BENEFICIAL APPLICATIONS OF CFB ASH AT MISSISSIPPI LIGNITE MINING COMPANY'S RED HILLS MINE

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Abstract

Mississippi Lignite Mining Company (MLMC) operates the Red Hills Mine, an open pit, multiple seam, lignite mining operation, in northeast Mississippi. The mine produces and supplies approximately 3.6 million tons of lignite annually to the neighboring Red Hills Power Plant which is operated by an affiliate of Tractebel Power Inc. The Red Hills Power Plant is a 440 megawatt power station utilizing modern circulating fluidized bed (CFB) boiler technology. Fuel conversion produces 670,000 tons of dry CFB ash annually that is disposed of in excavated, lined, and permitted solid waste disposal cells adjacent to the power plant.

Mine production is impacted greatly by haul road conditions. Roads must support haulage trucks that weigh 550,000 pounds and carry 150 ton payloads at speeds up to 34 mph. During inclement weather, roads become soft, spongy, and rutted. Haul truck speeds and production are seriously impacted. Construction of all-weather roads is difficult because of a lack of suitable, locally available, sub-base soils and surfacing materials. Trucking costs for aggregate from distant Mississippi and Alabama quarries make this material too costly for use on most primary haulage roads.

Following extensive reviews, the Mississippi Department of Environmental Quality (MDEQ) gave MLMC approval to use CFB ash for the construction of primary heavy earth moving and coal haulage equipment roads, dragline walkways, pit ramps, parking areas, and other minor construction purposes. MDEQ considers these uses to be beneficial and an economical replacement of crushed limestone the mine has traditionally imported from considerable distances. The use of ash as a mine road building material not only has improved haulage production, reduced diesel fuel consumption, and reduced road maintenance, but also will conserve natural aggregates from quarries and lengthened the life span of the primary ash disposal facility.

This paper describes the environmental considerations given for ash applications, permitting and monitoring requirements of MDEQ, ash handling methods that the mine has used in various applications, and results the mine has observed.

Introduction

Red Hills Mine is a surface lignite mine that has been in operation for seven years and is located 7 miles northwest of Ackerman, in Choctaw County, Mississippi (Figures 1 and 2). It is owned and operated by the Mississippi Lignite Mining Company (MLMC), an affiliate of The North American Coal Corporation. Development of the Red Hills Mine began in 1998, with commercial lignite deliveries in 2002. Coal production of the Red Hills Mine is approximately 3.6 million tons-per-year. Lignite from the Red Hills Mine fuels the neighboring Red Hills Generation Facility (RHGF), which is owned and operated by Choctaw Generation Limited Partnership, an affiliate of Tractebel Power Inc. (Tractebel). The RHGF generates 440 MW of electricity using two circulating fluidized bed (CFB) boilers. Fuel conversion produces 670,000 tons of dry CFB ash annually that is primarily disposed of in excavated, lined, and permitted solid waste disposal cells (referred to as Ash Management Units (AMU's) in this paper) adjacent to the power plant (Figure 3).

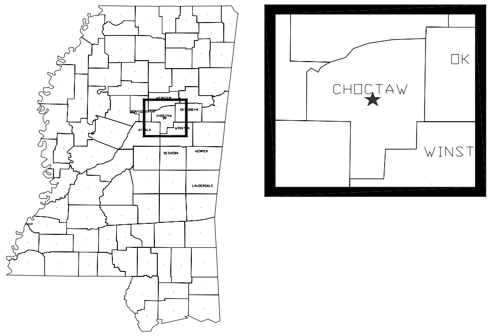

Figure 1. Project Location Map.

Figure 2. Aerial photo of the Red Hills Mine.

Figure 3. Aerial photo of the RHGF and AMU (right of plant).

The 5,800 acre life-of-mine area is characterized as wooded, rural countryside with occasional pasturelands, ponds, sparse residential development, and few industrial features. The terrain is gently rolling with wide valleys, small streams and dissected uplands. More than 80% of the area is woodland, with deciduous, evergreen, and mixed timber stands. The predominant pre and post mine land use is and will be commercial forest.

The Red Hills Mine lies within the Wilcox Group of Mississippi. This is the most abundant lignite bearing stratum in the State. Within the mining area, ten major lignite seams (A through J Seam) have been mapped with A seam being the deepest. Of the ten seams, only six relatively continuous lignite seams (C through H Seam) are being mined. Average depth to the C seam is 200 feet, with the average depth to the A seam being 340 feet. Only the upper portion of the Wilcox Group, principally the Tuscahoma Formation and Grampian Hills Member of the Nanafalia Formation, will be disturbed by mining. Compared to the Gravel Creek Member and Tuscahoma Formation, the Grampian Hills Member is relatively sand-poor and has no ground water resource value. Little or no ground-water development has occurred within this stratum. The Lower Wilcox Aquifer, a fresh water aquifer of local importance, is located below the A seam and is overlain by 70 to 80 feet of interbedded clay, silt, sand, and the relatively discontinuous A and B lignite seams. Since the depth of the Lower Wilcox Aquifer is over 100 feet below the C Seam and is separated from the mine floor by several strata of fine-textured materials, it has not been impacted by ongoing mining operations and is not expected to be impacted in the future.

Mining involves the removal of six lignite seams (C, D, E, F, G, and H) uncovered by continuous removal of overlying burden soils. Suitable plant growth materials (SPGM) and overburden materials are removed by a combination of truck and shovel operations, dozer push operations, and with a dragline. In general, the truck and shovel operations remove the upper SPGM and overburden to the first lignite seam. Caterpillar D-11 class dozers sequentially uncover the next three seams by pushing overburden into the preceding pit. The last two seams are uncovered by an 82 cubic yard walking dragline. As lignite seams are exposed they are recovered using 22 cubic yard excavators, a 40 cubic yard electric loading shovel, and an Easi-Miner to load 165-ton end dump trucks for delivery.

Reclamation involves grading spoil to a gently rolling terrain, which approximates original contours, covering or re-spreading the graded spoil with four feet of SPGM, seeding with a grass cover crop for erosion control, and planting with loblolly pine seedlings to achieve the primary post-mine forest land use requested by area landowners.

Surface coal mining operations in Mississippi are regulated by MDEQ's Office of Geology under delegated authority granted by the United State Department of the Interior, Office of Surface Mining, pursuant to the Surface Mining Control and Reclamation Act of 1977, 30 U.S.C. **§** 1201 et seq. Solid waste disposal is regulated by MDEQ's Office of Pollution Control. This office is in charge of regulating the disposal and beneficial uses of RHGF ash. Currently there are no specific regulations that address the beneficial use of coal combustion products. MLMC and RHGF working with both aforementioned MDEQ offices, developed beneficial ash use criteria that could be used to prepare a proposal for regulatory framework and incorporation into MLMC's Surface Coal Mining and Reclamation Permit. These criteria included:

- a description of the proposed beneficial use of the ash
- a description of how the use of ash would replace or conserve other natural resources or other materials, thereby qualifying RHGF ash as a "product" and it's use as "beneficial"
- a chemical and physical characterization of the ash
- the potential environmental consequences of the beneficial use of the ash.

Most of what is known today about coal combustion products in the United States is based on ash produced in pulverized coal boilers (PCBs) that combust coal at approximately 3,000^{o} F. Comparatively little is known about CFB combustion products because fluidized bed boilers are relatively new and few in number. Fluidized bed boilers combust a mixture of coal and limestone at about 1,400^{o} F. These boilers have two significant benefits over PCB units, they capture and bind sulfur and lime into calcium sulfate and reduce nitrogen oxides (NOX).

The source of lime used by RHGF in its boilers is the Selma chalk, a lime rich clay, which is mined about 60 miles from the plant. The ash that RHGF produces has properties specifically associated with the lignite and lime burned in its CFB. As such, Tractebel is very interested in characterizing the ash as having a beneficial use and developing marketable applications for it rather than disposing of it as a solid waste. Currently, RHGF's Ash Management Units occupy 72 acres and have cost millions of dollars to design and construct. Additional disposal storage areas will be needed in the future unless other beneficial applications can be developed. In addition to RHGF ash that MLMC is using as described in this paper, this ash is being used locally by Choctaw County and neighboring counties as an inexpensive county road stabilization material, by various contractors as a building site stabilization material, and by several landfills as a solidification or absorbent material. RHGF also is working with the Mississippi Department of Transportation to have RHGF ash approved as a stabilization product for State Highway construction projects.

Beneficial Use of CFB Ash at the Red Hills Mine

Mining conditions at the Red Hills Mine can be best characterized as challenging. Removal of SPGM, multiple lignite seams and overlying burden material from a 7,000 foot long pit requires continuous construction of new haul roads, ramps, trails, and dragline walkways capable of supporting the large and heavy earth moving equipment used. While ground water is less of an operational concern, surface water runoff has significant impact on the trafficability of the roadways which has a tremendous impact on productivity. Red Hills Mine has received from 55 to over 80 inches of annual rainfall since it began operations. The only road building materials available on-site are sandy or silty Wilcox clays, which exhibit high shear strength under dry conditions but rapidly lose shear strength as their moisture content increases. Furthermore, suitable road base aggregates are not available in the area and need to be purchased and imported from distant suppliers. During the winter months shorter daylight hours, lower temperatures, and common back-to-back storms result in saturated roads that remain rutted, soft, and spongy for long periods. Under these conditions, truck traffic on primary roads becomes slow, and trafficability on spoil trails and softening dragline walkways is almost impossible. Until RHGF ash was used, the only option for constructing durable haul roads was to place a crushed limestone base over woven textile over the clay sub-grade of the roads. The nearest source of base rock is located 170 miles from the mine making its use too expensive for all but the most important and long life segments of primary haul roads.

Road deterioration is not the only problem that rain causes. The clay backfill placed in culvert installations becomes soft and erodes. Rutting and excessive settlement of soft soils, result in the collapse of culverts under heavy vehicle loads.

Since crushed limestone, a common road base material, is used as acid neutralizing medium in the RHGF CFB boiler, MLMC surmised that the CFB ash might possess attractive binding characteristics and might be used as a clay stabilizer and help improve the trafficability of the mine roads, dragline walkways, parking, and shop entrance areas. If so, then the use of ash as a clay stabilizer and/or road base material would be a "beneficial use." Its use would also have the benefit of reducing natural limestone demand from quarries and associated transportation costs.

Also, the beneficial use of ash as a mine road stabilization product would reduce the land area needed for disposal/storage of ash at the RHGF AMU's and extend the life of the AMU. For the mine operation, stabilization of roads, trails, ramps, walkways, and parking areas would certainly be beneficial. Rain delays would be shortened, vehicle wear would be reduced, safety would improve, and productivity would be enhanced.

Ash Characterization and Application Considerations

As previously described, the ash generated at the RHGF consists of fly ash and bottom ash from a fluidized bed combustion boiler. The dry ash from the boilers is hydrated (pugged) using blow-down water from the power plant water cooling tower system prior to being loaded on trucks for final disposition. Hydrating ash controls dust during transportation and uses excess cooling tower water. Blow-down water has concentrated amounts of salts found in the raw water and extracted during treatment of the cooling water stream.

Mineralogical Analysis

Mineralogical analyses of the RHGF ash (dry), Selma chalk and a common brand of commercially available limestone, Vulcan, were performed as an initial step in comparing ash to natural limestone (Table 1). The Selma chalk is used in the CFB boiler. Vulcan brand limestone is used widely as a road base material in northern Mississippi. Dry samples of RHGF ash taken approximately a year after the initial sample analysis confirmed the stable composition of the ash (Table 2). Alumina, silica, lime, and sulfur trioxide constitute over 90 percent of the mineral content of ash. These oxides provide the pozzolanic properties commonly observed in many lignitic fly ashes. Notably, as seen on Table 2, the RHGF ash does not quite meet all the classification standards of either a Class F or Class C ash. This is not surprising since the RHGF ash comes from a CFB boiler rather than a PC boiler.

Mineralogical analyses shown on Tables 1 and 2 indicate that the RHGF ash is basically a soil (aluminum silicate) with moderate cementing properties.

Table 1. Initial Mineralogical Analysis of the RHGF Ash and commercial limestone used at the RHGF and mine site (as percentage of weight on a dry basis).

	RHGF ASH	SELMA CHALK	VULCAN LIMESTONE
Silica, SiO_2	49.63	Not Reported	10.28
Alumina, Al_2O_3	18.65	3.80	0.28
Titania, TiO2	0.89	Not Reported	0.00
Ferric Oxide, Fe_2O_3	3.35	1.70	0.23
Lime, CaO	15.90	44.80	86.04
Magnesia, MgO	2.21	3.40	1.70
Potassium Oxide, K_2O	1.06	0.06	1.13
Sodium Oxide, Na_2O	0.34	0.04	0.00
Sulfur Trioxide, SO_3	6.17	0.06	0.31
Phosphorous Pentoxide, P_2O_5	0.18	0.02	0.00
Strontium Oxide, SrO	0.18	Not Reported	0.05
Barium Oxide, BaO	0.17	Not Reported	0.00
Manganese Oxide, Mn_3O_4	0.11	0.03	0.00
Undetermined	1.16		0.00
Alkalis, as Na_2O, Dry Coal Basis	1.01	Not Reported	Not Reported
Base: Acid Ratio	0.33	Not Reported	Not Reported

Table 2. Additional Mineralogical and Physical Analyses of the RHGF ash (as a percentage of weight on a dry basis). Note: Ash classification standards are provided as reference only.

	February 2004	**October 2003**	**CLASS C Classification**	**CLASS F Classification Criteria**
Mineralogical Analysis				
Silicon Dioxide ($Si0_2$)	41.73	46.69		
Aluminum ($A1_20_3$)Oxide	16.71	14.47		
Iron Oxide (Fe_20_3)	6.04	4.52		
Sum of $Si0_2$, $A1_20_3$, and Fe_20_3	64.48	65.48	50 Min.	70 Min.
Magnesium Oxide (MgO)	1.65	1.65		
Sulfur Trioxide ($S0_3$)	6.25	5.43	5.0 Max.	5.0 Max.
Moisture	0.17	0.14	3.0 Max.	3.0 Max.
Loss on ignition	0.32	0.29	6.0 Max.	6.0 Max.
Available Alkalies as Na_20	0.44	0.38		
Calcium Oxide (CaO)	22.53	21.60		
Free (CaO)	2.20	1.90		
Physical Analysis				
Fineness: percent retained by the 325 sieve	35.29	34.95	34% Max.	34% Max.
Water Requirement, % Control	111%	110%	105% Max.	105% Max.
Specific Gravity	2.53	2.60		
Autoclave Expansion, %	0.00	+ 0.01	0.8% Max.	0.8% Max.

Table 2 continued.

Strength activity index with Portland Cement:				
7 Day	82%	80%	75% Min.	75% Min.
28 Day	86%	95%		

As part of characterizing the chemistry of the ash, trace metal analyses were performed. The results indicate a concentration of trace metals of less than five (5) grams per kilogram of ash (Table 3).

Leachate Analysis

After evaluating the chemical content of the ash, the investigation focused on the chemistry of the RHGF ash leachate. This was done by first carrying out standard leachate extraction procedures and, in a second phase, analyzing the leachate obtained from column tests. The latter tests also served to determine the hydraulic conductivity of the ash after being saturated in water and during the ensuing cementing process. Results of Toxicity Characteristic Leaching Procedure (TCLP) analysis performed on two samples are presented in Table 4. For comparison, the maximum contaminant level (MCL) concentrations for drinking water, established by the US. Environmental Agency (USEPA) in 40 CFR § 146.62, are also indicated in Table 4. TCLP results reported in Table 4 indicate that RHGF ash leachate is non-toxic.

Table 3. Concentration of Trace Metal Analyses in the ash.

Metal	**Concentration (mg/g)**		**Metal**	**Concentration (mg/g)**	
	Oct 2002	Jun 2003		Oct 2002	Jun 2003
Antimony	14		Manganese	1320	
Arsenic	15	10.8	Mercury	0.7	<0.1
Barium	930	318	Molybdenum	29	
Beryllium	<2		Nickel	96	14.8
Cadmium	<2	<0.5	Selenium	6	<1.25
Chromium	120	47.3	Silver	5.7	<0.125
Cobalt	82		Strontium	1830	
Copper	115	47.3	Tin	13	
Lead	62	9.87	Vanadium	67	
Lithium	81		Zinc	52	10.7
			Zirconium	21	

Table 4. TCLP Analysis (test concentrations in mg/l)

	Sample 1	Sample 2	MCL
Arsenic, As	<0.05	<0.05	0.05
Barium, Ba	0.34	0.36	2.0
Cadmium, Cd	<0.005	<0.005	0.005
Chromium, Cr	0.04	0.03	0.1
Lead, Pb	<0.01	<0.014	0.015
Mercury, Hg	<0.0002	<0.0002	0.002

Selenium, Se	<0.05	<0.05	0.05
Silver, Ag	<0.005	<0.005	no MCL

Note: Current arsenic MCL is 0.05 mg/l. However the level of 0.01 mg/l will be effective on 1/23/2006.

Results of the column tests performed on ash from the bag house (dry ash) and the AMU (pugged ash) are presented in Table 5. The column tests were performed using groundwater obtained from a well constructed in the Wilcox Formation. The rationale for using groundwater was to better simulate groundwater found in the mine excavations.

Results presented in Table 5 indicate, as do the results shown in Table 4, that ash from the RHGF is non-toxic. The ratio of sulfate to calcium indicates a chemically stable calcium sulfate matrix with other inorganic elements like sodium and potassium in smaller concentrations. Use of the ash as a road stabilization material was not expected to have an adverse environmental impact.

The pH range of the deeper overburden soils at the mine varies from 6.0 to 8.5. Topsoil and subsoil have a lower pH range of 4.0 to 6.0. Limestone is basically inert within the pH ranges of the deeper overburdens and only minor dissolution should be expected at the lower pH levels found in soils with a pH of less than 5. On the road base, water re-binds limestone fines generated during application and compaction of limestone gravel. Conversely, ash when applied to soils is expected to promote physical stabilization of the clay soils by chemically binding the clay minerals with the aluminum silicates and the lime contained in the ash. The pH, measured in the column leachate tests, is presented in Table 5. It ranges between 10 and 10.5. This indicates that RHGF ash is less basic than hydrated lime, which is commonly used in road sub-grade stabilization.

Table 5. Column Test Leachate Analyses

General Parameters	**Ash from the Bag House**	**Ash from the AMU**
Sample Date	11/19/2002	11/19/2002
Field pH	10.00	10.27
Lab pH	10.11	10.44
Electrical Conductivity (mS)	2620	3390
Magnesium (mg/l)	0.62	0.86
Calcium (mg/l)	545	725
Potassium (mg/l)	43.5	33.4
Sodium (mg/l)	60.3	96.8
Chloride (mg/l)	21.4	31.2
Sulfate (mg/l)	1040	1570
Nitrate/Nitrite (mg/l)	ND	ND
Trace Metals Total Concentration in mg/l		
Antimony	ND	ND
Arsenic	ND	ND
Barium	0.16	0.16
Beryllium	ND	ND
Chromium	ND	ND
Copper	ND	ND
Iron	ND	ND
Manganese	ND	ND
Mercury	0.0027	0.0012
Molybdenum	ND	ND
Nickel	0.14	0.14
Selenium	ND	ND
Silver	ND	ND
Zinc	0.027	0.046

Hydraulic Properties of the ash

Lime and magnesium oxides found in RHGF ash are present in the form of calcium and magnesium sulfates. The addition of water causes quick hydration of the ash and converts into a cementing mixture of low permeability.

Permeability or hydraulic conductivity was measured during the leaching experiments. The measured hydraulic conductivity of the ash during the initial leaching of the columns was in the order of $1x10^{-5}$ centimeters per second (0.028 feet per day) and showed a decreasing trend over time. The clay nature of the soils combined with the low permeability of the ash exhibited during column tests further suggest that no adverse consequences will result from the proposed use of this ash.

Geotechnical Investigation

Pritchard Engineering Laboratory in Starkville, Mississippi conducted a geotechnical investigation to provide an initial assessment of the stabilization benefits to be derived by incorporating RHGF ash into prevalent mine site soils. Varying dosage rates and different hydrating sources of water were studied. The scope of geotechnical work consisted of:

1) Identifying and classifying prevalent soil types utilized in earthwork activities and establishing baseline compressive strength data for these soils.
2) Incorporating ash into the prevalent soils at 10%, 20%, and 60% rates and evaluating changes in strength through unconfined compression testing. Ash dosage rates of 10%, 20%, and 60% by weight were evaluated.
3) Evaluating the use of both cooling tower water (CT) and plant process brine water (BW) (the possible ash hydrating sources from the power plant) in the sample preparation process.

Representative samples of selected mine site soils were collected, classified, and tested for compressive strength. Soil samples were then mixed with 10%, 20%, and 60% ratios of ash (hydrated with CT or BR water). Selected mine site soil samples were taken from the overburden above the D, F, and H coal seams and an upper sandy clay soil above the H burden, with D being the lowest and H being the upper coal seam in the list. These are the burden soils most often used for road construction purposes. Initial classification testing revealed that the upper sand clay material is very similar in physical characteristics to the overburden above the F seam. Consequently, compression strength tests on the F-Burden were not performed. Results of the classification tests are included in Table 6.

Typically, soils exhibiting a high PI are susceptible to significant changes in volume (i.e. shrinkage and swelling) with fluctuations in moisture content and experience severe loss of shear strength as a result of saturation and increased water content. Low PI soils experience minor volume changes in response to moisture changes and normally are suitable for use as road sub-grade material. High PI soils, on the other hand, can have dramatic volume changes induced by moisture changes and are not a good sub-grade material.

Table 6. Soil Classification of Burden Soils.

Material	Ash Content (%)	LL	PI	Percent Fines	Unified Classification
D - Burden	0	39	19	81.9	CL
	10	50	18		ML
	60	62	23		MH
F - Burden	0	51	27	97.5	CL-CH
	10	59	28		MH
	60	66	28		MH
H - Burden	0	36	7	85.0	CL
	10	50	19		ML-MH

Table 6 continued

H-Burden	60	58	18		M H
Upper Sandy Clay	0	50	27	92.4	CL-CH

The increase in liquid limit with increased ash content suggests that clay/ash mixture takes on a silty character. As ash content increases, soils tend to acquire an MH (highly plastic silt) Unified Classification.

Some geotechnical properties of the ash used in the mixtures were measured to assess the intrinsic properties of the RHGF ash. These are shown in Table 7.

Table 7. Geotechnical Properties of RHGF Ash.

Property	Value
Maximum Wet Density	97.5 pcf
Maximum Dry Density	64.2 pcf
Optimum Moisture	51.8%
Dry Unit Weight:	
Loose in Stockpile Moisture	37.61 pcf
Compacted Unit Weight	57.27 pcf
Unconfined Compressive Strength (100% Compaction):	
7 day	851 psi
28 days	951 psi
Yield (Tons per cubic yard at 100% Compaction)	1.32
Coverage: (Pounds per square yard per 1” depth at 100% compaction)	13.13
Loss On Ignition:	0.66
Fineness:	34.95
Specific Gravity:	2.60
pH	10.53
Absorption:	0.96 fly ash : 1.0 H_20

The compressive strength results of the soil/ash mixtures using CT and BW hydration are presented in Table 8.

Table 8. Compressive Strength of Burden Soils.

Material	Ash Content (%)	Compressive Strength (psi)	
		CT Water	BW Water
D - Burden	0	23.1	
	10	22.3	38.9
	20	18.6	33.0
	60	27.8	42.9
F - Burden	0	23.6	
	10	23.9	40.2
	20	32.2	33.0
	60	61.9	71.7
H - Burden	0	39.3	
	10	40.5	44.6

Table 8 continued

H-Burden	20	38.4	43.2
	60	56.3	87.2

Results presented in Table 8 indicate that only significant doses of ash result in a beneficial use as a soil stabilizer. Indeed ash without soil exhibits significant compressive strength (851 psi at 7 days and 951 psi at 28 days) as seen in Table 7. Observations of trucks operating on the AMU's also suggested that a 100% ash road base could support heavy mining equipment traffic better than an ash/soil mixture and would compared fairly well vis-a-vis a crushed limestone base.

MDEQ Review, Approval and Monitoring Considerations

In 2003 MLMC prepared and submitted to MDEQ an initial plan entitled Plan for Beneficial Use of Coal Combustion Byproducts to Stabilize Mine Roads, Dragline Benches and Truck Fills at the Red Hills Mine. This plan included the proposed uses, application methods, approximate tonnage, the characterization previously described and an assessment of potential environmental impacts. The plan was submitted to MDEQ as a revision to be incorporated into MLMC's State of Mississippi Surface Coal Mining and Reclamation Permit (MS002) which required review under both relevant surface mining regulations and other State regulated programs. The proposal was reviewed by various MDEQ Offices including the Office of Geology (mining regulations), Office of Pollution Control (solid waste), and Office of Land and Water (ground and surface water quality).

In this plan, MLMC described potential environmental impacts and proposed mitigation measures, where applicable.

> "*Dust Control*
> *Ash will be delivered from the RHGF to the Red Hills Mine by the R-dump haul route, which connects the plant to the mine. No ash will be hauled over county roads. The ash may be transported in a hydrated (pugged) or dry state. Hydrated ash will produce little or no dust during haulage and incorporation. If ash is transported in a dry state, it will be hauled by fully enclosed tanker truck or the top of the dry ash will be wetted to prevent ash dust generation during transportation. Ash will be hauled and incorporated immediately into the area requiring stabilization. No ash will be stockpiled prior to incorporation but rather will be incorporated concurrent with its delivery.*
>
> *Probable Hydrologic Consequences*
> *The use of ash as a stabilization product is not expected to have an adverse impact on the ground or surface water systems. The characterization of the ash indicates the RHGF ash does not contain hazardous substances and has chemical characteristics of natural clays. When incorporated into roads, truck fills, and dragline walkways, the ash and clay soil mixture will become a cemented matrix of low permeability, resistant to erosion. The compacted ash and soil admixture will remain in the place in which it is applied. Places where ash will be applied consist of clayey soils with confining characteristics. The usable ground water resources of the area will not come in contact with the ash-clay admixture. Due to the disposition of the ash and clay admixture, its low hydraulic conductivity, and the characteristics of the leacheate, described in the charaterization, no adverse impact is foreseeable as a result of the use of ash as proposed. The cemented nature of the admixture will result in only minor erosion of the ash clay admixture. Any erosion and dissolution of the ash will not result in toxic concentrations as documented by the characterization.*
>
> *Potential Effect on Rooting Depth of Pine Trees*
> *Ash used to stabilize haul routes and truck fills will be placed at varying depths. The shallowest placement of the ash clay admixture (routes and truck fills) will not be less than ten feet from the surface of the reclaimed surface topography. Ash used to stabilize dragline walkways will not be near the ground surface. Pine tree roots may reach the admixture at the shallower placement depths. Loblolly pine trees normally have root depths of two to three feet but can go as deep as ten-feet. The minimum depth of ten feet, at which the ash clay admixture will be placed, will provide an adequate rooting zone above the cemented admixture.*

<u>Effect on RHGF Ash Disposal Area</u> While only a very small quantity of the total ash produced at the RHGF is proposed for beneficial use at the Red Hills Mine, the quantity represents a volume of disposal area that will no longer be needed for ash disposal purposes. Basically, this means less land area will be needed for ash disposal purposes, a positive environmental effect resulting from the beneficial use of ash."

MDEQ approved the plan in July 2003 with the following conditions:

1) *"The roadbed construction and equipment platform construction activity will be restricted to the use of the coal combustion ash produced by the Red Hills Electric Generating Facility and only applied to the project areas in the mine in the manner described in the approved proposal.*

2) *During the construction phase of the mine construction projects, Mississippi Lignite Mining Company shall ensure that the coal combustion ash material is properly managed such that storm water discharge or washout of the material to state surface waters is prevented and such that the project does not cause or contribute to a violation of applicable state and federal water quality standards."*

Surface Mining Regulations require mine operators to construct and operate sediment control ponds that catch and retain surface water runoff from all areas disturbed by mining activities. Before being discharged from the mine, surface water runoff contained in these ponds must meet specific water quality standards approved by the State in a National Pollutant Discharge Elimination System (NPDES) permit issued and regulated by the State. All discharges are sampled and analyzed for pH, total suspended solids, iron and manganese with reports submitted monthly to MDEQ. During review of MLMC's proposal, MDEQ considered the sediment control ponds as primary containment for ash that might be transported by surface runoff and, based on the characteristics of the ash, required no additional monitoring parameters. Sampling of discharges from AMU ponds operated by the RHGF indicate that storm water runoff from ash covered areas is innocuous. Table 9 contains results of storm water analysis from the AMU ponds and from runoff from ash treated roads.

Table 9. Analysis of storm water runoff from AMU ponds and ash treated haul roads (results in mg/l unless specified).

Parameter	AMU	Ash Treated Road	Detection Limit
pH (s.u.)	7.74	8.06	
Total Suspended Solids	37	43	1.0
Specific Conductance (mS)	613	2020	
Total Dissolved Solids	314	1540	1.0
Chloride	102	194	1.0
Fluoride	0.1	0.2	0.1
Sulfate	61.9	717	20
Chromium	ND	0.05	0.05
Selenium	ND	0.05	0.05
Arsenic	ND	0.05	0.05
Barium	0.08	0.01	0.01
Boron	0.09	0.01	0.01
Cadmium	ND	0.02	0.02
Silver	ND	0.005	0.005
Copper	0.013	0.010	0.01
Iron	0.85	0.02	0.02
Lead	ND	0.050	0.05
Manganese	0.05	0.01	0.01
Mercury	ND	0.0002	0.0002

Table 9 continued

Molybdenum	ND	0.05	0.05
Nickel	ND	0.02	0.02
Zinc	0.056	0.025	0.025

3) *"The Mississippi Lignite Mining Company shall maintain records listing the locations and quantity of ash applied to those locations."*

MLMC keeps records of the volumes of ash used for each project by documenting the number of loads of ash hauled to the mine for each project. Locations of ash are documented by surveying each location and preparing an annual map of these locations.

4) *"A beneficial use summary report including the locations, quantity, and description of the observed performance of the material shall be provided to the Department by July 1 of each year of the project life. The Department may consider a request to reduce the frequency of such reporting upon the collection of appropriate historical data."*

In accordance with MDEQ's reporting requirement, MLMC submits an annual Beneficial Ash Use Report for Mississippi Lignite Mining Company's Red Hills Mine that describes where ash was used and the results observed, provides the yearly analytical characterization (required by condition 5), and proposes further beneficial application projects for the upcoming year. MDEQ reviews these reports (one to date) and responds accordingly.

5) *"A yearly analytical characterization of the coal combustion ash which should include total metals, % moisture, sieve size analysis, and pH should be conducted and submitted to the Department by July 1 of each year and may be coordinated with other analytical testing by Tractabel Power, Inc. and other users of the ash. Please be advised that should the results of the total metals analysis approach or exceed twenty (20) times the TCLP characteristics limit for any particular parameter, a TCLP analysis will need to be conducted for that particular parameter. Should collection of adequate historical data indicate that the characteristics of the coal combustion ash are consistent and that continued use would be of low hazard, the Department may consider a request to decrease the frequency of sampling."*

MDEQ further stated that approved used of ash was *"not considered to be an endorsement of those uses or that material nor an absolution of liability should problems arise and should not be construed as such"*. MDEQ retained the authority to modify, terminate or rescind any approval of beneficial use activity.

In addition to these conditions and specific ash monitoring requirements, surface coal mining regulations require various other monitoring requirements as a normal part of mine operation including life-of-mine surface and ground water monitoring, SPGM soil monitoring, and vegetation monitoring on reclaimed lands. These monitoring activities have been conducted before and during mine development and establish pre ash-use baseline parameters from which post ash-use parameters can be compared. Surface coal mining regulations also require an operator to post a performance bond with the regulatory agency to ensure compliance with regulations and adherence to all plans in the operator's approved surface mining permit. Red Hills Mine currently is bonded for approximately $19,500,000, which can be adjusted to reflect additional or reduced operational liability over the life of the mine.

The basic proposal and approval criteria used by MLMC and MDEQ are that the use must be beneficial and serve to replace or conserve some other natural resource. Initially, the focus was conserving natural limestone, but many other conservation and non-conservation factors are being considered as experience with beneficial ash use advances. These factors include increased mine safety, higher productivity and efficiency, reduced diesel fuel use and emissions, and lower steel usage for repairs of damaged equipment components.

Methods of Application and Results Observed

Ash is delivered to the mine via an ash haul road constructed between the mine and power plant. This road allows the ash to be delivered directly to the mine, eliminating the need to operate trucks on public roads and highways as required by MLMC's initial proposal. Forty-ton haul trucks deliver hydrated ash to the desired mine location. Initially, MLMC attempted to incorporate or disc ash into existing roadway surfaces with little if any improvement being observed. However, MLMC discovered that placing a 4-foot base layer of 100% ash resulted in a competent and durable road with sufficient bearing capacity for all mining equipment, including machinery having the highest applied ground pressures (i.e. up to 115 psi). Ash is dumped and spread with a dozer, graded with a motor grader and compacted with a smooth steel drum vibratory roller compactor. Heavy equipment traffic is kept off of newly constructed road base for several days allowing the hydrated ash to set and cure. Interestingly, MLMC tried to lay ash in small 1 foot lifts and compact each lift individually to form a more compacted 4 foot platform but found that this only complicated the construction process and provided no performance benefit.

Ash has also been found to be superior to soils available on the mine site for culvert bedding and backfill material. Traditional culvert installations typically require laborers to work in a backhoe trench between the culvert and trench wall within the operating radius of a backhoe. Employees slowly level and mechanically pack layers of dirt deposited by the backhoe up the sides and over the top of the culvert. For large and long culvert installation this process can take several days. At Red Hills Mine, even the best installed culverts have been crushed or badly compressed over time. MLMC has found that a backhoe can be used to backfill and lightly tamp hydrated ash (using the heel of the bucket) into a culvert trench, let the ash set for several days and complete the installation with ash or clay. These ash installations are fast and require no employee exposure to potential safety hazards associated with traditional installation methods. Culverts installed in ash backfill have shown no signs of failure to date.

Ash has not yet been used to construct dragline walkways, as improving the haul road network has been a higher priority.

Since beneficial ash use was approved, MLMC has used 88,678 tons of ash to construct 2.9 miles of primary haul roads and 0.7 miles of pit ramps, install several culverts, and place an ash base over a large equipment parking area. Thousands of loads of lignite, overburden, and ash have been hauled over these roads, ramps, and culvert installations (Figures 4, 5 and 6). Wet or dry, the ash roads and culvert installations do not exhibit compression failures and remain firm and compacted. With MDEQ's approval, an additional 806,000 dry ash tons will be used to complete haul roads and pit ramps and to construct dragline walkways and equipment spoil trails.

To date, using RHGF ash to construct base layers for operation of heavy equipment has allowed MLMC to reduce by 52,000 tons the amount of mechanically mined and crushed limestone used – limestone that would have been hauled 170 miles (one-way) over Mississippi State Highways by 8000 diesel powered trucks to cover 64,000 square feet of engineering fabric at a cost of $1,090,000. Data collected on the ash, the leachate tests, column tests, and storm water runoff indicate that use of the RHGF ash as applied at Red Hills Mine is beneficial and does not pose adverse environmental impacts.

Modern large scale mining equipment is designed to operate at peak efficiency on running surfaces capable of consistently supporting the weight, speed, and payloads of the equipment. Poor running surfaces causes vehicle engines and drive trains to work harder resulting in higher fuel consumption and greater wear of all mechanical and structural components. MLMC uses approximately 4.8 million gallons of diesel fuel per year to uncover and deliver lignite to the power plant. Trucks hauling over soft and rutted roads and other diesel powered equipment needed to maintain these roads will consume an estimated 10% more fuel (400,000 gallons/year) than those running on hard roads that require little or no maintenance. At the current diesel fuel price of $1.38/gal, this translates into a savings of $662,400 per/year. Also, as roads improve, productivity improves, which allows trucks to run fewer hours to meet production requirements.

In addition to the natural resource conservation and cost benefits, the use of ash constructed roads has improved safety in several ways, especially during the rainy winter months. First, when wet, ash roads are not quite as slippery and are easier to maintain and dry faster than clay roads. Second, ash running surfaces reduce the amount of mud that must be graded or dozed to the sides so road width can remain constant eliminating equipment crowding. Third, ash base on roads requires less maintenance and reduces the time that road graders and haul trucks are both present on the same haul road. One negative is that during the dry and warmer summer months, ash roads have required more frequent water spraying to control dust than clay surface roads. Dust suppressants applied to roads may provide enhanced dust control during dry periods and further reduce slippery conditions during wetter periods.

Environmentally, erosion and sediment transfer from ash constructed roads is much less than that from clay constructed roads. The continual rutting and removal of clay mud during and following rain events and the re-spreading and drying of the same material during dry periods causes much more material to be transferred to road ditches and ultimately sediment control structures during heavy precipitation events. Ash roads and back slopes are competent and resistant to erosion. Rills and small gullies often observed in clay road back slopes are non-existent in ash road back slopes.

Figure 4. Loaded haul truck coming up pit ramp constructed of ash.

Figure 5. Haul truck fleet parking area constructed with ash.

Figure 6. Sixty-six inch culvert bedded in and backfilled with ash.

Summary

The use of RHGF ash as a replacement alternative to using natural limestone to construct various equipment platforms at Red Hill Mine has proven to be an economical and beneficial use of this coal combustion product. The use of ash as a mine road construction material also allows secondary roads and trails that could not economically be surfaced with limestone to be improved significantly. Secondary benefits in the form of increased productivity, lower operational costs, reduced diesel fuel consumption and emissions, and enhanced operator and equipment safety have resulted from the use of ash. The beneficial use of ash at the mine also aids the RHGF by reducing the amount of ash to be disposed of, reducing the land area needed for future disposal and the associated construction costs of future ash disposal facilities.

The properties of RHGF ash combined with appropriate handling and application methods allow this material to be used with little if any environmental risk. Monitoring programs and bonding requirements provide for the long-term assurance that the beneficial use of this product will be carefully evaluated as its use continues.

Acknowledgements

The authors acknowledge and thank the following individuals for providing some of the analytical data presented in this paper.

Jim Ward, Environmental Engineer, Tractabel Power Inc., provided AMU water analysis data.

Shawn Ivey, (AMU) Site Manager for Headwaters Resources Inc., provided some of the physical ash analysis data.

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