Stream Dosing for Acid Mine Drainage Pollution at Carbondale and Jobs Hollow in Southeastern, Ohio

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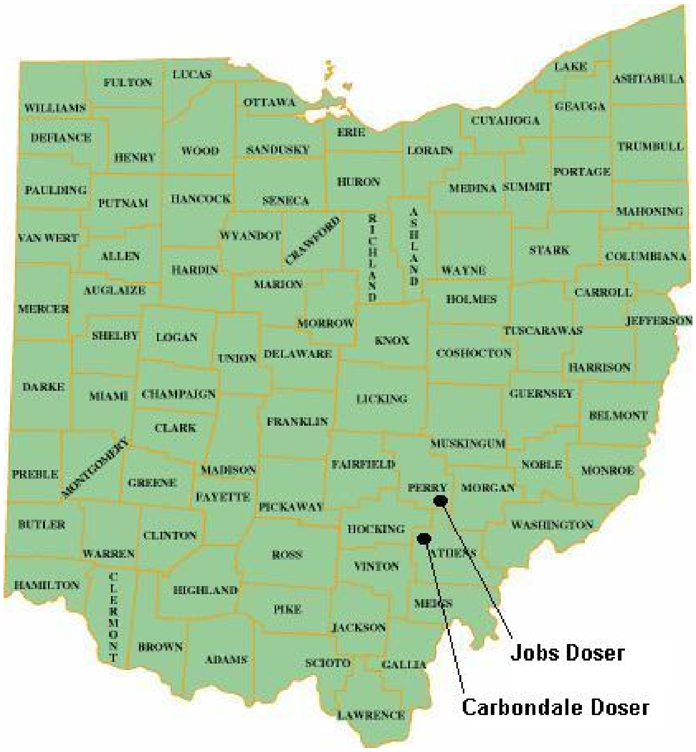
Abstract

Dosing machines have been constructed at two locations in Southeastern Ohio during 2003-2004. The purpose of these water driven devices is to apply lime or lime waste products to streams impacted by acid mine drainage (AMD). AMD is a pollution problem that impacts over 1300 miles of streams in Ohio and occurs in many locations where abandoned coal mines exist.

Extensive investigations were conducted to site the dosers at locations where they were expected to be most efficient in attaining stream restoration goals set by local watershed groups. The Carbondale Doser was installed at a site in Athens County that includes two seeps from underground mines in the headwaters of Hewett Fork, a principal tributary of Raccoon Creek. Prior to the installation of the doser, the two seeps combined to discharge an average acid load of about 1200 lbs/day to Hewett Fork. The Jobs Hollow Doser was installed in the headwaters of Monday Creek in Perry County. The Jobs Hollow sub-watershed discharged an average acid load of about 575 lbs/day to Monday Creek prior to the installation of the doser.

Preliminary results indicate that the dosers are effectively neutralizing the site-specific AMD and providing alkalinity to assist in treating additional AMD discharges downstream of the doser locations, thus exceeding treatment estimates that were developed in bench and laboratory studies. Water quality and biologic monitoring is underway and should aid in determining if this approach is a viable tool in reducing AMD pollution in Ohio.

<u>**Background**</u>



Carbondale Doser

The Carbondale II Reclamation Project site is located in the eastern portion of Athens County, Ohio in Waterloo Township, just east of the Town of Carbondale. The property is owned and managed by the Ohio Department of Natural Resources (ODNR), Division of Forestry. Acid mine drainage (AMD) is discharged continuously at two (2) locations from an adjacent underground mine complex associated with the Middle Kittanning No. 6 coal seam. The Rice Hocking abandoned underground mine ceased operation in 1923.

In 1991 by the ODNR, Division of Mineral Resources Management (DMRM) funded a reclamation project that included the construction of a passive wetland treatment system designed to mitigate the AMD that discharged from the seeps. The constructed wetland system consisted of a series of ten (10) treatment cells through which the AMD was directed. The east seep, which accounts for the majority of the discharge, was initially routed through an anoxic limestone drain (ALD) followed by five (5) cells that encompass an average surface area of approximately 14,000 ft^2. The west seep was directed through three (3) smaller cells that were constructed with an average surface area of approximately 3,150 ft^2 prior to converging with the east seep discharge. The combined flow was then routed through a final treatment cell and a half-acre polishing pond prior to being discharged into Hewett Fork, a tributary to Raccoon Creek. Tables 1 through 3 on the following page summarize the water quality and flow data of the east and west seep discharge to Hewett Fork prior to the Carbondale II Reclamation Project.

Jennifer Bowman, an Ohio University graduate student, concluded that the existing wetland system resulted in annual average removal efficiencies of 23% for aluminum, 15% for manganese, 63% for iron, 21% for acidity, and 16% for sulfate. Although the system appeared to be removing a considerable portion of the iron load, the wetland continued to discharge an average acid load of over 725 lbs/day into Hewett Fork and remained a high priority AMD source in the Raccoon Creek watershed.

The Vinton Soil and Water Conservation District, the Ohio Environmental Protection Agency, DMRM and the Office of Surface Mining's Appalachian Clean Streams Program jointly provided funds for investigation, design and construction.

Table 1. East Seep AMD Characterization
Carbondale II Reclamation Project

	Range	Average	Average Loading	Maximum Loading
pH	3.53 – 4.16 s.u.	3.96 s.u. (median)	--	--
Total Iron	109 – 139 mg/l	117 mg/l	220 lbs/day	592 lbs/day
Total Aluminum	27 – 49 mg/l	37 mg/l	70 lbs/day	158 lbs/day
Total Manganese	5.4 – 7.6 mg/l	7.0 mg/l	11 lbs/day	30 lbs/day
Total Acidity	406 – 527 mg/l	466 mg/l	877 lbs/day	2,245 lbs/day
Discharge	0.18 – 0.79 cfs	0.35 cfs	--	--

Table 2. West Seep AMD Characterization
Carbondale II Reclamation Project

	Range	Average	Average Loading	Maximum Loading
pH	3.18 – 4.05 s.u.	3.52 s.u. (median)	--	--
Total Iron	61 – 114 mg/l	98 mg/l	71 lbs/day	224 lbs/day
Total Aluminum	22 – 43 mg/l	33 mg/l	25 lbs/day	56 lbs/day
Total Manganese	5.1 – 7.5 mg/l	7.0 mg/l	6 lbs/day	15 lbs/day
Total Acidity	361 – 486 mg/l	430 mg/l	318 lbs/day	499 lbs/day
Discharge	0.04 –0.40 cfs	0.14 cfs	--	--

Table 3. Combined Loading Values – East and West Seeps
Carbondale II Reclamation Project

	Average Loading	Average Loading	Maximum Loading
Total Iron	53 tons/year	290 lbs/day	697 lbs/day
Total Aluminum	17 tons/year	95 lbs/day	191 lbs/day
Total Manganese	3 tons/year	17 lbs/day	37 lbs/day
Total Acidity	218 tons/year	1,195 lbs/day	2,678 lbs/day

Site investigations and subsequent designs for an Aqua-fix brand doser were prepared for DMRM by ATC Associates Inc**.** The primary design components of the final design of the 75 ton Aqua-Fix dosing unit alternative included the grading plan, a concrete lined V-notch mixing zone, the dosing unit foundation design, and associated surface water drainage. The construction drawings included plan views and cross-sectional mapping of the existing and proposed site conditions in addition to profile details of the proposed concrete lined V-notch mixing zone. The design of the mixing zone incorporated the use of a perforated cellular confinement system to serve a double use as a permanent erosion control feature in addition to providing a form for the concrete channel lining. The perforated cellular confinement system was designed to provide a 6-inch concrete lining installed over a nonwoven geotextile. Nine (9) six inch elevations drops were included in the design of the mixing zone to increase turbulence and reagent dissolution and Type II cement was required in the concrete lining to minimize the degradation of the channel by sulfate attack. A 12 ft wide maintenance road was also included along the bank of the proposed mixing zone to facilitate channel cleanouts as needed.

Jobs Hollow Doser

The Jobs Hollow Doser Project is located in the southern portion of Perry County, Ohio in Salt Lick Township. The property is owned and managed by the USDA – Forest Service. Personnel from the Wayne National Forest prepared the environmental assessment documents for the construction project. The doser is located along a perennial unnamed stream that receives year round discharge from several abandoned underground mines. Acid mine drainage issues from several complexes, with the main discharge from the Middle Kittanning No. 6 coal seam mined at the Thorn Hill Mine, abandoned in 1949.

The Ohio Environmental Protection Agency, DMRM and the Office of Surface Mining's Appalachian Clean Streams Program jointly provided funds for investigation, design and construction.

The partners in the Monday Creek Restoration Project, a citizens watershed group, have completed Acid Mine Drainage Abatement and Treatment (AMDAT) investigations that showed Jobs Hollow, the very headwaters of Monday Creek, as being responsible for approximately 15% of the acid loading in the watershed. The following table summarizes the water quality that discharged from the Jobs Hollow sub-watershed prior to the Jobs Hollow Doser Project.

Table 4. Site 148 Characterization
Jobs Hollow Doser Reclamation Project
4/1998 –9/1999

Parameter	Units	Loading lbs/day
Acidity	92.8 mg/l	1262.1
Alkalinity	0 mg/l	0
Iron	3.1 mg/l	42.1
Aluminum	7.0 mg/l	95.2
Manganese	3.6 mg/l	48.9
Sulfate	529 mg/l	7194.7
pH	5.23 SU	

Raw water in the unnamed tributary proposed for dosing has a pH of 2.96, acidity 225.4 mg/l, iron 12.0 mg/l, aluminum 12.1 mg/l, manganese 4.2 mg/l and sulfate 529 mg/l prior to the Jobs Hollow Doser Project.

Site investigations and a subsequent design for an Environmental Doser International (EDI) water operated dosing unit were prepared for DMRM by ATC Associates Inc. The primary design components of the 75-ton EDI dosing unit alternative included development of an all weather access road, grading plan, a concrete water intake structure, dosing unit foundation and associated surface water drainage. The construction drawings included plan views and cross sectional mapping of the existing and proposed site conditions in addition to profile details of the piping intake system. The mixing zone is the unnamed tributary downstream of the dosing unit.

Sediment Issues Downstream of the Dosers

Consideration was initially given to directing the mixing zones into sediment ponds to contain the treatment-generated sediment, however, the quantity of sludge that would be generated by metal precipitates and unreacted reagent would require a considerable management effort. As an example, using the reported TDS concentrations and the AMDesign© model, it was estimated that about 66,000 c.y. of sludge could be generated each year by neutralizing the Carbondale II seeps (based on 1.5% sludge solids content), not including potential impact of unreacted reagent. This volume would fill an existing polishing pond in about 40 days. Treatment with LKD would result in a larger quantity of unreacted reagent because up to 30% of the material is inert and will not dissolve. Based on observations made during the bench tests, it appears that the larger particles of the calcium oxide pebbles material could also increase the sediment load to a sediment basin since a considerable portion of the material did not react.

As an alternative to initiating a sludge management program, the DMRM decided to allow the mixing zone downstream of the Jobs Hollow Doser to extend into Monday Creek and the mixing zone of the Carbondale Doser to extend into Hewett Fork. Allowing for mixing zones in natural stream sections immediately downstream of dosing units is a tactic that has been used by the Maryland Bureau of Mines (MBOM) for several years. Many studies have been completed for the MBOM that investigated the impacts of in-stream mixing zones on pre-dosing vs. post-dosing water quality, fish and benthic communities, and the dosing-generated sediment toxicity effects on aquatic biota. In addition to meeting or exceeding water quality goals, the studies concluded that AMD-neutralizing lime dosing units are generally having a positive influence on the North Branch of the Potomac River watershed and that fish and other organisms are not at significant risk of acute mortality due to sediment exposures.

It is noted that Hewett Fork and Monday Creek would likely become characterized by high embeddedness immediately downstream of the dosing unit as the mixing zone is allowed to extend beyond the constructed outlets, however, this is considered a trade-off for improved water quality and improving aquatic habitat further downstream. In general, the dosing-generated sediments have been observed to extend approximately one (1) mile downstream of the dosing units in Maryland.

An in-stream mixing zone within AMD impacted watersheds may also receive acid loadings from unidentified sources or through an extended treatment system failure. This circumstance may provide conditions conducive for metal remobilization. However, a study conducted for the MBOM concluded that as the settled precipitate ages it becomes more stable, minimizing resolubilization. The stability of aged floc is not temporary, even if acidic conditions are introduced, since precipitated metals form stable colloids with organic material and mineral particles downstream and eventually become soil-like in nature. It is also possible that portions of unreacted reagent within the streams could become part of the bed load and assist in neutralizing unanticipated slugs of acidity.

Carbondale Doser Results

Loading AquaFix Silo

Construction was completed between April 2003 and January 2004 by Law General Contracting of Dennison, Ohio at a cost of $401,622.04. A period of field trials using different alkaline reagents (lime kiln dust, dolomitic kiln dust) began immediately after construction was complete. The doser worked only intermittently using kiln dust reagents during periods of high humidity. Bridging of clumped material immediately above the screw auger created a need for regular inspection and cleaning.

Table 5. Total vs. Dissolved Chemistry at Final Project Discharge (HF131)
Using Lime Kiln Dust
Carbondale Reclamation Project
1/27/04

Parameter	Concentration	
	Total	**Dissolved**
Alkalinity, Total	34.3 mg/l	13.5 mg/l
Aluminum, Total	28.3 mg/l	0.371
Hardness, Total	994 mg CaCO3/L	744 mg CaCO3/L
Iron, Total	97.5 mg/l	68.9 mg/l
Manganese Total	5.92 mg/l	5.38 mg/l
pH	6.48 SU	6.03 SU
Specific Conductivity	1380 uS/cm	1380 uS/cm
Sulfate	914 mg/l	897 mg/l
Solids, Total Dissolved	1370 mg/l	1370 mg/l
Solids, Total Suspended	317 mg/l	9 mg/l

A decision was made by the DMRM to institute a one-year study period using calcium oxide (CaO) pebbles, starting in April 2004. A proven material source from Morgantown, West Virginia was selected based on the experiences of the Maryland Bureau of Mines in their North Branch of the Potomac dosing project. The material is 98% CaO and is screened on both ends of the gradation with 100% passing a ¼" mesh, 20% passing a 1/8" mesh and only 2.5% passing a #10 mesh. Alternate sources of material from other suppliers closer to the site are being sought.

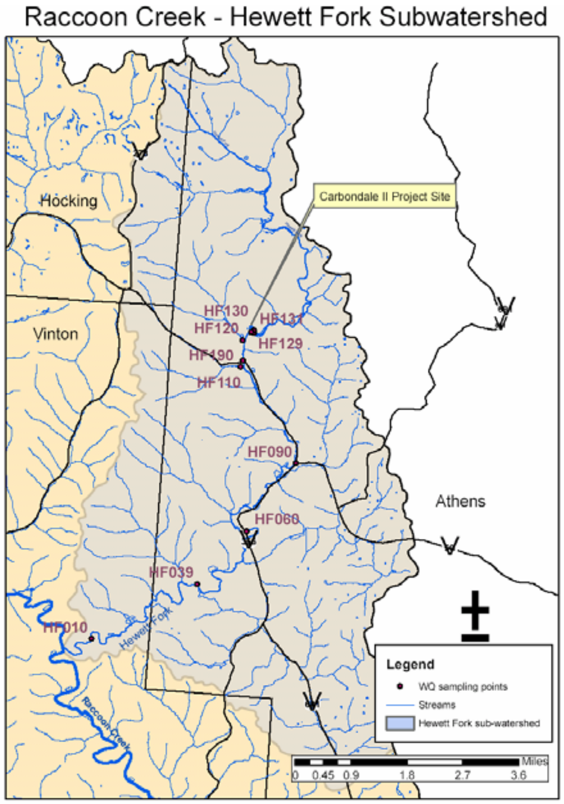
Initial results indicate better dissolution from the calcium oxide pebbles than from limekiln dust (Table 6). Calcium oxide is not fully dissolving in the mixing channel either because only 203 mg/l of alkalinity is dissolved compared to the 521 mg/l of total alkalinity before leaving the project site. However, this is a dramatic improvement over limekiln dust. With calcium oxide pebbles there is a net alkalinity (dissolved) of 203 mg/l compared to 13.5 mg/l with limekiln dust, a 15 fold increase. It appears that dissolved metals are precipitating into the solid form in suspension within the mixing channel at an increased rate due to the increased alkalinity generated by CaO. At the project discharge, only 1.7 mg/l of iron remains dissolved (97% precipitated), 0.10 mg/l of manganese (97% precipitated), and 3.2 mg/l of aluminum (92% precipitated). The present application rate of CaO from the doser is approximately 1421 lbs/day at 11 revolutions per minute. A 25-ton truckload of material is being used in about 40 days at this application rate.

Table 6. Total vs. Dissolved Water Chemistry at Final Project Discharge (HF131)
Using Calcium Oxide Pebbles
Carbondale Reclamation Project
6/1/04

Parameter	**Concentration**		**Load lbs/day**	
	Total	Dissolved	Total	Dissolved
Acidity, Total	0 mg/l	0 mg/l	0	0
Alkalinity, Total	521 mg/l	203 mg/l	1621.81	631.91
Aluminum, Total	17.5 mg/l	3.2 mg/l	54.6	10.0
Hardness, Total				
Iron, Total	64.8 mg/l	1.7 mg/l	202.1	5.3
Manganese Total	3.79 mg/l	0.10 mg/l	11.8	0.3
PH	11.0	11.1		
Specific Conductivity	2.090 uS/cm	2.240 uS/cm		
Sulfate	930 mg/l	922 mg/l	2899.8	2874.9
Solids, Total Dissolved				
Solids, Total Suspended				

Water chemistry samples were collected at 10 sites downstream on Hewett Fork (Map 1) and at the doser project site (Map 2) on three different occasions: 6/21/04, 7/19/04, and 9/28/04. The purpose of this sampling is to analyze the projects effect (i.e. water quality improvement) in Hewett Fork post-construction of the Carbondale doser.

AquaFix Doser



Map 1.

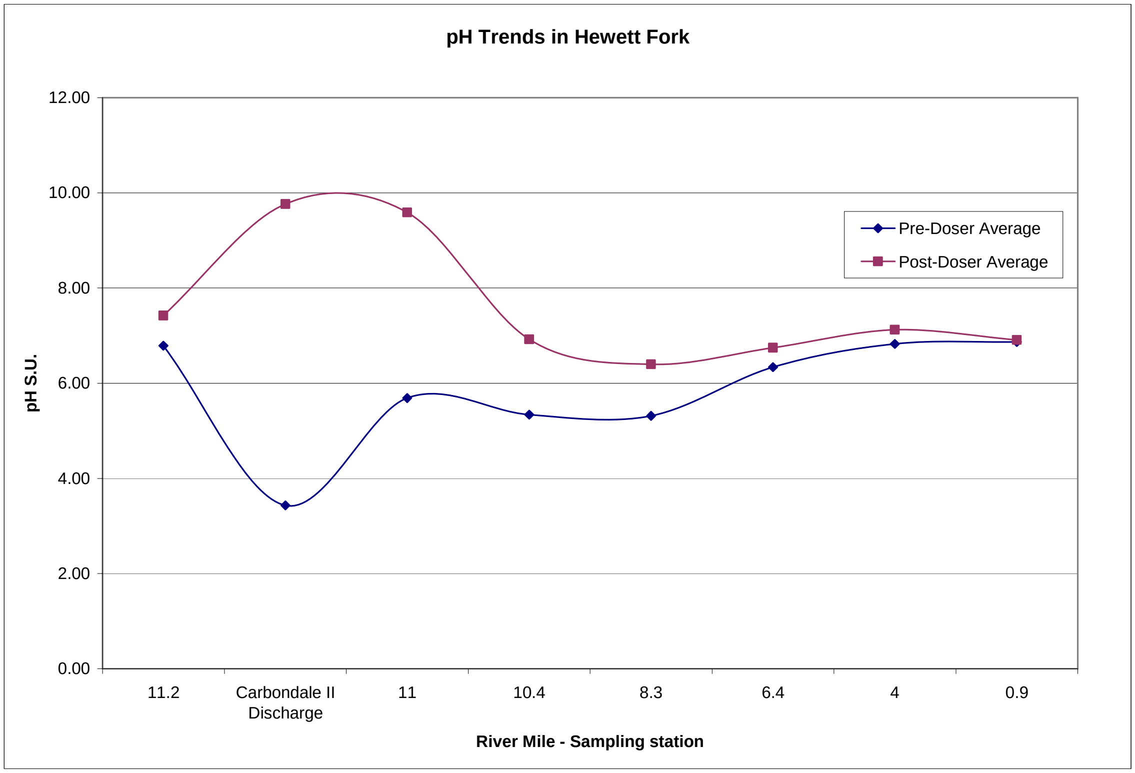
Map 2.

Table 7: Carbondale II and Hewett Fork Water Sampling Locations

Location	Drainage Area	River Mile	River Mile to HF
HF 010 - Mouth of Hewett Fork	40.19	0.9	
HF 039 - Rockcamp Road	35.53	4	
HF 060- SR 356	22.74	6.4	
HF 090 - Waterloo Research Station	19.22	8.3	
HF 095. Hockingport at field pull off	14.96	9.8	
HF 190 - SR 56	12	10.4	
HF 130 - Downstream CII discharge	NA	11	
HF 129 Upstream CII Discharge	9.69	11.2	
HF 110 -Trace Run	2.53	0.1	10.8
HF 120 - Carbondale Creek	2	0.1	10.3
HF 131 - Carbondale II discharge	NA	NA	11.1

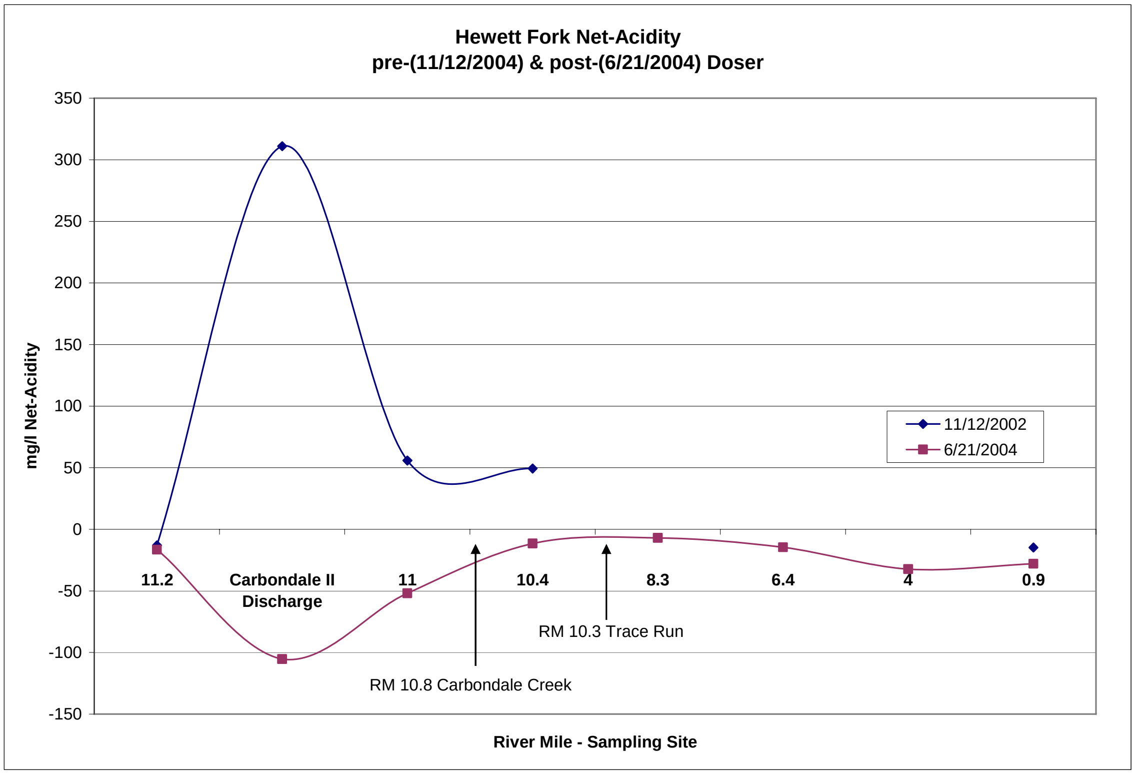
As shown in Figure 1 on the following page, the average pH reading in Hewett Fork has been increased dramatically when compared to pre-doser data. Only at one time during the three post-doser sampling events has the pH been below 6.0 at river mile 8.3 which was 9/28/2004 with a reading of 5.63. This is likely due an increase in acid in Hewett Fork due to large rainfall events in August and early September.

Figure 1: Hewett Fork pH Analysis



For comparison purposes, water quality was compared from two sampling dates – one pre-doser (11/12/02) and one post-doser (6/21/04) in Figure 2. The two sampling dates were used because measured flows were similar in Hewett Fork, which allows for comparative analysis. Although the doser project is consistently exporting alkalinity, a considerable portion (56%) of it appears to be consumed when the dissolved iron precipitates as ferric oxide within the first 100' in Hewett Fork (RM 11.0). Hewett Fork is hit with two more AMD sources/tributaries downstream of the doser project. Carbondale Creek enters Hewett Fork approximately at RM 10.8 and Trace Run at RM 10.3. 2004 data collected at the confluence of Carbondale Creek (HF120) and Trace Run (HF190) show net acidic conditions ranging from 85 – 114 mg/l and 76.3 – 99.0 mg/l respectively. At no point during the 6/21/2004 sampling did Hewett Fork become net-acidic as it was during a comparable flow pre-doser. Although more monitoring is needed to document changing conditions due to seasonal fluctuations in water quality, current data shows that the Carbondale doser is effectively treating the acidity from the Carbondale seeps and appears to be adding some additional alkalinity to assist Hewett Fork in buffering AMD from Carbondale Creek and Trace Run.

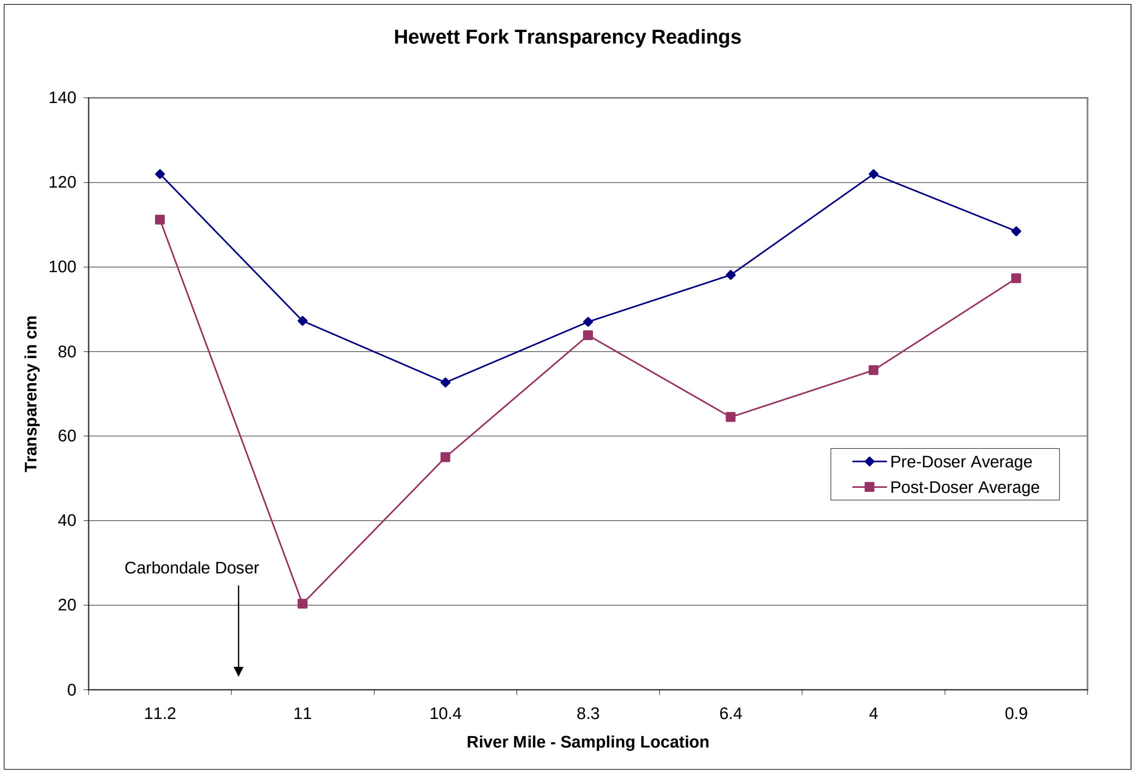
Figure 2: Hewett Fork Acidity & Alkalinity Analysis



The Carbondale doser project was designed to increase alkalinity dramatically at Carbondale seep site and then allow for metals to precipitate in the stream, creating a "sacrifice" zone close to the discharge for recovery further downstream. The extent of this "sacrifice" zone will depend largely on the amount and length of iron and aluminum precipitates in Hewett Fork. Transparency tube data was collected at the same sampling locations to document changes in suspended metal loads (Figure 3). Transparency is dramatically decreased (70 cm) directly downstream of the doser at RM 11.0 due to large amounts of metal flocculent. Transparency is decreased post-doser downstream to RM 8.3, the last site where iron flocculent is noticeably visible, which is 2.7 miles downstream of the Carbondale doser. The decrease in transparency downstream of RM 8.3 is not due to metal flocculent from AMD but possibly to current land use practices in the watershed.

Doser Channel and Hewett Fork Mixing Zone

Figure 3: Hewett Fork Transparency Analysis



Maintenance of the doser includes routine lubrication of the bearings and drive chain is done during twice weekly inspections by the Division of Forestry. A purchase order for one year's worth of CaO has been established with a West Virginia vendor. In the future, bids will be sought from several vendors in order to obtain the best price for the specified reagent. A one-time grant from the Ohio Division of Wildlife will fund most of the first year's operations. Regular water sampling is done by the Ohio University (ILGARD) sponsored Raccoon Creek Coordinator. Extraordinary maintenance needs are handled by DMRM.

Buildup of unreacted materials around the project outlet has been completed recently. It appears that this will be an annual maintenance need. It is also an indication of over application of reagent.

Operators once allowed the doser to run out of reagent for approximately 18 hours. An immediate decline in pH downstream of the doser was noted. Residual material in the stream channel was not adequate to keep the pH elevated for that length of time. This may be due to the relatively low gradient of Hewett Fork in the area.

2004 Fish Survey – Carbondale Doser

In August and September of 2004, electrofishing surveys were conducted at seven sites on Hewett Fork and two on Raccoon Creek to evaluate stream fish community response to the treatment of AMD using a lime doser. Fish sampling was conducted by the ODNR-Division of Wildlife (DOW) in conjunction with the Ohio University – ILGARD and the DMRM. Funding for the 2004 survey came from the DOW Wildlife Diversity and Endangered Species Fund that is supported by state income tax check refund donations and the Wildlife License Plate program. Historical fish data for Hewett Fork was provided by OEPA for two sites, one upstream of the doser at river mile (RM) 13.4 (background site) and at RM 8.3. Sampling methods followed Ohio Environmental Protection Agency (OEPA) protocol (OEPA 1989).

Hewett Fork Survey

The background site (RM 13.4 upstream of the Carbondale doser) had similar species composition and abundance both in 2000 and 2004. Seven species were present in 2000 and 2004 (Figure 4). Species abundance was also similar with the exception of creek chubs (*Semotilus atromaculatus*), which were more abundant in 2004. This difference could be attributed to natural fluctuations in abundance from year to year. The fish assemblages seem to be stable from year to year at this site and should provide a good reference for species recovery end points for the headwater portion of the stream (~10sq.mi. drainage area) in the vicinity of the dosing station.

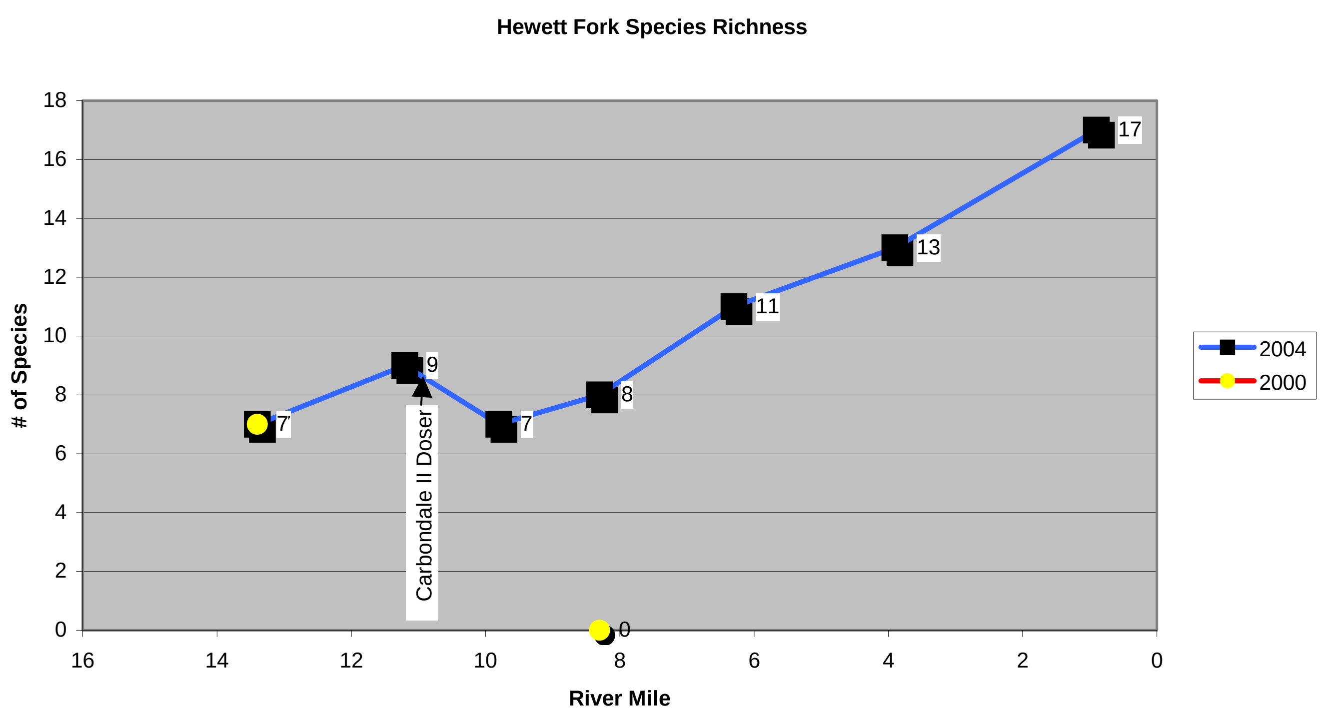


Figure 4. Fish Species Richness in Hewett Fork Year 2000 (*pre-doser*) and *2004 (treatment on-line)*

The only other historical data was from RM 8.3 at the Waterloo Experiment Station at SR 356 and SR56. No fish were collected from this site prior to treatment (2000). Eight species were collected from this site in 2004 including one tolerant darter species, blackside darter (*Percina maculata*), which is common to Raccoon Creek. The 2004 sample represents a significant improvement in species richness since the dosing began; however, species abundance was not high with only a few individuals representing the species collected at this site. Water clarity was good at the time of sampling at this site and marks the point where there was a significant improvement in the amount of suspended iron precipitate. However, a significant amount of iron precipitant and sediment was present on the substrate at this site.

Fish assemblages at RM 9.8 (downstream of SR 56), and to a lesser extent 8.3 (Waterloo Experiment Station), represent the portion of Hewett Fork where fish colonization is occurring less, primarily from the excessive amounts of suspended and settled iron precipitant. It is believed that most of the impacts in this three-mile stretch below the dosing station are caused by physical impairment of stream substrate rather than any toxic effects of the mine discharge or dosing compounds. One exception might be any excess amounts of neutralizing material, especially immediately downstream of the doser, which could cause chemical stress if the stream becomes too alkaline. The lower abundance and diversity of fish within this reach may be a result of impaired/coated substrates adversely affecting macroinvertebrate production, fish feeding efficacy, and reproduction. Even though this reach is now supporting fish life, it may ultimately serve as a sacrificial segment for the restoration of Hewett Fork.

With the exception of the slightly depressed areas downstream of the doser, Hewett Fork shows a typical longitudinal trend towards increasing diversity as one moves downstream with increasing drainage area and proximity to the Raccoon Creek confluence (Osborne and Riley 1992). It is expected that this trend will continue if water quality is maintained in Hewett Fork.

Raccoon Creek Survey

Although the species count was similar upstream and downstream of the Hewett Fork confluence, species composition was somewhat different. Species differences between sites can be explained by differences in habitat between sites. The upstream site contained riffle/run habitat while the downstream site was exclusively deep pool habitat. Had the downstream site contained riffle/run habitat, it probably would have supported another 3-5 riffle/run dependent species. At this point, there seems to be little, if any differences between sites other than that which can be explained by habitat differences between sites. Further analysis is needed using IBI (Index of Biotic Integrity) and QHEI (Qualitative Habitat Evaluation Index) indices for these sites that should provide more information on any impacts to Raccoon Creek from Hewett Fork.

Overall, this first evaluation shows some encouraging and exciting benefits from the dosing project. The sustainability of these improvements will be tested through time as the evaluation continues. Macroinvertebrate data from these sites will be collected in 2005. This information will be most valuable in the three miles or so downstream of the doser due to macroinvertebrates long residence time, limited mobility and varying degrees of sensitivity to pollutants. These data would be most valuable in evaluating the impacts to the substrate and benthic community caused by large amounts of iron precipitant, especially in the three miles or so downstream of the historic mine discharges and the more recent effects of dosing.

Jobs Hollow Doser Results

Construction was completed between April and July 2004 by Tucson, Inc. of New Philadelphia, Ohio at an estimated cost of $308,886.50. An initial 25-ton load of dolomitic kiln dust (DKD) has been run through the dosing unit. The DKD material is 43% calcium oxide, 30% magnesium oxide with 99.8% passing a 12 mesh and 74.6% passing a 200 mesh.

A ball valve was added to the intake line outlet to control excess head created in the construction process. The doser worked throughout the first load with no problems or adjustments being necessary. After the first load was dispensed, vibration of the empty bucket caused several components to become unscrewed from the doser assembly. A longer line to direct exhaust to the stream during loading will be added before limekiln dust (LKD) and calcium oxide (CaO) are tested at this site.

EDI Silo

The following table summarizes the water quality of the discharge from the Jobs Hollow sub-watershed during a September 2004 sampling event while the doser was dispensing dolomitic kiln dust (DKD).

Table 8. Results of Project Discharge
At Station MC 148
Using Dolomitic Kiln Dust
Jobs Hollow Doser Project
9/9/04

Parameter	Units	Est. Load lbs/day
Acidity	1.06 mg/l	14.4
Alkalinity	19.9 mg/l	270.7
Aluminum, Total	5.5 mg/l	74.3
Iron, Total	4.6 mg/l	59.1
Manganese, Total	2.7 mg/l	37.0
pH	7.85 SU	
Specific Conductivity	1230 uS/cm	
Sulfate	652 mg/l	8,867
Solids, Total Dissolved	980 mg/l	734
Solids, Total Suspended	54 mg/l	

The Monday Creek Restoration Project is performing maintenance of the doser. A weekly inspection often includes field measurements or collection of water samples for analysis at the DMRM laboratory. Extraordinary maintenance needs are handled by DMRM.

EDI Doser

Conclusions

Both the EDI and AquaFix dosers met project goals and can be successfully employed to neutralize significant AMD discharges in the stream and seep settings where they are employed. Bench testing and selection of the appropriate chemical treatment agent is important during the design process. The physical interaction between the machines and reagent type is a critical consideration. Operational testing will help determine the optimum flow and reagent application ratio for the hydrology and hydraulic setting at the treatment site. Regular inspection and maintenance of the systems is key to their successful operation. Minor breakdowns will require direct intervention by the operator. Fluctuations in flow and chemistry will require field adjustments in the doser applications rates. Once a chemical reagent is settled on, curves can be developed to illustrate optimum application rates for the water quality that is desired.

Biologic monitoring will help to determine the minimum level of treatment necessary to restore aquatic use designations and life to local streams. Biological sampling will drive the modifications to the dosing program.

The cost per year for operation will be determined by the reagent selected and the level of over treatment desired. Funds for operation are presently coming from DMRM's AMD Set-Aside program. A more sustainable method for long term funding is being studied.

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