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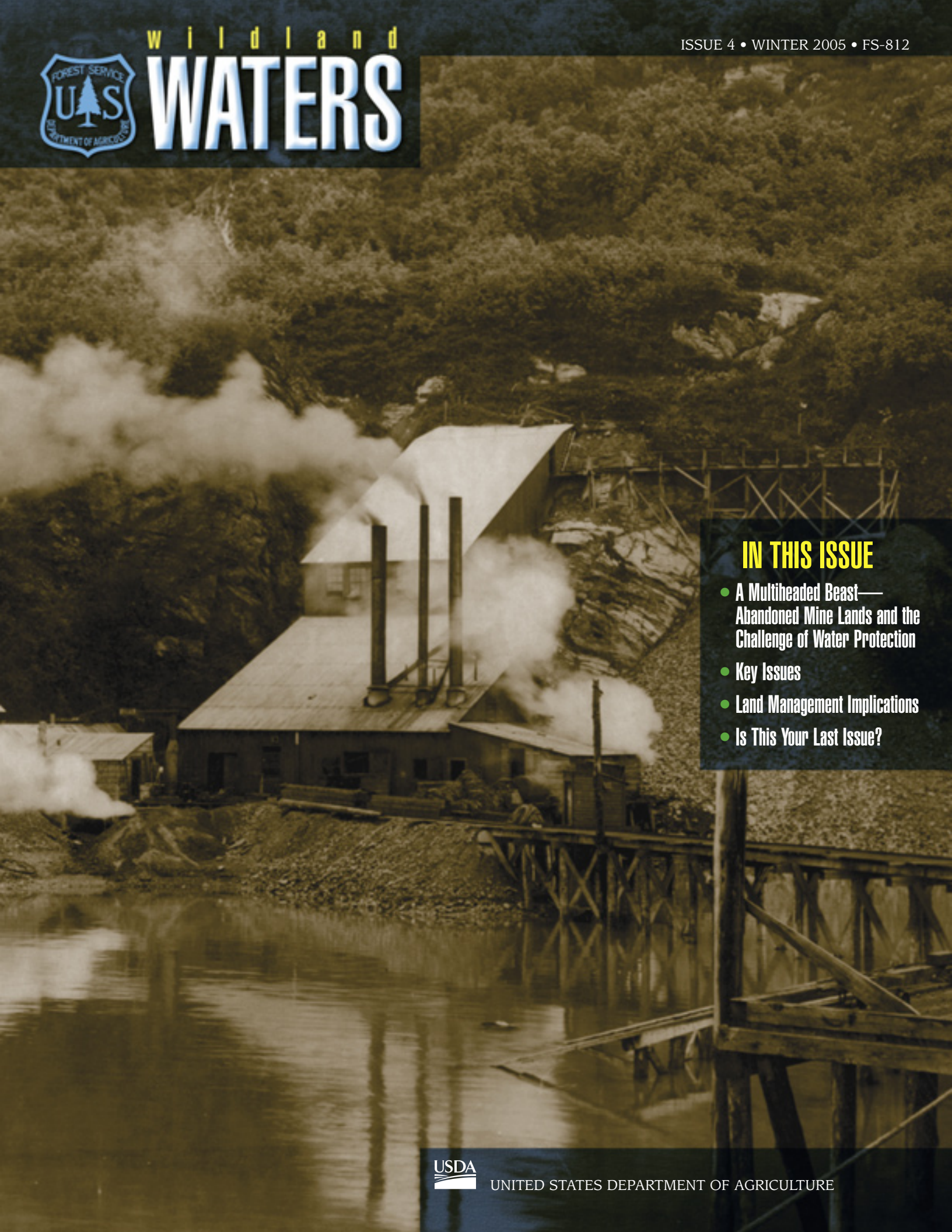

IN THIS ISSUE

USDA UNITED STATES DEPARTMENT OF AGRICULTURE

A Multiheaded Beast:

Abandoned Mine Lands and the Challenge of Water Protection

"The process for reclamation of abandoned mine sites is a multiheaded beast that has been difficult to master."

—Forest Service Geologist Mike Greeley

Wildland Waters is a periodic publication of the USDA Forest Service Washington Office. Questions, comments, ideas for improvements, and future topics should be sent to:

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As producers of gold, silver, copper, lead, and other "hardrock minerals," the hardrock miners once held a prominent place in our 19th century social and economic fabric. Now, the deserted remains of tens of thousands of these mines are scattered across the landscape of national forests, many posing immediate or potential threats to our water and watersheds.

The movement to clean up abandoned mines on public lands has gained momentum in recent years as the U.S. Department of Agriculture (USDA) Forest Service and numerous Tribal, Federal, State, and private partners have begun to tackle mutual problems of health and safety with new authority and heightened commitment. Although complex challenges remain, substantial progress is being made toward reclaiming abandoned hardrock mine sites in priority watersheds and other sites across public and private boundaries.

In this issue, we will examine how past hardrock mining activities can affect water today and tomorrow. We'll also explore a few of the successful efforts to date that demonstrate creative solutions to complex clean up challenges, along with a sampling of the research, technology, and policy issues that may help us tackle this beast.

Photo and cover photo courtesy of the Library of Congress, Prints and Photographs Division.

Not all mining is hardrock

"Hardrock minerals" refer to "locatable" materials in rock, such as metals, uranium, and uncommon varieties of sand, stone, and gravel claimed and developed under the General Mining Law of 1872. But not all mining is hardrock. Coal, oil, gas, phosphate, potash, sodium, sulphur, and other nonmetalliferous minerals are considered "leasable" minerals. Common varieties of sand, stone, gravel, and other rocks are considered "salable" minerals. Leasable and salable minerals have their own sets of laws, regulations, and impacts.

Minerals used for heating, fuel, plastics, wiring, coins, building products, manufacturing materials, and electronics, for a few examples, all come from mines.

Ghosts from the past—old laws and old ways

One of the most significant laws regulating the use of Federal lands for mining today was passed more than a century ago. The United States Mining Law of 1872 promoted and provided for the use of several hundred million acres of public lands in the United States for the exploration, location, and development of gold, silver, copper, iron, nickel, and other hardrock minerals.

The promotion of mining for metals and mineral resources on federally administered lands helped encourage industrial growth and settlement of the West. Many of these mineral deposits were located in remote areas far from population centers. When a mine was no longer profitable, common practice was to abandon the site and, in some cases, to vacate entire mining districts.

Although many Federal lands have been withdrawn from mineral entry, approximately 65 percent of lands administered by the Forest Service are still open to hard rock mining. Mining remains one of the core industries of the U.S. economy.

Current environmental laws and permitting procedures aim to minimize and prevent impacts on human health and the environment from contemporary mining operations. But things were different in the old days when land was cheap and environmental laws were practically unheard of.

"The miners of yore were operating in different times," noted Mike Greeley, minerals program manager for the Forest Service, in a presentation to the Society for Mining, Metallurgy, and Exploration.

"Mine sites were remote, often almost inaccessible; population density was low; and prospectors and miners were not constrained generally by environmental concerns or regulations," he added. "The attention and understanding of scientists and the public to the cause and effect of environmental hazards was weak. The practices of the miners were, for the most part, the practices of society." Today, miners are well acquainted with environmental laws and use best management practices in their mining and mineral processing operations.

The most common casualty: water

Water has been called mining's "most common casualty" (Environmental Mining Council of British Columbia [EMCBC]) because the most pressing environmental problems associated with abandoned hardrock mine sites relate to water pollution.

ATTENTION ANGLERS

FISH CONSUMPTION ADVISORY

Due to high arsenic levels found in brown and cutthroat trout in the North Fork of the American Fork River, it is recommended that adults limit their consumption of these fish to one meal per month. Pregnant women, nursing mothers, and children under twelve should avoid eating any brown or cutthroat trout from the river.

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Traditionally, it takes a LOT of rock to end up with a little valuable metal, let alone a finished product. The production of a single 18-karat gold ring, for example, can generate over a ton of mine waste.

"Mining by its nature consumes, diverts, and can seriously pollute water resources," notes the EMCBC. "Water contamination … can occur when streams, rainwater, and melting snow come into contact with toxic mine material…," threatening wildlife, fish, insects, soil, and vegetation.

The problem is particularly acute in the Western United States where "thousands of stream miles are impaired by drainage and runoff from such [abandoned] mines, one of the largest sources of adverse water quality impacts in several Western States," according to the Western Governors Association (WGA 2001).

"As the West's population expands," described environmental consultants Debra Struhsacker and Jeffrey Todd in a report for the National Mining Association (Struhsacker and Todd 1998), "more people are at risk of coming into contact with abandoned mines scattered throughout the region."

Abandoned mines pose a danger to water on a number of scores:

- **Earth disturbance.** To reach and extract the desired minerals, most mining operations displace massive amounts of soil and rock, either at the surface or underground.
- **Toxic processing.** Desired metals must be extracted or leached using chemicals that can be toxic if released into the environment.
- **Piles of waste.** Waste rock, spent ore, or tailings are generally disposed of in large heaps, ponds, or tailing impoundments, which can occupy a few or a hundred or more acres. If these facilities are poorly designed, improperly sealed, or abandoned, their failure can lead to contamination of streams and aquifers. Toxic powders from dried-up tailings ponds can blow away and contaminate surface and groundwater far from the original site.
- **Acid mine drainage.** Exposure of the Earth's crust to water, air, and bacteria can transform the sulfide minerals —which are frequently associated with metallic ores—into sulfuric acid and metal ions, which were once locked within rock. The toxic liquid, known as "acid mine drainage," constitutes one of the most common, serious, and long-term water pollution problem associated with mining.

The orange-stained toxic effluent known as acid mine drainage is the most visible and pervasive effect on water from abandoned hardrock mines.

Little Bear Abandoned Mine Site, Arapaho National Forest, south of Idaho Springs, CO. Sulphide-bearing waste rock pile, discharging directly into Little Bear Creek, is stabilized and vegetated to stop sediment and heavy metal runoff. Such clean up efforts can be complicated, time-consuming, and expensive.

Just the facts: A big reach and a big job

Estimates of the numbers of abandoned hardrock mine lands and the costs to clean them up are rough because data collection has been difficult and highly variable. The following are some rough numbers indicating the size and scope of the task:

• **Abandoned hardrock mine sites in country**	**557,000**
• **Abandoned sites on or affecting National Forest System (NFS) lands**	**38,500**
• **Abandoned sites on or affecting NFS lands with identified pollution problems**	**6,000—about a third of which are high-priority for clean up because of potential releases of hazardous substances**
• **Sites on or affecting NFS lands already cleaned up**	**203 from 1998 to 2003—83 of which were Comprehensive Environmental Response, Compensation, and Liability Act (hazardous) clean ups**
• **Sites on or affecting NFS lands with the clean up underway**	**In 2004, clean up should be completed at 21 sites, work ongoing at 103 more**
• **Estimated cost to clean up identified sites on or affecting NFS lands**	**$4 billion**

Compiled from various sources including the U.S. Environmental Protection Agency and Forest Service reports.

Substantial progress is being made toward reclaiming abandoned hardrock mine sites across public and private boundaries.

Taming the beast: a clean up challenge

Abandoned mines may require management or treatment for decades, or forever, often far downstream from the mine site itself. The challenge to clean up and stabilize these sites was likened by Mike Greeley to a massive "multiheaded beast" whose taming will require inventories to find the most dangerous sites, laws and new approaches to be effective, and a willingness to work together to overcome daunting jurisdictional disputes.

Inventory: first you have to find them

Locating the many thousands of abandoned mining operations on Federal land is the first step in the effort to clean them up. Some operations, particularly those that produced and milled ore were described and entered into databases by various State and Federal agencies, for example the Bureau of Mines and the U.S. Geological Survey. Many mine facilities, however, were never described or documented. The task for Federal land management agencies, like the Forest Service, was to use existing records to find, locate, and assess the human health and environmental hazards at these sites.

In the 1990s, the national effort to inventory abandoned mine sites became more systematic. Today, the focus is more on determining which sites in existing inventories most put human health or the environment at risk and prioritizing these for immediate action.

Laws and new approaches

Clean up responsibility of abandoned sites is often shared by both government and private entities. The goals of clean up efforts under the various laws are similar:

- Removal or modification of mining facilities for environmental or safety reasons;
- Isolation, removal, and/or treatment of toxic or hazardous materials;
- Reshaping and stabilization of disturbed lands;
- Establishment of vegetative communities; and
- Monitoring and maintenance of the site.

Federal law sampler

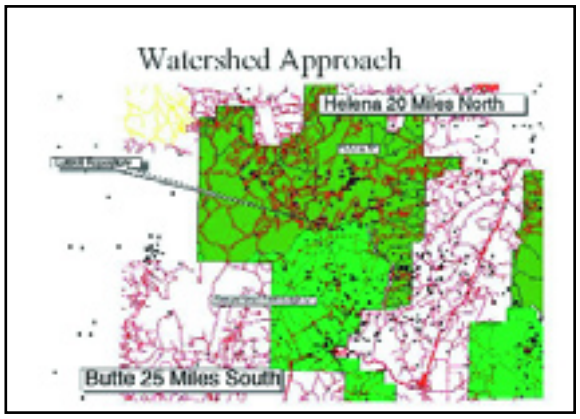
Several Federal laws are relevant to abandoned mine clean up, including:

- *the Clean Water Act,*
- *the National Historic Preservation Act,*
- *the Endangered Species Act, and*
- *the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or otherwise known as Superfund). Through Executive Order 12580 (1987), the Forest Service has authority to administer CERCLA on National Forest System lands.*

Four steps in a watershed approach

Four general components of a watershed approach include:

- *Statewide analysis and prioritization,*
- *Watershed characterization,*
- *Site characterization, and*
- *Monitoring (Nimick and von Guerard 1998).*



This map illustrates part of the logic behind a watershed approach for abandoned mine land work. Each dot represents an inventoried abandoned mine site. The centralized Luttrell Pit repository was the focal point for clean up efforts across two major watersheds in Montana.

Under the authority provided by environmental laws and agency regulations, the Forest Service completed more than 200 clean ups between 1998 and 2003 at an agency cost of more than $80 million. Responsible parties also have paid for more than $230 million worth of clean up at sites since 1998. For 2004, the agency plans to spend more than $13 million on abandoned mine land clean ups in more than 70 watersheds in 13 Western States and 1 Eastern State. In addition, the Forest Service has started multiyear clean up projects at more than 100 abandoned mine sites of varying size.

The sequence of events generally starts with agencies identifying hazardous sites and potentially responsible parties for clean up. Agencies then attempt to secure funding from responsible parties and, eventually, take clean up action themselves if no viable responsible party can be found (Smit and Broetzen 1998).

Although each individual situation requires its own solution, managers must understand what is going on throughout the watershed and identify the various sources of contamination if the clean up is to be effective. For example, in some mining districts, the geology and hydrology that produced the desirable minerals also produce water whose natural acidic levels is unrelated to mining. In a cleanup program, the manager must prioritize the watersheds, as well as abandoned mine sites within a watershed, to be the most cost effective in reducing stream pollution.

Consequently, Federal agencies today use a more holistic "watershed" approach to identify entire watersheds that are most at risk. "The concept behind this approach," Greeley pointed out, "is to unify all stakeholders in the identification, prioritization, and clean up of important drinking water supplies, fisheries, and wildlife habitat."

In a watershed approach, scientists undertake water and soil sampling, biological assessments, and engineering cost estimates across the watershed; managers then identify for remediation those sites that may pose the most serious threats.

The holistic approach also involves identifying and engaging all the relevant players—across administrative, political, and geographic boundaries. By working together, watershed-wide clean up efforts can address all significant abandoned mine problems within watersheds regardless of ownership—faster, cheaper, and more efficiently than struggling site by site.

The Forest Service completed more than 200 clean ups from 1998 to 2003 at an agency cost of more than $80 million.

Impediments to progress

Even the most committed efforts to clean up abandoned mine lands are hindered by a variety of challenges and problems. The most vexing include:

- **Mixed ownership patterns—**Pockets of private mine lands within the boundaries of Federal lands can hinder access, funding, data gathering, and authority to conduct work, making clean up a complicated procedure.
- **Costs—**The huge amounts of person-power, time, and money required to address the enormous problems are hard to come by with limited budgets.
- **Concerns about liability—** Efforts by States, municipalities, citizen groups, and private parties to voluntarily clean up abandoned mine sites have been limited because of concerns over liability. Good Samaritan parties who may want to clean up the private land portions of mixed-ownership watersheds fear that pollution permit requirements might be imposed on them even though they had no previous liability for the site and might have actually reduced the amount of pollution being discharged from the site.

Working together: sampler of success stories

While the process has often been slow, tedious, and frustrating, there are encouraging successes as Federal, State, and private organizations have combined resources to tackle mutual, often controversial, problems. The following examples are from the Western United States, representing a cross-section of the challenges, opportunities, pitfalls, partnerships, costs, and creative solutions for protecting and restoring waters from the impacts of abandoned mine lands.

Moon Gulch before and after

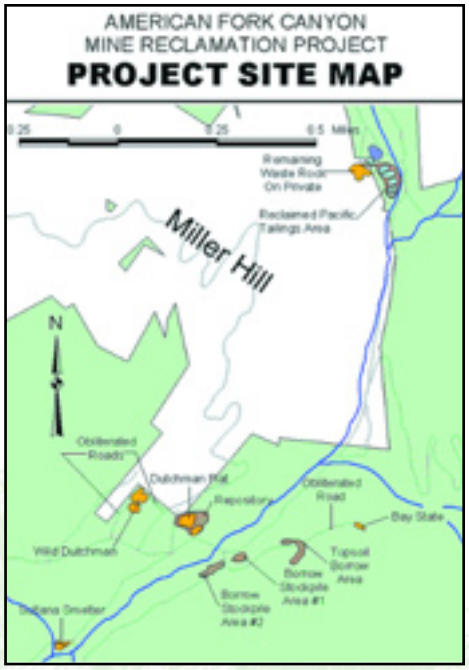
Moon Gulch before and after

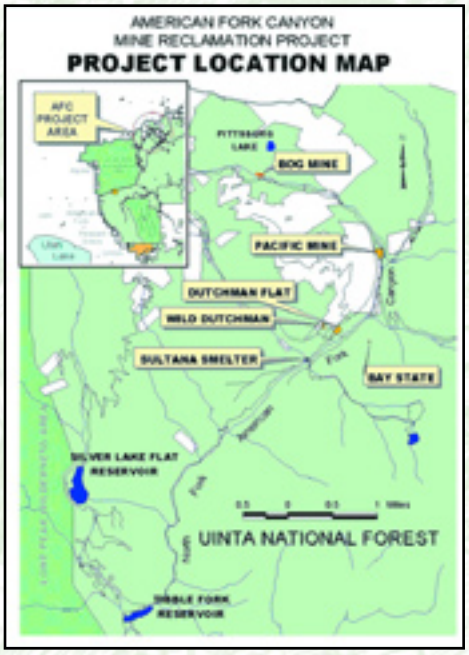
Moon Creek/Moon Gulch Reclamation Project, Idaho

http://ecorestoration.montana.edu/mineland/histories/metal/moon_gulch/default.htm

Less than a decade ago, a 20-acre abandoned hardrock mine and mill complex on the East Fork of Moon Creek, within the Coeur d'Alene District of the Idaho Panhandle National Forest, posed an impending risk to humans, fish, and wildlife. High concentrations of lead, zinc, mercury, arsenic, and other toxic metals were draining and eroding from this early 20th century mine site, creating a treeless, lifeless moonscape. In the mid 1990s, a multiagency team of engineers, scientists, and forest managers from the Forest Service, Bureau of Mines, and a private engineering company began an extensive effort to reduce human health hazards, improve habitat for native Westslope Cutthroat trout, and restore the adjacent riparian area to premining conditions. The $1.9 million Comprehensive Environmental Response, Compensation, and Liability Act removal action, completed in 2000, diverted the stream away from the tailings impoundment, removed the road that was causing sedimentation, and revegetated the slopes and floodplain with native plants. An innovative waste containment uses a compacted gravel drain system, a hi-tech "geocell mattress," a 5-foot impervious berm armored with riprap, and a special cap designed to keep water out. "Water quality measurements show vast improvement, erosion no longer occurs, and the project's removal action goals have been achieved," explained Forest Service geologist Jeff Johnson, who added, "but we are still not finished." Plans are underway with Tribal and Federal trustees to accomplish a more complete restoration of the ecosystem than originally envisioned. "We are now looking at true restoration focused on fisheries and wildlife habitats, including better upland habitat for wintering elk," Johnson noted. "We want to be able to say, 'It's finished—human health has been addressed and we have also restored this place to pre-mining conditions for fish and wildlife.'" Construction of the next phase for Moon Creek is planned for completion during the 2005 field season.

The excavated repository at American Fork before material placement.





American Fork Canyon Watershed Reclamation Project, Utah

http://www.fs.fed.us/r4/mine_clean up/mc_projects/american.pdf

The high, rugged alpine lakes, canyons, and ridges of the North Fork area of the American Fork River Canyon in Utah are premier recreation destinations for skiing, hunting, fishing, camping, hiking, and off-road-vehicle use. They are also popular for exploring the more than 100 abandoned mine sites that date from the 1870s through the 1950s. But the abandoned mines, mills, and smelters that once produced lead, silver, and gold—extending across both public and private lands—presented more than a recreational opportunity; they also posed serious threats to people and wildlife. "ATVs [all-terrain vehicles] kicked up lead dust at 2,000 times acceptable limits, and arsenic levels were so high that a State advisory was issued against eating local trout," noted Forest Service Regional Mine Clean up Coordinator Maggie Manderbach. Important habitats for wildlife and fish, including the sensitive Bonneville cutthroat trout, were also at risk from toxic metal mine pollution.

In partnership with State and Federal agencies, local recreation interest groups, county commissioners, and landowners, the Uinta National Forest launched a $1.2 million study and complex watershed-scale reclamation effort in 2002 to restore the six historical sites that posed the highest risks to people and the environment. A private contractor excavated and stockpiled more than 20,000 cubic yards of soil and rock from a 3-acre site designated as the permanent repository for contaminated materials. "Borrow" material was then used to backfill other sites after toxic materials were removed and placed into the repository. Temporary roads were constructed, then obliterated and revegetated. New ponds were created to help filter metals from continuing mine drainage before it enters the river. Once the repository was filled, a unique four-layer composite liner was placed over the carefully shaped area to prevent future water from reaching the stored toxics; the whole thing was covered with 2 feet of soil and revegetated. The repository design even allowed for the concrete foundations of one of the mill sites to remain as a cultural artifact.

Completed in 2003, the project benefited from an excellent on-scene coordinator and committed State support. According

A guardrail barrier (weathering steel) was installed at the base of the American Fork repository to prevent access by motorized vehicles and disturbance to the repository cover materials and vegetation.

Cleanup of the Pennsylvania Mine on the White River National Forest. This is one of the abandoned mines in the Peru Creek Basin.

Successful clean up of abandoned mine lands on public and private lands ultimately will rely on effective public policy.

to Manderbach, "One hurdle not quite leapt was that parts of the project site are on private land, with no support from the landowners. But the good news is that Trout Unlimited has hired the recently retired on-scene coordinator to develop a plan for cleaning up the private land with grant funds. That's pretty exciting." Future challenges will be to monitor and prevent damage to the liner from motorized vehicles, moose, beavers, and acts of vandalism. Environmental monitoring will also include sampling of water quality and testing of fish and invertebrate tissues beginning in 2006; native vegetation will continue to be planted during 2004–2006.

Peru Creek Basin Site Assessment, Colorado

http://www.epa.gov/brownfields/pdf/asummit.pdf

Lingering acid contamination from numerous abandoned 19th century mine sites posed a contemporary dilemma for the nearly 25,000 people living and recreating in the Peru Creek basin in Colorado. Community attempts to fix environmental problems associated with the sites had floundered for more than a decade, in part because of an overwhelming fear of potential liability. In 2001, Summit County proposed to take the lead in conducting environmental site assessments and legal analysis of about 1,200 acres of privately held mining claims. A $200,000 U.S. Environmental Protection Agency (EPA) grant has helped the county and many partners start the long clean up process in this high-elevation area that is a prime recreational draw in peak season. This dynamic community-based environmental protection effort involves county, State, and Federal agencies along with a nonprofit land trust, academics, and community members who are conducting environmental site assessments and legal analysis of the mining claims. The hope is that with sufficient accurate information and an understanding of the liability issues, proven management techniques can be used to clean up the creek and contain the contamination.

Workers in the foreground are preparing the Luttrell Abandoned Mine Waste Repository for 2003 remediation work. Previously placed abandoned mine wastes with temporary cover are shown in the background.

Luttrell Pit Joint Repository, Montana

A creative collaborative approach is being used to address complex technical, financial, legal, and political challenges at more than 60 abandoned mines within two major watersheds on the Beaverhead-Deerlodge National Forest in Montana. Mined since the 19th century, the sites were contaminating and degrading the Boulder and Upper Tenmile Creek watersheds, which are the sources of drinking water for the town of Basin and the capital city of Helena.

Stimulated in part by energetic community efforts, an EPA- and Forest Service-led multiagency clean up of the sites focuses on use of the Luttrell Pit within the defunct Basin Mine complex as the first regional joint mine waste repository to be implemented in the Nation. In the first year alone, numerous partners cleared the 6-acre repository, improved access roads, backfilled the floodplain with top soil, planted 5,000 native trees and shrubs to stabilize streambanks, constructed a streambed and two sediment ponds for settling out toxic chemicals, and excavated and hauled away some 40,000 cubic yards of mine wastes. The repository provides a geographically centralized and topographically stable engineered facility to safely seal more than 2 million yards of contaminated soil and mine waste in a lined and capped pit using state-of-the-art technology. The U.S. Geological Survey began monitoring the drainages prior to and during the reclamation process, and several deep wells surrounding the pits provide a way to monitor water quality over time.

"Vegetation is beginning to return to the sites, and conditions in the drainages are improving," described Bob Wintergerst of the Forest Service's Northern Regional Office. "The ultimate success will be the elimination of the human health risks associated with historical mining sites and substantial improvement to the water quality in the drainages." The project is expected to be completed in 2010.

Exorcising the ghosts: research, technology, and public policy

Creative research collaborations

Numerous initiatives began to emerge in the 1990s to address research and remediation needs through Federal/State/private collaborative alliances. One example is the Abandoned Mine Land (AML) Initiative, launched in 1997, initially involving the National Mining Association, the Western Governors' Association, U.S. Department of Energy, Bureau of Land Management, EPA, National Park Service, Forest Service, and U.S. Geological Survey. This initiative has evolved to the point where affected Federal agencies work together on a site-by-site basis when mutual interests make regional collaboration most fruitful.

Creative research discoveries and technologies that emerged from the AML Initiative include:

- **Tracer tests:** A harmless tracer, such as a dye, is put into a stream, where its movements are measured and modeled to help identify sources of contamination.
- **Water quality and flow measurements:** The movements of contaminants are studied over time and the seasons.
- **Determination of pre-existing environmental conditions:** Natural levels of metals in streams are estimated and realistic restoration goals established.
- **Mapping:** Identification of those areas where land surfaces and stream channels have been affected by historical mining activities (U.S. Geological Survey1999).

Federal agencies today use a more holistic "watershed" approach to abandoned mine land clean up.

The huge amounts of person-power, time, and money required to address the enormous problems are hard to come by with limited budgets.

Advances in technology

Advancements in technology could make the abandoned mine land clean up efforts more efficient and affordable. Some examples include:

- **Wood-fiber water filters:** The Forest Service Forest Products Laboratory (FPL) is researching whether a new kind of water filter made from a variety of wood fibers, such as juniper, could be an effective way of removing heavy metals that drain from mine sites (Forest Service 2002). Tests at a coal mine indicate that the filters can be about 80 to 90 percent effective. Based on these successes, Forest Service Northern Region engineers and geologists are evaluating the effectiveness of this technology for hardrock mine drainage. The region is planning a pilot system that would be installed at the abandoned Charter Oak mine on the Helena National Forest.
- **Fly ash:** Fly ash is a by-product of coal-burning electrical production facilities. When mixed with water the ash forms an impermeable grout-like barrier that can effectively contain mill tailings and may also help to minimize certain chemical reactions associated with the production of acid mine drainage. One study revealed that after 4 years of monitoring a site grouted with fly ash, concentrations of most mine drainage parameters were reduced 40–90 percent (Sheetz, Silsbee, Schueck 1998).
- **Biological methods:** At the Zortman–Landusky Mine area in central Montana in 2000, a pilot bioremediation treatment system used specifically selected bacteria and microbes to dramatically reduce the concentrations of nitrates, selenium, and cyanide from a contaminated leach pad, at a cost estimated to be three to seven times lower than that of other water treatment systems. The results of the test were used to develop a full-scale water treatment system whose processes and bacteria could be tailored to other mine sites.

Public policy implications

Successful clean up of abandoned mine lands on public and private lands ultimately will rely on effective public policy that supports, encourages, and provides incentives for the daunting task.

To alleviate the hesitancy to undertake voluntary clean ups engendered by Clean Water Act liability stipulations, parties interested in abandoned mine land clean ups have proposed legislation to amend the act to protect a Good Samaritan remediating party from becoming liable for continuing discharges from an abandoned mine site after the clean up is complete. The Good Samaritan would have to demonstrate that he or she has attempted to improve the conditions and is not otherwise a potentially responsible party for the site.

Various bills have been introduced in recent years. Some proposed Good Samaritan abandoned mine land clean up bills would fund clean up through the imposition of a fee on hardrock mining operations. Other bills simply provided for the issuance of a special abandoned mine remediation permit that would allow the implementation of best available clean up technology but would not burden a Good Samaritan with Clean Water Act discharge limits. Some would shield the remediating party from liability under the Clean Water Act, and some have proposed shielding the Good Samaritan from liability under all environmental laws.

There is consensus among interested parties that a well-crafted Good Samaritan Abandoned Mine Remediation Act could have tremendous water-quality benefits. However, there is also concern that such a law could make it easier for potentially responsible parties to avoid their clean up obligations. Another major concern has been finding a reliable source of funding for abandoned mine land clean ups that does not divert from other important programs. Discussions on these issues are continuing.

Science and communication: up front and personal

Some environmental managers emphasize that the scientific process underlying abandoned mine land clean up needs to be at the front end of any policy decisions so that people remain knowledgeable and involved. Public involvement will depend on dependable timelines, shared data, and an open communication process that is sensitive to the problems and needs of each individual watershed and community.

"Watersheds provide a framework for using scientific information to make informed decisions," wrote Margot Smit and Gary Broetzman of the Colorado Center for Environmental Management (Smit and Broetzman 1998). However, just doing good science is not enough, they noted. "There is a need for the information to be synthesized and for it to be presented in an understandable format, using consistent terminology, so that everyone can communicate with each other. This kind of communication of the science will hopefully enable an easier marriage between the scientific community and land management practitioners."

Toward a future of clean water

Since many abandoned mine sites have been around for decades, some more than a century, clean up will be a long-term process taking substantial human and financial resources.

Experience gained by the Forest Service and others during the past few decades has demonstrated that there are no quick and easy solutions to abandoned mine lands and water protection. However, modern mining regulations and progress made using collaborative partnerships and a watershed approach point positively to the potential for solid success. As Mike Greeley noted, there is every expectation that, "as stakeholders continue to meet and work together to attempt reasonable techniques and implement balanced, equitable solutions, increased success will be gained."

Times have changed since earliest mine practices. Contemporary environmental laws, public attitudes, and reclamation requirements leave no room for the antiquated practices of the past. Current Forest Service regulations that require approval of a plan of operations, mitigation measures to lessen the adverse impacts to other resources, and reclamation performance bonds are extremely helpful in preventing environmental harm after an active mining operation ceases. As research, technology, and policy decisions continue to evolve, so will the effectiveness of the effort to exorcise the ghosts of contamination from abandoned mine lands and to minimize the need for future generations to wrestle with this multiheaded beast. ▮

Key Issues

- Approximately 6,000 abandoned hardrock mine sites on or affecting National Forest System lands may pose a threat to water resources across the country, especially in the West.
- About one-third, or 2,000, sites are a high clean up priority due to the threat of hazardous substance releases. Their clean up is vital to the restoration of many wetlands and watersheds.
- The main threat is water pollution from past mining processes, chemicals, or residues; management or treatment may be needed for years, often far downstream from the mine itself.
- A major goal of mine inventory and clean up is to identify and clean up those mines that put human health or the environment at risk.
- Impediments to effective clean up include mixed ownership patterns, costs, and fears of liability.
- The focus of research and technology must be on developing more efficient treatments and making them more passive and affordable. ▮

Land Management Implications

- Inventory and clean up efforts require a watershed-scale approach and effective use of partnerships.
- Adequate funding and leveraged funding from other sources for abandoned mine land clean up must be a management priority.
- Risk of liability can be reduced by Good Samaritan legislation, proactive management and policy actions.
- Vigorous oversight and enforcement of mine operating plans, including bonding and reclamation provisions, will prevent ongoing mining operations from becoming future threats to human health and the environment. ▮

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