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Project Summary

An Evaluation of the Disposal of Flue Gas Desulfurization Wastes in Coal Mines and the Ocean: Mine Disposal Demonstration Tests

Chakra J. Santhanam, James R. Valentine, and
Armand A. Balasco

This report gives results of an assessment of a full-scale flue gas desulfurization (FGD) waste disposal operation at the Baukol-Noonan Mine near Center, ND. FGD wastes from the alkaline fly ash scrubbing system are disposed of in the mine area in V-notches and in the pit bottoms. A program of evaluating this disposal operation consisted of placement of monitoring wells, physical and chemical sampling and analysis of groundwater and wastes, and environmental and engineering cost assessment.

The primary environmental effect potential of FGD waste disposal in mining may be in the generation of leachates showing increased concentrations of sulfate, sodium, magnesium, and (to a lesser extent) calcium. However, such FGD waste disposal when properly practiced reduces potential effects of fly-ash-related leachate generation. Placement of the FGD wastes in V-notches appears preferable to pit bottom disposal.

The capital cost for mine disposal of FGD wastes (including thickening and filtration prior to disposal) from a 438 MW (net) lignite-fired boiler is estimated at about $10.85 million: the annual operating cost is estimated at about $10.70 per ton.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Program Purpose and Scope

This is a report on part of Phase III of a project under EPA's Waste and Water Program. The project consisted of investigations of the feasibility of the disposal of flue gas desulfurization (FGD) waste in mines and at sea. In this program, the FGD wastes studied were those from non-recovery FGD systems and mixtures of FGD wastes and coal ash.

Two earlier reports describe project Phases I and II:

- Report EPA-600/7-77-051 gives results of a preliminary assessment of the environmental, technical, regulatory, and economic aspects of projected mine and at-sea disposal operations.
- Report EPA-600/7-84-005 gives a refinement of the preliminary assessment based on additional evaluation of selected impact issues identified in the initial effort as requiring further study.

The objectives of project Phase III, described in this report, included monitoring a full-scale FGD waste disposal operation at the Baukol-Noonan mine near Center, ND. The purpose was to evaluate the environmental effects of full-scale

FGD waste disposal in mines and develop capital and operating costs of such disposal operations.

This is the third (and final report) on mine disposal and assesses the field demonstration of a mine disposal operation. The mine supplies coal to and receives waste from the Milton R. Young Station, operated by the Minnkota Power Cooperative.

Demonstration Project Description

The field studies were carried out at the Center Mine, operated by Baukol-Noonan, using FGD wastes from the Milton R. Young Station, operated by the Minnkota Power Cooperative near Center, ND. There are two boilers, Units 1 and 2, at this power plant; the latter, a 438-MW (net) cyclone-fired boiler, has an FGD system that uses alkaline fly ash from both boilers as the principal source of alkali for removal of sulfur oxides (SO_x).

The FGD waste (as wet filter cake) was transported to the mine area in rear-dump trucks. To faciliate removal during cold weather, boiler slag (3-4 tons) was loaded into each truck to serve as a liner for the 24-28 tons of FGD waste that was subsequently added to the truck's load. The FGD waste was placed in V-notches (Vees) and pit bottoms.

The above waste disposal scheme began in 1977, but was constantly plagued with problems. Consequently, it was decided to retire the thickener and vacuum filter, and direct the scrubber effluent directly to settling ponds for dewatering. This interim pond/mine disposal scheme has been in operation since November 1981.

The environmental assessment part of this project focussed on the original operation. However, capital and operating costs were estimated for both the orginal and current process schemes.

The approach for environmental and engineering/cost assessment involved a series of sequential data gathering and assessment steps designed to provide both a data base and general guidance in its assessment.

- Geological and geohydrological data on the site and environs were gathered during site development, which included placement of water wells and piezometers.
- Data on the composition and characteristics of waters, wastes, and geologic strata were obtained during sampling and analysis.
- Using site data, data from the laboratory tests, and existing background information on FGD wastes and disposal effects, cause/effect relationships are developed and tested to fit the measured site data.
- The cause/effect hypotheses are used to develop projects of the generic implications of effects observed at the test site to similar FGD waste disposal scenarios.

Figure 1 shows the disposal-area location of groundwater and leachate wells installed after sludge disposal in the bottom of the strip pit and in Vees formed during removal of overburden (mining spoil banks) from the strip pit.

Environmental Assessment

Table 1 provides an overview of some of the data to illustrate the discussion of environmental effects. Overall, it appears

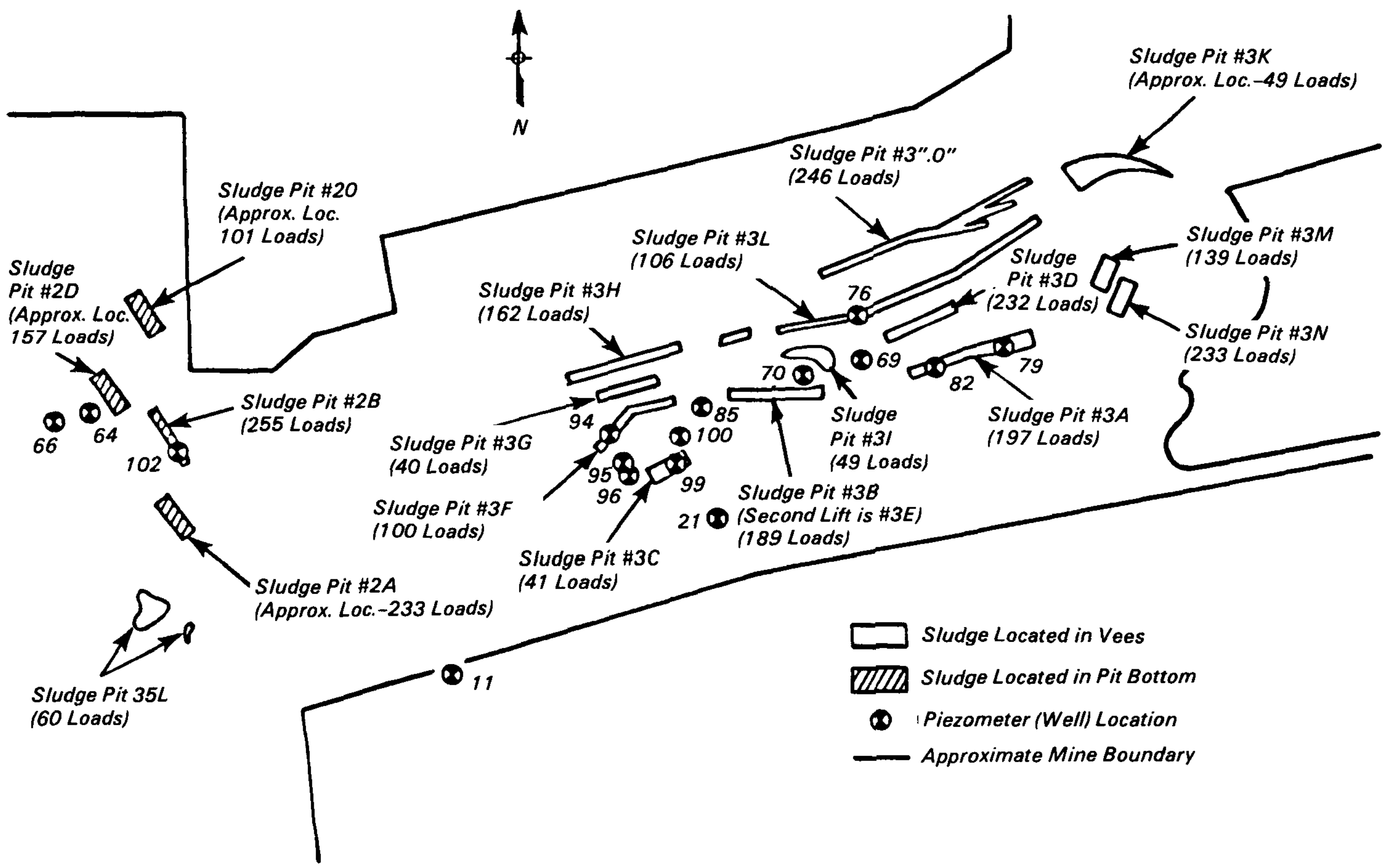

Figure 1. Location of groundwater and leachate wells installed after sludge disposal in Vees and dry pits.

Table 1. Parameters of Interest for Wells Showing Evidence of FGD-Related Leachate

Well No.	Waste Well Locations	Date Sampled	Sulfate	Sodium	Magnesium	Calcium	Waste Disposal	Over-burden Return
		Chemical Analysis Data					Approximate Dates	
			Analyte Concentrations (mg/L)					
99	Vee 3C/ below waste	3/27/80	4111	960	530	215.5	10/78	5/79
		6/09/80	3811	1050	408	393		
		9/09/80	3500	776	457	331		
94	Vee 3F/ offset from waste	3/27/80	4917	900	615	195.3	11/78	5/79
		6/09/80	3572	493	262	307		
		9/09/80	4980	730	596	404		
79	Vee 3A/ below waste	6/09/80	1922	331	358	215	9/78	4/79
		9/09/80	2891	567	421	416		
102	Pit bottom 2B/below and offset from waste	3/27/80	1465	823	49.5	65.8	6/78	4/79
		6/09/80	4343	1845	105	186		
		9/09/80	5108	2200	151	560		
Data for Related Groundwater Wells-								
76	Vee 3L/ below waste?	6/09/80	222	322	34	65	3/79	5/79
		9/09/80	148	377	30	58		
Average of "spoils wells"		1978-79	1455	361	232	348		
Average of "below Hagel" wells		1978-79	1217	568	80.4	153		
Average of "Hagel Bed" wells		1978-79	668	297	74.3	105		

that placement of FGD wastes from alkaline-fly-ash FGD systems will result in generation of liquors and leachates which show increased concentrations of sulfate, sodium, magnesium, and (to some extent) calcium when compared with the original coal bed. Of these, the sulfate (and, consequently, total dissolved solids—TDS) will be substantially above drinking water limits (250 and 10,000 mg/L, respectively). At the same time, the results indicate that, for FGD wastes, trace elements in leachates are likely to be within the allowable range for drinking water.

The concentration of sulfate and magnesium found in the groundwater well samples are substantially lower than the compositions of undiluted FGD waste porewater. Sodium concentrations are also lower than porewater except in the pit bottom location where higher sodium and correspondingly lower magnesium concentrations may be the result of ion exchange. Calcium appears to be under solubility control by sulfate. These data suggest two possible scenarios related to FGD waste leaching: either the groundwater (even near the waste) is a mixture of waste leachate and other infiltrating groundwater which bypassed or "channeled" through the waste; or the contact of infiltrating groundwater does not provide as efficient an extraction of solubles as predicted by the laboratory leaching column tests. While the cause cannot be ascertained, for Vee disposal, the net effect is the same: such disposal may not result in the appearance of a "plug" of full-strength FGD-waste porewater in the groundwater. Data for pit bottom placement suggest that the leachate concentration (i.e. the fraction of leachate) is higher than for the Vees.

Data indicate that the major impact on groundwater from FGD wastes generated at the Milton R. Young plant stems from the high concentrations of sulfate, and those portions of other major species which contribute to the dissolved solids. These TDS contributors are present in the wastes as soluble species readily available for leaching.

A University of North Dakota study (outside the scope of this study) also focussed on characterization and assessment of the environmental effects relating to the disposal of alkaline fly ash itself. This phase of the investigation indicates that, in the absence of a working FGD system, the alkaline ash was disposed of in a mine in the same manner as the FGD wastes. In contrast to FGD wastes, alkaline fly ash appears to have a rather significant potential to impact the environment, particularly in trace metal mobility. Although the primary purpose of fly-ash FGD systems is to reduce atmospheric SO_2 contamination, the results indicate that a potential secondary benefit of this method of FGD is the conversion of fly ash from a form that can cause groundwater to acquire severe toxicity because of high arsenic and selenium levels to a form that causes increased sulfate concentrations but generally no significant increases in the more toxic elements. Placement of these wastes in Vees appears to be highly preferable to bottoms in most areas. Vees are commonly above the postmining watertable, and thus offer much less opportunity for the dissolution and leaching of soluble salts present in these waste products.

Engineering/Cost Assessment

The original and current waste disposal schemes are shown in Figures 2 and 3, respectively. The original waste handling/processing/disposal system, in operation about 4 years at the Milton R. Young plant, consisted of thickening and vacuum filtering the fly ash/FGD scrubber effluents from about 15 to about 65 wt% solids. From the vacuum filter, the 65 wt% fly ash/FGD waste was directed by belt conveyor to one of two surge bins. The surge bins acted as temporary storage for the waste until it was loaded onto 35-ton coal haul trucks. These trucks transported the waste to Baukol-Noonan's Center Mine, about 5 miles

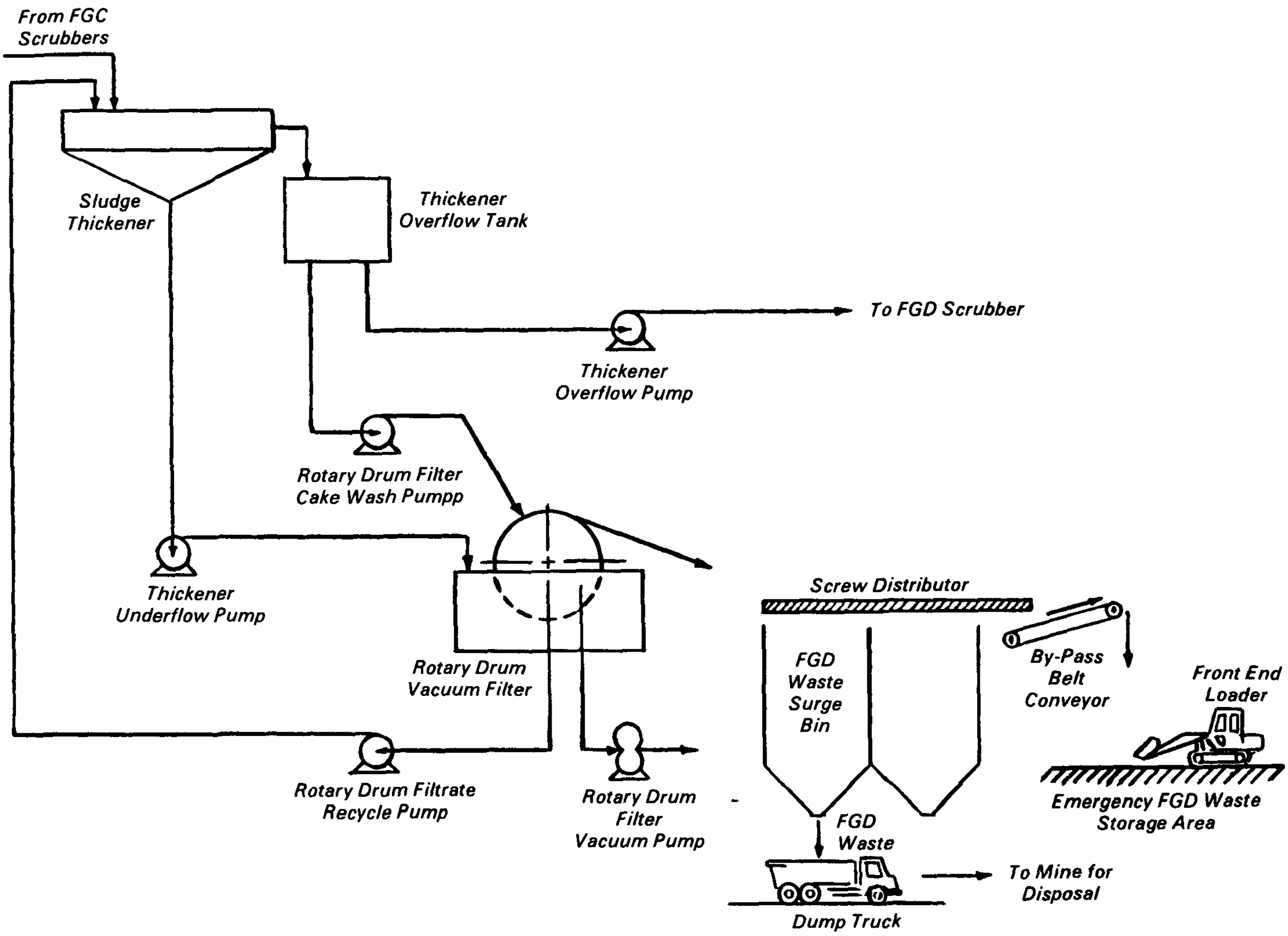

Figure 2. *Original Milton R. Young FGD waste processing/interim storage/transport (1977-78).*

from the plant. At the mine, the waste was deposited as a relatively dry soil-like material in either: (a) pit bottoms prior to the return of overburden; or (b) spoil banks (Vees) before rough contouring.

The current scheme, shown in Figure 3, eliminates thickening and filtration. Instead, the scrubber effluent is ponded directly. Table 2 summarizes capital costs. Tables 3 and 4 provide the basis for, and summarize, annual operating costs for both original and current schemes.

Mine disposal appears to be among the lowest cost methods of FGD waste disposal. In generic terms, mine disposal may be 20-25% less expensive than disposal in managed fill due to lower land and mobile equipment costs; additionally, reclamation is a normal part of mine operation with or without waste disposal and hence not charged to disposal operation (since it is required in any case).

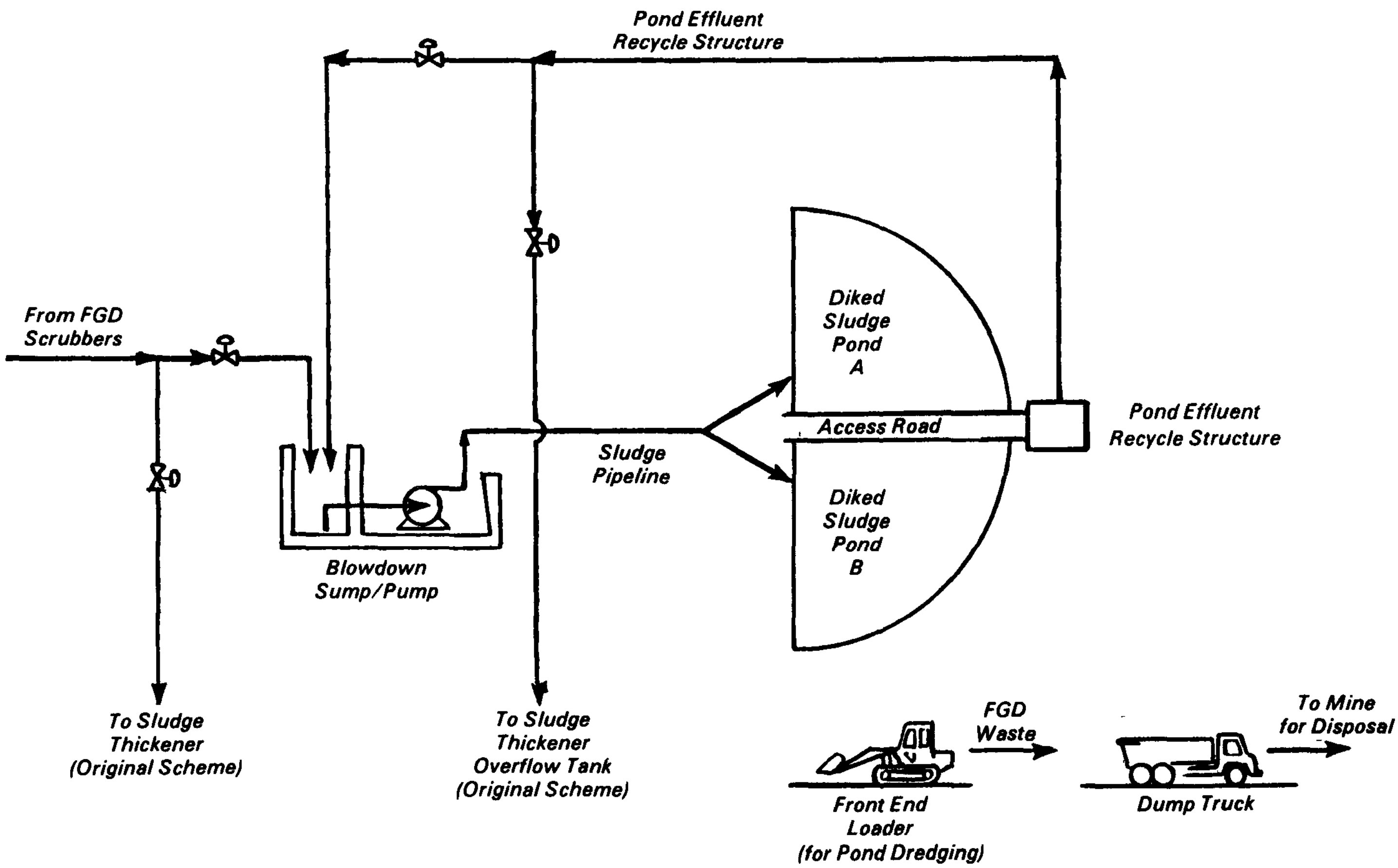

Figure 3. *Current Milton R. Young FGD waste handling/interim storage/transport (1980-81).*

Table 2. *Capital Costs — FGD Waste Disposal*

Basis: 1. Operation of Baukol-Noonan Mine disposal.
2. All costs in 1981 dollars.
3. Unit 2 (438 MW net, cyclone-fired) uses North Dakota lignite and has aklaline-fly-ash-based FGD system.

No.	Detail	Original Scheme	Capital Cost $1000	Current Scheme	Capital Cost $1000
1.	Handling, processing, and storage	Thickeners with auxiliaries Rotary vacuum filter with auxiliaries Surge bin By-pass con-verger	10,000	Blowdown pump and auxiliaries Sewage Pond Pipeline and access road Effluent recycle lime Dredging equipment	4,500
2.	Transportation, placement, and disposal	Truck, loader Dozers and graders	850		850
3.	Total cost		10,850		5,350

Table 3. Waste Disposal Engineering Operating Basis Milton R. Young (Unit 2)		
Boiler		
Capacity, MW	476	
Annual load factor, %	90	
Heat rate, Btu/kWh	10,000	
Fly ash/bottom ash ratio	35/65	
Coal		
Heating value, Btu/lb	6,422	
Sulfur content, %	0.64	
Ash content, %	9.74	
Emission Control		
SO_2 removal, %	60	
Particulate removal, %	99+	
Wastes Generated		
Fly ash[a], tons/yr	157,300	
FGD sludge, tons/yr	58,475	
Total FGD waste, tons/yr	217,775	(dry basis)
Total FGD waste, tons/yr	332,000	(wet basis)

[a]Includes fly ash from Units 1 and 2, since fly ash from Unit 1 is used in alkaline fly ash scrubbing operation. Capacity of Unit 1 is 265 MW.

Table 4. Annual Operating Cost Summary[a]

	($1000s/year)	
	Original Scheme[b]	Current Scheme[c]
Direct Costs		
• Operating/supervisory labor	$417.2	$496.8
• Maintenance (labor and materials)	354.0	214.0
• Utilities		
- Water (@ $0.01/1000 gal.)	0.3	0.3
- Electricity (@ $0.03/kWh)	156.0	54.0
- Diesel fuel (@ $0.95/gal.)	255.7	332.4
Indirect Costs		
• Plant overhead (@ 50% direct costs minus electricity)	513.6	521.3
• Administrative overhead (@ 16.5% of total capital cost)	59.4	60.3
• Capital charges (@ 16.5% of total capital cost)	1798.5	891.0
Total Annual Operating Cost		
• ($1000s/year)	$3554.7	$2570.1
• ($/ton)	$ 10.70	$ 7.75

[a]In 1981 Dollars.
[b]Thickening/Vacuum Filtration/Mine Disposal—Milton R. Young (Unit 2)
[c]Interim Ponding/Mine Disposal—Milton R. Young (Unit 2)

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C. J. Santhanam, J. R. Valentine, and A. A. Balasco are with Arthur D. Little, Inc., Cambridge, MA 02140.
***Julian W. Jones** is the EPA Project Officer (see below).*
The complete report, entitled "An Evaluation of the Disposal of Flue Gas Desulfurization Wastes in Coal Mines and the Ocean: Mine Disposal Demonstration Tests," (Order No. PB 85-137 081; Cost: $26.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
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The EPA Project Officer can be contacted at:
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