

Hazard Management: Managing Chemical Hazards at Abandoned Mine Sites

An estimated 5,000 legacy abandoned mines in California contaminate watersheds and adversely affect humans, fish and other wildlife, drinking water (surface and ground water), vegetation, soils, and air quality. Sources of abandoned mine-related contamination include: acid mine drainage (AMD); mercury (used as amalgamate with gold to enhance recovery), arsenic (commonly associated with gold deposits and occurring naturally in many areas), and other substances in waters and sediments; and windborne tailings. Although state agencies with statutory authority, such as the State Water Boards and Department of Toxic Substances Control, and equivalent federal agencies traditionally serve as lead on chemical remediation projects, the Division of Mine Reclamation (DMR) in the California Department of Conservation (DOC) also assists agencies that own or manage abandoned mine lands where its services are a good fit to meet project objectives. Types of assistance include: (1) site characterization (sampling to determine contaminant presence and extent); (2) remediation design and implementation, particularly where site revegetation is involved; and (3) remediation project management. Examples of such assistance are summarized below.

DMR Mine Environmental Hazard Reclamation or Remediation Projects

Walker Mine Tailings Site

The 100-acre Walker Mine Tailings site is on the Plumas National Forest, Plumas County. During its operation (1915 - 1941), the Walker Mine produced large quantities of copper, and the Mine's mill deposited fine-grained, sandy, silty, and clayey tailings that filled the drainage below. Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the U.S. Forest Service (USFS) needed to eliminate both exposure of the public to fugitive silica-laden dust blown by wind from the tailings surface and contaminant releases from the tailings to Dolly and Little Grizzly Creeks. Pursuant to a USFS agreement, DMR implemented a study of soil and vegetation conditions on the tailings and prepared a revegetation and mulching plan.



Vegetation test plot at Walker Mine Tailings site, Plumas National Forest, Plumas County. Photo: DOC (2015)

Robinson Mine

DMR partnered with the USFS and obtained a grant from the Sierra Nevada Conservancy's Proposition 84 grant program to develop a Preliminary Assessment and Site Inspection (PA/SI) for the historic abandoned Robinson Mine and stamp mill. The Robinson Mine is located in the Plumas National Forest, southwest of Quincy in Plumas County. The mine site is immediately adjacent to Frazier Creek, which is located in the Middle Fork Feather River watershed. The USFS is remediating the Robinson Mine site under its CERCLA program due to contamination from mercury used at the mill to extract gold. Environmental sampling of the site was completed in fall 2015.



Robinson mine and stamp mill in Plumas National Forest in Plumas County. Photo: DOC (2014)

Malakoff Diggins State Historic Park and Humbug Creek Watershed

At what is now Malakoff Diggins State Historic Park (SHP) in Nevada County, the historic technique of hydraulic mining to find gold carved huge cliffs and washed away entire mountains with mighty jets of water. The resulting sedimentation along with the mercury used in gold mining contaminated downstream watersheds. The site is part of the Malakoff Diggins Hydraulic Mine Feasibility Study, led by The Sierra Fund and a multi-agency project team funded by a Department of Water Resources Integrated Regional Water Management Plan Proposition 84, grant (the Cosumnes, American, Bear, Yuba Headwaters Resilience and Adaptability Program). DMR helped fund the preparation of an aerial LiDAR map of the main hydraulic pit and Humbug Creek watershed that was used, with ground-based LiDAR performed by the U.S. Geological Survey, to measure erosion rates and sediment sources in and around the main hydraulic pit. DMR is also assisting the Department of Parks and Recreation (State Parks) with evaluating visitor protection at several deep shafts along a heavily used park trail. The trail parallels the major drain tunnel that can discharge mercury-laden sediment directly into Humbug Creek, a tributary to the South Yuba River. Some of the shafts are flooded or have inadequate fencing, and one shaft drains water across and down a segment of the trail, which makes the trail muddy and unsafe for Park visitors. The Park is developing a new trail design and with funding assistance from DMR may relocate this trail segment.



Mercury-laden sediment discharges from massive hydraulic gold mine in Malakoff Diggins State Historic Park. Photo: DOC (2014)

Bodie State Historic Park

In the late 1800s to early 1900s, the town of Bodie in Mono County was part of a major gold mining district. In 1962, the town and adjacent area became Bodie SHP, which is owned and managed by State Parks. The Park is preserved in a state of "arrested decay," and a critical priority for State Parks is to maintain the appearance and historical setting of mining, including structures, artifacts, tailings, and other cultural resources. As a consequence of mining and gold processing, Bodie was contaminated by lead (used in the assay process, which allows for measuring the amount of gold in an ore sample), mercury (used as amalgamate with gold to enhance recovery), and arsenic (often associated with gold deposits and occurring naturally in the area). In 2007, DMR received funding from the State Legislature (Assembly Bill 1801, Item 3480-001-0035, 2006) and partnered with State Parks and a U.S. Environmental Protection Agency Region 9 Emergency Response Section team (USEPA) to investigate, characterize, and remediate chemical hazards at Bodie SHP generated by historic mining activities. The USEPA sampling and remediation procedures were designed to fully characterize and remediate contaminants and protect human health, while project activities were reviewed and monitored by State Parks archaeologists to preserve cultural resources and artifacts. The project, completed in 2009, included the following tasks.

- Installed a modified radon extraction system to reduce mercury vapor concentrations inside Bodie's Standard Mill and remediated lead-contaminated soil on the slope below the Mill (placed filter fabric and clean fill, revegetated slope, and installed fences to reduce disturbance).
- Remediated lead-contaminated soil from Assay building areas (removed top foot of soil in and around buildings; replaced soil with clean fill).
- Removed lead-contaminated dust in Wheaton-Hollis Hotel using a HEPA vacuum.
- Controlled erosion of mine tailings adjacent to Bodie Creek by building a diversion channel lined with rocks collected onsite to carry runoff away from the tailings, by constructing weirs to slow stream flows, and by composting and revegetating the tailings to promote native plant growth.



Left: Standard Mill at Bodie State Historic Park. Right: A lined diversion ditch prevents runoff from reaching and eroding mine tailings. Photo: DOC (2009)

Spenceville Mine

Spenceville Mine was a copper mine that operated from 1875 through 1918 in Nevada County. Problems with the abandoned open-pit mine included AMD and the forming of an open pit lake in the abandoned mine workings. The mine water had a pH of about 2.5 with elevated levels of iron, copper, and zinc. During high precipitation, water from the pit overflowed into Little Dry Creek, which is under the jurisdiction of the California Department of Fish and Wildlife (CDFW). Under contract with CDFW, DMR developed a strategy to mitigate AMD and reclaim the mine site to a safe and stable condition. DMR's objective was to identify and select a low-cost, low-maintenance treatment strategy that would: (1) prevent future discharges to state waters by cleaning up and containing AMD and associated heavy metal problems onsite; (2) provide a stabilizing vegetative cover; and (3) meet Central Valley Regional Water Quality Control Board (RWQCB) requirements. DMR's contract work included three phases:

- Phase 1. Evaluate existing site conditions and the adequacy of existing information on the site contained in previous studies. Gather additional site data, as needed.
- Phase 2. Multiple tasks, including: evaluate alternative control strategies; conduct a feasibility study; develop conceptual design criteria for alternative strategies; estimate capital, operating, and maintenance costs for the proposed alternatives; select an abatement and remedial strategy based on the feasibility study and testing; and prepare a preliminary design report for the recommended source control and cleanup alternative.
- Phase 3. Develop biddable plans and specifications for the selected strategy.

Upon completion of Phase 3, CDFW contracted with a private firm to implement site remediation and with DMR to provide an Engineer-In-Charge to oversee the contractor's work.



Left: Open mine pit drained acidic water into Little Dry Creek. Right: Treated mine waste was used to backfill the pit, and then the site was recontoured, covered with topsoil and revegetated. Photos: DOC (2001, 2009)

Gambonini Mercury Mine

During historic mining at the Gambonini Mercury Mine, in Marin County, mine wastes were placed in a steep canyon covering an area of about 11 acres. Consequently, large quantities of mercury-laden sediment would discharge each year into Salmon Creek—a tributary to Walker Creek and Tomales Bay. Threats to the beneficial uses of these waters included degradation of fish spawning areas in Walker Creek and bioaccumulation of mercury by wildlife and fish in Tomales Bay. Under contract with the San Francisco Bay RWQCB, DMR provided revegetation, erosion and construction monitoring, and consulted on creek remediation options.



Gambonini Mine final grade with drainage ditches and native vegetation. Photo: DOC (2005)

Sulphur Bank Mercury Mine

Sulphur Bank Mercury Mine in Lake County was once one of the largest producers of mercury in California. It was initially mined for sulfur (1865 – 1871), then intermittently for mercury ore by underground methods (1873 – 1905). Pit mining occurred periodically from 1915 to 1957, when it became inactive. About 120 acres of mine tailings and waste rock and an open, unlined mine pit (the Herman Impoundment) were located on the property. After mercury was found in the tailings and bottom sediments in Clear Lake, and high levels of mercury were detected in fish from the lake, the State issued an advisory against eating fish from the lake. Under contract with the USEPA, DMR performed statistical analyses of data, revegetation monitoring, and provided botanical expertise for revegetation and weed control strategies.



Harmon impoundment and mine waste at Sulphur Bank Mine. Photo: DOC (1999)