United States
Environmental Protection
Agency

Industrial Environmental Research
Laboratory
Research Triangle Park NC 27711

Research and Development

EPA-600/S7-81-071a Oct. 1981

EPA

Project Summary

Environmental Assessment: Source Test and Evaluation Report - Coal Preparation Plant No. 1

J. Buroff, A. Jung, L. McGilvray, and J. Strauss

This report gives results and conclusions of a Source Test and Evaluation Program conducted at a coal preparation facility. The major objective of the test program was to perform a screening Environmental Assessment (Level 1) on the discharge streams and fugitive emissions of the facility.

Results from the Source Analysis Model—IA (SAM/IA)—evaluation for the multimedia streams sampled indicated that all streams, except for fugitive particulates, contained some constituents which may have a potentially harmful health or ecological effect. For streams which showed potential for ecological effects, manganese was found to be of concern; for streams which showed a large health-related value, manganese and chromium were of prime concern. Contrary to previous studies, high ammonia concentrations were also observed. Further investigation of the ammonia source is warranted.

The bioassay test results for all fugitive particulates were negative. The fine refuse sedimentation pond waters, the coarse refuse, and fine refuse slurry samples indicated a moderate biological effect. For leachates, all health-based bioassay tests showed a low or nondetectable effect; however, the coal and coarse refuse leachate composite and the pond sediment composite produced a moderate effect on the ecological-related algae test.

The results of this environmental assessment and future Level 1 Environmental Assessments performed on other coal preparation facilities will identify those substances in a given waste stream that are the most potentially harmful and will determine the need for further characterization of the discharge streams and development of control technology.

This Project Summary was developed by EPA's Industrial Environmental 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).

Introduction

Versar Inc., under contract to the U.S. EPA's Industrial Environmental Research Laboratory at Research Triangle Park, NC (IERL-RTP), is performing a comprehensive environmental assessment of coal preparation technologies. A significant part of this assessment involves Source Test and Evaluation (STE) programs at operating coal cleaning facilities. The primary objective of each STE program is to perform a screening (Level 1) Environmental Assessment that characterizes multimedia emissions from the source, assesses the data on a health and ecological basis, and evaluates the effectiveness of pollution control systems.

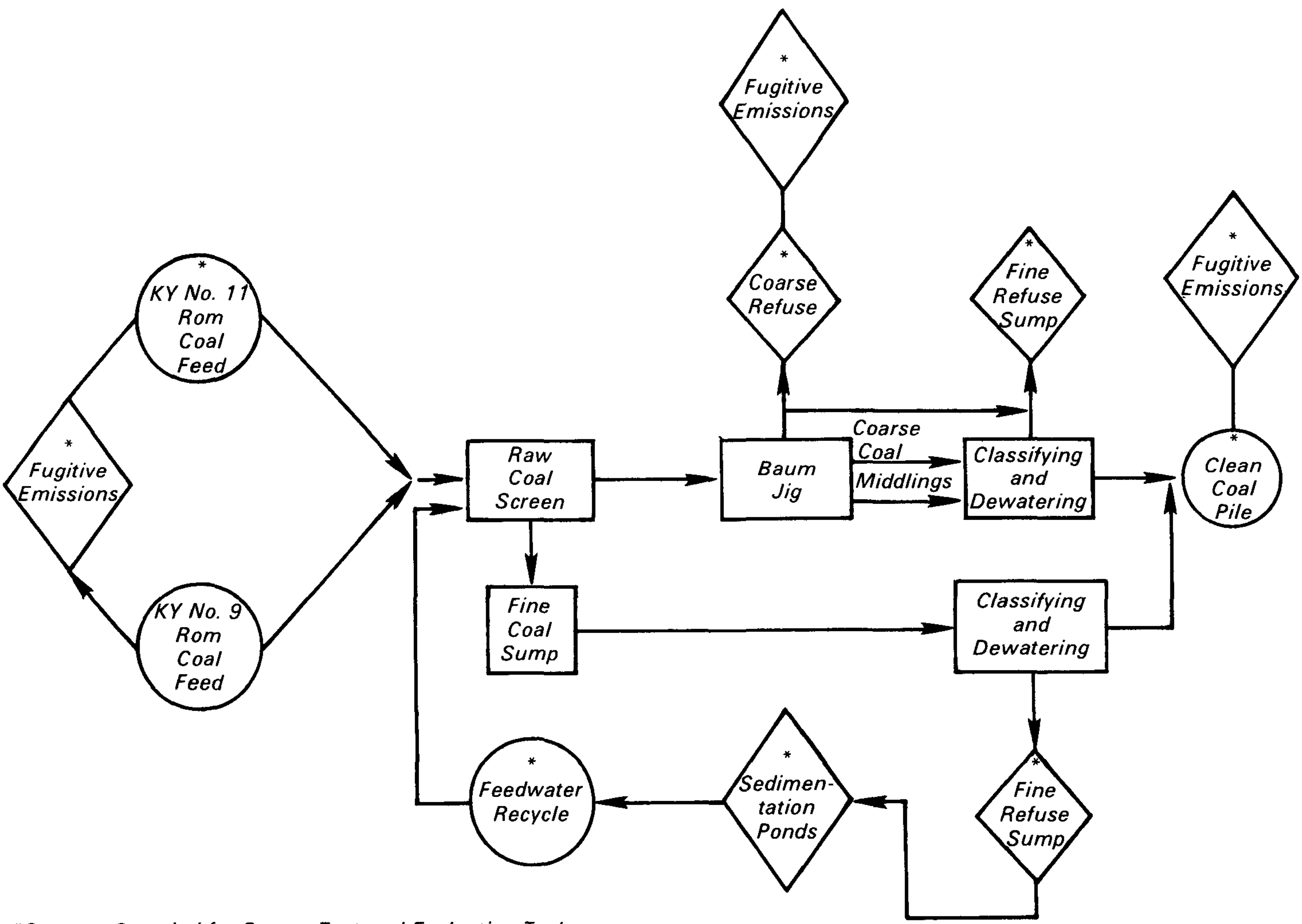
The field testing program is designed to determine the physical, chemical, and relative toxicological characteristics of coal preparation plant effluent streams sampled at their respective sources. The results of the Level 1 testing and analysis provide the quantities of pollutants in process and effluent streams and identify those areas of the process needing additional control technology development. The field testing program is not designed to assess the environmental quality in the general vicinity of the cleaning plant. Therefore, results of the present testing program cannot be used to evaluate cause/effect relationships between discharge stream characteristics and ecological effects observed in the field.

General Plant Description

The coal cleaning plant chosen for this first assessment is representative of a group of cleaning plants that process run-of-mine (ROM) coal with low pyritic sulfur ($\leq$ 2 percent) content, use high technology coal cleaning processes, and operate in an environment with high rainfall ($\geq$ 60 cm/yr) and a low soil neutralization potential (pH $<$6.0). The facility is designated as preparation plant No. 1. The clean coal from this plant is sent directly to a large steam electric power plant. A schematic flow diagram of coal preparation plant No. 1 is shown in Figure 1.

Preparation plant No. 1 is a 450 Mg/h (500 t/h) coal washing plant. Its yield is about 250-275 Mg/h (275-300 t/h) of clean coal (i.e., 55-60 percent yield). The plant cleans Kentucky No. 9 and No. 11 coals to an average yearly sulfur content of 2.9 percent (as received) and an energy content of about 6.1 Mcal/kg (11,000 Btu/lb). Proximate and ultimate analysis for ROM coal, clean coal, and coarse refuse are shown in Table 1.

The plant processes the coal by first sending the stored ROM coal to a raw coal screen. The overflow from the raw coal screen is treated in a Baum jig, which produces two product streams (a coarse and a middling fraction) and a refuse stream. The product streams are dewatered and sent to the clean coal pile. The underflows from the raw coal



Streams Sampled for Source Test and Evaluation Task

Figure 1. *Schematic flow diagram of coal preparation plant No. 1.*

Table 1. Properties of ROM Coal, Clean Coal, and Coarse Refuse

Proximate Analysis	ROM Coal		Clean Coal		Coarse Refuse	
	As Received	Dry Basis	As Received	Dry Basis	As Received	Dry Basis
(% Weight)						
Moisture	2.72	—	6.15	—	1.11	—
Ash	22.16	22.78	12.70	13.53	75.69	76.54
Volatile	34.14	35.09	37.21	39.65	13.66	13.81
Fixed Carbon	40.98	42.13	43.94	46.82	9.54	9.65
	100.00	100.00	100.00	100.00	100.00	100.00
Btu/lb	10764	11065	11808	12582	2658	2688
Sulfur	3.93	4.04	3.36	3.58	9.21	9.31
Ultimate Analysis						
Moisture	2.72	—	6.15	—	1.11	—
Carbon	59.60	61.16	64.82	69.07	13.55	13.70
Hydrogen	4.09	4.20	4.35	4.63	1.24	1.25
Nitrogen	1.48	1.52	1.48	1.58	0.40	0.40
Chlorine	0.13	0.13	0.11	0.12	0.05	0.05
Sulfur	3.93	4.04	3.36	3.58	9.21	9.31
Ash	22.16	22.78	12.70	13.53	75.69	76.54
Oxygen (by difference)	5.99	6.17	7.03	7.49	-1.25	-1.25
	100.00	100.00	100.00	100.00	100.00	100.00

stream and dewatering circuit are combined to recover fine coal. Recovery is accomplished by centrifugation of the fine coal slurry after collection and initial thickening by classifying cyclones. Coarse refuse is sent to an onsite landfill and fine refuse is slurried to a series of onsite sedimentation ponds.

Test Program Description

Samples of 25 process and waste streams were obtained to meet the objectives of this STE program. Because slurry streams were split into two samples (solid and liquid states) and non-fugitive solid samples were analyzed as the solid and a leachate of the solid, 31 samples were analyzed to characterize facility waste streams, raw materials, and product.

Samples collected at the coal preparation facility included:

- Fugitive particulates and gases from coal and coarse refuse storage areas.
- Fine refuse sedimentation ponds.
- Runoff from coal and coarse refuse storage areas.
- ROM coal, clean coal, and coarse refuse.
- Fine refuse slurry.

These samples were selected based on their potential for pollution.

The following chemical analyses were performed:

- Spark Source/Mass Spectroscopy for inorganic element determinations (all streams).
- Inductively Coupled Argon Plasma for inorganic element determinations (liquid streams only).
- Total Chromatographable Organics and Gravimetric Analysis for assessing total organic content (all gaseous, liquid, and sediment streams).
- Atomic Absorption Spectroscopy for mercury (all streams).

The following tests were conducted:

- AMES test for mutagenesis (all streams).
- A second, suitable biological assessment test for cytotoxicity or toxicity, such as rabbit alveolar macrophage (solids), Chinese hamster ovary assay (liquids), rodent acute toxicity (liquids), or an aquatic bioassay on algae, daphnia, or fathead minnows (all liquid streams and leachates).

In addition, classical water quality parameters were measured for each liquid stream: pH, conductivity, temperature, dissolved oxygen, hardness, alkalinity, acidity, ammonia, nitrates, nitrites, cyanide, phosphorus, sulfate, sulfite, fluoride, and chloride.

Methods for Characterizing Waste Streams

Three methods were used to evaluate the characteristics of the coal preparation plant samples:

- Source Assessment Models (SAM)/IA evaluation for inorganic constituents.
- Water quality parameter comparisons with existing standards.
- Bioassay screening tests.

Source Assessment Models

The Energy Assessment and Control Division (EACD) of EPA's IERL-RTP has developed a standardized methodology for interpreting the results obtained from environmental assessment test programs. This methodology uses the Source Analysis Model which represents prototype approaches to multimedia, multipollutant problem identification and control effectiveness evaluation for complex effluents.

The simplest member of the Source Analysis Models, SAM/IA, was used for this STE program. SAM/IA provides a rapid screening technique for evaluating the pollution potential of gaseous liquid, and solid waste streams. In performing a SAM/IA evaluation, an index, the Discharge Severity (DS), is determined for each substance in a discharge stream.

The DS is calculated by dividing the detected concentration of a compound, or class of compounds, by its Discharge Multimedia Environmental Goal (DMEG) value (for both health and ecological effects) as reported in Multimedia Environmental Goals for Environmental Assessment, Volume II.[1]

MEG's are concentration levels of contaminants in air, water or solid water effluents that will not evoke significant harmful responses in surrounding populations or ecosystems.

For example, the estimated concentration of aluminum in the fine waste slurry filtrate sample was 190 μg/l. The health-based DMEG value for aluminum in a liquid discharge is 8.0×10^4 μg/l.

$$DS = \frac{190\ \mu g/l}{8.0 \times 10^4 \mu g/l} = 2.4 \times 10^{-3}$$

Therefore, the DS for aluminum is 2.4×10^{-3} or 2.4 E-3. A DS greater than 1.0 indicates a potential hazard, while a DS less than 1.0 indicates little or no potential hazard. A total stream discharge severity (TDS) is calculated by summing the DS values for all constituents found in a sample.

The total concentration of organic extractables in each sample was given as the sum of the gravimetric (Grav) and total chromatographable organic (TCO) determinations. These results were not evaluated using the SAM/IA methodology because the MEG values are specific to individual organic compounds, which are not identified by Grav and TCO analyses, and most Grav and TCO values were at or below detection limits.

Water Quality Comparisons

Water quality tests were performed on the runoff and filtrate samples. The test concentrations were compared to the most stringent state effluent water regulations for eastern and midwestern states.[2] The applicable water quality test concentrations for runoff and leachate samples were also compared to the Resource Conservation and Recovery Act (RCRA) Extraction Procedure-Toxicity Concentrations for determining hazardous wastes, although a neutral leachant procedure was used.[3]

Bioassay Screening Tests

The use of biological assays in conjunction with physical and chemical analyses provides a comprehensive data base from which to prioritize streams relative to further study and/or control technology needs.

Biological test result evaluations are based on an interpretation of the data in terms of low, moderate, or high effects for each test. These interpretations are based on the biological responses of highly sensitive cellular and whole-organism cultures. Since highly sensitive cells or organisms are tested, a positive response may not indicate actual field impacts. "Low or nondetectable effects" means that the material will not have any adverse health or ecological effects. "Moderate or high effects" means that the material may be potentially hazardous and more rigorous testing should be initiated.

Results

Fugitive Emissions

The ambient Total Suspended Particulates (TSP) values were highest adjacent to the coal storage piles, as expected, because of the continual truck activities in those areas. The contribution of plant fugitive emissions to the ambient air quality can be measured as the downwind TSP value minus the upwind TSP value. When the high ambient air TSP value is subtracted from the downwind results, the contribution to the ambient air 500 m downwind from the preparation plant was found to be 175 $\mu g/m^3$. Although 500 m downwind is still within the plant boundary, this value is less than the 24-hour primary ambient air quality standard of 260 $\mu g/m^3$ for TSP and slightly higher than the secondary ambient air quality standard of 150 $\mu g/m^3$.

The TCO + Grav analyses of fugitive vapors were determined to be 120 $\mu g/m^3$ after subtracting the upwind contribution. It can be concluded that the preparation plant and specific coal and refuse piles contribute little or no organic vapors to the environment. The TDS values for organic vapors were less than 100 for both health and ecological criteria. Chromium and nickel were generally the only elements with a DS greater than 1.0; however, for four of the nickel concentrations, the DS value can be attributed to contamination in the XAD-2 resin blank. The bioassay test results for both fugitive particulate and vapor samples were negative (i.e., low or nondetectable effect).

Liquids

The filtrate sample from the fine waste slurry had health- and ecological-based TDS values greater than 1.0. These values indicate potential for hazard, especially for the ecological-based criteria with a TDS value greater than 100. However, the low total extractable organic concentration shows that there was very little dissolved organic material in the fine coal waste slurry filtrate.

The feedwater to the plant was obtained from pond No. 3. No element had a DS value greater than 1.0. The feedwater results show low inorganic concentrations, no detectable chromatographable organics, and relatively low gravimetrically determined organic concentrations. Also, the health-related bioassay tests for the feedwater produced low or nondetectable effects.

The waters from ponds No. 1, 2, and 3 exhibited low potential for effect based on the health-related TDS value and a relatively higher potential for hazard based on the ecological-related TDS value. There were no chromatographable organics detected; however, gravimetrically determined organic concentrations were 600 μg/l, 500 μg/l, and 1,000 μg/l for ponds No. 1, 2, and 3, respectively. The results of the bioassays were mixed. One health-related test (Ames assay) gave negative results, whereas another health-related test (Chinese Hamster Ovary (CHO) clonal assay) indicated moderate effects. The aquatic bioassays on the composite sample (ponds No. 1, 2, and 3) showed low or nondetectable effects on fish and invertebrates and moderate effects on algae.

The results of the inorganic tests for the runoff samples were similar to the pond water results; i.e., low potential for hazard on a health-related basis and greater potential on an ecological basis. The total extractable organic concentrations were relatively high (3,300 μg/l) for the ROM coal pile runoff sample and were reduced to a nondetectable level in the clean coal runoff sample. The biological tests (Ames and CHO clonal assays) showed negative results for both samples.

Solids and Leachates

The inorganic analyses for the fine refuse waste solids gave a health-related TDS value greater than 100 and an ecological-based TDS value that was greater than 10,000. The high ecological-based TDS value was primarily due to a high phosphorous DS value. In contrast, the health-related bioassays and the ecological assay on fish showed low or nondetectable effects. However, the bioassays on invertebrates and algae showed moderate effects.

The TDS values for the coarse refuse solids sample were of the same magnitude as those for the fine refuse. The coarse refuse leachate TDS values were considerably lower and contained no detectable, extractable organic concentrations. The health-related bioassays showed mixed results for the coarse refuse solid; i.e., negative results for the Ames assay and moderate effects for the Rabbit Alveolar Macrophage (RAM) assay. The coarse refuse leachate produced negative results for the health-related bioassays.

The TDS values for the ROM coal leachate were similar to those for the coarse refuse leachate (greater than 1.0 for the health-based TDS and greater than 100 for the ecological-based TDS). Only gravimetrically determined organics contributed to the relatively moderate concentration of total extractable organics (1,500 μg/l). The health-related bioassays indicated low or nondetectable effects for the ROM coal leachate.

The TDS values for the clean coal leachate samples were of the same magnitude as the coarse refuse and ROM coal leachates. The extractable organic concentrations were below the detection limit. The results of the health-related bioassays were negative for both the clean coal and the clean coal leachate.

A composite of coarse refuse, ROM, and clean coal leachates were used for the aquatic bioassays. The results showed low or nondetectable effects on fish and invertebrates and moderate effects on algae. The major contributors to the biological results for the solids and leachates were the high phosphorus and ammonia concentrations.

The TDS values for the pond sediments were fairly high (health TDS >100 and ecological TDS >1,000), with the highest values for pond No. 1 (health TDS >1,000 and ecological TDS >10,000). The TDS values for the pond sediment leachates were significantly lower (health TDS >1 and ecological TDS >10). The concentrations of chromatographable and gravimetric organics in the sediments were 864, 199, and 85 mg/g for ponds No. 1, 2, and 3, respectively, with lower concentrations detected in the leachates (2.3 mg/l, <1 mg/l, 1 mg/l, respectively). The leachates from ponds No. 2 and 3 sediments were below the 1 mg/l detection limit for extractable organics.

The health-based bioassays indicated low or nondetectable effects for both sediment and leachates. The aquatic bioassays performed on a composite of the leachate samples showed no effect on fish and invertebrates and a moderate effect on algae.

Summary and Conclusions

A summary of the multimedia chemical and biological stream characteristics and control strategy recommendations are provided in Table 2.

For air samples there is a low potential for hazard from both the fugitive particulates and fugitive vapors. Improved dust control measures are recommended to decrease fugitive particulate emissions.

For liquid streams the major constituents of concern were manganese and ammonia. Previous water pollution studies identified manganese, but not ammonia, as a problem in coal preparation plant discharges. The presence of ammonia may be an artifact of sampling and analysis procedures. It is recommended that analytical protocols be changed to better characterize the presence and concentration of ammonia. Manganese would require control if the pond waters were discharged or runoff water was collected and then discharged.

The solid samples showed the highest potential for hazard. However, the leachates from the solids had considerably lower discharge severity values than the solids themselves. The recommendation is to retain solids onsite via sedimentation or filtration.

Table 2. *Summary of Environmental Results*

	Total Discharge Severity		Major Contributors (Discharge Severity >10)		Biological Results			
Waste Stream	Health	Ecological	Health	Ecological	Health	Ecological	Conclusions	Recommendations
Clean Coal Fugitives Particulates	5E-3	9E-3	—	—	L.N.	N.C.	• Low potential for hazard according to TDS values and bioassay test results.	• Improve dust control/ suppression techniques
Coarse Refuse Fugitive Particulates	3E-3	1E-3	—	—	L.N.	N.C.	• High downwind TSP values for particulates.	
ROM Fugitive Particulates	1E-2	1E-2	—	—	L.N.	N.C.	• Particulate morphology shows mostly dust, not coal in downwind samples.	
Upwind Fugitive Particulates	4E-3	3E-3	—	—	L.N.	N.C.		
Downwind Fugitive Particulates	3E-3	2E-3	—	—	L.N.	N.C.		
Clean Coal Storage Pile Vapors	3E0	2E-1	—	—	L.N.	N.C.	• Low potential for hazard according to TDS values and bioassay test results.	
Coarse Refuse Pile Vapors	1E1	3E-1	—	—	L.N.	N.C.		
ROM Storage Pile Vapors	4E0	2E-1	—	—	L.N.	N.C.		
Upwind Vapors	3E0	3E-1	—	—	L.N	N.C.		
Downwind Vapors	6E1	2E0	Cr	—	L.N.	N.C.		

Table 2. (continued)

Waste Stream	Total Discharge Severity: Health	Total Discharge Severity: Ecological	Major Contributors (Discharge Severity >10): Health	Major Contributors (Discharge Severity >10): Ecological	Biological Results: Health	Biological Results: Ecological	Conclusions	Recommendations
Fine Waste Slurry * Filtrate	1E1	7E1	NI_3-N	NI_3-N	N.C.	N.C.	● Potentially hazardous according to SAM/IA evaluation.	● Should not discharge directly to offsite surface waters; should be treated onsite.
Feedwater Filtrate *	7E-1	1E1	—	—	L.N.	N.C	● Low potential for hazard according to TDS values and bioassay test results.	
Pond Water No. 1 * Filtrate	2E0	3E1	—	NI_3-N	M	M	● Potentially hazardous for ecological-based SAM/IA evaluation.	
Pond Water No. 2 * Filtrate	7E-1	1E1	—	—	M	M	● Complied with most stringent state effluent regulations for states in Eastern, Midwest and Northern Appalachian coal regions.	● Further characterization during Level 2 environmental assessment phase to determine origin of ammonia.
Pond Water No. 3 * Filtrate	1E0	2E1	—	—	M	M		
ROM Storage Pile Runoff	2E0	3E1	—	NI_3-N	L.N.	N.C.	● Low potential hazard for health-based criteria.	● Collect runoff and treat for control of manganese.
Clean Coal Storage Pile Runoff	1E1	1E2	—	Mn,Ni, NI_3-N	L.N.	N.C	● Potentially hazardous for ecological-based criteria.	● Further characterization during Level 2 environmental assessment phase to determine origin of ammonia.
Coarse Refuse Pile Runoff	9E0	4E1	—	Mn	L.N.	N.C.	● Water quality results in compliance with most stringent state effluent regulations.	
Filtered Solids from Fine Waste Slurry	6E2	1E4	CR,Mn,Ba, Be,Cd,Li, P,Se,V	P,Cd	M	M	● Potentially hazardous according to SAM/IA evaluation.	● Retain material onsite via sedimentation or filtration.
Coarse Refuse	7E2	1E4	Cr,MN,As Ba,Be,Pb, Li,P,Se,V	P,Ni	M	N.C.	● Potentially hazardous according to SAM/IA evaluation.	● Further characterization during Level 2 environmental assessment phase to determine origin of ammonia.
Coarse Refuse Leachate	2E0	4E1	—	NI_3-N	L.N.	M	● Does not exceed RCRA EP Toxicity Concentrations.	
ROM Coal Leachate	1E0	3E1	—	NI_3-N	L.N.	M	● Potentially hazardous according to SAM/IA evaluation.	● See runoff recommendations.
Clean Coal Leachate	3E0	3E1	—	—	L.N	M	● Does not exceed RCRA EP Toxicity Concentrations.	
Pond No. 1 Sediment	2E3	1E4	Sr,Cr,Mn, As,Ba,Pb Li,Ni,P, Se,V	P,Mn	L.N.	N.C.	● Potentially hazardous according to SAM/IA evaluation	● Further characterization during the Level 2 environmental assessment phase
Pond No. 1 Sediment Leachate	2E0	2E1	—	—	L.N.	M	● Does not exceed RCRA EP Toxicity Concentrations	
Pond No. 2 Sediment	6E2	3E3	Ba,Mn,Cr, Pb,Ni, P,Se	P	L.N.	—		
Pond No. 2 Sediment Leachate	2E0	1E1	—	NI_3-N	L.N.	M		
Pond No. 3 Sediment	8E2	3E3	Mn,As,Ba, Cd,Cr,Pb, Li,Ni,P, V	P,Mn	L.N.	N.C.		
Pond No. 3 Sediment Leachate	4E0	2E1	—	—	L.N.	M		

N.C. = Not conducted
L.N. = Low or Nondetectable
M = Moderate
* Bioassays conducted on the raw material.
EP Toxicity = Extraction Procedure Toxicity.

References

1. Cleland, J.G., and G.L. Kingsbury. Multimedia Environmental Goals for Environmental Assessment, Volume II: MEG Charts and Background Information. EPA-600/7-77-136b (NTIS PB 276920), U.S. EPA, IERL, Research Triangle Park, NC, November 1977. p. 449.
2. Bureau of National Affairs. **Environment Reporter**. State Water Laws.
3. **Federal Register**. May 19, 1980. Volume 45 - No. 98.

J. Buroff, A. Jung, L. McGilvray, and J. Strauss are with Versar, Inc., Springfield, VA 22151.

***D. A. Kirchgessner** is the EPA Project Officer (see below).*

The complete report, entitled "Environmental Assessment: Source Test and Evaluation Report—Coal Preparation Plant No. 1," (Order No. PB 81-239 030; Cost: $21.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

☆U. S. GOVERNMENT PRINTING OFFICE: 1981/559-092/3332

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

Postage and
Fees Paid
Environmental
Protection
Agency
EPA 335

Official Business
Penalty for Private Use $300

PS 0000329
U S ENVIR PROTECTION AGENCY
REGION 5 LIBRARY
230 S DEARBORN STREET
CHICAGO IL 60604