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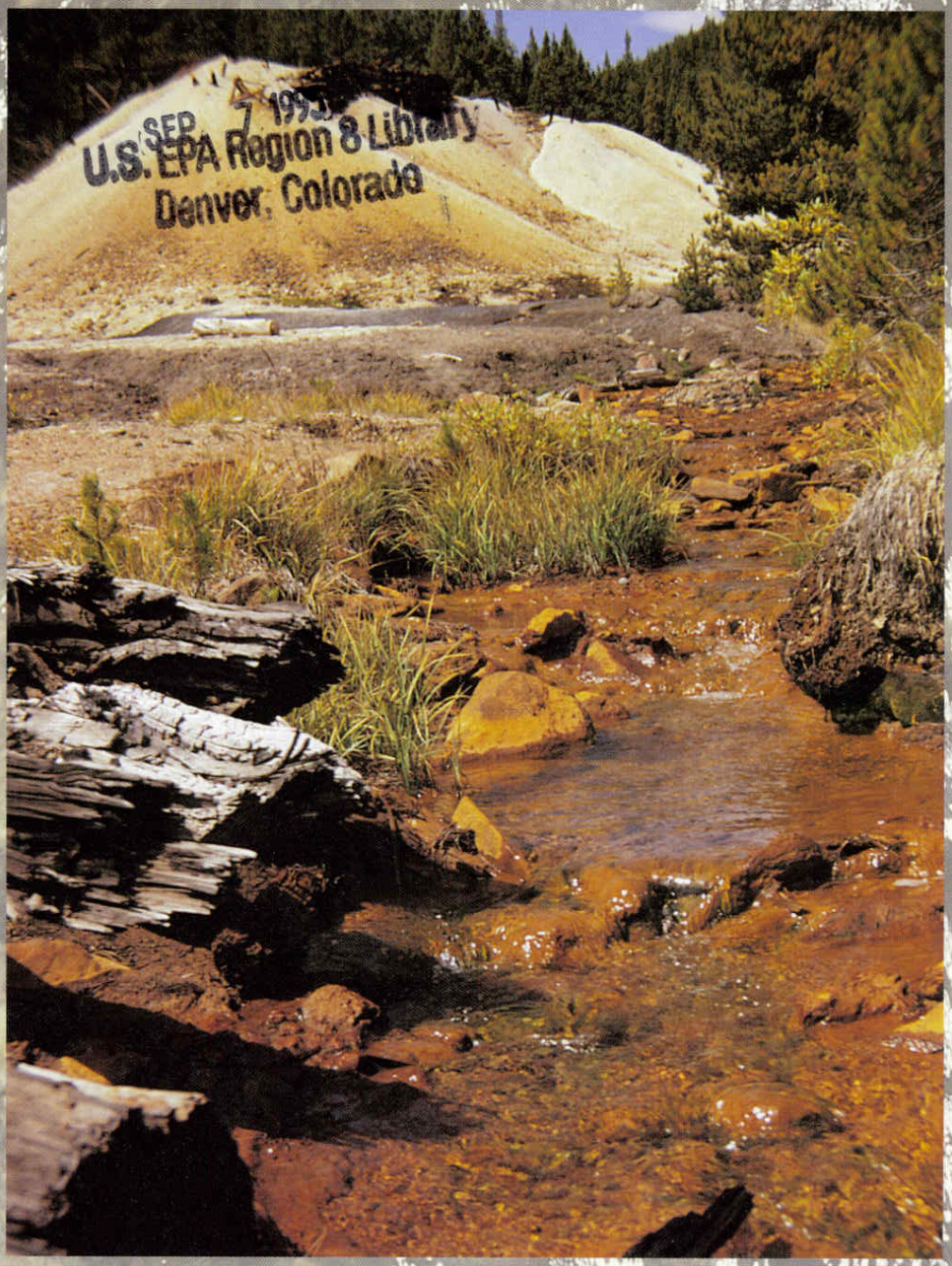
Historic Hardrock Mining: The West's Toxic Legacy

The Critical Link between Water Quality and Abandoned Mine Sites



"Drainage from hardrock mine sites is a major water quality problem in our state. This is true for many Western states. We need to stay focused on cleanup of these sources of severe water contamination—for restoration of our natural systems, and maintenance of our environment."

Geoff Harvey
Senior Surface Water Analyst
Idaho Division of Environmental Quality

The Trouble with Historic Mine Sites

Historic hardrock mining activities in the West have created hundreds of thousands of geological disturbances. Drainage and runoff from mine sites impact water quality in streams throughout the Rocky Mountain states. While cleanup of mine sites is a high priority, the sheer number and geographic distribution of these disturbed areas make addressing them a formidable task.

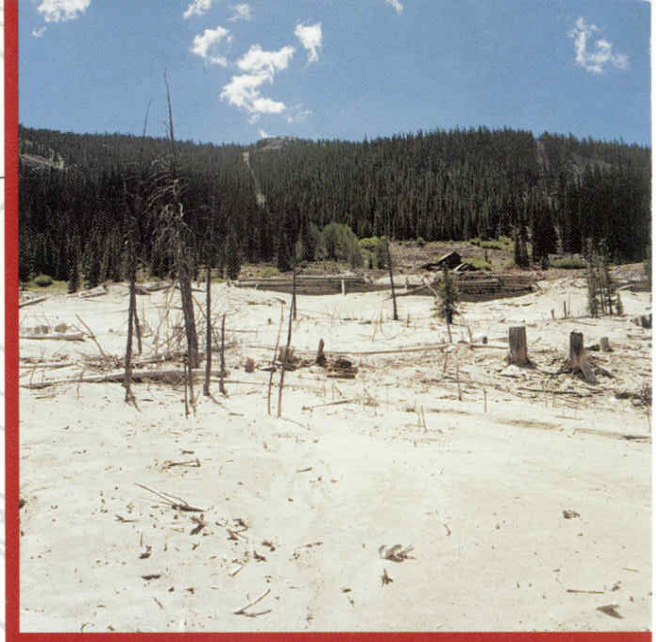
This metals deposit on the wall of a mine shaft is nearly pure zinc.

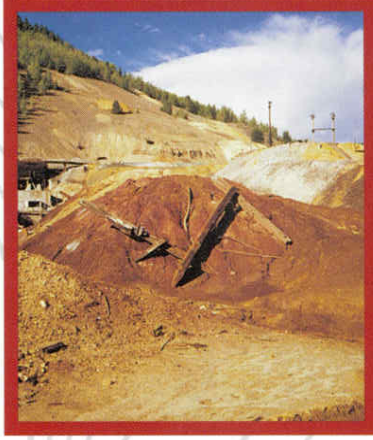
Traditional metals mining usually involves digging tunnels and adits to reach lodes of mineral-rich ore. Rock is removed from deep within the earth, and milled to extract desired minerals. When the ore is exhausted, miners move on leaving behind finely-ground tailings and waste rock above ground, and tunnels underground.

Such mining activities expose part of the earth's crust to water, oxygen, and bacteria. Layers of metals-rich rock that have been underground become oxidized and chemically altered. When water flows through and over the newly-disturbed material, metals that were once locked within rock can dissolve in the water. Zinc, iron, cadmium, copper, lead—metals that are toxic to aquatic life and can damage human health—end up contaminating surface waters and ground water.

"If we don't understand what is going on and how the water moves through the earth, we'll end up spending a lot more money and getting a lot less done."

Bruce Stover
Senior Geologist and Project Director
Division of Minerals and Geology
Colorado Department of Natural Resources

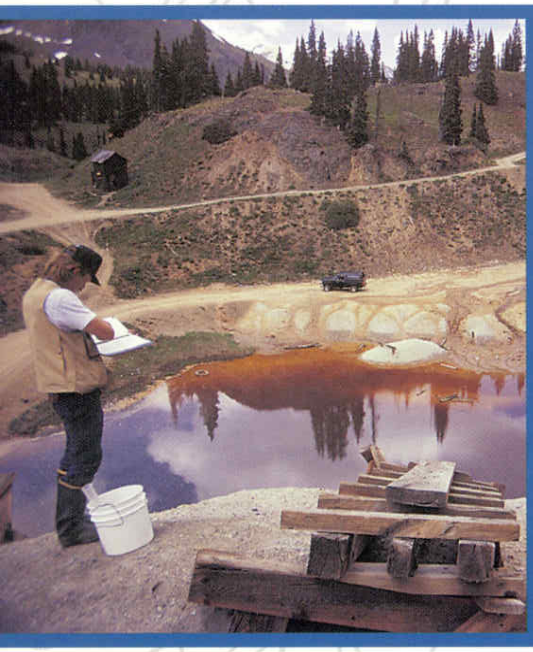


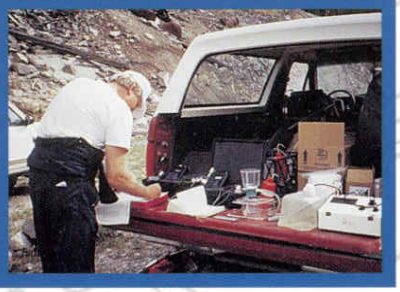


Top: **The eerie effects of windblown tailings near the former Mary Murphy Mine and Mill in Colorado.** ***Bottom Left:*** **Tailings and the remains of historic mine workings exhibit the characteristic reddish-brown color of iron oxide leaching.** ***Bottom Right:*** **Blocked by mine waste dumped in the stream channel, the flow in French Creek was reduced to ponding near the former Wellington-Oro Mine near Breckenridge, Colorado.**

Investigate, Investigate:
The Importance of Detective Work

The activities that created the mine workings, residual wastes, and other impacts to the environment at inactive and abandoned mine sites are generally poorly documented. Consequently, little or no useful information is available as the reclamation specialist steps onto the site to determine specific water quality impacts, their origins, and remediation strategies.





Since every mine site is unique, using "off-the-shelf" characterization strategies can lead to an improper or incomplete understanding. Remedial actions based on a partial picture of a site may overlook important contaminant sources or pathways, resulting in no improvement to water quality. With limited financial resources available to address mine sites, failure of remediation will only be tolerated to a limited extent.

Adequate resources and time must be dedicated to extensive site characterization before remedial activities are proposed and undertaken. Characterization includes five steps: 1) reconstructing pre-mining conditions, 2) inventorying what has been deposited above ground, 3) mapping what has occurred underground, 4) monitoring the movement of water, and 5) estimating the impacts of mining disturbances.

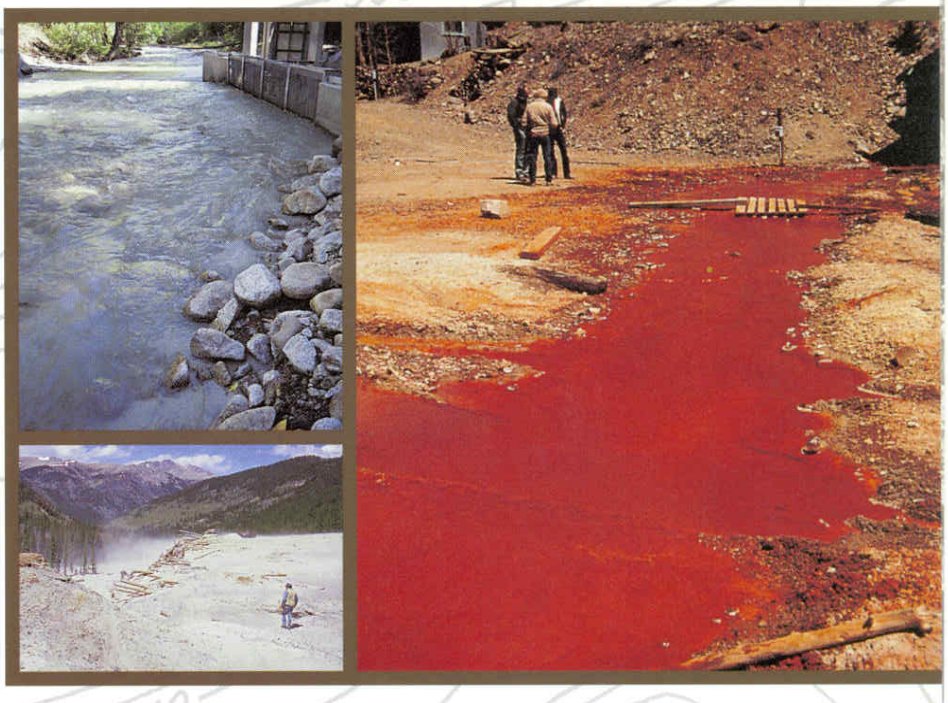
Far Left: **Gathering data on water from a mine pond.** ***Top Right:*** **Collecting ground water from a well for sampling purposes.** ***Bottom Right:*** **Water quality analysis can sometimes be performed on site, from the back of a truck equipped with laboratory equipment.**

Chalk Creek and French Gulch:
Two Colorado Test Sites

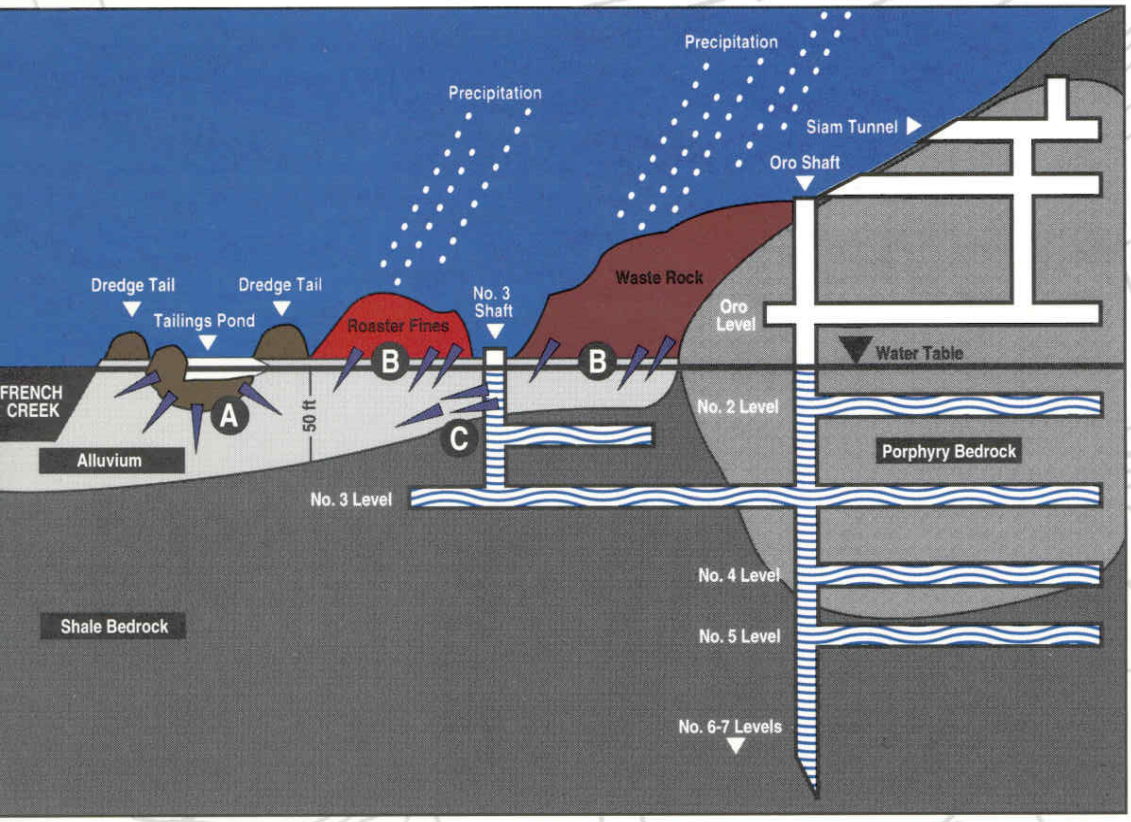
Chalk Creek and French Gulch are typical of the many inactive and abandoned mining and ore processing sites in the Rocky Mountain West. Neither site has produced the catastrophic environmental damage that might place it on the Superfund priority list. Yet from the perspective of the Colorado Department of Public Health and Environment, these two sites—like hundreds of others across the state—pose definite threats. As such, these sites were recognized as possible test cases for using experimental characterization techniques at mine sites.

To tackle the task of characterization at these two sites, specialists from several complementary disciplines came together to combine their expertise. The teams approached Chalk Creek and French Gulch with few preconceptions about the geologic, hydrologic, and physical systems operating at each site.

Water quality improvement goals at Chalk Creek and French Gulch have not yet been achieved. Yet these two sites have been extremely valuable laboratories for agencies and reclamation specialists involved in characterization and remediation efforts. Ongoing work will help to better understand and solve the impacts to water quality at the sites.



Far Right: **Water draining from a mine tunnel in the Chalk Creek area runs bright red with dissolved metals.**
Top Left: **Just upstream from a fish hatchery intake gate, the stream bottom reveals the tell-tale whitish-gray coloring of tailings.** ***Bottom Left:*** **A moonscape caused by mine tailings contrasts starkly with the natural alpine vegetation.**



Cross Section through French Gulch at Wellington-Oro Mine, High Flow Conditions

Potential Sources of Heavy Metals Contamination

- **A** Mill tailings in alluvium, saturated by French Creek
- **B** Precipitation leaches metals from mine and mill waste to water table
- **C** Mine pool from Wellington-Oro complex drains to French Creek alluvium

KEY

- Alluvium
- Porphyry Bedrock
- Shale Bedrock
- Waste Rock
- Roaster Fines
- Dredge Tails
- Flooded Workings
- Precipitation
- Direction of Seepage

Lessons Learned from Chalk Creek and French Gulch

- Sites can be far more complex than they appear—hydrologically, geologically, and physically. Obvious metals sources may not be the only ones contributing to water quality problems.
- Without appropriate levels of human resources and the ability to commit them in a concentrated effort, mine sites can take an extremely long time to characterize.
- It is nearly impossible to plan work in advance because it's a "learn as you go" process.
- After remediation activities, water quality may actually get worse before it gets better. Follow-up work is essential to achieve objectives.
- Even with a total cleanup, it could take decades to see complete restoration of water quality at a site. Additional causes of contamination are likely to become apparent only after cleanup of obvious sources.
- Securing funding for characterization work continues to be a challenge.

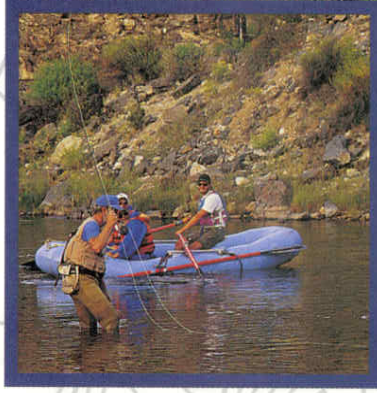
The Road Map:

Steps for Understanding Effective Site Characterization and Cleanup

"Using the tools currently available for use in mine site characterization feels like conducting an autopsy with a butter knife. We need more sophisticated, more reliable tools. Experience together with better tools is the winning combination."

Carol Russell
Environmental Scientist
Environmental Protection Agency, Region 8

- Ask—and answer—the hard questions before beginning cleanup at any site.
  1) Why should this site be cleaned up?
  2) Will it make measurable differences in water quality to clean up the site and leave other nearby sources as they are?
  3) How much time and money will the cleanup take?
- When attempting cleanup of a mine site, pay attention to available technology, institutional commitment, and financial resources. Failure to manage any one of these could derail good effort in the others.
- Set achievable goals and objectives. Remember: one size does not fit all.
- Do a good job of analyzing the data collected. Use information on flows, concentrations, water levels, and contamination to forecast trends or see anomalies.
- Follow up once surface reclamation is completed. Which techniques were successful? Which were not? Why?



Top: **Revegetated wetland area, formerly covered by tailings and barren of any life.** ***Bottom Left:*** **Fly fishing and rafting on the Arkansas River in Colorado—reminders of why cleaning up abandoned mine sites is so important. Good water quality makes possible *many* uses of our Western streams.** ***Bottom Right:*** **Drilling a ground water well near the French Gulch site.**

Into the Future

Initially, EPA and other agencies approached mine site investigations in a relatively simplistic manner. Experience has proven, however, that a minimalist approach does not provide the complete story. Reaching a thorough understanding of what causes water quality problems at a mine site can take significant resources, money, and time. Yet many people—from agency managers to the general public—continue to expect cheaper, quicker fixes than are possible to deliver. Solving problems related to mine sites must be considered a long-term effort. In addition, the overall structure must allow for experimentation and learning. Instead of regarding an activity that doesn't work as a "failure," it must be seen as a valuable lesson to be transferred to other situations. An important tenet of the scientific process remains true: You don't always prove a theory by conducting experiments; rather, you disprove false hypotheses.

Many of the West's inactive and abandoned mine sites have been around for a hundred years or more. Five, ten, even twenty years of remediation efforts probably won't undo all the damage done. Nevertheless, it's important to remember why we continue to try: for clean water. If not today, then perhaps tomorrow.

Photographs by Paul Osborne, Mike Wireman, Colorado Division of Minerals and Geology, and ECOS Communications (Boulder, CO). Copyrights held by individual photographers. Special acknowledgement to Bruce Stover for his illustrations, adapted for this publication.

COLORADO DEPARTMENT OF NATURAL RESOURCES

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