



Mine Site Remediation by Good Samaritans in the Animas Watershed, Colorado

Matthew Storosh

Faculty Mentor: Dr. Peter McCormick

Environmental Studies

Fort Lewis College

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Located in Colorado's southern San Juan Mountains, the town of Silverton was established as a mining community in 1872. Over the next 120-years, the Animas watershed became a retainer for over 8.6 million short tons of mining and milling by-products containing high levels of potentially toxic elements. As a result of largely unregulated mining and milling practices, ecological impairment and habitat degradation in the Animas watershed are reflected through reduced abundance and diversity of aquatic invertebrates, and in some cases, the absence of viable fish communities.

In the early 1990's, the State Water Quality Control Program designated the upper Animas watershed as one of the most deteriorated stream segments in the state as a result of elevated levels of toxic metals. Due to a lack of potentially responsible parties for the remediation of mine sites found on both private and public lands the task of meeting instream water-quality standards has been problematic. In response to potential designation as a Superfund site, the Animas River Stakeholders Group (ARSG) formed in 1994. Operating as third-party volunteer group, ARSG has spent the past eighteen years seeking to improve water quality and habitats in the Animas River through a collaborative process designed to encourage participation from all interested parties.

This paper exposes the need to give greater attention to the correlation between past mining activities and the degraded water quality in the Animas watershed. An amendment to section 402 of the CWA would serve as a means to create a National Pollution Discharge Elimination System (NPDES) permit specifically for accomplishing the partial cleanup of abandoned mines by third-party volunteers seeking to improve watershed quality in areas such as Silverton and San Juan County. By drafting a bill that addresses the concerns of various interest groups such as environmentalists, mining corporations, and state and local agencies, an amendment to section 402 of CWA would serve in the remediation of several major draining mines. Such remediation action would go a long way to improve water quality, yet until the liability issues faced by Good Samaritans are addressed and resolved, all action is on hold.

Table of Contents

1. Introduction.....	1
2. Description of Study Area.....	2
3. Mining Legacy.....	3
4. Environmental Effects of Metal Loading.....	7
5. Formation of the Animas River Stakeholders Group.....	12
6. Progress of the ARSG.....	13
7. Environmental Liability.....	16
8. Conclusions.....	19

List of Figures

1. General location map of study area, southwestern Colorado, U.S.A.....	2
2. Locality map of mines, mills and mill tailings in the Animas watershed.....	4
3. Distribution of zinc during low flow.....	9
4. Illustration depicting acid mine drainage.....	10
5. Summary of risk categories, status of stream biota, and risk categories for each metal, by stream reach.....	11
6. San Antonio Mine Site before and after remediation.....	15
7. Pride of the West stope before and after remediation.....	15

Introduction:

According to certain estimates there are over half a million abandoned mines nationwide, most of which are former hard rock mines located in the western United States. Acid mine drainage associated with these mines has damaged watersheds and degraded water qualityⁱ. Although abandoned mines are recognized as an issue in the Southwest, there is a general lack of potentially responsible parties (PRP) such as owners or operators of these mines. As a result, there is a growing demand for voluntary work to address the release of acid mine drainageⁱⁱ. Third-party volunteers (often referred to as Good Samaritans) seek to reduce the number of sites contributing to water quality degradation through the remediation of abandoned mines, but face various obstacles in taking on this task.

Located in Colorado's southern San Juan Mountains, the Animas River watershed has been subject to substantial metal loading as a result of 120 years of mining. In an attempt to improve the watershed and fishery quality the Animas River Stakeholders Group (ARSG) operates as a third-party volunteer group working on the remediation of mine waste, and abandoned mines that drain toxic substances into the watershed. In conducting remediation projects, ARSG becomes responsible for the site and the drainage of toxic substances under jurisdiction the Clean Water Act (CWA)ⁱⁱⁱ. In becoming the responsible party for a given site, ARSG faces the potential of being sued by a third-party group for the discharge of toxic substances.

The objective of this paper is to examine the history of mining and milling practices in the Animas River watershed in order to better understand the correlation between historical mining and water-quality degradation. In examining this relationship it becomes apparent that work by Good Samaritans such as ARSG is pertinent not only to mine site remediation, but also to ecological remediation. Elevated communal understanding of the source and magnitude of the issue promotes the possibility of reducing liability for Good Samaritans. An amendment to the CWA would serve as a means to create a new National Pollution Discharge Elimination System (NPDES) permit^{iv} specifically for accomplishing the partial treatment of abandoned mines by third-party volunteers seeking to improve watershed quality.

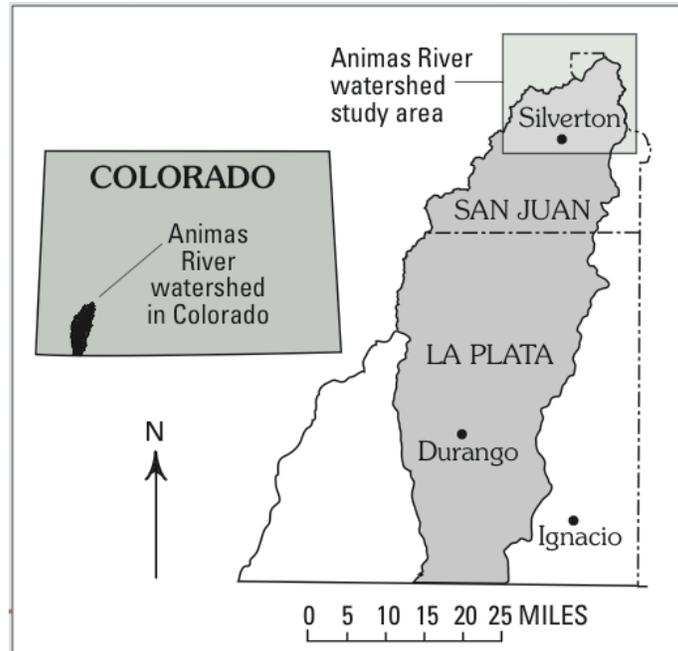


Figure 1. General location map of study area, southwestern Colorado, U.S.A. (United States Geological Survey 2007)

Description of Study Area:

The Animas River watershed encompasses roughly 146 mi² in the San Juan Mountains of southwestern Colorado (see figure 1). Major tributaries to the Animas River are Mineral and Cement Creek, which represent about 50 percent of the Animas Basin drainage area. Elevations in the basin range from 9,200 feet near the town of Silverton, Colorado, to nearly 13,900 feet at the summit of Vermilion Peak. The climate of the area is characterized by long, cold winters and short (three to four months), cool summers. Average monthly air temperature at Silverton ranges from 16 °F in January to 55.3 °F in July. Precipitation averages 45 inches annually, of which about 70 percent accumulates in a seasonal snowpack between November and April^v. Most of the remaining precipitation falls during monsoonal thundershowers in late summer and early fall.

Flow in the upper Animas River originates primarily from melting snowpack. Snowpack ranges from 10 to 20 feet in depth and averages 10 to 15 percent water content depending on seasonal variations. Peak flows in the Animas basin generally occur from late May to early July. It has been noted that during rising stages water has a considerably higher concentration of cadmium, copper, and zinc loading than water passing a sampling point at an equal flow rate after peak discharge has passed^{vi}. This condition is referred to as “hysteresis” and has been documented in the upper Animas River by Besser and Leib (1999) who found concentrations of dissolved zinc and copper during the rising limb of the snowmelt hydrograph, can be two or three times than those that occur at similar flow rates during the receding portion of the snowmelt hydrograph, as a result of weathering of exposed minerals.

The rock in the Animas River Basin are extensively mineralized as a result of the emplacement of the Silverton Caldera, which was the second of two volcanoes that collapsed and formed cylindrical pits (or calderas) about 26 million years ago^{vii}. The development of numerous faults and fracture zones formed thereafter, which acted as a discharge system for later circulation of hot, acidic fluids that contained large amounts of dissolved copper, gold, lead, manganese, silica, sulfur, and zinc^{viii}. As these ore fluids cooled near the land surface, minerals were precipitated in the faults, forming veins that would later produce acid drainage over the course of centuries of weathering processes and provide ideal sites for mineral extraction.

Mining Legacy:

Silverton's mining legacy was fueled by Ulysses S. Grant signing the Mining Act of 1872. The act provided a means to promote the development and settlement of publicly owned land in western United States. Migration followed and was further promoted by mining industry advertisements found in local and foreign newspapers, promising jobs and the opportunity to buy valuable mineral bearing public lands for no more than \$5 per acre. Due to the high-mineralized content of the Silverton caldera, Southwest Colorado represented an ideal location for mineral extraction. On September 13, 1873 the Brunot Treaty was enacted, opening a 5,400 square mile region of Ute territory in the heart of the San Juan Mountains to settlement by miners^{ix}.

Over the next 120 years America's high demand for metal drove Silverton and San Juan County to progress predominantly as a mining county. In response to new technologies and investments, mining and milling techniques on how crude-ore was extracted and processed changed. These developments would come to define how Silverton's mining legacy would alter a landscape over the course of a century that was millions of years in the making.

Prior to the signing of the Brunot Treaty in 1873 miners were utilizing hand methods to extract and produce a few tons of higher-grade silver-lead ores a day from the Little Giant mine (mine # 303, see figure 2) in Arrastra Creek. During this era miners developed a technique of filling the void left from extraction with mine waste and low-grade ores unmarketable for smelting. This technique became known as "cut-and-fill stopping," and persisted throughout much of Silverton's mining legacy as a primary disposal technique.

Silverton's isolated past came to an end when the Greene & Co. Smelter moved to Durango, Colorado where needed coal and limestone flux for smelting were easily accessible. In 1882 Silverton and Durango were connected with a 45 mile narrow gauge railroad that stimulated development and increased mining production. During the following years mines and production were expanded using the same hand sorting practices, but saw a steady increase in production to 100 short tons of ore per day^x. Throughout the 1880's smelters were unable to process ores containing more than 10 percent zinc. This zinc laden ore was disposed of in waste dumps at the mine and as part of the waste ore used to fill stopes^{xi}, and came to represent significant weathering sites for sulfide materials that have been identified as limiting factors for aquatic life (see figure 6)^{xii}.

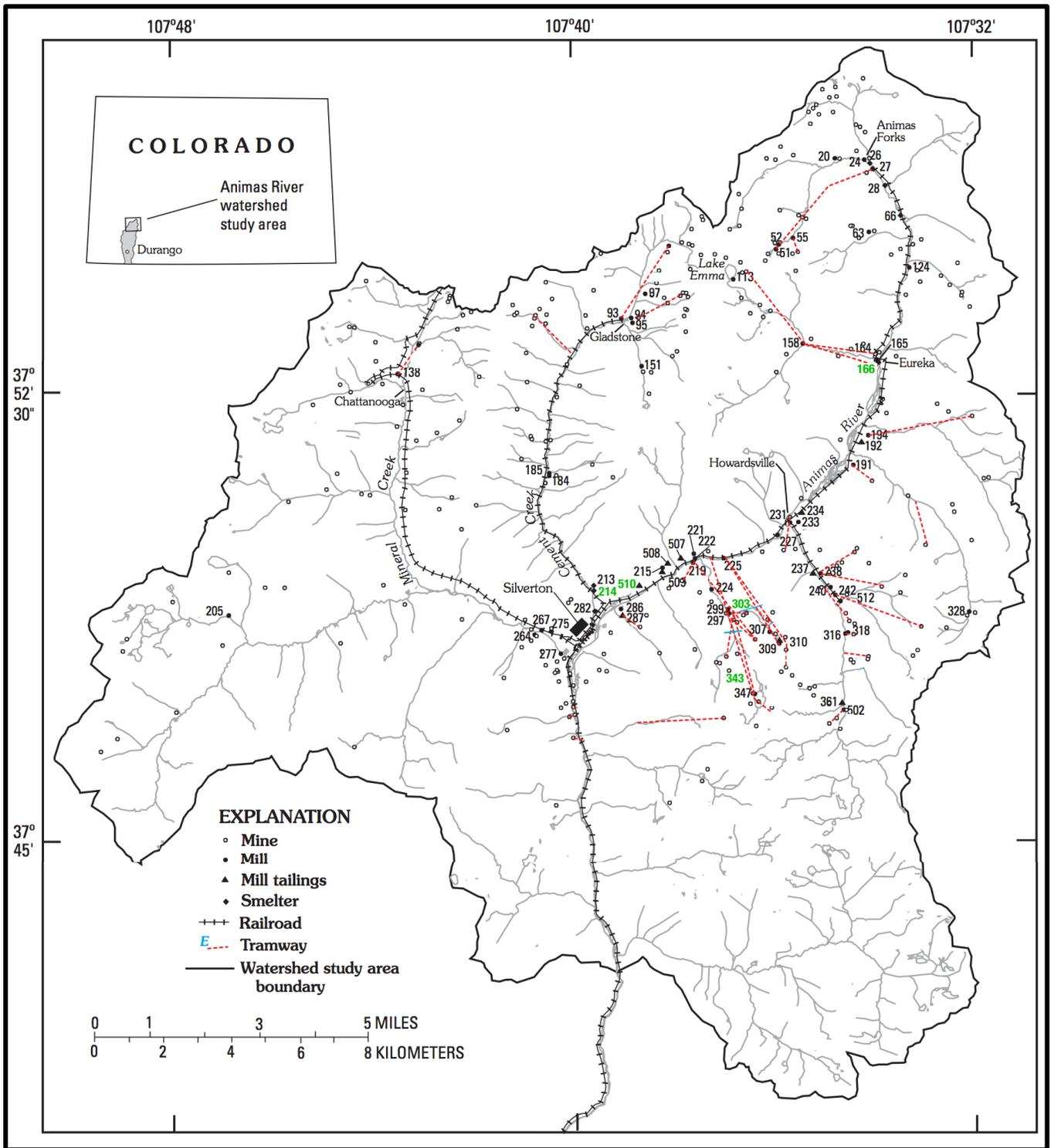


Figure 2. Locality map of mills, smelters tramways, and railroads in the Animas River watershed (Church, Mast, Martin, and Rich 2007).

From the 1890s till roughly 1913, increased Federal government support, stable to rising commodity prices, and improved technologies boosted mining production in Silverton. In 1890, with the signing of the Sherman William Silver Act, Silverton's economy boomed from the federal purchase of 54 million ounces a year of silver and as a result saw the value of silver rise from \$0.84 per ounce to as high as \$1.50^{xiii}. Shortly thereafter new mining technologies such as wire-rope aerial tramways, compressed air-powered machine drills, and the application of electricity further increased the production of ore. Larger mines were producing over 200 short tons per day and upward of 400 men could work year round at remote high-altitude sites such as Silver Lake (mine # 343, see figure 2).

By 1900 the addition of various new mills in the area resulted in active daily production to yield 1,470 short tons, while annual production had began to exceed 200,000 short tons^{xiv}. Despite technological advancements in mining and milling practices, zinc ores were still unmarketable due to inefficient techniques to separate it from the waste rock and the inability by local smelters to process it. During this era it is estimated that waste dumps from the sorting houses exceeded 500,000 short tons at some locations and remained susceptible to weathering and runoff into the Animas watershed at various sites until major remediation began in the early 1990s^{xv}. Acid mine drainage became recognized as an issue for miners in San Juan County in 1901 in the nearby Red Mountain mining district as acidic water dissolved pumps and piping. This process was occurring as water infiltrated into the "filled-type" stopes and dumps, where the water would have become acidic. The presence of acidic water would have aided in the transportation of metals exposed by mining practices to the aquatic environment for generations to come.

Increased milling during this period had negative effects on surface-water quality that was made quantifiable by tracking the release of a muddy slurry waste product called "tailings". Due to a lack of State or Federal jurisdiction on the disposal of tailings at the time it was common practice to discharge tailing into a nearby stream for disposal or on the ground or riverbanks near mills. Despite gravity mills typical recovery rate of 80 percent of the metals in the ore, metals such as zinc, iron pyrite, and a portion of the copper were still unrecoverable.

As a result of degraded water quality, Durango was forced to acquire an entirely new reservoir and delivery system that was constructed on the Florida River for a public water supply in 1902. By 1903 a reported 500,000 short tons of mill tailings were reported to be in Silver Lake. As milling technologies improved Silver Lake Milling Co. pumped out roughly 400,000 tons of these tailing between 1914 and 1919 for processing in a new mill. None the less a reported 500 short tons a day of reprocessed tailing residues were directly discharged into the Animas River near the mouth of Arrastra Creek^{xvi}.

In the ten year period of 1910 to 1920 the development of the ball mill grinding and froth flotation methods for concentration ores created a more uniform and finer product. This new process allowed mills to "separate zinc (sphalerite) from the lead and copper sulfide minerals, and worked well on the small-particle sized "slims" that were not amenable to gravity concentration,"^{xvii}. This proved to be a monumental development in the reduction of tailing disposal. With this new technology a new mill at Eureka was

constructed in 1918 that could recover as much as 90 percent of the valuable minerals, including the once disposed of sphalerite.

Mining practices were also improved upon with the introduction of “shrinkage stopping,” in which entire veins could now be mined opposed to just seeking out the most valuable ore. Once the process was complete, a large void was created from where all the broken ore was removed and miners continued filling these voids with low-grade ore or waste rock. In 1920 more than 200,000 short tons of ore had been produced in San Juan County representing a peak of ore production in the era. During the post war recession mining production dropped to a mere 1,100 short tons in 1921. Over the next ten years the mining industry slightly rebounded in response to a stabilizing economy, but was short lived with the onset of the Great Depression in 1930 when metal prices collapsed again.

The trend for mines to grow in size and to integrate more extensive workings continued, thus creating the potential for a larger impact on ground-water hydrology. Improved milling techniques and the processing of once unmarketable ores became more common in the area. None the less some of the galena, sphalerite, and most of the pyrite were discharged into the environment as tailings and became limiting factors in aquatic habitats^{xviii}. The much finer tailing produced by the ball mill technique may have contained less metal per ton, but the milled tonnage increased dramatically, yielding a net increase in the amount of tailings being deposited in the streams^{xix}. Additionally, the oil flotation process involved in the new milling technique utilized various chemicals compounds, but due to a lack of State or Federal regulation on chemical discharge at the time there is no account on the amounts released with tailings into the Animas watershed and its tributaries.

The disposal of mill tailing being deposited into the Animas went unaddressed until 1935 when a Colorado Supreme Court case required a mining company to cease the discharge of mill tailings into streams. In response, mining companies such as Shenandoah-Dives Mining Co. sought out more affordable solutions that would prevent legal cases from being brought against them. In July 1935, construction of mill tailings settling ponds began, and by June 1936 the majority of the mill tailings produced in the Animas River watershed were retained^{xx}. Many mill tailing ponds were constructed in this era, but were left to be washed out into the Animas River once the related mines and mills were closed due to economic reasons.

From the 1940s through the 1970s, little attention was given to the surface conditions of lands surrounding mines and mills in Silverton and San Juan County as wartime demand, and Federal government policy stimulated development of roads, processing of old mine-waste dumps, and the reopening of old mines. In 1976 Colorado passed one of the first comprehensive surface reclamation laws, which required surface disturbances to be reclaimed after mining was completed on both private and Federal lands; thus beginning an era of environmental consciousness. Despite government and public attention being given to the adverse effects of mining in San Juan County much of the damage was already done. On Sunday, June 4th of 1978, Lake Emma broke through into the 2580 Stope on C level where Standard Metals Corp. was mining the Spur Vein.

As a result of the collapse the Animas River turned black from the accumulated glacial mud and sediment well past Farmington, New Mexico, more than 70 miles downstream. In response the towns of Durango and Aztec had to shut off intake of water at their pumping plants to prevent the polluted water from entering municipal water systems. Despite a direct correlation between the flooding and mining activity, “Standard Metal Corp. was not fined by any State or Federal agency, and the accident was determined to be an “act of God” in Federal court action brought by the mine’s insurance company, which was trying to avoid pay \$9,000,000 in damage claims,”^{xxi}.

Regulators and industry did not address the potential for ground-water contamination by mill tailings pond deposits until the 1980s. Settling ponds built in prior years were not sealed and infiltration into ground water or near surface water is known to have occurred below various ponds. Historical mining and milling practices in San Juan County impacted the environment in various ways during the 120-year period of active mining. During the boom of Silverton’s mining legacy (1890 to 1935) it is estimated that 8.6 million short tons of mill tailings were deposited into the Animas River and various tributaries, a number that represents 47.5 percent of the total reported and estimated mine production^{xxii}.

Although the mining industry was an inconsistent source of financial income throughout the duration of its legacy, it carried Silverton through the Great Depression of the thirties and on into the eighties. In 1991 Sunnyside Mines closed the last major mine in Silverton, and the town became a federally designated National Historic Landmark District known as the Silverton Historic District^{xxiii}. In its current state the Silverton economy primarily depends on seasonal tourism from recreational opportunities tied to the Animas River, surrounding mountains and its mining heritage. Despite the lack of recent mining activity in the region, little public attention was given to the roughly 400 abandoned mine sites within a 200-mile radius above the town of Silverton which contribute to the release of hazardous substances^{xxiv}.

Environmental Effects of Metal Loading:

Historical mining occurred during a time when the environmental effects of mining were poorly understood, and were of little understanding or concern to the public and government agencies. Many streams in the Animas Basin have been effected by acid mine drainage. Elevated concentrations of potentially toxic trace elements from these sources have caused a reduction or elimination of fish and invertebrate communities^{xxv}. Since 1991 various government agencies have established initiatives, which, through collaborative efforts seek to study the geology, hydrology, water quality, and biology of the watershed as a means to determine the effects of historical mining on water quality in the basin. By examining the nature of potentially toxic trace elements, agencies such as the ARSG are provided with pertinent information for making remediation plans that address the most pressing issues (such as the highest ranked drainage mines listed in figure 3) in hopes of meeting the instream water-quality standards being proposed by the Colorado Department of Public Health and Environment to comply with the 1977 Clean Water Act^{xxvi}.

Silverton and San Juan County's historical mining has largely contributed to poor water quality, degraded habitat, and acidic streams, but the natural weathering of hydrothermally altered pyritic rock that is often found in the region has also contributed to degraded water quality. The annual freeze-thaw cycle each winter exposes fresh mineral surfaces to the weathering process. As pyrite is weathered, "the ubiquitous iron sulfide present in hydrothermally altered and mineralized rock, results in the release of sulfuric acid and trace elements that are potentially toxic to aquatic life,"^{xxvii}. Regardless of whether or not a mineral deposit had been mined or the ground disturbed this weathering process takes place. As a result of mining activity in this past century, there has been a substantial increase in exposed mineral surfaces to the weathering process.

In the process of extracting minerals and metals from the geological substructure of the San Juan Mountains the Animas watershed has become susceptible to various sources of contamination. A primary source is mine waste, due to the fact that only a small portion of the total ore extracted from a mine consists of the minerals or metals that are needed for industrial or commercial use. The remaining rock matter after this separation, or beneficiation, is the waste left at the mine site. The portion of waste generated varies with the mineral or metal and can range from 10 percent (potash) to 99.99 percent (gold). When metals such as gold, copper, silver and molybdenum are excavated and exposed to water and air during mining sulfuric acid is produced. Sulfuric acid has the potential to dissolve other harmful metals in the surrounding rock where it can then runoff into streams or river or leach into groundwater if uncontrolled (see figure 4)^{xxviii}.

Sulfuric acid is commonly found in waste rock piles, tailings, open pits, underground tunnels, and leach pads such as are common around the Animas River Basin study area in Silverton, Colorado. Acid mine drainage often lowers pH values in streams and can also dissolve toxic metals such as zinc, copper, aluminum, cadmium, arsenic, lead and mercury from the surrounding rock^{xxix}. These toxic metals have the tendency to create perpetual pollution and to bio-accumulate because the metals do not break down in the environment. Once settled in streambeds, the metals provide a long-term source of contamination, are continuously introduced at low flow periods of January and February, and eliminate or fill in the deep pools that trout utilize during the winter months^{xxx}.

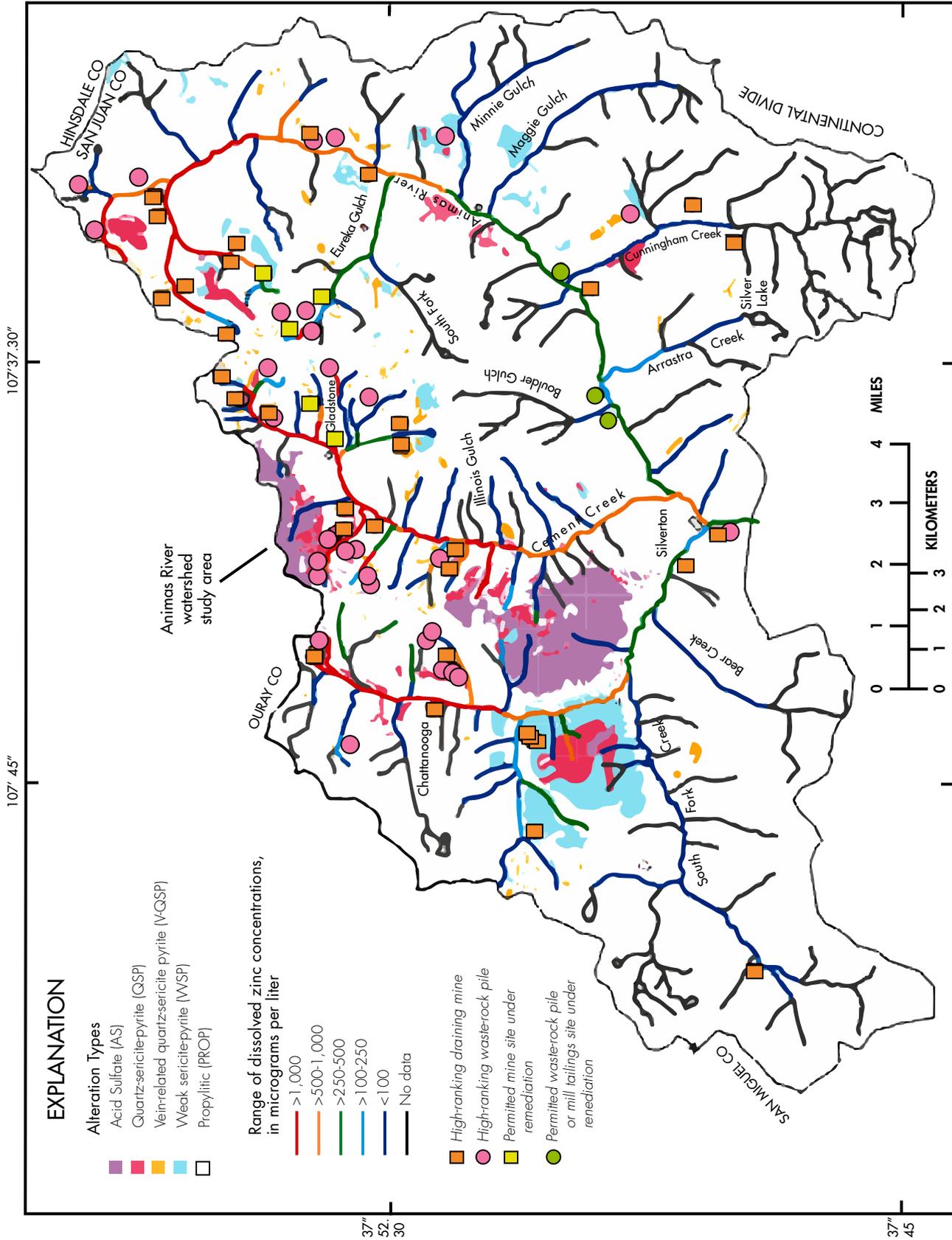


Figure 3. Distribution of zinc in surface water during low flow in January (Wright, Simmon, Bove, Mast, and Lieb 2007)

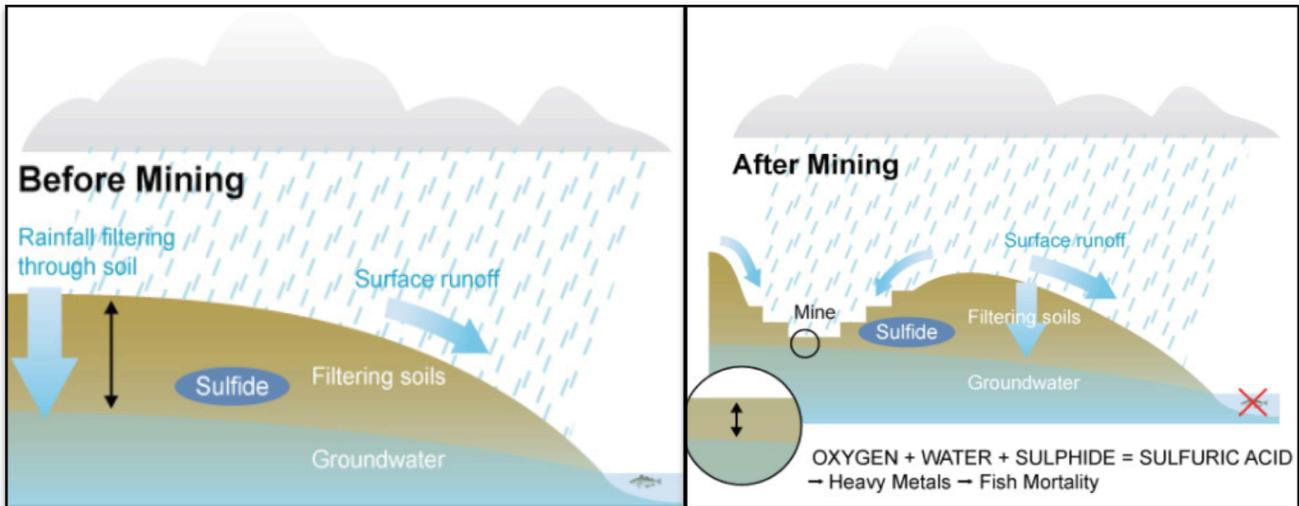


Figure 4. Acid Mine Drainage: extraction decreases groundwater depth and natural filtration, and increases the groundwater contamination (Rekacewicz 2005).

The recovery of marketable metals required the milling of 18.6 million tons of ore that created large volumes of mill tailings. Between the years of 1890 to 1935 it is estimated that nearly eight million short tons of mill tailings were directly discharged into surface streams^{xxx1}. Until 1935, when the first tailings pond was constructed (Mayflower tailings pond #4 repository, site # 510, see figure 2) it was common practice to dispose of mill tailing directly into the river. Even with new precautions such as tailing ponds, the high precipitation—particularly snowfall—in this area infiltrates mine workings, mine-waste dumps, and mill tailings to create acidic drainage that in places carries high concentrations of metals. It was reported that mining at large and small mines, and the excavation of countless prospects has disturbed millions of tons of mineralized rock in the Silverton area and “resulted in chemical reactions that release acid and metals to receiving waters in the watershed,”^{xxxii}.

Ecological impairment and habitat degradation are reflected through reduced abundance and diversity of aquatic invertebrates, and in some cases, the absence of viable fish community^{xxxiii} (see figure 5). Native cutthroat trout have been largely eliminated from streams in the study area with the exception of a few tributaries, and brook trout are now the only widespread fish species. Determining the effects of historical mining in the Animas River watershed study area necessarily involved many detailed and specific scientific studies to quantify aspects of the environmental effects attributable to historical mining and milling. There is still much data to be collected from most of the large and famous historical mines of the area located on private land, such as the Sunnyside (mine #116), Mayflower (mine # 304), and Shenandoah-Dives (mine #335).

Stream	Reach	Risk category	Status of biota			Toxicity risk			
			Fish	Inverts.	AI (diss.)	AI (total)	Zn	Cu	Cd
Animas River	North Fk.	D	Yellow	White	White	Red	Red	Orange	Red
	West Fk.	D	Red	White	Red	Red	Red	Orange	Red
	Above Eureka	C	Red	Orange	Blue	White	Yellow	Green	Yellow
	Eureka - Minnie	CB	Red	Orange	Green	Orange	Yellow	Green	Yellow
	Minnie - Arrastra	B	Green	Green	Blue	Blue	Blue	Blue	Blue
	Arrastra - Cement	B	Green	White	Blue	Blue	Yellow	Blue	Blue
	Cement - Mineral	CD	Red	Red	Blue	Red	Yellow	Green	Yellow
	Mineral - Deer Park	CB	Red	Yellow	Blue	Orange	Yellow	Blue	Green
	Deer Park - Molas	B	Yellow	White	Blue	Orange	Yellow	Blue	Green
	Molas-Elk	B	Green	Yellow	Blue	Orange	Yellow	Blue	Green
Cement Creek	Above Gladstone	D	Red	Red	Red	Red	Red	Red	Red
	South Fork	D	Red	Orange	White	Red	Yellow	White	Green
	Prospect Gulch	D	Yellow	White	Red	Red	Red	Red	Red
	Below Gladstone	D	Red	Red	Red	Red	Yellow	Red	Red
Mineral Creek	Above Mill Cr.	D	Red	Orange	Blue	Red	Yellow	Red	Green
	Mill - Middle Fk.	D	Red	White	Red	Red	Yellow	Blue	White
	Middle Fk.	D	Red	Red	Red	Red	Yellow	Red	Yellow
	Middle Fk. - South Fk.	D	Green	White	Green	White	Blue	Blue	Blue
	Upper South Fk.	A	Green	Green	Blue	Orange	White	Blue	Blue
	Lower South Fk.	B	Green	Green	Blue	Orange	Yellow	Orange	Blue
	Below South Fk.	CD	Red	Yellow	Blue	Red	Yellow	Orange	Blue
Other tributaries	Eureka	U	Yellow	White	Green	White	Yellow	Green	Yellow
	Minnie	A	Blue	White	Blue	Green	Blue	Blue	Blue
	Maggie	A	Green	White	Blue	Blue	Blue	Blue	Blue
	Cunningham	A	Blue	Green	Blue	Blue	Blue	Blue	Blue
	Arrastra	U	Red	White	Blue	Blue	Blue	Blue	Blue
	Boulder	U	Yellow	Blue	Blue	Blue	Blue	Blue	Blue
	Deer Park	A	Blue	Blue	Blue	Blue	Blue	Green	Blue
	Molas	A	Green	Blue	Blue	Blue	Blue	Blue	Green
Elk	A	Green	Blue	Blue	Blue	Blue	Blue	Green	

Color Code	Fish (Presence/absence)	Invertebrates (Percentile range)	Metals (Toxicity threshold)
Red	No fish	Lowest quality	Brook trout acute
Orange	(not used)	Poor quality	Brook trout chronic
Yellow	Uncertain	Medium quality	Acute WQC
Green	Brook Trout	Good quality	Chronic WQC
Blue	Cutthroat Trout	Highest quality	No toxicity
White	No data	No data	Mixed scores

Figure 5. Summary of risk categories, status of stream biota, and risk categories for each metal, by stream reach (Besser, Finger and Church 2007).

Formation of the Animas River Stakeholders Group:

The Animas River Stakeholders Group has worked for the past eighteen years “to improve water quality and habitats in the Animas River through a collaborative process designed to encourage participation from all interested parties,”^{xxxiv} by reducing metal loading from abandoned and inactive mines. The ARSG formed in 1994 at the urging of the Water Quality Control Division (WQCD) and in response to potential Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)^{xxxv} designation by U.S. Environmental Protection Agency (EPA) of most of the Animas River watershed. Led by Gary Broetzman of the Colorado Center for Environmental Management (CCEM) and Greg Parsons of the WQCD. The Animas River Stakeholders Group was facilitated as a means to bring money and time commitment to the Animas Basin by working under a grant from the Department of Energy.

Although 83 percent of the land in San Juan County is federally owned, the abandoned mining sites that produce the majority of pollutants are located on private lands and the majority of the owners of these sites are absentee landowners^{xxxvi}. While local efforts have been made to locate these landowners, results have been scarce and often produce landowners incapable of funding remediation projects. Indeed, Silverton recognized the detrimental effects Superfund designation would have on the local economy, but strong ties to mining heritage within the community had the potential to outweigh the need to focus on meeting the water quality standards. In order to protect the regional economy there was a dire need to assess the primary cause of degrading water quality of the Animas River.

Through biological and chemical sampling the WQCD found that dissolved aluminum, cadmium, copper, and zinc in the river and its tributaries were toxic to most forms of aquatic life and resulted in an abnormal reduction in diversity and abundance of related flora and fauna^{xxxvii}. “Elevated levels of toxic metals had just about wiped out aquatic life throughout many segments in the upper part of the watershed with contamination and came from the following sources: current (in the process of closing down) and historical mining sites, as well as natural contributions,”^{xxxviii}.

In response to these findings, the WQCD adopted strict goal based (numeric) standards in 1995 but delayed the effective date to 1998. During this time the ARSG was allowed time to investigate metal sources and strategies to reduce them. The ARSG monitored 400 abandoned mine sites with two goals in mind as defined by Bill Simon, Coordinator of the ARSG: “1) To Develop the information necessary to set appropriate standards and classifications; and 2) To demonstrate ongoing remediation and to develop a remediation plan for the basin so that standards and classifications could be maintained within the CWA”^{xxxix}.

The ARSG determined a three-phase plan would need to be developed in order to achieve these goals. After WQCD findings reported metal loading and acidity as the main factors limiting aquatic health and habitat, the ARSG determined that the establishment of baseline data for water quality in the Animas watershed to be a priority. Second, the group began a program in late 1995 to determine sites that were the most significant loaders of metals. Finally, the ARSG sought to undertake remediation projects, but by

1998 the necessary work to complete a Use Attainability Analysis (UAA)^{xi} had not yet been achieved^{xli}.

In 1996 Sunnyside Gold Company and WQCD signed a consent decree that allowed Sunnyside to bulkhead its mine workings and turn off its treatment plant in Gladstone in return for remediating a number of historic mine sites. The goal of the WQCD was to ensure that water quality would be no worse off in the Animas River below Silverton than it was before the treatment plant was turned off. As a result of this decision, the WQCC granted an extension of the effective date of the water standards to 2001. That same year the Department of Interior began the Abandoned Mined Lands Initiative to study the effects of abandoned mines on water quality and designated the Animas as one of two initial, national pilot project sites.

In 2001 the ARSG presented a Use Attainability Study (UAA) to WQCC with recommendations for use classifications and water quality standards. Based upon calculations presented in the ARSG Animas UAA, the WQCD developed 27 Total Maximum Daily Loads (TMDL)^{xlii} to set standards for the emission of pollutants in the Upper Animas. TMDL's now exist for several tributaries and the Animas main stem for Al, Cd, Cu, Fe, Mn, Pb, Zn, and pH as a means to set goals for remediation projects by the ARSG and other stakeholders or PRP's^{xliii}.

The ARSG has continued to focus on conducting further studies, satisfying regulatory commitments, conducting remediation programs, and attempting to promote a Good Samaritan legislation that would reduce legal liability faced by Good Samaritans such as the ARSG. From 1999 to 2011 the ARSG completed 16 remediation projects in Silverton and the surrounding San Juan County as well as assisting in the completion of various other remediation projects alongside mining companies and federal agencies.

Progress of the ARSG:

Through an effort on behalf of both volunteers and agency personnel, the ARSG has sampled, characterized and compiled data pertaining to stream conditions, pollution sources, and biological integrity of the watershed into a publicly accessible database. The group has also characterized and recorded all major sources of mine introduced loadings as a means to rank metal pollutant sources (mine drainage) and potential pollutant sources (mine waste sites) for each sub-basin. Based upon these rankings and other relevant criteria presented by various agencies such as the USGS, the group has prioritized sites for remediation. The ARSG has determined specific factors that limit aquatic life through several different investigations so remediation can be focused on reducing these limiting factors such as acidic pH (see figure 8). As part of a continuous process to monitor the water quality of the Animas River Basin the group continues to monitor physical, chemical and biological water quality, demonstrating the results of remediation efforts and providing information to modify programs and develop new programs.

Since ARSG's establishment they have played a monumental role in a series of regulatory accomplishments. Since the early 1990's the ARSG has repeatedly diverted the EPA from placing the Upper Animas Watershed on the National Priority List (Superfund designation)^{xliv}, appeared before the WQCC and influenced the decision

making process to ensure community involvement. As addressed before, many sites that emit the lion's share of pollution are found on private land and therefore are not under federal agency jurisdiction. As part of ongoing attempts to address the lack of PRP for mines found on private property ARSG has influenced federal agency policies which have enabled the use of public funds for remediation of private lands that impact BLM and/or Forest Service lands.

In the process of improving the water quality in the Animas River ARSG has assessed its success so far based on two qualifications: improvements in the watershed and fish populations and remediation work completed. The success of this work is already apparent when considering that in 1989 the Animas, below Durango produced only 29 pounds per acre of trout, by 1997 this number had increased to over 90 pounds. Additionally, it was in 1997 that evidence was first recorded of trout reproducing naturally in the Lower Animas. In 1998 ARSG documented significant population increases and some indication of possible natural reproduction in segments of the Upper Animas, which had previously been stifled in areas such as where Cement and Mineral Creek meet (see figure 5). As a result of continual work by the ARSG and other organizations, concentrations of toxic metals have been diminished in Mineral Creek and slightly in the Upper Animas above Silverton. However, metal concentrations have continued to rise in Cement Creek since the bulk heading of the American Tunnel by Sunnyside Gold Corporation and the related closing of the water treatment plant at Gladstone on Cement Creek^{xlv}.

The ARSG has worked with several other entities in an attempt to treat mine waste and address other issues in the Animas River. This includes efforts by the San Juan Research Center and Division (SJRC&D)^{xlvi}—an agency that provides non-profit status and general financial oversight for coordination, water quality and mine site characterization, and remediation projects. ARSG has also worked with the Forest Service, BLM, Office of Surface Mining and various private companies such as Sunnyside Gold Corporation has contributed \$13,005,367 towards remediation efforts^{xlvii}. From 1991 till 2011 the ARSG has recorded these efforts in a document found on their website titled, "Summary of Reclamation Projects in the Animas River Basin (ARSG 2011)". The continuous efforts by the ARSG and other organizations to improve water quality in the Animas River Watershed have been successful in helping to reduce metal loading and further understand the effects abandoned mines can have on water quality.

When the Sunnyside mine reopened for a brief period in 1937, mill tailing pond dams were built south of Eureka, but after the mine was abandoned and the Sunnyside Mill at Eureka was scrapped in 1949, these tailing dams partly washed out and some of these tailings entered the Animas River. It was not until reclamation activities in the 1990s that the remaining mill tailings were removed to the Mayflower tailings pond #4 repository (site # 510, see figure 2). In 1999 ARSG completed a drainage modification to tailings pond #4 to capture groundwater and divert it around tailing impoundments as a means to minimize potential for contact of groundwater with tailings and reduce potential for metal loading; a project that cost \$409,000^{xlviii}.

Another example of successful mine site remediation conducted by the ARSG was in 2004 when the ARSG completed the San Antonio Mine Waste Control project at Red Mountain with the SJRC&D (see figure 6). By installing hydrological controls,

removing wastes from stream, consolidating, neutralizing and vegetating the area the group was able to reduce metal loading and acid drainage in Mineral Creek, while stabilizing the site and restoring the streambed. Another of the ARSG's many notable remediation projects has been the Pride of the West Mine Open Stopes Infiltration Control Project that was conducted in 2005 (see figure 7).

This project combined the safety and infiltration closure of two large open stopes and one raise^{xlix} to reduce surface water infiltration into the mine as a means to reduce metal loading at mine discharge. This project cost approximately \$700,000, of which \$125,000 came from the Colorado Non-Point Source program^l of CWA (public funds), \$84,000 came from voluntary in kind contributions (stakeholders), and the remainder was paid for by the Colorado Mineral Severance Tax program^{li}.

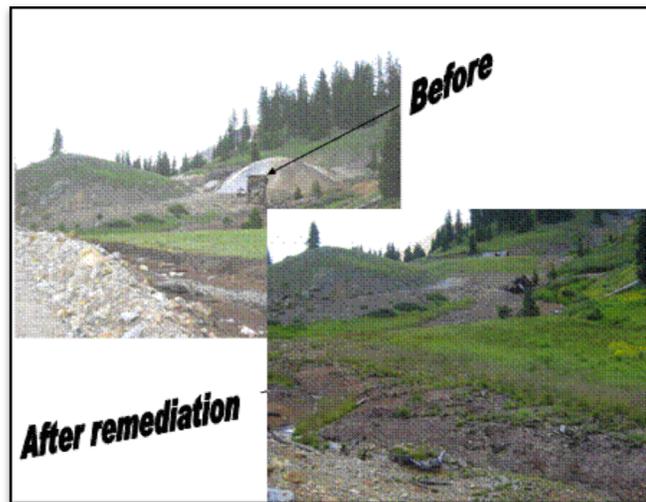


Figure 6. San Antonio Mine Site (ARSG 2013)

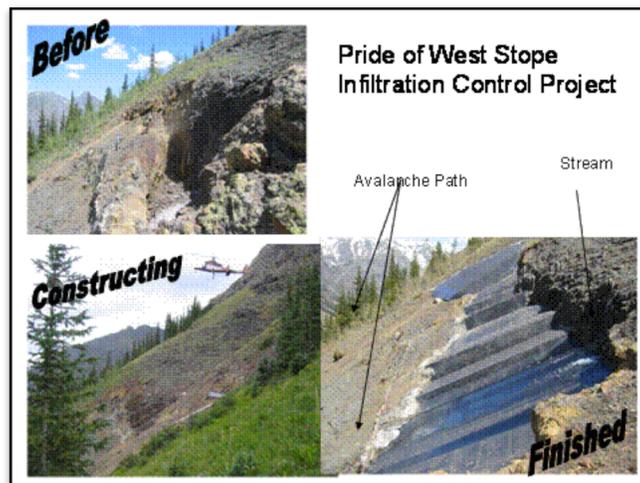


Figure 7. Pride of the West Stope (ARSG 2013)

The process of mine site remediation is an ongoing task that requires continuous attention to water quality, the health of aquatic communities and the physical state of abandoned and remediated sites alike. The Gladstone Treatment Facility is a prime example of how Good Samaritan Groups such as the ARSG play a key role in maintaining water quality standards so that they meet the instream water-quality standards being proposed by the Colorado Department of Public Health and Environment to comply with the 1977 Clean Water Act:

This is a project we have been developing to address the increase in metal loading coming from discharging mines in the Gladstone area—site C18 of figure 3—of Cement Creek since the bulk heading of the American Tunnel. Initially an EPA Targeted Brownfields grant was used to investigate treatment plant options using existing technologies and methods of funding construction, maintenance, and operation cost. An additional Targeted Brownfields grant, awarded to San Juan County, was used to identify the possibilities for the structure of a permanent funding and operational entity. Since then ARSG has been exploring the possibility of developing a facility so as to test newly emerging technologies, providing a much needed capability of taking a bench tested technology and testing it in the field on a pilot level of 50 to 300 GPM. Both these possibilities are being further explored with the cooperation of State and Federal agencies. We have identified good possibilities for significant financial contributions^{lii}.

The ARSG evaluates sites throughout the watershed for feasibility of cleanup, researching the processes that work best in this area and to prioritize those sites for possible cleanup throughout a basin-wide, cost-effective remediation plan in cooperation with landowners. The stakeholders approach this task with an emphasis on the preservation of both cultural and naturally significant sites. In implementing and assisting with remediation activities the ARSG works in collaboration with various federal and state agencies, as well as private organizations. The ARSG continuously works to improve water quality and aquatic habitats in the Animas River watershed as a third party “Good Samaritan Group” who has no legal binding to the properties they seek to remediate, but the mere admirable nature of their actions do not protect them or other Good Samaritans from incurring potential environmental liabilities.

Environmental Liability:

Similar to property owners and operators of mine sites, Good Samaritans such as ARSG can incur environmental liabilities under the Clean Water Act (CWA). This is because in the current iteration of CWA, the Environmental Protection Agency (EPA) considers draining mines as point sources of pollution^{liii}, which require a National Pollutant Discharge Elimination System (NPDES) permit. In the past the EPA has had little success in addressing the issue of abandoned mines due to the lack of PRP that could be held legally responsible for meeting the regulations associated with NPDES permits. As Good Samaritan groups take on remediation projects for a mine, they become responsible parties and are required to obtain NPDES permits. Holders of NPDES permits are required to use the “best available technology” for removing toxic substances,

which ends up being very costly^{liv}. Most Good Samaritan remediation projects employ lower-cost, lower-maintenance methods known as passive treatment systems that succeed in stopping the lion's share of toxic flow, but fail to prevent relatively small amounts of acid drainage into the watershed. This small amount is enough to be considered "a discharge of pollutants" under CWA and opens up the group to citizen lawsuits and various other legal complications^{lv}.

For Good Samaritans, "the issue of CWA liability can arise after the Good Samaritan satisfactorily completes its obligations pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and leaves the site, but the discharge of pollutants from a point source continues." In the current iteration of the CWA, EPA considers draining mines as point sources of pollution, which require National Pollutant Discharge Elimination System (NPDES) permits. Holders of NPDES permits are required to use the "best available technology" for removing toxic substances, which ends up being very costly even when considering fiscal contributions from various public and private entities^{lvi}. Most Good Samaritan remediation projects employ lower-cost, lower-maintenance methods known as passive treatment systems that succeed in stopping the lion's share of toxic flows, but fail to prevent relatively small amounts of acid drainage from entering the watershed. This small amount is enough to be considered "a discharge of pollutants" under CWA.

According to the precedent set the 1994 case *Committee to Save the Mokelumne River v. East Bay Municipal Utility District*^{lvii}, the "discharge of pollutants," can undermine agreements with CWA if a third-party lawsuit is brought on. A third-party suit exposes Good Samaritans to the potential liability of building an active treatment plant that meets NPDES requirement and operating it in perpetuity. In hopes of resolving this liability issue, most Good Samaritan legislation has focused on passing federal legislation to amend section 402 of the CWA to create a new NPDES permit specifically for Good Samaritans seeking to accomplish the partial treatment of an abandoned mine site without having to meet standards of an active treatment plant.

Since 1995 various U.S. and Senate members, state legislative actors, and local politicians have been involved in attempts to reform legislation. These attempts have generally received little support from environmental or mining interests, and have thus prevented any amendments to the legislation from becoming law. Environmental interests such as Trout Unlimited, the American Bird Conservancy, the Sierra Club, and the U.S. Public Interest Research Group are wary of creating loopholes, want strict limitations placed upon Good Samaritans and are concerned about not reducing liability for PRP who already have an obligation to cleanup up sites. Those who have worked on new legislation—such as Democratic U.S. Sen. Mark Udall of Colorado—have tried to narrow the law so it can not be abused. Mining interests greatly benefit from the voluntary nature of Good Samaritan actions and want broad liability protections in order to apply their considerable financial and technical resources to abandoned mine remediation. As for watershed groups, interests are split in that they want to ensure that proper responsibility is placed on PRP for damages, while ensuring that water quality is improved.

Despite the fact that some of these bills never made it through Senate, while others never left the committee floor each has made the liability and related

environmental issues more apparent in the public eye. In the meantime the ARSG seeks to continue improving the water quality of the Animas River while working within the legal parameters set by the current iteration of the CWA. In 2007 and 2012 the U.S. Environmental Protection Agency submitted memorandums that they hoped “to provide clarification regarding permit obligations for Good Samaritans,”^{lviii}. The EPA would loosen restrictions on “Good Samaritans” looking to clean up abandoned hard-rock mines throughout the West. Under the new policy, the EPA can include an extended legal liability time period to Good Samaritans and there is no longer a need to provide a CWA permit during or after a successful cleanup.

The EPA defines Good Samaritans as anyone who was not a previous owner of the mine. However under previous policies, if Good Samaritans clean up the mines, they could still be liable for any damage they cause afterward or waste left behind. EPA’s new interpretation focuses on the CWA rather than legislation creating a new permit. Both the CWA and EPA note that in order for Good Samaritans to avoid a lawsuit, the site must be completely cleaned up, but the EPA’s memo issued in 2007 was applicable only to solid waste released after cleanup. The 2012 memo revised this, noting that Good Samaritans can be exempt from point-source pollution, or polluted water coming out of a mine that carries metal^{lix} (Giangeco 2012).

Bill Simon, coordinator of the Animas River Stakeholders Group, commented that the main liability protection EPA proposes is to define Good Samaritans, if they meet certain criteria, as non-operators at a site once the project is completed and the CERCLA removal action is concluded. In Simon’s eyes the 2012 memo still leaves a great deal of potential liability concerns for Good Samaritans and someone must still be responsible for the point-source pollution left behind^{lx}. Shortly after the EPA submitted its new policies concerning Good Samaritans the ARSG published “Comments on EPA’s 2012 Memorandum on its 2007 Good Samaritan Guidance,” which expressed further liability concerns.

The draft identifies the fact that any treatment system for a draining mine will need maintenance. Regardless of the type of treatment utilized to remove metal and treat discharge, the “media” whether it is a settling pond, wetland, limestone, or resin is going to need to be cleaned or replaced at some point. For the ARSG it is, “hard to imagine that anyone doing maintenance at a site is not going to be considered an operator—unless each periodic maintenance was conducted under a separate CERCLA removal action and the entity doing the maintenance fit the criteria for non-operator,”^{lxi}. The ARSG comments that it might be possible to have the property owner of a site take on maintenance, but finding such an owner could prove difficult as it has in the past. In addition, enforcing a maintenance agreement with an owner would be problematic because enforcement may require access and authority to enter which means the enforcement party could be considered an operator under the EPA memo.

The ARSG further comments on the fact that while the EPA interpretation of the 2007 guidance provides quite a bit of liability protection from EPA, it is guidance, not regulation or statute and therefore provides much less protection from a possible citizen-suit. “Since one does not know where a third-party lawsuit may come from or what type of leverage that third-party may be trying to gain, the protection from citizen suits is of particular interest to funders and partners working with ARSG,”^{lxii}. The ARSG and the

non-profit (SJRC&D) they work with have little assets and are not very likely targets of a third-party lawsuit. ARSG works very closely with the state agencies for contracting, protection under CERCLA, and funding. Their willingness and ability to undertake projects concerning draining mines will be strongly influenced by the state's position regarding liability and EPA's memo.

Conclusions:

In the meantime sites such as the American Tunnel, Red and Bonita, Gold King No. 7 and Mogul, are draining up to 800 gallons a minute of iron, zinc, copper, lead, cadmium, mercury and manganese into Cement Creek, a tributary to the Animas River^{lxiii}. The problem is considered so serious that the EPA found the site eligible for Superfund in 2011. Lacking community support, the EPA backed off its proposed listing in April of 2012 and agreed to proceed with a collaborative process with the ARSG. Building a treatment plant to remove heavy metals from Cement creek would cost an estimated \$6.5 million, including up to \$5 million a year to operate it according to a Sunnyside Gold Corporation consultant. In the mean time Bill Simon said, "all action is on hold until more than an understanding or agreement with the EPA on the definition of a non-operator is all that stands between Good Samaritans and a third-party lawsuit. (Esper 2012)

Citizens of San Juan and La Plata County are all stakeholders of the Animas River watershed at various levels. As individuals they depend on it for their daily needs and as a community, are tied to the decisions made pertaining to the watershed's quality. The continuous discharge of toxic pollutants in the Animas River watershed threatens the quality of the watershed and has been shown to have detrimental effects on aquatic habitats in the area. Third-party volunteer groups such as the Animas River Stakeholders Group are seeking to improve watershed and fishery quality for the good of the Animas watershed through remediation projects on abandoned mine sites. In doing this communal service, Good Samaritans face potential liability risks if third-party suits are presented and force the Clean Water Act to mandate National Pollution Discharge Elimination System permits to Good Samaritans groups. The potential for third-party suits would force Good Samaritans to install active-treatment facilities, which are costly beyond the fiscal abilities of many volunteer groups, and often times unreasonable when considering space and access to various mine sites.

There is hope that water quality will be improved in the Animas River Watershed. By amending section 402 of the CWA, Congress could create a new NPDES permit specifically for accomplishing abandoned mine cleanup by third-party volunteers that would prevent the release of the majority of toxic pollutants. Due to the lack of responsible parties, the current iteration of the CWA and the continuous discharge of toxic pollutants into the Animas River watershed from abandoned mine sites, there is a growing need for Good Samaritans to act on behalf of the general public to improve the environment we depend on.

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- ⁱ Outline of the Good Samaritan Clean Watershed Act | Adopt Your Watershed | US EPA.
- ⁱⁱ Acid mine drainage is the formation and movement of highly acidic water rich in heavy metals. The acidic water forms through the chemical reaction of surface water and shallow subsurface water with rocks that contain sulfur- resulting in sulfuric acid. The resulting fluids may be highly toxic, and when mixed with ground water, surface water and soil, may have harmful effects on humans, animals and plants. http://water.epa.gov/polwaste/nps/acid_mine.cfm
- ⁱⁱⁱ Established in 1972, the Clean Water Act (CWA) provides the statutory basis for the NPDES permit program and the basic structure for regulating the discharge of pollutants from point sources to waters of the United States. http://cfpub.epa.gov/npdes/cwa.cfm?program_id=45
- ^{iv} National Pollution Discharge Elimination System (NPDES) permit is the regulatory agency document issued by either a federal or state agency, which is designated to control the discharges of pollutants form point sources into U.S. waterways. <http://www.alken-murray.com/fuel-glossary.htm>
- ^v U.S. Department of the Interior. 2003. *Using Water-Quality Profiles to Characterize Seasonal Water Quality and Loading in the Upper Animas River Basin, Southwestern Colorado*. By Kenneth J. Leib, M. Alisa Mast, and Winfield G. Wright. U.S. Geological Survey, Water Resource Investigations Report 02-4230. <http://pubs.usgs.gov/wri/wri024230/> (accessed January 15, 2013)
- ^{vi} U.S. Department of the Interior 2003, 4.
- ^{vii} U.S. Department of the Interior 2003, 5.
- ^{viii} Alan Septoff, "Acid Mine Drainage," *Earthworks*, December 16, 2005, http://www.earthworksaction.org/library/detail/fact_sheet_acid_mine_drainage#.UnqfiJR4b2F (accessed January 15, 2013).
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- ^{xi} Stopes are a steplike part of a mine where minerals are extracted.
- ^{xii} U.S. Department of the Interior. 2007. *Impacts of Historical Mining on Aquatic Ecosystems—An Ecological Risk Assessment*. By John M. Besser, Susan E. Finger, and Stanley E. Church. Chapter D of *Integrated Investigations of Environmental Effects of Historical Mining in the Animas River Watershed, San Juan County, Colorado*. Edit by Church, S.E., con Guerard, Paul, and Finger, S.E., eds. U.S. Geological Survey, Professional Paper 1651. <http://pubs.usgs.gov/pp/1651/> (accessed January 15, 2013).
- ^{xiii} Jones 2007, 57.
- ^{xiv} Jones 2007, 61.
- ^{xv} Jones 2007
- ^{xvi} Jones 2007, 64.
- ^{xvii} Jones 2007, 68.
- ^{xviii} Besser, Finger, and Church 2007.
- ^{xix} Jones 2007, 68.
- ^{xx} Jones 2007, 78.
- ^{xxi} Jones 2007, 81.
- ^{xxii} Jones 2007, 83.

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- xxiii University of Michigan, “School of Natural Resources and Environment,” *Chapter 5: Animas River Stakeholders Group*, 1999, prepared by Chrissy Coughlin.
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- xxiv U.S. Department of the Interior, 2003; Coughlin, 1999.
- xxv U.S. Department of the Interior, 2003 1.
- xxvi Besser, Finger, and Church 2007.
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- xxx Septoff 2005; U.S. Geological Survey 2007.
- xxxi Jones 2007, 66 and 69.
- xxxii U.S. Department of the Interior, 2007. *Mine Adits, Mine-waste Dumps, and Mill Tailings as Sources of Contamination*. By Thomas Nash and David L. Fey. Chapter E6 of *Integrated Investigations of Environmental Effects of Historical Mining in the Animas River Watershed, San Juan County, Colorado*. Edit by Church, S.E., con Guerard, Paul, and Finger, S.E., eds. U.S. Geological Survey, Professional Paper 1651. <http://pubs.usgs.gov/pp/1651/> (accessed January 15, 2013), 5.
- xxxiii U.S. Geological Survey 2007.
- xxxiv Animas River Stakeholders Group, “Home,” *Mission of the Animas River Stakeholders Group (ARSG)*, <http://www.animasriverstakeholdersgroup.org/> (accessed January 15, 2013).
- xxxv Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is a law commonly known as Superfund, which created a tax on chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment.
<http://www.epa.gov/superfund/policy/cercla.htm>
- xxxvi Coughlin 1999, 2.
- xxxvii Tomas M. Koontz, “Government-Led Community Collaboration: The Animas River Stakeholders Group” in *Collaborative Environmental Management: What Roles for Government?* (Washington, D.C.: Resources for the Future, 2004 126-145).
- xxxviii Coughlin 1999, 14.
- xxxix Coughlin 1999.
- xl Use Attainability Analysis (UAA) is a structured scientific assessment of the factors affecting the attainment of uses specified in Section 101(a)(2) of the Clean Water Act (the so-called “fishable/swimmable” uses).
http://water.epa.gov/scitech/swguidance/standards/uses/uaa/about_uas.cfm
- xli Animas River Stakeholders Group, “History and Process,” *Stakeholder Process*, <http://www.animasriverstakeholdersgroup.org/page2.php> (accessed January 20, 2013).
- xliv Total Maximum Daily Loads (TMDL) is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that load among various sources of that pollutant.
(<http://water.epa.gov/lawsregs/lawguidance/cwa/tmdl/overviewoftmdl.cfm>)

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- ^{xliv} The *National Priorities List* (NPL) is the list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. http://www.epa.gov/superfund/sites/npl/npl_hrs.htm
- ^{xlv} ARSG 2013.
- ^{xlvi} San Juan Research Center and Division (SJRC&D) was established under the authority of the Food and Agriculture Act of 1962 to assist multi-county areas in enhancing conservation, water quality, wildlife habitat, and rural development. <http://sanjuanrcd.org/blog/>
- ^{xlvii} Animas River Stakeholders Group, “Summary of Remediation Projects 2011,” *ARSG and SJRC&D*, October 31, 2011, <http://www.animasriverstakeholdersgroup.org/page6.php> (accessed January 25, 2013).
- ^{xlviii} Animas River Stakeholders Group, “Animas River Update,” *Remediation Work Completed*, <http://www.animasriverstakeholdersgroup.org/page6.php> (accessed January 20, 2013).
- ^{xlix} Raise: a shaft that starts under ground and goes upwards, often connecting an ore chute to a stope above
- ¹ Colorado Non-Point Source Program seeks to address pollution caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters. <http://npsc Colorado.com/>
- ^{li} ARSG 2013.
- ^{lii} ARSG 2013.
- ^{liii} Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river. <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/glossary.cfm#pointsource>
- ^{liv} Coughlin 1999.
- ^{lv} "DRAFT ARSG Meeting Summary for the Technical Workgroup 10/18/12." Animas River Stakeholders Group. http://www.animasriverstakeholdersgroup.org/attachments/File/Oct_18_2012_Technical_Workgroup_meeting_summary.pdf. (accessed January 20, 2013).
- ^{lvi} U.S. Environmental Protection Agency, “EPA Home,” *CERCLA Overview*, <http://www.epa.gov/superfund/policy/cercla.htm> (accessed February 1, 2013).
- ^{lvii} Katie Redding, “Colo. Water Cleanups Hobbled by ‘Good Samaritan’ Legal Risks,” *The Colorado Independent*, September 24, 2009, <http://www.coloradoindependent.com/38169/colo-water-cleanup-projects-hobbled-by-%E2%80%98good-samaritan%E2%80%99-legal-risks> (accessed January 22, 2013).
- ^{lviii} U.S. Environmental Protection Agency, *Memorandum: Clean Water Act § 402 National Pollutant Discharge Elimination System (NPDES) Permit Requirements for “Good Samaritans” at Orphan Mine Sites December 12, 2012*, Washington, D.C. 20460. <http://water.epa.gov/action/goodsamaritan/upload/2012-good-samaritan-memo-signed.pdf> (accessed January 22, 2013) 2.
- ^{lix} Leign Giangreco, “New Flexibility May Aid Mine Cleanup,” *The Durango Herald*, December 12, 2012, <http://www.durangoherald.com/article/20121212/NEWS01/121219850/0/SEARCH/New-flexibility-may-aid-mine-cleanup> (accessed January 22, 2013).
- ^{lx} ARSG 2013; Giangreco 2012.
- ^{lxi} DRAFT ARSG Meeting Summary 10/18/2012
- ^{lxii} "DRAFT Comments on EPA’s 2012 Memorandum on Its 2007 Good Samaritan Guidance: Animas River Stakeholders Group (12/27/2012)." Good Samaritan Info, 27 Dec. 2012.

<http://goodsamaritaninfo.org/wp-content/uploads/2013/01/ARSG-Comments-on-EPA-Good-Sam-Memo.pdf> (accessed January 20, 2013).

^{lxiii} Dale Rodebaugh, "Gold Miners Offer \$6.5M for Cleanup," *The Durango Herald*, October 5, 2011. [http://www.durangoherald.com/article/20111006/NEWS01/710069924/0/rss/Gold-miner-offers-\\$65M-for-cleanup](http://www.durangoherald.com/article/20111006/NEWS01/710069924/0/rss/Gold-miner-offers-$65M-for-cleanup) (accessed January 20, 2013).

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