc concentrations were approximately 30 percent lower than pre-project concentrations. During low flow post-project cadmium, lead, and zinc concentrations were approximately 75 percent lower than pre-project concentrations. Consistent and uniform reductions in cadmium, lead, and zinc concentrations indicate that the Sneffels Creek Bank Stabilization Project at the Atlas Mill improved water quality conditions in Sneffels Creek.

Michael Breen Project

Following the Michael Breen project, dissolved copper and lead concentrations, measured during high flow, decreased by 46 and 12 percent, respectively. After the Michael Breen project, cadmium, lead, manganese, and zinc concentrations, measured during low flow, declined by 20, 67, 11, and 19 percent, respectively. Although, the metal removal rate is uncertain due to natural variation in stream flows, decreased metal concentrations suggest that the Michael Breen project improved water quality by a small margin.

Vernon Mine Project

During high flow conditions the average pre-project flow was five times greater than the post-project flow. During low flow conditions the average pre-project flow was ten times greater than the post-project flow. This variation in flow created artificial load reductions that are a result of variable stream flows, not the success or failure of the Vernon Mine project. Additional water quality and flow monitoring are recommended at the Vernon Mine site.

All three projects were consistent with 2012 NPS Management Plan. As each project reduced and or prevented nonpoint source water quality impacts in impaired waterbodies.

2.3 SUPPLEMENTAL INFORMATION

The following photographs illustrate pre- and post-project conditions at the three remediation sites: Atlas Mill, Vernon Mine, and Michael Breen Mine.

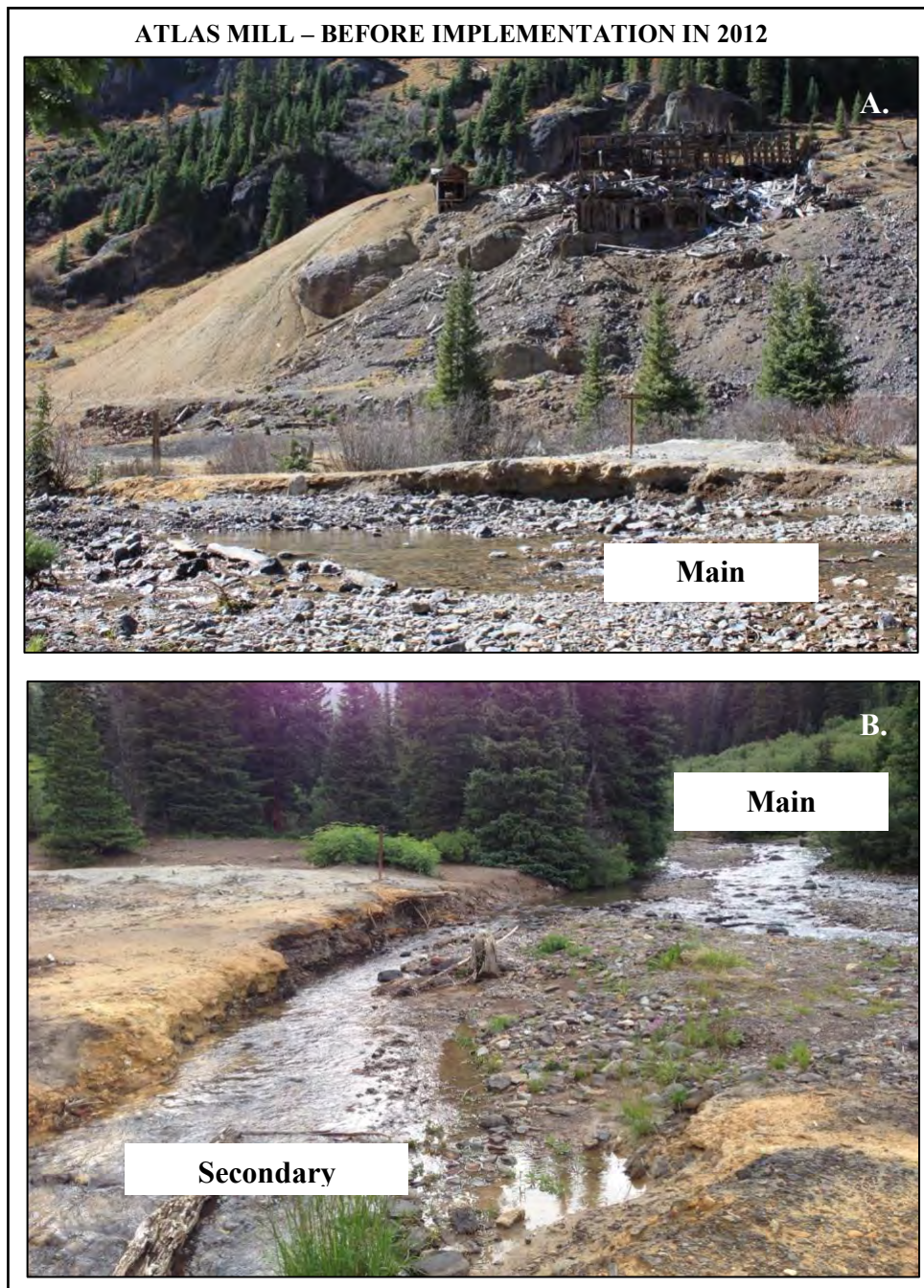


Figure 3. Atlas Mill above Sneffels Creek (A) before the bank stabilization project in 2012. Sneffels Creek main channel and secondary channel which cut into the tailings (A, B) were eroding the mill tailings and transporting heavy metal laden sediment into Sneffels Creek.



Figure 4. Atlas Mill above Sneffels Creek (A) after the bank stabilization project in 2016. **A.** The new channel was stabilized with three constructed vane arms (large, buried boulders on the far bank), log cribbing, willow transplants and pole cuttings on both stream banks. The bare areas were seeded with alpine herbaceous riparian and upland species. **B.** The new multistage channel includes Stage 1: typical low volume discharge (seasonal low flows), Stage 2: higher volume discharge (seasonal bankful flows), and Stage 3: bankful discharge to upper floodplain.

A. VERNON MINE – BEFORE IMPLEMENTATION IN 2014



B. VERNON MINE – AFTER IMPLEMENTATION IN 2017



Figure 5. **A.** Waste rock pile in Gray Copper Gulch at the Vernon Mine site in 2014. The 1,500 cubic yards of waste was excavated in 2015 and placed in a repository away from the gulch (upstream view). **B.** The excavated area (upstream view) was amended with woody compost, seeded with high elevation herbaceous species, and covered with aspen blankets in 2015. This photo was taken in 2017, two years after seeding.

A. VERNON MINE – VEGETATION COVER IN SUMMER 2017

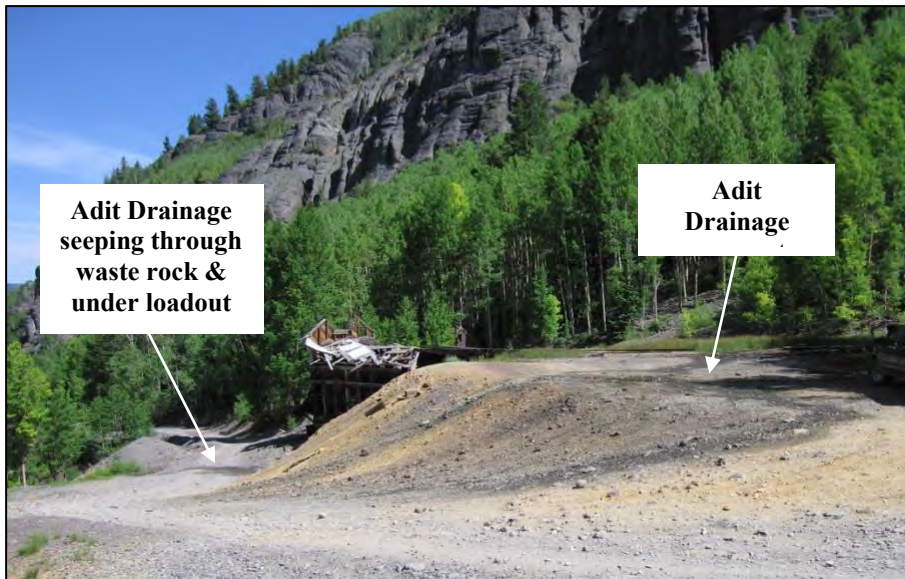


B. VERNON MINE – ADDITIONAL TREATMENTS IN FALL 2017

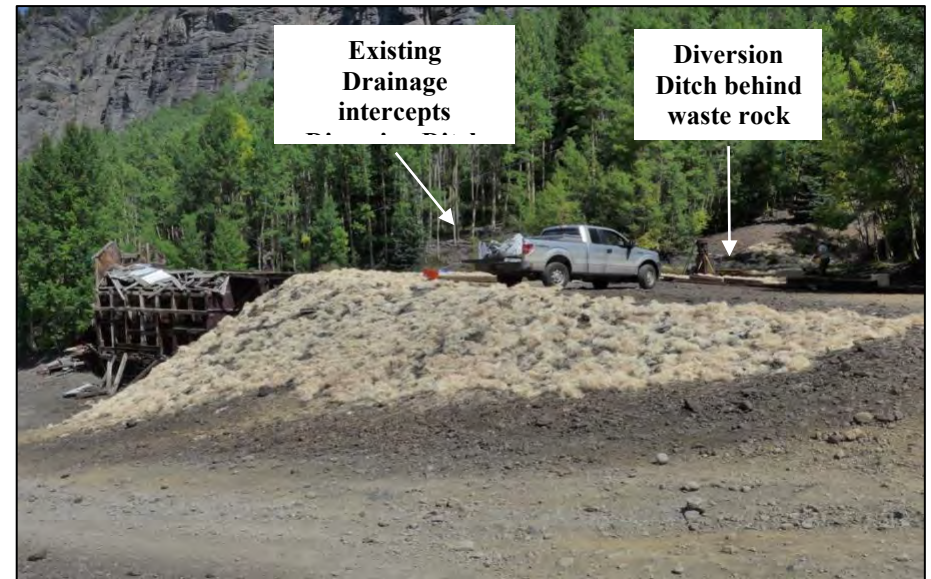


Figure 6. A. Established herbaceous cover in summer 2017 after initial seeding and amendments along Gray Copper Gulch in fall 2015; area excavated of waste rock at Vernon Mine site (downstream view). B. Barren areas were treated with more soil amendments (biochar, mycorrhizal inoculum, and nitrogen fertilizer), seed and hydromulch in fall 2017 (downstream view).

A. MICHAEL BREEN MINE – BEFORE IMPLEMENTATION IN 2014



B. MICHAEL BREEN MINE – AFTER IMPLEMENTATION IN 2015



C. MICHAEL BREEN MINE – AFTER IMPLEMENTATION IN 2017



Figure 7. **A.** Michael Breen Mine site before implementation in 2014. The adit discharge flowed over and seeped through the waste rock pile and loadout structure before crossing the county road and draining into the Uncompahgre River below. **B.** A diversion ditch was constructed in fall 2014 to route the adit discharge around the waste rock and into an existing drainage behind the load out structure. The waste rock was amended with biochar, seeded with a high elevation herbaceous seed mix and covered with aspen mulch shown in this photo. **C.** Photo-point of waste rock pile in 2017 showing that very little vegetation established after treatments in 2015 (photo B.)

A. MICHAEL BREEN MINE – BEFORE IMPLEMENTATION IN 2014



B. MICHAEL BREEN MINE – AFTER IMPLEMENTATION IN 2017



Figure 8. A. Adit discharge flowing onto, over and through the waste rock pile at the Michael Breen Mine before implementation in 2014. The top of the load out structure is in the background. B. The diversion ditch was constructed in fall 2014 and routes the adit discharge around the waste rock and the load out.

3.0 BEST MANAGEMENT PRACTICES DEVELOPED AND/OR REVISED

The locations of the BMPs implemented in this project are shown in Figure 1. The details of BMPs implemented at each site are in Section 2.1 and summarized here in Table 3.

Table 3. Best Management Practices (BMPs) implemented at each site.

Project Site	Best Management Practice (BMP)	Photos
Atlas Mill (Sneffels Cr.)	450 feet of streambank stabilized to reduce tailings erosion	Figure 3, 4
	4 acres of riparian & upland areas amended, seeded, mulched	
Vernon Mine (Gray Copper Gulch)	1,500 cubic yards of waste rock removed & repositied	Figure 5, 6
	1 acre of excavated waste rock area amended, seeded, mulched	
Michael Breen Mine (Uncompahgre R.)	1 cfs of adit drainage re-routed with diversion ditch	Figure 7, 8
	1 acre of waste rock pile & diversion ditch amended, seeded, mulched	

4.0 MONITORING RESULTS

4.1 TMDL IMPLEMENTATION EFFECTIVENESS

TMDLs relevant to this project exist only for COGUUN02 – Uncompahgre River where Michael Breen remediation was completed. BMPs at this site were constructed successfully and mitigated non-point sources, however, this sole project did not fully implement the load allocations for the Uncompahgre River segment. Remedial BMPs reduced metal loads at the impacted stream reach but a portion of the reductions were attributed to lower flows during the post-project monitoring events.

4.2 BMP EFFECTIVENESS EVALUATIONS

The sections below discuss BMPs’ construction evaluations. Surface water improvements are detailed in Section 4.3.

Atlas Mill

Stabilization of the Sneffels Creek stream reach at the Atlas Mill site was successful one year after implementation: channel surveys showed that channel structure was maintained after peak snowmelt, tailings erosion within the reach was eliminated, willows and herbaceous species were well established (See Sec. 4.5).

Michael Breen

Diversion of adit discharge around the waste rock pile was successful three years post implementation. The ditch was functioning adequately to route adit water to a natural gully. However, the culvert that was installed to improve this drainage across the highly utilized county road had filled with sediment causing majority of the runoff to trickle down the road. The county road and bridge department was contacted and they agreed to conduct culvert improvements in 2018. There was a modest increase in seeded vegetative cover along the diversion ditch and the proximity of existing herbaceous species should further facilitate ground cover. However, vegetation measures on the

waste rock pile were not successful (See Sec. 4.5). This was likely a result of the area being devoid of soil organic matter and our inadequate amendments and/or mulching. Stabilization of the historic load out structure was successful as there was no visible evidence of deterioration of supports three years after construction.

Vernon Mine

Site assessments one and two years after BMP implementation indicated that the waste rock repository area was stable with no evidence of erosion or drainage. The streambanks adjacent to the area excavated of waste rock were stable but the area itself was only partially vegetated with new herbaceous cover because some of the initial landscape blankets were blown off within the first year of seeding (See Sec. 4.5). Additional amendments, seeding and hydromulching two years after excavation, should facilitate further establishment of vegetative cover. The small ditch diverting adit drainage was stable. BMP effectiveness on surface water quality could not be determined.

4.3 SURFACE WATER IMPROVEMENTS

Surface water samples were collected before and after BMPs implementation at the three abandoned mine according to respective sampling analysis plans (SAP). Samples were collected primarily above and below the project sites and from any draining adits. Field blanks and field duplicates were collected according to the SAPs and all water quality samples were analyzed by certified laboratories (ACZ Laboratories or CDPHE-WQCD). Stream flows were measured using flow meters on a cross-section or with a flume. In some cases, deep and swift flows prevented safe access to measure stream flow. Flow and metal concentrations were used to calculate pre and post-project metal loads. The assessment of the measurable results associated with each of the three reclamation projects is detailed in the Measurable Results Assessment for the Atlas Mill, Michael Breen, and Vernon Abandoned Mine Sites in the Uncompahgre River Watershed (AEC 2018a; Appendix A). This report also summarizes locations of the relevant sampling locations.

Atlas Mill

UWP, DRMS, WQCD, and other project partners completed eight sample events prior to the start of the Atlas Mill stabilization project. Four of the pre-project sample events were completed during high flow conditions and four occurred during low flow conditions.

UWP, DRMS, WQCD, and other project partners completed two sample events after the Atlas Mill stabilization project. One post-project sample event occurred during high flow conditions and one event occurred during low flow conditions.

The bank stabilization project decreased cadmium and lead loads by 21 and 25 percent, respectively (Table 4). Zinc loads did not decrease following the project. This may be attributed to lower flows during the post-project monitoring events- particularly during September 2017. The average flow downstream of the Atlas Mill during the pre-project low flow events was 6.0 cfs. The post-project low flow downstream of the Atlas Mill was

4.4 cfs or 31 percent lower than flow measured during the pre-project monitoring period (Appendix A, Table 13).

Table 4. Pre and post-project loading summary for the Sneffels Creek Bank Stabilization project near the Atlas Mill Site.

Flow Condition	Cadmium Load	Lead Load	Zinc Load
Pre-project Average High Flow (lbs/day)	0.015	0.015	2.82
Post-project High Flow (lbs/day)	0.013	0.020	2.98
Percent Change: High Flow	-13%	32%	6%
Pre-project Average Low Flow (lbs/day)	0.001	0.006	0.022
Post-project Low Flow (lbs/day)	<i>0.000</i>	<i>0.0003</i>	0.102
Percent Change: Low Flow^{1,2,3}	-71%	-95%	367%
Pre-Project Average Annual Load (lbs/year)	2.1	3.3	344
Post-Project Annual Load (lbs/year)	1.7	2.5	382
Percent Change: Post-Project	-21%	-25%	11%
Pounds Removed per Year	0.4	0.8	-39

Notes

1. Values in italics incorporate estimated metal concentrations.
2. The post-project low flow cadmium and lead loads include results that were less the MDL. These values are estimated.
3. Where 0.000 is reported the load was less than 0.001 lbs/day or less than half a pound per year.

Post-project metal concentrations were lower for dissolved cadmium, lead, and zinc (Table 5). Metal concentrations decreased 30 to 34 percent during high flow and 71 to 80 percent during low flow (Table 5). Consistent and uniform reductions in cadmium, lead, and zinc concentrations suggest that the Sneffels Creek Bank Stabilization Project at the Atlas Mill improved water quality conditions in Sneffels Creek. Additional sample collection and flow measurements would be useful to better characterize the effect of the bank stabilization project.

Table 5. Summary of pre and post-project metal concentrations for the Sneffels Creek Bank Stabilization project near the Atlas Mill Site.

Flow Condition	Cadmium	Lead	Zinc
	ug/L		
Pre-project Average High Flow	0.71	0.67	158
Post-project High Flow	0.49	0.44	110
Percent Change: High Flow	-30%	-34%	-30%
Pre-project Average Low Flow	0.40	0.50	95
Post-project Low Flow	0.08	0.10	28
Percent Change: Low Flow	-79%	-80%	-71%

Michael Breen

UWP, DRMS, WQCD, and other project partners completed six sample events prior to the start of the Michael Breen project. Three of the pre-project sample events were completed during high flow conditions and three occurred during low flow conditions.

UWP, DRMS, WQCD, and other project partners completed four sample events after the Michael Breen project. Two post-project sample events occurred during high flow conditions and two events occurred during low flow conditions.

The Michael Breen project decreased cadmium loads by 91 percent which equates to approximately 4 pounds per year (Table 6). The Michael Breen project decreased zinc loads by 71 percent, which equates to 692 pounds per year (Table 6). However, a portion of the reductions are attributed to lower flows during the post-project monitoring events- particularly during September 2017. The average flow downstream of the Michael Breen Mine during the pre-project low flow events was 9.0 cfs. The post-project low flow downstream of the Atlas Mill was 2.64 cfs or 109 percent lower than flow measured during the pre-project monitoring period.

Table 6. Pre and post-project loading summary for the Uncompahgre River near the Michael Breen Mine site.

Flow Condition	Cadmium Load	Copper Load	Lead Load	Manganese Load	Zinc Load
Pre-project Average High Flow (lbs/day)	0.014	0.001	0.0003	0.215	2.57
Post-project Average High Flow (lbs/day)	-0.001	0.000	0.009	0.540	1.03
Percent Change: High Flow	-104%	-100%	NA	151%	-60%
Pre-project Average Low Flow (lbs/day)	0.011	0.000	0.002	0.093	2.72
Post-project Average Low Flow (lbs/day)	0.002	0.084	0.001	0.089	0.655
Percent Change: Low Flow	-86%	NA	-29%	-4%	-76%
Pre-Project Average Annual Load (lbs/year)	4.40	0.12	0.46	48.5	976
Post-Project Annual Load (lbs/year)	0.39	20.7	1.46	86.6	284
Percent Reduction: Post-Project	-91%	NA	NA	NA	-71%
Pounds Removed per Year	4.0	-21	-1.0	-38	692

During high flow dissolved copper and lead concentrations decreased by 46 and 12 percent, respectively following the Michael Breen project (Table 7). After the Michael Breen project, cadmium, lead, manganese, and zinc concentrations, measured during low flow, declined by 20, 67, 11, and 19 percent, respectively (Table 7). Copper concentrations remained flat during low flow conditions.

Table 7. Summary of pre and post-project metal concentrations for the Michael Breen project near the Uncompahgre River.

Flow Condition	Cadmium	Copper	Lead	Manganese	Zinc
	ug/L				
Pre-project Average High Flow	1.03	7.5	0.50	128	192
Post-project Average High Flow	1.3	4.1	0.44	165	220
Percent Change: High Flow	27%	-46%	-12%	29%	15%
Pre-project Average Low Flow	0.75	6	0.55	45	180
Post-project Average Low Flow	0.61	7	0.19	40	145
Percent Change: Low Flow	-20%	3%	-67%	-11%	-19%

Although, the metal removal rate is uncertain due to variation in stream flows, decreased metal concentrations suggest that the Michael Breen project improved water quality by a small margin. If monitoring occurs in the future, the event should be scheduled to allow field staff to safely measure flow in the Uncompahgre River upstream and downstream of the Michael Breen Mine.

Vernon Mine

UWP, DRMS, WQCD, and other project partners completed six sample events prior to the start of the Vernon Mine project. Three of the pre-project sample events were completed during high flow conditions and three occurred during low flow conditions.

UWP, DRMS, WQCD, and other project partners completed two sample events after the Vernon Mine project. One post-project sample event occurred during high flow conditions and one event occurred during low flow conditions.

The Vernon Mine project decreased metal loads (Table 8). However, the reductions are completely attributed to lower flows during the post-project monitoring events. During high flow conditions the average pre-project flow was five times greater than the post-project flow (Appendix C, Tables 18 and 20). During low flow conditions the average pre-project flow was ten times greater than the post-project flow (Appendix C, Tables 19 and 21). This variation in flow creates artificial load reductions that are a result of variable stream flows, not the success or failure of the Vernon Mine project.

Table 8. Pre and post-project loading summary for Grey Copper Gulch near the Vernon Mine site.

Flow Condition	Cadmium Load	Copper Load	Iron Load	Lead Load	Zinc Load
Pre-project Average High Flow (lbs/day)	0.002	1.032	137	0.040	2.05
Post-project Average High Flow (lbs/day)	0.001	0.600	72	0.013	0.21
Percent Change: High Flow¹	-50%	-42%	-48%	-66%	-90%
Pre-project Average Low Flow (lbs/day)	0.000	0.228	6.3	0.005	0.08
Post-project Average Low Flow (lbs/day)	0.000	0.000	0.924	0.000	0.000
Percent Change: Low Flow²	NA	-100%	-85%	-100%	-100%
Pre-Project Average Annual Load (lbs/year)	0.34	180	17966	5.9	267
Post-Project Annual Load (lbs/year)	0.10	72	8809	1.6	26
Percent Change: Post-Project	-71%	-60%	-51%	-73%	-90%
Pounds Removed per Year	0.24	108	9157	4.3	241

Notes

1. The average pre-project flows were five times greater than the post-project flow measured in September 2017.
2. The average pre-project flows were ten times greater than the post-project flow measured in September 2017.

Metal concentrations measured after the Vernon project were higher than pre-project concentrations, except for dissolved zinc (Table 9). During high flow conditions zinc concentrations decreased by 64 percent.

Table 9. Summary of pre and post-project metal concentrations for the Vernon Mine near Gray Copper Gulch.

Flow Condition	Cadmium	Copper	Iron	Lead	Zinc
	ug/L				
Pre-project Average High Flow	0.21	103	22867	5	178
Post-project High Flow	0.25	200	39000	8	64
Percent Change: High Flow	17%	94%	71%	60%	-64%
Pre-project Average Low Flow	0.48	248	5923	10	96
Post-project Low Flow	0.6	310	8700	13	110
Percent Change: Low Flow	25%	25%	47%	28%	15%

Additional water quality and flow monitoring are recommended at the Vernon Mine site. Maintenance activities were completed in the fall of 2017. Site maintenance and or additional time may improve water quality in Gray Copper Gulch near the Vernon Mine.

4.4 GROUNDWATER IMPROVEMENTS

Not Applicable

4.5 OTHER MONITORING

Vegetation prescriptions were evaluated at each project site with monitoring of herbaceous cover in 1-m² plots or mortality measures of woody vegetation. The stream channel at the Atlas Mill site was also surveyed before and after construction to evaluate its integrity.

Atlas Mill

The channel profile, willow transplants and seeding were evaluated ten months after prescriptions were implemented. Construction and vegetation treatments were completed in October 2016 and evaluated in August 2017 after peak discharge/snowmelt.

Channel Integrity & Structure

- The three vane arms were untested within the second stage channel grade.
- Both meanders widened but retained intended sinuosity ratio:
Meander 1 (upstream): channel width increased from 25 to 29.2 feet within first stage. An estimated 7 feet of alluvium was transported to channel.
Meander 2 (downstream): channel widened from 24 to 27 feet within the first stage. An estimated 5 feet of alluvium was transported to channel.

Willow Establishment

- 65% of willow transplants survived
- 95% of willow bundles survived
- 65% of willow stakes survived

Herbaceous Cover

- 50% vegetative cover established in 3-acre seeded riparian area
- 40% vegetative cover established in 1-acre seeded upland area
- Target herbaceous cover was 40%-60% and appears to have been met 10 months after initial prescriptions.

Vernon Mine

Seven 1-m² plots were randomly established in September 2015 in the area excavated of waste rock along Gray Copper Gulch. At this time, average relative cover was 5% woody compost and 95% aspen fiber. Two years later in August 2017, average relative cover comprised of 32% grass, 4% forb, 29% soil, 3% rock, 47% waste rock, 25% woody compost, and 48% aspen fiber (Fig. 9). The grasses and forbs established best in areas amended with deeper layer of woody compost. Target herbaceous cover was 40%-60% which was not met but should increase after additional amendments, seeding, and mulching were implemented in October 2017.

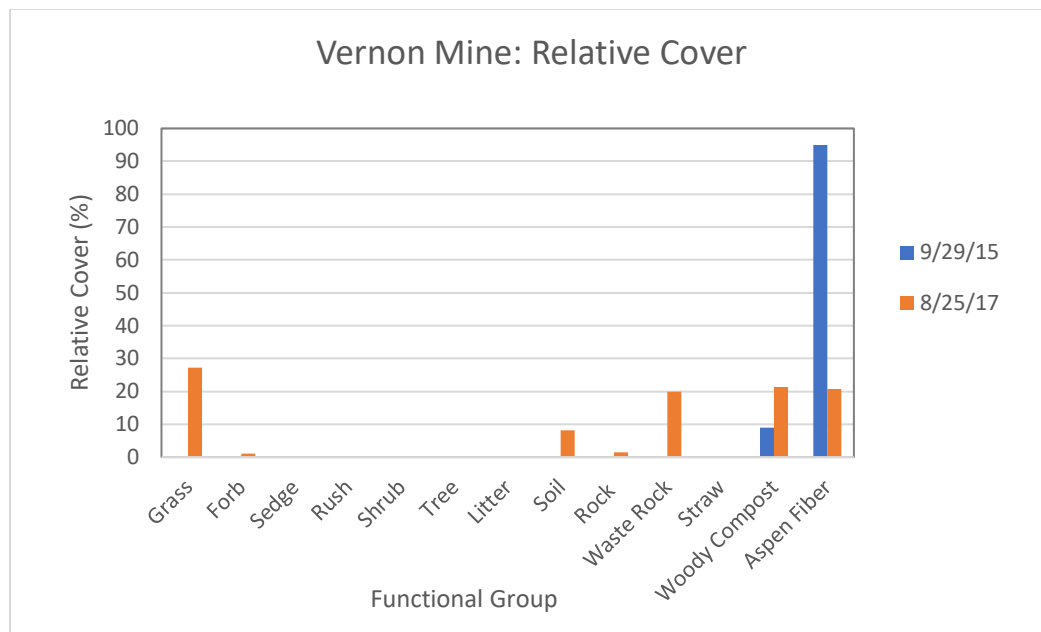


Figure 9. Average relative cover by functional group measured in seven, 1-m² plots before seeding and amendments on 9/29/15 and two years after prescriptions on 8/25/17.

Michael Breen Mine

Three 1-m² plots were randomly established on the waste rock pile in August 2015 and three 1-m² plots were established along the diversion ditch. Before seeding prescriptions, average relative cover on the waste rock pile consisted primarily of waste rock (80%) and some soil (18%, Fig. 10A). Vegetative cover on the waste rock pile did not increase significantly two years later and target 40%-60% herbaceous cover was not met. Instead, some of the soil and waste rock remained covered by decomposing aspen fiber. Soil and rock cover in the three 1-m² plots along the diversion ditch collectively decreased by 29% (Fig. 10B). This could be attributed to a 22% increase in litter cover (senesced litter, straw, aspen fiber) and 7% increase in herbaceous cover (grass, forb, sedge, rush, shrub, tree functional groups); see Figure 10B.

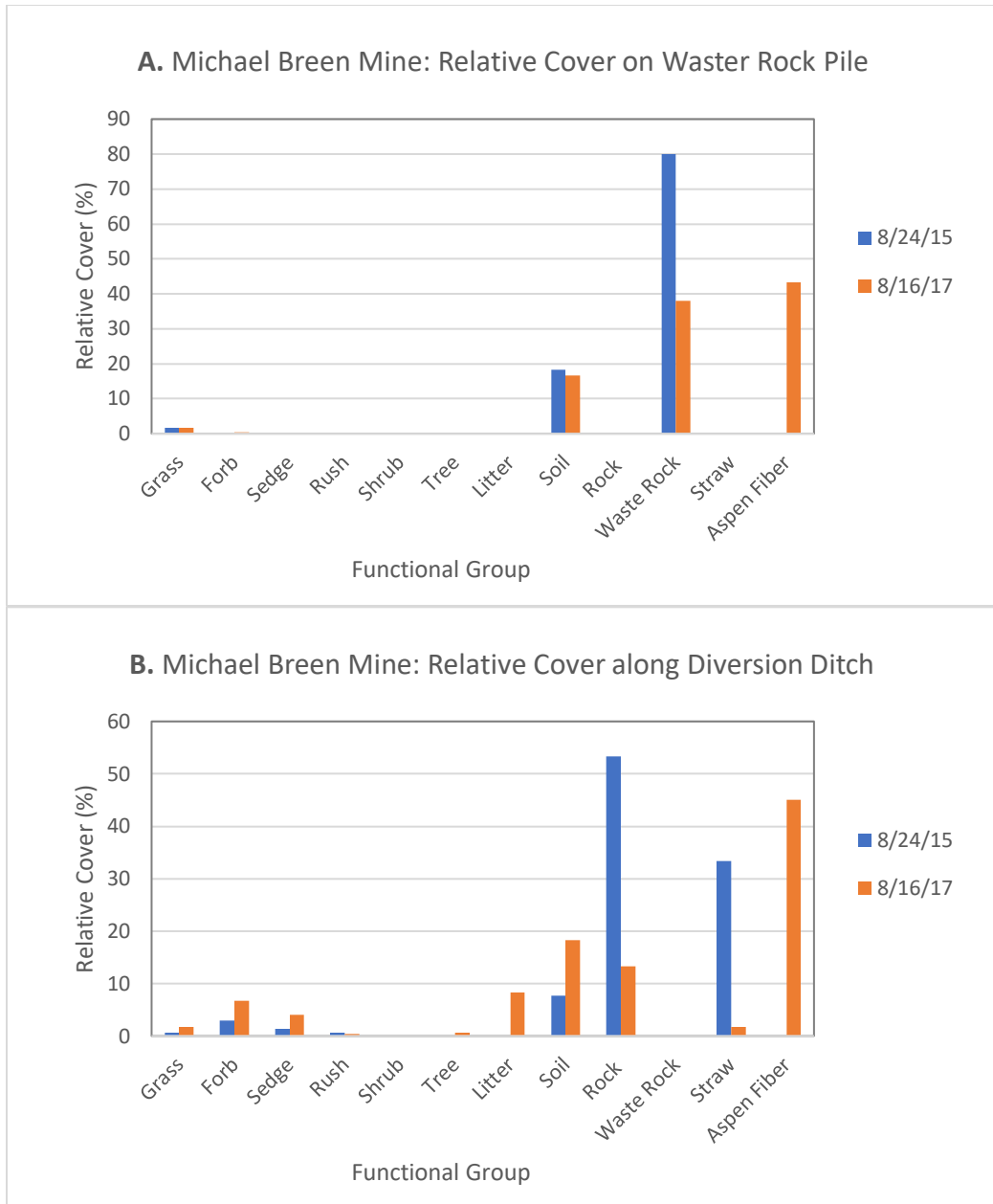


Figure 10. Average relative cover by functional group measured in **A.** three, 1-m² plots on waste rock pile and **B.** three, 1-m² plots along the diversion ditch before seeding and amendments on 8/24/15 and two years after prescriptions on 8/16/17.

Headwaters Assessment

101 samples were collected from 42 locations throughout the Upper Uncompahgre River Watershed during high and low flows in 2016 and 2017 to evaluate other potential metals impairments to water quality. Analysis included water standards evaluation, metal loading, and identification of pollution sources. Data analysis approach and results are presented in the Upper Uncompahgre River Watershed: Water Quality Report: 2016 and 2017 (AEC 2018b; Appendix B).

During the headwaters assessment several tributaries to the Uncompahgre River were sampled at multiple locations. The data demonstrate that natural attenuation (driven by dilution and metal precipitation) occurred from upstream to downstream in each major tributary. This pattern is largely intuitive, but is significant with respect to standards attainment, and the frequency, duration, and magnitude of impairment. Broadly speaking, aquatic life standards may be attained within the tributaries on a more regular basis than perceived by the community. A summary of the water quality standards evaluation for the most downstream location in each major tributary is provided below:

- **Mineral Creek upstream of the confluence with the Uncompahgre River:** Listed as impaired for cadmium, copper, and zinc due to exceedance of the aquatic life standards. Except for copper which exceeded the chronic standard by a small margin during low flow, Mineral Creek upstream of the Uncompahgre River attained the aquatic life standards for cadmium, acute copper, and zinc during high and low flow during 2016 and 2017.
- **Grey Copper Gulch upstream of the confluence with Red Mountain Creek:** Listed as impaired for copper, lead, pH, and zinc due to exceedance of the aquatic life standards. In Grey Copper Gulch upstream of the confluence with Red Mountain Creek pH is as high as 6.2 during low flow conditions, which approaches the low end of the acceptable pH range (6.5). In Grey Copper Gulch upstream of the confluence with Red Mountain Creek copper concentrations exceeded the chronic and acute aquatic life standards during high flow, but not during low flow where copper was not detected. In Grey Copper Gulch upstream of the confluence with Red Mountain Creek the chronic and acute standards for lead and zinc were attained during high and low flow in 2017. Unfortunately, iron concentrations exceeded the site-specific aquatic life standard and the water supply standard during high and low flow conditions during 2017.
- **Uncompahgre River upstream of the confluence with Red Mountain Creek:** Listed as impaired for manganese due to exceedance of the water supply standard; and potentially impaired for lead (aquatic life). The Uncompahgre River upstream of Red Mountain Creek exceeded the manganese water supply standard during high flow conditions, but the water supply standard was attained during low flow conditions. The chronic and acute lead standards were attained during high and low flow in 2016 and 2017. The Uncompahgre River upstream of Red Mountain Creek exceeded the cadmium and zinc standards for aquatic life during high flows in 2016 and 2017.
- **Sneffels Creek upstream of Canyon Creek:** Listed as impaired for cadmium, lead, and zinc due to exceedance of the aquatic life standards; also, potentially impaired for macroinvertebrates. In 2017 Sneffels Creek upstream of the confluence with Canyon Creek attained water quality standards, except for zinc which exceeded the chronic and acute standards during high flow in 2017 (Sneffels Creek was not sampled in 2016).

- **Imogene Creek upstream of Canyon Creek:** Listed as impaired for cadmium, copper, and zinc due to exceedance of the aquatic life standards. In 2016 and 2017 during high and low flow conditions, dissolved copper concentrations attained the aquatic life standard. In 2016 and 2017 during high and low flow conditions, dissolved cadmium concentrations exceeded the chronic, but not acute aquatic life standards. In 2016 and 2017 during high and low flow conditions dissolved zinc exceeded both the chronic and acute aquatic life standards.
- **Canyon Creek upstream of the Uncompahgre River:** Listed as impaired for zinc due to exceedance of the aquatic life standard. Canyon Creek downstream of the Lower Camp Bird mine site and upstream of the Uncompahgre River attained all water quality standards in 2017, except for dissolved zinc which exceeded the chronic aquatic life standard during high flow (Canyon Creek was not sampled in 2016).
- The standards evaluation presented above were completed for each individual sample using paired hardness data. During the 303(d) and M&E listing process, water quality data are compiled from multiple events and evaluated on a segment-wider basis. Both evaluation techniques are valid but are used for different purposes and produce different outcomes. The information provided above does not contest the 303(d) and M&E listing on any of these segments. But demonstrates that on the lower portion of each reach the water quality standards, including chronic aquatic life standards, are attained for a considerable portion of the year.

4.6 QUALITY ASSURANCE REPORTING

Water quality samples were collected using a field method derived from USGS and EPA protocols for “clean hands- dirty hands” sample collection. Field blanks and field duplicates were collected at the rates identified in the sample and analysis plan (SAP). All water quality samples were analyzed by certified laboratories. The laboratories were responsible for all laboratory-based QA-QC. None of the laboratory data were qualified due to QA-QC issues. The field blank and field duplicate data were reviewed per the guidelines provided in the SAP. Data were not qualified or omitted due to the QA-QC review.

Note, CDPHE protocol recommends collecting macroinvertebrate samples between July 1 and September 30. July sample collection is not recommended in headwaters streams (collection is more difficult and less consistent due to swift flows and deep water and cold water temperatures decrease productivity which influences phenology). The macroinvertebrate community may be more robust during late summer or early fall. If macroinvertebrate sample collection occurs in the future it should occur during August or early September.

If macroinvertebrate samples are used to evaluate the outcome of project, it is strongly recommended that field staff use the National Aquatic Monitoring Center (NAMC)

protocol. The NAMC protocol, developed by the BLM and Utah State University, creates a composite sample by using 8 randomly selected sub-samples along a 500-foot transect. By sampling a larger area at random the range of natural variability within the habitat and community is characterized better and the sample collection process becomes more consistent between events. The CDPHE protocol relies on a single sample point. Even with the use of GPS, it is very difficult to return to the precise location sampled in the past. Collecting multiple sub-samples on a fixed transect (with permanently marked endpoints) allows for more consistent sample collection during multiple events.

4.7 RESULTS OF BMP OPERATIONS AND MAINTENANCE (O&M) REVIEWS

The Uncompahgre Watershed Partnership staff will make periodic site visits to the three project sites to assess the BMPs. Regarding the Michael Breen site, Ouray County Road and Bridge Department will be advised of any issues with the county road culvert and the State Historical Preservation Office as well as the local Ouray County Historical Society will be notified of further degradation of the ore loadout structure. Western Stream Works will monitor the functioning of the new channel and vane arms they installed in Sneffels Creek at the Atlas Mill site. No maintenance needs are anticipated at the Vernon Mine. No active operations are required for any of the BMPs.

5.0 COORDINATION EFFORTS

5.1 COORDINATION FROM OTHER STATE AGENCIES

DRMS - Division of Reclamation of Mining and Safety

The agency contributed both cash and in-kind services that were invaluable to the success of the project. The region's Project Manager, Jeff Litteral, participated in the conceptualization of the overall NPS project by providing reconnaissance information, water quality data, and feasibility assessments on potential remediation sites. He assisted in development of the Sampling Analysis Plans (SAPs) for project evaluation and aided in selection of sites for the Headwaters Assessment. Mr. Litteral facilitated coordination with various project stakeholders, informed project designs, contracted and oversaw contractors for implementation work at the Vernon and Michael Breen Mines and provided feedback on construction of the Atlas Mill – Sneffels Creek Bank Stabilization Project. He has also participated in outreach activities related to this project and provided review of various grant and outreach reports. Lastly, DRMS staff completed the Cultural Resource Survey of the Vernon Mine. DRMS' in-kind match was valued at \$43,000 and cash contributions were \$60,000 for implementation work at the Atlas Mill, Vernon and Michael Breen Mines.

WQCD – Water Quality Control Division

The agency was involved in the original conceptualization of the project and contributed data for justification of the grant proposal. Skip Feeney led the preparation of the SAPs, assisted with sample collection, laboratory analyses and data interpretation.

5.2 OTHER STATE ENVIRONMENTAL PROGRAM COORDINATION

No other state environmental programs were involved in this project.

5.3 FEDERAL COORDINATION

US ACOE – United States Army Corps of Engineers

The Corps reviewed the project design and issued a Nationwide Permit for the Atlas Mill – Sneffels Creek Bank Stabilization Project.

USFS – United States Forest Service

The USFS is a neighboring property owner at the Atlas Mill site. Ouray District and Grand Mesa Uncompahgre National Forest Staff participated in discussions on potential remediation approaches at the Atlas Mill site. The USFS's Cultural Resource Survey of the area was referenced in consultations with State Historical Preservation Office during preparation of the final project design.

5.4 USDA PROGRAMS

No USDA programs were involved in this project.
preparation of the final project design.

5.5 ACCOMPLISHMENTS OF AGENCY COORDINATION MEETINGS

The primary agency coordination meetings included phone conferences with CDPHE-WQCD (Skip Feeney and Bonie Pate), DRMS (Jeff Litteral) and UWP (Agnieszka Przeszlowska) to develop the original Sampling Analysis Plan (SAP) in spring 2014. Accomplishments included site selection, access, coordination of field teams, and sample processing. The team re-convened via teleconference in spring 2015, 2016, and 2017 to revised the original SAP for each annual sampling event. Meetings with UWP staff and board members and DRMS Project Manager occurred regularly throughout the project to discuss project designs, implementation logistics, and outreach activities. Other significant agency coordination meetings included Atlas Mill BMP brainstorming meetings with USFS staff, DRMS Project Manager, UWP Project Manager, operators of Revenue-Virginus Mine (property owner of final project site) occurred in Aug. 2013, March Aug. 2015. Ultimately, a mixed ownership project on the actual Atlas Mill tailings became unworkable and USFS was not actively involved in the final Sneffels Creek Bank Stabilization Project.

5.6 RESOURCES/COORDINATION FROM FEDERAL LAND MANAGEMENT AGENCIES

The only federal land management resource utilized in this project was a Cultural Resource Survey of the Atlas Mill area. It was used in consultation with the State Historical Preservation Office for Atlas Mill – Sneffels Creek Bank Stabilization Project design.

5.7 OTHER SOURCES OF FUNDS

ACZ Laboratories, Inc.: \$1,200
Alpine Environmental Consultants, LLC: \$1,500 (in-kind labor)
Agnieszka Przeszlowska, Project Management: \$1,943
Colorado Healthy Rivers Fund: \$5,000
Division of Reclamation, Mining and Safety: \$103,020
Ouray County Road and Bridge: \$1,000
Ouray Silver Mines, Inc: \$9,000
Timberline Aquatics: \$220
Town of Ridgway: \$1,000
Volunteers: \$1,284
Wester Stream Works: \$1,425
Water Quality Control Division: \$500
Water Quality Improvement Fund: \$67,884

6.0 SUMMARY OF PUBLIC PARTICIPATION

This project was broadly supported by local governments, organizations, industry, citizens and private land owners. The Board of Ouray County Commissioners supported the overall project with a letter of support for the NPS grant application. They have been updated on the progress of the project at several commissioner meetings. The Town of Ridgway supported the project by contributing cash match toward water sampling at the three remediation sites. UWP's stakeholders have expressed support and appreciation for UWP's clean-up efforts via e-mails and verbally to UWP board and staff at community presentations, field tours and casual meetings. More specifically the four primary project tasks were supported as follows:

Atlas Mill: The property owner, Ouray Silver Mines, Inc., granted access to the project site, contributed in-kind resources for implementation, expressed support at conferences and local public meetings. The general public participated in a field tour of the project site in May 2017.

Vernon Mine: The private property owner, a multi-generational mining family from Ouray County, granted access to the property and cooperation for project implementation, improvements and monitoring.

Michael Breen: Ouray County donated a culvert for installation at the site to improve drainage across the county road. Ouray County Historical Society provided review and feedback of content of the two interpretive signs installed at the site. Community volunteers also assisted with revegetation measures at the site.

Sampling (Evaluation Task): Several community volunteers helped to collect water and macroinvertebrate samples during the various field events.

7.0 ASPECTS OF THE PROJECT THAT DID NOT WORK

The main element of the overall project that did not work out as initially planned was Task 1 – Atlas Mill project. The original concept for the project was to collaborate with the operators of the neighboring Revenue-Virginus Mine to remove the Atlas Mill tailings from the Sneffels Creek floodplain, process them in the mine's mill and deposit them in the mine's waste repository. The floodplain would have been revegetated and designed to a functional riparian zone. However, the scope of the final implementation changed and was delayed by two years because of changes in operators and creditors of the Revenue-Virginus Mine and mixed ownership complications at the site. Nevertheless, UWP maintained communications with involved parties and ultimately all agreed on and implemented bank stabilization of Sneffels Creek that reduced erosion of tailing and heavy metals to the stream.

The success of re-vegetation prescriptions varied at project sites. The target 40%-60% herbaceous cover was met at the Atlas Mill project site, was just below 40% at the Vernon Mine, and was 2% on the waste rock and 13% along the diversion ditch at the Michael Breen site. It was concluded that seeds established best where soil and organic matter were present (i.e. riparian banks void of tailings or waste rock at the Atlas Mill project) or waste rock areas were covered with a thick layer of woody compost (i.e. Vernon Mine). Vegetation likely did not establish on the Michael Breen waste rock pile because insufficient growing media and/or amendments (ex. fertilizer or mycorrhizal inoculum) were used.

Changes in metal loads were the primary tool used to evaluate the effect of each mine remediation project. Metal loads are calculated by multiplying the stream flow by the metal concentration. Typically, project success is evaluated by comparing the pre-project load to the post-project load; where decreases in metal loads indicates success. This approach assumes that metal concentrations are the only component of the load to vary before and after the project. However, stream flows vary widely, on a daily and annual basis. To effectively evaluate the benefit of a given project the variation in stream flow between the pre and post-project data must be accounted for to assure that changes in metal loads are attributed to the project rather than variation in stream flow. As detailed in the Measurable Results Assessment report, stream flow variation created several challenges in assessing the outcome of each project. Additional data collection within the same year or for a longer time following the project could mitigate challenges attributed to variation in stream flow.

8.0 FUTURE ACTIVITY RECOMMENDATIONS

Due to variable stream flows in Grey Copper Gulch additional sample collection is strongly recommended to evaluate changes in loading following completion of the Grey Copper project. High and low flow sample collection in 2019 would be ideal to allow vegetation (reseeded in late 2017) to establish prior to the sample event, which would be more characteristic of long-term conditions following the project.

UWP and partners are planning additional work at the Atlas Mill site. Any water quality monitoring completed as part of the second project should be designed to allow for additional evaluation of the original bank stabilization project.

UWP compiled, reviewed, and mapped thousands of water quality results as part of the Uncompahgre River Watershed Data Compilation and GIS Analysis (AEC 2018c; Appendix C). The data set is a tremendous resource that can be evaluated in greater detail. To date, the analysis has been used to evaluate reclamation potential near the Altas Mill, in Governor Basin, at the Larson Brothers Adit. Currently, UWP plans to complete additional analysis with financial support and technical assistance from DRMS. The initial analysis completed as part of this NPS grant and subsequent work will support future reclamation projects. UWP also plans to update the community in the summer or fall of 2018 following the Idarado Project Update and prior to release of the draft Total Maximum Daily Load for the Upper Uncompahgre Watershed.

The EPA and other organizations plan to characterize mine waste within the Upper Uncompahgre Watershed. UWP and DRMS have provided and will provide additional recommendations regarding which mine waste features appear to be the most problematic based on existing water quality data.

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LIST OF TABLES

- Table 1.** Waterbodies included in this project: beneficial uses classification under Regulation 35 (effective Jun. 30, 2016) and Regulation 93. Regulation 93 effective Mar. 30, 2012 was used for development of the Project Implementation Plan but it was modified in November 2016.
- Table 2.** Project tasks, products, actual (filled cells) and planned (dotted cells) timelines.
- Table 3.** Best Management Practices (BMPs) implemented at each site.
- Table 4.** Pre and post-project loading summary for the Sneffels Creek Bank Stabilization project near the Atlas Mill Site.
- Table 5.** Summary of pre and post-project metal concentrations for the Sneffels Creek Bank Stabilization project near the Atlas Mill Site.
- Table 6.** Pre and post-project loading summary for the Uncompahgre River near the Michael Breen Mine site.
- Table 7.** Summary of pre and post-project metal concentrations for the Michael Breen project near the Uncompahgre River.
- Table 8.** Pre and post-project loading summary for Grey Copper Gulch near the Vernon Mine site.
- Table 9.** Summary of pre and post-project metal concentrations for the Vernon Mine near Gray Copper Gulch.

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Figure 1. Map of the Upper Uncompahgre Watershed showing land ownership and location of the three project sites: Atlas Mill, Vernon Mine, and Michael Breen Mine.

Figure 2. Schematic of design for Sneffels Creek Bank Stabilization Project.

Figure 3. Atlas Mill above Sneffels Creek (A) before the bank stabilization project in 2012. Sneffels Creek main channel and secondary channel which cut into the tailings (A, B) were eroding the mill tailings and transporting heavy metal laden sediment into Sneffels Creek.

Figure 4. Atlas Mill above Sneffels Creek (A) after the bank stabilization project in 2016. **A.** The new channel was stabilized with three constructed vane arms (large, buried boulders on the far bank), log cribbing, willow transplants and pole cuttings on both stream banks. The bare areas were seeded with alpine herbaceous riparian and upland species. **B.** The new multistage channel includes Stage 1: typical low volume discharge (seasonal low flows), Stage 2: higher volume discharge (seasonal bankfull flows), and Stage 3: bankfull discharge to upper floodplain.

Figure 5. **A.** Waste rock pile in Gray Copper Gulch at the Vernon Mine site in 2014. The 1,500 cubic yards of waste was excavated in 2015 and placed in a repository away from the gulch (upstream view). **B.** The excavated area (upstream view) was amended with woody compost, seeded with high elevation herbaceous species, and covered with aspen blankets in 2015. This photo was taken in 2017, two years after seeding.

Figure 6. **A.** Established herbaceous cover in summer 2017 after initial seeding and amendments along Gray Copper Gulch in fall 2015; area excavated of waste rock at Vernon Mine site (downstream view). **B.** Barren areas were treated with more soil amendments (biochar, mycorrhizal inoculum, and nitrogen fertilizer), seed and hydromulch in fall 2017 (downstream view).

Figure 7. **A.** Michael Breen Mine site before implementation in 2014. The adit discharge flowed over and seeped through the waste rock pile and loadout structure before crossing the county road and draining into the Uncompahgre River below. **B.** A diversion ditch was constructed in fall 2014 to route the adit discharge around the waste rock and into an existing drainage behind the load out structure. The waste rock was amended with biochar, seeded with a high elevation herbaceous seed mix and covered with aspen mulch shown in this photo. **C.** Photo-point of waste rock pile in 2017 showing that very little vegetation established after treatments in 2015 (photo B.)

Figure 8. **A.** Adit discharge flowing onto, over and through the waste rock pile at the Michael Breen Mine before implementation in 2014. The top of the load out structure is in the background. **B.** The diversion ditch was constructed in fall 2014 and routes the adit discharge around the waste rock and the load out.

Figure 9. Average relative cover by functional group measured in seven, 1-m² plots before seeding and amendments on 9/29/15 and two years after prescriptions on 8/25/17.

Figure 10. Average relative cover by functional group measured in A. three, 1-m² plots on waste rock pile and B. three, 1-m² plots along the diversion ditch before seeding and amendments on 8/24/15 and two years after prescriptions on 8/16/17.

LIST OF APPENDICES

A. Measurable Results Assessment for the Atlas Mill, Michael Breen, and Vernon Abandoned Mine Sites in the Uncompahgre River Watershed. Prepared for Uncompahgre Watershed Partnership by Alpine Environmental Consultants. 2018.

B. Upper Uncompahgre River Watershed: Water Quality Report: 2016 and 2017. Prepared for Uncompahgre Watershed Partnership by Alpine Environmental Consultants. 2018.

C. Upper Uncompahgre River Watershed Data Compilation and GIS Analysis. Prepared for Uncompahgre Watershed Partnership by Alpine Environmental Consultants. 2018.

D. Uncompahgre Watershed Plan. 2018.