SDMS # 56213

AR0184

TECHNICAL MEMORANDUM

SFUND RECORDS CTR
1652-02238

PREPARED FOR: Rick Sugarek/ EPA

PREPARED BY: Jim Mavis/ CH2M HILL

DATE: April 15, 1994

SUBJECT: Alternative AMD By-Product Recovery Process
Iron Mountain Mine

PROJECT: SWE69205.04.02

Background and Objectives

Stauffer Management Company (SMC) has recently presented alternatives to recover by-products from acid mine drainage (AMD) at Iron Mountain Mine. These alternatives have been shown to be more expensive than the cost to simply treat the AMD with lime in a high density sludge plant (see CH2M HILL memorandum to EPA "Review of SMC By-Product Recovery Proposal"). A potential alternative to SMCs by-product recovery processes has been identified. This alternatives uses sludge from the high density sludge treatment process.

The by-product recovery process outlined below was prepared in response to SMC's proposed recovery alternatives. SMC's proposed alternatives were both speculative and more costly than simple neutralization. The process outlined below was developed to overcome the high cost of SMC's alternatives, and to use the waste sludge from the planned high density sludge plant as a starting material for by-product recovery.

It should be noted that the following discussion is not a proposal to develop the described process; it is simply presented as an example of the direction that parties that are interested in by-product recovery might investigate in lieu of more expensive alternatives that are currently being discussed.

Process Description

The proposed sludge-based by-product recovery process (see Figure 1) includes copper cementation, similar to the SMC proposals, but places this step ahead of the high density sludge process. The high density sludge process, as it is now conceived, follows cementation, and produces a treated effluent of higher quality than is anticipated under SMC's proposed alternatives. Dense sludge is dried and calcined to decompose gypsum into sulfur dioxide and lime, both of which are recovered. The sulfur dioxide is converted into commercial-grade sulfuric acid for resale. The crude lime is radioactively roasted to fume off zinc and cadmium, which are collected in the form of the oxides. Iron is converted to magnetite, the magnetic form of iron oxide. The iron is magnetically separated and milled for resale, and the purified lime is recycled to the high density sludge plant. Impurities and grit are removed during slaking, and losses are made up with purchased lime from commercial sources.

The methods used in the preceding by-product alternative rely on conventional processes or adaptations of commercially available equipment for infrequently used chemical reactions. No reliance has been placed on the development of special reagents, as is the case with SMC's schemes.

Cost Analysis

Operation and maintenance (O&M) costs and recovered by-product values are shown in Table 1. The value of recovered copper, $196 per day, is the same as was presented in a recent memorandum describing corrected O&M costs and by-product values for SMC's by-product schemes.

There is a high net cost to recover lime (<$1,888> per day), mainly because of the higher energy cost to calcine gypsum than to calcine limestone, the normal feedstock for making lime.

The dense sludge-based by-product recovery process yields a greater value for sulfuric acid ($1,039 per day) than SMC's process ($428 per day) because more of the sulfate in the effluent is precipitated and is recovered from gypsum than is recovered by SMC's proposed process using solvent extraction. (A higher quality treated effluent is also produced because the high density sludge process removes more sulfate than would SMC's proposed scheme.)

The value of fumed zinc is low, amounting to only $14 per day; however, this is more favorable than the net loss of <$831> per day that would occur with SMC's proposed scheme. Iron oxide has a published value that might yield a net return of at least $2,165 per day (the value could exceed $16,000 per day if higher quality pigment-grade iron oxide were produced).

The small purge stream for removing impurities (grit separated during slaking), and the reduced road maintenance cost because of reduced sludge hauling would reduce the net cost to treat AMD to <$4,388> per day, before adding credits for recovered by-products. When by-product recovery is taken into account, the net daily cost to treat AMD is <$2,862> per day (<$1.04 million> per year), which is far lower than for any of SMC's options, and half the cost to simply treat AMD in a high density plant (see Table 8, attached, from the memorandum: "Review–SMC's By-Product Recovery Proposal").

To be consistent with SMC's evaluation of their by-product recovery alternatives, no capital cost estimates have been prepared and the abbreviated operation and maintenance cost estimating methods they had used were followed to keep comparisons among alternatives on a common basis.

Summary

The cost basis for the preceding analysis is the revised basis used to evaluate SMC's proposed by-product recovery schemes. The costs for the current by-product recovery scheme are more favorable than those for other schemes previously proposed by SMC. Capital costs were not estimated in order to be consistent with SMC's estimating methods and to facilitate comparisons among alternatives.

The quality of treated effluent from the current sludge-based process would be superior to the quality of effluent from SMC's recovery schemes because the sulfate concentration would be lower, and iron and aluminum would be removed.

The sludge-based by-product recovery process described above supports proceeding with design and construction of a high density sludge plant and allows SMC to pursue by-product recovery independently of this effort. Consequently, no further delays in the design and construction of the high density sludge plant would be necessary.

The governmental agencies involved in controlling AMD from Iron Mountain are not positioned to engage in commercial ventures involving by-product recovery. Such an enterprise should be undertaken by SMC, if by-product recovery remains a priority.

EPA should proceed with the installation of a high density sludge plant, and SMC should independently develop processes to recover by-products from the sludge if this approach looks attractive upon further evaluation.

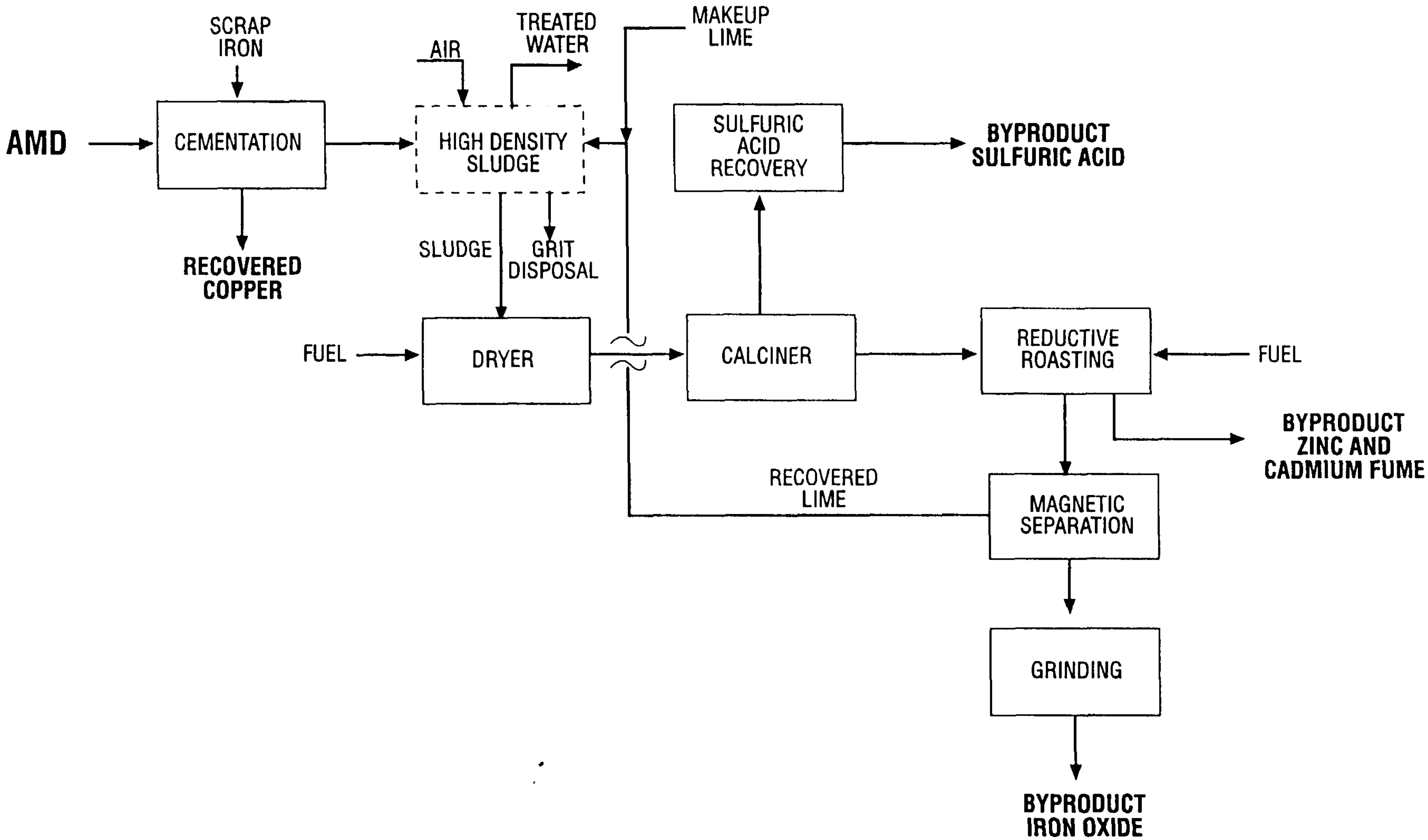

FIGURE 1
HIGH DENSITY SLUDGE-DERIVED BYPRODUCT RECOVERY
IRON MOUNTAIN MINE
REDDING, CALIFORNIA

CH2M HILL

Table 1
Byproduct Recovery from Dense Sludge

Copper Cementation	
• Quantity recovered (lb/day)	372
• Value ($/day)	242
• Scrap iron cost ($/day)	<46>
• Net value ($/day)	196
Lime	
• Quantity recovered, net (lb/day) (as CaO)	24,304
• Cost of recovered lime ($/day)	<1,459>
• Total lime demand (lb/day)	41,462
• Net purchase lime (lb/day)	17,158
• Purchased lime cost ($/day)	<429>
• Total lime cost ($/day)	<1,888>
Sulfuric Acid Recovery	
• Quantity recovered (lb/day)	47,536
• Value ($/day)	1,783
• Labor cost ($/day)	<744>
• Net value ($/day)	1,039
Zinc Fume Recovery (ZnO)	
• Quantity recovered (lb/day)	1,946
• Value ($/day)	973
• Power cost ($/day)	<215>
• Labor ($/day)	<744>
• Net value ($/day)	14
Iron Oxide Recovery	
• Quantity recovered (lb/day)	21,459
• Value ($/day)	4,459
• Power cost ($/day)	<806>
• Labor value ($/day)	<1,488>
• Net value ($/day)	2,165
Neutralization Treatment	
• Net solids for disposal (ton/day)	3.1
• Cake volume (yd^3/day)	6.1
• Disposal cost ($/day)	<52>
• Labor cost ($/day)	<1,488>
• Power cost ($/day)	<1,093>
• Maintenance cost ($/day)	<1,317>
• Drying bed maintenance ($/day)	<216>
• Road maintenance cost ($/day)	<222>
• Net value <loss> ($/day)	<4,388>
Overall Value Recovered <lost>	
($/day)	<2,862>
($ million/year)	<1.04>

Table 2
Comparison of Revised Treatment and Byproduct Recovery Options

	Lime and Simple Mix	Caustic and Simple Mix	Lime and High Density Sludge	Caustic and High Density Sludge	Cementation, Acid Recovery, and High Density Sludge	Cementation, Acid Recovery, Zinc Sulfide Recovery, and High Density Sludge	Cementation, Ammonium Sulfate Recovery, Zinc Sulfide Recovery, and High Density Sludge
Copper (Cementation)							
• Quantity Recovered (lb/day)					372	372	372
• Value ($/day)					242	242	242
• Scrap Iron Cost ($/day)					<46>	<46>	<46>
• Net Value					196	196	196
Sulfuric Acid Recovery							
• Quantity Recovered (lb/day)					32,333	32,333	
• Value ($/day)					1,212	1,212	
• Operating Costs ($/day)					<784>	<784>	
• Net Value ($/day)					428	428	
Zinc Sulfide Sludge Recovery							
• Quantity Recovered (lb/day)						4,666	4,666
• Value ($/day)						96	96
• Operating Costs ($/day)						<927>	<927>
• Net Value ($/day)						<831>	<831>
Ammonium Sulfate Recovery							
• Quantity Recovered (lb/day)							106,612
• Value ($/day)							1,317
• Operating Costs ($/day)							<2,142>
• Net Value ($/day)							<825>
Neutralization Treatment							
• Sludge Quantity (dry tons/day)	63.3	19.3	63.3	19.3	42.3	40.2	40.2
• Disposal Cost ($/day)	<2,510>	<1,725>	<645>	<290>	<430>	<410>	<410>
• Operating Costs ($/day)	<4,880>	<12,411>	<5,346>	<13,078>	<7,114>	<7,092>	<4,892>
• Net Cost ($/day)	<7,390>	<14,136>	<5,994>	<13,368>	<7,544>	<7,502>	<5,302>
Overall Value <cost>							
($/day)	<7,390>	<14,136>	<5,994>	<13,368>	<6,920>	<7,709>	<6,762>
($ million/year)	<2.70>	<5.16>	<2.19>	<4.88>	<2.53>	<2.81>	<2.47>

RDD10013795.WP5