EXECUTIVE SUMMARY

This project will evaluate the technical, economic and environmental feasibility of filling abandoned underground mine voids with coal combustion byproducts. Success will be measured in terms of technical feasibility of the approach (i.e. % void filling), cost, environmental benefits (acid mine drainage and subsidence control) and environmental impacts (noxious ion release).

Phase I of the project was completed in September 1995 and was concerned with the development of the grout and a series of predictive models. These models were verified through the Phase II field phase and will be further verified in the large scale field demonstration of Phase III. The verification will allow the results to be packaged in such a way that the technology can be easily adapted to different site conditions. Phase II was successfully completed with 1000 cubic yards of grout being injected into Anker Energy's Fairfax mine. The grout flowed over 600 feet from a single injection borehole. The grout achieved a compressive strength of over 1000 psi (twice the level that is needed to guarantee subsidence control). Phase III is to take 26 months and will be a full scale test at Anker's eleven acre Longridge mine site.

It is expected that the CCB grout will replace what is now an acid mine pool with alkaline solid so that the groundwater will tend to flow around and through the pillars rather than through the previously mined areas. The project has demonstrated that CCBs can be successfully disposed in underground mines. Additionally, the project is directed towards showing that such disposal can lead to reduction or elimination of environmental problems associated with underground mining such as acid mine drainage and subsidence.

During Phase III the majority of the activity involves completing two full scale demonstration projects. The eleven acre Longridge mine in Preston County will be filled with 53,000 cubic yards of grout. The second demonstration involves stowing 2000 tons of ash into an abandoned mine to demonstrate the newly redesigned Burnett Ejector.

This document will report on progress made during Phase III. The report will be
divided into three major sections. The first will be the Hydraulic Injection component. This section of the report will report on progress and milestones associated with the grouting activities of the project. The Phase III tasks of Economic Analysis and Regulatory Analysis will be covered under this section. The second component is Pneumatic Injection. This section reports on progress made towards completing the demonstration project. The last component involves evaluating the migration of contaminants through the grouted mine. A computer model has been developed in earlier phases and will model the flow of water in and around the grouted Longridge mine.
A. Hydraulic Injection

1.0 Task Description:

**Task 11 - Hydraulic Injection:** The purpose of this task is to grout the eleven acre Longridge mine with a grout consisting of coal combustion byproducts.

**Task 12 - Economic Analysis:** Burnett Engineering, Inc. shall develop economic analyses to compare the cost associated with disposal of coal ash in landfills with disposal of coal ash in underground mines to control subsidence and acid mine drainage.

**Landfill disposal of MEA AFBC Power Plant ash.** Burnett Engineering, Inc. shall develop an economic analysis for disposing of MEA AFBC ash in a landfill located near the Fairfax and Longridge mines. Costs to be included in the economic analysis include, but are not limited to, loading of ash at the power plant, transportation to the disposal site, landfill construction, landfill operation, landfill maintenance, and regulatory compliance. In addition, long-term cost impact on property values shall be estimated.

**Landfill disposal practices of Northeast utilities.** Burnett Engineering, Inc. shall use published data from the Electric Power Research Institute, and data from Monongahela Power Company and Allegheny Power Company to generate a range of cost estimates for disposing power plant ash in landfills. Burnett Engineering, Inc. shall describe the similarities and differences in ash disposal practices and costs for three utilities. Description of the similarities and differences shall include, but is not limited to, regulatory environment, environmental protection features in landfill design (e.g., liners), monitoring requirements, transportation, and ash handling.

**Underground coal mine disposal of MEA AFBC Power Plant ash.** Burnett Engineering, Inc. shall develop an economic analysis for disposing of MEA AFBC ash in the Longridge coal mine. Costs to be included in the economic analysis include, but are not limited to, loading of ash at the power plant, transportation to the disposal site, production of grout, injection of grout, mine maintenance, and regulatory compliance.

Burnett Engineering, Inc. shall analyze the costs associated with the benefits of underground mine disposal of the MEA AFBC Power Plant ash. These benefits include, but are not limited to, lower quantities of waste to be placed in the landfill, reduction in land subsidence, and improvements in water quality.

**Task 13 - Water Quality Model:** WVU shall use existing water quality model(s) or modifications of existing water quality model(s) to estimate the impact of ash disposal in underground mines on the concentrations of contaminants in nearby surface and ground water. Data from a geographical information system (GIS)
shall be coupled with the water quality model results to estimate the impact of
disposal of MEA AFBC ash in the Longridge mine on concentrations of
contaminants in nearby surface and ground water.

Task 14 - Regulatory Analysis: WVU shall review existing Federal, State of
West Virginia, and local regulations and policies which could impact the disposal
of ash from advanced coal combustion technologies in underground mines. The
contractor shall identify any regulatory barriers to the widespread adoption of this
disposal practice in West Virginia.

2.0 Summary of Accomplishments

2.1 Completion of grouting operations at Longridge.

3.0 To-Date Accomplishments

Successfully completed Phase II grout injection. Completed site preparation
activities for Phase III Demonstration.

4.0 Technical Progress Report

The Longridge mine in Preston County West Virginia is an 11-acre deep mine. The
mine void is intercepted by an auger hole that was installed to drain a mine pool so that
surface mining could proceed down dip of the Longridge mine. The auger hole allows a
11,000 cubic yard or 2.2 million gallon mine pool to remain in the Longridge Mine. The
auger hole discharged about 100 gallons per minute of acid mine drainage prior to any
work at the site.

The Longridge injection began in late January 1999. A total of 3000 cubic yards of
grout was injected into the up dip section of the mine. After two weeks of injection, it
was observed that the grout was communicating with the auger hole drainage; grout
began to flow from the auger hole that is located 2000 feet from the injection hole.
Grouting ceased while plans were made to stop the grout from leaving the mine. In
early April, the project team decided to place a barrier 200 feet down dip from the
injection borehole. The barrier was to be made by pneumatically injecting gravel into
the mine void from the surface via the Burnett Ejector. A total of 300 tons of gravel was
placed into two headings to create a barrier. Three thousand yards of stiff grout (2/5
cement kiln dust to 3/5 class F ash with one bucket of gravel, solids to water ratio 3:2)
were placed directly up-dip from the barrier. The installation of the barrier decreased
the auger hole flow by 90% (from 92 gpm to 9 gpm). Grouting with the prescribed thin
grout (1/4 cement kiln dust, 3/4 class F ash, solids to water ratio 1:1) continued in holes
above the barrier. A total of 12,500 yards of thin grout was placed in the upper cell
after barrier construction. The auger hole continued to flow at less than 10 gpm during
the Spring and summer of 1999.

After the upper cell (Cell 1) was complete, grouting commenced just below Cell 1.
While grouting cell 1, holes were drilled at across the mine void to divide it in half. The OSM camera was employed to investigate the mine void. The mine was collapsed and no void could be seen. Thin grout injected below Cell 1 did communicate with the auger hole so a thicker grout mix was employed to stop up the void space in the collapsed barrier. This has worked as 12,000 yards of grout have been placed in cell 2 with no communication with the auger hole. An investigation of the mine void via the OSM camera on 29 July 1999, indicated that solid grout could be seen 2 feet above the mine roof in boreholes just above the barrier for Cell 2. The auger hole flow is below 5 gpm and has continued to stay at this level through Summer of 2000. Table 1 shows the water quality data from the auger hole before, during and after grouting.

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<td>631</td>
<td>47</td>
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<td>0.127</td>
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<td>0.011</td>
<td>90</td>
<td>59</td>
<td>18</td>
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<td>254</td>
<td>27</td>
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<td>0.049</td>
<td>0.060</td>
<td>0.015</td>
<td>42</td>
<td>45</td>
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<td>571</td>
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<td>0.063</td>
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<td>0.047</td>
<td>53</td>
<td>33</td>
<td>11</td>
<td>0.187</td>
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</table>

Drinking Water Limit

|                        | 0.006| 2 | 0.005 |
|                        |      |   |       |

TCLP Limit

|                        | 0.015| 0.05 |
|                        | 5     | 1   |
|                        |      |     |

**Conclusions**

The placement of a chemically stable grout in underground mine voids is technically feasible and environmentally sound. No adverse water quality affects can be seen from the placement of the Class F fly ash/Cement Kiln Dust grout in the mine. While barium did triple in concentration, it is still well below the drinking water limit established by the U.S. Environmental Protection Agency. Injection costs (labor, water, mixing, pumping) remain below $3.00 per yard. When transportation of cement kiln dust and Class F fly ash are factored in, a cubic yard of grout costs about $12.85 to get into the mine void. A full-scale economic analysis will be completed.

**5.0 Plans for Next Quarter**

5.1 Preparations for Draft Final Report will be made.

5.2 Regulatory analysis will be updated and a draft report prepared.

5.3 Economic analysis of both technologies will commence and draft report will be prepared.
B. Pneumatic Injection

1.0 Task Description

The purpose of this task is to inject coal combustion byproducts into an underground mine via the Burnett Ejector. A complete economic analysis will be completed on the feasibility of this method of injection. Two thousand tons of ash are scheduled to be injected.

2.0 Summary of Accomplishments & Significant Events This Quarter

3.0 To Date Accomplishments

Redesigned and manufactured pneumatic ejector.
Completed Phase II demonstration.
Used ejector to assist in hydraulic injection by making barriers.

4.0 Technical Progress Report

No progress to report this quarter.

5.0 Plans for next Quarter

5.1 Incorporate demonstration results into the economic analysis.
C. Contaminant Transport

1.0 Task Description

Task 6.0 Contaminant Transport

Determine how contaminants will migrate from the grout (if any) and determine how the water that was filling the void will interact with the impermeable plug filling the void after injection.

2.0 Summary of Quarters Accomplishments and Significant Events


3.0 To Date Accomplishments

3.1 Groundwater flow and contaminant transport simulations were carried out to study the impact of grouting on contaminant transport trends. This study was based on several assumptions on input data since specific data was not available.

3.2 Influence of geometric parameters of the idealized model on computed results was investigated.

3.3 Parametric studies were performed to study the influence of material and geometric parameters on the contaminant transport around a mine cavity.

3.4 Different scenarios of the area around the mine affected by cracks and fissures (i.e. fracture zones) were considered. Several groundwater flow and contaminant transport modeling cases were analyzed based on these scenarios and assumed material properties to study the impact of fracture zones on the contaminant migration trends. These computer results are being analyzed.

3.5 A draft version of the final report was prepared.

4.0 Technical Progress Report

A draft version of the final was delivered to U.S. Department of Energy.

5.0 Plans for the Next Quarter

Incorporate draft report into final project report.