Selected Abandoned Mined Land Reclamation Projects and Passive Treatment in Ohio

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Introduction

Ohio has a long history of both surface and underground mining for bituminous coal. Early reclamation laws began to be passed in the mid 1940's and later were primarily related to the planting of trees, closing mine entries, minor grading, covering coal seams and providing for the establishment of impoundments. Subsequent laws passed in 1972 and later yielded a product that would be recognizable today as "reclaimed", including backfilled highwalls, topsoil replacement and establishment of grassland cover.

Early mined land inventories after the passage of SMCRA revealed about 400,000 acres of abandoned surface mined (AML) lands and about 600,000 acres of abandoned underground mines. Reforestation of mined lands was very successful in Ohio. Of these, only about 20,000 acres of surface mined land was rated priority one or two in the AML priority ranking system. No estimate was made of lands contributing to priority three water chemistry problems.

Unfortunately, revegetation of abandoned surface mined lands often does an incomplete job in preventing the formation of acid mine drainage. Coal refuse piles and abandoned underground mine discharges also persist unabated across Southeastern Ohio. Over 1300 miles of streams are polluted by mine drainage in Ohio.

Geology of the coal bearing regions definitely plays a part in residual water quality after mining. The Conemaugh and Monongahela groups of Eastern and Northeastern Ohio may produce acid or alkaline mine drainage, but their effects are much less pronounced than the strong acid mine drainage produced in the Allegheny and Pottsville groups of Southeastern Ohio. The Hocking River and Raccoon Creek drainages are particularly troublesome restoration areas.

Discussion

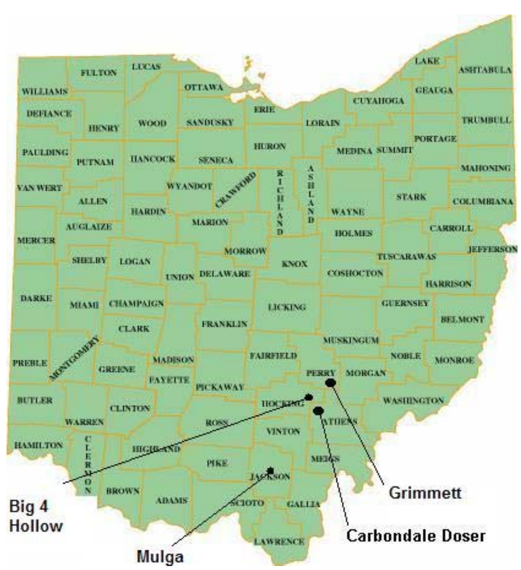
Since 1995, a partnership of agencies and citizens groups have been organizing watershed restoration projects in some of the most profoundly polluted stream systems. Partnerships often include Watershed Coordinators, their staff and citizen members, the Ohio Department of Natural Resources (ODNR), the Ohio Environmental Protection Agency (OEPA), the Office of Surface Mining (OSMRE), Colleges and Universities, local Soil and Water Conservation Districts, the U.S. Forest Service (USFS) and others.

Remediation plans are based on a thorough, basin wide investigation and planning reports produced by the watershed groups and Ohio EPA. These plans prioritize reclamation of all mine land sites needed to effect restoration and include cost estimates and potential funding sources. Leveraging AML funds is key to the success of the watersheds restoration effort being led by ODNR and OEPA. Funding and in-kind services for project work has been obtained from all the major partners. Major sources of construction funding have come from ODNR AMD Set Aside funds, EPA #319(h) grants, OSM Appalachian Clean Streams Initiative funds and USFS Land and Water Conservation monies.

Case Studies

Four case studies are presented here. They represent a variety of challenging treatment settings that are typical of Southeastern Ohio. Typically, these are headwater locations with dozens or hundreds of AMD sources both up and downstream. So it is often critical to not only treat the AMD reporting to the site but to account for additional AMD inputs downstream. Flows in these watersheds are not only highly seasonal but subject to flood surges during storms. Most of the underground mines outcrop very near stream banks leaving little room for treatment. The AMD is invariably high in ferric iron and aluminum eliminating treatment options such as anoxic limestone drains and vertical flow wetlands. It is important to note that all post reclamation results are based on limited data generated since completion of the projects.

Technical guidance for AML reclamation and passive treatment technologies has been received from a variety of sources, including West Virginia and Ohio Universities, published research documents, OSMRE and other State case studies and private consultants. Despite published results, the performance of various remediation techniques is unique to the site and engineering characteristics of each project.



Ohio Location Map

Grimmett

The Grimmett Project is located in Perry County, Salt Lick Township in the Monday Creek watershed. Key reclamation characteristics included a small coarse refuse pile laying astride a stream valley and numerous low flow, acidic underground mine discharges. A wetland had formed above the coal refuse pile and one of the underground mines discharged through the coal refuse into a tributary of Monday Creek.

Pre-reclamation water quality downstream of the site had a pH of 3.4, acidity of 62 mg/L, iron of 5.2 mg/L and aluminum of 2.2 mg/L. The acid load was 761 lbs/day.

Consultation with the Water Research Institute at West Virginia University yielded a conceptual design that included regrading and soil capping the refuse pile, installation of open limestone channels and two "J" trenches. The "J" trenches involved excavating down to original ground beneath mine sediments at two locations in the upstream wetland and placing a lift of limekiln dust (LKD) in the trenches up to normal pool elevation. The LKD was topped with a limestone rock dam to normalize pool level in the wetland and to prevent channelized flow. The LKD exhibited an exothermic reaction immediately after placement in the flooded trenches.

The project work was completed in September 2004 at a cost of $155,641.

Post reclamation water sampling shows the downstream pH is now 6.7, net alkalinity of 14 mg/L, iron of 0.7 mg/L and aluminum of 0.5 mg/L. The alkaline loading is 21 lbs/day or a 100% decrease in acid loading.

Carbondale Doser

The Carbondale Doser Project is located in Athens County, Waterloo Township in the Hewett Fork tributary of Raccoon Creek. High flow discharges from an abandoned underground mines rendered Hewett Fork virtually lifeless for miles downstream and periodically impacted Raccoon Creek at low flow. An anaerobic wetland was installed by ODNR at the site in 1991. Performance of the wetland became unsatisfactory over time. After consultation with the Maryland Bureau of Mines, ODNR installed an AquaFix water wheel type doser in late 2003.

Pre-reclamation water quality at the larger of two seeps was pH 3.96, acidity 466 mg/L, iron 117 mg/L, aluminum 37 mg/L. The combined acid loading from both seeps at the site was 1195 lbs/day.

The cost of the project, including a permanent road, installation of the doser and reclamation of the wetland was $401,622.00. Operation and maintenance costs are approximately $40,000.00/year.

An additional 376 lbs/day of acid enters Hewett Fork from downstream tributaries Trace Run and Carbondale Creek.

Early operation using dolomitic and limekiln dust wastes were problematic. Both materials had a tendency to clog in the silo and doser. Neither material provided the neutralization potential sought by ODNR, despite bench tests that indicated they would. The AquaFix machine was originally designed for pebble quick lime (CaO) so testing proceeded with this material. The results were appreciably better in material handling and downstream neutralization.

Post reclamation water quality at the project outlet has a pH of 11.1, an alkalinity of 203 mg/L, iron 64.8 mg/L total and 1.7 dissolved and aluminum 17.5 total and 3.2 dissolved. The alkaline load is 631 lbs/day and is largely consumed by two other downstream sources of acid mine drainage from Carbondale Creek and Trace Run.

The project has effectively neutralized all sources of acidity in the watershed. Downstream alkalinity is approximately 15 mg/L. The Waterloo Experiment Station, two miles downstream historically has recorded no fish species. However, after installation of the doser, good water clarity and minimal sedimentation were recorded at the station and in the summer of 2004, seven species of fish were found.

Mulga

The Mulga Project is located in Jackson County, Milton Township in the Little Raccoon Creek Drainage. A major tributary to Little Raccoon Creek, Mulga Run has multiple sources of acid mine drainage from abandoned underground mines. A preliminary study showed that individually treating each discharge with passive treatment technologies could cost over $1,300,000 and burden ODNR with maintenance of up to fourteen separate systems.

Pre reclamation water quality at the mouth of Mulga Run had a pH of 4.9 (ranging from 3.2 to 6.7), acidity 77 mg/ (ranging from 243 mg/L to 30 mg/L alkalinity), iron 9.8 mg/L and aluminum 8.5 mg/L. The acid load was 775 lbs/day.

A new strategy was formulated for using a basin wide treatment approach though a minimal number of sites. Large steel slag leach beds were installed in the only two clean water tributaries in Mulga Run. Both were sited below reconstructed surface water impoundments. An existing 24-acre wetland at the mouth of Mulga Run was found to be functionally improving water quality, except at low flow when it became channelized. Four limestone rock berms were placed across the wetland to prevent channelized flow and keep water impounded at a normal pool elevation. Increasing the storm water stage required an expensive program to elevate local roads and a single residence.

The project was completed in September 2004 at a cost of $441,283.25.

Post reclamation evaluations show that the wetland is functioning well to remove precipitated metals. The two slag beds are working well, though expected levels of alkaline production are not being achieved. Alkalinities are presently between 200 mg/L and 400 mg/L at the slag bed outlets. The –3/8" sized steel slag has become cemented together, perhaps due to the periodic flooding and drying out during construction. Calcite may have formed and is cementing the particles together, diminishing hydraulic conductivity. Preferential flow paths may have begun around clean out pipes and the interface between slag and embankment materials. A dye tracer test will be run this summer prior to making any adjustments.

The pH is no lower than 6.7 anywhere on the mainstem of Mulga Run. The mouth of Mulga Run has a pH of 7.18, a net alkalinity of 36 mg/L, iron 4.77 mg/L (as opposed to 17.3 mg/L, total, above the wetland) and aluminum of 1.22 mg/L. All acidity has been eliminated and the alkaline load is approximately 1000 lbs/day.

Interestingly, the worst acid mine drainage source, Tributary 6, had a tremendous improvement in pH and reduction in acidity between design and construction completion. While the last two years have had record rainfalls, it is thought that remining adjacent to the abandoned deep mines in Tributary 6 was primarily responsible for the improvement.

Big 4 Hollow

The Big 4 Hollow Project is located on the Wayne National Forest in Hocking County, Ward Township and is a tributary of Monday Creek Watershed. Funds for the project were provided by the Ohio Department of Transportation, ODNR and the USFS. The USFS prepared the design and supervised the contracting and construction of the project. Davis-Bacon wages were paid.

The Big 4 Hollow site was underground mined for the Middle Kittaning coal seam. It was subsequently crop strip mined, and where possible, augered as well. Strip mining provided multiple outlets for underground mine drainage to discharge.

Pre reclamation water quality showed a pH of 3.1, acidity of 154 mg/L, iron 3.1 mg/L and aluminum 91 mg/L. The acid load was 573.4 lbs/day. Fifty-seven percent (57%) of the acidity came from a single seep, #Big-49.

Thirty five hundred (3500') feet of open limestone channels were constructed below the outfalls of most major seeps. In addition, two limestone leach beds were installed, including one very large one below site #Big-49. Over 6800 tons of limestone were originally estimated to be needed for the project. Final quantities are still being calculated by the USFS.

Construction was completed in 2004 at a cost of approximately $322,124.

Post reclamation water sample results show the pH to now be 4.22, acidity 48.8 mg/L, iron 0.9 mg/L and aluminum 7.49 mg/L. The acid load has been reduced to 235 lbs/day or a 41% reduction. Most residual acidity seems associated with aluminum. A conceptual design called for a steel slag leach bed in the basin's one clean water tributary. It was, however, left out of the construction project. Future installation of this feature could eliminate the remaining acidity.

Another very similar site completed concurrently, Snake Hollow, and has shown much less improvement. Initial sampling shows flows well in excess of what was designed for. Further investigation should show why these two projects have, apparently, achieved differing results.

Conclusions

A variety of approaches to acid mine drainage show promise for usefulness across Appalachia. Each potential project site is unique and will perform in differing ways. Further research and field trialing of limestone systems, steel slag, wetlands and lime dosers will improve the predictability of their use for remediating acid mine drainage problems. Waters with relatively low concentrations of iron are a definite advantage in designing passive treatment.

It is instructive to examine the cost per ton of acidity removed over a 20-year service life.

Project	Cost	Tons / 20-Years	Cost / Ton
Grimmett	$155,641	2,853	$54
Carbondale	$1,201,622	6,665	$180
Mulga	$441,283	6,479	$68
Big 4	$322,124	1,234	$261

* (Results likely Skewed by effects of remining)

Cost per ton of acid removed is only one consideration in designing a remediation project. Water chemistry, project goals, available funding and landowner and site constraints often dictate the option selected for construction.

Ohio's Acid Mine Drainage Abatement program and its valuable partners have benefited from the efforts of those working in neighboring States. We look forward to contributing in the future to the body of knowledge in mine drainage remediation.

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References

ATC Engineering Services of Ohio L.P., 2001, Carbondale II Wetland Project – Design Feasibility Report.

ATC Engineering Services of Ohio L.P., 2001, Mulga Run Reclamation Project – Design Feasibility Report

Mitchell Farley, Ben McCamment, Don Bryenton, Brent Miller, Michael Greenlee, 2004, Stream Dosing for Acid Mine Drainage Pollution at Carbondale and Jobs Hollow in Southeastern, Ohio

Donald L. Bryenton, P.E., Brent A. Miller, Nancy A. Seger, P.E., Mitchell E. Farley, 2003, Chemical Treatment of Acid Mine Drainage for Stream Restoration, A Case History of the Carbondale II Reclamation Project, Athens County, Ohio

Shimala, Jennifer R., 2000, Hydrogeochemical Characterization of the Carbondale Wetland, Athens County, Ohio: Evaluation of Acid Mine Drainage Remediation Alternatives, Masters Thesis, Ohio University.

Maryann Borch, Jennifer Shimala, 1999, Monday Creek Watershed Acid Mine Drainage Abatement and Treatment Plan

Rebecca Black, Monday Creek Restoration Project, 2005, Personal Communication