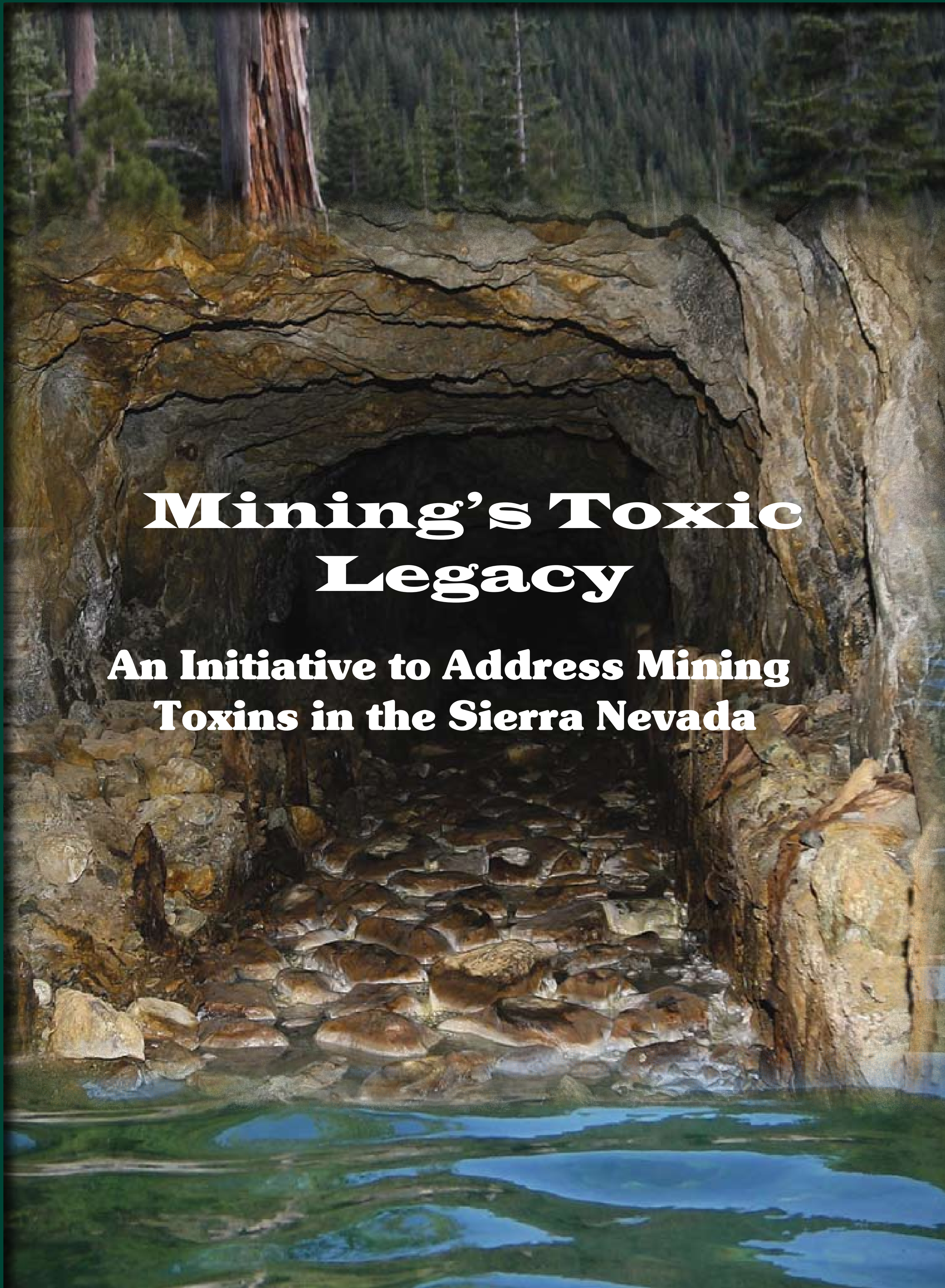

Mining's Toxic Legacy

An Initiative to Address Mining Toxins in the Sierra Nevada

Acknowledgements

The Sierra Fund would like to thank Dr. Carrie Monohan, contributing author of this report, and Kyle Leach, lead technical advisor. Thanks as well to Dr. William M. Murphy, Dr. Dave Brown, and Professor Becky Damazo, RN, of California State University, Chico for their research into the human and environmental impacts of mining toxins, and to the graduate students who assisted them: Lowren C. McAmis and Melinda Montano, Gina Grayson, James Guichard, and Yvette Irons. Thanks to Malaika Bishop and Roberto Garcia for their hard work to engage community partners in this effort, and Terry Lowe and Anna Reynolds Trabucco for their editorial expertise.

For production of this report we recognize Elizabeth "Izzy" Martin of The Sierra Fund for conceiving of and coordinating the overall Initiative and writing substantial portions of the document, Kerry Morse for editing, and Emily Rivenes for design and formatting. Many others were vital to the development of the report, especially the members of our Gold Ribbon Panel and our Government Science and Policy Advisors.

We also thank the Rose Foundation for Communities and the Environment and The Abandoned Mine Alliance who provided funding to pay for a portion of the expenses in printing this report.

Special thanks to Rebecca Solnit, whose article "Winged Mercury and the Golden Calf," published in the September/October 2006 issue of *Orion* magazine, is extensively quoted in this report.

Mining's Toxic Legacy

An Initiative to Address Mining Toxins in the Sierra Nevada

Published March 2008
by
The Sierra Fund

THE SIERRA FUND

The Sierra Fund's Mining Toxins Initiative has been made possible by the support of:

The California Endowment
The Richard and Rhoda Goldman Fund
and True North Foundation

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Printed on 100% recycled paper by:
Sutter Printing, Sacramento, CA
www.sutterprinting.com

Purpose and Scope of This Report

The purpose of this report is to present current information on the nature and extent of mining toxins in the Sierra, the problems they pose to human and environmental health, and recommendations for action to address these problems. This is accomplished by examining the best available science from the perspective of communities in the Gold Country, and directing the results to regional non-profit organizations and local, state, federal, and tribal governments.

The area considered by this Initiative is defined to be consistent with the State of California's Sierra Nevada Conservancy service boundary. Areas of the Sierra Nevada in the State of Nevada were also considered as a secondary topic. This enabled the Initiative to address both the east and west sides of the Sierra, as well as some parts of the Cascade region, all of which were heavily impacted by historic mining.

Though the impact of gold mining is the primary focus of the Initiative, gold prospectors found other commodities, including iron, copper, lead, silver, and tungsten which they then mined and sold. This report considers the impact of these mining activities as a secondary topic and in less detail.

The findings and recommendations presented here are solely those of The Sierra Fund and Gold Ribbon Panel members. The Government Science and Policy Advisors who assisted in this effort provided the authors with a more thorough understanding of the complex issues and problems associated with historic mining in the Sierra, but are not responsible for the report's conclusions.

Objectives of This Report

1. Describe basic mining practices and their impacts;
2. Summarize best available scientific information on mining toxins and their effect on health;
3. Define the problems using the lenses of science and community;
4. Identify information gaps in current scientific, environmental, and medical research;
5. Propose areas for future research and outreach;
6. Develop strategies to protect human and environmental health that reflect community needs, are scientifically valid, and achieve the greatest impact; and
7. Propose policy changes and funding mechanisms to address the toxic legacy of historic mining in the Sierra Nevada.

Methods

This Initiative has engaged regional indigenous tribes; health clinics; consultants; watershed and conservation groups; and local, state, and federal government land management technical staff and regulators. The Sierra Fund worked with scientists, professors, and doctors to provide the Initiative with an underpinning of science and clinical observation. The Sierra Fund hired outreach workers to target specific regions and constituencies of the Sierra to ensure meaningful community involvement in every stage of this program.

California State University (CSU), Chico's Department of Geological and Environmental Studies and School of Nursing were contracted to conduct literature reviews on mining's toxic legacy and its effects on human health in the Sierra and check the validity of their analyses. These reports are incorporated into this document along with expert opinion from public agencies.

Gold Ribbon Panel and Agency Science Advisors

Over the course of 2007 The Sierra Fund convened a dozen meetings, workshops, and other events to engage tribes, watershed organizations, scientists and medical professionals in the development of this report. The Sierra Fund created two panels of individuals to advise on this project:

Gold Ribbon Panel: Leaders on this panel include doctors, tribal representatives, environmental scientists, and local leaders who have studied these problems and stand behind this report's findings and recommendations.

Malaika Bishop	The Sierra Fund
Dr. Dave Brown	CSU, Chico, Dept. of Geological & Environmental Sciences (GEOS)
Dr. Kenneth Cutler	Nevada County First 5 Commission
Becky Damazo, RN	CSU, Chico, School of Nursing
Don Flint	Cranmer Analytical Lab
Dr. Hank Foley	Plumas County Health Officer
Roberto Garcia	United Native Nations
Alison Harvey	Friends of the North Fork American River
Dr. Roger Hicks	Yubadocs Urgent Care
Joanne Hild	Friends of Deer Creek
John Lane	Chico Environmental Science and Planning, LLC
Kyle Leach	Holdrege & Kull, Consulting Engineers and Geologists
Julie Leimbach	Sierra Nevada Alliance & Foothills Water Network
Dr. William M. Murphy	CSU, Chico, Dept. of Geological & Environmental Sciences (GEOS)
Sherri Norris	California Indian Environmental Alliance
Michael Ben Ortiz	Calling Back the Salmon Committee
Ren Reynolds	Enterprise Rancheria
Don Ryberg	Chair, Tsi-Akim Maidu Tribe

Gold Ribbon Panel members and Agency Science and Policy Advisors at The Sierra Fund's May 2007 Charette.


Figure 1

Agency Science and Policy Advisors: Several local, state and federal agencies participated as resources to the project, working with The Sierra Fund to ensure that this report accurately characterizes their agencies' roles, responsibilities and actions.

Dr. Charles Alpers	US Geological Survey
Diane Colborn	CA State Assembly Water, Parks & Wildlife Committee
Rick Humphreys	State Water Resources Control Board
David Lawler	US Bureau of Land Management
Caroll Mortensen	CA State Assembly Environmental Safety & Toxic Substances Committee
Cy Oggins	CA Department of Conservation
Steve Rosenbaum	Central Valley Water Quality Control Board
Jim Tjosvold	CA Department of Toxic Substances Control
Kathryn Tobias	CA Department of State Parks and Recreation
Alyce Ujihara	CA Department of Public Health
Rick Weaver	USDA Forest Service

Executive Summary

Is human health, water quality or the environment at risk from historic mining toxins?

The Gold Rush changed California demographics as indigenous people were dislocated and mining towns appeared and disappeared across the Sierra Nevada Mountains. A less recognized consequence of the California Gold Rush was the massive environmental destruction that took place, which still plagues the Sierra today.

Working with partners from state, federal, and tribal governments as well as from the academic, health, and environmental communities, The Sierra Fund's report *Mining's Toxic Legacy* is the first comprehensive evaluation of what happened during the Gold Rush, including: the cultural, health, and environmental impacts of this era; the obstacles that lie in the way of addressing these impacts; and a strategic plan of action for cleaning up the Sierra Nevada, the headwaters for more than 60% of California's drinking water.

Figure 2

Mining the Mountains

Using techniques including placer, hard rock, and hydraulic mining, millions of ounces of gold were extracted from the Sierra Nevada "Mother Lode" during the 19th and 20th centuries. Mining practices commonly included extensive use of mercury, millions of gallons of which still contaminate the landscape. Abandoned mines have left behind toxic pits and acid mine drainage. Naturally occurring minerals, including arsenic and asbestos, were disturbed, crushed, and distributed throughout the region as gravels for road construction. Much of the land impacted by these activities is now publicly owned by state, federal, and local governments.

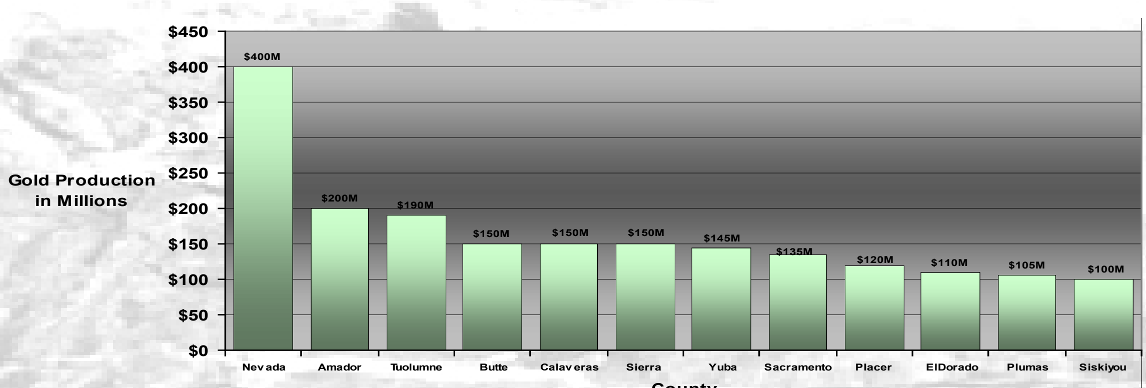


Figure 3

Impacts of the Gold Rush

Cultural: The Gold Rush devastated the Native People in the region. Forced relocation, disease, and outright murder shattered their villages and tribes. Toxic materials that remain from this era isolate Native Californians from their traditional ceremonial activities such as fishing and collection of medicinal and ceremonial plants, continuing the devastation begun over a century ago.

Environmental: The Sierra Nevada provides more than 60% of the drinking water for the state of California. Mercury, acid mine drainage, and other contaminated sediments left behind from mining threaten the water, plants, and people of the entire state. Elemental mercury remaining from historic gold mining is the primary source of mercury contamination in the Sacramento River, and flows downstream to pollute the San Francisco Bay and Delta. Although the presence of mercury in the Bay and Delta is a significant issue, the impact of exposure on Sierra watersheds is unknown, for lack of studies.

Health: Mercury, arsenic, and asbestos are known to cause severe human health problems with continued exposure. Mercury contamination of fish has caused the State to issue warnings about fish consumption in Sierra water bodies that have been tested. Arsenic and asbestos, naturally occurring toxic materials crushed during the Gold Rush and left in huge tailings piles, have been found in dangerously high levels throughout the region and can be breathed in as dust particles when working or recreating in these areas.

Despite the extensive evidence of potential exposure to these many toxins, human health studies have never been done in the Sierra Nevada to learn if there are health impacts due to this exposure. A survey of thirteen health clinics throughout the Gold Country documented that none of these clinics currently collect environmental health histories from their patients or provide information about mercury contamination of fish as part of their maternal health program, even though many serve areas where there are recently adopted advisories to limit fish consumption.

> The California Gold Rush clawed out of the foothills of the Sierra Nevada considerable gold—93 tons or 2.7 million troy ounces in the peak year of 1853 alone... In the course of doing so, everything in the region and much downstream was ravaged. Wildlife was decimated. Trees were cut down to burn for domestic and industrial purposes and to build the huge mining infrastructure that was firmly in place by the 1870s. ...The earth was dug into desolation and later hosed out so that some landscapes—notably the Malakoff Diggins and San Juan Ridge near Nevada City—are still erosive badlands of mostly bare earth.
>
> But most of all, the streams and rivers were devastated. The myriad waterways of the Sierra Nevada were turned into so much plumbing, to be detoured, dammed, redirected into sluices high above the landscape, filled with debris and toxins. Water as an industrial agent was paramount, and water as a source of life for fish, riparian creatures, downstream drinkers, farmers, and future generations was ignored.
>
> *-- Solnit, Rebecca.*
> *"Winged Mercury and the Golden Calf." Orion, September/October 2006.*

Obstacles to Solving the Problem

1. Lack of appropriate health hazard screening: The presence of mercury, arsenic, and other mining toxins in the region has been established, and the potential health risks from exposure to each agent are understood to some degree. No evidence exists, however, showing what impact, if any, this exposure is having on humans in the region. This is due to the fact that there has been no research, no screening, and no studies to look into the extent of human impact from exposure to these materials.

2. Poor methods of community and tribal engagement: Sierra residents do not know the environmental dangers to which they may be exposed on a daily basis. As a result, the community remains uninvolved in cleaning up mining toxins. The public has not been widely involved in development of the regulations affecting mining toxins and cleanup plans. Additionally, local tribes have not been consulted in site prioritization and cleanup methods for state and federal mine remediation projects that occur on ancestral lands. Tribal input into the assessment and remediation process is essential, especially direct and regular consultation with tribes that may have sacred or historic lands affected by toxic materials.

3. Underfunded and inadequate government programs: A patchwork of government agencies and regulations on the local, state, and federal levels relate to mining toxin problems on both public and private property.

Figure 4

The government is the largest landowner in the Sierra Nevada, and many of the lands affected are owned by public agencies. However, the state and federal governments have not established a clear plan for assessing and addressing the many problems associated with the impact of gold mining on public land. Ineffective communication among state, federal, and local agencies regarding remediation efforts and techniques makes proper remediation difficult. Public land managers such as regional Forest Service offices and BLM field offices are faced with costly environmental cleanup actions on severely limited budgets.

There are no incentives for private land cleanup, and regulations regarding cleanup are not consistent or understandable. General Mining Law enables current mining operations to continue to operate without reclamation plans that are specific to mitigation addressing legacy mining waste. Some policies need closer examination:

- Regulations on suction dredging are outdated. New studies indicate that suction dredging has the potential to spread mercury in the environment in highly mobile and highly reactive forms.

- Reservoir management may aggravate mercury mobilization and reactivity. Accumulation of sediment contaminated with mercury behind reservoirs requires dredging out this excess material to maintain water storage capacity. Dangers associated with this procedure include re-suspending and re-mobilizing toxins and increasing mercury methylation.

- Mine tailings and materials left over from reservoir dredging are not tested for arsenic or other heavy metals before being sold for aggregate, even though many of the materials dredged from reservoirs or left over from mining are known to be contaminated. The use of local aggregate fill is not effectively regulated for arsenic, mercury, and other contaminants.

Key Recommendations

The Initiative's Gold Ribbon Panel of tribal leaders, watershed scientists, medical professionals, and community members have identified four activities to begin to address mining toxin issues. Effective implementation of these recommendations requires new institutional relationships and funding.

A strategic alignment among indigenous tribes, scientists, local landowners, government representatives, philanthropic and conservation organizations, and the health community in the Sierra Nevada, based on mutual need and desire to find solutions, is the key to solving this vast problem.

An important recommendation is that the newly established Sierra Nevada Conservancy should serve as primary coordinator for the actions proposed by this Panel. Another top priority of the Panel is the call for a new, strategic investment in research, education, and cleanup. State, federal, and private philanthropic funding must be directed to the Sierra Nevada mining problem over the next several decades.

The Gold Ribbon Panel recommends the following four activities:

1. Increase Collaboration and Research

Improving collaboration among key governmental, academic, and medical institutions to stimulate the implementation of this Initiative is crucial. State and federal governments should form a Mining Toxins Working Group including researchers at the University of California and California State University, government researchers, tribal and community leaders, and others to ensure effective information exchange on these issues.

More information is needed on a number of issues in order to inform policy and develop best practices, with priorities:

A. Human health impacts resulting from exposure to mining toxins and naturally occurring toxic minerals disturbed during the Gold Rush.

B. The geographic distribution and biogeochemical behavior of mining toxins, especially as they relate to exposure routes.

C. How to assess priorities and clean up the pollution distributed throughout the region most effectively.

Figure 5 - Photo by John Wentworth

2. Improve Outreach and Education on Human Health

Public awareness of the potential human health hazards associated with mining toxins needs to be increased dramatically. Education and outreach campaigns should be aimed at people working with families and children, in health care, and those who may be exposed to these materials at work, at home, or through recreational activities. Best outreach practices need to be established to ensure materials are culturally appropriate and understandable, and to improve training for medical professionals.

Figure 6

3. Improve Environmental Education in the Health Community

There needs to be a much better understanding of what, if any, epidemiological impacts this exposure is having on the residents of the Gold Country. The medical and conservation communities must be engaged in development and distribution of an environmental health assessment tool. This needs to be implemented in health education programs at schools and clinics. Community monitoring of mining toxins using high quality scientific tools needs to be supported. The public needs access to all testing data in order to effectively participate in decisions about mine cleanups.

4. Reform and Fund Government Programs

The complexity of the mining toxin problem requires evaluation of scientific information and policy solutions among a number of local, state, and federal agencies. The Sierra Nevada Conservancy can facilitate this important task. Improved methods for engaging the public and local tribes in assessment and remediation are critical.

State and federal agencies need to coordinate the development of plans for public land cleanup carefully, as they own a majority of the lands in the region with abandoned mines. The state and federal government should each carefully assess their publicly owned land for mining toxins and develop plans to clean up or contain these wastes from contaminating the land and water of the state. Additional state and federal funding is critically needed to clean up legacy mining contamination. Local governments need to develop general plan policies and strategies for managing land use impacts of mining toxins. Solutions to the obstacles to cleanup of private lands must be developed and funding mechanisms for these identified. Legal mechanisms need to be explored to look for ways for downstream urban users to help pay for cleanup upstream in the Gold Country.

Figure 7

Wetlands restoration and reservoir management need to reflect mercury methylation concerns. Materials dredged from reservoirs that may contain toxins need to be carefully monitored. Hazardous materials recovered from cleanups need to be carefully disposed.

Regulatory actions should be adopted to implement provisions of the Clean Water Act applicable to instream suction dredging and its impacts on mercury. The Clean Water Act needs to be reformed to make it easier to conduct cleanup activities.

The Federal 1872 Mining Act needs to be reformed to require meaningful mitigation of cultural and environmental impacts from both modern-day and historic mining. Good Samaritan laws must be reformed to provide incentives for cleanup. The California Surface Mining and Reclamation Act needs to be strengthened to require minimum verifiable standards for reclamation.

A Call to Action

After nearly two years of effort to build relationships among new constituencies, this Initiative has laid the foundation to bring to light this long-neglected issue. The time has come for the state of California and the nation to recognize and remediate the lasting impact of California's Gold Rush.

The Sierra Nevada covers 25 million acres of California -- a third of the state.

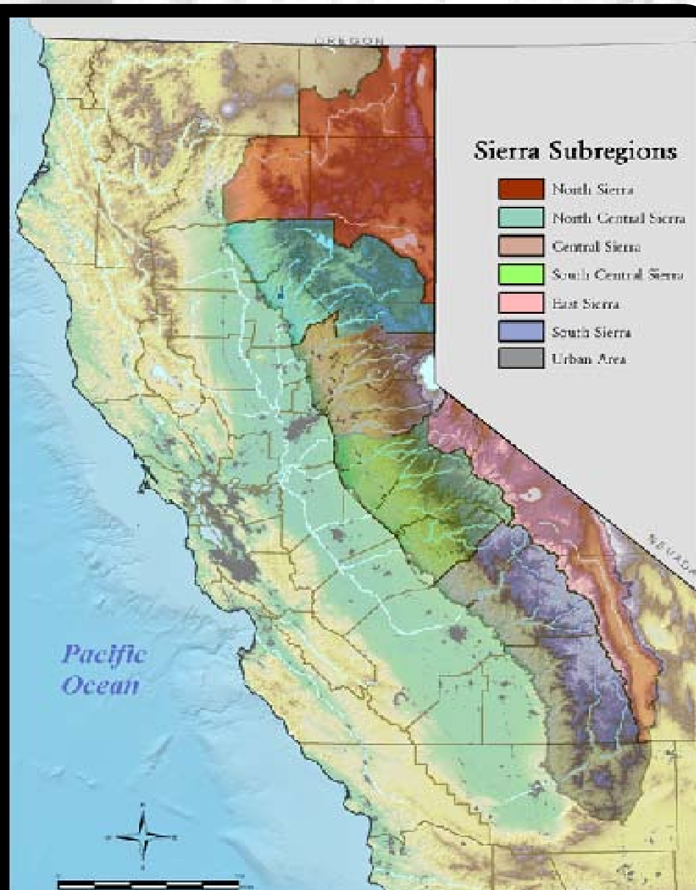


Figure 8

California's Gold Rush: Mining the Mountains

The State of California burst into existence with the discovery of gold in 1848 along the western slope of the Sierra Nevada on Maidu land, an area still the home of Native Peoples who for thousands of years had been undisturbed by colonists. As word spread across America and the world in 1849, hopeful prospectors swarmed up the Sacramento River to the gold fields in the Sierra. California's gold was rushed from the hills using boats and wagons and later trains, and taken back to the east coast where it paid for the Union soldiers' uniforms and the explosive growth of the industrial Northeast in the late 19th century. The image of the California gold miner is still everywhere, from the California State Seal to high school football mascots in the Gold Country.

The Gold Rush changed the demographic landscape of California as the indigenous people were dislocated and towns appeared and disappeared across the Sierra Nevada Mountains. A less recognized consequence of the California Gold Rush was the massive environmental destruction that took place, which still plagues the Sierra today.

What are the long-term consequences of this "golden" time period? The impacts of various methods of mining, the clearing of the land of its people and forest, and the impact on the water system are only now being examined.

Gold Rush Mining Methods

When the Gold Rush began, little was known about the best method of procuring gold from the river gravels (placer deposits) and quartz veins (hard rock). At first, gold miners literally picked up golden nuggets from streams, riverbeds, and rock outcroppings. Over time, the equipment used for gold mining became more sophisticated. Larger machinery was substituted for the original pickaxe and pan as the Gold Rush met the Industrial Revolution.

Placer Mining

The first method for mining placer deposits was panning, which soon gave way to use of cradles, rockers, sluices, and longtoms. Placer mining employed a series of sifting and sluicing actions to concentrate gold-bearing sediments. Large quantities of mercury were added to sluice boxes to bind with the fine-grained gold, forming an amalgam that was more easily separated from the sediment.

Hydraulic Mining

Hydraulic mining operations utilized the force of water to wash large quantities of gold-bearing terrace materials into sluice boxes. The first hydraulic nozzle was turned on Sierra hillsides in 1853.

Hydraulic mining was very successful in the Sierra because abundant surface water was available. By 1865, miners had constructed an estimated 5,000 miles of flumes, ditches, and canals to convey water to mine sites across the western slope of the Sierra.[1] Later these canals and associated reservoirs became the basis of the water rights and infrastructure for hydroelectric power generation and the state's water supply system.

The massive volume of sediment moved by hydraulic mining and the extensive use of mercury polluted California's waterways from the Sierra to the Pacific Ocean.

Figure 9

As hydraulic mining excavated deeper gold deposits, miners found it necessary to construct tunnels to supply and drain the hydraulic pits.

Often, miners placed long mercury-laden sluice boxes in these tunnels to facilitate gold recovery. These tunnels subsequently discharged mercury-impacted sediments to adjacent waterways.

The massive volume of sediment moved by hydraulic mining and the extensive use of mercury polluted the rivers, streams, lakes, and soils of the Sierra; downstream channels; the San Joaquin Delta; and the San Francisco Bay. Farmlands were repeatedly flooded and destroyed, so farmers filed the first environmental protection lawsuit of its kind against the hydraulic mines. Consequently, hydraulic mining was effectively banned in 1884 by the California courts in what became known as the "Sawyer Decision."

Hydraulic mining recommenced to a lesser extent, however, after Congress passed the Caminetti Act of 1893 and continued until 1950. This act allowed hydraulic mining to occur as long as downstream movement of sediment was controlled by debris dams such as Englebright Dam on the Yuba River.[2] An unknown number of debris dams containing toxic sediments were left behind. Although many of the abandoned debris dams have collapsed during storm events, others still pose a danger of collapsing and releasing more contaminated sediment.

Figure 10

Hard Rock Mining

As the easily exploited placer deposits in the Sierra were depleted and gold-bearing quartz veins were discovered deep underground, gold production shifted largely to hard rock mining. Hard rock mining required building adits and shafts to reach underground quartz veins, and using ore carts, mules, and pulley systems to bring mine ore to the surface. Elaborate pumping and drainage systems were constructed to remove groundwater from the mines.

During the construction of shafts, adits, and tunnels, miners brought waste rock, containing elevated levels of heavy metals such as arsenic and lead, to the surface and deposited it in large tailings piles near the shaft openings.

Major lode mines in the Sierra region processed millions of tons of ore from underground workings, which were then crushed by large stamp mills and ball mill facilities, generating millions of tons of sand- and dust-sized particles known as mill tailings. Mill tailings were spread over large areas near the mill or discharged into creeks. Later they were discharged into impoundments, or ponds. This type of lode mill waste product currently represents a significant source of toxic environmental contamination.

Mercury Used for Gold Mining

Hard rock, placer, and hydraulic mining all used mercury to extract gold. In hydraulic and placer mining, miners added mercury to sluice boxes; in hard rock mining, they added mercury to crushed ore. Mercury forms an amalgam with gold and is later burned off, or volatilized, by a retort process, leaving the gold behind.

An estimated 26 million pounds of mercury were used to extract gold from ore in California.[3] Of this, an estimated 10 million pounds were lost to the environment in placer mining operations and another 3 million pounds were lost from hard rock mining.[4] The mercury was washed into streams, rivers, and reservoirs with the excess sediment. Although a significant portion of this mercury migrated downstream to the

Gold is heavy, and it sinks to the bottom of a pan, a rocker, a long tom, or whatever device you might have used to get the metal out of the stream in the early days of the California Gold Rush. Some of the gold always slipped away—unless you added mercury, also known as quicksilver, to the water and silt in your pan… Then you poured mercury, one flask—seventy-five pounds—at a time, into the washing device. This was one of the most extravagant uses of mercury during the Gold Rush, and much of it escaped into the environment...

Overall, approximately ten times more mercury was put into the California ecosystem than gold was taken out of it.

--Solnit

Sacramento Delta and San Francisco Bay and some was lost to the atmosphere during retorting of amalgams, much remains entrapped behind dams and attached to sediment in the Sierra's rivers.

Mercury Sources

Mercury in California is both naturally occurring and introduced by mining activities. Cinnabar, the mineral form of mercury, occurs naturally in many areas on the west side of California's Central Valley, in the Coast Range, the Cascade Range, and the eastern side of the Sierra, and from hydrothermal systems such as in the Lassen area.

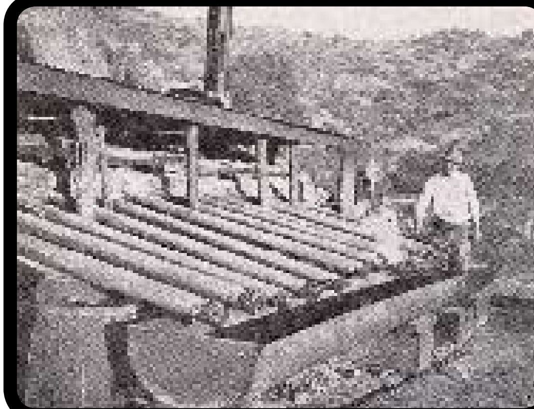


Figure 11

World-class mercury deposits exist in the Coast Range region between Los Angeles and Eureka. Mercury mines in the Coast Range still discharge mercury into the streams and thence downstream into the San Francisco Bay and Delta. Mercury was mined from this area, particularly from the mountains around San Jose and Clear Lake, and transported to the Sierra Nevada for use in thousands of gold mining operations. Much of the state policy attention to mercury problems in the San Francisco Bay and Delta focuses on mercury from the Coast Range.

Recent studies by the Delta Tributary Mercury Council indicate, however, that runoff and erosion from gold mines in the Sierra are a significant source of mercury to the Sacramento Delta. Total mercury loading estimates for several sources in the Sacramento River watershed include: urban runoff (4 kg/yr); flow from mineral springs (18 kg/yr); runoff and erosion from mercury mine sites (3 kg/yr); and runoff and erosion from gold mine sites (61 kg/yr).[5] Scientists have not yet quantified other potential mercury sources, such as resuspension of contaminated fluvial sediments, erosion and leaching of pesticide residue in soils, atmospheric sources, and releases from other mineral mines and waste disposal sites.

The primary source of mercury in Sierra water bodies is historic gold mining activity. Elemental mercury or "quicksilver" imported for use during the Gold Rush is still commonly encountered in Sierra watersheds. It can be panned out of gravel or sucked from creek and riverbeds with a turkey baster.

Mercury from the Gold Rush can still be panned out of gravel or sucked from creek beds with a turkey baster.

Figure 12

Despite estimates, mercury loads in watersheds, rivers, and streams throughout the gold mining regions of California remain relatively unknown. Accurate quantification of mercury in the Sierra is further complicated because mercury exists in many different forms. Scientists measure a number of different factors including water, tissue, and sediment when testing a system for the level of mercury contamination.

Methylmercury

Mercury takes on different forms in the environment. Methylmercury is a particularly toxic form that bioaccumulates in humans and wildlife.

Mercury is transported by erosion and runoff as elemental mercury adsorbed to particles of sediment. Mercury is converted by microbial action into methylmercury, which can then be incorporated into the tissues of microbes, plants, and animals (bioaccumulation). As methylmercury moves through the food chain, it is concentrated (biomagnification). Mercury concentrations in larger predatory fish can exceed levels of concern for human and wildlife consumption.

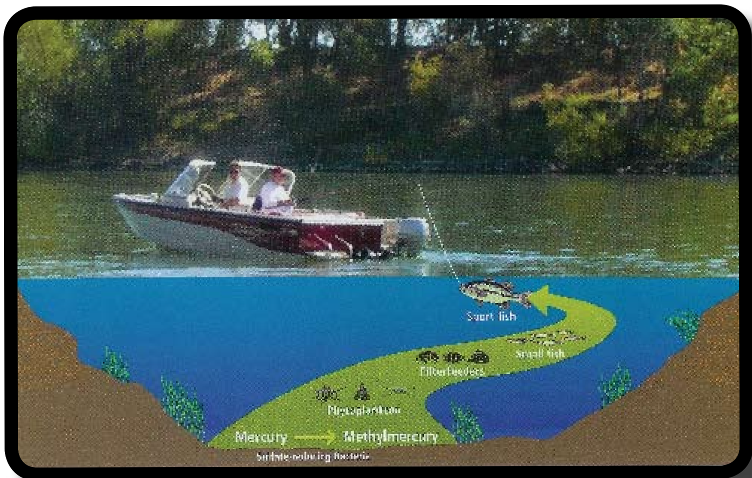


Figure 13

The vast majority of the mercury-associated human health impacts discussed in this report are caused by consumption of methylmercury in fish. These effects are described in detail later in this report.

Tons of crushed rock were removed from underground shafts daily during the Gold Rush.

Figure 14

Mining Tailings, Crushed Rock, and Gravel Roads

Hard rock mining left deposits of sand-sized sediment in mill tailings, some of which were allowed to flow downstream. Hydraulic mining left behind vast deposits of gravel-sized sediment in downstream streams and rivers, and flood deposits of sand and silt at lower elevations. For more than 100 years it was common practice to use the tailings from former mine sites for construction of buildings, highways, and roads. Toxic materials such as mercury, arsenic, and asbestos contained in the tailings were thus distributed far and wide across California's Gold Country for more than a century.

In 1990 the California Air Resources Board established regulations restricting levels of asbestos allowed in gravel sold for roads. In 1998 these rules were made more stringent, reflecting increased concern about potential human health exposures.[6]

Abandoned Mines

Today, there are an estimated 47,000 abandoned mine sites in California, according to the California Department of Conservation (CDOC). Some of these sites have been found to contain toxic waste rock piles and associated contamination. These waste rock piles erode downhill into drainages, rivers, and streams, spreading toxic chemicals far beyond the mine site (see Acid Mine Drainage).

The CDOC estimates that of abandoned mines in California, 84% present physical safety hazards and 11% present environmental hazards.[7] Physical hazards of abandoned mines consist of collapsing tunnels or hidden shafts. For example, a man was killed when his home collapsed into an old mine shaft near Dutch Flat in 2006. Acute environmental hazards include old explosives, drums of chemicals, or direct exposure to toxic mine tailings.

There are more than 40,000 abandoned mines in California.

Figure 15

Abandoned mine sites also generate chronic environmental hazards. Contaminated runoff from abandoned mines impacts land, groundwater, streams, rivers, and lakes. Principal environmental pollutants from abandoned mines are mercury from contaminated sediments, arsenic, lead, and other heavy metals associated with acid rock drainage. The degree of potential contamination depends on the commodity being mined (gold, copper, chromium, etc.), mining methods, ore processing methods, and disposal methods. Other contaminants can include chemicals used to process ore and fuel, lubricants, and solvents used to operate and maintain equipment.

Acid Mine Drainage

Acid mine drainage refers to the outflow of acidic waters from abandoned mine shafts and drain tunnels. The Leviathan Mine (a sulphur mine) in the eastern Sierra is a Superfund site where acid drainage is a primary concern. Other abandoned mines, among them many gold mines, with acid drainage are scattered throughout the mining regions of the Sierra in areas where sulfide rock is abundant.

Acid mine drainage often includes toxic levels of dissolved heavy metals and can cause fish kills, environmental damage, and water quality degradation. Oxidation of pyrite, which commonly contains arsenic as a trace component as well as the mineral arsenopyrite, causes acid mine drainage and high arsenic concentrations in mine water discharges at many gold mines in the Sierra Nevada. In placer mine areas, some pit lakes caused by clogged drainage tunnels contain acid water with elevated concentrations of toxic trace metals including cadmium, copper, cobalt, nickel, and zinc.[8]

Acid drainage mainly affects smaller streams and tributaries, but can also impact larger rivers during periods of low flow. Cleanup of acidic drainage is extremely costly and must be maintained over long periods of time. Cleanup methods including carbonate neutralization, ion exchange, constructed wetlands, active treatment with aeration, and precipitation of metal ions have been attempted at high cost and with varying results. Additionally, neutralized waters (and neutral mine drainage) can still contain high concentrations of certain heavy metals such as cadmium, nickel, and zinc.

Assessment of abandoned mine lands must include testing for acid drainage at the mine and in downstream areas. Considering the abundance of abandoned mines that have not been adequately assessed, acid drainage may be a more serious problem in the Sierra than is currently realized.

After the Gold Rush: Who Owns the Mines Now?

The magnitude of mining's impact on the people and places of the Sierra is staggering, covering millions of acres and hundreds of lakes, rivers, wetlands, and reservoirs. Assessing and addressing these problems is complicated by the checkered land ownership patterns in the region. More than a century after the Gold Rush, these lands are owned by several entities.

Federal Ownership

The federal government owns more than one-third of the Sierra region through the US Forest Service, the Bureau of Land Management, and the National Park Service. These lands include a great number of properties with abandoned mines, as well as many active mines.

State Ownership

The state of California owns some significant properties in the Sierra through the Department of Parks and Recreation and the Department of Fish and Game. The State also has jurisdiction over the beds of navigable waters, which it holds in public trust for all Californians. These waters include streams that are still actively mined with pans or suction dredges.

Local Government Ownership

Local governments in the Gold Country sometimes have mining toxins in their historic parks or properties. For example, the City of Nevada City recently received an Environmental Protection Agency (EPA) Brownfields grant for a community-wide assessment of five abandoned mine sites, including a hydraulic mining pond. Sanitation systems and water districts in the region could also be heavily impacted by mining toxins.

Private Property

Many of the towns and cities of the Sierra were built around the heart of the gold mines, and thus are ground zero for mining toxins. Ranches, forests, and even little city lots can be endangered by acid mine drainage, arsenic, lead, mercury, or asbestos, and tunnel collapses. Liability questions arise over activities that occurred a hundred years before the current property owner bought the polluted property.

Property Value Impacts of Mining Toxins

The problems associated with mining toxins are increasingly discovered as property changes hands or undergoes development. Property owners have purchased land with naturally occurring toxins, such as arsenic or lead, brought to the surface by mining but lying undiscovered until a house or other development is started. In some cases the toxic mineral levels on these abandoned mine sites are above EPA safety limits so development is prohibited, dramatically decreasing the value of the land.

Property owners who receive the bad news that there is evidence of mining on the property are faced with difficult choices. It is hard to sell the land because once a toxin problem is identified the owner is required to reveal it to all prospective purchasers. It is equally difficult to clean up the land, especially if naturally occurring or "background" levels of the toxic mineral exceed existing safety regulations.

There are no federal or state fiscal incentives for landowners to clean up these properties. Additionally, on arsenic sites, property owners cannot know the extent to which cleanup is required, as the state has not set cleanup standards for naturally occurring arsenic. As a result, toxin problems are left unaddressed and property owners individually face the economic consequences of historic mining.

Modern Day Gold Mining in the Sierra

This Initiative is mainly concerned with the pollution of the Sierra by historic mining activities, but gold mining has by no means come to an end. The high value of gold is driving an increase in current mining activities all over the world. Even in the 21st century, toxic materials such as mercury and cyanide continue to be used in gold mining.

Today, large-scale gold mining operations located in California, Nevada, Utah, and other states use techniques such as open pit mining, including cyanide leach dumps that can cover hundreds of acres. In rural Nevada, these dumps cover thousands of acres. Cyanide leach mining, although not a common practice, is still legal in California.

Current mining in the Sierra Nevada ranges from individuals panning in the rivers recreationally, to suction dredging, to small- and large-scale hard rock mines.

In the suction dredging process, individual miners remove gravels from the riverbed with a suction hose powered by an engine, and then use pans or other methods to retrieve the gold. Suction dredgers often encounter mercury and gold-mercury amalgam, which tend to fall into the cracks of the riverbed like gold. Dredgers often collect the mercury and amalgam, and retort it or treat it with nitric acid to release any gold that may have amalgamated with the mercury. They then recover the mercury and usually store it, though some miners dispose of it in an unauthorized manner, such as pouring it back into the river, onto the ground, or in to municipal sewer systems.

Typical suction dredging operation

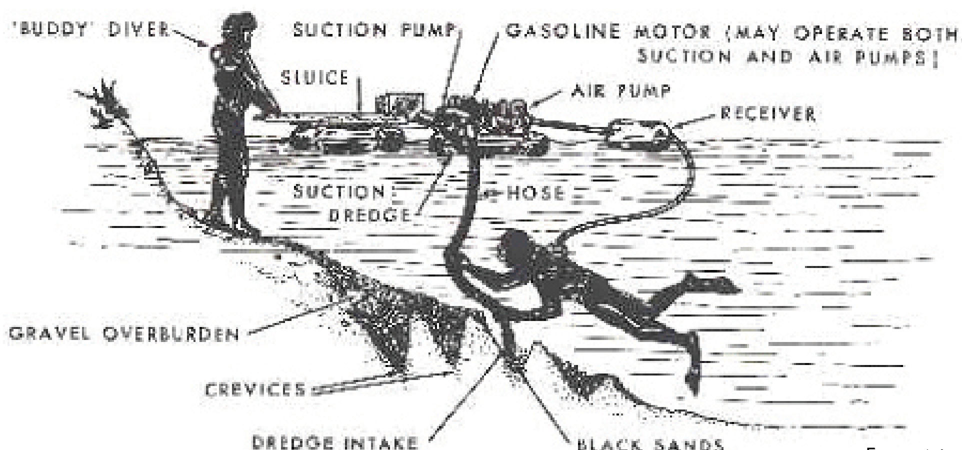


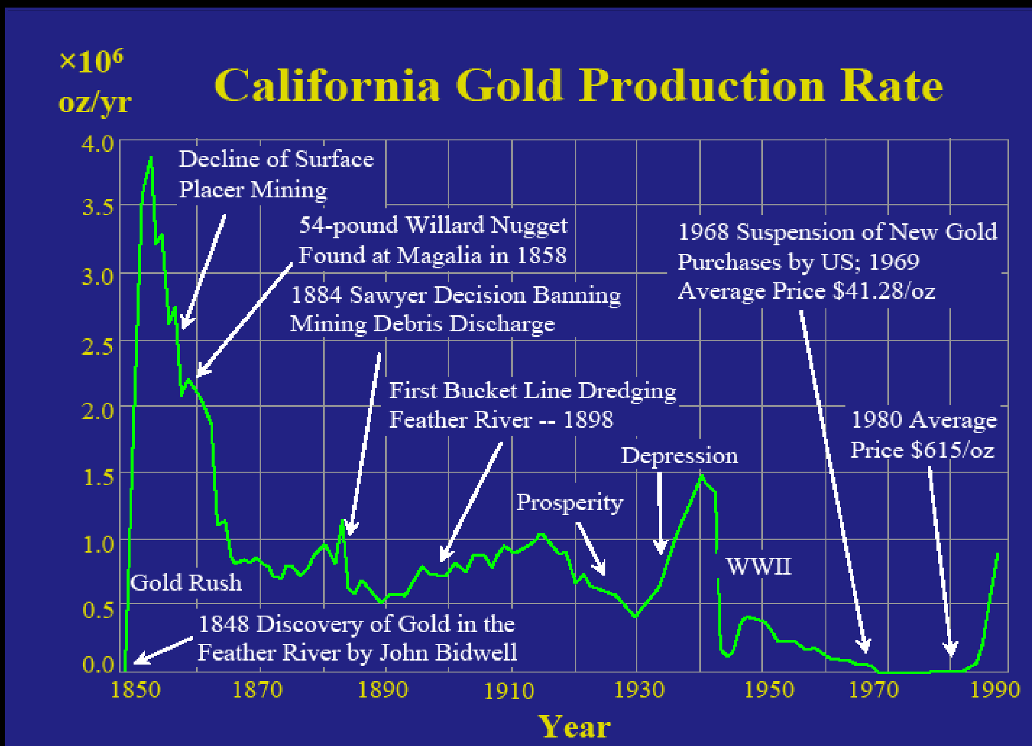
Figure 16

Such small-scale mining, although it does not introduce new toxins to the environment, has the potential to aggravate the existing toxin problem. Suction dredging may cause mercury in the sediment to "flour" into tiny particles, increasing the surface area and reactivity of the mercury, leading to increased methylation, bioaccumulation, and associated human health risks.

Efforts to reintroduce large-scale mining in the Sierra in response to the high price of gold have occasionally surfaced. However, local residents remain concerned about the impact of these mines on groundwater quality and quantity.

Sierra residents value their environment and water, and have taken action when mining has jeopardized the future of these. The new information this Initiative provides on the hazards stemming from historic mining activities should trigger the same concern and action.

California gold sustained the nation during the banking "panics" of the late 19th Century, and helped fund World Wars I and II.



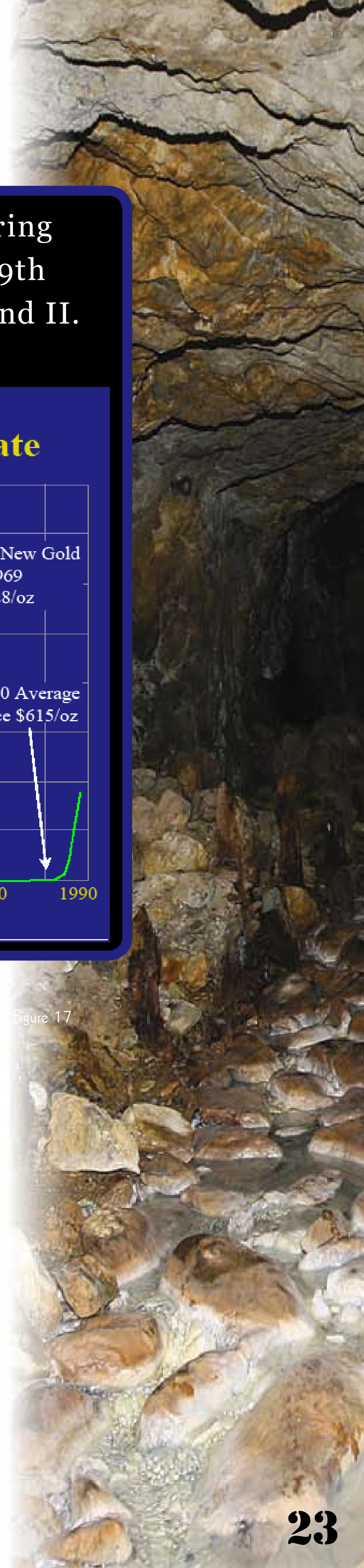


Figure 17

1. Hardrock Mining in California 2004
2. James 2005
3. Alpers et al. 2005a
4. Churchill 2000
5. Delta Tributary Mercury Council 2002
6. CA State Senate Hearings on Air Quality 2005
7. CDOC 2000; data updated 2007
8. Alpers et al. 2005b

The Cultural Legacy of the Gold Rush

Native Peoples have inhabited California for more than 7,500 years.[1] They have an inherent sense of place and connection to the land. Their identity and spiritual and social makeup is tied to the land, plants, animals, and rivers that have sustained them for generations. Native Peoples cannot abandon the place that has defined them for millennia without risking cultural annihilation.

Gold miners from all over the world streamed into California 150 years ago. They had no intrinsic connection with the place and therefore viewed it as a commodity to be used up. This mentality allowed the massive resource extraction of the Gold Rush, at great environmental and cultural cost.

> The Gold Rush was a huge giveaway of public or indigenous resources to private profiteers, a mass production of long-term poverty disguised as a carnival of riches. Which is to say that the profit the mining operations made was contingent on a very peculiar, if familiar, form of enterprise it might be a mistake to call free: one in which nature and the public domain could be squandered for private gain, in which the many were impoverished so that a few could be enriched.
>
> ----- *Solnit*

Death and Dislocation

Anthropologists estimate that the presettlement population of the Maidu tribes was between 9,000 and 9,500 people. These numbers, however, may be grossly underrepresented. For example, according to local tribes, at least 6,000 people lived in the Nevada City/Grass Valley area alone. In 1910 noted anthropologist Alfred Louis Kroeber recounted the local population as 1,100. By 1930 the US Census counted only 93.[2]

The drastic decline in the Native American population was caused by disease and outright murder during the Gold Rush. Some indigenous people were forced to march to other areas of the state, such as the march of the Maidu people from Chico to Round Valley on the north coast in the late 1880s.[3]

Cultural Practices Affected

Along with the decimation of their populations, the Gold Rush and its attendant throngs of miners forced the remaining Native Peoples off their ancestral lands and onto reservations, away from the plants and animals fundamental to their cultural practices. Today, the toxic legacy of that brutal time period continues to rend the Native Californians from their ancestral practices.

The Natives of the Sierra are admired the world over for their skill in weaving baskets, tools important to all aspects of indigenous life. Women traditionally bend and fold the grasses using their mouths. Basket making has become a hazardous occupation because the reeds used have often absorbed toxic chemicals and leave women with mouth sores and unknown internal medical problems.

To the Native Peoples of the Sierra, making a basket is a prayer. The loss of healthy materials with which to make a basket is therefore the loss of a sovereign right.

The toxic chemicals that remain from the Gold Rush era also threaten salmon for ceremonies, medicinal plants, and ceremonial plants. The fish that have been the staple of the native diet have become a poison. This threat further separates Native Californians from their traditions.

In the popular version of the California Gold Rush, every man is free to seek his fortune, and flannel-shirted miners panning for gold in mountain streams strike it rich... It was almost nearly briefly true, if you ignore the racist laws and the violence that deprived Asians and Latinos of mining access and basic rights. Non-Europeans were subject to special taxes, denied the right to stake claims or work them independently, intimidated, lynched, driven off the richest sites, and barred from legal recourse, but their lot was far more pleasant than that of the native Californians. Bounties were paid for their scalps or ears, and they had no legal or treaty rights. (Though they owned the mother lode from which the gold came, most received nothing from the rush but ruin.) Disease, deracination, starvation, despair, and outright murder reduced the indigenous population by about four-fifths during those early years of the Gold Rush.

----- *Solnit*

Native basketweavers use fingernails, lips and teeth to make these world-renowned baskets, exposing themselves to high levels of mining toxins.

Figure 18

The Heritage of the Gold Rush

California's Gold Rush helped fuel the transformation of this quiet corner of the earth into one of the largest economies on the planet today. Historians have credited the victory of the Union over the Confederate armies to the gold from California that purchased the supplies needed to win the Civil War.

Salmon is an important part of traditional ceremonies and diet, forcing Native Peoples to choose between tradition and health.

Figure 19

John McPhee recounts:

By 1865, at the end of the American Civil War, seven hundred and eighty five million dollars had come out of the ground in California (Sierra Nevada), making a difference -- possibly the difference -- in the Civil War. The early Californian John Bidwell, expressed this in his memoirs:

'It is a question whether the United States could have stood the shock of the great rebellion of 1861 had the California gold discovery not been made. Bankers and businessmen of New York in 1864 did not hesitate to admit that but for the gold of California, which monthly poured its five or six millions into that financial center, the bottom would have dropped out of everything. These timely arrivals so strengthened the nerves of trade and stimulated business as to enable the government to sell its bonds at a time when its credit was its life blood and the main reliance by which to feed, clothe, and maintain its armies. Once our bonds went down to thirty eight cents on the dollar. California gold averted a total collapse and enabled a preserved Union to come forth from the great conflict.'[4]

In 1853, an Indian agent wrote of the native peoples in the region, "They formerly subsisted on game, fish, acorns, etc. but it is now impossible for them to make a living by hunting or fishing, for nearly all the game has been driven from the mining region or has been killed by the thousands of our people who now occupy the once quiet home of these children of the forest. The rivers or tributaries of the Sacramento formerly were clear as crystal and abounded with the finest salmon and other fish. . . . But the miners have turned the streams from their beds and conveyed the water to the dry diggings and after being used until it is so thick with mud that it will scarcely run it returns to its natural channel and with it the soil from a thousand hills, which has driven almost every kind of fish to seek new places of resort where they can enjoy a purer and more natural element."

There was no new place of resort; the fish mostly just died off.

----- *Solnit*

California gold also sustained the nation during the banking "panics" of the late 19th century, and helped fight World Wars I and II. The Gold Rush brought immigrants to this country from all over the world with their strengths and dreams, and the attendant gifts of a culturally rich and diverse state.

This enormous contribution of wealth to the nation should be recognized, as well as the costs that this intensive extraction left in its wake. The nation owes the gold fields of California, the people displaced from them, and the people who live on the pollution left behind its support in cleaning up gold mining's toxic legacy.

We do not inherit the earth from our ancestors, we borrow it from our children.

- Native American proverb

Figure 20

1. Four Directions Institute 2007
2. *Ibid.*
3. Downing 2007
4. McPhee 1993

Environmental Legacy of the Gold Rush

With a grant from The Sierra Fund, scientists from the Geological and Environmental Sciences Department at California State University (CSU), Chico conducted a literature survey and assessment of scientific issues concerning mining toxins in the Sierra Nevada. The CSU, Chico literature review focused on identification of information resources and assessment of scientific issues related to toxic mine wastes, predominant mine wastes, hydrologic processes, and water quality. The objective of the literature review was to gain a comprehensive perspective on the scientific aspects of toxic mine wastes in the Sierra Nevada and to identify critical data gaps. Information discovered by this process has been used throughout this report.

The volume of mercury-tainted soil washed into the Yuba [by hydraulic mining] was three times that excavated during construction of the Panama Canal, and the riverbed rose by as much as eighty feet in some places. So much of California was turned into slurry and sent downstream that major waterways filled their own beds and carved new routes in the elevated sludge again and again, rising higher and higher above the surrounding landscape and turning ordinary Central Valley farmlands and towns into something akin to modern-day New Orleans: places below water level extremely vulnerable to flooding.

-- *Solnit*

Case Studies

CSU Chico scientists reviewed three reports representing approaches to addressing mining toxins at the statewide, watershed, and site-specific level:

1. *California's Abandoned Mines: A Report on the Magnitude and Scope of the Issue in the State,* by the California Department of Conservation (CDOC 2000), summarizes the number and distribution of abandoned mines across California. This report portrays the extent of the area affected by mining toxins.

2. The *Abandoned Mine Lands Assessment of the North Yuba Watershed*, also by the California Department of Conservation (CDOC 2003), is an example of a watershed-scale report. This assessment identifies areas where abandoned mines are of local concern, but was not intended to contain information on the ecosystem processes that affect exposure pathways.

3. The USGS report, *Geochemical Characterization of Water, Sediment, and Biota Affected by Mercury Contamination and Acidic Drainage from Historical Gold Mining, Greenhorn Creek, Nevada County, California, 1999-2001* (Alpers et al. 2005b), is an example of a comprehensive scientific study that investigates key aspects of biogeochemical processes.

Reviews of these reports are summarized below.

Figure 21

Statewide Assessment of Abandoned Mines

California's Abandoned Mines Report

The *California's Abandoned Mines* report (CDOC 2000) describes the program of the Abandoned Mine Lands Unit (AMLU). The goal of this program is to conduct a comprehensive inventory of abandoned mines in California. Abandoned mines are defined as mines which have ceased operations for at least one year and have no management plan or financial assurances for reclamation. The report estimates the existence of approximately 40,000 (subsequently updated to 47,000) historic abandoned mine sites in California, of which an estimated 84% present physical safety hazards and 11% present environmental hazards. Approximately half of all abandoned mine sites in California are on federal land (the number has been subsequently updated to 67%), and "less than 2% of these [physical hazards] have been mitigated to any degree, and less than 1% have been closed or remediated."[1]

Hydraulic mining transformed pristine mountain forests into toxin-laden moonscapes.

Figure 22

The AMLU program developed a statistical approach to estimating the potential hazards of abandoned mine lands. "[T]his investigation embodies several new concepts in characterizing abandoned mine lands (AML). They are the use of features (a single physical entity and its location) instead of 'mine sites' as the point of reference; the segregation of those features into physical and chemical hazards; the use of an environmental model to rank hazards; and the use of legacy databases for statistical modeling to characterize the 'magnitude and scope' of AML on a state-wide basis."[2]

The CDOC's statistical approach to identifying and assessing abandoned mines also uses watershed and bioregion data from the California Department of Forestry and California Department of Fish and Game, in addition to regional screening tools including: the 1972 Principal Areas of Mine Pollution (PAMP) dataset, the Surface Mining and Reclamation Act (SMARA) database, US Forest Service and National Park Service data, geologic, mineralogic, and petrologic data for selected mines and mining locations in the USGS Mineral Resource Data System, the Department of the Interior's Minerals Availability System/Mineral Industry Location System (MAS/MILS), CDOC's MINEFILE databases, historic hard rock and hydraulic mine sites based on USGS topographic mapping, Geographic Names Information System (GNIS), literature searches using the Reports of the State Mineralogist, USGS Open File Reports and Professional Papers, CDMG publications, and other sources.[3]

Key Findings: Despite the availability of these regional information sources and mine inventories, the toxic risk of the majority of abandoned mines is unclear. Available mining databases such as PAMP provide only limited information on mine locations and mining activities.

The CDOC report states that identifying the extent and concentration of toxic materials in soil and water around and downstream of the mine sites would require extensive work. The report estimates that the work of ten people for twenty-six years would be required to complete an inventory of abandoned mines on public land in California. The report identifies short-term options dealing primarily with prioritizing assessments and focusing remediation efforts, as well as long-term options focused on acquiring funding for remediation.

Watershed-Scale Assessment of Abandoned Mines

Abandoned Mine Lands Assessment of the North Yuba Watershed

In 2002, the CDOC conducted a survey of watersheds on the west slope of the Sierra using regional screening criteria for potential mining impacts. Watersheds were prioritized based on potential impacts from acid rock drainage, arsenic, asbestos, and/or mercury. The North Yuba River watershed, including its extensive gravel field, was identified as the watershed within the Bay-Delta region that was potentially the most impacted by historic mining. Pursuant to a grant from the California Bay-Delta authority, the CDOC subsequently prepared a detailed study, entitled *Abandoned Mine Lands Assessment of the North Yuba Watershed* (CDOC 2003).

The North Yuba Watershed was identified as potentially the most impacted by abandoned mines.

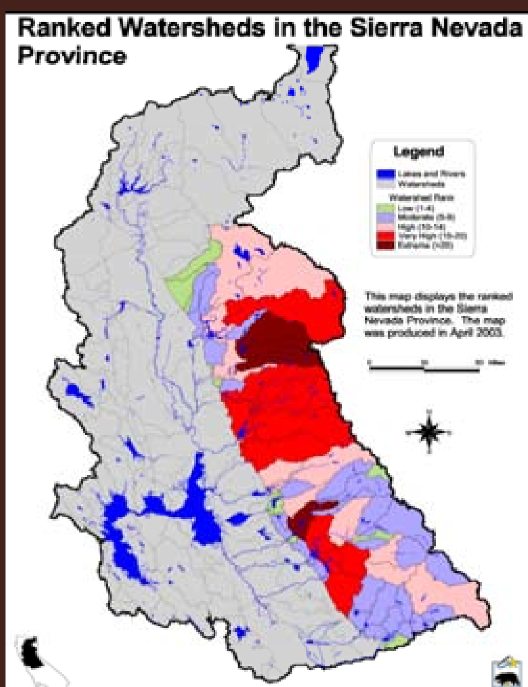


Figure 23

The assessment consists of a field reconnaissance of the North Yuba watershed. One hundred twenty-eight localities were cataloged and ranked; 45 soil samples from 24 sites were analyzed for arsenic, mercury, and lead. Approximately half of the mine sites in the area were assessed. Data from literature and the field were evaluated using the CDOC's Preliminary Appraisal and Ranking (PAR) Model to develop a priority list of mine sites. Twenty-three mine sites were identified with high or very high chemical PAR scores and ten mine sites were determined to have high combined PAR scores and high soil sample data.

Key Findings: Methods employed by the CDOC to assess the North Fork of the Yuba watershed provide a model by which other watersheds could be evaluated. Assessments utilizing existing databases of geology, topography, and landscape features are cost effective.

Conducting assessments at the watershed scale is the first step to identifying individual mine sites for remediation. At this time, many watersheds in the Sierra still do not have assessments that include information on mining and mining impacts. In fact, some watersheds in the Sierra have yet to be the subject of an assessment of any kind.

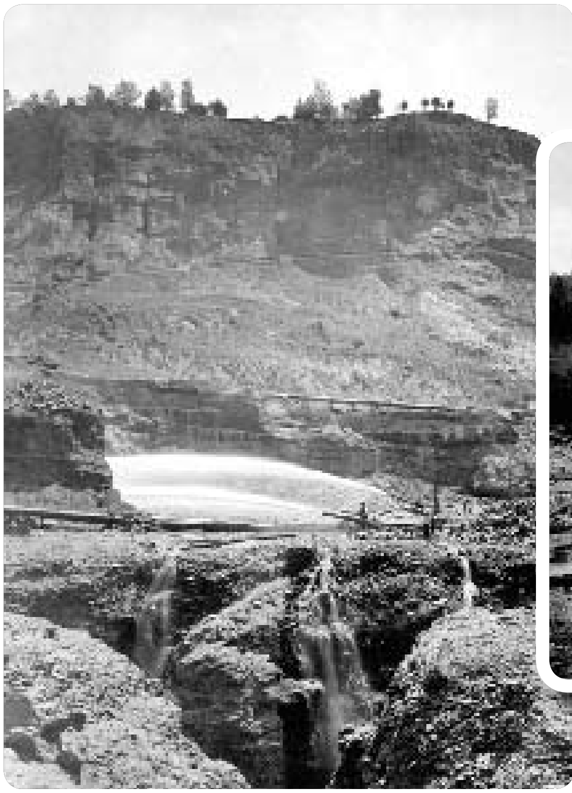


Figure 25

Figure 24

Figure 26

Figure 27

Gold is the paradise of which the bankers sang; mercury is the hell hidden in the fine print.

-- *Solnit*

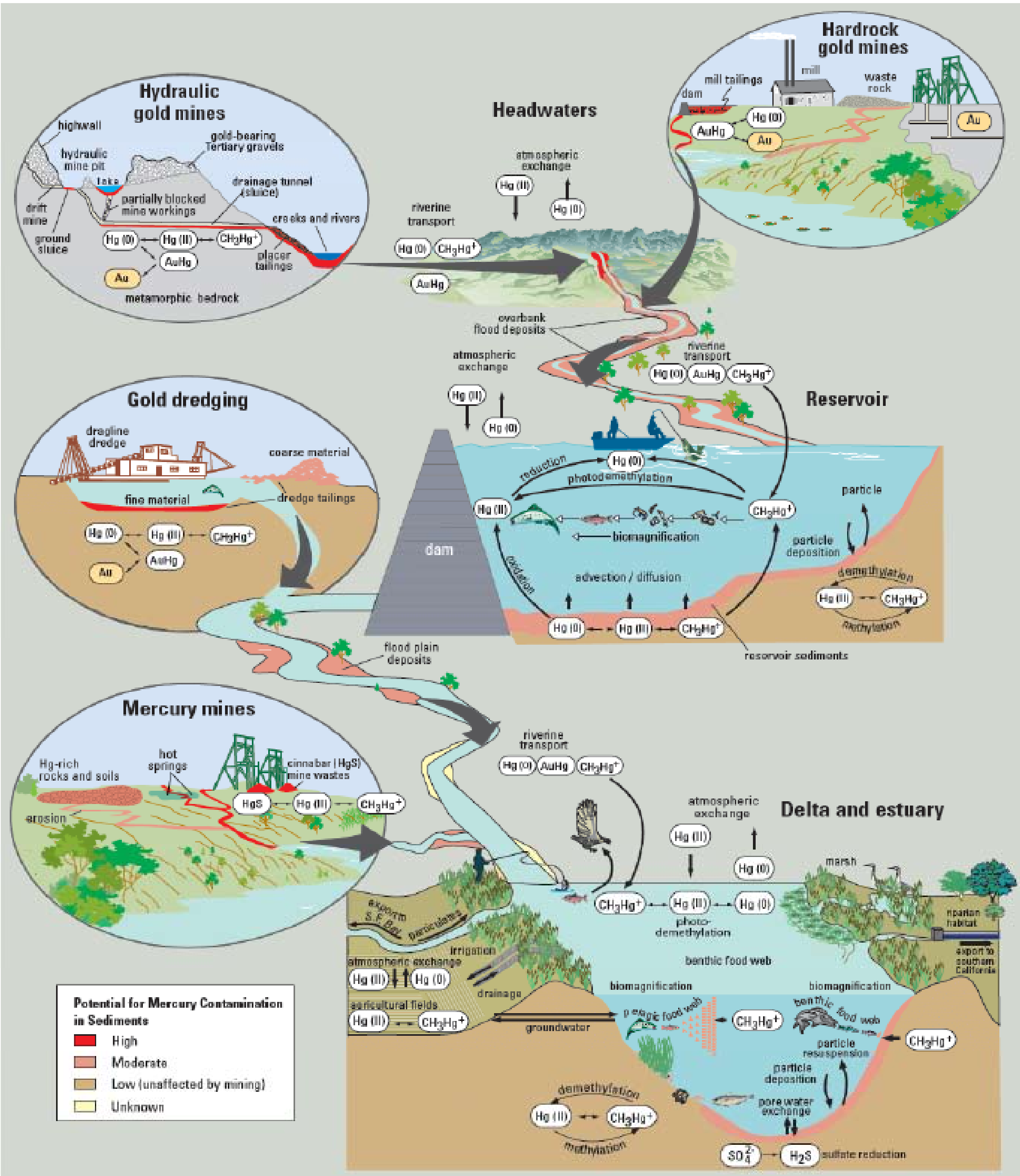


Figure 8. Schematic diagram showing transport and fate of mercury and potentially contaminated sediments from the mountain headwaters (hydraulic, drift, and hardrock mine environments) through rivers, reservoirs, and the flood plain, and into an estuary. A simplified mercury cycle is shown, including overall methylation reactions and bioaccumulation; the actual cycling is much more complex. Hg(0), elemental mercury; Hg(II), ionic mercury (mercuric ion); HgS, cinnabar; CH_3Hg^+, methylmercury; Au, gold; AuHg, gold-mercury amalgam; H_2S, hydrogen sulfide; SO_4^{2-}, sulfate ion; DOC, dissolved organic carbon. Mark Stephenson (California Department of Fish and Game) contributed to the development of this diagram.

Figure 28

Site-Specific Study on Fate and Transport of Toxins

Geochemical Characterization of Water, Sediment, and Biota Affected by Mercury Contamination and Acidic Drainage from Historical Gold Mining, Greenhorn Creek, Nevada County, California, 1999-2001

The USGS Greenhorn Creek Report (Alpers et al., 2005b) presents a detailed geochemical study of mercury pollution in a watershed that had experienced intensive hydraulic mining. Water samples from ground sluices, pit lakes, ponds, wetlands, streams, and mine tunnels were analyzed for total mercury in both filtered and unfiltered samples. Samples of water, sediment, and biota were also analyzed for methylmercury. Extensive physical and geochemical data, including suspended sediment loads, were collected from unfiltered and filtered water. Elemental mercury was extracted from sediments by panning. Total mercury and methylmercury levels were measured in invertebrates and frogs.

Few studies have been done to assess the environmental impacts of mining toxins in the Sierra.

Figure 29

Key Findings: The USGS report exemplifies the extensive data requirements, technical expertise, and analytical facilities required for state-of-the-art characterization of mining contaminants (primarily mercury) in a small watershed. This study vastly refined the knowledge of the hydrobiogeochemical processes that control the occurrences and migration of mercury.

A primary objective of the study was identifying "hot spots" of mercury contamination and bioaccumulation, so that land management agencies and other stakeholders could design appropriate remediation strategies to protect public health and ecological systems. As a result of this study, the US Forest Service (USFS) and the Bureau of Land Management (BLM) selected two sites in the area, which were then remediated: the Sailor Flat tunnel and pit, remediated by the USFS in 2003, and the Boston Mine tunnel, remediated by the BLM in 2006.

1. CDOC 2000; vol. 1, p. 32
2. *Ibid.*; vol. 2, p. 1
3. *Ibid.*; vol 2, p. 9

Health Impacts of Mining Toxins

More is known about the toxicity of contaminants used in mining than the exposure routes by which they may impact the people of the Sierra. In most cases, existing environmental hazard, exposure, and disease-tracking systems are not linked together, making it difficult to study and monitor relationships among hazards, exposures, and health effects.[1]

With a grant from The Sierra Fund, the CSU, Chico School of Nursing reviewed more than 100 articles pertaining to gold mining; routes by which human populations are exposed to mercury, arsenic, and asbestos in the environment; and the potential health risks from these exposures. The literature review was conducted between June 2006 and March 2007. Researchers used Academic Search, PUBMed and CINAHL, and CSU, Chico Meriam Library sources. Many of the articles reviewed were government reports documenting the dangers of mercury, arsenic, and asbestos and associated health risks.

The gold was the point. The mercury was the secret.

The former yielded a one-time profit and was thereafter mostly sequestered, made into coins or worn as ornaments… The latter was dispersed in all the streams in which and near which gold was mined... More than a century and a half later, the mercury continues to spread, pervading thousands of miles of stream and river, continually flowing with the rivers of the Gold Rush into the San Francisco Bay ...In stream, river, bay, and ocean, it enters the bodies of aquatic creatures, moves up the food chain into bigger fish, and then into other predators, including our own species, where it particularly affects the mental capacities and nervous systems of young children and unborn children, so you can say that at least indirectly, gold dims the minds and drains the futures of the youngest among us.

-- Solnit

Mercury

Mercury is an element used in mining to extract gold from sediment. Sediments polluted with mercury from placer, hard rock, and especially hydraulic mining are distributed throughout the stream system of the Gold Country, and wash downstream into the San Francisco Bay and Delta. Elemental mercury in the water system can be converted by microbial action to methylmercury, a form that bioaccumulates in tissue, working its way up the food chain to fish, humans, and wildlife.

Health Impacts of Mercury

The CSU, Chico School of Nursing reviewed articles pertaining to mercury, its history in the Sierra Nevada, and its ubiquitous existence in Sierra water bodies.

The key finding from this review is that fish consumption is the primary route for mercury exposure. Consumption of fish is part of a healthy diet, as it provides a good source of beneficial proteins and omega-3 fatty acids. However, mercury from contaminated fish can accumulate in the human body and cause serious health problems.

Mercury damages the brain, nerves, and immune system. Mild mercury poisoning causes tingling in the lips, tongue, fingers, and toes. In some cases, these symptoms do not appear until long after exposure. Severe mercury poisoning causes headaches, memory loss, difficulty coordinating movement and vision, dizziness, a metallic taste in the mouth, muscle spasms, pain and stiffness in joints and muscles, and nervous heart. Breathing the vapor released by retorting (boiling off) the mercury from an amalgam with gold can cause immediate death.

Children and fetuses are especially vulnerable to even low levels of mercury exposure. The effects of mercury exposure during childhood include slow development and impairment of language and memory. Mercury may cause coordination problems, delayed walking, and attention disorder. High exposures during pregnancy can cause birth defects and mental retardation in children.[2]

Although all forms of mercury are toxic to humans, methylmercury is considered the most toxic. Methylmercury is the form most readily incorporated into the body and which most readily crosses the blood-brain barrier.[3]

The Federal Drug Administration (FDA) and the Environmental Protection Agency (EPA) recommend that young children, women who are pregnant or could become pregnant, and nursing mothers limit their exposure to mercury. The EPA recommends limiting consumption of fish likely to contain mercury to no more than 12 ounces per week.[4]

All women and children should be especially alert to the hazards of fish caught in Sierra lakes, rivers, and streams. Predator species that are higher on the food chain such as bass and brown trout are of particular concern. Biomagnification of mercury results in exponentially higher levels of mercury in these fish than in fish lower on the food chain.[5]

This Initiative did not find any articles quantifying the number of individuals who eat contaminated fish and measuring the subsequent levels of mercury in their bodies. Anecdotal evidence suggests that individuals who rely on fishing for a part of their diet may not obtain fishing licenses and therefore might not be aware of where fish advisories would be posted. No reports tracked individuals who ignore or are not aware of posted fish consumption warnings in areas of high exposure. Additionally, there are no studies of baseline mercury loads in the human body in the Sierra.

Because of this lack of studies, the full magnitude of the effect that mercury has had on the health of Northern California human populations is unknown.

Children and fetuses are especially vulnerable to even low levels of mercury exposure.

Figure 30

Mercury-Contaminated Fish

Methylmercury contamination of fish is the main source of human exposure to mercury in the Sierra. The highest levels of mercury in fish tissue tested in the Sierra Nevada were found in the Bear River and South Yuba River watersheds. The Office of Environmental Heath Hazard Assessment (OEHHA) screening level for mercury is 0.30 parts per million (ppm) and the FDA action level is 1 ppm. In the Bear River, brown trout were found to have 0.45 ppm of mercury,[6] 25% over the OEHHA screening level. In Camp Far West Reservoir on the Bear River, spotted bass were found to have up to 1.6 ppm of mercury, more than one-and-a-half times the FDA action level.[7] Many other streams, creeks, lakes, and rivers in the Sierra have not been tested for mercury.

Figure 31

Fish advisories are in effect for numerous water bodies in the Sierra where fish tissues have been found high in mercury. These advisories are posted in areas where gold mining occurred, especially in the Yuba and Bear watersheds.

A 2002 report by the Delta Tributary Mercury Counsel (DTMC) concludes: "Modification of human fish consumption patterns is the only control measure that can, at this time, be predicted with certainty to protect human health from excess mercury uptake."

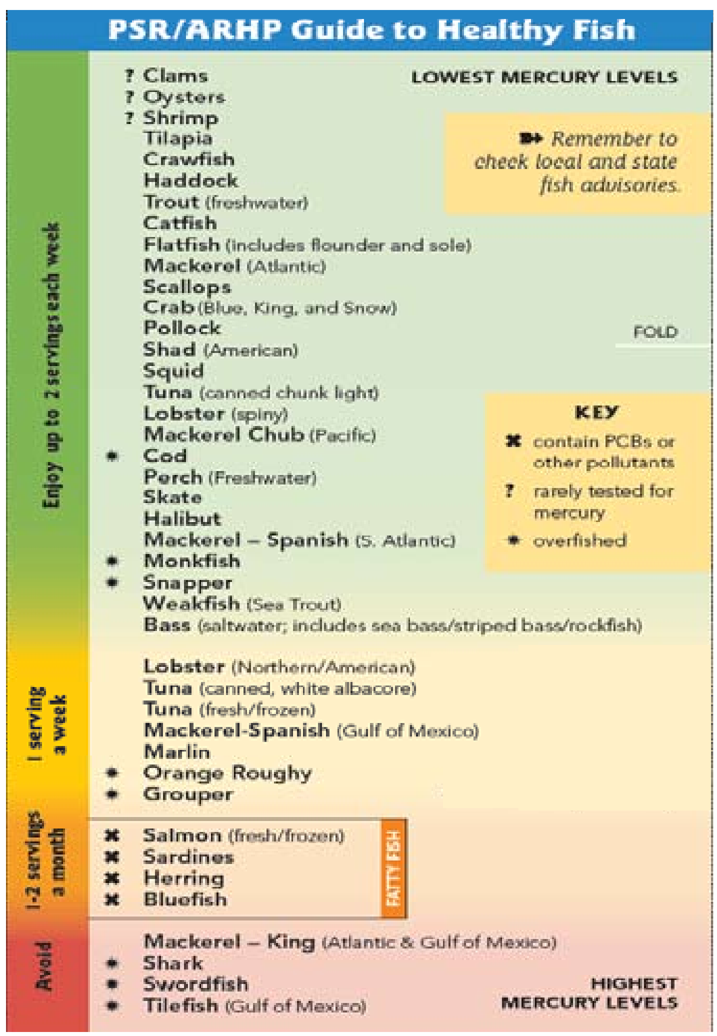


Figure 32

Arsenic

Arsenic is associated with gold mineralization throughout large regions of the Sierra Nevada. Natural, "background" levels of arsenic in the Sierra sometimes exceed EPA standards for arsenic in soil.[8] Moderate to high concentrations of arsenic are found in mine waste such as lode mill tailings and waste rock deposits, which often discharge arsenic to the environment.[9] Not surprisingly, concentrations of arsenic exceeding safe drinking water standards have been identified in domestic wells in the various Sierran gold mining regions.

Arsenic is #1 on the top twenty most toxic substances list and is found in the rocks and soils of the Sierra.

Figure 33

Health Impacts of Arsenic

Arsenic is a well-known carcinogen that causes cancer of the skin, lungs, bladder, and kidney, as well as various non-cancerous skin conditions. Arsenic exposure is also linked to diseases of the heart, lungs, and brain. The potential bioavailability of arsenic (the amount of arsenic absorbed by the human body when ingested) in soil and the presence of elevated levels of dissolved arsenic in domestic wells and groundwater supplies are of primary concern to human health in the Sierra.

The California EPA has recommended lowering the currently acceptable levels of arsenic in drinking water due to documented cancer risk. In January 2006 the US government officially lowered the maximum contaminant level for arsenic in drinking water from 50 micrograms per liter (μg/L) to 10 μg/L. California has established a risk-based public health goal of 0.004 μg/L.[10]

Estimated daily dietary intake of inorganic arsenic in the United States ranges from 8.3 to 14 micrograms per day (μg/day).[11] Food, smoke, and drinking water are the main exposure routes for arsenic.

Background levels of arsenic in Sierra Nevada soil can range from 10 to 25 ppm or higher in mineralized areas.[12] The California Human Health Screening safety level for arsenic in residential soils is 0.07 ppm. This indicates the significant potential human health risk associated with arsenic and accentuates the need for further studies on the bioavailability and toxicity of arsenic in the Sierra.

The bioavailability of arsenic in Sierra Nevada soils has not been extensively studied. The degree of human health risk associated with arsenic exposure by inhaling particles during activities such as road construction or off-road vehicle recreation has not been studied for the amount of arsenic absorbed and the impact of exposure on human health. Finally, the epidemiologic connection between living in the Sierra Nevada and increased risk of disease or other health effects from arsenic exposure has not been studied.

Asbestos

Asbestos is a group of highly fibrous minerals associated with serpentine and ultramafic rock. Minerals containing asbestos are found in distinct geological zones across the Sierra Nevada foothills. Some of these areas were disturbed by historic mining activities. Asbestos occurring in natural mineral deposits can be released to the atmosphere when these deposits are disturbed.

Asbestos fibers are chemically inert and do not undergo significant degradation in the environment. Although asbestos is not volatile, when disturbed, small fibers and clumps of fibers can be released into the air as dust. Because of their small size and durability, asbestos fibers can lodge in lung tissue and remain for long periods of time. Asbestos has long been recognized as a health hazard and has been regulated in the United States since 1972. Exposure can result from occupational contact or contact with naturally occurring asbestos in the environment.

In California, asbestos is commonly found near fault zones and in ultramafic rock, including "apple green" serpentine. Serpentine is so prevalent in California that it is the state rock. The amount of asbestos typically present in these rocks ranges from less than 1% up to about 25%, and sometimes more. The three common types of asbestos in the Sierra are actinolite, amphibole, and chrysotile.[13] Asbestos can be released from ultramafic and serpentine rock if the rock is broken or crushed, as is often the case in mining operations.[14]

Serpentine rock, which bears asbestos fibers, is so prevalent in California that it is the state rock.

Figure 34

Health Impacts of Asbestos

Asbestos is proven to cause asbestosis, lung cancer, pulmonary fibrosis, mesothelioma, and possibly gastrointestinal, colorectal, throat, kidney, esophageal, and gallbladder cancers. Asbestos has been classified as a known human carcinogen by the U.S. Department of Health and Human Services, the EPA, and the International Agency for Research on Cancer.[15] Mesothelioma is the most common form of cancer associated with asbestos exposure, and is almost always caused by inhalation of asbestos fibers.

The health risk from asbestos exposure is estimated based on exposure concentration, duration and frequency, and the size, shape and chemical makeup of the asbestos fibers. A history of smoking can compound the health risk.

Inhalation is the primary route by which the general population can be exposed to asbestos. Small quantities of asbestos fibers are ubiquitous in the air in California. Common sources include windblown soil from hazardous waste sites, deterioration of automobile clutches and brakes, or breakdown of other asbestos-containing products such as insulation.

In some areas of the Gold Country where serpentine materials were mined for gold, large piles of crushed waste rock were left behind. This waste rock was later used as gravel in road construction. Recognizing that the use of serpentine for gravel road construction was common in certain areas of California, the State of California Department of Toxic Substances Control (DTSC), with funding from the United States Environmental Protection Agency (EPA), conducted a study of potential human exposure to asbestos from gravel roads.

Figure 35

In April 2005, DTSC published a study indicating that vehicle traffic on roads surfaced with serpentine gravel may pose a health risk. For this study, researchers drove vehicles down roads surfaced with serpentine gravel to determine the amount of airborne asbestos particles generated. DTSC measured levels of asbestos in dust generated at various speeds and at various distances from the road. Road surfaces in the Garden Valley, California (El Dorado County) study contained an average asbestos concentration of 2%. DTSC also demonstrated that resurfacing the roadway would reduce the amount of asbestos in the air by 98%. DTSC currently recommends that driveways covered with serpentine aggregate be resurfaced.[16]

In El Dorado County, residential development has expanded into areas where outcrops of naturally occurring asbestos are present. Naturally occurring asbestos has been identified in rocks and soils on and around Oak Ridge High School in El Dorado Hills where a vein of asbestos was disturbed during construction of a soccer field in 2002. Results of a United States EPA study of the Oak Ridge High sports field showed that engaging in a variety of sports and play activities can expose individuals to significantly elevated levels of amphibole and chrysotile asbestos.[17] Other studies have shown a correlation between exposure from riding dirt bikes in areas of naturally occurring asbestos and increased cancer risk.[18]

The health risk posed by naturally occurring asbestos exposure in populated areas, including housing developments, hiking trails, and schools, remains a topic of contention. The literature reviewed, however, indicates that no measurable level of exposure to asbestos can be considered safe, and Sierra residents are subject to particularly high levels as a result of historic mining activities.

Impact of Mining Toxins on Wildlife and Ecosystems


Figure 36

Mining toxins' impacts on wildlife have been well documented in the cases of acid mine drainage from abandoned mines. Before the Walker Copper Mine in Plumas County (now a Superfund site) was remediated, overflow from the acid mine toxins during storms would cause conspicuous fish kills for miles down the Feather River.

In contrast to acid mine drainage, the impact on wildlife of exposure to mercury has not been studied. Although the bioaccumulation and biomagnification of mercury through food chains is understood, the full impact of mercury consumption on wildlife, from invertebrates to fish, birds, and mammals, is not well understood.[19] Bioaccumulation and biomagnification through the food chain are especially important in evaluating wetlands restoration projects, which may facilitate the conversion of elemental mercury to methylmercury.

The full impact of mining toxins on wildlife has not been studied.


Figure 37

Human Exposure in the Gold Country

Survey of Sierra Health Care Providers

The CSU, Chico School of Nursing conducted Key Informant Interviews with health care providers in the Sierra region. The methods used and questions asked in the Key Informant Interview process were first approved by the Human Subjects Ethics Review panel at CSU, Chico, where use of human subjects in research is governed by federal regulations for the protection of human subjects.

The goal of the study was to see whether people in the Sierra Nevada seek care for health symptoms that may be related to environmental exposure to mining toxins. Targeted communities included Nevada City/Grass Valley, Oroville, and Red Bluff. Public health clinics, family clinics, Indian health clinics, and community clinics were contacted for an interview, or to complete a questionnaire.

Researchers in hazmat suits found elevated levels of asbestos at a school playing field.

Figure 38

The completed interviews and questionnaires present a sobering picture. The nursing study found that none of the health clinics interviewed had an environmental history form, and only six of the thirteen clinics requested information about ways to recognize environmental exposure to toxins. None of them included information about mercury contamination as part of their maternal/infant health programs, despite the fact that the clinics serve a population known to fish, in a region with published warnings against eating the locally caught fish.

Informants were asked to report their greatest environmental concern for their community. Air pollution was the greatest environmental concern, followed by pesticide exposure. Despite the fact that each informant had environmental concerns, none reported the use or availability of an environmental history form in their clinic.

Only 55% of the individuals completing the interview stated that they lived in the community where they worked as a health professional. The fact that 45% of individuals completing the interview did not live in the community should be noted, as it may indicate that clinic staff are not familiar with local conditions such as fish advisories.

Obstacles

Difficulties in the Key Informant Interview process identified potential barriers to acquiring comprehensive data. Of the thirteen clinics contacted initially, two completed the interview. One interview was conducted in person and one was conducted by telephone. Due to the low Key Informant Interview completion rate, the Sierra Fund contacted the Northern Sierra Rural Health Clinic Network, which assisted by distributing and collecting an additional nine questionnaires.

Health care professionals were reluctant to provide information for the interview about the potential health effects of mining in their area. In some cases the interviewers were passed from person to person as clinic personnel were unwilling—or stated a "lack of authority"—to complete the interview, even though the standard interview text assured clinics and informants that they would remain anonymous. Nurses and Nurse Practitioners were the most likely to complete the interview.

Figure 39

While the information collected is from a small sample of area clinics and health professionals, it can still be used to distinguish whether the public is being informed of potential exposure risks. Without access to an environmental history, practitioners will certainly be less likely to ask questions that may alert them to possible environmental exposure. Even without an environmental history, 36% of informants indicated that they had seen a client at the clinic with symptoms that might indicate environmental exposure to mining toxins.

Figure 40

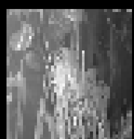
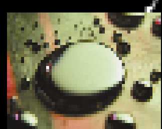
Toxin	Source	Potential Exposure	Potential Health Effects
Arsenic 	Naturally occurring in the Sierra Disturbed and distributed by historic mining	Consumed in Sierra well water Inhaled in dust from mine tailings	Cancer of the skin, lungs, bladder, and kidneys Skin conditions Heart, lung, and brain diseases
Asbestos 	Naturally occurring in the Sierra Disturbed and distributed by historic mining	Inhaled in dust from mine tailings, gravel roads, and other exposed areas	Asbestosis Mesothelioma Pulmonary fibrosis Lung cancer
Mercury 	Imported to the Sierra during the Gold Rush Currently present in Sierra watersheds	Consumed in fish from mercury-polluted areas, particularly predatory fish	Damage to brain and nerves Damage to immune system Birth defects Developmental disorders in children

Figure 41 - 44

1. McGeehin, Qualters, and Niskar 2004
2. Hardrock Mining in California 2004
3. ATSDR 1999; ATSDR 2006b; Morbidity and Mortality Weekly Report 2001
4. Goldman and Shannon 2001; Schober and Jones 2003; California DHHS 2006; Levenson and Axelrad 2006
5. Levinson and Axelrad 2006
6. Alpers and Hunerlach 2000
7. *Ibid.*
8. Welch 2006
9. Ashley 2002
10. OEHHA, California EPA 2004
11. Tsujii et al. 1998
12. Ashley 2002
13. CA Geologic Survey
14. ATSDR 2001a
15. ATSDR 2001d; National Toxicology Program 2005
16. DTSC 2005
17. U.S. EPA 2005
18. U.S. EPA 2006a
19. Efroymson et al 1997

Obstacles to Solving the Problem

Many obstacles to responding to this problem have been identified. These obstacles can be grouped into three broad categories:

1. Lack of Health Hazard Screening
2. Poor Community Education and Consultation
3. Inadequate or Underfunded Government Programs

1. Lack of Health Hazard Screening

The presence of mercury, arsenic, and other mining toxins in the region has been established. The potential health risks from exposure to each agent are understood to some degree. There is no existing evidence, however, showing the impact of this exposure on humans in the region. This is due to the fact that there has been no research, no screening, and no studies to look into evidence of impact. Consequently, few Sierra residents comprehend the magnitude of the toxin problem in their region.

It is striking that none of the health clinics surveyed by CSU had an environmental history form of any kind, and none of them included information about mercury contamination as part of their maternal/infant health programs. This finding was particularly problematic in light of the fact that the clinics serve a population known to fish, in a region with published warnings against eating the locally caught fish. This also reflects the lack of documented impact of mining toxins on human health, without which the medical community has no basis on which to act.

2. Poor Community Education and Consultation

Sierra residents do not know the environmental dangers that they may be exposed to on a daily basis. School-age children in the Gold Country are often not taught about much of the cultural and environmental destruction that was a result of the Gold Rush. The magnitude of abandoned mine lands and the threat they pose to human and environmental health are a sleeping giant in our community. As a result of lack of awareness, the community remains uninvolved.

Public meetings are required by the National Environmental Protection Act (NEPA) process to determine if there is substantial community support for mine cleanup. In many cases, however, the majority of people who show up at these public meetings are from the mining community and not the health or environmentally concerned community. With greater community support for abandoned mine remediation, more cleanup operations will be funded by state dollars.

In addition, the public has not been widely involved in development of the regulations and programs affecting mining toxins and cleanup plans. Many regulations affecting mining are adopted in Sacramento or in Washington, D.C., where it is difficult for Sierra residents to participate.

Tribal Consultation Inadequate

Public agencies struggle to coordinate and communicate with the Native community both because there is not a history of successful relationships and also because there can be a range of different governance structures and fund availability among the Native communities.

Tribes have not been consulted in site prioritization and cleanup methods on state and federal mine remediation projects that occur on ancestral lands. Tribal input into the assessment and remediation process is essential, particularly direct and regular consultation with tribes that may have sacred or historic lands affected by toxic materials.

3. Inadequate or Underfunded Government Programs

A patchwork of government agencies and regulations on the local, state, and federal levels relate to mining toxin problems, whether they are on public or private property. Additionally, the government is the largest landowner in the Sierra Nevada, and many of the lands affected are owned by public agencies.

While there are many dedicated government scientists and leaders who have devoted decades to understanding the science behind mining toxin problems, in many ways the government's response has been nearly non-existent for over 100 years. The Gold Ribbon Panel identified a number of obstacles:

Public Land Cleanup Is Not Strategic

The state and federal governments have not established a clear plan for assessing and addressing the many problems associated with the impact of gold mining on public land.

Current cleanup approaches on many public lands may not be sensitive to the long-term use of the site and deleterious effects on the environment. Site cleanup boundaries are set by parcel ownership and therefore fail to address toxins that have been transported off-site. This also makes it difficult to do a total remediation in an economical way.

Site cleanup standards depend on the relatively short-term use of that site. For example, if the site is a park with frequent use by children and families, then soil remediation levels are conservative. Sites less frequently used by the public have less stringent remediation goals.

No Incentive for Private Land Cleanup

About half the land in the Sierra Nevada region is privately owned. The responsible party is often, by default, the current property owner, even if that individual did not create the pollution or profit from the mining operation that left it. Land-use changes such as dividing or developing a property can lead to abandoned mine cleanups, but there are no incentives for private landowners to conduct voluntary cleanup. In fact, the regulatory basis at this time discourages landowners from admitting to the presence of historic mine wastes on their properties.

Regulations Not Consistent or Understandable

State regulations are ambiguous on the difference between background levels of naturally occurring toxins such as arsenic, and arsenic contamination from human activity. Where naturally occurring arsenic levels in the soil are higher than those considered safe under EPA standards, cleanup requirements can be difficult to design. The extensive, non-point nature of much of the mining toxin pollution requires a different approach than the regulations for point sources such as sewer pipes or smokestacks.

Agencies Not Coordinated Around Site Remediation

Ineffective communication among state, federal, and local agencies regarding remediation efforts and techniques makes proper remediation difficult. State, federal, and local agency cleanup projects face many similar challenges, including technical challenges, funding needs, and liability issues. All parties could benefit from increased coordination.

On private property cleanups, different agencies regulate different parts of the cleanup, and the individual owner and his or her consultant are often the only ones interacting with the local and state agencies that have jurisdiction over cleanups. This can result in differences in approach to assessing and regulating mining problems. Differing techniques for remediating the different aspects of the problem and evolving cleanup standards make it difficult for the landowner to come into compliance. Hiring an experienced consultant may be helpful to successfully moving a project through the regulatory process. Regulatory fees, consultant fees, and mitigation costs can add significant expense to private-land mine cleanups.

Abandoned Mine Cleanup Hard to Fund

Unfortunately, the majority of abandoned mine sites are currently unaddressed and have been so for a long time. Physical hazards associated with abandoned mine sites are often the primary concern of public landowners. Sites with environmental contamination are not considered high priority to public agencies unless gross contamination or an imminent health threat is apparent.

Most often the mining outfit that caused the damage has gone out of business, and the cost as well as the liability for the environmental violation falls on the public agency. Cleanup projects often begin with a potential responsible party (PRP) search.

Public land managers such as regional US Forest Service offices and BLM field offices are faced with costly environmental cleanup actions with severely limited budgets. Cleanup funds are often unavailable.

The General Mining Law enables current mining operations to continue to operate without reclamation plans that are specific to mitigation addressing legacy mining waste (i.e., mill tailings and waste rock). While new or prospective mining operations are required to mitigate environmental impacts by posting bonds, use of these funds is usually restricted to normal reclamation and revegetation when operations cease, not for undertaking cleanup of legacy mining contaminant issues.

Suction Dredging Regulations Outdated

Regulations on suction dredging are outdated. New studies indicate that suction dredging has the potential to spread mercury in the environment in highly mobile and highly reactive forms. Suction dredging tests run by the State Water Resources Control Board (SWRCB) found that mercury concentrations in the sediment processed by the dredge were more than ten times higher than those required to classify it as hazardous waste.[1] The consequences of having floured (atomized) mercury are unknown. Floured mercury may be more likely to methylate and enter the food chain because of its highly reactive form. In addition, the effects of multiple suction dredges operating year-round are unknown.

Improper Disposal of Recovered Mercury

Suction dredgers have publicly testified about the large quantities of mercury that they recover during routine gold mining. Questions have been raised about how and where this mercury has been or should be disposed of. Currently, much of the mercury recovered from industrial filtration or other sources is "recycled" into the world market. This material can be sold to miners in other countries who may use it for gold mining, potentially contaminating watersheds around the world.

Mercury concentrations in the sediment processed by a suction dredge were ten times higher than classified hazardous waste.

Figure 45

Reservoir Management Aggravates Toxin Issues

Reservoirs in the Sierra are filling up with sediment from the stream network above the dams and from undammed tributaries. These headwaters networks and tributaries transport material from hydraulic mining operations during high-flow events.

The hydraulic mining debris generated over a century ago is still in tributary channels because streams do not have sufficient power to flush the sediments downstream except during storm events. In many cases the hydraulic mining debris is laden with elevated levels of mercury, lead, and arsenic. The accumulation of this contaminated sediment behind reservoirs reduces the water storage capacity of the reservoirs and creates a maintenance problem for agencies that operate the reservoirs.

Current reservoir management practices include dredging out this excess material and selling it as gravel aggregate. Dangers associated with this procedure include re-suspending and re-mobilizing toxins, increasing mercury methylation and therefore increasing the chances of impacting aquatic life in the reservoir and downstream.

Construction Materials Not Tested

The use of local aggregate fill is not effectively regulated for arsenic, mercury, and other contaminants, although there are regulations requiring road gravels to be tested for asbestos before sale. There is no routine screening of construction materials, nor is the source of the materials available. In fact, some construction materials sold for remediation or restoration purposes have had the same concentration of toxic constituents as the sites that are being remediated. Without regular testing of construction and remediation materials, stream restoration and mine remediation will not be effective.

Government Mine and Reclamation Policies Outdated

Two laws govern mining and reclamation activities: the state's Surface Mining and Reclamation Act (SMARA) and the federal General Mining Law of 1872.

Mining practices and land-use practices have changed dramatically since 1872. The 1872 General Mining Law provided a legislative foundation for frontier mining practices and encouraged westward migration. It included no consideration for environmental damage caused by mining or for reclamation of mining lands.

The 1872 General Mining Law enables current mining operations to continue to operate without reclamation plans. The mining industry is currently exempt from the Emergency Planning Community Right to Know Act. New or prospective mining operations, on the other hand, are required to mitigate operations, which includes setting aside funds for cleanup when operations cease.

After a mine is remediated it can still be reopened by any "prospective miner." Due to the antiquated General Mining Law of 1872, any mining operation can mine public lands, including areas that have undergone a formal cleanup process. Public landowners, such as the US Forest Service and BLM, risk allocating funds to clean up lands that may not stay retired.

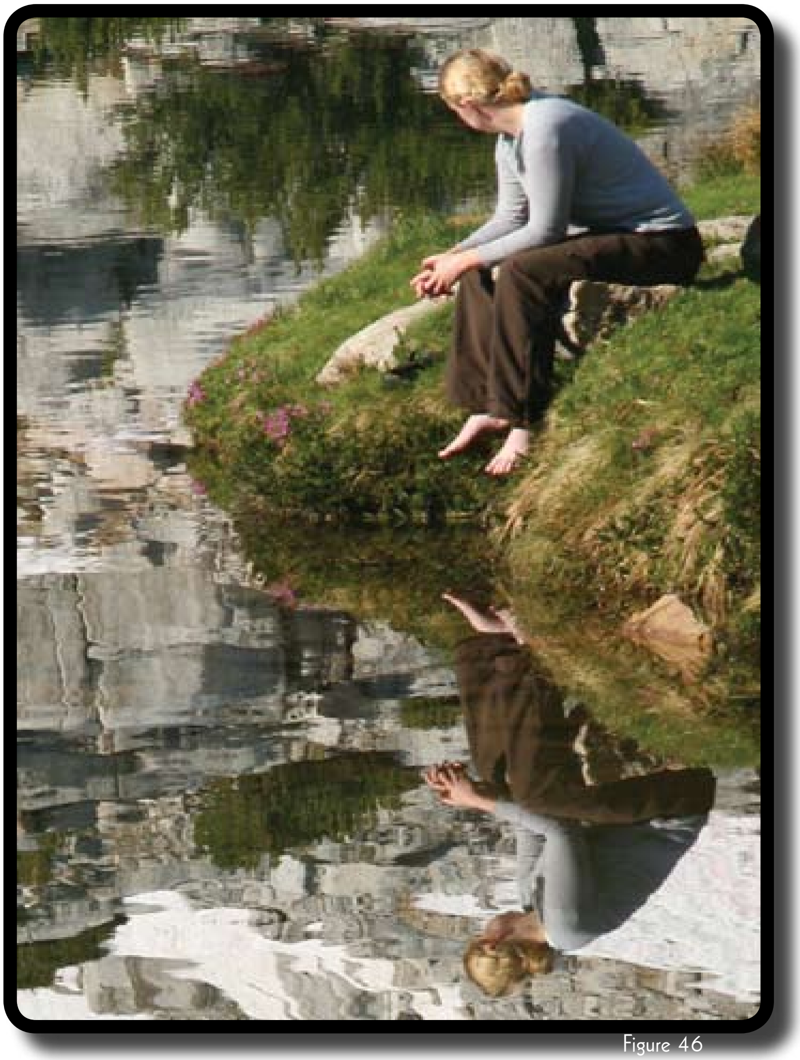


Figure 46

1. Humphreys 2005

Recommendations for Action

The Initiative's Gold Ribbon Panel of experts has identified the key to solving this vast problem as the development of a strategic alignment among indigenous tribes, scientists, local landowners, government representatives, philanthropic and conservation organizations, and the health community in the Sierra Nevada, based on mutual need and desire to find solutions.

The Panel recommends that the newly established Sierra Nevada Conservancy (SNC) serve as primary coordinator to implement the areas of activity proposed. The Conservancy's tightly described geographic scope includes a majority of the areas impacted by mining; its governance structure includes state, local, and federal representatives; and its mandate clearly encompasses the issue and approach. Funding for this purpose should be made available to the Conservancy immediately.

Also relating to implementation of all the areas of activity, the Panel calls for strategic investment in research, education, and cleanup. Private philanthropic resources need to be recruited to document and highlight the problem in order to help attract the public funds needed to address mining's toxic legacy. State and federal funding must be directed to the Sierra Nevada mining problem over the next several decades.

The Panel further identified four key areas of activity to begin to address mining toxin issues:

1. Increase Collaboration and Research
2. Improve Outreach and Education on Human Health Hazards
3. Improve Environmental Health Awareness and Outreach
4. Reform and Fund Government Programs

Figure 47

1. Increase Collaboration and Research

The most crucial finding of this Initiative is that research across many topics, disciplines, and regions is needed to understand what the problems are and how to solve them. A new communication infrastructure is needed to promote new collaborations between key governmental, academic, and medical institutions; facilitate sharing of research; and stimulate the implementation of this Initiative.

Form a Mining Toxins Working Group

The Sierra Nevada Conservancy should support the development of a Mining Toxins Working Group to include researchers at the University of California and California State University, government researchers, tribes, community-based groups, and others to ensure good information exchange on these issues. A mining toxins clearinghouse needs to be created and maintained by the SNC for all information related to this Initiative. Information would include reports, scientific research, legislation, present and potential funding, and present and proposed agency policies and law.

The Working Group should address some of the following topics identified by the Gold Ribbon Panel. Based on the literature reviews, interviews, and community input, the Initiative has identified three areas needing research:

A. The health impacts from exposure to mining toxins
B. The distribution of mining toxins
C. How to clean up mining toxins in the region

A. Research human health impacts resulting from exposure to mining toxins

A comprehensive risk screening program should be established to identify and prioritize risks of abandoned mine sites and mining-related toxins that affect human and ecosystem health.

Determine Exposure

Studies to determine exposure in the Sierra should begin with surveys designed to provide information on exposure routes. People's recreational and occupational activities should be studied, as well as eating habits and sources of food. While people are being surveyed, they should be informed of the Initiative and given educational materials on known risks of toxic mine wastes such as local fish consumption and the dangers of dust from off-road vehicle use or driving on gravel roads.

Figure 48

Human Screening Is a Top Priority

There is a need for immediate testing of individuals in the Sierra to determine exposure to and absorption into the body of mining toxins. Testing protocols should also include survey questions about potential exposure routes and education on how to avoid future exposure. Testing must be conducted with full disclosure to the participant, and individual results must remain confidential with stringent privacy controls in place.

Any human health screening must be done with sensitivity to cultural practices and privacy, and with a clear educational component. Determining the most appropriate tests for various mining toxins and ensuring high quality of data analysis are important tasks for medical researchers to develop in consultation with rural and tribal health clinics and other entities with a presence in the region.

Particular emphasis should be placed on testing individuals from vulnerable populations for certain toxins. Testing for mercury exposure should include, for example, the fetus and newborn/nursing infants, and persons at risk for high mercury exposures due to local environmental conditions, high dietary sources, and activities such as sustenance or sport fishing. Local environmental conditions also define high-risk populations for arsenic and asbestos exposure.

B. Research the Geographic Distribution and Biogeochemical Behavior of Mining Toxins

An important conclusion from the Initiative's science advisors was the outstanding need for research in two areas that will shed light on the overall problems at hand: (I) source and speciation, and (II) monitoring and modeling of mining toxins.

Although the locations of historic mines are known, the present day distribution of mining toxins is not.

Figure 49

I. Source and Speciation Research Needs

The sources and volume of mine waste and associated toxins are widespread and difficult to track and quantify. The sediment transport and erosion processes responsible for transporting mine wastes in watersheds make identification of hotspots and effective remediation strategies complex. Identifying areas where sediments originate and accumulate, however, will assist in targeting areas for remediation.

Areas where sediments are known to accumulate include reservoirs and smaller tributaries of rivers in the Sierra. Tributaries typically have low stream power and have not flushed mining debris from their channels.

Research Mercury Methylation, Bioaccumulation, and Exposure Routes

The Strategic Plan for the Reduction of Mercury-Related Risk in the Sacramento River Watershed (DTMC 2002) identifies several sources contributing to mercury transport in the environment:

a. Erosion and leaching from historic gold mining sites

b. Re-suspension of contaminated sediments

c. Releases from mineral mines and waste disposal sites

Erosion and leaching from historic gold mining sites has not been estimated for watersheds in the Sierra Nevada. Re-suspension of contaminated sediments and release of toxic chemicals from mineral mines, reservoir operations and maintenance, and waste disposal are also unquantified sources. Additional research is needed in these areas so that sources of mining sediments can be eliminated by removal or immobilization.

The episodic, variable nature of sediment-bound mercury transport from mine-impacted watersheds requires that water quality sampling efforts employ continuous stormwater sampling rather than isolated stormwater samples. Studies in the Sacramento River watershed indicate that movement of total mercury occurs during peak flow events that carry mercury adsorbed to particulate material.[1] These studies found that large flood events, such as the January 1997 event, transport mercury adsorbed onto fine-grained suspended sediments to downstream areas. Studies linking sediment transport and toxic mining constituents, such as mercury and arsenic, in the Sierra Nevada are mostly lacking.

Mining areas that produce elevated sediment loads require continuous monitoring of discharge and suspended sediments along with periodic water sampling for total metals. Even relatively short-term sampling programs of one or two winter/spring runoff seasons could yield greatly improved datasets for evaluating remediation priorities.[2] Non-governmental organizations such as the South Yuba River Citizens League or Friends of Deer Creek could be helpful in recruiting volunteer monitors for this activity.

Understanding the mechanisms by which key chemical elements cycle through the environment and the processes that make them more toxic will help identify actions that could reverse these processes. For example, understanding the processes and conditions that favor mercury methylation may lead to a way to interrupt them and reduce the amount of methylmercury in the environment.

Understanding Mercury Methylation

Controls on methylation of mercury are fundamental to controlling the hazards posed by the toxin. The State Water Board regulates for total mercury in water and sediment, when in fact the constituent of concern is methylmercury in tissue. No current studies confirm that reducing the amount of total mercury in the environment will also reduce the amount of methylmercury found in fish tissue.

Research on the impact of methylmercury on wildlife reproduction and survival is also a critical data gap. The environmental conditions that favor mercury methylation need to be understood in order to reduce the amount of methylmercury found in fish and birds.

Recent research has shown that methylation of mercury depends on a complex interaction of sulfate- and/or iron-reducing bacteria, oxygen, organic matter, and pH. Some studies indicate that organic processes and conditions present in reservoirs and wetlands may play a role in mercury methylation, but the precise conditions and management practices that contribute to methylation are not well understood.

A more complete understanding of how these factors interact may make it possible to monitor a precursor to methylmercury, predict the methylation potential of an area, and use wetlands to remediate methylmercury via de-methylation. Research on wetland de-methylation is primarily taking place in the Bay and Delta; however, parallel studies should also be conducted in the Sierra. The role that Sierra riparian wetlands, reservoirs, and meadow wetland environments play in methylating or de-methylating mercury is unknown.

A number of activities are occurring in Sierra watersheds that may increase the likelihood of mercury methylation:

- Dredging during routine reservoir operation and maintenance re-suspends sediment settled at the bottom of the reservoir and may create an environment where elemental mercury becomes methylated and incorporated into the food chain.
- Hydropower turbines oxygenate and agitate suspended sediment and may increase the reactivity of elemental mercury. Monitoring is necessary above and below hydropower turbines on Sierra reservoirs to determine the extent of this threat.
- Suction dredges re-suspend and flour mercury, increasing the surface area and making it more readily available for bacteria to methylate.[3]

These technologies need to be evaluated for their impact on water quality. In addition, further studies on the water quality impacts of these activities must be conducted, particularly as they relate to mercury toxicity and bioavailability.

The processes that lead to methylation of mercury are incompletely understood and fundamental research on the hydrologic, biological, and geochemical mercury cycle is warranted in order for regulation of mercury to be effective at protecting human health.

Research Arsenic Bioavailability and Exposure Routes

Arsenic can be found in numerous forms that can be inorganic or organic in nature. Some of these forms are more bioavailable, or more readily taken up by living organisms, and therefore have a greater toxic effect.[4] Understanding the bioavailability of arsenic and exposure pathways to human receptors is long overdue and essential to evaluating the health risk to residents of Sierra communities.

Elevated levels of naturally occurring arsenic frequently occur in the soil and geologic formations in the Sierra. Soil remediation levels for arsenic are based on site-specific determination of background levels. Cleanup goals are usually set based on the total arsenic concentration; however, the bioavailable fraction of the total arsenic may be from as little as 2% to as much as 50%.

Research and Map Asbestos Sources

Exposure to naturally occurring asbestos in the Sierra is caused by disturbance of geologic formations and soils. In contrast to arsenic toxicity, asbestos toxicity is well understood. Areas where naturally occurring asbestos (NOA) occurs can be deduced from geologic mapping, though more specific mapping of the Sierra at a level of detail useful for land-use planning is needed. These maps should be made readily available by the SNC to county land-use and planning departments to mitigate development in areas where there is NOA.

II. Monitoring and Modeling Research Needs

Very few monitoring programs address the transport of mining toxins within the Sierra region. Environmental assessment of mining toxins generally occurs only when a development is proposed on parcels with historic mining features. Regular monitoring across the Sierra is needed to identify source areas and to understand the processes that transport mining toxins off site and redistribute them in downstream and downslope areas. This calls for studying areas downstream of known mining sites that have released or continue to release toxic chemicals and studying secondary sources of toxins such as sediment and vegetation.

A comprehensive approach to addressing mining toxins would include incorporation of site characterization data and predictive modeling. Analysis of existing data combined with additional monitoring could be used to build predictive models for the toxic risk of a site based on factors including: mining history (aerial extent of ground disturbance, volume of mine waste on site, etc.), hydrologic characteristics (runoff production, proximity to surface waters, soil hydrologic group, etc.), and particularly environmental hazards that could endanger nearby urban areas.

Developments in the Sierra have been built on mine tailings, houses have been built over shafts, and mine waste has been used as road aggregate. All of these activities can spread mining toxins. Transporting mine waste off site spreads the problem and affects new areas. Areas where development and toxins come in contact need to be identified and research conducted into best practices for managing these hazards.

Developments in the Sierra have been built on mine tailings, houses have been built over shafts, and mine waste has been used as road aggregate. All of these activities can spread mining toxins.

A Sierra-wide database needs to be created that enables a systematic approach to identifying and prioritizing areas of concern. Lack of funding and limited agency coordination continue to be limiting factors to the development of such a database. Spatial information technologies make it possible to conduct system-wide approaches that compile and synthesize many data types into a single database.

C. Research how to effectively assess and clean up the contamination distributed throughout the region

Any remediation plan must address how to identify, prioritize, and stabilize sites of acute toxic contamination and how to apply innovative remediation techniques to sites of acute toxic substance release.

Development of a comprehensive and interrelated inventory of abandoned mine sites in California and a strategy to rank the sites for toxic risk and, therefore, remediation potential is crucial. More research is needed into the vast number of mines and mining features to ensure systematic and comprehensive efforts to clean up the abandoned mine sites. Numerous efforts have been made to map existing mining features on public lands, but many areas have not yet been mapped in detail and many areas that have been mapped have not been verified.

Prioritizing abandoned mine sites for cleanup remains an important process for which there are numerous approaches. Unfortunately, the majority of abandoned mine sites are currently unaddressed and have been so for a long time. Physical hazards associated with abandoned mine sites are often the primary concern for public landowners. Sites with environmental contamination are not considered high priority to public agencies unless gross contamination or an imminent health threat is apparent. These health threats are often not identified.

Fish consumption advisories have been posted on many Sierra water bodies. Those currently without advisories are ones that have not been tested.

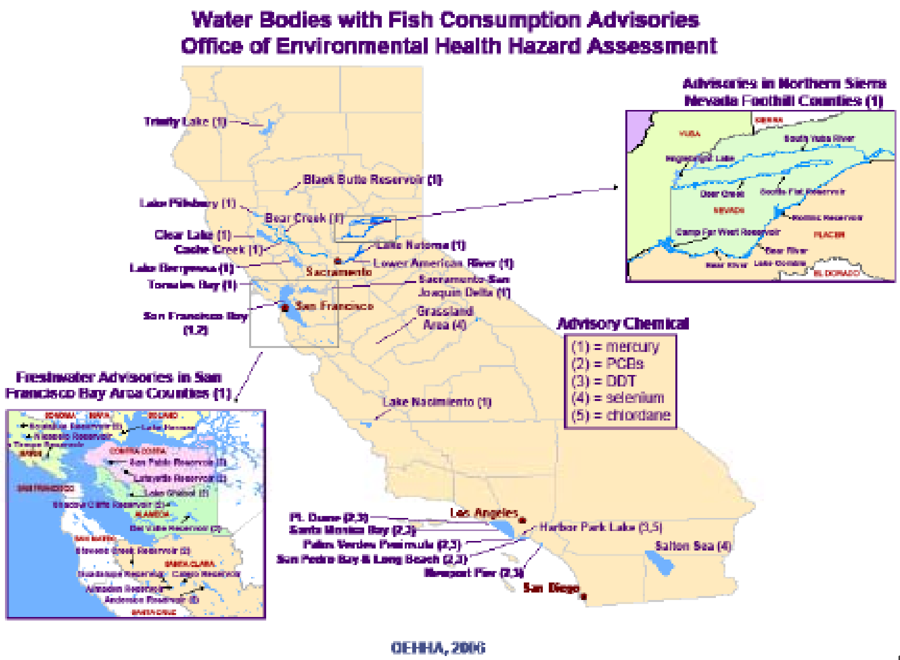


Figure 50

Standardized, science-based methods need to be developed for abandoned mine cleanups. Landowning public agencies, including the US Forest Service and the Bureau of Land Management, are tasked with technically complex environmental cleanups that are extremely expensive and challenging. The site-specific and complex nature of the problem and limited public funds for carrying out remediation projects on public lands require that planning be careful and effective.

More research is also needed to understand best practices for removing mercury and other heavy metals from sediments dredged out of reservoirs.

2. Improve Outreach and Education on Human Health Hazards

Public health outreach and education on the potential dangers of mining toxins is long overdue. A widespread and comprehensive public health education and outreach campaign aimed at limiting future exposures should begin as soon as possible.

To inform direct outreach, there must first be an investigation of potential exposures in each community to determine which populations are most at risk, what exposure levels are, what the source of that exposure is, and what actions are appropriate to take for these exposure levels. This information can then be used to develop education and training activities for health professionals and others. Health impacts from exposure to mercury or other mining toxins are very difficult to identify, but actions can be taken to reduce exposures even if health effects have not yet been demonstrated.

The goal of public health outreach is to bring about broader public understanding of the risk posed by historic mining toxins, leading to greater public awareness of and support for funding, assessment, and remediation of mining toxin problems. Health clinics in the Sierra that serve at-risk populations need information regarding recognition of symptoms and treatment for exposure to mining toxins, as well as the most cost-effective methods for testing.

State and federal agencies need to work together to improve public understanding of the potential impacts to human health presented by mining toxins. Crucial partners in this effort will be medical practitioners, First Five Commissions, and tribal and local governments.

Figure 51

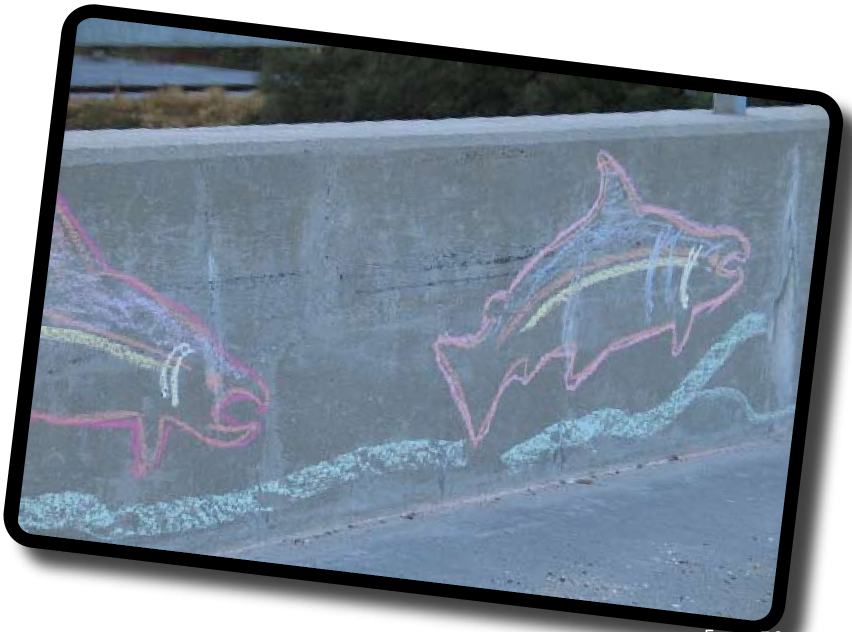


Figure 52

Top priorities for this effort include:

Outreach and Public Education

Outreach to affected communities and individuals in the Sierra should begin with information on the potential risks posed by historic mining toxins, steps to protect the health of the individual's family and community, and testing to determine exposure. Outreach should be informed by research on the effect of mining toxins on health, such as dose and response studies and risk assessments.

Outreach efforts must be sensitive to the fact that even people who have been raised in the Gold Country are unaware of potential health problems. Information needs to be made available in a variety of languages and formats, including direct outreach to sensitive individuals where possible.

Information needs to be tailored to specific communities. For example, outreach regarding fish consumption advisories should be done at bait shops and places where people are known to fish. Education about potential health impacts of dust exposure and methods to reduce dust exposure need to be directed at individuals exposed through recreation or work activities. Where asbestos is known to exist, individuals should be advised to limit their exposure to dust generated from outdoor activities.

Any information about fish consumption should include the importance of fish in a healthy diet, and education on what kinds of low-mercury fish are safe for consumption.

Establish Best Outreach Practices

Best practice models need to be established for education and outreach to the general public through the public health system. Focus groups or polling could help establish current public understanding of the issues. The results of this research could help design materials explaining risks of varying levels of exposure to the specific toxins and communicating actions that could reduce risk. These programs could include: creating and distributing brochures at Sierra clinics; publishing survey results; making public presentations; getting information into area newspapers and newsletters; and development of Web sites, a calendar of events, radio shows, videos, and Web bytes. This information should be made available in languages that reflect the community served.

Training for Medical Professionals

Clinical guidelines should be disseminated to physicians and other health providers regarding symptoms of exposure to mining toxins and appropriate diagnostic, therapeutic, and preventative actions for specific chemicals known to or likely to cause disease. Additionally, results of human health screening should be made available to these providers.

School Curriculum Improvements Needed

A curriculum should be developed for elementary- through college-age Californians that is historically accurate regarding the events and long-term impacts of the Gold Rush. It should include information on human health and environmental impacts of mining toxins in the Sierra.

Figure 53

Tribal Involvement and Resolutions

Figure 54

The Tsi-Akim Maidu Tribe is playing a lead role in bringing recognition to the grisly legacy of the Gold Rush and working to heal the wounds caused during the 19th and 20th centuries. Working in partnership with The Sierra Fund, the Tribe has sponsored a series of "Mercury in our Water, our Fish and our Peoples" workshops with tribes and community groups throughout the Sierra Nevada Gold Country. These events have resulted in the drafting of the following Call to Action by participating organizations:

We, the Tribes and Organizations supporting the Tribal Convergences "Mercury in our Waters, our Fish and our Peoples" addressing the mining toxins and the continued poisoning of our Sacred lands, water, plants and environment, recognize the need to heal ourselves and our future generations;

Whereas, there are tens of thousands of abandoned gold mine sites throughout the state of California that have left mercury, arsenic, cyanide, asbestos and other toxic metals and minerals in our water and our environment;

Whereas, one gram of mercury can contaminate an entire lake to levels above what are federally acceptable;

Whereas, recognizing that mercury and other heavy metals have a permanent and irreversible, devastating health effect on the human body;

Whereas, mining toxins have an adverse impact on salmon, other fish, birds and all other aquatic life,

Whereas, Indigenous Peoples of California depend on fishing, hunting and gathering for our traditional way of life;

Now, therefore, in the spirit of healing ourselves, our communities and our world, we the undersigned hereby make the following demands:

1. That Indigenous People exercise their sovereign rights to ensure that remediation cleanup efforts are culturally acceptable;
2. That Indigenous People work in partnership with best available technology;
3. That the State and Federal Governments conduct a timely assessment of the full extent of the toxic contamination left by gold mining;
4. That the State and Federal Governments concurrently develop and implement a comprehensive plan to remediate environmental problems;
5. That the State concurrently develop and implement health interventions;
6. That the State involve the Tribes and the public in the design of appropriate solutions to the problem and immediate implementation of those solutions.

3. Improve Environmental Health Awareness and Outreach

A crucial element of the solution is to engage the medical and conservation communities in understanding and identifying potential threats from mining toxins at work, at school, and at home.

Activities should include:

Implement Environmental Health Assessment Tool

A standardized environmental health assessment tool should be developed and distributed for clinics in the Sierra region that includes a protocol for use. An environmental health questionnaire similar to the one on lead exposure could be used as a screening tool at Sierra clinics. Health insurers should be educated about the utility of this tool to encourage them to pay for this procedure.

Encourage Public Participation in Planning and Policy Making

The medical and conservation communities should support local mine cleanup plans by attending public meetings, encouraging broad community support, and being aware of and involved in policy changes at the state and federal levels.

Encourage Community Monitoring

The local community (tribes, watershed groups, etc.) should be encouraged to collect environmental samples of water, sediment, and biota from impacted watersheds and submit them to qualified analytical testing labs. Labs with testing expertise in the region should be contacted to seek their cooperation in this effort.

Private wells in new developments are not required to be tested for low levels of mining-related toxins such as arsenic or other heavy metals. Existing wells should be tested on a regular basis. Particular attention should be placed on achieving high-quality laboratory reporting limits to match more sensitive water quality objectives. Well-test results should be compiled (to protect confidentiality) and made available to local officials and the public in order to track well-contamination problems.

Figure 55

4. Reform and Fund Government Programs

Policies pertaining to mining toxin issues range from local land-use zoning issues to federal Clean Water Act enforcement. As a general principle, these laws and policies need to be reformed to ensure that the public is informed and involved in cleanup efforts, that full disclosure and transparency are the rule when problems are found, and that, when possible, those earning money from mineral extraction contribute directly to remediation projects.

The complexity of the problem will require assessment of state and federal policy solutions across a number of topics. The Sierra Nevada Conservancy should play an important role in coordinating these activities.

Coordinate and Fund Public Land Cleanup

USFS, BLM, Fish and Game, State Parks, and other land management agencies are responsible for cleanup on thousands of acres of land. State and federal agencies should develop plans for assessing and addressing problems on public land. State and federal agencies should regularly communicate about remediation priorities and projects. Greatly increased funding for cleanup of public lands is crucial for these agencies to accomplish these tasks. State and federal land managers must define funding strategies for remediation.

To move this process forward, the Resources Agency and Cal/EPA should work together with the Sierra Nevada Conservancy to conduct an inventory of state lands in the Sierra Nevada impacted by mining toxins, including parks, wildlife refuges, reservoirs, and other properties. The state should then develop a plan for approaching these state land contamination problems, including prioritizing sites and using pilot projects to evaluate mining remediation practices. Water quality bond funds could be used for some of these projects.

The state of California should work closely with representatives in Congress to procure much more federal money for assessing, prioritizing, and remediation of federal lands with abandoned mines or other mining toxin problems in the Sierra Nevada.

Refine and Monitor Remediation Practices

The government should encourage the advancement of cleanup methods and technology by funding pilot projects. Characterization of historical mine sites should include downstream areas, and monitoring of remediation and/or land development effects should continue for long periods of time. Upstream monitoring is important to establish a baseline between normally occurring levels of toxic minerals and levels of contamination caused by mining.

All remediation, restoration, and construction activities should advance cautiously to avoid exacerbating mine waste problems. The environmental effects of various proposed remediation activities should be tested in small-scale experiments prior to implementation at larger project sites. This would include assessing the potential to remobilize sediment and induce chemical transformations of toxins.

Create Funding Mechanisms for Cleanup

Funding for watershed cleanup over the next several decades should be prioritized. This approach is clearly more environmentally and economically sound than continuing to filter out contamination forever. Opportunities for downstream water users to help fund upstream watershed cleanup need to be identified and established as soon as possible. Options include using the Pollution Credit Finance Authority mechanism, a fund created from a mitigation fee on development activities, or development of an "ecosystem" services fee for investment in the region.

Reform Suction Dredging Law

The State Water Resources Control Board (SWRCB) should consider regulatory actions to implement provisions of the Clean Water Act applicable to instream suction dredge mining. The Department of Fish and Game's regulations regarding permitting of suction dredging should address the size of the dredge, location of dredging, and the kind of dredge to ensure that water quality impacts from floured mercury are eliminated.

Improve Public Access to Decision Making

Agencies need to work harder to publicize public comment workshops and make them fully accessible and understandable to lay people unfamiliar with government regulations. Beyond running legal notices, agencies need to be pro-active in getting local governments, newspapers, organizations, and community leaders involved in helping solve the problems of mining toxins in their communities.

Improve Consultation with Tribes

Full tribal consultation and partnerships are warranted for on-site prioritization and cleanup methods for state and federal remediation projects that occur on ancestral lands. Remediation and restoration activities in the region that impact sacred or historic Native American lands need to be led and directed by local tribes. Funding for assessment, monitoring, remediation, or other activities must include funds for input from Native scientists and tribal leaders. In particular, all aspects of the California Sacred Sites Bill of 2005 must be observed before approval of any new mining activities or remediation of existing mine sites.

Figure 56

To ensure that all efforts meet proper cultural considerations and protections that are sensitive to traditional usage, agency training on effective ways to work with diverse cultural groups would benefit both parties.

Improve Coordination among Agencies

High-quality communication among local, state, and federal agencies regarding private property remediation benefits all parties. Site-by-site coordination between the federal and state cleanups could improve the effectiveness of abandoned mine cleanups.

Increased coordination and communication between the CA State Department of Toxic Substances Control (DTSC), Central Valley Regional Water Quality Control Board (CVRWQCB), and local communities would generate greater support for abandoned mine cleanups. At this time DTSC and the CVRWQCB are negotiating a Memorandum with the US Forest Service and BLM to facilitate this process.

Increase Support for Local Government Policies and Practices

Local governments hold lead authority over private land use, and in order to protect public health, must ensure management of private land development to minimize mobilization of mine wastes. Support for rural counties facing changing regulations on sanitation and water quality standards could include providing technical training and resources for local government land use staff and County Environmental and Public Health officers.

No historic mining areas should be developed without characterization and evaluation of potential adverse effects.

Provide Incentives for Private Land Cleanup

Programs to support cleanup on private lands need to be developed that both provide incentives for landowners to clean up their own property, and also present the most effective remediation practices.

Manage Reservoirs to Minimize Mercury Methylation

Improved reservoir operation and management could include dredging the contaminated material and cleaning it, using a centrifuging technology whereby the gold and mercury are removed. This type of cleanup, if proved successful, could be implemented in numerous reservoirs across the Sierra. Innovative cleanup technologies should be encouraged to keep up with operation and maintenance needs in areas that are heavily impacted by mining toxins.

Improve Gravel Testing

Sediments removed from reservoirs or recovered from mining sites or areas impacted by mining wastes should be tested for heavy metals and asbestos fibers if the presence of any of these materials is suspected. Appropriate measures need to be taken to ensure that gravels containing toxic heavy metals or dangerous fibers are not used without proper precautions to prevent further contamination.

Improve Disposal of Recovered Toxic Materials

Permitting the disposal of hazardous waste recovered from mining cleanups should be done in the most conservative and conscientious way. This includes materials that can be disposed of in landfills or by other technological methods.

This is particularly important for mercury, which can either be disposed of or recycled. There are a limited number of mercury recycling facilities that receive mercury from cleanup sites and dispose of it as hazardous waste. Methods for proper disposal of mercury cleaned up from sites need to be developed.


Figure 57

Reform Federal Mining Law

The 1872 General Mining Law needs to be reformed to require mitigation of environmental impacts from both modern-day mining and historical or legacy mining. Land managers must be empowered with discretionary authority over current mining activities that involve legacy mine sites.

Provisions for environmental standards should be specified and minimum reclamation standards established. Mine reclamation standards should include strict requirements pertaining to the characterization and remediation of legacy mine waste materials, prior to the approval of a mining plan or mining project.

The mining industry is currently exempt from the Emergency Planning Community Right to Know Act, with the exception of legacy mine sites that are designated as CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) sites. Reform of the General Mining Law should include a requirement for public notice of toxic material in use and produced by mines.

Sites where public funds are used for AML (abandoned mine lands) site cleanup must remain undisturbed in perpetuity. Agencies should use existing regulatory policies and authority to impose a land-use covenant for land-use control after remediation, such as deed restrictions on public property, so that these remediated or repository areas cannot be re-disturbed by current or future mining operations.

There is a critical need for additional federal funding to clean up legacy mining contamination. Federal mining law reform could provide these funds through a tax or royalty on active mines, as was done for the coal industry.

Strengthen the California SMARA

The California SMARA is administered by the Mines and Geology Board, and the Office of Mine Reclamation implements its policies. Environmental representation on the Mines and Geology Board should be strengthened by adding a fishery and a wildlife biologist, and strengthening the requirements for the environmental representative. The Board should also establish minimum verifiable standards for reclamation success, including revegetation of mine sites.

Reform and Enforce the Federal Clean Water Act

The Clean Water Act needs to be amended to allow public entities, such as counties or non-profit organizations, to take ownership of abandoned mines on private land in order to clean them up. Good Samaritan laws must be reformed to provide incentives for voluntary risk assessments and to encourage remediation activities.

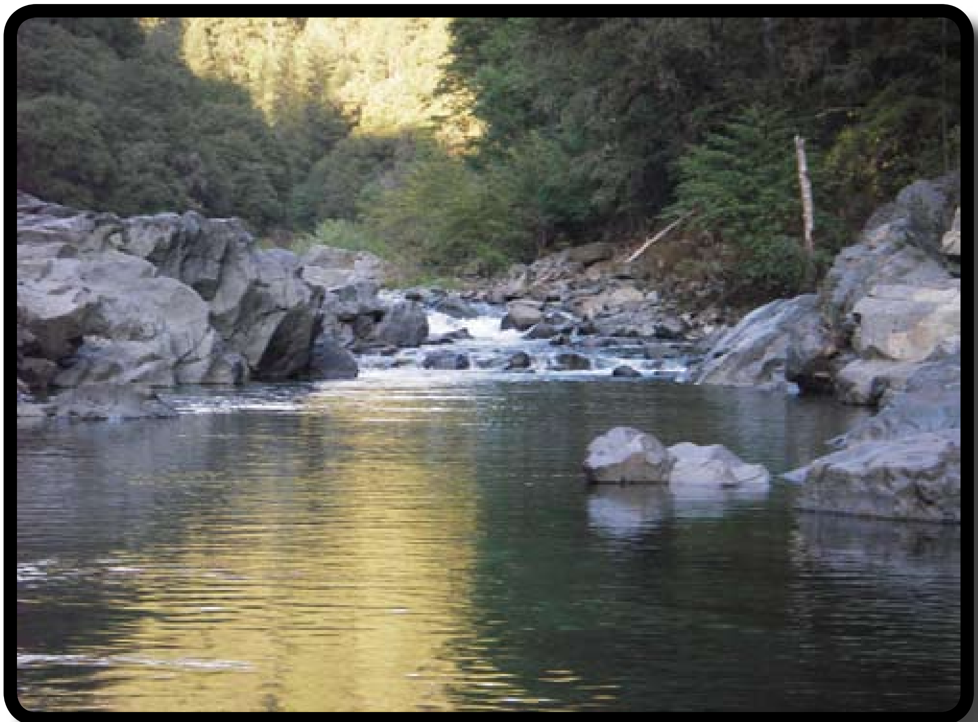


Figure 58

1. Domagalski 2001; Miller et al. 1999
2. Whyte and Kirchner 2000
3. Humphreys 2005
4. Rytuba et al. 2007; Kim et al. 2007; Savage et al. 2000; Foster et al. 1998

Numerous public agencies are addressing mining toxins on public lands in the Sierra. These include the State and Regional Water Boards, California Department of Conservation, the Department of Toxic Substances Control (DTSC), the California State Parks, the United States Geological Survey (USGS), the Bureau of Land Management, the United States Department of Agriculture Forest Service, Native American Tribes, and local governments, including cities, counties, and special districts. Non-profit groups have also received limited state and federal grants and private foundation support that have enabled them to address these issues locally.

Until recently there was no forum for public agencies to discuss their ongoing efforts to address mining toxins with one another. In 1997 an interagency group (Sierra Trinity AML Group) was founded, which focused on environmental problems associated with historic placer and lode gold mining sites in the Sierra and Klamath regions. More recently, the California Department of Conservation created a public forum in 2003 to promote dialogue on statewide abandoned mine lands issues.

There are several other public forums on facets of the mining toxin problem, especially regarding mercury contamination of the Sierra, Trinity, and San Francisco Bay and Delta regions. In many cases these forums are focused on environmental problems stemming from mine waste materials that have migrated from historic mercury and gold mine sites throughout northern and central California.

The efforts of each of these agencies, particularly in regard to legacy mining toxins from California's "golden past," are far from integrated. This Initiative proposes a more integrated intra-agency approach to addressing mining toxins on public and private lands.

This appendix serves to describe current activities of state, federal, and local non-profit and tribal agencies working on these issues.

1. California State Agencies

California Department of Conservation

The California Department of Conservation's (CDOC's) Abandoned Mine Lands Unit (AMLU) was created in 1997 to prepare a report to the governor and legislature on the "magnitude and scope" of the abandoned mine lands issue in California. The AMLU implements a field program to inventory abandoned mines, provide a preliminary assessment of any health and safety hazards observed, and remediate hazardous sites. The AMLU estimates that approximately 165,000 mine features on more than 47,000 abandoned mine sites exist statewide.

Since 1997, the AMLU has conducted field inventories of more than 16,000 mine features on more than 2,400 abandoned mine sites on public and private lands in California. The AMLU uses its Topographically Occurring Mine Symbols (TOMS) database, comprised of mine symbols scanned and digitized from US Geological Survey 7.5-minute topographical maps of California, to support its field inventory work.

Since 2002, the AMLU has also helped to remediate hundreds of physically hazardous features on public lands throughout California, using fences, backfills, bat-compatible gates, and other closures. This program is ongoing and includes working with partners such as the Bureau of Land Management, California State Office; National Park Service; US Forest Service; California Department of Parks and Recreation; California State Lands Commission; local governments; non-profits; and private companies.

Since January 2006, the AMLU's primary funding to remediate abandoned mine hazards, approximately $400,000 per year, has come from a fee collected on gold and silver ($5 per ounce of gold and 10¢ per ounce of silver) mined in California.

The CDOC's Office of Mine Reclamation (OMR) has conducted or participated in several remediation strategies to mitigate chemical hazards associated with abandoned mine lands at the Spenceville Mine, Walker Mine, Sulphur Bank and Gambonini Mercury Mines, and Leviathan Mine. For example, at the Spenceville Mine in Nevada County, the Department of Fish and Game contracted with OMR to develop a strategy to mitigate an acid mine drainage problem and reclaim the mine site to a safe and stable condition. Recently, the Budget Act of 2006 made limited funds available for CDOC to "develop remediation strategies for statewide specified chemical hazards."

The AMLU also convenes the California Abandoned Mine Lands Forum. Forum members meet quarterly to discuss and coordinate on environmental hazard and public health and public safety issues related to abandoned mine lands. Since 2007, the CDOC has also coordinated the California Abandoned Mine Lands Agency Group (formerly hosted by CALFED) and participated in abandoned mine land-related discussions relative to Southern California held by the Desert Managers Group (see http://www.dmg.gov/).

California Department of Fish and Game

The Department of Fish and Game (DFG) issues permits for suction dredge mining under Section 5653 of the Fish and Game Code. A court order entered in December 2006 in the case of Karuk Tribe v. DFG (Alameda County Superior Court case # RG05 211597) requires DFG to conduct an environmental review of its existing suction dredge regulations and to update the regulations, as necessary, to address impacts of suction dredge mining on Coho salmon and other species listed as threatened or endangered since the regulations were last updated in 1994.

DFG owns wildlife refuges throughout the Sierra Nevada. Some of them have abandoned mines on them, such as the historic copper mine in Spenceville Wildlife Refuge in Nevada County. DFG cleaned up this historic mine in 2000.

California Department of Parks and Recreation

California State Parks owns a number of "mining parks," including the frequently visited Empire Mine in Grass Valley and Bodie State Park near Bishop. These mining parks present modern-day problems for State Parks, which is charged with maintaining the integrity of the Park by highlighting the mining history and historic resources, while remediating any lasting problems on Park properties. Costs to clean up the Empire Mine alone have easily topped $10 million in the last few years.

California Department of Toxic Substances Control

The Department of Toxic Substances Control (DTSC) regulates the management of hazardous waste and the remediation of hazardous substance release sites in California. DTSC implements the federal Resource Conservation and Recovery Act (RCRA) program and the more expansive State of California law regarding the generation, transportation, treatment, and disposal of hazardous waste. In general, most active mining activities are exempt from hazardous wastes regulations because of the federal "Bevill Exemption" and the similar State exemption.

Abandoned mine lands (AML) may be regulated as hazardous substance release sites through a number of different programs within DTSC. DTSC is the lead State agency for several National Priority List (Superfund) sites. These AML sites are usually Fund Lead sites where EPA and the State fund the site cleanup. For the State, DTSC funds 10% of the cost of remedial construction and initial operation and maintenance (O&M), and all of long-term O&M.

DTSC may use state authority under the Health and Safety Code (Division 20, Chapter 6.8) to require responsible parties to investigate and clean up hazardous substance release sites including AML sites.

DTSC also implements a Voluntary Cleanup Program where oversight is provided in accordance with reimbursement agreements. Because of the rapid land development in the Sierra foothills, DTSC has provided oversight for many investigations and cleanups for the development of properties with mine wastes.

DTSC has sought to facilitate the investigation of AML sites and has prepared a guidance document, the Abandoned Mine Lands Preliminary Assessment Handbook (1998), which describes considerations and procedures for conducting initial AML site assessments. DTSC also prepared an Abandoned Mine Lands Site Discovery Process (2006) to identify AML sites that pose a threat to public health and the environment. The process integrates existing databases and other informational resources into a GIS format to identify mine features and characteristics and human population to prioritize AML sites for investigation.

EnviroStor is a Web site where much of the information about DTSC cleanup projects can be found, including schedules and documents on the AML sites.

California State University, Chico

Founded in 1887, the California State University (CSU), Chico is recognized for teaching, scholarship, research, service, and innovation. CSU, Chico brings its distinguished record to the Mining's Toxic Legacy Initiative, providing research and literature review on the health and environmental impacts of mining in the Sierra.

Sierra Nevada Conservancy

The newly established Sierra Nevada Conservancy (SNC) has a broad mission that includes protecting water quality and cultural resources of the region. Although it has no specific mining program at this time, it is developing an extensive library that will include information about mining issues. In addition, the SNC has developed grant-making programs that may be a source of funding for projects with local government, non-profit agencies, and tribes around improving water quality, protecting historic and cultural values of the region, and educating the public about environmental and cultural impacts of the Gold Rush.

State and Regional Water Boards

The State Water Resources Control Board works with its nine Regional Water Quality Control Boards (Regional Boards) to protect California's water resources. With passage of the Porter-Cologne Water Quality Control Act in 1969, the Boards together became the "principal state agencies with primary responsibility for the coordination and control of water quality." In 1991, the Boards were brought together with five other State environmental protection agencies under the newly crafted California Environmental Protection Agency (Cal/EPA).

The State Water Resources Control Board (SWRCB) is responsible for providing a statewide perspective on a wide range of water quality planning and regulatory functions. The Regional Boards issue permits for active mine operators and direct cleanups by responsible parties where appropriate. The SWRCB works with federal agencies, such as the US Forest Service, to identify mines on federal lands that threaten water quality. It also supports watershed restoration projects that address water quality degradation from mine waste discharged into watersheds.

Projects are prioritized by threat to water quality and exposure. Regulatory programs include the 303d listings program, the National Pollutant Discharge Elimination System (NPDES) program, and the Land Disposal Program. There is no specific program at the SWRCB to address water pollution from mines directly, but rather a general approach to addressing water quality violations.
The State Board gives regulatory authority to the Regional Boards, which are more local to the cleanup site. The nine Regional Boards are semi-autonomous, with their own volunteer Board members. Decisions can be made independently from the State Board. In general, the State Board provides administration and legal support for the Regional Boards. The Regional Boards are involved in basin planning, beneficial uses, and water quality objectives such as developing Total Maximum Daily Loads (TMDL). The Regional Boards primarily grant discharge permits, called Non-Point Source Discharge Permits (NPDS).

The SWRCB is currently considering regulatory action on instream suction dredge mining. The Board held a public workshop on June 12, 2007, to gather public comments related to the effects of suction dredge mining on water quality. Clean Water Act certifications for suction dredge mining activities previously issued by the US Army Corps of Engineers and SWRCB expired in 2000 and have not been reissued. In order to protect the quality of California waters, the SWRCB is reviewing the water quality impacts of suction dredge mining, including impacts of dredging on mercury left in California streams from the Gold Rush era.

2. Federal Agencies

Bureau of Land Management

The Abandoned Mine Lands (AML) program addresses physical safety and environmental hazards associated with abandoned mines on public lands administered by the Bureau of Land Management (BLM). Abandoned mines addressed by the program are those that were abandoned prior to January 1, 1981, the effective date of BLM's Surface Management regulations issued under authority of the Federal Land Policy and Management Act of 1976, as amended (43 U.S.C. 1701 et seq.).

Over the last 150 years, much of the land managed by BLM has experienced mining activity, ranging from exploration to full development. As ore was mined and eventually depleted, mining operations were abandoned or moved to other locations, leaving scarred and contaminated land across many parts of the West. In many cases, these lands were not properly reclaimed, and typically, there are no financially responsible parties to help pay for cleanup. As a result, BLM must pay for and address physical safety and environmental threats associated with abandoned mines.

The AML program has identified approximately 11,500 abandoned mine sites on BLM land. Of these, approximately 500 have been remediated and 10,500 require further investigation and/or remediation. BLM maintains an inventory of known abandoned mine lands on public lands, most of which are abandoned hard rock mines.

BLM prioritizes and takes appropriate action on historic abandoned mine sites using a risk-based approach. AML sites are divided into physical safety and water quality sites, although there can be overlap. The AML program selects cleanup projects through a BLM program-wide collaborative process that occurs once a year. The selection process includes:

- Using a risk-based approach for physical safety hazard sites
- Applying a watershed approach reflecting State government priorities
- Coordinating with state and federal partners
- Planning projects through multi-year AML work plans
- Focusing on priority watersheds and high-use areas
- Conducting peer review by program leads

US Forest Service

The Pacific Southwest Region of the US Forest Service manages 20 million acres of National Forest land in California. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) engages the US Forest Service in the cleanup and reclamation of abandoned mines.

The Distribution of Abandoned and Inactive Mines on National Forest System Lands states that before 1970, reclamation of mine sites was not required on UDSA Forest Service land, and was not performed for most sites. In 1993 the US Department of the Interior conducted an assessment based on the nonconfidential, nonproprietary portions of the Minerals Availability System/Mineral Industry Location System (MAS/MIL) database. The data provide a reasonable basis for characterizing a lower limit on the number of abandoned and inactive mines on and near national forests throughout the United States. The MAS/MIL database lists more than 13,500 former producing mines within the administrative boundaries of the National Forest System (NFS) alone. Many of them currently, or potentially, degrade surface or ground water, and impact natural ecosystems (Shields et al 1995).

The current reclamation policy of the US Forest Service (FSM 2840) includes minimizing the environmental impacts resulting from mining activities and ensuring that disturbed lands are returned to a use that is consistent with long-term forest land and resource management plans. Specific policy objectives include:

1. All lands disturbed by mineral activities shall be reclaimed to a condition that is consistent with forest land and resource management plans, including applicable State air and water quality requirements.
2. All reclamation requirements included in a Plan of Operations shall include measurable performance standards. Reclamation requirements shall be those reasonable, practicable, and necessary to attain cleanup standards.
3. Reclamation shall be undertaken in a timely fashion and occur sequentially with ongoing mineral activities.
4. Reclamation bonds, sureties, or other financial guarantees shall ordinarily be required for all mineral activities that require a Plan of Operations; dollar amounts of such guarantees shall be sufficient enough to cover the full cost of reclamation.
5. To the extent practicable, reclaimed National Forest System land shall be free of long-term maintenance requirements.

CERCLA provides the US Forest Service with its primary enforcement and cost recovery authority against potentially responsible parties at contaminated sites on National Forest System lands, such as abandoned mine lands. The statute and regulations specifically set forth the roles of the lead CERCLA agency and other federal and state agencies for responding to hazardous substance release. They also specify requirements for obtaining community input and for response actions to meet applicable federal and state environmental standards and requirements such as cleanup standards. When the US Forest Service initiates a CERCLA action it must follow EPA guidance and procedures for site characterization, remedy evaluation, selection, and implementation.

United States Geological Survey

The mission of the United States Geological Survey (USGS) is to do science in the public interest. Specifically, the USGS "serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life." USGS is part of the US Department of the Interior. It is a full-service science agency and often partners with other agencies in the Sierra on mining issues. USGS is responsible for cutting-edge research on the distribution, transport, and fate of mercury, arsenic, asbestos, and other toxins in the Sierra Nevada.

3. Non-Profit Organizations

California Indian Environmental Alliance

The California Indian Environmental Alliance (CIEA) was launched in 2006 in response to numerous requests for a statewide, California-specific, tribally responsive environmental health organization to work on the issue of mercury contamination left over from the California Gold Rush and other toxin issues. Educational materials for this work currently include: *Mercury in Fish: Protecting our Future Generations* health brochure to inform and protect pregnant women, women of childbearing age, and children; CIEA E-News!, a monthly digital newsletter; and an annual printed newsletter.

Sherri Norris, Executive Director
California Indian Environmental Alliance
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sherri@cieaweb.org
www.cieaweb.org

Friends of Deer Creek

Friends of Deer Creek (FoDC) is a watershed group based in Nevada City. FoDC was started by a group of concerned citizens that received funding from the State to monitor the water quality of Deer Creek. After collecting seven years of water quality data, the group applied for and received EPA funding to address mining toxins in the watershed. The EPA Brownfields grant is a three-year grant to conduct a community-wide assessment of mine wastes. The watershed group partnered with the City of Nevada City to assess five abandoned mine sites owned by the City of Nevada City, and will apply for additional funding to conduct cleanup on these sites. The watershed group has selected sites that are on Deer Creek or on tributaries to Deer Creek with the hope that cleaning up these abandoned mine sites will improve the water quality of Deer Creek. This is a successful example of how community members can come together to address mining's toxic legacy in their watershed.

Friends of Deer Creek
132 Main Street
Nevada City, CA 95959
(530) 265-6090
info@friendsofdeercreek.org
www.friendsofdeercreek.org

Foothills Water Network

The overall goal of the Foothills Water Network is to provide a forum that increases the effectiveness of conservation organizations to achieve river and watershed restoration and protection benefits for the Yuba, Bear, and American. This includes negotiations at the county, state, and federal levels, with an immediate focus on the upcoming FERC relicensing processes.

Foothills Water Network
Coordinator
PO Box 713
Lotus, CA 95651
Tel: (530) 622-8497
julie@foothillswaternetwork.org

Sierra Nevada Alliance

Since 1993 the Sierra Nevada Alliance (SNA) has been protecting and restoring Sierra lands, water, wildlife, and communities. SNA's mission is to protect and restore the natural resources of the Sierra Nevada for future generations while promoting sustainable communities. The organization is an Alliance of conservation groups that are based or work in the Sierra Nevada region. Over eighty member groups span the entire 400-mile mountain range. The Sierra Nevada Alliance unites individuals and groups behind a common vision: a Sierra where natural and human communities coexist in harmony, and where residents and visitors alike understand and value the unique qualities of the range and protect the places they love. Several member organizations are working with The Sierra Fund on mining project issues.

Sierra Nevada Alliance
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South Lake Tahoe, CA 96158
sna@sierranevadaalliance.org

South Yuba River Citizens League

The South Yuba River Citizens League (SYRCL) is a community-based educational non-profit corporation committed to the protection, preservation, and restoration of the entire Yuba Watershed. SYRCL works to fulfill its mission by aggressively seeking environmental solutions through the tools of education, organization, collaboration, litigation, and legislation. SYRCL has implemented a model, citizen-based river monitoring program and has initiated numerous highly successful collaborations with businesses, property owners, and local, state, and federal agencies in efforts to restore the Yuba Watershed.

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The Sierra Fund

(see inside back cover page)

The Sierra Fund
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Tsi-Akim Maidu Tribe

The Tsi-Akim Maidu Tribe has resided in the Sierra Nevada for well over 10,000 years. The Tribe's indigenous lands stretch from Mount Lassen on the north, the Consumnes River to the south, the Sierra Crest on the east, and the Sacramento River on the west—the heart of the California gold strike. Less than 200 years ago there were five Maidu round houses where Nevada City now stands. As part of the Gold Rush, nearly all of their members were killed. Despite their well-documented presence in the region for thousands of years, they are not a federally recognized Tribe.

In 1999 the Maidu Tribe approached the Nevada County Board of Supervisors asking it to officially recognize the Tribe, which the County did on a unanimous vote. Both Plumas and Sierra counties' Board of Supervisors and nearly a dozen community and civic organizations have also officially recognized the Tribe.

Over the last ten years the Maidu Tribe members have begun to re-secure land in their indigenous region in order to both steward that land and restore their own tribal traditions and community. They have built relationships with the "new inhabitants" of this area, and now have strong partnerships with a number of organizations, including the Nevada County Land Trust, The Sierra Fund, and the South Yuba River Citizens League.

The Tsi-Akim Tribe has been a leading voice in drawing tribal and community attention to mining toxin issues. With other community organizations, the Tribe has sponsored a series of "Mercury in our Water, our Fish and our Peoples" workshops with tribes and community groups throughout the Sierra Nevada Gold Country. These events have resulted in the drafting of a Call to Action by participating organizations, outlining problems caused by the Gold Rush and solutions to address these historic injustices. See page 60 for the Call to Action.

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Private Consultants

Private consultants are performing abandoned mine land assessment and cleanup on private and public property throughout the Sierra Nevada region. The results of these site-specific investigations add to the growing knowledge of mine lands. The partnership of private consultants with regulatory agencies and landowners often results in innovative solutions for remediation and development of mine-impacted land. Lessons learned from the work of private consultants improve the site assessment and cleanup technologies that can be applied to other local and watershed-based projects.

Mine land investigation is generally performed under the authority of a local department of environmental health, the DTSC, or a Regional Water Quality Control Board. DTSC typically plays a lead agency role when human and ecological health is the primary concern, while the RWQCB may assume lead agency status if water quality is of primary concern.

The mine land mitigation process typically includes site characterization, remedial design, and CEQA review. Site characterization includes historical research, surface and subsurface investigation, media sampling and analysis, human and ecological risk assessment, and water quality evaluation. Depending upon the nature and scale of the impact, site characterization may follow DTSC's Preliminary Endangerment Assessment (PEA) format, a Remedial Investigation/Feasibility Study (RI/FS) format, or an equivalent format.

Based on the estimated cost of mitigation, a Removal Action Workplan (RAW) or Remedial Action Plan (RAP) is prepared that describes the proposed remedial action. The CEQA process typically includes the research of community demographics and potential community concerns, as well as public notification, review, and comment on proposed remediation activities.

AML	abandoned mine lands
AMLU	Abandoned Mine Lands Unit
ATSDR	Agency for Toxic Substances and Disease Registry
BLM	Bureau of Land Management
Cal/EPA	California Environmental Protection Agency
CALFED	CALFED Bay-Delta Program
CDMG	California Division of Mines and Geology
CDOC	California Department of Conservation
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIEA	California Indian Environmental Alliance
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CSU	California State University
CVRWQCB	Central Valley Regional Water Quality Control Board
DFG	Department of Fish and Game
DTMC	Delta Tributary Mercury Council
DTSC	Department of Toxic Substances Control
EPA	(United States) Environmental Protection Agency
FDA	Federal Drug Administration
FoDC	Friends of Deer Creek
GEOS	(CSU Chico Department of) Geological and Environmental Studies
GNIS	Geographic Names Information System
kg/yr	kilograms per year
MAS/MILS	Minerals Availability System/Mineral Industry Location System
MRDS	Mineral Resource Data System
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Protection Act
NFS	National Forest System
NOA	naturally occurring asbestos
NPDES	National Pollutant Discharge Elimination System
NPDS	Non-Point source Discharge Permits
OEHHA	Office of Environmental Health Hazard Assessment
OMR	Office of Mine Reclamation
PAMP	Principal Areas of Mine Pollution
PAR	Preliminary Appraisal and Ranking
PEA	Preliminary Endangerment Assessment
ppb	parts per billion
ppm	parts per million
PRP	potentially responsible party
PUBMed	Public/Publisher MEDLINE
RAP	Remedial Action Plan
RAW	Removal Action Workplan
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RN	registered nurse
RWQCB	Regional Water Quality Control Boards
SFEI	San Francisco Estuary Institute
SMARA	Surface Mining and Reclamation Act
SNA	Sierra Nevada Alliance
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
TOMS	Topographically Occurring Mine Symbols
USFS	United States Forest Service
USGS	United States Geological Survey

This glossary is merely informative and has been compiled directly from the following five sources:

American Geological Institute *Glossary of Geology, 4th ed.*
DTSC *Abandoned Mine lands Preliminary Assessment Handbook*
McGraw Hill Encyclopedia of Science and Technology, 9th ed.
US Bureau of Mines *Dictionary of Mining, Mineral and Related Terms*
US Geological Survey Website: *www.usgs.gov*

abandoned mine: An excavation, either open, caved, or sealed, that is deserted or in which further mining is not currently intended.

absorption: The process by which substances in gaseous, liquid, or solid form dissolve or mix with other substances.

acid mine drainage: Contaminated water from a mine or mine waste pile, which contains sulfuric acid, mainly due to the oxidation of pyrite.

adit: A horizontal or nearly horizontal passage driven in rock from the surface for the workings or dewatering of the mine.

adsorption: Adherence of gas molecules, ions, or molecules in solution to the surface of solids.

amalgam: A general term for alloys of mercury, especially an alloy of mercury with gold.

background (level): Concentrations of inorganic elements unimpacted, and thus not elevated, by anthropogenic activities.

bioaccumulation: A general term for the accumulation of substances, such as pesticides, methylmercury, or other organic chemicals, in an organism or part of an organism.

bioavailability: The ability of a substance to be absorbed by the body.

biomagnification: The bioaccumulation of a substance up the food chain by transfer of residues of the substance in smaller organisms that are food for larger organisms in the chain.

characterization (of mine waste): Identification of components including chemical constituents, physical properties and areal estent.

cyanide: A salt or ester of hydrocyanic acid. In solution, cyanide is used to dissolve gold and silver from unwanted material for later recovery.

(suction) dredging: A process of placer mining by which gravels are removed from the riverbed with a suction hose powered by an engine.

epidemiology: The study of the distribution of diseases in populations and of factors that influence the occurrence of disease.

floured (mercury): Elemental mercury that has been atomized, increasing its surface area.

flume: An artificial inclined channel used for industrial purposes such as mining or for diverting the water of a stream from its channel for the purpose of washing or dredging.

geochemistry: The study of the distribution and amounts of the chemical elements in minerals, ores, rocks, soils, water, and the atmosphere, and the study of the circulation of the elements in nature on the basis of the properties of their atoms and ions.

hard rock mining: A technique of mining used when mineralized rock occurs deep beneath the Earth's surface. To reach the ore body, remove ore and waste, and provide ventilation, miners must excavate either a vertical or inclined shaft, a horizontal tunnel called an adit, or a gently inclined tunnel called a decline.

heap leaching: A recovery process in which prepared ore is stacked in heaps on impervious pads and a lixiviant is percolated through the heap to dissolve selected metals, most commonly gold.

heavy metal: Principally the metals zinc, copper, cobalt, and lead. Usually the term is used to include one or more of the following metals: bismuth, cadmium, chromium, gold, indium, iron, manganese, mercury, molybdenum, nickel, palladium, platinum, silver, thallium, tin, and vanadium.

hydraulic mining: The recovery of desired material by means of strong jets of water.

hydrobiogeochemical (process): A process pertaining to the hydrologic, biological, geologic, and chemical cycles.

methylation (of mercury): The process by which elemental mercury is turned into methylmercury.

methylmercury: A neurotoxin, and the form of mercury that is most easily bioaccumulated in organisms.

mill: A mineral treatment plant in which crushing, grinding, and further processing of ore is conducted to produce a product.

mill tailing: The refuse material resulting from the washing, concentration, or treatment of milled ore. Material can be coarse gravel to sand-size particles to silt-like "flour." Particles tend to be more uniform in size and are typically deposited in one or a series of piles. Tailings can contain unwanted heavy metals and sulfide minerals.

mineralization: The formation of minerals.

mine waste: Solid waste from mining operations, including waste rock, tailings, and slag.

ore: A mineral, or mineral aggregate, containing precious or useful metals or metalloids, which occur in such quantity, grade, and chemical combination as to make extraction commercially profitable.

petrology: The study of rocks.

pH: The degree of acidity or basicity of a solution or substance expressed as a negative logarithm of the hydrogen ion activity (concentration). A pH value of 7 is neutral. pH values less than 5 are considered moderately acidic; less than 3 are very acidic.

placer: A surficial mineral deposit formed by mechanical concentration of mineral particles from weathered debris, the process usually involving water.

quicksilver: A common name for mercury.

reactivity: Susceptibility to chemical change.

retort process: Removal of mercury from an amalgam by volatizing it in an iron retort, conducting it away, and condensing it.

shaft: A vertical or inclined excavation through which a mine is worked.

sluice: A conduit or passage for carrying off surplus water, often at a high velocity.

sluice box: A long inclined trough for washing or separating ores.

slurry: Fine solid particles suspended in a liquid, typically water, of a consistency that allows flow by gravity or pumping.

speciation (chemical): The process of identifying the various species of a chemical.

species (chemical): The form that an element takes in aqueous solution, such as individual metal ion, ion pair, or aqueous complex. Certain metal species (e.g., methylated mercury compounds) are known to be more toxic than others to human and aquatic life.

sulfate: The most oxidized form of sulfur. Sulfates can combine with metals to form soluble salts; however, some sulfate salts are relatively insoluble.

sulfide: A group of minerals in which metallic ions are combined with reduced forms of sulfur.

tailings pond: A pond with a constraining wall or dam to which mill effluents are run.

terrace material: Made of river deposits such as gravel or sand.

toxin: A substance harmful to living cells or organisms.

ultramafic rock: An intrusive igneous rock very rich in iron and magnesium and with much less silicon and aluminum than most crustal rocks. Most come from the Earth's mantle.

volatile: Readily vaporizable.

volatization: The process of converting a chemical substance from a liquid or solid state to a gaseous or vapor state.

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The Sierra Fund's mission is to "Save the Sierra" by protecting and restoring the natural resources and communities of the Sierra Nevada. An innovative community foundation for the environment, we partner with private donors and public agencies to increase and organize investment in the land, air, water and human resources of the Sierra Nevada. We assess capacity and need in the region, connect a broad array of stakeholders, identify resources and distribute funds.

THE SIERRA FUND

Since 2001, we have assisted in generating more than $100 million in new public and private funds to help organizations throughout the Sierra strengthen their communities. We have encouraged new philanthropy in the range by creating a vehicle that Sierra residents can use to organize their wealth into philanthropic vessels, and since 2002 have made grants totaling over $1.5 million to protect and restore our natural and human resources.

The Sierra Fund's Mining's Toxic Legacy Initiative focuses on the threat to environmental and community health from historical gold mining activities. The Initiative lays the groundwork for development and implementation of a comprehensive plan to remediate environmental problems, develop health interventions to reduce the risk to gold mining communities, and protect the health of humans and wildlife throughout the Gold Country. Launched in 2006 with help from The California Endowment, the Richard & Rhoda Goldman Fund, and the True North Foundation, the Initiative is building a significant voice for addressing the long-neglected issue of mining toxins in the Sierra Nevada.

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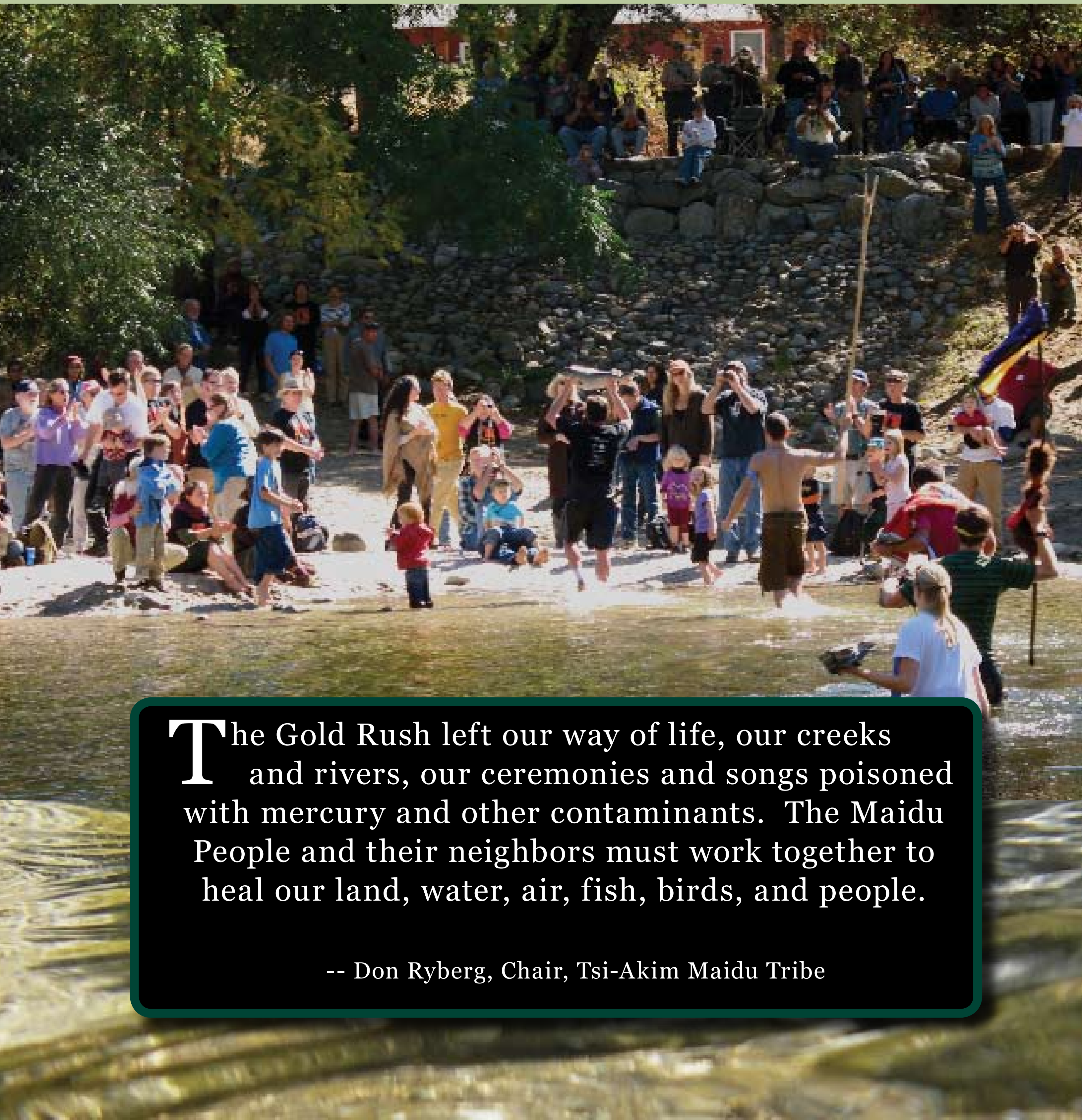

The Gold Rush left our way of life, our creeks and rivers, our ceremonies and songs poisoned with mercury and other contaminants. The Maidu People and their neighbors must work together to heal our land, water, air, fish, birds, and people.

-- Don Ryberg, Chair, Tsi-Akim Maidu Tribe