



Bunker Hill Mining and Metallurgical Complex, Idaho, Superfund Case Study

Revitalization of the Bunker Hill Hillsides and Wetlands

This is the story of ecological revitalization at two areas of the Bunker Hill Mining and Metallurgical Complex Superfund site (the Site), where a decades-long cleanup continues to turn contaminated streams and land into sustainable ecosystems. Heavy metals contamination in soil, sediment, surface water and groundwater, the result of over 100 years of historic commercial mining, milling and smelting industrial operations and disposal practices, has affected both human health and environmental resources in many areas of the Site. Estimates indicate that these mining activities resulted in more than 100 million tons of contaminated materials distributed over thousands of acres in Northern Idaho's Coeur d'Alene River Basin.

Erosion of contaminated soils from the hillsides, which were devoid of trees from years of toxic emissions from mineral processing operations, has conveyed contamination to additional areas, including streams and gulches. The remote location, steep terrain, lack of topsoil, difficult access, and other constraints made it challenging to reestablish fertile plants on the hillsides. The adaptive approach to revegetation of the 1,100-acre southern hillsides near Smelterville and Kellogg, Idaho, included preliminary studies, amending soil, planting more than two million trees, anticipation of repair and maintenance needs during revegetation efforts, and modifications to seed mixes and application techniques as the project progressed.

Within the main stem Coeur D'Alene River Basin, more than 15,000 acres of site wildlife habitat contain sediments and soils that are acutely toxic to waterfowl. Waterfowl deaths attributed to lead-contaminated sediment from historic mining upstream have been recorded at the Site for decades. In 2011, to begin addressing the impacts, EPA finished converting a 400-acre private agricultural property southwest of Cataldo, Idaho, to healthy wetland habitat. The area was made into clean feeding habitat for swans, ducks and other wetland birds, as well as large mammals such as moose. Today, the remediated and revitalized clean habitat is attracting some of the highest levels of waterfowl usage, waterfowl feeding, and waterfowl diversity in the Coeur d'Alene River Basin. Moreover, blood lead data suggest that waterfowl using the conservation easement are experiencing reduced exposures to lead. Ecological revitalization has not only helped to mitigate environmental exposure risks in this area, but is also providing a refuge to sustain ecological habitat and migratory corridor connectivity while cleanup activities continue.

This case study is part of a series focused on ecological revitalization as part of contaminated site remediation and reuse; these case studies are being compiled by the U.S. Environmental Protection Agency (EPA) Technology Innovation and Field Services Division (TIFSD). The purpose of these case studies is to provide site managers with ecological reuse information, including principles for implementation, recommendations based on personal experiences, a specific point of contact, and a network of sites with an ecological reuse component.

- Topics Highlighted in this Case Study:**
- Erosion
 - Soil Amendments
 - Use of Native Plants
 - Water Management
 - Wildlife Habitat
 - Pollinator Habitat
 - Freshwater Wetlands
 - Woodlands
 - Streams

Ecological Revitalization

Ecological Revitalization is the process of returning land from a contaminated state to one that supports functioning and sustainable habitat.

Site History

- The Site is within one of the largest historical mining districts in the world. Commercial mining for lead, zinc, silver and other metals began in the Silver Valley in 1883.
- Smelter operations ceased in 1981, and while mining and milling activities have significantly decreased since the late 1980s, several mining operations continue today in the Silver Valley.
- This site covers a large geographic area and is divided into three operable units (OUs) for cleanup:
 - OU1 - Bunker Hill Box populated areas: populated areas within a 21-square-mile area that includes the Idaho cities of Kellogg, Wardner, Smelterville and Pinehurst.
 - OU2 - Bunker Hill Box non-populated areas: non-populated areas within the 21-square-mile area of the Bunker Hill Box including the former smelter complex and large waste piles.
 - OU3 - Coeur d'Alene River Basin: includes all areas of the Coeur d'Alene River Basin outside the Bunker Hill Box where mining-related contamination is located. This includes 45 miles of the South Fork of the Coeur d'Alene River and its tributaries; 37 river miles of the main stem of the Coeur d'Alene River and associated floodplains and lakes; Coeur d'Alene Lake; and depositional areas of the Spokane River, which flows from Coeur d'Alene Lake into Washington State.
- Contamination from mining operations in the Silver Valley spread along more than 160 river miles and over tens of thousands of acres of wetlands of the Coeur d'Alene and Spokane Rivers, resulting in contamination of soil, sediment, surface water and groundwater.
- Many communities were built on mine wastes.
- Residential, community and smelter area cleanups have been ongoing since the 1980s.
- The hillsides (OU2) are located across portions of Portal, Deadwood, Magnet, Government, Page, and Grouse Gulches, and have been affected by mining and metals-refining-related activities.
- Natural events have contributed to the severe erosion and reduced vegetation in many areas of the hillsides.
- Erosion of contaminated soils from the hillsides has conveyed contaminants to streams, sediments, gulch floors and other areas.
- In the Coeur d'Alene River Basin, many miles of streams cannot sustain a reproducing fish population, and a number of tributaries have no or limited aquatic life.
- Lead poisoning is responsible for many waterfowl deaths each year.
- The site ecological cleanup goals are to reduce heavy metals contamination, improve fisheries, reduce downstream migration of contaminated sediments, and provide safe feeding habitat for waterfowl.

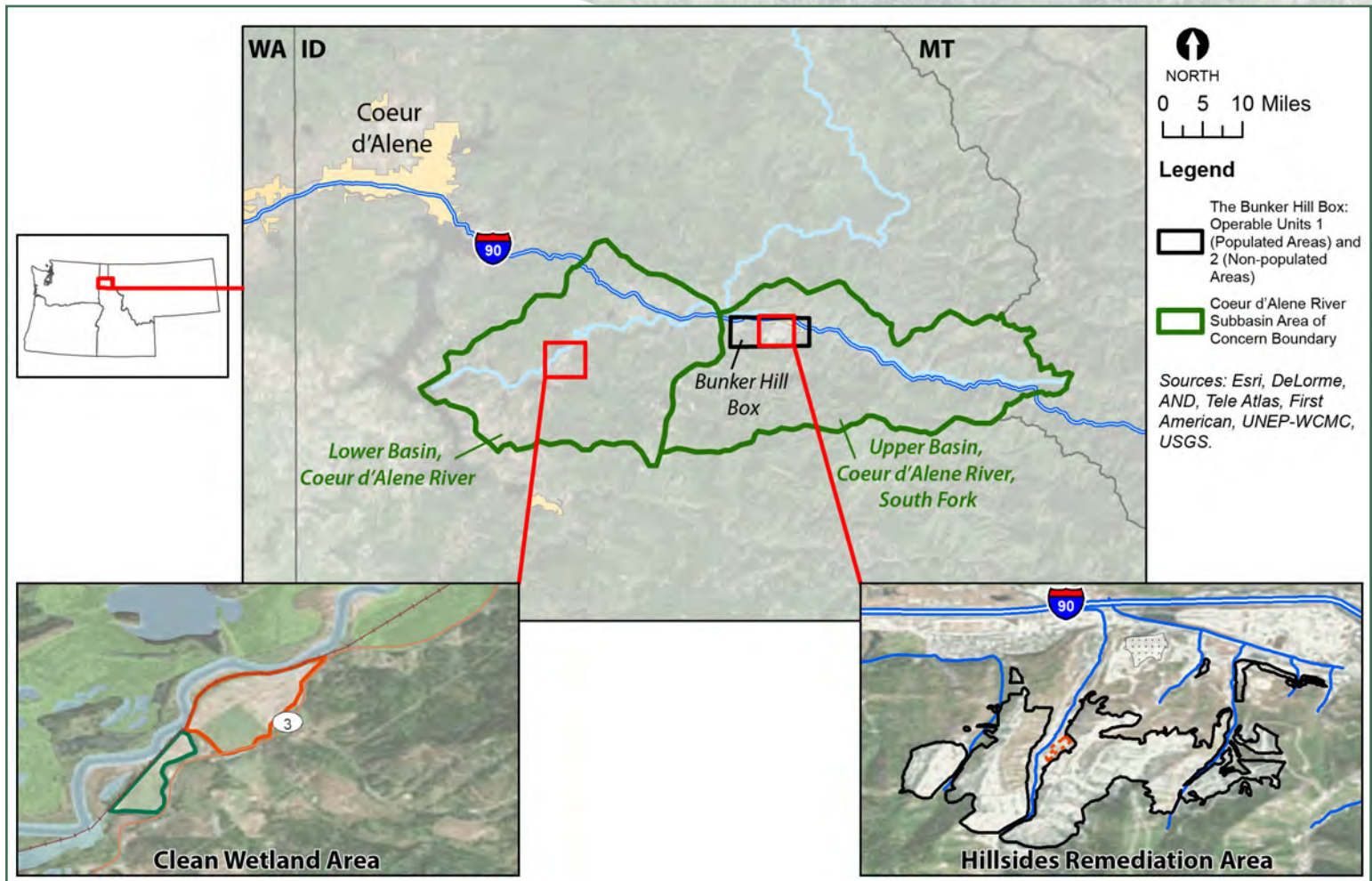
Bunker Hill Hillsides Revitalization

Understanding Hillside Remediation Issues

The hillsides within the Bunker Hill Box non-populated areas (OU2) have been affected by 100 years of mining and metals-refining-related activities. Mine waste rock dumping, and emissions and fugitive dust from processing operations resulted in acidic soils depleted of nitrogen, phosphorus and potassium. Logging and clearing resulted in severe erosion to the hillsides. Natural events such as forest fires, wind and flooding have further increased the severe erosion and contributed to reduced vegetation in many areas of the hillsides. Topsoil loss has also resulted in a lack of available soil moisture.

In addition to the lack of topsoil and adverse growing conditions for vegetation, site hillside remediation was a challenge because of the distance from available soil amendments needed to revegetate the hillsides. Furthermore, the hillside watersheds were topographically steep and difficult to access by land-based equipment, but the

Site Map



survival of tree seedlings was imperative to reestablish the native ecosystem. The potentially responsible parties (PRPs) tried to establish vegetation on portions of the hillsides in 1975-1994, but efforts were largely unsuccessful. Remediation activities on the roughly 1,100-acre hillsides project area account for about 8 percent of the 21-square-mile Bunker Hill Box land area and include portions of six watersheds near the towns of Smelterville and Kellogg, Idaho. This area presented the most barren view shed to people living in and moving through the region.

Adaptive Management

Adaptive management is a decision-making process based on trial, monitoring and feedback, and employs a multi-scalar perspective.

Hillside Remediation Objectives

- The ultimate goal for the hillsides is to return them to a coniferous forest ecosystem similar to that found elsewhere in northern Idaho. However, due to extensive soil loss in this area, the near-term focus of the hillsides project was to reduce erosion and increase soil development to reduce pollution of the South Fork of the Coeur d'Alene River. Adaptive management during this process allowed for decision-making flexibility.
- To improve watershed function through reduced runoff, soil erosion and pollutant transport, the following goals were established:



Hillsides aerial hydroseeding ~1998

- Establish herbaceous cover on areas with less than 50 percent cover, with priority to areas with high contaminant levels or less than 25 percent cover.
- Establish check dams in gullies and on terraces.
- Establish herbaceous and woody vegetation in gullies and on terraces.
- Improve physical and chemical characteristics of soil that impair watershed function and plant growth.
- Reduce runoff from existing terraces.
- Establish self-regenerating plant species and, where needed, soil-building plant species.
- Minimize colonization by noxious weeds.
- Manage the hillsides using adaptive management techniques.

Hillside Remediation Results

- Using adaptive management as a basis for the program, a phased treatment program was implemented and the resulting hillside stability performance guided new decision-making during each phase which reduced expenses. Prescriptions for hillside restoration were modified over time as demonstration studies matured and results became evident.
- Plant species were chosen based on field performance and included drought and acid-tolerant species, nitrogen-fixing species and species that establish rapidly.
- Soil amendments to offset soil nutrient deficiencies had the potential to stimulate growth of hundreds of thousands of previously planted trees.
- Initial use of pelletized limestone for soil pH adjustment was considered relatively ineffective because the pellets bounced and rolled down steep slopes. Instead, a hydrated lime product was subsequently applied with a tackifier and mulch to successfully “stick” the product to the steep hill slopes.
- Changes to the seed mix and tree species composition occurred as monitoring revealed the performance of individual species within the mix and in seedling trials.
- Sikorsky S-64 air crane helicopters were used for aerial hydroseeding and liming.
- Soil amendments were applied to 371 acres in 2000 and 132 acres in 2001, followed by tree/shrub planting. The 2001 work represented the final, large-scale revegetation operation on the hillsides.
- The landscape monitoring program used infrared aerial imagery, GIS and land-based methods.

ECOLOGICAL REVITALIZATION OF CONTAMINATED SITES CASE STUDY

- Vegetation monitoring began in 2001 and was discontinued after 2005 because results indicated steady hillside revegetation progress that was capable of controlling erosion and increasing infiltration.
- Water quality monitoring, which was discontinued in 2006, indicated the effectiveness of vegetation cover and check dams in reducing transfer of sediments from the hillsides to streams.
- As of 2014, vegetation had been fully established at all but a few isolated rocky sites.
- Using native herbaceous plants, such as penstemon, and trees, such as woods rose, at this site helped create an attractive habitat for wildlife and pollinators.
- Adaptive management converted the hillsides from a barren landscape to one supporting early-successional plant communities and wildlife.
- In addition to environmental benefits, the landscape has become more scenic and aesthetically pleasing. This has enhanced economic prospects for Idaho's Silver Valley, which is featured by the local chamber of commerce as a tourist destination.

Hillside Team

CH2M Hill, U.S. Army
Corps of Engineers,
U.S. Forest Service,
IDEQ, EPA, DJN, Inc.



Hillsides 1993



Hillsides 2003



Hillsides 2014



2014 Hillside vegetation growth

Native Pollinators

Not only do native pollinators provide us with a significant amount of the food we eat and contribute to the economy, they also perform key roles in natural ecosystem. By helping to keep plant communities healthy and able to reproduce naturally, native pollinators assist plants in providing food and cover for wildlife, preventing erosion, and keeping waterways clean.

Source: http://plants.usda.gov/pollinators/Native_Pollinators.pdf

Herbaceous Plant Species Used on Hillsides in Seed Mix Application

Common Name	Scientific Name
Slender wheatgrass	<i>Elymus trachycaulus ssp. Trachycaulus var. Revenue</i>
Idaho fescue	<i>Festuca idahoensis var. Joseph</i>
Sheep fescue	<i>Festuca ovina var. Covar</i>
Mountain brome	<i>Bromus marginatus var. Bromar</i>
Meadow brome	<i>Bromus biebersteinii var. Paddock</i>
White yarrow	<i>Achillea millefolium</i>
Blue flax	<i>Linum lewisii var. Appar</i>
Rocky mountain penstemon	<i>Penstemon strictus</i>
Alfalfa*	<i>Medicago sativa var. Alfagraz</i>
Redtop*	<i>Agrostis alba</i>
Canada bluegrass*	<i>Poa compressa</i>
Big bluegrass	<i>Poa ampla var. Sherman</i>
Canby bluegrass	<i>Poa canbyi var. Canbar</i>
Cicer milkvetch*	<i>Astragalus cicer</i>
Lupine	<i>Lupinus perennis</i>
*Not native to northern Idaho	

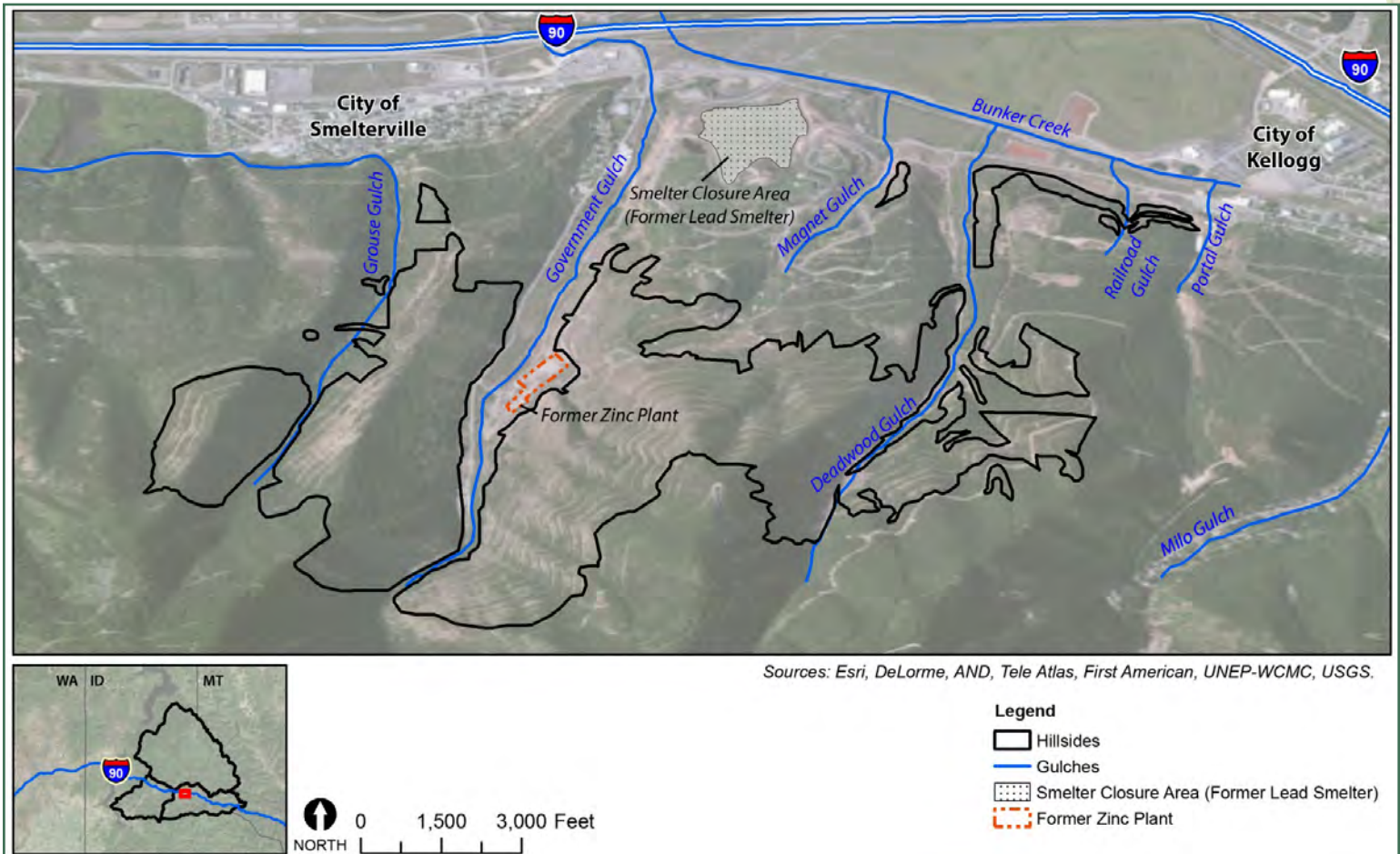
Tree and Shrub Species Planted on Hillsides During 2001-2002 Planting Seasons^a

Common Name	Scientific Name
Snowbrush ceanothus	<i>Ceanothus velutinus</i>
Red stem ceanothus	<i>Ceanothus sanguineus</i>
Black locust*	<i>Robinia pseudoacacia</i>
Rocky mountain maple	<i>Acer glabrum</i>
Quaking aspen	<i>Populus tremuloides</i>
Saskatoon serviceberry	<i>Amelanchier alnifolia</i>
Woods rose	<i>Rosa woodsii</i>
Mountain alder	<i>Alnus incana</i>
a - In addition to these species, five species of conifers were planted on the hillsides in the past, including western white pine, western larch, douglas fir, ponderosa pine, and lodgepole pine.	
*Not native to northern Idaho	

Timeline – Hillsides

- **1975-1992:** The Bunker Hill Company (PRP) planted about two million tree seedlings over 2,290 acres of the Site. They also hydroseeded and terraced the hillsides to control erosion control and stabilize the hillside.
- **1994:** EPA and the State of Idaho assumed hillside remedial work responsibility.
- **1996:** EPA and the State of Idaho planted tree seedlings in areas not previously planted by the PRP.
- **1998:** EPA began aerial application of lime and hydroseeds and began check dam installation.
- **1999:** EPA completed check dam installation along terrace benches and began hillside surface water quality pilot study.
- **2001:** EPA completed liming and hydroseeding; began tree/shrub planting.
- **2002:** EPA completed tree/shrub planting.
- **2005:** EPA discontinued vegetation monitoring.
- **2006:** EPA discontinued surface water monitoring.

Hillsides Map



Bunker Hill Wetlands Revitalization

Understanding Wetland Remediation Issues

About 25 miles west of the hillsides remedial area and downstream along the Coeur d'Alene River, a private, contaminated agricultural property was converted to healthy wetland habitat. Soil and sediment throughout the floodplains of the lower Coeur d'Alene River Basin (OU3) are contaminated with lead washed downstream over the years from the historic upper Basin mining disposal activities. Lead contaminated sediments in the floodplains have caused adverse effects to wildlife. Studies conducted during the remedial investigation indicate that over 18,000 acres of waterfowl habitat in the lower Basin exceed adverse effects levels and over 15,000 acres exceed lethal thresholds. Notably, waterfowl, (e.g., tundra swans and ducks) ingest highly contaminated sediment to the extent that many have suffered toxic effects or died from ingestion of lead. The area is a critical part of the Pacific migration flyway and waterfowl deaths due to lead-contaminated sediment have been recorded in the Coeur d'Alene River Basin for decades. Because lead is stable in the environment, the contamination presents a continued unacceptable exposure risk. Actions to address the widespread contamination in the Lower Basin are included in EPA's 2002 OU3 (Basin) Superfund Record of Decision.

Wetland Remediation Objectives

Under the EPA 2002 Superfund cleanup plan, the remedial action objectives for addressing wetland areas include:

- Remediate contaminated soil, sediment and water to create habitat areas capable of supporting a functional ecosystem.
- Prevent ingestion and dermal contact by ecological receptors with toxic levels of heavy metals.

Wetlands Remediation

In April 2006, EPA used settlement monies to purchase a perpetual conservation easement that allows for remediation and restoration of a functional wetland to create a clean waterfowl feeding habitat. Remediation of the nearly 400-acre easement area southwest of Cataldo, Idaho, was phased starting with the smaller East Field and followed by the larger West Field. Remedial designs were developed using a team approach involving EPA, the property owner and the Coeur d'Alene Basin Natural Resource Trustees. The design and planning process included substantive compliance with the Clean Water Act Sections 401 and 404, National Historic Preservation Act, and Native American



Farmland before wetland restoration
(Source: http://restorationpartnership.org/wetland_restoration_project.html)



Tundra swans feeding in the clean wetlands following Superfund remediation and restoration by the Natural Resource Trustees.

Graves Protection Repatriation Act. EPA also obtained a legal water right for the project. Design objectives included no off-site disposal of contaminated soil and minimizing the long-term operation and maintenance requirements.

The wetland remedial action included the following construction activities:

- Remediation of soil with elevated metal concentrations using several techniques depending on soil contamination depth.
- Installation of water diversion structures to provide clean water for the wetland under a water right.
- Development of water control and drainage structures to allow effective water management.
- Installation of overflow weirs to reduce the potential for recontamination of the wetland from flooding of the contaminated Coeur d'Alene River.

Wetland Team

Private property owner, U.S. Fish and Wildlife Service (USFWS), Ducks Unlimited, Coeur d'Alene Basin Natural Resource Trustees, U.S. Army Corps of Engineers, CH2M Hill, and EPA

Wetland Restoration

Following EPA's implementation of the phased remedial actions using settlement monies, the Coeur d'Alene Basin Natural Resource Trustees, led by USFWS in cooperation with Ducks Unlimited, performed restoration activities also using settlement monies. Restoration activities included:

- Planting of native upland and meadow grasses, shrubs and trees.
- Control of invasive species such as canary grass.
- Water management.

The Coeur d'Alene Basin Natural Resource Trustees are performing habitat management and long-term operation and maintenance using settlement monies. This project demonstrates collaboration and coordination between Superfund and the Natural Resource Trustees resulting in ecological revitalization of this site.

Environmental Outcomes of the Wetland Remediation and Restoration

- Using settlement monies, EPA's remedial action established nearly 400 acres of clean waterfowl feeding habitat and was followed by additional restoration work by the Natural Resource Trustees.
- The Superfund remediation reduced waterfowl exposure to toxic levels of heavy metals.
- USFWS monitoring data show that the remediated and restored clean habitat is attracting some of the highest levels of waterfowl usage, waterfowl feeding and waterfowl diversity in the Coeur d'Alene River Basin.
- Blood lead data suggest that waterfowl using the conservation easement are experiencing reduced exposures to lead.
- Using native herbaceous plants, such as buckwheat, at this site helped create an attractive habitat for wildlife and pollinators.
- This project is the first of its kind in the Coeur d'Alene River Basin, and is an important step in addressing serious ecological contamination issues in the Basin.
- The property is owned by a private party, but the operations of the wetland are performed under a conservation easement that governs the land use. Due to the private ownership of the land, it is not open to the public.



Other wildlife such as bull elk also use the remediated wetlands.

Agriculture to Wetland Map



Lessons Learned/Next Steps

1. Adaptive management on the hillsides revegetation gave flexibility to engage other approaches in areas where performance was not satisfactory (e.g., switching lime from pelletized to a hydrated product after one year).
2. Adaptive management reduced potential expenses on the hillsides revegetation.
3. Sikorsky S-64 air crane helicopters allowed application of the hydroseed mixture in a time- and cost-effective manner. At the time of its execution, the hillsides revegetation project was the largest of its type in the world and it was the first significant project using air cranes for hydroseeding work. The success of the hillsides revegetation demonstrated the feasibility of this technology which can lead to subsequent application of this technology elsewhere.
4. Cooperation between various stakeholders, including the private land owner, was essential to supporting cleanup efforts and the agriculture-to-wetland conversion.
5. Creating alternative safe habitat, particularly for migratory species to use while cleanup activities proceed, redirects wildlife to safer areas.
6. Lead contamination from historical mining practices continues to pose a risk to people and the environment in the area, especially children and sensitive species. EPA is working with many partner organizations to help reduce this risk.

Additional Information

Websites to obtain additional information on the Bunker Hill Mining and Metallurgical Complex Superfund site and ecological revitalization include the following:

EPA Region 10 Site Profile

<http://yosemite.epa.gov/r10/cleanup.nsf/sites/bh>

EPA's Eco Tools Website

<http://www.clu-in.org/ecotools/>

IDEQ Site Profile

<http://www.deq.idaho.gov/bunkerhillsuperfundsite>

Restoration Partnership

<http://restorationpartnership.org/index.htm>

Frequently Asked Questions About Ecological Revitalization of Superfund Sites

<http://www.clu-in.org/download/remed/542f06002.pdf>

Contact Information

For additional information on the Bunker Hill Mining and Metallurgical Complex Superfund site, you can also contact the EPA project managers:

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