Demonstrating a Market-Based Approach to the Reclamation of Mined Lands in West
Virginia

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ABSTRACT

This is the fourth quarter progress report of Phase II of a three phase project to develop and evaluate the efficacy of developing multiple environmental market trading credits on a partially reclaimed strip mined site near Valley Point, Preston County, WV. The focus of this quarters work was directed at preparing the tree plantation site. A contract was negotiated to clear and grub the site of trees and brush, construct a haul road for trucking class F fly ash onto the site and to rip and till the fly ash into the soil as an alkaline amendment. Additionally, initial performance monitoring of the passive acid mine drainage (AMD) treatment system was conducted in October and reported herein. We also included as-built final costs into our AMD system cost structure.

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EXECUTIVE SUMMARY

This is the fourth quarter progress report of work accomplished to develop and evaluate the efficacy of developing multiple environmental trading credits on mined land to encourage enhanced reclamation, more quickly and at less public cost. Project objectives are to develop hypothetical carbon sequestration and water quality trading credits by reforesting a 12-hectare area with five species of commercial hardwood tree seedlings and designing and constructing a passive AMD treatment system to improve water quality. The project site is located on a partially reclaimed surface mine near Valley Point, Preston County, WV.

Delays in acquiring site access moved the initiation of construction to late summer, early fall. The project team in conjunction with the DOE project officer agreed to construct the AMD treatment system first. This was completed on Sept. 29, 2004. Site preparation for the tree-planting site then began in October 2004. This involved four main tasks as follows:

1. Site clearing and grubbing;
2. Construction of a haul road for the ash trucks;
3. Ash placement, spreading and tilling; and
4. Tree planting

Our goal was to complete as many of these tasks as possible prior to the onset of wet weather. If the fall of 2004 proved as dry and mild as the previous two falls this would not be a problem since ash haulage would only require minimal road preparation and ash haulage could proceed through the fall and winter. However, if the weather turned wet and snowy, then we would need to build a limestone based haul road for the complete distance to the test plots. The project budget would not support this option so test plot preparation was planned to terminate in the event the ground became too wet to support the ash haul trucks with startup as early in the spring as possible.

Carbon sequestration credits are to be developed through reforestation of a 12-hectare area. The area was divided into six, two-hectare plots. Five of the six plots are to receive an application of class F fly ash from Allegheny Energy's Albright coal-fired power plant to neutralize soil acidity. The remaining plot will serve as the control. Five commercial hardwood tree species are to be planted in the six plots and growth and survival measured. Vegetative and soil carbon will be measured and compared to baseline measurements (Phase I project) to determine the amount of carbon sequestered.

A local contractor was hired to prepare the 12-hectare experimental area for tree seedling planting. Extensive negotiations with the contractor were required to arrive at a contract cost in compliance with the project budget. The contractor began work in October improving and constructing a 670-meter ash truck haul road into the project site as well as clearing and grubbing trees and shrubs from a portion of the project site. The onset of wet weather then heavy snows in the latter portion of the quarter slowed and eventually stopped site preparation activities.

Initial passive AMD treatment system performance monitoring, conducted in October 2004 indicated that removal efficiencies for acidity, iron and aluminum exceeded ninety five percent. Other than confirming hydraulic connectivity, we recognize that discharge water quality in the first several months of a passive treatment system's operation has limited application to long-term performance. Observations in the subsequent weeks indicated that while cold weather prevented germination of our cover crop, post construction sediment had diverted surface runoff into the alkaline recharge trench (ART) preventing treatment of significant portions of the site's water. In addition to redirecting flow and cleaning out sediment, we decided to wait until January 2005 for the sedimentation to abate prior to taking additional water samples.

Thus far, we have identified a number of site specific cost factors that are important considerations in attracting investment in environmental credit development on mined lands. These include site location and topography, soil chemistry and compaction, the type, size and density of vegetation cover, AMD quality and quantity and the amount of post restoration monitoring required to quantify and verify credits developed.

EXPERIMENTAL

Passive AMD treatment system performance sampling was conducted at the treatment system discharge using sampling and analytical methodologies described in the first quarter report.

Class F fly ash from Allegheny Energy's Albright coal-fired power plant will be trucked to the site and applied as an alkaline soil amendment. The amount of fly ash to apply was determined by analyzing soil chemistry (Phase I project). Soil cores were collected by laying out two random transects within the proposed project area. Five samples per hectare were collected with a hollow stem soil sampler. The soil cores were placed in separate Zip-lock baggies and placed in a cooler on ice.

Approximately 60 samples were collected in this manner throughout the proposed project area.

Upon return to the laboratory, the soil samples were analyzed for Neutralization potential as well as soil pH. These values were presented in the Phase I report.

Soil pH was determined by placing the air-dried soil in either water or a calcium chloride solution and measuring the pH using a pH meter.

Neutralization Potential is a measure of the soil's ability to neutralize acid. It is measured by adding hydrochloric acid and heating to near boiling. The pH is checked and more acid is added if the pH is greater than 4. Hydrogen peroxide is also added to ensure complete oxidation of iron and manganese ions. The soil solution is then titrated to a pH of 8.2 with sodium hydroxide.

The collected soil samples had an average pH of 4.3, which is indicative of an acidic soil typical of surface mine spoil overlying the Freeport coal seam. The neutralization potential of the soil is indicative of the amount of neutralizers present in the soil. The average value of these samples was -1.5 indicating the absence of alkaline material.

Fly ash from the burning of bituminous coal at the Allegheny Energy's Albright Power Plant will be used as a soil amendment. The beneficial effect of fly ash amendments on mine soil reclamation is well documented (Keefer et al. 1983, Capp 1978, Bhumbra 1991, and Singh et al. 1992). Adding fly ash to mine soils may reduce the undesirable chemical and physical conditions, such as acidity, compaction and low water holding capacity, present in mine soils. A 1995 study by Dhaliwal et al. demonstrated that even after 22 years, fly ash amended mine soil had higher soil pH than untreated mine soil. In addition, the fly ash treated soils had thicker A horizons and more prolific plant roots. The site's existing soil is not suitable for productive forest development. The fly ash amendment will correct its physical and chemical shortcomings and improve the site's capacity to sequester carbon.

The fly ash will be trucked approximately 17.5 kilometers to the site and dumped along the eastern edge of the site. After dumping, ash will be spread over the site and tilled and/or ripped into the upper fifteen centimeters of soil. Based on the fly ash and the soil analysis, it was determined that approximately 6,936 metric tons of fly ash will be required to amend the five, two hectare test plots.

RESULTS AND DISCUSSION

The first sample for evaluating the AMD passive treatment system performance was collected approximately a month after completion of the AMD passive treatment system. The data indicated that the treatment system was providing excellent treatment of the AMD by significantly reducing acidity, increasing alkalinity and significantly reducing iron and aluminum compared to pre-construction data (Table 1). Table 1 also shows the calculated removal efficiency and pollutant load reductions resulting from the passive AMD treatment system. These performance results were calculated from an average of seven AMD seep samples averaged within quarters. The samples were collected prior to construction and constitute the baseline condition for judging system performance. The data show that the removal efficiencies for acidity, iron and aluminum exceeded ninety-five percent. Loadings (tons/yr) for these same constituents were reduced by several orders of magnitude. Manganese is much more difficult to remove with passive treatment technology used at this site, but nevertheless receives treatment within the system.

Table 1 Calculated Loading Reductions Resulting from Treatment (t/yr)

Sampling Station	units	Pre-Construction Averages					Post-Construction	% Reduction	Amount Reduced kg/year
		1st quarter	2nd quarter	3rd quarter	4th quarter	Average	10/27/2005		
quarter/date									
Flow	gpm	9.70	12.04	1.80	0.75	6.07	1.97		
Flow	m ³ /s	0.0006	0.0008	0.0001	0.0000	0.0004	0.0001		
Field pH		2.85	3.25	3.15	3.00	3.06	5.5		
pH		3.55	3.20	3.05	2.90	3.18	5.3		
acidity	mg/L	136.50	127.50	244.50	319.00	206.88	0		
est. acidity	mg/L	164.98	145.27	388.40	301.79	250.11	11.90	95	
alkalinity	mg/L	0.00	0.00	0.00	0.00	0.00	104		
acid-alk	mg/L	136.50	127.50	244.50	319.00	206.88	-92.10		
Mg	mg/L	24.25	24.00	44.10	81.20	43.39	25		
Ca	mg/L	29.35	31.85	62.90	80.60	51.18	108		
Fe	mg/L	20.05	11.39	18.89	25.80	19.03	0.79	96	
Al	mg/L	10.65	9.93	45.03	19.40	21.25	0.42	98	
Mn	mg/L	7.62	8.25	12.97	25.30	13.53	6.6	51	
SO ₄	mg/L	292.00	334.00	668.50	735.00	507.38	400		
Cond	µS/cm	619.00	970.00	1609.00	2080.00	1319.50	713		
PRE-CONSTRUCTION LOADINGS							PCL*		
acid load	kg/yr	3194.05	3490.94	1395.34	451.74	3031.29	46.78	98	2984.51
Fe Load	kg/yr	388.16	273.58	67.86	38.62	230.65	3.11	99	227.55
Al Load	kg/yr	206.18	238.50	161.75	29.04	257.54	1.65	99	255.89
Mn Load	kg/yr	147.52	198.13	46.58	37.87	164.01	25.95	84	138.06

* Denotes Post Construction Loading

Table 2 As Built Costs for Passive Treatment System

Item	Length	Width	Depth	Tons Limestone	Tons CKD	Cost
Mobilization/Demobilization						\$ 3,000
LS 1	18	18	3		25	\$ 2,000
ART 1	200	4	4	150	550	\$ 26,711
OLC 1	160	6	4	170		\$ 6,800
OLC 2	150	5	4	127		\$ 6,000
FD 1	50	6	6	40		\$ 5,463
Imp "A"	50	15	2	35	15	\$ 5,086
Imp "B"	100	50	3			\$ 5,086
Excavation (3,958 cy @3.50cy)						\$ 13,854
TOTAL				522	590	\$ 74,000

The initial contractor bid for clearing and grubbing, constructing the ash haul road and spreading and tilling the ash into the project site soil was well above the allotted project budget. In addition, the cost for constructing the passive AMD treatment system necessitated limiting the contractor award until sufficient funds are made available in the next project phase. This necessitated reducing the proposed reforestation project area from 12 hectares to approximately 10 hectares. The current plan is to amend the soil on eight hectares with class F fly ash and to leave the remaining two hectares un-amended as a control plot.

Tumbleweed Enterprises began clearing and grubbing trees and shrubs from the reforestation site and constructing a haul road for fly ash transport in early October (Figures 1 and 3). Adverse weather conditions in the latter part of the quarter stopped construction activity. At this time, the contractor is approximately 20% complete and it is anticipated that ash placement will begin in the spring to be followed by tree seedling planting.

Figure 1 Reforestation Site Partially Cleared and Grubbed.

Figure 2 Partially Constructed Fly Ash Haul Road to Reforestation Site.

CONCLUSION

Water quality monitoring data collected approximately one month following completion of the passive AMD treatment system indicate that the AMD passive treatment system is, at least in the short term, achieving significant reductions in acidity, iron and aluminum in comparison to baseline monitoring data. The resulting loading reductions are relatively small because the AMD flow volume is small. As a result of the change in location of the passive treatment site to Connor Run and the mandated completion date of Sept. 30, 2004, we were only able to collect seven baseline (pre-construction) samples. Clearly it would have been more desirable to have additional monitoring data over a full year including both high and low flow events. Therefore, this analysis provides only an initial perspective of treatment system performance and associated loading reductions.

In order for environmental credit markets to become attractive to investors, credit development must be accomplished at a reasonable cost. It is obvious that the larger the return to investors, the greater the incentive to invest. In this project a number of site specific cost factors have become evident that should be considered in selecting a site to restore for development of environmental credits. These include the following:

- Stand conversion: Existing vegetation can assist or interfere with tree seedling growth. Control or removal of this vegetation is generally warranted. In addition, this vegetation has some carbon sequestration potential and it represents baseline conditions against which gains in carbon sequestration potential should be measured.
- Soil chemistry and compaction: Trees planted in spoil that has been heavily compacted and is of poor quality and composition do not survive and grow as vigorously as those planted in good soils (Burger and Zipper, 2002). Soil chemistry and composition becomes an issue when determining the tree species to be planted. Some species, such as commercial hardwoods (oaks, black cherry and tulip poplar), do better in slightly acidic and non-compacted spoil while sycamore, red maple and green ash are more tolerant of sites that are compacted and poorly drained and are more alkaline in nature. Spoil requiring an alkaline amendment and significant ripping will result in additional costs to prepare for reforestation.
- Site topography: Reclamation sites with steep grades or that contain an unreclaimed high wall may require extensive grading and backfilling at additional cost.
- Location: Location may become a cost issue if a soil amendment is required. For example, in this project an alkaline amendment was needed to neutralize the acidic spoil in preparation for planting hardwood tree species. Class F fly ash was chosen as the amendment because the product is relatively inexpensive compared to lime and it has been widely used for mine reclamation. This choice dictated that the site be located within a reasonable trucking distance of a coal-fired power plant in order to reduce trucking costs. Additionally, the distance from a road to the reclamation site may be a cost issue if a road must be constructed to accommodate the heavy ash-haul trucks. For example, the reforestation site

chosen for this project required construction of a 670-meter ash haul road at an estimated cost of \$ 20,000.

- AMD quality and volume: The AMD volume and quality dictate both the size and configuration and thus the cost of designing and constructing a passive treatment system. In general, the greater the flow volume and the worse the quality the greater the system cost. On the other hand, the greater the volume and the greater the treatment efficiency the more water quality credits that will be generated.
- Pre-and Post development monitoring requirements: Intensive and burdensome baseline and post restoration monitoring that may be required to quantify and verify environmental credits can add significant costs to the project.

Credit developers should also be aware that a potential issue related to using coal combustion products (CCPs) as a soil amendment is the public concern regarding the potential release of toxic metals. Although numerous researchers (Parizek, R.R. 1986, Daniels, et.al., 2002 Ziemkiewicz 2004, White, 2004) have demonstrated that the beneficial use of CCPs for mine land reclamation is not an environmental concern, if managed properly, a public stigma remains. Moreover, many states, including West Virginia, have recognized the value of using CCPs for mine reclamation and have policies and regulations in place that guide this practice. Nevertheless, environmental credit developers must be aware of and prepared to address any public concerns that might arise as a result of utilizing CCPs in site restoration.

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