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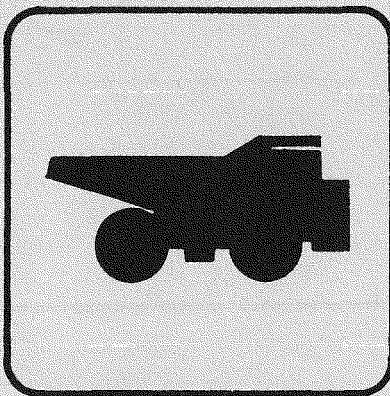
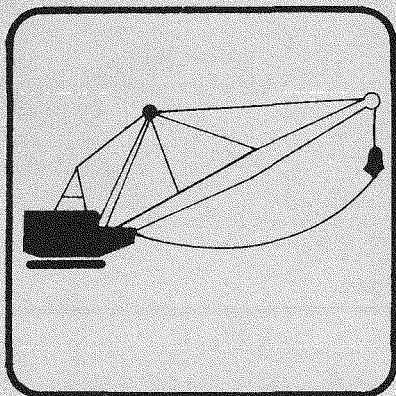
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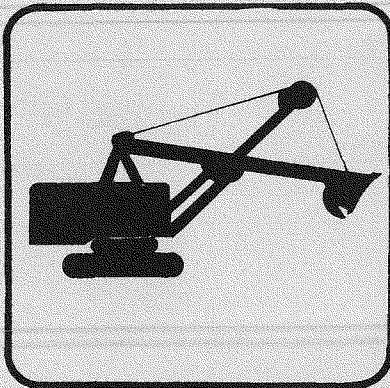
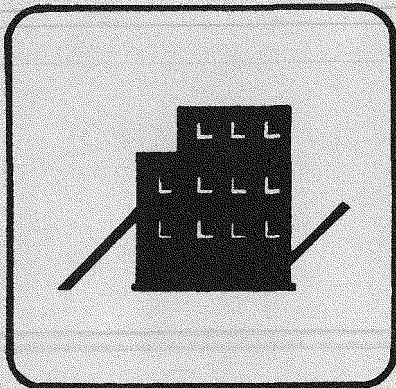
Economics of Large-Scale Surface Coal Mining Using Simulation Modes

Area Stripping with Draglines
Using Fort Union Region Test Case

MASTER



ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION
OFFICE OF FOSSIL ENERGY

WORK PERFORMED UNDER CONTRACT NO. EX-76-C-01-1520

FLUOR UTAH, INC.
SAN MATEO, CALIF.

BONNER & MOORE ASSOCIATES, INC.
HOUSTON, TEXAS

MARCH, 1977

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Final Report

Volume 4

ECONOMICS OF LARGE-SCALE SURFACE COAL MINING
USING SIMULATION MODELS

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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Under Contract No. EX-76-C-01-1520

ECONOMIC SYSTEM ANALYSIS OF
COAL PRECONVERSION TECHNOLOGY

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ABSTRACT

Large-scale surface coal mining will play a key role in meeting the future energy needs of the United States, especially in affecting the costs of coal conversion and advanced combustion processes being developed by the U.S. Energy Research and Development Administration (ERDA). Fluor Utah, Inc., with Bonner & Moore Associates, Inc. as subcontractor, was contracted by ERDA to study the costs and problems of large-scale surface coal mining. This project resulted in a series of computer models for use by the industry in mine planning and analysis, and by government in estimating future energy costs.

This report describes the simulation models representative of area stripping with dragline mining techniques which were developed, documented and tested. Two types of models were developed: detailed micromodels, which provide detailed information on mining systems and equipment to assist in mine design and equipment selection; and broad macromodels, which provide a first-order evaluation of deposits and new ventures for an entire mining complex.

The Fort Union Strippable Coal Resource Region was used to test the models. A hypothetical mining situation representative of typical mining problems and conditions encountered in the Fort Union Region was selected.

The models were used to estimate mining costs for the hypothetical baseline situation and for sensitivity analysis varying both mining parameters and financial assumptions. The results of the test case indicate potential coal prices for a range of geologic and economic assumptions.

The models are part of a series developed for mine planning and economic analysis of surface coal mines. The complete series designed for use by government or private industry, permits examination of large-scale surface coal mining under a variety of terrain conditions and overburden depths. Each major operation in the coal mining process is represented in these models so that the best methods and equipment may be selected and so that the impact of such selection will be reflected in estimates of capital investment, operating costs, and sales price.

1.0 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

The purpose of this report is to describe the development of simulation models for large-scale surface coal mining projects using the area stripping with draglines mining method. A hypothetical test situation in the Fort Union Region is described, and simulation results for this test situation are presented.

1.2 PROJECT OVERVIEW

Realizing that large-scale surface coal mines would be needed to supply feedstocks for conversion processes currently under development, the U.S. Energy Research and Development Administration sponsored this project to be better able

to determine expected costs for future energy, and

to provide the industry with planning and analysis models to aid in meeting future increased production needs.

The project encompassed 42 months of work at a cost of \$2.5 million involving both the mining and process engineering staff of Fluor Utah, Inc. as prime contractor and the consulting and computer programming staff of Bonner & Moore Associates, Inc. as the major subcontractor.

Successful completion of the project has provided the following immediate benefits:

Scientific planning for coal deposit exploitation by the U.S. coal industry has taken a significant step forward in this project.

Both government and industry, as a result of this project, have a number of powerful tools at their disposal for use in future expansion of surface coal mining.

Information provided by the models will aid in proper planning, equipment selection and exploitation techniques so the coal industry can efficiently scale up to meet the energy needs of the United States.

1.3 PROJECT OBJECTIVES

The first objective of this project is to develop, test and document simulation models representative of current surface mining techniques. The models provide mine designers, policy planners, and engineering managers with the ability to analyze a surface coal mine at two levels of detail. To achieve this goal two types of computer models have been developed:

Detailed Micromodels. These models provide estimates for a detailed part of a large-scale surface mining complex. Individual models allow the user to separately analyze overburden removal, overburden drilling and blasting, coal drilling and blasting, coal loading and hauling, coal preparation and handling, land reclamation, and premining, facilities, and administrative expenses.

Broad Macromodels. These models provide a first order estimate for an entire mining complex. All the detailed operations considered separately by the micromodels are contained as subroutines in the macromodel. In several cases simplified macromodel relationships were derived from detailed micromodel studies. Macromodels have been developed for three mining methods identified by the method of removing overburden: area stripping with draglines, area stripping with shovels and trucks, and contour mining with draglines.

These detailed micromodels and broad macromodels plus supporting information and user manuals, are available to all interested private and public organizations.

The second objective is to use these computer models to estimate mining costs for hypothetical test situations in the eight major United States coal resource regions where coal is likely to be surface mined. The coal resource regions investigated are shown on Figure 1. Results of these analyses, including the sensitivity of coal costs to different mining and financial parameters, are presented in eight separate reports listed in Appendix A.

The objective of Phase I was to delineate the large deposits of surface minable coal in the United States, collect equipment costs and performance data needed to calculate surface coal mining costs, describe major surface mining and coal preparation methods, and investigate the socioeconomic impact of large mining complexes. This information provided a framework for achieving the project objectives. A six-volume Phase I report listed in Appendix B, was issued.

A total of fifteen models have been developed: eleven detailed micromodels, three simplified macromodels, and one economic analysis model. Table 1 shows the mining functions analyzed by each model as well as the types of mining that can be studied.

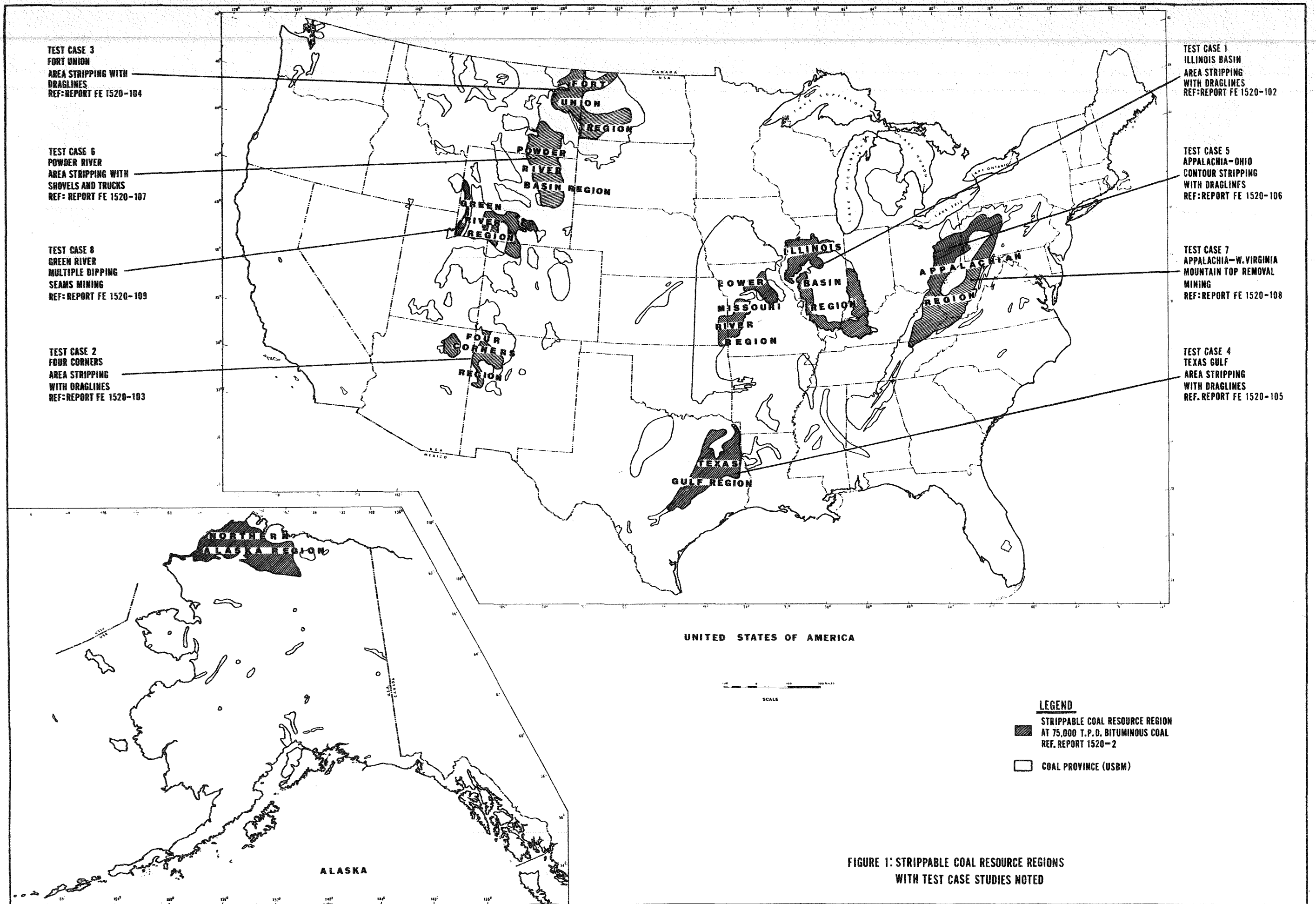
1.4 COMPARISON OF BROAD MACROMODEL AND DETAILED MICROMODELS

Figure 2 is a flow diagram of the micromodeling and macromodeling systems as applied to the area stripping with draglines mining method. The diagram would have the same form for the other mining methods but would show different models as appropriate to the mining operations. It can be seen that the micromodel system involves using up to seven models, while the macromodel system involves a single model preceding the cash flow analysis. With the micromodel system the user must analyze the model results and prepare the cash flow input, whereas that input is developed directly by the macromodel system.

Both systems begin with a tract description and end with the results of a cash flow analysis. The main difference between the types of models is the number of steps required to reach a solution.

The macromodel system requires only one manual step, i.e., defining case study parameters. The computer programs perform all calculations required to obtain a solution. Thus, first-order estimates can be obtained in a single step. The macromodels are designed to provide answers even for cases where little verified field data are available about the site or region under study. The macromodel user may define all mining and financial parameters; however, each model uses default values, typical of the mining method and region, for all parameters not supplied by the user.

In contrast, the micromodel system requires several manual steps since each mining function is examined separately with the user interpreting the results from each model. This procedure permits interactive use of the computer with decisions being made by the user at each stage of the analysis. The micromodels are designed for use where considerable field data are available. They may be used in less well defined situations since each micromodel also has default values which may be acceptable substitutes for unavailable field data.



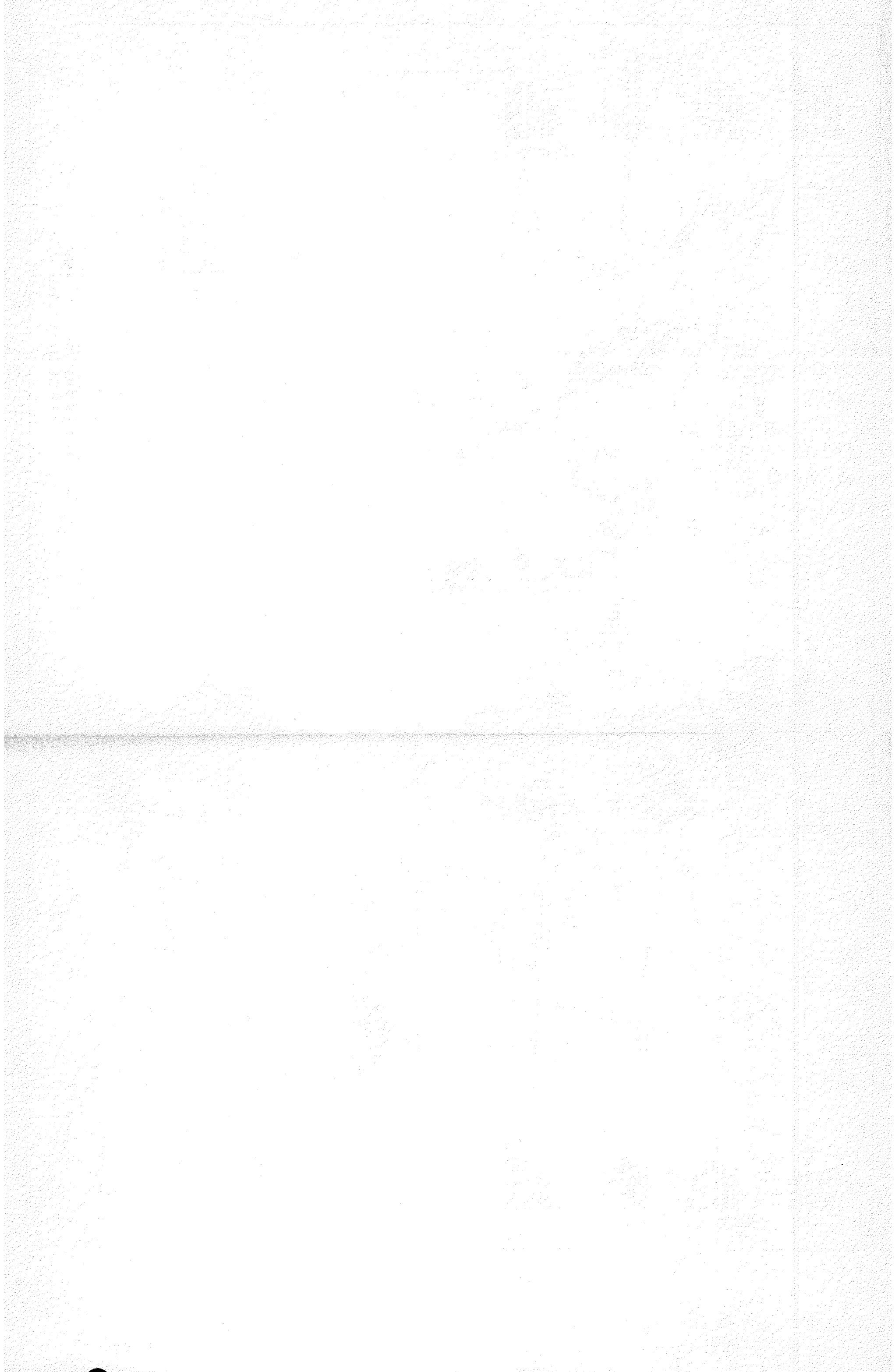








Table 1. Computer Models for Simulation of Surface Coal Mining

	Detailed Micromodels		Broad Macromodels		
	Dragline Mining	Shovel Truck Mining	Area Dragline Mining	Shovel Truck Mining	Contour Dragline Mining
Overburden Removal	Basic Stripping Method (BSM) Extended Bench Method (EBM) Contour Stripping Dragline (CSD) (Ref: Report FE-1520-114)	Shovel Truck Stripping (STS) Multiple Dipping Seams (MDS) Mountain Top Removal (MTR) (Ref: Report FE-1520-115)	 Area Dragline Macromodel (ADM) (Ref: Report FE-1520-110) 	 Area Shovel Truck (AST) (Ref: Report FE-1529-111) 	 Contour Dragline Macromodel (CDM) (Ref: Report FE-1520-112) 
Coal Load and Haul	Haul Unit Simulation (HUS) Coal Load/Haul (CLH) (Ref: Report FE-1520-116)				
Overburden Drilling & Blasting	Drilling And Blasting (DAB) (Ref: Report FE-1520-116)				
Coal Drilling & Blasting	Drilling And Blasting (DAB) (Ref: Report FE-1520-116)				
Land Reclamation	Land Reclamation Simulation (LRS) (Ref: Report FE-1520-116)				
Coal Handling and Preparation	Preparation/General Administrative (PGA) (Ref: Report FE-1520-116)				
Premining, Facilities and Administrative	Preparation/General Administrative (PGA) (Ref: Report FE-1520-116)				
Economic Analysis	Cash Flow Analysis (CFA) (Ref: Report FE-1520-113)				

7

Thus, the type of model used depends on the following factors:

1. Availability of field data:
If little, use broad macromodel.
If great, use detailed micromodels.
2. Desired interaction between user and computer:
If little, use broad macromodel.
If great, use detailed micromodels.
3. Desired detail of analysis:
If little, use broad macromodel.
If great, use detailed micromodels.

Once equipment selections have been made the next step is to develop equipment and manpower lists and investment and operating costs. These data are manually compiled when the micromodels are used but developed directly by the macromodels. The final step is the estimation of the coal sales price required to yield a specified return on investment or the return that could be expected from a specified sales price. The Cash Flow Analysis (CFA) model is used for this final step. It develops a complete discounted cash flow analysis of the project and prepares the following reports:

- Financial Summary Report
- Case Description
- Investment List
- Operating Personnel List
- Maintenance Personnel List
- Services and Materials List
- Infrastructure Report
- Production and Cash Expenditure Table
- Financial Statements.

These reports provide the user with a wide range of information useful in evaluating a large-scale surface coal mining project in terms of capital investment, operating costs, and profitability.

1.5 POTENTIAL APPLICATIONS

1.5.1 DETERMINATION OF COAL COSTS FOR COAL CONVERSION AND COMBUSTION

The cost of coal comprises a significant portion of the selling price of synthetic gas, liquid products or electricity produced from coal. Because the competitiveness of these energy options depends so strongly on coal costs, it is important to make reasonably accurate estimates of mining costs. This is particularly true for surface coal mines

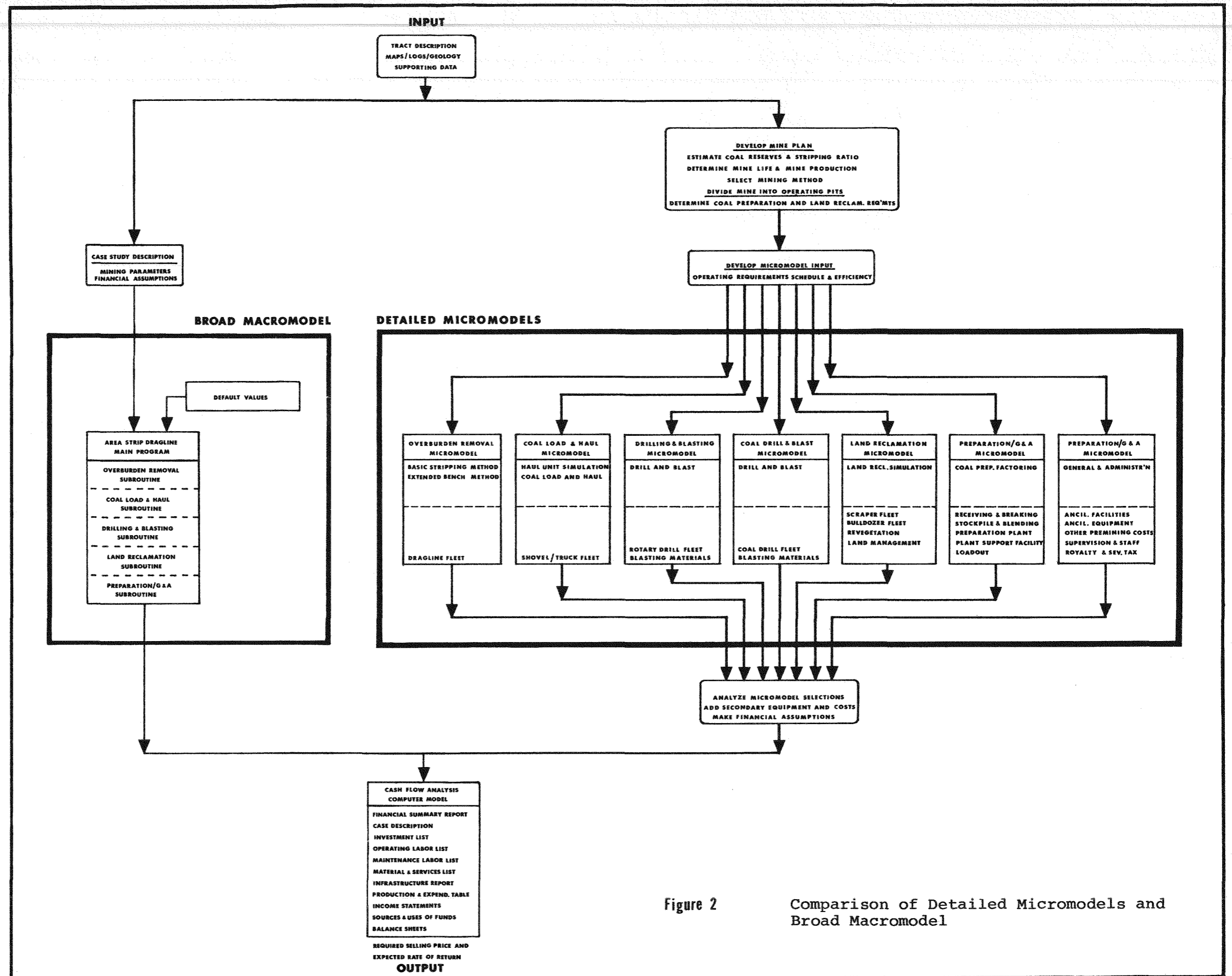


Figure 2

Comparison of Detailed Micromodels and Broad Macromodel

1870

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which currently supply approximately one-half of U.S. coal production and are expected to supply even more of the U.S. coal demand in the future.*

The macromodels can be used to develop first-order costs for coal conversion process evaluation. The detailed micromodels can be used for more precise cost determination for specific plants.

1.5.2 MINE EVALUATION

Mine evaluation typically progresses through a series of steps from initial order-of-magnitude estimates through final engineering and start-up as follows:

- Order-of-Magnitude Estimate
- Preliminary Estimate
- Basic Engineering
- Detailed Engineering
- Procurement
- Construction
- Start-up.

The broad macromodels can be used to inexpensively obtain order-of-magnitude estimates for initial reserve evaluation.

As more field data is collected, preliminary estimates can be made using: 1) the macromodels for analyzing the overall mining complex, and 2) the detailed micromodels for analyzing critical mining functions.

In the basic engineering stage the computerized models can be used to examine a wide range of alternatives for both mining and processing prior to committing large expenditures for the preparation of detailed engineering drawings, specifications, calculations, and estimates. Using the results of field investigation and testing to further refine model default values with actual realistic data, a great many cases can be run rapidly and inexpensively to examine many alternative mining methods, mining plans, processing methods, equipment types, and equipment sizes.

*REFERENCE: Cyril W. Draffin, Martin R. Adams, Paul O. Hedman and Christian W. Knudsen, "Economic Analysis of Coal Conversion Processes," presented at Third International Conference on Coal Research, Sidney, Australia, October 6-8, 1976. (Available from ERDA Fossil Energy, Washington, D.C. 20545).

The detailed micromodels can be used as an aid in preparing year-by-year mine plans.

The cash flow analysis model can be used to update profitable projections as construction and purchase commitments are made.

1.5.3 EVALUATION OF GOVERNMENT POLICY

Government policies affecting coal mining costs that could be evaluated include: leasing of federal lands, alternative land reclamation requirements, various depreciation methods, increased labor and equipment costs due to safety requirements, state severance taxes, royalty costs, price subsidies, and construction grants.

The models can also be valuable in estimating long term coal price projections. Curves representing the cost of coal as a function of the cumulative amount of coal mined (coal supply curves) could be constructed for coal resource regions.

1.5.4 ENVIRONMENTAL IMPACT ASSESSMENT AND EVALUATION

The infrastructure report printed by the Cash Flow Analysis model presents information in four categories:

- Physical Effects
- Economic Impact
- Utility Requirements
- Manpower Requirements.

This type of information can be used to assess environmental and socioeconomic impact.

1.5.5 PUBLIC ACCESS TO THE SIMULATION MODELS

The simulation models are on line on a Xerox Sigma Seven computer as of the completion of the project. They can be run either in time share (remote terminal) or batch mode. The ultimate method of continued public access to the models has not been decided. Those desiring an up-to-date status of the availability of the models should contact one or more of the following as appropriate:

1. The Fossil Energy Office of the Energy Research and Development Administration in Washington, D.C., which sponsored the project, should be contacted for questions regarding government participation and government agency use.

2. Fluor Utah, Inc., San Mateo, California, which supplied the mining and process engineering expertise for the project, should be contacted for questions regarding the formulation of mining problems, equipment selection logic, and interpretation of simulation results.
3. Bonner & Moore Associates, Inc., Houston, Texas, which supplied the simulation modeling and consulting expertise for the project should be contacted for questions regarding mathematical modeling techniques and details of time share or batch use of the models.

1.6 TEST CASE RESULTS

The first step in analyzing the test case was to develop a baseline solution using both the detailed micromodels and the broad macromodel for a mining complex producing coal with sufficient Btu content to nominally supply a 250 million cubic feet per day gasification plant, a 40,000 barrel per day liquefaction plant, or a 1500 megawatt power plant.

The result was a mining complex with three pits and one preparation plant producing approximately 9.2 million tons of prepared coal per year. A 12-foot coal seam with a stripping ratio of approximately 4 bank cubic yards of overburden per ton of run-of-mine coal was assumed.

The situation was selected for the test case to describe conditions that would represent practical mining problems typical of the region. The geologic and topographic situation chosen is representative of a typical situation, not a statistical average nor an actual situation.

The next step in analyzing the test case was to determine the sensitivity of solution values to the following mining and financial parameters:

Mining Parameters

Coal Preparation Requirements (Crush and Screen, Baum Jig, or Heavey Media)	Annual Energy Demand for Complex
Height of Overburden	Run-of-Mine Coal
Height of Topsoil Saved	Heat Value
Height of Coal	Reclamation Cost Per Acre for Dozing, Revegetation, and Land Management

Financial Parameters

Capital/Debt Ratio	Federal Income Tax
Mineral Rights	Rate
Surface Rights	Long-Term Interest
Royalty Payment	Rate
Severance Taxes	Short-Term Interest
Cash Flow Discount Rate	Rate

The parameters were varied one at a time through a range of values from extreme low to extreme high. The range of values used represents practical limits for each variable based on operating experience and field investigation. The results illustrate the relative sensitivity of the coal price to changes in the primary input parameters. These results are reported in detail in Section 6 of this report.

Regional studies, which are recommended for future study, were not considered as part of the current project. Nevertheless the test case results are of interest because they provide a first-order estimate of the costs and problems of mining in a given region using a specified mining method. With the caution in mind that the values shown represent only hypothetical test situations, it is of interest to compare results in the following key areas:

- Coal Price
- Capital Investment
- Annual Direct Operating Cost
- Requirements for Individual Mining Functions.

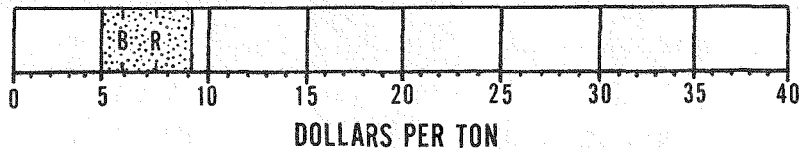
1.6.1 COAL PRICE

The required coal price can be expressed in two ways: 1) dollars per ton of coal shipped, or 2) dollars per million Btu of heat value of coal shipped. As shown in Figure 3, the coal price varies from approximately \$5.00/ton to \$9.00/ton with a baseline value of approximately \$6.00/ton (no escalation, 10 percent rate of return). The ranges shown in Figure 3 are based on the highest and lowest values resulting from variation of mining parameters only.

TEST CASE 3
IN FORT UNION

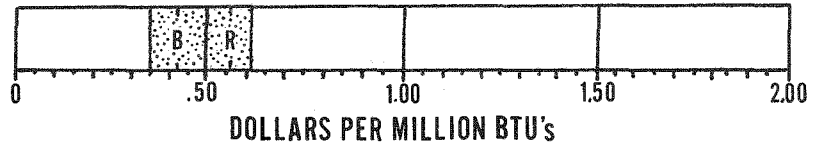
EXAMPLE TEST CASE RESULTS

**ESTIMATED PRICE (DOLLARS PER TON OF COAL) *
TO ACHIEVE SPECIFIED RETURN ON INVESTMENT**



(ALL COSTS IN JANUARY 1975 DOLLARS WITH NO ESCALATION)

**ESTIMATED PRICE (DOLLARS PER MILLION BTU's) *
TO ACHIEVE SPECIFIED RETURN ON INVESTMENT**



(ALL COSTS IN JANUARY 1975 DOLLARS WITH NO ESCALATION)

* **COVERS COST OF MINING AND PROCESSING;
TRANSPORTATION NOT INCLUDED**
B = BASELINE SOLUTION, RETURN ON INVESTMENT = 10%.
R = RETURN ON INVESTMENT SET TO 15%.

Figure 3. Estimated Price of Coal

The most important financial parameters affecting coal price are return on investment and escalation. The effect of changing return on investment from 10 percent to 15 percent, as an example, is shown in Figure 3. To underscore the impact of escalation, an additional set of example sensitivity studies were made to compare baseline results (no escalation) with 5 percent escalation of all investment and operating costs holding price constant, and with 5 percent escalation allowing price to escalate at 5 percent also. The results are shown in the following tabulation:

Estimated Coal Price (Dollars per ton)

<u>No Escalation Price Constant</u>	<u>5% Cost Escalation Price Constant</u>	<u>5% Cost Escalation 5% Price Escalation</u>
all years 5.93	all years 11.03	first year last year 6.54 to 24.49

1.6.2 CAPITAL INVESTMENT

The range of capital investment resulting from variation of mining parameters is shown in Figure 4. Capital investment includes all equipment, premining, and facilities costs. For the Fort Union test case the capital investment varies from approximately \$121 million to approximately \$214 million with a baseline value of approximately \$137 million.

1.6.3 ANNUAL DIRECT OPERATING COST

The range of annual direct operating costs resulting from variation of mining parameters is also shown in Figure 4. Operating costs vary from approximately \$14 million/year to approximately \$23 million/year with a baseline value of approximately \$16 million/year.

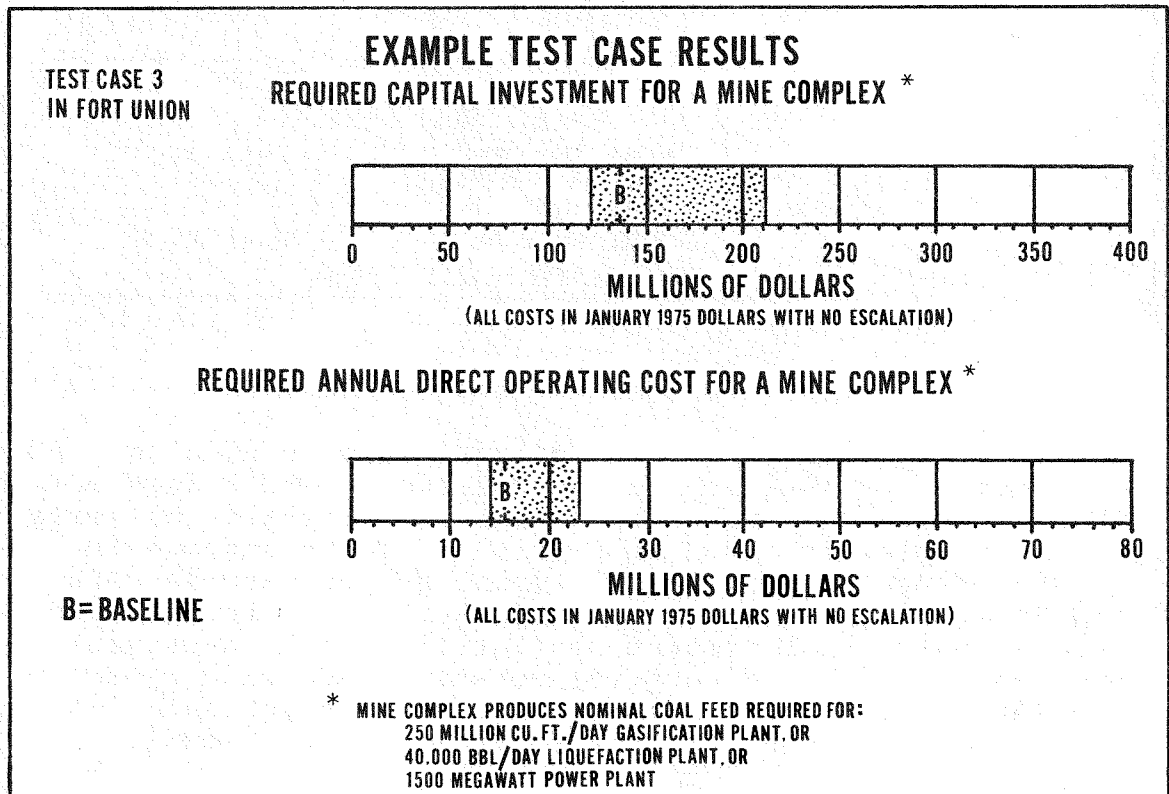


Figure 4. Comparison of Required Capital Investment and Operating Cost

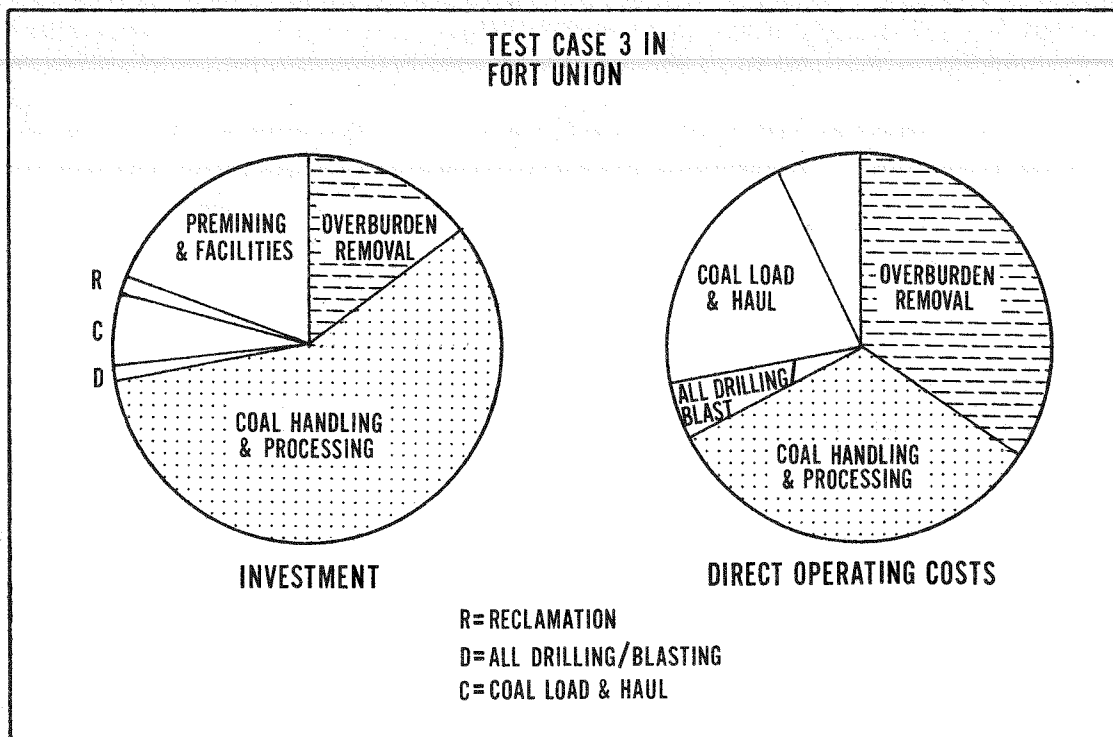


Figure 5. Percent of Capital Investment and Operating Cost by Mining Function

1.6.4 RELATIVE IMPORTANCE OF MINING FUNCTIONS

The percentage of capital investment and operating costs for each mining function is shown in Figure 5. Overburden removal accounts for approximately 14 percent of investment and 34 percent of operating costs. Coal handling and processing account for approximately 59 percent of investment and 34 percent of operating costs.

One reason for the high percentage of capital cost for coal handling and processing is the extensive blending and stockpiling facilities which may be required to provide a uniform, stable feedstock to a coal conversion plant.

This comparison of capital investment and annual operating costs underscores the fact that in large-scale surface coal mining, especially to produce feedstock for a coal conversion plant, it is not the extraction of the coal that has the greatest impact on cost. Rather, it is the removal of the overburden and the processing of the coal to meet feedstock requirements that account for the major costs.

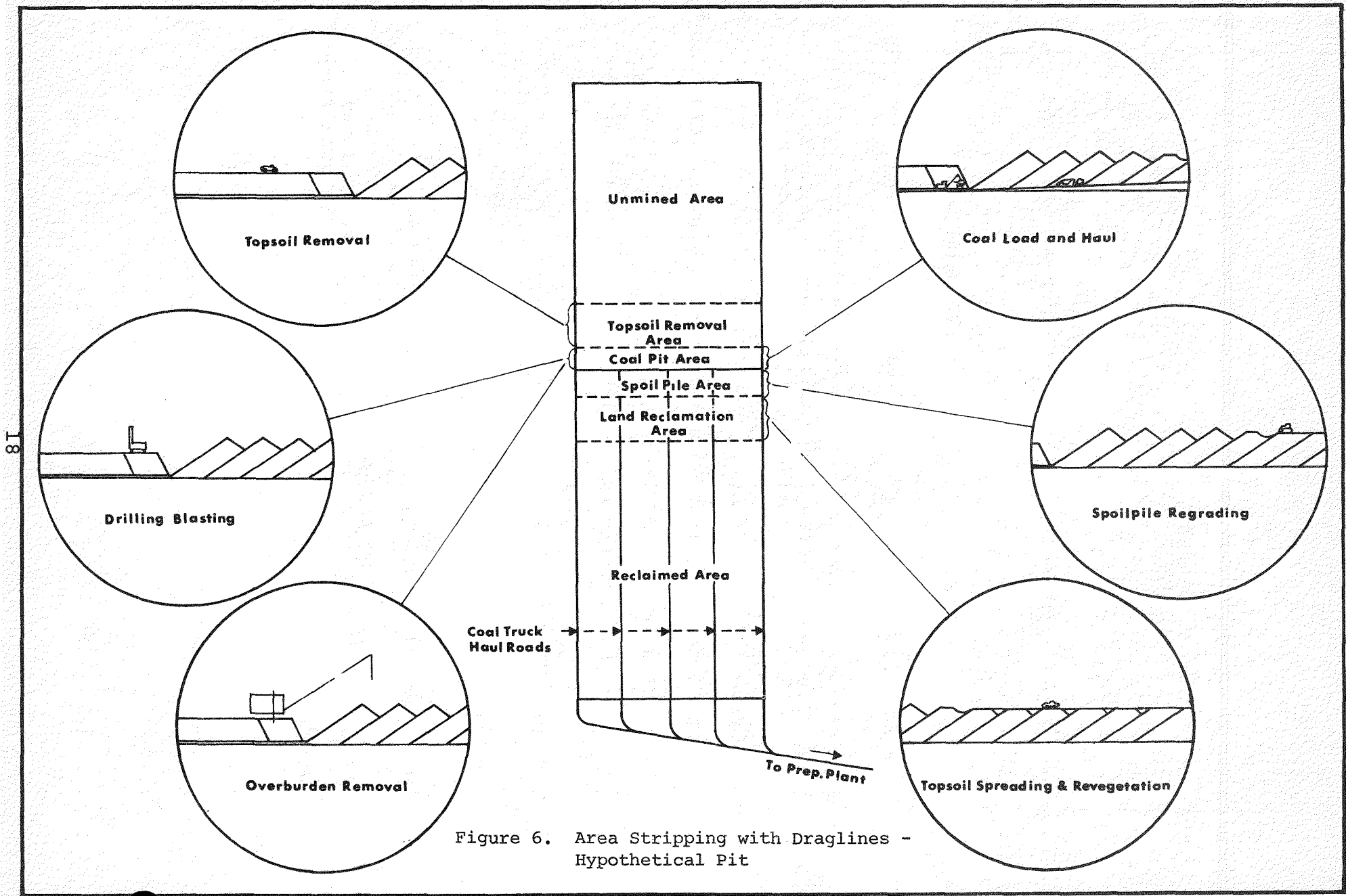


Figure 6. Area Stripping with Draglines - Hypothetical Pit

2.0 DESCRIPTION OF THE MINING METHOD - AREA STRIPPING WITH DRAGLINES

2.1 MINING OPERATIONS AT EACH PIT

A mining complex may consist of one or more pits. A pit is the active working area where coal is being uncovered and loaded. When the area stripping with draglines mining method is employed, the following activities are part of the mining operations at each pit:

- Overburden drilling and blasting (not required for Fort Union)
- Overburden removal
- Coal drilling and blasting
- Coal loading and hauling
- Land reclamation.

These mining operations are largely independent activities, but must be coordinated to avoid delays or bottlenecks. All operations must advance at the same annual rate to provide uniform progress through the mine property. The physical relationship of the various operations is shown schematically in Figure 6, the plan view of a hypothetical area stripping pit. A detailed discussion of large-scale surface mining methods and equipment can be found in Volume 3 of the Phase I Report (Ref: FE-1520-3).

2.1.1 OVERBURDEN REMOVAL

Overburden is excavated by a walking dragline one panel at a time and cast to spoil piles occupying the panel mined previously. A typical walking dragline is shown in Figure 7.

With the removal of the overburden, the coal seam is exposed and ready for drilling and blasting.

2.1.2 COAL DRILLING AND BLASTING

Prior to drilling and blasting coal, the top of the coal seam is cleaned by a front-end loader or, possibly, a motor grader.

Coal is easily drilled and generally requires much less blasting agent to achieve the desired fragmentation. Blast holes in coal are drilled with an auger type drill. The blast hole pattern is generally designed to reduce the production of fine coal to a minimum.

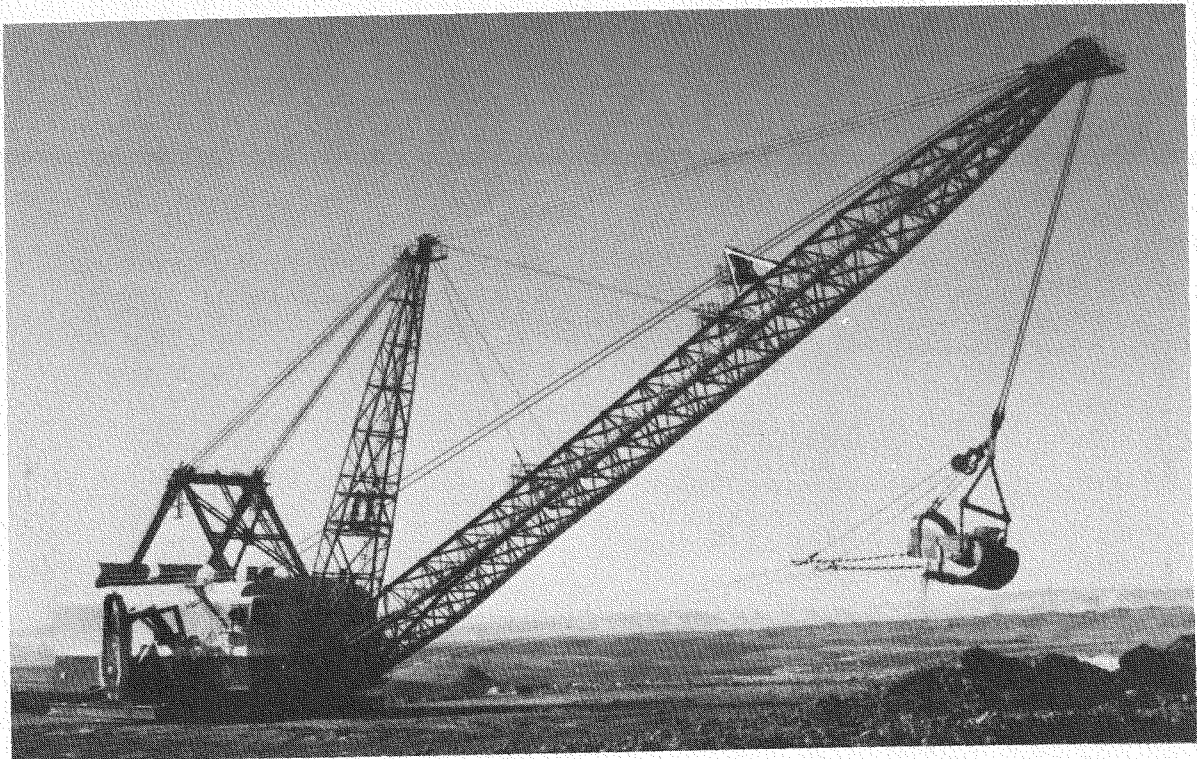


Figure 7. Walking Dragline for Overburden Stripping

Blast holes are stemmed with coal fines to avoid extraneous contamination, and detonated in a manner to obtain the desired fragmentation.

Figure 8 shows a typical self-propelled auger coal drill.

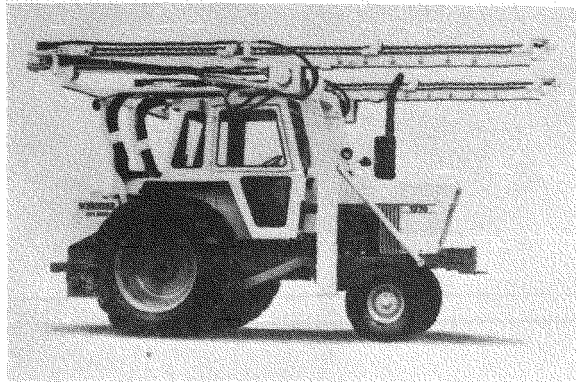


Figure 8. Auger Drill for Coal Drilling

2.1.3 COAL LOADING AND HAULING

Coal is loaded by a shovel located in the pit bottom and hauled by a fleet of bottom dump trucks which shuttle between the pit and the receiving station at the preparation plant. The shovel loads the coal from the exposed seam into waiting trucks adjacent to the point of excavation. The trucks will travel either on top of the coal seam or on the pit bottom. The trucks have access to the pit via ramps through the spoil piles. A typical coal shovel and bottom dump coal truck are shown in Figures 9 and 10.

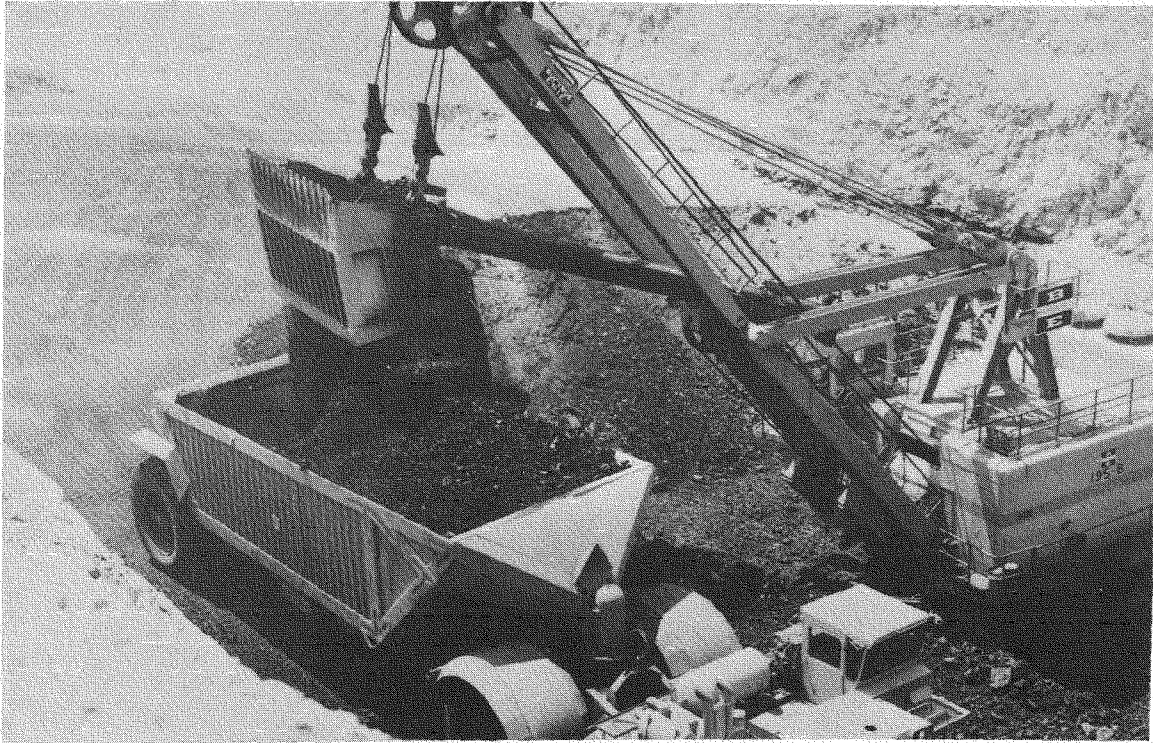


Figure 9. Coal Loading Shovel

2.1.4 LAND RECLAMATION

Land reclamation includes the following operations:

- Topsoil removal
- Topsoil spreading
- Spoil pile regrading
- General dozing
- Revegetation
- Land management.

Topsoil removal is accomplished by a fleet of self-loading elevating scrapers. The scraper fleet hauls the topsoil from the cleared area, ahead of drilling and blasting, to the regraded area on the spoil piles on the other side of the pit. Scrapers are also used to spread the topsoil prior to revegetation. A typical self-loading scraper is shown in Figure 11.

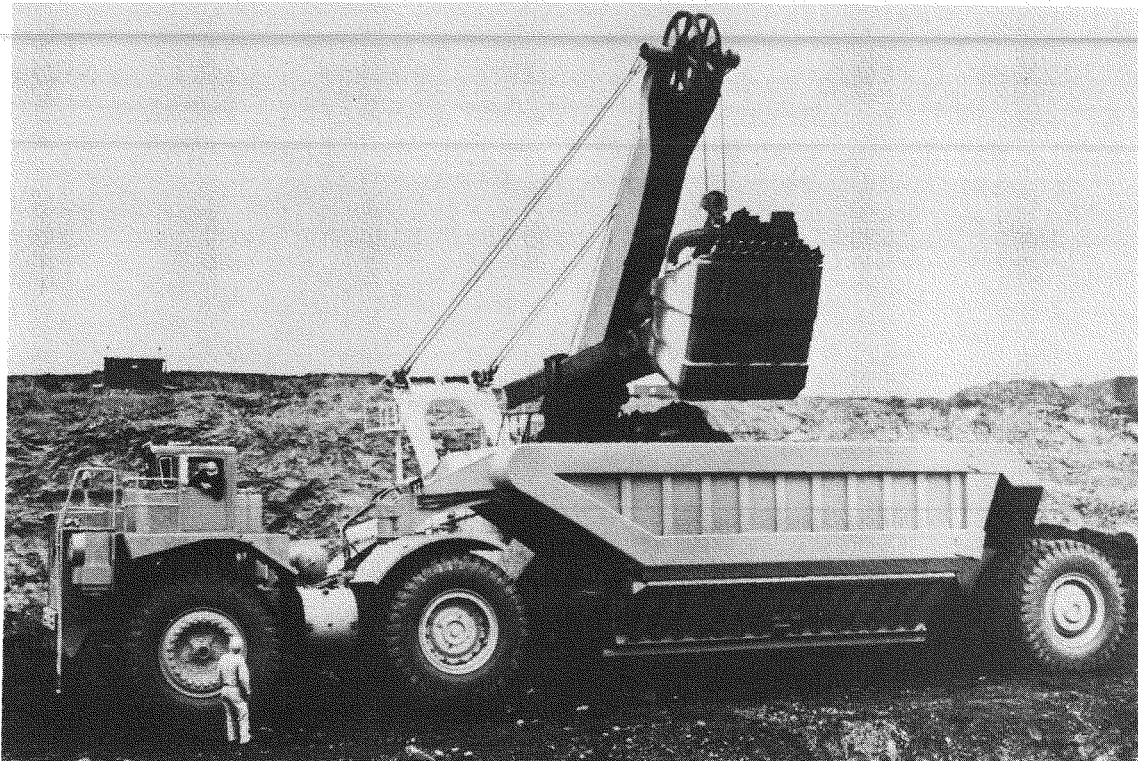


Figure 10. Bottom Dump Coal Hauling Truck

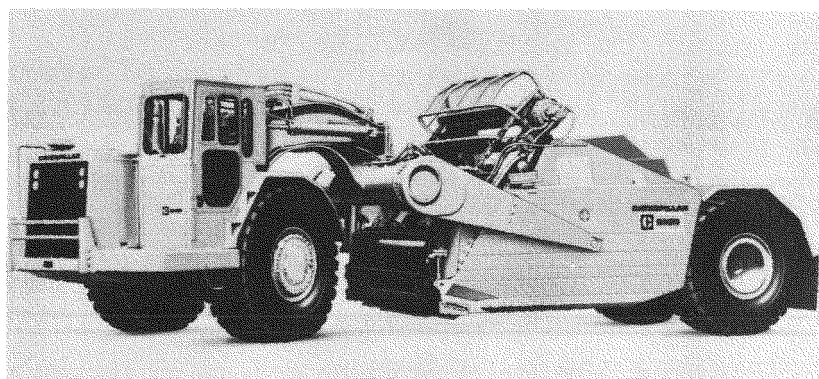


Figure 11. Self-Loading Scraper for Removal and Redistribution of Topsoil

Spoil piles are regraded by a fleet of bulldozers which level the peaks and valleys left behind by the dragline. Bulldozers are also required for general reclamation activities, including recontouring, drainage control, erosion control, ditching, and dam work. A typical track-type tractor with bulldozer is shown in Figure 12.

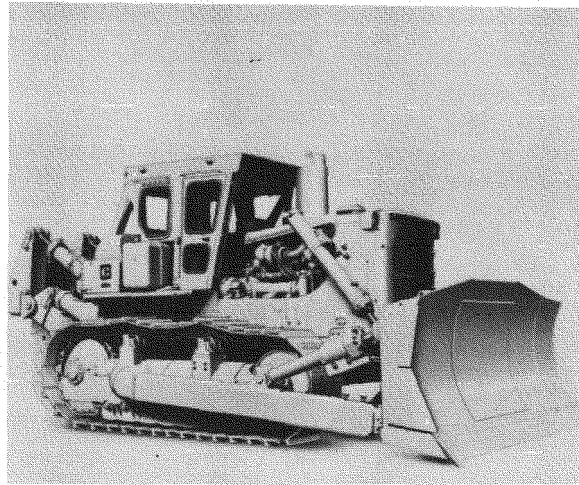


Figure 12. Track-Type Tractor with Bulldozer for Regrading Spoil Piles and General Reclamation

Revegetation includes preparation of the soil prior to planting, the addition of required soil amendments, and reseeding.

Land management costs include follow-up activities to ensure long-term revegetation (including reseeding of areas remaining barren following initial revegetation effort), plus interest on posted land reclamation bonds.

2.1.5 SUPPORT EQUIPMENT FOR MINING OPERATIONS AT EACH PIT

Several types of support equipment are required for the primary operations at each pit:

Overburden drilling and blasting:

- Bulldozer to prepare bench for drill
- Bulldozer to push cuttings into holes
- Prill truck to deliver blasting agents and supplies.

Overburden removal:

Bulldozer to clean up bench for dragline movement
Loader with cable reel to handle dragline power supply cable
Secondary dragline with small bucket to remove high spots, build level bench for primary machine, control drainage, etc.

Coal loading and hauling:

Loader to clean the top of coal
Grader to maintain the haul road
Water truck to maintain the haul road
Pumps to remove water from pit.

It is assumed that no major road-building equipment is required.

2.2 CENTRAL OPERATIONS FOR THE MINE COMPLEX

A mine complex consists of one or more pits, each providing coal to a central preparation and loadout facility. The central operations serving the entire complex provide two basic functions: coal handling and preparation, and general and administrative activities.

2.2.1 COAL HANDLING AND PREPARATION

Coal preparation is a process for treating run-of-mine or raw coal to meet market specifications. Commonly, this is accomplished by mechanical sorting of particles in a medium of water. (Chemical processes are currently under investigation.) Prepared coal normally has defined physical property specifications, higher calorific value, and lower moisture, sulfur and ash contents than raw coal. It is a premium quality coal which has advantages in the conversion process.

Coals, as they occur in the ground, are extremely heterogeneous with characteristics that vary widely from seam to seam and within an individual seam. They tend to be adulterated with "deleterious dirt" which results in ash or sulfur products upon conversion. Complicating the inherent complexity and heterogeneity of coals is the mining process which introduces additional adulterants, including waste rock, mineral partings within the seam, and tramp materials. Therefore, run-of-mine coal usually requires preparation.

Three Levels of Preparation Difficulty

Through the use of developed flowsheets, equipment lists and arrangement drawings, capital costs have been determined for three different coal preparation plants. The plants represent levels of preparation difficulty which provide three cost alternatives for study, as shown in Table 2.

TABLE 2. THREE TYPES OF PREPARATION PLANTS

DIFFICULTY OF PREPARATION	THEORETICAL WASHABILITY DATA REQUIRED	PLANT DESIGN (FLOWSHEET)
Slight	Size consist	Crushing and screening plant
Moderate	Size consist Sink/float Washability curves	Baum jig plant
Great	Size consist Sink/float Washability curves	Heavy media plant

Coal conversion and combustion processes are expected to require different degrees of preparation; however, the benefits and extent of coal preparation are likely to be more fully recognized and defined as more becomes known about the conversion processes.

In an actual situation, the coal preparation plant is designed based on detailed knowledge of the properties of the run-of-mine coal (plant input) and the feedstock specifications of the prepared coal (plant output). For the generalized or hypothetical situation, neither coal properties nor the feedstock specifications are known.

Therefore, to provide three alternatives which would indicate the relative cost of hypothetical coal preparation approaches that might be considered in the future, the following plants have been examined:

Crushing and screening plant
Baum jig plant
Heavy media plant.

These plants have been designed based on assumed properties for the incoming coal. A coal that requires slight preparation effort was chosen as the basis for a crushing and screening plant; a coal that requires a moderate preparation effort was chosen as the basis for a Baum jig plant, and a coal that requires a great preparation effort was chosen as the basis for design of a plant requiring two-stage heavy media separation and flotation.

For each of the three hypothetical plants being studied, the following general specifications and costs have been estimated for a plant with a baseline rated capacity of 75,000 tons per day (TPD) of run-of-mine coal:

1. Capital cost
2. Yield factor $\frac{(\text{tons output of prepared coal})}{(\text{tons input of run-of-mine coal})}$
3. Rated capacity.

Cost extrapolation factors have been developed to establish preparation plant costs as shown in the following formula:

$$\text{Cost for plant of specified capacity} = \text{Cost for plant of baseline capacity} \times \left(\frac{\text{Rated Production Specified Plant}}{\text{Rated Production Baseline Plant}} \right)^Y$$

Where: Y = plant cost scaling factor.

Other facilities may be required in addition to the preparation plant:

- Raw coal receiving and breaking
- Blending and stockpiling
- Prepared coal loadout
- Support facilities.

Capital costs have been estimated for hypothetical designs of each of the additional facilities.

A hypothetical overall plot plan for the coal handling and preparation facility is shown in Figure 13.

The estimated costs are hypothetical and would vary widely in actual situations. Many alternate process steps, such as grinding, briquetting, thermal drying, etc., that may be required to feed a specific conversion process with a particular coal are not included in the general hypothetical plant designs.

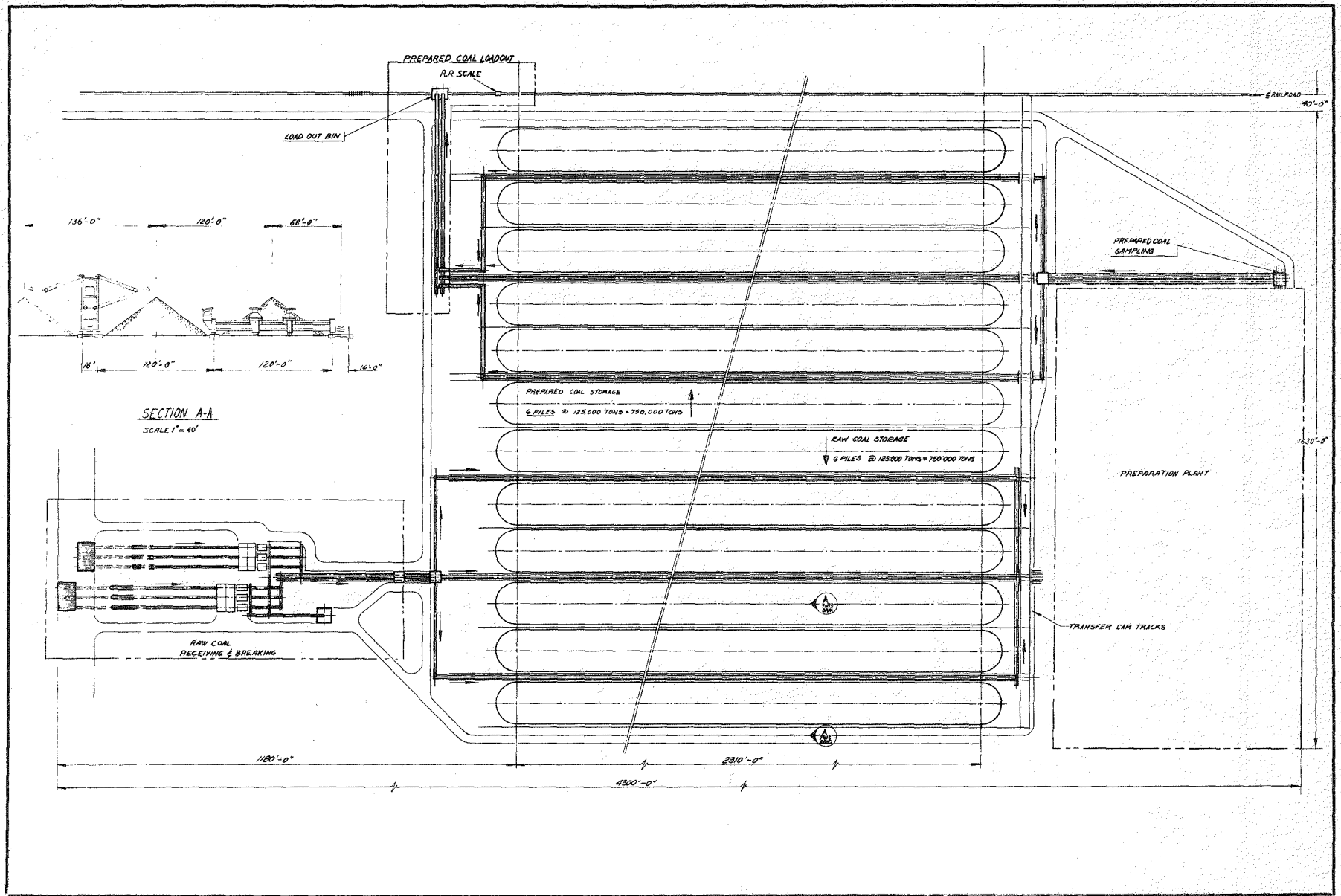


Figure 13. Hypothetical Overall Plot Plan Coal Handling & Preparation

Any one of the hypothetical plants can be combined with one or more of the required additional support facilities to form a complete preparation unit to provide coal for conversion into synthetic fuels. In order to adjust for different production rates, factoring formulas are available for each of the three plants or four facilities. However, due to the different assumptions used in the development of the plants and facilities, the probability of an actual situation matching a theoretical combination is very low; and therefore, any final results should be used with great caution.

A detailed discussion of large-scale coal processing for coal conversion can be found in Volume 4 of the Phase I Report (Ref: FE-1520-4).

2.2.2 GENERAL AND ADMINISTRATIVE FUNCTIONS

The centralized general and administrative functions serving the entire mining complex have been divided into five categories:

- Ancillary facilities
- Ancillary equipment
- Other premining costs
- Supervisory and support staff
- Miscellaneous overhead costs.

Ancillary facilities include roads and site work, buildings (shops, warehouses, offices, laboratories, and other facilities), electric power system, water system, and communications system.

Ancillary equipment includes mobile equipment such as utility trucks and cranes, as well as shop equipment for maintenance operations, such as machine tools and overhead cranes.

Other premining costs include initial payments for land rights, exploration drilling costs, contract engineering costs (feasibility study plus final design), and environmental impact statement costs.

The supervisory and support staff consists of mine management, supervision, technical staff, safety, administration, and purchasing.

Miscellaneous overhead costs include a cash reserve, home office expenses, royalty and severance taxes, insurance and property taxes, and inventories of spare parts, supplies, and stockpiled coal.

3.0 HYPOTHETICAL TEST CASE - FORT UNION

3.1 MINING SITUATION DESCRIPTION

In order to develop a macromodel for area stripping with draglines, a representative test situation was selected for the detailed analysis that would eventually form the foundation of the generalized macromodel relationships. The Fort Union Strippable Coal Resource Region, described in detail in Volume 2 of the Phase I Interim Report (Ref: FE-1520-2) was selected for the test case, and a hypothetical situation was constructed. While this hypothetical situation does not represent an actual site, every effort has been made to describe a situation which would present itself to practical mining problems typical of the Fort Union region.

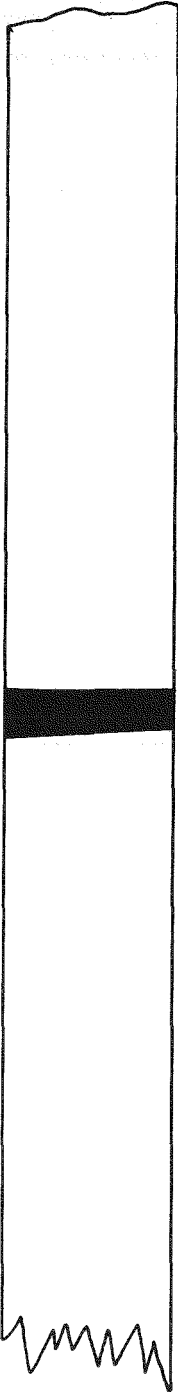
In order to fully document the underlying problems and assumptions related to the test case, the following paragraphs describe in detail the test case geology, mining complex requirements, and individual pit requirements.

3.1.1 GEOLOGY FOR TEST CASE

The geologic and topographic situation chosen for the Fort Union test case is representative of a majority of the conditions encountered in the region. It is not a statistical average nor an actual condition, but only a typical situation. The topography chosen for the test case was taken from U.S. Geological Survey 1:24,000 scale topographic maps of the region.

The coal seam for the test case geology is patterned after coal seams found in the Beulah-Zap coal field of the Fort Union region. Overburden thickness and characteristics, and coal seam thickness and quality are composites of data taken from the geology data base described in Volume 2 of the Phase I Report (Ref: FE-1520-2), and information obtained during field visits. The geologic situation chosen is summarized in a stratigraphic column (Figure 14), which was used in compiling a hypothetical geology map of the area.

The key geologic parameters are summarized in Table 3. The overburden density was determined by taking a weighted average of the density of the materials shown in the stratigraphic column. The overburden height was determined by the average distance between the top of coal and the surface. The swell factors, highwall angle, spoil angle and topsoil thickness are based on data gathered during field visits.



SOIL: Chestnut soil 3 feet thick. _____

ROCK INTERVAL: Poorly consolidated claystone.

0-220'

11-13' COAL: Lignite. Typical analysis shows Btu/lb 7,070, sulfur 0.5%, moisture 34%, and ash 5.5%.

ROCK INTERVAL: Material similar to coal overburden.

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			Figure 14							

Table 3.

GEOLOGY FOR FORT UNION TEST CASE

Coal Height	ft	12
Coal Heat Value	Btu/lb	7070
Coal Density	lb/bank yd ³	2000
Coal Swell Factor		.35
Coal Face Angle	degrees	76
Burden Height Avg	ft	42.00
Burden Density	lb/bank yd ³	2935
Burden Swell Factor		.35
Burden Highwall Angle	degrees	63.43
Burden Spoil Angle	degrees	33.69
Topsoil Thickness Saved	ft	1.25

3.1.2 MINING COMPLEX REQUIREMENTS FOR TEST CASE

The prime factor in determining the overall size of a mining complex is the annual amount of energy in the form of prepared coal that must be shipped from the complex. For the test case, an energy demand of 130 trillion Btu's per year was selected. This energy demand is roughly equivalent to the annual feedstock requirement for either a 250 million standard cubic feet per day coal gasification plant, a 40,000 barrel per day coal liquefaction plant, or a 1500 megawatt power plant.

Assuming a 30 year life for the project and assuming that the combination of feedstock specifications and coal characteristics allow a low degree of coal preparation as represented by a crushing and screening plant, the overall production requirements for the mining complex can be determined as shown in Table 4.

3.1.3 INDIVIDUAL PIT REQUIREMENTS FOR TEST CASE

The mining complex has been divided into three identical adjacent operating pits which feed run-of-mine coal into a single crushing and screening plant. In an actual practical situation the size of each pit would vary depending on the geologic variations and land ownership patterns. For similar reasons the pits would not necessarily be adjacent to one another. Note that the rail system for long distance shipping is not included as part of the cost of the mining complex (i.e., costs carried through to the unit train loadout point).

Each individual pit in the hypothetical mining complex contains approximately 100 million tons of coal in place. The detailed individual pit requirements for a 30-year pit life are shown in Table 5.

Table 4.

MINING COMPLEX REQUIREMENTS FOR FORT UNION TEST CASE

Energy Demand	Btu/yr	1.3×10^{14}
Coal Delivered	Prep tons/yr	9,160,435
Preparation Plant Type		Crushing & Screening
Preparation Plant Recovery	Prep tons/ROM tons	.99
Coal Demand	ROM tons/yr	9,252,963
Expected Coal Recovery in Mine		.92
Production Life	Years	30
Total Coal in Place	Tons	301,745,730
Stripping Ratio		
Burden bank yd^3 /ton of recovered coal		3.80
Burden Demand	Bank yd^3 /yr	35,203,970
Total Pits in Complex		3
Years in Each Pit		30
No. of Active Pits		3
Total Preparation Plants in Complex		1
Rated Capacity of Preparation Plants (Combined Total)	ROM tons/day	37,011

Table 5.

INDIVIDUAL PIT OPERATING REQUIREMENTS
FOR FORT UNION TEST CASE

Overburden Drilling & Blasting	Bank yd^3 /yr	None
Overburden Removal	Bank yd^3 /yr	11,734,656
Coal Drilling & Blasting	Bank yd^3 /yr	3,352,523
Coal Loading & Hauling	ROM tons/yr	3,084,321
Coal Handling & Preparation (Each Plant)	ROM tons/day (250 days/yr)	37,011
Land Reclamation	Acres recl./yr	173

3.2 MINE OPERATION SCHEDULE AND EFFICIENCY

Once annual operating requirements for each pit have been established, the operating schedules and efficiency for each function are determined. In Table 6, the following six factors are defined for each mining operation:

SHY = Scheduled Hours per Year

Total number of hours in a year

(365 days x 24 hours per day = 8760 hours
less days, shifts, or hours not worked due
to the following:

- a. Holidays
- b. Weekends
- c. Strikes
- d. Vacation shutdown
- e. Severe weather seasonal shutdown
- f. Preventative maintenance shifts during week
- g. Idle shifts during day
- h. Less than 8-hour shift (work rules).

AEF = Annual Efficiency Factor

Discount factor used to account for lost scheduled hours during a year due to the following:

- a. Unscheduled minor repair
- b. Unscheduled major repair
- c. Scheduled overhaul.

PHY = Productive Hours per Year

Scheduled hours per year times annual efficiency factor

ESO = Efficiency of Simulated Operation

Discount factor (sometimes expressed as minutes per hour) used to account for lost production due to:

- a. Shift startup and shutdown
- b. On-shift routine preventative maintenance
- c. Fueling
- d. Breaks
- e. Operator skill
- f. Job conditions
- g. Weather
- h. Mobility
- i. Difficulty of material
- j. Job supervision
- k. Interfaces with other operations
- l. Short moves to reposition within work area.

PTF = Propel Time Factor

Discount factor used to account for lost production due to:

- a. Moving to a working position on a new panel
- b. Moving to a working position on a new bench
- c. Moving to a working position in a new mine.

FF = Fill Factor

Discount factor used to account for lost or extra production due to:

- a. Inability of machine to carry 100% of its rated capacity
- b. Ability of machine to carry in excess of 100% of its rated capacity.

The schedules and efficiencies shown in Table 6 are used to compute machine annual production capabilities which are compared with pit annual production requirements.

Table 6.

MINE OPERATION SCHEDULE AND EFFICIENCY

	Coal Drill	Stripping Dragline	Coal Shovel	Coal Truck	Topsoil Scraper	Regrading Bulldozer
Scheduled Hours Per Year	3625	8297	3625	3625	2000	2000
Annual Efficiency Factor	.90	.90	.90	.90	.90	.90
Productive Hours Per Year	3262.5	7467	3262.5	3262.5	1800	1800
Efficiency of Simulated Oper.	1.00*	.833	.833	.833	.833	.75
Propel Time Factor	1.00*	.98	N/A	N/A	N/A	N/A
Fill Factor	N/A	.95	.95	1.10**	N/A	N/A

*Drilling rate specified accounts for efficiency and propel time.

**Indicates 10% overload is allowable.

3.3 BASELINE SOLUTION USING MICROMODELS

During Phase I of the project, a series of computerized micromodels was developed to analyze separately the various required mining operations. These micromodels require detailed input to define a problem, and are intended for use by a user who desires a high degree of interaction with the models.

The following micromodels are pertinent to the Fort Union test case:

- Basic Stripping Method (BSM)
- Drilling/Blasting Coal (DBC)
- Coal Load and Haul (CLH)
- Haul Unit Simulation (HUS)
- Land Reclamation Simulation (LRS)
- Preparation/General Administrative (PGA)
- Cash Flow Analysis (CFA).

In brief, each model uses input based on the mining situation, schedule and efficiency, and the user's judgment to select a combination of equipment with the least ownership and operating cost for each function. The selections are reviewed by the user, and with the addition of suitable support equipment, a cash flow analysis is used to estimate a required price for the coal in the deposit. The use of the micromodels to solve a mining problem is shown schematically in Figure 15. A solution to a mining problem using the micromodels is developed in six steps:

1. Tract Description (analyst)
2. Develop Mine Plan (analyst)
3. Develop Micromodel Input (analyst)
4. Run Micromodel Solutions (computer)
5. Analyze Micromodel Selections, Add Secondary Equipment, and Make Financial Assumptions (analyst)
6. Cash Flow Analysis (computer).

As previously described, the macromodels are intended to require a brief set of input data and little interaction by the user. In order to develop such a macromodel, a baseline or reference point is developed against which eventual macromodel results are tested. This reference point has been established by running a detailed micromodel solution for the hypothetical situation in the Fort Union region as defined by the test case mining situation description. The test case mine operation schedules and efficiencies were also used. The results of the test case baseline solution using micromodels are described in the following paragraphs.

3.3.1 BASIC STRIPPING METHOD

The Basic Stripping Method (BSM) computer micromodel simulates area stripping with a single dragline. The model determines the range and production requirements based on

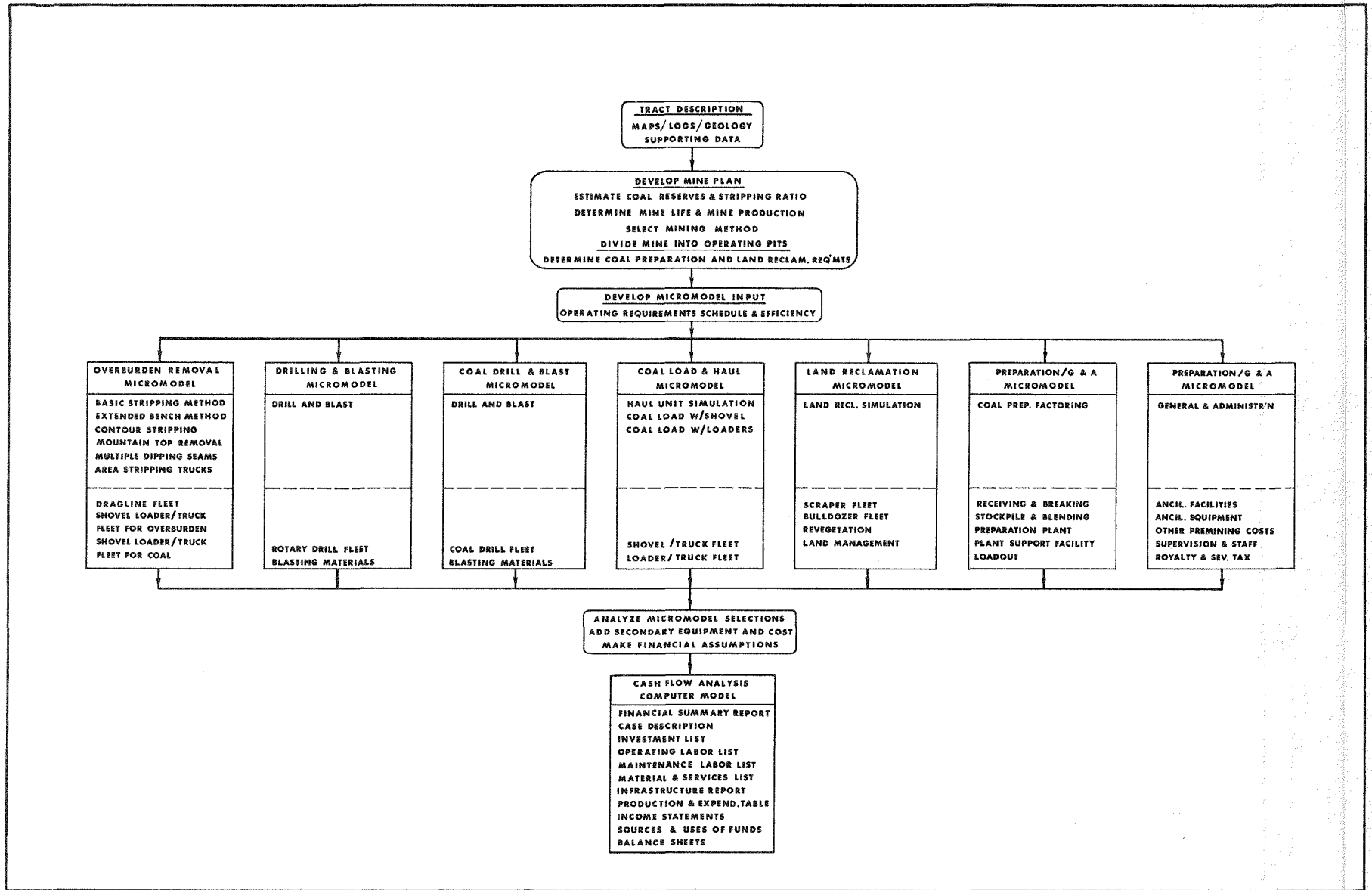


Figure 15. The Micromodeling System

input for the pit geometry and required coal production. It then processes the Dragline Data File to compare the requirements to the capabilities of the full range of machines commercially available.

For each dragline processed, the model obtains the range information from the data file and compares these values with the requirements.

The machine is tested against the requirements when operating at the minimum height. If it does not meet the conditions of dumping radius, dumping height, and digging depth, the machine is considered to be physically unsuited for the job and is dropped from future consideration. If the machine meets the minimum requirements, it is checked for the average and maximum operations. The model prints these requirements, but it does not automatically eliminate machines which fail to meet the average or maximum range.

The model is now ready to determine the production capability and costs of operation. It first calculates a bucket capacity using the manufacturer's allowable load figure, and the density of overburden and weight of bucket, as defined by the engineer. The machine cycle time from the data file is adjusted if the machine has a larger-than-required dumping radius, and the annual production rate is calculated.

The desired annual production rate is used to determine the number of years required to strip the area using this machine. The annual coal production is then determined from the amount of recoverable coal and the number of years to strip the area.

The annual operating costs from the data file are extended according to the number of years to determine the total cost of operation. The total cost is allocated to the total recoverable coal to calculate stripping costs (\$/ton of coal).

If the dragline is capable of uncovering coal faster than necessary to sustain the coal demand specified by the user, the model calculates a second cost figure. This second figure is the cost of stripping when the dragline is slowed to meet the coal demand rate.

As the draglines in the data file are processed, the model keeps track of the two cost figures. At the end of the run, it identifies the machines resulting in least cost at the full production rate and least cost at the required coal demand rate.

Thirty-six input parameters must be defined in order to run the Basic Stripping Method micromodel. These parameters are listed with definitions and baseline values in Appendix B.1.

The Basic Stripping Method output indicates that dragline No. 104 with a 229-foot dumping radius and 36-cubic-yard bucket would provide the least cost solution of \$.487 per ton of recoverable coal uncovered at the desired rate of production (Note: costs are extended to significant figures to facilitate comparison between text and computer runs in the appendices; the number of significant figures is not meant to imply accuracy). An abbreviated listing of the computer output is shown in Appendix B.2. All costs are in January 1975 dollars (no escalation). In addition, a plotter can be used in conjunction with the computer to draw a cross section of the pit showing the selected dragline to scale, including its relationship to the spoil pile. Such a plot of the baseline solution is shown in Figure 16.

3.3.2 DRILLING/BLASTING COAL

The Drilling and Blasting (DAB) computer micromodel simulates the drilling of vertical blast holes in coal and determines the required amounts of blasting materials related to coal drilling and blasting. When the DAB model is used for analysis of coal drilling and blasting, it has been given the code DBC to differentiate from overburden drilling and blasting.

The DBC model must be run as Case 3, in which spacing, burden and drill diameter are specified. There are two choices of drill hole size using an auger-type drill: 3 inches and 6 inches. Specifying one or the other drill hole diameter causes the model to automatically select the appropriate size auger drill for analysis.

The program determines the number of holes that must be drilled per year, the quantity of machinery required, and the quantity of blasting materials required. Costs are determined based on the selected drill size.

Input parameters for the Drilling and Blasting Coal micromodel with definitions and baseline values are listed in Appendix B.3.

The DBC output indicates that 1.07 (or 2) Drill No. 23, a 3-inch auger-type drill, would provide the required number of drill holes for blasting the coal. Drilling and Blasting Coal costs amount to \$.068 per ton of recoverable coal (i.e., $\frac{\$210,520}{3,084,321 \text{ tons}}$). An abbreviated listing of the computer output is shown in Appendix B.4. All costs are in January 1975 dollars (with no escalation).

BASIC STRIPPING METHOD - PANEL X SECTION

CASE NO 507

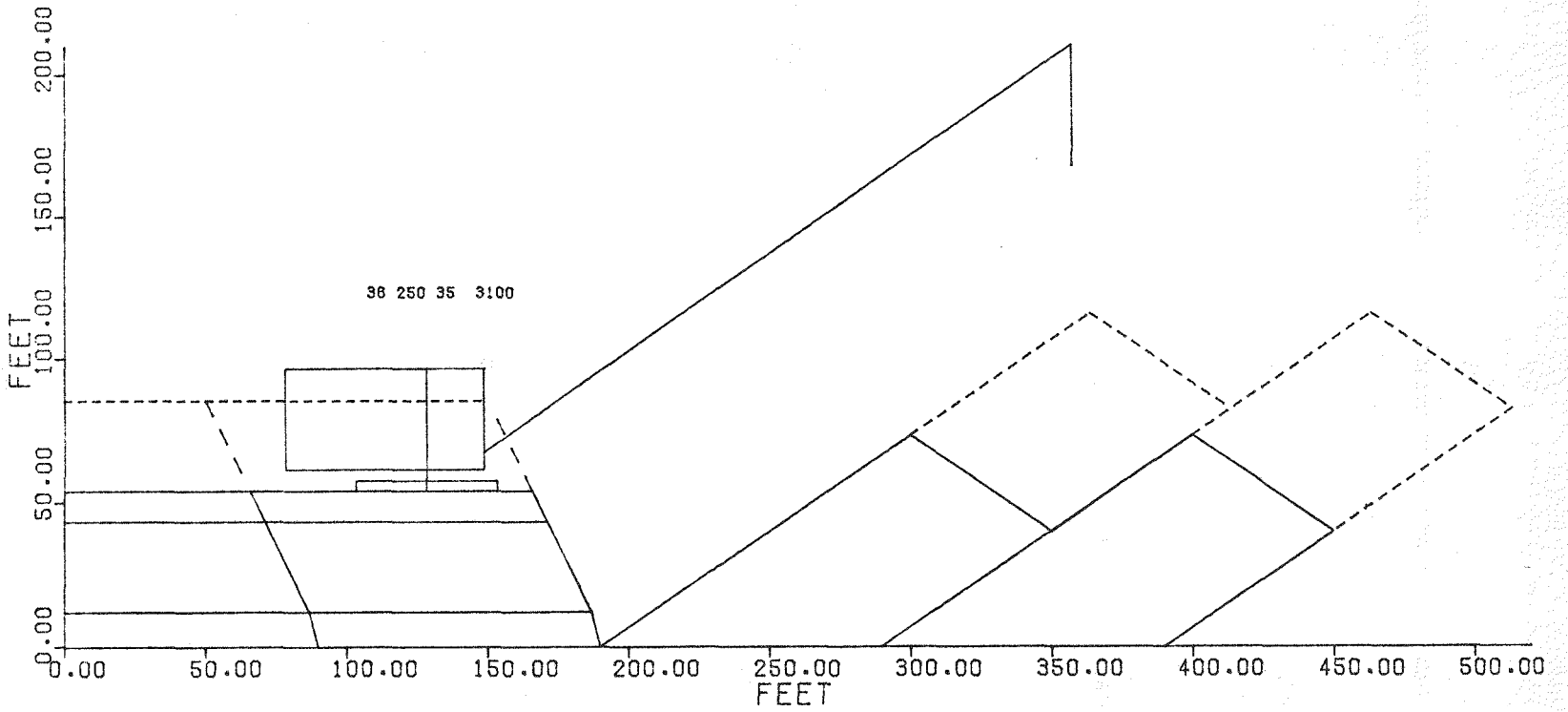


Figure 16. Computer Drawn Baseline Solution for Basic Stripping Method

3.3.3 HAUL UNIT SIMULATION AND COAL LOAD AND HAUL

Two separate micromodels, Haul Unit Simulation (HUS) and Coal Load and Haul (CLH), are used in the selection of the shovel/truck combination for loading the coal in the pit and transportation from the pit to the receiving station of the preparation plant.

The HUS model simulates the performance of an off-highway truck on a given haul road. The model evaluates the ability of a truck according to the following criteria:

- Possible truck speed and time to travel the haul road

- Possible coal production (tons/hour) that could be sustained by one truck

- Size of the fleet required to maintain a given coal production rate

- Cost of ownership and operation of each truck in the fleet

- Cost of haulage for each truck (\$/ton of coal).

The equipment data base contains all the parameters required by the HUS model. The following parameters are used for each truck to be studied:

- Weight capacity
- Performance data
- Braking data
- Ownership and operating cost data
- Number and size of tires
- Engine characteristics.

The HUS model begins with a specification of the mine and the haul road, from pit to tippie. The road is described in segments with distance, grade, speed limits, stop, etc., defined for each segment. The model simulates the hauling operation, and calculates operating statistics and operating and investment costs. Input and output for the HUS model are shown in Appendices B.5 and B.6.

The data developed with the HUS model is used in running the CLH model. The CLH model processes shovel and truck files to evaluate the ability of the shovel and truck in combination, to meet the requirements of physical dimensions and production during the coal loading operation. Production and cost information are calculated and printed for the user.

The model operates the shovel and truck separately, at full capacities, to determine possible production. Then the combination of shovel and truck is evaluated, taking into account the necessary losses in possible production due to waiting time for the truck to spot at the shovel.

Twenty input parameters plus a description of each segment of the haul road are required to run the HUS micromodel. In addition, 24 input parameters must be defined to run the CLH micromodel. These parameters are listed with definitions and baseline values in Appendix B.7.

The CLH output indicates that one No. 34 shovel (16-yd³ bucket) with a fleet of five No. 18 trucks (180-ton payload) would provide a least cost solution of \$.502 per ton of recoverable coal. An abbreviated listing of the computer output is shown in Appendix B.8. All costs are in January 1975 dollars (no escalation).

3.3.4 LAND RECLAMATION

The Land Reclamation Simulation (LRS) micromodel analyzes four separate operations: required scraper fleet for topsoil removal and redistribution; required bulldozer fleet for spoil pile regrading and for general dozer work; costs of revegetation; and land management.

Input to the LRS program requires both a definition of the geometry and desired production and a definition of the performance specifications of the equipment to be used. The input parameters and baseline values are shown in Appendix B.9.

The LRS output indicates that a fleet of 2.82 (or 3) scrapers would be required for topsoil removal and a fleet of 1.33 bulldozers (or 2) would be required for spoil pile regrading and general dozing. Combining scraper and bulldozer fleets with revegetation and land management yields a cost of \$.154/recoverable ton of coal. An abbreviated listing of the computer output is shown in Appendix B.10. All costs are in January 1975 dollars (no escalation).

3.3.5 COAL PREPARATION FACTORING

The Preparation/General Administrative (PGA) micromodel determines the coal handling and processing costs by means of extrapolation from a standard size facility. In addition, it allows plant selection based on three levels of difficulty of preparation effort: crushing and screening, Baum jig, and heavy media. The micromodel separates ownership and operating costs into five categories:

Receiving and Breaking
Blending and Stockpiling
Coal Loadout
Preparation Plant
Preparation Plant Support.

The input parameters for the PGA model are used to define the costs of the standard size facility and the extrapolation factors for determining the costs of a new size facility. The key input parameters are energy demand and plant type which are used to determine the daily rated capacity of the new plant in run-of-mine tons of coal. Coal washability curves are not directly considered.

Abbreviated listings of the input and output of the PGA model when used for coal preparation factoring are shown in Appendices B.11, B.12, and B.13. The output indicates that the cost of coal handling and preparation in a facility rated at 37,011 TPD run-of-mine coal would be \$1.254/ton of recoverable coal. All costs are in January 1975 dollars (no escalation).

3.3.6 GENERAL AND ADMINISTRATIVE

The Preparation/General Administrative (PGA) micromodel determines the central facilities, staff, and premining costs by means of extrapolation from a standard size facility. The micromodel separates ownership and operating costs into thirteen categories:

- Roads and Site Work
- Buildings
- Electric Power System
- Water System
- Communications System
- Mobile Support Equipment
- Shop Equipment
- Land Rights
- Exploration Drilling
- Contract Engineering
- Environmental Impact Statement
- Supervisory and Support Personnel
- Royalty and Severance Tax.

The input parameters for the PGA model are used mainly to define the general and administrative costs for the standard size mine and to define the extrapolation factors. The key input parameters are energy demand and stripping ratio which are used to determine the size of premining costs, facilities, and administration for the new mine. An abbreviated list of input variables is shown in Appendices B.14 and B.15.

The output of the PGA model indicates that a General and Administrative cost of \$.867/ton of recoverable coal would be required. An abbreviated listing of the computer output is shown in Appendix B.16. All costs are in January 1975 dollars (no escalation).

3.3.7 CASH FLOW ANALYSIS

The Cash Flow Analysis (CFA) computer model is used to determine the required selling price of coal for a required return on investment. The CFA model takes into account the time value of money, as well as such financial parameters as interest rates, tax rates, and escalation rates. All expenditures and revenues are compiled each year for the project. In addition, initial investment, deferred investment, and replacement investment requirements are determined.

Three types of input data are required to run the CFA model:

- Mining operation data
- Personnel data
- Case description parameters, financial assumptions, and default values.

The mining operation data defines the performance and cost of all items required for the mining complex. For each item in a mine operation approximately 40 parameters must be input to provide sufficient data for the cash flow analysis. Data from micromodel results are transferred to cash flow input, using the form shown in Appendix C.1.

The personnel data defines the classifications, salary grades, schedules, effective hours per year, and dollars per effective hour for all types of manpower required for the mine complex. The baseline input classifications and work schedules are shown in Appendix C.2.

The financial assumptions and default values define the economic conditions and accounting provisions for the project. More than 30 financial assumptions must be input to provide sufficient data for the cash flow analysis as shown in Appendix C.3.

The output generated by the CFA model is contained in eight reports:

1. Financial Summary Report and Case Description
2. Investment List
3. Operating Personnel List
4. Maintenance Personnel List

5. Services and Materials List
6. Infrastructure Report
7. Production and Cash Expenditure Table
8. Financial Statements.

These reports are discussed in detail in Section 6.0.

4.0 DEVELOPMENT OF MACROMODEL RELATIONSHIPS

4.1 MACROMODEL SUBROUTINES

In order to provide a macromodel computer modeling system requiring little interaction by the user, simplified subroutines were developed which provide similar solutions to those provided by the micromodels described previously. Table 7 shows the macromodel subroutines required to solve an area dragline mining problem along with the equivalent micromodels. A detailed description of the macromodel subroutines is contained in the macromodel user's manual (Final Report Volume 10, ref: FE-1520-110). The following paragraphs briefly describe how the simplified macromodel relationships were derived from micromodel data.

Table 7. REQUIRED MACROMODEL SUBROUTINES AND MICROMODEL EQUIVALENTS

Macromodel Subroutine	Micromodel Equivalent	Modeling Method
1. Dragline	Basic Stripping Method (BSM)	Simulation
2. Drilling and Blasting	Drilling and Blasting (DAB) Drilling/Blasting Coal (DBC)	Simulation Simulation
3. Coal Load and Haul	Haul Unit Simulation (HUS) Coal Load and Haul (CLH)	Simulation
4. Land Reclamation	Land Reclamation Simulation (LRS)	Simulation
5. Coal Preparation	Coal Prep Factoring (CPF)	Extrapolation
6. General and Administrative	General and Administrative (GAA)	Extrapolation

4.2 SUBROUTINES FOR SIMULATED FUNCTIONS

To develop the relationships used in the simplified macromodel subroutines for simulated functions, the equivalent micromodels were run varying all key parameters through an expected range of values. The resulting sets of solutions were used along with a knowledge of the micromodel mathematical relationships for curve fitting to develop formulas that would yield macromodel solutions in close approximation to solutions generated by the equivalent micromodel.

The Least-Squares Fit (LSF) program was used to develop the equations that are used in the macromodel in place of the more complex micromodel logic. The equation forms were developed from the micromodel logic. The model parameters were transformed as required to fit a linear equation of the form:

$$a_1x_1 + a_2x_2 + a_3x_3 + \dots + a_mx_m = y$$

The LSF program processes the results from the micromodel cases, determines the coefficients, resolves the expression for each case, and displays the calculated deviation between the recalculated values and the micromodel solution values. In most cases, it was possible to transform the model parameters into a truly linear equation, and the R squared term for these cases is .99 or better. In a few cases, the response was almost linear and for these cases, the R squared term drops to around .95. Note that the R squared term denotes degree of fit between micro and macro solutions and should not be used to imply accuracy versus actual situations. R^2 equal to 1.00 implies a perfect curve fit.

To develop the equations for the subroutines, a single parameter was varied for each micromodel case with all other parameters held at baseline values to obtain the set of observations for curve fitting. This approach would not be valid for general regression analysis since interactions between variables could be masked by the procedure itself. Masking is not considered to be a problem in this situation since the potential interactions are known from the micromodel logic. However, several of the fits were verified by runs in which the model parameter values were randomly varied. The LSF results did not differ materially between the random selection process and the structured selection process.

4.2.1 DRAGLINE SUBROUTINE

The dragline size is determined by the production required (bucket size) and by the dumping distance required by the pit geometry (boom length). Unless oversize is specified, it is assumed that a dragline could be built that would match the required size. The cost for the resulting synthesized dragline of the required size is based on correlation using the dragline "DLX" value as the input variable where "DLX" is defined as:

$$DLX = \frac{DLRMA * DLSW}{1000}$$

where DLRMA = boom length * cosine boom angle
DLSW = bucket size

An iterative solution is used to determine the boom length required to meet the dumping distance resulting from the pit geometry.

The derivation of the following dragline formula is shown in Appendix D.1.

Base price of synthesized machine (DLCA):

$$DLCA = 981.71 + 410.6 * DLX$$

4.2.2 DRILLING AND BLASTING OVERBURDEN SUBROUTINE

In the drilling and blasting subroutine the drill size and powder ratio are held constant. The quantity of drills and the cost of blasting materials are based on curve fitting. The derivation of the following formulas for drill quantities and blasting materials costs for overburden are shown in Appendices D.2 and D.3.

Quantity of drills for overburden (RNDR):

$$RNDR = 5.609 * (CDRTY * HB) / (1E6 * HC * DRSMFH)$$

where HC = height of coal in feet

CDRTY = coal demand recoverable tons per year

HB = height of burden in feet

DRSMFH = drilling rate in soft material in feet per hour

Cost of blasting materials for overburden (CEMDY):

$$CEMDY = 111 + 109.22 (CDRTY * HB * PR) / 1E6 * HC$$

where PR = powder ratio pounds per bank cubic yard

4.2.3 DRILLING AND BLASTING COAL SUBROUTINE

Curve fitting was not used in the derivation of the following formulas for drill quantities and blasting materials cost for coal. The formula for quantity of drills is based on baseline data showing a need for approximately .3 drills per million tons of coal recovered. The formula for cost of blasting materials is based on baseline data showing a need for approximately \$.05 for blasting materials per ton of recovered coal.

Quantity of drills for coal (RNOQD):

$$RNOQD = .3 * QBCD / 1E6 * 3263 / QDCROH$$

where QBCD = coal demand recoverable tons per year

QDCROH = coal drilling operating hours per year

Cost of blasting materials for coal (QBTEC):

$$QBTEC = .05 * QBCD * QLCRLO$$

where QLCRLO = life of mining operation in years

4.2.4 COAL LOAD AND HAUL SUBROUTINE

In the coal load and haul subroutine the shovel size and the truck size are preselected. The required quantity of shovels and trucks is based on the required production and on a truck cycle time derived from curve fitting. The derivation of the following formula for truck cycle time is shown in Appendix D.4.

Truck cycle time (TDCT):

$$TDCT = 7.41 + CHCT * SPL + 0.26673 * \frac{CHHD}{5280} + \frac{20.434 * TDSL * \frac{CHHD}{5280}}{TDSC}$$

where CHCT = shovel cycle time in minutes

SPL = no. of swings to load truck

CHHD = haul distance in feet

TDSL = truck payload in thousands of pounds

TDSC = truck horsepower

4.2.5 LAND RECLAMATION SUBROUTINE

In the land reclamation subroutine the scraper size and bulldozer size are held constant. The required quantities of scrapers and bulldozers are based on curve fitting. The derivation of the following two formulas is shown in Appendices D.5 and D.6.

Quantity of scrapers (TSCR):

$$TSCR = \left[.0157046 + 5.43198 * \frac{CDRTY}{HC} + 7.36661 * \left(\frac{CDRTY}{HC} \right)^2 \right] * HBT$$

Quantity of bulldozers (RNØCD):

$$\begin{aligned} RNØCD = & - .00384704 * \frac{CDRTY * TAN ABSD * PWF}{1 E6 * HC} \\ & + .000618961 * \frac{CDRTY * TAN ABSD * PWF^2}{1 E6 * HC} \\ & + .00660554 * \frac{CDRTY * CGD}{1 E6 * HC} \end{aligned}$$

where CDRTY = coal demand
 HC = height of coal
 HBT = height of topsoil
 CGD = cost for general dozing
 PWF = panel width in feet
 ABSD = angle of burden spoils in degrees

4.3 SUBROUTINES FOR EXTRAPOLATED FUNCTIONS

The macromodel subroutines for extrapolated functions are a direct adaptation of the equivalent micromodels. These micromodels determine quantities and costs using the following general type of formula:

$$\text{New Qty} = \text{Baseline Qty} \times \left(\frac{\text{New Size}}{\text{Baseline Size}} \right)^Y$$

$$\text{New Cost} = \text{Baseline Cost} \times \left(\frac{\text{New Size}}{\text{Baseline Size}} \right)^Y$$

The baseline values are based on estimates made for a specific size operation. The exponent "Y" is the scaling factor used to scale up or down from the baseline size.

4.3.1 COAL PREPARATION SUBROUTINE

The baseline size for the coal preparation facilities is 75,000 TPD as described in Volume 4 of the Phase I Report (Ref: FE-1520-4). A detailed description of the various extrapolation formulas for ownership and operating costs, personnel, etc., is contained in the user's manual (ref: Report FE-1520-116).

4.3.2 GENERAL AND ADMINISTRATIVE COSTS

The baseline size for the mining complex for which the general and administrative costs were estimated is 185,617,000 tons of material moved per year. A detailed description of the various extrapolation formulas for ownership and operating costs, personnel, etc., is contained in the user's manual (ref: Report FE-1520-116).

4.4 SUPPORT EQUIPMENT

Several of the mining operations require supplementary equipment to be used in support of the primary equipment. For the baseline case, support equipment requirements were determined for each pit. These requirements have been programmed as part of the subroutines as follows.

4.4.1 SUPPORT EQUIPMENT FOR DRAGLINE

Based on field observation and experience, it was determined that each primary dragline requires one each of the following support equipment:

Track-type Tractor	- 300 HP (General Dozing, Bench Prep)
Wheeled Loader	- 325 HP (Cable Handling)
Secondary Dragline	- (Remove High Spots, Bench Building, and Drainage Control).

An initial box cut excavation is required to open the first panel.

4.4.2 SUPPORT EQUIPMENT FOR DRILLING AND BLASTING

Based on field observation and experience, it was determined that each pit requires one each of the following equipment:

Track-type Tractor	- 300 HP (General Dozing, Bench Prep)
Wheeled Loader	- 80 HP (Handle Cuttings)
Prill Truck	- (Haul Blasting Agents).

4.4.3 SUPPORT EQUIPMENT FOR COAL LOADING AND HAULING

Each pit requires one each of the following equipment:

Wheeled Loader	- 325 HP (Clean Top of Coal)
Grader	- 180 HP (Maintain Haul Road)
Pump Set	- 125,000 GPH (Clear Pit of Water)
Water Truck	- 5000 GAL (Maintain Haul Road).

This selection of support equipment assumes that the construction and maintenance of haul roads will not require such items as air track drills, rollers, or a materials crushing plant. The user may wish to add to or modify the support equipment shown to better match his personal experience or preference.

5.0 MACROMODEL DESCRIPTION

5.1 ELEMENTS OF THE MACROMODEL

The basic elements of the macromodel for area stripping with draglines include a case study description, a main program, subroutines, and a cash flow analysis. The macromodel is described in greater detail in the macromodel user's manual (Final Report Volume 10, ref: FE-1520-110).

5.1.1 CASE STUDY DESCRIPTION

In order to maintain minimum interaction between the user and the macromodel, only a few key parameters are required to describe a case study. Two types of input are included in the case study description:

Mining Parameters

Prep. Plant Type Based on Difficulty of Preparation
(1=crush & screen; 2=Baum jig; 3=heavy media)
Topsoil Thickness Saved (ft)
Height of Burden Average (ft)
Height of Coal (ft)
Energy Demand for Mine Complex (Btu/yr)
Run-of-Mine Coal Heat Value (Btu/lb)
Other Reclamation Costs (\$/acre)

Financial Assumptions

Paid in Capital Long-Term Debt Ratio
Land Rights-Surface (\$/acre)
Land Rights-Mineral (\$/acre)
Royalty (\$/ton)
State and Local Severance Tax (\$/ton)
*Desired Rate of Return (percent)
Federal Income Tax Rate (percent)
Long-Term Interest Rate (percent)
Short-Term Interest Rate (percent)
*Required Selling Price (\$/prepared ton)

*Specify one parameter and set the other (which is to be calculated) to zero.

5.1.2 MAIN PROGRAM

The main program of the macromodel develops the production requirements for each function using the mining parameters, along with many built-in default values and assumptions.

The main program sets the life for each mining operation. It then sizes the preparation plant based on the required energy demand, the run-of-mine coal heat value, and the difficulty of preparation effort.

Next, the annual run-of-mine coal production for the mining complex is established and divided among one or more pits. The volume of coal and overburden, the stripping ratio, and the number of acres are calculated for each pit.

Finally, the main program calls the subroutines which establish the equipment requirements for each function.

5.1.3 SUBROUTINES

As discussed in Section 4.0, the subroutines are based on equivalent micromodels for each of the following mining functions:

- Dragline
- Drilling and Blasting of Overburden
- Drilling and Blasting of Coal
- Coal Load and Haul
- Land Reclamation
- Coal Preparation
- General and Administrative.

These subroutines generate three types of data: size and quantity of primary equipment and facilities; size and quantity of support equipment; and a cash flow input data file containing all equipment and facilities data required to run the Cash Flow Analysis program.

5.1.4 CASH FLOW ANALYSIS

The Cash Flow Analysis program described previously as part of the micromodeling system, Section 3.3.7, is also used in the macromodeling system. Manual transfer of data to the cash flow program is not required, as is the case for the micromodeling system, because the macromodel and the cash flow program can be run in sequence. Thus, no interaction is required on the part of the user between the point of defining the input parameters and receiving the cash flow output. Specified case description parameters and financial assumptions are input to the macromodel and passed through to the cash flow program.

5.2 UNDERLYING ASSUMPTIONS

Because the macromodeling system is designed to require minimum interaction between the user and the computer, there are, by necessity, many assumptions built into programs.

5.2.1 MINING PARAMETERS

Many parameters which describe the mining situation are assumed to be constant in the macromodel at the baseline values established for the test case. For example, the safe working angle of the highwall, the panel width, the swell factor, and spoil angle of repose are all assumed constant in the macromodel.

Similarly, the basic physiography and stratigraphy of the site and the desired production per pit are assumed constant at baseline values.

5.2.2 SCHEDULE AND EFFICIENCY

The macromodel also assumes that the pit operation schedule and efficiency are held constant at the test case baseline values.

5.2.3 FINANCIAL ASSUMPTIONS

As with the mining parameters, many financial assumptions are also held constant in the macromodel. For example, the long-term borrowing repayment rate, regional adjustments for costs, assumptions concerning accounts payable, accounts receivable and inventory, home office costs, and insurance costs are all assumed constant at the test baseline values.

It should also be noted that only the costs directly associated with the project are included. Costs are not included for a construction camp, infrastructure improvements in surrounding communities, etc. However, local property and severance taxes are included which could be used for community development.

5.2.4 REASONABLE RANGE OF VALUES

The macromodel will make calculations based on the input provided. Thus, it is assumed that when the user specifies the mining parameters and the financial assumptions, he has chosen values which define a practical, realistic problem. The values used in the macromodel sensitivity analysis can be used as a general guide to the reasonable range of values that will yield good results with the macromodel.

5.3 INTENDED USE

The macromodeling system is intended to provide useful information related to macroeconomic studies and energy planning and policy analysis. The macromodel can be used for regional studies and to analyze a specific property at an early stage when little field data is available.

Because the macromodel is based on many simplified relationships and contains many built-in assumptions, the user should be aware of possible shortcomings in the results when the problem is beyond the flexibility of the macromodel to analyze. (Such a problem might require use of one or more micromodels to reach a reasonable solution.) In addition, the user should not imply an accuracy to the result solely due to the quantity and detail of the output. The accuracy is influenced by how well the case being studied matches the built-in assumptions. As long as the user bears in mind that the model is intended to provide first-order estimates of costs which can be used for planning purposes, the macromodel can be used to generate valuable information for a variety of decision making situations.

The use of the macromodels and micromodels at various stages of a large-scale surface coal mining project is shown in Figure 17. The macromodels are most useful for early estimating while the micromodels are most useful in more detailed estimating and engineering. At the latter stages of a project the bulk of the engineering and estimating is done by traditional methods.

A macromodel needs only seven mining parameters and nine financial parameters as input. All other parameters are set at default values generally descriptive of the region being studied. The user who desires little or no interaction with the model can obtain an answer quickly by defining only the needed input and accepting all other parameters at the default values. The user also has the option of changing any or all the default values to match his own field data or operating experience.

The accuracy of results when using either the macromodel or the micromodels depends in large part on two factors:

Quantity and accuracy of field data describing the deposit.

Accuracy of financial assumptions describing future economic conditions.

LARGE-SCALE MINING PROJECT STAGES OF DEVELOPMENT

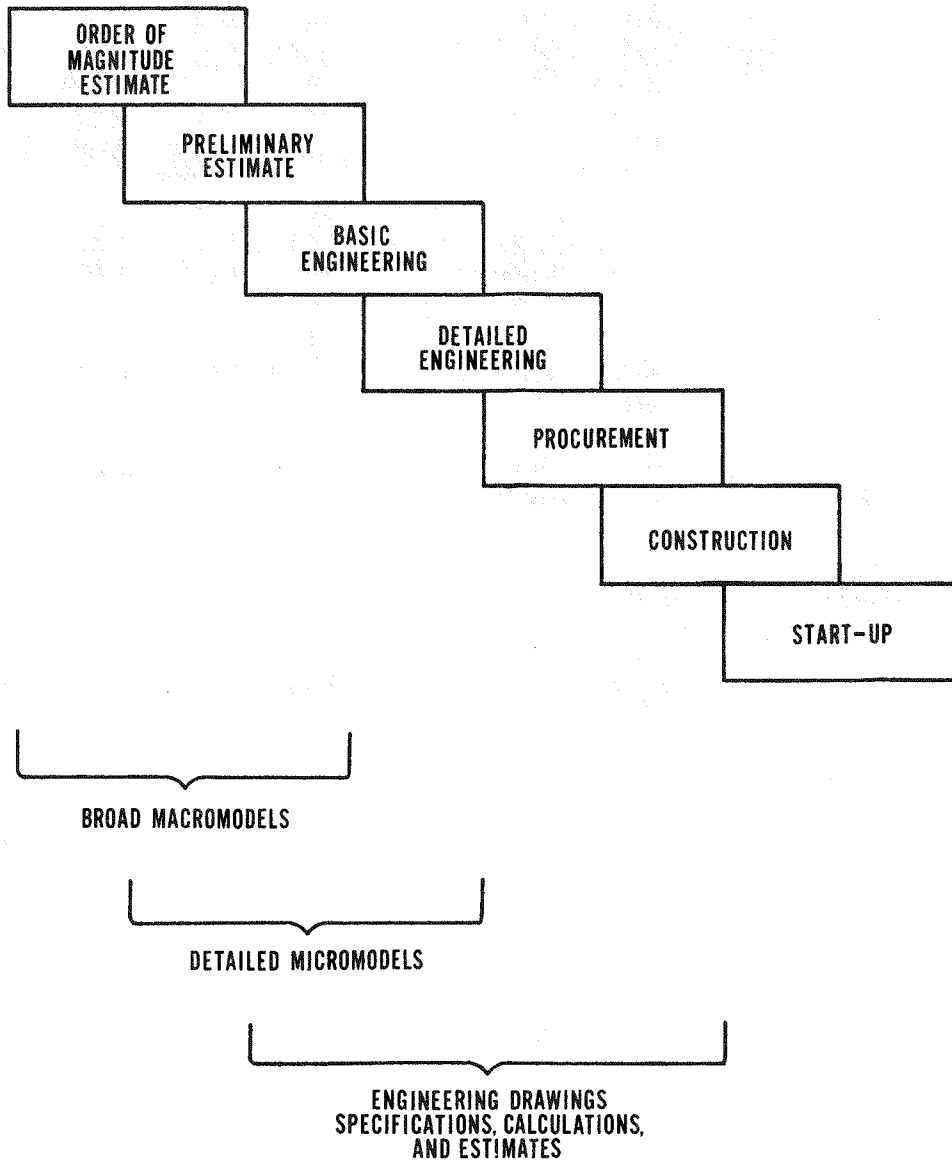


Figure 17. Typical Mining Project Stages of Development

Generally, as a large-scale mining project progresses from the order-of-magnitude stage through start-up, the accuracy of the estimates improves due to better field data and more time and depth spent in analysis.

The Area Dragline Macromodel has been tested for representative cases not only in Fort Union but also in the Illinois Basin (Final Report Volume 2), the Four Corners Region (Final Report Volume 3), and the Texas Gulf Region (Final Report Volume 5). The default values used by the macromodel are different for each region. Thus, if the model were to be used for other regions, such as the Powder River Region, a new set of default values would be required.

The prerequisite for using a macromodel for a specific site in any region is the suitability of the mining method to the characteristics of the deposit. While dragline stripping is an economical mining method, its application must be tempered with the following considerations:

- Flexibility of operation
- Savings on initial investment
- Irregular topography
- Greater mining selectivity
- Safety from catastrophic slope failures
- Pit geometry exceeds capacity of draglines.

6.0 MACROMODEL TEST CASE AND SENSITIVITY ANALYSIS

6.1 TEST CASE SOLUTION

The baseline solution for a hypothetical mine complex in the Fort Union Region, producing 9,160,000 tons per year of prepared coal from three pits and processed in a single coal preparation plant, is shown in detail in the eight reports contained in Appendix E:

1. Financial Summary Report and Case Description
2. Investment List
3. Operating Personnel List
4. Maintenance Personnel List
5. Services and Materials List
6. Infrastructure Report
7. Production and Cash Expenditure Table
8. Financial Statements.

The Financial Summary Report lists key financial information and the Case Description records the basic mining parameters and financial assumptions as shown in Appendix E.1 and summarized as follows:

FINANCIAL SUMMARY REPORT

Sales price in base dollars	: \$/prepared ton	5.93
	: \$/million Btu	.42
Return on investment	: Percent	10.00*
Return on paid-in capital	: Percent	10.87**
Cummulative investment to steady state:	M\$	137395.
Cummulative investment total project	: M\$	179628.
Annual operating cost at steady state	: M\$	15630.
Base year is	1975	
Project begins	1976	
First coal production in	1982	
Steady state begins in	1985	
Steady state ends in	2011	
Last coal production in	2013	
Project ends in	2015	

*Discounted cash flow internal rate of return assuming project is financed completely by internal capital.

**Discounted cash flow internal rate of return assuming project is financed by user-set combination of internal capital and external debt.

CASE DESCRIPTION

Mining Parameters

Index to Plant Type***	1
Coal Demand ROM Tons/Year (Complex)	9,252,963
Stripping Ratio (Bank Yards/Recovered Ton)	3.80
Height of Topsoil in Feet	1.25
Height of Coal in Feet	12
Prepared Coal Tons/Year	9,160,435
Energy Demand for Complex Trillion Btu/Year	130
ROM Coal Heat Value Btu/lb	7070
Reclamation - Other Costs - \$/Acre	600

FINANCIAL ASSUMPTIONS

Capital/Debt Ratio	2
GAA-Mineral Rights (\$/Acre)	50.00
GAA-Royalty Amount (\$/Ton)	.25
GAA-Surface Rights (\$/Acre)	250.00
GAA-Severance Tax (\$/Ton)	0
Rate - Cash Flow Discount	.10
Rate - Federal Income Tax	.48
Rate - Long Term Interest	.08
Rate - Short Term Interest	.10
Value - Req. Price of Coal - \$/Ton	0

***Preparation Plant Types:

- 1 = Crushing and Screening
- 2 = Baum Jig
- 3 = Heavy Media

The coal price for the baseline solution may be considerably different from current prices for Fort Union coals for several reasons:

1. Costs of equipment have increased drastically over the last decade.
2. Operating costs have increased drastically over the last decade.
3. Some long-term contracts had low profit margins and little or no escalation.
4. The market price for coals varies widely (for example: steam coal versus metallurgical coal).
5. Higher stripping ratios are being encountered (i.e., the thickest seams with the least overburden were mined first).
6. Some coals are sold with little or no blending, stockpiling, or preparation.

In addition, the sensitivity analysis shows a wide range of prices in response to mining parameters and financial assumptions.

To underscore the impact of financial assumptions on required coal price, a set of alternative studies were run to compare with baseline results.

Baseline -----	\$5.93/ton
(No escalation, 10% Rate of Return, price constant for all project years)	
Alternate 1 -----	\$7.67/ton
(No escalation, 15% Rate of Return, price constant for all project years)	
Alternate 2 -----	\$11.03/ton
(5% Cost Escalation, 10% Rate of Return, price constant for all project years)	
Alternate 3 -----	first year \$6.54/ton; last year \$24.49/ton
(5% Cost Escalation, 10% Rate of Return, Price Escalates at 5%)	

The Investment List shows all required equipment, facilities, and premining costs. The total investment is divided into initial investment (required to reach steady state production), deferred investment (required additions as mining proceeds), and replacement capital (required to replace worn out equipment) as shown in Appendix E.2.

The initial capital investment requirements for the baseline solution are shown in detail in Table 8. Note that overburden removal plus coal handling and preparation together account for nearly 73 percent of the initial investment while general and administrative items (including premining costs) account for over 19 percent of the initial investment.

Table 8. INITIAL CAPITAL INVESTMENT FOR HYPOTHETICAL TEST CASE IN FORT UNION**

MINING STEP	BASELINE INVESTMENT*	PERCENT
Overburden Removal	19,017,000	14.0
Drilling/Blasting Coal	220,000	0.2
Coal Load & Haul	7,736,000	5.7
Coal Handle & Prep	79,602,000	58.6
Land Reclamation	2,772,000	2.0
Premining and Facilities	26,591,000	19.5
TOTAL	\$135,938,000	100.0

*Baseline investment from Investment List (Appendix E). All costs are in January 1975 dollars (no escalation).

Table 9. ANNUAL DIRECT OPERATING COST FOR HYPOTHETICAL TEST CASE IN FORT UNION**

MINING STEP	BASELINE ANNUAL* OPERATING COST	PERCENT
Overburden Removal	5,144,300	34.2
Drilling/Blasting Coal	673,400	4.5
Coal Load & Haul	3,199,500	21.2
Coal Handle & Prep	5,040,900	33.5
Land Reclamation	993,000	6.6
TOTAL	\$15,051,600	100.0

*Baseline annual operating cost from operating personnel table, maintenance personnel table, and materials and services table (Appendix E). General and administrative not included. All costs are in January 1975 dollars (no escalation).

**Mine complex with 3 pits and 1 preparation plant produces nominal coal feed required for:
 250 million cu.ft./day gasification plant, or
 40,000 BBL/day liquefaction plant, or
 1500 megawatt power plant

The Operating Personnel List shows all equipment/plant operating crews plus the general and administrative staff. As shown in Appendix E.3, the baseline solution indicates that an initial operating staff of 327 people would be required with an annual payroll of \$6,816,200 (January 1975 dollars with no escalation).

The Maintenance Personnel List shows all personnel required to maintain the equipment fleet and the plant. As shown in Appendix E.4, the baseline solution indicates that an initial maintenance staff of 147 people would be required with an annual payroll of \$2,845,800 (January 1975 dollars with no escalation).

The Services and Materials List shows all required contract services, spare parts, and consumable items. Power, water, and fuel quantities are compiled. As shown in Appendix E.5, the baseline solution indicates an annual services and materials cost of \$17,339,100 (January 1975 dollars with no escalation).

The annual direct operating costs (labor plus materials and services) are shown in detail in Table 9. Overburden removal accounts for over 34 percent of the total operating costs while drilling and blasting coal accounts for less than 5 percent and coal handling and preparation over 33 percent of the total operating costs.

Note that the total initial investment and the total annual operating costs shown in Tables 8 and 9 are derived from the investment list, operating manpower list, maintenance manpower list, and materials and services list, while the steady state values in the financial summary are derived from the pro forma financial statements for the first year of rated production. Therefore, the values found in Tables 8 and 9 will be approximately, but not exactly, the same as the values found in the financial summary.

The Infrastructure Report (Appendix D.6) contains items of interest with regard to environmental impact statements and socioeconomic studies under the following headings:

- Physical Effects
- Economic Impact
- Utility Requirements
- Manpower Requirements

The environmental and socioeconomic impact of the mine complex can be summarized as follows:

Acres Disturbed:	518 acres/yr
Payrolls, Purchases and Taxes:	\$25,341,000/yr
Water Requirements:	165-acre-ft/yr
Electric Power:	110,589 megawatt hrs/yr
Manpower - Operating:	327
- Maintenance:	147

The Production and Cash Expenditure Table (Appendix E.7) shows the year by year production for each mining operation as well as the cash expenditure for equipment, manpower, and services and materials.

The Financial Statements show yearly pro forma income statements, sources and uses of funds, and balance sheets for the life of the project (Appendix E.8).

Default values for Fort Union mining parameters and financial assumptions are shown in Appendix E.9.

6.2 CONTRIBUTION OF INDIVIDUAL MINING FUNCTIONS TO PRICE OF COAL

To investigate the portion of the total price of coal attributable to each mining function, a series of cases was run with the macromodel. Each case utilized all baseline values except that only one mining operation's investment and operating costs were included each time. The results, presented in Table 10, show overburden removal contributing nearly 22 percent of the price while coal handling and preparation contributes over 36 percent and premining and facilities contribute approximately 25 percent. The sum of the individual baseline solutions does not equal the exact combined baseline solution due to the combined effects of taxes, etc.

Table 10. CONTRIBUTION OF MINING FUNCTIONS TO COAL PRICE FOR FORT UNION BASELINE CASE

INDIVIDUAL BASELINE SOLUTION	PRICE \$/TON	PERCENT
Overburden Removal	1.38	21.7
Coal Drilling & Blasting	.08	1.3
Coal Load & Haul	.74	11.6
Coal Handle & Prep	2.29	36.1
Land Reclamation	.27	4.3
Premining, Facilities, & Admin	1.59	25.0
	<u>6.35</u>	<u>100.0</u>
COMBINED BASELINE SOLUTION	5.93	

6.3 SENSITIVITY ANALYSIS - MINING PARAMETERS

The mining parameters used in the sensitivity analysis were selected because of their significant impact on cost or because of policy issues that might be related to them. The seven mining parameters selected are as follows:

- Energy Demand for Mine Complex (Btu/yr)
- Run-of-Mine Coal Heat Value (Btu/ft)
- Height of Burden Average (ft)
- Height of Coal (ft)
- Preparation Plant Type
- Topsoil Thickness Saved
- Other Reclamation Costs

The sensitivity range for these mining parameters is shown in Table 11. The baseline values were selected to be representative of a typical mining situation in the Fort Union Region. The expected low and expected high values represent the range of situations commonly found in Fort Union. The extreme low and extreme high values represent the range of situations that would be unlikely or marginal situations for mining. All values were selected based on a review of data collected during mine visits and a review of coal resource and reserve data compiled during Phase I (Ref: Report FE-1520-2).

The results of the mining parameter sensitivity analysis are tabulated in Appendix F.1. Coal price versus sensitivity range is plotted in Figure 18. An analysis of Figure 18 shows that four parameters have a major effect on coal price and three have less effect (under 10 percent) as follows:

Major Effect:

1. Preparation Plant Type
2. Energy Demand for Mine Complex
3. Height of Burden Average
4. Height of Coal

Less Effect:

1. Run-of-Mine Coal Heat Value
2. Topsoil Thickness Saved
3. Other Reclamation Costs

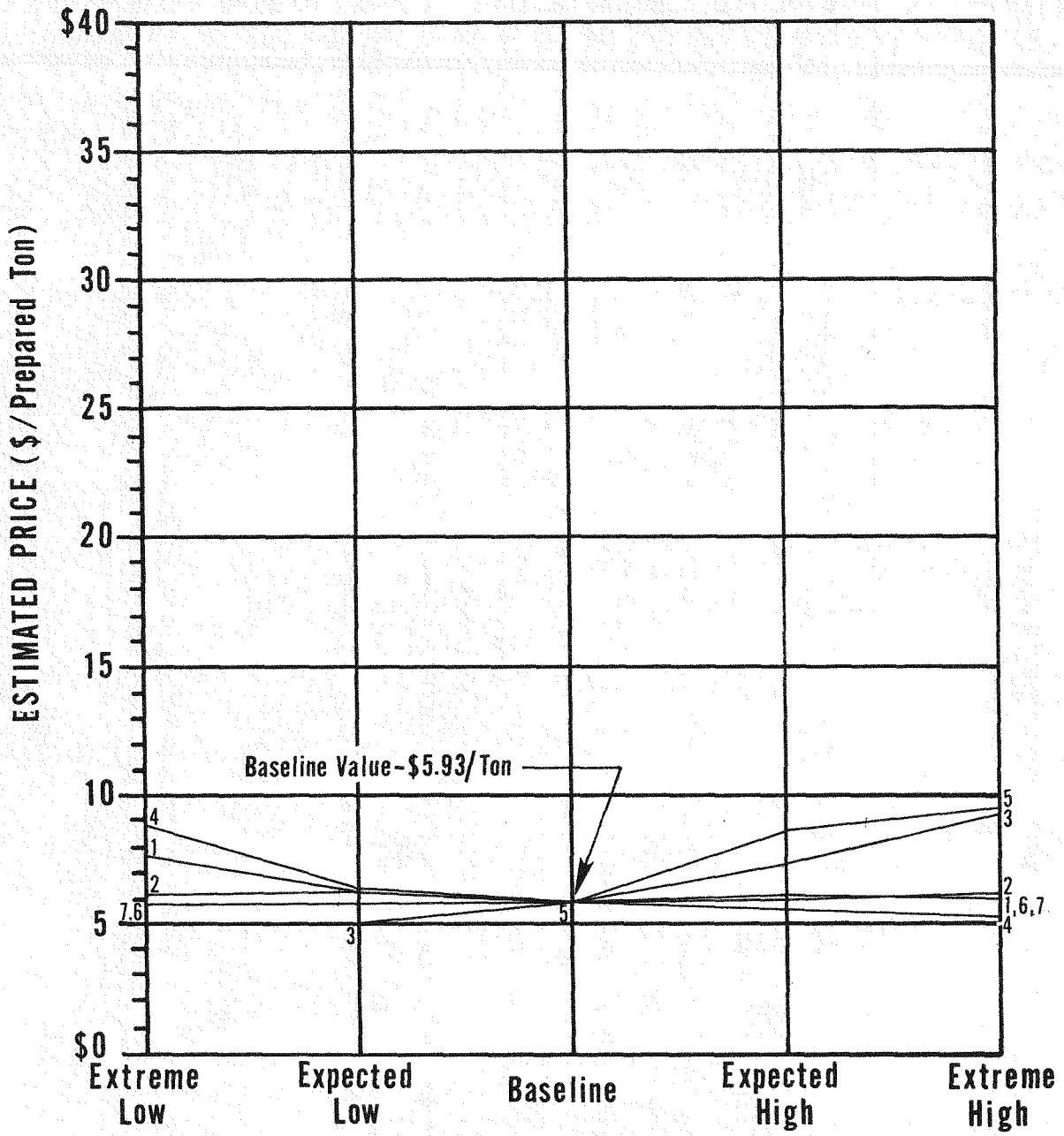
Thus, the first group of mining parameters deserves to be studied and determined with relatively more emphasis than the second group when analyzing a mining situation or region. The analyst should also keep in mind that at a production of several million tons per year, items affecting costs by less than 1¢ per ton can represent savings or losses of hundreds

Table 11. MINING PARAMETERS SENSITIVITY RANGE
FORT UNION TEST CASE

	Sensitivity Range				
	5 Extreme Low	4 Expected Low	3 Baseline Value	2 Expected High	1 Extreme High
Mining Parameters					
Energy Demand for Mine Complex (Trillion Btu/yr)	32.5	81.3	130	195	243.8
Run-of-Mine Coal Heat Value (Btu/lb)	6,000	6,500	7,070	7,400	7,700
Height of Burden Average (ft)	-	20	42	70	100
Height of Coal (ft)	4	8	12	17	22
Prep Plant Type Based on Difficulty (1=crush & screen; 2=Baum jig; 3=heavy media)	-	-	1	2	3
Topsoil Thickness Saved (ft)	0	.5	1.25	2.00	2.5
Other Reclamation Costs (\$/acre)	300	450	600	750	900

Note: These values apply to the range of coal prices shown on Figure 18.

FORT UNION



SENSITIVITY RANGE

(WITH BASELINE VALUES SHOWN IN PARENTHESIS)

- 1 - Energy Demand (130 Trillion BTU's/yr.)
- 2 - ROM Coal Heat Value (7070 BTU's/lb.)
- 3 - Height Of Burden (42 ft.)
- 4 - Height Of Coal (12 ft.)
- 5 - Prep. Plant Type (Crush & Screen)
- 6 - Height Of Topsoil (1.25 ft.)
- 7 - Other Reclamation Cost (\$600/acre)

(All Costs in January 1975 dollars
with no escalation)

Figure 18 Mining Parameter Sensitivity Analysis

of thousands of dollars for an actual operating mine. Therefore, even items which have "less effect" when making an order of magnitude study, can be of considerable importance during actual mine operations.

6.4 SENSITIVITY ANALYSIS - FINANCIAL ASSUMPTIONS

The financial assumptions used in the sensitivity analysis were also selected because of their significant impact on cost or because of policy issues that might be related to them. The twelve financial assumptions selected are as follows:

- Long-Term Interest Rate (percent)
- Desired Return on Investment (Cash Flow Discount Rate) (percent)
- Federal Income Tax Rate (percent)
- Paid-in Capital/Long-Term Debt Ratio
- Labor Escalation Rate
- Materials and Services Escalation Rate
- Equipment Investment Escalation Rate
- Depreciation Method
- Land Rights-Surface (\$/acre)
- Land Rights-Mineral (\$/acre)
- Royalty (\$/ton)
- State and Local Severance Tax (\$/ton)

The sensitivity range for these financial assumptions is shown in Table 12. The baseline values represent average conditions with no inflation using straight line depreciation. The expected low and expected high values represent a range of common economic conditions (note that negative numbers are not shown for the expected low value of inflation, that is, deflationary conditions are not included). The extreme high and extreme low values represent a range of economic conditions that are possible but not likely. The variation of depreciation method represents a comparison of alternatives rather than a range of expected values.

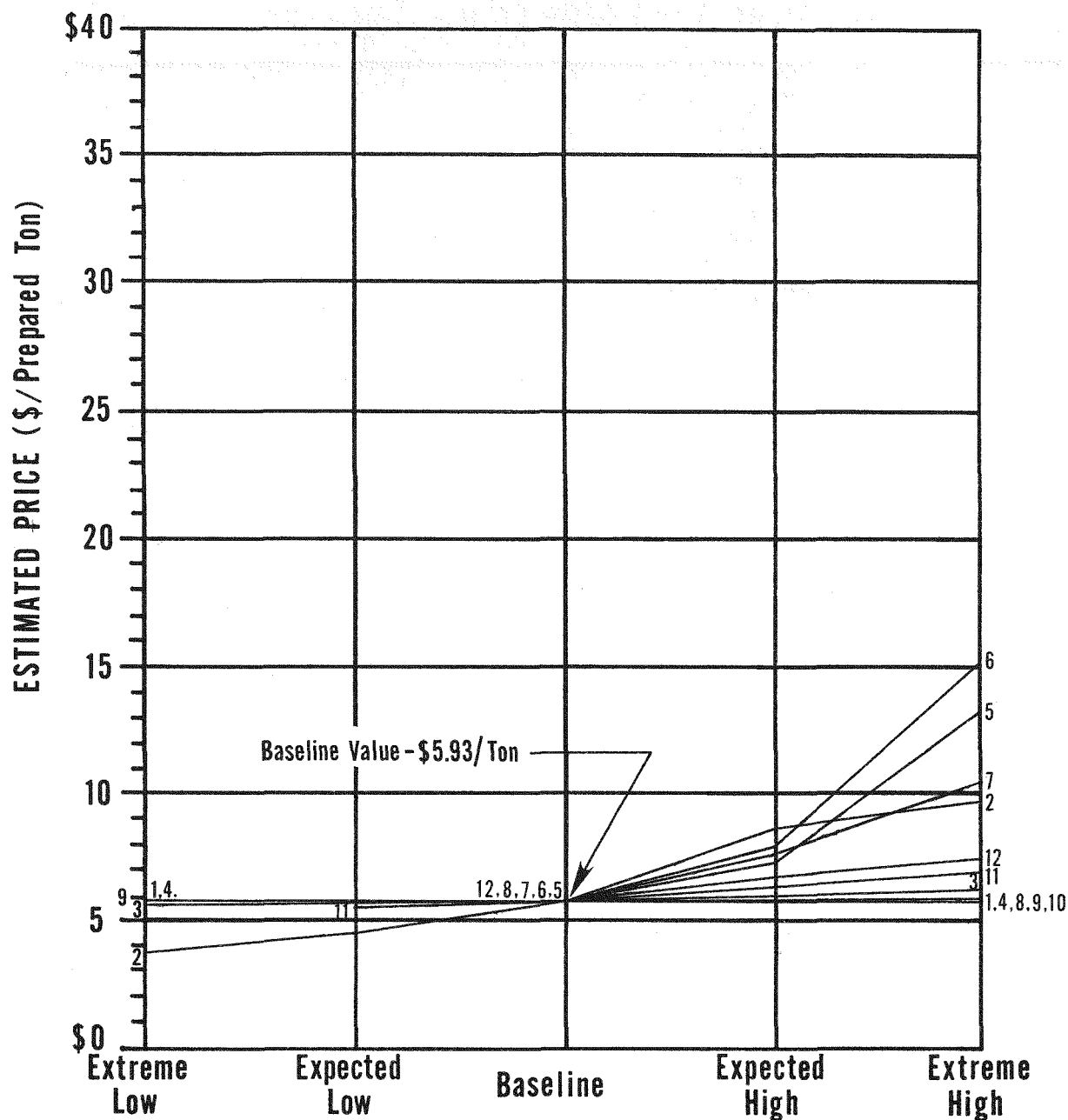
The results of financial assumption sensitivity analysis are tabulated in Appendix F.2. Coal price versus sensitivity range is plotted in Figure 19. An analysis of Figure 19 shows that four assumptions have a major effect on coal price and eight have less effect (under 10 percent) as follows:

Table 12. FINANCIAL ASSUMPTIONS SENSITIVITY RANGE
FORT UNION TEST CASE

	Sensitivity Range				
	5	4	3	2	1
	Extreme Low	Expected Low	Baseline Value	Expected High	Extreme High
Financial Assumptions					
Long-Term Interest Rate (percent)	-	6.0	8.0	10.0	12.0
Desired Return on Investment (Cash Flow Discount Rate) (percent)	0	5.0	10.0	15.0	20.0
Federal Income Tax Rate (percent)	38.4	43.2	48.0	52.8	57.6
Paid-in Capital/Long-Term Debt Ratio	.00	1	2	4	99
Labor Escalation Rate	-	-	.00	.05	.10
Materials and Services Escalation Rate	-	-	.00	.05	.10
Equipment Investment Escalation Rate	-	-	.00	.05	.10
Depreciation Method	-	-	St.Line	Decl.Bal.	Dbl.Decl.
Land Rights-Surface (\$/acre)	0	125	250	375	500
Land Rights-Mineral (\$/acre)	0	25	50	75	100
Royalty (\$/ton)	-	0	.25	.50	1.00
State and Local Severance Tax (\$/ton)	-	-	0	.50	1.00

Note: These values apply to the range of coal prices shown on Figure 19.

FORT UNION



SENSITIVITY RANGE

(WITH BASELINE VALUES SHOWN IN PARENTHESIS)

- | | |
|---|---|
| 1 - Long Term Interest Rate (8%) | 7 - Equipment Investment Escalation Rate (0%) |
| 2 - Return On Investment (10%) | 8 - Depreciation Method (Straight Line) |
| 3 - Federal Income Tax Rate (48%) | 9 - Surface Rights (\$250/acre) |
| 4 - Paid-in Capital/Debt Ratio (2:1) | 10 - Mineral Rights (\$50/acre) |
| 5 - Labor Escalation Rate (0%) | 11 - Royalty (\$.25/ton) |
| 6 - Materials & Services Escalation Rate (0%) | 12 - Severance Tax (\$0/ton) |

(All baseline costs in January 1975 dollars with no escalation)

Figure 19 Financial Assumption Sensitivity Analysis

Major Effect:

1. Materials and Services Escalation Rate
2. Labor Escalation Rate
3. Equipment Investment Escalation Rate
4. Desired Return on Investment (Cash Flow Discount Rate)

Less Effect:

1. Federal Income Tax Rate
2. State and Local Severance Tax
3. Royalty
4. Land Rights-Surface
5. Land Rights-Mineral
6. Depreciation Method
7. Long-Term Interest Rate
8. Paid-in Capital/Long-Term Debt Ratio

Thus, the user should be aware of the major impact of projected escalation rates. And, as with the mining parameters, it should be noted that financial assumptions which have "less effect" can be very important to operating mine management.

APPENDICES

- A. List of Final Reports and Phase I Reports
- B. Micromodel Test Case Analysis Input and Results
- C. Cash Flow Analysis Input
- D. Curve Fitting Analysis
- E. Macromodel Baseline Solution
- F. Macromodel Sensitivity Analysis

APPENDIX A

- A.1 Final Report List (Phase II Report)
- A.2 Phase I Report List

The Final Report consists of sixteen volumes which include a one volume executive summary; eight volumes, documenting example applications of the simulation models for hypothetical test situations; and seven volumes giving user documentation on how each model operates.

The Phase I Report consists of six volumes documenting data gathering activities and modeling efforts completed during the first 24 months of the project.

Appendix A.1 Final Report List (Phase II Report)

Economics of Large-Scale Surface Coal Mining
Using Simulation Models

SUMMARY

Volume 1: Executive Summary (ref: FE-1520-101).

REGIONAL TEST CASES

- Volume 2: Area Stripping with Draglines Using Illinois Basin Region Test Case (ref: FE-1520-102).
Volume 3: Area Stripping with Draglines Using Four Corners Region Test Case (ref: FE-1520-103).
Volume 4: Area Stripping with Draglines Using Fort Union Region Test Case (ref: FE-1520-104).
Volume 5: Area Stripping with Draglines Using Texas Gulf Region Test Case (ref: FE-1520-105).
Volume 6: Contour Stripping with Draglines Using Appalachia-Ohio Region Test Case (ref: FE-1520-106).
Volume 7: Area Stripping with Shovels and Trucks Using Powder River Region Test Case (ref: FE-1520-107).
Volume 8: Mountain Top Removal Mining Using Appalachia-West Virginia Region Test Case (ref: FE-1520-108).
Volume 9: Multiple Dipping Seam Mining Using Green River Region Test Case (ref: FE-1520-109).

USER'S MANUALS FOR COMPUTER MODELS

- Volume 10: User's Manual for Area Dragline Macromodel (ref: FE-1520-110).
Volume 11: User's Manual for Area Shovel Truck Macromodel (ref: FE-1520-111).
Volume 12: User's Manual for Contour Stripping with Draglines Macromodel (ref: FE-1520-112).
Volume 13: User's Manual for Cash Flow Analysis Model (ref: FE-1520-113).
Volume 14: User's Manual for Dragline Stripping Micro-models (ref: FE-1520-114).
Volume 15: User's Manual for Shovel Truck Mining Micro-models (ref: FE-1520-115).
Volume 16: User's Manual for Nonstripping Mining Function Micromodels (ref: FE-1520-116).

All volumes available from:

National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22161

Appendix A.2 Phase I Report List

Volume 1: Introduction, Summary, Conclusions, and Recommendations for Research.

Summary of Phase I results (31 pages, ref: FE-1520-1).

Volume 2: Characterization of Coal Deposits for Large-Scale Surface Mining.

Delineates strippable coal resource regions of the U.S. and describes their physiography, surficial deposits, soils, structural geology, general stratigraphy, and coal stratigraphy (346 pages, ref: FE-1520-2).

Volume 3: Surface Coal Mining Methods and Equipment.

Describes mining methods and equipment used in large scale surface coal mining (109 pages, ref: FE-1520-3).

Volume 4: Large-Scale Coal Processing for Coal Conversion.

Discusses coal preparation plant design related to producing feedstocks for coal conversion and describes hypothetical plants for three types of coal preparation (80 pages, ref: FE-1520-4).

Volume 5: Survey of Socioeconomics, Financial Statistics, and Legal Aspects.

Provides an overview of the socioeconomic, financial, and legal factors which affect surface coal mining (121 pages, ref: FE-1520-5).

Volume 6: Computer Systems to Support Mine Planning.

Describes the status of the simulation models and supporting data files at the end of Phase I (307 pages, ref: FE-1520-6).

Available from the National Technical Information Service,
U.S. Department of Commerce,
Springfield, Virginia 22161.

Further information not contained in these volumes can be obtained from Fluor Utah, Inc., in San Mateo, California or the Fossil Energy Office of the Energy Research and Development Administration in Washington, D.C.

APPENDIX B

Micromodel Test Case Analysis Input and Results

- B.1 Basic Stripping Method (BSM) Input
- B.2 Basic Stripping Method (BSM) Output
- B.3 Drilling, Blasting and Coal (DBC) Input
- B.4 Drilling, Blasting and Coal (DBC) Output
- B.5 Haul Unit Simulation (HUS) Input
- B.6 Haul Unit Simulation (HUS) Output
- B.7 Coal Load and Haul (CLH) Input
- B.8 Coal Load and Haul (CLH) Output
- B.9 Land Reclamation Simulation (LRS) Input
- B.10 Land Reclamation Simulation (LRS) Output
- B.11 Preparation/General Administrative (PGA) Input
(Coal Preparation Factoring)
- B.12 Preparation/General Administrative (PGA) Default
Values (Coal Preparation Factoring)
- B.13 Preparation/General Administrative (PGA) Output
(Coal Preparation Factoring)
- B.14 Preparation/General Administrative (PGA) Input
(Premining, Facilities, and Administration)
- B.15 Preparation/General Administrative (PGA) Default
Values (Premining, Facilities, and Administration)
- B.16 Preparation/General Administrative (PGA) Output
(Premining, Facilities, and Administration)

User's manuals for the above micromodels are contained in Volumes 14 and 16 of the Final Report (ref: FE-1520-114 and FE-1520-116).

B.1 Basic Stripping Method (BSM) Input

DATE 07/08/76

BASIC STRIPPING METHOD
0507 (BSMU0507) FORT UNION
0507 BASIC STRIPPING METHOD

INPUT PARAMETERS

PCPM = 2.00000
PCSA = 3.00000
PCSO = 1.00000
MFC = 0
KULN = 0
ABHD = 63.4350
ACFB = 76.0000
ABSU = 33.6890
SWDH = 2.00000
BARH = .000000
BACF = .000000
CATC = .000000
FFP = .950000
SFR = .350000
ESD = .833000
ECP = .920000
PIF = .980000
DCRPPY = 2000.00
DBRPPY = 2935.00
DBUC = 2000.00
DBSHY = 5277.00
PSSHY = 7447.00
CURTY = 3.384321E 06
DDY = 1.00000
TRAD = 10.0000
TDMH = 5.00000
TDCD = 5.00000
KAC = 1
ALF = 10560.0
ARF = 21431.0
PLF = 10560.0
PWF = 100.000
HBN = 31.5000
HBA = 42.0000
HBY = 73.5000
HC = 12.0000

B.1 Basic Stripping Method (BSM) Input - Definitions

PCPM	Plot Control Primary	DBBPY	Density of Overburden
PCSM	Plot Control Secondary	DBUC	Density of Bucket
PCSD	Plot Control Direction	ØSSHY	Scheduled Hours Per Year
MFG	Manufacturer Code	PSSHY	Productive Hours Per Year
KDLN	Dragline Identification	CDRTY	Coal Demand Recov. Tons/Year
ABHD	Angle Burden Highwall Degrees	DDY	Dragline Depreciation Years
ACFD	Angle Coal Face Degrees	TRAD	Tolerance on Radius
ABSD	Angle Burden Spoil Degrees	TDMH	Tolerance on Dump Height
SWDH	Safe Working Dist Highwall	TDGD	Tolerance on Dig Depth
BWBH	Bench Width Burden Highwall	KAC	Area of Panel or Segment
BWCF	Bench Width Coal Face	ALF	Area Length Feet
CATC	Clearance at Toe of Coal	AWF	Area Width Feet
FFB	Fill Factor Bucket	PLF	Panel Length Feet
SFB	Swell Factor of Burden	PWF	Panel Width Feet
ESØ	Efficiency of Stripping Op	HBN	Height Burden Minimum
ECR	Expected Coal Recovery	HBA	Height Burden Average
PTF	Propel Time Factor	HBX	Height Burden Maximum
DCBPY	Density of Coal	HC	Height Coal

B.2 Basic Stripping Method (BSM) Output

DATE 07/08/76

BASIC STRIPPING METHOD
0507 (BSM0507) FORT UNION
0507 BASIC STRIPPING METHOD

SELECTION STATISTICS

NO. MACHINES	200
NO. O.K. ON MINIMUM	200
NO. O.K. ON AVERAGE	199
NO. O.K. ON MAXIMUM	109
NO. O.K. FOR COAL DEMAND	145
REFERENCE TO LEAST-COST MACHINE	84 \$/TON .369
REFERENCE TO COAL DEMAND MACHINE	104 \$/TON .487

78

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>L</u>	<u>M</u>	<u>N</u>	<u>O</u>
					BY/Y	YEARS	CT/Y	INVEST	OPER	TOT \$	\$/TON	CDR \$/T	\$/C.Y.	
1	1525	175	30	19	.5300E 07	66.42	.1393E 07	.1768E 08	.3837E 08	.5605E 08	.6057	.0000	.1592	NA
2	1525	175	35	19	.5076E 07	69.35	.1334E 07	.1800E 08	.3951E 08	.5751E 08	.6215	.0000	.1634	NA
3	1525	175	40	19	.4890E 07	71.99	.1285E 07	.1815E 08	.4037E 08	.5852E 08	.6324	.0000	.1662	NA
4	1567	195	30	17	.4980E 07	70.70	.1309E 07	.1868E 08	.4067E 08	.5934E 08	.6413	.0000	.1685	NA
5	1567	195	35	18	.5155E 07	68.29	.1355E 07	.1813E 08	.3937E 08	.5750E 08	.6213	.0000	.1633	NA
6	1567	195	40	19	.5256E 07	66.97	.1382E 07	.1725E 08	.3796E 08	.5523E 08	.5969	.0000	.1569	NA
82	10670	285	30	125	.3961E 08	8.888	.1041E 08	.1396E 08	.2261E 08	.3656E 08	.3951	1.334	.1039	NAXP
83	10670	285	35	131	.4098E 08	8.591	.1077E 08	.1347E 08	.2182E 08	.3529E 08	.3814	1.332	.1002	NAXP
84	10670	285	38	137	.4246E 08	8.291	.1116E 08	.1305E 08	.2110E 08	.3415E 08	.3690	1.335	.9700E-01	NA-P
85	10900	310	30	113	.3641E 08	9.670	.9570E 07	.1505E 08	.2443E 08	.3948E 08	.4267	1.324	.1122	NAXP
86	10900	310	35	119	.3793E 08	9.281	.9970E 07	.1437E 08	.2335E 08	.3773E 08	.4077	1.318	.1072	NAXP
87	10900	310	38	125	.3951E 08	8.911	.1038E 08	.1390E 08	.2253E 08	.3642E 08	.3936	1.325	.1035	NAXP
88	13550	325	34	149	.4804E 08	7.327	.1263E 08	.1465E 08	.2277E 08	.3741E 08	.4043	1.656	.1063	NAXP
103	3100	225	30	45	.1364E 08	25.81	.3585E 07	.1391E 08	.2602E 08	.3993E 08	.4315	.5015	.1134	NA P
104	3100	250	35	41	.1258E 08	27.98	.3307E 07	.1450E 08	.2753E 08	.4203E 08	.4542	.4870	.1194	NA P
105	3100	275	30	31	.9861E 07	35.70	.2592E 07	.1685E 08	.2962E 08	.4647E 08	.5022	.0000	.1320	NAX
106	3850	300	32	35	.1129E 08	31.18	.2968E 07	.1718E 08	.3210E 08	.4929E 08	.5326	.0000	.1400	NAX
194	6398	340	33	52	.1716E 08	20.52	.4511E 07	.1716E 08	.3148E 08	.4864E 08	.5257	.7687	.1382	NAXP
195	6437	340	36	58	.1903E 08	18.50	.5001E 07	.1630E 08	.2936E 08	.4566E 08	.4934	.8000	.1297	NAXP
196	6455	340	38	61	.1992E 08	17.67	.5236E 07	.1572E 08	.2821E 08	.4393E 08	.4747	.8060	.1248	NAXP
197	3180	225	30	45	.1378E 08	25.55	.3622E 07	.1380E 08	.2712E 08	.4092E 08	.4422	.5193	.1162	NA P
198	3180	235	30	43	.1330E 08	26.47	.3496E 07	.1395E 08	.2770E 08	.4165E 08	.4501	.5102	.1183	NA P
199	3180	245	30	40	.1250E 08	28.16	.3286E 07	.1469E 08	.2931E 08	.4400E 08	.4755	.5066	.1250	NA-P
200	3180	260	30	35	.1110E 08	31.70	.2919E 07	.1585E 08	.3219E 08	.4804E 08	.5191	.0000	.1365	NAX

(See next page for definitions of Columns A thru O.)

B.2 Basic Stripping Method (BSM) Output - Definitions

Column A Dragline data base identification number
B Dragline weight (thousands of pounds)
C Boom length (feet)
D Boom angle (degrees)
E Bucket size (cubic yards)
F Machine capacity (bank cubic yards/year)
G Years required to mine property at full machine capacity
H Recoverable coal uncovered at full machine capacity (tons/year)
I Total investment cost
J Total operating cost
K Total cost
L Stripping cost in dollars per ton of recoverable coal at full machine capacity
M Stripping cost in dollars per ton of recoverable coal at required production rate
N Stripping cost in dollars per bank cubic yard
O Machine acceptability code: N = meets geometry at minimum overburden
 A = meets geometry at average overburden
 X = meets geometry at maximum overburden
 P = meets required production rate

Appendix B.3 & B.4 Drilling and Blasting Input and Output

The Drilling and Blasting Coal (DBC) computer model simulates the drilling of vertical blast holes and determines the required amounts of blasting materials related to overburden drilling and blasting.

Computer input and output for the hypothetical baseline situation for the Fort Union test case are shown on the following 3 pages.

B.3 Drilling/Blasting Coal Input

DRILLING AND BLASTING SIMULATION
INPUT PARAMETERS

11/19/76

0507 (JOB0507) FORT UNION
1 DRILLING AND BLASTING COAL

KMED	0.	MEDIUM FOR DRILLING, 0=COAL 1=O.B.
ICASE	3.	ICASE = 1, NO S,B,SDDI SPECIFIED ICASE = 2, SDDI SPECIFIED ICASE = 3, S,B, AND SDDI SPECIFIED
OSRHY	1812.50	SCHEDULED OPERATING HOURS PER YEAR
OPRHY	1631.25	PRODUCTIVE OPERATING HOURS PER YEAR
EDD	1.000	EFFICIENCY OF DRILLING OPERATIONS - FRACTION
PTF	1.00	PROPEL TIME FACTOR - FRACTION
P	100.00	PANEL WIDTH - FEET
HBMF	.00	HOLE BOTTOM MARGIN - FEET
DPGCC	.00	DENSITY OF PRIMER - GRAM / CC
DAGCC	.80	DENSITY OF ANFO - GRAM / CC
DSGCC	.00	DENSITY OF SLURRY - GRAM / CC
PRPY	.15	PCWOFF RATIO - LBS. / YARD
POH	1.00	PERCENTAGE DRY HOLES
PWH	.00	PERCENTAGE WET HOLES
HPF	.00	HEIGHT OF PRIMER - FEET
PEBC	.05	% EX. BLASTING CAPS/CAST BOOSTERS
CRCC	125.00	COST OF BLASTING CAPS/CAST BOOSTERS - \$/100
CDCMP	44.00	CCST OF DETONATING CORD - \$ / M FT
CPDP	.00	CCST OF PRIMER - \$ / LB.
CADP	.08	CCST OF ANFO - \$ / LB.
CSDP	.32	COST OF SLURRY - \$ / LB.
PLY	30.00	PROJECT LIFE - YEARS
DRSMFH	360.	DRILLING RATE IN SOFT MAT'L - FT./HR.
CORTY	3084512.	COAL DEMAND - TONS/YEAR
CRYY	.3353E 07	COAL DEMAND - BANK YDS/YR
HC	12.00	HEIGHT OF COAL - FEET
SDDI	3.000	SPECIFIED DRILL DIAMETER - INCHES
S	12.00	SPACING - FEET
B	12.00	BURDEN - FEET

B.4 Drilling/Blasting Coal (DBC) Output

DRILLING AND BLASTING SIMULATION
INTERMEDIATE VARIABLES

11/19/76

0507 (UDBC0507) FORT UNION
1 DRILLING AND BLASTING COAL

CAF	5195.39	COAL ACRE FEET
ACRY	.10058E 09	AREA COAL - BANK YDS
RLADFY	75437.06	RATE OF LINEAR ADVANCE - FT. / YR.
RHLF	12.00	REQUIRED HOLE LENGTH - FT.
VCFYH	5.23	VOLUME EFFECTED - CU. YD. / FOOT OF HOLE
PEH	10.00	POUNDS OF EXPLOSIVE PER HOLE
VECYH	64.00	VOLUME EFFECTED - CU. YD. / HOLE
NHY	52386.00	NUMBER OF HOLES PER YEAR
WAPFH	2.45	WEIGHT OF ANFO - LBS. / FT. OF HOLE
WSPFH	.00	WEIGHT OF SLURRY - LBS. / FT. OF HOLE
WPPFH	.00	WEIGHT OF PRIMER - LBS. / FT. OF HOLE
HAF	4.08	HEIGHT OF ANFO IN HOLE - FT.
HSF	.00	HEIGHT OF SLURRY IN HOLE - FT.
SHDF	7.92	STEMMING HEIGHT FOR DRY HOLES - FT.
SHWF	12.00	STEMMING HEIGHT FOR WET HOLES - FT.
RLDCFY	1445853.00	REQUIRED LENGTH OF DETONATING CORD - FT / YR
CCCDY	63617.52	COST OF DETONATING CORD - \$ / YR.
NBCY	55005.00	NO. OF BLASTING CAPS/CAST BOOSTERS / YEAR
CCCDY	68756.19	COST OF BLASTING CAPS/CAST BOOSTERS - \$/YR
WPPY	.00	WEIGHT OF PRIMER - LBS. / YR.
CPDY	.00	COST OF PRIMER - \$ / YR.
WAPY	523860.00	WEIGHT OF ANFO - LBS. / YR.
CADY	41938.79	COST OF ANFO - \$ / YR.
WSPY	.00	WEIGHT OF SLURRY - LBS. / YR.
CSDY	.00	COST OF SLURRY - \$ / YR.
APRPY	.16	ACTUAL POWDER RATIO - LBS. / CU. YD.
CFDY	174282.44	COST OF EXPLOSIVES - \$ / YR.
CEFH	.28	COST OF EXPLOSIVES - \$ / FT. OF HOLE
CEUB	.06	COST OF EXPLOSIVES - \$ / UNIT BLASTED

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DRILLING AND BLASTING COAL

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>L</u>	<u>M</u>	<u>N</u>
23 CD 3-18	NDR 1.070	M\$GWN 5.76	M\$OPN 30.48	M\$OEO 36.24	\$/FT .06	\$/UNIT .012	M\$/YR 174.28	\$/FT .28	\$/UNIT .057	C\$/YR 210.52	C\$/FT .33	C\$/UNIT .068	C\$/AFT 1215.63

LEAST COST MACHINE - 23

(See next page for definitions of Columns A thru N.)

B.4 Drilling and Blasting (DAB) Output - Definitions

Column A Rotary drill data base identification number
B Number of drills required
C Annual ownership cost for drills (thousands of dollars)
D Annual operating cost for drills (thousands of dollars)
E Annual ownership and operating cost for drills (thousands of dollars)
F Drilling cost (\$/foot of hole drilled)
G Drilling cost (\$/cubic yard of overburden drilled and blasted)
H Annual operating cost for explosives (thousands of dollars)
I Explosives cost (\$/foot of hole drilled)
J Explosives cost (\$/cubic yard of overburden drilled and blasted)
K Combined annual ownership and operating costs for drilling and explosives
(thousands of dollars)
L Combined cost (\$/foot of hole drilled)
M Combined cost (\$/cubic yard of overburden drilled and blasted)
N Combined cost (\$/acre of coal uncovered)

Appendix B.5 and B.6 Haul Unit Simulation
Input and Output

The HUS model simulates the performance of an off-highway truck on a given haul road. The model evaluates the ability of a truck according to the following criteria:

Possible truck speed and time to travel the haul road

Possible coal production (tons/hour) that could be sustained by one truck

Size of the fleet required to maintain a given coal production rate

Cost of ownership and operation of each truck in the fleet

Cost of haulage for each truck (\$/ton of coal).

Computer input and output for the hypothetical baseline situation for the Fort Union test case are shown on the following 2 pages.

B.5 Haul Unit Simulation (HUS) Input

-----HAUL DATA-----

TRUCK UBD180D180TE--* (UHUS0507) FORT UNION HAUL UNIT SIMULATION

----- LOADED -----

SEG NO	LENGTH (FT.)	GRADE (%)	ROLLING RES.(%)	SPEED LIMIT	SAS IND	SAE IND
1.	2640.0	.0	6.0	12.0	1.	0.
2.	2430.0	4.0	3.0	.0	0.	0.
3.	10716.0	.0	3.0	.0	0.	0.
4.	7040.0	.0	3.0	.0	0.	1.
22826.0						

----- EMPTY -----

SEG NO	LENGTH (FT.)	GRADE (%)	ROLLING RES.(%)	SPEED LIMIT	SAS IND	SAE IND
4.	7040.0	.0	3.0	30.0	1.	0.
3.	10716.0	.0	3.0	30.0	0.	0.
2.	2430.0	4.0	3.0	30.0	0.	0.
1.	2640.0	.0	6.0	12.0	0.	1.
22826.0						
45652.0						

INPUT FACTORS USED IN HAUL UNIT CALCULATIONS

HAULING MEDIUM = 0=COAL,1=D.B.	0. KMED
TRUCK TYPE = 1=REAR,2=TRAILER,3=BOTH	2. KTT
TRUCK SPD AND WAIT = 0=NO,1=YES	0. KSWT
AVERAGE SITE TEMPERATURE	65.00 AST
ALTITUDE	1500.00 ATF
COAL PRODUCTION DEMAND	945.39 CDPTH
DENSITY OF BANK COAL	2000.00 DCBPY
SWELL FACTOR OF COAL	.35 SFC
EFFICIENCY OF LOADER OPERATION	.833 EQD
EFFICIENCY OF TRUCK OPERATION	.833 ETD
FILL FACTOR	.95 FF
EMPTY SPEED FACTOR=LONG HAUL	.95 RSFLH
EMPTY SPEED FACTOR=SHORT HAUL	.80 RSFSH
COST OF FUEL PER GAL.	.30 CF
TRUCK AVAILABILITY FACTOR	1.00 TA
OIL AND LUBE FACTOR	.30 OLF
SCHEDULED OPERATING HOURS PER DAY	14.50 DSTHD
PRODUCTIVE OPERATING HOURS PER DAY	13.05 OPTHD
INDEX FOR JOB CONDITIONS	2.00 IJC
TOLERANCE FOR PAYLOAD OVERLOAD	.10 PLT

SAS IND = Stop at start of segment required

SAE IND = Stop at end of segment required

B.6 Haul Unit Simulation (HUS) Output

-----HAUL DATA-----

TRUCK UBD180D180TE--* (UHUS0507) FORT UNION HAUL UNIT SIMULATION

----- LOADED -----

SEG NO	LENGTH (FT.)	GRADE (%)	ROLLING RES.(%)	SPEED LIMIT	SAS IND	SAE IND	ACTUAL SPEED	TIME (MIN)
1.	2640.0	.0	6.0	12.0	1.	0.	6.8	4.4
2.	2430.0	4.0	3.0	.0	0.	0.	5.8	4.8
3.	10716.0	.0	3.0	.0	0.	0.	16.0	7.6
4.	7040.0	.0	3.0	.0	0.	1.	16.0	5.0
								21.8
22826.0								

----- EMPTY -----

SEG NO	LENGTH (FT.)	GRADE (%)	ROLLING RES.(%)	SPEED LIMIT	SAS IND	SAE IND	ACTUAL SPEED	TIME (MIN)
4.	7040.0	.0	3.0	30.0	1.	0.	30.0	2.7
3.	10716.0	.0	3.0	30.0	0.	0.	30.0	4.1
2.	2430.0	4.0	3.0	30.0	0.	0.	30.0	.9
1.	2640.0	.0	6.0	12.0	0.	1.	12.0	2.5
22826.0								10.1
45652.0								TOTAL MOVING TIME & LENGTH 32.0

-----CYCLE TIME-----

LOADED TIME	21.81
EMPTY TIME	10.15
LOADING TIME	3.60
WAIT TIME AT LOADER	1.80
TIME TO SPOT AT LOADER	.00
TURN AND DUMP TIME	.60

-----TOTAL CYCLE TIME----- 37.96

-----PRODUCTION DATA-----

EFFECTIVE MINUTES / HOUR	50.0	
NO. OF TRIPS / HOUR	1.3	
ACTUAL - CAPACITY PAYLOAD IN TONS	181.9	182.2
NO. OF TONS / HOUR	239.6	
NO. OF HAUL UNITS NEEDED	4.0	

-----COST DATA-----

APPLICATION - RATED TON MILES PER HOUR	212.23	230.00
EFFECTIVE TIRE LIFE-HRS	5000.0	
FUEL CONSUMPTION-GAL/HR	28.8	
OWNERSHIP COST - \$/HR	22.81	

-----OPERATING COST-----

MAINTENANCE - MAT'L	11.28
LABOR	7.52
FUEL COST	11.23
LABOR	11.26
TIRE COST	17.86
OPERATING COST - \$/HR	59.15

TOTAL OWNERSHIP & OPERATING COST 81.96
 0 & 0 DOLLARS PER TON .34

Appendix B.7 and B.8 Coal Load and Haul
Input and Output

The data developed with the HUS model is used in running the CLH model. The CLH model processes shovel and truck files to evaluate the ability of the shovel and truck, in combination, to meet the requirements of physical dimensions and production during the coal loading operation. Production and cost information is calculated and printed for the user.

The model operates the shovel and truck separately, at full capacities, to determine possible production. Then the combination of shovel and truck is evaluated, taking into account the necessary losses in possible production due to waiting time for the truck to spot at the shovel.

Computer input and output for the hypothetical baseline situation for the Fort Union test case are shown on the following 3 pages.

B.7 Coal Load and Haul (CLH) Input

INPUT FACTORS USED IN COAL LOAD AND HAUL SIMULATION 09/23/76 RUN NO. = 1

0507 (UCL40507) FORT UNION
1 COAL LOAD AND HAUL SIMULATION

LOAD AND HAUL MEDIUM - 0=COAL,1=O.B.	0.	KMED
SHOVEL-SCHEDULED HOURS PER YEAR	3625.00	USQHY
SHOVEL-PRODUCTIVE HOURS PER YEAR	3262.50	DPGHY
SHOVEL CYCLE TIME IN MINUTES	.50	QCTH
EFFICIENCY OF SHOVEL OPERATIONS	.83	EQO
SHOVEL DIPPER FILL FACTOR	.95	FF
MINIMUM NUMBER OF SHOVEL SWINGS TO LOAD	4.0	MINMC
MAXIMUM NUMBER OF SHOVEL SWINGS TO LOAD	20.0	MAXMC
PANEL WIDTH	100.00	P
HEIGHT OF COAL	12.00	HC
EXPECTED COAL RECOVERY	.92	ECR
AREA COAL IN RECOVERABLE MILLION TONS	92.53	ACRT
COAL DEMAND	3084321.	CORTY
DENSITY OF COAL \pm BANK	2000.00	DCBPY
SWELL FACTOR OF COAL	.35	SFC
CLEARANCE OF OPERATION	2.00	CLD
EFFICIENCY OF TRUCK OPERATION	.83	ETD
TRUCK AVAILABILITY	1.00	TA
TRUCK-SCHEDULED HOURS PER YEAR	3625.00	USTHY
TRUCK-PRODUCTIVE HOURS PER YEAR	3262.50	DPTHY
PAYLOAD TOLERANCE	.10	PLT
METHOD OF OPERATION	2.00	ICASE
NUMBER OF CUTS TO REMOVE MATERIAL	1.00	NCS
DEPRECIATION SWITCH	.0	IDEP

CASE = 2 ---TRUCK LOADED ON SIDE OF SHOVEL

B.8 Coal Load and Haul (CLH) Output

INTERMEDIATE VARIABLES CALCULATED BY SIMULATION 09/23/76 RUN NO. = 1

0507 (UCLH0507) FORT UNION
1 COAL LOAD AND HAUL SIMULATION

ACTUAL ANGLE OF SWING	90.0 AANGS
ACTUAL SHOVEL CYCLE TIME	.50 QCTNA
SHOVEL EFFECTIVE MINUTES PER HOUR	50.0 SEMH
NUMBER OF SHOVEL SWINGS PER HOUR	100.0 SWSH
HEIGHT OF BERM ABOVE FLOOR - CASE 1	12.0 CLM
COAL ACRES	5195.04 CAF

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<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>L</u>	<u>M</u>
SER	#	I MM\$	Q MM\$	\$/TON	C\$/TON	C\$/AFT	\$/TON	I MM\$	Q MM\$	#	#	SEQ
23	1.00	3,528	4,888	.091	.538	9576.	.447	12,029	29,305	6.70	9	1
23	1.00	3,528	4,888	.091	.537	9556.	.446	11,998	29,229	6.68	9	2
23	1.00	3,528	4,888	.091	.653	11316.	.572	18,594	34,374	7.69	8	5
23	1.00	3,528	4,888	.091	.616	10973.	.525	16,546	32,046	6.92	7	6
23	1.00	3,528	4,888	.091	.498	8879.	.408	11,163	26,545	4.58	5	18
23	1.00	3,528	4,888	.091	.571	10168.	.480	15,175	29,230	7.26	8	45
23	1.00	3,528	4,888	.091	.571	10168.	.480	15,175	29,230	7.26	8	46
23	1.00	3,528	4,888	.091	.547	9744.	.456	12,666	29,538	6.68	7	51
23	1.00	3,528	4,888	.091	.547	9744.	.456	12,666	29,538	6.68	7	52
23	1.00	3,528	4,888	.091	.532	9480.	.441	12,881	27,950	5.19	6	53
25	1.00	5,017	5,941	.118	.573	10210.	.459	12,029	30,054	8.92	9	1
31	2.00	4,066	9,159	.143	.601	10701.	.458	12,881	29,486	5.48	6	53
34	1.00	4,011	5,376	.101	.556	9908.	.455	12,029	30,054	8.92	9	1
34	1.00	4,011	5,376	.101	.555	9887.	.454	11,998	29,976	8.90	9	2
34	1.00	4,011	5,376	.101	.683	12158.	.581	18,594	35,180	7.87	8	5
34	1.00	4,011	5,376	.101	.629	11198.	.527	16,546	32,244	6.97	7	6
34	1.00	4,011	5,376	.101	.502	8945.	.401	11,163	25,921	4.48	5	18
34	1.00	4,011	5,376	.101	.538	10480.	.487	15,175	29,885	7.43	8	45
34	1.00	4,011	5,376	.101	.588	10480.	.467	15,175	29,885	7.43	8	46
34	1.00	4,011	5,376	.101	.559	9963.	.458	12,666	29,703	6.71	7	51
34	1.00	4,011	5,376	.101	.559	9963.	.458	12,666	29,703	6.71	7	52
34	1.00	4,011	5,376	.101	.539	9597.	.437	12,881	27,590	5.12	6	53
36	1.00	4,776	5,988	.116	.556	9900.	.440	12,029	28,639	8.50	9	1
36	1.00	4,776	5,988	.116	.555	9879.	.438	11,998	28,562	8.48	9	2
36	1.00	4,776	5,988	.116	.677	12061.	.561	18,594	33,302	7.45	8	5
36	1.00	4,776	5,988	.116	.636	11321.	.520	16,546	31,558	6.82	7	6
36	1.00	4,776	5,988	.116	.497	8851.	.381	11,163	24,054	4.15	5	18
36	1.00	4,776	5,988	.116	.565	10055.	.448	13,278	28,195	7.01	7	45
36	1.00	4,776	5,988	.116	.565	10055.	.448	13,278	28,195	7.01	7	46
36	1.00	4,776	5,988	.116	.567	10091.	.450	12,666	28,993	6.55	7	51
36	1.00	4,776	5,988	.116	.567	10091.	.450	12,666	28,993	6.55	7	52
36	1.00	4,776	5,988	.116	.514	9102.	.398	10,735	26,100	4.35	5	53

LEAST COST COMBINATION - 36 18

(See next page for definitions of Columns A thru M.)

B.8 Coal Load and Haul (CLH) Output - Definitions

Column A Shovel data base identification number
B Number of shovels required (rounded to integer)
C Total project ownership cost for shovels (millions of dollars)
D Total project operating cost for shovels (millions of dollars)
E Shovel cost (\$/ton of coal recovered)
F Combined cost for shovels and trucks (\$/ton of coal recovered)
G Combined cost (\$/acre of coal uncovered)
H Truck cost (\$/ton of coal recovered)
I Total project ownership cost for trucks (in millions of dollars)
J Total project operating cost for trucks (in millions of dollars)
K Number of trucks required
L Number of trucks required (rounded to integer)
M Truck data base identification number

Appendix B.9 and B.10 Land Reclamation Simulation
Input and Output

The Land Reclamation Simulation (LRS) micromodel analyzes four separate operations: required scraper fleet for top-soil removal and redistribution; required bulldozer fleet for spoil pile regrading and for general dozer work; costs of revegetation; and land management.

Computer input and output for the hypothetical baseline situation for the Fort Union test case are shown on the following 4 pages.

B.9 Land Reclamation Simulation (LRS) Input

LAND RECLAMATION SIMULATION
LOG PARAMETERS

07/20/76

0507 (ULR50506) FORT UNION
1 LAND RECLAMATION SIMULATION

I KAC	1	METHOD OF INPUT - 1, 2, 3, OR 4
I KSR	1	SPOIL REGRADE - 1=YES, 0=NO
I LOGPA	1	PRINT INPUT VARIABLES IF = 1
* ACRES	5195.39	ACRES ON PROPERTY
* ACRT	.925362E 08	AREA COAL IN RECOVERABLE TONS
I CDRTY	.308432E 07	COAL DEMAND - RECOVERED TONS / YEAR
I CGD	300.000	COST FOR GENERAL DOZING - \$/ACRE
I CLM	100.000	COST FOR LAND MANAGEMENT - \$/ACRE
I CRV	200.000	COST FOR REVEGETATION - \$/ACRE
C EMH	49.9800	EFFECTIVE MINUTES PER HOUR
I ERD	.833000	EFFICIENCY OF LAND RECLAMATION - FRACTION
I HBT	1.25000	HEIGHT OF TOPSOIL - FEET
I PLRHY	1590.00	PRODUCTIVE LAND RECLAMATION - HRS / YR
* PWF	100.000	PANEL WIDTH - FEET
C RAY	173.168	RECLAMATION ACRES PER YEAR
C TANT	.666641	TANGENT OF ANGLE OF SPOILS
C THY	30.0021	TOTAL MINING YEARS
I MAP	3	NUMBER OF ADDITIONAL PANELS
* NP	214	NUMBER OF PANELS
C ABBY	.352040E 09	AREA BURDEN IN BANK YARDS
I ABHD	63.4350	ANGLE OF BURDEN HIGHWALL - DEGREES
C ACBT	.100583E 09	AREA COAL IN BANK TONS
C ACBY	.100583E 09	AREA COAL IN BANK YARDS
I ACFD	76.0000	ANGLE OF COAL FACE - DEGREES
* ALF	10560.0	AREA LENGTH - FEET
* AWF	21431.0	AREA WIDTH - FEET
I BWH	.000000	BERM WIDTH ON HIGHWALL - FEET
I BWF	.000000	BERM WIDTH ON COAL FACE - FEET
I CATC	.000000	CLEARANCE AT TOE OF COAL - FEET
C COTA	.499997	COTANGENT OF ANGLE OF THE COAL
C COTB	.249326	COTANGENT OF ANGLE OF THE OVERBURDEN
C COTT	1.50006	COTANGENT OF ANGLE OF SPOIL
I DBBPY	2935.00	DENSITY OF BURDEN - BANK LBS / YD
I DCBPY	2000.00	DENSITY OF COAL - BANK LBS / YD
I ECR	.920000	EXPECTED COAL RECOVERY - FRACTION
* HBA	42.0000	AVERAGE HEIGHT OF OVERBURDEN - FEET
* HC	12.0000	HEIGHT OF COAL - FEET
C HSA	73.3660	HEIGHT OF SPOIL (AVERAGE) - FEET
* PLF	10560.0	PANEL LENGTH - FEET
I RAP	.300000E-01	RAMP GRADE - FRACTION
C SC	4.010E2	SLOPE OF THE COAL
I SFB	.350000	SWELL FACTOR OF OVERBURDEN - FRACTION
C SH	2.00001	SLOPE OF THE HIGHWALL
C SRYT	3.80435	STRIPPING RATIO - BANK YDS / REC. TONS
C SS	1.50006	SLOPE OF THE SPOILS
* SSL	.2259E4E 07	SUM OF THE SEGMENT LENGTHS
C TAN4	2.00001	TANGENT OF ANGLE OF COAL
C TANB	4.010E2	TANGENT OF ANGLE OF OVERBURDEN
C TRSLAFY	75431.7	LINEAR ADV. OF THE STRIPPING OP. - FT/YR
I WPLF	2640.00	WORKING PANEL LENGTH - FEET
C XHRA	20.9999	EXTENSION OF AVERAGE OVERBURDEN - FEET
C XHC	2.99151	EXTENSION OF COAL - FEET
C XHSA	110.053	EXTENSION OF AVERAGE SPOIL - FEET
C XRAMP	1890.00	EXTENSION OF RAMP - FEET

B.9 Continued

I	NTBPY	2320.00	DENSITY OF TOPSOIL - BANK LBS / YC
I	SCA	1.00000	SCRAPER AVAILABILITY - FRACTION
I	SCCN	38.2100	SCRAPER HOURLY OPERATING COST - \$/HR
I	SCCP	22.2600	SCRAPER HOURLY OWNERSHIP COST - \$/HR
I	SCPA	-318100	SCRAPER PERF. COEF. A
I	SCPB	126.400	SCRAPER PERF. COEF. B
I	SCPC	33.5000	SCRAPER MAXIMUM PERF. SPEED - MPH
I	SCPD	.225400	SCRAPER BRAKING COEF. A
I	SCPE	247.800	SCRAPER BRAKING COEF. B
I	SCPF	33.0000	SCRAPER MAXIMUM BRAKING SPEED - MPH
I	SCSA	32.0000	SCRAPER HEAPED CAPACITY - CU YDS
I	SCSC	91.2000	SCRAPER EMPTY WEIGHT - M LBS
I	SCSD	72.0000	SCRAPER PAYLOAD - M LBS
I	SFT	.430000	SWELL FACTOR OF TOPSOIL - FRACTION
I	TMSM	.700000	TIME TO MANUEVER AND SPREAD - MINUTES
I	TRF	.600000E-01	TOTAL RESISTANCE ON HAUL - FRACTION
C	TRMY	349.221	TOPSOIL REMOVAL DEMAND M YDS/YR - BANK
C	TRSA	173.167	T.S. REM. & SPRD. ACRES / YR
C	TRSP	28.5726	T.S. REM. & SPRD. NO. OF PANELS / YR
*	TRTDF	5012.61	TOPSOIL REMOVAL DISTANCE MOVED - FEET
C	TSMY	499.385	TOPSOIL SPREAD DEMAND M YDS/YR - LOOSE
*	TSTD	2748.63	TOPSOIL SPREAD DISTANCE MOVED - FEET
I	TTLM	.900000	TIME TO LOAD SCRAPER - MINUTES
I	ABSD	33.6890	ANGLE OF BURDEN SPOILS - DEGREES
I	COA	1.00000	DOZER AVAILABILITY - FRACTION
I	COCN	31.1800	DOZER HOURLY OPERATING COST - \$/HR
I	COCP	21.3000	DOZER HOURLY OWNERSHIP COST - \$/HR
I	COCA	-49.5700	DOZER PRODUCTION COEF. A
I	COCB	158000.	DOZER PRODUCTION COEF. B
I	COPHY	2190.00	DOZER PRODUCTIVE HOURS PER YEAR
C	DDMF	150.000	DOZING DISTANCE - FEET
I	DDMDF	50.0000	DOZING MINIMUM DISTANCE - FEET
I	DDMXDF	600.000	DOZING MAXIMUM DISTANCE - FEET
I	ECDD	.750000	EFFICIENCY OF DOZER OPERATION
I	FPW	1.50000	FRACTION PANEL WIDTH DOZED MAT'L MOVED
I	FR	.250000	FRACTION OF DOZED MAT'L REHANDLED
C	SRAY	173.168	SPOIL REGRADE ACRES PER YEAR
C	SRMY	1455.03	SPOIL REGRADE DEMAND M YDS / YR
C	SRYA	6721.96	SPOIL REGRADE YARDS / ACRE
C	SRYAR	8402.45	SPOIL REGRADE YDS / ACRE INCL. R/H

B.10 Land Reclamation Simulation (LRS) Output

LAND RECLAMATION SIMULATION
CALCULATED RESULTS

07/20/76

0507 (ULRS0506) FORT UNION
1 LAND RECLAMATION SIMULATION

	<u>A</u>	<u>B</u>	<u>C</u>
SCRAPER	CUYD	P-MLBS	A-MLBS
	32.00	72.00	51.92

	<u>D</u>	<u>E</u>
DOZER	D/F	CUYD/HR
	150.00	1003.76

	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>L</u>	<u>M</u>	<u>N</u>	<u>O</u>	<u>P</u>	<u>Q</u>
	L-MPH	E-MPH	CTM	TPH	MCYY	#	I-M\$/YR	D-M\$/YR	IOM\$/YR	\$/CY	\$/A	\$/TON
TS REMOVAL	12.24	22.78	8.75	5.71	203.15	1.72	60.84	104.44	163.28	.473	954.428	.054
TS SPREAD	11.95	22.78	5.58	8.95	455.40	1.10	38.81	66.62	105.43	.211	608.851	.034
						2.82					1563.278	.088
SPOIL REGRADE					1648.68	.88	41.17	60.26	101.43	.070	585.742	.033
GENERAL DOZING						.43			51.95		300.000	.017
						1.33					885.742	.050
REVEGETATION									34.63		200.000	.011
LAND MANAGEMENT									17.32		100.000	.006
TOTAL LAND RECLAMATION									476.04		2749.021	.154

(See next page for definitions of Columns A thru Q.)

B.10 Land Reclamation Simulation (LRS) Output - Definitions

Column A Scraper rated capacity (cubic yards)
B Scraper rated payload (thousands of pounds)
C Scraper actual payload (thousands of pounds)
D Dozing distance (feet)
E Dozing hourly capacity (cubic yards/hr)
F Scraper average speed loaded (miles/hr)
G Scraper average speed empty (miles/hr)
H Scraper cycle time (minutes)
I Scraper production (tons/hr)
J Scraper production (thousands cubic yards/year)
K Number of scrapers required
Number of dozers required
L Annual ownership costs (thousands of dollars)
M Annual operating costs (thousands of dollars)
N Annual ownership and operating costs (thousands of dollars)
O Cost (\$/cubic yard of topsoil)
P Cost (\$/acre)
Q Cost (\$/ton of coal recovered)

Appendix B.11, B.12 and B.13 Coal Preparation Factoring
Input and Output

The Preparation/General Administrative (PGA) micromodel determines the coal handling and processing costs by means of extrapolation from a standard size facility. In addition, it allows plant selection based on three levels of difficulty of preparation effort: crushing and screening, Baum jig, and heavy media. The micromodel separates ownership and operating costs into five categories:

- Receiving and Breaking
- Blending and Stockpiling
- Coal Loadout
- Preparation Plant
- Preparation Plant Support.

Computer input and output for the hypothetical baseline situation for the Fort Union test case are shown on the following 4 pages.

B.11 Preparation/General Administrative (PGA) Input (Coal Preparation Factoring)

PGA MODEL ECONOMIC SUMMARY

RUN DATE 12:13 OCT 29, '76 PAGE NO. 7.1

CASE NO. 1019 TITLE (PGA1019) HYPOTHETICAL MINE STUDY - BASELINE SOLUTION
 ALT. NO. 507 TITLE FORT UNION

1975 DOLLARS

I IMOGA	0	INCLUDE GENERAL & ADMINISTRATIVE
I IMOPP	1	INCLUDE PREP PLANT
I IPPT	1	PP - INDEX TO PLANT TYPE
I LOGCF	1	WRITES CFA CONTROL FILE IF 1
I LOGDV	1	PRINTS DEFAULT VARIABLES IF 1
I LOGEC	1	WRITES CFA EQUIPMENT FILE IF 1
I LOGPA	1	PRINTS PARAMETERS IF 1
I LOGRO	1	PRINTS REGRESS. DATA FILE IF 1
I LOGSD	1	WRITES SPECIFICATION DATA IF 1
I LOGSM	1	WRITES ECONOMIC SUMMARY IF ONE
I NY	3	NO. OF YEARS TO STARTUP
I PPBED	.409500E 15	PP - BASE ENERGY BTU/YEAR
I PPBT	75000.0	PP - BASE TONS/DAY
I PPNEO	.130000E 15	PP - COMPLEX ENERGY DEMAND BTU/YEAR
I PPNHV	7070.00	PP - COAL HEAT VALUE BTU/LB
I PPRODY	250.000	PP - OPERATING DAYS/YEAR
I SFR	.350000	SWELL FACTOR FOR BURDEN
I SFC	.350000	SWELL FACTOR FOR COAL
I SRYT	3.00400	STRIPPING RATIO YARDS/RUM TONS
I THY	30.0000	TOTAL MINING YEARS

B.12 Preparatoon/General Administrative (PGA) Default Values (Coal Preparation Factoring)

PGA MODEL ECONOMIC SUMMARY

RUN DATE 12:13 OCT 29, '76 PAGE NO. 7.3

CASE NO. 1019 TITLE (PGA1019) HYPOTHETICAL MINE STUDY - BASELINE SOLUTION
ALT. NO. 507 TITLE FORT UNION

1975 DOLLARS

PPRHV	BASE HEAT VALUES	10990.	12760.	13084.						
PPBSF	BASE SIZE FACTORS	.9900	.8250	.7870						
PPBHF	BASE HEAT FACTORS	1.0036	1.0373	1.0600						
PPCCF	CAP. COST FACTORS	17700.	67400.	3600.	9500.	8100.	52100.	8100.	70200.	8100.
PPCCX	CAP. COST EXP.	.80	.80	1.00	.80	.50	.75	.50	.70	.50
PPPSF	OPER. PER. FRACTIONS	2.00	8.50	2.00	2.00	9.60	6.00	9.60	6.00	9.60
		2.00	2.00	2.00	2.00	4.80	2.00	7.20	6.00	9.60
		3.00	.00	1.00	3.00	.00	3.00	.00	3.00	.00
		.00	.00	.00	1.00	.00	3.00	.00	5.00	.00
		.00	.00	.00	.00	.00	2.00	.00	2.00	.00
		.00	.00	.00	.00	.00	.00	.00	2.00	.00
		.00	.00	.00	.00	.00	.00	.00	.00	.00
		.00	.00	.00	.00	.00	.00	.00	.00	.00
PPPSX	OPER. PER. EXP.	.35	.35	.35	.35	.35	.35	.35	.35	.35
PPCS	OPER. SCHED. CODES	5.	9.	12.	9.	5.	9.	5.	9.	5.
PPCC	OPER. CLASS CODES	13.	13.	13.	13.	11.	13.	11.	13.	11.
		18.	23.	18.	18.	22.	17.	22.	17.	22.
		23.	0.	23.	22.	0.	22.	0.	22.	0.
		0.	0.	0.	23.	0.	23.	0.	5.	0.
		0.	0.	0.	0.	0.	10.	0.	23.	0.
		0.	0.	0.	0.	0.	0.	0.	10.	0.
		0.	0.	0.	0.	0.	0.	0.	0.	0.
		0.	0.	0.	0.	0.	0.	0.	0.	0.
PPMLF	MAINT. LABOR COST F.	71.52	81.09	30.56	54.31	174.02	184.13	215.38	249.38	232.32
PPMLX	MAINT. LABOR EXP.	.35	.35	.35	.35	.35	.35	.35	.35	.35
PPMHF	MAINT. MATL. COST F.	122.07	309.86	10.33	43.67	101.25	267.42	101.25	516.37	101.25
PPMMX	MAINT. MATL. EXP.	.80	.80	.80	.80	.50	.75	.50	.70	.50
PPFCF	FUEL COST FACTORS	.00	.00	.00	12.41	.00	15.45	.00	17.93	.00
PPFCX	FUEL COST EXP.	.00	.00	.00	.80	.00	.75	.00	.70	.00
PPWCF	WATER COST FACTORS	.00	.00	.00	.00	.00	2.40	.00	4.20	.00
PPWCX	WATER COST EXP.	.00	.00	.00	.00	.00	1.00	.00	1.00	.00
PPECF	ELEC. COST FACTORS	45.05	99.87	22.12	19.08	128.12	185.00	128.12	314.65	128.12
PPECX	ELEC. COST EXP.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

B.12 Continued

PGA MODEL ECONOMIC SUMMARY

RUN DATE 12:13 OCT 29, '76 PAGE NO. 7.4

CASE NO. 1019 TITLE (PGA1019) HYPOTHETICAL MINE STUDY - BASELINE SOLUTION
 ALT. NO. 507 TITLE FORT UNION

1975 DOLLARS

PPLCF	LABOR COST FACTORS	68.78	105.53	55.83	79.24	143.62	161.06	166.80	220.21	189.99
PPLCX	LABOR COST EXP.	.35	.35	.35	.35	.35	.35	.35	.35	.35
PPWCF	OWN. COST FACTORS	3625.	5438.	8712.	5438.	2000.	5438.	2000.	5438.	2000.
PPDTF	OPER. HOURS/DAY	14.50	21.75	38.45	21.75	8.00	21.75	8.00	21.75	8.00
PPQTY	UNIT QUANTITIES	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
PPMS	MAINT. SCHED. CODES	5.	5.	5.	5.	5.	5.	5.	5.	5.
PPMC	MAINT. CLASS CODES	4.	4.	4.	4.	4.	4.	4.	4.	4.
		5.	5.	5.	5.	5.	5.	5.	5.	5.
		6.	6.	6.	6.	6.	6.	6.	6.	6.
		14.	14.	14.	14.	12.	14.	12.	14.	12.
		12.	12.	12.	12.	13.	12.	13.	12.	13.
		18.	18.	18.	18.	22.	18.	22.	18.	22.
		23.	23.	23.	23.	0.	23.	0.	23.	0.
		0.	0.	0.	0.	0.	0.	0.	0.	0.
PPMF	MAINT. FRACTIONS	.074	.087	.069	.131	.097	.096	.118	.113	.146
		.074	.044	.069	.064	.195	.096	.157	.099	.146
		.296	.261	.278	.259	.292	.288	.315	.311	.328
		.371	.342	.366	.361	.233	.092	.226	.068	.210
		.212	.125	.199	.187	.093	.128	.075	.122	.070
		.205	.401	.256	.239	.090	.248	.109	.249	.100
		.068	.040	.063	.059	.000	.052	.000	.039	.000
		.000	.000	.000	.000	.000	.000	.000	.000	.000
PPCRSY	START YEAR	7.								
PPCRNY	NO. YEAR STARTUP	3.								
PPCRSE	STARTUP EFF.	1.								
PPCRPL	PURCHASE LEAD TIME	3.								
PPCRLO	LIFE OF OPERN.	30.								
PPD2SF	SALVAGE FRACTION	.00								
PPD2JM	DEPREC. METHOD	0.								
PPD2PC	PURCHASE CODE	5.								
PPD2RA	REGIONAL ADJ.	1.00								
PPD2EF	ESCAL. FACTOR	.00								
PPD2CD	CONSTRUCTION CODE	1.								

Appendix B.14, B.15 and B.16 Premining, Facilities, and
Administration input and output

The Preparation/General Administrative (PGA) micromodel determines the central facilities, staff, and premining costs by means of extrapolation from a standard size facility. The micromodel separates ownership and operating costs into thirteen categories:

- Roads and Site Work
- Buildings
- Electric Power System
- Water System
- Communications System
- Mobile Support Equipment
- Shop Equipment
- Land Rights
- Exploration Drilling
- Contract Engineering
- Environmental Impact Statement
- Supervisory and Support Personnel
- Royalty and Severance Tax.

Computer input and output for the hypothetical baseline situation for the Fort Union test case are shown on the following 4 pages.

B.14 Preparation/General Administrative (PGA) Input (Premining, Facilities, and Administration)

PGA MODEL ECONOMIC SUMMARY

RUN DATE 12:13 OCT 29,'76 PAGE NO. 7.1

CASE NO. 1019 TITLE (PGA1019) HYPOTHETICAL MINE STUDY - BASELINE SOLUTION
ALT. NO. 507 TITLE FORT UNION

1975 DOLLARS

I IMGA	1	INCLUDE GENERAL & ADMINISTRATIVE
I IMOPP	0	INCLUDE PREP PLANT
I IPPT	1	PP - INDEX TO PLANT TYPE
I LDSCF	1	WRITES CFA CONTROL FILE IF 1
I LOGDV	1	PRINTS DEFAULT VARIABLES IF 1
I LDSEC	1	WRITES CFA EQUIPMENT FILE IF 1
I LDSPA	1	PRINTS PARAMETERS IF 1
I LDGRD	1	PRINTS REGRESS. DATA FILE IF 1
I LTRSD	1	WRITES SPECIFICATION DATA IF 1
I LDGSM	1	WRITES ECONOMIC SUMMARY IF ONE
I NY	3	NO. OF YEARS TO STARTUP
I DRBPY	2935.00	DENSITY OF OVERRURDEN BANK LBS/YARD
I DCRPY	2160.00	DENSITY COAL BANK LBS/YARD
I ECR	.920000	EXPECTED COAL RECOVERY FACTOR
I GAMR	50.0000	GAA - MINERAL RIGHTS (\$/ACRE)
I GARA	.250000	GAA - ROYALTY AMOUNT (\$/TON)
I GASR	250.000	GAA - SURFACE RIGHTS (\$/ACRE)
I GAST	.000000	GAA - SEVERANCE TAX (\$/TON)
I GATAD	15587.0	TOTAL ACRES DISTURBED IN COMPLEX
I GATYB	60.9047	GAA - TONS/YEAR - BASELINE
I GAHP	.110000	GAA - UNION PAYMENT (\$/TON)
I SFB	.350000	SWELL FACTOR FOR BURDEN
I SFC	.350000	SWELL FACTOR FOR COAL
I SRYT	3.80400	STRIPPING RATIO YARDS/ROM TONS
I TMY	30.0000	TOTAL MINING YEARS

B.15 Continued

GACRPL PURCHASE LEAD TIME	3.	3.	3.	3.	3.	2.	2.	5.	5.	6.	4.	0.	0.
GACRQT QUANTITY	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
GACRSY STARTUP YEAR	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	1.	7.
GAD2BY BASE YEAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GAD2CO CONSTRUCTION CODE	1.	1.	1.	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.
GAD2DM DEPRECIATION METHOD	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
GAD2EF STARTUP EFF. FACTOR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
GAD2PC PURCHASE CODE	5.	5.	5.	5.	5.	5.	5.	1.	1.	5.	1.	1.	1.
GAD2RA REGIONAL ADJUSTMENT FACTOR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
GAD2SF SALVAGE FRACTION	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

B.16 Preparation/General Administrative (PGA) Output
(Premining, Facilities and Administration)

PGA MODEL ECONOMIC SUMMARY

RUN DATE 12:13 OCT 29, '76 PAGE NO. 7.5

CASE NO. 1019 TITLE (PGA1019) HYPOTHETICAL MINE STUDY - BASELINE SOLUTION
ALT. NO. 507 TITLE FORT UNION

1975 DOLLARS

GENERAL & ADMINISTRATIVE COSTS

	UNIT INVESTMENT	OWNERSHIP \$/HOUR	OPERATING \$/HOUR	O&O \$/TON
ROADS & SITE ANC. FAC.	.300000E 07	155.16	.00	.036
BUILDINGS ANC. FAC.	.489375E 07	253.10	32.62	.066
ELECT. SYS. ANC. FAC.	.450000E 07	232.73	.00	.054
WATER SYS. ANC. FAC.	200000.	10.34	.00	.002
COMMUN. SYS. ANC. FAC.	125000.	6.46	.00	.001
MOBILE SUP. ANC. FAC.	.120000E 07	62.06	.00	.014
EQUIP. SHOP ANC. FAC.	.100000E 07	51.72	.00	.012
LAND RIGHTS PREMINE	467610.	24.18	70.14	.022
EXPL. DRILL. PREMINE	389674.	20.15	.00	.005
CONT. ENG. PREMINE	.600000E 07	310.31	.00	.072
F. I. S. PREMINE	.100000E 07	51.72	.00	.012
SUPERV. PER.	.000000	.00	916.20	.211
ROY-SEV. TAX	.000000	.00	1561.39	.360
	.227760E 08	1177.95	2580.36	.867

TOTAL MM TONS/YEAR 60.9047
TOTAL ACRES DISTURBED 15587.0

C BPRYY	.351973E 08	COMPLEX OVERBURDEN PROD. YARDS/YEAR
C CORTYX	.925271E 07	COMPLEX COAL DEMAND ROM TONS/YEAR
C V8BY	.105592E 10	VOL. OVERBURDEN BANK YARDS
C VCBY	.275365E 09	VOL. COAL BANK YARDS
C VCRT	.277581E 09	VOL. COAL ROM TONS

APPENDIX C

Cash Flow Analysis Input

- C.1 Definition of Equipment and Facilities Requirements for the Project.
- C.2 Definition of Personnel Data.
- C.3 Definition of Case Description Parameters, Financial Assumptions, and Default Values.

A User's Manual for the Cash Flow Analysis Model is contained in Volume 13 of the Final Report (ref: FE-1520-113). The following examples of manually prepared input data are for the hypothetical baseline situation for the Fort Union test case.

The equipment data (Appendix C.1) is prepared manually by the user based on the results of the micromodel analysis shown in Appendix B.

The personnel data (Appendix C.2) establishes wage categories and work schedules for all employees.

The case description, financial parameters, and default values (Appendix C.3) record the values used for the major mining and economic variables.

Appendix C.1 Definition of Equipment and Facilities

Each item of equipment, facilities, or premining costs must be defined on a series of input cards as follows:

- 1) ECRG Card: Defines the mining operation code; the equipment identification number from the equipment data base; the initial quantity required; the quantity of fleet spares; the operating hours per year; the steady state annual production in 1000's; the start year (first year of production); the number of years to complete startup (time from first production to reach steady state production); the startup efficiency (discounts production in early years); the purchase lead time in years; deferred purchase; life of operation in years; and scheduled hours per year.
- 2) EDI Card; Defines equipment type and size.
- 3) ED2 Card: Defines equipment investment cost; depreciation (replacement) life; salvage fraction; depreciation method; purchase code for progress payment schedule; investment base year; investment regional adjustment; investment escalation; construction and tax credit treatment.
- 4) ED3 Card: Defines the equipment operating costs for maintenance labor, maintenance material, fuel, tires, electric power, water, and other.
- 5) ED01 Card: Defines the personnel wage classification, personnel work schedule basis, and quantity of operating personnel required for the equipment.
- 6) EPM1 Card: Defines the personnel wage classification for personnel work schedule basis and fractional proportion of maintenance expenditure for that classification required for the equipment.
- 7) EMSU Card: Defines the usage adjustment, if any, to the operating costs shown on the ED3 card to account for any variation from the assumed conditions used in the equipment data file.

A worksheet, as shown on the following page, is used to code the equipment and facilities information for entry into a computerized data file for the cash flow program.

CASE IDENTIFICATION Project Name <u>AREA STRIP W/ DRAGLINES</u> Location <u>FORT UNION</u> Run No. <u>CFAU-0507</u>	USER IDENTIFICATION Name <u>Philip Morey</u> Organization <u>FLUOR-UTAH</u> Date <u>14 October 76</u>	NOTES Page <u>1</u> of <u>40</u> HYPOTHETICAL MINE STUDY BASELINE SOLUTION
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EQUIPMENT AND FACILITIES WORKSHEET

	MO	ID	QT	FS	OH	CP	SY	NY	SE	PL	DP	LO	SH
Equip. Common Row Guide	Mining Operation	Equipment Identification	Equipment Quantity	Fleet Spares	Operating Hrs/Yr	Steady State Production (1000s)	Annual Start Year	No. Yrs. Startup	Start up Efficiency	Purchase Lead Time	Defer'd Purchase	Life of Operat'n	Scheduled Hrs/Yr
ECRG	01	DLI	3	0	7467	35200.5	7	3	.80	4	0	30	8297

	MO	ID	TEXT	Equipment Size	Equipment Data File Code
Equip. Data Card 1	Mining Operation	Equipment Identification	Equipment Type		
ED1	01	DLI	DRAGLINE	45 CY 182 FT	2767 182 35

	MO	ID	UI	DH	SF	DM	PC	BY	RA	EF	C
Equip. Data Card 2	Mining Operation	Equipment Identification	Unit Investment	Depreciation Life in Hours	Salvage Fraction	Dep'n Method	Purchase Code	Investment Base Year	Investment Regional Adjustnt	Investment Escalation	Construct. & Tax Credit
ED2	01	DLI	4201.05	224010		0	1	5	0	1	0

	MO	ID	ML	MM	FU	T1	EL	WA	OT
Equip. Data Card 3	Mining Operation	Equipment Identification	Maintenance Hourly Cost (\$)	Labor Maintenance Mat'l Hourly Cost (\$)	Fuel Hourly Cost (\$)	Tires Hourly Cost (\$)	Elect. Power Hourly Cost (\$)	Water Hourly Cost (\$)	Other Hourly Cost (\$)
ED3	01	DLI	27.91	41.86	0	0	13.28	0	0

	MO	ID	C1	S1	Q1	C2	S2	Q2	C3	S3	Q3	C4	S4	Q4	C5	S5	Q5
Eq. Personnel Operators	Mining Operation	Equipment Identification	Class Sched		Qty	Class Sched		Qty	Class Sched		Qty	Class Sched		Qty	Class Sched		Qty
EP01	01	DLI	2	12	1	8	12	2									

	MO	ID	C1	S1	F1	C2	S2	F2	C3	S3	F3	C4	S4	F4	C5	S5	F5
Eq. Personnel Maintenance	Mining Operation	Equipment Identification	Class Sched		Fraction	Class Sched		Fraction	Class Sched		Fraction	Class Sched		Fraction	Class Sched		Fraction
EPM1	01	DLI	6	10	1												
EPM2																	

	MO	ID	I1	F1	I2	F2	I3	F3	I4	F4	I5	F5	I6	F6
Ea. Material & Suppl. Usage	Mining Operation	Equipment Identification	Hourly Item	Adjust Factor	Hourly Item	Adjust Factor	Hourly Item	Adjust Factor	Hourly Item	Adjust Factor	Hourly Item	Adjust Factor	Hourly Item	Adjust Factor
EMSU														

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Appendix C.2 Definition of Personnel Data

All operating and maintenance personnel must be identified by two codes:

- 1) PWC: Personnel Wage Classification which identifies the person's union pay grade and work description.
- 2) PSB: Personnel Schedule Basis which identifies the possible work schedules (shifts per day, hours per shift, and shifts per week).

Two additional parameters are defined for each combination of wage classification and schedule basis:

- 1) EHPY: Effective Hours Per Year which is an estimate of the annual number of hours the person is expected to be on the job ready to work (accounts for overtime, holidays, etc.).
- 2) PDPH: Personnel Dollars Per Hour which is an estimate of the total wages plus overtime, pre-mining and payroll added costs per hour. This personnel data is organized into a computerized file for the cash flow program.

The personnel wage classifications schedules used for the hypothetical baseline situation for the Fort Union test case are shown on the following 3 pages.

C.2 Definition of Personnel Data

<u>Personnel</u> <u>Wage</u> <u>Classification</u>	<u>Grade</u>	<u>and Work Description</u>	<u>Personnel</u> <u>Schedule</u> <u>Basis</u>	<u>Shifts</u> <u>Per</u> <u>Day</u>	<u>Hours</u> <u>Per</u> <u>Shift</u>	<u>Days</u> <u>Per</u> <u>Week</u>
PWC 1	5	Coal Loading Operator	PSB 1	1	7.25	5
PWC 2	5	Strip Mach Operator	PSB 2	1	7.25	6
PWC 3	5	Master Electrician	PSB 3	1	8.00	5
PWC 4	4	Electrician	PSB 4	1	8.00	6
PWC 5	4	Machinist	PSB 5	2	7.25	5
PWC 6	4	Mechanic	PSB 6	2	7.25	6
PWC 7	4	Welder 1st Class	PSB 7	2	8.00	5
PWC 8	4	Oiler	PSB 8	2	8.00	6
PWC 9	4	Groundman	PSB 9	3	7.25	5
PWC 10	4	Central Control	PSB 10	3	7.25	6
PWC 11	3	Mobile Equip Operator	PSB 11	3	8.00	5
PWC 12	3	Repairman	PSB 12	3	8.00	6
PWC 13	3	Stat Equip Operator				
PWC 14	3	Welder				
PWC 15	3	Driller & Shooter				
PWC 16	3	Car Loader				
PWC 17	2	Tipple Attendant				
PWC 18	2	Helper				
PWC 19	1	Car Operation				
PWC 20	1	Sampler				
PWC 21	1	Svc Vehicle Driver				
PWC 22	1	Utility Man				
PWC 23	1	Laborer				
PWC 24	S	Gen & Adm Staff				

Personnel Effective Hours Per Year

Personnel

Wage

Personnel Schedule Basis

<u>Classification</u>	<u>Grade</u>	<u>PSB 1</u>	<u>PSB 3</u>	<u>PSB 5</u>	<u>PSB 6</u>	<u>PSB 9</u>	<u>PSB 10</u>	<u>PSB 12</u>
PWC 1	5	1618		1618	1942	1618	1942	2269
PWC 2	5	1618		1618	1942	1618	1942	2269
PWC 3	5	1618		1618	1942	1618	1942	2269
PWC 4	4	1618		1618	1942	1618	1942	2269
PWC 5	4	1618		1618	1942	1618	1942	2269
PWC 6	4	1618		1618	1942	1618	1942	2269
PWC 7	4	1618		1618	1942	1618	1942	2269
PWC 8	4	1618		1618	1942	1618	1942	2269
PWC 9	4	1618		1618	1942	1618	1942	2269
PWC 10	4	1618		1618	1942	1618	1942	2269
PWC 11	3	1618		1618	1942	1618	1942	2269
PWS 12	3	1618		1618	1942	1618	1942	2269
PWC 13	3	1618		1618	1942	1618	1942	2269
PWC 14	3	1618		1618	1942	1618	1942	2269
PWC 15	3	1618		1618	1942	1618	1942	2269
PWC 16	3	1618		1618	1942	1618	1942	2269
PWC 17	2	1618		1618	1942	1618	1942	2269
PWC 18	2	1618		1618	1942	1618	1942	2269
PWC 19	1	1618		1618	1942	1618	1942	2269
PWC 20	1	1618		1618	1942	1618	1942	2269
PWC 21	1	1618		1618	1942	1618	1942	2269
PWC 22	1	1618		1618	1942	1618	1942	2269
PWC 23	1	1618		1618	1942	1618	1942	2269
PWC 24	S							

2000

Personnel Dollars Per Hour

Personnel

Wage

Personnel Schedule Basis

Classification Grade		PSB 1	PSB 3	PSB 5	PSB 6	PSB 9	PSB 10	PSB 12
PWC 1	5	11.32		11.42	12.37	11.52	12.48	12.90
PWC 2	5	11.32		11.42	12.37	11.52	12.48	12.90
PWC 3	5	11.32		11.42	12.37	11.52	12.48	12.90
PWC 4	4	10.49		10.59	11.47	10.69	11.58	12.10
PWC 5	4	10.49		10.59	11.47	10.69	11.58	12.10
PWC 6	4	10.49		10.59	11.47	10.69	11.58	12.10
PWC 7	4	10.49		10.59	11.47	10.69	11.58	12.10
PWC 8	4	10.49		10.59	11.47	10.69	11.58	12.10
PWC 9	4	10.49		10.59	11.47	10.69	11.58	12.10
PWC 10	4	10.49		10.59	11.47	10.69	11.58	12.10
PWC 11	3	10.03		10.13	10.97	10.23	11.08	11.46
PWS 12	3	10.03		10.13	10.97	10.23	11.08	11.46
PWC 13	3	10.03		10.13	10.97	10.23	11.08	11.46
PWC 14	3	10.03		10.13	10.97	10.23	11.08	11.46
PWC 15	3	10.03		10.13	10.97	10.23	11.08	11.46
PWC 16	3	10.03		10.13	10.97	10.23	11.08	11.46
PWC 17	2	9.67		9.77	10.58	9.87	10.69	11.07
PWC 18	2	9.67		9.77	10.58	9.87	10.69	11.07
PWC 19	1	9.56		9.66	10.46	9.76	10.57	10.77
PWC 20	1	9.56		9.66	10.46	9.76	10.57	10.77
PWC 21	1	9.56		9.66	10.46	9.76	10.57	10.77
PWC 22	1	9.56		9.66	10.46	9.76	10.57	10.77
PWC 23	1	9.56		9.66	10.46	9.76	10.57	10.77
PWC 24	S		10.28					

Appendix C.3 Definition of Case Description Parameters, Financial Assumptions, and Default Values

The parameters to be defined are in three categories as follows:

- 1) Mining Parameters which provide identifying information for the case description report but which do not directly affect the cash flow calculations.
- 2) Financial Assumptions and Control Parameters which define the major items that determine the method and cost of financing the project and that determine the revenue and profitability. Depreciation method, escalation rate, and purchase method are also defined.
- 3) Default Values which define the major items needed to create yearly pro-forma financial statements for the project. Regional adjustment factors are also defined.

The mining parameters, financial assumptions, and default values for the hypothetical baseline situation for the Fort Union test case are shown on the following 2 pages.

CASE DESCRIPTION

MINING PARAMETERS

IPPT\$	1	INDEX TO PLANT TYPE
CDRTY\$	.925271E 07	COAL DEMAND ROM TONS/YEAR (COMPLEX)
SRYS\$	3.80434	STRIPPING RATIO YARDS/ROM TONS
H3T\$	1.25000	HEIGHT OF TOPSOIL - FEET
HC\$	12.0000	HEIGHT OF COAL IN FEET
PPFTY\$	.916018E 07	PREPARED COAL TONS/YEAR
PPNED\$	.130000E 15	ENERGY DEMAND FOR COMPLEX BTU/YEAR
PPNHV\$	7070.00	ROM COAL HEAT VALUE BTU/LB
ROC\$	600.000	RECLAMATION - OTHER COSTS - \$/ACRE
VCBP	7095.45	VALUE - COAL BTU/POUND

FINANCIAL ASSUMPTIONS

CDR	2.00000	CAPITAL/DEBT RATIO
GAMR\$	50.0000	GAA - MINERAL RIGHTS (\$/ACRE)
GARA\$	.250000	GAA - ROYALTY AMOUNT (\$/TON)
GASR\$	250.000	GAA - SURFACE RIGHTS (\$/ACRE)
GAST\$	.000000	GAA - SEVERANCE TAX (\$/TON)
RCFD	.100000	RATE - CASH FLOW DISCOUNT
RFIT	.480000	RATE - FEDERAL INCOME TAX
RLTI	.800000E-01	RATE - LONG TERM INTEREST
RSTI	.100000	RATE - SHORT TERM INTEREST
VSPC	.000000	VALUE - REQ. PRICE OF COAL - \$/TON

FINANCIAL CONTROL PARAMETERS

DM1	.000000	RESET DEP. METHOD 1 TO NONZERO VALUE
DM2	.000000	RESET DEP. METHOD 2 TO NONZERO VALUE
DM3	.000000	RESET DEP. METHOD 3 TO NONZERO VALUE
ERAEI	.000000	ESCAL. RATE - ALL EQUIP. INVEST.
EREL	.000000	ESCAL. RATE - ELECTRICITY
ERFU	.000000	ESCAL. RATE - FUELS
ERML	.000000	ESCAL. RATE - MAINTENANCE LABOR
ERMM	.000000	ESCAL. RATE - MAINTENANCE MATERIALS
EROL	.000000	ESCAL. RATE - OPERATING LABOR
EROT	.000000	ESCAL. RATE - OTHER COSTS
ERSPC	.000000	ESCAL. RATE - SELLING PRICE OF COAL
ERTI	.000000	ESCAL. RATE - TIRES
EPWA	.000000	ESCAL. RATE - WATER
ESPC	.000000	ESC. COAL PRICE PER COST ESC. IF 1
PC1	.000000	RESETS PUR. CODE 1 TO NONZERO VALUE
PC2	.000000	RESETS PUR. CODE 2 TO NONZERO VALUE
PC3	.000000	RESETS PUR. CODE 3 TO NONZERO VALUE
PC4	.000000	RESETS PUR. CODE 4 TO NONZERO VALUE
PC5	.000000	RESETS PUR. CODE 5 TO NONZERO VALUE
PC6	.000000	RESETS PUR. CODE 6 TO NONZERO VALUE
PC7	.000000	RESETS PUR. CODE 7 TO NONZERO VALUE

\$ IN NAME INDICATES A MEMO ITEM FOR CFA

PARAMETER LIST

LCFCO	1	BUILDS CORRELATION DATA FILE IF 1
LCFDB	0	LCGS DEBUG ARRAYS IF 1
LCFFP	1	PRINTS THE FINANCIAL PARAMETERS IF 1
LCFFSR	1	PRINTS FINANCIAL SUMMARY REPORT IF 1
LCFIL	1	PRINTS INVESTMENT LIST IF 1
LCFIR	1	PRINTS INFRASTRUCTURE REPORT IF 1
LCFMPL	1	PRINTS MAINTENANCE MANPOWER LIST IF 1
LCFOPL	1	PRINTS OPERATING MANPOWER LIST IF 1
LCFPCE	1	PRINTS PRODN. & CASH EXP. REPORT IF 1
LCFPFS	1	PRINTS PRO-FORMA STATEMENTS IF 1
LCFSML	1	PRINTS SERVICE & MATERIALS LIST IF 1
LCFXV	1	BUILDS X,Y PLOT FILE IF 1
NEQNC	0	NEW EQUIP. DATA FOR NEXT CASE IF 1
CFDMW	10.0000	COST OF ELECTRICITY - \$/MEGAWATT HOUR
CFDMG	300.000	COST OF FUEL - \$/M GALS.
CDWNG	.500000E-01	COST OF WATER - \$/M GALS
DAPG	.100000	DEPLETION ALLOWANCE - PERCENT OF GROSS
DAPN	.500000	DEPLETION ALLOWANCE - PERCENT OF NET
DEC	.000000	DEBT/EQUITY RATIO CONTROL
DER	1.00000	DEBT/EQUITY RATIO
DERT	.100000	DEBT/EQUITY RATIO TOLERANCE
EYAEI	.000000	ESCAL. YEAR - ALL EQUIP. INVEST.
EYHC	.000000	ESCAL. YEAR - HOURLY COSTS
EYML	.000000	ESCAL. YEAR - MAINTENANCE LABOR
EYOL	.000000	ESCAL. YEAR - OPERATING LABOR
EYSPC	.000000	ESCAL. YEAR - SELLING PRICE OF COAL
FALC	1.20000	FACTOR - ANNUAL LEASE COSTS
FCR	.250000	FACTOR - CASH REQUIRMENTS
FHOC	.200000E-01	FACTOR - HOME OFFICE COSTS
FIPT	.500000E-01	FACTOR - INSURANCE & PROPERTY TAX
FSI	.100000	FACTOR - SUPPLIES INVENTORY
FWI	.625000E-01	FACTOR - WAREHOUSE INVENTORY
RAAEI	1.00000	REGIONAL ADJ. - ALL EQUIP. INVEST.
RAEL	1.00000	REGIONAL ADJ. - ELECTRICITY
RAFU	1.00000	REGIONAL ADJ. - FUELS
RAML	1.00000	REGIONAL ADJ. - MAINTENANCE LABOR
RAMM	1.00000	REGIONAL ADJ. - MAINTENANCE MATERIALS
RAOL	1.00000	REGIONAL ADJ. - OPERATING LABOR
RAOT	1.00000	REGIONAL ADJ. - OTHER COSTS
RATI	1.00000	REGIONAL ADJ. - TIRES
RAWA	1.00000	REGIONAL ADJ. - WATER
RCD	.000000	RATE - CASH DIVIDENDS
RCI	.120000	RATE - CONSTRUCTION INTEREST
RITC	.700000E-01	RATE - INVESTMENT TAX CREDIT
RLTDR	10.0000	RATE - L-T DEBT REPAYMENT (YEARS)
VCDY	365.000	VALUE - CALENDAR DAYS/YEAR
VDAP	20.0000	VALUE - DAYS ACCOUNTS PAYABLE
VDAR	45.0000	VALUE - DAYS ACCOUNTS RECEIVABLE
VDCI	10.0000	VALUE - DAYS OF COAL INVENTORY
VFCY	1976.00	VALUE - FIRST CALENDAR YEAR
VDDY	250.000	VALUE - OPERATING DAYS/YEAR
VSC	.000000	VALUE - STARTING CASH
VUPDH	.000000	VALUE - UNION PENSION \$/HOUR

APPENDIX D

Curve Fitting Analysis

- D.1 Dragline Price
- D.2 Quantity of Drills for Overburden
- D.3 Cost of Blasting Materials for Overburden
- D.4 Truck Cycle Time for Coal Hauling
- D.5 Quantity of Scrapers for Land Reclamation
- D.6 Quantity of Bulldozers for Land Reclamation

This appendix presents the results of work done with the micromodels and the Least-Squares Fit (LSF) program to develop the equations that are used in the macromodel in place of the more complex micromodel logic. The equation forms were developed from the micromodel logic. The model parameters were transformed as required to fit a linear equation of the form:

$$a_1x_1 + a_2x_2 + a_3x_3 + \dots + a_mx_m = y$$

The LSF program processes the results from the micromodel cases, determines the coefficients, resolves the expression for each case, and displays the calculated deviation between the recalculated values and the micromodel solution values. In most cases, it was possible to transform the model parameters into a truly linear equation, and the R squared term for these cases is .99 or better. In a few cases, the response was almost linear and for these cases, the R squared term drops to around .95.

For all equations presented here, a single parameter is varied for each micromodel case with all other parameters held at baseline values to obtain the set of observations for curve fitting. This approach would not be valid for general regression analysis since interactions between variables could be masked by the procedure itself. Masking is not considered to be a problem in this situation since the potential interactions are known from the micromodel logic. However, several of the fits were verified by runs in which the model parameter values were randomly varied. The LSF results did not differ materially between the random selection process and the structured selection process.

Initially, the LSF program did not develop an Analysis of Variance report since the primary objective was to see how well the fitted curve reproduced the micromodel results. This fit is demonstrated by the recalculated values and

deviations; the Standard Deviation of the deviations between micromodel results and recalculated values is used as the criterion of fit. However, the LSF program was modified to print an Analysis of Variance report for those interested in regression analysis statistics. The method used is described by N. R. Draper and H. Smith in APPLIED REGRESSION ANALYSES (John Wiley & Sons, New York, 1968).

Appendix D.1
Dragline Price

Base Price of Synthetized Machine:

$$DLCA = 981.71 + 410.6 * DLX$$

where DLCA = Dragline Base Price

$$DLX = \frac{DLRMA * DLSW}{1000}$$

DLRMA = Boom length in feet * cosine boom angle

DLSW = Bucket size in cubic yards

The following sheet shows the curve fitting results for the above equation.

D.1 Dragline - Base Price of Synthetized Machine
(Curve Fitting Results)

Equation:

$$DLCA = A + B * DLX$$

Coefficients: A = 981.71 B = 410.60

COUNT	Data File	Curve Fit	Comparison between	
	<u>Solution</u>	<u>Solution</u>	<u>Data File & Curve Fit</u>	
	INPUT Y	CALC Y	DEV	% DEV
1	2039.60010	2039.62305	-.023	-.001
2	2784.60010	2784.57568	.024	.001
3	4182.10156	4182.05469	.047	.001
4	4742.10156	4742.11328	-.012	-.000
5	5440.89844	5440.83203	.066	.001
6	8189.80078	8189.80469	-.004	-.000
7	7366.39844	7366.55078	-.152	-.002
8	8481.19922	8481.33203	-.133	-.002
9	9793.30078	9793.20313	.098	.001
10	12140.00000	12139.78516	.215	.002
11	15475.00000	15474.68359	.316	.002
12	22139.00000	22138.73437	.266	.001
13	2424.60010	2424.60205	-.002	-.000
14	3572.19995	3572.23120	-.031	-.001
15	4916.80078	4916.82422	-.023	-.000
16	6137.00000	6137.21094	-.211	-.003
17	7160.10156	7160.01953	.082	.001
18	7482.89844	7482.75000	.148	.002
19	8973.69922	8973.64062	.059	.001
20	9832.30078	9832.20703	.094	.001
21	13292.00000	13292.33984	-.340	-.003
22	18382.00000	18382.55859	-.559	-.003
23	2226.30005	2226.28198	.018	.001
24	2781.00000	2781.00366	-.004	-.000
25	3353.50000	3353.54517	-.045	-.001
26	4971.50000	4971.47656	.023	.000
27	7800.19922	7800.14453	.055	.001
28	4182.10156	4182.05469	.047	.001
AVER.	7509.35156	7509.34375	.172	.002

Appendix D.2

Quantity of Drills for Overburden

Quantity of Drills for Overburden:

$$\text{RNDR} = 5.609 * (\text{CDRTY} * \text{HB}) / (1\text{E}6 * \text{HC} * \text{DRSMFH})$$

where RNDR = Required number of drills

HC = Height of coal in feet

CDRTY = Coal demand recovered tons per year

HB = Height of burden in feet

DRSMFH = Drilling rate in soft material in feet per hour

The following sheets show the curve fitting results for the above equation and the supporting variation of parameters and resulting micromodel solutions.

D.2 Quantity of Drills for Overburden
(Curve Fitting Results)

Equation:

$$RNDR = A * CDRTY/1E6/HC * HB/DRSMFH$$

Coefficients: A = 5.60855

COUNT	Micromodel Solution	Curve Fit Solution	Comparison Between Micromodel & Curve Fit	
	INPUT Y	CALC Y	DEV	% DEV
1	3.61600	3.61771	-.002	-.047
2	2.41100	2.41156	-.001	-.023
3	1.80800	1.80886	-.001	-.047
4	.90400	.904429	-.000	-.947
5	.72300	.723542	-.001	-.075
6	.45200	.451965	.000	.008
7	1.13000	1.13091	-.001	-.080
8	1.80800	1.80886	-.001	-.047
9	2.71300	2.71378	-.001	-.029
10	3.39000	3.39178	-.002	-.051
11	.47200	.509537	-.038	-7.953
12	1.25800	1.27384	-.016	-1.259
13	1.80800	1.80886	-.001	-.047
14	2.17500	2.16553	.009	.435
15	2.56800	2.54768	.020	.791
16	3.61600	3.61771	-.002	-.047
17	2.41100	2.41121	-.000	-.009
18	1.80800	1.80886	-.001	-.047
19	1.44600	1.44708	-.001	-.075
20	1.20500	1.20596	-.001	-.080

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS
TOTAL (CORRECTED)	19	18.0521	
REGRESSION	0	18.0499	.723701E 76
RESIDUAL	19	.217846E-02	.114656E-03
R SQUARED		.999879	

AVERAGE INPUT Y = 1.88610
 STD. DEV. OF RESIDUAL = .107078E-01
 S.D. AS PCT OF AV. Y = .57

D.2 Quantity of Drills for Overburden (Variation of Parameters and Micromodel Results)

COUNT	Equation Parameters				Micromodel
	1/HC	CDRTY/1E6	HB	1/DRSMFH	Solution RNDR
1	.50000	1.8170	71.000	.10000E-01	3.6160
2	.33333	1.8170	71.000	.10000E-01	2.4110
3	.25000	1.8170	71.000	.10000E-01	1.8080
4	.12500	1.8170	71.000	.10000E-01	.90400
5	.10000	1.8170	71.000	.10000E-01	.72300
6	.25000	.45400	71.000	.10000E-01	.45200
7	.25000	1.1360	71.000	.10000E-01	1.1300
8	.25000	1.8170	71.000	.10000E-01	1.8080
9	.25000	2.7260	71.000	.10000E-01	2.7130
10	.25000	3.4070	71.000	.10000E-01	3.3900
11	.25000	1.8170	20.000	.10000E-01	.47200
12	.25000	1.8170	50.000	.10000E-01	1.2580
13	.25000	1.8170	71.000	.10000E-01	1.8080
14	.25000	1.8170	85.000	.10000E-01	2.1750
15	.2500	1.8170	100.00	.10000E-01	2.5680
16	.2500	1.8170	71.000	.20000E-01	3.6160
17	.25000	1.8170	71.000	.13333E-01	2.4110
18	.25000	1.8170	71.000	.10000E-01	1.8080
19	.25000	1.8170	71.000	.80000E-02	1.4460
20	.25000	1.8170	71.000	.66667E-02	1.2050

Appendix D.3

Cost of Blasting Materials for Overburden

Cost of Blasting Materials for Overburden:

$$\text{CEMDY} = 111 + 109.22 * (\text{CDRTY} * \text{HB} * \text{PRPY}) / (1\text{E}6 * \text{HC})$$

where CEMDY = Cost of explosives in thousands of dollars per year

HC = Height of coal in feet

CDRTY = Coal demand recovered tons per year

HB = Height of burden in feet

PRPY = Powder ratio pounds per bank cubic yard

The following sheets show the curve fitting results for the above equation and the supporting variation of parameters and resulting micromodel solutions.

D.3 Cost of Blasting Materials for Overburden
(Curve Fitting Results)

Equation:

$$CEMDY = A+B * CDRTY/1E6/HC * HB * PRPY$$

Coefficients: A = 111.033 B = 109.220

COUNT	Micromodel	Curve Fit	Comparison Between	
	<u>Solution</u>	<u>Solution</u>	<u>Micromodel & Curve Fit</u>	
	INPUT Y	CALC Y	DEV	% DEV
1	2341.10	2224.54	116.559	4.979
2	1560.80	1519.90	40.900	2.620
3	1170.50	1167.79	2.709	.231
4	585.250	639.411	-54.161	-9.254
5	468.170	533.736	-65.566	-14.005
6	292.490	375.077	-82.587	-28.236
7	731.770	771.724	-39.954	-5.460
8	1170.50	1167.79	2.709	.231
9	1756.20	1696.45	59.746	3.402
10	2194.90	2092.53	102.373	4.664
11	442.420	408.711	33.709	7.619
12	870.910	855.228	15.682	1.801
13	1170.50	1167.79	2.709	.231
14	1369.60	1376.17	-6.597	-.479
15	1583.90	1599.42	-15.523	-.980
16	494.870	463.286	31.584	6.382
17	832.690	815.538	17.152	2.060
18	1170.50	1167.79	2.709	.231
19	2688.90	2752.92	-64.023	-2.381
20	3533.40	3633.56	-100.161	-2.835

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS
TOTAL (CORRECTED)	19	.135482E 08	
REGRESSION	1	.134862E 08	.134862E 08
RESIDUAL	18	62076.5	3448.69
R SQUARED		.995418	

AVERAGE INPUT Y = 1321.47
 STD. DEV. OF RESIDUALS = 58.7256
 S.D. AS PCT OF AV. Y = 4.44

D.3 Cost of Blasting Materials for Overburden
 (Variation of Parameters and Micromodel Results)

COUNT	Equation Parameters				Micromodel
	1/HC	CDRTY/1E6	HB	PRPY	CEMDY
1	.50000	1.8170	71.000	.30000	2341.1
2	.33333	1.8170	71.000	.30000	1560.8
3	.25000	1.8170	71.000	.30000	1170.5
4	.12500	1.8170	71.000	.30000	585.25
5	.10000	1.8170	71.000	.30000	468.17
6	.25000	.45400	71.000	.30000	292.49
7	.25000	1.1360	71.000	.30000	731.77
8	.25000	1.8170	71.000	.30000	1170.5
9	.25000	2.7260	71.000	.30000	1756.2
10	.25000	3.4070	71.000	.30000	2194.9
11	.25000	1.8170	20.000	.30000	442.42
12	.25000	1.8170	50.000	.30000	870.91
13	.25000	1.8170	71.000	.30000	1170.5
14	.25000	1.8170	85.000	.30000	1369.6
15	.25000	1.8170	100.00	.30000	1583.9
16	.25000	1.8170	71.000	.10000	949.87
17	.25000	1.8170	71.000	.20000	832.69
18	.25000	1.8170	71.000	.30000	1170.5
19	.25000	1.8170	71.000	.75000	2688.9
20	.25000	1.8170	71.000	1.0000	3533.4

Appendix D.4

Truck Cycle Time for Coal Hauling

Truck Cycle Time:

$$TCDT = 7.41 + CHCT * 0.26673 * \frac{CHHD}{5280} + \frac{20.434 * TDSL * \frac{CHHD}{5280}}{TDESC}$$

where TDC T = Truck cycle time in minutes
CHCT = Shovel cycle time in minutes
SPL = Number of swings to load truck
CHHD = Coal haul distance in feet
TDSL = Truck payload in thousands of pounds
TDESC = Truck horsepower

All correlations were made for an assumed shovel cycle time = .5 and number of swings to load truck = 6. Therefore, the initial term in the equation for cycle time is 10.41

$$(i.e., 7.41 + CHCT * SPL = 10.41 \\ \text{when } CHCT = .5 \text{ and } SPL = 6).$$

The test cases were run with haul roads varying in length from 13,239 feet to 42,164 feet (six haul roads) using 32 coal haulers. The result was 192 data points to be used in the correlations.

The following sheets show the curve fitting results and the supporting variation of parameters.

D.4 Truck Cycle Time
(Curve Fitting Results)

Equation:

$$CTM = A + (B * DIST) + (C * (PL * DIST / HP))$$

Coefficients: A = 10.410 B = .26673 C = 20.434

COUNT	Micromodel	Curve Fit	Comparison Between		
	Solution	Solution	Micromodel &	Curve Fit	
	INPUT Y	CALC Y	DEV	% DEV	
1	77.66	70.82	6.85	8.81	
2	69.48	62.53	6.95	10.00	
3	61.29	54.24	7.05	11.50	Truck A
4	53.10	45.95	7.15	13.46	Haul Road
5	44.91	37.67	7.25	16.14	1-6
6	36.80	29.38	7.42	20.16	
7	77.43	70.82	6.61	8.54	
8	69.26	62.53	6.73	9.72	Truck B
9	61.09	54.24	6.85	11.21	Haul Road
10	52.92	45.95	6.97	13.16	1-6
11	44.75	37.67	7.08	15.83	
12	36.65	29.38	7.27	19.84	
13	65.55	59.16	6.39	9.74	
14	58.72	52.47	6.25	10.64	Truck C
15	51.89	45.79	6.10	11.76	Haul Road
16	45.06	39.10	5.96	13.23	1-6
17	38.23	32.41	5.82	15.23	
18	31.45	25.72	5.74	18.24	
19	70.45	68.49	1.96	2.78	
20	63.24	60.52	2.73	4.31	Truck D
21	56.04	52.55	3.49	6.23	Haul Road
22	48.84	44.58	4.26	8.72	1-6
23	41.64	36.61	5.02	12.06	
24	34.50	28.65	5.85	16.96	
25	43.50	40.51	2.98	6.86	
26	38.84	36.38	2.46	6.33	Truck E
27	34.19	32.25	1.93	5.66	Haul Road
28	29.53	28.12	1.41	4.77	1-6
29	24.88	23.99	.89	3.56	
30	20.25	19.86	.39	1.93	
31	45.37	43.62	1.75	3.86	
32	40.54	39.07	1.47	3.63	Truck F
33	35.70	34.51	1.19	3.34	Haul Road
34	30.87	29.95	.91	2.96	1-6
35	26.03	25.40	.63	2.44	
36	21.23	20.84	.39	1.82	

37	44.71	41.68	3.03	6.78	
38	39.81	37.39	2.42	6.08	
39	34.91	33.10	1.81	5.19	Truck G
40	30.01	28.81	1.20	4.01	Haul Road
41	25.11	24.52	.59	2.37	1-6
42	20.25	20.23	.02	.09	
43	44.50	41.68	2.82	6.33	
44	39.61	37.39	2.22	5.62	
45	34.73	33.10	1.63	4.70	Truck H
46	29.85	28.81	1.04	3.48	Haul Road
47	24.96	24.52	.44	1.78	1-6
48	20.11	20.23	-.12	-.58	
49	42.25	45.18	-2.92	-6.92	
50	37.35	40.41	-3.06	-8.18	
51	32.45	35.64	-3.19	-9.82	Truck I
52	27.55	30.87	-3.32	-12.05	Haul Road
53	22.64	26.10	-3.45	-15.25	1-6
54	17.77	21.33	-3.55	-19.99	
55	42.21	45.18	-2.96	-7.02	
56	37.36	40.41	-3.05	-8.17	
57	32.50	35.64	-3.14	-9.66	Truck J
58	27.64	30.87	-3.23	-11.67	Haul Road
59	22.78	26.10	-3.31	-14.54	1-6
60	17.96	21.33	-3.37	-18.75	
61	45.95	51.70	-5.75	-12.51	
62	40.69	46.04	-5.34	-13.13	
63	35.44	40.37	-4.94	-13.93	Truck K
64	30.18	34.71	-4.53	-15.00	Haul Road
65	24.92	29.04	-4.12	-16.53	1-6
66	19.70	23.38	-3.67	-18.65	
67	47.80	51.70	-3.90	-8.16	
68	42.40	46.04	-3.64	-8.59	
69	36.99	40.37	-3.38	-9.14	Truck L
70	31.58	34.71	-3.12	-9.89	Haul Road
71	26.18	29.04	-2.86	-10.93	1-6
72	20.81	23.38	-2.56	-12.32	
73	43.55	47.90	-4.34	-9.97	
74	38.54	42.75	-4.21	-10.92	
75	33.53	37.61	-4.08	-12.16	Truck M
76	28.52	32.47	-3.95	-13.84	Haul Road
77	23.51	27.32	-3.82	-16.23	1-6
78	18.53	22.18	-3.65	-19.70	
79	40.88	43.14	-2.26	-5.53	
80	36.38	38.65	-2.27	-6.24	
81	31.88	34.16	-2.28	-7.16	Truck N
82	27.38	29.67	-2.29	-8.37	Haul Road
83	22.88	25.18	-2.30	-10.06	1-6
84	18.40	20.69	-2.28	-12.40	

85	42.79	47.22	-4.42	-10.33	
86	38.19	42.17	-3.97	-10.40	
87	33.59	37.12	-3.52	-10.49	Truck Ø
88	28.99	32.07	-3.08	-10.61	Haul Road
89	24.39	27.02	-2.63	-10.77	1-6
90	19.82	21.97	-2.15	-10.84	
91	57.18	62.02	-4.84	-8.47	
92	50.87	54.94	-4.07	-8.00	Truck P
93	44.57	47.86	-3.29	-7.39	Haul Road
94	38.26	40.78	-2.52	-6.58	1-6
95	31.96	33.70	-1.74	-5.44	
96	25.70	26.62	-.91	-3.56	
97	46.87	39.74	7.13	15.21	
98	41.65	35.71	5.93	14.25	Truck Q
99	36.42	31.69	4.74	13.00	Haul Road
100	31.20	27.67	3.54	11.34	1-6
101	25.98	23.64	2.34	9.01	
102	20.80	19.62	1.18	5.67	
103	43.32	36.59	6.73	15.53	
104	38.50	33.00	5.50	14.29	Truck R
105	33.67	29.40	4.27	12.68	Haul Road
106	28.85	25.81	3.04	10.54	1-6
107	24.03	22.22	1.81	7.53	
108	19.24	18.63	.61	3.18	
109	41.61	38.24	3.38	8.11	
110	37.05	34.42	2.63	7.11	Truck S
111	32.50	30.60	1.89	5.83	Haul Road
112	27.94	26.78	1.15	4.12	1-6
113	23.38	22.97	.41	1.76	
114	18.85	19.15	-.30	-1.60	
115	43.98	38.24	5.75	13.06	
116	39.13	34.42	4.71	12.04	Truck T
117	34.28	30.60	3.67	10.72	Haul Road
118	29.42	26.78	2.64	8.96	1-6
119	24.57	22.97	1.60	6.51	
120	19.74	19.15	.60	3.02	
121	46.30	51.09	-4.79	-10.35	
122	40.92	45.51	-4.59	-11.21	Truck U
123	35.54	39.93	-4.38	-12.34	Haul Road
124	30.16	34.34	-4.18	-13.86	1-6
125	24.78	28.76	-3.98	-16.05	
126	19.44	23.18	-3.74	-19.22	
127	45.50	47.51	-2.01	-4.42	
128	40.25	42.42	-2.17	-5.39	Truck V
129	35.00	37.33	-2.33	-6.66	Haul Road
130	29.75	32.24	-2.49	-8.38	1-6
131	24.50	27.15	-2.65	-10.83	
132	19.28	22.06	-2.78	-14.40	

133	45.50	47.51	-2.01	-4.42	
134	40.25	42.42	-2.17	-5.39	
135	35.00	37.33	-2.33	-6.66	Truck W
136	29.75	32.24	-2.49	-8.38	Haul Road
137	24.50	27.15	-2.65	-10.83	1-6
138	19.28	22.06	-2.78	-14.40	
139	53.20	51.09	2.12	3.98	
140	47.47	45.51	1.97	4.14	
141	41.74	39.93	1.82	4.35	Truck X
142	36.01	34.34	1.66	4.62	Haul Road
143	30.28	28.76	1.51	5.00	1-6
144	24.59	23.18	1.40	5.71	
145	51.25	52.17	-.92	-1.79	
146	45.46	46.44	-.98	-2.15	
147	39.68	40.71	-1.04	-2.61	Truck Y
148	33.89	34.98	-1.09	-3.23	Haul Road
149	28.10	29.25	-1.15	-4.10	1-6
150	22.36	23.52	-1.17	-5.22	
151	48.48	47.22	1.27	2.61	
152	43.00	42.17	.83	1.94	
153	37.52	37.12	.40	1.07	Truck Z
154	32.04	32.07	-.03	-.09	Haul Road
155	26.55	27.02	-.46	-1.74	1-6
156	21.11	21.97	-.85	-4.05	
157	46.22	45.18	1.05	2.27	
158	41.10	40.41	.70	1.70	
159	35.98	35.64	.35	.96	Truck 0
160	30.86	30.87	-.00	-.01	Haul Road
161	25.74	26.10	-.35	-1.38	1-6
162	20.66	21.33	-.67	-3.25	
163	62.97	63.94	-.96	-1.53	
164	56.45	56.59	-.14	-.26	
165	49.92	49.25	.68	1.35	Truck 1
166	43.40	41.90	1.49	3.44	Haul Road
167	36.88	34.56	2.31	6.28	1-6
168	30.40	27.22	3.19	10.48	
169	62.97	63.94	-.96	-1.53	
170	56.45	56.59	-.14	-.26	
171	49.92	49.25	.68	1.35	Truck 2
172	43.40	41.90	1.49	3.44	Haul Road
173	36.88	34.56	2.31	6.28	1-6
174	30.40	27.22	3.19	10.48	
175	61.04	68.49	-7.44	-12.19	
176	54.07	60.52	-6.45	-11.94	
177	47.09	52.55	-5.46	-11.60	Truck 3
178	40.11	44.58	-4.47	-11.15	Haul Road
179	33.13	36.61	-3.48	-10.51	1-6
180	26.21	28.65	-2.44	-9.29	

181	61.04	68.49	-7.44	-12.19	
182	54.07	60.52	-6.45	-11.94	
183	47.09	52.55	-5.46	-11.60	Truck 4
184	40.11	44.58	-4.47	-11.15	Haul Road
185	33.13	36.61	-3.48	-10.51	1-6
186	26.21	28.65	-2.44	-9.29	
187	72.15	73.73	-1.59	-2.20	
188	64.33	65.04	-.72	-1.11	
189	56.51	56.36	.15	.27	Truck 5
190	48.69	47.67	1.02	2.10	Haul Road
191	40.88	38.98	1.89	4.64	1-6
192	33.13	30.29	2.83	8.55	
AVER.	37.73	37.73	3.60	9.03	

D.4 Truck Cycle Time
(Variation of Truck Size and Haul Distance)

<u>Truck</u>	<u>Payload</u>	<u>Horsepower</u>	<u>Road</u>	<u>Haul Distance</u>
A	200.	560.	1	42,164
B	200.	560.	2	36,379
C	200.	700.	3	30,594
D	240.	700.	4	24,809
E	72.	420.	5	19,024
F	80.	420.	6	13,239
G	100.	560.		
H	100.	560.		
I	170.	850.		
J	200.	1000.		
K	240.	1000.		
L	240.	1000.		
M	260.	1200.		
N	300.	1600.		
Ø	340.	1600.		
P	364.	1200.		
Q	70.	420.		
R	70.	475.		
S	100.	635.		
T	100.	635.		
U	150.	635.		
V	150.	700.		
W	150.	700.		
X	150.	635.		
Y	170.	700.		
Z	170.	800.		
0	170.	850.		
1	200.	635.		
2	200.	635.		
3	240.	700.		
4	240.	700.		
5	300.	800.		

Appendix D.5

Quantity of Scrapers for Land Reclamation

Quantity of Scrapers:

$$\text{TSCR} = \left[.0157046 + 5.43198 \times \text{CD}/\text{HC} + 7.36661 \times (\text{CD}/\text{HC})^2 \right] \times \text{HBT}$$

where TSCR = Required number of scrapers

CD = Coal demand recovered tons per year

HC = Height of coal in feet

HBT = Height of topsoil in feet

Note: HBT was not included in the correlation because all coefficients are equally affected by the HBT value.

The following sheets show the curve fitting results for the above equation and the supporting variation of parameters and resulting micromodel solutions.

D.5 Quantity of Scrapers
(Curve Fitting Results)

Equation:

$$TSCR = A + B * CD/HC + C * (CD/HC) ** 2$$

Coefficients A = .157046E-01 B = 5.43198 C = 7.36661

COUNT	Micromodel	Curve Fit	Comparison Between	
	<u>Solution</u>	<u>Solution</u>	<u>Micromodel & Curve Fit</u>	<u>Micromodel & Curve Fit</u>
	INPUT Y	CALC Y	DEV	% DEV
1	.720000	.727133	-.007	-.991
2	2.15000	2.15255	-.003	-.119
3	4.00000	4.00378	-.004	-.094
4	7.14000	7.13896	.001	.015
5	9.99000	9.98671	.003	.033
6	11.0300	11.0325	-.003	-.023
7	6.01000	6.00885	.001	.019
8	4.00000	4.00378	-.004	-.094
9	1.64000	1.62965	.010	.631
10	1.25000	1.24605	.004	.316

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS
TOTAL (CORRECTED)	9	120.225	
REGRESSION	2	120.225	60.1123
RESIDUAL	7	.228335E-03	.326194E-04
R SQUARED		.999998	

AVERAGE INPUT Y = 4.79300
 STD. DEV. OF RESIDUALS = .571133E-02
 S.D. AS PCT OF AV. Y = .12

D.5 Quantity of Scrapers

(Variation of Parameters and Micromodel Results)

COUNT	Equation Parameters		Micromodel Solution
	CD/HC	(CD/HC) ²	TSCR
1	.113500	.128822E-01	.720000
2	.284000	.806559E-01	2.15000
3	.454295	.206384	4.00000
4	.681500	.464442	7.14000
5	.851750	.725478	9.99000
6	.908590	.825535	11.0300
7	.605727	.366905	6.01000
8	.454295	.206384	4.00000
9	.227147	.515960E-01	1.64000
10	.181718	.330214E-01	1.25000

Appendix D.6

Quantity of Bulldozers for Land Reclamation

Quantity of Bulldozers:

$$\begin{aligned} \text{RN}\emptyset\text{CD} &= -.00384704 * \frac{\text{CDRTY} * \tan \text{ABSD} * \text{PWF}}{1\text{E}6 * \text{HC}} \\ &+ .000618961 * \frac{\text{CDRTY} * \tan \text{ABSD} * \text{PWF}^2}{1\text{E}6 * \text{HC}} \\ &+ .00660554 * \frac{\text{CDRTY} * \text{CGD}}{1\text{E}6 * \text{HC}} \end{aligned}$$

where RN \emptyset CD = Required number of dozers
CDRTY = Coal demand recovered tons per year
ABSD = Angle of burden spoils in degrees
PWF = Panel width in feet
HC = Height of coal in feet
CGD = Cost of general dozing in \$/acre

The following sheets show the curve fitting results for the above equation and the supporting variation of parameters and resulting micromodel solutions.

D.6 Quantity of Bulldozers
(Curve Fitting Results)

Equation:

$$\begin{aligned} \text{TCDR} &= A * \text{CDRTY}/1\text{E}6/\text{HC} * \text{TABS D} * \text{PWF} \\ &+ B * \text{CDRTY}/1\text{E}6/\text{HC} * \text{TABS D} * \text{PWF} ** 2 \\ &+ C * \text{CDRTY}/1\text{E}6/\text{HC} * \text{CGD} \end{aligned}$$

Coefficients: A = -.384704E-02 B = .618961E-03 C = .660554E-02

COUNT	Micromodel	Curve Fit	Comparison Between	
	<u>Solution</u>	<u>Solution</u>	<u>Micromodel & Curve Fit</u>	
	INPUT Y	CALC Y	DEV	% DEV
1	.889000	.889097	-.000	-.011
2	2.22400	2.22470	-.001	-.032
3	3.55700	3.55834	-.001	-.038
4	5.33600	5.33849	-.002	-.047
5	6.67000	6.67214	-.002	-.032
6	2.20700	2.20809	-.001	-.049
7	2.65700	2.65817	-.001	-.044
8	5.35700	5.35868	-.002	-.031
9	8.95700	8.95936	-.002	-.026
10	3.06100	3.06209	-.001	-.036
11	3.30600	3.30679	-.001	-.024
12	3.71700	3.71814	-.001	-.031
13	3.90800	3.90984	-.002	-.047
14	7.11500	7.11669	-.002	-.024
15	4.74300	4.74399	-.001	-.021
16	1.77900	1.77917	-.000	-.010
17	1.42300	1.42334	-.000	-.024
18	2.22900	2.21072	.018	.820
19	2.77600	2.76737	.009	.311
20	4.58000	4.58363	-.004	-.079
21	5.85300	5.84324	.010	.167

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS
TOTAL (CORRECTED)	20	84.9297	
REGRESSION	2	84.9291	42.4646
RESIDUAL	18	.551891E-03	.306606E-04
R SQUARED		.999993	

AVERAGE INPUT Y = 3.92114
 STD. DEV. OF RESIDUALS = .553720E-02
 S.D. AS PCT OF AV. Y = .14

D.6 Quantity of Bulldozers

(Variation of Parameters and Micromodel Results)

COUNT	Equation Parameters					Micromodel
	CDRTY/1E6	CGD	TAN A	1/HC	PWF	TCDR
1	.454	600.	.6667	.2500	100.	.889
2	1.136	600.	.6667	.2500	100.	2.224
3	Vary Coal	600.	.6667	.2500	100.	3.557
4	Demand	600.	.6667	.2500	100.	5.336
5		600.	.6667	.2500	100.	6.670
6	1.817	150.	.6667	.2500	100.	2.207
7	Vary Cost	300.	.6667	.2500	100.	2.657
8	of General	1200.	.6667	.2500	100.	5.357
9	Dozing	2400.	.6667	.2500	100.	8.957
10	1.817	600.	.4785	.2500	100.	3.061
11	1.817	600.	.5713	.2500	100.	3.306
12	Vary Spoil	600.	.7273	.2500	100.	3.717
13	Angle	600.	.8000	.2500	100.	3.908
14	1.817	600.	.6667	.5000	100.	7.115
15	1.817	600.	.6667	.3333	100.	4.743
16	Vary Height	600.	.6667	.1250	100.	1.779
17	of Coal	600.	.6667	.1000	100.	1.423
18	1.817	600.	.6667	.2500	50.	2.229
19	1.817	600.	.6667	.2500	75.	2.776
20	Vary Panel	600.	.6667	.2500	125.	4.580
21	Width	600.	.6667	.2500	150.	5.853

APPENDIX E

Macromodel Baseline Solution

- E.1 Report 1 Financial Summary Report - provides economic highlights such as required investment, selling price, and rate of return.
- Case Description - identifies the case being analyzed, including mining parameters and financial assumptions.
- E.2 Report 2 Investment List - identifies all equipment facilities, and other premining costs; shows total investment and replacement capital.
- E.3 Report 3 Operating Personnel List - identifies all operating personnel, including supervision and staff; shows total manpower needs and payroll.
- E.4 Report 4 Maintenance Personnel List - identifies all maintenance personnel; shows total manpower needs and payroll.
- E.5 Report 5 Services and Materials List - identifies all services and materials; shows annual cost; shows annual quantity of electric power, water, and fuel.
- E.6 Report 6 Infrastructure Report - summarizes physical effects, economic impact, utility requirements, and manpower requirements.
- E.7 Report 7 Production and Cash Expenditure Table - for each year of the project shows production and cash expenditure.
- E.8 Report 8 Financial Statements - for each year of the project compiles an income statement, sources and uses of funds statement, and a balance sheet.
- E.9 Default values for Fort Union.

All costs are in January 1975 dollars (no escalation).

Appendix E.1 Financial Summary Report
and Case Description

The Financial Summary report provides economic highlights including required investment, selling price, and rate of return.

The Case Description identifies the case being analyzed, including mining parameters and financial assumptions.

CFA MODEL:

507 (ADMU0507) HYPOTHETICAL MINE STUDY - FORT UNION
1 BASELINE SOLUTION

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FINANCIAL SUMMARY REPORT

SALES PRICE IN BASE DOLLARS	: \$/PREPARED TON	5.93
	: \$/MILLION BTU	.42
RETURN ON INVESTMENT	: PERCENT	10.00
RETURN ON PAID-IN-CAPITAL	: PERCENT	10.87
CUMULATIVE INVESTMENT TO STEADY STATE	: M\$	137395.
CUMULATIVE INVESTMENT TOTAL PROJECT	: M\$	179628.
ANNUAL OPERATING COST AT STEADY STATE	: M\$	15630.

BASE YEAR IS	1975
PROJECT BEGINS IN	1976
FIRST COAL PRODUCTION IN	1982
STEADY STATE BEGINS IN	1985
STEADY STATE ENDS IN	2011
LAST COAL PRODUCTION IN	2013
PROJECT ENDS IN	2015

- * DISCOUNTED CASH FLOW INTERNAL RATE OF RETURN ASSUMING PROJECT IS FINANCED COMPLETELY BY INTERNAL CAPITAL.
- ** DISCOUNTED CASH FLOW INTERNAL RATE OF RETURN ASSUMING PROJECT IS FINANCED BY USER-SET COMBINATION OF INTERNAL CAPITAL AND EXTERNAL DEBT.

CASE DESCRIPTION

MINING PARAMETERS

I JPPTS	1	INDEX TO PLANT TYPE
C CDPTY\$	.925271E 07	COAL DEMAND ROM TONS/YEAR (COMPLEX)
I SRYT\$	3.80434	STRIPPING RATIO YARDS/ROM TONS
I HRT\$	1.25000	HEIGHT OF TOPSOIL - FEET
I HC\$	12.0000	HEIGHT OF COAL IN FEET
C PPFTYS	.916018E 07	PREPARED COAL TONS/YEAR
I PPNED\$	.130000E 15	ENERGY DEMAND FOR COMPLEX BTU/YEAR
I PPNHVS	7C7C.00	ROM COAL HEAT VALUE BTU/LB
I ROC\$	600.000	RECLAMATION - OTHER COSTS - \$/ACRE
D VCBP	7C95.45	VALUE - COAL BTU/POUND

FINANCIAL ASSUMPTIONS

I CDR	2.00000	CAPITAL/DEBT RATIO
I GAMR\$	50.0000	GAA - MINERAL RIGHTS (\$/ACRE)
I GAPAS	.250000	GAA - ROYALTY AMOUNT (\$/TON)
I GASR\$	250.000	GAA - SURFACE RIGHTS (\$/ACRE)
I GAST\$	.000000	GAA - SEVERANCE TAX (\$/TON)
I RCFD	.100000	RATE - CASH FLOW DISCOUNT
I RFIT	.480000	RATE - FEDERAL INCOME TAX
I RLTI	.800000E-01	RATE - LONG TERM INTEREST
I PSTI	.100000	RATE - SHORT TERM INTEREST
I VSPC	.000000	VALUE - REQ. PRICE OF COAL - \$/TON

FINANCIAL CONTROL PARAMETERS

I DM1	.000000	RESET DEP. METHOD 1 TO NONZERO VALUE
I DM2	.000000	RESET DEP. METHOD 2 TO NONZERO VALUE
I DM3	.000000	RESET DEP. METHOD 3 TO NONZERO VALUE
I FRAEI	.000000	ESCAL. RATE - ALL EQUIP. INVEST.
I EREL	.000000	ESCAL. RATE - ELECTRICITY
I ERFU	.000000	ESCAL. RATE - FUELS
I EP4L	.000000	ESCAL. RATE - MAINTENANCE LABOR
I ERMM	.000000	ESCAL. RATE - MAINTENANCE MATERIALS
I EROL	.000000	ESCAL. RATE - OPERATING LABOR
I EROT	.000000	ESCAL. RATE - OTHER COSTS
I ERSPC	.000000	ESCAL. RATE - SELLING PRICE OF COAL
I EPTI	.000000	ESCAL. RATE - TIRES
I FRWA	.000000	ESCAL. RATE - WATER
I ESPC	.000000	ESC. COAL PRICE PER COST ESC. IF 1
I PC1	.000000	RESETS PUR. CODE 1 TO NONZERO VALUE
I PC2	.000000	RESETS PUR. CODE 2 TO NONZERO VALUE
I PC3	.000000	RESETS PUR. CODE 3 TO NONZERO VALUE
I PC4	.000000	RESETS PUR. CODE 4 TO NONZERO VALUE
I PC5	.000000	RESETS PUR. CODE 5 TO NONZERO VALUE
I PC6	.000000	RESETS PUR. CODE 6 TO NONZERO VALUE
I PC7	.000000	RESETS PUR. CODE 7 TO NONZERO VALUE

\$ IN NAME INDICATES A MEMO ITEM FOR CFA

Appendix E.2 Investment List

The investment list identifies all equipment facilities, and other premining costs; shows total investment and replacement capital. Columns A through R of the investment list are defined as follows:

- Column A: For each mining operation the steady state annual production requirement is given followed by a list of equipment or facilities giving the equipment file number, type, and size. Note that the general and administrative operation includes ancillary facilities, ancillary equipment (including mobile equipment, such as pick-ups, service vehicles, and maintenance vehicles), and premining costs.
- Column B: Original quantity of equipment required to reach steady state production.
- Column C: Fleet Spares.
- Column D: Total quantity equals original quantity plus fleet spares.
- Column E: Unit investment is the regionally adjusted base year required investment per item.
- Column F: Total investment equals total quantity times unit investment. Note that items with an asterisk are deferred purchases which are additional equipment required as the mine development becomes further away from the central plant.
- Column G: Productive hours per year for the equipment.
- Column H: Depreciation life in hours.
- Column I: Replacement years equals depreciation life divided by productive hours per year.
- Column J: Replacement quantity is the number of new machines that must be purchased at intervals later in the project to replace worn out machines.
- Column K: Replacement capital equals replacement quantity times unit investment.

- Column L: Salvage fraction is the portion of the purchase price which can be recovered when the equipment is replaced.
- Column M: Depreciation method
1 = straight line
2 = declining balance
3 = double declining balance.
- Column N: Purchase year is the project year in which a commitment must be made to purchase equipment (takes into account purchase lead time).
Purchase plan is the method of progress payments for the equipment.
1 = Lump sum with order
2 = Lump sum at delivery
3 = 25% with order, 75% at delivery
4 = 50% with order, 50% at delivery
5 = Equal payments each year
6 = Lease
- Column O: Base year for escalation of unit investment determined by subtracting the calendar year of the cost file from the calendar year of the start of the project.
- Column P: Escalation rate as an annual fraction.
- Column Q: Regional adjustment as a multiplier for base costs.
- Column R: Beginning and ending operating year of the machines.

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		INVESTMENT LIST																		
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R			
MINING	ORIG	SPR	TOT	UNIT	TOTAL	PRD	DEPREC	REPL	REPL	REPL	SAL	DP	PUR	STAS	INFL	REG	OPR YRS			
OPERATION	QTY	QTY	QTY	INVEST	INVEST	HRS	HOURS	YRS	QTY	CAPITAL	FRC	MD	YR	PL	YR	RATE	ADJ	1ST-LAST		
				(M\$)	(M\$)	(H/YR)				(M\$)										
OVERPURDEN REMCVL (THOUSAND CU YDS)		35200																		
DL1	DRAGLINE	45	0	3	4201.0	12603.	7467	224010	30.0	0	0.	.00	1	3	5	0	.00	1.00	7-38	
CD3	TR TRACTOR	300	0	3	135.3	406.	7467	24000	3.2	27	3653.	.00	1	6	2	0	.00	1.00	7-38	
LD16	WH LOADER	325	0	3	123.0	369.	2374	12000	5.1	15	1845.	.00	1	6	2	0	.00	1.00	7-38	
DL2	DRAGLINE	11	0	3	1879.8	5639.	7467	224010	30.0	0	0.	.00	1	3	5	0	.00	1.00	7-38	
TOTAL (LESS DEFERRED)				19017.						5498.										
COAL DRILL & BLAST (THOUSAND CU YDS)		10057																		
QD23	AUGER DRILL	3.000	0	3	37.3	112.	1632	20000	12.3	6	224.	.00	1	6	2	0	.00	1.00	7-38	
TDQ1	PRILL TRUCK		0	3	36.0	108.	1632	20000	12.3	6	216.	.00	1	6	2	0	.00	1.00	7-38	
TOTAL (LESS DEFERRED)				220.						440.										
COAL LOAD & HAUL (THOUSAND RCM TONS)		9252																		
SD34	SHOVEL	16	0	3	1043.0	3129.	3262	60000	18.4	3	3129.	.00	1	5	5	0	.00	1.00	7-38	
TD18	TRUCK	180	0	9	399.3	3594.	3262	30000	9.2	27	10781.	.00	1	6	2	0	.00	1.00	7-38	
L16	WH LOADER	325	0	3	123.0	369.	3262	12000	3.7	24	2952.	.00	1	6	2	0	.00	1.00	7-38	
G05	GRADER	180	0	3	80.1	240.	3262	15000	4.6	18	1442.	.00	1	6	2	0	.00	1.00	7-38	
PUMP	PUMP SET	125000	0	3	10.0	30.	1440	21600	15.0	3	30.	.00	1	6	2	0	.00	1.00	7-38	
TDX2	H2O TRUCK	5000	0	3	124.6	374.	1631	20000	12.3	6	748.	.00	1	6	2	0	.00	1.00	7-38	
TD18	TRUCK	180	0	3	399.3	1198.*	3262	30000	9.2	9	3594.	.00	1	7	2	0	.00	1.00	8-38*	
TD18	TRUCK	180	0	3	399.3	1198.*	3262	30000	9.2	3	1198.	.00	1	18	2	0	.00	1.00	19-38*	
TD18	TRUCK	180	0	3	399.3	1198.*	3262	30000	9.2	0	0.	.00	1	30	2	0	.00	1.00	31-38*	
TOTAL (LESS DEFERRED)				7736.						23873.										
TOTAL (DEFERRED)				3594.*																
COAL HANDLE & PREP (THOUSAND CLEAN TONS)		9160																		
CONSTRUCTION INTEREST				18370.																
PRR8	REC & BREAK	PREP. PLANT	1	0	1	10059.8	10060.	3625	108750	30.0	0	0.	.00	1	4	5	0	.00	1.00	7-38
PR85	BLEND-STOCK	PREP. PLANT	1	0	1	38306.6	38307.	5438	163140	30.0	0	0.	.00	1	4	5	0	.00	1.00	7-38
PRCL	COAL LOADOUT	PREP. PLANT	1	0	1	1776.5	1777.	8712	261360	30.0	0	0.	.00	1	4	5	0	.00	1.00	7-38
PRCS	CRUSH-SCREEN	PREP. PLANT	1	0	1	5399.3	5399.	5438	163140	30.0	0	0.	.00	1	4	5	0	.00	1.00	7-38
PR81	CS SUPPORT	PREP. PLANT	1	0	1	5690.1	5690.	2000	60000	30.0	0	0.	.00	1	4	5	0	.00	1.00	7-38
TOTAL (LESS DEFERRED)				79602.						0.										
LAND RECLAMATION (ACRES)		519																		
CD 5	TR TRACTOR	410	0	5	192.5	963.	1800	12000	6.7	20	3850.	.00	1	6	2	0	.00	1.00	7-38	

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A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R					
SC 6 SCRAPER	32	CY	415	HP	8	1	9	201.1	1810.	1800	17000	6.7	32	6435.	.00	1	6	2	0	.00	1.00	7-38
TOTAL (LESS DEFERRED)					2772.					10285.												
GENERAL & ADMINISTRATION																						
CONSTRUCTION INTEREST																						
SITE	ROADS & SITE	ANC.	FAC.	1	0	1	3000.0	3000.	2000	64000	32.0	0	0.	.00	1	4	5	0	.00	1.00	7-38	
BLDG	BUILDINGS	ANC.	FAC.	1	0	1	4893.7	4894.	2000	64000	32.0	0	0.	.00	1	4	5	0	.00	1.00	7-38	
PWR	ELECT. SYS.	ANC.	FAC.	1	0	1	4500.0	4500.	2000	64000	32.0	0	0.	.00	1	4	5	0	.00	1.00	7-38	
H2C	WATER SYS.	ANC.	FAC.	1	0	1	200.0	200.	2000	64000	32.0	0	0.	.00	1	4	5	0	.00	1.00	7-38	
COM	COMMUN. SYS.	ANC.	FAC.	1	0	1	125.0	125.	2000	64000	32.0	0	0.	.00	1	4	5	0	.00	1.00	7-38	
MREQ	MOBILE SUP.	ANC.	FAC.	1	0	1	1200.0	1200.	2000	64000	32.0	0	0.	.00	1	5	5	0	.00	1.00	7-38	
SREQ	EQUIP. SHOP	ANC.	FAC.	1	0	1	1000.0	1000.	2000	64000	32.0	0	0.	.00	1	5	5	0	.00	1.00	7-38	
LAND	LAND RIGHTS	PREMINE		1	0	1	467.5	467.	2000	64000	32.0	0	0.	.00	1	2	1	0	.00	1.00	7-38	
XDRL	EXPL. DRILL.	PREMINE		1	0	1	389.6	390.	2000	64000	32.0	0	0.	.00	1	2	1	0	.00	1.00	7-38	
ENG	CONT. ENG.	PREMINE		1	0	1	6000.0	6000.	2000	64000	32.0	0	0.	.00	1	1	5	0	.00	1.00	7-38	
EIS	E. I. S.	PREMINE		1	0	1	1000.0	1000.	2000	64000	32.0	0	0.	.00	1	3	1	0	.00	1.00	7-38	
TOTAL (LESS DEFERRED)					26591.					0.												
TOTALS					135939.					40096.												
TOTAL (DEFERRED)					3594.*																	

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Appendix E.3 Operating Personnel List

The operating personnel list identifies all operating personnel, including supervision and staff; shows total manpower needs and payroll. Columns A through M of the operating personnel list are defined as follows:

- Column A: For each mining operation the equipment file number and type is given as well as the operator's wage classification description.
- Column B: Union pay grade.
- Column C: Personnel schedule basis (shifts per day - hours per shift - days per week).
- Column D: Quantity of operators required per machine shift.
- Column E: Quantity of machines requiring operators.
- Column F: Scheduled machine hours per year.
- Column G: Total scheduled hours equals quantity of machines times scheduled machine hours.
- Column H: Effective hours per year (hours on the job per man) for the personnel schedule basis.
- Column I: Manpower needs represent the total number of men that must be hired to have men on the job for every scheduled hour for the machine.
- Column J: Base year dollars per hour per man based on wage table plus regional adjustment and additional union pension.
- Column K: Annual payroll in base year dollars for steady state production.
- Column L: Manpower required to operate the deferred equipment.
- Column M: Annual payroll for operators of deferred equipment.

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A M I N I N G O P E R A T I O N		B :	C G D	OPERATING PERSONNEL SCHEDULE	D QTY	E EQP QTY	F LIST SCHED HR/YR	G TOTAL SCHED HR	H EFF HR/YR	I MANPOWER NEEDS	J PAYRL RATE	K INITIAL PAYROLL (MS/YR)	L DEFR MANP (MAX)	M DEFR PAYROLL (MS/YR)	
OVERBURDEN REMOVAL															
DL1	DRAGLINE			STRIP MACH OPERATOR	5	3-8.00-6	1.00	3	8297	24891	2269	11.0	12.90	321.1	
				OILER	4	3-8.00-6	2.00	3	8297	24891	2269	21.9	12.10	602.4	
CO3	TR TRACTOR			STRIP MACH OPERATOR	5	3-8.00-6	1.00	3	8297	24891	2269	11.0	12.90	321.1	
LD16	WH LOADER			STRIP MACH OPERATOR	5	3-8.00-6	1.00	3	2638	7914	2269	3.5	12.90	102.1	
DL2	DRAGLINE			STRIP MACH OPERATOR	5	3-8.00-6	1.00	3	8297	24891	2269	11.0	12.90	321.1	
				OILER	4	3-8.00-6	1.00	3	8297	24891	2269	11.0	12.10	301.2	
COAL DRILL & BLAST															
QD23	AUGER DRILL			DRILLER & SHOOTER	3	1-7.25-5	1.00	3	1813	5439	1618	3.4	10.03	54.6	
QLST	BLASTING			DRILLER & SHOOTER	3	1-7.25-5	1.00	3	1813	5439	1618	3.4	10.03	54.6	
TOQ1	PRILL TRUCK			MOBILE EQUIP OPERAT	3	1-7.25-5	1.00	3	1813	5439	1618	3.4	10.03	54.6	
COAL LOAD & HALL															
SD34	SHOVEL			COAL LOADING OPERAT	5	2-7.25-5	1.00	3	3625	10875	1618	6.7	11.42	124.2	
				OILER	4	2-7.25-5	1.00	3	3625	10875	1618	6.7	10.59	115.2	
TD19	TRUCK			MOBILE EQUIP OPERAT	3	2-7.25-5	1.00	9	3625	32625	1618	20.2	10.13	330.5	
L16	WH LOADER			STRIP MACH OPERATOR	5	2-7.25-5	1.00	3	3625	10875	1618	6.7	11.42	124.2	
GD5	GRADER			MOBILE EQUIP OPERAT	3	2-7.25-5	1.00	3	3625	10875	1618	6.7	10.13	110.2	
	PUMP SET			UTILITY MAN	1	2-7.25-5	1.00	3	1440	4320	1618	2.7	9.66	41.7	
TDX2	H2O TRUCK			SVC VEHICLE DRIVER	1	1-7.25-5	1.00	3	1812	5436	1618	3.4	9.56	52.0	
TD18	TRUCK			MOBILE EQUIP OPERAT	3	2-7.25-5	1.00	3						6.7*	110.2
TD18	TRUCK			MOBILE EQUIP OPERAT	3	2-7.25-5	1.00	3						6.7*	110.2
TD19	TRUCK			MOBILE EQUIP OPERAT	3	2-7.25-5	1.00	3						6.7*	110.2
COAL HANDLE & PREP															
PRRB	REC & BREAK			STAT EQUIP OPERATOR	3	2-7.25-5	1.56	1	3625	3625	1618	3.5	10.13	57.3	
				HELPER	2	2-7.25-5	1.56	1	3625	3625	1618	3.5	9.77	55.2	
				LABORER	1	2-7.25-5	2.34	1	3625	3625	1618	5.2	9.66	81.9	
PRBS	BLEND-STOCK			STAT EQUIP OPERATOR	3	3-7.25-5	6.64	1	5438	5438	1618	22.3	10.23	369.4	
				LABORER	1	3-7.25-5	1.56	1	5438	5438	1618	5.2	9.76	82.8	
PRCL	COAL LOADOUT			STAT EQUIP OPERATOR	3	3-8.00-6	1.56	1	8712	8712	2269	6.0	11.46	155.7	
				HELPER	2	3-8.00-6	1.56	1	8712	8712	2269	6.0	11.07	150.4	
				LABORER	1	3-8.00-6	.78	1	8712	8712	2269	3.0	10.77	73.2	
PRCS	CRUSH-SCREEN			STAT EQUIP OPERATOR	3	3-7.25-5	1.56	1	5438	5438	1618	5.2	10.23	86.8	
				HELPER	2	3-7.25-5	1.56	1	5438	5438	1618	5.2	9.87	83.7	
				UTILITY MAN	1	3-7.25-5	2.34	1	5438	5438	1618	7.9	9.76	124.2	
				LABORER	1	3-7.25-5	.78	1	5438	5438	1618	2.6	9.76	41.4	
PRSI	CS SUPPORT			MOBILE EQUIP OPERAT	3	2-7.25-5	7.50	1	2000	2000	1618	9.3	10.13	151.9	
				UTILITY MAN	1	2-7.25-5	3.75	1	2000	2000	1618	4.6	9.66	72.4	
LAND RECLAMATION															
CD 5	TR TRACTOR			MOBILE EQUIP OPERAT	3	2-7.25-6	1.00	5	2000	10000	1942	5.1	10.97	109.7	
SC 6	SCRAPER			STRIP MACH OPERATOR	5	2-7.25-6	1.00	8	2000	16000	1942	8.2	12.37	197.9	
GENERAL & ADMINISTRATION															
STF	SUPERV. PER. GEN & ADM STAFF				5	1-8.00-5	92.00	1	2000	2000	2000	92.0	10.28	1891.5	
TOTALS										327.5		6816.2	20.2*	330.5	

INFLATION ESCALATION RATE = .00
REGIONAL ADJUSTMENT FACTOR = 1.00

Appendix E.4 Maintenance Personnel List

The maintenance personnel list identifies all maintenance personnel; shows total manpower needs and payroll. Columns A through M of the maintenance personnel list are defined as follows:

- Column A: For each mining operation the equipment file number and type is given as well as the maintenance wage classification description.
- Column B: Union pay grade.
- Column C: Personnel schedule basis (shifts per day-hours per shift-days per week).
- Column D: Fraction of maintenance labor hourly cost to be allocated to a particular maintenance wage classification type.
- Column E: Base year maintenance hourly cost including regional adjustment.
- Column F: Total productive hours equals the number of machines times productive machine hours.
- Column G: Effective hours per year (hours on the job per man) for the personnel schedule basis.
- Column H: Manpower needs represents the total number of men that must be hired to have men on the job for every maintenance labor hour required for the machine.
- Column I: Base year dollars per hour per man based on wage table plus regional adjustment and additional union pension.
- Column J: Required maintenance labor hours equals the hourly cost times total productive hours divided by payroll rate.
- Column L: Manpower required to maintain the deferred equipment.
- Column M: Annual payroll for maintenance of deferred equipment.

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MINING OPERATION	A	B	C	D	E	F	G	H	I	J	K	L	M
		GD	SCHEDULE	FRAC	HOURLY COST	TOTAL PROD HRS	EFF HR/YR	MANPOWER NEEDS	PAYR RATE	REQD HOURS	INITIAL PAYROLL (M\$/YR)	DEPR MANP (MAX)	DEFR PAYROLL (M\$/YR)
OVERBURDEN REMOVAL													
DL1 DRAGLINE	MECHANIC	4	3-7.25-6	1.00	27.91	22401	1942	27.8	11.58	53990	625.2		
CD3 TR TRACTOR	MECHANIC	4	3-7.25-6	1.00	2.00	22401	1942	2.0	11.58	3868	44.8		
LD16 WH LOADER	MECHANIC	4	3-7.25-6	1.00	3.81	7122	1942	1.2	11.58	2343	27.1		
DLZ DRAGLINE	MECHANIC	4	3-7.25-6	1.00	13.92	22401	1942	13.9	11.58	26927	311.8		
COAL DRILL & BLAST													
OD23 AUGER DRILL	MECHANIC	4	3-7.25-6	1.00	1.02	4896	1942	.2	11.58	431	5.0		
TDQ1 PRILL TRUCK	MECHANIC	4	3-7.25-6	1.00	.95	4896	1942	.2	11.58	401	4.7		
COAL LOAD & HAUL													
SD34 SHOVEL	MECHANIC	4	3-7.25-6	1.00	6.76	9786	1942	2.9	11.58	5712	66.2		
TD18 TRUCK	MECHANIC	4	3-7.25-6	1.00	7.52	29358	1942	9.8	11.58	19064	220.8		
L16 WH LOADER	MECHANIC	4	3-7.25-6	1.00	3.81	9786	1942	1.7	11.58	3219	37.3		
GD5 GRADER	MECHANIC	4	3-7.25-6	1.00	1.61	9786	1942	.7	11.58	1360	15.8		
PUMP PUMP SET	MECHANIC	4	3-7.25-6	1.00	3.65	4320	1942	.7	11.58	1361	15.8		
TDX2 H2O TRUCK	MECHANIC	4	3-7.25-6	1.00	6.35	4893	1942	1.4	11.58	2683	31.1		
TD18 TRUCK	MECHANIC	4	3-7.25-6	1.00								3.3*	73.6
TD18 TRUCK	MECHANIC	4	3-7.25-6	1.00								3.3*	73.6
TD18 TRUCK	MECHANIC	4	3-7.25-6	1.00								3.3*	73.6
COAL HANDLE & PREP													
PRRB REC & BREAK	ELECTRICIAN	4	2-7.25-5	.07	55.86	3625	1618	.9	10.59	1414	15.0		
	MACHINIST	4	2-7.25-5	.07	55.86	3625	1618	.9	10.59	1414	15.0		
	MECHANIC	4	2-7.25-5	.30	55.86	3625	1618	3.5	10.59	5659	59.9		
	WELDER	3	2-7.25-5	.07	55.86	3625	1618	.9	10.13	1419	14.4		
	REPAIRMAN	3	2-7.25-5	.21	55.86	3625	1618	2.6	10.13	4237	42.9		
	HELPER	2	2-7.25-5	.20	55.86	3625	1618	2.6	9.77	4248	41.5		
	LABORER	1	2-7.25-5	.07	55.86	3625	1618	.9	9.66	1425	13.8		
PRBS BLEND-STOCK	ELECTRICIAN	4	2-7.25-5	.09	63.33	5438	1618	1.7	10.59	2829	30.0		
	MACHINIST	4	2-7.25-5	.04	63.33	5438	1618	.9	10.59	1430	15.2		
	MECHANIC	4	2-7.25-5	.26	63.33	5438	1618	5.2	10.59	8487	89.9		
	WELDER	3	2-7.25-5	.04	63.33	5438	1618	.9	10.13	1427	14.5		
	REPAIRMAN	3	2-7.25-5	.12	63.33	5438	1618	2.6	10.13	4249	43.0		
	HELPER	2	2-7.25-5	.40	63.33	5438	1618	8.7	9.77	14135	138.1		
	LABORER	1	2-7.25-5	.04	63.33	5438	1618	.9	9.66	1426	13.8		
PRCL COAL LOADOUT	ELECTRICIAN	4	2-7.25-5	.07	23.87	8712	1618	.8	10.59	1354	14.3		
	MACHINIST	4	2-7.25-5	.07	23.87	8712	1618	.8	10.59	1354	14.3		
	MECHANIC	4	2-7.25-5	.28	23.87	8712	1618	3.4	10.59	5459	57.8		
	WELDER	3	2-7.25-5	.07	23.87	8712	1618	.8	10.13	1354	13.7		
	REPAIRMAN	3	2-7.25-5	.20	23.87	8712	1618	2.5	10.13	4085	41.4		
	HELPER	2	2-7.25-5	.26	23.87	8712	1618	3.4	9.77	5448	53.2		
	LABORER	1	2-7.25-5	.06	23.87	8712	1618	.8	9.66	1356	13.1		
PRCS CRUSH-SCREEN	ELECTRICIAN	4	2-7.25-5	.13	42.42	5438	1618	1.8	10.59	2853	30.2		
	MACHINIST	4	2-7.25-5	.06	42.42	5438	1618	.9	10.59	1394	14.8		
	MECHANIC	4	2-7.25-5	.26	42.42	5438	1618	3.5	10.59	5641	59.7		
	WELDER	3	2-7.25-5	.06	42.42	5438	1618	.9	10.13	1389	14.1		
	REPAIRMAN	3	2-7.25-5	.19	42.42	5438	1618	2.6	10.13	4258	43.1		
	HELPER	2	2-7.25-5	.24	42.42	5438	1618	3.5	9.77	5643	55.1		
	LABORER	1	2-7.25-5	.06	42.42	5438	1618	.9	9.66	1408	13.6		

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A		B	C	D	E	F	G	H	I	J	K	L	M	
PRSI CS SUPPRT	ELECTRICIAN	4	2-7.25-5	.10	135.91	2000	1618	1.5	10.59	2489	26.4			
	MACHINIST	4	2-7.25-5	.19	135.91	2000	1618	3.1	10.59	5005	53.0			
	MECHANIC	4	2-7.25-5	.29	135.91	2000	1618	4.6	10.59	7494	79.4			
	REPAIRMAN	3	2-7.25-5	.23	135.91	2000	1618	3.9	10.13	6252	63.3			
	STAT EQUIP OPERATOR	3	2-7.25-5	.09	135.91	2000	1618	1.5	10.13	2495	25.3			
	UTILITY MAN	1	2-7.25-5	.09	135.91	2000	1618	1.6	9.66	2532	24.5			
LAND RECLAMATION														
CD 5 TR TRACTOR	MECHANIC	4	3-7.25-6	1.00	5.64	9000	1942	2.3	11.58	4383	50.8			
SC 6 SCRAPER	MECHANIC	4	3-7.25-6	1.00	9.19	14400	1942	5.9	11.58	11427	132.3			
GENERAL & ADMINISTRATION														
TOTALS								146.7		2845.8		9.8*		220.8
INFLATION ESCALATION RATE = .00														
REGIONAL ADJUSTMENT FACTOR = 1.00														

Appendix E.5 Services and Materials List

The services and materials list identifies all services and materials; shows annual cost; shows annual quantity of electric power, water, and fuel. Columns A through K of the services and materials list are defined as follows:

- Column A: For each mining operation the equipment file number and type is given as well as a listing of the types of hourly services and materials costs associated with the equipment.
- Column B: Total productive hours equals the number of machines times productive machine hours.
- Column C: Base year materials and services hourly cost including regional adjustment.
- Column D: Usage adjustment to account for any variation from the assumed conditions used in the equipment data file.
- Column E: Annual cost equals total productive hours times hourly cost times use factor.
- Column F: Annual steady state electric power requirements.
- Column G: Annual steady state water requirements.
- Column H: Annual steady state fuel requirements.
- Column I: Electric power for deferred equipment.
- Column J: Water for deferred equipment.
- Column K: Fuel for deferred equipment.

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- Column F: Annual steady state electric power requirements.
- Column G: Annual steady state water requirements.
- Column H: Annual steady state fuel requirements.
- Column I: Electric power for deferred equipment.
- Column J: Water for deferred equipment.
- Column K: Fuel for deferred equipment.

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MINING OPERATION		A	B	C	SERVICES AND MATERIALS LIST			DEFERRED QUANTITY				
			TOTAL	HOURLY	D	E	F	G	H	I	J	K
			PROD	COST	USE	ANNUAL	ANNUAL	QUANTITY		DEFERRED	ANNUAL	QUANTITY
		(HR/YR)	(HR/YR)	(ADJ)	(M\$)	10.00	10.00	.05	300.00	10.00	.05	300.00
						E-MWH	W-MGAL	F-MGAL		E-MWH	W-MGAL	F-MGAL
OVERBURDEN REMOVAL												
DL1	DRAGLINE	45 CY 182 FT										
	MATERIAL		22401	41.86	1.000	937.7	0	0	0	0	0	0
	ELECTRIC		22401	13.28	1.000	297.5	29748	0	0	0	0	0
CD3	TRACTOR	300 HP										
	MATERIAL		22401	3.50	1.000	78.4	0	0	0	0	0	0
	FUELS		22401	1.90	1.000	42.6	0	0	141	0	0	0
LD16	WH LOADER	325 HP										
	MATERIAL		7122	20.49	1.000	145.9	0	0	0	0	0	0
	FUELS		7122	3.93	1.000	28.0	0	0	93	0	0	0
	TIRES		7122	2.75	1.000	19.6	0	0	0	0	0	0
BXCT	BOX CUTS	1987 MCY										
	OTHER		6000	994.00	1.000	5964.0#	0	0	0	0	0	0
DL2	DRAGLINE	11 CY 170 FT										
	MATERIAL		22401	20.88	1.000	467.7	0	0	0	0	0	0
	ELECTRIC		22401	6.65	1.000	149.0	14896	0	0	0	0	0
TOTALS (LESS DEFERRED)						2166.4						
COAL DRILL & BLAST												
OD23	AUGER DRILL	3.000 IN										
	MATERIAL		4896	.68	1.000	3.3	0	0	0	0	0	0
	ELECTRIC		4896	.90	1.000	4.4	440	0	0	0	0	0
	OTHER		4896	3.60	1.000	17.6	0	0	0	0	0	0
QLST	BLASTING											
	OTHER		4896	94.49	1.000	462.6	0	0	0	0	0	0
TDQ1	DRILL TRUCK											
	MATERIAL		4896	1.31	1.000	6.4	0	0	0	0	0	0
	FUELS		4896	.66	1.000	3.2	0	0	10	0	0	0
	TIRES		4896	.57	1.000	2.8	0	0	0	0	0	0
TOTALS (LESS DEFERRED)						500.4						
COAL LOAD & HAUL												
SD34	SHOVEL	16 CU. YD.										
	MATERIAL		9786	20.27	1.000	198.4	0	0	0	0	0	0
	ELECTRIC		9786	3.44	1.000	33.7	3366	0	0	0	0	0
TD18	TRUCK	180 TON										
	MATERIAL		29358	11.28	1.000	331.2	0	0	0	0	0	0
	FUELS		29358	11.23	1.000	329.7	0	0	1098	0	0	0
	TIRES		29358	17.86	1.000	524.3	0	0	0	0	0	0
L16	WH LOADER	325 HP										
	MATERIAL		9786	20.49	1.000	200.5	0	0	0	0	0	0
	FUELS		9786	3.93	1.000	38.5	0	0	128	0	0	0
	TIRES		9786	2.75	1.000	26.9	0	0	0	0	0	0
G05	GRADER	180 HP										
	MATERIAL		9786	12.93	1.000	126.5	0	0	0	0	0	0
	FUELS		9786	2.14	1.000	20.9	0	0	69	0	0	0
	TIRES		9786	1.26	1.000	12.3	0	0	0	0	0	0
PUMP	PUMP SET	125000 GPH										

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	A	B	C	D	E	F	G	H	I	J	K
	MATERIAL	4320	1.50	1.000	6.5	0	0	0	0	0	0
	FUELS	4320	1.09	1.000	4.7	0	0	15	0	0	0
TDX2	H2O TRUCK 5000 GAL										
	MATERIAL	4893	5.70	1.000	27.9	0	0	0	0	0	0
	FUELS	4893	5.65	1.000	27.6	0	0	92	0	0	0
	TIRES	4893	.50	1.000	2.4	0	0	0	0	0	0
	WATER	4893	.50	1.000	2.4	0	48929	0	0	0	0
TD18	TRUCK 180 TON										
	MATERIAL	9786	11.28	1.000	110.4*	0	0	0	0	0	0
	FUELS	9786	11.23	1.000	109.9*	0	0	0	0	0	366
	TIRES	9786	17.86	1.000	174.8*	0	0	0	0	0	0
TD18	TRUCK 180 TON										
	MATERIAL	9786	11.28	1.000	110.4*	0	0	0	0	0	0
	FUELS	9786	11.23	1.000	109.9*	0	0	0	0	0	366
	TIRES	9786	17.86	1.000	174.8*	0	0	0	0	0	0
TD18	TRUCK 180 TON										
	MATERIAL	9786	11.28	1.000	110.4*	0	0	0	0	0	0
	FUELS	9786	11.23	1.000	109.9*	0	0	0	0	0	366
	TIRES	9786	17.86	1.000	174.8*	0	0	0	0	0	0
TOTALS (LESS DEFERRED)					1914.5						
COAL HANDLE & PREP											
PRRB	REC & BREAK PREP. PLANT										
	MATERIAL	3625	69.38	1.000	251.5	0	0	0	0	0	0
	ELECTRIC	3625	22.23	1.000	80.6	8058	0	0	0	0	0
PRBS	BLEND-STOCK PREP. PLANT										
	MATERIAL	5438	176.11	1.000	957.7	0	0	0	0	0	0
	ELECTRIC	5438	49.28	1.000	268.0	26798	0	0	0	0	0
PRCL	COAL LOADOUT PREP. PLANT										
	MATERIAL	8712	5.87	1.000	51.1	0	0	0	0	0	0
	ELECTRIC	8712	10.92	1.000	95.1	9513	0	0	0	0	0
PRCS	CRUSH-SCREEN PREP. PLANT										
	MATERIAL	5438	24.82	1.000	135.0	0	0	0	0	0	0
	FUELS	5438	7.05	1.000	38.3	0	0	127	0	0	0
	ELECTRIC	5438	9.42	1.000	51.2	5122	0	0	0	0	0
PRSI	CS SUPPORT PREP. PLANT										
	MATERIAL	2000	71.13	1.000	142.3	0	0	0	0	0	0
	ELECTRIC	2000	63.22	1.000	126.4	12643	0	0	0	0	0
TOTALS (LESS DEFERRED)					2197.3						
LAND RECLAMATION											
CD 5	TR TRACTOR 410 HP										
	MATERIAL	9000	10.32	1.000	92.9	0	0	0	0	0	0
	FUELS	9000	5.35	1.000	48.1	0	0	160	0	0	0
SC 6	SCRAPER 32 CY 415 HP										
	MATERIAL	14400	9.19	1.000	132.3	0	0	0	0	0	0
	FUELS	14400	5.13	1.000	73.9	0	0	246	0	0	0
	TIRES	14400	3.55	1.000	51.1	0	0	0	0	0	0
RVGT	REVEGETATION										
	OTHER	1800	38.48	1.000	69.3	0	0	0	0	0	0
LMGT	LAND MGT										
	OTHER	1800	19.24	1.000	34.6	0	0	0	0	0	0
TOTALS (LESS DEFERRED)					502.3						
GENERAL & ADMINISTRATION (STEADY-STATE YEAR)											
	SITE ROADS & SITE ANC. FAC.										
BLDG	BUILDINGS ANC. FAC.										
	FUELS	2000	32.50	1.000	65.0	0	0	216	0	0	0

	A	B	C	D	E	F	G	H	I	J	K
	WATER	2000	.12	1.000	.2	0	4749	0	0	0	0
PWR	ELECT. SYS. ANC. FAC.										
H2O	WATER SYS. ANC. FAC.										
COM	COMMUN. SYS. ANC. FAC.										
MREQ	MOBILE SUP. ANC. FAC.										
SHEQ	EQUIP. SHOP ANC. FAC.										
LAND	LAND RIGHTS PREMINE										
	OTHER	2000	70.13	1.000	140.3	0	0	0	0	0	0
XORL	EXPL. DRILL. PREMINE										
ENG	CONT. ENG. PREMINE										
EIS	E. I. S. PREMINE										
STF	SUPERV. PER.										
	MATERIAL	2000	92.80	1.000	185.6	0	0	0	0	0	0
RLTX	ROY-SRV. TAX										
	OTHER	2000	1561.39	1.000	3122.8	0	0	0	0	0	0
	INSURANCE & PROP. TAX				5992.9						
	HOME OFFICE CCSTS				551.6						
TOTALS (LESS DEFERRED)					10058.3						
TOTALS (LESS DEFERRED)					17339.1	110588	53729	2401	0	0	1098
TOTAL DEFERRED					1185.2*						
# MEMO ITEM : NOT INCLUDED IN TOTALS											

		REGIONAL	INFLATION								
		ADJUSTMENT	ESCALATION								
		FACTOR	RATE								
MATERIAL :		1.00	.00								
FUELS :		1.00	.00								
TIRES :		1.00	.00								
ELECTRIC :		1.00	.00								
WATER :		1.00	.00								
OTHER :		1.00	.00								

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Appendix E.6 Infrastructure Report

The infrastructure report summarizes the physical effects, economic impact, utility requirements, and manpower requirements as follows:

- 1) **Physical Effects:** Gives the steady state annual amount and the total for the project life for acreage disturbed, preparation plant reject material, prepared coal production, and overburden handled.
- 2) **Economic Impact:** Gives the steady state annual amount and the maximum annual amount for the payroll (operating and maintenance personnel), fuel purchases, tire purchases, other materials and services purchases, insurance and property tax and royalty and severance tax.
- 3) **Utility Requirements:** Gives the steady state annual water and electric power requirements.
- 4) **Manpower Requirements:** Gives the steady state annual manpower requirements and the maximum annual manpower requirements for both operating and maintenance personnel.

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INFRASTRUCTURE REPORT

ALL FIGURES IN BASE DOLLARS

PHYSICAL EFFECTS :	UNITS	ANNUAL	PROJECT TOTAL
ACREAGE DISTURBED	ACRES	518	15466
PREP PLANT PEJECT	MTONS	91	2737
COAL PRODUCTICA	MTONS	9160	272972
OVERBURDEN HANDLED	MCYDS	35200	1048973

ECONOMIC IMPACT :	UNITS	ANNUAL	+ DEF
PAYROLL	M\$	9662.	10213.
FUEL PURCHASES	M\$	721.	1050.
TIRE PURCHASES	M\$	640.	1164.
MATL & OTHER SERVICES	M\$	5203.	5534.
INS. & PROP. TAXES	M\$	5993.	5993.
ROYALTY & SEVR. TAXES	M\$	3123.	3123.
TOTAL		25341.	27077.

UTILITY REQUIREMENTS :	UNITS	ANNUAL
WATER	ACRE-FEET	165.
ELECTRICITY	MEGA WH	110589.

GRADE	OPERATING		MAINTENANCE	
	ANNUAL	+ DEF	ANNUAL	+ DEF
5	92.0	92.0	.0	.0
2	14.7	14.7	18.2	18.2
1	34.6	34.6	5.0	5.0
3	88.4	108.6	19.3	19.3
4	39.6	39.6	104.2	114.0
5	58.1	58.1	.0	.0
TOTAL	327.5	347.7	146.7	156.5

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Appendix E.7 Production and Cash Expenditure Table

The production and cash expenditure table shows for each year of the project the production and cash expenditure as follows:

- 1) **Production:** For each mining operation the total production is shown for each year and summarized for the total project. The total energy content of the prepared coal is also shown for each year.
- 2) **Expenditures:** For each mining operation the expenditures are shown for three categories. The equipment expenditures include all progress payments and final payments for the original quantity, fleet spares, replacements, and deferred purchases. The manpower expenditures include the payroll for both operating and maintenance personnel. The services and materials expenditures include the costs of maintenance materials, fuel, tires, electric power, water, and other services and materials.

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PRODUCTION AND CASH EXPENDITURE TABLE (\$M)

	1976	1977	1978	1979	1980	1981	1982	1983
	*****	*****	*****	*****	*****	*****	*****	*****
OVERBURDEN REMOVAL (MILLION CU YDS)	0	0	0	0	0	0	9	21
EQUIPMENT	0	0	1216	2432	3649	3649	3907	2691
MANPOWER	0	0	0	0	0	0	993	1985
SERVICES & MATERIALS	0	0	0	0	0	5964	6686	7408
COAL DRILLING & BLASTING (MILLION CU YDS)	0	0	0	0	0	0	3	6
EQUIPMENT	0	0	0	0	0	0	73	73
MANPOWER	0	0	0	0	0	0	58	116
SERVICES & MATERIALS	0	0	0	0	0	0	167	334
COAL LOADING & HAULING (THOUSAND RCM TCNS)	0	0	0	0	0	0	2467	5551
EQUIPMENT	0	0	0	0	348	695	2579	2630
MANPOWER	0	0	0	0	0	0	428	918
SERVICES & MATERIALS	0	0	0	0	0	0	638	1408
COAL HANDLING & PREP. (THOUSAND CLEAN TONS)	0	0	0	0	0	0	2443	5496
EQUIPMENT	0	0	0	0	0	0	26534	26534
MANPOWER	0	0	0	0	0	0	948	1896
SERVICES & MATERIALS	0	0	0	0	0	0	732	1465
LAND RECLAMATION (ACRES)	0	0	0	0	0	0	138	311
EQUIPMENT	0	0	0	0	0	0	924	924
MANPOWER	0	0	0	0	0	0	164	327
SERVICES & MATERIALS	0	0	0	0	0	0	133	300
GENERAL & ADMINISTRATIVE								
EQUIPMENT	857	1714	1857	857	1590	1590	18125	0
MANPOWER	210	420	631	841	1051	1261	1471	1681
SERVICES & MATERIALS	21	41	62	82	103	124	350	370
MISCELLANEOUS	5	9	14	19	24	150	6542	8331
TOTAL EXPENDITURE	***** 1093	***** 2184	***** 3780	***** 4231	***** 6765	***** 13433	***** 71452	***** 59391
BILLION BTU PRODUCED	0	0	0	0	0	0	34664	77995

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PRODUCTION AND CASH EXPENDITURE TABLE (\$M)

	1984	1985	1986	1987	1988	1989	1990	1991
	=====	=====	=====	=====	=====	=====	=====	=====
OVERBURDEN REMOVAL (MILLION CU YDS)	33	35	35	35	35	35	35	35
EQUIPMENT	1474	135	135	258	258	258	135	135
MANPOWER	2978	2978	2978	2978	2978	2978	2978	2978
SERVICES & MATERIALS	2166	2166	2166	2166	2166	2166	2166	2166
COAL DRILLING & BLASTING (MILLION CU YDS)	9	10	10	10	10	10	10	10
EQUIPMENT	73	0	0	0	0	0	0	0
MANPOWER	173	173	173	173	173	173	173	173
SERVICES & MATERIALS	500	500	500	500	500	500	500	500
COAL LOADING & HAULING (THOUSAND RCM TONS)	8635	9252	9252	9252	9252	9252	9252	9252
EQUIPMENT	2283	522	203	203	80	123	123	1401
MANPOWER	1407	1468	1468	1468	1468	1468	1468	1468
SERVICES & MATERIALS	2178	2310	2310	2310	2310	2310	2310	2310
COAL HANDLING & PREP. (THOUSAND CLEAN TONS)	8549	9160	9160	9160	9160	9160	9160	9160
EQUIPMENT	26534	0	0	0	0	0	0	0
MANPOWER	2844	2844	2844	2844	2844	2844	2844	2844
SERVICES & MATERIALS	2197	2197	2197	2197	2197	2197	2197	2197
LAND RECLAMATION (ACRES)	484	518	518	518	518	518	518	518
EQUIPMENT	924	0	0	0	857	857	857	0
MANPOWER	491	491	491	491	491	491	491	491
SERVICES & MATERIALS	468	502	502	502	502	502	502	502
GENERAL & ADMINISTRATIVE								
EQUIPMENT	0	0	0	0	0	0	0	0
MANPOWER	1892	1892	1892	1892	1892	1892	1892	1892
SERVICES & MATERIALS	391	391	391	391	391	391	391	391
MISCELLANEOUS	9916	9667	9397	9132	8903	8676	8445	8237
TOTAL EXPENDITURE	=====	=====	=====	=====	=====	=====	=====	=====
	58889	28236	27647	27505	28010	27826	27472	27685
BILLION BTU PRODUCED	121325	129991	129991	129991	129991	129991	129991	129991

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PRODUCTION AND CASH EXPENDITURE TABLE (\$M)

	1992	1993	1994	1995	1996	1997	1998	1999
	*****	*****	*****	*****	*****	*****	*****	*****
OVERBURDEN REMOVAL (MILLION CU YDS)	35	35	35	35	35	35	35	35
EQUIPMENT	258	258	258	135	135	123	258	258
MANPOWER	2978	2978	2978	2978	2978	2978	2978	2978
SERVICES & MATERIALS	2166	2166	2166	2166	2166	2166	2166	2166
COAL DRILLING & BLASTING (MILLION CU YDS)	10	10	10	10	10	10	10	10
EQUIPMENT	0	0	73	73	73	0	0	0
MANPOWER	173	173	173	173	173	173	173	173
SERVICES & MATERIALS	500	500	500	500	500	500	500	500
COAL LOADING & HAULING (THOUSAND PCM TONS)	9252	9252	9252	9252	9252	9252	9252	9252
EQUIPMENT	1677	1800	1046	727	727	213	481	705
MANPOWER	1468	1468	1530	1591	1652	1652	1652	1652
SERVICES & MATERIALS	2310	2310	2441	2573	2705	2705	2705	2705
COAL HANDLING & PREP. (THOUSAND CLEAN TONS)	9160	9160	9160	9160	9160	9160	9160	9160
EQUIPMENT	0	0	0	0	0	0	0	0
MANPOWER	2844	2844	2844	2844	2844	2844	2844	2844
SERVICES & MATERIALS	2197	2197	2197	2197	2197	2197	2197	2197
LAND RECLAMATION (ACRES)	518	518	518	518	518	518	518	518
EQUIPMENT	0	0	0	857	857	857	0	0
MANPOWER	491	491	491	491	491	491	491	491
SERVICES & MATERIALS	502	502	502	502	502	502	502	502
GENERAL & ADMINISTRATIVE								
EQUIPMENT	0	0	0	0	0	0	0	0
MANPOWER	1892	1892	1892	1892	1892	1892	1892	1892
SERVICES & MATERIALS	391	391	391	391	391	391	391	391
MISCELLANEOUS	8050	7870	7659	7467	7271	7041	6770	6496
TOTAL EXPENDITURE	27897	27840	27141	27557	27554	26725	26000	25950
BILLION BTU PRODUCED	129991	129991	129991	129991	129991	129991	129991	129991

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PRODUCTION AND CASH EXPENDITURE TABLE (\$M)

	2000	2001	2002	2003	2004	2005	2006	2007
	*****	*****	*****	*****	*****	*****	*****	*****
OVERBURDEN REMOVAL (MILLION CU YDS)	35	35	35	35	35	35	35	35
EQUIPMENT	135	135	258	258	258	135	135	258
MANPOWER	2978	2978	2978	2978	2978	2978	2978	2978
SERVICES & MATERIALS	2166	2166	2166	2166	2166	2166	2166	2166
COAL DRILLING & BLASTING (MILLION CU YDS)	10	10	10	10	10	10	10	10
EQUIPMENT	0	0	0	0	0	0	73	73
MANPOWER	173	173	173	173	173	173	173	173
SERVICES & MATERIALS	500	500	500	500	500	500	500	500
COAL LOADING & HAULING (THOUSAND RCN TONS)	9252	9252	9252	9252	9252	9252	9252	9252
EQUIPMENT	2444	2496	2148	799	602	602	727	647
MANPOWER	1652	1652	1652	1652	1652	1652	1713	1775
SERVICES & MATERIALS	2705	2705	2705	2705	2705	2705	2836	2968
COAL HANDLING & PREP. (THOUSAND CLEAN TONS)	9160	9160	9160	9160	9160	9160	9160	9160
EQUIPMENT	0	0	0	0	0	0	0	0
MANPOWER	2844	2844	2844	2844	2844	2844	2844	2844
SERVICES & MATERIALS	2197	2197	2197	2197	2197	2197	2197	2197
LAND RECLAMATION (ACRES)	518	518	518	518	518	518	518	518
EQUIPMENT	0	857	857	857	0	0	0	0
MANPOWER	491	491	491	491	491	491	491	491
SERVICES & MATERIALS	502	502	502	502	502	502	502	502
GENERAL & ADMINISTRATIVE								
EQUIPMENT	0	0	0	0	0	0	0	0
MANPOWER	1892	1892	1892	1892	1892	1892	1892	1892
SERVICES & MATERIALS	391	391	391	391	391	391	391	391
MISCELLANEOUS	6335	6233	6136	5938	5690	5435	5193	4952
TOTAL EXPENDITURE	27405	28212	27890	26343	25041	24663	24811	24807
BILLION BTU PRODUCED	129991	129991	129991	129991	129991	129991	129991	129991

CFA MODEL:

507 (ADMU0507) HYPOTHETICAL MINE STUDY - FORT UNION
1. BASELINE SOLUTION

DATE: 11:43 DEC 06, '76 PAGE NO. 7.05

PRODUCTION AND CASH EXPENDITURE TABLE (\$M)

	2008	2009	2010	2011	2012	2013	2014	2015
	=====	=====	=====	=====	=====	=====	=====	=====
OVERBURDEN REMOVAL (MILLION CU YDS)	35	35	35	35	23	12	0	0
EQUIPMENT	258	258	135	135	135	0	0	0
MANPOWER	2978	2978	2978	2978	1985	993	0	0
SERVICES & MATERIALS	2166	2166	2166	2166	1444	722	0	0
COAL DRILLING & BLASTING (MILLION CU YDS)	10	10	10	10	7	3	0	0
EQUIPMENT	73	0	0	0	0	0	0	0
MANPOWER	173	173	173	173	116	58	0	0
SERVICES & MATERIALS	500	500	500	500	334	167	0	0
COAL LOADING & HAULING (THOUSAND RCN TONS)	9252	9252	9252	9252	6168	3084	0	0
EQUIPMENT	647	1401	1677	1800	522	123	0	0
MANPOWER	1836	1836	1836	1836	1224	612	0	0
SERVICES & MATERIALS	3100	3100	3100	3100	2066	1033	0	0
COAL HANDLING & PREP. (THOUSAND CLEAN TONS)	9160	9160	9160	9160	6107	3053	0	0
EQUIPMENT	0	0	0	0	0	0	0	0
MANPOWER	2844	2844	2844	2844	1896	948	0	0
SERVICES & MATERIALS	2197	2197	2197	2197	1465	732	0	0
LAND RECLAMATION (ACRES)	518	518	518	518	345	172	0	0
EQUIPMENT	857	857	857	0	0	0	0	0
MANPOWER	491	491	491	491	327	164	0	0
SERVICES & MATERIALS	502	502	502	502	369	202	35	0
GENERAL & ADMINISTRATIVE								
EQUIPMENT	0	0	0	0	0	0	0	0
MANPOWER	1681	1471	1261	1051	841	631	420	210
SERVICES & MATERIALS	370	350	329	309	288	267	41	21
MISCELLANEOUS	4748	4573	4406	4201	3877	3586	269	264
TOTAL EXPENDITURE	25421	25697	25452	24283	16889	10238	765	495
BILLION BTU PRODUCED	129991	129991	129991	129991	86661	43330	0	0

CFA MODEL:

SC7 (ADMU0507) HYPOTHETICAL MINE STUDY
1 BASELINE SOLUTION

DATE: 11:43 DEC 06, '76 PAGE NO. 7-06

PRODUCTION AND CASH EXPENDITURE TABLE (\$M)

	TOTALS
	=====
OVERBURDEN REMOVAL (MILLION CU YDS)	1049
EQUIPMENT	24515
MANPOWER	89336
SERVICES & MATERIALS	82883

	156734
COAL DRILLING & BLASTING (MILLION CU YDS)	300
EQUIPMENT	660
MANPOWER	5199
SERVICES & MATERIALS	15013

	20871
COAL LOADING & HAULING (THOUSAND RCM TONS)	275709
EQUIPMENT	35202
MANPOWER	48280
SERVICES & MATERIALS	78373

	161856
COAL HANDLING & PREP. (THOUSAND CLEAN TCNS)	272973
EQUIPMENT	79602
MANPOWER	85316
SERVICES & MATERIALS	65918

	230836
LAND RECLAMATION (ACRES)	15466
EQUIPMENT	13058
MANPOWER	14721
SERVICES & MATERIALS	15068

	42847
GENERAL & ADMINISTRATIVE	
EQUIPMENT	26591
MANPOWER	60528
SERVICES & MATERIALS	12515
MISCELLANEOUS	217922

	317557
	=====
TOTAL EXPENDITURE	970700
BILLION BTU PRODUCED	3873731

Appendix E.8 Financial Statements

Pro-forma financial statements are prepared for each year of the project as follows:

- 1) **Income Statement:** Shows selling price and resulting revenue, costs, net income, federal (accounts for depletion and investment tax credit), and net earnings.
- 2) **Sources and Uses of Funds:** Shows from where funds are derived balanced against how they are utilized.
- 3) **Balance Sheet:** Shows year end financial status balancing assets against liabilities and net worth.

ALL FIGURES IN THOUSANDS OF DOLLARS

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
<u>INCOME STATEMENT</u>										
SALES PRICE \$/TON	.00	.00	.00	.00	.00	.00	5.93	5.93	5.93	5.93
REVENUES (NET)	0	0	0	0	0	0	14481	32582	50682	54303
<u>COSTS</u>										
MANPOWER	0	0	0	0	0	0	2590	5242	7893	7954
SERVICES & MATERIALS	0	0	0	0	0	5964	8356	10915	7510	7676
LEASING COSTS	0	0	0	0	0	0	0	0	0	0
G & A	236	471	707	942	1178	1535	8363	10383	12199	11950
INTEREST	58	174	374	623	1011	2175	5180	6388	5904	3554
DEPRECIATION	0	0	0	0	0	0	2378	3968	5558	5633
TOTAL COSTS	293	645	1081	1565	2189	9673	26867	36895	39064	36768
NET INCOME	-292	-644	-1080	-1564	-2188	-9672	-12385	-4312	11619	17535
TAXES	0	0	0	0	0	0	0	0	0	0
NET EARNINGS	-292	-644	-1080	-1564	-2188	-9672	-12385	-4312	11619	17535
<u>MEMO : FOR THIS PROBLEM, PERCENTAGE DEPLETION IS</u>										
	0	0	0	0	0	0	0	0	5068	5430
<u>SOURCE AND USE OF FUNDS</u>										
<u>SOURCE</u>										
NET EARNINGS	-292	-644	-1080	-1564	-2188	-9672	-12385	-4312	11619	17535
DEPRECIATION	0	0	0	0	0	0	2378	3968	5558	5633
SALE OF ASSETS	0	0	0	0	0	0	0	0	0	0
INCREASE IN DEBT	286	571	1024	1096	1862	1978	17380	10951	10429	219
INCREASE IN CAPITAL	571	1143	2049	2193	3724	3956	34761	21901	20859	438
TOTAL SOURCE	564	1069	1993	1724	3398	-3738	42133	32507	48465	23826
<u>USE</u>										
SURPLUS CASH	0	0	0	0	0	0	0	0	0	0
SHORT TERM BORROW&REP	348	728	1252	1768	2631	10450	16709	5294	-10293	-19910
A/R, INV, A/P, CASH CHAN	26	-2	-16	-94	-41	94	4280	1434	2325	-1321
INC OR DEC(-) IN WORK C	-321	-730	-1268	-1862	-2672	-10354	-12427	-3859	12619	18589
FIXED ASSET PURCHASE	857	1714	3073	3289	5587	5934	52142	32852	31288	658
REDUCTION IN DEBT	29	86	188	298	484	682	2420	3515	4558	4580
PAYMENT OF DIVIDEND	0	0	0	0	0	0	0	0	0	0
TOTAL USE	564	1069	1993	1724	3398	-3738	42133	32507	48465	23826

CFA MODEL:

507 (ADMU0507) HYPOTHETICAL MINE STUDY - FORT UNION
1 BASELINE SOLUTION

DATE: 11:43 DEC 06, '76 PAGE NO. 8.02

ALL FIGURES IN THOUSANDS OF DOLLARS

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
BALANCE SHEET										
CURRENT ASSETS										
CASH	0	0	0	0	0	0	648	1310	1973	1989
SURPLUS CASH	0	0	0	0	0	0	0	0	0	0
ACCOUNTS RECEIVABLE	0	0	0	0	0	0	1785	4017	6249	6695
INVENTORY	56	111	198	214	359	980	4709	4485	4773	3020
TOTAL CURRENT ASSETS	56	111	198	214	359	980	7142	9812	12995	11703
FIXED ASSETS										
DEPRECIABLE ASSETS	0	0	0	0	0	0	63040	99889	136737	137395
LESS DEPRECIATION	0	0	0	0	0	0	2378	6346	11904	17538
NET DEPRECIABLE ASSET	0	0	0	0	0	0	60663	93543	124833	119857
NON-DEPRECIABLE ASSET	0	0	0	0	0	0	0	0	0	0
FIXED ASSET PRCG. PAY	857	2571	5645	8934	14521	20455	9556	5560	0	0
TOTAL FIXED ASSETS	857	2571	5645	8934	14521	20455	70219	99103	124833	119857
TOTAL ASSETS	913	2683	5843	9148	14880	21435	77360	108915	137828	131561
CURRENT LIABILITIES										
ACCOUNTS PAYABLE	1	2	3	5	6	334	477	618	433	442
SHORT TERM BORROW	348	1076	2328	4096	6727	17176	33885	39179	28885	8974
CURRENT PORTION OF DEBT	29	86	188	298	484	682	2420	3515	4558	4580
TOTAL CURRENT LIAB.	377	1163	2519	4398	7216	18192	36782	43313	33876	13996
LONG TERM DEBT	257	743	1579	2378	3756	5052	20013	27449	33320	28960
TOTAL LIABILITIES	634	1906	4098	6776	10972	23244	56795	70761	67196	42955
NET WORTH										
PAID-IN CAPITAL	571	1714	3763	5956	9681	13637	48398	70299	91158	91597
RETAINED EARNINGS	-292	-937	-2018	-3583	-5771	-15445	-27831	-32144	-20525	-2990
TOTAL NET WORTH	278	776	1745	2372	3908	-1808	20566	38154	70632	88605
TOTAL LIAB + NET	913	2683	5843	9148	14880	21435	77360	108915	137828	131561

CFA MODEL:

507 (ADMU0507) HYPOTHETICAL MINE STUDY - FORT UNION
1 BASELINE SOLUTION

DATE: 11:43 DEC 06, '76 PAGE NO. 8.03

ALL FIGURES IN THOUSANDS OF DOLLARS

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
<u>INCOME STATEMENT</u>										
SALES PRICE \$/TON	5.93	5.93	5.93	5.93	5.93	5.93	5.93	5.93	5.93	5.93
REVENUES (NET)	54303	54303	54303	54303	54303	54303	54303	54303	54303	54303
<u>COSTS</u>										
MANPOWER	7954	7954	7954	7954	7954	7954	7954	7954	8016	8077
SERVICES & MATERIALS	7676	7676	7676	7676	7676	7676	7676	7676	7808	7939
LEASING COSTS	0	0	0	0	0	0	0	0	0	0
G & A	11679	11415	11185	10959	10727	10520	10333	10152	9941	9749
INTEREST	2326	1973	1643	1320	998	700	424	285	210	227
DEPRECIATION	5644	5645	5694	5674	3655	5599	5598	5605	5584	5639
TOTAL COSTS	35279	34663	34153	33582	33011	32449	31986	31673	31559	31631
NET INCOME	19024	19640	20150	20720	21292	21853	22317	22630	22743	22672
TAXES	0	5850	6976	7250	7562	7871	8096	8091	8077	8037
NET EARNINGS	19024	13789	13174	13471	13729	13983	14221	14539	14666	14634
MEMO : FOR THIS PROBLEM, PERCENTAGE DEPLETION IS	5430	5430	5430	5430	5430	5430	5430	5430	5430	5430
<u>SOURCE AND USE OF FLNDS</u>										
<u>SOURCE</u>										
NET EARNINGS	19024	13789	13174	13471	13729	13983	14221	14539	14666	14634
DEPRECIATION	5644	5645	5694	5674	3655	5599	5598	5605	5584	5639
SALE OF ASSETS	0	0	0	0	0	0	0	0	0	0
INCREASE IN DEBT	113	154	398	413	372	512	645	686	459	598
INCREASE IN CAPITAL	226	308	797	826	744	1024	1290	1372	919	1195
TOTAL SOURCE	25006	19896	20064	20383	20500	21118	21755	22203	21628	22066
<u>USE</u>										
SURPLUS CASH	11134	14864	14302	14684	15003	15315	15700	17716	18877	19829
SHORT TERM BORROWING	-8573	0	0	0	0	0	0	0	0	0
A/R, INV, A/P, CASH CHAN	-2	49	108	71	141	173	1698	1034	976	9
INC OR DEC(-) IN WORK C	20105	14914	14410	14755	15144	15488	17399	18750	19853	19839
FIXED ASSET PURCHASE	338	461	1195	1238	1115	1536	1936	2059	1378	1793
REDUCTION IN DEBT	4563	4521	4458	4390	4241	4094	2421	1394	397	435
PAYMENT OF DIVIDEND	0	0	0	0	0	0	0	0	0	0
TOTAL USE	25006	19896	20064	20383	20500	21118	21755	22202	21628	22066

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CFA MODEL:

5C7 (ADMU0507) HYPOTHETICAL MINE STUDY - FORT UNION
1 BASELINE SOLUTION

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ALL FIGURES IN THOUSANDS OF DOLLARS

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
BALANCE SHEET										
CURRENT ASSETS										
CASH	1989	1989	1989	1989	1989	1989	1989	1989	2004	2019
SURPLUS CASH	11134	25998	40300	54983	69986	85300	101001	118716	137593	157422
ACCOUNTS RECEIVABLE	6695	6695	6695	6695	6695	6695	6695	6695	6695	6695
INVENTORY	3000	3008	3054	3056	3049	3075	3100	3107	3078	3117
TOTAL CURRENT ASSETS	22817	37689	52036	66723	81718	97059	112784	130507	149370	169254
FIXED ASSETS										
DEPRECIABLE ASSETS	137733	138195	139390	140629	141744	143280	145216	147274	148652	150445
LESS DEPRECIATION	23181	28827	34521	40194	45849	51449	57047	62652	68237	73876
NET DEPRECIABLE ASSET	114552	109368	104870	100434	95895	91832	88169	84622	80416	76569
NON-DEPRECIABLE ASSET	0	0	0	0	0	0	0	0	0	0
FIXED ASSET PRCG. PAY	0	0	0	0	0	0	0	0	0	0
TOTAL FIXED ASSETS	114552	109368	104870	100434	95895	91832	88169	84622	80416	76569
TOTAL ASSETS	137369	147057	156906	167157	177612	188890	200953	215129	225786	245823
CURRENT LIABILITIES										
ACCOUNTS PAYABLE	442	442	442	442	442	442	442	442	449	456
SHORT TERM BORROW	0	0	0	0	0	0	0	0	0	0
CURRENT PORTION OF DEBT	4563	4521	4458	4390	4241	4094	2421	1394	397	435
TOTAL CURRENT LIAB.	5005	4963	4900	4832	4683	4536	2863	1836	846	891
LONG TERM DEBT	24510	20143	16083	12106	8237	4655	2880	2172	2234	2396
TOTAL LIABILITIES	29514	25106	20983	16938	12920	9191	5742	4008	3080	3288
NET WORTH										
PAID-IN CAPITAL	91822	92130	92927	93752	94496	95520	96810	98183	99101	100296
RETAINED EARNINGS	16032	29822	42996	56467	70196	84179	98400	112939	127604	142239
TOTAL NET WORTH	107854	121952	135923	150219	164692	179699	195210	211121	226706	242535
TOTAL LIAB + NET	137369	147057	156906	167157	177612	188890	200953	215129	229786	245823

ALL FIGURES IN THOUSANDS OF DOLLARS

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
INCOME STATEMENT										
SALES PRICE \$/TON	5.93	5.93	5.93	5.93	5.93	5.93	5.93	5.93	5.93	5.93
REVENUES (NET)	54303	54303	54303	54303	54303	54303	54303	54303	54303	54303
COSTS										
MANPOWER	8138	8138	8138	8138	8138	8138	8138	8138	8138	8138
SERVICES & MATERIALS	8071	8071	8071	8071	8071	8071	8071	8071	8071	8071
LEASING COSTS	0	0	0	0	0	0	0	0	0	0
G & A	9553	9323	9053	8778	8617	8515	8419	8220	7972	7718
INTEREST	240	233	212	198	228	279	318	317	289	260
DEPRECIATION	5705	5703	5693	5652	5732	5835	5854	5804	5720	5719
TOTAL COSTS	31707	31468	31166	30837	30786	30838	30800	30551	30191	29906
NET INCOME	22595	22834	23136	23465	23516	23465	23503	23752	24112	24397
TAXES	8134	8312	8463	8621	8642	8597	8613	8745	8937	9104
NET EARNINGS	14461	14522	14673	14844	14875	14868	14890	15007	15174	15293
MEMO : FOR THIS PROBLEM, PERCENTAGE DEPLETION IS										
	5430	5430	5430	5430	5430	5430	5430	5430	5430	5430
SOURCE AND USE OF FUNDS										
SOURCE										
NET EARNINGS	14461	14522	14673	14844	14875	14868	14890	15007	15174	15293
DEPRECIATION	5705	5703	5693	5652	5732	5835	5854	5804	5720	5719
SALE OF ASSETS	0	0	0	0	0	0	0	0	0	0
INCREASE IN DEBT	598	398	246	321	860	1163	1088	638	287	246
INCREASE IN CAPITAL	1195	795	493	642	1720	2325	2176	1276	574	492
TOTAL SOURCE	21959	21418	21105	21460	23186	24191	24007	22725	21755	21750
USE										
SURPLUS CASH	19710	19779	19887	19990	20022	20114	20161	20254	20324	20400
SHORT TERM BORROWING	0	0	0	0	0	0	0	0	0	0
A/R, INV, A/P, CASH CHAN	-26	-61	-12	23	52	-7	-57	-79	-48	27
INC OR DEC(-) IN WORK C	19683	19717	19873	20013	20074	20105	20102	20174	20275	20428
FIXED ASSET PURCHASE	1793	1193	739	964	2579	3488	3263	1914	861	738
REDUCTION IN DEBT	483	508	493	483	532	597	642	637	620	584
PAYMENT OF DIVIDEND	0	0	0	0	0	0	0	0	0	0
TOTAL USE	21959	21418	21105	21460	23186	24191	24007	22725	21755	21750

ALL FIGURES IN THOUSANDS OF DOLLARS

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
BALANCE SHEET										
CURRENT ASSETS										
CASH	2035	2035	2035	2035	2035	2035	2035	2035	2035	2035
SURPLUS CASH	177132	196911	216798	236788	256810	276924	297084	317338	337662	358062
ACCOUNTS RECEIVABLE	6695	6695	6695	6695	6695	6695	6695	6695	6695	6695
INVENTORY	3130	3093	3064	3079	3180	3236	3222	3138	3072	3064
TOTAL CURRENT ASSETS	188992	208734	228592	248596	268719	288889	309036	329205	349463	369855
FIXED ASSETS										
DEPRECIABLE ASSETS	152238	153431	153822	154090	156670	160505	164464	166378	167239	167976
LESS DEPRECIATION	79581	85284	90977	96629	102361	108196	114051	119855	125575	131294
NET DEPRECIABLE ASSET	72657	68147	62845	57461	54308	52309	50413	46523	41663	36682
NON-DEPRECIABLE ASSET	0	0	0	0	0	0	0	0	0	0
FIXED ASSET PROG. PAY	0	0	348	1043	1043	695	0	0	0	0
TOTAL FIXED ASSETS	72657	68147	63193	58504	55351	53004	50413	46523	41663	36682
TOTAL ASSETS	261648	276880	291784	307099	324070	341893	359449	375728	391126	406537
CURRENT LIABILITIES										
ACCOUNTS PAYABLE	464	464	464	464	464	464	464	464	464	464
SHORT TERM BORROWING	0	0	0	0	0	0	0	0	0	0
CURRENT PORTION OF DEBT	483	508	493	483	532	597	642	637	620	584
TOTAL CURRENT LIAB.	947	972	956	947	996	1061	1105	1100	1083	1048
LONG TERM DEBT	2510	2400	2154	1992	2319	2884	3331	3332	2999	2661
TOTAL LIABILITIES	3458	3372	3110	2939	3315	3945	4436	4432	4082	3709
NET WORTH										
PAID-IN CAPITAL	101492	102287	102780	103422	105142	107467	109643	110919	111492	111984
RETAINED EARNINGS	156700	171222	185895	200739	215614	230481	245371	260378	275553	290845
TOTAL NET WORTH	258191	273509	288675	304161	320755	337948	355013	371297	387045	402830
TOTAL LIAB + NET	261649	276880	291785	307100	324070	341893	359449	375729	391127	406538

ALL FIGURES IN THOUSANDS OF DOLLARS

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
INCOME STATEMENT										
SALES PRICE \$/TON	5.93	5.93	5.93	5.93	5.93	5.93	5.93	5.93	.00	.00
REVENUES (NET)	54303	54303	54303	54303	54303	54303	36202	18101	0	0
COSTS										
MANPOWER	8199	8261	8322	8322	8322	8322	5548	2774	0	0
SERVICES & MATERIALS	8203	8334	8466	8466	8466	8466	5679	2857	35	0
LEASING COSTS	0	0	0	0	0	0	0	0	0	0
G & A	7475	7234	6799	6394	5996	5560	5005	4484	731	495
INTEREST	238	219	224	245	265	265	236	199	164	131
DEPRECIATION	5769	5783	5819	5841	5857	5864	4693	3491	138	0
TOTAL COSTS	29884	29831	29631	29268	28906	28478	21161	13804	1067	625
NET INCOME	24419	24471	24672	25035	25396	25825	15041	4297	-1066	-624
TAXES	9114	9140	9236	9410	9584	9789	5482	1194	0	0
NET EARNINGS	15304	15332	15436	15625	15813	16035	9559	3103	-1066	-624
MEMO : FOR THIS PROBLEM, PERCENTAGE DEPLETION IS										
	5430	5430	5430	5430	5430	5430	3620	1810	0	0
SOURCE AND USE OF FUNDS										
SOURCE										
NET EARNINGS	15304	15332	15436	15625	15813	16035	9559	3103	-1066	-624
DEPRECIATION	5769	5783	5819	5841	5857	5864	4693	3491	138	0
SALE OF ASSETS	0	0	0	0	0	0	0	5078	0	0
INCREASE IN DEBT	312	326	612	839	890	645	219	41	0	0
INCREASE IN CAPITAL	624	652	1224	1678	1780	1290	438	82	0	0
TOTAL SOURCE	22009	22093	23091	23982	24340	23835	14910	11795	-928	-624
USE										
SURPLUS CASH	20455	20535	20632	20838	21024	21307	17520	14981	2424	-1035
SHORT TERM BORROWING	0	0	0	0	0	0	0	0	0	0
A/R, INV, A/P, CASH CHAN	62	31	37	-9	6	5	-3768	-3750	-3765	22
INC OR DEC(-) IN WORK C	20517	20566	20670	20828	21030	21312	13751	11230	-1341	-1013
FIXED ASSET PURCHASE	536	978	1836	2516	2670	1936	658	123	0	0
REDUCTION IN DEBT	556	549	585	637	640	588	501	442	413	388
PAYMENT OF DIVIDEND	0	0	0	0	0	0	0	0	0	0
TOTAL USE	22009	22093	23090	23982	24340	23835	14910	11794	-928	-625

ALL FIGURES IN THOUSANDS OF DOLLARS

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
<u>BALANCE SHEET</u>										
CURRENT ASSETS										
CASH	2050	2065	2080	2080	2080	2080	1387	693	0	0
SURPLUS CASH	378517	399052	419684	440522	461546	482853	500373	515354	517778	516742
ACCOUNTS RECEIVABLE	6695	6695	6695	6695	6695	6695	4463	2232	0	0
INVENTORY	3090	3106	3170	3211	3218	3171	2086	1044	8	2
TOTAL CURRENT ASSETS	390351	410917	431630	452508	473540	494799	508309	519323	517785	516744
FIXED ASSETS										
DEPRECIABLE ASSETS	168912	169890	171726	174242	176912	178848	179505	174550	174550	174550
LESS DEPRECIATION	137063	142846	148666	154506	160364	166228	170922	174412	174550	174550
NET DEPRECIABLE ASSET	31849	27044	23060	19736	16548	12619	8584	138	0	0
NON-DEPRECIABLE ASSET	0	0	0	0	0	0	0	0	0	0
FIXED ASSET PROG. PAY	0	0	0	0	0	0	0	0	0	0
TOTAL FIXED ASSETS	31849	27044	23060	19736	16548	12619	8584	138	0	0
TOTAL ASSETS	422200	437961	454690	472244	490088	507418	516893	519461	517785	516744
CURRENT LIABILITIES										
ACCOUNTS PAYABLE	471	478	484	483	482	481	327	171	4	1
SHORT TERM BORROW	0	0	0	0	0	0	0	0	0	0
CURRENT PORTION OF DEBT	556	549	585	637	640	588	501	442	413	388
TOTAL CURRENT LIAB.	1027	1027	1069	1120	1122	1069	828	613	417	390
LONG TERM DEBT	2417	2194	2221	2423	2673	2730	2447	2047	1634	1245
TOTAL LIABILITIES	3443	3221	3290	3543	3794	3799	3276	2659	2051	1635
NET WORTH										
PAID-IN CAPITAL	112608	113260	114484	116161	117941	119232	119670	119752	119752	119752
RETAINED EARNINGS	306150	321481	336916	352541	368353	384389	393947	397050	395983	395358
TOTAL NET WORTH	418757	434741	451400	468702	486295	503620	513617	516802	515735	515110
TOTAL LIAB + NET	422201	437962	454690	472245	490089	507419	516893	519462	517786	516744

STOP 0

Appendix E.9 Default Values for Fort Union

Mining parameters and financial assumptions which are not input values but which are required by the macromodel are assigned default values appropriate to the region being studied. Macromodel control parameters are also set at default values.

Appendix E.9 Default Values for Fort Union

ADM MODEL ECONOMIC SUMMARY

RUN DATE 11:43 DEC 06, '76 PAGE NO. 1.1

CASE NO. 507 TITLE (ADMU0507) HYPOTHETICAL MINE STUDY - FORT UNION
 ALT. NO. 1 TITLE BASELINE SOLUTION

1975 DOLLARS; FINANCIAL PARAMETERS AS PER MICRO MODEL ASSUMPTIONS

I IMQCH	1	INCLUDE COAL LOAD AND HAUL
I IMQDB	0	INCLUDE ROCK DRILL AND BLAST
I IMQDL	1	INCLUDE DRAGLINE
I IMOGA	1	INCLUDE GENERAL & ADMINISTRATIVE
I IMQLR	1	INCLUDE RECLAMATION
I IMQPP	1	INCLUDE PREP PLANT
I IMQDB	1	INCLUDE COAL DRILL AND BLAST
I IPPT	1	PP - INDEX TO PLANT TYPE
I LOGCF	1	WRITES CFA CONTROL FILE IF 1
I LOGDV	1	PRINTS DEFAULT VARIABLES IF 1
I LOGEC	1	WRITES CFA EQUIPMENT FILE IF 1
I LOGPA	1	PRINTS PARAMETERS IF 1
I LOGRD	1	PRINTS REGRESS. DATA FILE IF 1
I LOGSD	1	WRITES SPECIFICATION DATA IF 1
I LOGSM	1	WRITES ECONOMIC SUMMARY IF ONE
I GAUP	.110000	GAA - UNION PAYMENT (\$/TON)
D ABHD	63.4300	ANGLE BURDEN HIGHWALL (DEGREES)
D ABSO	33.6900	ANGLE BURDEN SPOILS (DEGREES)
D ACFD	76.0000	ANGLE COAL FACE (DEGREES)
D CDRTYD	.308400E 07	COAL DEMAND ROM TONS/YEAR
D CHHDF	9680.00	COAL HAUL DISTANCE IN FEET - YEAR 1
D DBRPY	2935.00	DENSITY OF OVERBURDEN BANK LBS/YARD
D DCBPY	2000.00	DENSITY COAL BANK LBS/YARD
D DRSMFH	100.000	DRILLING RATE IN SOFT MAT'L. - FT/HR
D ECR	.920000	EXPECTED COAL RECOVERY FACTOR
D GATYB	60.9047	GAA - TONS/YEAR - BASELINE
D PPBED	.409500E 15	PP - BASE ENERGY BTU/YEAR
D PPBT	75000.0	PP - BASE TONS/DAY
D PPODY	250.000	PP - OPERATING DAYS/YEAR
D PRPY	.300000	POWDER RATIO - POUNDS / CU. YD.
D PWF	100.000	PANEL WIDTH (FEET)
D SFB	.350000	SWELL FACTOR FOR BURDEN
D SFC	.350000	SWELL FACTOR FOR COAL
D TMY	30.0000	TOTAL MINING YEARS
D TPF	.600000E-01	TOTAL RESISTANCE ON TOPSOIL HAUL ROAD

Appendix E.9 Default Values for Fort Union (continued)

CFA MODEL:

507 (ADMU0507) HYPOTHETICAL MINE STUDY - FORT UNION
1 BASELINE SOLUTION

DATE: 11:43 DEC 06,'76

PAGE NO. 01

PARAMETER LIST

D LCFCD	1	BUILDS CORRELATION DATA FILE IF 1
D LCFDB	0	LOGS DEBUG ARRAYS IF 1
D LCFDP	1	PRINTS THE FINANCIAL PARAMETERS IF 1
D LCFFSR	1	PRINTS FINANCIAL SUMMARY REPORT IF 1
D LCFIL	1	PRINTS INVESTMENT LIST IF 1
D LCFIR	1	PRINTS INFRASTRUCTURE REPORT IF 1
D LCFMPL	1	PRINTS MAINTENANCE MANPOWER LIST IF 1
D LCFOPL	1	PRINTS OPERATING MANPOWER LIST IF 1
D LCFPCE	1	PRINTS PRODN. & CASH EXP. REPORT IF 1
D LCFPFS	1	PRINTS PRO-FORMA STATEMENTS IF 1
D LCFFML	1	PRINTS SERVICE & MATERIALS LIST IF 1
D LCFXY	1	BUILDS X,Y PLOT FILE IF 1
D NEDNC	0	NEW EQUIP. DATA FOR NEXT CASE IF 1
D CEDMW	10.0000	CCST OF ELECTRICITY - \$/MEGAWATT HOUR
D CFDMG	300.000	COST OF FUEL - \$/M GALS.
D CWDMG	.500000E-01	COST OF WATER - \$/M GALS.
D DAPG	.100000	DEPLETION ALLOWANCE - PERCENT OF GROSS
D DAPN	.500000	DEPLETION ALLOWANCE - PERCENT OF NET
D DEC	.000000	DEBT/EQUITY RATIO CONTROL
D DER	1.000000	DEBT/EQUITY RATIO
D DFRT	.100000	DEBT/EQUITY RATIO TOLERANCE
D EYAEI	.000000	ESCAL. YEAR - ALL EQUIP. INVEST.
D EYHC	.000000	ESCAL. YEAR - HOURLY COSTS
D EYML	.000000	ESCAL. YEAR - MAINTENANCE LABOR
D EYOL	.000000	ESCAL. YEAR - OPERATING LABOR
D EYSPC	.000000	ESCAL. YEAR - SELLING PRICE OF COAL
D FALC	1.20000	FACTOR - ANNUAL LEASE COSTS
D FCR	.250000	FACTOR - CASH REQUIREMENTS
D FHQC	.200000E-01	FACTOR - HOME OFFICE COSTS
D FIPT	.500000E-01	FACTOR - INSURANCE & PROPERTY TAX
D FSI	.100000	FACTOR - SUPPLIES INVENTORY
D FWI	.625000E-01	FACTOR - WAREHOUSE INVENTORY
D RA AEI	1.000000	REGIONAL ADJ. - ALL EQUIP. INVEST.
D RAEL	1.000000	REGIONAL ADJ. - ELECTRICITY
D RAFU	1.000000	REGIONAL ADJ. - FUELS
D PAML	1.000000	REGIONAL ADJ. - MAINTENANCE LABOR
D RAMM	1.000000	REGIONAL ADJ. - MAINTENANCE MATERIALS
D RAUL	1.000000	REGIONAL ADJ. - OPERATING LABOR
D RAOT	1.000000	REGIONAL ADJ. - OTHER COSTS
D RATI	1.000000	REGIONAL ADJ. - TIRES
D RAWA	1.000000	REGIONAL ADJ. - WATER
D RCD	.000000	RATE - CASH DIVIDENDS
D RCI	.120000	RATE - CONSTRUCTION INTEREST
D RITC	.700000E-01	RATE - INVESTMENT TAX CREDIT
D PLTD	10.0000	RATE - L-T DEBT REPAYMENT (YEARS)
D VCDY	365.000	VALUE - CALENDAR DAYS/YEAR
D VDAP	20.0000	VALUE - DAYS ACCOUNTS PAYABLE
D VDAE	45.0000	VALUE - DAYS ACCOUNTS RECEIVABLE
D VDCI	10.0000	VALUE - DAYS OF COAL INVENTORY
D VFCY	1976.00	VALUE - FIRST CALENDAR YEAR
D VDDY	250.000	VALUE - OPERATING DAYS/YEAR
D VSC	.000000	VALUE - STARTING CASH
D VUPDH	.000000	VALUE - UNION PENSION \$/HOUR

APPENDIX F

Macromodel Sensitivity Analysis

F.1 Vary Mining Parameters

- Energy Demand
- ROM Coal Heat Value
- Height of Burden Average
- Height of Coal
- Difficulty of Preparation Effort
- Topsoil Thickness Saved
- Other Reclamation Costs

F.2 Vary Financial Assumptions

- Long-Term Interest Rate
- Desired Return on Investment
(Cash Flow Discount Rate)
- Federal Income Tax Rate
- Paid in Capital/Long Term Debt Ratio
- Labor Escalation Rate
- Materials and Services Cost Escalation Rate
- Equipment Investment Escalation Rate
- Depreciation Method
- Land Rights - Surface
- Land Rights - Mineral
- Royalty
- State and Local Severance Tax

The mining parameters and financial assumptions were varied one at a time through a range of values from extreme high to extreme low for the Fort Union test case to indicate the impact of each on the following:

Sales Price in Base Dollars:	\$/prepared ton
Sales Price in Base Dollars:	\$/million Btu
Return on Investment:	percent
Return on Paid-in-Capital:	percent
Cummulative Investment to Steady State:	M\$
Cummulative Investment Total Project:	M\$
Annual Operating Cost at Steady State:	M\$

The range of values used and the results for each are shown on the following 4 pages.

Appendix F.1

Mining Parameter Sensitivity Analysis

Seven mining parameters were varied at the following values:

Mining Parameter	Sensitivity Range				
	Value 1	Value 2	Value 3	Value 4	Value 5
	Ext.High	Exp.High	Baseline Value	Exp.Low	Ext.Low
1 PPNE D	.2438E15	.195E15	.13E15	.0813E15	.0325E15
2 PPNHY	7700	7400	7070	6500	6000
3 HBA	100	70	42.00	20	-
4 HC	22	17	12	8	4
5 IPPT	3	2	1	-	-
6 HBT	2.5	2	1.25	.5	0
7 ROC	900	750	600	450	300

where:

- PPNE D = Energy Demand for Mine Complex (Btu/yr)
- PPNHV = Run-of-Mine Coal Heat Value (Btu/lb)
- HBA = Height of Burden Average (ft)
- HC = Height of Coal (ft)
- IPPT = Prep. Plant Type Based on Difficulty
(1=crush & screen; 2=Baum Jig; 3=heavy media)
- HBT = Topsoil Thickness Saved (ft)
- ROC = Other Reclamation Costs (\$/acre)

Appendix F.1

Mining Parameter Sensitivity Analysis (Fort Union)

	Dollars Prep'd <u>Ton</u>	Dollars Million <u>BTU</u>	Return on <u>Invest.</u>	Return on Paid <u>Capital</u>	Invest. to steady <u>State</u>	Invest. Total <u>Project</u>	Annual Operate <u>Cost</u>
Energy Demand for Mine Complex (Btu/yr)							
.243800E 15	6.03	.43	9.99	10.66	231566.	308501.	27636.
.195000E 15	6.08	.43	10.00	10.73	192066.	257298.	22686.
.130000E 15	5.93	.42	10.00	10.87	137395.	179628.	15630.
.813000E 14	6.29	.44	10.00	10.94	94545.	122319.	10496.
.325000E 14	7.58	.53	10.00	10.98	47758.	60045.	5578.
Run-of-Mine Coal Heat Value (Btu/lb)							
7700.00	6.10	.39	10.00	10.87	128464.	168695.	14562.
7400.00	6.02	.41	10.00	10.87	132655.	174483.	15132.
7070.00	5.93	.42	10.00	10.87	137395.	179628.	15630.
6500.00	6.31	.48	10.00	10.79	149598.	198207.	17861.
6000.00	6.12	.51	10.00	10.80	157848.	208858.	18379.
Height of Burden Average (ft)							
100.0	9.09	.64	10.00	10.82	195847.	239278.	21550.
70.0	7.44	.52	10.00	10.85	163554.	210579.	18722.
42.0	5.93	.42	10.00	10.87	137395.	179628.	15630.
20.0	5.02	.35	10.00	10.89	121208.	163841.	14065.
Height of Coal (ft)							
22.0000	5.25	.37	10.00	10.88	123542.	159021.	13977.
17.0000	5.51	.39	10.00	10.87	128716.	166568.	14858.
12.0000	5.93	.42	10.00	10.87	137395.	179628.	15630.
8.00000	6.66	.47	10.00	10.86	151618.	202973.	17232.
4.00000	8.81	.62	10.00	10.84	194051.	277270.	22155.
Prep. Plant Type Based on Difficulty*							
3.00000	9.38	.63	10.00	10.82	214222.	266830.	22999.
2.00000	8.43	.57	10.00	10.81	193182.	243389.	20694.
1.00000	5.93	.42	10.00	10.87	137395.	179628.	15630.

* (1=crush & screen; 2=Baum Jig; 3=heavy media)

(Continued next page)

Appendix F.1 (Continued)

	<u>Dollars Prep'd Ton</u>	<u>Dollars Million BTU</u>	<u>Return on Invest.</u>	<u>Return on Paid Capital</u>	<u>Invest. to steady State</u>	<u>Invest. Total Project</u>	<u>Annual Operate Cost</u>
Topsoil Thickness Saved (ft)							
2.50000	6.03	.42	10.00	10.87	139004.	186868.	16144.
2.00000	5.99	.42	10.00	10.87	138400.	183851.	15924.
1.25000	5.93	.42	10.00	10.87	137395.	179628.	15630.
.500000	5.86	.41	10.00	10.87	136389.	174601.	15263.
.000000	5.82	.41	10.00	10.87	135585.	171383.	15043.
Other Reclamation Costs (\$/acre)							
900.000	5.94	.42	10.00	10.87	137587.	180591.	15742.
750.000	5.94	.42	10.00	10.87	137587.	180591.	15716.
600.000	5.93	.42	10.00	10.87	137395.	179628.	15630.
450.000	5.93	.42	10.00	10.87	137395.	179628.	15604.
300.000	5.91	.42	10.00	10.87	137202.	178666.	15518.

Appendix F.2

Financial Assumption Sensitivity Analysis

Twelve financial assumptions were varied at the following values:

Financial Assumption	Sensitivity Range				
	Value 1	Value 2	Value 3	Value 4	Value 5
	Ext.High	Exp.High	Baseline Value	Exp.Low	Ext.Low
1 RLTI	12.0	10.0	8.0	6.0	-
2 RCFD	20.0	15.0	10.0	5.0	0
3 RFIT	57.6	52.8	48.0	43.2	38.4
4 CDR	99	4	2	1	.00
5 EROL, ML	.10	.05	.00	-	-
6 ERMM, FU, TI, EL, WA, OT	.10	.05	.00	-	-
7 ERAEI	.10	.05	.00	-	-
8 DM 1,2,3	3	2	1	-	-
9 GASR	500	375	250	125	0
10 GAMR	100	75	50	25	0
11 GARA	1.00	.50	.25	0	-
12 GAST	1.00	.50	0	-	-

where:

- RLTI = Long Term Interest Rate (percent)
- RCFD = Desired Return on Investment (percent)
(Cash Flow Discount Rate)
- RFIT = Federal Income Tax Rate (percent)
- CDR = Paid in Capital/Long Term Debt Ratio
- EROL,ML = Labor Escalation Rate
- ERMM,FU,TI,
EL,WA,OT = Materials and Services Escalation Rate
- ERAEI = Equipment Escalation Rate
- DM 1,2,3 = Depreciation Method (1=St.Line,2=Decl.Bal,
3=Dbl.Decl)
- GASR = Land Rights-Surface (\$/acre)
- GAMR = Land Rights-Mineral (\$/acre)
- GARA = Royalty (\$/ton)
- GAST = State and Local Severance Tax (\$/ton)

Appendix F.2

Financial Assumption Sensitivity Analysis (Fort Union)

	Dollars Prep'd Ton	Dollars Million BTU	Return on Invest.	Return on Paid Capital	Invest. to steady State	Invest. Total Project	Annual Operate Cost
Long Term Interest Rate (percent)							
.120	5.93	.42	10.00	10.74	137395.	179628.	15630.
.100	5.93	.42	10.00	10.80	137395.	179628.	15630.
.080	5.93	.42	10.00	10.87	137395.	179628.	15630.
.060	5.93	.42	10.00	10.93	137395.	179628.	15630.
Desired Return on Investment (percent)							
.200	9.69	.68	20.00	21.05	137395.	179628.	15630.
.150	7.67	.54	15.00	15.98	137395.	179628.	15630.
.100	5.93	.42	10.00	10.87	137395.	179628.	15630.
.050	4.58	.32	5.02	5.41	137395.	179628.	15630.
.000	3.76	.26	.08	999.99	137395.	179628.	15630.
Federal Income Tax Rate (percent)							
.576	6.20	.44	10.00	10.90	137395.	179628.	15630.
.528	6.06	.43	10.00	10.89	137395.	179628.	15630.
.480	5.93	.42	10.00	10.87	137395.	179628.	15630.
.432	5.83	.41	10.00	10.85	137395.	179628.	15630.
.384	5.74	.40	10.00	10.84	137395.	179628.	15630.
Paid In Capital/Long Term Debt Ratio							
99.000	5.93	.42	10.00	10.00	137395.	179628.	15630.
4.000	5.93	.42	10.00	10.47	137395.	179628.	15630.
2.000	5.93	.42	10.00	10.87	137395.	179628.	15630.
1.000	5.93	.42	10.00	11.51	137395.	179628.	15630.
.000	5.93	.42	10.00	999.99	137395.	179628.	15630.
Labor Escalation Rate							
.100	3.24	.93	10.01	10.84	137395.	179628.	28307.
.050	7.39	.52	10.00	10.89	137395.	179628.	20632.
.000	5.93	.42	10.00	10.87	137395.	179628.	15630.
Materials and Services Escalation Rate							
.100	5.02	1.06	10.16	11.01	137395.	179628.	27863.
.050	7.80	.55	10.03	10.92	137395.	179628.	20457.
.000	5.93	.42	10.00	10.87	137395.	179628.	15630.

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Appendix F.2 (Continued)

	Dollars Prep'd Ton	Dollars Million BTU	Return on Invest.	Return on Paid Capital	Invest. to steady State	Invest. Total Project	Annual Operate Cost
Equipment Escalation Rate							
.100	0.25	.72	10.00	10.93	290427.	871266.	15630.
.050	7.53	.53	10.00	10.90	201380.	354761.	15630.
.000	5.93	.42	10.00	10.87	137395.	179628.	15630.
Depreciation Method*							
3.000	5.78	.41	10.00	10.85	137395.	179628.	15630.
2.000	5.91	.42	10.00	10.87	137395.	179628.	15630.
1.000	5.93	.42	10.00	10.87	137395.	179628.	15630.
Land Rights-Surface (\$/acre)							
500.000	5.96	.42	0.00	10.87	137785.	180018.	15630.
375.000	5.94	.42	0.00	10.87	137590.	179823.	15630.
250.000	5.93	.42	10.00	10.87	137395.	179628.	15630.
125.000	5.91	.42	10.00	10.87	137200.	179433.	15630.
.000000	5.90	.42	10.00	10.87	137005.	179239.	15630.
Land Rights-Mineral (\$/acre)							
100.000	5.93	.42	10.00	10.87	137473.	179706.	15630.
75.0000	5.93	.42	10.00	10.87	137434.	179667.	15630.
50.0000	5.93	.42	10.00	10.87	137395.	179628.	15630.
25.0000	5.93	.42	10.00	10.87	137356.	179589.	15630.
.000000	5.92	.42	10.00	10.87	137317.	179550.	15630.
Royalty (R/ton)							
1.00000	6.76	.48	10.01	10.87	137395.	179628.	15630.
.500000	6.21	.44	10.00	10.87	137395.	179628.	15630.
.250000	5.93	.42	10.00	10.87	137395.	179628.	15630.
.000000	5.66	.40	10.00	10.87	137395.	179628.	15630.
State and Local Severance Tax (\$/ton)							
1.00000	7.03	.50	10.01	10.87	137395.	179628.	15630.
.500000	6.49	.46	10.01	10.88	137395.	179628.	15630.
.000000	5.93	.42	10.00	10.87	137395.	179628.	15630.

* (1=St. Line, 2=Decl. Bal, 3=Dbl. Decl)