OPPORTUNITIES FOR RECLAMATION OF MINED LANDS IN OHIO USING COAL COMBUSTION BY-PRODUCTS

by

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Abstract. Ohio generates approximately 10 million tons of coal combustion by-products (CCBs) annually. Many of these by-products, particularly flue gas desulfurization (FGD) material and some fly ashes, are alkaline. Research conducted at The Ohio State University has shown that CCBs can be used for surface reclamation of abandoned and currently coal-mined lands to remediate acid mine drainage and off-site sedimentation. An overview of the research and demonstration projects conducted at The Ohio State University in the last decade on use of CCBs for surface reclamation of abandoned mined lands is presented. Monitoring results for demonstration projects are presented. A cost benefit analysis of gob pile reclamation using FGD and conventional natural materials shows that using FGD can result in savings of about $10,000 per acre. A comprehensive review of uncompleted reclamation work in the state is presented and the potential for CCB use is evaluated. With over 800 acres of unreclaimed gob piles in the state, the potential cost savings for gob pile reclamation using FGD could be as high as $8 million. Overall, $100 million worth of uncompleted reclamation work in Ohio has potential for CCB use.

Additional Key Words: flue gas desulfurization by-product, FGD, fly ash.

Introduction

In Ohio, nearly 90% of the electricity produced is generated by burning coal, and the state generates about 10% (approximately 10 million tons) of all coal combustion by-products (CCBs) produced in the US. Approximately 4 million tons of FGD material are generated annually in Ohio. Flue Gas Desulfurization (FGD) material and some fly ashes are alkaline and can be effectively used in the reclamation of abandoned and currently coal-mined lands to remediate acid mine drainage and sedimentation problems. The use of CCBs, particularly FGD material, in reclamation of mined lands can result in several advantages:

- Cleaner and safe environment
- Conservation of conventional natural resources (e.g. clay, sand, stone aggregate, etc.)
- Decrease in the need for landfill space
- Reduced environmental effects of landfill disposal
- Continuation of use of coal as a source of fossil fuel
- Significant economic savings for end users
- Boost economic development through recreational and industrial opportunities
- Reduced overall cost of generating electricity.

Several researchers at The Ohio State University participated in a long-term study aimed at characterizing the physical, chemical, mineralogical and engineering properties of dry and wet FGD material and its land application (Stehouwer *et al.*, 1995a, 1996, 1998, Wolfe *et al.*, 1992, Adams *et al.*, 1992, Beeghly *et al.*, 1993, 1994, 1995, Wolfe and Cline, 1995, Dick, *et al.*, 1997,1998). An extensive review of the state of the art for the characterization and utilization of FGD material was performed (Stehouwer *et al.*, 1995a, 1998, Dick *et al.*, 1998). Samples were collected from 13 different coal-fired boilers and representative samples of FGD technologies being tested in Ohio were selected for detailed analysis. The technologies included Lime Injection Multistage Burners (LIMB), Pressurized Fluidized Bed

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Combustion (PFBC), Spray Dryer, and Duct Injection. Several land applications uses of FGD including alkaline amendments for strip mine reclamation, highway and construction related applications, and agricultural liming substitute were identified and studied. The social costs and economic benefits of CCP utilization were presented by Hite *et al.* (1994) and Hitzhusen (1992).

Laboratory investigations into the use of FGD for mine reclamation applications were carried out by Sutton and Stehouwer, 1992, Stehouwer *et al.*, 1993 and Soto *et al.*, 1993. Greenhouse column studies were carried out by Stehouwer *et al.* (1995b) to study the element solubility and mobility characteristics of amended minespoils while Stehouwer *et al.* (1995c) studied the plant growth in minespoils amended with dry FGD. Issues relating to the extension of laboratory tests to field demonstration of minespoil amendments were presented by Dick *et al.*, 1994a.

Demonstration Projects

Several field demonstration projects have been conducted in Ohio that have studied the use of alkaline FGD material for reclamation of highly degraded abandoned mines. An abandoned clay and coal mine near Dover commonly referred to as the Fleming demonstration site was regraded in summer of 1994 and three types of amendment treatment were applied in fall of 1994. The treatment schemes included separate equivalent applications of limestone, FGD material (PFBC) and a 2.5:1 mixture of FGD and yard waste compost. The treatments were incorporated to a depth of approximately 8 inches. Surface water and drainage water samples were collected. Arsenic was found to be the only trace element that approached a level that would preclude the use of FGD for mine reclamation. The concentrations of all other elements were below the regulation concentrations or loading limit. It was observed that often these metal concentrations were lower than those in the existing overburden spoil that required reclamation. All three treatments improved water quality. The concentration of Boron in the leachate was particularly high from the FGD plots (median value ranging from 440 to 850 μg/L) but was below the phytotoxic levels. Surface water quality has remained almost unchanged from 1995. All treatments resulted in water pH of approximately 7. The drainage water samples collected in spring of 1995 showed the FGD plots were neutral while others were acidic (pH of 4-5.5). In July of 1996, the pH values of the treatments whose pH had declined earlier, rose to the neutral level. All the treatments provided complete ground cover. However, all treatments showed a decline in the vegetative growth in 1996 as compared with 1995 with the decline being the greatest for lime treated plots. Long-term effectiveness of the FGD treatments is being studied at the site to learn more about the ecological sustainability of these materials.

Additional mine reclamation field-testing was carried out at Unit II of the Eastern Ohio Resource Development Center near Caldwell, in Southeastern Ohio. The aim of the project was to evaluate the reclamation performance of two wet FGD materials and compare them with borrow soil and sewage sludge minespoil amendments. The two types of FGD materials used in this demonstration project were generated by the wet lime scrubbers of American Electric Power's Conesville plant and an experimental scrubber at Cinergy's Zimmer plant. The original field plot sites had low levels of extractable nutrients. The site was regraded in summer of 1995 and treated with six different types of mine soil amendments. These treatments included: 1) sewage sludge, 2) gypsiferous Zimmer FGD, 3) Conesville FGD, 4) Zimmer FGD mixed with sewage sludge, 5) Conesville FGD mixed with sewage sludge, and 6) red silty clay borrow soil. Details on the applications rates were presented by Kost *et al.* (1997). All the amendments were rototilled to a depth of about 30 cm. These treatments were applied in the fall of 1995. A flume was installed at the bottom of each plot to collect surface water runoff. Appropriate fertilization of the plots was carried out and they were seeded in fall of 1995 with winter wheat cover crop, and a mix of birdsfoot trefoil, red clover, perennial ryegrass and timothy. Ten seedlings each of white ash, black locust, sycamore and sweetgum were planted in spring of 1996 in each plot. Tree survival, tree height, biomass cover, soil and water quality were monitored. Preliminary results (Kost et al., 1997) of samples collected at the site indicate that all amendments except the sewage sludge alone are effective in decreasing soil acidity within the zone of incorporation. Vigorous herbaceous cover has existed on all the treatments for two years. During this time, herbaceous biomass was reported to be the greatest for plots that were treated with a mixture of Conesville FGD and sewage sludge (Kost, 1997). Additional observations and conclusions for these demonstration projects can be found in Dick *et al.*, 1994b and Stehouwer and Dick, 1997.

Abandoned Mine Land Program Statistics and FGD Use Potential for Ohio

The potential use of FGD in reclamation of abandoned Ohio mine lands was evaluated using the Abandoned Mine Land Inventory System (AMLIS) database. The U.S. Department of Interior, Office of Surface Mining (OSM)-Reclamation and Enforcement Department has developed this database to inventory abandoned mine land problems. The AMLIS database contains cumulative information regarding costs, quantities, and types of problems/hazards for AML programs across the United States.

Two queries of the AMLIS database were carried out to help determine how much reclamation has been completed in Ohio, how many problems remain unreclaimed, and which of the unreclaimed problems have the potential for FGD utilization during reclamation. During the AMLIS queries, the items considered relevant to the search were the number of problem areas, problem types, size, and costs for all Abandoned Mine Land (AML) program areas and types of mining. The information was sorted and printed by county and by problem type according to whether the problem had been unfunded, funded but not reclaimed, or completed. An unfunded problem is one that has been documented by a state employee as a mining related problem or hazard and recorded in the AMLIS database. An unreclaimed problem is moved from unfunded to funded when it is placed in a federal grant as a project. Upon project reclamation, the problem is moved from funded to completed.

Problems potentially amenable to solution using FGD were extracted from the AMLIS data search on a county basis. Reclamation cost data was complied by county for AML projects and the results are shown in Table 1. More than 70% of the estimated cost of Ohio projects inventoried under AMLIS are unreclaimed (i.e., unfunded or funded but not reclaimed). Over $209 million (1998 dollars) of reclamation work is still needed in the State of Ohio. In a typical year, Ohio Department of Natural Resources – Division of Mines and Reclamation (DMR) funds approximately $2.5 million of reclamation. Table 1 and Figure 1 also show, by county, the funding required to solve the AMLIS documented problems that have the potential for FGD utilization. These figures only reflect potential usage. Over $100 million worth of reclamation work to be done on AML has potential for FGD utilization. There are extensive reclamation needs in Ohio and a substantial portion of AML problems have the potential to be reclaimed by using FGD as part of the solution.

The AMLIS database information was further refined on a county basis for the areas to be reclaimed and categorized under potential FGD uses such as gob piles, spoil areas, dangerous piles and embankments, and pits (refer Table 2). Approximately 22,000 acres of spoil areas, 800 acres of gob piles, 350 acres of pits, and 29 acres of dangerous piles and embankments inventoried in AMLIS may need reclamation. Applications rates for reclamation of each of these problem areas were chosen with due consideration to past estimates and projects recently completed in Ohio. Table 3 indicates that approximately 8.3 million tons of FGD may have potential of being used for AMLIS inventoried problems.

FGD Utilization Cost Benefits for Gob Pile Reclamation

Cost saving is usually the most attractive reason for using FGD in reclamation project construction. In some cases, conventional materials may not be available and by process of elimination, FGD may be the best or only material available as a substitute. When FGD is the only material available, a cost analysis does not seem relevant. However, in this section the cost savings realized when making a choice between available conventional materials and FGD utilization are reviewed and discussed. For this cost comparison, the Rehoboth and Rock Run gob pile reclamation projects were selected. The cost analysis presented in this section does not include the cost of FGD transportation to the site since FGD material was delivered to the project site by the generator for both the reclamation projects. Only items that included FGD were incorporated into the analysis since other construction items were not dependent on FGD application.

Rehoboth Phase 1 Reclamation Project

Project Description. The Rehoboth Phase 1 Reclamation Project site is a 65-acre gob pile located south of the Village of Rehoboth and approximately 1.5 miles north of New Lexington. The site had an extensive history that includes contour strip mining, underground mining, coal tipple operations with a railroad load-out, coal preparation/wash plant operations, portland cement manufacturing and storage, explosives manufacturing and testing, and fertilizer manufacturing. This extensive use of the land left an abandoned mine site that contained many environmental, health and safety issues. Erosion was the primary concern associated with the Rehoboth site. Studies have shown that the Rehoboth site contributed over 2,000 tons/acre/year of sediments to an unnamed tributary of Rush Creek that passes through the site. In recent years, State Route 345, adjacent farmland and cemetery frequently experienced flooding during storm events. The primary sediment source was determined to be the unreclaimed gob pile which was left from surface mining operations. The Rehoboth site was also a significant source of acid mine drainage. The pyrite and sulfur in the mineral substrate were responsible for the formation and subsequent leaching of AMD from the site.

The primary objective of the reclamation project was to control flooding at State Route 345 by regrading and vegetating the gob pile. A secondary objective was the elimination of AMD effluent from the site. In 1994, DMR hired a consulting company to incorporate the two project objectives into a design for the Phase 1 site. The use of FGD was included in the design. The final design included constructing a sediment pond using a two-foot thick compacted layer of FGD as a liner. After pond construction, the 43.1 acre gob pile was regraded to a slope no steeper than 5:1 (horizontal : vertical). This was followed by a two-foot thick layer of Conesville FGD, which was placed over the gob within 10 days from the time of production of FGD. The low permeability FGD cap was included in the design to keep runoff from percolating into the regraded spoil material. Then a two-foot thick layer of buffer material consisting of a mixture of fifty-percent coal refuse and fifty-percent FGD was placed over the cap. This buffer zone was designed to protect the FGD cap from freeze-thaw and to help provide a loose rooting medium for vegetation. The design also required nine inches of re-soil over the buffer to provide the proper nutrients for successful vegetative growth. The re-soil was comprised of a mixture of four inches of aged (7 and 365 days from the date of production) FGD, four inches of spoil, and one inch of cured yard waste compost. The final component of the design was revegetating the entire site.

Construction proceeded from August 1997 to October 1998. Over 250,000 tons of wet FGD were used. The FGD was supplied by American Electric Power's Conesville plant, Monday through Friday, at an average of over 1,500 tons per delivery day. The contractor, Trans-Ash, used typical pond construction equipment. The pond was shaped using dozers, and the FGD liner was placed in two 12-inch lifts, compacted with a smooth drum vibratory roller. After the pond construction, the contractor used dozers to perform the earthwork and regrade the gob pile in preparation for FGD placement. The FGD cap was placed over the gob in one two-foot lift as soon as the earthwork was completed. The two-foot buffer material was placed over the cap by alternating six inches of coal refuse with six inches of FGD. A disc plow was used to mix the coal refuse and FGD after placing the first foot of buffer and again after the final foot was placed. A disc plow was also used to mix the re-soil material.

Cost Analysis. Cost comparison data for the Rehoboth Phase 1 project are presented in Table 4. The data presented are actual construction costs for the project. Alternative 1 and Alternative 2 were designed to meet the project objectives of reducing off-site sedimentation and AMD production, and reflect the two most likely alternatives to FGD utilization. These figures were obtained by using cost data from similar projects located in the same geographical area. Alternative 1 required placing 1 foot of compacted clay in the sediment pond and over the gob pile to form a seal. The cost for the compacted clay includes the cost of purchasing the clay and the cost for labor and materials required for construction. To ensure an adequate rooting zone, Alternative 1 includes 1 foot of re-soil material over the entire site. On-site and local (within ¼ mile) borrow was available. The re-soil costs also include incorporating lime into the re-soil material at the rate of 25 tons per acre. The lime quantity is an estimate that reflects a typical incorporation rate for borrows in the same geographical area. Alternative 2 was designed to eliminate off-site sedimentation but would not reduce AMD production as effectively as the Rehoboth Phase 1 design or Alternative 1. Alternative 2 included placing a 2-foot layer of compacted, limed spoil over the gob pile. With proper compaction, the 2-foot layer of spoil would have reduced infiltration into the gob pile, resulting in less AMD production. Thick, compacted spoil was not an alternative for the pond since it does not provide a low permeability seal so the pond still required the 1-foot clay seal detailed in Alternative 1. Only 8 inches of limed re-soil would be required for this design.

It can be observed from Table 4 that the use of FGD for Rehoboth Phase 1 project cost approximately $382,000, while traditional Alternative 1 which would remediate AMD and off-site sedimentation would have an estimated cost of $925,000. This resulted in saving of approximately $8,350 per acre of gob pile reclaimed. Further, it can be observed that Alternative 2, which would remediate sedimentation problems but not resolve the AMD production effectively, would still cost 29% more than FGD use.

Rock Run Reclamation Project

Project Description. The Rock Run Reclamation site is located immediately west of County Road 41, approximately 1.5 miles north of New Straitsville in Perry County, Ohio. Along the eastern bank of Rock Run was a gob pile approximately sixty feet high. The gob pile filled a valley, covering approximately fourteen acres of the original valley floor. Water entered the gob pile through two tributaries and from an abandoned underground mine. The mine drainage had a pH of 3.29 and the water seeping from the toe of the gob pile and discharging into Rock Run had a pH of 2.77.

Ohio Department of Natural Resources - Division of Mines and Reclamation partnered with United States Department of Agriculture - Forest Service and Monday Creek Restoration Project/Rural Action, Inc. to reclaim the Rock Run site by reducing the discharge of acidic water and offsite sedimentation. The final scope of the Rock Run Reclamation project included re-contouring the coal refuse pile and construction of a five acre, two foot FGD cap over the regraded refuse using FGD from Conesville power plant. The low permeability cap was constructed to eliminate percolation of surface water into the regraded coal refuse, reducing AMD production. Project construction began during the summer of 1998 and was completed in Fall of 1999. Approximately 16,000 tons of stabilized FGD by-product was utilized for the reclamation of the site.

Cost Analysis. An analysis of the costs of the Rock Run Reclamation Project is presented in Table 5. The data shows that the 2-foot FGD seal over the 5-acre gob pile was the most economical solution. Alternative 1 included replacing the FGD seal with 1 foot of clay liner and increasing the re-soil from 8 inches to 1 foot. Alternative 2, with 2 feet of spoil, would only reduce AMD production, which would not meet the project objective. Using FGD for Rock Run project cost approximately $25,000, while Alternative I with traditional materials, would cost approximately $88,000. Estimated saving were approximately $12,600 per acre of gob pile reclaimed. Alternative 2, which would remediate the sedimentation problem only, would cost 52% more than FGD use.

Potential Savings for Gob Pile Reclamation

In many cases, conventional construction materials like clay and re-soil material may not be available and by the process of elimination FGD may be the best or the only suitable material to be used for reclamation. For projects in which FGD and conventional materials both are available and being considered, a cost comparison is necessary. The Rehoboth and Rock Run cost analyses in Table 4 and 5 show that using FGD for gob pile reclamation can result in savings ranging from $8,350 to $12,600 per acre. With approximately 800 acres of gob piles identified as being unreclaimed in Ohio, the potential savings could be as high as $8 million for just this one type of reclamation work.

Conclusions

Laboratory and field demonstration research projects conducted in Ohio over the last decade have shown that coal combustion by-products, particularly dry and wet FGD materials, can be favorably utilized in an environmentally beneficial, technically sound, and cost-effective manner for reclamation of abandoned surface mined lands. Over $200 million (1998 dollars) worth of inventoried abandoned mine land reclamation work still needs to be completed in Ohio. Of this, over $100 million worth of reclamation work has potential for FGD use. Inventoried problem areas include 22,000 acres of spoil areas, 800 acres of gob piles, 350 acres of pits, and 29 acres of dangerous piles and embankments. The reclamation of these problem areas using FGD material as a part of the solution will require approximately 8.3 million tons of alkaline FGD material, which is generated in abundance within the state. In many reclamation projects, conventional raw materials such as clay and re-soil material are not readily available and by process of elimination, FGD may be the best or only material suitable for use. In such cases, a cost benefit analysis is irrelevant. However, when conventional materials as well as FGD material are available, a cost comparison is necessary. Cost benefit analysis of two reclamation projects in Ohio using stabilized FGD material has shown that use of FGD in reclamation of gob piles can result in significant savings of approximately $10,000 per acre. With over 800 acres of unreclaimed gob piles area within the state, the potential cost savings by using FGD could be as high as $ 8 million for just this one type of reclamation.

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Table 1: Cost Data for Ohio AML Projects Reported in AMLIS (1998 dollars)

County	Cost of all projects (constructed, funded, unfunded)	Cost of all constructed projects	Cost of projects within pads (funded and unfunded) needing construction	Projects needing construction percentage of total cost	Unfunded and funded costs for projects that have FGD utilization potential
	($)	($)	($)	(%)	($)
Athens	10,214,356	2,646,088	7,568,268	74	5,727,462
Belmont	25,748,955	8,567,819	17,181,136	67	2,232,228
Carroll	2,929,151	148,809	2,780,342	95	607,342
Columbiana	3,136,633	815,923	2,320,710	74	1,356,867
Coshocton	2,764,272	303,784	2,460,488	89	1,232,801
Gallia	35,011,496	11,861,201	23,150,295	66	8,102,376
Guernsey	1,985,288	948,750	1,036,538	52	639,809
Harrison	6,600,418	1,744,472	4,855,946	74	2,821,149
Hocking	3,155,483	368,248	2,787,235	88	2,787,233
Holmes	208,725	208,725	0	0	0
Jackson	14,213,903	2,004,624	12,209,279	86	9,644,661
Jefferson	11,521,471	5,053,474	6,467,997	56	3,992,495
Lawrence	5,986,518	3,329,134	2,657,384	44	1,392,728
Mahoning	3,156,396	1,877,557	1,278,839	41	1,140,839
Medina	93,603	0	93,603	100	40,000
Meigs	32,253,938	10,615,891	21,638,047	67	13,529,269
Morgan	633,056	462,030	171,026	27	106,683
Muskingham	5,304,085	666,549	4,637,536	87	2,361,612
Noble	46,815,119	7,770,523	39,044,596	83	19,378,559
Perry	37,046,972	7,819,756	29,227,216	79	18,126,690
Portage	1,771,867	50,086	1,721,781	97	1,313,200
Scioto	220,586	220,586	0	0	0
Stark	7,336,102	1,876,545	5,459,557	74	4,635,057
Summit	77,698	13,448	64,250	83	64,250
Trumbull	2,422,110	398,175	2,023,935	84	2,010,160
Tuscarawas	16,246,719	3,565,681	12,681,038	78	6,301,455
Vinton	3,204,538	850,829	2,353,709	73	1,593,500
Washington	5,089,363	1,212,913	3,876,450	76	792,850
Wayne	122,469	91,969	30,500	25	28,500
Total	285,271,290	75,493,589	209,777,701	74	111,959,775

(Source: AMLIS database)

Note: FGD cost data has been evaluated by the authors

Table 2: Potential FGD Use Areas for Uncompleted AML Reclamation Projects

County	Gobs	Spoil Area	Dangerous Piles & Embankments	Pits
	(Acres)	(Acres)	(Acres)	(Acres)
Athens	92	769	0	30
Belmont	141	350	3	4
Carroll	0	70	1	10
Columbiana	39	20	0	0
Coshocton	39	0	0	0
Gallia	0	3,028	0	0
Guernsey	4	15	0	0
Harrison	44	1,300	0	0
Hocking	47	464	0	0
Jackson	54.5	2,111	0	140
Jefferson	59	7	0	1
Lawrence	0	374.2	0	0
Mahoning	0	322	0	5
Medina	0	0	0	0
Meigs	29	3,479	0	0
Morgan	30	0	0	0
Muskingham	106	325	25	0
Noble	3	2,770	0	0
Perry	53	3,872.4	0	150
Portage	0	0	0	0
Stark	0	1,062	0	0
Summit	0	0	0	0
Trumbull	0	0	0	0
Tuscarawas	41	827.5	0	9.5
Vinton	16	378	0	0
Washington	0	449	0	0
Wayne	0	0	0	0
Total	797.5	21,993.1	29	349.5

(Source: AMLIS database)

Note: FGD data has been evaluated by the authors

Table 3: Potential FGD Tonnage for Uncompleted AML Projects

County	Gobs	Spoil Area	Dangerous Piles & Embankments	Pits	Total for each county
	FGD (tons)	FGD (tons)	FGD (tons)	FGD (tons)	FGD (tons)
Athens	322,000	184,560	0	15,000	521,560
Belmont	493,500	84,000	1,500	2,000	581,000
Carroll	0	16,800	500	5,000	22,300
Columbiana	136,500	4,800	0	0	141,300
Coshocton	136,500	0	0	0	136,500
Gallia	0	726,720	0	0	726,720
Guernsey	14,000	3,600	0	0	17,600
Harrison	154,000	312,000	0	0	466,000
Hocking	164,500	111,360	0	0	275,860
Jackson	190,750	506,640	0	70,000	767,390
Jefferson	206,500	1,680	0	500	208,680
Lawrence	0	89,808	0	0	89,808
Mahoning	0	77,280	0	2,500	79,780
Medina	0	0	0	0	0
Meigs	101,500	834,960	0	0	936,460
Morgan	105,000	0	0	0	105,000
Muskingham	371,000	78,000	12,500	0	461,500
Noble	10,500	664,800	0	0	675,300
Perry	185,500	929,376	0	75,000	1,189,876
Portage	0	0	0	0	0
Stark	0	254,880	0	0	254,880
Summit	0	0	0	0	0
Trumbull	0	0	0	0	0
Tuscarawas	143,500	198,600	0	4,750	346,850
Vinton	56,000	90,720	0	0	146,720
Washington	0	107,760	0	0	107,760
Wayne	0	0	0	0	0
Total	2,791,250	5,278,344	14,500	174,750	8,258,844

Assumed FGD application rates: Gobs: 3500 tons/acre
Spoil Area: 240 tons/acre
Dangerous piles & embankments: 500 tons/acre
Pits: 500 tons/acre

(Source: AMLIS database)
Note: FGD data has been evaluated by the authors

Table 4: Cost Analysis for Rehoboth Phase 1 Project

Rehoboth Phase 1 (Sedimentation and AMD remediation)

Item	Quantity	Unit	Cost/Unit			Total Cost
			Labor	Material	Total	
Gob Cap						
FGD Seal	139,200	C.Y.	$ 0.61	$ -	$ 0.61	$ 84,912.00
Pond Liner						
FGD liner	8,310	S.Y.	$ 0.58	$ -	$ 0.58	$ 4,819.80
Resoil						
Buffer	139,200	C.Y.	$ 0.54	$ -	$ 0.54	$ 75,168.00
Resoiling	65	Acre	$ 903.50	$ -	$ 903.50	$ 58,727.50
Alternative Organic Resoil	2,145	Dton	$ 24.00	$ 50.00	$ 74.00	$ 158,730.00
					Total	$ 382,357.30

Alternative 1 (Sedimentation and AMD remediation)

Item	Quantity	Unit	Cost/Unit			Total Cost
			Labor	Material	Total	
Gob Cap						
Clay Seal	69,600	C.Y.			$ 9.10	$ 633,360.00
Pond Liner						
Clay Seal	8,310	C.Y.			$ 9.10	$ 75,621.00
Resoil						
Resoiling	65	Acre			$ 2,827.50	$ 183,787.50
Lime	1,625	Dton			$ 20.00	$ 32,500.00
					Total	$ 925,268.50

Alternative 2 (Sedimentation remediation only)

Item	Quantity	Unit	Cost/Unit			Total Cost
			Labor	Material	Total	
Gob Cap						
Borrow	139,200	C.Y.			$ 1.75	$ 243,600.00
Lime	1,625	Ton			$ 20.00	$ 32,500.00
Pond Liner						
Clay Seal	8,310	C.Y.			$ 9.10	$ 75,621.00
Resoil						
Resoiling	65	Acre			$ 1,885.00	$ 122,525.00
Lime	975	Dton			$ 20.00	$ 19,500.00
					Total	$ 493,746.00

(Source: Ohio Department of Natural Resources – Division of Mines and Reclamation)

Table 5: Cost Analysis for Rock Run Reclamation Project

Rock Run (Sedimentation and AMD remediation)

Item	Quantity	Unit	Cost/Unit Labor	Cost/Unit Material	Cost/Unit Total	Total Cost
Gob Cap						
FGD Seal	16,133	C.Y.	$ 0.93	$ -	$ 0.93	$ 15,003.69
Resoil						
Resoiling - 8"	5	Acre	$ 2,000.00	$ -	$ 2,000.00	$ 10,000.00
					Total	$ 25,003.69

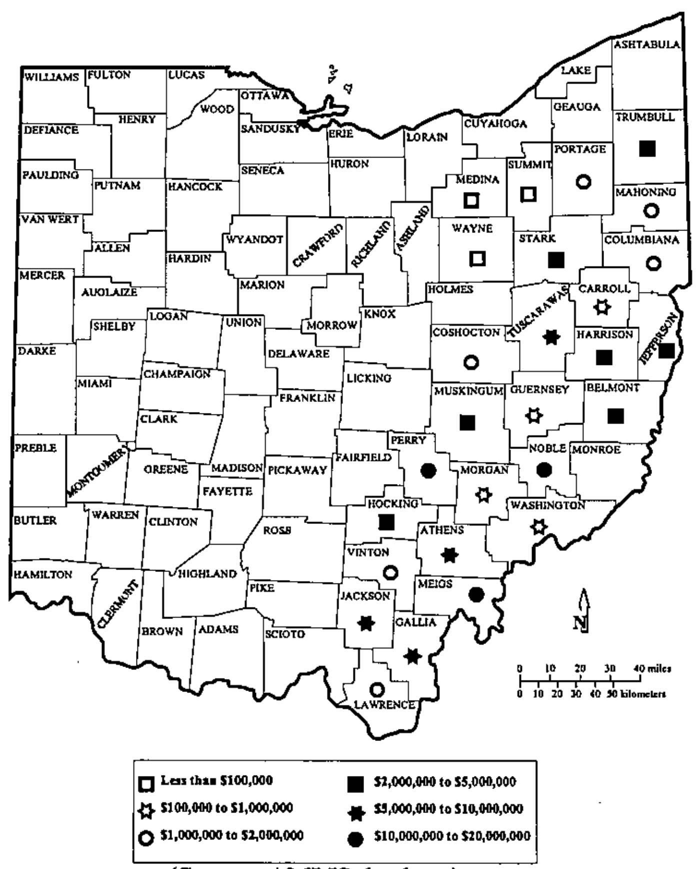
Alternative 1 (Sedimentation and AMD remediation)

Item	Quantity	Unit	Cost/Unit Labor	Cost/Unit Material	Cost/Unit Total	Total Cost
Gob Cap						
Clay Seal	8,067	C.Y.			$ 9.10	$ 73,409.70
Resoil						
Resoiling - 12"	5	Acre			$ 3,000.80	$ 15,004.00
					Total	$ 88,413.70

Alternative 2 (Sedimentation remediation only)

Item	Quantity	Unit	Cost/Unit Labor	Cost/Unit Material	Cost/Unit Total	Total Cost
Gob Cap						
Borrow	16,133	C.Y.			$ 1.75	$ 28,232.75
Resoil						
Resoiling - 8"	5	Acre			$ 2,000.00	$ 10,000.00
					Total	$ 38,232.75

(Source: Ohio Department of Natural Resources – Division of Mines and Reclamation)



(Source: AMLIS database)

Note: FGD cost data has been evaluated by the authors

Figure 1: Funded and Unfunded AML Problems in Ohio (1998 dollars) with Potential for FGD Utilization