



PALMERTON ZINC PILE PALMERTON, CARBON COUNTY, PENNSYLVANIA Superfund Case Study

Land Once Barren from Nearby Smelter Becomes Native Prairie

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.

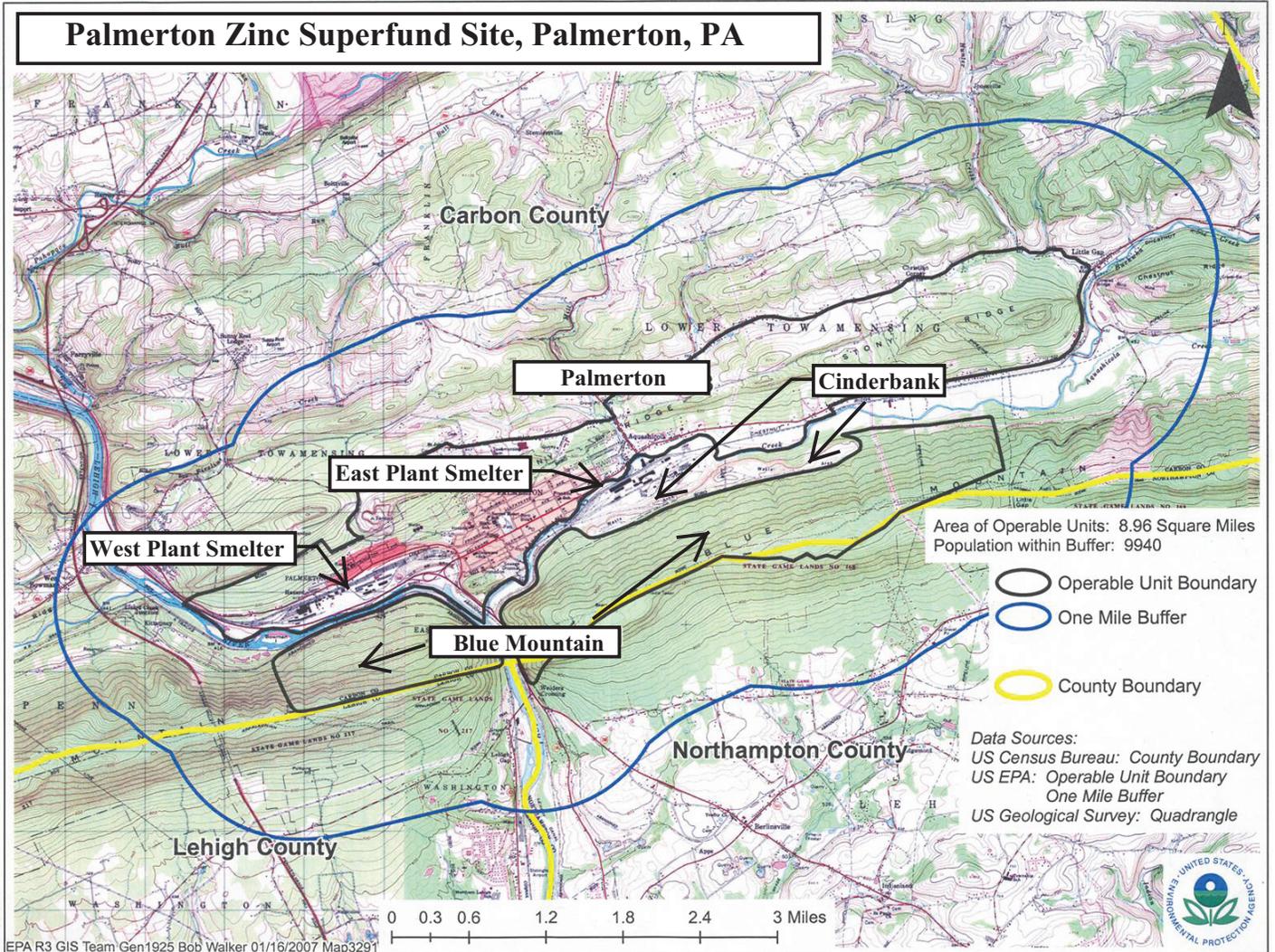
This is the story of the Palmerton Zinc Pile Superfund Site, where a decades-long cleanup continues to include ever-evolving revitalization techniques turning thousands of acres of barren wasteland into thriving native prairie. Zinc smelting operations initiated in the late 1800s distributed heavy metals throughout the surrounding soil at concentrations that resulted in ecosystem collapse and prevented plant growth across a 3,000-acre area. With no plants to keep the soil in place, erosion of contaminated soil impacted the nearby Lehigh River and Aquashicola Creek. To stabilize the contaminated soil, the site was revegetated using a variety of ecological revitalization techniques. After a risk analysis was completed to make sure the site was safe for passive recreational visitors, a 450-acre portion of the site is now filled with warm-season grasses and is the home of the Lehigh Gap Nature Center, where both wildlife and the public are able to enjoy the lush open space.

At the start of cleanup activities, the revitalization crews used a spreader truck to apply a specialized soil amendment mixture including, sewage sludge, fly ash, lime and fertilizer with grass and tree seed to revegetate the area. The use of the spreader truck required more

Topics Highlighted in this Case Study:

- ✓ Attractive Nuisance
- Bioavailability
- ✓ Erosion
- ✓ Invasive Species
- Predator Control
- ✓ Recreation
- ✓ Soil Amendments
- ✓ Use of Native Plants
- Use of Volunteers
- ✓ Water Management
- Wildlife Habitat
 - Freshwater Wetland
- ✓ Prairie
- Saltwater Wetland
- Savannah
- ✓ Stream
- Woodland

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



than 60 miles of switchback roads be built up the mountain. As the cleanup progressed, this amendment mixture was replaced with a mushroom compost mixture. In addition, because of (1) the failure of the tree seeds to successfully germinate and (2) an increased knowledge of the importance of using native plants for revitalization (especially the use of warm-season grasses at contaminated sites), the crews replaced sod grass and tree seed with a specialized native warm-season grass seed mix. Additionally, to prevent the need to create access roads, the spreader truck was replaced on slopes less than 25 percent by an agricultural tractor modified with tank tracks and a spreader box. On steeper slopes, a crop duster plane was used to apply the seed mixture. Willingness to adapt the strategy and incorporate these state-of-the-art ecological

revitalization techniques has led to hundreds of acres of diverse, native prairie.

Background

- The over two thousand-acre site is located in the Lehigh Gap area in Palmerton, Pennsylvania near the Lehigh River and Aquashicola Creek. The surrounding area is rural and consists of a series of deep, narrow valleys.
- The site consists of two former primary zinc smelters – west smelter operations began in 1898 and east smelter operations began in 1911. The smelters operated until December 1980.
- Previous smelting activities at the site emitted large quantities of zinc, lead, cadmium, and sulfur dioxide, defoliating more than 2,000-acres near the east smelter

Make Sure You Know What's In Your Soil Amendment

The sludge and ash used in a soil amendment can contain small amounts of heavy metals. Therefore, maximum concentrations of metals and other constituents in the sludge and ash used in the soil amendment were (1) based on Pennsylvania Department of Environmental Protection (PADEP) maximum allowable concentrations in sludge and cumulative metal loading rates and (2) adjusted down to help ensure that no combination of sludge and ash meeting the specified limits would exceed the PADEP lifetime metals loading limits.

on the adjacent Blue Mountain. Process residue and other plant wastes were disposed of in a cinder bank, which is a 2.5-mile, 255-acre waste pile located behind the east smelter at the base of Blue Mountain. The cinder bank contains approximately 33 million tons of material containing leachable metals, including: lead, zinc, and cadmium. Additional defoliation has also occurred along Stoney Ridge.

- The surface soil, shallow groundwater, and stream sediments are contaminated with heavy metals from site operations. Elevated levels of zinc and cadmium in the soil are responsible for the vegetation damage; this damage increases the potential for erosion of the contaminated soil, contributing to surface and groundwater contamination.
- Revegetation was the main treatment technology selected on Blue Mountain to address the heavy metal contamination. Remedial activities for the cinder bank included capping and revegetation in addition to a system to divert surface water and treat leachate. A final cleanup plan for groundwater/surface water contamination and ecological risks will be issued in

2012. In 1991, the responsible parties began applying biosolids to accelerate revegetation of the area. Through mid-2006, almost 1,300 acres of Blue Mountain, 220 acres of the cinder bank, and 40 acres of Stoney Ridge have been revegetated. In 2008, an additional 700 acres of state and federally owned land on Blue Mountain was revegetated via aerial application. The plan is to revegetate the remaining acres in 2011 and 2012. Soil amendments used included mushroom compost or municipal sewage sludge, power plant fly ash and/or bottom ash, and/or agricultural limestone and seed mixtures. Revegetation has stabilized the treated area, reduced soil erosion, and improved water quality (i.e. decreased soluble metals contaminant concentration) associated with runoff from the site.

Ecological Revitalization

The sheer size of the Palmerton site resulted in a lengthy cleanup process. Initially, surface water was diverted around the cinder bank, and a treatment system for the leachate was installed. The longer term remedy for both the cinder bank and denuded areas of Blue Mountain included revegetation. The remedy used techniques that evolved over time and considered up-to-date knowledge regarding successful revitalization techniques. Originally, the Record of Decision required revegetation to prevent continued erosion into



Soil amendments applied using a spreader truck

Use of Warm Season Grasses on Mine Sites

In the Mid-Atlantic region, native warm season grasses, such as gamagrass (*Tripsacum* spp.) and deertongue (*Dichanthelium clandestinum*), have proven to be effective at establishing cover to stabilize highly degraded and acidic mine-land soil and were successfully used at the Palmerton site. When using warm season grass seed, it is important to consider the longer establishment period, relatively high seed cost, and short seeding window of warm season grasses. However, the benefits of using native warm season grasses can far outweigh the costs associated with these considerations. For additional information on warm season grasses, visit these websites:

<http://www.plant-materials.nrcs.usda.gov/pubs/mdpmctn8100.pdf>

<ftp://ftp-fc.sc.egov.usda.gov/NJ/programs/pmcl/NativeGrassesforCriticalAreaStabilization.pdf>

the Lehigh River. In the early 1990s, a cutting edge idea to use a mixture of sewage sludge, power plant fly ash and/or bottom ash, and agricultural limestone was incorporated into the plan. So, for initial revegetation activities at Blue Mountain and the cinder bank these soil amendments were mixed with specialized sod grass and tree seed mixes before application. Full-scale implementation of the revegetation began in 1991. Between 1991 and 1998, approximately 850 acres were revegetated using a spreader truck. The ratio of sludge to ash was 2:1 by volume. The amendment was applied at a rate of approximately 60 dry tons of sludge per acre.

Initial revegetation activities were successful, but as time went on, the specific soil amendment mix developed a negative public perception because it included the use of municipal sewage sludge. Contractors at



Mushroom compost, fertilizer, lime, and seed mix applied using a tractor/spreader

the Palmerton site continued revegetation activities, but after testing alternatives, replaced the use of sewage sludge in the soil amendment with mushroom compost. In 2005, approximately 40 acres along Stoney Ridge were revegetated using a mixture of mushroom compost, lime, and fertilizer.

While continuing the revegetation activities, contractors addressed additional challenges using creative methods. Initially, land owned by the responsible parties was revegetated using a spreader truck which required over 60 miles of roads to be constructed. For privately-owned land, a modified agricultural tractor and spreader were used to apply the soil amendment and seed mixture. On



Soil amendment and seed mixture applied using a plane

steep slopes, the seed mixture was applied using a fixed wing crop-duster. This method eliminated the need to build switchback roads throughout the area for truck access to apply the amendments, which saved a considerable amount of money and gave the land a more natural appearance.

The seed mixture included (1) grasses that establish themselves quickly, (2) perennial grasses for long-term erosion control, (3) trees, and (4) birdsfoot trefoil (*Lotus corniculatus*), a nitrogen-fixing legume to maintain the soil long-term without the need of fertilizers. At Blue Mountain, grass cover was highly successful. However, tree seeds were not as successful because of fungal disease, competition with plants, and foraging animals. In addition, limited sampling showed that trees may have been taking up contaminants. The idea of using native species for revegetation had evolved further at this point in the revitalization activities, and additional test plots were planted in 1995 and 1999. Based on the test plot results, changes were made to the seed mixture and planting plan, including:

- Self-sustaining meadowland (native warm season grasses) seed mixture was used with plants that have minimal metal uptake.
- Indicator plant species for metals were sampled and analyzed to determine if any uptake was occurring.

- Volunteer tree species with high metals uptake, like birch and poplar, were evaluated, as necessary.

Measures to Improve Chances of Success

Other erosion control activities conducted in the Stoney Ridge area include installation of rock/stone check dams, diversion berms, and sedimentation basins along with revegetation in and around erosion channels. These efforts were undertaken to eliminate the deposition of sediment onto local roadways and residential properties during major storm events. Since these actions were completed, this previously common occurrence has not been noted.

During revegetation and cleanup of the cinder bank, the responsible parties built a system to divert surface water around the cinder bank and are treating contaminated leachate before it is discharged to the nearby Aquashicola Creek. These clean-up efforts have reduced the overall metals loading to the creek by more than 60 percent.

Palmerton Today and Moving Forward

The native warm season grasses have become successfully established and have become a thriving prairie habitat for wildlife in the area. Specifically, for over 10 years, the 850 acres reclaimed on Blue Mountain have maintained



Blue Mountain revitalization in (left) October 2002 and (right) August 2003



Blue Mountain revitalization in (left) September 2004 and (right) August 2006

more than 70 percent vegetative cover with increasing emergence of volunteer tree species.

The Lehigh Gap Nature Center was built on a 750-acre parcel that is open to the public daily, 450 acres of which is successfully remediated land on Blue Mountain. The land includes walking trails as well as bike trails, linking (1) the Delaware and Lehigh Rails to Trails systems, (2) the Philadelphia and Scranton trail systems, and (3) the Appalachian Trail on the property. The nature center and trail systems on the property allow the public to enjoy and learn about nature and local wildlife.

The nature center also helps to ensure that much of the land will continue to be maintained. Environmental easements are in place for the land that is managed by the nature center and land owned by the Game Commission and Park Service. The agencies

have partnered with the responsible parties to ensure the portion of land revegetated using soil amendments will also be maintained.

Because some level of soil contamination has remained in place, EPA has worked with the responsible parties to implement institutional controls. Most recently, EPA is working to make sure institutional controls for the last remaining private parcels are implemented.

Cost

Traditional cleanup techniques, which included removal of contaminated soil and associated smelting residue from the over 2,000-acre site, was initially estimated to cost more than \$4 billion and take up to 45 years to complete. While total costs for all revegetation activities are not available, the responsible parties estimate that it cost approximately \$9 million to reclaim the initial 850 acres of Blue Mountain. Risk assessments and extensive testing was required to ensure that this approach would be protective as well as cost effective. A significant portion of the initial cost for revegetation of the first 850 acres was associated with construction of over 60 miles of switchback roads for truck access. Subsequent revegetation activities (the remaining portion of Blue Mountain, the cinder bank, and Stoney Ridge) used planes and did not require roads construction; therefore, the anticipated cost per acre is expected to be lower than for the initial 850 acres.



The Lehigh Gap Nature Center

Stakeholders Involvement

- **EPA** – Palmerton Zinc Pile is a Superfund site, so EPA plays an active role in providing regulatory and technical oversight to support Comprehensive Environmental Response Control and Liability Act (CERCLA) activities at the site.
- **U.S. Fish and Wildlife Service (USFWS)** – As part of the Biological and Technical Assessment Group (BTAG) for the region, USFWS provides technical guidance for remediation and revitalization activities.
- **National Park Service (NPS)** – The Appalachian Trail, which runs through the site on Blue Mountain, is owned/managed by the NPS. EPA continues to work cooperatively with NPS to remediate this portion of Blue Mountain.
- **State of Pennsylvania** – The State of Pennsylvania through the Game Commission owns some of the land on Blue Mountain that was revegetated. EPA coordinated with the state to remediate this portion of Blue Mountain.
- **Pennsylvania Game Commission and Forestry Service** – Provided technical guidance for attempted tree restoration and is an affected landowner.
- **U.S. Department of Agriculture (USDA)** – Acted as a consultant for the nature center and provided technical guidance on the use of warm-season grasses for the revitalization activities.

Lessons Learned

1. **Be willing to modify the planned habitat, if necessary:** Establishing forestland at the site was extremely challenging and was ultimately abandoned in favor of prairie. Various challenges were encountered during forestland development efforts, including small mammals eating tree

seedlings. Extensive efforts to establish trees on the site include the following: (1) all grass was cut in a 3.3 ft. area with a weed-whacker prior to putting tree seedlings into the ground to minimize competition from grass; (2) seedlings were inoculated with a microrrhizium developed for contaminated soils prior to planting; (3) a plastic protective tube was placed around each seedling to protect from animal grazing, (4) animal repellent and an iron chelate were applied to seedlings; and (4) insect control was used, as needed. When these efforts were ineffective, additional measures included a ground weed control mat (3 by 3 foot) and a netting type of seedling protector. A cost comparison estimated prairie establishment at \$1,125/acre versus \$6,125/acre for forestland.

2. **Consider potential attractive nuisance issues:** Due to metals uptake, the types of grass seeds were replaced with those having minimal metals uptake.
3. **Take into account community concerns:** As a result of negative public perception, the sewage sludge soil amendment was replaced with mushroom compost.
4. **Don't discount creative alternatives:** Application methods were modified from land application to aerial application. This less intrusive method eliminated the need for road construction, which significantly decreased costs and resulted in a more natural habitat.
5. **Consider ongoing invasive species management control:** The invasive plant species, butterfly bush, had established itself before the revegetation project and has widely spread since. Every year, efforts are made to control its spread, with some success. Tree of Heaven, an invasive tree species, was present in the highway corridor that runs through the gap and has been difficult to control. A major component of ongoing maintenance will be invasive species management.

Additional Information

Websites to obtain additional information on the Palmerton Zinc Pile site and ecological revitalization include the following:

EPA Abandoned Mine Lands Innovative Technology Case Study

<http://www.epa.gov/aml/tech/palmerton.pdf>

EPA's Eco Tools Website

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

Ecological Revitalization: Turning Contaminated Properties Into Community Assets

http://www.clu-in.org/download/issues/ecotools/Ecological_Revitalization_Turning_Contaminated_Properties_into_Community_Assets.pdf

Frequently Asked Questions About Ecological Revitalization of Superfund Sites

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

Revegetating Landfills and Waste Containment Areas Fact Sheet

http://www.clu-in.org/download/remed/revegetating_fact_sheet.pdf

Ecological Revitalization and Attractive Nuisance Issues

<http://www.epa.gov/tio/download/remed/542f06003.pdf>

**For additional information on the Palmerton Zinc Pile site,
you can also contact the EPA project manager:**

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**If you have any questions or comments on this fact sheet,
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