UTILIZATION OF WET FGD MATERIAL FOR AMD ABATEMENT IN UNDERGROUND COAL MINES[1]

by

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Abstract. Electric utility response to certain amendments of the Clean Air Act has resulted in the production of several types of alkaline coal combustion byproducts. Alkaline combustion byproducts are gaining increasing usage for acid mine drainage mitigation as research leads to a better understanding of their beneficial applications. Since January of 1997, Mettiki Coal Corporation has been injecting alkaline flue gas desulfurization material from Virginia Power's Mt. Storm Unit #3 wet limestone scrubber into abandoned portions of the active Mettiki mine. This paper provides an overview of the key design, transportation, regulatory, and environmental issues faced in the project.

Additional Key Words: Coal combustion byproducts, flue gas desulfurization, hydroclones, underground injection, NPDES.

Introduction

Electricity constitutes a crucial input in sustaining the Nation's economic growth and development. Coal combustion has historically accounted for the bulk of electrical energy production in the United States, accounting for over 56% of the total net generation of electricity in 1996 according to the Energy Information Administration (National Energy Information Center, 1997). One of the concerns of fossil-fueled combustion is the emission of sulfur dioxide (SO_2) during the combustion process. Title IV of the Clean Air Act Amendments of 1990 was enacted to reduce the emissions of SO_2 in two phases. Phase I, running from 1995 through 1999, affects approximately 435 generating units while Phase II, which is more stringent than Phase I, begins in the year 2000 and affects more than 2000 generating units. Though fuel switching has become the Phase I compliance method chosen by most utilities to meet these reduction requirements, flue gas scrubber systems have been installed on 27 units at sixteen utilities and have accounted for 28 percent of the 1995 SO_2 emission reductions, the second largest share after fuel switching (Energy Information Administration, March, 1997).

All scrubbing units utilize a chemical reaction with a sorbant to remove SO_2 from combustion gases and are classified as either "wet" or dry". In the most widely used wet scrubber systems, combustion gases are contacted with a sorbent liquid which results in the formation of a wet solid byproduct. Most scrubber systems utilize an alkaline limestone sorbent, resulting in an alkaline calcium sulfite and / or calcium sulfate sludge byproduct. Approximately 20 million tons of these flue gas desulfurization (FGD) byproducts are being produced per year in the United States (U.S. DOE, 1994). As increased cost of disposal and heightened regulations make disposal less desirable, alternatives to disposal are being investigated. Alkaline FGD byproducts are finding increased uses in environmental applications as extensive research provides a more comprehensive understanding of their benefits and behavior.

In November of 1994, Mettiki Coal Corporation (MCC) made application to the State of Maryland Department of the Environment (MDE) for a permit modification to inject FGD material into abandoned sections of its underground mining operation in southwestern Garrett County. Material available for injection was available from Virginia Power's Mt. Storm Power Station Unit #3 wet scrubber located approximately 17 miles away in Mt. Storm, West Virginia.

Mt. Storm Unit #3 Scrubber

The Mt. Storm Unit #3 forced oxidation wet limestone scrubber is a General Electric Environmental Systems unit placed in operation in October, 1994. The

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SO_2 laden flue gas from Unit #3 enters an absorber vessel down stream of the precipitators and flows up through a spray of limestone ($CaCO_3$) slurry. The SO_2 is contacted by the spray and falls into a reaction tank below. The initial collection of SO_2 is primarily with water, but once the slurry falls into the reaction tank, the SO_2 reacts with excess calcium to produce calcium sulfite. Additional oxygen is provided to the reaction tank by oxidation air blowers resulting in a conversion of calcium sulfite to calcium sulfate (gypsum) (Figure 1). The reaction tank provides suction for the recycle slurry pumps, which continually pump slurry to the spray headers in the absorber vessel. For Mt. Storm Unit 3, approximately 100 gallons of slurry is sprayed into the absorber vessel for every 1000 ACFM of flue gas. As the larger gypsum particles settle in the reaction tank , they are pumped by the absorber bleed pumps to the waste dewatering system which consists of a bank of hydroclones and a drum vacuum filter. The hydroclones separate the gypsum slurry into two streams. The overflow stream, containing less than 5% solids, flows into a filtrate tank for recirculation back into the scrubber. The underflow stream, containing approximately 50% solids, is fed to the drum vacuum filters. The vacuum filters further concentrate the solids to approximately 80% solids with the resultant water also being recycled back into the scrubber. The byproduct solids are then temporally stored in an enclosed building sized to hold a 3 day supply of product where it is loaded into trucks for transportation to Mettiki for injection. Production averages approximately 400 tons per day.

Figure 1

$$SO_2 + CaCO_3 + 1/2H_2O \rightarrow CaSO_3 \bullet 1/2H_2O + CO_2$$

$$SO_2 + 1/2O_2 + CaCO_3 + 2H_2O \rightarrow CaSO_4 \bullet 2H_2O + CO_2$$

Regulatory Issues

In 1993, the Environmental Protection Agency (EPA) issued its final regulatory determination on FGD residues. They were deemed to be non-hazardous and therefore, regulated under Subtitle D of the Resource Conservation and Recovery Act (RCRA). This determination gave individual States regulatory authority which can vary widely from state to state.

Based on available data, it is felt that FGD addition will assist MCC in maintaining an alkaline environment in its underground mine pool at closure and aid in preventing acid generation. Since 1987, MCC has been injecting alkaline metal hydroxide sludge from its 10 million gallon per day mine drainage treatment facility along with thickener underflow from its coal preparation plant under an Underground Injection Control (UIC) permit. Though permitted under the UIC program, compliance monitoring and environmental impact assessment is handled through a National Pollution Discharge Elimination Systems (NPDES) permit.

Being the only permittee in the state to request the ability to inject FGD material - coupled with the fact that the material is not available in the State of Maryland added a level of complexity to permitting. Part of the problem faced by MCC was that coal combustion byproducts are not covered by any one regulatory unit in the state of Maryland.

In January of 1995, MDE requested a meeting of section heads from Solid Waste Management, Hazardous Waste, Underground Injection Control, and Mettiki to discuss which department would regulate the injection and maintain oversight.

Alkaline coal combustion byproducts are not considered hazardous in Maryland. FDG has its own line item exclusion ((Code of Maryland Regulations 26.13.02.04-1.A(4)) and does not fail any of the required RCRA tests used to determine if it is hazardous (Table 1). This excluded the material from MDE Hazardous Waste oversight.

Table 1. - Chemical Analysis - Mt. Storm FGD (mg/L)

TCLP DATA[1]

Arsenic	< 0.10	Calcium	186,000
Selenium	< 0.20	Magnesium	685
Barium	0.15	Iron	273
Cadmium	< 0.01	Aluminum	229
Chromium	< 0.03	Potassium	< 500
Lead	< 0.10	Sodium	< 50
Silver	< 0.02	Zinc	< 10
Mercury	< 0.002	Chloride	6000
		Moisture	39.7 %
		pH	7.88

1. Averaged analytical data. Tests performed with standard TCLP extraction fluid, raw mine water, and dilute sulfuric acid.

The fact the material would not be landfilled excluded it from Solid Waste oversight.

Since the material was chemically and physically similar to MCC's current injection materials, it was decided within MDE that oversight would be handled under MCCs' Underground Injection Permit. A modification of the existing NPDES permit was required to address what MDE felt was a potential for dissolution of the material in the underground mine pool. Of particular concern to MDE were chloride levels. Accordingly, discharge limits based upon US Fish and Wildlife Service recommendations were set at 230 mg/L quarterly average and 850 mg/L quarterly maximum. Given MCC's cooperative trout rearing facility location and potential impacts to trout production, MCC agreed to the limitations. Table 2 shows pre and post injection raw mine water analysis indicating negligible impacts to date. Figure 2 shows chloride levels in the mine pool in relation to injected tons of FGD.

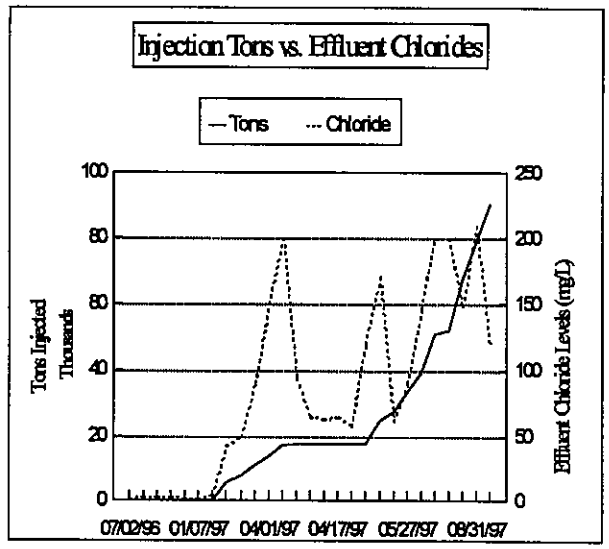
Table 2. - Raw Mine Water Analysis (mg/L)

	06/13/96	10/25/97	04/15/97	07/11/97
Chloride	3	3.3	69.4	146
Sulfate	830	1090	1240	1300
Bicarb.	37			
Aluminum	0.4	1.06	0.194	1.32
Antimony	<.050	<.050	<.050	<.050
Calcium	224	267	421	541
Iron	37.8	61.1	24.8	34.4
Magnesium	49.5	65.6	66.1	
Manganese	2.72	3.87	4.28	4.8
Potassium	7.43	11	10	10.2
Sodium	77.2	86.4	75.3	79.2
Arsenic	<.25	<.25	<.25	<.25
Selenium	<.05	<.05	<.05	<.05
Boron	0.065	0.073	0.47	0.937
Thallium	<1.3	<1.3	<1.3	<1.3
Barium	<.025	0.035	0.033	0.033
Beryllium	<.025	<.025	<.025	<.025
Cadmium	<.025	<.025	<.025	<.025
Chromium	<.075	<.075	<.075	<.075
Cobalt	0.1	0.146	0.133	0.137
Copper	<.063	0.0431	<.063	0.0095
Lead	<.25	<.25	<.25	<.25
Molybdenum	<.13	<.13	<.13	<.13
Nickel	0.139	0.206	0.183	0.195
Silver	<.050	<.050	<.050	<.050
Titanium	<.050	<.050	<.050	<.050
Zinc		0.273	0.201	0.266

The permitting process was fairly straight forward once the information, test results, and applications were submitted to MDE. MDE issued tentative determination in late January, 1996 and scheduled a public hearing for March . At the hearing, sixteen citizens appeared to voice concerns that injection of CCB's would CAUSE subsidence and any heavy metals in the material would automatically leach out and contaminate drinking water supplies, both surface and groundwater.

The meeting lasted approximately two hours and no amount of technical information or explanation seemed to allay the public perception of the material. Final permit issuance occurred in May 1996, approximately 19 months after initial application.

Figure 2. - Raw Mine Water Chloride Levels

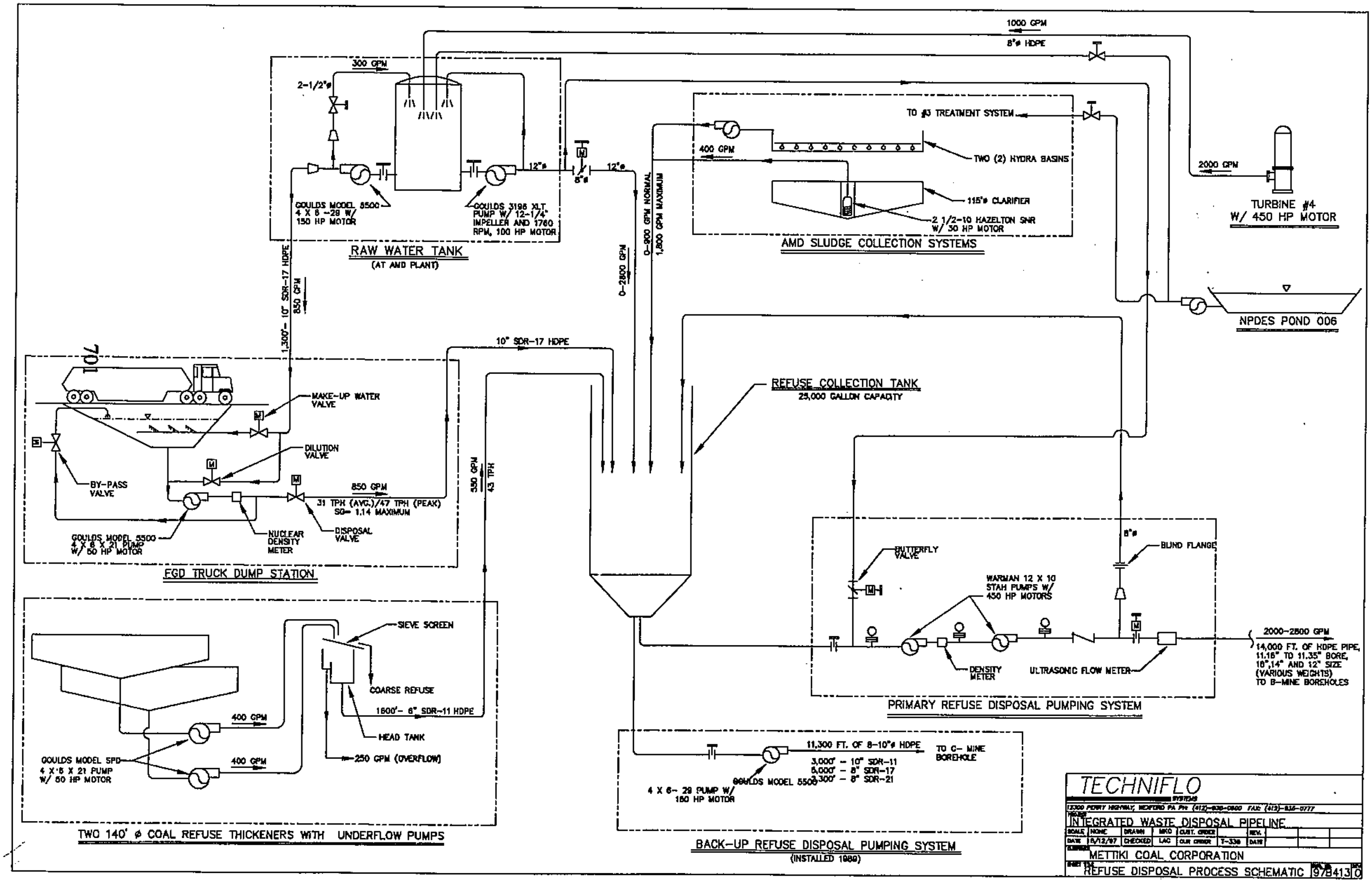


Underground Injection

To handle the additional injection material, MCC modified an injection system upgrade occurring at the time designed to carry MCC through the life of the mine reserves. To accommodate the delivery of the material to the site, MCC constructed an unloading facility with slurry water conveyed from existing deep well turbine pumps at the AMD plant. Figure 3 illustrates the process flows for the existing system.

Once slurried at approximately 15% percent solids content - controlled by a nuclear densometer and Allen Bradley SLC 503 programmable logic controller - the material is pumped in the existing thickener underflow lines to a disposal surge tank at the AMD plant. Tank level controls cycle two Warmen 10 x 12 discharge pumps arranged in series. Line velocities and the potential to sand out the line over the 14,000 foot distance to our B mine injection point required the

Figure 3 – Process Flow Diagram



high pressure, high volume pumps. Design capacity is 2500 gallons per minute at 200 psi at the pumps. Vertical elevation difference between the pumps and the highest point in the disposal line is 250 feet with approximately 150 feet of elevation to work with in the mine voids. Ultimate placement is 600 to 750 feet below surface elevations. Storage capacity within B mine at current peak solid injection rates is 13 years.

Mine Pool Impacts

Water which pools underground is either stage pumped through the mine in MCCs' active works or flows by gravity in the inactive portions (including the decant solution from the injection) to an underground sump and is then conveyed to the surface via a combination of one 400 hp Layne, one 400 hp Goulds, or two Peabody Floway 800 hp deep well turbine pumps and treated at the AMD plant. Under normal conditions, flow rates of from 2000 to 10,000 gal/min. are maintained depending upon what pump or combination of pumps are placed in operation. Treatment options consists of two identical modified High Density Sludge treatment systems, each capable of treating 4,000 gal/min. and one Techniflo in line aeration system presently capable of treating 4000 gal/min.

Raw mine water enters the ferric tank initially and is mixed with a hydrated lime slurry. The slurry is made from clear water taken from the settling basins or can be mixed from the raw mine water. Lime addition is controlled by Great Lakes pH probes located at the effluent end of the ferric tanks. The neutralized water reports to the aeration tank through 12 inch PVC pipe and is aerated using 10 hp splash aerators in the HDS system. The aerated water then discharges through a sluice-way where Baker polymer is added prior to entering the 36 ft. x 280 ft. x 14 ft. clarification basins for precipitation of the hydroxide sludge.

The in-line aeration system differs from the above in the oxidization step. Oxidization is accomplished by an air inductor that entrains air by a venturi device which is powered solely by the pressure of the raw water pump. Post aeration treatment involves anionic polymer addition to aid flocculation of the metal hydroxides and clarification in a concrete 115 ft. by 14 ft. circular classifier.

Metallic hydroxide accumulation in the bottom of the rectangular clarifiers is raked and suctioned to the combined sludge disposal tank via two Hazelton sludge pumps or by a centerwell pump in the circular clarifier. Final sludge disposal into old underground workings is accomplished by two Warmen 10 x 12, 400 hp disposal pumps mentioned above.

Transportation Issues

To make the project possible and to economically deliver the FGD material to the site, transportation had to be included as part of a haul back arrangement in a coal supply contract. To move coal to the Mt. Storm power plant and FGD material back, only two options were available - Rail or Truck. For economic reasons, trucking the materials was chosen but that choice presented its own unique problems. The two largest were infrastructure upgrades at the mine to convert from primarily rail shipments and route selection for the trucks.

Working with Savage Industries of Salt Lake City, Utah, who was chosen as our materials handler, a twin hopper aluminum trailer was selected to convey the materials, allowing for maximum payload potential.

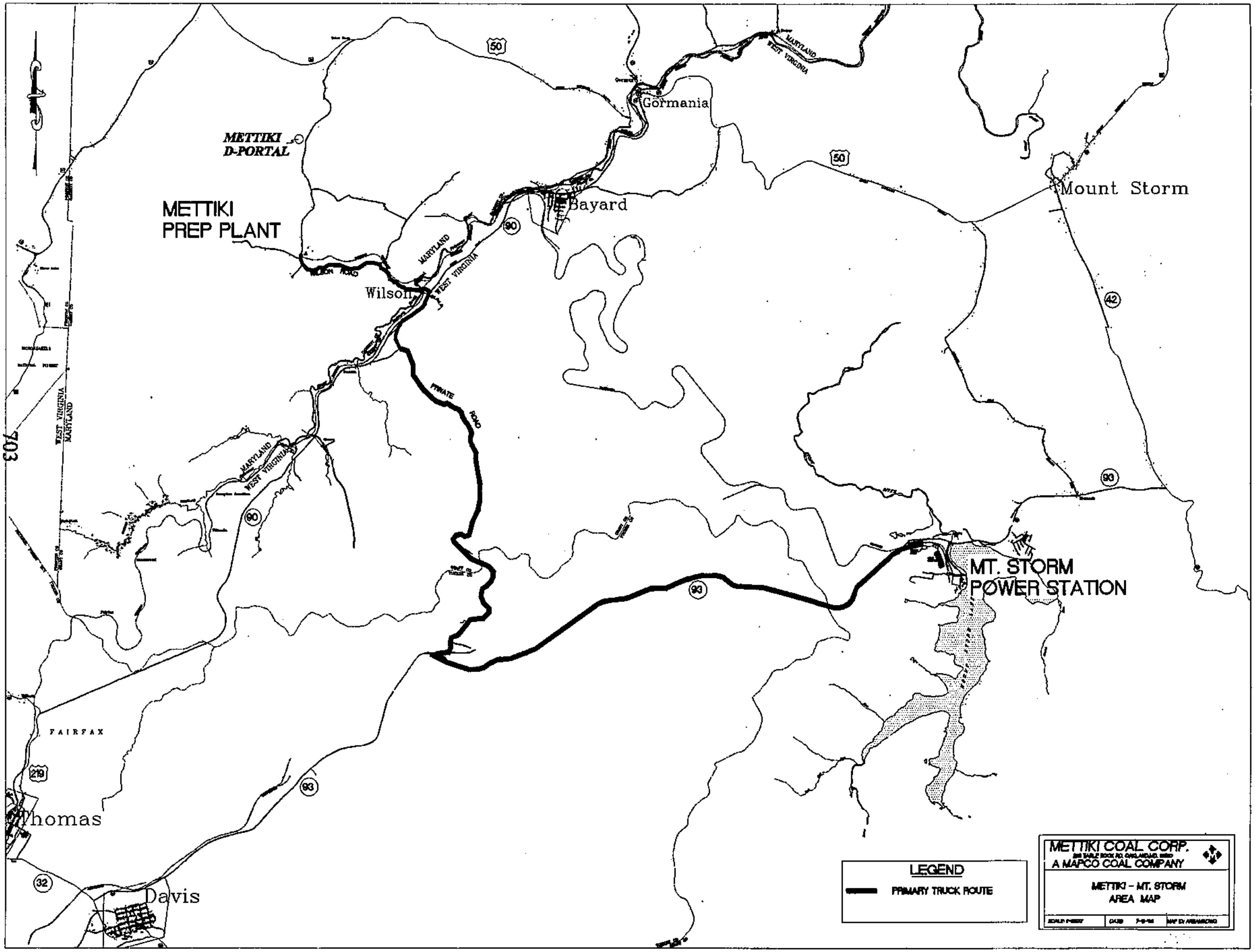
To accommodate this new mode of transportation, route selection became an issue both publicly and economically. Three options were available: 1). West Virginia Route 90 to 93 through the town of Thomas, West Virginia, 2). US Route 50 to West Virginia Route 42 to West Virginia Route 93 and 3). upgrade approximately 6.5 miles of a private haul road - which connects West Virginia Route 90 and 93 - to highway standards . Option 3 was chosen because it shortened the route somewhat but more importantly, it isolated the trucks as much as possible from public roads and local communities. Available options are shown in Figure 4.

Conclusion

This project, though complex in implementation, is intended to quantify the benefits of CCB utilization and affords a unique opportunity to provide real-life data on CCB interactions with acid producing mine waters. The fact that there are no exits to the environment other than the deep well pumps and through MCCs' treatment facility offers a controlled environment to observe those interactions and potential benefits.

Public concern regarding management of coal combustion byproducts is founded in a belief that small quantity toxic constituents contained within the

Figure 4 – Route Alternatives



material could potentially damage human health and the environment. Public opposition can create major obstacles to beneficially using coal combustion byproducts for acid mine drainage mitigation and should not be underestimated. Though potentially toxic elements may be present in some materials and, at certain concentrations, these elements may have toxic effects, with approximately 100,000 tons of FGD material injected thus far, raw water metals chemistry has remained similar to pre-injection conditions. Continued monitoring to determine if FGD injection produces expected long-term improvements in water quality is planned.

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