# Ecological Revitalization and Attractive Nuisance Issues

### Fact Sheets on Ecological Revitalization

- This fact sheet is the third in a series of fact sheets related to ecological revitalization.
- The first two fact sheets on "Frequently Asked Questions About Ecological Revitalization of Superfund Sites", EPA 542-F-06-002, and "Revegetation of Landfills and Waste Containment Areas", EPA 542-F-06-001, can be found at http://www.cluin.org/ecorevitalization.

**Ecological revitalization** of a Superfund site is the process of returning a site to a functioning and sustainable use. Ecological revitalization converts a site closer to a natural state, increasing or improving habitat for plants and animals by integrating components that are compatible with the remediation activities that ensure the protection of human health and the environment. Although ecological revitalization can be used to create habitat as a specific goal, when habitat mitigation is required, it also can be used to complement or enhance a traditional cleanup method; as a green remediation technology to remove or stabilize contaminants; or reduce erosion while providing valuable wildlife habitat.

## Introduction

The U.S. Environmental Protection Agency (EPA) encourages the beneficial reuse of Superfund, Brownfields, and other contaminated sites while protecting human health and the environment. Superfund sites are being cleaned up and restored while integrating natural features such as wetlands, meadows, streams, and ponds to provide habitat for terrestrial and aquatic plants and animals, and for low-impact or passive recreation, such as hiking and bird watching. In addition, many sites redeveloped primarily for other purposes, such as commercial or recreational facilities, also contain significant ecological resources or green space.

The potential exposure of wildlife can be a concern when waste or contaminants remain on a site following cleanup (i.e., attractive nuisance), but it need not prevent the ecological revitalization of that site. At many successfully redeveloped sites, contaminated material has been left on the property in containment systems designed to protect people, wildlife, and the environment from exposure and prevent contaminant migration. On-site or in situ remediation of contamination is used when it is impractical or unnecessary to completely remove all the contaminants. To prevent long-term risks to human health and the environment, including attractive nuisance issues, redevelopment planners integrate appropriate exposure reduction strategies, monitoring, and maintenance into the remedy design.

EPA is sensitive to attractive nuisance issues and has been conducting research and compiling references and case studies in this area. This fact sheet, the third in a series of fact sheets on ecological revitalization of contaminated sites developed by EPA Office of Superfund Remediation and Technology Innovation (OSRTI), discusses how to identify, assess, and manage potential attractive nuisance issues during ecological revitalization of Superfund sites and presents case studies that illustrate a variety of attractive nuisance issues and how they were managed. The information is intended for EPA site managers, state agency site managers, consultants, and others interested in the ecological restoration of contaminated sites.

Various information sources were used to prepare this fact sheet. These and additional information resources are listed at the end of the fact sheet.

## What is an attractive nuisance?

Once the basic physical and biological components of a viable habitat or ecosystem have been established as part of the ecological revitalization of a site, wildlife use is expected to change with either different or more diverse wildlife present and/or greater activity. For the purposes of the Superfund Program, an attractive nuisance

### Selected Benefits of Ecological Revitalization

- Removes stigma associated with prior waste sites
- Helps address or remove contamination
- Enhances property values
- Provides recreational uses for local residents
- Improves soil health and supports diverse vegetation
- Creates wildlife habitat
- Contributes to a green corridor
- Can reduce erosion, sequester carbon, and control landfill leachate
- Protects surface and groundwater from potential contamination

refers to an area, habitat, or feature that is attractive to wildlife and has, or has the potential to have, waste or contaminants left on site that are harmful to plants or animals after a completed remedial action. For the purposes of this fact sheet, the definition of attractive nuisance is strictly wildlife-focused and does not consider the potential for increased human activity at a site as an attractive nuisance.

One example is an abandoned mining site that is barren and void of life. After lime-treated biosolids were incorporated to complex the metals of concern, the health of the soil (fertility and general suitability to support root growth) improved to permit revegetation with native plants and promote a self-sustaining ecosystem as habitat for nongame species. Once the plants were established, animal life became re-established. Because the metals remained in the soil, the metals could move through the food chain to adversely affect animals at the top of the food chain (e.g., raptors). Thus, because no animals were present on the site prior to its revitalization, a potential attractive nuisance was created.

## Why are attractive nuisance issues a concern?

An attractive nuisance can potentially cause harm to wildlife if (1) an exposure pathway exists from contaminants left on site that could directly harm wildlife or could travel up the food chain or (2) wildlife interfere with the remedy, thereby creating an exposure pathway. While a remediated site may not create an attractive nuisance, project managers need to understand the nature of the contaminants present and the potential for exposure when developing plans to modify habitat that may attract wildlife. For example, if more than one operable unit (OU) is present on a site, animals attracted to an ecologically revitalized portion of the site might access adjacent, unremediated OUs or nearby contaminated areas and become exposed to contamination.

Site managers and developers may need to address the potential for contaminant bioaccumulation (i.e., the retention and buildup of chemicals) in plant and animal tissues. Bioaccumulation can result in biomagnification, which is increasing contaminant concentrations in the tissues of organisms proceeding up in the food chain to top predators (including humans). These processes can result in an organism having contaminant concentrations higher than concentrations in the surrounding environment or the organism's immediate food source.

EPA recommends that site managers and developers consider both exposure pathways and the ways in which wildlife attracted to the site can affect exposure pathways by interfering with the remedy, such as a cap.

Because of the variety of factors that affect wildlife behavior and ecosystems, it may be difficult to

### Ongoing EPA Research

Survival studies and tissue analyses conducted by EPA's Environmental Response Team (ERT) at three former mining sites (Bunker Hill, Idaho; Leadville, Colorado; and Jasper County, Missouri) show that these sites can become functional and support healthy wildlife habitat. Each site was originally barren but was treated with soil amendments. Results from earthworm and small mammal studies have shown that the bioavailability of heavy metals present on site was dramatically reduced after being treated with soil amendments and that wildlife attracted to the site are not unacceptably exposed to the site contaminants. For more information, contact Mark Sprenger, EPA ERT (sprenger.mark@epa.gov or (732) 906-6826).

anticipate all potential consequences of a newly created or altered ecosystem. However, to the extent possible, it is recommended that project managers be aware of, and manage, attractive nuisance issues, and consult with their Biological Technical Assistance Group (BTAG) or site biologist for measures to reduce or eliminate attractive nuisance issues.

## How do I assess potential attractive nuisance issues at my site?

It is essential to consider potential ecological risk throughout the RI process and conduct an ecological risk assessment thoroughly to avoid potential attractive nuisance issues. Information on conducting an ecological risk assessment is included in the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments – Interim Final* (http://www.epa.gov/oswer/riskassessment/ecorisk/ecorisk.htm). In addition to addressing human health concerns associated with the selected end use of the site, an ecological risk assessment is necessary to determine appropriate cleanup goals for protecting plants and wildlife. The ecological risk assessment will evaluate the potential for adverse ecological effects and bioaccumulation of contaminants that could occur as a result of exposure to contaminants left on-site. If ecological concerns are considered throughout the RI process, then information associated with attractive nuisance issues would have already been collected. For example, information gathered from an endangered species survey conducted during Section 7 consultation of the RI process could be used during design of the remedy to reduce the potential for bioaccumulation and exposure of plants and animals to contaminated material, and to ensure that the site is not an attractive nuisance, and does not pose an ecological risk. At the Bunker Hill Superfund site in Idaho, root-zone soil was amended to reduce or prevent the bioavailability of many heavy metals to plants (see case study 4 below). The amendments reduced both accessibility and bioavailability of the heavy metals and restored ecosystem function. The site is currently a wetland in a highly visible area and provides wildlife habitat.

It is recommended that site managers consider the future use of the site as well as the wildlife that would be attracted to features present once the ecological revitalization is complete. If waste is to be left on site, evaluation of all potential exposure pathways is necessary to determine whether any plants will bioaccumulate contaminants or any of the wildlife attracted to the area could be harmed. The conceptual site model that was developed as part of the ecological risk assessment for the site could be used to identify potential post-remediation exposure pathways for wildlife. In addition, the site-specific

### Lake Apopka Attractive Nuisance Issue

When farmland at Lake Apopka, Florida, was converted to a marsh area designed to enhance wildlife habitat, an environmental risk assessment showed that pesticide concentrations might affect wildlife in the area. Although contaminated areas were excavated prior to wetland revitalization, hundreds of migrating birds stopping at the newly created marsh area died of pesticide poisoning. The birds, which were attracted by the lake, preyed on fish in nearby ditches and small pools that were contaminated with pesticides. This incident demonstrates the importance of understanding all potential exposure pathways, including temporary site conditions created during the construction phase in addition to final site conditions created by a remedial action, to ensure that an attractive nuisance is not created during site revitalization.

### EPA Initiatives

**EPA's Superfund Redevelopment Initiative (SRI)** focuses on cleaning up Superfund sites and making them protective of human health and the environment while considering future use opportunities and integrating appropriate reuse options into the cleanup process. SRI supports all reuse types, especially ecological revitalization. For more information on SRI, please visit the following website: http://www.epa.gov/superfund/programs/recycle/index.htm

EPA developed the **Return to Use (RTU) Initiative** as part of the SRI and is designed to remove barriers to appropriate reuse once cleanup is completed. For more information on RTU, please visit the following website: http://www.epa.gov/superfund/programs/recycle/rtu/index.htm

ecological risk-based clean-up goals considered during the development of clean-up options and coordinated with stakeholders, such as property owners and the community, will prevent or minimize the creation of an attractive nuisance.

When sampling during an RI, EPA recommends that data collected from sampling activities provide the information necessary for the ecological risk assessment and consideration of potential attractive nuisance issues. Specifically, the following are recommended:

- The sampling plan could include appropriate multiple media exposure pathway sampling, such as surface water, sediments, surface and subsurface soils, and groundwater. Consult your regional technical expert (for example, BTAG) to assist in developing your plan.
- The sampling locations could be determined to collect information for both human health and ecological risk analyses. For example, in addition to soil sampling for human health, incorporate ecological aspects as well, such as wetlands or other sampling into the plan, if applicable.
- Analytes could include those that will allow for an evaluation of both human health and ecological risk. See Exhibit 1 at the end of this fact sheet for information about sensitive receptors and exposure pathways for a variety of contaminants. In addition to an analysis for potential contaminants of concern, samples could be collected and analyzed for parameters such as total organic carbon to assess the bioavailability of contaminants.
- Consult with the laboratory prior to conducting sampling activities because some analyses do not have a low enough reporting limit to assess ecological risk.

### Soil Remediation, Revitalization, and Reuse: Technical Performance Measures

When remediating and reusing a Superfund, RCRA, or Brownfields site, there is a hurdle for all stakeholders, including regulators, to face. The hurdle is how to determine what technical performance measures (TPM) or success criteria should be used to evaluate if the remediation worked well enough to support the beneficial reuse of the site. To answer this question, a web-based tool was developed to provide a tool which can be used to assist in the selection of appropriate TPMs for the evaluation of soil remediation using in-situ remediation techniques, such as soil amendments. This was completed by drawing on the collective knowledge and experience of experts to identify and document a core set of commercially available, cost effective, and proven TPMs. This web-based tool is intended to be used by site project managers and their technical support team and can be found at http://www.cluin.org/ecorevitalization.

Additional information might be needed for consideration of potential attractive nuisance issues, as shown in the following examples:

- Soil amendments as part of the remedy might have changed the bioavailability of metals. New data would be needed to demonstrate the efficacy of this treatment. See text box above.
- A groundwater pump-and-treat system has been installed to address human health concerns. New data on a groundwater seep would be needed prior to creating an emergent wetland habitat.

### Additional Assistance

Establishing remediation goals for ecological receptors can be challenging and less prescribed than establishing goals to protect human health because of: (1) the large variation in the species and populations of receptors present at sites; (2) the differences in receptor susceptibility to contaminants; and (3) wide variations in environmental bioavailability of many contaminants in different media. For these reasons, it is recommended that an ecological risk assessment be conducted with the assistance of an expert. For assistance in completing an ecological risk assessment, contact the appropriate risk assessors for your region (in most cases, this is the BTAG) or the ERT (http://www.ert.org/). For additional information on the role of BTAGs, visit the following website: http://www.epa.gov/oswer/riskassessment/ecoup/pdf/v1no1.pdf. The regional BTAG web sites, provided at the end of this fact sheet, provide contact information for BTAG members.

## How do I manage attractive nuisance issues at my site?

The potential for an attractive nuisance exists if waste or contaminants are left on site, whether contained or remediated in place. However, exposure pathways or other attractive nuisance issues can be eliminated or minimized through careful planning and consideration throughout the remediation process. The following activities can be employed to manage a potential attractive nuisance:

- **Eliminate the exposure pathway** through traditional or alternative remediation technologies. In addition, careful selection of habitat goals and plants can help to ensure that adequate barriers remain intact between wildlife and residual contamination. If contaminant uptake by vegetation is a potential issue and not part of the remedy, supplemental measures are recommended, including use of additional cover or soil amendments. Also, avoid conditions that will attract unwanted plant or wildlife species to the site. Artificial habitat can be constructed to maintain elimination of exposure pathways. Prevent invasive plants from taking over by selecting native plant species adapted to site-specific conditions. Plants can also be incorporated or wildlife introduced to reduce the attractiveness of the site to wildlife that could potentially damage the remedy. For example, at Rocky Mountain Arsenal, Colorado, one consideration during plant selection was height at maturity to deter prairie dog invasion and a biota intrusion layer of crushed concrete was added to the containment system as a barrier to badgers and other burrowing animals (for additional information on exposure pathways, visit the following website: http://www.epa.gov/oswer/riskassessment/ecorisk/ecorisk.htm).

- **Create habitat appropriate for the site** to reduce the attractiveness of a contaminated site to wildlife. For example, high selenium concentrations in a wetland area at the Kennecott North and South Zone site in Salt Lake County, Utah, caused EPA to recommend covering the wetland and capping the area (see case study 3 below). Rather than restoring the wetlands on site and creating an attractive nuisance (i.e., selenium exposure to wildlife using the wetland), a more appropriate upland site was created to avoid attractive nuisance issues and a wetland mitigation bank was created in an appropriate location.

- **Conduct routine maintenance** to ensure that exposure pathways do not become available over time. These activities would be included in a long-term operation and maintenance (O&M) plan. An example of routine maintenance is inspecting and repairing a containment cap as necessary to ensure it is kept intact. Visual inspection of habitat conditions is important to prevent attractive nuisance issues from developing. Activities such as removing burrowing or other wildlife species that could damage the remedy as well as vegetation that would attract nuisance wildlife, maintaining the health of the vegetation, and observing wildlife populations could be included in the O&M plan.

- As part of the **long-term monitoring plan**, confirm that the site does not become an attractive nuisance and that contaminants are not accumulating to levels that would be toxic to wildlife. Monitoring activities could include sampling of soil, surface water, vegetation, or animal tissue to monitor the effectiveness of the remedy and any bioaccumulation or biomagnification concerns; conducting wildlife counts to monitor population health; and monitoring for nuisance plants, insects, and wildlife (that could harm the remedy) to evaluate the need for control measures. If long-term monitoring indicates that an attractive nuisance develops, modify the long-term O&M plan as necessary.

Attractive nuisance issues are not likely to be a problem if:

- The site is remediated in a way that appropriately considers attractive nuisance issues
- Initial studies consider potential attractive nuisance issues
- Sampling and monitoring data is used to assess potential risk to wildlife
- Any risks are recognized and eliminated or properly managed

## Case Studies

This section includes brief descriptions of several sites that considered attractive nuisance issues during ecological revitalization of the site.

### Case Study 1

**Site Information**

**Name:** E-Pond Solid Waste Management Unit (SWMU), RCRA Corrective Action, Lima, Ohio

**Description:** The E-Pond (SWMU 62) is located adjacent to the west bank of the Ottawa River, outside the operational section of a petroleum refinery. E-Pond consists of two former ponds and one former landfill that encompass approximately 23 acres. The northern pond was used to dewater, by evaporation, solid wastes that were obtained from an on-refinery stormwater retention basin. The southern pond was used to dispose of the solid wastes from the northern pond after the material was stabilized with soil and fly ash. A landfill area received refinery wastes including sludge, emulsion plant vacuum filter cake, acid pond sludge, leaded tank bottoms, API separator sludge, and slop oil emulsions.

**Site Contact**

Thomas Matheson, EPA Region 5, Phone: (312) 886-7569, E-mail: matheson.thomas@epa.gov

**Site-Specific Resources**

http://www.epa.gov/epaoswer/hazwaste/ca/curriculum/download/eco-rec.pdf

http://www.epa.gov/epaoswer/hazwaste/ca/curriculum/download/eco-rec.ppt

**Site Conditions: Attractive Nuisance Issues**

E-Pond was investigated, and several samples were collected to provide the information necessary to conduct a risk assessment for both human health and ecological receptors. Based on these risk assessments, it was determined that the surface soils presented risks to ecological receptors (soil invertebrates, plants, and wildlife: short-tailed shrew, deer mouse, and American robin) and was on the high end of the human health risk range due to elevated levels of chromium, antimony, thallium, and PCB 1248 in the surface soil. Therefore, the risk from surface soils had to be addressed.

**Site Revitalization: Attractive Nuisance Management**

A site conceptual plan was developed, taking into consideration the risk levels at the site. The plan calls for creation of:

- Prairie habitat consisting of native grasses and flowers
- Native tree and shrub clusters to provide cover for wildlife
- A butterfly garden
- Interpretive areas and educational opportunities
- Artificial nesting structures to be built on the cover settling plates, which will help in locating the plates

A synthetic root barrier will inhibit the growth of roots into the waste, including the long root systems of native grasses and flowers, and will deter small mammals from burrowing into the waste. In addition, the 12-inch protective soil cover will eliminate exposure of soil biota to soil with elevated contaminant levels, thus reducing risk to acceptable levels. Clean soil will be enhanced with biosolids to augment the organic content of the clean soil. A berm with trees will be constructed in the northern area of the site to provide a barrier between E-Pond and a construction debris landfill to the north. The O&M plan will ensure the long-term integrity of the remedy.

**For additional information on land application of biosolids and compost, go to http://www.epa.gov/own/mtb/biosolids and http://www.epa.gov/compost**

## Case Study 2

**Site Information**

**Name:** Morgantown Ordnance Works Disposal Area, OU1, Monongalia County, West Virginia

**Description:** The Ordnance Works Disposal Area site consists of a 6-acre disposal area and a manufacturing plant area, which is over 100 acres. Since 1941, many private companies have operated chemical production facilities at this site; operations included ammonia and methanol production, coke plant operations, and production of various other organic chemicals. Contaminated materials from the manufacturing processes were disposed of in the disposal area (OU1), which includes a landfill, former lagoons, and contaminated soils and sediments.

**Site Contact**

Chris Corbett, EPA Region 3, Phone: (215) 814-3220, E-mail: corbett.chris@epa.gov

**Site-Specific Resources**

http://epa.gov/reg3hwmd/npl/WVD000850404.htm

**Site Conditions: Attractive Nuisance Issues**

At OU1, sediments and soils in and around the landfill and former lagoon area are contaminated with heavy metals and polycyclic aromatic hydrocarbons (PAH). Initially, the cleanup remedy for OU1 included construction of a cap on the landfill; bioremediation of soils and sediments contaminated with PAHs; solidification of soils contaminated with heavy metals; and post-remediation monitoring to ensure the effectiveness of the cleanup action. Treatability studies completed for bioremediation indicated that bioremediation could not meet cleanup standards within a reasonable time frame and was not cost-effective.

The revised remedy included construction of a cap, removal of contaminated soil and sediments, and construction of three consecutive treatment wetlands (Ponds 1, 2, and 3) to treat landfill leachate. The first pond is primarily a settling basin for heavier particulates. Cattails were established to ensure aerobic conditions. The second pond is anaerobic to reduce zinc and copper concentrations. The third or polishing pond removes any remaining metals from the leachate and reduces biochemical oxygen demand (BOD). This shallow pond was planted with cattails to dissuade wildlife from entering it. Wildlife needs to be kept away from the ponds to prevent contact with landfill leachate.

**Site Revitalization: Attractive Nuisance Management**

In order for the wetlands to operate as intended, vegetation was required to be absent from Pond 2 to maintain anaerobic conditions, but vegetation would need to flourish in Ponds 1 and 3 and remain dense enough to ensure aerobic conditions and deter wildlife. The treatment wetlands were inspected every 6 months during the first 2 years of the O&M period, and then inspected annually. Field observations during the regular inspections included (1) recording wildlife occurrences within the system habitat and the potential for wildlife exposure to residual leachate, (2) assessing sedimentation and erosion, and (3) assuring adequate aquatic vegetation in Ponds 1 and 3 and confirming negligible or nonexistent aquatic vegetation in Pond 2. The effectiveness of the treatment wetlands was also being monitored quarterly through water quality sampling activities.

To mitigate the use of wetlands for treatment, 1.05 acres of wetlands were constructed along the Monongahela River.

**Information about wetland mitigation requirements may be obtained at http://www.epa.gov/wetlandsmitigation. Also refer to the "Frequently Asked Questions About Ecological Revitalization of Superfund Sites" fact sheet (EPA 542-F-06-002).**

## Case Study 3

**Site Information**

**Name:** Kennecott North and South Zone Sites, Salt Lake County, Utah

**Description:** Mining in the area began in the 1860s, with copper being the primary metal produced. Since around 1900, Kennecott has operated a wide variety of mineral processing and production facilities on site. Kennecott sent much of the mineral processing waste and copper ore from these operations north to the Kennecott Site (North Zone). Tailings waste produced in the South Zone was shipped to the North Zone by slurry and rail.

**Site Contact**

Rebecca Thomas, EPA Region 8, Phone: (303) 312-6552, E-mail: thomas.rebecca@epa.gov

**Site-Specific Resources**

http://oaspub.epa.gov/enviro/cerclis_web.description_report?pgm_sys_id=UTD070926811

http://www.epa.gov/superfund/programs/aml/tech/kennecott.pdf

http://www.epa.gov/superfund/sites/fiveyear/f04-08002.pdf

**Site Conditions: Attractive Nuisance Issues**

The North Zone covers a large area, and sources of contamination include the 5,700-acre tailings pond, a slag pile, and the refinery evaporation pond. The main contaminants of concern are lead, arsenic, and selenium. The South Zone includes wastes associated with extracting and concentrating copper ore. The main sources identified were an open pit, creeks and reservoirs, tailings (including Lark Tailings), evaporation ponds, dumps, and residential soils. Contaminants found in waste sources at the South Zone include arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, and zinc.

Wetlands, springs, creeks, and marshes exist on site and have been used for a variety of purposes over the years, including storage areas for process water and dumping grounds for smelter and refinery wastes. There is concern that maintaining some of the wetlands would create an attractive nuisance because of high selenium concentrations in the water.

**Site Revitalization: Attractive Nuisance Management**

Wetlands with substantial amounts of selenium are not recommended for continued use as wetlands because of the threat to wildlife that would be attracted to the wetland areas. EPA recommended that the wetland habitat be removed by covering the wetlands and zoning the capped areas for light industrial activity. Other wetland areas on site were revitalized without creating attractive nuisance issues and are recommended for future use as wildlife habitat and potential passive recreational. In fact, over 1,000 acres of new wildlife habitat or open space was created, including a wetlands mitigation bank.

**More information on the revitalization and reuse of abandoned mine lands (AML) can be found at http://www.epa.gov/superfund/programs/aml/revital/index.htm**

West Page Swamp, Idaho -
Before Ecological Revitalization.
Source: Dr. Sally Brown, University of Washington

West Page Swamp, Idaho -
After Ecological Revitalization.
Source: Dr. Sally Brown, University of Washington

## Case Study 4

**Site Information**

**Name:** West Page Swamp (Bunker Hill NPL Site), Shoshone County, Idaho

**Description:** West Page Swamp is a naturally occurring 15-acre wetland that is part of the Coeur d'Alene River system in Northern Idaho. It was used as a tailings repository in the 1920s for a mill that processed zinc and lead ore.

**Site Contact**

Harry Compton, EPA ERT, Phone: (732) 321-6751, E-mail: compton.harry@epa.gov

**Site-Specific Resources**

Interstate Technology and Regulatory Council (ITRC). 2004. Making the Case for Ecological Enhancement ECO-1. Washington D.C.: ITRC and Wildlife Habitat Council (WHC).
On-Line Address: http://www.itrcweb.org

**Site Conditions: Attractive Nuisance Issues**

The soil material in the swamp consists of highly contaminated (up to 3 percent lead and 1.5 percent zinc) tailings. These materials were sufficiently toxic that the swamp showed no evidence of ecosystem function. Waterfowl feeding and nesting in these areas have routinely developed acute lead toxicity from ingesting the contaminated sediment.

To restore wetland function to the site, a cap consisting of biosolids compost and wood ash was spread over the surface of the tailings. Stakeholder concerns were primarily related to the ability of the surface amendment to reduce the bioavailability of the underlying metals at the site. There was concern that the site would become an attractive nuisance for wildlife.

**Site Revitalization: Attractive Nuisance Management**

The cap was sufficient to reduce both accessibility and bioavailability of the underlying tailings and restore ecosystem function characteristic of a naturally occurring wetland. The site is currently a wetland in a highly visible area. It provides wildlife habitat and helps a community that was known for undisturbed natural beauty recapture that image after mining and smelting operations ceased.

Stakeholders remain concerned that with leaving a contaminant in place, the remedy will only be temporary. An important component of the remedial plan includes monitoring, especially because the remedy does not completely remove contaminants from the site. Groundwater and surface water wells were installed throughout the site and are monitored quarterly or annually as part of the long-term O&M plan.

## Case Study 5

**Site Information**

**Name:** Tailings Associated with the California Gulch Superfund Site, Leadville, Colorado

**Description:** The California Gulch Superfund Site in Lake County, Colorado, encompasses more than 18 square miles in the Rocky Mountains, about 120 miles west of Denver. Mining, mineral processing, and smelting activities there produced gold, silver, lead, copper, manganese, and zinc for more than 130 continuous years. The site was listed on the National Priorities List in 1983, and included deposition of mine tailings along the Upper Arkansas River.

For over 100 years, these high-pyrite mine tailings have been eroded and re-deposited along the Upper Arkansas River and have created a 10-mile stretch of barren mine deposits. In addition, high metal concentrations in irrigated pastures had contributed to elevated rates of plant toxicity and high mortality in grazing livestock.

**Site Contact**

Rebecca Thomas, EPA Region 8, Phone: (303) 312-6652, E-mail: thomas.rebecca@epa.gov
Michael Holmes, EPA Region 8, Phone: (303) 312-6607, E-mail: holmes.michael@epa.gov
Michael Zimmerman, EPA Region 8, Phone: (303) 312-6828, E-mail: zimmerman.mike@epa.gov

**Site-Specific Resources**

http://clu-in.org/products/newsltrs/tnandt/view.cfm?issue=0705.cfm
http://jeq.scijournals.org/cgi/reprint/34/1/139.pdf
http://faculty.washington.edu/clh/leadville.html
http://www.epa.gov/superfund/programs/recycle/success/casestud/cal_gulch.pdf

**Site Conditions: Attractive Nuisance Issues**

The tailings along the Upper Arkansas River have low soil pH; have elevated concentrations of lead, cadmium, and zinc; and are phytotoxic. Without stabilizing vegetation, erosion would release the tailings into the river during high water events.

Removal of the tailings was not feasible due to (1) the potential for tailings to enter the river during field activities, (2) the high cost of replacement topsoil, and (3) the difficulty of locating an acceptable repository for contaminated soil.

**Site Revitalization: Attractive Nuisance Management**

High rates of lime amendment were used to neutralize the acidity of the tailings, and municipal biosolids were applied directly into the tailings. A majority of the 10-mile stretch along the Upper Arkansas River has been restored and now supports dense vegetation. Analytical sampling conducted by EPA and USDA indicates that although total soil concentrations of metals of concern have not changed, extractable and available lead, cadmium, and zinc are now below regulatory standards.

A wide range of earthworm, fish, and small mammal testing was conducted to determine whether the revitalized habitat was creating an attractive nuisance to the wildlife attracted there. Results showed that the bioavailability of heavy metals present on site was dramatically reduced after being treated with soil amendments and that wildlife exposure to metals is within acceptable limits. In addition, cattle grazing has resumed on land that was barren for more than 80 years, and a public park with a fishing area now operates on one of the former tailings deposits.

California Gulch Superfund Site, Colorado - Before Ecological Revitalization.
Source: Michael Holmes, EPA

California Gulch Superfund Site, Colorado - After Ecological Revitalization.
Source: Michael Holmes, EPA

## Exhibit 1: Sensitive Receptors and Exposure Pathways for Metals and Organic Contaminants

| Contaminant | Sensitive Receptor | | | | | | | | Pathway | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Surface Water | Groundwater | Aquatic | Plant | Pest | Herbivore | Worm | Shrew | Low risk in soil system | Movement to groundwater | Movement to surface water | Can methylate in small quantities | Soil to plant | Plant to herbivore | Direct ingestion of soil, carnivore |
| **Metals** | | | | | | | | | | | | | | | |
| Zinc | | | | ✓ | | | | | | | | | ✓ | | |
| Cadmium | | | | | | ✓ | ✓ | ✓ | | | | | ✓ | ✓ | ✓ |
| Lead | | | | | | | ✓ | ✓ | | | | | | | ✓ |
| Arsenic | | ✓ | | | | | ✓ | ✓ | | ✓ | | | | | ✓ |
| Chromium | | ✓ | | | | | | | | ✓ | | | | | |
| Selenium | ✓ | ✓ | | ✓ | | ✓ | | | | ✓ | ✓ | | ✓ | ✓ | |
| Mercury | | | | | | | ✓ | ✓ | | | | ✓ | | | |
| Copper | | | ✓ | | | | | | ✓ | | | | | | |
| Aluminum | | | | ✓ | | | | | | | | | ✓ | | |
| Manganese | | | | ✓ | | | | | | | | | ✓ | | |
| **Organic Contaminants** | | | | | | | | | | | | | | | |
| Pesticides/herbicides | | | | ✓ | ✓ | | | | | | | | ✓ | | |
| PAH/petroleum products | | | | | | | ✓ | ✓ | | | | | | | ✓ |
| TCE | | | | | | | ✓ | ✓ | | | | | | | ✓ |
| Dioxin/furans | | | | | | | ✓ | ✓ | | | | | | | ✓ |
| BTEX | | | | | | | ✓ | ✓ | | | | | | | ✓ |
| Chlorinated solvents | | | | | | | ✓ | ✓ | | | | | | | ✓ |
| POP | | | | | | | ✓ | ✓ | | | | | | | ✓ |
| Explosives | | | | | | | ✓ | ✓ | | | | | | | ✓ |

Source: Dr. Sally Brown, University of Washington

Contaminants in soil can affect a variety of sensitive receptors and travel through multiple exposure pathways (see the table above). For most metals, direct ingestion is the primary risk posed by elevated metal concentrations in soils. Therefore, animals that ingest soil, such as worms, and animals that eat worms, such as shrews, will be at the highest risk. Shrews are particularly sensitive because they live in a very limited area and eat many times their body weight of insects and worms each day. Some metals, such as zinc and aluminum, are primarily toxic to plants. Metals, such as, cadmium and selenium can be taken up by plants in sufficient quantities to pose a risk to herbivores. Direct ingestion of soil can also be a concern for cadmium. With the exception of herbicides and pesticides, direct ingestion of the soil is the primary concern for organic contaminants because they are highly insoluble in soil. Therefore, worms and animals that eat worms, such as shrews, are the most sensitive receptors.

## References and Additional Information


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Reference for Exhibit 1: Dr. Sally Brown, University of Washington


## EPA Regional BTAG Web Sites

EPA Region 2: http://www.epa.gov/region02/org/desa_hsw.htm

EPA Region 3: http://www.epa.gov/reg3hwmd/risk/eco/index.htm

EPA Region 4: http://www.epa.gov/region4/waste/ots/index.htm

EPA Region 5: http://www.epa.gov/region5superfund/ecology/index.html

EPA Region 8: http://www.epa.gov/region8/r8risk/eco.html

## Contact Us

If you have any questions or comments on this fact sheet, or suggestions for future fact sheets, please contact:


Ellen Rubin
(703) 603-0141
rubin.ellen@epa.gov

Scott Fredricks
(703) 603-8771
fredricks.scott@epa.gov



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