RECEIVED

SEP 11 1998

OSTI

**Management of Dry Flue Gas Desulfurization By-Products
in Underground Mines**

**Quarterly Report
August 1 - October 31, 1997**

**By
Y. P. Chugh**

Work Performed Under Contract No.: DE-FC21-93MC30252

For
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

By
Southern Illinois University at Carbondale
Carbondale, Illinois 62901

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

9/8

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

TABLE OF CONTENTS

Section 1	
Introduction and Summary.....	1
Section 2	
Environmental Studies	
Dr. Bradley Paul, Co-Principal Investigator.....	3
Section 3	
Materials Handling and Systems Economics	
Dr. H. Sevim, Co-Principal Investigator.....	5
Section 4	
Environmental Assessment and Geotechnical Stability	
Dr. S. Esling, Co-Principal Investigator.....	7
Section 5	
Underground Placement	
Dr. Y.P. Chugh, Principal Investigator	
Dr. D. Dutta, Co-Principal Investigator	
Mr. E. Powell, Researcher.....	9
Section 6	
Steel Intermodal Container	
Dr. Y.P. Chugh, Principal Investigator	
Mr. G. Wangler, Researcher.....	16
Section 7	
Plans for the Next Quarter.....	19

FIGURES

Figure 5.1	Relationship between Uniaxial Compressive Strength and Elastic Modulus.....	9
Figure 5.2	Strength Gain over Time.....	10
Figure 5.3	Gain in Elastic Modulus Value over Time	10
Figure 5.4	Strength Comparison between Cored and Cured Samples.....	12
Figure 5.5	Strength Comparison of Grout Samples Collected on Different Days.....	12
Figure 6.1	Design of the Steel Intermodal Container (SIC).....	17
Figure 6.2	Photograph of the Steel Intermodal Container (SIC).....	18

TABLES

Table 4.1	Tritium Analyses for Samples Collected from Selected Wells in the Study Area of October, 1997.....	8
Table 4.2	Tritium Analyses for Samples Collected from Selected Wells in the Study Area of July, 1997.....	8
Table 4.3	Single Well Permeability test Average Results.....	8

APPENDIX 1

Figure 1	Major anions and cations (mg/l) of well 3. Solid points to the left axes while open points refer to the right axes.....	
Figure 2	Major anions and cations (mg/l) of well 4. Solid points to the left axes while open points refer to the right axes.....	
Figure 3	Pumping and recovery of Well 2A (August 1997) in lower unconsolidated material.....	
Figure 4	Pumping and recovery of Well 2B (August 1997) in sandstone and siltstone.....	
Table 4.1	Screened Interval and Depth to Water Management in 1996, Monitoring Wells 2A, 3, and 4 Deepest Wells in Each Nest are the Sampled Wells.....	
Table 4.2	Screened Interval and Depth to Water Management in 1997, Monitoring Wells 2A, 3, and 4. Deepest Wells in Each Nest are the Sampled Wells.....	

APPENDIX 1 (Continued)

Table 4.3	Screened Interval and Depth to Water Management in 1996, Monitoring Wells 5 and 6. Deepest Wells in Each Nest are the Sampled Wells.....
Table 4.4	Screened Interval and Depth to Water Management in 1997, Monitoring Wells 5 and 6. Deepest Wells in Each Nest are the Sampled Wells.....
Table 4.5	Depth to Water Measurement, Samples Collected, and Flow-Through-Cell Parameters, for Deep Wells in Each Well Nest, February 6 to March 11, 1996.....
Table 4.6	Depth to Water Measurement, Samples Collected, and Flow-Through-Cell Parameters, for Deep Wells in Each Well Nest, March 29 to May 7, 1996.....
Table 4.7	Depth to Water Measurement, Samples Collected, and Flow-Through-Cell Parameters, for Deep Wells in Each Well Nest, July 10 to July 26, 1996.....
Table 4.8	Depth to Water Measurement, Samples Collected, and Flow-Through-Cell Parameters, for Deep Wells in Each Well Nest, August 30 to November 21, 1996.....
Table 4.9	Depth to Water Measurement, Samples Collected, and Flow-Through-Cell Parameters, for Deep Wells in Each Well Nest, January 7 to March 12, 1997.....
Table 4.10	Depth to Water Measurement, Samples Collected, and Flow-Through-Cell Parameters, for Deep Wells in Each Well Nest, March 20 to May 21, 1997.....
Table 4.11	Depth to Water Measurement, Samples Collected, and Flow-Through-Cell Parameters, for Deep Wells in Each Well Nest, May 28 to September 13, 1997.....
Table 4.12	Depth to Water Measurement, Samples Collected, and Flow-Through-Cell Parameters, for Deep Wells in Each Well Nest, October 20 to October 29, 1997.....
Table 4.13	Well 3B cation Data from Groundwater Samples Collected at the Peabody #10 Mine Site.....
Table 4.14	Well 4A cation Data (Al-Mn) from Groundwater Samples Collected at the Peabody #10 Mine Site.....
Table 4.15	Well 4A cation Data(Mo-Zr) from Groundwater Samples Collected at the Peabody #10 Mine Site.....
Table 4.16	Well 5C and Field Blank cation Data from Groundwater Samples Collected at the Peabody #10 Mine Site.....
Table 4.17	Shallow Wells (2A, 2B, 5A, 5B, 6A) cation data from Groundwater Samples Collected at the Peabody #10 Mine Site.....
Table 4-18	Well 3B Anion Data from Groundwater Samples Collected at the Peabody #10 Mine Site.....

APPENDIX 1 (Continued)

Table 4-19	Well 4A anion data from Groundwater Samples Collected at the Peabody #10 Mine Site.....
Table 4-20	Field Blank anion data from Groundwater Samples Collected at the Peabody #10 Mine Site.....
Table 4-21	Shallow Wells (2A, 2B, 5A, 5B, 6A) anion data from Groundwater Samples Collected at Peabody #10 Mine Site.....

SECTION I

INTRODUCTION AND SUMMARY

1.0 INTRODUCTION AND SUMMARY

1.1 Overview

On September 30, 1993, the U.S. Department of Energy - Morgantown Energy Technology Center (DOE-METC) and Southern Illinois University at Carbondale (SIUC) entered into a cooperative research agreement entitled "Management of Dry Flue Gas Desulfurization By-Products in Underground Mines" (DE-FC21-93MC-30252). Under the agreement SIUC was to develop and demonstrate two technologies for the placement of coal combustion by-products in abandoned underground coal mines, and will assess the environmental impact of these technologies for the management of CCB materials. The two technologies for the underground placement that were to be developed and demonstrated are: (1) pneumatic placement using virtually dry CCB products, and (2) hydraulic placement using a "paste" mixture of CCB products with about 70% solids.

The overall program was divided into three phases. Phase I was concerned primarily with the identification, analysis, and testing of CCB mixtures to find mixtures suitable physically, chemically, and environmentally for placement in abandoned underground coal mines. Other objectives of Phase I included the testing of the Collapsible Intermodal Container (CIC) developed in conjunction with this program by SEEC, Inc., and the drilling of boreholes to develop baseline data on groundwater around the injection site and to have injection wells ready for injection.

During Phase II of the program the equipment necessary for the underground placement of the CCB products was acquired and/or constructed and erected at the demonstration site at the Peabody Coal Company Mine 10 near Pawnee, Illinois. (Note: the Peabody 10 mine ceased operation during Phase I of the program, however, the site was retained for the remainder of the program). A mixing plant suitable for the hydraulic placement was acquired from Montgomery County, Illinois. The mixing plant had been used by the county to mix CCB material from the Coffeen electric power plant for road repair. The pneumatic injection equipment was fabricated "from scratch" by program personnel. However, a number of equipment suppliers and fabricators were used in the construction of the equipment.

Also during Phase II a "shake-down" test of both the pneumatic and hydraulic injection equipment was conducted, and operating parameters for the equipment established. In general both the pneumatic and hydraulic injection equipment operated satisfactorily, although some minor adjustments and "de-bugging" were required.

The period covered by this report (August 1 - October 31, 1997) is the second quarter of Phase III of the overall program. The primary objective of Phase III is the injection into the underground mine workings, by both the hydraulic and pneumatic technologies, of large amounts of the CCB material and mixtures heretofore developed. During this period over 8,000 tons of CCB mixtures was injected using the hydraulic paste technology. This amount of material virtually filled the underground opening around the injection well, and was deemed sufficient to demonstrate fully the hydraulic injection technology.

By the end of this quarter about 2,000 tons of fly ash had been placed underground using the pneumatic placement technology. While the rate of injection of about 50 tons per hour met design criteria, problems were experienced in the delivery of fly ash to the pneumatic demonstration site. The source of the fly ash, the Archer Daniels Midland Company power plant at Decatur, Illinois is some distance from the demonstration site, and often sufficient tanker trucks are not available to haul enough fly ash to fully load the injection equipment. Further, on some occasions fly ash from the plant was not available. The injection well was plugged three times during the demonstration. This typically occurred due to cementation of the FBC ash in contact with water. After considerable deliberations and in consultation with the technical project officer, it was decided to stop further injection of CCB's underground using the developed pneumatic technology.

Steel Intermodal Containers (SIC) was mechanically modified based on designs developed by the Wilson Manufacturing Company of Cecilia, Kentucky. The container is now ready for field demonstration.

Mr. Edwin Thomasson, Program Manager, retired from the program effective September 15, 1997.

During the next quarter, an additional core hole will be drilled through the hydraulically placed material and engineering studies will be performed on the recovered cores. The Steel Intermodal Container (SIC) will be field demonstrated. Groundwater monitoring and subsidence measurements over the backfilled areas will be continued as planned. Co-Principal investigators will initiate preparation of a draft final report.

SECTION 2

ENVIRONMENTAL STUDIES

**DR. BRADLEY PAUL
CO-PRINCIPAL INVESTIGATOR**

2.0 ENVIRONMENTAL CHARACTERIZATION

2.1 Overview

Most of the work scope in the demonstration contract has been performed. During the last quarter considerable effort was focused on compiling the completed information into a final topical report and preparing presentation materials for the projects featured by the U.S. Department of Energy at the International Ash Symposium, Lexington, Kentucky in October. As has been indicated in previous reports, rapid aging tests to measure changes in hydraulic conductivity were previously conducted. Some results were, however, not completely satisfactory because the hydraulic conductivities decreased to such an extent that the original apparatus could no longer measure them and became plugged. This was particularly the case with the pneumatic mix.

2.2 Long-Term Measurement of Hydraulic Conductivity

Although not strictly required by the agreement, efforts are being made to obtain a long term measure of hydraulic conductivity through lower values that are likely to result from longer runs. This effort has required several key components

- 1- Develop a modified pressurized column capable of measuring lower hydraulic conductivity.
- 2- Determine the packing density likely to be achieved by underground pneumatic placement.
- 3- Obtain sample material representative of the degree of hydration.

The modified pressure column has been described before (Ref. January, 1997). The column is 2 feet in diameter and 2 feet in length. The much larger cross sectional area provides for greater total flow at the same hydraulic conductivity as well as greater opportunity for macro scale defects that might occur in a large field scale test.

The packing density was determined from scaled pneumatic injection experiments. With dry unhydrated FBC fly ash the packing density achieved was 56 pounds per cubic foot at the advance front and 60 pounds per cubic foot in areas where air bursts had forced openings through. It would have been very desirable to core the pneumatic mix placed in the underground mine as was done for the hydraulic mix since this would have provided a more definitive measure of the packing achieved. However, this was not done.

Obtaining a "representative sample of material" was rather difficult in view of the way the hydration was achieved in the field. FBC fly ash was injected down the hole together with a water spray calculated to be of sufficient volume to hydrate the ash. The turbulent mixing down the hole was to fully and evenly distribute the water. There are many reasons to doubt whether the hydration procedure actually provided a uniformly hydrated mass of ash, and since no samples were cored any further discussion would be conjecture. What was done in the second generation rapid age test was to use laboratory prehydrated FBC fly ash. The ash was mixed with water in large tanks and using hoes and shovels. The procedure apparently is quite effective since there are no indication of immediate rise in temperature when the ash is subsequently contacted with water. This is not the case with ash that has not been prehydrated. The laboratory prehydrated

ash was selected as the end point because one of the factors contributing to early reduction in hydraulic conductivity is swelling reactions associated with hydration. Eliminating these initial swelling reactions provides a more critical test of hydraulic conductivity. (A very low hydraulic conductivity would reduce most chances for environmental damage since it would minimize the total leachate volume the injected material could produce).

The prehydrated FBC ash was poured into the column in two inch lifts. At the end of each lift material was packed around the edges to minimize the risk of water flow channeling along the column contact. The next lift was then applied. Most of the material was thus loose poured with a fall of only a few inches to achieve packing. A density of 60 lbs per cubic foot was achieved although it should be remembered that this was hydrated FBC ash. The modified test columns are large and much more expensive than the original design so no replicates were attempted. The column is operated by attempting to force water through the column every four days. Initially this meant turning the pressure onto the column for only an hour or so at a time in order to force water through, however, as hydraulic conductivities have fallen the time has gone from a matter of hours to over a day of continuous operation. The column has been in operation now for approximately one month. Hydraulic conductivity has fallen steadily from 5.73×10^{-5} cm/sec initially to 1.32×10^{-6} cm/sec. These values are nearing those where the previous column design plugged. Pressures on the column are still low (2 to 2.5 psi) and water flows are still not fully continuous from day to day so the apparatus will be able to measure lower hydraulic conductivities. Packed FBC fly ash in short term triaxial tests has shown hydraulic conductivities in the 10^{-8} to 10^{-9} cm/sec range. The present apparatus was designed with intent to measure into the 10^{-8} cm/sec range. As it stands now the column can be pressurized in bursts to force open new channels. When hydraulic conductivity reaches the 10^{-7} cm/sec range, pressure will be used to try to open new channels.

The column is intended to represent a worst case scenario with respect to the ability to produce leachate. One of the principle contentions from the standpoint of environmental risk is that the underground placement procedures that were demonstrated in this project pose minimal risk even to high quality groundwater supplies because the amount of contacted water mixed into the over-all hydraulic system is too small for materials with near Class I concentrations in the TCLP test to do any damage to the environment.

2.3 Plans for the Next Quarter

During the next quarter work will be done to complete the final report. We are planning to complete the report in time for its review before the close of the project. The Rapid Age test will continue to operate until the end of the project to give the largest baseline possible.

SECTION 3

**MATERIAL HANDLING
AND SYSTEM ECONOMICS**

**DR. H. SEVIM
CO-PRINCIPAL INVESTIGATOR**

3.0 MATERIALS HANDLING

3.1 Objectives

The objectives of the materials handling research are: 1) To identify the systems that are technically, economically, and environmentally feasible in handling and transporting the coal combustion by-products from the power plant to the injection site, 2) To demonstrate the operation of one or two of the identified systems.

The objectives of the system economics research are: 1) To conduct economic analyses of the selected materials handling and underground residue placement systems, and 2) To develop a generalized "Economic Evaluation" model that can be used in evaluating various types of materials handling and placement systems for different distances and tonnage.

The term "materials handling" in this research project includes loading, transporting, unloading, and temporary storage of the dry coal combustion by-products for the purpose of disposing them into abandoned areas of the underground coal mines in Illinois. Materials handling systems have been analyzed in four consecutive modules: 1) storage, handling and loading of the residues at the plant site, 2) transportation from the plant to the mine site, 3) unloading, handling and storage at the mine site, and 4) transportation from the mine site to the injection site.

3.2 Summary of Activities

During this quarter, two activities have been undertaken:

1. The case study that was evaluated in the previous quarter has been modified to reflect the new information that became available after the completion of the hydraulic and pneumatic placement demonstrations at the Peabody No. 10 Mine in Pawnee, Illinois. Under the cooperative research program, Peabody No. 10 Mine was the site for underground placement demonstration. To enhance this demonstration, it was decided to use the developed software to conduct an engineering design and economic evaluation analysis specifically for this site. The outcomes of the evaluation for this early version of the case study were summarized in the Topical Report (Sevim, 1996).

The placement demonstrations have been completed in October 1997; and as a result, new information on equipment, labor, cost, and operation principles have become available. The case study has then been updated using this new information. New evaluation runs have been conducted for the updated case, along with sensitivity analysis on the amount of byproduct that can be placed through a single borehole. The outcomes will be summarized within two weeks in a paper titled "Engineering Economic Analysis of Underground Placement of Byproducts in Central Illinois: A Case Study." This paper will be presented in the Annual Meeting of Society for Mining, Metallurgy, and Exploration Inc., to be held in Orlando, Florida, on March 9-11, 1998.

2. Preparation of the user's manual for the developed software is currently underway. In this quarter, approximately 25% of the manual have been completed.

3.3 Plans for the Next Quarter

In the next quarter three major tasks will be undertaken:

1. Prepare the paper for the SME Annual Meeting.
2. Finalize the software by making the necessary modifications to accommodate the new information coming from the hydraulic and pneumatic underground placement demonstration.
3. Complete the user's manual for the developed software.

3.4 References

Sevim, H., 1996. "Materials Handling and System Economics." A Final Topical Report, USDOE, Cooperative Agreement No. DE-FC21-93MC-30252, Morgantown Energy Technology Center, Morgantown, WV.

SECTION 4

ENVIRONMENTAL ASSESSMENT AND GEOTECHNICAL STABILITY

**DR. STEVE ESLING
CO-PRINCIPAL INVESTIGATOR**

4.0 Environmental Assessment and Geotechnical Stability

4.1 Accomplishments

Researchers from SIUC and the ISGS involved with the Environmental Assessment portion of the project continued groundwater monitoring during the second quarter of the third phase. Deep wells were sampled in August, September and October. The shallower monitoring wells were sampled in August. Water quality analyses are available for all samples collected through September. An appendix to this report summarizes depths to water, parameters determined in the field, and cation and anion concentrations. A graph in the appendix summarizes the trend in major cations and anions found in the strata bounding the target panels. The ISGS Geochemistry Laboratory completed all laboratory analyses. The water in the units bounding the target panels remains a nonpotable brine. Well development by circulating potable water down the well casings just after installation of the monitoring wells still influences groundwater quality.

The researchers also sampled and analyzed tritium content in selected wells in order to further evaluate the impact of well development. Two regularly sampled deep wells show elevated levels of tritium during the October sampling event (Table 4.1). In general, tritium concentrations on the recent samples have declined over samples collected in July (Table 4. 2). One deep well, however, shows a higher level of tritium in October, possibly suggesting a source of tritium other than development water.

Finally, well recovery in response to purging and sampling was analyzed to determine the hydraulic conductivity under the assumptions typical of a bail test (Hvorslev, 1951). Table 4.3 summarizes the results. These values are comparable to those determined from the packer tests conducted earlier in the project and suggest that the strata bounding the mine are characterized by very low values of hydraulic conductivity. Figures presented in the appendix show typical recovery trends from two of the wells.

4.2 Plans

Plans for the next quarter include continued monitoring of hydraulic head and groundwater chemistry at the study site.

Table 4.1. Tritium analyses for samples collected from selected wells in the study area in October, 1997.

Well Number	Lithology	Tritium Concentration (TU)	Standard Deviation
2a	Shallow Bedrock	1.29	0.21
5a	Shallow Bedrock	13.00	0.35
6a	Shallow Bedrock	2.68	0.22
2b	Sandstone	2.18	0.22
5b	Sandstone	4.22	0.23
4	Coal	3.82	0.22
3b	Fractured Zone	2.68	0.21

Table 4. 2. Tritium analyses for samples collected from selected wells in the study area in July, 1997.

Well Number	Lithology	Tritium Concentration (TU)	Standard Deviation
2a	Shallow Bedrock	2.65	0.23
5a	Shallow Bedrock	12.33	0.32
6a	Shallow Bedrock	5.29	0.25
2b	Sandstone	1.6	0.21
5b	Sandstone	5.8	0.27
4	Coal	3.63	0.25
3b	Fractured Zone	3.58	0.24

Table 4.3. Single well permeability test average results.

Well Number	Lithology	Hydraulic Conductivity (m/s)	n
2A	Upper Bedrock	$6.4 * 10^{-9}$	2
5A	Upper Bedrock	$8.7 * 10^{-7}$	2
6A	Upper Bedrock	$8.4 * 10^{-9}$	1
2B	Sandstone/Siltstone	$9.2 * 10^{-8}$	2
5B	Sandstone/Siltstone	$7.8 * 10^{-8}$	1
4A	Coal	$1.6 * 10^{-9}$	1

Reference

Hvorslev, M.J. 1951. Time lag and soil permeability in groundwater observations. U.S. Army Corps of Engineers Waterways Experimental Station Bulletin 36. Vicksburg, Mississippi.

SECTION 5

UNDERGROUND PLACEMENT

**DR. Y. P. CHUGH
CO-PRINCIPAL INVESTIGATOR**

**DR. D. DUTTA
CO-PRINCIPAL INVESTIGATOR**

**MR. E. POWELL
RESEARCHER**

5.0 UNDERGROUND PLACEMENT

5.1 Introduction

In the reporting quarter, we concentrated on testing cured grout samples and cored samples that were obtained after 30-days of stoppage of pumping operation. Sixty six samples were tested to determine uniaxial compressive strength and elastic modulus (stiffness) of cured grouts and cored samples. Data were analyzed to ascertain the relationship between compressive strength and stiffness of cured grouts, strength gain over time, and strength variations between cored samples and cured grout samples that were collected during the pumping operation. Also, strength variations of cured grout samples collected on different days during the pumping operation were analyzed to determine the consistency (with respect to strength) of grouts pumped.

5.2 Results and Discussions

Figure 5.1 shows the relationship between compressive strength and elastic modulus of all samples tested so far. A linear relationship indicating a value of 50 for the ratio of stiffness to strength is obtained for cured grouts and cored samples lumped together. However, scatter data indicate that the ratio 50 is more pronounced for strength 300 psi or more. For lower values of strength, the ratio is less than 50.

Figures 5.2 and 5.3 show the gain in strength and stiffness of cured grouts over time. Both the figures indicate logarithmic gain of strength and stiffness over time. Strength reaches a value of approximately 600 psi in 60 days and the rate of strength gain starts to slow down. The same behavior is exhibited by elastic modulus. The ratio of stiffness to strength is approximately 50 at 60 days of curing.

Figure 5.1 Relationship between uniaxial compressive strength and elastic modulus

Figure 5.2 Strength gain over time

Figure 5.3 Gain in elastic modulus value over time

5.3 Plans for the Next Quarter

We plan to continue testing more samples for strength and stiffness characteristics. Some of the samples have been kept immersed in water and those samples will be tested to determine the effects of water on cured samples. Permeability of the samples will also be determined. An additional core hole will be drilled to obtain cores. These samples will be tested for engineering properties.

5.4 Pneumatic Injection.

At the completion of the first quarter, when approximately 2,000 tons of flyash had been injected through the main test borehole, the hole became plugged. To remove the plug by drilling, the one inch water injection line had to be withdrawn. In doing so it was hoped that the passageway through the plug left by the injection line would allow sufficient air to flow through and possibly erode the flyash forming the plug and hence solve the plugging problem without having to bring in a drilling rig. The video camera, fitted with the vertical viewing lens was lowered down the borehole and the plug located approximately twenty feet from the roof of the entry. The hole in the plug left by withdrawing the injection line could be clearly seen. However, when the compressed air was applied to the borehole, the pressure built up to 100 psig, confirming that either the hole through the plug had resealed from the material absorbing the water draining down the borehole and swelling or the entry was completely filled in the vicinity of the borehole. To confirm which of these possibilities was the cause of the blockage, the borehole casing required reaming. As the drilling contractor was not available at this time, it was decided to continue filling this section of the mine through a ventilation hole approximately six hundred (?) feet to the north of the plugged borehole.

As the ventilation borehole was lined with a four inch casing, an adapter was fabricated to attach the six inch conveying line from the injection equipment to the casing. The equipment was moved to the new location in one day using a 5 cubic yard front end loader fitted with lifting forks (as previously used). It took three men one day to move the equipment and have it ready for operating by the next morning. Four tanker loads, each averaging 27 tons of flyash were unloaded and injected on the first morning following the move. The maximum number of tankers handled in any one day through the four inch borehole was seven. This however was not due entirely to the restricted size of the borehole, but due to the unavailability of flyash from the ADM power plant. The four inch borehole conveying pressure maxed at 15 psig and the material flow had to be restricted resulting in an injection rate of 40 tons per hour, i.e. it took 40 minutes to discharge a tanker load of 27 tons. This compares to a conveying pressure of 11.5 psig and an injection rate of 55 tons per hour for the six inch borehole. When a total of 600 tons of flyash had been injected through the four inch borehole, it too became plugged and required reaming.

During this test run a pressure transducer was lowered into the boreholes used for the preliminary test to measure the underground air pressure during injection and when the air blast was applied. The results are covered in section ? of this report.

Figure 5.4 shows strength at 60 and 120 days of curing for cored samples and cured grout samples that were collected during the pumping operation. At 60-day curing, strength of cored samples and cured grout samples are almost the same. This indirectly indicates that the grouts pumped underground were consistent (with respect to strength) from day to day because the strength of cured samples were obtained by averaging samples collected on different days during the pumping operation and the cored samples were collected from a point source that represented grouts produced in a particular day. However, strength of cored samples at 120-day curing indicates 19% higher value than the strength of cured grouts. The stiffness property also exhibits the same behavior.

Figure 5.4 Strength comparison between cored and cured samples

Figure 5.5 shows average 60-day strength of samples collected on different days during the pumping operation. Samples collected on the same day were grouped together and shown as batch (1 to 4) in Figure 5.5. For comparison purposes, average strength of cored samples (at 60-day curing) is also shown in the same chart. Average compressive strengths of samples collected on different days show clustering of strength data in the range of 500 to 600 psi. This indicates that the grout consistency (with respect to strength) was maintained during the pumping operation.

Figure 5.5 Strength comparison of grouts samples collected on different days

5.4.1 Reaming the Boreholes: The six inch and the four inch boreholes were reamed on September 5th. In both holes the drilling bit encountered the plug approximately 20 to 25 feet above the roof level of the mine entry. In the six inch hole, the drilling fluid was lost prior to the plug being completely reamed through. The reason for this became evident when the video camera was lowered down the borehole, showing the lower twenty foot section of the PVC borehole casing had broken away, dropping about 16 inches and now probably resting on the fill material. The drilling fluid would have escaped through the gap in the PVC casing and down the annular space between the outer wall of the casing and the bored hole. It was difficult to determine from the view received from the camera if there was an opening between the bottom of the PVC casing and the top of the fill material of sufficient size to allow the further conveying of flyash. We detected an upward flow of air through the borehole, but not of the magnitude prior to the plugging and may have been restricted due to the casing sitting on the fill material.

The video camera used for the exploration was of the surveillance type readily purchased in department stores. This was attached to the bottom of the camera sonde and as a result was too great a distance from the light source which had been set up for the original down the hole camera. This was rectified by installing a small flashlight closer to the surveillance camera. The inner wall of the bore hole liner was clearly seen and the sixteen inch opening at the break, however it was not possible to confirm if any passageway existed over or through the fill material in the vicinity of the borehole.

The four inch hole was reamed but the camera not lowered as there was a possibility of the unit becoming jammed in the borehole with the modifications made to the camera mounting and flashlight. An upward flow of air through the borehole indicated there is an opening to the entry but whether this is of a sufficient size to allow the conductivity of flyash remains a conjecture.

Borehole Blockages: There have been three occasions when the boreholes down to the underground entries have plugged. The first plug occurred whilst filling the pre-test six inch borehole. It was assumed that the blockage was as a result of the inclusion of adhesive clay in with the flyash as it was reclaimed from the stockpile, as at the time it plugged very little flyash had actually been transported through the borehole. The situation was further aggravated by the un-noticed flow of water into the borehole when the water from the storage tank siphoned through the water pump following shutting down the system. Following reaming of this hole, a further 400 tons of flyash was injected, and to date this borehole remains clear as observed by the upward flow of natural ventilation air.

The main test six inch borehole blockage was unexpected as up to the instant the plug occurred there was no indication from the conveying air pressure gauge of a restrictive passageway through the in place material. In addition, the water was being injected at the bottom of the borehole, at the roof level in the entry, where the conveying air is at its highest velocity to disperse the water emerging from the spray holes of the injection pipe. Now that we have observed the break in the PVC borehole liner, the escaping air could have resulted in the material plugging in the lower section of the borehole. The break however could have occurred during the plug reaming process, which could not be confirmed by the drill operator. The reason for the plugging may therefor be as a result of condense present in the borehole due to the expansion and cooling of the humid compressed air and the quick reaction of the ADM flyash to solidify and swell.

The four inch borehole plug may have occurred due to overfeeding the fly ash. Whereas with the six inch borehole the conveying pressure rarely exceeded 11.5 psig, the four inch hole would have attained pressures higher than 15 psig had it not been for the operator restricting the flow of material. (A four inch diameter casing is less than half the cross sectional area of a six inch diameter casing). With the long delay between tanker loads, the high air humidity and water injection at the elbow (the space would have been too restricted if the one inch injection line had been installed in this borehole), these various factors could have contributed to the plugging of the borehole after only six hundred tons had been injected. Without a video camera to confirm the fill conditions in the entry it is not known if filling can continue in this borehole.

Equipment Operation: During this phase of the injection program, a major wear problem has shown up in the operation of the vessel filling gate valves. These twelve inch, air cylinder actuated valves, which controls the flow of material from the hopper into the transporting tanks and seals against the conveying pressure, showed severe signs of wear in the stainless steel blades and seats. They have been kept operating by frequently repacking and inserting liberal amounts of heavy duty grease between the packing strips. In retrospect, butterfly valves should have been used in this application.

We also determined the probable cause of the lockup of the feed screws at the instant the air flow is switched to the transporting tanks. This resulted in the slowing and stalling of the air motors driving the hydraulic pumps as they were not designed to handle this overload condition. It appears the initial air flow into the tanks through the rotor tube and sliding valves heaves all the material to the discharge end of the tank forming a fairly solid plug which restricts the feed screw turning. The diesel power pack has just sufficient power to keep the feed screw turning under these conditions, though at reduced revolutions. As the material is gradually discharged, the feed screw revolutions return to the normal speed and the tanks are cleared of flyash. As using compressed air powered hydraulics is more economical than a diesel powered hydraulic unit when an air compressor is being utilized to supply the air for conveying, modifications to the design of the screws is required. The air flowing through the rear end slide valves should be restricted.

During the later operations of the pneumatic injection equipment, a sever vibration would be experienced on occasions emanating from the left hand side feed tank. It appeared one of the sliding valve rods has broken free of the retaining disc and is rubbing on the shell. The rotor was not removed at this time as the injection equipment continued to operate. However the tank end cover will require opening and the rotor withdrawn prior to any further prolonged test run.

The equipment has proven simple to run and operators readily trained in the sequencing of the valves. It is readily moved to a new location and with further experience could probably be moved and set up at the next borehole in one day by two men using a large front end loader fitted with lifting forks, or towing with a bulldozer.

It is important to make arrangements for the tanker- trailer units to "pull through" at the pneumatic injection equipment. This was the arrangement at the six inch borehole, but could not be arranged at the four inch hole without substantial road bed material being laid down. The tanker drivers in pulling up to the infeed end of the injection equipment readily spot their trucks to make the hose connection, whereas without the pull through they have to back up whilst turning into the equipment. It is also more convenient for the injection equipment operator, especially with the trailer material and air

flow control valves adjacent to and in full view of the operator. Both the operator and truck driver can visually signal each other for better overall performance.

Spacing of the tanker delivery is important in the overall efficiency. When injecting through the six inch hole a tanker could be completely discharged in thirty minutes, from pulling up to leaving. Therefor two tankers per hour spaced on the half hour would be ideal. However, we would often receive three tankers arriving at the same time. This resulted in the last tanker waiting one and a half hours before discharge could take place and therefor could not make the fourth trip to the ADM Power Plant.

5.5 Conclusion.

A review of the situation in regards to the next step to be taken in the pneumatic injection program was made on September 8, 1997. It was concluded that although both the six inch and four inch holes were now open to the mine entry, it could not be determined if there were a passageway through the material in place to allow the further injection of flyash. Therefore, the additional cost of setting up the equipment and providing an operator, support equipment, etc. was not justified as it was doubtful if any further experience would be gained. The pneumatic injection program was therefore concluded with a total of 3,000 tons of ADM flyash being injected into the Peabody Number 10 Mine.

SECTION 6

STEEL INTERMODAL CONTAINER

Dr. Y. P. Chugh
Co-Principal Investigator

Mr. Gary Wangler
Researcher

6.0 STEEL INTERMODAL CONTAINER

6.1 Objective

The "Steel Intermodal Container" portion of the overall program has as its objective the modification of a standard steel intermodal container (dimensions of 20 feet length, 8 feet width, and 8 feet height) to efficiently and effectively transport dry coal combustion by-products, particularly fly ash. By modifying the standard steel intermodal container CCB material could be transported by rail, by highway trucks, and by barges without the problem of fugitive dust. The modification of the steel intermodal container consists of developing ways to efficiently load and empty the container in environmentally friendly ways.

6.2 Work During the Quarter

In an earlier quarter a steel intermodal container was purchased. During this quarter the container was transported to the Wilson Manufacturing and Design, Inc. located in Cecilia, Kentucky. Wilson Manufacturing is one of the leading manufacturers of bulk handling equipment, and one of the cooperating companies in this portion of the program. It was decided that an emptying system would be designed around a Wilson manufactured conveyor system.

Originally it was thought that a 20-ton capacity for the steel intermodal container would be sufficient. However, studies indicated that to be competitive with other transportation methods the system should be designed to transport 25 tons. Transcraft Manufacturing Company in Anna, Illinois has a flat-bed trailer capable of hauling a steel intermodal container with a 25 ton load.

In consultation with Wilson Manufacturing, the container modification was redesigned so as to fit the flat-bed trailer transportation. A new door arrangement was designed to accommodate emptying to feed the Wilson conveyor system. The final for the SIC is shown in Figure 6.1. The design modifications for the container were completed early in October, 1997. A photograph of the redesigned SIC is shown in Figure 6.2.

6.3 Plans for the Next Quarter

Field demonstration of the SIC will be completed and a draft final report will be prepared.

PRELIMINARY

THIS DRAWING AND DESIGN AND CONTENTS
HEREIN ARE THE EXCLUSIVE
PROPERTY OF WILSON MANUFACTURING
& DESIGN, INC. AND ARE NOT TO
BE LOANED OR REPRODUCED OR COPIED
OR IN ANY MANNER, WITHOUT THE WRITTEN
CONSENT OF WILSON MANUFACTURING

Wilson Manufacturing & Design Inc									
Unit Train Unloading Systems					Steel Fabricators				
Bulk Materials Handling Systems					Project Design				
1011 East Main St. Cooke, Kentucky, 42724					Ph. 502-982-3200				
Date	Project Number	Scale	Drawn	CHK					
5-11-77		1/4" = 1'	JRN						
Sheet	Preliminary Layout for Ash Handling Equipment								
Drawn									
Customer	S.I.C. (Steel Intermodal 99999)								
Local	Org #	Sub-Shop	Shop	Revision					
	1201	05	02						
"It's Simple. Wilson Builds Equipment Better."									

Figure 6.1 Design of the Steel Intermodal Container (SIC)

Figure 6.2 Photograph of the Steel Intermodal Container (SIC)

SECTION 7

PLANS FOR THE NEXT QUARTER

7.0 PLANS FOR THE NEXT QUARTER

The following activities are planned.

- 1) Drill an additional corehole through hydraulically placed backfill.
Perform engineering tests on the recovered cores.
- 2) Continue to monitor subsidence and groundwater quality.
- 3) Finalize the User's Manual for the material handling evaluation system.
- 4) Initiate preparation of a draft final report.
- 5) Submit a topical report on the environmental studies.
- 6) Demonstrate the SIC at the Wilson's Manufacturing Facility in Cecilia, Ky.

APPENDIX I

APPENDIX 1

Figure 1. Major anions and cations (mg/l) of well 3. Solid points refer to the left axes while open points refer to the right axes.

Figure 2. Major anions and cations (mg/l) of well 4. Solid points refer to the left axes while open points refer to the right axes.

APPENDIX 1 (Continued)

Figure 3. Pumping and recovery of Well 2A (August 1997) in lower unconsolidated material.

Figure 4. Pumping and recovery of Well 2B (August 1997) in sandstone and siltstone.

APPENDIX 1 (Continued)

Table 1: Screened interval and depth to water measurement in 1996, monitoring wells 2A, 3, and 4. Deepest wells in each nest are the sampled wells.

Well nest	2A	2B	2C	3A	3B	4A
Screened interval (feet)	75-80	213.25-218.25	340-345	201-206	282.5-287.5	343.5-348.5
9/25/95*	16.87	83.7	237.45	27.5	13.17	257.73
1/8/96	21.22	82.46	NW	42.92	23.67	-
2/6/96	14.48	73.52	NW	-	-	341.43
2/7/96	-	-	-	44.51	274.21	-
3/1/96	-	-	-	-	279.18	341.77
3/2/96	12.9	72.5	NW	-	-	-
3/11/96	15.35	72.27	NW	47.36	282.8	344.16
3/29/96	14.37	71.54	NW	48.25	281.95	343.13
4/9/96	14.16	71.26	NW	48.83	282.81	343.91
5/7/96	14.46	70.33	NW	49.87	281.49	342.48
5/15/96	14.36	70.07	NW	49.97	NW	343.61
6/10/96	-	-	-	50.36	282.14	342.69
6/11/96	14.33	69.36	NW	-	-	-
6/23/96	14.09	69.25	NW	48.81	NW	343.44
7/18/96	14.65	68.90	NA	49.33	NA	NA
7/26/96	14.80	68.80	NW	49.51	NW	314.33
8/23/96	14.82	68.42	NA	**	**	NA
8/30/96	14.78	68.36	NA	51.95*	283.28*	NA
10/2/96	14.64	68.02	NW	**	**	NW
10/12/96	14.65	67.99	NW	**	**	344.99
11/12/96	14.605	67.755	345.72	**	**	NA
11/21/96	14.54	67.61	NW	**	**	NA
1/7/96	14.245	67.2	352.73	50.38	274.775	343.39

APPENDIX 1 (Continued)

Table 2: Screened interval and depth to water measurement in 1997, monitoring wells 2A, 3, and 4. Deepest wells in each nest are the sampled wells.

Well nest	2A	2B	2C	3A	3B	4A
Screened interval (feet)	75-80	213.25-218.25	340-345	201-206	282.5-287.5	343.5-348.5
1/22/97	14.165	51.67	NW	50.43	276.37	NA
2/13/97	14.11	66.88	NW	50.48	279.97	NA
2/20/97	14.085	66.82	NW	50.49	282.795	344.29
3/2/97	14.03	66.34	NW	-	-	-
3/13/97		67.33	NW	50.55	NW	344.02
3/20/97	-	-	-	50.44	NA	NA
4/xx/97	21.195	66.88	-	50.61	282.21	-
4/23/97	53.39	70.19	-	TS	NW	340
5/21/97	23.68	TS	348.38	TS	282.46	342.58
5/28/97	44.99	69.95	348.43	TS	283.1	343.35
6/26/97	19.585	68.15	NW	TS	282.64	242.51
7/2/97	17.83	68.19	348.36	TS	NW	343.62
8/6/97	19.49	68.43	348.43	TS	282.39	342.20
9/13/97	23.88	69.08	348.42	TS	282.82	342.23
10/20/97	20.92	69.27	348.45	TS	282.75	342.44
10/29/97	43.79	69.93	348.44	TS	NW	342.87

NA Indicates broken tape measure.

NW Indicates no measurable water level.

TS Tape measure unable to reach water due to obstruction

* Measuring tape not fully labeled so there is a greater, and unknown error with these readings.

** Well damaged, no measurement possible

- No measurement taken on this date.

APPENDIX 1 (Continued)

Table 3: Screened interval and depth to water measurement in 1996, monitoring wells 5 and 6.
Deepest wells in each nest are the sampled wells.

Well nest	5A	5B	5C	6A	6B	6C
Screened interval (feet)	73-78	215-220	337-342	71-76	216.5-221.5	311-316
9/25/95*	8.1	18.9	66.7	16.18	48.85	260.4
1/8/96	-	-	-	-	-	-
2/6/96	4.12	65.23	N/A	10.84	13.77	NW
2/7/96	4.56	83.94	313.44	13.4	21.47	312.77
3/1/96	-	-	-	-	-	-
3/2/96	3.38	55.13	326.4	11.1	25.8	NW
3/11/96	N/A	N/A	N/A	N/A	N/A	NW
3/29/96	3.34	64.37	NW	10.79	27.67	NW
4/9/96	35.2	64.17	NW	10.28	28.29	NW
5/7/96	N/A	N/A	N/A	N/A	N/A	N/A
5/15/96	2.75	62.89	325.84	10.31	30.16	NW
6/10/96	-	-	-	-	-	-
6/11/96	3.86	64.66	325.24	10.18	31.82	NW
6/23/96	4.19	62.31	325.26	10.03	25.21	NW
7/18/96	4.31	62.93	NA	9.45	26.28	NA
7/26/96	4.38	42.33	NW	9.24	26.55	NW
8/23/96	3.96	63.36	NA	9.33	27.59	NA
8/30/96	4.30	62.87	NA	NA	NA	NA
10/2/96	4.34	64.33	NW	9.36	28.87	NW
10/12/96	5.93	63.32	327.44	9.62	29.12	NW
11/12/96	4.15	63.89	NA	9.56	29.975	316.2
11/21/96	4.545	63.75	NA	9.555	30.23	NW
1/7/96	4.35	62.36	NW	9.60	31.27	316.68
1/22/97	4.245	61.75	NW	9.61	31.575	NW
2/13/97	3.88	61.51	NW	9.7	32.00	NW
2/20/97	-	-	-	-	-	-
3/2/97	-	-	-	-	-	-
3/13/97	3.31	61.4	NW	9.745	32.435	NW
3/20/97	3.285	61.47	327.84	8.95	31.615	NW

APPENDIX 1 (Continued)

Table 4: Screened interval and depth to water measurement in 1997, monitoring wells 5 and 6.
Deepest wells in each nest are the sampled wells.

Well nest	5A	5B	5C	6A	6B	6C
Screened interval (feet)	73-78	215-220	337-342	71-76	216.5-221.5	311-316
1/22/97	4.245	61.75	NW	9.61	31.575	NW
2/13/97	3.88	61.51	NW	9.7	32.00	NW
2/20/97	-	-	-	-	-	-
3/2/97	-	-	-	-	-	-
3/13/97	3.31	61.4	NW	9.745	32.435	NW
3/20/97	3.285	61.47	327.84	8.95	31.615	NW
4/xx/97	-	-	-	-	-	-
4/23/97	3.89	63.04	327.77	10.01	33.16	319.63
5/21/97	4.16	62.80	NW	11.19	42.475	319.38
5/28/97	4.52	63.15	327.84	20.74	TS	319.33
6/26/97	4.265	64.92	NW	10.97	TS	319.28
7/2/97	4.38	65.90	TS	-	-	-
8/6/97	5.41	66.98	NW	11.30	183.13	319.38
9/13/97	5.43	66.72	327.60	11.93	177.04	319.31
10/20/97	5.98	67.34	NW	12.12	NW	319.41
10/29/97	6.37	68.83	NW	20.65	176.67	319.36

N/A Indicates broken tape measure.

NW Indicates no measurable water level.

* Measuring tape not fully labeled so there is a greater, and unknown error with these readings.

- No measurement taken on this date.

APPENDIX 1 (Continued)

Table 5: Depth to water measurement, samples collected, and flow-through-cell parameters for deep wells in each well nest, February 6 to March 11, 1996.

Date	Well #	DTW (feet)	Time pumped (min)	Cation sample	Anion, Acidity, Alkalinity sample	Temperature (C)	ORP (mV)	Conductance (mhos)	pH	O2 (ppm)
2/6/96	2A	NW	38							
2/7/96	3	274.21	14	250	500, 250	17.5	27	11.3	12.87	2.3
2/6/96	4	341.43	20	250	IW (125)	13.3	169	2.51	8.21	3.1
2/7/96	4	ND	150	250	500					
2/6/96	5	NW	14	250	500, 250	15.7	56	17.2	12.88	4.3
2/6/96	6	NW	40							
3/2/96	2A	NW	20							
3/1/96	3	279.18	25	NW	IW (150)	11.7	-96	10	7.82	3.7
3/2/96	3	ND	65	IW (75)	NW					
3/1/96	4	341.77	118	NW	IW (25)	9.7	-78	5.03	7.24	2.3
3/2/96	4	ND	105	250	IW (75)					
3/2/96	5	NW	40							
3/2/96	6	NW	45							
3/11/96	2A	NW	18							
3/11/96	3	282.8	110	175	500					
3/11/96	3	ND	71	175	NS					
3/11/96	4	344.16	10	250	500	8.4	19	4.99	8.47	7.1
3/11/96	5	ND	20	IW	IW (25)					
3/11/96	6	NW	15							

APPENDIX 1 (Continued)

Table 6: Depth to water measurement, samples collected, and flow-through-cell parameters for deep wells in each well nest, March 29 to May 7, 1996.

Date	Well #	DTW (feet)	Time pumped (min)	Cation sample	Anion Acidity Alkalinity sample	Temperature (C)	ORP (mV)	Conductance (mhos)	pH	O2 (ppm)
3/29/96	2A	NW	13							
3/29/96	3	281.95	57			11.3	-52	12.6	7.24	7.3
3/29/96	4	343.13	82			9.6	-44	7.25	6.96	3.4
3/29/96	5	NW	20							
3/29/96	6	NW	*							
4/9/96	2A	NW	10							
4/9/96	3	282.81	118	230	500					
4/9/96	4	343.91	26	250	500					
4/9/96	5	NW	18	IW	IW (20)					
4/9/96	6	NW	11							
5/15/96	2A	NW	11							
5/15/96	3	NW	103	IW (50-75)	500					
5/15/96	4	343.61	7	250	500	20.2	40	12.1	8.14	3.3
5/15/96	5	325.84	15							
5/15/96	6	NW	*							
5/7/96	2A	NW	10							
5/7/96	3	281.49	28			16.3	-58	15	11.7	4.6
5/7/96	4	342.48	98			16.0	-29	9.23	8.11	4.1
5/7/96	5	NW	7							
5/7/96	6	NW	*							

APPENDIX I (Continued)

Table 7: Depth to water measurement, samples collected, and flow-through-cell parameters for deep wells in each well nest, July 10 to July 26, 1996.

Date	Well #	DTW (feet)	Time pumped (min)	Cation sample	Anion Acidity Alkalinity sample	Temperature (C)	ORP (mV)	Conductance (mhos)	pH	O2 (ppm)
6/11/96	2A	NW	10							
6/10/96	3	282.14	59			19.1	-61	13 uS	12.14	4.9
6/10/96	4	342.69	93			16.3	-44	16 uS	8.18	3.7
6/11/96	5	325.24	46			18.2	-108	28.9	12.258	4.5
6/10/96	6	NW	10							
6/23/96	2A	NW	10							
6/23/96	3	NW	112	IW (100)	IW (450)					
6/23/96	4	343.44	10	250	500	23.8	-75	15.8	7.87	3.4
6/23/96	5	325.26	23	250	500					
6/23/96	6	NW	10							
7/18/96	2A	NA	15							
7/18/96	3	NA	53			23.4	18	15.4	11.62	5.8
7/18/96	4	NA	64			19.2	42	16.4	8.02	8.4
7/18/96	5	NA	15							
7/18/96	6	NA	13							
7/26/96	2A	NW	10							
7/26/96	3	NW	60	NS	IW-(250)					
7/26/96	4	314.33	12	250	500	33.9	45	16.1	8.19	2.7
7/26/96	5	NW	8							
7/26/96	6	NW	20							

APPENDIX 1 (Continued)

Table 8: Depth to water measurement, samples collected, and flow-through-cell parameters for deep wells in each well nest, August 30 to November 21, 1996.

Date	Well #	DTW (feet)	Time pumped (min)	Cation sample	Anion Acidity Alkalinity sample	Temperature (C)	ORP (mV)	Conductance (mhos)	pH	O2 (ppm)
8/30/96	2A	NA	15							
8/30/96	3	283.28	0**	**	**					
8/30/96	4	NA	26	250	500					
8/30/96	5	NA	10							
8/30/96	6	NA	NA	NA	NA					
10/2/96	2A	NW	10							
10/2/96	3	**	**							
10/2/96	4	255.75	46			15.8	21	17.7 uS	8.31	6.2
10/2/96	5	NW	13							
10/2/96	6	NW	10							
10/12/96	2A	NW	12							
10/12/96	3	**	**	**	**					
10/12/96	4	344.99	77	250	500					
10/12/96	5	327.44	8							
10/12/96	6	NW	10							
11/12/96	2A	345.72	10							
11/12/96	3	NA	**							
11/12/96	4	NA	15							
11/12/96	5	NA	12							
11/12/96	6	316.2 ?	10							
11/21/96	2A	NW	11							
11/21/96	3	NA	**	**	**					
11/21/96	4	NA	95	500	250					
11/21/96	5	NA	10							
11/21/96	6	NW	*							

APPENDIX 1 (Continued)

Table 9: Depth to water measurement, samples collected, and flow-through-cell parameters for deep wells in each well nest, January 7, 1996 to March 12, 1997

Date	Well #	DTW (feet)	Time pumped (min)	Cation sample	Anion Acidity Alkalinity sample	Temperature (C)	ORP (mV)	Conductance (mhos)	pH	O2 (ppm)
1/7/97	2A	352.73	10							
1/7/97	3	274.78	20			9.4	51	13.3	6.33	6.9
1/7/97	4	343.39	35			8.0	76	14.6	7.46	6.4
1/7/97	5	NW	10							
1/7/97	6	316.68	10							
1/22/97	2A	NW	10							
1/22/97	3	276.37	10	500	250	11.1	27	13.5	10.02	3.3
1/22/97	4	NA	20	500	250	11.0	39	16.7	7.4	4.1
1/22/97	5	NW	10							
1/22/97	6	NW	0							
2/13/97	2A	NW	8							
2/13/97	3	279.97	31			8.9	-125	15.4	7.01	7.3
2/13/97	4	NA	57			6.4	-165	17.3	6.94	2.8
2/13/97	5	NW	8							
2/13/97	6	NW	7							
3/12/97	2A	NW	0							
3/12/97	3	344.02	23			11.0	-9	20.8	7.72	5.7
3/12/97	4	NA	0							
3/12/97	5	NW	0							
3/12/97	6	NW	0							

APPENDIX I (Continued)

Table 10: Depth to water measurement, samples collected, and flow-through-cell parameters for deep wells in each well nest, March 20 to May 21, 1997

Date	Well #	DTW (feet)	Time pumped (min)	Cation sample	Anion Acidity Alkalinity sample	Temperature (C)	ORP (mV)	Conductance (mhos)	pH	O2 (ppm)
3/20/97	2A	ND	0							
3/20/97	3	NA	155	350	175					
3/20/97	4	NA	26	500	250					
3/20/97	5	327.84	4							
3/20/97	6	NW	0							
4/X/97	2A	21.195	25			16.3	-147	14.7	12.11	3.8
4/X/97	2B	66.88	23			14.6	-132	311	9.58	1.4
4/X/97	3A	50.61	40			12.4	-72	247	10.03	2.3
4/X/97	4A		46			12.2	-103	17.8	8.62	2.3
4/X/97	5A		27			15.1	-126	2.20	11.83	3.5
4/X/97	5B		35			14.7	-129	346	11.17	3.8
4/23/97	2B	70.19	40			13.2	-161	18.1	9.72	
4/23/97	3B	NA	190	225	250					
4/23/97	4A	340.00	20	250	500					
4/23/97	5A	3.89	30			14.4	-114	1.196	11.12	
5/21/97	2A	23.68	24			13.6	-114	10.85	9.56	
5/21/97	2B	NA	43			13.7	-137	10.37	14.8	
5/21/97	3B	282.46	35			16.5	-64	10.37	13.8	
5/21/97	4A	342.58	18			15.0	-30	10.26	16.2	
5/21/97	5A	4.16	35			15.3	-172	10.46	1.061	
5/21/97	5B	62.80	45			15.4	-134	10.66	7.79	
5/21/97	6A	319.38	20			15.0	-156	10.99	9.04	
5/21/97	6B	42.475	46			15.1	-168	10.41	0.226	

APPENDIX I (Continued)

Table 11: Depth to water measurement, samples collected, and flow-through-cell parameters for deep wells in each well nest, May 28 to September 13, 1997

Date	Well #	DTW (feet)	Time pumped (min)	Cation sample	Anion Acidity Alkalinity sample	Temperature (C)	ORP (mV)	Conductance (mhos)	pH	O2 (ppm)
5/28/97	3B	283.10	110	150	300					
5/28/97	4A	343.35	10	250	500					
6/26/97	3B	282.64	50			17.9	-38	8.41	13.6	
6/26/97	4A	242.51	60			18.2	-22	7.81	15.4	
6/26/97	5A	4.265	26			17.8	-117	10.51	1.030	
6/26/97	5B	64.92	46			17.8	-94	10.97	7.77	
7/2/97	4A	343.62	30	250	500					
8/6/97	2A	19.49	19			14.4	17	7.94	10.67	1.7
8/6/97	2B	68.43	39			14.5	-108	17.6	8.31	1.5
8/6/97	3B	282.39	52			20.0	26	14.5	7.97	2.9
8/6/97	4A	342.20	58			18.4	8	15.0	7.51	3.0
8/6/97	5A	5.41	24			17.2	-61	0.978	9.11	2.3
8/6/97	5B	66.98	14			16.1	-60	9.48	10.2	3.2
8/6/97	6A	11.30	21			15.9	-59	11.19	7.28	2.1
9/13/97	2A	23.88	22			14.2	50	7.62	8.50	2.5
9/13/97	2B	69.08	26			14.2	35	17.0	7.20	6.2
9/13/97	3B	282.82	4							
9/13/97	4A	342.23	54			15.9	44	14.5	6.62	5.1
9/13/97	5A	5.43	23			17.4	28	0.956	7.50	3.1
9/13/97	5B	66.72	23			17.1	15	12.2	7.88	23
9/13/97	6A	11.93	18			16.6	6	6.9	9.13	2.2

Table 12: Depth to water measurement, samples collected, and flow-through-cell parameters for deep wells in each well nest, October 20 to October 29, 1997

Date	Well #	DTW (feet)	Time pumped (min)	Cation sample	Anion Acidity Alkalinity sample	Temperature (C)	ORP (mV)	Conductance (mS)	pH	O2 (ppm)
10/20/97	2A	20.92	23			13.3	22	7.22	8.25	4.1
10/20/97	2B	69.27	15			13.8	29	16.7	7.07	4.6
10/20/97	5A	5.98	28			16.1	20	7.63	0.930	13.4
10/20/97	5B	67.34	25			15.9	20	11.5	7.70	Fail
10/20/97	6A	12.12	23			14.9	39	8.50	6.74	4.4
10/29/97	2A	43.79	9							
10/29/97	2B	69.93	30			13.5	-40	18.0	6.79	3.8
10/29/97	3B	NW	237	175	300					
10/29/97	4A	342.87	5	250	500					
10/29/97	5A	6.37	27			16.0	-17	0.962	7.34	2.2
10/29/97	5B	68.83	23			16.0	-64	7.64	13.1	5.0
10/29/97	6A	20.65	23			15.7	-41	8.48	6.87	3.2

IW Water yielded but insufficient for full sample. Amount (ml) collected in parentheses.

NA Electric tape measure not functioning

ND No depth to water measurement taken.

NS No water available for sampling.

NW No measurable water in well.

* Could not access well with sampling equipment.

** Well damaged and unpumpable

APPENDIX 1 (Continued)

Table 13. Well 3B cation data from groundwater samples collected at the Peabody #10 Mine site.

Date	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	La	Li	Mg	Mn
07-Feb-96	0.11	0.008	0.54	0.37	<0.002	10.1	<0.01	<0.01	<0.01	<0.01	0.01	418	<0.002	1.22	0.02	<0.01
10-Mar-96	0.1	0.016	0.77	0.19	<0.002	14.8	<0.01	<0.01	<0.01	<0.01	0.01	324	<0.002	1.02	0.01	<0.01
09-Apr-96	0.1	0.004	0.77	0.14	<0.001	20.2	<0.01	<0.01	<0.01	<0.01	0.03	255	<0.002	0.88	0.03	<0.01
15-May-96	0.04	0.002	0.78	0.13	<0.001	19.4	<0.1	<0.1	<0.01	0.01	<0.01	229	<0.002	0.81	0.02	<0.01
23-Jun-96	0.05	0.003	0.78	0.13	<0.001	23	<0.1	<0.1	<0.01	<0.01	0.04	185	<0.002	0.66	0.12	<0.01
26-Jul-96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22-Jan-97	<0.04	0.009	1.72	0.05	<0.001	60.7	<0.01	<0.01	<0.01	<0.01	<0.1	50	<0.002	0.29	30.1	<0.01
20-Feb-97	<0.02	0.01	0.78	0.05	<0.001	35.8	<0.01	<0.01	<0.01	<0.01	<0.02	63	<0.002	0.29	20.5	<0.01
20-Mar-97	0.04	0.01	0.88	0.06	0.001	45	<0.01	<0.01	<0.01	0.01	<0.1	54	<0.002	0.27	31.5	<0.1
22-Apr-97	<0.2	<1	0.75	0.06	<0.001	56.5	<0.1	<0.1	<0.1	<0.1	<0.1	43	<0.004	0.2	34.2	0.01
28-May-97	<0.2	<1	1.3	0.06	<0.005	74	<0.05	<0.05	<0.05	<0.05	<0.05	39	<0.01	0.18	42.5	0.01
16-Aug-97	<0.2	<2	1.1	0.06	<0.001	121	<0.1	<0.1	<0.1	<0.1	<0.1	38	<0.002	0.23	54	0.04
29-Sep-97	<0.2	<1	0.92	0.06	<0.001	116	<0.1	<0.1	<0.1	0.01	<0.1	32	<0.002	0.2	52.4	0.04

Date	Mo	Na	Ni	Pb	S	Sb	Sc	Se	Si	Sr	Ti	Tl	V	Zn	Zr
07-Feb-96	0.13	1027	<0.03	<0.05		<0.2	<0.003	0.018	1.79	1.54	<0.01	<0.6	<0.01	0.01	<0.01
10-Mar-96	0.11	1680	<0.03	<0.08		<0.1	<0.003	0.039	2.11	1.86	<0.01	<0.3	<0.01	0.01	<0.01
09-Apr-96	0.12	1780	<0.03	<0.04		<0.1	<0.003	0.032	1.81	1.9	<0.01	<0.3	<0.01	<0.01	<0.01
15-May-96	0.12	1830	<0.3	<0.5		<0.1	<0.003	0.035	1.68	1.97	<0.01	<0.3	<0.01	<0.01	<0.1
23-Jun-96	0.1	2280	<0.02	<0.05		<0.2	<0.003	0.042	1.59	2.25	<0.01	<0.3	<0.01	<0.01	<0.1
26-Jul-96	ND	ND	ND	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22-Jan-97	0.04	3460	<0.03	<0.05		<0.2	<0.003	0.09	0.74	3.77	<0.01	<0.3	<0.01	<0.01	<0.01
20-Feb-97	0.04	3360	<0.03	<0.05		<0.2	<0.003	0.081	0.69	3.25	<0.01	<0.3	<0.01	<0.01	<0.01
20-Mar-97	0.03	3350	<0.03	<0.05	269	<0.2	<0.003	0.097	1.28	3.72	<0.01	<0.3	<0.01	<0.01	-
22-Apr-97	0.01	3840	<0.3	<0.5	296	<2	<0.003	<0.2	1.42	3.48	<0.01	<0.3	<0.01	<0.01	-
28-May-97	<0.01	3890	<15	<4	298	<1.0	<0.015	<1.0	1.88	4.55	<0.05	<1.5	<0.05	<0.05	-
16-Aug-97	<0.02	4140	<0.3	<0.5		<0.2	<0.003	<0.1	1.98	5.41	<0.01	<0.5	<0.01	<0.01	-
29-Sep-97	<0.02	4140	0.03	<0.5		<0.2	<0.003	<0.2	1.92	4.94	<0.01	<0.3	<0.01	0.03	.

APPENDIX 1 (Continued)

Table 14. Well 4A cation data (Al - Mn) from groundwater samples collected at the Peabody #10 Mine site.

Date	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	La	Li	Mg	Mn
06-Feb-96	<0.02	0.004	0.42	0.14	<0.002	39.7	<0.01	<0.01	<0.01	<0.01	0.02	7	<0.002	0.03	12	0.09
07-Feb-96	<0.02	0.004	0.4	0.12	<0.002	38.8	<0.01	<0.01	<0.01	<0.01	0.01	8	<0.002	0.03	12	0.08
10-Mar-96	0.03	0.008	0.51	0.14	<0.002	67.8	<0.01	<0.01	<0.01	<0.01	0.04	12	<0.002	0.05	20.2	<0.01
09-Apr-96	0.04	0.002	0.58	0.14	<0.001	97.6	<0.01	<0.01	<0.01	<0.01	0.09	12	<0.002	0.06	30	0.03
15-May-96	<0.02	0.002	0.66	0.15	0.001	118	<0.01	<0.01	<0.01	0.01	0.07	14	<0.002	0.07	36.7	0.03
23-Jun-96	0.04	0.004	0.82	0.16	0.002	168	<0.01	<0.01	<0.01	0.01	0.15	19	<0.002	0.09	52.7	0.04
26-Jul-96	<0.02	0.003	0.86	0.14	0.001	176	<0.01	<0.01	<0.01	<0.01	0.11	20	<0.002	0.09	56.9	0.07
30-Aug-96	0.04	0.008	1	0.15	0.003	200	<0.01	<0.01	<0.01	<0.01	0.1	22	<0.002	0.09	63.5	0.1
12-Oct-96	0.06	0.009	0.89	0.12	<0.001	166	<0.01	<0.01	<0.01	0.01	<0.01	22	<0.002	0.1	53.9	0.1
21-Nov-96	<0.03	0.01	0.99	0.12	<0.001	186	<0.01	<0.01	<0.01	0.01	<0.01	21	<0.002	0.12	57.5	0.15
22-Jan-97	0.07	0.01	2.08	0.14	<0.001	200	<0.01	<0.01	<0.01	<0.01	<0.1	25	<0.002	0.14	65.3	0.15
20-Feb-97	<0.02	0.012	1.07	0.12	<0.001	177	<0.01	<0.01	<0.01	<0.01	<0.02	24	<0.002	0.12	58.9	0.14
20-Mar-97	<0.02	0.012	1.11	0.12	<0.001	181	<0.01	<0.01	<0.01	<0.01	0.03	23	<0.002	0.12	59.7	0.2
22-Apr-97	<0.02	<0.1	0.95	0.1	<0.001	158.5	<0.01	<0.01	<0.01	0.01	0.04	22	<0.004	0.095	51.8	0.135
28-May-97	<0.02	<1.0	1.5	0.13	<0.005	176	<0.05	<0.05	<0.05	<0.05	1.16	22	<0.01	<0.05	60.1	0.24
16-Aug-97	<0.02	<0.2	1.43	0.11	<0.001	175	<0.01	<0.01	<0.01	<0.01	<0.01	24	<0.002	0.15	58.6	0.14
29-Sep-97	<0.02	<0.1	1.13	0.1	<0.001	140	<0.01	<0.01	<0.01	0.01	<0.01	20	<0.002	0.12	51.2	0.07

APPENDIX 1 (Continued)

Table 15. Well 4A cation data (Mo - Zr) from groundwater samples collected at the Peabody #10 Mine site.

Date	Mo	Na	Ni	Pb	S	Sb	Sc	Se	Si	Sr	Ti	Tl	V	Zn	Zr
06-Feb-96	0.03	377	<0.03	<0.05	<0.2	<0.003	0.006	1.79	0.62	<0.01	<0.6	<0.01	0.01	<0.01	
07-Feb-96	0.02	374	<0.03	<0.05	<0.2	<0.003	0.008	1.82	0.6	<0.01	<0.6	<0.01	0.02	<0.01	
10-Mar-96	<0.02	705	<0.03	<0.08	<0.1	<0.003	0.016	2.13	1.31	<0.01	<0.3	<0.01	0.01	<0.01	
09-Apr-96	<0.02	1030	<0.03	<0.05	<0.1	<0.003	0.021	2.46	2.1	<0.01	<0.3	<0.01	0.01	<0.01	
15-May-96	<0.02	1260	<0.3	<0.5	<0.1	<0.003	0.027	2.7	2.79	<0.01	0.4	<0.01	0.01	<0.1	
23-Jun-96	<0.02	2040	<0.02	<0.08	<0.2	<0.003	0.041	3.12	4.01	<0.01	<0.3	<0.01	0.02	<0.1	
26-Jul-96	<0.02	2290	<0.03	<0.04	<0.2	<0.003	0.054	3.16	4.4	<0.01	<0.2	<0.01	0.01	<0.01	
30-Aug-96	<0.02	2770	0.05	<0.05	<0.2	<0.007	0.08	3.52	5.11	<0.01	<0.3	<0.01	0.02	<0.01	
12-Oct-96	<0.02	2510	0.05	<0.05	<0.2	<0.003	0.094	3.21	4.44	<0.01	<0.3	<0.01	0.04	<0.01	
21-Nov-96	<0.02	2790	<0.03	<0.05	<0.2	<0.003	0.087	3.4	4.79	<0.01	<0.3	<0.01	0.02	<0.01	
22-Jan-97	<0.02	3390	<0.03	<0.05	<0.2	<0.003	0.092	3.91	5.5	<0.01	<0.3	<0.01	1.43	<0.01	
20-Feb-97	<0.02	3470	<0.03	<0.05	<0.2	<0.003	0.102	3.65	5.09	<0.01	<0.3	<0.01	0.02	<0.01	
20-Mar-97	<0.02	3590	<0.03	<0.05	<0.2	<0.003	0.103	3.71	5.54	<0.01	<0.3	<0.01	0.02	-	
22-Apr-97	<0.01	4060	0.045	<0.05	<2	<0.003	<0.2	3.285	4.5	<0.01	<0.3	<0.01	0.02	-	
28-May-97	<0.1	4180	<0.15	<0.4	<1	<0.015	<1.0	4.01	6.04	<0.05	<1.5	<0.05	0.06	-	
16-Aug-97	<0.02	4180	0.07	<0.05	<0.2	<0.003	<0.1	3.95	5.9	<0.01	<0.5	<0.01	0.02	-	
29-Sep-97	<0.02	3980	<0.03	<0.05	<0.2	<3.0	<0.2	3.29	5.14	<0.01	<0.3	<0.01	0.02	.	

APPENDIX 1 (Continued)

Table 16. Well 5C and field blank cation data from groundwater samples collected at the Peabody #10 Mine site.

Date	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	La	Li	Mg	Mn
------	----	----	---	----	----	----	----	----	----	----	----	---	----	----	----	----

Well 5C

06-Feb-96	0.29	0.009	0.42	1.73	<0.002	115	<0.01	<0.01	<0.01	<0.01	0.01	224	<0.002	1.51	0.01	<0.01
23-Jun-96	0.24	0.006	0.27	4.78	0.002	328	<0.01	<0.01	<0.01	<0.01	0.02	159	<0.002	1.07	0.01	<0.01

Field blanks

07-Feb-96	<0.02	<0.002	<0.02	<0.02	<0.002	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<0.002	<0.01	<0.01	<0.01
10-Mar-96	<0.01	<0.002	<0.02	<0.01	<0.002	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<0.002	<0.01	<0.01	<0.01
15-May-96	<0.02	<0.0004	<0.01	<0.01	<0.001	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<0.002	<0.01	<0.01	<0.01
23-Jun-96	<0.02	0.006	<0.02	<0.01	<0.001	0.06	<0.01	<0.01	<0.01	<0.01	0.02	<1	<0.002	<0.01	<0.01	<0.01
26-Jul-96	<0.02	<0.0004	<0.01	<0.01	<0.001	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<0.002	<0.01	0.02	<0.01
30-Aug-96	<0.01	<0.0004	<0.02	<0.01	<0.001	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<0.002	<0.03	0.01	<0.01
12-Oct-96	<0.03	<0.0001	<0.02	<0.01	<0.001	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	3	<0.002	<0.01	0.01	<0.01
21-Nov-96	<0.03	<0.0001	<0.01	<0.01	<0.001	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<0.002	<0.01	0.01	<0.01
20-Mar-97	<0.02	<0.0001	<0.02	<0.01	<0.001	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<0.002	<0.01	0.01	<0.01
22-Apr-97	<0.02	<0.1	<0.02	<0.01	<0.001	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1	<0.004	<0.01	0.01	<0.01

Date	Mo	Na	Ni	Pb	S	Sb	Se	Si	Sr	Ti	Tl	V	Zn	Zr
------	----	----	----	----	---	----	----	----	----	----	----	---	----	----

Well 5C

06-Feb-96	0.12	1605	<0.03	<0.05		<0.2	<0.003	0.023	1.77	8.68	<0.01	<0.6	<0.01	<0.01
23-Jun-96	0.15	4100	<0.02	<0.05		<0.2	<0.003	0.071	0.68	12.75	<0.01	<0.3	<0.01	0.02

Field blanks

07-Feb-96	<0.02	<0.1	<0.03	<0.05		<0.2	<0.003	<0.01	<0.01	<0.01	<0.01	<0.6	<0.01	<0.01
10-Mar-96	<0.02	0.6	<0.03	<0.08		<0.1	<0.003	<0.01	<0.01	<0.01	<0.01	<0.3	<0.01	<0.01
15-May-96	<0.02	1.1	<0.03	<0.05		<0.1	<0.003	<0.004	<0.01	<0.01	<0.01	<0.3	<0.01	<0.01
23-Jun-96	<0.02	0.36	<0.02	<0.08		<0.2	<0.003	<0.004	<0.01	0.01	<0.01	<0.3	<0.01	0.03
26-Jul-96	<0.02	1	<0.03	<0.04		<0.2	<0.003	<0.004	<0.01	<0.01	<0.01	<0.2	<0.01	<0.01
30-Aug-96	<0.02	1	<0.03	<0.05		<0.2	<0.003	<0.001	<0.01	<0.01	<0.01	<0.3	<0.01	<0.01
12-Oct-96	<0.02	0.4	<0.03	<0.05		<0.2	<0.003	<0.001	<0.01	<0.01	<0.01	<0.3	<0.01	<0.01
21-Nov-96	<0.02	<0.03	<0.03	<0.05		<0.2	<0.003	<0.001	<0.01	<0.01	<0.01	<0.3	<0.01	<0.01
20-Mar-97	<0.02	1.6	<0.03	<0.05	0.4	<0.2	<0.003	<0.001	<0.01	<0.01	<0.01	<0.3	<0.01	<0.01
22-Apr-97	<0.01	1.5	<0.03	<0.05	<0.1	<0.2	<0.003	<0.2	<0.01	<0.01	<0.01	<0.3	<0.01	<0.01

APPENDIX 1 (Continued)

Table 17. Shallow wells (2A, 2B, 5A, 5B, 6A) cation data from groundwater samples collected at the Peabody #10 Mine site.

Date	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	La	Li	Mg	Mn
------	----	----	---	----	----	----	----	----	----	----	----	---	----	----	----	----

Well 2A

16-Aug-97	0.75	<0.2	0.25	5.34	<0.001	461	<0.01	<0.01	<0.01	<0.01	<0.01	211	<0.002	1.55	<0.01	<0.01
-----------	------	------	------	------	--------	-----	-------	-------	-------	-------	-------	-----	--------	------	-------	-------

Well 2B

16-Aug-97	<0.02	<0.2	0.89	1.69	<0.001	161	<0.01	<0.01	<0.01	<0.01	<0.01	31	<0.002	0.16	21.1	0.01
-----------	-------	------	------	------	--------	-----	-------	-------	-------	-------	-------	----	--------	------	------	------

Well 5A

16-Aug-97	<0.02	<0.2	0.76	0.08	<0.001	96.3	<0.01	<0.01	<0.01	<0.01	0.01	11	<0.002	0.05	39	<0.01
-----------	-------	------	------	------	--------	------	-------	-------	-------	-------	------	----	--------	------	----	-------

Well 5B

16-Aug-97	<0.02	<0.2	0.7	0.38	<0.001	130	<0.01	<0.01	<0.01	<0.01	<0.01	15	<0.002	0.06	2.99	<0.01
-----------	-------	------	-----	------	--------	-----	-------	-------	-------	-------	-------	----	--------	------	------	-------

Well 6A

16-Aug-97	1.15	<.2	0.17	7.91	<0.001	536	<0.01	<0.01	0.01	<0.01	<0.01	119	<0.002	1.38	<0.01	<0.01
-----------	------	-----	------	------	--------	-----	-------	-------	------	-------	-------	-----	--------	------	-------	-------

Date	Mo	Na	Ni	Pb	Sb	Sc	Se	Si	Sr	Ti	Tl	V	Zn	Zr
------	----	----	----	----	----	----	----	----	----	----	----	---	----	----

Well 2A

16-Aug-97	<0.02	459	<0.03	<0.05	<0.2	<0.003	<0.1	0.2	11.2	0.01	<0.5	<0.01	<0.01	-
-----------	-------	-----	-------	-------	------	--------	------	-----	------	------	------	-------	-------	---

Well 2B

16-Aug-97	<0.02	5540	<0.03	<0.05	<0.2	<0.003	<0.1	2.69	8.23	<0.01	<0.5	<0.01	<0.01	-
-----------	-------	------	-------	-------	------	--------	------	------	------	-------	------	-------	-------	---

Well 5A

16-Aug-97	0.04	137	<0.03	<0.05	<0.2	<0.003	<0.1	8.89	1.53	<0.01	<0.5	<0.01	<0.01	-
-----------	------	-----	-------	-------	------	--------	------	------	------	-------	------	-------	-------	---

Well 5B

16-Aug-97	<0.02	3120	<0.03	<0.05	<0.2	<0.003	<0.1	8.75	2.87	<0.01	<0.5	<0.01	<0.01	-
-----------	-------	------	-------	-------	------	--------	------	------	------	-------	------	-------	-------	---

Well 6A

16-Aug-97	<0.02	523	<0.03	<0.05	<0.2	<0.003	<0.1	0.1	16.3	<0.01	<0.5	<0.01	<0.01	-
-----------	-------	-----	-------	-------	------	--------	------	-----	------	-------	------	-------	-------	---

APPENDIX I (Continued)

Table 18.: Well 3B anion data from groundwater samples collected at the Peabody #10 Mine site.

Date	Total Alk	PALK	Acidity	Cl	Hg	SO4	NO3-N	F	TDS	Specific Gravity
07-Feb-96	901.3	823.1		705	<0.00005	250	0.19			
10-Mar-96	1033	953		1668	<0.00005	549	0.07			
09-Apr-96	833.6	789.4		2059	0.00031	684	0.04			
15-May-96	629.9	597.7		2614	0.00006	682	<0.01			
23-Jun-96	382.6	367.5		2994	0.00008	745	0.39			
26-Jul-96	210.5	205.8	6	3259		759	<0.01			
22-Jan-97	109.6	108.4		4002	<0.0005	847	<0.01		7470	
20-Feb-97	55.9	51.5		5042		845	<0.01		8720	
20-Mar-97	52.5	35.2		5326		832	<0.01		8946	
22-Apr-97	61.7			4749		954	<0.01		9906	
28-May-97	76.8			4724		713	<0.1		9668	
16-Aug-97										
29-Sep-97	141.8		34.6	5720	<0.00005	736	<0.01	<0.05	10680	
10-Sep-97	145.3		64		<0.00005				10950	1.0112

Table 19. Well 4A anion data from groundwater samples collected at the Peabody #10 Mine site.

Date	Total Alk	PALK	Acidity	Cl	Hg	SO4	NO3-N	F	TDS	Specific Gravity
06-Feb-96	93.5		4		<0.0005					
07-Feb-96	127.6		3	478	<0.0005	214	0.1			
10-Mar-96	150.9		5	1113	<0.0005	291	0.08			
09-Apr-96	162.2		7	1527	0.00034	383	0.06			
15-May-96	171.3		9	2062	0.00009	327	<0.01			
23-Jun-96	205.5		13	3385	<0.0005	401	0.44			
26-Jul-96	226.9		7	4007	0.00016	417	<0.01			
30-Aug-96	239.2		8	4242	<0.0005	454	<0.01			
12-Oct-96	247.6		19	4490	<0.0005	434	<0.01		8204	
21-Nov-96	262		46	5203	<0.0005	449	<0.01		8584	
22-Jan-97	265.7		52	5466	<0.0005	404	<0.01		8860	
20-Feb-97	281		64	5947		413	<0.01		9600	
20-Mar-97	284.2		36.1	6456		425	<0.01		10080	
22-Apr-97	281.2		82.9	5656		394	<0.01		10320	
28-May-97	287.9		100	5626		369	<0.1		10890	

APPENDIX I (Continued)

Table 20. Field Blank anion data from groundwater samples collected at the Peabody #10 Mine site.

Date	Total Alk	PALK	Acidity	Cl	Hg	SO4	NO3-N	F	TDS	Specific Gravity
07-Feb-96					<0.00005					
10-Mar-96	1		2	2.14	0.00007	0.31	<0.01			
15-May-96	1.8			<0.01	0.00009	<0.01	<0.01			
23-Jun-96	0.9		1	0.29	<0.00005	<0.01	<0.01			
26-Jul-96	2			<0.01	<0.00005	0.31	<0.01			
30-Aug-96	<2			<0.01	<0.00005	<0.01	<0.01			
12-Oct-96	<1			<0.01	<0.00005	<0.01	<0.01		<10	
21-Nov-96	<1			<0.01		0.3	<0.01		<10	
20-Mar-97	<1		<1	<0.01		<0.01	<0.01		<10	
22-Apr-97	<1			<0.01		0.29	<0.01		<10	
29-Oct-97	2		89		<0.00005				<10	1.0024

Table 21. Shallow wells (2A, 2B, 5A, 5B, 6A) anion data from groundwater samples collected at the Peabody #10 Mine site.

Date	Total Alk	PALK	Acidity	Cl	Hg	SO4	NO3-N	F	TDS	Specific Gravity
Well 2A										
16-Aug-97	2134	2118	.		<0.0002				2454	
Well 2B										
16-Aug-97	28.7	16	.		<0.0002				14150	
Well 5A										
16-Aug-97	53.6	.	2.3		<0.0002				854	
Well 5B										
16-Aug-97	34.3	30.4	.		<0.0002				7992	
Well 6A										
16-Aug-97	2165	2138	.		<0.0002				2460	