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An Evaluation of the Coal and Electric Utilities Model Documentation

by

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1. INTRODUCTION AND SUMMARY

Introduction

The Energy Information Administration's Office of Analysis Oversight and Access (OAOA)* is sponsoring the M.I.T. Energy Model Analysis Program (EMAP) in a study of methods and procedures for the effective internal management and control of information model development, evaluation, and application. This project is part of a larger OAOA program to improve the quality and credibility of energy information developed and published by the EIA. Central to EIA's concern in developing good management practices is a recognition that documentation of information models and applications is the key to effective communication of results credible to EIA's clients. Accordingly, this first report of the EMAP project is concerned with the development of procedures for planning and implementing effective documentation.

EIA's interest in the development of good model documentation practice is an outgrowth of many pressures and needs.** As a result of its enabling legislation, EIA is responsible for carrying out a program of energy data/information collection, evaluation, analysis and dissemination [44]. The Office of Applied Analysis, in particular, is involved in producing energy analysis reports and forecasts and in developing, evaluating and maintaining the tools by which such analysis

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*Within the Applied Analysis Division at the Energy Information Administration (EIA).

**Predecessors to the Energy Information Administration (EIA) include the Federal Energy Administration, the Federal Energy Office, and the Office of Energy Data and Analysis of the Department of Interior. In this report we will refer to "EIA," instead of "EIA and predecessor agencies," unless the context requires more careful identification.

is performed. Energy information models have played an ever-increasing role in this work. However, to realize all the potential contributions of such models, the modeling process must be understandable and credible to all concerned. An essential ingredient of credibility is the potential for outside review of the models utilized. The model's documentation is, of course, the key to this review.

This critical need for model documentation was recognized by many groups after the production of the Project Independence Report (PIR) [27]. Although the system of models underlying that report was described in some detail in a series of appendices to the PIR, and in twenty separate technical reports, some of several volumes, the materials were not perceived as being complete, and comprehensible enough for effective digestion by administration and congressional policy makers. In addition, concerns were widespread that the models were somehow being tampered with by those interested in promoting either industry goals or Executive Office policies. These pressures, described in more detail elsewhere ([42] and [43]) were factors leading to the legislative mandate in the Energy Conservation and Production Act of 1976 requiring the "complete structural, parametric and operational" documentation of the PIES model [45]. In addition, the same law established an interagency oversight committee, called the Professional Audit Review Team (PART) to "review and evaluate EIA's work and to determine whether data collection and analysis activities are being performed in an objective and professional manner consistent with the intent of the Congress [47, p.3]." PART annually produces a report to Congress on its findings. In its first such report, dated December 5, 1977 [27] PART made the following comments on the state of model documentation within EIA.

> "Computer models can be useful tools, providing valuable assistance to energy policymakers. However, certain procedures and practices should be followed to insure that such models make credible predictions. These include ... procedures to document, verify, validate, and test the model. OEIA fell short [in its first 10 months of operation] in meeting these goals, and as a result, the credibility of its models has not been established."

In response to such mandates, the EIA launched a program for evaluating model documentation, for producing documentation of models already used at EIA, and for producing guidelines for the production of future model documentation.

This report, one of several sponsored by OAOA, presents the results of an M.I.T. analysis of policy model documentation and EIA's approach to it. As a means both of facilitating our analysis and of illustrating its application in documentation evaluation, a case study was undertaken of a particular energy model, the ICF Coal and Electric Utilities Model (CEUM). The third annual report of the PART staff to Congress stated that the first priority of EIA's documentation program is to "document all models used for the development of forecasts and analyses published in the Annual Report to Congress" [47]. The version of the CEUM maintained at the DOE's computer facility, known as the National Coal Model (NCM) is used to support the Annual Report to Congress. Therefore, the choice of the CEUM as a case study model met EIA's goals; in addition the M.I.T. group was concurrently conducting an in-depth assessment of the CEUM with the sponsorship of the Electric Power Research Institute (EPRI).

Approach

The case study approach has been useful in forming our ideas about preparing and evaluating documentation and has produced a great deal of information about the CEUM. Our approach involved the following steps.

We first obtained the EIA Draft Documentation Guidelines prepared by the OAOA. These guidelines are in a sense a synthesis of many sets of documentation standards, and of discussions held amongst modelers and model analysts. These guidelines call for five types of documents including Model Summaries, Description of Methodology, Model Description, Guide to Model Applications, and User's Guide. Together, the documents require a comprehensive description of a model, and they provided a starting point against which we could measure the case study documentation. In discussions with the modelers, however, it became evident that the documentation objectives represented by the guidelines did not conform to the objectives of the model developers (and presumably their sponsors), and that many of the documents suggested in the guidelines did not exist for that model. While we did not always agree with their objectives, the perspective provided by the modelers, in conjunction with our own analysis, led us to conclude that fixed documentation standards applicable to any policy model might not be the best approach to the production of cost-effective, complete, and satisfactory model documentation. Accordingly, in this report, we present the results of the use of the EIA interim documentation guidelines as criteria for evaluating the CEUM documentation, but also develop and apply an alternative recommendation for the planning and production of policy model documentation. This alternative approach is summarized in the next section.

Another important part of our approach to the case study model documentation evaluation was to conduct a verification of the documentation and its consistency with the computer code.
Model verification of documentation and code includes the following

activities: (1) examining the internal consistency of the documentation and its consistency with the coded version of the model, thereby uncovering errors or omissions in the documentation, (2) carefully inspecting the model's code for accuracy and internal consistency, thereby uncovering coding errors, and (3) describing potentially misleading aspects of the model of which the user should be aware.

The first step in the CEUM verification process was to certify that the version of this model transferred by ICF to the EIA computer center was in fact the version that DOE had agreed was to be evaluated. This was accomplished by having ICF independently replicate the Base Case using the transferred model.

The actual CEUM verification consisted of documentation/code comparisons and analysis of the computer code, plus the additional activity of independent reprogramming of a key portion of the code. The reprogramming focused upon the production costing portion of the coal supply submodel. The original purpose of this activity was to develop a means of obtaining analytical expressions for elasticities relating average production costs to geologic characteristics of coal deposition. However, it soon became clear that this reprogramming, using a different logical sequence, was also an extremely effective method of code verification since several errors in the original code were discovered in this way. The correspondence of the two codes was assured by parallel runs that matched coal supply prices to five decimal places, both with and without the errors.

Finally, as a result of the analytic work performed both under this contract and for a concurrent contract with the Electric Power Research Institute, additional documentation for the CEUM model was produced by the M.I.T. group. This documentation is presented in this report in a series of appendixes.

Guidelines for Planning and Preparing Model Documentation: Policy model documentation must be sufficient to satisfy the requirements of several different model clients including peer modelers, model users and operators, analysts using model-based results, decision makers, and constituencies potentially affected by model-influenced policies. Types of documentation to satisfy the various needs of these groups include technical description and development of scientific results employed in the model; technical documentation of the manner in which policy concepts and instruments are integrated with scientific results; documentation of model implementation and operator instructions; and documentation of model applications including input data and interpretation of results. The extent of documentation requirements will depend upon two major factors: (1) the model development environment, and (2) the model use environment. For example, policy models developed to study highly conflicted issues and requiring new scientific research will require more extensive and formal documentation than models involving accepted scientific results and/or less conflicted policy issues. Similarly, the use environment dictates much of the extent and formality of documentation. For example, models to be operated only by the originators will require minimal documentation of operating procedures (sufficient to demonstrate good practice), whereas models intended for use by many users at sites of their choosing will require considerable formalism in operations instructions. Regardless of the planned environment, however, documentation must be sufficient to support independent replication of model structure, associated data, and applications by peer modelers and scientists.

The documentation appropriate for any particular model thus depends upon many factors. Our analysis has led us to conclude that an effective procedure for considering these factors and developing a documentation plan would be the joint preparation of a documentation requirements analysis by the modeler and sponsor, at the initiation of model development activities. The objectives of the documentation requirements analysis would be:

- To provide an analysis of the expected policy model development and use environments to determine the document types, style, content, and format necessary to meet the needs of all model clients;
- To enable modelers, model sponsors, and other model clients to develop shared expectations about the documentation types, style, content, and format of documentation;
- To estimate resources (both financial and skills) required to support the modeler and documentation support groups in preparing satisfactory documentation.

The result of the analysis would be a documentation plan. The documentation categories included in the EIA interim documentation standards provide a good resource for the model sponsor and modeler in their consideration of documentation needs. If the modeler and model sponsor together formulate the plan for the production and distribution of documentation, misunderstandings or misplaced expectations should be avoided. The result should produce more meaningful and effective documentation, increasing the potential for model use and credibility.

While documentation requirements analysis may produce different documentation plans for each model, depending upon the development and use environments, the minimum acceptable level of documentation must be sufficient to permit in-depth scientific and peer review and evaluation of the model, including formulation and structure, associated data, and computer code. Such documentation represents the fundamental statement of the model.

Case Study Evaluation of CEUM Documentation: As noted, the preliminary evaluation of the CEUM documentation identified some differences between the EIA interim guidelines and the ICF documentation objectives. The results of the evaluation of the CEUM documentation against those guidelines are presented in Table 1. However, the model documentation was also evaluated in the context of the two factors described above, that is, the model development environment and the model use environment. Examining the documentation from these two perspectives, we concluded that the approach to model documentation adopted by ICF and its sponsors was most nearly consistent with (1) a development environment in which a well-known approach was being adopted, and (2) a use environment in which the modeler was to be the primary user and operator. Accordingly, our evaluation focused upon

- effectiveness in satisfying requirements for the perceived development and use environments;
- effectiveness of technical documentation of concepts and data employed in implementing the model; and
- correspondence between technical documentation and computer implementation.

In our view the CEUM documentation is most consistent with an environment in which the modeler/analyst works closely with an analyst/client to develop and interpret the application scenario. Thus the documentation of CEUM model-based studies is quite good when viewed from the perspective of the client's ability to understand how his scenario was combined with the model data to produce certain results. The documentation is also effective (with some exceptions) in communicating to the analyst/client the sources and characteristics of the model data base. The CEUM documentation is less successful in

TABLE 1. Evaluation of CEUM Documentation by EIA Category

Document Type and Description *	CEUM Materials	Primary Audience	Evaluation
Model Summary: nontechnical descriptions of the model and model applications	Ref. 5, Section I; Various Sections of Ref. 7,8,9,15	Nontechnical	Uniformly excellent discussions of study objectives and results; good descriptions of scenario data and methods of data development; good summary descriptions of model structure; poor or non-existent discussion of rationale and alternatives for key model concepts, a level of resolution required for intended applications.
Model Methodology: technical description of rationale, precedents, and comparative evaluations with alternative approaches	Ref. 5, Section II and Appendix D	Modelers, Peers, Model users, other Analysts	Good descriptions of modeling approach, but not usually in the "natural language" for peers/other modelers. Very little technical discussion justifying model concepts, approach; almost no comparative discussion of alternative approaches.
Model Description: presentation of the model sufficient to describe its structure, associated data, and conditions for understanding and interpreting results	Ref. 5, Section III and Appendix E; Ref. 7, Appendix; Ref. 8, Appendix; Ref. 9, Appendix	Analysts performing policy research	Consistently good description of associated data and results; relatively poor documentation of actual model implementation; almost no discussion of results in terms of limitations and approximations used in developing data at resolution required by the model. No adequate complete and detailed technical description of the model is provided. For additions to the technical documentation see Appendixes B,C,D,E, and F of this report.
Guide to Model Applications: nontechnical description of model, and model applications to support interpretation and use of model-based analyses	Ref. 5, Appendix A	Nontechnical groups, analysts interpreting policy research	A guide to applications is provided for the NCM. However, this is not complete and has not been updated for the CEUM.
User's Guide: detailed description of operating procedures	Ref. 5, Appendix A	User/operators	Same comment as for Guide to Model Applications.

*Based on EIA Interim Documentation Guidelines [24].

satisfying the needs of peer modelers in understanding the scientific basis of the concepts embodied in the model structure and of the procedures used in developing model data. Finally, a number of inconsistencies between the model documentation and computer code have been identified and several logical errors and questionable assumptions have been noted.

Summary results of the verification work performed on the CEUM documentation and computer code are listed below. The substantive errors found in the verification analysis include:

- incorrectly modeling the deep-cleaning of all metallurgical coals, resulting in the double counting of deep-cleaning costs for certain coal types, and other related problems,
- incorrectly escalating base-year (1975) price data for existing mines,
- skipping one year of cost escalation between the base year and the case year (1985) in the calculation of real annuity coal prices,
- inappropriate method for approximating treatment of initial capital cost expenditures,
- incorrectly escalating the property taxes and insurance component of coal mine operating costs,
- incorrectly calculating base-year Union Welfare Costs for coal mines,
- changing the smallest seam thickness input value in the midst of cost calculations for deep mines, and
- improperly allocating more than 100 percent of deferred capital over the lifetime of a mine when the lifetime is not perfectly divisible by four.

Other problems identified include:

- In parts, the CEUM Supply Code relates to old code used for the PIES Coal Supply Analysis. Such code can only lead to confusion and should be deleted;
- Because of an undocumented "patch" that exogenously overrides the coal supply curve output for Utah bituminous low-sulfur

coal, this particular supply curve should be considered invalid for CEUM sensitivity runs involving regeneration of supply curves;

- Real escalation of cost factors is not appropriately accounted for in 1990 and 1995 case-year model runs;
- The implementation of a change in the general rate of inflation is not at all straightforward and requires changes in both supply and non-supply oriented components of the CEUM;
- The real rail-rate escalation factor for transportation costs is not implemented as documented;
- All hydroelectric costs except for pumped storage O&M are excluded from the objective function of the linear program (and also from the imputed cost of electricity); and
- Electricity distribution costs are ignored in the LP but are added exogenously at the report-writing stage. This procedure is not documented.

Our effort in verifying implementation of the CEUM was intensive, both because this aspect of model evaluation is important, and because the CEUM technical documentation was not sufficient to permit our continuing on to further in-depth validation efforts. The errors and the proposed corrections were reviewed with DOE and the ICF modelers.

Conclusions

The documentation guidelines presently used by EIA are just that -- guidelines. Applying these guidelines in evaluating the CEUM documentation has demonstrated that the actual scope and extent of successful documentation requires more active analysis and planning. Documentation requirements analysis should be an integral part of the model development planning process reflecting the interests and expectations of the modeler, model sponsor, client and/or users, and must be separately budgeted for both financial and skill requirements. We recommend that EIA consider implementing such a procedure for all new modeling projects.

In the process of conducting this case study a number of errors and problems with the current documentation and implementation of the CEUM were identified. As noted, these have been discussed in detail with representatives from the EIA Office of Coal and Electric Utilities and with ICF. Since, with only one exception, all our points have been accepted, they should be incorporated into all current versions of the model. We include as Appendix H listings of the corrected versions of the relevant code.

2. EVALUATION OF THE ICF COAL AND ELECTRIC UTILITIES MODEL DOCUMENTATION

In this chapter we provide an evaluation of the technical documentation and computer implementation of the CEUM. In the next section, we provide an overview description of the model. In Section 2.2 we summarize the model development, evaluation and application history, and describe the materials available for evaluation. In Section 2.3 we discuss guidelines for documentation evaluation. In Section 2.4.1 we describe and evaluate the ICF approach to documentation. In Section 2.4.2 we evaluate the computer implementation of the CEUM and in Section 2.4.3 we note several points concerning differences between technical documentation and the computer implementation.

2.1 Overview Description of the ICF Coal and Electric Utilities Model CEUM

We begin with a general description of the CEUM.* The CEUM is a model of U.S. coal supply, transportation, and use structured as a static linear program. The model consists of three major components including a coal supply component providing coal via a transportation network to satisfy at minimum cost utility coal demands as well as all other coal demands. The coal supply submodel is based upon the distribution of coal resources by geologic characteristics, on mining costs for coal types by geologic characteristic, and on behavioral assumptions concerning producer decisions to open new mines. The output of the coal supply submodel analysis are step functions relating coal supply and the producers' minimum acceptable, or reservation, price. These step functions, the transportation network connecting coal supply regions with

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*The primary source for information on CEUM structure is [5, Sections I and II].

utility demand regions, and a model of utility capacity expansion and generation comprise the linear program. The objective function is to minimize the total cost of electricity delivered by utilities and the costs of coal consumed by the non-utility sectors. A distinguishing characteristic of the model is that utility capacity expansion decisions explicitly include consideration of scrubber technologies so that the model evaluates the trade-off between capacity type, control technology, and the type and quality of fuel input.

Table 2 summarizes the major components of the CEUM. Although the model formulation is static, in application intertemporal linkages are proxied by setting lower bounds on coal flows to insure that contracts undertaken in earlier years would continue in force, and setting lower bounds on utility capacity additions equal to those in prior years, Table 3 summarizes the key endogenous and exogenous variables in the CEUM. The model is essentially static in formulation, projecting changes in activities between a base year and a case year. The model workings may be characterized as follows.

1. Coal supply schedules are generated consistent with information on coal resources distributed by geologic characteristics and by cost of mining.

2. Coal mining activities transfer coal from available coal reserves to coal "stocks" in supply regions. Coal stocks may be deep cleaned to adjust coal quality, allowing for cleaning losses.

3. Transportation activities move coal from supply region coal stocks to utility region fuel piles, consistent with characteristics of the transportation network.

TABLE 2. Coal and Electric Utilities Model -- Major Components (From CEUM documentation, page II-2)

SUPPLY	UTILITY DEMAND
. 30 Regions	. 35 Regions
. 40 Coal types	. 19 Coal piles
- 5 Btu categories	- 3 Ranks of coal
- 8 sulfur levels	- 6 Sulfur categories
. Existing capacity	- Metallurgical pile includes only the highest grades of coal
- Contract (large mines)	
- Spot (small mines)	. Utility Sector
- Surge (up to 25 million tons)	- Point estimates for KWH sales by region
. New Capacity	- KWH sales allocated to four load categories (base, intermediate, seasonal peak, and daily peak)
- Based upon BOM demonstrated reserve base	
- Reserves allocated to model mine types	- Existing generating capacity utilized by model on basis of variable cost
- Minimum acceptable selling prices estimated for each model mine type	- New generating capacity utilized by model on basis of full costs (including capital costs)
- Upper bounds of new mine capacity for each region based upon planned mine openings	- Air pollution standards addressed explicitly
. Coal washing	- Transmission links between regions
- Basic washing assumed for all bituminous coals	- Oil and gas prices fixed
- Deep cleaning option available to lower sulfur content to meet New Source Performance Standard or a one percent sulfur emission limitation for existing sources	- Coal prices determined from supply sector through transportation network

NON-UTILITY DEMAND	TRANSPORTATION
. Five non-utility sectors (metallurgical, export, industrial, residential/commercial, synthetics)	. Direct links
. Point estimates of Btu's demanded	. Cost based upon unit train or barge shipment rates
. Allowable coals specified in terms of btu and sulfur content	. Lower bounds used to represent long-term contract commitments
. No price sensitivity	. Upper bounds could be used to represent transportation bottlenecks or limited capacity

Table 3. CEUM Variables

Endogenous Variables

- Coal Supply/Production
- Coal Cleaning and Mixing
- Coal Transport Patterns
- Oil/Gas Procurement by Utilities
- Coal Procurement by Non-Utilities
- Electricity Generation from Coal
- Electricity Generation from Non-Coal Sources
- Electricity Transmission
- Building Electrical Generating Capacity
- Building Scrubber Capacity

Exogenous Variables

- Electricity Demand
- Non-Utility Coal Demand
- Bounds on New Coal-Fired Capacity
- Fixed Nuclear and Hydro Capacity Additions
- Bounds on Scrubber Capacity
- Oil/Gas Prices
- Capital Costs, O&M Costs, Transportation Costs, Etc.
- Cost Adjustment Factors Used in Production Costing
- Available Coal Reserves and Resources by Region by Characteristic

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4. Oil/gas procurement activities locate these fuels in utility region fuel piles at a price, but with no explicit production/transportation representation.

5. Coal procurement activities for non-utility use remove coal from fuel piles to satisfy exogenous non-utility demands, consistent with restrictions on coal quality.

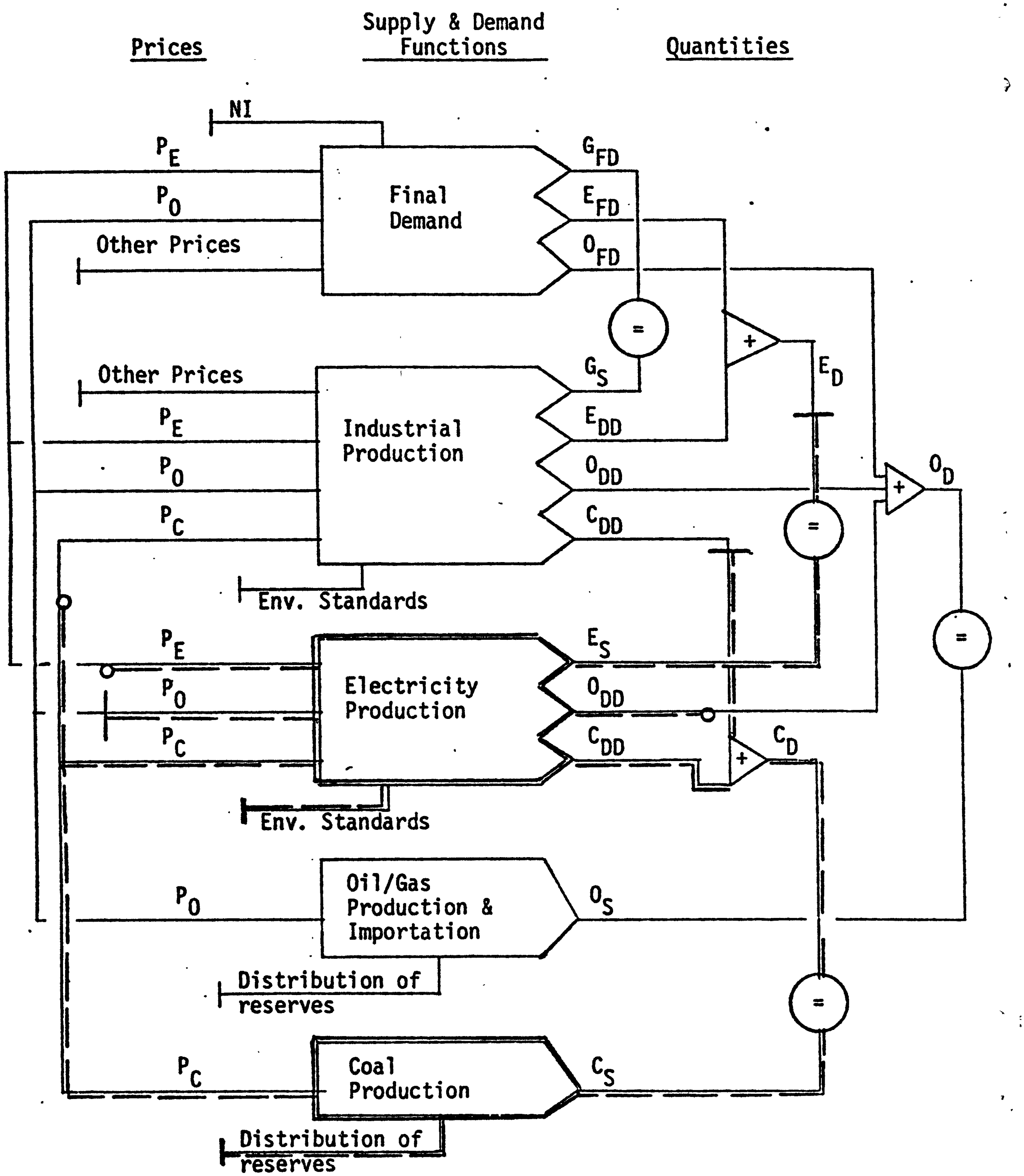
6. Coal-fired electricity generation activities remove coal from utility region fuel piles, and employ generating capacity and possibly scrubber capacity, to produce electricity. In parallel, non-coal-fired electricity generation activities remove non-coal fuels from fuel piles and use generating capacity to produce electricity.

7. Electricity transmission activities connect utility regions. In any region the sum of electricity generation minus exports plus imports satisfies exogenous electricity consumption requirements, allowing for both transmission and distribution losses.

8. In the process of satisfying exogenous electricity demand, new electrical generating and scrubbing capacity may be created, subject to expansion limits.

It is useful to place the CEUM in the context of a more general model of energy markets. In Figure 1 we characterize a more general energy market model, which includes the CEUM model, to illustrate both the coverage and the key linkage assumptions of the CEUM. Our energy market model includes the obvious end-use, conversion, and fuel production sectors and highlights the interaction of fuel production, demand, and the determination of equilibrium prices and quantities. In Figure 1, the overlay of the CEUM on the energy market model is designated by the heavy lines.

Figure 1. Market Equilibrium Analysis of Energy Production



C = coal
D = demand
DD = derived demand
E = electricity
FD = final demand
G = industrial goods
NI = national income
O = oil/gas
P = price

——— general model
— — CEUM

The CEUM contains only two sectors of the energy market model, electricity production and coal production. Final demand, industrial production, and oil and gas production are omitted. Note that there are six sets of linking variables between the CEUM and the complementary parts of the energy market model, including the prices of electricity, oil and coal, the total demand for electricity, the derived demand for coal and industrial production, and the derived demand for oil and electricity generation. Three of these variables--the demand for electricity, the industrial derived demand for coal, and the price of oil--are exogenously specified in CEUM. The other three variables--the price of electricity, the price of coal, and the derived demand for oil for electricity generation--are endogenous variables in CEUM. For the exogenous linking variables to be constant the CEUM must assume that (i) the supply functions for oil and gas are perfectly elastic, and (ii) that the demand for electricity and the industrial derived demand for coal are perfectly inelastic.

A distinctive feature of the CEUM is the effort to provide detail on coal production regions, quality, relation between geologic disposition, and mining costs. The coal supply submodel develops price-sensitive, multi-step coal supply curves for each coal type by coal supply region. The step function measures potential production levels at various prices. Each step of the function represents a different type of mine, with the length of the step indicating the potential production level for that mine type, and the step height measuring the minimum acceptable selling, or reservation, price. The reservation price is based upon average variable cost for mines currently in operation, and on average total cost for new mines.

The method for developing the coal supply functions is based upon analyses of data on the available coal resources classified by various coal quality and geologic factors, and a method of estimating mining costs sensitive to the geologic factors characterizing coal deposition. The key steps are the distribution of coal resources to the various geologic categories when no independent data are available, and the method by which the economic costs of mining resources with particular geologic characteristics are specified.

The dimensions of the ICF coal supply submodel are as follows. Thirty coal supply regions are distinguished producing coal with eight ranges of sulfur content, and five ranges of heat content. Two general types of mines are distinguished--surface and deep. For surface mines there are six possible mine sizes and seven possible overburden ratios (cubic yards of overburden per ton of coal in ground). For deep mines there are five mine sizes, five seam thickness categories and four seam depth categories.

The basic data used in allocating resources by production regions were the Bureau of Mines Reserve Base of U.S. Coal by Sulfur Content 1. The Eastern States (IC8680) and The Reserve Base of U.S. Coal by Sulfur Content 2. The Western States (IC8693). These data were updated to account for production and mine closings through 1975. The model makes use of the uniform distribution to allocate resources by geologic characteristics when no direct measurements are available. For example, the model uses this distribution to allocate resources to the seven categories of overburden ratio. The ICF argument is that when no real information is available to inform this distribution process, then the simplest distribution should be used, namely the uniform distribution.

A second significant aspect of the CEUM Coal Supply Submodel is the method used in evaluating mining costs for coal deposed by geologic characteristics (seam thickness, depth, etc.). The fixed and variable cost associated with a "model" mine were developed based on studies by the Bureau of Mines and TRW. The approach was to perform mining engineering analyses based on knowledge of existing technology and productivity. A deep mine characterized as producing one million tons annual output with mine characteristics of seventy-two inch seam thickness and seven hundred feet seam depth, and a one million ton per year surface mine with overburden ratio 10:1 (ten to one) were specified. Mining costs for mines associated with coal deposed by other geologic characteristics were developed by use of cost adjustment factors based on changes in mine size and geologic characteristics.

2.2 History of CEUM Development, Description of Materials Available for Evaluation, and Approach to Evaluation

The history of the ICF CEUM is complex, involving both sponsored model development for FEA, and subsequent unsponsored research by ICF to extend the model for application in support of studies sponsored by various government agencies including EPA, the Department of Interior, and the Office of Policy Analysis of the DOE. These policy studies each involved further extensions and refinements to the model, including the addition of new activities and then updating and improving the data base.

The earliest phase of model development begins with the contributions of ICF consultants in the preparation of the Project Independence Report [27] in 1974. In particular, Mr. Hoff Stauffer of ICF was a key consultant in transforming data and information provided by the Project Independence Coal Task Force into a form usable in the Project

Independence Evaluation System (PIES), and in interpreting PIES scenario results. Subsequently, a more formal effort to develop a coal supply model based upon the efforts of the Task Force and its contractors (primarily TRW) was initiated by ICF with FEA sponsorship. The product of this effort, the PIES Coal Supply Analysis, is documented in [1]. Subsequently an effort was undertaken to extend the PIES/CSA to include a utility coal demand submodel, a transportation network, and to close the extended system by specifying non-utility coal demands exogenously, thus providing a complete U.S. coal supply and demand model. This model was identified as the National Coal Model (NCM) and is documented in [4].

Upon completion of the NCM for FEA, ICF undertook an unsponsored research effort to extend the model still further to support policy studies relating to development of the domestic coal industry. Perhaps the most convenient way to summarize the relation between NCM and CEUM is to quote directly from the ICF report [5]:

> "Although the ICF model is based upon the National Coal Model (NCM) that ICF developed for the Federal Energy Administration, the ICF Coal and Electric Utilities Model is substantially different from the FEA's NCM. For example, the ICF model identifies the marginal deep mine by depth, size, and seam thickness instead of by only seam thickness, handles partial scrubbing and has a different procedure for estimating electrical transmission costs and losses. [5, Preface]

The description of the changes between the NCM and the first version of CEUM are described in Appendix E of [5], the remainder of which is the documentation of the NCM. Appendix E of [5] includes some 25 memoranda analyzing issues and data considered for revisions in the NCM-to-CEUM transition.

> "These memoranda recommend various changes to the data inputs and model structure. Essentially, all the data inputs have already been developed and are contained herein. Similarly, most if not all the changes to model structure (which are neither numerous nor major) have been thought through." [5, Appendix E, p. 8]

> "Some of our recommendations are to do nothing, because our in-depth analysis indicated the current data inputs are okay or because we have not yet been able to resolve the issue. Other of our recommendations concern changes that are refinements which will make the model more credible but will not necessarily impact the forecasts substantially. However, other of our recommendations concern changes that are much more than refinements; they are corrections of major mistakes." [5, Appendix E, p. 8]

Thus the revisions to NCM were primarily improvements to the associated data, not structural improvements. That these revisions were expected to produce significant changes in model results is indicated in Table 4 extracted from [5, Appendix E].*

The next phase of the CEUM development effort has involved the application of the CEUM in support of a series of policy studies focused on analysis of alternative new source performance standards (ANSPS)--changes in sulfur oxide emission standards--and on western coal development. The first major study is presented in a report prepared for EPA, reviewing the current new source performance standard (NSPS) following the 1977 amendments to the Clean Air Acts [7]. These amendments mandate the use, in new large fossil-fuel burning installations, of the best available technologies for pollution control.

A second study using CEUM was sponsored by the Departments of Interior and Energy, and deals with the demand for western coal and demand sensitivity to selected uncertainties, and considers the question of the need for additional leasing of Federal lands in the west [8]. The principal difference between this and the earlier study was development of a new, and significantly different, set of exogenous end-use electricity and non-utility coal demands.

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*We are unaware of any subsequent analysis to evaluate the actual effects of the revisions.

TABLE 4. Range of Expected Effects of Extending and Updating Associated Data in the NCM-to-CEUM Transition

Model or Data Revision	Expected Change
- Marginal deep mines	10 to 20 percent increase from original NCM data base values
- Productivity, wage rates, UMW Welfare and black lung	-10 to +20 percent change in mine-mouth prices
- Income taxes	8 percent decline in mine-mouth price
- Severance taxes and royalties	12 percent increase in mine-mouth price on Federal lands
- Coal preparation costs	25 percent increase in coal mine-mouth prices
- Western coal in eastern boilers	major changes in regional production levels
- Variation in scrubber costs	10 percent or less decrease in kwh cost from coal-fired plant with scrubber plus major impact on scrubber builds
- Utility capital and O&M costs	30 percent increase in kwh costs
- Transmission costs	300 percent increase in new long distance transmission costs per kwh
- Transportation costs	40 percent increase in transportation costs in the East

Source: [5, Appendix E, p. 8]

A third study, sponsored jointly by EPA and DOE focuses again on the impacts of ANSPS [9]. The primary differences between this and the earlier study include significant modifications in the end-use demand assumptions, much closer to the DOI/DOE assumptions, and new scenario specifications on the meaning and costs of ANSPS.

Each of the three studies has involved extensions and updates to the model, and in each case the revisions are documented in appendices to the report in a style and format similar to that described above. Most of the revisions are to data, not model structure. Thus the basic CEUM documentation consists of:

- o Coal and Electric Utilities Model Documentation, July 1977 [5].
- o Appendix B of Effects of Alternative New Source Performance Standards for Coal-Fired Electric Utility Boilers on the Coal Markets and on Utility Capacity Expansion Plans, Draft, September 1978 [7]. (Also see Scenario Specifications in Section II of [7].)
- o Appendix C of The Demand for Western Coal and its Sensitivity to Key Uncertainties, Draft, June 1978 [8].
- o Appendix A of Further Analysis of Alternative New Source Performance Standards for New Coal-Fired Powerplants, Draft, September 1978 [9].

In September 1978, ICF transferred the CEUM and associated data base extant at that time to the Energy Information Administration. It is the documentation and computer code associated with this version of the model which is considered in this report. The reader should note that ICF has continued its government sponsored studies with the model, and has recently published Still Further Analyses of Alternative New Source Performance Standards for New Coal-Fired Powerplants, a preliminary draft report to EPA [15]. This report includes some further model extensions, most importantly new data on scrubber costs. However, the style and general content of the new report is entirely consistent with the earlier work, and so will not affect our evaluation of the documentation.

Finally, the reader should note that various evaluations of the CEUM and its ancestors have been conducted, or are in progress. The original coal supply analysis in the Project Independence Report was reviewed by MIT [16] and by Battelle Memorial Institute [17]. The PIES Coal Supply Analysis effort [1] was reviewed by Resources for the Future in [2], and by Gordon in [3]. The NCM [4] was also reviewed by Gordon in [3]. The CEUM study reports [7, 8, 9, 15] have been extensively reviewed by the sponsoring agencies and their scientific consultants although, to our knowledge, none of this peer review has been, or will be, published. Finally, an in-depth evaluation of the CEUM is now being conducted by the MIT Energy Model Analysis Program. A summary of all this history is presented in Table 5.

TABLE 5. Development and Evaluation History, and Major Applications of the CEUM

January 1976 - May 1976	PIES Coal Supply Analysis
August 1976	RFF Evaluation of PIES Coal Supply Methodology
October 1976	National Coal Model (NCM) Documentation
July 1977	Gordon's Critique of NCM
July 1977	CEUM Documentation (NCM Documentation plus extensions in Appendix E)
July 1978	Energy Modeling Forum Study - Coal in Transition: 1980-2000
September 1977 - April 1978	CEUM EPA Study
April 1978 - June 1978	CEUM DOI/DOE Study
April 1978 - September 1978	CEUM EPA/DOE Study
September 1978	Transfer of CEUM and associated data base to EIA
September 1979	MIT Evaluation of CEUM Documentation
December 1979	MIT Independent Evaluation of CEUM

2.3 Guidelines for Documentation Evaluation*

2.3.1 Background

When policy modelers and model users meet it is a certainty that the topic of model documentation, or lack thereof, will be discussed, usually with considerable emotion. The gist of such discussions seems to center on differing perceptions by modelers and user/analysts as to what constitutes appropriate documentation. As one example: In 1976 at the EPRI-sponsored Workshop for Considering a Forum for the Analysis of Energy Options, the importance of appropriate documentation in establishing credibility of energy system models and model-based studies, although not on the Workshop agenda, was discussed with increasingly sharply worded exchanges between modelers and user/analysts. The Workshop report summarized the issues raised in the discussion as follows:

> The call for better documentation was repeated by nearly every speaker. The existence, timeliness, completeness, readability, dissemination, and purposes of most documentation were challenged or criticized by the workshop participants. The importance of a comprehensible documentation was emphasized to the degree of producing a proposal that the function of the Forum is to read and translate detailed model documentations. However, the sanctity of belief in good documentation was challenged by counter charges that current documentation is not read. There is no financial support for documentation preparation because, despite the rhetoric, users are not interested in having or reading documentation. When combined with the problems of disseminating proprietary information or defining good documentation, there is evidence of a major issue which deserves further discussion in the profession [8, p. III-5].

The need for "further discussions" was emphasized further by the unprecedented congressional attention to the documentation of the FEA Project Independence Evaluation System (PIES) expressed in Section 113 of the Energy Conservation and Production Act of 1976 in which "full and complete" structural, parametric and operating documentation was required to be produced for the model. Further the Congress created the

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*This material draws heavily on [43].

Professional Audit Review Team (PART) for the purpose of auditing EIA (and predecessor agency) activities [2]. The first PART report was most critical in comments relating to documentation of EIA models. Thus,

> ...the credibility of OEIA's [now Energy Information Administration] models has not been established because documentation, verification, and validation have been neglected. Furthermore, publications describing the current models are scarce, and procedures for public access to them are almost nonexistent. As a result, it is practically impossible for interested parties outside FEA [now part of the Department of Energy] to know whether OEIA's current models have been constructed properly and used correctly and thus whether OEIA's analytical products and forecasts can be used with confidence [26]

The EIA has responded to the concerns of the Congress and the PART in a variety of ways. For example, an Office of Analysis Oversight and Access (OAOA) has been organized to develop, implement and monitor operational procedures for internal management and control of model development, documentation, and application. Among its activities, OAOA has formulated and implemented a set of "Interim Model Documentation Standards" [24] to be applied to all new EIA-sponsored modeling efforts. The EIA standards include five types of documents as follows:

1. Model Summary: A short, one to two page, nontechnical description of the model. These summaries describe the model's role and usefulness in DOE analyses, its general structure including inputs needed and answers produced, its relationship to other models, and finally the status of any ongoing enhancements or model development. These summaries would be used to provide general information about the modeling activities of EIA.

2. Methodology Description: This constitutes a detailed description of a model's rationale, precedent for the model in the literature, and comparison to other similar models or approaches. This level of documentation details the capabilities of the model as well as its assumptions and limitations. The basic purpose of this documentation is to explain why the model structure chosen was selected and to communicate how the model compares to, and was chosen over, alternatives.

3. Model Description: A statement of the equations and other procedures which constitute the formal model structure, a description of the data and other information utilized in developing the model structure, statistical characteristics of estimated portions of the model and any other information necessary to an understanding of what the model is and how results derived from the model are obtained.

4. Guide to Model Applications: A nontechnical description of how to use a model for analysis or forecasting, how to specify alternative input assumptions and data, and how to interpret model output. The purpose of this documentation category is to communicate the range of issues the model is designed to address and the limitations of the model. The intended audience are those who would use model results.

5. User's Guide: This constitutes a detailed description of a model's operating procedures including names and locations of input files and computer programs, naming conventions, and required job control statements. These documents are intended for the use of EIA staff who actually operate the model on the computer and should enable an informed staff member to make model runs and label his input files and output files, so that subsequent users will be able to properly identify the files. An annotated listing of the computer program should be an appendix to the operating documentation. This documentation category will require frequent revision to be kept current.

The current interim standards are under review and evaluation by OAOA. In April, 1979 a workshop of EIA contractors working in the area of model assessment was held to discuss the effective standards for policy model documentation.* As a result a revised and much more detailed set of documentation standards, based largely on the proposals of Gass [18], is being considered by OAOA [23]. Thus, the description of the model development process and the generic document types necessary to record that process provide the framework for developing and implementing a documentation plan for a specific model, a plan which reflects

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*Organizations participating in the workshop included Argonne National Laboratory Energy Software Center, Idaho National Energy Laboratory, Logistics Management Institute, Los Alamos National Laboratory, MIT Energy Laboratory, and National Bureau of Standards.

the interests and legitimate needs, and expectations and perceptions of modelers, the model sponsor(s), and other model clients. We believe the generic framework provided by Gass should be employed by EIA in the analysis of model documentation requirements. In the remainder of this section we consider the obstructions to developing and implementing a documentation plan, and the factors to be considered in the planning process.

2.3.2 Guidelines for Planning Policy Model Documentation

The document types and general contents included in the EIA interim standards and the more detailed classification by Gass [18] provide a framework and checklist for documentation planning. The details of a plan for any particular policy model will depend upon a variety of factors dictating the particular document types required, their extent, format, and style, and their costs (both financial and skills), consistent with the legitimate needs of the model clients. The objective of the documentation planning process is to ensure the systematic evaluation of these factors, and to effectively communicate the results so that model clients (including the modeler and model sponsor) share common expectations about the outcome, and so that sufficient resources are devoted to satisfying documentation needs.

Table 6 summarizes the factors to be considered in the documentation planning process. We distinguish the model development from its application environment. Analysis of the model development environment will be most influential in determining the extent of technical documentation required. A policy model based upon new scientific results, concepts, or methods, will require more comprehensive

TABLE 6. Factors for Consideration in the Preparation of a Documentation Needs Analysis

<u>Environment for Model Development</u>

- Importance and scope of policy issues to be modeled.
- Diversity of potentially affected policy constituencies
- Potential contribution to state of the art.
- Role of model sponsor in the policy process.

<u>Environment for Model Use</u>

- Kinds of potential users and their needs
    - o Scientific peers, other policy modelers
    - o Policy analysts/users
    - o Operators
    - o Other groups concerned about the policy issue(s) under analysis
    - o Sponsoring agency
        - model development sponsor
        - application client
    - o Decision makers
- Potential Logistics of Model Use
    - o Hardware and software requirements
    - o Proprietary software or data considerations
    - o Need for portability: potential users
        - modeler only
        - single nonmodeler user at one site
        - many nonmodeler users at many sites
- Probable end uses of model
    - o Specific to one application; specific problem-solving
    - o Foundation for broad policy decisions
    - o Forecasting many interrelated results

documentation than a model based upon well-established scientific results. Likewise the more important and conflicted the policy issues under consideration, the greater the need for extensive technical documentation which motivates and describes the modeling approach, the scientific results employed, and the associated data used to implement the model. While the fundamental criterion for technical documentation is to ensure the understanding of peers, and possible replication of model implementation and model-based results, importance of issues and/or novelty of scientific basis may dictate efforts beyond this minimum level in order to establish model credibility.

The application environment for a policy model also influences the documentation plan. Important factors to consider include the needs of the different model clients, the potential uses of the model, and the logistics of model use. Distinguishing the legitimate documentation requirements of the different clients for a policy model and for model-based analysis is perhaps the single most important factor in the documentation planning process. Clearly a nontechnically oriented decision maker will have a different set of needs than a policy analyst, a computer operator, or a scientific peer from the modeling community.

Potential model clients often overlooked in discussions of model documentation requirements are groups who have a vested interest in the policy issue under analysis. Technical documentation, users' guides, and well-documented studies will partially satisfy the needs of such groups depending upon their analytic abilities. Planning for public access to the model may also help in meeting their concerns; the EIA project to transfer important models to the Argonne Software Center is a good example. But many groups will not have the analytical ability and/or resources to take advantage of such documentation or public access. When the importance of the users and the role of the model sponsor warrant it, more must be done to satisfy such groups that the models and model-based analyses are not "black boxes of predetermined results." Model sponsor support of peer review and evaluation of policy models and model-based studies with presentation aimed at both technical and nontechnical audiences is one way to deal with the legitimate concerns of this group.

A second major set of model characteristics affecting the need for documentation is that of the logistical requirements of the model design plan for use. As Table 6 indicates, such factors include data, hardware and software requirements, as well as consideration of the need for transferring the model. A model which was intended to be run by the developer at only one site might need different forms of documentation than one which was intended to be generally portable to a variety of sites.

Finally, consideration must be given in documentation planning to the kind of model results which will be produced. Has the model been designed to problem-solve in only one application with relatively simple and straightforward results, or will it produce a highly complex set of results that are interrelated in nature, complicated to analyze and apply, and perhaps controversial in terms of policy implications? Clearly, the document types, and their style, format, and content will differ between these two extreme applications.

The systematic planning for documentation requirements will go far to redress the problems of documentation discussed earlier. The minimum acceptable level of documentation, that which will permit full analytical review of the model, will fulfill the most basic needs to justify scientific acceptability. Further documentation, as determined through the analysis, will fulfill the needs of analyst/users, operators and other model clients. Advance planning will contribute to understanding and common expectations among modelers, model sponsors, and other model clients. In short, a documentation planning process will lead to a more orderly, thorough and competent production of model documentation, and should significantly increase credibility and usability of the model.

2.4 Evaluation of the ICF Documentation of the Coal and Electric Utilities Model (CEUM)

We now turn to an evaluation of the CEUM documentation. Our approach to evaluation is as follows: We first adopted the EIA interim documentation standards as a framework for documentation evaluation. In parallel we obtained from ICF the relevant model documentation, including technical documents, policy study applications, and the computer code. These materials were described in Section 2.2. The computer code represents the version of the model and associated data base as of September 1, 1978, as transferred to EIA by ICF. An important aspect of our effort was to certify that the transfer was complete and correct This was accomplished by having ICF replicate a base case run using the transferred model, in order to satisfy themselves that the model was properly transferred (see Appendix A).

The next stage was to analyze the model documentation materials and to evaluate them in terms of the EIA categories and our own documentation needs analysis. The outcome of this effort was mixed, since ICF's documentation objectives differed significantly from the EIA categories. In Section 2.4.1 we provide an analysis of the factors which contribute to the ICF approach, and a summary evaluation.

The third stage involved the comparative evaluation of documentation and actual implementation. This analysis is presented in two parts: an analysis of the correspondence between the documentation and the computer implementation for the non-coal supply components of the model (Section 2.4.3); and a more detailed analysis and verification of the computer implementation of the coal supply component of the CEUM (Section 2.4.2). In the process of this effort we have both augmented existing and developed new technical documentation (see Appendixes B, C, D, E, and F).

2.4.1 Summary Evaluation and Comparative Documentation Requirements Analysis for CEUM

A summary evaluation of the ICF CEUM documentation organized by EIA documentation categories is presented in Table 7. The single most striking feature of the evaluation is its binary character. When the ICF objectives correspond to an EIA category, the result is always excellent; but in several instances, ICF objectives do not include EIA categories, and so no documentation is available. In the remainder of this section we consider retrospectively how ICF arrived at its particular view of documentation requirements.

Recall from Section 2.3.2 the factors important in developing documentation requirements. They included:

Model Use Environment

- applications, their importance and "conflictedness,"
- model clients,
- logistics of use.

Model Development Environment

- maturity of scientific results being integrated into the model, and relation to state of the art,
- role of modeler/model sponsor in the policy process,
- complexity of policy issues.

Through review of the documentation and discussion with ICF representatives, the ICF perspective on these factors would seem to be as follows.

TABLE 7. Evaluation of CEUM Documentation by EIA Category

Document Type and Description *	CEUM Materials	Primary Audience	Evaluation
Model Summary: nontechnical descriptions of the model and model applications	Ref. 5, Section I; Various Sections of Ref. 7,8,9,15	Nontechnical	Uniformly excellent discussions of study objectives and results; good descriptions of scenario data and methods of data development; good summary descriptions of model structure; poor or non-existent discussion of rationale and alternatives for key model concepts, and level of resolution required for intended applications.
Model Methodology: technical description of rationale, precedents, and comparative evaluations with alternative approaches	Ref. 5, Section II and Appendix D	Modelers, Peers, Model users, other Analysts	Good descriptions of modeling approach, but not usually in the "natural language" for peers/other modelers. Very little technical discussion justifying model concepts, approach; almost no comparative discussion of alternative approaches.
Model Description: presentation of the model sufficient to describe its structure, associated data, and conditions for understanding and interpreting results	Ref. 5, Section III and Appendix E; Ref. 7, Appendix; Ref. 8, Appendix; Ref. 9, Appendix	Analysts performing policy research	Consistently good description of associated data and results; relatively poor documentation of actual model implementation; almost no discussion of results in terms of limitations and approximations used in developing data at resolution required by the model. No adequate complete and detailed technical description of the model is provided. For additions to the technical documentation see Appendixes B,C,D,E, and F of this report.
Guide to Model Applications: nontechnical description of model, and model applications to support interpretation and use of model-based analyses	Ref. 5, Appendix A	Nontechnical groups, analysts interpreting policy research	A guide to applications is provided for the NCM. However, this is not complete and has not been updated for the CEUM.
User's Guide: detailed description of operating procedures	Ref. 5, Appendix A	User/operators	Same comment as for Guide to Model Applications.

*Based on EIA Interim Documentation Guidelines [24].

Intended Applications: The CEUM is intended as an energy policy model for analysis of issues relating to U.S. coal production, conversion, and use. Reference [5, pp. I-1,2] includes the following application areas for the model.

- western coal development,
- Clean Air Act Amendments,
- strip mine reclamation requirements
- Energy Supply and Environmental Conversion Act conversion orders,
- effect of taxes on industry (depletion, investment tax credit),
- effect of changing factor and competing fuel prices,
- effect of changing equipment constraints, both in coal industry and in coal-using industry (e.g., utilities),
- impact of new technologies which use or compete with coal (e.g., synthetic fuels).

Thus the CEUM is intended for use in a wide variety of applications involving the most difficult and conflicted issues regarding the future production and use of coal resources in the U.S.

Model Clients: In understanding ICF's view on this element and its relation to documentation requirements, it is important to distinguish the sponsored model development by FEA from ICF's subsequent company-sponsored efforts. While the FEA-sponsored effort to develop the NCM was intended to be internalized and applied within the FEA policy analysis group, the extension of the NCM into the CEUM was an ICF-sponsored activity intended to provide an analytical capability to support ICF consultants in coal-related policy studies primarily for government clients. The style of the subsequent policy studies confirms this view. Typically, ICF consultants work with a client in structuring the issue to be analyzed and in developing data and information relevant to that issue. A part of this activity focuses upon structuring scenarios which may be analyzed via application of the model. Specific studies may identify a need to extend the model and/or its associated data base. The end result is an analysis report targeted to the issue of interest to the client using the model, as appropriate, to analyze specific scenarios.

The type and extent of documentation for technical extensions to the model are the result of client perceptions as to what is required to interpret model-based results, as well as what is required to establish the credibility of these results for others considering the study results in a larger policy context. The importance of the CEUM in policy research related to Alternative New Source Performance Standards, as well as in studies of the development of the U.S. coal industry, suggests that the technical documentation is judged acceptable by the clients of these studies.

Logistics of Use: Since the principal clients are interested in model-based results, the model is intended for use only by ICF analysts. Thus, preparation of user and operator guides, beyond that necessary for ICF personnel, is unnecessary.

Maturity of Scientific Basis: Recall from Section 2.2 the evolution of the CEUM. In the first stages ICF consultants were involved in interpreting and transforming data and information from the PIR Coal Task Force into a form usable by PIES. The results were not a formal model so much as a structuring of the data for assimilation in the PIES LP framework. The next phase involved formalization of the data structures into a model for FEA. The working relation between ICF and FEA was very close, and FEA's intent was primarily to incorporate the results as a PIES submodel. The important concepts such as the model mine concept, were considered mature at least by the ICF/FEA community. The subsequent extension to include the utility submodel and to close the model with respect to non-utility coal demands also employed a well-accepted approach, that being the PIES methodology. The effort to extend the NCM into CEUM involved primarily data revisions and extensions, not structural changes [5, Appendix C, p. 8]. Since the methodology (LP) was straightforward, and the model concepts mature, the need for detailed technical documentation was not thought to have significant value. Thus, in the basic report only 19 pages [5, Section II] are devoted to technical documentation, and all of this is descriptive of the model or of its potential applications. Almost none of the material may be interpreted as presenting scientific evidence which justifies and/or supports the choice of the LP formulation or the particular concepts and methods employed in the model.

Role of Modeler/Model Sponsor in Policy Process: The CEUM is clearly intended by ICF for use in support of their contract policy research for both government and private clients. ICF's self image is as a consultant to the community of those concerned with a particular issue, not as the agent for one or another of the various constituencies of that community. The relevant professional standards are to determine if the concerns of the potential client can be served by the consultant and, if so, to provide as complete and objective an analysis as possible consistent with the client's requirements and the consultant's perceptions as to what is necessary to understand and interpret his/her analysis. Given the maturity and relatively simplicity of the model methodology and concepts, ICF has interpreted good professional practice to mean careful attention to model data, and especially to the data associated with the client-oriented scenarios.

This anlysis of key factors influencing the ICF perspective suggests that ICF's documentation objectives were as follows.

- The most important documentation objective is to describe the model and associated data in a format designed to facilitate general understanding by study clients, as well as interpretation of specific studies and applications.
- Technical documentation of the scientific basis for the model, as contrasted with model description, is relatively unimportant since
  - the methodology and basic concepts are relatively simple and widely understood,
  - study clients do not need or require such documentation.
- The model is intended for use by ICF analysts and operators, not for transfer to other groups. Hence operator and user guides need only satisfy the requirements of good internal management and practice.

With this understanding of the ICF documentation objectives, the reader should now be able to interpret the evaluation of CEUM documentation presented in Table 7. In general we find the documentation to be excellent in terms of describing the model and model studies. There is little effort to justify the scientific basis for the model. Thus,

> "Even though the structural approach taken in the NCM is conceptually simple and straightforward, the NCM may appear complex. The model's apparent complexity is a result of the large number of options and fine level of resolution built into the model's design..." [5, p. II-19]

> "...the NCM design is based upon a series of engineering cost relationships and production functions. This attribute allows the components of the model to be easily understood, easily checked, and easily revised." [5, p. III-18]

> "The basic NCM structure is conceptually straightforward in that a supply component via a transportation network provides coal to satisfy the demand from both utility and non-utility consumers at least cost." [5, p. II-1]

As noted above we feel such scientific documentation is essential for any policy model, and so disagree with ICF's excluding it. The argument that clients do not require, or value, such documentation clearly is relevant--especially for a commercial model developer--but good professional and scientific practice should dictate the preparation of such documentation independent of the model application environment.

2.4.2 Verification of the CEUM Supply Code*

A discussion of errors, proposed corrections, programming improvements, questionable assumptions, and aspects for user awareness in the CEUM Supply Code (consisting of the SUPIN and RAMC files) is given below. The points discussed can roughly be broken down into the following categories:

A. Errors: Points 1, 5, 6a, 7, 8, 10, 14, 18, 19, 20, 21, 22.

B. Aspects of the code of which the user should be aware: Points 3, 4, 6b, 11, 15, 16, 17, 25, 26, 27.

C. Questionable Assumptions: Points 2, 9, 12, 13.

D. Totally Innocuous Errors: Points 23, 24.

The most substantive errors are those discussed in points 5, 6a, 7, 8, 10, 14, 18, and 20. The reader should note that the order in which points are presented has significance only in that the material is contextually related. For the aid of the reader, points relating to errors are denoted by an asterisk. Also, the referenced line numbers, from our versions of SUPIN and RAMC, are based on the consecutive numbering of all lines (including comment lines) by tens. These line numbers may not match precisely with the line numbers appearing in other versions of the code.

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*This material also appears in [50].

1.* On the first page of SUPIN, lines 15-16, global values of 0.1 are given to the parameters ISR (Illegal Surface Reserve Fraction) and IDR (Inaccessible Deep Reserve Fraction). In the RAMC code the values of ISR and IDR in SUPIN are assigned to B(21) and B(1) respectively (see RAMC, line 219). For regional use, the values of vector B are assigned to vector C (RAMC, line 352). Then, whenever there is a regional override for values of ISR and/or IDR, the new values are placed in C(1) and C(21), respectively (RAMC, lines 500-509 and 37-40). -- Note the curious interchange. -- Furthermore, the Equivalence statement on line 54 of RAMC verifies not only that the regional values of ISR and IDR (ISRR and IDRR) are in C(1) and C(2), respectively, but that the global values, ISRG, and IDRG, are in B(1) and B(21), respectively. This is in direct opposition to the manner in which the parameters are first read into RAMC, as mentioned above. Note that there are no resulting errors only because the initial global values of ISR and IDR in SUPIN are equal. The simplest correction would be to interchange lines 15 and 16 of SUPIN.

2. The user should note that the total base-year values of deferred capital (not present-valued) for surface and deep mines, given on line 14 of SUPIN, are for a mine lifetime of 20 years. These values are extrapolated for shorter or longer mine lifetimes in the Mine Costing Subroutine of RAMC, lines 1574-1580. No rationale is given for the manner in which the extrapolations are made. Of particular interest is why deferred capital is assumed to be zero for mine lifetimes of 10 years or less. Also, the non-operational comment on line 1577 which assumes a maximum lifetime of 30 years, should be deleted.

3. The user should be aware that the Annuity Price Factor, APFAC, exogenously specified as 16.748 in SUPIN, line 28, is both a function of mine lifetime and the <u>real</u> utility discount rate.

Recall that:

$$APFAC = \sum_{i=1}^{N} 1/(1+K_u)^i = K_u^{-1} [1-(1+K_u)^{-N}] \qquad (1)$$

where: $1 + K_u = (1+k_u)/(1+g)$

g = inflation rate = .055

k_u = utility's after-tax nominal cost of capital (defined as RUT in RAMC) = .10

K_u = utility's after-tax <u>real</u> cost of capital = .04265

N = mine lifetime

For N = 30, APFAC = 16.748.

For N = 20, APFAC = 13.276.

For N = 40, APFAC = 19.305. Etc.

After we discussed this point with Phil Childress of DOE, he internalized the calculation of APFAC in the DOE version of the CEUM. The version of the code that Michael Wagner of ICF certified for M.I.T. does not have APFAC internalized.

4. In general, the user should be aware that almost all of the global parameter values given at the beginning of the SUPIN file (see lines 15-26 and 29-32) can be overridden in regional data (e.g., see lines 48-49). It appears that the utility discount rate, RUT, and the annuity price factor, APFAC, cannot be overridden regionally because of their effect on the fixed charge rate used by utilities.

5.* In Memo O, Appendix E of the CEUM Documentation [5], cleaning costs for bituminous coals, in dollars per clean ton, are defined as follows:

	Fixed Cost	Variable Cost
Basic Cleaning	1.14	0.56
Deep Cleaning	2.03	1.67
Total	3.17	2.23

The cleaning costs given in SUPIN and employed in RAMC should relate only to the basic cleaning of bituminous coals. Deep cleaning costs occur in the LP (only for C and E sulfur level coals) as the objective function coefficients for the deep-cleaning variables. The cleaning costs specified in SUPIN for ZA, ZB, ZC, ZD, and ZE coals are total costs including deep-cleaning and should not include the deep cleaning component.

We have learned that ICF believes that all metallurgical coals should be deep-cleaned and this was their reason for adding deep-cleaning charges in SUPIN, as described above. In addition to the fact that there has been no documentation of this change, it appears that there have been errors made in implementing it. On page III-108 of the CEUM Documentation [5] it is stated that 70% of metallurgical coal is drawn from the ZA, ZB, ZC, or ZD coal types while the remaining 30% is drawn from a blend of ZF, HF, and MF coal types. By simply adding deep-cleaning charges in SUPIN for the ZA, ZB, ZC, ZD, and ZE coal types (and thereby claiming that all metallurgical is now deep-cleaned) several problems result:

- o double counting of deep-cleaning costs occurs whenever a ZC or ZE coal type is deep-cleaned in the LP,
- o deep-cleaning is not charged for the required percentage of ZF

coal (it is charged only for those ZE coals not deep-cleaned in the LP), and

- there is no allowance for deep-cleaning the percentage of HF and MF coals used to meet metallurgical coal demand.

It is also curious that in addition to increasing the cleaning costs for ZA through ZE coals in SUPIN, ICF has lowered the YIELD factors (both surface and deep) for ZA through ZD coals but not for ZE coals.

In our corrected version of the CEUM, we have decided to omit all exogenously imposed deep-cleaning charges for ZA through ZE coals in SUPIN, thereby allowing deep-cleaning to occur only via the LP, as was originally intended. While it may well be true that without ICF's adjustment not enough deep-cleaning of metallurgical coals occurs in the CEUM, the method that ICF chose to remedy the situation is inconsistent and incorrect, and at best represents only a crude approximate approach to modeling the deep cleaning of all metallurgical coals.

6.(a)* The factor used to escalate the average 1975 base-year price data for existing mines to the case year, 1985, is incorrect. The calculation is made on lines 360-367 of RAMC. A derivation of the correct escalator follows.

Let:

P_{1975} = given average 1975 price for an existing mine (includes a capital component)

f_L = fraction of P_{1975} relating to labor costs = .32

f_S = fraction of P_{1975} relating to supplies = .53

f_C = fraction of P_{1975} relating to capital = .15

g_L = total nominal escalation rate for labor costs = .065

g = general inflation rate = total nominal escalation rate for supplies = .055

P^*_{1975} = variable cost component of P_{1975}

$= (1-f_C)\, P_{1975} = (f_L + f_S)\, P_{1975}$

P^*_{1985} = 1985 price for an existing mine due to variable costs only

E = escalator of interest = P^*_{1985}/P_{1975}

Note that only variable costs for existing mines are subject to inflation.

It can easily be shown that:

$$P^*_{1985} = \frac{f_L}{f_L + f_S} P^*_{1975} (1+g_L)^{10} + \frac{f_S}{f_L + f_S} P^*_{1975} (1+g)^{10}$$

$$= \frac{P^*_{1975}}{f_L + f_S} [f_L(1+g_L)^{10} + f_S(1+g)^{10}] . \quad (2)$$

We then have:

$$P^*_{1985} / P_{1975} = E = f_L (1 + g_L)^{10} + f_S(1 + g)^{10} \quad (3)$$

With the values given above, E = 1.506. In RAMC the escalator is called ESCAL1 and is given by (see RAMC, lines 364-365):

$$\text{ESCAL1} = [1 + (f_L g_L + f_S g)]^{10} = 1.628 \quad (4)$$

ESCAL1 is incorrect and gives a value that is too high by 8.1%.

(b) A further correction of the escalator E may be necessary. As discussed below (Point 7), it appears that base year costs for new mines are in '<u>end</u> of 1975 dollars', and the real annuity coal prices in RAMC output are in '<u>end</u> of 1984 dollars'. If the P_{1975} prices for existing mines are also in '<u>end</u> of 1975 dollars' then the exponent used in the above calculation of E should be 9 instead of 10. If the P_{1975} prices are in '<u>end</u> of 1974 dollars' or in '<u>beginning</u> of 1975 dollars', then the exponent of 10 used in calculating E is correct. We believe that the latter statement is true, so the exponent used in Equation (3) is correct.

7.* Recall the following facts from the CEUM Documentation [5]:

(a) Initial capital is inflated at the nominal capital escalation rate from the base year, 1975, to eight months before the case year, 1985.

(b) Deferred capital, labor, and power and supplies are each escalated, using the appropriate rate, to the end of the year in which the money is considered spent (i.e., all cash expenses occur at the end of the year).

It can be verified from the Mine Costing Subroutine of RAMC (lines 1635 to 1719) that if real annuity coal prices (RACP) are calculated in 'end of 1984 dollars' then base-year mine costs must be in 'end of 1975 dollars'. If the RACPs for the 1985 case-year projection are considered to be in 'early 1985 dollars' (i.e., as of 1/1/85), then the base-year mine costs must be in 'early 1976 dollars' (not in 1975 dollars). If the base-year mine costs are truly meant to be given in 'end of 1974 dollars' or in 'early 1975 dollars' then the following corrections must be made in the Mine Costing Subroutine in order to calculate the RACPs in 'end of 1984 dollars' or in 'early 1985 dollars,' respectively:

(a) In lines 1641 and 1664, LL = JJ + NYR instead of LL = JJ + NYR - 1.

(b) The exponent in line 1649 should be (NYR - 2./3.) instead of (NYR - 5./3.).

(c) The exponent in line 1689 should be (NYR + 1) instead of NYR.

Note that this point is currently under active consideration by DOE personnel.

Even if we assume that base-year mine costs are indeed given in 'end of 1975 dollars', there are other errors and questionable assumptions related to the calculation of real annuity coal prices in the Mine Costing Subroutine (lines 1635-1719 of RAMC). -- See Points 8 through 21.

8.* By assuming that all initial capital is sunk (spent) at the end of April 1984, ICF is crudely approximating a stream of initial capital expenditures over time, together with the explicit use of 'interest during construction' at the nominal cost of capital for coal producers, as a means of summing these fractional expenditures. While ICF's approximation clearly simplifies the accounting of initial capital, the approximation is poor and its derivation is not documented. We believe that it is necessary to further escalate the sunk value of initial capital by eight months to the end of 1984 before it can appropriately be added to the present value of deferred capital as of 12/31/84 (for the purpose of calculating cash flow), i.e., initial capital and the present value of deferred capital must be in equivalent dollars before they can be added. For simplicity we implemented the required additional escalation using the general rate of inflation although, as seen from our formal discussion of how initial capital costs should have been treated in the CEUM (given below), the appropriate rate is the nominal cost of capital for coal producers. (Although we resolved this issue too late for the most appropriate correction to be implemented in our corrected version of the CEUM code, our approximation is more accurate than ICF's, as seen below.) Note that while both ICF and DOE personnel disagree with the need for any correction, there is no documentation or other evidence available to support the validity of their argument. A description of our implementation of the correction is as follows:

(a) After initial capital is escalated at the nominal escalation rate for capital, ECAP, to the end of April 1984 (eight months prior to the case year, 1985) and before the result is added to the present value of deferred capital as of the end of 1984 (i.e., 12/31/84), it must be escalated eight months at a rate we chose to be the general inflation rate. (Note that the appropriate rate is ROR, the nominal cost of capital for coal producers--see the formal treatment of initial capital costs given below.) A general GNP deflator is not defined in RAMC, but the cost of power and supplies escalates at the general inflation rate and its escalator, EPAS, can be used as a proxy for this rate. The correction for the escalation of initial capital can thereby be made as follows in line 1649 of RAMC:

```
Y(1,1) = IC*((1 + ECAP)**(NYR - 5./3.))*((1 + EPAS)**(2./3.))      (5)
```

The effect is a 3.6% increase in Y(1,1). Note that Y(1,JJ) has been set equal to Y(1,1), and with NYR = 10 the total number of years of escalation is 9, i.e., from the end of 1975 to the end of 1984. It can also be shown, from lines 1650-1654, that deferred capital in base year dollars is first escalated 9 years to the end of 1984 and then the spending of deferred capital over the mine lifetime (starting at the end of 1985) is present-valued to the end of 1984, i.e., 12/31/84.

(b) Because of our change in the calculation of escalated initial capital (Equation (5) above), an adjustment is required in the calculation of the annual depreciation charge (total nominal capital costs divided by the mine lifetime). Line 1680 of RAMC should now read:

```
Y(21,JJ) = (Y(6,MYR) + (Y(1,1)/((1+EPAS)**(2./3.))))/MYR      (5a)
```

rather than

```
Y(21,JJ) = (Y(6,MYR) + Y(1,1))/MYR
```

Formal Treatment of Initial Capital Costs

Let:

g = general rate of inflation = .055

g_c = nominal escalation rate in coal mine capital costs (g_c is denoted by ECAP in the CEUM) = .060

k_p = nominal after-tax cost of capital for coal producers (k_p is denoted by ROR in the CEUM) = .150

IC_{75} = initial capital cost in base year (beginning-1975) dollars

IC_t = initial capital spent at end of year t, in current year dollars

f_t = fraction of initial capital spent at end of year t

PV_{IC} = present value of initial capital costs in case year dollars (as of the end of 1984)

Following the convention that all expenditures occur at the end of the year, it can easily be shown that:

$$IC_t = IC_{75} (1 + g_c)^t f_t \quad \text{, and}$$

$$PV_{IC} = \sum_{t=1}^{10} IC_t (1 + k_p)^{10-t} = IC_{75} \sum_{t=1}^{10} (1 + g_c)^t (1 + k_p)^{10-t} f_t \; . \tag{5b}$$

We now illustrate calculations of PV_{IC} in terms of IC_{75}, using three different assumptions for the fractions f_t, and the parameter values of g_c, k_p, and g given above. The third case represents the assumption made by ICF.

(a) Assume equal initial capital expenditures in each year, i.e., f_t = .10 for t = 1, ..., 10. Using Equation (5b) we have:

$$PV_{IC} = IC_{75} (2.656) \; .$$

(b) Assume all initial capital is spent at the end of 1984, i.e., $f_t = 0$ for t = 1, ..., 9 and $f_t = 1$ for t = 10. This case results in the lowest possible value of PV_{IC}, and using Equation (5b) we have:

$$PV_{IC} = IC_{75}\ (1.7908)\ .$$

(c) Assume all initial capital is spent at the end of April 1984. This case represents the assumption made by ICF. Note that there is no documentation available to support the intent or validity of this assumption. Using the logic of Equation (5b) we have:

$$PV_{IC} = IC_{75}\ (1 + g_c)^{9+1/3}\ (1 + k_p)^{2/3} = IC_{75}\ (1.8908)\ .$$

The expression used by ICF is a poor approximation given by:

$$PV_{IC} = IC_{75}\ (1 + g_c)^{9+1/3} = IC_{75}\ (1.7226)\ .$$

The correction implemented by M.I.T. is given by:

$$PV_{IC} = IC_{75}\ (1 + g_c)^{9+1/3}\ (1 + g)^{2/3} = IC_{75}\ (1.7852)\ .$$

While our multiplier understates the true value by 5.6%. ICF's multiplier understates it by 8.9%. To implement the appropriate multiplier in the CEUM code, EPAS should be replaced by ROR in Equations (5) and (5a) given above.

Finally, it should be noted that the overall effect on CEUM output of the correction discussed in this point is small.

9. There is a question concerning the way in which two factors entering into the calculation of operating costs in the base year are escalated over time. The two factors are Royalty fees and Licensing fees, each specified on a dollar-per-clean-ton basis. They are both escalated over the mine lifetime using the nominal escalation rate for capital, ECAP (see lines 1672-1673). Why are these factors not simply escalated at the general inflation rate (using EPAS as a proxy)? While the intent could well have been to have these factors escalate somewhat faster than inflation (i.e., at a rate equal to ECAP), no justification is given.

It should be noted that a Licensing fee of $.10 per clean ton is charged in all regions and that all Royalty fees in the data base have been set to zero. Federal Royalties, applying to coal mined on Federal Lands, have now been included and are treated, like regional Severance Tax Rates, as a percentage charge on sales. The Royalty charge is 12.5% for surface coal and 8% for deep coal; it occurs only in the following regions: North Dakota, Eastern and Western Montana, Wyoming, Colorado South, Colorado North, and New Mexico.

The full Federal Royalty is applied to all coal from these regions even though, as stated in Memo N, Appendix E of the CEUM Documentation [5], less than 100% of the coal-bearing land is Federally owned. ICF's argument is that Federal reserves are such a large percentage of the total that they will set the price. This may be true for all the relevant regions except North Dakota, where only 25% of the reserves are Federally owned. In the other regions more than 50% of the coal lands are Federal.

10.* Property Taxes and Insurance, another factor entering into the calculation of operating costs, has been escalated incorrectly over the mine lifetime. Assuming that this factor, calculated as a percentage of initial capital costs, escalates with the nominal capital escalation rate, line 1676 of RAMC should read:

```
Y(20,JJ) = .02*(Y(1,1)/((1+EPAS)**(2./3.)))*(1+ECAP)**(JJ+2./3.)   (6)
```

rather than

```
Y(20,JJ) = .02*Y(1,JJ)*(1+ECAP)**LL                                 (7)
```

Note that the correction for Y(1,JJ) should be made as noted in Equation (5) (see Point 8) and that JJ = 1,2,...,MYR and LL = JJ+9, where

MYR = Mine Lifetime. The effect of the correction is a 38.5% decrease in the taxes and insurance charge for each year of the mine lifetime. Note that if Equation (7) is incorrectly used, there effectively will be a double counting of the number of years between the base year and the case year. (Referring to the discussion at the end of Point 8: we have become convinced that the most appropriate correction to Equation (7), which we ultimately formulated too late to be implemented in our corrected version of the CEUM code, is given by Equation (6) with EPAS replaced by ROR; however, the expression used in Equation (6) above gives results much closer to the appropriate values of Y(20,JJ) than does Equation (7) used by ICF.)

There is also a question concerning the rationale for using the capital escalation rate for property taxes and insurance. One argument, at least concerning insurance, is that the expenses incurred over the mine lifetime should cover the mine's replacement value.

11. The fixed (capital) components of both Reclamation and Cleaning Costs, escalated from the base year to the end of 1985, are added (in addition to the variable components) to operating costs in every year of a mine's lifetime (see lines 1689-1690 of RAMC). Apparently, this implies that the fixed charges must have been pre-annualized over mine lifetime and have been calculated, or are assumed, to be constant in nominal terms (constant in current dollars per clean ton per year) starting at the end of 1985. Such a procedure used to arrive at these data inputs has not been documented.

12. For each region in which Severance Taxes are non-zero, either a Severance Tax Rate (SEVTR) as a percentage of sales or a Severance Tax in base-year dollars per clean ton (SEVT$) is charged. The user should be aware that the RAMC code does not allow for the escalation of SEVT$ in the calculation of sales for each year of a mine's lifetime. It thereby assumes that SEVT$ is constant in nominal terms. If we were to assume that SEVT$ escalates at the general inflation rate (i.e., SEVT$ constant in real terms), then we would again use EPAS as a proxy for this rate, and replace SEVT$ by SEVT$*(1+EPAS)**LL in lines 1696, 1698, 1701, and 1702. Note that if SEVTR is used, the tax escalates with sales over time. Clearly, the allowance for a severance tax charge remaining constant in nominal terms could well have been intentional.

13. It should be noted that insurance charges for Black Lung Disease in base-year dollars per clean ton are assumed constant in nominal terms (i.e., are not escalated over time). See line 1691 of RAMC. It appears that Federal law does not provide for escalation of these charges.

There is also another add-on charge, AMR, given in base-year dollars per clean ton and assumed constant in nominal terms (see line 1691). This charge, defined in the CEUM case study application [8], is an abandoned mine reclamation tax mandated by Federal law.

14.* For both deep mines and surface mines, there is a question concerning the units of the input measure of tons per man-day (TPMD). Are they given in raw tons or in clean tons? If, as we strongly suspect, they are meant to be given in raw tons per man-day, then the calculation of base-year Union Welfare Costs has incorrectly used the YIELD factor. Line 1592 of RAMC should read:

B(16,KK) = 1000.*SZ*(WEL*YIELD + WPD/TPMD) (8)

rather than

B(16,KK) = 1000.*SZ*(WEL + WPD/TPMD)*YIELD (9)

If the data inputs for TPMD are given in clean tons per man-day, then:

(a) in the equations for the associated cost adjustment factors (lines 1561 and 1796, for surface and deep mines, respectively) mine size, SZ, must be multiplied by the YIELD factor; and

(b) in the equations calculating base-year labor costs (lines 1562 and 1799, for surface and deep mines, respectively) SZ must be multiplied by the YIELD factor.

Furthermore, although never stated in the code, the data inputs for reclamation costs, cleaning costs, royalty fees, licensing fees, and the union welfare costs per ton, must all be given in base-year dollars per <u>clean</u> ton according to their use in the Mine Costing Subroutine.

15. A Dimension statement in the Mine Costing Subroutine (line 1419 of RAMC) assumes a maximum mine lifetime of 30 years by dimensioning Y(23,30) and DCFRAC(30). The Y matrix contains cost factors for each year of a mine's lifetime and DCFRAC is a vector defining fractions of deferred capital to be spent over the lifetime of each mine. Clearly, if mine lifetimes greater then 30 years are to be considered, the Dimension statement must be changed.

16. A confusing aspect of the Mine Costing Subroutine is that in parts it relates to the code used for the old PIES Coal Supply Analysis, with calculations of minimum acceptable selling prices (MASP) for only the first year of mines. Although never stated, it should be made clear that these prices (case-year MASP in base-year dollars, not annuitized over mine lifetime--see line 1629 of RAMC) are calculated under the assumptions of no inflation and no real escalation, and thereby the code must incorrectly assume that the coal producer's discount rate, ROR, is given in real terms. An example of this confusion is the use of the present value factor PVFAC (calculated in Subroutine PRVAL for use in Subroutine MC) for the present-valuing of deferred capital. The calculation of PVFAC ignores inflation, real capital escalation, and uses the nominal discount rate, ROR. Clearly, in an older version of the code, ROR was real and calculations were in constant dollars with no real escalation.

Now, to be fair, PVFAC and the MASP are never used in the calculation of the real annuity coal prices (RACP) for each mine type. However, their unexplained presence in the code is misleading and can only lead to confusion. Such code should be omitted.

17. There are still other portions of the RAMC code (not only in the Mine Costing Subroutine) that appear to relate either to old PIES calculations or to early versions of the supply component of the CEUM.

A prime example is the calculation and use of two factors, COEF1 and COEF2. These factors are calculated early in the main program of RAMC as follows:

COEF1 =(1+ECAP)**(10./2.), and (10)

COEF2 = (10./40.)*((1+ECAP)**(10./4.)) (11)

COEF1 and COEF2 next appear at the end of the Mine Costing Subroutine after the calculations of the real annuity coal prices (RACP). They are suddenly used, in the creation of output, as escalators for the base-year values of initial and deferred capital divided by the annual output for each mine type (see RAMC, lines 1870 and 1893). The resulting values of SCAP and DCAP, for surface-mine and deep-mine types, respectively, appear in the RAMC output under column CAPL.

The first escalator, COEF1, appears to relate to an old definition of the point at which initial capital is assumed sunk (an updated definition is now used in the calculation of the RACP--see Point 8 above). There is no reasonable explanation of the second escalator.

At any rate, the output appearing under the column CAPL has an unclear meaning, is misleading, has no direct relationship to the production and price (RACP) output, and should be deleted.

18.* At the beginning of the calculations of real annuity coal prices for deep mines, the smallest seam thickness measure is suddenly changed from 28 to 24 inches (see line 1771 of RAMC). Recalling that coal reserves are allocated to seam thickness categories beginning at 28 inches, there can be no justification for this change. Interestingly, the RAMC output continues to display 28 instead of 24 inches as the smallest seam thickness measure used in pricing coal from deep mines (see line 1782 of RAMC). This is misleading. The simplest resolution of this problem is to delete line 1771 of RAMC.

19.* An error has been made in the Mine Costing Subroutine of RAMC by not declaring the variable LAB (1975 labor cost in thousands of dollars per year) as REAL. The default declaration on variable names beginning with I, J, K, L, M, or N is INTEGER. Thus, the fractional component of the labor cost for each mine is inadvertently dropped.

20.* In Subroutine PRVAL of RAMC, the fractions of deferred capital to be spent over a mine's lifetime are calculated and stored in vector DCFRAC. This vector is an important factor in the calculation of Cash Flow and Depreciation within the Mine Costing Subroutine. If careful attention is given to the allocation scheme used to create DCFRAC in Subroutine PRVAL, it can be shown that due to truncations with integer variables when the mine lifetime, MYR, is not perfectly divisible by four, more than 100% of deferred capital is allocated over the life of the mine. (The error is largest when MYR divided by four has a remainder of three, e.g., when MYR = 35.) An amended version of the allocation scheme that remedies this situation is as follows:

After line 1957 of RAMC, in Subroutine PRVAL, insert:

```
    IF ((MYR-(M75+M99)) .NE. 2) GO TO 120
    M50 = M50+1
    M75 = M75+1
    GO TO 130
120 IF ((MYR-(M75+M99)) .NE. 3) GO TO 130
    M25 = M25+1
    M75 = M75+1
    M99 = M99+1
130 CONTINUE
```

21.* In Memo I, Appendix E of the July 1977 CEUM Documentation [5], the calculation of two separate UMW Welfare Costs, one in 1975 dollars per clean ton and the other in 1975 dollars per man-day, for both surface and deep mines, is discussed. The Welfare Cost in dollars per man-day is determined to be $1.37 per hour or $10.96 per man-day. This data input, for both surface and deep mines, is correctly displayed on line 25 of SUPIN. Unfortunately, the main program of RAMC reads in values of $10.90 per man-day for this Welfare Cost (for both surface and deep mines) because of an error in the associated FORMAT statement, number 8010, on line 1013 of RAMC. A FORMAT of F4.2 is used instead of F5.2. Line 1013 of RAMC should read:

T30,F4.2,2(/,T23,F5.2,T50,F5.2),/,T15,F4.2,/,T27,F6.3,

rather than

T30,F4.2,2(/,T23,F4.2,T50,F4.2),/,T15,F4.2,/,T27,F6.3,

We note that the Welfare cost in dollars per man-day, denoted as WPD in the Mine Costing Subroutine, enters into the calculation of each mine's Operating Cost via lines 1592 and 1671 of RAMC.

It should also be noted that other variables, such as Mine Lifetime, Base Year, and Case Year, are displayed as floating point variables in SUPIN but are read into RAMC as integers. This would only result in errors if fractional values of these variables were specified in SUPIN.

22.* The variable reclamation cost, in base-year dollars per clean ton, for an overburden ratio of 15 in region OK (Oklahoma), is given on line 1308 of SUPIN as 0.30. This value is lower than the values 0.42 and 0.46 given for overburden ratios of 5 and 10, respectively. Since in every other supply region both fixed and variable reclamation costs increase with overburden ratio, this entry is suspicious and could well have been meant to be 0.50, given the value of 0.52 for an overburden ratio of 20 that follows it.

23. The value of YTD (deep-coal yield in clean tons per raw ton) for ZD coal in region OK (Oklahoma) should most likely be 0.60 instead of 0.70, as given in line 1356 of SUPIN. In every other supply region the value of YTD for ZD coal is given as 0.60. This possible data error has no effect since there are no deep ZD reserves in region OK.

24. There is a minor error in initializing the regional overburden ratio distribution vector on line 337 of RAMC. The Do Loop on I should be from 1 to 7 instead of 1 to 4. This error is innocuous.

25. The user should note that the RAMC code on lines 355-359, creating a distribution over deep-mine size given seam thickness and seam depth, is completely overridden by the code on lines 456-469.

26. Since the counter IK must equal 4 at line 947 of RAMC (see lines 750-752), lines 947-963 of the code can be omitted.

27. The user should be aware that the RAMC supply curve output for coal type UTHB (Utah Bituminous Low Sulfur Coal) is exogenously overridden in the GAMMA REVISE file of the CEUM computer code. The override exogenously resets the production level (supply curve step width) of each new mine type (defined by a particular combination of physical variables) on the UTHB supply curve at twice the value computed

by RAMC. Note that the override refers only to the number of the supply curve step and not to the particular mine type asssociated with the step. The undocumented reason for this 'patch' seems to be that the LP is infeasible without it.

An important consequence is that whenever a sensitivity analysis run of the CEUM is attempted that requires changes in the Supply Code and therefore, regeneration of all supply curves, the full-model (as opposed to RAMC) supply curve output for UTHB coal will most likely be incorrect and should be ignored. The only situation in which no error occurs--an example is our Corrected Base Case (CBC) model run--
would be one in which the number, order, and production levels of the UTHB mine types recomputed by RAMC remain identical to those computed by RAMC in the Base Case or Corrected Base Case. This is unlikely.

Three possible error-producing situations regarding UTHB coal can arise when full-model sensitivity runs involving changes in the Supply Code are attempted.

(a) The number of supply steps generated by RAMC for UTHB coal in the sensitivity run remains the same as in the Base Case (or CBC). If this occurs but the mine-type order and the associated production levels change, then the 'patch' will reset production levels at values equal to twice the Base Case (or CBC) production levels but not equal to twice the new values.

(b) The number of supply steps generated by RAMC for UTHB coal in the sensitivity run is fewer than in the Base Case (or CBC). If this occurs, the model will not run because the 'patch' will try to reset production levels of supply steps that do not exist. Once the relevant supply steps are deleted from the 'patch', the model will run but the basic problem referred to in (a) remains.

(c) The number of supply steps generated by RAMC for UTHB coal in the sensitivity run is greater than in the Base Case (or CBC). If this occurs, the 'patch' will not reset the production levels of the additional mine types generated in the sensitivity run, and as described in (a) it will also incorrectly reset those production levels in the Base Case (or CBC) that have now changed.

In summary, the UTHB supply curve should be considered invalid for CEUM sensitivity runs involving regeneration of supply curves via changes in the Supply Code.

2.4.3 Verification of Non-Supply Components of the CEUM

The following presents a list of undocumented aspects of non-supply oriented components of the CEUM of which the user should be aware and documented aspects of these parts of the model that have either not been implemented or have been implemented incorrectly by ICF.* The reader should note that the order in which points are presented has no particular significance.

1. We have learned, via communications with ICF personnel, that a most important but undocumented aspect of the CEUM is that real escalation of cost factors is not appropriately accounted for (with one exception) in the 1990 and 1995 case year model runs. The real annuity coal prices calculated in RAMC in 1985 dollars for 1985 case year model runs (see Section 2.4.2 and Appendix E), and later deflated to 1978 dollars for use in the LP, are used without change in the 1990 and 1995 case year model runs. This means that the coal-type supply curves generated in RAMC for 1985 model runs are not regenerated for 1990 and 1995 model runs. The only adjustments relate to depletion of resources for existing (as of 1975) mines. It should be noted that in the calculation of the RACPs for 1985 model runs, real escalation in capital and labor costs is employed over the life of mines beginning in 1985. For the 1990 and 1995 case year model runs, 5 years and 10 years of real escalation are omitted, respectively, prior to mine openings. Therefore, the 1990 and 1995 model runs use cost estimates appropriate only for mines opening in 1985.

*Note that points 1 and 2 in this section concern the entire CEUM and not just the non-supply oriented components of the model.

On the utility side, utility capital costs escalate in real terms only until 1985 (see Point 3 below). The one exception referred to above concerns real rail-rate escalation. A real escalation factor is employed over the entire model horizon but not as a constant percentage per year independent of the case year and not in a manner implied in the documentation (see Point 4 below).

2. In Memo J, Appendix E of the July 1977 CEUM Documentation [5] it is implied that in future applications the model will use a general inflation rate of 6%/yr, replacing the original rate of 5.5%/yr. Upon examination of the CEUM computer code it can be shown that this change has never been implemented and for all applications to date the CEUM has continued to use 5.5%/yr as the general rate of inflation.

3. On page 51 of ICF's first case study for EPA using the CEUM [7], it is stated that utility capital costs escalate at 7.5%/yr through 1985 and at 6.0%/yr thereafter. This statement is not entirely correct. In the CEUM case study applications [7], [8], [9], and [15], utility capital costs escalate at 7.5%/yr until 1985 and at the general rate of inflation, 5.5%/yr thereafter.

4. The version of the CEUM existing as of September 1, 1978 and as applied in ICF's third case study, prepared for EPA and DOE [9], claims to incorporate a real rail-rate escalation factor of 1%/yr over each year of the 1975-95 time horizon of the model. If implemented correctly, transportation costs, after being inflated appropriately from 1975 to 1978 dollars, would be multiplied by:

$(1.01)^{10}$ for a 1985 model run,

$(1.01)^{15}$ for a 1990 model run, and

$(1.01)^{20}$ for a 1995 model run.

Upon examination of the CEUM computer code it can be shown that what the model actually does is apply a transportation multiplier (TCMLT) of $(1.01)^{20}$ = 1.22019 for all case year model runs. The implicit effect of such an implementation is that real rail rates escalate at approximately 2%/yr from 1975-85 for a 1985 model run, 1.34%/yr from 1975-90 for a 1990 model run, and 1%/yr from 1975-95 for a 1995 model run.

5. (a) All costs appearing in the LP objective function are in 1978 dollars. In particular, the objective function coefficients of the build activity variables are case year annualized utility capital costs in 1978 dollars per KW-year (or 10^6\$/GW-yr), taking into account real capital escalation. The CEUM calculates these costs by first converting exogenously specified 1975 (base year) utility capital costs in 1975 dollars to case year costs in 1978 dollars, as follows:

Let:

Case Year = 1985

$CAP_{78\$}(85)$ = 1985 utility capital cost in 1978 dollars per KW

$CAP_{75\$}(75)$ = 1975 utility capital cost in 1975 dollars per KW (exogenously specified)

g_{uc} = total (nominal) capital escalation rate for utilities (including inflation)

g = general rate of inflation.

We then have:

$$CAP_{78\$}(85) = \frac{(1 + g_{uc})^{10}}{(1 + g)^{7}} \; CAP_{75\$}(75)$$

Note that both the 1990 and 1995 case year utility capital costs in 1978 dollars per KW are also given by $CAP_{78\$}(85)$ since utility capital costs escalate at the general rate of inflation after 1985 (see Point 3 above).

The case year costs in 1978 dollars are annualized by multiplying by a real fixed charge rate (FCR). The model uses a real FCR of 10%, except in Eastern and Western Tennessee where a value of 5% is used.

Applying the CEUM values of g_{uc} = .075 and g = .055, the annualized utility capital costs are given by:

$$\overline{CAP_{78\$}(85)} = (1.4168)(FCR)\ CAP_{75\$}(75)$$

$$= (0.14168) CAP_{75\$}(75)\ ,\ \text{outside Tennessee}$$

$$= (0.07084) CAP_{75\$}(75)\ ,\ \text{in Tennessee}\ .$$

(b) It has been learned via personal communications with ICF personnel that before plant capital costs are annualized there is a $50/KW add-on charge for hooking up the new plant to the existing local utility grid, i.e., for intermediate or intraregional transmission. Long-distance capital charges for new interregional transmission lines are treated separately.

6. The user should be aware that nuclear plant capacities are exogenously set, by utility region, in both 1985 and 1990. In 1995 the exogenous specification is derived differently. A national nuclear capacity is exogenously set and regional capacities are determined by multiplying each 1990 regional capacity by the ratio of the national 1995 capacity to the national 1990 capacity (the latter value being the sum of the 1990 regional capacities).

One of ICF's apparent reasons for fixing, rather than upper bounding, nuclear capacity is that nuclear plants have lower unit costs than coal plants in almost all utility regions. If nuclear capacity were treated as upper bounded rather than fixed, then examples of extreme "knife-edge" optimization could result if the unit costs of nuclear plants were increased. Other reasons for fixing nuclear capacity include very long construction lead times and political considerations.

7. All hydroelectric costs, both capital and O&M, are excluded in the CEUM except for new pumped storage O&M. The associated activity variables for building hydroelectric plants and operating existing hydroelectric plants thereby have zero cost. It has been learned via personal communications that ICF's justification for excluding these hydroelectric costs is that the costs are relatively small (they would just appear as add-on costs in the objective function) and that all the available capacity will be locked into the model solution. However, upon examination of the model output it can be observed that new hydroelectric capacity is upper bounded, not fixed as with nuclear, and that several utility regions have unused free hydroelectric capacity. Furthermore, in the Montana utility region, new oil/gas turbine capacity is built at a non-zero cost to meet daily peaking demands while free hydroelectric capacity is unused. This is quite strange. Either the LP has not reached a true optimal solution as is claimed or there are undocumented constraints that prevent utilization of Montana's hydroelectric capacity.

8. Distribution costs for the electricity distribution activity variables by utility region are also ignored by the CEUM. The apparent undocumented justification for this omission is that demands for electricity are fixed and distribution costs would be just an add-on to the objective function. Strangely, distribution costs suddenly appear in the CEUM's model output (Table 4 of the CEUM's Small Report)* with no explanation of how they are calculated. We have learned via personal communications with ICF personnel that an add-on distribution charge of $500/KW is used and annualized appropriately by region. From our examination of many model runs, it can be observed that nationally these distribution costs can be between 10 and 15% of total annual utility costs and can vary as much as 30% between runs. Thus it appears that such costs should be included in the objective function coefficients of the electricity distribution activity variables of the LP, rather than being added in an exogenous ex-post fashion at the report-writing stage.

9. The CEUM can set exogenous building limits on coal plant capacity by utility region individually for new NSPS bituminous, subbituminous, and lignite plants and for new ANSPS bituminous, subbituminous, and lignite plants. These build limits are treated as upper bound constraints on the associated build activity variables in the LP. At the same time there can be joint upper bound constraints on total (bituminous + subbituminous + lignite) new NSPS and total new ANSPS coal plant capacity by utility region. It should be noted that the joint upper bounds are not always consistent with the sum of the individual limits (when they all exist) on bituminous, subbituminous, and lignite plant capacity. For regions in

*References to CEUM Large and Small reports cite categories of computer output generated by running the model.

which all individual coal plant type build limits are set (for either NSPS or ANSPS plants), there are instances in which the associated joint upper bound is greater than the sum of the individual bounds. This causes no problems so long as it is understood that the sum of the individual limits is the binding constraint. Unfortunately, in Table 8 of the CEUM's Large Report, the total new coal build limits displayed, for the cases of interest, are the sums of the NSPS and the ANSPS joint upper bounds rather than the sums of the individual limits. This can be quite misleading in that the table will show extra unused capacity that could never exist under the given constraints. Furthermore, the user should be aware that in Table 8 of the CEUM's Large Report for case years 1990 and 1995 the build limits displayed are those for case year 1985 and have not been updated appropriately. This is the reason for the frequent appearance of negative unused capacity figures in this table for 1990 and 1995 model runs.

10. Recall from Point 5 that the case year utility capital costs (in base year dollars) take account of the full modeling period's real capital escalation above and beyond inflation. These case year costs are used for making all the base year to case year build decisions. This has the effect of strongly exaggerating impacts of the real escalation rate. A more appropriate approach might be to simulate an averaged effect of accumulated escalation over the modeling period, which could be approximated by reducing by about one-half the real escalation rate imposed.

11. We have learned via communications with ICF personnel that whenever the appropriate partial scrubbing fraction (percentage of the flue-gas scrubbed) is greater than 0.8 but less than 1.0, the model fully scrubs rather than partially scrubs the associated coal. The apparent <u>undocumented</u> justification for this procedure is that the magnitude of the cost savings associated with partially scrubbing such coals is small. ICF has no calculations available to support this claim. For a full discussion of this point see Appendix F.

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APPENDIXES

AN EVALUATION OF THE COAL AND ELECTRIC UTILITIES MODEL DOCUMENTATION

by

M.I.T. Energy Model Analysis Program

APPENDIXES

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APPENDIX A - LETTER ON CERTIFICATION OF MODEL TRANSFER

ICF INCORPORATED 1850 K Street, Northwest, Suite 950, Washington, D.C. 20006 (202) 862-1100

April 19, 1979

Dr. David Wood
M.I.T. Energy Laboratories
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Dave:

We believe that the base case equivalence run has been satisfactorily completed. There are three separate model versions relevant to the discussion:

Version A: Used to generate the September EPA case labelled "RF5x",

Version B: Our own copy of the version that we thought had been transmitted to Phil Childress,

Version C: Transmitted from Phil Childress to ICF.

The only difference between Version A and Versin B is in the supply curves. We have demonstrated this by solving Version B with the "A" supply curves substituted. The "B" supply curves correct errors in the "A" curves, with the overall effect of increasing coal minimum acceptable supply prices by about 5%. The "A" curves can no longer be generated.

Version C differs from Version B in four known substantive respects:

a. The 1985 revise in "C" does not contain the "BNDMAX" adjustment.

b. The Arizona ANSPS standard in "C" is .8 rather than .5.

c. The 1985 revise in "C" does not eliminate H coal for ANSPS plants.

d. The supply curves in "C" contain a seven percent payroll cost premium for surface coal in Western Montana.

The differences a), b), and c) are due to minor errors or scenario mis-specification in Version "C". Difference d) indicates that "C" supply curves post-date the "B" curves.

We have run a case using "C" with differences a)-c) corrected and with the "B" supply curves substituted. This differs from the all "B" version by less than one part in 70000 in objective function value (for reasons which we have not been able to determine). We propose that the modified "C" version with the "B" supply curve substitution be used in analysis. We have made a few non-substantive changes in operating procedures in the version.

Sincerely,

Michael H Wagner

Michael H. Wagner

MHW/adh

cc: Hoff Stauffer

APPENDIX B AN ILLUSTRATIVE LINEAR PROGRAMMING MATRIX*

The general structure of the ICF Coal and Electric Utilities Model (CEUM) consists of a supply component that provides coal, via a transportation network, to satisfy, at minimum cost, demands from both utility and non-utility users. The CEUM generates an equilibrium solution through a conceptually straightforward linear programming formulation that balances supply and demand requirements for each coal type for each region. The objective function of the linear program minimizes, over all regions, the total costs of electricity delivered by utilities and the costs of coal consumed by the non-utility sectors. The output of the model includes projections of coal production, consumption, and price by region, by consuming sector, and by coal type for the target year under consideration. The impacts of air pollution standards on electricity generation from coal are also considered explicitly.

Figure 1 outlines the basic elements of each of the four major components of the CEUM:

(1) Coal Supply
(2) Utility Demand
(3) Non-Utility Demand
(4) Transportation

This appendix focuses on the linear programming formulation and structure of the CEUM. By the use of an illustrative linear programming matrix it will be shown, in general terms, how the CEUM's four major components interrelate. This matrix is loosely based on an incomplete and unexplained sample matrix that appears in Appendix A of the CEUM Documentation [5]. Considerable reconstruction and interpretation were necessary.

*This material also appears in [51].

SUPPLY	UTILITY DEMAND

- 30 Regions
- 40 Coal types possible
  - 5 Btu categories
  - 8 sulfur levels
- Existing capacity
  - Contract (large mines)
  - Spot } No longer included in model
  - Surge }
- New Capacity
  - Based upon BOM demonstrated reserve base
  - Reserves allocated to model mine types
  - Minimum acceptable selling prices estimated for each model mine type
  - Upper bounds of new mine capacity for each region based upon planned mine openings
- Coal washing
  - Basic washing assumed for all bituminous coals
  - Deep-cleaning option available to lower sulfur content to meet New Source Performance Standard or a one-percent sulfur emission limitation for existing sources
	- 39 Regions
	- 19 Coal piles
	  - 3 Ranks of coal
	  - 6 Sulfur categories
	  - Metallurgical pile includes only the highest grades of coal
	- Utility Sector
	  - Point estimates for KWH sales by region
	  - KWH sales allocated to four load categories (base, intermediate, seasonal peak, and daily peak)
	  - Existing generating capacity utilized by model on basis of variable cost
	  - New generating capacity utilized by model on basis of full costs (including capital costs)
	  - Air pollution standards addressed explicitly
	  - Transmission links between regions
	  - Oil and gas prices fixed
	  - Coal prices determined from supply sector through transportation network

NON-UTILITY DEMAND	**TRANSPORTATION**
- Five non-utility sectors (metallurgical, export, industrial, residential/commercial, synthetics) - Point estimates of Btu's demanded - Allowable coals specified in terms of Btu and sulfur content - No price sensitivity	- Direct links - Cost based upon unit train or barge shipment rates - Lower bounds used to represent long-term contract commitments - Upper bounds could be used to represent transportation bottlenecks or limited capacity

Figure 1. Coal and Electric Utilities Model--Major Components (From CEUM Documentation [5], page II-2)

The linear programming (LP) matrix (Figure 2) presented on pages B-7 through B-11 illustrates the basic structure and the naming conventions used in the ICF Coal and Electric Utilities Model (CEUM) for one supply region, Virginia (VA), and one demand region, Western Pennsylvania (WP).

Each column in the LP matrix represents either a physical or a notional economic activity. Positive entries in a column represent an input into the associated activity; negative entries represent an output of the activity. The last entry in each column represents the annualized cost of operating each activity at unit level and forms the coefficient of that activity in the objective function. The numerical values appearing in the LP matrix, while representative, are used only for illustrative purposes.

Nine major types of activities appear in the illustrative LP matrix. These are:

- coal mining
- coal cleaning
- coal transportation
- oil/gas procurement
- coal procurement by non-utilities
- electricity generation from coal
- electricity generation from non-coal sources
- electricity transmission, delivery, and load management
- building electrical generating and scrubber capacity.

Each row of the LP matrix, except for the last, represents a constraint associated with a physical stock (coal, heat energy, electricity, etc.) or, in some cases, with a consumption requirement. Physical stocks may be of fixed size, exogenously specified, or of variable size, created by activities within the model. Constraints associated with stocks of variable size are called material balances; they force quantities created within the model to equal or exceed quantities used.

Seven major constraint categories appear in the illustrative LP matrix. These are:

- available coal reserves by mine type at supply regions
- coal stocks by coal type at supply regions (material balances)
- fuel "piles" at demand regions (material balances)
- non-utility energy requirements at demand regions
- electricity constraints, including electricity consumption requirements, and electricity supplies (material balances), at demand regions
- electrical generating and scrubber capacity constraints, including fixed generating capacity constraints for existing plants, material balances for capacities not yet built (new plants), and material balances for scrubber capacity on both existing and new plants
- new capacity building limitations for generating electricity

The following conventions have been adopted with respect to constraint rows in the LP matrix:

- constraints imposed by exogenous size limitations of existing stocks are specified with positive entries on the right-hand sides of the associated rows
- material balance constraints are specified with zero entries on the right-hand sides of the associated rows
- constraints imposed by exogenous consumption requirements are specified with negative entries on the right-hand sides of the associated rows
- negative entries in a constraint row indicate additions to a stock; positive entries indicate subtractions or use

The last row of the LP matrix designates the objective function. Its entries are the costs (1985 annuitized costs in 1978 dollars) of operating the associated activities at unit level. While the interpretation of most of these entries is straightforward, we note that the objective function coefficients for the electricity generation activities represent annualized O&M costs for all plants (existing and new) except for nuclear capacity which is modeled with its annualized fuel costs as part of its O&M expenses. The objective function coefficients for all building activities represent annualized capital costs, where a real annual fixed charge rate of 10% is used.

Each activity operates on stocks designated in one or more constraint categories. For example, consider Activity 1, SVAC1ZB. This is a coal mining activity in supply region VA, extracting coal type ZB from mine type C1ZB. There is a +1 entry in Row 1, associated with ZB coal reserves in mine type C1ZB in region VA, because these reserves are an input into the mining activity. There is a -1 entry in Row 7, the ZB coal type material balance row in region VA, because this material balance stock at supply region VA receives the output of the mining activity. The objective function entry for Activity 1 appears in Row 34. This quantity, 20.80, represents the cost (minimum acceptable real annuity price), in millions of dollars, of extracting 10^6 tons of ZB coal from mine type C1ZB in supply region VA.

In general, the various activities in the LP matrix have the following effects:

- Coal mining activities transfer coal from available coal reserves to coal stocks at supply regions.

- Coal cleaning activities transfer coal from a stock of one coal type to a stock of another coal type (always of lower sulfur level), allowing for cleaning losses. (There are also non-cleaning activities that transfer to a higher sulfur level coals that could be but are not deep-cleaned.)

- Coal transportation activities transfer coal from coal stocks at supply regions to fuel piles at demand regions.

- Oil/gas procurement activities place oil and gas in fuel piles at demand regions.

- Coal procurement activities by non-utilities remove coal from fuel piles in order to satisfy exogenous non-utility energy demands.

- Activities for electricity generation from coal remove coal from fuel piles, use electrical generating capacity and possibly scrubber capacity, and create electricity supplies.

- Activities for electricity generation from non-coal sources remove non-coal fuels from fuel piles, use electrical generating capacity, and create electricity supplies.

- Electricity transmission activities reduce electricity supplies in one region and increase them in another region, allowing for transmission losses. Electricity delivery activities reduce electricity supplies in order to satisfy exogenous electricity consumption requirements, allowing for distribution losses.

- Activities for building electrical generating or scrubbing capacity create new capacities. Exogenously specified limits may be imposed.

The unit of measurement is given for each activity variable and constraint in the illustrative LP matrix. For purposes of simplicity the time dimension has been omitted. All activity variables and constraints should be considered to be on a per-year basis except for those measured in capacity units of gigawatts (GW).

Figure 2. Illustrative LP Matrix for the ICF Coal and Electric Utilities Model

	Coal Mining (10^6 Tons)						Coal Cleaning (10^6 Tons)	
	1 S VA C1 ZB	2 S VA N1 ZB	3 S VA C1 HB	4 S VA N1 HB	5 S VA N1 HC	6 S VA C1 HD	7 C VA HC HB	8 C VA HC HD
1	1							
2		1						
3			1					
4				1				
5					1			
6						1		
7	-1	-1						
8			-1	-1			-.92	
9					-1		1	1
10						-1		-1
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								
33								
34	20.80	34.72	16.28	24.30	36.17	16.28	4.34	0

Figure 2. (continued)

Coal Transport (10^6 Tons)				Oil/Gas (Quads)	Coal Procurement by Non-Utilities (Quads)				
9 T VAWP CB	10 T VAWP ZB	11 T VAWP HB	12 T VAWP HD	13 TPI WP PG	14 D WP MT 01	15 D WP MT 02	16 D WP IN BB	17 D WP IN 03	
									1
									2
									3
									4
									5
									6
1	1								7
		1							8
									9
			1						10
-.027					.8	.8			11
	-.027	-.025			.2	.1	1	.5	12
			-.025			.1		.5	13
				-1					14
					-1	-1			15
							-1	-1	16
									17
									18
									19
									20
									21
									22
									23
									24
									25
									26
									27
									28
									29
									30
									31
									32
									33
6.96	6.96	6.96	6.96	2877					34

Figure 2. (continued)

Electricty Generation from Coal (10^9 KWH)						Electricity Generation Non-Coal (10^9 KWH)			
18 OWP O BB I	19 OWP E BB B	20 OWP E BD B	21 OWP P BD I	22 OWP N 01 B	23 OWP M BD I	24 OWP K PG I	25 OWP T PG Z	26 OWP Z NU B	
									1
									2
									3
									4
									5
									6
									7
									8
									9
									10
									11
.013	.009			.0046					12
		.009	.010	.0046	.010				13
						.011	.014		14
									15
									16
									17
									18
	-1	-1		-1				-1	19
-1			-1		-1	-1			20
							-1		21
									22
									23
.317									24
	.176	.176	.320						25
				.176	.317				26
						.317			27
							2.28		28
								.176	29
			.163						30
					.072				31
									32
									33
2.70	2.11	2.11	3.01	2.70	4.10	2.35	2.70	8.22	34

Figure 2. (continued)

Electricity (10^9 KWH)				Building Electrical Capacity (GW)				
Transmission		Delivery	Load	Coal	Other	Scrubbing		
27	28	29	30	31	32	33	34	
T WPNU	T WPCO	D WP	C WP	B WP	B WP	B WP	B WP	
EX	NW	EL XX	EL EL	CL 06	NU 16	S1 XX	S2 XX	
								1
								2
								3
								4
								5
								6
								7
								8
								9
								10
								11
								12
								13
								14
								15
								16
		-1						17
1	1	1.10	-1					18
			.75					19
			.20					20
			.05					21
-.90								22
	-.85							23
								24
								25
				-1				26
								27
								28
					-1			29
						-1		30
							-1	31
				1				32
					1			33
	1.41	0.82		70.84	113.34	17.0	17.0	34

Figure 2. (continued)

CONSTRAINT IDENTIFICATION

Constraint	Row Name	Row Number		VA = Supply Region WP = Demand Region
≤ 1.24	*	1		Available Coal Reserves (10^6 Tons)
≤ .12	*	2		
≤ .56	*	3		
≤ .08	*	4		
≤ .08	*	5		
≤ 1.27	*	6		
≤ 0	LC VA ZB	7		Coal Material Balances at Supply Regions (10^6 Tons)
≤ 0	LC VA HB	8		
≤ 0	LC VA HC	9		
≤ 0	LC VA HD	10		
≤ 0	LU WP MT	11	Coal	Fuel Material Balance "Piles" at Demand Regions (Quads)
≤ 0	LU WP BB	12	Coal	
≤ 0	LU WP BD	13	Coal	
≤ 0	LU WP PG	14	Oil/Gas	
= -.78	EU WP MT	15		Non-Utility Energy Requirements (Quads)
= -.13	EU WP IN	16		
= -70	EU WP XX	17	Consumption Requirement	Electricity (10^9 KWH)
≤ 0	LU WP EL	18	Material Balance--Total	
≤ 0	LU WP EB	19	Material Balance By Load Category	
≤ 0	LU WP EI	20		
≤ 0	LU WP EZ	21		
≤ 0	LU NU EB	22	Material Balance--Other Demand Regions	
≤ 0	LU CO EB	23		
≤ .50	LU WP 01	24	Existing Coal	Electrical Generating Capacity (GW)
≤ 5	LU WP 02	25		
≤ 0	LU WP 06	26	New Coal	
≤ .35	LU WP 20	27	Existing Non-Coal	
≤ .64	LU WP 17	28		
≤ 0	LU WP 16	29	New Non-Coal	
≤ 0	LU WP S1	30	Existing Plants	Scrubber Capacity (GW)
≤ 0	LU WP S2	31	New Plants	
≤ 10	LU WP CL	32	Coal	New Capacity Building Limits (GW)
= 5	*	33	Nuclear	
= (Min)	NUSCST	34	Objective Function	Total Cost (10^6\$)

*Upper bound constraint on activity variable.

APPENDIX C NAMING CONVENTIONS FOR THE CEUM LINEAR PROGRAMMING MATRIX*

This appendix details the naming conventions used in the column (activity variable) and row (constraint) structure of the CEUM LP matrix. A complete description of this type is not presented in the CEUM Documentation [5]. The LP matrix contains approximately 14,000 activity variables and 2000 constraints. In addition, there are on the order of 1000 nonbinding (free) rows used either to collect information or to force activity in the 1990 or later case years. The reader should note that definitions of supply regions, utility demand regions, and all BTU content levels and sulfur content levels can be found in the tables at the end of this appendix.

A. COLUMNS - Activity Variables

Coal Mining (10^6 Tons/year)

S(CR)(IT)(CT)

-coal supply columns, where

(CR) = coal region

(IT) = cost-of-extraction level

(CT) = coal type

(IT)(CT) = mine type

e.g., SVAC1ZB -- note that C1 refers to the first existing mine of coal type ZB; N1 would refer to the first new ZB mine; etc.

*This material also appears in [51].

<u>Coal Cleaning</u> (10^6 Tons/year)

C(CR)(CT_1)(CT_2)

-convert coal type CT_1 to CT_2, where the coal types that can be "deep cleaned" have sulfur levels C & E; the coal is either cleaned up to sulfur levels B & D, respectively, or not cleaned, in which case it is included in sulfur levels D & F, respectively.

e.g. CVAHCHB

<u>Coal Transportation</u> (10^6 Tons/year)

T(CR)(UR)(CT)

-transport coal type CT (in 10^6 tons/year) from coal region CR to demand region UR; in the demand region, each "coal pile" is in units of Quads (10^{15} BTUs), and BTU levels Z, M, and H are combined into B (bituminous).

e.g. TVAWPZB

T(CR)(UR)C(S)

-transport coal type C(S) into the metallurgical (coking coal) pile, MT, where C = BTU level Z, and S = sulfur levels A, B, or D.

e.g. TVAWPCB

Procurement of Other Fuels (Quads/year)

TPI(UR)OG

-provide old gas to demand region (UR)

TPI(UR)PG

-provide oil/gas to demand region (UR)

e.g. TPIWPPG

Note that in the model's more recent versions the energy form OG is no longer used; OG is replaced by DG and refers to distillate oil or gas for turbines, while PG refers to residual oil or gas for steam plants.

Coal Procurement by Non-Utilities (Quads/year)

D(UR)(OD)(UE)

-activity to satisfy non-utility demand of type (OD) using energy form (UE) in region (UR), where:

(OD) = MT (metallurgical coal)

= RC (residential/commercial)

= IN (industrial)

= EX (export)

= SY (synthetic fuel)

and:

(UE) = MT (metallurgical coal from MT pile)

= BA, BB, BD, BF, BG, BH,
SA, SB, SD, SF, SG, SH,
LA, LB, LD, LF, LG, LH } (steam coal from piles)

= OG (old gas)

= PG (oil/gas)

= HG (hydro or geothermal)

= NU (nuclear)

e.g. DWPINBB

D(UR)(OD)(BL)

-activity to satisfy non-utility coal demand of type (OD) using coal blend (BL) = 01, 02, ...in region (UR).

e.g. DWPMT01

<u>Electricity Generation from Coal</u> (10^9 KWH/year)

O(UR)(P)(UE)(L)

-operate in demand region (UR), coal plant type (P) using energy form (UE) in load mode (L), where:

(P) = O (old existing)

= E, F, G (existing w/o scrubber, subject to sulfur standards 1, 2, 3, respectively)

= S (existing w/existing scrubber)

= P, Q, R (existing w/o scrubber, build scrubber, subject to sulfur standards 1, 2, 3, respectively)

= N (new w/o scrubber, New Source Performance Standard -- NSPS)

= M (new w/scrubber, NSPS)

= 8 (new w/scrubber, Alternative New Source Performance Standards -- ANSPS)

= 0 (new MHD)

= 1 (new combined cycle)

= 2 (new coal gas turbine)

} Not used in the model' recent versions.

= 5, 6, 7 (existing with new conversion facility, subject to sulfur standards 1, 2, 3, respectively) etc.

and:

(L) = B (base)

= I (intermediate)

= P (seasonal peak)

= Z (daily peak)

e.g. OWPOBBI

O(UR)(P)(BL)(L)

-operate in demand region (UR), coal plant type (P) using coal blend (BL) in load mode (L), where (BL) = 01, 02, 03, ...etc.; note that these activities are unnecessary if coal mixing activities are employed (see page C-9).

e.g. OWPN01B

<u>Electricity Generation: Non-Coal</u> (10^9 KWH/year)

O(UR)(P)(UE)(L)

-operate in demand region (UR), non-coal plant type (P) using energy form (UE) = OG, PG, HG, or NU, in load mode, (L), where:

(P) = J (old gas steam)

= K (existing oil/gas steam)

= L (new oil/gas steam)

= T (existing oil/gas turbine)

= U (new oil/gas turbine)

= H (existing hydro)

= I (new hydro)

= Y (existing nuclear)

= Z (new nuclear)

etc.

e.g. OWPKPGI

<u>Electricity Transmission</u> (10^9 KWH/year)

T(UR_1)(UR_2)EX

-transmit baseload electricity from region (UR_1) to region (UR_2) using existing transmission links.

e.g. TWPNUEX

T(UR_1)(UR_2)NW

-transmit baseload electricity from region (UR_1) to region (UR_2) using new transmission links.

e.g. TWPCONW

<u>Electricity Delivery to Consumers - Demand</u> (10^9 KWH/year)

D(UR)ELXX

-activity to satisfy total electricity requirement by consumers (total sales) in demand region (UR); note that electricity generation will be greater than sales due to line losses.

e.g. DWPELXX

<u>Electricity Load Management</u> (10^9 KWH/year)

C(UR)ELEL

-activity that combines electricity from different load modes into a "total electricity pile" in demand region (UR).

e.g. CWPELEL

<u>Building Electrical Generating Capacity</u> (GW)

B(UR)(PT)(ID)

-build, in demand region (UR), new electrical generating capacity for power plants of type (PT) with identifier (ID), where:

(PT) = CL (coal, NSPS; on line by end of 1982)
= C9 (coal, ANSPS; on line after 1982)
= HG (hydro or geothermal)
= NU (nuclear)
= PT (oil/gas turbine)
= PS (oil/gas steam)
= NT (new technology)
= CV (conversion facility)
etc.

and:

(ID) = 06 (new bituminous coal plant, NSPS)
= 07 (new sub-bituminous coal plant, NSPS)
= 08 (new lignite coal plant, NSPS)
= 14 (new hydro plant)

= 16 (new nuclear plant)

= 18 (new oil/gas turbine plant)

= 21 (new oil/gas steam plant)

= 22 (new bituminous coal plant, ANSPS)

= 23 (new sub-bituminous coal plant, ANSPS)

= 24 (new lignite coal plant, ANSPS)

= 25, 26, 27 (new conversion facilities on existing coal plants, subject to sulfur standards 1, 2, 3, respectively)

= 28 (new MHD plant)

= 29 (new combined cycle plant)

= 30 (new coal gas turbine plant)

} Not used in the model's recent versions.

etc.

e.g. BWPCL06

<u>Building Scrubber Capacity</u> (GW)

B(UR)(ST)XX

-build, in demand region (UR), new scrubber capacity, where:

(ST) = S1 (existing plants)

= S2 (new plants, NSPS)

= S3 (new plants, ANSPS, sulfur level $\neq$ A)

= S4 (new plants, ANSPS, sulfur level = A)

e.g. BWPS1XX

<u>Coal Mixing</u> (Quads/year)

$MX(UR)(CT_1)(CT_2)(CT_3)$

-activity in demand region UR that mixes fractions of two coal types (coal pile fuels), CT_1 and CT_2, each with the same BTU level but different sulfur levels, to yield a unit of a third coal type, CT_3, with the same BTU level and a sulfur level in between those of CT_1 and CT_2.

e.g. MXWPBADB -- mixes coal types BA and BD to produce coal type BB.

Note that this type of activity is not represented in the illustrative LP matrix. If it is employed, there is no longer a need for operate activities using coal blends.

B. <u>ROWS - Constraints</u>

Constraints that represent simple bounds (upper, lower, or fixed) on activity variables are not named below. Nonbinding (free, accounting) rows are also not named below nor do they appear in the illustrative LP matrix of Appendix B. A descriptive list of the important constraint-types follows.

LC(CR)(CT) e.g. LCVAZB

-coal stocks (material balances) at supply region (CR) by coal type (CT); one row for each coal type in each supply region; 10^6 Tons/year.

LU(UR)(UE) e.g. LUWPMT

-fuel piles (material balances) of energy form (UE) at demand region (UR); both for utility and non-utility fuels; Quads/year

EU(UR)(OD)   e.g. EUWPMT

-exogenous non-utility energy requirements (demands) of type (OD) in demand region (UR); Quads/year.

EU(UR)XX   e.g. EUWPXX

-exogenous total electricity consumption requirement (demand) in demand region (UR); 10^9 KWH/year.

LU(UR)EL   e.g. LUWPEL

-total electricity supplies (material balance) in demand region (UR); 10^9 KWH/year.

LU(UR)E(L)   e.g. LUWPEB

-electricity supplies (material balances) by load category (L) in demand region (UR), where (L) = B, I, P, or Z; 10^9 KWH/year.

LU(UR)(ID)   e.g. LUWP01

-electrical generating capacity for plants identified by (ID) in demand region (UR), where (ID) = 01, 02, 03, ...; includes fixed generating capacity constraints for existing plants and material balances for new plant capacity; GW.

For new plants an ID listing is given on pages C-7 and C-8 For existing plants:

(ID) = 01 (old existing coal plants)
= 02, 03, 04 (existing coal plants subject to sulfur standards 1, 2, 3, respectively)
= 05 (existing coal plant w/existing scrubber)
= 09 (existing baseload hydro plant)
= 10 (existing intermediate load hydro plant)
= 11 (existing daily peaking hydro plant)
= 15 (existing nuclear plant)
= 17 (existing oil/gas turbine plant)
= 19 (existing old gas steam plant)
= 20 (existing oil/gas steam plant)
etc.

LU(UR)(ST) e.g. LUWPS1

-material balances for new scrubber capacity for existing plants (ST) = S1, or for new plants (ST) = S2, S3, S4, in demand region (UR); GW.

LU(UR)CL e.g. LUWPCL

-constraint row for total new coal plant capacity under NSPS, in demand region (UR); GW.

LU(UR)C9 e.g., LUWPC9

-constraint row for total new coal plant capacity under ANSPS, in demand region (UR); GW.

GA(CR)(UR)

-constraint row to force an aggregate or joint lower bound on coal transported between supply region (CR) and demand region (UR); note that this row-type does not appear in the illustrative LP matrix of Appendix B; 10^6 Tons/year.

GU(UR)S2

-constraint row to lower bound S2 scrubber capacity in demand region (UR); note that this row-type does not appear in the illustrative LP matrix of Appendix B; GW.

G(UR)(P)RET

-constraint row to lower bound retrofit scrubber capacity in demand region (UR) for coal plant types P, Q, and R; note that this row-type does not appear in the illustrative LP matrix of Appendix B; GW.

NUSCST

-objective function row; minimization of total cost in millions of dollars per year.

BTU CONTENT CATEGORIES AND CODES

Millions of BTU's per Ton	Code	Approximate Rank of Coal
≥26	Z	bituminous
23-25.99	H	bituminous
20-22.99	M	bituminous
15-19.99	S	sub-bituminous
<15	L	lignite

Source: Coal and Electric Utilities Model Documentation, [5], p. III-5.

SULFUR LEVEL CATEGORIES AND CODES

Pounds Sulfur per Million BTU's	Code	Justification
0.00-0.40	A	can be blended with higher sulfur coals to meet Federal new source performance standard
0.41-0.60	B	meets Federal new source performance standard
0.61-0.63	C	can be deep cleaned to meet new source performance standard (five percent decline in sulfur content)
0.64-0.83	D	roughly one percent sulfur (.01 x 2,000 pounds per ton ÷ 24 mmbtu/per ton = .833 pounds/mmbtu)
0.84-0.92	E	can be deep cleaned to meet one percent SIP standard (10 percent decline in sulfur content)
0.93-1.67	F	roughly two percent sulfur
1.68-2.50	G	roughly three percent sulfur
>2.50	H	greater than three percent sulfur

Source: Coal and Electric Utilities Model Documentation, [5], p. III-5.

SUPPLY REGION DEFINITIONS

PIES Region	CEUM Region	BOM Districts
Northern Appalachia	Pennsylvania (PA)	1, 2
	Ohio (OH)	4
	Maryland (MD)	1
	West Virginia, north (NV) 1/	3, 6
Central Appalachia	West Virginia, south (SV)	7, 8
	Virginia (VA)	7, 8
	Kentucky, east (EK)	8
	Tennessee (TN)	8, 13
Southern Appalachia	Alabama (AL)	13
Midwest	Illinois (IL)	10
	Indiana (IN)	11
	Kentucky, west (WK)	9
Central West	Iowa (IA)	12
	Missouri (MO)	15
	Kansas (KN)	15
	Arkansas (AR)	14
	Oklahoma (OK)	14, 15
Gulf	Texas (TX)	15
Eastern Northern Great Plains	North Dakota (ND)	21
	South Dakota (SD)	21
	Montana, east (EM) 2/	22
Western Northern Great Plains	Montana, west (WM)	22
	Wyoming (WY)	19
	Colorado, north (CN)	16
Rockies	Colorado, south (CS)	17
	Utah (UT)	20
Southwest	Arizona (AZ)	18
	New Mexico (NM)	17, 18
Northwest	Washington (WA)	23
Alaska	Alaska (AK)	23

1/ Includes all of Nicholas County.

2/ Includes the following counties: Carter, Daniels, Fallon, McCone, Prairie, Richland, Roosevelt, Sheridan, Valley, and Widaux.

Source: Coal and Electric Utilities Documentation, [5], p. III-3.

REGIONAL DEFINITIONS FOR CEUM DEMAND REGIONS

Census Region	CEUM Region	State	Counties
New England	MV	Maine	All
		Vermont	All
		New Hampshire	All
	MC	Massachusetts	All
		Connecticut	All
		Rhode Island	All
Middle Atlantic	NU	New York, upstate	All counties not in New York, downstate
	PJ	New York, downstate	Suffolk, Orange, Putnam, Bronx, Rockland, Richmond, Nassau, Weschester, New York, Queens, Kings
		New Jersey	All
		Pennsylvania, east	Wayne, Pike, Monroe, Northhampton Bucks, Montgomery, Philadelphia, Delaware, Chester, York, Lancaster, Dauphin, Lebanon, Berks, Schuylkill, Lehigh, Carbon, Susquehanna, Wyoming, Lackawanna, Luzerne, Columbia, Montour, Northumberland, Union, Snyder, Juniata, Perry, Cumber-land, Adams, Franklin
	WP	Pennsylvania, west	All counties not in Pennsylvania, east
South Atlantic	VM	Virginia	All
		Maryland	All
		Delaware	All
		District of Columbia	
	WV	West Virginia	All
	CA	North Carolina	All
		South Carolina	All
	GF	Georgia	All
		Florida, north	All counties not in Florida, south
	SF	Florida, south	Nassau, Duval, Baker, Union, Bradford, Clay, St. Johns, Putnam, Flagler, Volusia, Indian River, Okeechobee, Martin, St. Lucie, Manatee, Sarasota, DeSota, Charlotte, Glades, Palm Beach, Lee, Hendry, Collier, Broward, Monroe, Dade
East North Central	ON	Ohio, north	Lucas, Ottawa, sandusky, Erie, Lorain, Cuyahoga, Lake, Ashtabula

REGIONAL DEFINITIONS FOR CEUM DEMAND REGIONS

Census Region	CEUM Region	State	Counties
	OM	Ohio, central	All counties not in Ohio, north or Ohio, south
	OS	Ohio, south	Hamilton, Clermont, Brown, Highland, Adams, Pike, Scioto, Lawrence, Gallia, Jackson, Meigs, Athens, Washington, Morgan, Noble, Monroe, Belmont, Harrison, Jefferson, Columbiana
	MI	Michigan	All
	IL	Illinois	All
	IN	Indiana	All
	WI	Wisconsin	All
st South Central	EK	Kentucky, east	Mason, Lewis, Fleming, Bath, Montgomery, Menifee, Clark, Powell, Madison, Estill, Jackson, Rockcastle, Pulaski, Laurel, Clinton, Wayne, McCreary, Greenup, Rowan, Carter, Boyd, Elliott, Lawrence, Morgan, Johnson, Martin, Wolfe, Magoffin, Floyd, Pike, Lee, Breathitt, Knott, Owsley, Perry, Letcher, Clay, Leslie, Knox, Bell, Harlan, Whitley
	WK	Kentucky, west	All counties not in Kentucky, east
	ET	Tennessee, east	Pickett, Fentress, Scott Morgan, Cumberland, Bledsoe, Sequatchie, Marion, Hamilton, Rhea, Meigs, Roan, Campbell, Claiborne, Union, Anderson, Knox Loudon, Blount McMinn, Monroe, Bradley, Polk, Hancock, Hawkins, Grainger, Hamblen, Jefferson, Sevier, Cocke, Greene, Sullivan, Washington, Unicoi, Carter, Johbson
	WT	Tennessee, west	All counties not in Tennessee, east
	AM	Alabama	All
		Mississippi	All
st North Central	DM	North Dakota	All
		South Dakota	All
		Minnesota	All
	KN	Kansas	All
		Nebraska	All
	IA	Iowa	All
	MO	Missouri	All
st South Central	AO	Arkansas	All
		Oklahoma	All
		[illegible]	[illegible]

REGIONAL DEFINITIONS FOR CEUM DEMAND REGIONS

Census Region	CEUM Region	State	Counties
	TX	Texas	All
Mountain	MW	Montana	All
		Wyoming	All
		Idaho	All
	CO	Colorado	All
	UN	Utah	All
		Nevada	All
	AN	Arizona	All
		New Mexico	All
Pacific	WO	Washington	All
		Oregon	All
	CN	California, north	All counties not in California, south
	CS	California, south	San Diego, Imperial, Orange, Sant Barbara, Ventura, Los Angeles, San Bernadino, Kern, Inyo, Mono

Source: Coal and Electric Utilities Documentation, [5], pp. III-57 to III-59.

APPENDIX D - DETAILED MATHEMATICAL FORMULATION OF THE CEUM *

In this section a detailed mathematical formulation of the basic set of equations employed in the ICF Coal and Electric Utilities Model is presented. An explicit formulation of this type is not presented in the CEUM documentation. This formulation does not necessarily adhere to the CEUM naming conventions documented in Appendix C.

A. Definition of Subscript Categories

Note that an underscore on a subscript implies that a particular value of the subscript category is being used.

- CR = coal supply region.
- IT = cost-of-extraction level associated with step-heights on the appropriate coal supply curve.
- HL = BTU content level, in supply regions; the levels are $\underline{Z}$, $\underline{H}$, $\underline{M}$, $\underline{S}$, $\underline{L}$; (see Appendix C, page C-13).
- SL = sulfur content level; the levels are $\underline{A}$, $\underline{B}$, $\underline{C}$, $\underline{D}$, $\underline{E}$, $\underline{F}$, $\underline{G}$, $\underline{H}$, with levels $\underline{C}$ and $\underline{E}$ omitted in demand regions; (see Appendix C, page C-13).
- UR = utility demand region.
- UE = utility fuel type; a listing of fuel types is given in Appendix C on page C-4. (Note that the coal fuel types in each demand region are identified by rank and sulfur level. The ranks are $\underline{B}$, $\underline{S}$, and $\underline{L}$, corresponding to bituminous, sub-bituminous, and lignite, respectively, where $\underline{B}$ coal comes from the three highest BTU categories, $\underline{Z}$, $\underline{H}$, and $\underline{M}$, in the supply regions.)
- OD = non-utility demand type; a listing of demand types is given in Appendix C on page C-3.

*This material also appears in [51].

BLM = coal blend type for metallurgical demand; e.g. BLM = 11, 12, ...

BLE = coal blend type for export demand; e.g. BLE = 10, 13, ...

P = plant type for electricity generation activities; a listing of both existing, P_e, and new plant types, P_n, is given in Appendix C on pages C-4, C-5, and C-6.

L = load mode; a listing of load modes is given in Appendix C on page C-5.

ID = plant type identifier; a listing is given in Appendix C on pages C-7, and C-8 for new plant type identifiers, ID_n, and on page C-11 for existing plant type identifiers, ID_e.

PT = plant type for build activities; a listing is given in Appendix C on page C-7.

B. Definition of Parameters

ℓ_C = fractional coal loss in deep cleaning.

$\ell_D(UR)$ = fractional electricity distribution loss in delivery to consumers in demand region UR, measured in terms of the additional fraction of pre-delivered electricity required to produce a unit of delivered electricity.

$\ell_{TE}(UR_i,UR_j)$, $\ell_{TN}(UR_i,UR_j)$ = fractional electricity transmission losses over existing and new lines, respectively, from source region UR_i to sink region UR_j.

ℓ_{PS} = fractional electricity loss in the pumped storage process, measured in terms of the additional fraction of baseload electricity required to produce a unit of daily peaking electricity from pumped storage.

hc(CR,HL) = heat content of coal of BTU level HL, in Quads/10^6 Tons, in supply region CR.

hr(UR,P,L) = heat rate in Quads/10^9 KWH, in demand region UR, for plant type P, operating in load mode L.

f_{UE}(BLM) = fraction of fuel type UE in metallurgical blend type BLM.

f_{UE}(BLE) = fraction of fuel type UE in export blend type BLE.

f_L(UR) = fraction, in load mode L, of total electricity supplies in demand region UR.

f_{SC}(P,SL,L) = partial scrubbing fraction; the fraction of a plant type's exhaust required to be scrubbed, associated with a scrubber on plant type P, operating in load mode L, using coal of sulfur level SL.

CF(UR,L) = capacity factor (in decimal form) for plants operating in load mode L, in demand region UR.

C. Definition of Activity Variables

Coal Mining--Supply (10^6 Tons/year): $S_{CR,IT,HL,SL}$

Coal Cleaning (10^6 Tons/year): C_{CR,HL,SL_1,SL_2}

Coal Transportation (10^6 Tons/year): $T_{CR,UR,HL,SL}$

Oil/Gas Procurement (Quads/year): $TP_{UR,UE}$, UE = $\underline{OG}$, $\underline{PG}$

Non-Utility Coal Procurement (Quads/year): $D_{UR,OD,UE}$, OD $\neq$ $\underline{MT}$, $\underline{EX}$

$D_{UR,\underline{MT},BLM}$, OD = $\underline{MT}$

$D_{UR,\underline{EX},BLE}$, OD = $\underline{EX}$

Electricity Generation (10^9 KWH/year): $O_{UR,P,UE,L}$

Electricity Transmission (10^9 KWH/year)

Existing Lines: TRE_{UR_i,UR_j}

New Lines: TRN_{UR_i,UR_j}

Electricity Delivery--Distribution to Users (10^9 KWH/year): DEL_{UR}

Electricity Load Management (10^9 KWH/year): CEL_{UR}

Building Electrical Generating Capacity (GW): BP_{UR,PT,ID_n}

Building Scrubber Capacity (GW): $BS1_{UR}$, $BS2_{UR}$, $BS3_{UR}$, $BS4_{UR}$

D. Constraint Equations

1. Available Coal Reserves (10^6 Tons/year)

$$S_{CR,IT,HL,SL} \leq S^{*}_{CR,IT,HL,SL} \qquad (1)$$

where $S^{*}_{CR,IT,HL,SL}$ represents exogenous supply limitations on coal types, by mine type in each supply region.

2. Coal Stocks by Coal Type at Supply Regions--Material Balances (10^6Tons/year)

(a) For HL $\neq \underline{Z}$ and SL = $\underline{A}$, or for any HL with SL = $\underline{G}$ or $\underline{H}$:

$$-\sum_{IT} S_{CR,IT,HL,SL} + \sum_{UR} T_{CR,UR,HL,SL} \leq 0 \qquad (2)$$

(b) For HL $\neq \underline{Z}$ and SL = $\underline{B}$:

$$-\sum_{IT} S_{CR,IT,HL,\underline{B}} - (1 - \ell_C) C_{CR,HL,\underline{C},\underline{B}} + \sum_{UR} T_{CR,UR,HL,\underline{B}} \leq 0 \qquad (3)$$

(c) For any HL and SL = $\underline{C}$:

$$-\sum_{IT} S_{CR,IT,HL,\underline{C}} + C_{CR,HL,\underline{C},\underline{B}} + C_{CR,HL,\underline{C},\underline{D}} \leq 0 \qquad (4)$$

(d) For HL $\neq \underline{Z}$ and SL = $\underline{D}$:

$$-\sum_{IT} S_{CR,IT,HL,\underline{D}} - C_{CR,HL,\underline{C},\underline{D}} - (1 - \ell_C) C_{CR,HL,\underline{E},\underline{D}}$$

$$+ \sum_{UR} T_{CR,UR,HL,\underline{D}} \leq 0 \qquad (5)$$

(e) For any HL and SL = $\underline{E}$:

$$-\sum_{IT} S_{CR,IT,HL,\underline{E}} + C_{CR,HL,\underline{E},\underline{D}} + C_{CR,HL,\underline{E},\underline{F}} \leq 0 \qquad (6)$$

(f) For any HL and SL = $\underline{F}$:

$$-\sum_{IT} S_{CR,IT,HL,\underline{F}} - C_{CR,HL,\underline{E},\underline{F}} + \sum_{UR} T_{CR,UR,HL,\underline{F}} \leq 0 \qquad (7)$$

(g) For HL = $\underline{Z}$ and SL = $\underline{A}$, $\underline{B}$, or $\underline{D}$, in Equations (2), (3), and (5), respectively: replace $T_{CR,UR,\underline{Z},SL}$ by $T_{CR,UR,\underline{C},SL} + T_{CR,UR,\underline{Z},SL}$. (A definition of activity $T_{CR,UR,\underline{C},SL}$ is given in Appendix C on page C-2).

3. Fuel Piles at Demand Regions--Material Balances (Quads/year)

For simplicity we ignore coal blending for industrial coal demand, and electricity generation activities that use coal blends. Coal mixing activities are also excluded.

(a) For UE = $\underline{BA}$, $\underline{BB}$, $\underline{BD}$, $\underline{BF}$, $\underline{BG}$, $\underline{BH}$ and HL = $\underline{Z}$, $\underline{H}$, $\underline{M}$:

$$-\sum_{CR} \sum_{HL=\underline{Z},\underline{H},\underline{M}} hc(CR,HL)\ T_{CR,UR,HL,SL} + \sum_{BLM} f_{UE}(BLM)\ D_{UR,\underline{MT},BLM}$$

$$+ \sum_{BLE} f_{UE}(BLE)\ D_{UR,\underline{EX},BLE} + \sum_{OD \neq \underline{MT},\underline{EX}} D_{UR,OD,UE}$$

$$+\sum_{P} \sum_{L} hr(UR,P,L)\ O_{UR,P,UE,L} \leq 0 \qquad (8)$$

(b) For UE = $\underline{SA}$, $\underline{SB}$, $\underline{SD}$, $\underline{SF}$, $\underline{SG}$, $\underline{SH}$, $\underline{LA}$, $\underline{LB}$, $\underline{LD}$, $\underline{LF}$, $\underline{LG}$, $\underline{LH}$:

$$-\sum_{CR} hc(CR,HL)\ T_{CR,UR,HL,SL} + \sum_{OD \neq \underline{MT},\underline{EX}} D_{UR,OD,UE}$$

$$+\sum_{P} \sum_{L} hr(UR,P,L)\ O_{UR,P,UE,L} \leq 0 \qquad (9)$$

(c) For UE = $\underline{MT}$, HL = $\underline{Z}$, and SL = $\underline{A}$, $\underline{B}$, or $\underline{D}$:

$$-\sum_{CR} hc(CR,\underline{Z})\, T_{CR,UR,\underline{C},SL} + \sum_{BLM} f_{\underline{MT}}(BLM)\, D_{UR,\underline{MT},BLM}$$

$$+ \sum_{BLE} f_{\underline{MT}}(BLE)\, D_{UR,\underline{EX},BLE} \leq 0 \qquad (10)$$

(d) For UE = $\underline{OG}$,$\underline{PG}$:

$$-TP_{UR,UE} + \sum_{P}\sum_{L} hr(UR,P,L)\, O_{UR,P,UE,L} \leq 0 \qquad (11)$$

4. Lower Bounds on Transportation Activities (if required)

(10^6 Tons/year)

$$T_{CR,UR,HL,SL} \geq T^*_{CR,UR,HL,SL} \qquad (12)$$

where $T^*_{CR,UR,HL,SL}$ represents exogenous lower bounds on transport between regions CR and UR.

5. Upper Bounds on Old Gas Procurement (Quads/year)

$$TP_{UR,\underline{OG}} \leq TPOG^*_{UR} \qquad (13)$$

where $TPOG^*_{UR}$ represents exogenous upper bounds on procurement of old gas in demand regions UR.

6. Non-Utility Energy Requirements at Demand Regions (Quads/year)

(a) For OD $\neq$ $\underline{MT}$ or $\underline{EX}$:

$$-\sum_{UE} D_{UR,OD,UE} = -D^*_{UR,OD} \qquad (14)$$

where $D^*_{UR,OD}$ represents exogenous consumption requirements of demand type OD in demand regions UR.

(b) For OD = MT:

$$- \sum_{BLM} D_{UR,\underline{MT},BLM} = -DMT^{*}_{UR} \tag{15}$$

where DMT^{*}_{UR} represents exogenous metallurgical coal demand in regions UR.

(c) For OD = EX:

$$- \sum_{BLE} D_{UR,\underline{EX},BLE} = -DEX^{*}_{UR} \tag{16}$$

where DEX^{*}_{UR} represents exogenous export coal demand in regions UR.

7. Electricity Consumption Requirements (10^9 KWH/year)

$$-DEL_{UR} = -DEL^{*}_{UR} \tag{17}$$

where DEL^{*}_{UR} represents exogenous electricity consumption requirements in demand regions UR.

8. Total Electricity Supplies--Material Balances (10^9 KWH/year)

$$\sum_{UR_j} \left(TRE_{UR_i,UR_j} + TRN_{UR_i,UR_j}\right) + \left(1 + \ell_D(UR_i)\right) DEL_{UR_i} - CEL_{UR_i} \leq 0 \tag{18}$$

where UR_i represents source regions and UR_j represents sink regions.

9. Electricity Supplies by Load Category--Material Balances (10^9 KWH/year)

(a) For L = B:

$$- \sum_{P} \sum_{UE} O_{UR_j,P,UE,\underline{B}} + (1 + \ell_{PS}) \sum_{P=\underline{H},\underline{I}} O_{UR_j,P,\underline{HG},\underline{Z}} + f_{\underline{B}}(UR_j)\, CEL_{UR_j} - \sum_{UR_i} \left[\left(1 - \ell_{TE}(UR_i,UR_j)\right) TRE_{UR_i,UR_j} + \left(1 - \ell_{TN}(UR_i,UR_j)\right) TRN_{UR_i,UR_j}\right] \leq 0 \tag{19}$$

(b) For L ≠ B:

$$- \sum_{P} \sum_{UE} O_{UR,P,UE,L} + f_L(UR)\ CEL_{UR} \leq 0 \qquad (20)$$

10. Electrical Generating Capacity for Existing Plants (GW)

Let:

P_e = existing plant types, and

ID_e = plant type identifiers for existing plant types.

Recall from the lists given in Appendix C that:

P_e = (O, E, F, G, S, P, Q, R, H, Y, T, J, K), and

ID_e = (01, 02, 03, 04, 05, 02, 03, 04, (09, 10, 11), 15, 17, 19, 20).

Note that there are three identifiers, one for each of load modes L = B, I and Z, associated with existing plant type H.

(a) For P_e = O, S, Y, T, J, K:

$$\sum_{UE} \sum_{L} \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,P_e,UE,L} \leq EGW^*_{UR,ID_e} \qquad (21)$$

where EGW^*_{UR,ID_e} represents exogenous electrical generating capacity limits on existing plant types identified by ID_e in demand regions UR.

(b) For P_e = E and P:

$$\sum_{P_e=E,P} \sum_{UE} \sum_{L} \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,P_e,UE,L}$$

$$+ BP_{UR,CV,25} \leq EGW^*_{UR,02} \qquad (22)$$

(c) For $P_e = \underline{F}$ and $\underline{Q}$:

$$\sum_{P_e=\underline{F},\underline{Q}} \sum_{UE} \sum_{L} \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,P_e,UE,L}$$

$$+ BP_{UR,\underline{CV},\underline{26}} \leq EGW^{*}_{UR,\underline{03}} \qquad (23)$$

(d) For $P_e = \underline{G}$ and $\underline{R}$:

$$\sum_{P_e=\underline{G},\underline{R}} \sum_{UE} \sum_{L} \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,P_e,UE,L}$$

$$+ BP_{UR,\underline{CV},\underline{27}} \leq EGW^{*}_{UR,\underline{04}} \qquad (24)$$

(e) For $P_e = \underline{H}$ and $L = \underline{B}, \underline{I}, \underline{Z}$:

$$\left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,\underline{H},\underline{HG},L} \leq EGW^{*}_{UR,ID_e} \qquad (25)$$

11. Electrical Generating Capacity for New Plants--Material Balances (GW)

Let:

P_n = new plant types, and

ID_n = plant type identifiers for new plant types.

Recall from the lists given in Appendix C that:

P_n = ($\underline{N}$, $\underline{M}$, $\underline{8}$, $\underline{0}$, $\underline{1}$, $\underline{2}$, $\underline{5}$, $\underline{6}$, $\underline{7}$, $\underline{I}$, $\underline{Z}$, $\underline{U}$, $\underline{L}$),

ID_n = (($\underline{06}$, $\underline{07}$, $\underline{08}$), ($\underline{06}$, $\underline{07}$, $\underline{08}$), ($\underline{22}$, $\underline{23}$, $\underline{24}$), $\underline{28}$, $\underline{29}$, $\underline{30}$, $\underline{25}$, $\underline{26}$, $\underline{27}$, $\underline{14}$, $\underline{16}$, $\underline{18}$, $\underline{21}$), and

PT = ($\underline{CL}$, $\underline{CL}$, $\underline{C9}$, $\underline{NT}$, $\underline{NT}$, $\underline{NT}$, $\underline{CV}$, $\underline{CV}$, $\underline{CV}$, $\underline{HG}$, $\underline{NU}$, $\underline{PT}$, $\underline{PS}$).

Note that there are three identifiers, one for each coal rank, associated with new plant types $P_n = \underline{N}$, $\underline{M}$ and $\underline{8}$.

(a) For $P_n \neq \underline{N}$, $\underline{M}$, or $\underline{8}$:

$$\sum_{UE} \sum_{L} \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,P_n,UE,L} - BP_{UR,PT,ID_n} \leq 0 \qquad (26)$$

(b) For $P_n = \underline{N}$ and $\underline{M}$ and UE = $\underline{BA}$, $\underline{BB}$, $\underline{BD}$, $\underline{BF}$, $\underline{BG}$, $\underline{BH}$:

$$\sum_{P_n=\underline{N},\underline{M}} \sum_{UE} \sum_{L} \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,P_n,UE,L} - BP_{UR,\underline{CL},\underline{06}} \leq 0 \qquad (27)$$

(c) For $P_n = \underline{N}$ and $\underline{M}$ and UE = $\underline{SA}$, $\underline{SB}$, $\underline{SD}$, $\underline{SF}$, $\underline{SG}$, $\underline{SH}$ use Equation (27) with $BP_{UR,\underline{CL},\underline{06}}$ replaced by $BP_{UR,\underline{CL},\underline{07}}$.

(d) For $P_n = \underline{N}$ and $\underline{M}$ and UE = $\underline{LA}$, $\underline{LB}$, $\underline{LD}$, $\underline{LF}$, $\underline{LG}$, $\underline{LH}$ use Equation (27) with $BP_{UR,\underline{CL},\underline{06}}$ replaced by $BP_{UR,\underline{CL},\underline{08}}$.

(e) For $P_n = \underline{8}$ and UE = $\underline{BA}$, $\underline{BB}$, $\underline{BD}$, $\underline{BF}$, $\underline{BG}$, $\underline{BH}$:

$$\sum_{UE} \sum_{L} \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,\underline{8},UE,L} - BP_{UR,\underline{C9},\underline{22}} \leq 0 \qquad (28)$$

(f) For $P_n = \underline{8}$ and UE = $\underline{SA}$, $\underline{SB}$, $\underline{SD}$, $\underline{SF}$, $\underline{SG}$, $\underline{SH}$ use Equation (28) with $BP_{UR,\underline{C9},\underline{22}}$ replaced by $BP_{UR,\underline{C9},\underline{23}}$.

(g) For $P_n = \underline{8}$ and UE = $\underline{LA}$, $\underline{LB}$, $\underline{LD}$, $\underline{LF}$, $\underline{LG}$, $\underline{LH}$ use Equation (28) with $BP_{UR,\underline{C9},\underline{22}}$ replaced by $BP_{UR,\underline{C9},\underline{24}}$.

12. <u>Scrubber Capacity on Existing Coal Plants--Material Balances</u> (GW)

$$\sum_{P_e=\underline{P},\underline{Q},\underline{R}} \sum_{UE} \sum_{L} f_{SC}(P_e,SL,L) \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,P_e,UE,L}$$

$$- BS1_{UR} \leq 0 \qquad (29)$$

13. Scrubber Capacity on New Coal Plants--Material Balances (GW)

(a) NSPS (New Source Performance Standard) Coal Plants, $P_n = \underline{M}$:

$$\sum_{UE} \sum_{L} f_{SC}(\underline{M},SL,L) \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,\underline{M},UE,L} - BS2_{UR} \leq 0 \quad (30)$$

(b) ANSPS (Alternative NSPS) Coal Plants, $P_n = \underline{8}$, $SL \neq \underline{A}$:

$$\sum_{UE} \sum_{L} f_{SC}(\underline{8},SL,L) \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,\underline{8},UE,L} - BS3_{UR} \leq 0 \quad (31)$$

(c) ANSPS Coal Plants, $P_n = \underline{8}$, $SL = \underline{A}$:

$$\sum_{UE=\underline{BA},\underline{SA},\underline{LA}} \sum_{L} f_{SC}(\underline{8},\underline{A},L) \left[(8.76)\ CF(UR,L)\right]^{-1} O_{UR,\underline{8},UE,L}$$

$$- BS4_{UR} \leq 0 \quad (32)$$

14. New Capacity Building Limits (GW)

(a) NSPS Coal Plants, $PT = \underline{CL}$:

$$\sum_{ID_n=\underline{06},\underline{07},\underline{08}} BP_{UR,\underline{CL},ID_n} \leq BCL^*_{UR} \quad (33)$$

where BCL^*_{UR} represents exogenous new capacity limits on NSPS coal plants in demand regions UR.

(b) ANSPS Coal Plants, $PT = \underline{C9}$:

$$\sum_{ID_n=\underline{22},\underline{23},\underline{24}} BP_{UR,\underline{C9},ID_n} \leq BC9^*_{UR} \quad (34)$$

where $BC9^*_{UR}$ represents exogenous new capacity limits on ANSPS coal plants in demand regions UR.

(c) Nuclear Plants, PT = $\underline{NU}$, ID_n = $\underline{16}$:

$$BP_{UR,\underline{NU},\underline{16}} = BNU^*_{UR} \qquad (35)$$

where BNU^*_{UR} represents exogenously specified fixed nuclear capacity in demand regions UR.

(d) Hydro Plants, PT = $\underline{HG}$, ID_n = $\underline{14}$:

$$BP_{UR,\underline{HG},\underline{14}} = BHG^*_{UR} \qquad (36)$$

where BHG^*_{UR} represents exogenously specified fixed hydro capacity in demand regions UR.

(e) Oil/Gas Steam Plants, PT = $\underline{PS}$, ID_n = $\underline{21}$:

$$BP_{UR,\underline{PS},\underline{21}} = 0.0 \qquad (37)$$

(f) There are no capacity building limits for:

Oil/Gas Turbine Plants: PT = $\underline{PT}$, ID_n = $\underline{18}$,

New Technology Plants: PT = $\underline{NT}$, ID_n = $\underline{28}$, $\underline{29}$, $\underline{30}$,

Conversion Facilities: PT = $\underline{CV}$, ID_n = $\underline{25}$, $\underline{26}$, $\underline{27}$.

15. <u>Lower Bounds on Scrubber Capacity for NSPS Coal Plants</u> (GW)

$$\sum_{UE} \sum_{L} \left[(8.76)\ CF(UR,L)\right]^{-1} \ O_{UR,\underline{M},UE,L} \geq BS2^*_{UR} \qquad (38)$$

where $BS2^*_{UR}$ represents exogenous lower bounds on scrubber capacity for NSPS coal plants in demand regions UR.

E. Objective Function (10^6 \$/year)

$$\text{Minimize} \left\{ \sum_{CR} \sum_{IT} \sum_{HL} \sum_{SL} RACP(CR,IT,HL,SL)\ S_{CR,IT,HL,SL} \right.$$

$$+ DCC \sum_{CR} \sum_{HL} \left(C_{CR,HL,\underline{C},\underline{B}} + C_{CR,HL,\underline{E},\underline{D}} \right)$$

$$+ \sum_{CR} \sum_{UR} TC(CR,UR) \left[\sum_{HL} \sum_{SL} T_{CR,UR,HL,SL} + \sum_{SL=\underline{A},\underline{B},\underline{D}} T_{CR,UR,\underline{C},SL} \right]$$

$$+ \sum_{UR} \sum_{UE=\underline{OG},\underline{PG}} FC(UR,UE)\ TP_{UR,UE}$$

$$+ \sum_{UR} \sum_{P} \sum_{UE} \sum_{L} OMC(P,UE,L)\ O_{UR,P,UE,L}$$

$$+ \sum_{UR_i} \sum_{UR_j} TRC(UR_i,UR_j)\ TRN_{UR_i,UR_j}$$

$$+ \sum_{UR} DC(UR)\ DEL_{UR}$$

$$+ \sum_{UR} \sum_{PT} \sum_{ID_n} ACP(UR,PT,ID_n)\ BP_{UR,PT,ID_n}$$

$$+ \sum_{UR} \left[ACS1(UR)\ BS1_{UR} + ACS2(UR)\ BS2_{UR} + ACS3(UR)\ BS3_{UR} \right.$$

$$\left. \left. + ACS4(UR)\ BS4_{UR} \right] \right\} \qquad (39)$$

where:

RACP = real annuity coal price (see Appendix E), \$/Ton

DCC = deep cleaning cost, \$/Ton

TC = transportation cost, \$/Ton

FC = non-coal fuel cost, 10^6 \$/Quad

OMC = O&M cost (includes fuel cost for nuclear plants), mills/KWH

TRC = transmission cost for new lines, mills/KWH

DC = electricity delivery cost, mills/KWH

ACP = annualized capital cost for new power plants, \$/KW-yr

ACS1 = annualized capital cost for scrubber-type S1, \$/KW-yr

ACS2 = annualized capital cost for scrubber-type S2, \$/KW-yr

ACS3 = annualized capital cost for scrubber-type S3, \$/KW-yr

ACS4 = annualized capital cost for scrubber-type S4, \$/KW-yr.

F. Additional Details

There are a few additional minor factors that would complicate the preceding mathematical formulation without substantially adding to a further understanding of the model. For those interested in such additional precise details see Appendix F of this report and several descriptive memoranda appearing in Appendix E of [5]. These details, not explicitly accounted for in the preceding mathematical formulation, concern the following:

1. (a) Heat rate penalties and capacity factor penalties due to full or partial scrubbing.

   (b) Capital cost and O&M cost savings due to partial rather than full scrubbing.

   (c) The fact that the partial scrubbing fraction is a function of the relevant environmental standard and the scrubber efficiency, in addition to the sulfur level of the coal being scrubbed.

2. Coal blending for industrial coal demand and coal mixing activities.

3. Joint (aggregate) lower bounds on total coal transported from supply to demand regions, where required.

4. (a) Both upper and lower bounds on electricity transmission via existing lines between demand regions, where required.

   (b) Lower bounds on electricity transmission via new lines between demand regions, where required.

5. Some changes in the CEUM's more recent versions pointed out in parts of Appendix C, such as the use of $\underline{DG}$ in place of $\underline{OG}$, the omission of new technologies, etc.

APPENDIX E THE CONCEPT OF MINIMUM ACCEPTABLE REAL ANNUITY COAL PRICES--A FORMULATION*

The ultimate objective of the coal supply component of the ICF Coal and Electric Utilities Model is to produce supply schedules for coal as viewed by purchasers. Supply schedules reflecting the producer's point of view are derived, and these schedules are then adjusted to reflect the purchaser's point of view. A central concept of this procedure is the notion of minimum acceptable real annuity coal prices. The CEUM Documentation [5] does not adequately describe this concept; our own construction of it is included below.

ICF's objectives in employing the minimum acceptable real annuity coal pricing concept were twofold. First, the coal prices ought to reflect the stream of required prices for the entire life of the mine, and second, the prices must be internally consistent with other inflating price series such as oil/gas prices, coal transportation costs, and electric utility O&M costs. The objectives were achieved by the use of real annuity prices that implicitly inflate at the general rate of inflation, thereby remaining constant in real terms. All other inflating series employed in the CEUM are expressed in similar terms.

In this appendix the coal pricing logic employed in the CEUM and in its more recent versions is explained in a step-by-step manner starting with the calculation of the coal producer's minimum acceptable selling price. The

*This material also appears in [49].

analysis employs two relevant Verification Corrections (Points 7 and 8) from Section 2.4.2.

1. For each model mine type in each supply region the present value of capital investment (as of the case year, 1985) is calculated using a given initial capital cost and a given distribution of deterred capital costs over the mine lifetime.*

The present value of the total capital investment of coal producers, PV_{CAP} (in case year dollars, as of the beginning of the case year, 1985) is given by:

$$PV_{CAP} = PV_{IC} + PV_{DC}$$

$$PV_{IC} = IC_{75}(1 + g_c)^{10-2/3}(1 + k_p)^{2/3}$$

$$PV_{DC} = DC_{75}(1 + g_c)^{10} \sum_{i=1}^{N} DCF_i \frac{(1 + g_c)^i}{(1 + k_p)^i} \qquad (1)$$

where:

PV_{IC} = present value of initial capital cost, in case year dollars, as of beginning of case year (1985)

PV_{DC} = present value of deferred capital cost, in case year dollars, as of beginning of case year (1985)

IC_{75} = initial capital cost in base year, beginning-1975, dollars

DC_{75} = deferred capital cost in base year, beginning-1975, dollars

*Note that the table of costs for the base case model mines given on page III-51 of the CEUM Documentation uses ICF's PIES costing (constant dollars for cash flow) rather than the CEUM methodology (current dollars, constant in nominal terms). The table also implies a real discount rate of 8% for coal producers. This is inconsistent with the statement on page III-55 of the documentation that a nominal rate of 15% is used together with a 5% capital inflation rate. In more recent versions of the model, a 6% capital escalation rate is used, including approximately (1/2)% real escalation.

DCF_i = fraction of deferred capital spent at end of year i

k_p = coal producer's nominal discount rate (after-tax nominal cost of capital)

g_c = total capital escalation rate (including general inflation and real escalation)

g = general rate of inflation

N = mine lifetime in years

Note that initial capital is inflated at the nominal escalation rate from the base year to eight months before the case year. Deferred capital is escalated to the end of the year in which the money is considered spent.

Let: K_p = coal producer's real discount rate (after-tax real cost of capital)

Recalling that $1 + K_p = \frac{1+k_p}{1+g}$, we point out that

$$PV_{CAP} \neq PV_{IC} + DC_{75}(1 + g_c)^{10} \sum_{i=1}^{N} \frac{DCF_i}{(1 + K_p)^i} \qquad (2)$$

Equation (2) only holds if $g = g_c$.

Using the distribution for deferred capital costs given on page III-49 of the CEUM Documentation [5], we have for N = 20:

DCF_i = .01 , i = 1-5

= .09 , i = 6-15

= .0125 , i = 16-19

Except for mine lifetime, the following paramete. values represent recent figures used by ICF to calculate PV_{CAP}. Although ICF is currently using a mine lifetime of 30 years, we use a value of 20 years in Equations (3) and (4) since for this lifetime, the distribution used by ICF for deferred capital costs is documented.

k_p = ..15 , g_c = .06 , g = .055

$$1 + K_p = 1.15/1.055 \quad \Rightarrow \quad K_p \cong .09$$

Utilizing Equations (1) and (3), we now have:

$$PV_{CAP} = PV_{IC} + DC_{75}(1 + g_c)^{10} \left[.01 \sum_{i=1}^{5} \left(\frac{1.06}{1.15}\right)^i \right. \quad (4)$$

$$\left. + .09 \sum_{i=6}^{15} \left(\frac{1.06}{1.15}\right)^i + .0125 \sum_{i=16}^{19} \left(\frac{1.06}{1.15}\right)^i \right].$$

2. A minimum acceptable or required annual cash flow (equivalent to annualized capital cost) in nominal terms, CF, can be calculated by annualizing PV_{CAP} using the coal producer's nominal discount rate, k_p, and the mine lifetime, N. This cash flow is constant in nominal terms (i.e., constant in current year dollars). It is given by:

$$CF = \frac{PV_{CAP}}{\sum_{i=1}^{N} \frac{1}{(1+k_p)^i}} = PV_{CAP} \bullet CRF_{k_p, N} \quad (5)$$

where:

$CRF_{k_p, N}$ = capital recovery factor = $k_p \left[1 - (1+k_p)^{-N}\right]^{-1}$.
(based on nominal discount rate)

A minimum acceptable annual cash flow with the same present value but constant in real terms is obtained simply by substituting K_p for k_p in Equation 4.

Note that for ICF's PIES analysis, a cash flow constant in real terms was used. Such a cash flow is implicit in the costing table on page III-51 of the CEUM Documentation [5]. Also, the PIES analysis assumes no real escalation and employs constant base year dollars.

3. Utilizing given total operating costs for the base year, depreciation, and the above calculated minimum acceptable annual cash flow, total required revenues (referred to as sales by ICF) for the case year can be estimated from the appropriate equation on page III-50 of the CEUM Documentation [5]. (Since ICF assumes that the depletion allowance equals 10 percent of required revenues up to 50 percent of gross profit, there are two possible required-revenue equations. Both are derived in the addendum to this appendix. Adjustments to these equations, including severance tax rates as a percentage of sales, severance tax charges in dollars per ton, and Federal royalties, are not included.)

The coal producer's minimum acceptable selling price, MASP, for the case year is determined by dividing required revenue by the annual output of the mine. Note that the case year MASP in case year dollars, calculated in the CEUM via a required cash flow in nominal terms, is higher than the MASP would be for the same model mine type in ICF's PIES analysis, which uses a cash flow in real terms and works in constant base year dollars.

4. Starting from the MASP in the case year, 1985, a minimum acceptable coal price series in nominal terms is generated over the assumed 20-year mine lifetime as follows: The minimum acceptable cash flow or annualized capital cost is constant in nominal terms over the mine

lifetime. Variable costs are escalated from year to year over the life of the mine using a 6.5% rate for labor costs, including approximately 1% real escalation, and the 5.5% general inflation rate for the cost of power and supplies and for other operating expenses. Required revenues are recalculated (as described in step 3 above) for each year, creating a stream of minimum acceptable prices in nominal terms (i.e., in current year dollars). By construction, via this required price stream, the coal company will recover all of its costs and earn the required return on its investment.

5. The coal producer's minimum acceptable coal price series in nominal terms, calculated in the previous step, is present-valued or discounted to the case year using the after-tax nominal cost of capital to electric utilities, k_u. The utility industry's discount rate is used at this stage because the utilities decide which stream of prices is preferable (i.e., which mines are opened) and make the trade-off decisions between various fuels and between capital-intensive and high-variable cost plants. Currently, ICF is using a 10% after-tax nominal cost of capital to utilities. The present-value (as of the case year) of the coal price series, PV_{ps}, is calculated as follows (note that the values p_i are neither constant in real terms nor in nominal terms):

$$PV_{ps} = \sum_{i=1}^{N} \frac{p_i}{(1+k_u)^i} = \sum_{i=1}^{20} \frac{p_i}{(1.10)^i} \qquad (6)$$

where:

p_i = coal producer's minimum acceptable coal price in ith year in nominal terms (for model mine type and supply region under consideration).

6. Finally, a minimum acceptable "real annuity coal price," RACP, is calculated from PV_{ps} using k_u and the general inflation rate, g. This calculation implicitly defines an after-tax real cost of capital to electric utilities, K_u.

$$\text{RACP (constant in real terms)} = \frac{PV_{ps}}{\sum_{i=1}^{N} \left(\frac{1+g}{1+k_u}\right)^i} = \frac{PV_{ps}}{\sum_{i=1}^{N} \frac{1}{(1+K_u)^i}} \qquad (7)$$

$$= PV_{ps}/APFAC$$

where:

APFAC = annuity price factor, and

$$1 + K_u = 1.10/1.055 \Rightarrow K_u \cong .0427.$$

The real annuity coal price is a case year value in case year dollars that inflates at the general rate of inflation (i.e., RACP is constant in real terms). Note that while the methodology described above is projecting coal prices p_i in actual nominal terms, it is only the present value of the coal price series that is important. The associated real annuity, given by Equation (7), has the same present value to the utility as does the nominal price series.

Other prices in the CEUM are all assumed to inflate at the general rate of inflation (i.e., to remain constant in constant case year dollars). Therefore, the 1985 price for, say, oil/gas is both its actual price in 1985 and the value of the real annuity for oil/gas stated in 1985 dollars. So the real annuity coal price has the advantage of being consistent with other data inputs, such as oil prices. Its other advantage is that it makes the CEUM's static linear programming framework possible.

It is the minimum acceptable real annuity coal price (deflated to 1978 dollars), for each model mine type in each supply region, that appears in the linear programming matrix as the cost coefficients of the coal mining activity variables in the objective function (see Appendix B).

Addendum: Derivation of Required-Revenue (Sales) Equations
(For further discussion see page III-50 of the CEUM Documentation [5].)

Case 1: Depletion = .50 • Gross Profit (GP) (1)

By definition:

Annual Cash Flow (CF) = Net Profit (NP) + Depreciation (DEP) + Depletion. (2)

Assuming a 50% Federal income tax rate,

$$NP = .50\ (GP - \text{Depletion}) \tag{3}$$

Substituting Equation (1) into Equation (3) yields:

$$NP = .50\ (GP - .5\ GP) = .25\ GP \tag{4}$$

Substituting Equations (1) and (4) into Equation (2) we have:

$$GP = 4\ (CF\text{-}DEP)/3. \tag{5}$$

By definition:

$$GP = \text{Required Revenue} - \text{Operating Costs (OC)} \tag{6}$$

From Equations (5) and (6) we have:

$$\left[\text{Required Revenue} = OC + \frac{4}{3}\ (CF\text{-}DEP)\right]. \tag{7}$$

Case 2: Depletion = .10 • Required Revenue (8)

From Equations (3) and (8):

$$NP = .50\ (GP - .10\ \text{Required Revenue}) \tag{9}$$

Substituting Equations (6), (8), and (9) into Equation (2) yields:

$$CF - DEP = (.55)\ \text{Required Revenue} - (.50)OC \tag{10}$$

Rearranging Equation (10) we have:

$$\left[\text{Required Revenue} = \frac{(.50)OC + CF - DEP}{.55}\right]. \tag{11}$$

APPENDIX F THE USE OF PARTIAL SCRUBBING IN THE CEUM*

This appendix presents a detailed analytical description of the use of partial scrubbing in the CEUM. An explicit presentation of this material does not appear in the CEUM Documentation [5] nor in the applications reports [7], [8], [9], and [15].

Several alternative new source performance standards (ANSPS) are analyzed by ICF in [9]. Each ANSPS is defined by a floor and a ceiling on SO_2 emissions. For any ANSPS coal plant, scrubbers are mandatory and 85% sulfur removal (on a daily average basis) down to the specified floor is required. Note that utilities are not required to reduce emissions below the floor, thus allowing for partial scrubbing (i.e., floors are emissions limitations that can be met in place of a percentage removal requirement). The ceiling is an emission limitation that cannot be exceeded on a daily average basis unless there are exemptions allowed that permit it to be exceeded three days per month. In "without exemptions" cases the scrubber efficiency is assumed to be 75%. Under the current new source performance standard (NSPS), scrubbers are not mandatory and a maximum emission level of 1.2 lbs. $SO_2/10^6$ Btu is required. If scrubbers are employed with an NSPS coal plant, a 90% efficiency on an annual average basis is employed.

A. Definition of Terms

Let: S = average sulfur content in a specified coal type; note that lbs. $S/10^6$ Btu = $(\frac{1}{2})$ lbs. $SO_2/10^6$ Btu.

C = ceiling or cap on SO_2 emissions in lbs. $SO_2/10^6$ Btu.

F = floor on SO_2 emissions in lbs. $SO_2/10^6$ Btu.

*This material also appears in [51].

E = scrubber efficiency (percentage sulfur removal) on a daily average basis = .85 (with exemptions), .75 (without exemptions).

E_A = scrubber efficiency (percentage sulfur removal) on an annual average basis = .90.

R_A = annual SO_2 emissions rate in lbs. $SO_2/10^6$ Btu.

X = percentage of flue-gas scrubbed (partial scrubbing fraction).

RSD = relative standard deviation above the long-run mean sulfur content of a specified coal; this daily average variability factor accounts for differences in peak sulfur content on a daily basis versus an annual average; 3 RSD's are assumed in the "without exemptions" ANSPS scenarios and 2 RSD's are assumed in the "with exemptions" scenarios; RSD = 0.15.

B. Definitions of Sulfur Levels in Utility Demand Regions

	Level	Range (lbs. $S/10^6$ Btu)	Assumed Average Sulfur Content (lbs. $S/10^6$ Btu)
Low	A	0.00-0.40	0.40
	B	0.41-0.60	0.60
Medium	D	0.61-0.83	0.83 (approximately 1% S)
	F	0.84-1.67	1.67 (approximately 2% S)
High	G	1.68-2.50	2.50 (approximately 3% S)
	H	greater than 2.50	3.33

C. Alternative New Source Performance Standards (ANSPS)

Each of the ANSPS listed below is analyzed in [9] and is denoted by: ceiling/floor, exemption status. The ceilings and floors are given in lbs. $SO_2/10^6$ Btu.

1.2 (current NSPS)

1.2/.2, with exemptions; 1.2/.2, without exemptions;

1.2/.5, with exemptions; 1.2/.5, without exemptions;

1.2/.67, with exemptions;

1.2/.80, with exemptions

D. Determination of Maximum Allowable Sulfur Contents under Alternative Standards

Let: S_{max} = maximum allowable sulfur content, given an emissions ceiling and an enforcement standard.

1. Annual Average Enforcement--NSPS:

$$2S(1 - E_A) = C$$

$$\Rightarrow \quad S_{max} = \frac{1.2}{2(1 - .90)} = 6.0 \qquad (1)$$

2. Daily Average Enforcement--ANSPS:

$$2S(1 - E)(1 + n * RSD) = C, \; n = 2, \text{ with exemptions}$$
$$= 3, \text{ without exemptions}$$

$$\text{with exemptions:} \quad S_{max} = \frac{1.2}{2(1 - .85)(1.3)} = 3.08 \qquad (2)$$

$$\text{without exemptions:} \quad S_{max} = \frac{1.2}{2(1 - .75)(1.45)} = 1.66 \qquad (3)$$

3. Coal Types Disallowed:

From Equations (1), (2), and (3) and the definition of sulfur levels in Section B, we have:

ANSPS cases with exemptions: H

ANSPS cases without exemptions: G, H

NSPS: none

E. Calculation of Partial Scrubbing Fractions

1. Annual Average Enforcement--NSPS:

$$F = 2S(1 - E_A)X + 2S(1 - X) \tag{4}$$

$$\Rightarrow \quad X = (1 - F/2S)/E_A \tag{5}$$

Recall that for NSPS: $F = C = 1.2$ and $E_A = .90$.

2. Daily Average Enforcement--ANSPS:

Note here that partial scrubbing fractions are calculated by ICF using the 'with exemptions' parameters.

$$F = 2S(1 + 3*RSD)(1 - E)X + 2S(1 + 3*RSD)(1 - X) \tag{6}$$

$$\Rightarrow \quad X = \frac{1 - F/[2S(1 + 3*RSD)]}{E} = \frac{1 - F/(2.9)S}{.85} \tag{7}$$

F. Calculation of Annual Emissions Rate for ANSPS Standards

$$R_A = 2S(1 - E_A)X + 2S(1 - X) \tag{8}$$

where $E_A = .90$ and X is determined from Equation (7).

G. Determination of Coals That Must Be Fully Scrubbed and Coals That Can Be Partially Scrubbed Under Alternative Standards

Let: S_{min} = minimum sulfur level that requires full scrubbing, i.e., X = 1.

1. Annual Average Enforcement--NSPS:

From Equation (4) we have:

$$F = 2S_{min}(1 - E_A)$$

$$\Rightarrow \quad S_{min} = \frac{F}{2(1 - E_A)} = \frac{1.2}{2(.1)} = 6.0 \tag{9}$$

The following table displays the scrubbing status of coals for different floors with annual average enforcement. Equation (9) and the definition of sulfur levels in Section B are used.

	F	S_{min}	Coals Not Scrubbed (X=0)	Coals Partially Scrubbed (0 < X < 1)	Coals Fully Scrubbed (X=1)	Coals Disallowed
	.2	1.0	-	A, B, D	F, G, H	-
	.5	2.5	-	A, B, D, F	G, H	-
	.67	3.35	-	A, B, D, F, G	H	-
	.80	4.0	A	B, D, F, G, H	-	-
NSPS	1.2	6.0	A,B	D, F, G, H	-	-

2. Daily Average Enforcement--ANSPS:

From Equation (6) we have:

$$F = 2S_{min}(1 + 3*RSD)(1 - E)$$

$$\Rightarrow \quad S_{min} = \frac{F}{2(1.45)(.15)} = \frac{F}{.435} \qquad (10)$$

The following table displays the scrubbing status of coals for each ANSPS scenario under daily average enforcement. The definition of sulfur levels in Section B, the results of Section D, and Equation (10) are used. Note that we have added an ANSPS that duplicates the NSPS but under daily average enforcement (E = .85) and with exemptions.

ANSPS	F	S_{min}	Coals Partially Scrubbed (0 < X < 1)	Coals Fully Scrubbed (X=1)	Coals Disallow
1.2/.2, with	.2	.46	A	B, D, F, G	H
1.2/.2, without	.2	.46	A	B, D, F	G, H
1.2/.5, with	.5	1.15	A, B, D	F, G	H
1.2/.5, without	.5	1.15	A, B, D	F	G, H
1.2/.67, with	.67	1.54	A, B, D	F, G	H
1.2/.80, with	.80	1.84	A, B, D, F	G	H
1.2/1.2, with	1.2	2.76	A(X=0), B, D, F, G	-	H

It is important to point out the manner in which ICF has chosen to implement the information contained in the preceding table. We have learned via communications with ICF personnel that whenever the partial scrubbing fraction is greater than 0.8 but less than 1.0, the model fully scrubs (i.e., sets X = 1) rather than partially scrubs the associated coal.* The apparent undocumented justification for this procedure is that the magnitude of the cost savings associated with partially scrubbing coals when $.8 < X < 1$ is small. ICF has no calculations available to support this claim.

*The effected coals (those fully scrubbed instead of partially scrubbed) in the case of daily average enforcement are: with a .2 floor, A coals; with a .5 floor, B and D coals; with a .67 floor, D coals; with a .80 floor, F coals; and with a 1.2 floor, F and G coals. The effected coals in the case of annual average enforcement are: with a .2 floor, B and C coals; with a .5 floor, F coals; with a .67 floor, F and G coals; with a .80 floor, F, G, and H coals; with a 1.2 floor (NSPS), G and H coals.

APPENDIX G AN EVALUATION OF THE OPERATING CHARACTERISTICS OF THE CEUM*

1. Introduction: Model Structure and Operation

The Coal and Electric Utilities Model (CEUM), developed by ICF, Inc., was maintained on the DOE Energy Information Administration's IBM 370 facility at OSI in Rockville, Maryland. While the general design and key characteristics of the CEUM have been discussed elsewhere in this report (see Section 2.1 and Appendix B), here we consider the operating characteristics and ease of use of the model. It is important to note that no user or operator guide was provided with the model. While the EIA has prepared a draft User's Manual for their version of the model that was of some interest to us, our ability to run the CEUM is largely based upon a study of the computer code and extensive consultation with the modelers. In particular, Dr. Michael Wagner of ICF was extremely helpful in our learning process.

The CEUM is a large-scale, linear programming (LP) model with a highly resolved data base, and it has been designed to be run for three case years: 1985, 1990, and 1995. For each year, a large LP matrix is generated, consisting of approximately 2,000 constraints and 14,000 variables. The matrix is first generated for 1985, and is subsequently updated through a revision operation for the other two case years. In order to complete its operations, the CEUM relies upon a fairly complex file structure. System files are used to generate data files, a composite data tape (GAMOUTC), a matrix file, revise files, and various output files. Major aspects of this file structure are illustrated in Figure 1. Here we provide a summary discussion of each of the major

*This material also appears in [52].

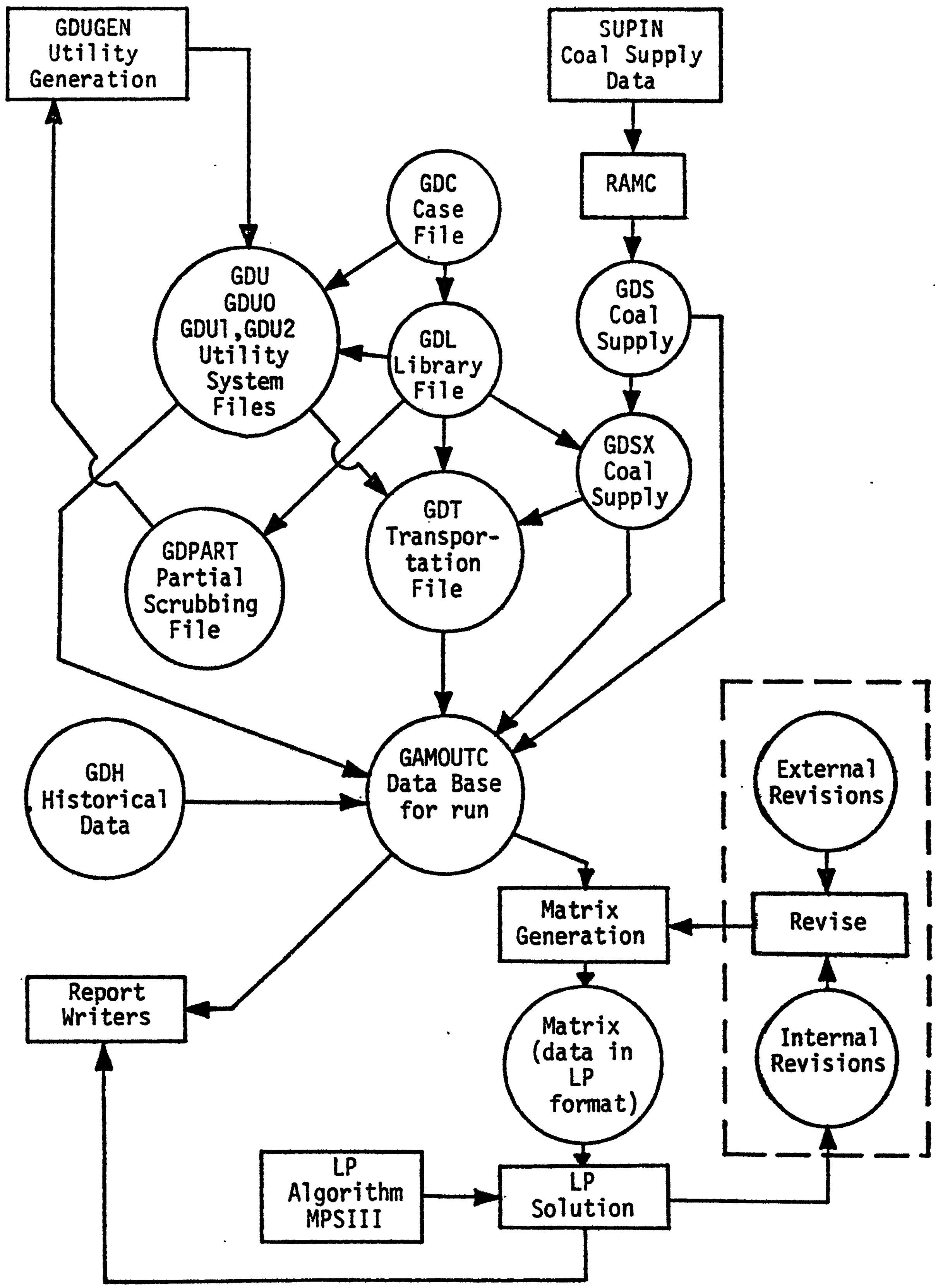

Figure 1. Flow Diagram Indicating the Basic File Structure of the CEUM
(Not a Comprehensive Listing of All Files)

steps, together with an indication of the estimated CPU time required for execution of those steps. It should be noted that elapse time for accomplishing each of these steps is a function of the condition of the machine. It might also be noted that in our experience these jobs were run at low priority, and were subject to being lost when the system crashed.

The first major step involves creation of the basic input data files, and the execution of the coal supply module.* The basic data files contain input data for the coal supply model, the utility model, and data characterizing the transportation system. The output of this processing is a single file (GAMOUTC) structured for input to the LP matrix. The time required to process all input data and execute the coal supply model varies depending upon the number of updates, etc. On average the required time is 5 to 6 CPU minutes.

Given the basic input data, the next major phase of the system is to generate the constraint matrix and to solve the LP for the first case year (1985). The matrix generation program, written in GAMMA, takes the variables and puts them in a format usable by the LP algorithm. The LP is then solved, using a software package called MPSIII. The output of this activity consists of files produced for use by the report generators. The estimated CPU time to complete this phase of operations

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*The coal supply data are treated somewhat differently from the other basic data inputs. Coal supply data are entered via a file entitled SUPIN, and are then run through a FORTRAN program called RAMC. RAMC produces supply curves for coal types in step form. Each step represents a different type of mine with the height of the step representing the cost of production, and the width representing the maximum level of operation for that mine type. In short, RAMC supplies the upper limits to the coal production activities in the model.

is 25-30 minutes. It is, however, possible to enter and make a run of the CEUM from an advanced basis. When only minor updates are made to the constraint matrix and the advanced basis from which the solution begins is very close to the new solution, the estimated solution and output report times are somewhat shorter in duration.

Finally, the report writers convert the LP solution into output format. Approximately 15 CPU minutes are required to generate the reports containing model output for the 1985 case year.

Solutions for the case years subsequent to 1985 require some modification of the constraint matrix and solution. Approximately 10 to 15 minutes of CPU time usually are required. However, generation of the output reports for subsequent case years requires the same amount of time as for 1985, approximately 15 CPU minutes.

As noted above, the elapse time for accomplishing these tasks will vary significantly depending upon the status of the equipment.

2. Evaluation of Operating Characteristics

In general, the characteristics of a model that are of importance to the operator are as follows:

1) Ease of updating data,
2) Flexibility through input and parameter changes only,
3) Extensibility of model structure,
4) Efficiency of operation,
5) Interpretability of model output,
6) Clarity of model format, and
7) Transferability--accessibility of documentation, training required, ease of use by persons other than the modeler.

We have considered the CEUM in the context of each of these characteristics, and a summary of each point is presented below.

2.1 Ease of Updating Data

M.I.T. operators found that updating model data is not as easily accomplished and straightforward a process as one might suppose. As illustrated in Figure 1 and discussed above, the CEUM computational structure is complex, involving many input, intermediate, and output files. Attached to this appendix is a listing and brief description of the files associated with the model. In order to update data, the user enters the GAMMA-coded data files and appropriately inserts the new information. However, these new data are not always carried automatically through the necessary series of intermediate steps. It is up to the operators to remember which files the new data may explicitly and implicitly affect, and to change those as well. In short, the many interdependencies among various levels of the structure cause data updating to be a highly operator-dependent operation.

2.2 Flexibility Through Input and Parameter Changes

The above comments on data changes are also applicable to input and parameter changes. The CEUM is not set up to easily accommodate changes to parameters. Again, operator knowledge is required to ensure that correct changes are made in all the necessary places. At this time, given the existing documentation, only the model developer or experienced assessors of this model have a chance of being fully cognizant of all the places in the code where such changes may be necessary.

2.3 Extensibility of Structure

Issues concerning the structure of the CEUM are discussed in detail in Appendix B. In brief, the model is structured as a complex set of preliminary programs that feed information into a straightforward linear programming framework that has a very high level of disaggregation. The modelers' emphasis on detail necessitated a simple model design, which resulted in both structural advantages and disadvantages.

From an operational point of view, the LP structure is simple to understand and execute. In general, revised data or new activities can be added to the model without significant difficulty, providing that the operator understands the matrix generation language and is aware of all places where changes must be made. Some structural changes are, however, not that easy to make. For example, one of the proposed audit runs involved substantial regional aggregation of the model. This run was not completed due to the complexity of implementing the change. In such cases, changes or extensions of the structure would be quite complicated, and would require extensive reprogramming.

2.4 Efficiency of Model Operation

The version of the CEUM evaluated by M.I.T. is somewhat inefficient in terms of operating time. As discussed above, several model operations, particularly the solve and report-generation steps, are quite time-consuming in CPU minutes. Table 1 below indicates the approximate amount of time required to execute a specific model run entitled EDMD for 1985 and 1990 (1995 run times would be similar if not identical to 1990 run times).

TABLE 1

Time Required to Run EDMD 1985 and 1990

Step	Approximate CPU Minutes Required
Creation of GAMOUTC	3.5
Generation of 1985 Matrix	2.3
Completion of LP Solution for 1985	10.9
Generation of Report-Writing Files	15.8
Creation of Reports	9.8
Revise, Set-up, and Solve for 1990	15.1
Creation of Reports for 1990	9.0
TOTAL	66.4

While these numbers are approximate due to the large number of steps of extremely short duration, the large amount of time required by certain processes is evident.

It should be observed that there is a trade-off between model extensibility and computational efficiency. In the present system, some model extensibility is preserved at the expense of using a generalized matrix generator program. The computational costs of this interpretive language are substantial, and could be reduced by programming the model in a compiler language such as FORTRAN. The disadvantage of such reprogramming would be that extensions to the model would be more costly to implement.

EPRI is currently supporting ICF in developing a FORTRAN version of the CEUM system. Concurrent with this effort, ICF has been analyzing various decompositions of the model to obtain improvements in computational efficiency. It is our understanding that such improvements could dramatically decrease the amount of CPU execution time required for model runs.

2.5 Interpretability of Output

The output from model runs is presented in four formats: (1) a "small" report, (2) a "large" report, (3) an LP solution report, and (4) a "slim file" which reproduces selected results. In general, the tables are well organized, and finding specific model outputs is not a difficult task. Operationally speaking, interpreting output is a straightforward process. However, as discussed in the documentation evaluation (Section 2.4), interpreting the meaning of results and comprehending their implications are very difficult with the CEUM, due to gaps in the descriptions of assumptions, methodology, and mathematical structure. In addition, several hundred pages of output per run are expensive to print and unwieldy to use and store.

2.6 Clarity of Model Format

As discussed above, the CEUM has proven to be somewhat difficult to comprehend from an analytical viewpoint, due to the obscure nature of some of its scientific and methodological bases. However, from an operational viewpoint, the structural relationships, although very cumbersome, are straightforward and provide no difficulty for the competent operator willing to make a substantial time commitment. The aspect of awkwardness is contributed to by the model's size, and the corresponding complexity of its file structure.

2.7 Transferability

Our evaluating team concluded that effective transfer of control of the CEUM is for all practical purposes impossible without significant input from the model developer. (As mentioned earlier, our own grasp of the model was made possible by the cooperation we received from ICF.) Given modeler assistance, it is not extraordinarily difficult to gain enough control over the model to perform straightforward sensitivity analysis. However, personal assistance is essential; the extant documentaton and user's materials are not, by themselves, sufficient to enable operation. This fact, coupled with the complexity of the file structures, makes transfer of the CEUM an expensive process. Moreover, since the model has not been transferred from one type of machine environment to another, but has always been run on one specific configuration of IBM equipment, we are unable to comment on further procedures that such a transfer might require.

In order to be able to work with the CEUM, the operator must have, at a minimum, a working knowledge of the following systems:

- FORTRAN
- GAMMA (the matrix- and report-generating system)
- MPSIII (a proprietary software package developed by Ketron; used to solve the linear program)
- SUPERWYLBUR (an editing system necessary for operation at OSI)
- IBM 370 JCL

These language and system requirements present something of an operating problem, since GAMMA and SUPERWYLBUR are not widely known, and MPSIII is proprietary. Any learning time associated with the software must be added to the start-up time.

In addition, as discussed above, the documentation is not presented in a sufficiently complete fashion to permit more than a basic marginal control over the model. If important or complex structural changes were desired, much more personal training of the operator by the modeler would be required.

The evaluation of these seven categories has led us to conclude that, while the model structure is straightforward, several problems exist with model operation, including difficulties in transferability, file complexity, and computation times. Attached below is a listing of the files associated with the CEUM.

2.8 Basic File Structure of the CEUM

'FGAM' is the generic name of the data base from which the run is to be made.

'FRUN' is the generic name of the output files corresponding to various "rim" changes on a given data base.

(These "rim" changes are implemented via the REVISE files.)

'YYYY' represents the system files required by the model (additional sets such as 'XXXX' and 'ZZZZ' may be utilized to make additional parallel runs).

'FGAM' Files

FGAM.GAMOUTC - Data Base

FGAM.MATRIX - Matrix

FGAM.THINDIR, FGAM.THINRWF } Directory and report-writer-files to publish SLIM and SMALL reports

FGAM.GAMDIR, FGAM.GAMRWF } Report-writer files to publish LARGE reports

'FRUN' Files

FRUN85/90/95.LPSOLN - Contains solution to LP in MPSIII format

FRUN85/90/95.SMALL - SMALL output report

FRUN85/90/95.LARGE - LARGE (detailed) output report

System files ('XXXX'/'YYYY'/'ZZZZ')

XXXX.SLIM85
XXXX.SLIM90
XXXX.SLIM95
} Files used to pass information from 1985 to 1990 run and from 1990 to 1995 run

XXXX.REV90
XXXX.REV95
} Revise files for 1990 and 1995

XXXX.PROBFILE
XXXX.PROB90
XXXX.PROB95
} Probfiles required by MPSIII to solve LP; Special characteristic: //SPACE = (TRK, (80),, CONTIG)

XXXX.BASIS85
XXXX.BASIS90
XXXX.BASIS95
} Basis files for LP

Input Data Files ("GD" Files)

GDS
GDSX
} Coal Supply Files

GDU
GDU0
GDU1
GDU2
} Utility Sector Files

GDT - Transportation File

GDPART - Partial Scrubbing File

GDH - Historical Data File

GDL - Library File

GDC - Case File--Global Paramters

Revise Files

DATA.REV85 - 1985 revise deck created by GAMMA.REV85

GAMMA.REVISE - Revise program for the 1990 and 1995 case years; generates revise decks in YYYY.REV90 and YYYY.REV95

GAMMA Programs

GMG - Matrix generator program

THIN, THINNER - Programs to create SLIM and SMALL, respectively

GRW - Program to create LARGE report

GAMMA.REVISE - See above

GAMMA.REV85 - Program that generates DATA.REV85

JCL Files

GRACE85 - Contains the entire JCL to prepare data, to generate the LP matrix, to revise, convert, and solve the LP, and to extract and publish the SLIM, SMALL, and LARGE reports for 1985.

GRACE90 - Contains JCL to revise the LP matrix for the 1990 case year, to solve the LP, and to extract and publish the SLIM, SMALL, and LARGE reports for 1990

GRACE95 - Same as GRACE90 but for the 1995 case year

RAMCJCL - Contains the JCL to create GDS using the input file SUPIN; GDS is the file containing the coal supply curves

GRACE.REV - Contains the JCL to create DATA.REV85 from the GAMMA program GAMMA.REV85

Miscellaneous Files for Special Purposes

ALLOC - Creates space for a file whose name is used in place of "FILE"

CRPROBS - Creates space for Probfiles (special characteristics)

PRINTREP - Program to print output reports on line printer

UNCAT - Program to uncatalog a file

RESTORE - Program to restore a file that has been retired

WHIZ85 - Program used to solve the LP if, due to some problem in the system, the LP solution fails before an optimal solution is found

APPENDIX H

LISTING OF THE CEUM SUPPLY CODE AS CORRECTED BY EMAP

(CONSISTING OF THE SUPIN AND RAMC FILES)

Note: The corrections to the CEUM Base Case that were implemented to produce this "corrected" supply code relate to the verification errors detailed in Points 1, 5, 6a, 7, 8, 10, 14, 15, 18, 19, 20, 21, 22, 23 and 24 of Chapter 2.4.2.

```
GLOBAL PARAMETERS                                                     SUP00010
CASE=1985 BASE CASE 8/11           5A4 START COL 6                    SUP00020
SEAM THICKNESS VS MINE SIZE (PERCENT DISTRIBUTION) - DEEP MINES       SUP00030
      0.1 0.5 1.0 2.0 3.0        5F4.1  START IN COL 7                SUP00040
  >72 34. 33. 33.  0.  0.        5F4.1  START IN COL 7                SUP00050
60-72 33.433.333.3 0.  0.                                             SUP00060
48-60 25. 25. 25. 25.  0.                                             SUP00070
36-48 34. 33. 33.  0.  0.                                             SUP00080
28-36 50. 50.  0.  0.  0.                                             SUP00090
RECOVERY FACTOR: SURF=0.8 DEEP=0.6                                    SUP00100
MINE LIFE IN YEARS=SURF  (1.MMT=20.,SURF =>1.MMT=20.                  SUP00110
                   DEEP  (1.MMT=20.,DEEP =>1.MMT=20.                  SUP00120
CONTRACT LIFE YEARS=20                                                SUP00130
ICAP SURF= 17700. ICAP DEEP= 29300. DCAP SURF=  3200. DCAP DEEP= 11700. SUP00140
IDR=INACCESSBL DEEP RESERVE FRACTION=0.1                              SUP00150
ISR=ILLEGAL SURFACE RESERVE FRACTION=0.1                              SUP00160
ECP=ESCCAP=0.060EMP=ESCMP=0.065EPS=ESCP&S=0.055ROR=0.150              SUP00170
BASE YEAR=1975.  CASE YEAR=1985.                                      SUP00180
$SV=SEV TAX $/CLEAN TON=00.00  SVT=SEV TAX RATE=0.00                  SUP00190
$SD=$PMD SURF=78.04 $DD=$PMD DEEP=69.24                               SUP00200
TSD=TPMD SURF=45.0  TDD=TPMD DEEP=17.3                                SUP00210
PSS=P&S SURF=1226.  PDS=P&S DEEP=2835.                                SUP00220
LIC=LICENSE=0.10 RLT=ROYALTY=0.00                                     SUP00230
SWL=WELF FUND/TN SURF=.72  DWL=WELF FUND/TN DEEP=0.72                 SUP00240
SWD=WELF FUND/DY SURF=10.96DWD=WELF FUND/DY DEEP=10.96                SUP00250
CTX=CORP. TAX=0.50                                                    SUP00260
RUT=UTILITY DISCOUNT RATE=0.100                                       SUP00270
APFAC=ANNUITY PRICE FACTOR=13.276
INS=EXPOSURE INSURANCE $/$100 PAYROLL COST SURF=00.00                 SUP00290
IND=EXPOSURE INSURANCE $/$100 PAYROLL COST DEEP=00.00                 SUP00300
YTS=CLEAN TON YIELD, FRACTION OF RAW TONS  SURF=00.85                 SUP00310
YTD=CLEAN TON YIELD, FRACTION OF RAW TONS  DEEP=00.80                 SUP00320
MINE SIZE  MMTONS=4.0,3.0,2.0,1.0,0.5,0.1                             SUP00330
MINE SIZE LITERAL=40,30,20,10,05,01                                   SUP00340
ENDPARMS                                                              SUP00350
TABLE PA $  PENNSYLVANIA                                              SUP00360
RCL=RECLAMATION COST              1.74      2.77      3.63            SUP00370
                                  4.61      5.44      6.38            SUP00380
                                  9.25                                SUP00390
                                  1.32      2.08      2.70            SUP00400
                                  3.40      3.99      4.68            SUP00410
                                  6.74                                SUP00420
OBR=OVERBURDEN RATIO DISTR 0 MIN=17. MAX=46.                          SUP00430
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=60.                          SUP00440
MCM 0 0 0 1 2 0 0 1 2 2 2 2 3 3 2 2 2 3 3 2                           SUP00450
DSY=SEAM DEPTH DISTR DR=05.0 D04=25.0 D07=35.0 D10=35.0               SUP00460
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0      SUP00470
OVR   TSD=41.4       TDD=18.2       INS=18.       IND=34.             SUP00480
OVR   ISR=.15                                                         SUP00490
ENDTABLE                                                              SUP00500
COAL TYPE ZB $ COAL                                                   SUP00510
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.             SUP00520
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                        SUP00530
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.     SUP00540
CLEANING COST S/TON (FIXED)= 1.14  (VARIABLE)= 0.56                   SUP00550
```

```
DMR=DEMONSTRATED RESERVE DEEPTHN=    53. DEEPTHK=   390. SURF=     1.   SUP00560
CMR=COMMITTED RESERVE        DEEP=046.83     SURF=000.64                SUP00570
OVR   YTS=.70          YTD=.60                                          SUP00580
TEXT          PROD  PRCE  SURF                                          SUP00590
C1ZB CTR.01 1.108 18.59 0.02                                            SUP00600
ENDCOAL                                                                 SUP00610
COAL TYPE ZC $ COAL                                                     SUP00620
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP00630
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP00640
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP00650
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                     SUP00660
DMR=DEMONSTRATED RESERVE DEEPTHN=     7. DEEPTHK=     0. SURF=     1.   SUP00670
OVR   YTS=.70          YTD=.60                                          SUP00680
ENDCOAL                                                                 SUP00690
COAL TYPE ZD $ COAL                                                     SUP00700
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP00710
KSW=0   THIS IS KSW..IF=1,PRINT BALANCE SHEETS.                         SUP00720
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP00730
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                     SUP00740
DMR=DEMONSTRATED RESERVE DEEPTHN=   557. DEEPTHK=   471. SURF=    49.   SUP00750
CMR=COMMITTED RESERVE        DEEP=080.74     SURF=032.63                SUP00760
OVR   YTS=.70          YTD=.60                                          SUP00770
TEXT          PROD  PRCE  SURF                                          SUP00780
C1ZD CTR.01 2.882 18.59 0.35                                            SUP00790
ENDCOAL                                                                 SUP00800
COAL TYPE ZE $ COAL                                                     SUP00810
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP00820
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP00830
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP00840
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                     SUP00850
DMR=DEMONSTRATED RESERVE DEEPTHN=   580. DEEPTHK=   143. SURF=    76.   SUP00860
ENDCOAL                                                                 SUP00870
COAL TYPE ZF $ COAL                                                     SUP00880
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP00890
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP00900
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP00910
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP00920
DMR=DEMONSTRATED RESERVE DEEPTHN=  2702. DEEPTHK=  6261. SURF=   283.   SUP00930
CMR=COMMITTED RESERVE        DEEP=115.83     SURF=187.32                SUP00940
TEXT          PROD  PRCE  SURF                                          SUP00950
C1ZF CTR.01 10.89 16.27 0.68                                            SUP00960
ENDCOAL                                                                 SUP00970
COAL TYPE ZG $ COAL                                                     SUP00980
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP00990
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP01000
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP01010
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP01020
DMR=DEMONSTRATED RESERVE DEEPTHN=  1052. DEEPTHK=   323. SURF=    74.   SUP01030
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=043.76                SUP01040
TEXT          PROD  PRCE  SURF                                          SUP01050
C1ZG CTR.01 1.736 16.27 1.00                                            SUP01060
ENDCOAL                                                                 SUP01070
COAL TYPE HD $ COAL                                                     SUP01080
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP01090
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP01100
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ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    86. DEEPTHK=    17. SURF=     8.
CMR=COMMITTED RESERVE        DEEP=002.15     SURF=005.36
TEXT          PROD  PRCE SURF
C1HD CTR.01  .276 14.90 0.77
ENDCOAL
COAL TYPE HE $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    66. DEEPTHK=    30. SURF=    18.
ENDCOAL
COAL TYPE HF $ COAL
PRT=1   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=1   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=1   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   830. DEEPTHK=  3868. SURF=   218.
CMR=COMMITTED RESERVE        DEEP=109.61     SURF=144.30
TEXT          PROD  PRCE SURF
C1HF CTR.01 8.994 14.90 0.64
ENDCOAL
COAL TYPE HG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=  1258. DEEPTHK=  1578. SURF=   235.
CMR=COMMITTED RESERVE        DEEP=439.57     SURF=160.45
TEXT          PROD  PRCE SURF
C1HG CTR.01 19.49 14.90 0.33
ENDCOAL
COAL TYPE HH $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     4. DEEPTHK=    34. SURF=     0.
CMR=COMMITTED RESERVE        DEEP=084.16     SURF=000.30
TEXT          PROD  PRCE SURF
C1HH CTR.01 1.965 14.90 0.00
ENDCOAL
ENDREGION********** PA $ PENNSYLVANIA
TABLE OH $  OHIO
RCL=RECLAMATION COST              1.59       2.63       3.49
                                  4.47       5.29       6.24
                                  9.10
                                  1.31       2.06       2.67
                                  3.38       3.97       4.65
                                  6.71
OBR=OVERBURDEN RATIO DISTR 0 MIN=17. MAX=46.
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=60.
MDM 0 0 3 3 2 0 1 3 3 2 0 2 4 3 2 0 5 4 3 2
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DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0
OVR   $SV=.04          TSD=41.4        TDD=18.2        INS=18.
OVR   ISR=.21          IND=34.
ENDTABLE
COAL TYPE ZG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   476. DEEPTHK=   645. SURF=     4.
CMR=COMMITTED RESERVE       DEEP=003.27      SURF=000.53
TEXT          PROD  PRCE SURF
C1ZG CTR.01   .109 13.04 0.17
ENDCOAL
COAL TYPE HF $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   641. DEEPTHK=  1536. SURF=   362.
CMR=COMMITTED RESERVE       DEEP=    .59      SURF=  0.00
TEXT          PROD  PRCE SURF
ENDCOAL
COAL TYPE HG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=  3139. DEEPTHK=  5618. SURF=  2002.
CMR=COMMITTED RESERVE       DEEP=000.00      SURF=024.94
TEXT          PROD  PRCE SURF
C1HG CTR.01   .891 11.45 1.00
ENDCOAL
COAL TYPE HH $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   629. DEEPTHK=   417. SURF=   336.
CMR=COMMITTED RESERVE       DEEP=083.76      SURF=046.00
TEXT          PROD  PRCE SURF
C1HH CTR.01 3.911 11.45 0.42
ENDCOAL
COAL TYPE MF $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   154. DEEPTHK=   131. SURF=    32.
CMR=COMMITTED RESERVE       DEEP=000.00      SURF=003.66
TEXT          PROD  PRCE SURF
C1MF CTR.01   .130 11.17 1.00
ENDCOAL
COAL TYPE MG $ COAL
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PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                 SUP02210
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                            SUP02220
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP02230
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                       SUP02240
DMR=DEMONSTRATED RESERVE DEEPTHN=   162. DEEPTHK=   235. SURF=   187.     SUP02250
CMR=COMMITTED RESERVE       DEEP=000.00      SURF=076.66                  SUP02260
TEXT          PROD  PRCE SURF                                             SUP02270
C1MG CTR.01 2.737 11.17 1.00                                              SUP02280
ENDCOAL                                                                   SUP02290
COAL TYPE MH $ COAL                                                       SUP02300
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                 SUP02310
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                            SUP02320
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP02330
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                       SUP02340
DMR=DEMONSTRATED RESERVE DEEPTHN=   334. DEEPTHK=   357. SURF=   359.     SUP02350
CMR=COMMITTED RESERVE       DEEP=188.14      SURF=248.00                  SUP02360
TEXT          PROD  PRCE SURF                                             SUP02370
C1MH CTR.01 13.95 11.17 0.64                                              SUP02380
ENDCOAL                                                                   SUP02390
ENDREGION********** OH $ OHIO                                             SUP02400
TABLE MD $  MARYLAND                                                      SUP02410
RCL=RECLAMATION COST                1.74       2.77       3.63            SUP02420
                                    4.61       5.43       6.39            SUP02430
                                    9.25                                  SUP02440
                                    1.32       2.07       2.69            SUP02450
                                    3.39       3.98       4.67            SUP02460
                                    6.73                                  SUP02470
OBR=OVERBURDEN RATIO DISTR 0 MIN=17. MAX=46.                              SUP02480
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=60.                              SUP02490
MDM 0 0 0 1 2 0 0 1 2 2 2 2 3 3 2 2 2 3 3 2                               SUP02500
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0                   SUP02510
MSS=SURFACE MINE SIZE DISTR    SIX=50.0 50.0 00.0 00.0 00.0 00.0          SUP02520
OVR   TSD=41.4       TDD=18.2       INS=10.       IND=31.                 SUP02530
OVR   ISR=.15                                                             SUP02540
ENDTABLE                                                                  SUP02550
COAL TYPE ZD $ COAL                                                       SUP02560
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                 SUP02570
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                            SUP02580
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP02590
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                       SUP02600
DMR=DEMONSTRATED RESERVE DEEPTHN=   138. DEEPTHK=   180. SURF=    39.     SUP02610
OVR   YTS=.70        YTD=.60                                              SUP02620
ENDCOAL                                                                   SUP02630
COAL TYPE ZF $ COAL                                                       SUP02640
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                 SUP02650
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                            SUP02660
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP02670
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                       SUP02680
DMR=DEMONSTRATED RESERVE DEEPTHN=   222. DEEPTHK=    71. SURF=    34.     SUP02690
ENDCOAL                                                                   SUP02700
COAL TYPE ZG $ COAL                                                       SUP02710
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                 SUP02720
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                            SUP02730
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP02740
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                       SUP02750
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DMR=DEMONSTRATED RESERVE DEEPTHN=    50. DEEPTHK=    10. SURF=    19.
ENDCOAL
COAL TYPE HD $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    14.
CMR=COMMITTED RESERVE         DEEP=000.00     SURF=010.43
TEXT          PROD  PRCE SURF
C1HD CTR.01   .292 11.10 1.00
ENDCOAL
COAL TYPE HG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    68. DEEPTHK=    64. SURF=     6.
CMR=COMMITTED RESERVE         DEEP=044.22     SURF=007.98
TEXT          PROD  PRCE SURF
C1HG CTR.01 1.156 11.10 0.96
ENDCOAL
ENDREGION********** MD $ MARYLAND
TABLE NV $  W.VIRGINIA,NORTH
RCL=RECLAMATION COST               1.74       2.78       3.63
                                   4.61       5.44       6.39
                                   9.25
                                   1.26       2.01       2.63
                                   3.33       3.92       4.61
                                   6.67
OBR=OVERBURDEN RATIO DISTR 0 MIN=17. MAX=46.
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=60.
MDM 0 2 2 3 2 0 2 3 3 2 0 2 3 3 2 0 2 4 3 2
DSM=SEAM DEPTH DISTR DR=05.0 D04=25.0 D07=35.0 D10=35.0
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0
OVR   SVT=.0385       TSD=41.4       TDD=18.2       INS=6.
OVR   IND=13.         ISR=.25
ENDTABLE
COAL TYPE ZA $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    69. DEEPTHK=    51. SURF=    26.
CMR=COMMITTED RESERVE         DEEP=041.92     SURF=002.75
OVR   YTS=.70         YTD=.60
TEXT          PROD  PRCE SURF
C1ZA CTR.01 1.241 16.66 0.08
ENDCOAL
COAL TYPE ZB $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   690. DEEPTHK=   833. SURF=   229.
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CMR=COMMITTED RESERVE       DEEP=000.00     SURF=023.38                    SUP03310
OVR   YTS=.70          YTD=.60                                             SUP03320
TEXT           PROD  PRCE SURF                                             SUP03330
C1ZB CTR.01   .305 16.66 1.00                                              SUP03340
ENDCOAL                                                                    SUP03350
COAL TYPE ZC $ COAL                                                        SUP03360
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP03370
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP03380
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP03390
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                        SUP03400
DMR=DEMONSTRATED RESERVE DEEPTHN=    66. DEEPTHK=    92. SURF=    33.      SUP03410
OVR   YTS=.70          YTD=.60                                             SUP03420
ENDCOAL                                                                    SUP03430
COAL TYPE ZD $ COAL                                                        SUP03440
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP03450
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP03460
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP03470
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                        SUP03480
DMR=DEMONSTRATED RESERVE DEEPTHN=     7. DEEPTHK=    12. SURF=     0.      SUP03490
CMR=COMMITTED RESERVE       DEEP=026.77     SURF=000.00                    SUP03500
OVR   YTS=.70          YTD=.60                                             SUP03510
TEXT           PROD  PRCE SURF                                             SUP03520
C1ZD CTR.01   .733 16.66 0.00                                              SUP03530
ENDCOAL                                                                    SUP03540
COAL TYPE ZF $ COAL                                                        SUP03550
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP03560
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP03570
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP03580
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP03590
DMR=DEMONSTRATED RESERVE DEEPTHN=   288. DEEPTHK=  1741. SURF=   198.      SUP03600
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=009.07                    SUP03610
TEXT           PROD  PRCE SURF                                             SUP03620
C1ZF CTR.01   .312 14.58 1.00                                              SUP03630
ENDCOAL                                                                    SUP03640
COAL TYPE ZG $ COAL                                                        SUP03650
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP03660
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP03670
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP03680
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP03690
DMR=DEMONSTRATED RESERVE DEEPTHN=    66. DEEPTHK=  3865. SURF=   173.      SUP03700
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=004.19                    SUP03710
TEXT           PROD  PRCE SURF                                             SUP03720
C1ZG CTR.01   .144 14.58 1.00                                              SUP03730
ENDCOAL                                                                    SUP03740
COAL TYPE HB $ COAL                                                        SUP03750
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP03760
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP03770
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP03780
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP03790
DMR=DEMONSTRATED RESERVE DEEPTHN=    32. DEEPTHK=    32. SURF=    43.      SUP03800
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=003.55                    SUP03810
TEXT           PROD  PRCE SURF                                             SUP03820
C1HB CTR.01   .122 13.64 1.00                                              SUP03830
ENDCOAL                                                                    SUP03840
COAL TYPE HD $ COAL                                                        SUP03850
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PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP03860
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP03870
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP03880
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                         SUP03890
DMR=DEMONSTRATED RESERVE DEEPTHN=     13. DEEPTHK=     57. SURF=     9.     SUP03900
CMR=COMMITTED RESERVE         DEEP=017.39     SURF=002.56                   SUP03910
TEXT          PROD  PRCE SURF                                               SUP03920
C1HD CTR.01  .563 13.64 0.16                                                SUP03930
ENDCOAL                                                                     SUP03940
COAL TYPE HE $ COAL                                                         SUP03950
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP03960
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP03970
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP03980
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                         SUP03990
DMR=DEMONSTRATED RESERVE DEEPTHN=     81. DEEPTHK=    542. SURF=    32.     SUP04000
ENDCOAL                                                                     SUP04010
COAL TYPE HF $ COAL                                                         SUP04020
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP04030
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP04040
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP04050
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                         SUP04060
DMR=DEMONSTRATED RESERVE DEEPTHN=    199. DEEPTHK=  1238. SURF=    99.     SUP04070
CMR=COMMITTED RESERVE         DEEP=006.20     SURF=022.12                   SUP04080
TEXT          PROD  PRCE SURF                                               SUP04090
C1HF CTR.01  .931 13.64 0.82                                                SUP04100
ENDCOAL                                                                     SUP04110
COAL TYPE HG $ COAL                                                         SUP04120
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP04130
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP04140
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP04150
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                         SUP04160
DMR=DEMONSTRATED RESERVE DEEPTHN=    217. DEEPTHK=  1551. SURF=   120.     SUP04170
CMR=COMMITTED RESERVE         DEEP=409.47     SURF=026.48                   SUP04180
TEXT          PROD  PRCE SURF                                               SUP04190
C1HG CTR.01 12.12 13.64 0.08                                                SUP04200
ENDCOAL                                                                     SUP04210
ENDREGION********** NV $ W.VIRGINIA,NORTH                                   SUP04220
TABLE SV $  W.VIRGINIA,SOUTH                                                SUP04230
RCL=RECLAMATION COST              1.56       2.90       4.28                SUP04240
                                  5.65       7.10       8.48                SUP04250
                                 12.65                                      SUP04260
                                  1.57       2.53       3.53                SUP04270
                                  4.51       5.55       6.55                SUP04280
                                  9.55                                      SUP04290
OBR=OVERBURDEN RATIO DISTR 0 MIN=12. MAX=46.                                SUP04300
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                                SUP04310
MCM 1 1 2 3 2 2 2 3 3 2 3 3 4 3 2 4 4 4 3 2                                 SUP04320
DSM=SEAM DEPTH DISTR DR=05.0 D04=25.0 D07=35.0 D10=35.0                     SUP04330
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0            SUP04340
OVR    SVT=.0385        TSD=32.4        TDD=17.3        INS=6.              SUP04350
OVR    IND=18.          ISR=.18                                             SUP04360
ENDTABLE                                                                    SUP04370
COAL TYPE ZA $ COAL                                                         SUP04380
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP04390
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP04400
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ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP04410
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                          SUP04420
DMR=DEMONSTRATED RESERVE DEEPTHN=   109. DEEPTHK=    19. SURF=    24.      SUP04430
CMR=COMMITTED RESERVE        DEEP=448.25      SURF=001.99                    SUP04440
OVR   YTS=.70          YTD=.60                                               SUP04450
TEXT          PROD  PRCE SURF                                                SUP04460
C1ZA CTR.01 12.71 23.67 0.01                                                 SUP04470
ENDCOAL                                                                      SUP04480
COAL TYPE ZB $ COAL                                                          SUP04490
PRT=1    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                   SUP04500
KSW=1    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                              SUP04510
ISN=1    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP04520
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                          SUP04530
DMR=DEMONSTRATED RESERVE DEEPTHN=  2689. DEEPTHK=  3935. SURF=  1867.      SUP04540
CMR=COMMITTED RESERVE        DEEP=078.15      SURF=152.35                    SUP04550
OVR   YTS=.70          YTD=.60                                               SUP04560
TEXT          PROD  PRCE SURF                                                SUP04570
C1ZB CTR.01 8.038 23.67 0.73                                                 SUP04580
ENDCOAL                                                                      SUP04590
COAL TYPE ZD $ COAL                                                          SUP04600
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                   SUP04610
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                              SUP04620
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP04630
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                          SUP04640
DMR=DEMONSTRATED RESERVE DEEPTHN=   963. DEEPTHK=  1534. SURF=   323.      SUP04650
CMR=COMMITTED RESERVE        DEEP=137.02      SURF=026.18                    SUP04660
OVR   YTS=.70          YTD=.60                                               SUP04670
TEXT          PROD  PRCE SURF                                                SUP04680
C1ZD CTR.01 4.866 23.67 0.21                                                 SUP04690
ENDCOAL                                                                      SUP04700
COAL TYPE ZE $ COAL                                                          SUP04710
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                   SUP04720
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                              SUP04730
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP04740
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                          SUP04750
DMR=DEMONSTRATED RESERVE DEEPTHN=   172. DEEPTHK=   161. SURF=    32.      SUP04760
ENDCOAL                                                                      SUP04770
COAL TYPE ZF $ COAL                                                          SUP04780
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                   SUP04790
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                              SUP04800
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP04810
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP04820
DMR=DEMONSTRATED RESERVE DEEPTHN=   574. DEEPTHK=   674. SURF=   1 9.      SUP04830
CMR=COMMITTED RESERVE        DEEP=152.26      SURF=009.03                    SUP04840
TEXT          PROD  PRCE SURF                                                SUP04850
C1ZF CTR.01 4.637 20.71 0.08                                                 SUP04860
ENDCOAL                                                                      SUP04870
COAL TYPE HB $ COAL                                                          SUP04880
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                   SUP04890
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                              SUP04900
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP04910
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP04920
DMR=DEMONSTRATED RESERVE DEEPTHN=   145. DEEPTHK=   457. SURF=   312.      SUP04930
CMR=COMMITTED RESERVE        DEEP=000.00      SURF=024.42                    SUP04940
TEXT          PROD  PRCE SURF                                                SUP04950
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C1HB CTR.01  .935 18.81 1.00                                          SUP04960
ENDCOAL                                                               SUP04970
COAL TYPE HE $ COAL                                                   SUP04980
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.             SUP04990
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                        SUP05000
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.     SUP05010
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                   SUP05020
DMR=DEMONSTRATED RESERVE DEEPTHN=   134. DEEPTHK=    54. SURF=     0. SUP05030
CMR=COMMITTED RESERVE       DEEP=166.92     SURF=000.00               SUP05040
TEXT          PROD  PRCE SURF                                         SUP05050
C1HD CTR.01 4.705 18.81 0.00                                          SUP05060
ENDCOAL                                                               SUP05070
COAL TYPE HG $ COAL                                                   SUP05080
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.             SUP05090
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                        SUP05100
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.     SUP05110
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                   SUP05120
DMR=DEMONSTRATED RESERVE DEEPTHN=    20. DEEPTHK=    95. SURF=     2. SUP05130
CMR=COMMITTED RESERVE       DEEP=250.90     SURF=000.20               SUP05140
TEXT          PROD  PRCE SURF                                         SUP05150
C1HG CTR.01 7.079 18.81 0.00                                          SUP05160
ENDCOAL                                                               SUP05170
ENDREGION********** SV $ W.VIRGINIA,SOUTH                             SUP05180
TABLE VA $  VIRGINIA                                                  SUP05190
RCL=RECLAMATION COST              1.56       2.91       4.28          SUP05200
                                  5.65       7.10       8.48          SUP05210
                                 12.65                                SUP05220
                                  1.61       2.58       3.58          SUP05230
                                  4.56       5.60       6.59          SUP05240
                                  9.59                                SUP05250
OBR=OVERBURDEN RATIO DISTR 0 MIN=12. MAX=46.                          SUP05260
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                          SUP05270
MDM 3 4 4 3 2 3 4 4 3 2 3 4 4 3 2 3 4 4 3 2                           SUP05280
DSM=SEAM DEPTH DISTR DR=05.0 D04=25.0 D07=35.0 D10=35.0               SUP05290
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0      SUP05300
OVR   TSD=32.4       INS=16.       IND=31.       ISR=.20              SUP05310
ENDTABLE                                                              SUP05320
COAL TYPE ZA $ COAL                                                   SUP05330
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.             SUP05340
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                        SUP05350
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.     SUP05360
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                   SUP05370
DMR=DEMONSTRATED RESERVE DEEPTHN=   115. DEEPTHK=    78. SURF=    42. SUP05380
CMR=COMMITTED RESERVE       DEEP=131.56     SURF=013.82               SUP05390
OVR   YTS=.70        YTD=.60                                          SUP05400
TEXT          PROD  PRCE SURF                                         SUP05410
C1ZA CTR.01  3.436 19.16 0.12                                         SUP05420
ENDCOAL                                                               SUP05430
COAL TYPE ZB $ COAL                                                   SUP05440
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.             SUP05450
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                        SUP05460
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.     SUP05470
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                   SUP05480
DMR=DEMONSTRATED RESERVE DEEPTHN=   748. DEEPTHK=   236. SURF=   326. SUP05490
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=074.07               SUP05500
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OVR   YTS=.70        YTD=.60                                                    SUP05510
TEXT          PROD  PRCE SURF                                                   SUP05520
C1ZB CTR.01 2.263 19.16 1.00                                                    SUP05530
ENDCOAL                                                                         SUP05540
COAL TYPE ZC $ COAL                                                             SUP05550
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP05560
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP05570
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP05580
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                             SUP05590
DMR=DEMONSTRATED RESERVE DEEPTHN=    16. DEEPTHK=     0. SURF=     9.           SUP05600
OVR   YTS=.70        YTD=.60                                                    SUP05610
ENDCOAL                                                                         SUP05620
COAL TYPE ZD $ COAL                                                             SUP05630
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP05640
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP05650
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP05660
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                             SUP05670
DMR=DEMONSTRATED RESERVE DEEPTHN=   406. DEEPTHK=    23. SURF=    99.           SUP05680
CMR=COMMITTED RESERVE       DEEP=019.31     SURF=032.15                         SUP05690
OVR   YTS=.70        YTD=.60                                                    SUP05700
TEXT          PROD  PRCE SURF                                                   SUP05710
C1ZD CTR.01 1.423 19.16 0.69                                                    SUP05720
ENDCOAL                                                                         SUP05730
COAL TYPE ZE $ COAL                                                             SUP05740
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP05750
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP05760
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP05770
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                             SUP05780
DMR=DEMONSTRATED RESERVE DEEPTHN=     2. DEEPTHK=    10. SURF=     7.           SUP05790
ENDCOAL                                                                         SUP05800
COAL TYPE ZF $ COAL                                                             SUP05810
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP05820
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP05830
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP05840
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                             SUP05850
DMR=DEMONSTRATED RESERVE DEEPTHN=   133. DEEPTHK=    55. SURF=    39.           SUP05860
CMR=COMMITTED RESERVE       DEEP=241.81     SURF=012.87                         SUP05870
TEXT          PROD  PRCE SURF                                                   SUP05880
C1ZF CTR.01 5.930 16.78 0.07                                                    SUP05890
ENDCOAL                                                                         SUP05900
COAL TYPE HA $ COAL                                                             SUP05910
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP05920
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP05930
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP05940
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                             SUP05950
DMR=DEMONSTRATED RESERVE DEEPTHN=    33. DEEPTHK=     8. SURF=     6.           SUP05960
CMR=COMMITTED RESERVE       DEEP=018.35     SURF=001.89                         SUP05970
TEXT          PROD  PRCE SURF                                                   SUP05980
C1HA CTR.01  .478 15.00 0.12                                                    SUP05990
ENDCOAL                                                                         SUP06000
COAL TYPE HB $ COAL                                                             SUP06010
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP06020
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP06030
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP06040
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                             SUP06050
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DMR=DEMONSTRATED RESERVE DEEPTHN=    53. DEEPTHK=   248. SURF=      6.   SUP06060
CMR=COMMITTED RESERVE        DEEP=000.00      SURF=033.18                   SUP06070
TEXT          PROD  PRCE  SURF                                               SUP06080
C1HB CTR.01 1.013 15.00 1.00                                                 SUP06090
ENDCOAL                                                                      SUP06100
COAL TYPE HC $ COAL                                                          SUP06110
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP06120
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP06130
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP06140
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP06150
DMR=DEMONSTRATED RESERVE DEEPTHN=    36. DEEPTHK=    13. SURF=      5.   SUP06160
ENDCOAL                                                                      SUP06170
COAL TYPE HD $ COAL                                                          SUP06180
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP06190
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP06200
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP06210
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP06220
DMR=DEMONSTRATED RESERVE DEEPTHN=    39. DEEPTHK=    56. SURF=     52.   SUP06230
CMR=COMMITTED RESERVE        DEEP=076.91      SURF=018.04                   SUP06240
TEXT          PROD  PRCE  SURF                                               SUP06250
C1HD CTR.01 2.312 15.00 0.24                                                 SUP06260
ENDCOAL                                                                      SUP06270
ENDREGION*********** VA $ VIRGINIA                                           SUP06280
TABLE EK $  KENTUCKY,EAST                                                    SUP06290
RCL=RECLAMATION COST             1.56       2.90       4.28                  SUP06300
                                 5.65       7.06       8.48                  SUP06310
                                12.65                                        SUP06320
                                 1.54       2.51       3.50                  SUP06330
                                 4.48       5.52       6.52                  SUP06340
                                 9.52                                        SUP06350
OBR=OVERBURDEN RATIO DISTR 0 MIN=12. MAX=46.                                 SUP06360
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                                 SUP06370
MDM 1 1 2 3 2 2 2 3 3 2 3 3 4 3 2 4 4 4 3 2                                  SUP06380
DSM=SEAM DEPTH DISTR DR=05.0 D04=25.0 D07=35.0 D10=35.0                      SUP06390
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0             SUP06400
OVR   SVT=.045        TSD=32.4       INS= 9.        IND=23.                  SUP06410
OVR   ISR=.23                                                                SUP06420
ENDTABLE                                                                     SUP06430
COAL TYPE ZB $ COAL                                                          SUP06440
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP06450
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP06460
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP06470
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                          SUP06480
DMR=DEMONSTRATED RESERVE DEEPTHN=  1610. DEEPTHK=  1529. SURF=    579.   SUP06490
CMR=COMMITTED RESERVE        DEEP=000.00      SURF=240.46                   SUP06500
OVR   YTS=.70         YTD=.60                                                SUP06510
TEXT          PROD  PRCE  SURF                                               SUP06520
C1ZB CTR.01 7.863 16.39 1.00                                                 SUP06530
ENDCOAL                                                                      SUP06540
COAL TYPE ZC $ COAL                                                          SUP06550
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP06560
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP06570
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP06580
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                          SUP06590
DMR=DEMONSTRATED RESERVE DEEPTHN=   380. DEEPTHK=   279. SURF=     79.   SUP06600
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OVR   YTS=.70        YTD=.60
ENDCOAL
COAL TYPE ZD $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   460. DEEPTHK=   258. SURF=   273.
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=070.09
OVR   YTS=.70        YTD=.60
TEXT         PROD  PRCE SURF
C1ZD CTR.01 2.290 16.39 1.00
ENDCOAL
COAL TYPE ZE $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   174. DEEPTHK=   215. SURF=    90.
ENDCOAL
COAL TYPE ZF $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    54.
CMR=COMMITTED RESERVE       DEEP=068.19     SURF=024.50
TEXT         PROD  PRCE SURF
C1ZF CTR.01 2.471 14.34 0.32
ENDCOAL
COAL TYPE ZG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    38. DEEPTHK=     6. SURF=    26.
ENDCOAL
COAL TYPE HB $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    71. DEEPTHK=   226. SURF=   460.
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=127.22
TEXT         PROD  PRCE SURF
C1HB CTR.01 4.161 13.24 1.00
ENDCOAL
COAL TYPE HC $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    70. DEEPTHK=    14. SURF=    35.
ENDCOAL
COAL TYPE HD $ COAL
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PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP07160
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP07170
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP07180
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP07190
DMR=DEMONSTRATED RESERVE DEEPTHN=   171. DEEPTHK=   189. SURF=   158.        SUP07200
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=179.79                     SUP07210
TEXT          PROD  PRCE SURF                                                SUP07220
C1HD CTR.01 5.878 13.24 1.00                                                 SUP07230
ENDCOAL                                                                      SUP07240
COAL TYPE HE $ COAL                                                          SUP07250
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP07260
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP07270
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP07280
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP07290
DMR=DEMONSTRATED RESERVE DEEPTHN=    19. DEEPTHK=     3. SURF=    13.        SUP07300
ENDCOAL                                                                      SUP07310
COAL TYPE HF $ COAL                                                          SUP07320
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP07330
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP07340
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP07350
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP07360
DMR=DEMONSTRATED RESERVE DEEPTHN=    65. DEEPTHK=    39. SURF=   100.        SUP07370
CMR=COMMITTED RESERVE        DEEP=713.62     SURF=095.17                     SUP07380
TEXT          PROD  PRCE SURF                                                SUP07390
C1HF CTR.01 20.60 13.24 0.15                                                 SUP07400
ENDCOAL                                                                      SUP07410
COAL TYPE HG $ COAL                                                          SUP07420
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP07430
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP07440
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP07450
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP07460
DMR=DEMONSTRATED RESERVE DEEPTHN=   105. DEEPTHK=    50. SURF=    40.        SUP07470
CMR=COMMITTED RESERVE        DEEP=129.46     SURF=018.25                     SUP07480
TEXT          PROD  PRCE SURF                                                SUP07490
C1HG CTR.01 3.772 13.24 0.16                                                 SUP07500
ENDCOAL                                                                      SUP07510
ENDREGION*********** EK $ KENTUCKY,EAST                                      SUP07520
TABLE TN $  TENNESSEE                                                        SUP07530
RCL=RECLAMATION COST              1.24      2.28      3.14                   SUP07540
                                  4.12      4.94      5.89                   SUP07550
                                  8.75                                       SUP07560
                                  1.31      2.06      2.67                   SUP07570
                                  3.38      3.97      4.66                   SUP07580
                                  6.71                                       SUP07590
OBR=OVERBURDEN RATIO DISTR 0 MIN=12. MAX=46.                                 SUP07600
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                                 SUP07610
MDM 2 3 4 3 2 2 3 4 3 2 2 3 4 3 2 2 3 4 3 2                                  SUP07620
DSM=SEAM DEPTH DISTR DR=05.0 D04=25.0 D07=35.0 D10=35.0                      SUP07630
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0             SUP07640
OVR   $SV=.18         TSD=32.4       INS=6.          IND=25.                 SUP07650
OVR   ISR=.15                                                                SUP07660
ENDTABLE                                                                     SUP07670
COAL TYPE ZB $ COAL                                                          SUP07680
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP07690
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP07700
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ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   103. DEEPTHK=    30. SURF=    45.
CMR=COMMITTED RESERVE       DEEP=016.02     SURF=026.11
OVR   YTS=.70        YTD=.60
TEXT         PROD  PRCE SURF
C1ZB CTR.01 1.178 14.26 0.69
ENDCOAL
COAL TYPE ZC $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    24. DEEPTHK=     2. SURF=    17.
OVR   YTS=.70        YTD=.60
ENDCOAL
COAL TYPE ZD $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    36. DEEPTHK=     4. SURF=    19.
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=003.07
OVR   YTS=.70        YTD=.60
TEXT         PROD  PRCE SURF
C1ZD CTR.01  .095 14.26 1.00
ENDCOAL
COAL TYPE ZF $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    28. DEEPTHK=     6. SURF=    19.
ENDCOAL
COAL TYPE ZG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    48. DEEPTHK=    38. SURF=    34.
ENDCOAL
COAL TYPE HD $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    18. DEEPTHK=     9. SURF=    18.
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=0 9.96
TEXT         PROD  PRCE SURF
C1HD CTR.01  .371 11.95 1.00
ENDCOAL
COAL TYPE HE $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
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CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP08260
DMR=DEMONSTRATED RESERVE DEEPTHN=    12. DEEPTHK=     1. SURF=     5.      SUP08270
ENDCOAL                                                                    SUP08280
COAL TYPE HF $ COAL                                                        SUP08290
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP08300
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP08310
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP08320
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP08330
DMR=DEMONSTRATED RESERVE DEEPTHN=    63. DEEPTHK=    10. SURF=    29.      SUP08340
CMR=COMMITTED RESERVE       DEEP=026.61      SURF=023.28                   SUP08350
TEXT         PROD  PRCE SURF                                               SUP08360
C1HF CTR.01 1.349 11.95 0.54                                               SUP08370
ENDCOAL                                                                    SUP08380
COAL TYPE HG $ COAL                                                        SUP08390
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP08400
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP08410
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP08420
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP08430
DMR=DEMONSTRATED RESERVE DEEPTHN=    49. DEEPTHK=    36. SURF=    50.      SUP08440
CMR=COMMITTED RESERVE       DEEP=034.81      SURF=029.06                   SUP08450
TEXT         PROD  PRCE SURF                                               SUP08460
C1HG CTR.01 1.723 11.95 0.52                                               SUP08470
ENDCOAL                                                                    SUP08480
ENDREGION********** TN $ TENNESSEE                                         SUP08490
TABLE AL $  ALABAMA                                                        SUP08500
RCL=RECLAMATION COST              1.15        2.18        3.04             SUP08510
                                  4.02        4.84        5.80             SUP08520
                                  8.66                                     SUP08530
                                  1.34        2.09        2.70             SUP08540
                                  3.41        4.00        4.68             SUP08550
                                  6.74                                     SUP08560
OBR=OVERBURDEN RATIO DISTR 0 MIN=20. MAX=92.                               SUP08570
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=48.                               SUP08580
MDM 2 3 4 3 2 2 3 4 3 2 2 3 4 3 2 2 3 4 3 2                                SUP08590
DSM=SEAM DEPTH DISTR DR=05.0 D04=25.0 D07=35.0 D10=35.0                    SUP08600
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0           SUP08610
OVR   $SV=.31         TSD=41.4        TDD=18.2       INS=5.                SUP08620
OVR   IND=23.         ISR=.17                                              SUP08630
ENDTABLE                                                                   SUP08640
COAL TYPE ZB $ COAL                                                        SUP08650
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP08660
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP08670
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP08680
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                        SUP08690
DMR=DEMONSTRATED RESERVE DEEPTHN=    48. DEEPTHK=     2. SURF=     6.      SUP08700
OVR   YTS=.70         YTD=.60                                              SUP08710
ENDCOAL                                                                    SUP08720
COAL TYPE ZD $ COAL                                                        SUP08730
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP08740
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP08750
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP08760
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                        SUP08770
DMR=DEMONSTRATED RESERVE DEEPTHN=   225. DEEPTHK=   380. SURF=    21.      SUP08780
CMR=COMMITTED RESERVE       DEEP=000.00      SURF=024.73                   SUP08790
OVR   YTS=.70         YTD=.60                                              SUP08800
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TEXT          PROD  PRCE  SURF                                                 SUP08810
C1ZD CTR.01  .964 20.34 1.00                                                   SUP08820
ENDCOAL                                                                        SUP08830
COAL TYPE ZE $ COAL                                                            SUP08840
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                      SUP08850
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                 SUP08860
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.              SUP08870
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)= 0.56                            SUP08880
DMR=DEMONSTRATED RESERVE DEEPTHN=    18. DEEPTHK=     0. SURF=     2.          SUP08890
ENDCOAL                                                                        SUP08900
COAL TYPE ZF $ COAL                                                            SUP08910
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                      SUP08920
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                 SUP08930
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.              SUP08940
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                            SUP08950
DMR=DEMONSTRATED RESERVE DEEPTHN=   104. DEEPTHK=    77. SURF=    13.          SUP08960
CMR=COMMITTED RESERVE       DEEP=023.53     SURF=034.73                        SUP08970
TEXT          PROD  PRCE  SURF                                                 SUP08980
C1ZF CTR.01 2.040 17.80 0.66                                                   SUP08990
ENDCOAL                                                                        SUP09000
COAL TYPE HB $ COAL                                                            SUP09010
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                      SUP09020
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                 SUP09030
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.              SUP09040
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                            SUP09050
DMR=DEMONSTRATED RESERVE DEEPTHN=   283. DEEPTHK=   105. SURF=    25.          SUP09060
ENDCOAL                                                                        SUP09070
COAL TYPE HD $ COAL                                                            SUP09080
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                      SUP09090
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                 SUP09100
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.              SUP09110
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                            SUP09120
DMR=DEMONSTRATED RESERVE DEEPTHN=    31. DEEPTHK=    41. SURF=    14.          SUP09130
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=065.54                        SUP09140
TEXT          PROD  PRCE  SURF                                                 SUP09150
C1HD CTR.01 2.558 16.42 1.00                                                   SUP09160
ENDCOAL                                                                        SUP09170
COAL TYPE HF $ COAL                                                            SUP09180
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                      SUP09190
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                 SUP09200
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.              SUP09210
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                            SUP09220
DMR=DEMONSTRATED RESERVE DEEPTHN=   212. DEEPTHK=    66. SURF=    32.          SUP09230
CMR=COMMITTED RESERVE       DEEP=125.49     SURF=102.77                        SUP09240
TEXT          PROD  PRCE  SURF                                                 SUP09250
C1HF CTR.01 7.194 16.42 0.49                                                   SUP09260
ENDCOAL                                                                        SUP09270
ENDREGION********** AL $ ALABAMA                                               SUP09280
TABLE IL $  ILLINOIS                                                           SUP09290
RCL=RECLAMATION COST                0.13        0.19        0.25               SUP09300
                                    0.29        0.34        0.37               SUP09310
                                    0.40                                       SUP09320
                                    0.22        0.27        0.31               SUP09330
                                    0.33        0.36        0.38               SUP09340
                                    0.40                                       SUP09350
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OBR=OVERBURDEN RATIO DISTR 0 MIN=16. MAX=89.                                    SUP09360
TSM=SEAM THICKNESS DISTR  0 MIN=28. MAX=66.                                     SUP09370
MDM 0 0 0 0 0 5 5 4 2 2 5 4 4 3 2 5 5 4 3 2                                     SUP09380
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0                         SUP09390
MSS=SURFACE MINE SIZE DISTR    SIX=20.0 20.0 20.0 20.0 20.0 00.0                SUP09400
OVR   TSD=46.8        TDD=19.7        INS=20.         IND=32.                   SUP09410
OVR   ISR=.25         IDR=.20                                                   SUP09420
ENDTABLE                                                                        SUP09430
COAL TYPE HD $ COAL                                                             SUP09440
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP09450
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP09460
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP09470
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                             SUP09480
DMR=DEMONSTRATED RESERVE DEEPTHN=     7. DEEPTHK=  1901. SURF=    50.           SUP09490
CMR=COMMITTED RESERVE       DEEP=026.44     SURF=002.41                         SUP09500
TEXT          PROD  PRCE SURF                                                   SUP09510
C1HD CTR.01  .884  9.45 0.11                                                    SUP09520
ENDCOAL                                                                         SUP09530
COAL TYPE HE $ COAL                                                             SUP09540
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP09550
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP09560
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP09570
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                             SUP09580
DMR=DEMONSTRATED RESERVE DEEPTHN=     5. DEEPTHK=  1301. SURF=     0.           SUP09590
ENDCOAL                                                                         SUP09600
COAL TYPE HF $ COAL                                                             SUP09610
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP09620
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP09630
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP09640
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                             SUP09650
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=  1604. SURF=   358.           SUP09660
CMR=COMMITTED RESERVE       DEEP=012.97     SURF=017.34                         SUP09670
TEXT          PROD  PRCE SURF                                                   SUP09680
C1HF CTR.01 1.076  9.45 0.64                                                    SUP09690
ENDCOAL                                                                         SUP09700
COAL TYPE HG $ COAL                                                             SUP09710
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP09720
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP09730
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP09740
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                             SUP09750
DMR=DEMONSTRATED RESERVE DEEPTHN=    61. DEEPTHK=  1895. SURF=   900.           SUP09760
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=034.77                         SUP09770
TEXT          PROD  PRCE SURF                                                   SUP09780
C1HG CTR.01 1.384  9.45 1.00                                                    SUP09790
ENDCOAL                                                                         SUP09800
COAL TYPE HH $ COAL                                                             SUP09810
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP09820
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP09830
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP09840
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                             SUP09850
DMR=DEMONSTRATED RESERVE DEEPTHN=     3. DEEPTHK=     6. SURF=   157.           SUP09860
CMR=COMMITTED RESERVE       DEEP=046.79     SURF=007.58                         SUP09870
TEXT          PROD  PRCE SURF                                                   SUP09880
C1HH CTR.01 1.698  9.45 0.18                                                    SUP09890
ENDCOAL                                                                         SUP09900
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COAL TYPE MF $ COAL                                                     SUP09910
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP09920
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP09930
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP09940
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP09950
DMR=DEMONSTRATED RESERVE DEEPTHN=   183. DEEPTHK=   495. SURF=   134.   SUP09960
CMR=COMMITTED RESERVE        DEEP=000.00      SURF=005.69               SUP09970
TEXT         PROD  PRCE SURF                                            SUP09980
C1MF CTR.01  .226 10.38 1.00                                            SUP09990
ENDCOAL                                                                 SUP10000
COAL TYPE MG $ COAL                                                     SUP10010
PRT=1   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP10020
KSW=1   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP10030
ISN=1   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP10040
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP10050
DMR=DEMONSTRATED RESERVE DEEPTHN=   969. DEEPTHK= 12683. SURF=  4580.   SUP10060
CMR=COMMITTED RESERVE        DEEP=000.00      SURF=133.02               SUP10070
TEXT         PROD  PRCE SURF                                            SUP10080
C1MG CTR.01 5.295 10.38 1.00                                            SUP10090
ENDCOAL                                                                 SUP10100
COAL TYPE MH $ COAL                                                     SUP10110
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP10120
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP10130
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP10140
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP10150
DMR=DEMONSTRATED RESERVE DEEPTHN=   688. DEEPTHK=  8940. SURF=  1550.   SUP10160
CMR=COMMITTED RESERVE        DEEP=490.69      SURF=173.63               SUP10170
TEXT         PROD  PRCE SURF                                            SUP10180
C1MH CTR.01 21.55 10.38 0.32                                            SUP10190
ENDCOAL                                                                 SUP10200
ENDREGION********** IL $ ILLINOIS                                       SUP10210
TABLE IN $  INDIANA                                                     SUP10220
RCL=RECLAMATION COST               .14        .20        .26            SUP10230
                                   .30        .35        .37            SUP10240
                                   .41                                  SUP10250
                                   .25        .29        .33            SUP10260
                                   .35        .39        .40            SUP10270
                                   .43                                  SUP10280
OBR=OVERBURDEN RATIO DISTR 0 MIN=16. MAX=69.                            SUP10290
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=66.                            SUP10300
MDM 0 0 0 0 0 5 5 4 2 2 5 4 4 3 2 5 5 4 3 2                             SUP10310
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0                 SUP10320
MSS=SURFACE MINE SIZE DISTR    SIX=20.0 20.0 20.0 20.0 20.0 00.0        SUP10330
OVR   TSD=46.8        TDD=19.7        INS=14.        IND=21.            SUP10340
OVR   ISR=.29         IDR=.20                                           SUP10350
ENDTABLE                                                                SUP10360
COAL TYPE HE $ COAL                                                     SUP10370
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP10380
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP10390
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP10400
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP10410
DMR=DEMONSTRATED RESERVE DEEPTHN=    44. DEEPTHK=   277. SURF=    73.   SUP10420
ENDCOAL                                                                 SUP10430
COAL TYPE HG $ COAL                                                     SUP10440
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP10450
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KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   256. DEEPTHK=  1506. SURF=   581.
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=000.79
TEXT          PROD  PRCE SURF
C1HG CTR.01  .032 10.04 1.00
ENDCOAL
COAL TYPE HH $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    10.
CMR=COMMITTED RESERVE       DEEP=001.93     SURF=003.40
TEXT          PROD  PRCE SURF
C1HH CTR.01  .193 10.04 0.70
ENDCOAL
COAL TYPE MB $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     2. DEEPTHK=   105. SURF=     1.
ENDCOAL
COAL TYPE MD $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   289. DEEPTHK=   593. SURF=   255.
ENDCOAL
COAL TYPE ME $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     2. DEEPTHK=    34. SURF=    48.
ENDCOAL
COAL TYPE MF $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    27. DEEPTHK=   158. SURF=    61.
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=000.79
TEXT          PROD  PRCE SURF
C1MF CTR.01  .032  9.57 1.00
ENDCOAL
COAL TYPE MG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=   720. DEEPTHK=  2257. SURF=   289.
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CMR=COMMITTED RESERVE        DEEP=001.50     SURF=321.51
TEXT          PROD  PRCE SURF
C1MG CTR.01 12.78  9.57 1.00
ENDCOAL
ENDREGION********** IN $ INDIANA
TABLE WK $  KENTUCKY,WEST
RCL=RECLAMATION COST                  .13         .20         .26
                                      .30         .34         .37
                                      .40
                                      .22         .27         .31
                                      .33         .36         .38
                                      .40
OBR=OVERBURDEN RATIO DISTR 0 MIN=16. MAX=67.
TSM=SEAM THICKNESS DISTR   0 MIN=24. MAX=66.
MDM 0 0 3 3 2 0 0 4 3 2 0 0 4 3 2 0 0 4 3 2
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0
MSS=SURFACE MINE SIZE DISTR    SIX=20.0 20.0 20.0 20.0 20.0 00.0
OVR   SVT=.045        TSD=46.8        TDD=19.7       INS= 9.
OVR   IND=23.         ISR=.25         IDR=.20
ENDTABLE
COAL TYPE HF $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     5. SURF=    55.
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=002.94
TEXT          PROD  PRCE SURF
C1HF CTR.01  .116  9.86 1.00
ENDCOAL
COAL TYPE HG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    53. DEEPTHK=  5028. SURF=  1230.
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=078.61
TEXT          PROD  PRCE SURF
C1HG CTR.01 3.118  9.86 1.00
ENDCOAL
COAL TYPE MF $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=    17. DEEPTHK=   153. SURF=   171.
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=035.35
TEXT          PROD  PRCE SURF
C1MF CTR.01 1.401  9.32 1.00
ENDCOAL
COAL TYPE MG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
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DMR=DEMONSTRATED RESERVE DEEPTHN=   101. DEEPTHK=   168. SURF=   450.   SUP11560
CMR=COMMITTED RESERVE        DEEP=428.34     SURF=287.00                SUP11570
TEXT          PROD  PRCE SURF                                           SUP11580
C1MG CTR.01 24.12  9.32 0.47                                            SUP11590
ENDCOAL                                                                 SUP11600
COAL TYPE MH $ COAL                                                     SUP11610
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP11620
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP11630
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP11640
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP11650
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    28.   SUP11660
ENDCOAL                                                                 SUP11670
ENDREGION********** WK $ KENTUCKY,WEST                                  SUP11680
TABLE IA $  IOWA                                                        SUP11690
RCL=RECLAMATION COST               .19         .25         .31          SUP11700
                                   .35         .40         .43          SUP11710
                                   .46                                  SUP11720
                                   .24         .28         .32          SUP11730
                                   .35         .38         .40          SUP11740
                                   .42                                  SUP11750
OBR=OVERBURDEN RATIO DISTR 0 MIN=23. MAX=46.                            SUP11760
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                            SUP11770
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                             SUP11780
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0                 SUP11790
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0        SUP11800
OVR   TSD=46.8        TDD=19.7        INS=7.         IND=26.            SUP11810
OVR   ISR=.15                                                           SUP11820
ENDTABLE                                                                SUP11830
COAL TYPE MG $ COAL                                                     SUP11840
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP11850
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP11860
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP11870
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP11880
DMR=DEMONSTRATED RESERVE DEEPTHN=   102. DEEPTHK=   409. SURF=     0.   SUP11890
ENDCOAL                                                                 SUP11900
COAL TYPE MH $ COAL                                                     SUP11910
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP11920
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP11930
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP11940
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP11950
DMR=DEMONSTRATED RESERVE DEEPTHN=   250. DEEPTHK=   284. SURF=     0.   SUP11960
TEXT          PROD  PRCE SURF                                           SUP11970
C1MH CTR.01   .461  9.13 1.00                                           SUP11980
ENDCOAL                                                                 SUP11990
COAL TYPE SH $ COAL                                                     SUP12000
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP12010
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP12020
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP12030
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP12040
DMR=DEMONSTRATED RESERVE DEEPTHN=   248. DEEPTHK=   503. SURF=     0.   SUP12050
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=019.02                SUP12060
OVR   YTS=.95        YTD=.95                                            SUP12070
ENDCOAL                                                                 SUP12080
ENDREGION********** IA $ IOWA                                           SUP12090
TABLE MO $  MISSOURI                                                    SUP12100
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RCL=RECLAMATION COST                .15        .21        .27            SUP12110
                                    .31        .36        .38            SUP12120
                                    .42                                  SUP12130
                                    .27        .31        .35            SUP12140
                                    .38        .41        .43            SUP12150
                                    .45                                  SUP12160
OBR=OVERBURDEN RATIO DISTR 0 MIN=23. MAX=107.                            SUP12170
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                             SUP12180
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                              SUP12190
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0                  SUP12200
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0         SUP12210
OVR   TSD=46.8       TDD=19.7       INS=10.       IND=33.                SUP12220
OVR   ISR=.15                                                            SUP12230
ENDTABLE                                                                 SUP12240
COAL TYPE HG $ COAL                                                      SUP12250
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                SUP12260
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                           SUP12270
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.        SUP12280
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP12290
DMR=DEMONSTRATED RESERVE DEEPTHN=   205. DEEPTHK=   108. SURF=   298.    SUP12300
ENDCOAL                                                                  SUP12310
COAL TYPE HH $ COAL                                                      SUP12320
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                SUP12330
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                           SUP12340
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.        SUP12350
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP12360
DMR=DEMONSTRATED RESERVE DEEPTHN=    40. DEEPTHK=     0. SURF=   284.    SUP12370
ENDCOAL                                                                  SUP12380
COAL TYPE MG $ COAL                                                      SUP12390
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                SUP12400
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                           SUP12410
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.        SUP12420
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP12430
DMR=DEMONSTRATED RESERVE DEEPTHN=   113. DEEPTHK=    32. SURF=   130.    SUP12440
ENDCOAL                                                                  SUP12450
COAL TYPE MH S COAL                                                      SUP12460
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                SUP12470
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                           SUP12480
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.        SUP12490
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP12500
DMR=DEMONSTRATED RESERVE DEEPTHN=   987. DEEPTHK=   694. SURF=   786.    SUP12510
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=099.25                  SUP12520
TEXT          PROD  PRCE SURF                                            SUP12530
C1MH CTR.01  2.990  8.38 1.00                                            SUP12540
ENDCOAL                                                                  SUP12550
ENDREGION********** MO S MISSOURI                                        SUP12560
TABLE KS $  KANSAS                                                       SUP12570
RCL=RECLAMATION COST                .19        .25        .31            SUP12580
                                    .35        .40        .42            SUP12590
                                    .46                                  SUP12600
                                    .40        .44        .48            SUP12610
                                    .51        .54        .56            SUP12620
                                    .58                                  SUP12630
OBR=OVERBURDEN RATIO DISTR 0 MIN=23. MAX=107.                            SUP12640
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                             SUP12650
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MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0
MSS=SURFACE MINE SIZE DISTR    SIX=50.0 50.0 00.0 00.0 00.0 00.0
OVR   TSD=46.8        TDD=19.7         INS=8.          IND=33.
OVR   ISR=.15
ENDTABLE
COAL TYPE ZG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    42.
ENDCOAL
COAL TYPE HF $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=   112.
ENDCOAL
COAL TYPE HG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=   321.
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=016.07
TEXT          PROD  PRCE SURF
C1HG CTR.01   .485   9.52 1.00
ENDCOAL
COAL TYPE MH $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    54.
ENDCOAL
ENDREGION********** KS $ KANSAS
TABLE OK $  OKLAHOMA
RCL=RECLAMATION COST              .15        .21        .27
                                  .31        .36        .38
                                  .41
                                  .42        .46        .50
                                  .52        .56        .57
                                  .6
OBR=OVERBURDEN RATIO DISTR 0 MIN=23. MAX=107.
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0
MSS=SURFACE MINE SIZE DISTR    SIX=50.0 50.0 00.0 00.0 00.0 00.0
OVR   TSD=46.8        TDD=19.7         INS=6.          IND=23.
OVR   ISR=.15
ENDTABLE
COAL TYPE ZA $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
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KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP13210
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP13220
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP13230
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=     8.   SUP13240
CMR=COMMITTED RESERVE         DEEP=000.00      SURF=002.53              SUP13250
OVR   YTS=0.70         YTD=0.60                                         SUP13260
TEXT           PROD  PRCE SURF                                          SUP13270
C1ZA CTR.01   .073 13.51 1.00                                           SUP13280
ENDCOAL                                                                 SUP13290
COAL TYPE ZB $ COAL                                                     SUP13300
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP13310
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP13320
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP13330
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP13340
DMR=DEMONSTRATED RESERVE DEEPTHN=    89. DEEPTHK=     8. SURF=    42.   SUP13350
CMR=COMMITTED RESERVE         DEEP=000.00      SURF=001.57              SUP13360
OVR   YTS=0.70         YTD=0.60                                         SUP13370
TEXT           PROD  PRCE SURF                                          SUP13380
C1ZB CTR.01   .045 13.51 1.00                                           SUP13390
ENDCOAL                                                                 SUP13400
COAL TYPE ZC $ COAL                                                     SUP13410
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP13420
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP13430
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP13440
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP13450
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    16.   SUP13460
OVR   YTS=0.70         YTD=0.60                                         SUP13470
ENDCOAL                                                                 SUP13480
COAL TYPE ZD $ COAL                                                     SUP13490
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP13500
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP13510
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP13520
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP13530
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    68.   SUP13540
CMR=COMMITTED RESERVE         DEEP=000.00      SURF=002.22              SUP13550
OVR   YTS=0.70         YTD=0.60                                         SUP13560
TEXT           PROD  PRCE SURF                                          SUP13570
C1ZD CTR.01   .060 13.51 1.00                                           SUP13580
ENDCOAL                                                                 SUP13590
COAL TYPE ZE $ COAL                                                     SUP13600
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP13610
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP13620
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP13630
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP13640
DMR=DEMONSTRATED RESERVE DEEPTHN=     1. DEEPTHK=    13. SURF=     7.   SUP13650
ENDCOAL                                                                 SUP13660
COAL TYPE ZF $ COAL                                                     SUP13670
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP13680
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP13690
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP13700
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                     SUP13710
DMR=DEMONSTRATED RESERVE DEEPTHN=   125. DEEPTHK=    76. SURF=    32.   SUP13720
CMR=COMMITTED RESERVE         DEEP=000.00      SURF=018.44              SUP13730
TEXT           PROD  PRCE SURF                                          SUP13740
C1ZF CTR.01   .052 13.51 1.00                                           SUP13750
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ENDCOAL                                                                    SUP13760
COAL TYPE ZG $ COAL                                                        SUP13770
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP13780
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP13790
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP13800
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP13810
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=     3.      SUP13820
ENDCOAL                                                                    SUP13830
COAL TYPE HA $ COAL                                                        SUP13840
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP13850
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP13860
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP13870
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP13880
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    35.      SUP13890
ENDCOAL                                                                    SUP13900
COAL TYPE HB $ COAL                                                        SUP13910
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP13920
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP13930
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP13940
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP13950
DMR=DEMONSTRATED RESERVE DEEPTHN=    26. DEEPTHK=    58. SURF=     0.      SUP13960
ENDCOAL                                                                    SUP13970
COAL TYPE HG $ COAL                                                        SUP13980
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP13990
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP14000
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP14010
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP14020
DMR=DEMONSTRATED RESERVE DEEPTHN=    50. DEEPTHK=   106. SURF=    18.      SUP14030
CMR=COMMITTED RESERVE         DEEP=000.00      SURF=020.03                 SUP14040
TEXT          PROD  PRCE SURF                                              SUP14050
C1HG CTR.01 1.794  9.41 1.00                                               SUP14060
ENDCOAL                                                                    SUP14070
COAL TYPE MG $ COAL                                                        SUP14080
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP14090
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP14100
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP14110
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                        SUP14120
DMR=DEMONSTRATED RESERVE DEEPTHN=     8. DEEPTHK=    29. SURF=    17.      SUP14130
ENDCOAL                                                                    SUP14140
ENDREGION********** OK $ OKLAHOMA                                          SUP14150
TABLE AR $  ARKANSAS                                                       SUP14160
RCL=RECLAMATION COST              .18        .25        .31                SUP14170
                                  .35        .36        .38                SUP14180
                                  .41                                      SUP14190
                                  .40        .44        .48                SUP14200
                                  .51        .54        .56                SUP14210
                                  .58                                      SUP14220
OBR=OVERBURDEN RATIO DISTR 0 MIN=23. MAX=46.                               SUP14230
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                               SUP14240
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                                SUP14250
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0                    SUP14260
MSS=SURFACE MINE SIZE DISTR   SIX=50.0 50.0 00.0 00.0 00.0 00.0            SUP14270
OVR   $SV=.02        TSD=46.8      TDD=19.7       INS= 9.                  SUP14280
OVR   IND=22.        ISR=.15                                               SUP14290
ENDTABLE                                                                   SUP14300
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COAL TYPE ZB $ COAL                                                          SUP14310
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP14320
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP14330
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP14340
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP14350
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    25.        SUP14360
OVR   YTS=0.70        YTD=0.60                                               SUP14370
ENDCOAL                                                                      SUP14380
COAL TYPE ZD $ COAL                                                          SUP14390
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP14400
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP14410
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP14420
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP14430
DMR=DEMONSTRATED RESERVE DEEPTHN=    10. DEEPTHK=    30. SURF=    11.        SUP14440
OVR   YTS=0.70        YTD=0.60                                               SUP14450
ENDCOAL                                                                      SUP14460
COAL TYPE ZE $ COAL                                                          SUP14470
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP14480
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP14490
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP14500
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP14510
DMR=DEMONSTRATED RESERVE DEEPTHN=   136. DEEPTHK=   133. SURF=    58.        SUP14520
ENDCOAL                                                                      SUP14530
COAL TYPE ZF $ COAL                                                          SUP14540
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP14550
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP14560
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP14570
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                          SUP14580
DMR=DEMONSTRATED RESERVE DEEPTHN=    78. DEEPTHK=     0. SURF=   114.        SUP14590
CMR=COMMITTED RESERVE      DEEP=000.00     SURF=012.94                       SUP14600
TEXT         PROD  PRCE SURF                                                 SUP14610
C1ZF CTR.01  .395 19.74 1.00                                                 SUP14620
ENDCOAL                                                                      SUP14630
ENDREGION********** AR $ ARKANSAS                                            SUP14640
TABLE ND $  NORTH DAKOTA                                                     SUP14650
RCL=RECLAMATION COST              .14        .21        .26                  SUP14660
                                  .30        .35        .38                  SUP14670
                                  .41                                        SUP14680
                                  .14        .19        .22                  SUP14690
                                  .25        .29        .30                  SUP14700
                                  .32                                        SUP14710
OBR=OVERBURDEN RATIO DISTR 0 MIN= 6. MAX=13.                                 SUP14720
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                                 SUP14730
MOM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                                  SUP14740
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0                      SUP14750
MSS=SURFACE MINE SIZE DISTR    SIX=00.0  0.0 10.0 20.0 30.0 40.0             SUP14760
OVR   $SV=.58        SWL=0.        DWL=0.        INS= 9.                     SUP14770
OVR   YTS=0.95       YTD=0.95      ISR=.15       F$S=.125                    SUP14780
OVR   F$D=.080                                                               SUP14790
ENDTABLE                                                                     SUP14800
COAL TYPE LA $ COAL                                                          SUP14810
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                    SUP14820
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                               SUP14830
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.            SUP14840
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                          SUP14850
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DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=   649.    SUP14860
OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0                          SUP14870
ENDCOAL                                                                    SUP14880
COAL TYPE LB $ COAL                                                        SUP14890
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP14900
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP14910
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP14920
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP14930
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=   117.    SUP14940
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=008.75                   SUP14950
OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0                          SUP14960
TEXT          PROD  PRCE SURF                                              SUP14970
C1LB CTR.01    440  2.47 1.00                                              SUP14980
ENDCOAL                                                                    SUP14990
COAL TYPE LD $ COAL                                                        SUP15000
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP15010
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP15020
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP15030
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP15040
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=  5087.    SUP15050
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=001.34                   SUP15060
OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0                          SUP15070
TEXT          PROD  PRCE SURF                                              SUP15080
C1LD CTR.01     67  2.47 1.00                                              SUP15090
ENDCOAL                                                                    SUP15100
COAL TYPE LF $ COAL                                                        SUP15110
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP15120
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP15130
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP15140
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP15150
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=  4190.    SUP15160
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=143.55                   SUP15170
OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0                          SUP15180
TEXT          PROD  PRCE SURF                                              SUP15190
C1LF CTR.01   7209  2.47 1.00                                              SUP15200
ENDCOAL                                                                    SUP15210
COAL TYPE LG $ COAL                                                        SUP15220
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP15230
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP15240
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP15250
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP15260
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=  2633.    SUP15270
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=006.80                   SUP15280
OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0                          SUP15290
TEXT          PROD  PRCE SURF                                              SUP15300
C1LG CTR.01    341  2.47 1.00                                              SUP15310
ENDCOAL                                                                    SUP15320
ENDREGION********** ND $ NORTH DAKOTA                                      SUP15330
TABLE SD $  SOUTH DAKOTA                                                   SUP15340
RCL=RECLAMATION COST                  .14         .21         .26          SUP15350
                                      .30         .35         .38          SUP15360
                                      .41                                  SUP15370
                                      .14         .19         .22          SUP15380
                                      .25         .29         .30          SUP15390
                                      .32                                  SUP15400
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OBR=OVERBURDEN RATIO DISTR 0 MIN= 6. MAX=18.
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0
MSS=SURFACE MINE SIZE DISTR    SIX=00.0  0.0 10.0 20.0 30.0 40.0
OVR   SWL=0.00         DWL=0.00        INS= 9.        YTS=0.95
OVR   YTD=0.95         ISR=.16         SVT=.006
ENDTABLE
COAL TYPE LD $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00
DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=     0. SURF=   160.
OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0
ENDCOAL
COAL TYPE LG $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00
DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=     0. SURF=    40.
OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0
ENDCOAL
ENDREGION********** SD $ SOUTH DAKOTA
TABLE EM $  MONTANA,EAST
RCL=RECLAMATION COST                 .11        .17        .23
                                     .27        .32        .34
                                     .38
                                     .09        .14        .18
                                     .20        .24        .25
                                     .28
OBR=OVERBURDEN RATIO DISTR 0 MIN= 6. MAX=22.
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0
MSS=SURFACE MINE SIZE DISTR    SIX=00.0  0.0 10.0 20.0 30.0 40.0
OVR   SVT=0.20         SWL=0.00        DWL=0.00        INS=7.
OVR   ISR=.14          YTS=0.95        YTD=0.95        F$S=.125
OVR   F$D=.080
ENDTABLE
COAL TYPE LB $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00
DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=     0. SURF=   000.
OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0
ENDCOAL
COAL TYPE LD $ COAL
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00
DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=     0. SURF=  1330.
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CMR=COMMITTED RESERVE       DEEP=000.00     SURF=009.74                SUP15960
OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0                      SUP15970
TEXT          PROD  PRCE SURF                                          SUP15980
C1LD CTR.01    498  3.10 1.00                                          SUP15990
ENDCOAL                                                                SUP16000
ENDREGION*********** EM $ MONTANA,EAST                                 SUP16010
TABLE WM $  MONTANA,WEST                                               SUP16020
RCL=RECLAMATION COST                  .11        .17        .23        SUP16030
                                      .27        .32        .34        SUP16040
                                      .38                              SUP16050
                                      .09        .14        .18        SUP16060
                                      .20        .24        .25        SUP16070
                                      .28                              SUP16080
OBR=OVERBURDEN RATIO DISTR 0 MIN= 2. MAX=22.                           SUP16090
TSM=SEAM THICKNESS DISTR   0 MIN=60. MAX=102.                          SUP16100
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                            SUP16110
DSM=SEAM DEPTH DISTR DR=00.0 D04=33.3 D07=33.3 D10=33.4                SUP16120
MSS=SURFACE MINE SIZE DISTR    SIX=00.0  0.0 10.0 20.0 30.0 40.0       SUP16130
OVR   SVT=.30         TSD=50.4        TDD=18.8        SWL=0.00         SUP16140
OVR   DWL=0.00        YTS=0.95        YTD=0.95        ISR=.30          SUP16150
OVR   F$S=.125        F$D=.080        INS=7.                           SUP16160
ENDTABLE                                                               SUP16170
COAL TYPE MB $ COAL                                                    SUP16180
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.              SUP16190
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                         SUP16200
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.      SUP16210
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                     SUP16220
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=  3357. SURF=   110.  SUP16230
OVR   YTS=.85         YTD=.80                                          SUP16240
OVTSM=0 MIN=28. MAX=102.                                               SUP16250
ENDCOAL                                                                SUP16260
COAL TYPE MF $ COAL                                                    SUP16270
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.              SUP16280
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                         SUP16290
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.      SUP16300
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                     SUP16310
DMR=DEMONSTRATED RESERVE DEEPTHN=   113. DEEPTHK=   622. SURF=     0.  SUP16320
OVR   YTS=.85         YTD=.80                                          SUP16330
ENDCOAL                                                                SUP16340
COAL TYPE MG $ COAL                                                    SUP16350
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.              SUP16360
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                         SUP16370
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.      SUP16380
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                     SUP16390
DMR=DEMONSTRATED RESERVE DEEPTHN=    75. DEEPTHK=   234. SURF=     0.  SUP16400
OVR   YTS=.85         YTD=.80                                          SUP16410
OVTSM=0 MIN=28. MAX=102.                                               SUP16420
ENDCOAL                                                                SUP16430
COAL TYPE SA $ COAL                                                    SUP16440
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.              SUP16450
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                         SUP16460
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.      SUP16470
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                    SUP16480
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK= 40441. SURF= 29410.  SUP16490
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=138.91                SUP16500
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OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                SUP16510
TEXT          PROD  PRCE SURF                                    SUP16520
C1SA CTR.01  7096  3.38 1.00                                     SUP16530
ENDCOAL                                                          SUP16540
COAL TYPE SB $ COAL                                              SUP16550
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.        SUP16560
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                   SUP16570
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE. SUP16580
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00              SUP16590
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK= 18969. SURF=  7513.  SUP16600
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=269.46          SUP16610
OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                SUP16620
TEXT          PROD  PRCE SURF                                    SUP16630
C1SB CTR.01 13766  3.38 1.00                                     SUP16640
ENDCOAL                                                          SUP16650
COAL TYPE SF $ COAL                                              SUP16660
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.        SUP16670
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                   SUP16680
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE. SUP16690
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00              SUP16700
DMR=DEMONSTRATED RESERVE DEEPTHN=    83. DEEPTHK=   127. SURF=     0.  SUP16710
OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                SUP16720
OVTSM=0 MIN=28. MAX=102.                                         SUP16730
ENDCOAL                                                          SUP16740
ENDREGION********** WM $ MONTANA,WEST                            SUP16750
TABLE WY $  WYOMING                                              SUP16760
RCL=RECLAMATION COST                .11       .17       .23      SUP16770
                                    .27       .32       .35      SUP16780
                                    .38                          SUP16790
                                    .09       .13       .17      SUP16800
                                    .20       .23       .25      SUP16810
                                    .28                          SUP16820
OBR=OVERBURDEN RATIO DISTR 0 MIN= 2. MAX=36.                     SUP16830
TSM=SEAM THICKNESS DISTR   0 MIN=60. MAX=102.                    SUP16840
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                      SUP16850
DSM=SEAM DEPTH DISTR DR=00.0 D04=33.3 D07=33.3 D10=33.4          SUP16860
MSS=SURFACE MINE SIZE DISTR    SIX=00.0  0.0 10.0 20.0 30.0 40.0 SUP16870
OVR   SVT=.105       TSD=50.4      TDD=18.8      SWL=0.00        SUP16880
OVR   DWL=0.00       YTS=0.95      YTD=0.95      INS=14.         SUP16890
OVR   IND=24.0       ISR=.14       F$S=.125      F$D=.080        SUP16900
ENDTABLE                                                         SUP16910
COAL TYPE HB $ COAL                                              SUP16920
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.        SUP16930
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                   SUP16940
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE. SUP16950
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56               SUP16960
DMR=DEMONSTRATED RESERVE DEEPTHN=    49. DEEPTHK=   507. SURF=  1000.  SUP16970
OVR   YTS=.95       YTD=.80                                      SUP16980
OVTSM=0 MIN=28. MAX=102.                                         SUP16990
ENDCOAL                                                          SUP17000
COAL TYPE MB $ COAL                                              SUP17010
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.        SUP17020
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                   SUP17030
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE. SUP17040
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56               SUP17050
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DMR=DEMONSTRATED RESERVE DEEPTHN=     9. DEEPTHK=  1815. SURF=   467.     SUP17060
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=147.28                   SUP17070
OVR   YTS=.85        YTD=.80                                               SUP17080
OVTSM=1    SIX=64.0 17.9 17.9  0.2 42.9 57.1                               SUP17090
TEXT          PROD  PRCE SURF                                              SUP17100
C1MB CTR.01   7426  4.84 1.00                                              SUP17110
ENDCOAL                                                                    SUP17120
COAL TYPE MD $ COAL                                                        SUP17130
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP17140
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP17150
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP17160
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                         SUP17170
DMR=DEMONSTRATED RESERVE DEEPTHN=   738. DEEPTHK=  2887. SURF=  1116.     SUP17180
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=052.46                   SUP17190
OVR   YTS=.85        YTD=.80                                               SUP17200
OVTSM=1    SIX=50.3 20.3 20.3  9.1 42.9 57.1                               SUP17210
TEXT          PROD  PRCE SURF                                              SUP17220
C1MD CTR.01   2645  4.84 1.00                                              SUP17230
ENDCOAL                                                                    SUP17240
COAL TYPE MF $ COAL                                                        SUP17250
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP17260
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP17270
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP17280
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                         SUP17290
DMR=DEMONSTRATED RESERVE DEEPTHN=    16. DEEPTHK=   6 9. SURF=     0.     SUP17300
OVR   YTS=.85        YTD=.80                                               SUP17310
OVTSM=1    SIX=49.4 21.5 21.5  7.6 42.9 57.1                               SUP17320
ENDCOAL                                                                    SUP17330
COAL TYPE MH $ COAL                                                        SUP17340
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP17350
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP17360
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP17370
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                         SUP17380
DMR=DEMONSTRATED RESERVE DEEPTHN=    10. DEEPTHK=    48. SURF=     0.     SUP17390
OVR   YTS=.85        YTD=.80                                               SUP17400
OVTSM=1    SIX=45.9 25.8 25.8  2.5 42.9 57.1                               SUP17410
ENDCOAL                                                                    SUP17420
COAL TYPE SA $ COAL                                                        SUP17430
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP17440
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP17450
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP17460
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP17470
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK= 11035. SURF=  1812.     SUP17480
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=000.95                   SUP17490
OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                          SUP17500
TEXT          PROD  PRCE SURF                                              SUP17510
C1SA CTR.01     48  3.82 1.00                                              SUP17520
ENDCOAL                                                                    SUP17530
COAL TYPE SB $ COAL                                                        SUP17540
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP17550
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP17560
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP17570
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP17580
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=  3716. SURF=    32.     SUP17590
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=163.03                   SUP17600
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OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                          SUP17610
TEXT          PROD  PRCE SURF                                              SUP17620
C1SB CTR.01  8220  3.82 1.00                                               SUP17630
ENDCOAL                                                                    SUP17640
COAL TYPE SD $ COAL                                                        SUP17650
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP17660
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP17670
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP17680
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP17690
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=  2111. SURF=  1113.      SUP17700
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=085.71                    SUP17710
OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                          SUP17720
TEXT          PROD  PRCE SURF                                              SUP17730
C1SD CTR.01  4322  3.82 1.00                                               SUP17740
ENDCOAL                                                                    SUP17750
COAL TYPE SF $ COAL                                                        SUP17760
PRT=1   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP17770
KSW=1   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP17780
ISN=1   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP17790
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP17800
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=  2024. SURF= 17870.      SUP17810
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=012.69                    SUP17820
OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                          SUP17830
TEXT          PROD  PRCE SURF                                              SUP17840
C1SF CTR.01   640  3.82 1.00                                               SUP17850
ENDCOAL                                                                    SUP17860
COAL TYPE SG $ COAL                                                        SUP17870
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP17880
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP17890
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP17900
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP17910
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     3. SURF=     0.      SUP17920
OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                          SUP17930
ENDCOAL                                                                    SUP17940
COAL TYPE SH $ COAL                                                        SUP17950
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP17960
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP17970
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP17980
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP17990
DMR=DEMONSTRATED RESERVE DEEPTHN=     1. DEEPTHK=     1. SURF=     0.      SUP18000
OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                          SUP18010
ENDCOAL                                                                    SUP18020
ENDREGION********** WY $ WYOMING                                           SUP18030
TABLE CS $  COLORADO,SOUTH                                                 SUP18040
RCL=RECLAMATION COST                 .15         .22         .28           SUP18050
                                     .31         .36         .39           SUP18060
                                     .42                                   SUP18070
                                     .17         .22         .26           SUP18080
                                     .28         .32         .33           SUP18090
                                     .36                                   SUP18100
OBR=OVERBURDEN RATIO DISTR 0 MIN= 9. MAX=21.                               SUP18110
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=102.                              SUP18120
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                                SUP18130
DSM=SEAM DEPTH DISTR DR=00.0 D04=33.3 D07=33.3 D10=33.4                    SUP18140
MSS=SURFACE MINE SIZE DISTR    SIX=20.0 20.0 20.0 20.0 20.0 00.0           SUP18150
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OVR   $SV=.26          TSD=50.4        TDD=18.8        INS=8.                     SUP18160
OVR   IND=22.          ISR=.11         F$S=.125        F$D=.080                   SUP18170
ENDTABLE                                                                          SUP18180
COAL TYPE ZA $ COAL                                                               SUP18190
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                         SUP18200
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                    SUP18210
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                 SUP18220
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                               SUP18230
DMR=DEMONSTRATED RESERVE DEEPTHN=     2. DEEPTHK=   154. SURF=      0.            SUP18240
CMR=COMMITTED RESERVE         DEEP=040.36      SURF=000.00                        SUP18250
OVR   YTS=0.80         YTD=0.70                                                   SUP18260
OVTSM=1     SIX=46.1 25.6 25.6  2.8 42.9 57.1                                     SUP18270
TEXT           PROD  PRCE SURF                                                    SUP18280
C1ZA CTR.01   1568  9.83 0.00                                                     SUP18290
ENDCOAL                                                                           SUP18300
COAL TYPE ZB $ COAL                                                               SUP18310
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                         SUP18320
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                    SUP18330
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                 SUP18340
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                               SUP18350
DMR=DEMONSTRATED RESERVE DEEPTHN=     9. DEEPTHK=    22. SURF=      0.            SUP18360
CMR=COMMITTED RESERVE         DEEP=025.22      SURF=000.00                        SUP18370
OVR   YTS=0.80         YTD=0.70                                                   SUP18380
TEXT           PROD  PRCE SURF                                                    SUP18390
C1ZB CTR.01    980  9.83 0.00                                                     SUP18400
ENDCOAL                                                                           SUP18410
COAL TYPE ZD $ COAL                                                               SUP18420
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                         SUP18430
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                    SUP18440
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                 SUP18450
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                               SUP18460
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     6. SURF=      0.            SUP18470
CMR=COMMITTED RESERVE         DEEP=006.00      SURF=000.00                        SUP18480
OVR   YTS=0.80         YTD=0.70                                                   SUP18490
TEXT           PROD  PRCE SURF                                                    SUP18500
C1ZD CTR.01    394  9.83 0.00                                                     SUP18510
ENDCOAL                                                                           SUP18520
COAL TYPE ZF $ COAL                                                               SUP18530
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                         SUP18540
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                    SUP18550
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                 SUP18560
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                               SUP18570
DMR=DEMONSTRATED RESERVE DEEPTHN=     8. DEEPTHK=   292. SURF=      0.            SUP18580
CMR=COMMITTED RESERVE         DEEP=  0.10      SURF=  0.00                        SUP18590
TEXT           PROD  PRCE SURF                                                    SUP18600
C1ZF CTR.01      3  9.83 0.00                                                     SUP18610
ENDCOAL                                                                           SUP18620
COAL TYPE HA $ COAL                                                               SUP18630
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                         SUP18640
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                    SUP18650
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                 SUP18660
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                               SUP18670
DMR=DEMONSTRATED RESERVE DEEPTHN=    68. DEEPTHK=   761. SURF=      0.            SUP18680
ENDCOAL                                                                           SUP18690
COAL TYPE HB $ COAL                                                               SUP18700
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PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP18710
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP18720
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP18730
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP18740
DMR=DEMONSTRATED RESERVE DEEPTHN=    143. DEEPTHK=   581. SURF=    60.   SUP18750
ENDCOAL                                                                  SUP18760
COAL TYPE HC $ COAL                                                      SUP18770
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP18780
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP18790
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP18800
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP18810
DMR=DEMONSTRATED RESERVE DEEPTHN=     21. DEEPTHK=    26. SURF=     0.   SUP18820
ENDCOAL                                                                  SUP18830
COAL TYPE HD $ COAL                                                      SUP18840
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP18850
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP18860
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP18870
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP18880
DMR=DEMONSTRATED RESERVE DEEPTHN=     98. DEEPTHK=   451. SURF=   413.   SUP18890
ENDCOAL                                                                  SUP18900
COAL TYPE HF $ COAL                                                      SUP18910
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP18920
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP18930
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP18940
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP18950
DMR=DEMONSTRATED RESERVE DEEPTHN=     51. DEEPTHK=    41. SURF=     0.   SUP18960
ENDCOAL                                                                  SUP18970
COAL TYPE MA $ COAL                                                      SUP18980
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP18990
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP19000
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP19010
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP19020
DMR=DEMONSTRATED RESERVE DEEPTHN=     86. DEEPTHK=   734. SURF=   270.   SUP19030
CMR=COMMITTED RESERVE        DEEP=000.00     SURF=021.72                 SUP19040
TEXT           PROD  PRCE SURF                                           SUP19050
C1MA CTR.01     916  8.21 1.00                                           SUP19060
ENDCOAL                                                                  SUP19070
COAL TYPE MB $ COAL                                                      SUP19080
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP19090
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP19100
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP19110
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP19120
DMR=DEMONSTRATED RESERVE DEEPTHN=     34. DEEPTHK=   575. SURF=     0.   SUP19130
CMR=COMMITTED RESERVE        DEEP=078.22     SURF=000.00                 SUP19140
TEXT           PROD  PRCE SURF                                           SUP19150
C1MB CTR.01    2928  8.21 0.00                                           SUP19160
ENDCOAL                                                                  SUP19170
COAL TYPE MF $ COAL                                                      SUP19180
PRT=0    THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP19190
KSW=0    THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP19200
ISN=0    THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP19210
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                      SUP19220
DMR=DEMONSTRATED RESERVE DEEPTHN=     20. DEEPTHK=     0. SURF=     0.   SUP19230
CMR=COMMITTED RESERVE        DEEP=020.75     SURF=000.00                 SUP19240
TEXT           PROD  PRCE SURF                                           SUP19250
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C1MF CTR.01    756  8.21 0.00                                                    SUP19260
ENDCOAL                                                                          SUP19270
ENDREGION********** CS $ COLORADO,SOUTH                                          SUP19280
TABLE UT $  UTAH                                                                 SUP19290
RCL=RECLAMATION COST                  .00        .00        .00                  SUP19300
                                      .00        .00        .00                  SUP19310
                                      .00                                        SUP19320
                                      .00.       .00        .00                  SUP19330
                                      .00        .00        .00                  SUP19340
                                      .00                                        SUP19350
OBR=OVERBURDEN RATIO DISTR 0 MIN= 9. MAX=27.                                     SUP19360
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=102.                                    SUP19370
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                                      SUP19380
DSM=SEAM DEPTH DISTR DR=00.0 D04=33.3 D07=33.3 D10=33.4                          SUP19390
MSS=SURFACE MINE SIZE DISTR    SIX=33.4 33.3 33.3 00.0 00.0 00.0                 SUP19400
OVR   SVT=.0          TSD=50.4       TDD=18.8       INS=8.                       SUP19410
OVR   IND=31.                                                                    SUP19420
ENDTABLE                                                                         SUP19430
COAL TYPE HA $ COAL                                                              SUP19440
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP19450
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP19460
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP19470
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                              SUP19480
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     6. SURF=    10.            SUP19490
ENDCOAL                                                                          SUP19500
COAL TYPE HB $ COAL                                                              SUP19510
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP19520
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP19530
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP19540
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                              SUP19550
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=   767. SURF=     0.            SUP19560
CMR=COMMITTED RESERVE        DEEP=172.29     SURF=000.00                         SUP19570
TEXT          PROD  PRCE  SURF                                                   SUP19580
C1HB CTR.01   6501 13.35 0.00                                                    SUP19590
ENDCOAL                                                                          SUP19600
COAL TYPE HF $ COAL                                                              SUP19610
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP19620
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP19630
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP19640
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                              SUP19650
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=    10.            SUP19660
ENDCOAL                                                                          SUP19670
COAL TYPE SD $ COAL                                                              SUP19680
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP19690
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP19700
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP19710
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                              SUP19720
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     6. SURF=    24.            SUP19730
OVR   YTS=.95          YTD=.95                                                   SUP19740
ENDCOAL                                                                          SUP19750
COAL TYPE SF $ COAL                                                              SUP19760
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP19770
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP19780
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP19790
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                              SUP19800
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DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=      0. SURF=    200.   SUP19810
OVR   YTS=.95         YTD=.95                                              SUP19820
ENDCOAL                                                                    SUP19830
ENDREGION********** UT $ UTAH                                              SUP19840
TABLE AZ $  ARIZONA                                                        SUP19850
RCL=RECLAMATION COST                   .11        .17        .23           SUP19860
                                       .27        .32        .35           SUP19870
                                       .38                                 SUP19880
                                       .11        .16        .20           SUP19890
                                       .22        .25        .27           SUP19900
                                       .29                                 SUP19910
OBR=OVERBURDEN RATIO DISTR 0 MIN= 5. MAX=23.                               SUP19920
TSM=SEAM THICKNESS DISTR   0 MIN=60. MAX=102.                              SUP19930
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                                SUP19940
DSM=SEAM DEPTH DISTR DR=00.0 D04=33.3 D07=33.3 D10=33.4                    SUP19950
MSS=SURFACE MINE SIZE DISTR    SIX=05.0  5.0 30.0 30.0 30.0 00.0           SUP19960
OVR   TSD=50.4        TDD=18.8        INS=14.        IND=39.               SUP19970
OVR   YTS=0.95        YTD=0.95                                             SUP19980
ENDTABLE                                                                   SUP19990
COAL TYPE MD $ COAL                                                        SUP20000
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP20010
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP20020
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP20030
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                         SUP20040
DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=      0. SURF=    294.   SUP20050
CMR=COMMITTED RESERVE       DEEP=000.00      SURF=131.57                   SUP20060
OVR   YTS=.85         YTD=.80                                              SUP20070
TEXT          PROD  PRCE SURF                                              SUP20080
C1MD CTR.01   6587  4.19 1.00                                              SUP20090
ENDCOAL                                                                    SUP20100
COAL TYPE SF $ COAL                                                        SUP20110
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                  SUP20120
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                             SUP20130
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.          SUP20140
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                        SUP20150
DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=      0. SURF=     56.   SUP20160
ENDCOAL                                                                    SUP20170
ENDREGION********** AZ $ ARIZONA                                           SUP20180
TABLE NM $  NEW MEXICO                                                     SUP20190
RCL=RECLAMATION COST                   .13        .19        .25           SUP20200
                                       .29        .34        .36           SUP20210
                                       .39                                 SUP20220
                                       .13        .17        .21           SUP20230
                                       .24        .27        .29           SUP20240
                                       .31                                 SUP20250
OBR=OVERBURDEN RATIO DISTR 0 MIN= 5. MAX=16.                               SUP20260
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=102.                              SUP20270
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                                SUP20280
DSM=SEAM DEPTH DISTR DR=00.0 D04=33.3 D07=33.3 D10=33.4                    SUP20290
MSS=SURFACE MINE SIZE DISTR    SIX=05.0  5.0 30.0 30.0 30.0 00.0           SUP20300
OVR   $SV=.34         TSD=50.4        TDD=18.8       INS=7.                SUP20310
OVR   IND=23.         YTS=1.00        YTD=1.00       FSS=.125              SUP20320
OVR   FSD=.080                                                             SUP20330
ENDTABLE                                                                   SUP20340
COAL TYPE ZD $ COAL                                                        SUP20350
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PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP20360
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP20370
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP20380
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                              SUP20390
DMR=DEMONSTRATED RESERVE DEEPTHN=     4. DEEPTHK=     3. SURF=     0.           SUP20400
OVR   YTS=.80          YTD=.70                                                  SUP20410
ENDCOAL                                                                         SUP20420
COAL TYPE HA $ COAL                                                             SUP20430
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP20440
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP20450
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP20460
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                              SUP20470
DMR=DEMONSTRATED RESERVE DEEPTHN=   431. DEEPTHK=   950. SURF=     0.           SUP20480
OVR   YTS=.85          YTD=.80                                                  SUP20490
ENDCOAL                                                                         SUP20500
COAL TYPE HB $ COAL                                                             SUP20510
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP20520
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP20530
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP20540
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                              SUP20550
DMR=DEMONSTRATED RESERVE DEEPTHN=     6. DEEPTHK=     1. SURF=     0.           SUP20560
OVR   YTS=.85          YTD=.80                                                  SUP20570
ENDCOAL                                                                         SUP20580
COAL TYPE HD $ COAL                                                             SUP20590
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP20600
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP20610
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP20620
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                              SUP20630
DMR=DEMONSTRATED RESERVE DEEPTHN=     8. DEEPTHK=     3. SURF=     0.           SUP20640
OVR   YTS=.85          YTD=.80                                                  SUP20650
ENDCOAL                                                                         SUP20660
COAL TYPE MB $ COAL                                                             SUP20670
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP20680
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP20690
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP20700
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                              SUP20710
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=   114. SURF=   250.           SUP20720
CMR=COMMITTED RESERVE       DEEP=000.00      SURF=010.64                        SUP20730
OVR   YTS=.85          YTD=.80                                                  SUP20740
TEXT          PROD  PRCE SURF                                                   SUP20750
C1MB CTR.01    528  4.19 1.00                                                   SUP20760
ENDCOAL                                                                         SUP20770
COAL TYPE MC $ COAL                                                             SUP20780
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP20790
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP20800
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.               SUP20810
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                              SUP20820
DMR=DEMONSTRATED RESERVE DEEPTHN=    31. DEEPTHK=   506. SURF=  2008.           SUP20830
CMR=COMMITTED RESERVE       DEEP=026.84      SURF=151.73                        SUP20840
OVR   YTS=.85          YTD=.80                                                  SUP20850
OVTSM=1    SIX=45.0 26.9 26.9  0.2 42.9 57.1                                    SUP20860
ENDCOAL                                                                         SUP20870
COAL TYPE MD $ COAL                                                             SUP20880
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                       SUP20890
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                  SUP20900
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ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP20910
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                        SUP20920
DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=     0. SURF=      0.   SUP20930
OVR   YTS=.85          YTD=.80                                            SUP20940
TEXT         PROD  PRCE SURF                                              SUP20950
C1MD CTR.01  8579  4.19 0.88                                              SUP20960
ENDCOAL                                                                   SUP20970
COAL TYPE MF $ COAL                                                       SUP20980
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                 SUP20990
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                            SUP21000
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP21010
CLEANING COST $/TON (FIXED)=1.14  (VARIABLE)= 0.56                        SUP21020
DMR=DEMONSTRATED RESERVE DEEPTHN=      4. DEEPTHK=    48. SURF=      0.   SUP21030
OVR   YTS=.85          YTD=.80                                            SUP21040
ENDCOAL                                                                   SUP21050
ENDREGION********** NM $ NEW MEXICO                                       SUP21060
TABLE WA $  WASHINGTON                                                    SUP21070
RCL=RECLAMATION COST                .12       .18        .24              SUP21080
                                    .28       .33        .35              SUP21090
                                    .39                                   SUP21100
                                    .10       .15        .19              SUP21110
                                    .21       .25        .26              SUP21120
                                    .29                                   SUP21130
OBR=OVERBURDEN RATIO DISTR 0 MIN= 9. MAX=45.                              SUP21140
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=102.                             SUP21150
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                               SUP21160
DSM=SEAM DEPTH DISTR DR=00.0 D04=33.3 D07=33.3 D10=33.4                   SUP21170
MSS=SURFACE MINE SIZE DISTR    SIX= 5.0  5.0 30.0 30.0 30.0 00.0          SUP21180
OVR   TSD=45.8         TDD=15.7       INS=13.        IND=23.              SUP21190
OVR   YTS=0.95         YTD=0.95                                           SUP21200
ENDTABLE                                                                  SUP21210
COAL TYPE HA $ COAL                                                       SUP21220
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                 SUP21230
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                            SUP21240
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP21250
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                       SUP21260
DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=    12. SURF=      0.   SUP21270
OVR   YTS=.80          YTD=.70                                            SUP21280
ENDCOAL                                                                   SUP21290
COAL TYPE HB $ COAL                                                       SUP21300
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                 SUP21310
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                            SUP21320
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP21330
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                       SUP21340
DMR=DEMONSTRATED RESERVE DEEPTHN=      0. DEEPTHK=     7. SURF=      0.   SUP21350
OVR   YTS=.80          YTD=.70                                            SUP21360
ENDCOAL                                                                   SUP21370
COAL TYPE MA $ COAL                                                       SUP21380
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                 SUP21390
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                            SUP21400
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.         SUP21410
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                       SUP21420
DMR=DEMONSTRATED RESERVE DEEPTHN=      2. DEEPTHK=    76. SURF=      0.   SUP21430
OVR   YTS=.80          YTD=.70                                            SUP21440
ENDCOAL                                                                   SUP21450
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COAL TYPE MB $ COAL                                                              SUP21460
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP21470
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP21480
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP21490
CLEANING COST $/TON (FIXED)= 1.14  (VARIABLE)=00.56                              SUP21500
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     1. SURF=     0.            SUP21510
OVR   YTS=.80          YTD=.70                                                   SUP21520
ENDCOAL                                                                          SUP21530
COAL TYPE SA $ COAL                                                              SUP21540
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP21550
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP21560
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP21570
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                              SUP21580
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     9. SURF=     0.            SUP21590
ENDCOAL                                                                          SUP21600
COAL TYPE SD $ COAL                                                              SUP21610
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP21620
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP21630
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP21640
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                              SUP21650
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     2. SURF=   400.            SUP21660
CMR=COMMITTED RESERVE       DEEP=000.31     SURF=073.44                          SUP21670
TEXT           PROD  PRCE SURF                                                   SUP21680
C1SD CTR.01    3668  7.83 1.00                                                   SUP21690
ENDCOAL                                                                          SUP21700
COAL TYPE SG $ COAL                                                              SUP21710
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP21720
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP21730
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP21740
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                              SUP21750
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=   100.            SUP21760
ENDCOAL                                                                          SUP21770
ENDREGION********** WA $ WASHINGTON                                              SUP21780
TABLE TX $  TEXAS                                                                SUP21790
RCL=RECLAMATION COST                 .11         .17         .23                 SUP21800
                                     .27         .31         .34                 SUP21810
                                     .37.                                        SUP21820
                                     .17         .22         .25                 SUP21830
                                     .28         .31         .33                 SUP21840
                                     .35                                         SUP21850
OBR=OVERBURDEN RATIO DISTR 0 MIN= 4. MAX=16.                                     SUP21860
TSM=SEAM THICKNESS DISTR   0 MIN=28. MAX=54.                                     SUP21870
MDM 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                                      SUP21880
DSM=SEAM DEPTH DISTR DR=00.0 D04=30.0 D07=35.0 D10=35.0                          SUP21890
MSS=SURFACE MINE SIZE DISTR    SIX=00.0  0.0 10.0 20.0 30.0 40.0                 SUP21900
OVR   YTS=0.95       YTD=0.95       TSD=54.        SWL=0.00                      SUP21910
OVR   DWL=0.00       INS=16.                                                     SUP21920
ENDTABLE                                                                         SUP21930
COAL TYPE LF $ COAL                                                              SUP21940
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP21950
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP21960
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP21970
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                              SUP21980
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=     0. SURF=  2828.            SUP21990
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=187.50                          SUP22000
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OVOBR=1  SEVEN=60.0 40.0  0.0  0.0  0.0  0.0  0.0                               SUP22010
TEXT          PROD  PRCE SURF                                                    SUP22020
C1LF CTR.01 10007  2.47 1.00                                                     SUP22030
ENDCOAL                                                                          SUP22040
ENDREGION********** TX $ TEXAS                                                   SUP22050
TABLE CN $  COLORADO,NORTH                                                       SUP22060
RCL=RECLAMATION COST                .15         .21         .27                  SUP22070
                                    .31         .36         .39                  SUP22080
                                    .42                                          SUP22090
                                    .17         .21         .25                  SUP22100
                                    .28         .31         .33                  SUP22110
                                    .35                                          SUP22120
OBR=OVERBURDEN RATIO DISTR 0 MIN= 2. MAX=21.                                     SUP22130
TSM=SEAM THICKNESS DISTR   0 MIN=60. MAX=102.                                    SUP22140
MDM 0 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                                    SUP22150
DSM=SEAM DEPTH DISTR DR=00.0 D04=33.3 D07=33.3 D10=33.4                          SUP22160
MSS=SURFACE MINE SIZE DISTR    SIX=00.0  0.0 10.0 20.0 30.0 40.0                 SUP22170
OVR   $SV=.26         TSD=50.4        TDD=18.8        SWL=0.00                   SUP22180
OVR   DWL=0.00        INS=8.          IND=22.         YTS=0.95                   SUP22190
OVR   YTD=0.95        ISR=.11         F$S=.125        F$D=.080                   SUP22200
ENDTABLE                                                                         SUP22210
COAL TYPE SA $ COAL                                                              SUP22220
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP22230
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP22240
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP22250
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                              SUP22260
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=   295. SURF=   115.            SUP22270
CMR=COMMITTED RESERVE         DEEP=0 9.30     SURF=0 9.25                        SUP22280
OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                                SUP22290
TEXT          PROD  PRCE SURF                                                    SUP22300
C1SA CTR.01  1031   3.82 0.58                                                    SUP22310
ENDCOAL                                                                          SUP22320
COAL TYPE SD $ COAL                                                              SUP22330
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.                        SUP22340
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                                   SUP22350
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.                SUP22360
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                              SUP22370
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=   249. SURF=     0.            SUP22380
OVOBR=1  SEVEN=80.0 15.0  5.0  0.0  0.0  0.0  0.0                                SUP22390
ENDCOAL                                                                          SUP22400
ENDREGION********** CN $ COLORADO,NORTH                                          SUP22410
TABLE AK $  ALASKA                                                               SUP22420
RCL=RECLAMATION COST                .16         .22         .28                  SUP22430
                                    .32         .37         .39                  SUP22440
                                    .42                                          SUP22450
                                    .10         .14         .18                  SUP22460
                                    .21         .24         .26                  SUP22470
                                    .28                                          SUP22480
OBR=OVERBURDEN RATIO DISTR 0 MIN= 2. MAX=92.                                     SUP22490
TSM=SEAM THICKNESS DISTR   0 MIN=60. MAX=102.                                    SUP22500
MDM 0 0 0 0 0 0 5 5 4 3 2 5 5 4 3 2 5 5 4 3 2                                    SUP22510
DSM=SEAM DEPTH DISTR DR=00.0 D04=33.3 D07=33.3 D10=33.4                          SUP22520
MSS=SURFACE MINE SIZE DISTR    SIX=05.0  5.0 30.0 30.0 30.0 00.0                 SUP22530
OVR   SVT=.02         TSD=54.00       TDD=18.8        SWL=0.00                   SUP22540
OVR   DWL=0.00        INS=13.         IND=36.         YTS=0.95                   SUP22550
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OVR   YTD=0.95                                                          SUP22560
ENDTABLE                                                                SUP22570
COAL TYPE SA $ COAL                                                     SUP22580
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP22590
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP22600
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP22610
CLEANING COST $/TON (FIXED)= 0.00  (VARIABLE)=00.00                     SUP22620
DMR=DEMONSTRATED RESERVE DEEPTHN=     0. DEEPTHK=  2348. SURF=    38.   SUP22630
CMR=COMMITTED RESERVE       DEEP=000.00     SURF=015.62                 SUP22640
TEXT         PROD  PRCE SURF                                            SUP22650
ENDCOAL                                                                 SUP22660
ENDREGION********** AK $ ALASKA                                         SUP22670
ENDDATA                                                                 SUP22680
PRT=0   THIS IS PRNTR.IF=1,PRINT PRODUCTION AND CUM PROD.               SUP22690
KSW=0   THIS IS KSW.IF=1,PRINT BALANCE SHEETS.                          SUP22700
ISN=0   THIS IS ISENS.IF=1,PRINT LOOK-AHEAD PRICES FOR MINE LIFE.       SUP22710
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      REAL           ISRC, ISRR, ISRG, IDRC, IDRR, IDRG
      REAL           MDM
      INTEGER        PRNTR
C
      COMMON /COEFS/COEF1,COEF2,IPIES
      DIMENSION    ICASE(5),STHMNS(5,5),RECFCT(2),A(4),B(25),C(25),
     2             COMPR(25),COMPC(5),COMPT(4),CARD(20),HDTAB(8),
     3             TEXT(9),BRDNR(7),SMTHR(6),SMDPR(4),SIZER(6),DEMR(3),
     4             CMTD(2),BRDNC(7),SMTHC(6),SMDPC(4),SIZEC(6),ALPHA(4),
     5             VALUE(4),TYPE(4),PROD(3),T2(8),T3(13),T4(10),
     6             BB(6),SZELET(6),BDNLET(7),THKLET(5),
     7             DIPLET(4),RESREQ(2,6),INTER(33),TEMPSZ(5),
     8             TEMP2(6),THKMN(6),
     9             TMARG(5,5,4),KMARG(4,5)
      DIMENSION DPSMDT(5,6)
      EQUIVALENCE  (TEMP2(1),TEMPSZ(1))
C
      COMMON      /COST/  SZEMIN(6),RECL(14),MLIFE(2,2),CLEAN(2),ASZ(2,6),
     2                    RUT,ISENS,APFAC
C
      DATA         MDM,F$DS,F$DD/'MDM','F$S','F$D'/
C
      DATA         IN, KIO, KOUT, IPRT, KINTR/21, 22, 23, 31, 32/
C
C 'IN'=INPUT DATA,   'KIO'=WORK FILE,
C 'KOUT'=DISK FILE GENERATED FOR INPUT TO LP,
C 'IPRT'=PRINTED OUTPUT,   'KINTR'=TEMPORARY DISK-
C       FILE FOR INTERMEDIATE RESULTS.
C
      DATA         ENDPRM,ENDTAB,ENDRGN,ENDCOL,ENDALL,TABLER,OBR,THKSM,
     2             ORIDE,BLNK,COAL
     3            /'ENDP','ENDT','ENDR','ENDC','ENDD','TABL','OBR','TSM',
     4             'OVR ','    ','COAL'/
C
      DATA         MXOVR/25/
C
      DATA COMPR/  'ISR','ECP','EMP','EPS','ROR',
     5             'N/A','SVT','$SD','$DD','TSD','TDD','PSS','PDS',
     6             'LIC','RLT','SWL','DWL','SWD','DWD','CTX','IDR',
     7             'INS','IND','YTS','YTD'/
C
      DATA         $SVT/'$SV'/
C
      DATA COMPC/'OVOB','OVTS','OVDS','OVMS','TEXT'/
C
      DATA COMPT /'C','S','X','E'/, RCL/'RCL'/
C
      DATA           AXE,DSM,SWTCH,XISN,XPRT/'X','DSM','KSW','ISN',
     C   'PRT'/
C
      EQUIVALENCE  (T3(1),BRDNC(1)),  (T3(8),SIZEC(1)),
     2             (T4(1),SMTHC(1)),  (T4(7),SMDPC(1))
C
      EQUIVALENCE  (B(1),ISRG),(C(1),ISRR),(B(21),IDRG),(C(21),IDRR),
     2             (A(1),CAPIS),(A(2),CAPID),(A(3),CAPDS),(A(4),CAPDD),
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     3            (C(2),ECAP),(C(3),EMP),(C(4),EPAS),(C(5),ROR),
     4            (C(7),SEVT),(C(8),$PMDS),(C(9),$PMDD),
     5            (C(10),TPMDS),(C(11),TPMDD),(C(12),PSS),(C(13),PSD),
     6            (C(14),XLIC),(C(15),ROY),(C(16),SWEL),(C(17),DWEL),
     7            (C(18),SWELD),(C(19),DWELD),(C(20),CTAX),
     8            (C(22),XINSS),(C(23),XINSD),(C(24),YIELDS),
     9            (C(25),YIELDD)
C
C
C        PROGRAM NAME   FSRAMC
C
C        AUTHOR         PAL KHERA OF THC, AND
C                       PHIL CHILDRESS OF FEA
C
C        DATE           FEBRUARY 1976
C
C        PURPOSE        CALCULATE POSSIBLE NEW MINES
C                       AND PREPARE PARTIAL INPUT FOR
C                       LP TO DEVELOP THE COAL MODEL
C
C        SUBROUTINES CALLED
C
C             OBDN (BY PAL)  ASSIGN DISTRIBUTION OF      FOR PARAMS SEE
C                            OVERBURDEN RATIOS  FOR      THE SUBROUTINE
C                            SURFACE MINES
C
C             STHK (BY PAL)  ASSIGN SEAM THICKNESS       FOR PARAMS SEE
C                            RATIOS FOR DEEP MINES       THE SUBROUTINE
C
C             MC    (BY PHIL) COSTING AND SELECTION      FOR PARAMS
C                            OF NEW MINES BASED ON       SEE BELOW
C                            THEIR ASSIGNED COSTS
C
C        INPUT          SEE FILE  RP2.SUPIN.DATA
C
C        OUTPUT         IN A FORMAT SUITABLE FOR LP
C
C   LIST OF PARAMS FOR SUBROUTINE 'MC' FOR MINE COSTING
C
C
C    CALL MC(ICASE,KSW,KIO,KOUT,CT,ECAP,EMP,EPAS,ROR.IBASYR,
C           ICASYR,SEVT,SVT$C,$PMDS,$PMDD,TPMDSC,TPMDDC,PSS,PSD,
C           CAPIS,CAPID,CAPDS,CAPDD,XLIC,ROY,SWEL,DWEL,CTAX,
C     X     MCYR,ESCAL1,CUM,PRNTR,XINSS,XINSD,YIELDS,YIELDD)
C
C PARAM    INFORMATION                     INPUT    NAME IN    ALIAS
C                                          FORMAT   SUB (MC)
C
C ICASE    DETAILS OF CASE                 5A4      T
C
C KSW      PRINT TABLES   0=NO, 1=YES       I1
C
C KIO      WORK FILE NUMBER                 I2
C
C KOUT     OUTPUT FILE NUMBER               I2
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C
C CT      COAL TYPE (MC, SF, ETC)            A2
C
C MLIFE   MINE LIFE IN YEARS SURF/DEEP        IN COMMON BLOCK /COST/
C
C ECAP    ESCALATOR FOR CAPITAL              F4.2                C(2)
C
C EMP     ESCALATOR FOR HUMAN RESOURCES      F4.2                C(3)
C
C EPAS    ESCALATOR FOR POWER AND SUPPLY     F4.2                C(4)
C
C ROR     RATE OF RETURN                     F5.3                C(5)
C
C IBASYR  BASE YEAR(E.G., 1975)              I4
C
C ICASYR  CASE YEAR(E.G., 1980)              I4
C
C RECL    RECLAMATION COST $/TON              IN COMMON BLOCK /COST/
C         (FIXED AND VARIABLE)
C
C CLEAN   CLEANING COST (FIXED AND VARIABLE)  IN COMMON BLOCK /COST/
C
C
C RUT     UTILITY DISCOUNT RATE               IN COMMON BLOCK /COST/
C
C ISENS   SWITCH TO PRINT COSTS FOR ALL YEARS
C
C APFAC   ANNUITY PRICE FACTOR FOR ANNUITY
C         PRICE CALCULATION AT MINE COSTING   IN COMMON BLOCK /COST/
C
C
C SEVT    SEVERANCE TAX (FIXED)              F4.2                C(7)
C
C SEVT$C  SEVERANCE TAX $/CLEAN TON OF COAL  F4.2
C
C $PMDS   $/MAN DAY  SURFACE MINES           F6.2     SLAB       C(8)
C
C $PMDD   $/MAN DAY  DEEP MINES              F6.2     DLAB       C(9)
C
C TPMDS   TONS/MAN DAY SURFACE MINES         F6.2     TPMDBS     C(10)
C
C TPMDD   TONS/MAN DAY DEEP MINES            F6.2     TPMDBD     C(11)
C
C PSS     POWER & SUPPLIES SURFACE MINES     F6.0     PASBS      C(12)
C
C PSD     POWER & SUPPLIES DEEP MINES        F6.0     PASBD      C(13)
C
C CAPIS   INITIAL CAPITAL SURFACE MINES      F7.0     XICBS      A(1)
C
C CAPID   INITIAL CAPITAL DEEP MINES         F7.0     XICBD      A(2)
C
C CAPDS   DEFFERED CAPITAL SURFACE MINES     F7.0     DCBS       A(3)
C
C CAPDD   DEFFERED CAPITAL DEEP MINES        F7.0     DCBD       A(4)
C
```

```
C XLIC     LICENSE FEE PER TON              F4.2                C(14)
C
C ROY      ROYALTY FEE PER TON              F4.2                C(15)
C
C SWEL     WELFARE FUND SURFACE MINES       F4.2                C(16)
C
C DWEL     WELFARE FUND DEEP MINES          F4.2                C(17)
C
C CTAX     CORPORATE TAX                    F4.2                C(18)
C
C
C MCYR     CONTRACT TERM, YEARS            I2
C
C ESCAL1   ESCALATOR TO CASE YEAR                    CALC IN MAIN
C
C PRNTR    SWITCH TO PRINT PRODUCTION, 1-YES, 0-NO
C
C XINSS    EXPOSURE INSURANCE SURF          F5.2               C(22)
C
C XINSD    EXPOSURE INSURANCE DEEP          F5.2               C(23)
C
C YIELDS   CLEAN COAL YIELD FRACTION SURF   F4.2               C(24)
C
C YIELDD   CLEAN COAL YIELD FRACTION DEEP   F4.2               C(25)
C
C
      DATA        BDNLET/'05','10','15','20','25','30','45'/,
     2            THKLET/'72','60','48','36','28'/,
     3            DIPLET/'00','04','07','10'/,
     4            THKMN/'72','60','48','42','36','28'/
C
C
      KSTT = 20
C
C  LOOK FOR PRINT SWITCH
C  1 IN COL 20 OF 1ST CARD MEANS PRINT ALL
C  1 IN COL 30 OF 1ST CARD MEANS PIES DATA (OUTPUT ICAP & DCAP)
C
      READ(IN,198)II,IPIES
  198 FORMAT(19X,I1,9X,I1)
      IF(II.NE.1) GO TO 19
      REWIND IN
      PRINT 199
  199 FORMAT(1H1)
   18 READ(IN,8050,END=19)CARD
      PRINT 201,CARD
  201 FORMAT(1X,20A4)
      GO TO 18
   19 REWIND IN
C
C  GLOBAL PARAMS
C
   20 READ(IN,8010,END=2650,ERR=40) ICASE,((STHMNS(I,J),J=1,5),I=1,5),
     2           RECFCT,MLIFE,MCYR,A,B(21),(B(I),I=1,5),IBASYR,ICASYR,
     3           SVT$G,(B(I),I=7,20),RUT,APFAC
```

```
C
C READ RATES FOR EXPOSURE INSURANCE AND YIELD OF CLEAN TONS
C
      DO 21 I = 22,MXOVR
   21    B(I) = 0.0
C
   22 KSTT = 22
      READ(IN,8070,END=2650,ERR=40) AA
      BACKSPACE IN
C
      DO 23 I = 22,MXOVR
         IF(AA .EQ. COMPR(I)) GO TO 24
   23 CONTINUE
C
      GO TO 4020
C
   24 KSTT = 24
C
      READ(IN,8012,END=2650,ERR=40) B(I)
      GO TO 22
C
 4020 CONTINUE
C
      XNYR=ICASYR-IBASYR
      ECAP=B(2)
      ALC=ALOG(1.+ECAP)
      ALC1=ALC*(XNYR/2.)
      ALC2=ALC*(XNYR/4.)+ALOG(XNYR/40.)
      PRINT 19711,ECAP,XNYR,ALC,ALC1,ALC2
19711 FORMAT('  ECAP=',F10.3,' XNYR=',F10 .3,' ALC=',F10.3,
     2         ' ALC1=',F10.3,' ALC2=',F10.3)
C  THE FACTORS COEF1 & COEF2 RELATE TO AN OLDER VERSION
C    OF THE CODE AND HAVE NO DIRECT RELATIONSHIP
C    TO THE CURRENT PRODUCTION AND PRICE (RACP) OUTPUT OF RAMC
      COEF1=EXP(ALC1)
      COEF2=EXP(ALC2)
      PRINT 19712,COEF1,COEF2
19712 FORMAT(' COEFS',2E10.3)
C
C  (INSERT FROM MIT MODEL ASSESSMENT LABORATORY)
C       READ AND WRITE AN IDENTIFICATION CARD FOR 'KOUT LPIN'
C
      DIMENSION IDTTT(18)
      WRITE(6,7701)
 7701 FORMAT('PLEASE ENTER RUN IDENTIFIER:'/)
      READ(5,7702)IDTTT
      WRITE(KOUT,7702) IDTTT
 7702 FORMAT(18A4)
C  (END OF MIT INSERT)
C
      WRITE(KOUT,197)COEF1,COEF2
  197 FORMAT('ELEMENT GDS',10X,'$  COEF1 ',F10.3,' COEF2 ',F10.3)
      KSTT = 25
C
C READ MINESIZE AND LETTER ASSOCIATED THEREWITH
```

```
C   NOTE:ISENS,WHICH WAS READ HERE,NOW IN INPUT FOR COAL
C   TYPR FOLLOWING COAL TYPE HEADER CARD.
C
C
      READ(IN,8015,END=2650,ERR=40) SZEMIN
      READ(IN,8020,END=2650,ERR=40) SZELET
C
C TRANSFER MINESIZE AND MINE LETTER TO ARRAY 'ASZ' FOR USE BY 'MC'
C
      DO 25 I = 1, 6
          ASZ(1,I) = SZEMIN(I)
          ASZ(2,I) = SZELET(I)
   25 CONTINUE
      LMIN=28
      LMAX=96
      DO 26 I=1,5
      CALL STHK(SMTHR,LMIN,LMAX)
      DO 27 J=1,6
   27 DPSMDT(I,J)=SMTHR(J)
      LMAX=LMAX-12
      IF(I.EQ.1)LMAX=LMAX-13
   26 CONTINUE
C
      GO TO 80
C
   40 WRITE(IPRT,9010) KSTT
      STOP 40
C
C CALCULATE RESERVE REQUIREMENTS FOR DIFFERENT MINE SIZES
C
   80 DO 120 I = 1,2
        XX = RECFCT(I)
        DO 120 J = 1,6
          MYR = MLIFE(2,I)
          IF(SZEMIN(J) .LT. 1.0) MYR = MLIFE(1,I)
  120 RESREQ(I,J) = SZEMIN(J) * MYR / XX
C
      NAMELIST /BUGP1/ RESREQ, SZEMIN
C     WRITE(IPRT,BUGP1)
C
      KSTT = 150
  150 READ(IN,8030,END=2650,ERR=40) AAA
C
      IF(AAA .NE. ENDPRM) GO TO 280
C
C PRINT GLOBAL PARAMETERS.
C -----
C
      WRITE(IPRT,823)
      DO 160 I = 1, 6
  160     TEMP2(I) = SZEMIN(7-I)
C
      WRITE(IPRT,9175) ICASE, IBASYR, ICASYR, IBASYR, TEMPSZ,
     2                 ((STHMNS(I,J),J=1,5),I=1,5), SZEMIN, RECFCT,
     3                 MLIFE, MCYR, A, (B(I),I=2,5)
```

```
      WRITE(IPRT,9177) RUT, APFAC                                       NEI03310
C                                                                       NEI03320
C INITIALIZE OUTPUT FILE                                                NEI03330
C                                                                       NEI03340
C       WRITE(KOUT,9170)                                                NEI03350
C                                                                       NEI03360
C REGIONAL PARAMETERS                                                   NEI03370
C                                                                       NEI03380
C  TRANSFER GLOBAL PARAMS TO REGIONAL PARAMS                            NEI03390
C  WHERE OVER-RIDE IS PERMISSIBLE                                       NEI03400
C                                                                       NEI03410
C       RETURN HERE FOR NEW REGION                                      NEI03420
C       --------------------------                                      NEI03430
C                                                                       NEI03440
  200 DO 202 I = 1,6                                                    NEI03450
C                                       SEAM THICKNESS                  NEI03460
        SMTHR(I) = 0.0                                                  NEI03470
C                                       SURFACE MINESIZE                NEI03480
        SIZER(I) = 0.0                                                  NEI03490
  202 CONTINUE                                                          NEI03500
C                                                                       NEI03510
C  MIT CORRECTION                                                       NEI03520
C   ORIGINAL DO 204 I =1,4                                              NEI03530
        DO 204 I =1,7                                                   NEI03540
C                                       OVERBURDEN RATIO                NEI03550
  204 BRDNR(I) = 0.0                                                    NEI03560
C                                                                       NEI03570
      DO 206 I = 1,4                                                    NEI03580
C                                       SEAM DEPTH RATIO                NEI03590
  206 SMDPR(I) = 0.0                                                    NEI03600
C                                                                       NEI03610
      DO 207 I = 1, 14                                                  NEI03620
C                                       RECLAMATION COST                NEI03630
  207     RECL(I) = 0.0                                                 NEI03640
C                                       SEVERANCE TAX $/TON             NEI03650
      SVT$R  = SVT$G                                                    NEI03660
C                                                                       NEI03670
      DO 220 I = 1,MXOVR                                                NEI03680
  220 C(I) = B(I)                                                       NEI03690
      FEDS=0.                                                           NEI03700
      FEDD=0.                                                           NEI03710
C NOTE THAT LINES 355 TO 359 ARE COMPLETELY OVER-RIDDEN                 NEI03720
C BY THE CODE ON LINES 456 469                                          NEI03730
      DO 221 M=1,5                                                      NEI03740
      DO 221 J=1,5                                                      NEI03750
      DO 221 L=1,4                                                      NEI03760
  221 TMARG(J,M,L)=STHMNS(J,M)                                          NEI03770
      MARGSW=0                                                          NEI03780
C  COMPUTE ESCALATION FACTOR                                            NEI03790
      MMM= ICASYR-IBASYR                                                NEI03800
      IF (MMM.LT.0.OR.MMM.GT.100) MMM=5                                 NEI03810
CC    ESCAL=.38*ECAP+.38*EMP+.24*EPAS                                   NEI03820
C  MIT CORRECTION                                                       NEI03830
C ORIGINAL VERSION:                                                     NEI03840
      ESCAL = .32*EMP+.53*EPAS                                          NEI03850
```

```
C      ESCAL1=(1+ESCAL)**MMM
        ESCAL1= .32*(1+EMP)**10 +  .53*(1+EPAS)**10
      PRINT 8999,ESCAL,MMM,ESCAL1
 8999 FORMAT(' ESCALATOR=',F9.3,' **',I5,' YEARS=',F9.3)
C
C TABLE HEADING
C
      KSTT = 222
      READ(IN,8050,END=2650,ERR=40) HDTAB
      IF(HDTAB(1) .NE. TABLER) GO TO 280
      IF (IPIES.NE.0) WRITE(KOUT,9190) HDTAB
      IF (IPIES.EQ.0) WRITE(KOUT,9191) HDTAB
C
C READ RECLAMATION COST, OVERBURDEN RATIO,SEAM THICKNESS,
C   SEAM DEPTH, AND SURFACE MINE SIZE RATIO.
C
  255 KSTT = 260
  260 READ(IN,8070,END=2650,ERR=40) TEXT, I
      BACKSPACE IN
C                                  RECLAMATION COST.
      IF(TEXT(1) .EQ. RCL) GO TO 310
C                                  OVERBURDEN RATIO
      IF(TEXT(1) .EQ. OBR) GO TO 320
C                                  SEAM THICKNESS RATIO
      IF(TEXT(1) .EQ. THKSM) GO TO 480
C                                  SEAM DEPTH & SURFACE MINESIZE.
      IF(TEXT(1) .EQ. DSM) GO TO 580
      IF(TEXT(1) .EQ. MDM) GO TO 525
      GO TO 300
C
C ERROR  -  INCORRECT INPUT CARD
C
  280 BACKSPACE IN
  300 READ(IN,8050) CARD
      WRITE(IPRT,9020) KSTT,CARD
      STOP 300
C
C RECLAMATION COST. - - - -
C
  310 KSTT = 311
      READ(IN,8060,END=2650,ERR=40) RECL
C
      GO TO 255
C
C OVERBURDEN RATIO. - - - -
C
  320 IF(I .EQ. 0) GO TO 370
      IF(I .EQ. 1) GO TO 420
C
C ERROR
C
  340 READ(IN,8050) CARD
      WRITE(IPRT,9030) CARD, I
      STOP 340
C
```

```
C                        MINIMUM AND MAXIMUM VALUES..
C
  370 KSTT = 371
      READ(IN,8095,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 255
      BACKSPACE IN
      KSTT = 375
      READ(IN,8090,END=2650,ERR=40) XMIN, XMAX
      LMIN = XMIN
      LMAX = XMAX
      CALL OBCN(BRDNR,LMIN,LMAX)
      GO TO 255
C
C                        ACTUAL PERCENTAGE..
C
  420 KSTT = 421
      READ(IN,8115,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 255
      BACKSPACE IN
      KSTT = 425
      READ(IN,8110,END=2650,ERR=40) BRDNR
      GO TO 255
C
C SEAM THICKNESS. - - - -
C
  480 IF(I .EQ. 0) GO TO 550
      IF(I .NE. 1) GO TO 340
C
C                        ACTUAL PERCENTAGE..
C
      KST = 520
  520 READ(IN,8115,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 255
      BACKSPACE IN
      KSTT = 524
      READ(IN,8110,END=2650,ERR=40) SMTHR
      GO TO 255
  525 READ(IN,8147,END=2650,ERR=40) ((KMARG(L,J),J=1,5),L=1,4)
 8147 FORMAT(3X,20I2)
      DO 526 J=1,5
      DO 526 L=1,4
      DO 527 M=1,5
  527 TMARG(J,M,L)=0.
      K4=KMARG(L,J)
      IF (K4.EQ.0) GO TO 526
      DO 528 KK=1,K4
  528 TMARG(J,KK,L)=100/K4
  526 CONTINUE
      MARGSW=1
       WRITE(IPRT,8311) (((TMARG(II,KK,LL),KK=1,5),II=1,5),LL=1,4)
 8311 FORMAT(' MINE SIZE DIST BY SEAM BY DEPTH'/(5E20.5))
      GO TO 255
C
C                        MINIMUM AND MAXIMUM VALUES..
C
```

```
  550 KSTT = 551
      READ(IN,8095,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 255
      BACKSPACE IN
      KSTT = 555
      READ(IN,8090,END=2650,ERR=40) XMIN,XMAX
      LMIN = XMIN
      LMAX = XMAX
      CALL STHK(SMTHR,LMIN,LMAX)
      GO TO 255
C
C SEAM DEPTH(DSM)=SMDPR, AND MINE SIZE DISTRIBUTIONS(MSS)=SIZER
C
  580 KSTT = 581
      READ(IN,8130,END=2650,ERR=40) SMDPR, SIZER
C
C OVER-RIDE OARAMETERS - - - -  OVER.RIDE  -
C
  600 KSTT = 600
      READ(IN,8030,END=2650,ERR=40) AAA
      IF(AAA .NE. ORIDE) GO TO 780
C
C OVER-RIDE PARAMS, IF ANY, OVER GLOBAL PARAMS
C
      BACKSPACE IN
      KSTT = 620
  620 READ(IN,8150,END=2650,ERR=40) ((ALPHA(I),VALUE(I)),I=1,4)
      DO 740 J = 1,4
      IF(ALPHA(J) .EQ. BLNK) GO TO 740
      IF(ALPHA(J) .EQ. $SVT) GO TO 730
       IF(ALPHA(J) .EQ. F$DS) GO TO 731
       IF(ALPHA(J).EQ.F$DD) GO TO 732
        DO 720 I = 1,MXOVR
          IF(ALPHA(J) .NE. COMPR(I)) GO TO 720
          C(I) = VALUE(J)
          GO TO 740
  720   CONTINUE
        GO TO 740
  730   SVT$R = VALUE(J)
      GO TO 740
  731 FEDS=VALUE(J)
      GO TO 740
  732 FEDD=VALUE(J)
  740 CONTINUE
      GO TO 600
C
C
  780 IF(AAA .NE. ENDTAB) GO TO 280
C
C PRINT REGIONAL PARAMETERS
C -----
C
      WRITE(IPRT,823)
C
      WRITE(IPRT,9195) ICASE, (HDTAB(J),J=4,8), ISRR, IDRR, SEVT, SVT$R,
```

```
     2                 XLIC, ROY, CTAX, SWEL, DWEL, SWELD, DWELD,
     3                 PSS, PSD, TPMDS, TPMDD, $PMDS, $PMDD
      WRITE(IPRT,9197) RECL, XINSS, XINSD, YIELDS, YIELDD
      WRITE(IPRT,9198) FEDS,FEDD
 9198 FORMAT(' FEDERAL ROYALTY SURFACE,DEEP= ',2F8.3)
      YTSTEM=YIELDS
      YTDTEM=YIELDD
C
C
C COAL PARAMS
C
      KSTT = 782
      READ(IN,8030,END=2650,ERR=40) AAA
      IF(AAA .NE. COAL) GO TO 280
C
C              RETURN HERE FOR NEW COAL
C              ------------------------
C
  820 BACKSPACE IN
C
      WRITE(IPRT,823)
  823 FORMAT(///)
      CUM = 0.0
      SVT$C = SVT$R
C
      KSTT = 822
C
C COAL TYPE
C
      READ(IN,8170,END=2650,ERR=40) CT
      PRNTR=0
      KSW=0
      ISENS=0
      READ(IN,8200,END=2650,ERR=40) PRNTR
      READ(IN,8200,END=2650,ERR=40) KSW
      READ(IN,8200,END=2650,ERR=40) ISENS
C
C COAL PARAMETERS.   PRINT HEADING.
C                    -----
C
      WRITE(IPRT,835) ICASE, (HDTAB(J),J=4,8), CT
  835 FORMAT(1H1,10X,5A4,//,  4X,'---- COAL PARAMETERS FOR ',5A4,
     2         ', COAL TYPE -',A2,'-',//)
  837 FORMAT(/,9X, 15H      MINE TYPE, 7X,22HPROD  PRICE  CUM PROD,/)
C
C CLEANING COST
C
C CLEANING COST, DEMONSTRATED RESERVES, COMMITTED RESERVES,
C   AND PRINT SWITCH FOR INTERMEDIATE RESULTS.
C
      KSTT = 850
  850 READ(IN,8190,END=2650,ERR=40) CLEAN, DEMR
      CMTD(1)=0.
      CMTD(2)=0.
      READ(IN,8030,END=2650,ERR=40)AABB
```

```
      BACKSPACE IN
      DATA COMIT/'CMR='/
      IF (AABB.NE.COMIT) GO TO 890
      READ(IN,8192,END=2650,ERR=40)CMTD
  890  CONTINUE
C
C TRANSEFER REGIONAL PARAMS TO COAL PARAMS
C
      ISRC = ISRR
      IDRC=IDRR
      TPMDSC = TPMDS
      TPMDDC = TPMDD
      YIELDS=YTSTEM
      YIELDD=YTDTEM
      DO 900 I = 1,7
C                                   OVERBURDEN RATIO
  900 BRDNC(I) = BRDNR(I)
      DO 940 I = 1,6
C                                   SEAM THICKNESS FOR DEEP MINES
        SMTHC(I) = SMTHR(I)
C                                   SURFACE MINE SIZE
        SIZEC(I) = SIZER(I)
  940 CONTINUE
      DO 970 I = 1,4
C                                   SEAM DEPTH DISTRIBUTION RATIO
  970 SMDPC(I) = SMDPR(I)
C
C OVER-RIDE PARAMS, IF ANY, OVER GLOBAL AND/OR REGIONAL PARAMS
C
 1000 KSTT = 1001
      READ(IN,8030,END=2650,ERR=40) AAA
      IF(AAA .EQ. COMPC(5)) GO TO 1500
      BACKSPACE IN
      IF(AAA .NE. ORIDE) GO TO 1130
      KSTT = 1040
 1040 READ(IN,8145,END=1650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 1000
      BACKSPACE IN
      KSTT = 1050
C
C
 1050 READ(IN,8150,END=2650,ERR=40) ((ALPHA(I),VALUE(I)),I=1,4)
      DO 1080 I = 1, 4
C .SEVERANCE TAX S/TON OF CLEAN COAL
          IF(ALPHA(I) .EQ. $SVT) SVT$C = VALUE(I)
C .ILLEGAL SURFACE RESERVE FRACTION
          IF(ALPHA(I) .EQ. COMPR( 1)) ISRC  = VALUE(I)
C .INACCESSIBLE DEEP RESERVE FRACTION
          IF(ALPHA(I) .EQ. COMPR(21)) IDRC  = VALUE(I)
C .TONS/MANDAY SURFACE
          IF(ALPHA(I) .EQ. COMPR(10)) TPMDSC= VALUE(I)
C .TONS/MANDAY DEEP
          IF(ALPHA(I) .EQ. COMPR(11)) TPMDDC= VALUE(I)
          IF(ALPHA(I) .EQ.COMPR(24)) YIELDS=VALUE(I)
          IF(ALPHA(I) .EQ.COMPR(25))YIELDD=VALUE(I)
```

```
 1080 CONTINUE
      GO TO 1000
C
C
 1130 DO 1160 II = 1,4
         IF(AAA .EQ. COMPC(II)) GO TO(1210,1310,1410,1450), II
 1160 CONTINUE
      IF(AAA .EQ. ENDCOL) GO TO 1500
      GO TO 300
C
C OVERBURDEN RATIO DISTRIBUTION - - - -
C
 1210 KSTT = 1211
      READ(IN,8210,END=2650,ERR=40) TEXT(1), TEXT(2), I
      BACKSPACE IN
C
      IF(I .EQ. 0) GO TO 1280
      IF(I .NE. 1) GO TO 300
C
      KSTT = 1250
 1250 READ(IN,8225,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 1000
      BACKSPACE IN
C
C                                  ACTUAL PERCENTAGE..
C
      KSTT = 1260
 1260 READ(IN,8230,END=2650,ERR=40) BRDNC
      GO TO 1000
C
 1280 KSTT = 1281
      READ(IN,8245,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 1000
      BACKSPACE IN
C
C                                  MINIMUM AND MAXIMUM VALUES..
C
      KSTT = 1285
      READ(IN,8250,END=2650,ERR=40) XMIN, XMAX
      LMIN = XMIN
      LMAX = XMAX
      CALL OBDN(BRDNC,LMIN,LMAX)
      GO TO 1000
C
C .SEAM THICKNESS DISTRIBUTION. - - - -
C
 1310 KSTT = 1311
      READ(IN,8210,END=2650,ERR=40) TEXT(1), TEXT(2), I
      BACKSPACE IN
      IF(I .EQ. 0) GO TO 1380
      IF(I .NE. 1) GO TO 300
C
      KSTT = 1316
      READ(IN,8225,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 1000
```

```
      BACKSPACE IN
      KSTT = 1360
 1360 READ(IN,8230,END=2650,ERR=40) SMTHC
C
C                                ACTUAL PERCENTAGE..
C
      GO TO 1000
C
 1380 KSTT = 1381
      READ(IN,8245,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 1000
      BACKSPACE IN
      KSTT = 1385
C
C                                MINIMUM AND MAXIMUM VALUES..
C
      READ(IN,8250,END=2650,ERR=40) XMIN, XMAX
      LMIN = XMIN
      LMAX = XMAX
      CALL STHK(SMTHC,LMIN,LMAX)
      GO TO 1000
C
C SEAM DEPTH DISTRIBUTION  - -  ACTUAL PERCENTAGE..
C
 1410 KSTT = 1411
      READ(IN,8145,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 1000
      BACKSPACE IN
      KSTT = 1415
      READ(IN,8270,END=2650,ERR=40) SMDPC
      GO TO 1000
C
C SURFACE MINE DISTRIBUTION RATIO - - ACTUAL PERCENTAGE..
C
 1450 KSTT = 1451
      READ(IN,8225,END=2650,ERR=40) AA
      IF(AA .EQ. AXE) GO TO 1000
      BACKSPACE IN
      READ(IN,8230,END=2650,ERR=40) SIZEC
      KSTT = 1455
      GO TO 1000
C
C PRINT COAL PARAMETERS
C -----
C
 1500 WRITE(IPRT,9200) DEMR, CMTD, ((TEMP2(I),SIZEC(I)),I=1,6),
     2                 BRDNC, ((THKMN(I),SMTHC(I)),I=1,6),
     3                 SMDPC, SEVT, SVT$C, CLEAN
C
      IF(PRNTR .EQ. 1) WRITE(IPRT.837)
C
C READ AND PRINT PRESENT PRODUCTION
C
C
 1510 KSTT = 1511
```

```
      READ(IN,8290,END=2650,ERR=40) TYPE, PROD
      DO 1560 IK = 1,4
      IF(TYPE(1) .EQ. COMPT(IK)) GO TO(1610,1610,1650,1650), IK
 1560 CONTINUE
      GO TO 280
C
C
C   EXISTING PRODUCTION PRICE ESCALTED HERE
C
C
 1610 PROD(2)=PROD(2)*ESCAL1
      WRITE(KOUT,9210) TYPE, PROD
C
C PRINT PRODUCTION AND CUMULATIVE PRODUCTION HERE, IF DESIRED
C
      IF(PRNTR .NE. 1) GO TO 1510
      CUM = CUM + PROD(1)
      PROD(3) = CUM
      TYPE(1) = BLNK
      TYPE(2) = BLNK
      WRITE(IPRT,9215) TYPE, PROD
C
       GO TO 1510
C
C
C CALCULATE NEW MINES
C
C
C CALCULATE VARIOUS ELEMENTS OF TABLE - 2
C
C TRANSFER DEMONSTRATED AND COMMITTED RESERVES
C
C                                    SURFACE DEMO
 1650 T2(1) = DEMR(3)  * (1.-ISRC)
C1650 T2(1) = DEMR(3)
C                                    DEEP THICK DEMO
      T2(4) = DEMR(2)*(1.-IDRC)
C                                    DEEP THIN DEMO
      T2(7) = DEMR(1)*(1.-IDRC)
C                                    SURFACE COMMITTED
      T2(2) = CMTD(2)
C                                    DEEP COMMITTED
      T2(5) = CMTD(1)
C
C CALCULATE RESERVE AVAILABLE FOR NEW MINES
C
      TEMP = 0.0
C                                    SURFACE
      T2(3) = T2(1) - T2(2)
CC    T2(3) = (T2(1) - T2(2)) * (1.0 - ISRC)
      IF(T2(3) .LT. 0.0) T2(3) = 0.0
C                                    DEEP THICK
      T2(6) = T2(4) - T2(5)
      IF(T2(6) .GE. 0.0) GO TO 1780
      TEMP = T2(6)
```

```
      T2(6) = 0.0
C                                 DEEP THIN
 1780 T2(8) = T2(7) + TEMP
      IF(T2(8) .LT. 0.0) T2(8) = 0.0
C
      NAMELIST /BUGP2/ T2, T3, T4
C     WRITE(IPRT,BUGP2)
C
C
C CALCULATE MINE SIZES, AND WRITE THEM ON FILE
C
C    WRITE NEW SURFACE MINES, FOLLOWED BY DEEP MINES.
C
C
C SURFACE MINES.
C
      REWIND KIO
C
C 'NEWMIN' IS THE SWITCH TO DETERMIN IF NEW MINES WERE OPENED
C
              NEWMIN = 0
              DO 1790 I = 1, 6
                 BB(I) = 0.0
 1790         CONTINUE
C
              IF(T2(3) .LT. .001) GO TO 2010
C
          DO 1970 J = 1,7
            IF(T3(J) .EQ. 0.0) GO TO 1970
            XX = T3(J) * T2(3) / 100.0
            DO 1800 M = 1,6
              M2 = 14 - M
 1800       BB(M) = T3(M2) * XX / 100.0
            TEMP = 0.0
            DO 1950 M = 1,6
              IF(BB(M) .EQ. 0.0) GO TO 1950
              TEMP = TEMP + BB(M)
              DIV = RESREQ(1,M)  *YIELDS
              IF(DIV .LT. 1.0) DIV = 99.9E+20
              K = TEMP / DIV
              IF(K .EQ. 0.0) GO TO 1950
              TEMP = TEMP - K * DIV
              PRODN = K * SZEMIN(M) * YIELDS
              NEWMIN = NEWMIN + 1
C
C WRITE ON FILE FOR LATER USE
C
              WRITE(KIO,9130) SDNLET(J),SZELET(M),PRODN
 1950       CONTINUE
 1970     CONTINUE
C
C DEEP MINES.
C
      DO 2000 I = 1, 6
 2000       BB(I) = 0.0
```

```
C
 2010       DO 2310 L3=7,10
              L4 = L3 - 6
              IF(T4(L3) .EQ. 0.0) GO TO 2310
             IF (MARGSW.EQ.0)GO TO 2011
            DO 2315 LL=1,5
             IF (TMARG(LL,1,L4).GT.0)GO TO 2316
 2315  CONTINUE
       GO TO 2310
 2316  DO 2317 L2=1,6
 2317  T4(L2)=DPSMDT(LL,L2)
 2011  DO 2320 J=1,5
       IF (TMARG(J,1,L4).LE.0.)GO TO 2320
            IF(J .LT. 4) GO TO 2040
            IF(J .EQ. 4) GO TO 2030
            IF(T4(6) .EQ. 0.0) GO TO 2320
            XX = T4(6) * T2(8)
C
            GO TO 2050
C
 2030       IF(T4(4)+T4(5) .EQ. 0.0) GO TO 2320
            XX = T4(5)*T2(8) + T4(4)*T2(6)
            GO TO 2050
C
 2040       IF(T4(J) .EQ. 0.0) GO TO 2320
            XX = T4(J) * T2(6)
C
 2050       IF(XX  .LT. .1E-02) GO TO 2320
              ZZ = T4(L3) * XX / 10000.0
              DO 2100 M = 2,6
                M2 = 7 - M
C2100         BB(M) = STHMNS(J,M2) C ZZ / 100.0
 2100         BB(M) =TMARG(J,M2,L4) * ZZ / 100.0
              TEMP = 0.0
              DO 2300 M = 1,6
                IF(BB(M) .EQ. 0.0) GO TO 2300
                TEMP = TEMP + BB(M)
                DIV = RESREQ(2,M) *YIELDD
                IF(DIV .LT. 1.0) DIV = 99.9E+20
                K = TEMP / DIV
C
      A1 = BB(M)
      NAMELIST /BUGP3/ A1, TEMP, DIV, K
C     WRITE(IPRT,BUGP3)
C
                IF(K .EQ. 0.0) GO TO 2300
                TEMP = TEMP - K * DIV
                PRODN = K * SZEMIN(M) * YIELDD
C
      NAMELIST /BUGP4/ M, PRODN, TEMP
C     WRITE(IPRT,BUGP4)
C
                NEWMIN = NEWMIN + 1
C
C WRITE ON FILE FOR LATER USE.
```

```
C
                 WRITE(KIO,9150) THKLET(J),DIPLET(L4),SZELET(M),PRODN
C
 2300           CONTINUE
 2320       CONTINUE
 2310         CONTINUE
            IF(NEWMIN .LT. 1) GO TO 2370
C
C
C CALL MINE COSTING SUBROUTINE
C
C
C  THIS SUBROUTINE COSTS NEW MINES, SORTS THEM ON PRICE,
C  AND WRITES THEM ON 'KOUT' FILE.
      ENDFILE KIO
      REWIND KIO
C
C .IF SEVERANCE TAX $/TON IS TO BE USED, SET
C     SEVERANCE TAX FRACTION = 0.
C
      IF(SVT$C .GT. 0.0) SEVT = 0.0
C
      NAMELIST/DBG5/ T,KSW,KIO,KOUT,CT,MYR,ECAP,EMP,EPAS,ROR,
     1  ICASYR,RECL,SEVT,$PMDS,$PMDD,TPMDS,TPMDD,PSS,
     2  PSD,CAPIS,CAPID,CAPDS,CAPDD,XLIC,ROY,SWEL,DWEL,CTAX
C     WRITE(6,DBG5)
      CALL MC(ICASE,KSW,KIO,KOUT,CT,ECAP,EMP,EPAS,ROR,IBASYR,ICASYR,
     2          SEVT,SVT$C,$PMDS,$PMDD,TPMDSC,TPMDDC,PSS,PSD,CAPIS,CAPID,
     3          CAPDS,CAPDD,XLIC,ROY,SWEL,DWEL,SWELD,DWELD,CTAX,MCYR,
     4          ESCAL1,CUM,PRNTR,XINSS,XINSD,YIELDS,YIELDD,FEDS,FEDD)
C
C WRITE REMAINING MINES, IF ANY.
C
C   SINCE THE COUNTER IK MUST EQUAL 4 (SEE LINES 750-752)
C     THEREFORE, LINES 947-963 COULD BE OMITTED
 2370 IK = IK - 2
      GO TO(2400,2450), IK
 2400 PROD(2)=PROD(2)*ESCAL1
      WRITE(KOUT,9210) TYPE, PROD
C
C PRINT DEEP MINES, AND THEIR PRODUCTION HERE
C
      IF(PRNTR .NE. 1) GO TO 2408
      CUM = CUM + PROD(1)
      PROD(3) = CUM
      TYPE(1) = BLNK
      TYPE(2) = BLNK
      WRITE(IPRT,9215) TYPE, PROD
C
 2408 KSTT = 2410
 2410 READ(IN,8290,END=2650,ERR=40) TYPE, PROD
      IF(TYPE(1) .EQ. COMPT(3)) GO TO 2400
C
C END COAL
C
```

```
 2450 BACKSPACE IN
      READ(IN,8030,END=2650,ERR=40) AAA
      IF(AAA .NE. ENDCOL) GO TO 280
      KSTT = 2490
 2490 READ(IN,8030,END=2650,ERR=40) AAA
      REWIND KIO
C
C NEW COAL TYPE
C
      IF(AAA .EQ. COAL) GO TO 820
C
C END REGION
C
      IF(AAA .NE. ENDRGN) GO TO 280
      KSTT = 2550
 2550 READ(IN,8030,END=2650,ERR=40) AAA
      IF(AAA .EQ. ENDALL) GO TO 2700
C
C NEW REGION
C
      IF(AAA .NE. TABLER) GO TO 280
      BACKSPACE IN
      GO TO 200
C
C PHYSICAL END OF FILE ENCOUNTERED BEFOR LOGICAL END
C
 2650 WRITE(IPRT,9080)
      STOP 2650
C
C
C ALL DONE
C
C
 2700 CONTINUE
      WRITE(KOUT,9230)
      WRITE(IPRT,9100)
      CALL EXIT
C
C FORMATS         --------  INPUT  --------
C
 8010 FORMAT(/,T6,5A4,//,5(/,T7,5F4.1),/,T23,F4.2,T32,F4.2,
     1        2(/, T33,I2,T50,I2), /, T21,I2, /,
     2        4(10X,F7.0,1X),2(/,T38,F4.2),/,T12,F5.3,T27,F5.3,T43,F5.3,
     3        T52,F5.3,/.T11,I4,T28,I4,/,T25,F5.2,T49,F7.4,/,T15,F6.3,
     4        T35,F6.2,
     5        /,T15,F6.2,T35,F6.2,/,T14,F6.0,T34,F6.0./,T13,F4.2,
C       MIT CORRECTION
C       ORIGINAL VERSION  ....(/,T23,F4.2,T50,F4.2).......
     6        T30,F4.2,2(/,T23,F5.3,T50,F5.3),/,T15,F4.2,/,T27,F6.3,
     7        /,T28,F6.3)
C
 8012 FORMAT(T49,F5.2)
C
 8015 FORMAT(18X,6(F3.1,1X))
C
```

```
 8020 FORMAT(18X,6(A2,1X))
C
 8025 FORMAT(T7,I1)
C
C
 8030 FORMAT(A4)
C
 8050 FORMAT(20A4)
C
 8060 FORMAT(33X,3(F5.2,6X),/,33X,3(F5.2,6X),/,33X,F5.2,/,
     2        33X,3(F5.2.6X),/,33X,3(F5.2,6X),/,33X,F5.2)
C
 8070 FORMAT(9A3,I1)
C
 8090 FORMAT(T34,F4.0,T42,F4.0)
C
C
 8095 FORMAT(T34,A1)
 8110 FORMAT(T36,7(F4.1,1X))
C
C
 8115 FORMAT(T36,A1)
C
 8130 FORMAT(T25,4(F4.1,5X),/, T36,6(F4.1,1X))
C
 8145 FORMAT(T11,A1)
C
 8150 FORMAT(T7,4(A3,1X,F11.3))
C
 8170 FORMAT(T11,A2)
C
 8190 FORMAT(T29,F5.2,T47,F5.2,/,T34,F7.0,T50,F7.0,T63,F7.0)
C
 8192 FORMAT(T34,F7.0,T50,F7.0)
C
 8195 FORMAT(A3,1X,A1)
C
 8200 FORMAT(T5,I1)
C
 8210 FORMAT(2A3,I1)
C
 8225 FORMAT(T16,A1)
C
 8230 FORMAT(T16,7(F4.1,1X))
C
 8245 FORMAT(T13,A1)
C
 8250 FORMAT(T13,F4.0,T21,F4.0)
C
 8270 FORMAT(T11,4(F4.1.5X))
C
C      8290 FORMAT(A1,2A4,A3,1X,3F7.3)
 8290 FORMAT(A1,2A4,A3,F5.3,1X,F5.2,1X,F4.2)
C
 8300 FORMAT(33A4)
```

```
C
C FORMATS        --------  OUTPUT  --------
C
 9010 FORMAT(///,1X,6('* '),' READ ERROR - PROCESSING STOPPED',//,
     2       14X,'READ STATEMENT IN PROCESS IS = ',I4)
C
 9020 FORMAT(///,1X,6('. '),' INPUT ERROR - WRONG CARD ENCOUNTERED',
     2       //,14X,'READ STATEMENT LAST PROCESSED = ',I4,//,
     3       14X,'FURTHER PROCESSING STOPPED',/,1X,20A4)
C
 9030 FORMAT(//,1X,6('- '),' INPUT ERROR - COL 28 = ',I1,' INSTEAD OF',
     2       '0 OR 1',//,10X,20A4)
C
 9050 FORMAT(/,1X,6('+ '),' INPUT ERROR -(',A3,') EXPECTED -(',A3,
     2       ') ENCOUNTERED',/,14X,7A4,2X,'COAL=',A2,'. INPUT REJECTED')
C
 9060 FORMAT(/4X,'MAXIMUM OVERBURDEN RATIO EXCEEDS 45:1, SURFACE',
     2       ' MINES NOT CALCULATED',/,4X,7A4,2X,'COAL=',A2,'.')
C
 9080 FORMAT(//,1X,6(':.'),' PHYSICAL END OF INPUT FILE REACHED',
     2       ' BEFORE LOGICAL END. PROCESSING INTERRUPTED')
C
 9100 FORMAT(//,1X,6('<>'),' ALL DONE ',6('<>'))
C
 9130 FORMAT('S',2A2,3X,F10.2)
C
 9150 FORMAT('D',3A2,1X,F10.2)
C
 9170 FORMAT('ELEMENT  SUPPLY')
C
 9175 FORMAT(1H1,10X, 5A4, //,T20,'---- GLOBAL PARAMETERS ----', //,
     2       4X,'ALL INPUT PRICES ARE IN JANUARY 1, ',I4,' DOLLARS',
     3       //, 4X,'CASE YEAR = ',I4, 10X,'BASE YEAR = ',I4,//,
     2       4X,'SEAM THICKNESS VS MINE SIZE ',
     3       '(PERCENT DISTRIBUTION) - DEEP MINES',//,4X,'MINE-SIZE',
     4       ' (MMTONS)',T25,5(F3.1,2X),/,4X,9('--'),/,4X,'SEAM THICK',
     5       'NESS',/, T16,'=> 72', T23,5F5.1,/, T10,'=> 60  < 72',
     6       T23,5F5.1,/, T10,'=> 48  < 60',T23,5F5.1,/, T10,'=> 36 ',
     7       ' < 48',T23,5F5.1,/, T10,'=> 28  < 36',T23,5F5.1, //,
     8       4X,'MINE-SIZE (SURFACE - MMTONS) ',6F6.1,//, 4X,
     9       'RECOVERY FACTOR - SURFACE = ',F3.1,'  DEEP = ',F3.1, //,
     A       4X,'MINE LIFE IN YEARS - SURFACE  SMALL ( <1 MMTONS) =',
     B       I3,/, T35,'LARGE (=>1 MMTONS) =',I3,/, T26,'DEEP', T35,
     C       'SMALL ( <1 MMTONS) =',I3,/, T35,'LARGE (=>1 MMTONS) =',I3,
     C       //,4X,'MINE CONTRACT LIFE IN YEARS = ',I4,
     D       //,4X,'CAPITAL - INITIAL - SURFACE = ',F8.1,/,T25,'DEEP',
     E       '    = ',F8.1,/, T13,'- DEFERRED- SURFACE = ',F8.1,/,T25,
     F       'DEEP    = ',F8.1,//,4X,'ESCALATOR - CAPITAL',T33,'= ',F5.3
     G       ,/,T17,'MANPOWER',T33,'= ',F5.3,/,T17,'POWER & SUPPLY  = '
     H       F5.3,//,4X,'RATE OF RETURN',T33,'= ',F5.3,/)
C
 9177 FORMAT(4X,'UTILITY DISCOUNT RATE',T33,'= ',F5.3,//,
     2       4X,'ANNUITY PRICE FACTOR',T33,'= ',F6.3,//,T20,10('--'))
C
C
```

```
 9190 FORMAT(4X,2A4,',R=500,C=6,T=12,ZERO',6A4,/,
     2       9X,19H*      '      T       ',
     3        '     PROD    PRCE    SURF    ICAP    DCAP    DRAG')
C
 9191 FORMAT(4X,2A4,',R=500,C=5,T=12,ZERO',6A4,/,
     2       9X,19H*      '      T       ',
     3        '     PROD    PRCE    SURF    CAPL    DRAG')
C
 9195 FORMAT(1H1,10X, 5A4,//, 12X,'---- REGIONAL PARAMETERS FOR ',5A4,
     2       ' ----',//,4X,'ILLEGAL SURFACE RESERVE FRACTION     = ',F4.2,
     2       /,4X,'INACCESSIBLE DEEP RESERVE FRACTION = ',F4.2,
     3       //, 4X,'SEVERANCE TAX RATE = ',F6.4,4X,
     3       'OR $',F5.2,' PER TON',/,4X,'LICENSE FEE',
     4       T24,'= ',F4.2,/, 4X,'ROYALTY FEE',T24,'= ',F4.2,/, 4X,
     5       'CORPORATE TAX', T24,'= ',F4.2,//, 4X,'WELFARE FUND - ',
     5       '($ PER TON) - SURFACE = ',F5.2,/,T3 4,'DEEP    = ',F5.2,/,
     6       T20,'($ PER DAY) - ',
     6       'SURFACE = ',F5.2,/,T34,'DEEP    = ',F5.2,//,4X,'POWER &',
     7       ' SUPPLY - SURFACE = ',F6.1,/, T22,'DEEP    = ',F6.1,//,4X,
     8       'TONS PER MANDAY - SURFACE   = ',F6.2,/,T23,'DEEP',T33,'= '
     9       ,F6.2,//, 4X,'COST $ PER MANDAY - SURFACE = ',F6.2,/, T25,
     A       'DEEP    = ',F6.2,/)
 9197 FORMAT(4X,'RECLAMATION COST $/TON (5)= ',
     B       F5.2,', (10)= ',F5.2,', (15)= ',F5.2,', (20)= ',F5.2,/,
     C       6X,'(FIXED)',T27,'(25)= ',F5.2, ', (30)= ',F5.2,
     D       ', (45)= ',F5.2,/,  6X,'(VARIABLE)',T28,'(5)= ',F5.2,
     B       ', (10)= ',F5.2,', (15)= ',F5.2,', (20)= ',F5.2,/,
     C       T27,'(25)= ',F5.2, ', (30)= ',F5.2,', (45)= ',F5.2,//,
     D       4X,'EXPOSURE INSURANCE, PERCENT OF PAYROLL COST',
     E       ' - SURFACE = ',F6.2,/,T49,'- DEEP    = ',F6.2,//,4X,
     F       'CLEAN TONS YIELD, FRACTION OF RAW TONS',T49,'- SURFACE',
     G       ' = ',F6.2,/,T49,'- DEEP    = ',F6.2,///,20X, 20('--'))
C
 9200 FORMAT(4X,'DEMONSTRATED RESERVES - DEEP THIN',T40,'= ',F9.2,/,T29,
     2       'DEEP THICK = ',F9.2,/,T29,'SURFACE    = ',F9.2,//, 4X,
     3       'COMMITTED    RESERVES - DEEP',T40,'= ',F9.2,/,
     4       T29,'SURFACE',T40,'= ',F9.2,//, 4X,
     5       'SURFACE MINE SIZE DISTR (',F3.1,')=',F6.2,', (',F3.1,')=',
     6       F6.2,', (',F3.1,')=',F6.2,/, T8,'(PERCENT)',T29,'(',
     7       F3.1,')=',F6.2,', (',F3.1,')=',F6.2,', (',F3.1,')=',F6.2,
     8       //,4X,'OVERBURDEN RATIO DISTR   (5)=',F6.2,', (10)=',F6.2,
     9       ', (15)=',F6.2,', (20)=',F6.2,/, T8,'(PERCENT)',T29,
     A       '(25)=',F6.2,', (30)=',F6.2,', (45)=',F6.2,//, 4X,'SEAM',
     B       ' THICKNESS DISTR',T29,'(',A2,')=',F6.2,', (',A2,')=',
     C       F6.2,', (',A2,')=',F6.2,/, T8,'(PERCENT)',T29,'(',A2,
     D       ')=',F6.2,', (',A2,')=',F6.2,', (',A2,')=',F6.2, //,
     E       4X,'SEAM DEPTH DISTR (%)  (00)=',F6.2,', (04)=',F6.2,
     F       ', (07)=',F6.2,', (10)=',F6.2,//,4X,'SEVERANCE TAX RATE = ',
     G       F7.4,4X,'OR $',F5.2,' PER TON',//,
     H       4X,'CLEANING COST (FIXED) = ',F5.2,6X,'(VARIABLE) = ',
     I       F5.2, //)
C
 9210 FORMAT(T10,A1,A4,1X,A4,A3,T30,F7.3,2(1X,F6.2))
C
 9215 FORMAT(T10,A1,A4,1X,A4,A3,T30,F7.3,2(F7.2,2X))
```

```
C
 9230 FORMAT('ENDATA')
C
C
      END
C*        SUBROUTINE STHK(ARY,LMIN,LMAX)
C*C
C*C GIVEN MINIMUM AND MAXIMUM SEAM THICKNESSES FOR DEEP MINABLE RESERVES
C*C THIS SUBROUTINE ASSIGNS PERCENTAGE DISTRIBUTION OF RESERVES TO
C*C SEAM THICKNESS CATAGORIES USING EVEN DISTRIBUTION.
C*C
C*C IF MINIMUM THICKNESS IS LESS THAN 42 INCHES, MINIMUM IS ASSUMED
C*C TO BE 42 INCHES, FOR THICK RESERVES.
C*C
C*C IF MINIMUM AND MAXIMUM ARE ZERO, OR MINIMUM IS GREATER OR EQUAL TO
C*C MAXIMUM, PERCENTAGE ASSIGNED IS  ZERO.
C*C
C*C THIN RESERVES ARE ALWAYS ASSIGNED 57.1% TO TO 28-36, AND 42.9%
C*C TO 36-42 INCHES SEAM THICKNESSES RESPECTIVELY.
C*C
C*C
C*C  ---- INPUT ----
C*C
C*C       LMIN  MINIMUM SEAM THICKNESS
C*C
C*C       LMAX  MAXIMUM SEAM THICKNESS
C*C
C*C  ---- OUTPUT ----
C*C
C*C       ARY   ARRAY CONTAINING PERCENTAGES OF ASSIGNED DISTRIBUTION
C*C
C*C
C*        INTEGER       THIK(6)
C*C
C*        DIMENSION     ARY(1), AA(6), ITHK(4)
C*C
C*        DATA          AA/4*0.0,42.9,57.1/, THIK/72,60,48,42,36,28/
C*C
C*C
C*C SET RETURN ARRAY 'ARY' = 0.
C*C
C*        DO 20 I = 1, 6
C*     20 ARY(I) = 0.0
C*C
C*        IF(LMIN+LMAX .EQ. 0  .OR.  LMIN .GE. LMAX) RETURN
C*C
C*        DO 40 J = 1,4
C*          ITHK(J) = THIK(J)
C*     40 AA(J) = 0.0
C*C
C*        DO 80 J = 1,4
C*          IF(LMIN - THIK(J)) 80,100,100
C*     80 CONTINUE
C*C
C*        J = 4
```

```
C*C
C*  100 LIM = J
C*      ITHK(J) = LMIN
C*      IF(ITHK(J) .LT. 42) ITHK(J) = 42
C*      JSET = 1
C*      TOT = 0.0
C*C
C*C
C*      DO 240 J = 1,LIM
C*        GO TO(150,200), JSET
C*C
C*  150   IF(ITHK(J) .GE. LMAX) GO TO 240
C*           AA(J) = LMAX - ITHK(J)
C*           TOT = TOT + AA(J)
C*           JSET = 2
C*           GO TO 240
C*C
C*  200   AA(J) = ITHK(J-1) - ITHK(J)
C*           TOT = TOT + AA(J)
C*  240 CONTINUE
C*C
C*C
C*      IF(TOT .LT. 1.0) TOT = 100.0
C*      THOU = 1000.0 / TOT
C*      NTOT = 0
C*C
C*      DO 350 J = 1,4
C*        NEXT = AA(J) * THOU + .5
C*        ARY(J) = NEXT / 10.0
C*  350 NTOT = NTOT + NEXT
C*      IF(IABS(NTOT - 1000) .GT. 0) ARY(LIM) = ARY(LIM)+100.0-NTOT/10.0
C*C
C*      ARY(5) = AA(5)
C*      ARY(6) = AA(6)
C*C
C*      RETURN
C*C
C*      END
      SUBROUTINE  OBDN(ARY,LMIN,LMAX)
C
C GIVEN MINIMUM AND MAXIMUM OVERBURDEN RATIOS FOR SURFACE MINABLE
C RESERVES, THIS SUBROUTINE ASSIGNS PERCENTAGE DISTRIBUTION OF
C RESERVES TO OVERBURDEN RATIO CATAGORIES FROM 5:1 TO 45:1 USING
C EVEN DISTRIBUTION BETWEEN LIMITS SET BY LMIN AND LMAX WITH STEPS
C OF 5 FROM 5 TO 30, AND OF 15 FROM 30 TO 45.
C
C IF MINIMUM AND MAXIMUM ARE ZERO, OR MINIMUM IS GREATER OR EQUAL TO
C MAXIMUM, PERCENTAGE ASSIGNED IS ZERO.
C
C IF THE MAXIMUM OVERBURDEN RATIO IS GREATER THAN 45:1,
C A RECOVERY FACTOR IS CALCULATED = (45-LMIN)/(LMAX-LMIN), AND
C LMAX IS SET = 45.  THIS RECOVERY FACTOR IS USED TO CALCULATE THE
C PERCENTAGES OF DISTRIBUTION RATIOS.
C
C
```

```
C  ---- INPUT ----
C
C     LMIN  MINIMUM OVERBURDEN RATIO
C
C     LMAX  MAXIMUM OVERBURDEN RATIO
C
C  ---- OUTPUT ----
C
C     ARY   ARRAY CONTAINING PERCENTAGE OF ASSIGNED EVEN DISTRIBUTION
C
C
      INTEGER      BDNCLS(7)
C
      DIMENSION    IBDN(7), AA(7), ARY(1)
C
      DATA         IBDN/5,10,15,20,25,30,45/
C
C
C
      TOT = 0.0
C
      DO 80 J = 1,7
        BDNCLS(J) = IBDN(J)
        ARY(J) = 0.0
   80 AA(J) = 0.0
C
      IF(LMIN+LMAX .EQ. 0  .OR. LMIN .GE. LMAX) RETURN
C
      RECFR=1
      DO 120 J = 1,7
        IF(LMAX - BDNCLS(J)) 160,160,120
  120 CONTINUE
C
C LMAX GREATER THAN 45.   MODIFY RECOVERABLE FRACTION RECFR.
C
      RECFR=FLOAT(45-LMIN)/FLOAT(LMAX-LMIN)
      LMAX=45
      J=7
C
C ASSIGN DISTRIBUTION
C
  160 LIM = J
      JSET = 1
      BDNCLS(J) = LMAX
C
      DO 280 J = 1,LIM
        GO TO(200,250), JSET
  200   IF(BDNCLS(J) .LE. LMIN) GO TO 280
          AA(J) = BDNCLS(J) - LMIN + 1
          TOT = TOT + AA(J)
          JSET = 2
          GO TO 280
C
  250   AA(J) = BDNCLS(J) - BDNCLS(J-1)
        TOT = TOT + AA(J)
  280 CONTINUE
```

```
C
      IF(TOT .LT. 1.0) TOT = 100.0
      THOU = 1000.0 / TOT
      NTOT = 0
C
C
      DO 380 J = 1,7
        NEXT = AA(J) * THOU + .5
        ARY(J) = (NEXT / 10.0)*RECFR
  380 NTOT = NTOT + NEXT
C
C
C
      RETURN
C
      END
      SUBROUTINE MC(T,KSW,KIO,KOUT,CT,ECAP,EMP,EPAS,ROR,
     1  IBASYR,ICASYR,SEVTR,SEVT,SLAB,DLAB,TPMDBS,TPMDBD,PASBS,
     2  PASBD,XICBS,XICBD,DCBS,DCBD,XLIC,ROY,SWEL,DWEL,SWELD,DWELD,CTAX,
     3  MCYR,ESCAL1,CUMUL,PRNTR,XINSS,XINSD,YIELDS,YIELDD,FEDS,FEDD)
C****PICEM MINE COSTING SUBROUTINE
C     FEA/CHILDRESS/FEBRUARY.1976
C  THIS PROGRAM DETERMINES MINIMUM ACCEPTABLE SELLING
C  PRICES FOR MODEL COAL MINES ACCORDING TO FORMULAE
C  ESTABLISHED IN BOM IC8632 AND IC8535 FOR SURFACE AND DEEP
C  MINES. IT INTERPOLATES FOR CAPITAL,POWERAND SUPPLIES,AND TONS
C  PER MAN DAY,ACCORDING TO RULES DEVELOPED BY ICF CORP.  IT
C  IS PASSED INPUT PARAMETERS AND MINE TYPES FOR WHICH
C  COSTING IS REQUESTED FROM THE MAIN PROGRAM,PERFORMS THE
C  REQUIRED CASH FLOW ANALYSIS, AND IF KSW IS 1,CREATES A PRINT
C  FILE ON LOGICAL UNIT MPRT. IT THEN WRITES ON KOUT THE NEW MINE
C  INFORMATION IN GAMMA FORMAT,SORTED BY PRICE,FOR USE IN THE
C  PICEM MODEL. THIS SUBROUTINE IS CALLED IN THE MAIN PROGRAM EACH
C  TIME A NEW COAL TYPE IS PROCESSED.
C****ARRAYS****
C  A(4,25) TEXT FOR MINE COSTS
C  B(26,166)  DATA FOR MINE COSTS
C  P(15)  PARAMETER BUFFER
C  BUF(2,166)  SURFACE OR DEEP TEXT BUFFER
C  D(4,166)  MINE TYPE HEADER INFORMATION
C
C
      DOUBLE PRECISION A,DUMY,RMINE
      DIMENSION A(4,25),B(26,166),T(5)
      DIMENSION C(2,166),SF(2),DS(2),DD(2),D(4,166),DUMY(4,10),AC(2)
C
      COMMON /COST/ SZEMIN(6),RECL(14),MLIFE(2,2),CLEAN(2),ASZ(2,6),
     2              RUT,ISENS,APFAC
C
      DATA IPRT,MPRT,KSC/31,32,12/
      REAL          BLACKL(2)
      DATA          BLACKL/.25,.50/
      DATA   DDRAG/0.0/
C    MIT CORRECTION
C    ORIGINAL VERSION
```

```
C     REAL  IC,IC1                                                      NEI14310
      REAL IC,IC1,LAB                                                   NEI14320
      REAL TLIG(8)                                                      NEI14330
      DATA TLIG/'LA','LB','LC','LD','LE','LF','LG','LH'/                NEI14340
       INTEGER DR, PRNTR                                                NEI14350
      DIMENSION BUF(11,160),AST(2,7),ADP(2,7),AOB(2,7)                  NEI14360
      DATA AST/0.,'00  ',28.,'28  ',36.,'36  ',48.,'48  ',              NEI14370
     X 60.,'60  ',72.,'72  ',0.,0./                                     NEI14380
      DATA ADP/400.,'04  ',700.,'07  ',1000.,'10  ',                    NEI14390
     C '0000',0.,'0000',0.,'0000',0.,'0000',0./                         NEI14400
      DATA AOB/5.,'05  ',10.,'10  ',15.,'15  ',20.,'20  ',              NEI14410
     X 25.,'25  ',30.,'30  ',45.,'45  '/                                NEI14420
      DATA BLK/'    '/                                                  NEI14430
      DATA BUF/1760*0./                                                 NEI14440
      DATA ZRO/'0000'/                                                  NEI14450
      EQUIVALENCE (A(53),DUMY(1))                                       NEI14460
      DATA AC/'S   ','D   '/                                            NEI14470
C  MIT CORRECTION                                                       NEI14480
C   ORIGINAL :  DIMENSION Y(23,30),ORD(166),DCFRAC(30)                  NEI14490
      DIMENSION Y(23,40),ORD(166),DCFRAC(40)                            NEI14500
      DATA ORD/'1','2','3','4','5','6','7','8','9','A','B','C',         NEI14510
     1 'D','E','F','G','H','I','J','K','L','M','N',                     NEI14520
     2 'O','P','Q','R','S','T','U','V','W','X','Y','Z',131*'#'/         NEI14530
      DATA B/4316*0./                                                   NEI14540
      DATA A/8HINITIAL ,8H CAPITAL,8H        ,8H        ,               NEI14550
     C8HDEFERRED,8H CAPITAL,8H        ,8H        ,8HPRESENT ,           NEI14560
     C8HVALUE,CA,8HPITAL IN,8HV.      ,8HCASH FLO,8HW       ,           NEI14570
     C8H        ,8H        ,8HSALES   ,8H        ,8H        ,           NEI14580
     C8H        ,8HOPERATIN,8HG COSTS ,8H        ,8H        ,           NEI14590
     C8HGROSS PR,8HOFIT    ,8H        ,8H        ,8HDEPLETIO,           NEI14600
     C8HN       ,8H        ,8H        ,                                 NEI14610
     C8HPROFIT B,8HEFORE TA,8HXES     ,8H        ,8HFEDERAL ,           NEI14620
     C8HINCOME T,8HAX      ,8H        ,8HNET PROF,8HIT      ,           NEI14630
     C8H        ,                                                       NEI14640
     C8H        ,8HSELLING ,8HPRICE ($,8H/TON)   ,8H        ,           NEI14650
     C8H   LABOR,8H        ,8H        ,8H        /                      NEI14660
      DATA DUMY/8H   POWER,8H AND SUP,                                  NEI14670
     C8HPLIES   ,8H        ,8H   PAYRO,8HLL OVERH,                      NEI14680
     C8HEAD     ,8H        ,8H   UNION,8H WELFARE,8H        ,           NEI14690
     C8H        ,8H   ROYAL,8HTY      ,8H        ,8H        ,           NEI14700
     C8H   LICEN,8HSES     ,8H        ,8H        ,8H   INDIR,           NEI14710
     C8HECT COST,8HS       ,8H        ,8H   TAXES,8H AND INS,           NEI14720
     C8HURANCE  ,8H        ,8H   DEPRE,8HCIATION ,8H        ,8H        ,NEI14730
     C8H      TO,8HTAL OPER,8HATING CO,8HSTS     ,8HOUTPUT P,           NEI14740
     C8HER MAN-D,8HAY (TONS,8H)       /                                 NEI14750
      DATA SF,DS,DD/'SURF','ACE ','DP/S','HAFT','DP/D','RIFT'/          NEI14760
C                                                                       NEI14770
 301  FORMAT(A1)                                                        NEI14780
 302  FORMAT(1H ,'CONTROL STMT-',A4,'  WRONG..STOPPING')                NEI14790
 303  FORMAT(1X,2F2.0,3X,F10.2,T1,A8)                                   NEI14800
 305  FORMAT(1X,3F2.0,1X,F10.2,T1,A8)                                   NEI14810
 306  FORMAT(10X,F3.2,2(5X,F5.2),2(4X,F4.2),5X,F5.2)                    NEI14820
 320  FORMAT(1H ,'***END CARD.WILL NOW EXEC.')                          NEI14830
 322  FORMAT(1H ,////,50X,'MINE COSTING AND CASH FLOW ANALYSIS')        NEI14840
 321  FORMAT(1H1,'CASE:',5A4,/,1H ,'PAGE:',I3,' OF ',I3)                NEI14850
```

```
 379   FORMAT(11X,5A4)
 380   FORMAT(3(6X,I2,/),6X,I2)
 381   FORMAT(15(6X,F10.2,/))
 324   FORMAT(1H ,55X,'(THOUSANDS OF DOLLARS)',///)
 326   FORMAT(1H ,33X,6('TP=',2A4,3X))
 327   FORMAT(1H ,33X,6('SZ=',F3.1,' MMT/YR '))
 328   FORMAT(1H ,33X,6('OB=',F4.0,7X))
 329   FORMAT(1H ,33X,6('ST=',F4.0,'  IN.  '))
 330   FORMAT(1H ,33X,6('DP=',F5.0,' FT.  '),//)
 332   FORMAT(1H ,4A8,6(F10.0,4X))
 300   FORMAT(1H1)
 340   FORMAT(1H ,///)
 341   FORMAT(1H )
 362   FORMAT(1H ,4A8,6(F10.2,4X),/,1H ,'OPERATING COSTS')
 372   FORMAT(1H ,4A8,6(F10.1,4X))
C
       REWIND KSC
       NAMELIST /BUGDC/ MDIV
       SMAL=.0000001
       MDIV=100
       IF(ROR.LT.SMAL) WRITE(6,BUGDC)
C
C 'KK' DEFINES THE NUMBER OF THE PRESENT MINE UNDER CALCULATION.
C MAXIMUM LIMIT AT PRESENT IS 160 MINES.
C
       KK=0
C
C  CALCULATE PRESENT VALUE FACTOR FOR DEFERRED CAPITAL DIST'N
C   ACCORDING TO ICF'S  RECCOMENDATION
C
C      SEE  SUBROUTINE 'PRVAL' FOR THIS.
C
       X1=XICBS
       X2=XICBD
       X3=DCBS
       X4=DCBD
       NAMELIST /DBUG3/ X1,X2,X3,X4
C      WRITE(6,DBUG3)
C****BEGIN READING INPUT****
 10    READ(KIO,301,END=999) ACONT
       BACKSPACE KIO
       DO 15 K=1,2
       IF(ACONT.EQ.AC(K)) GO TO (100,200),K
 15    CONTINUE
       WRITE(6,302) ACONT
       NAMELIST /DBUG2/ K,KK,AC,ACONT
       WRITE(6,DBUG2)
       STOP
C
C    100=STRIP,200=DEEP
C .MAKE CALCULATIONS FOR SURFACE MINES
C                       ------- -----
C
 100   READ(KIO,303) OB,SZ,PROD,RMINE
C
```

```
C MINE LIFE IN YEARS.
C
      AMR=.35
      BLUNG=BLACKL(1)
      DO 101 K=1,8
      IF (CT.EQ.TLIG(K)) AMR=.25
      IF (CT.EQ.TLIG(K)) BLUNG=0
  101 CONTINUE
      MYR = MLIFE(2.1)
      IF(SZ .LT. 10.0) MYR = MLIFE(1,1)
      CALL PRVAL(MYR,ROR,PVFAC,DCFRAC)
C
      SZ=SZ/10.
C
C RECLAMATION COST - $/TON.
C
      DO 35 II = 1, 7
      IF(AOB(1,II) .GE. OB-SMAL) GO TO 37
   35 CONTINUE
      II = 7
   37 XRECL = RECL(II)
      YRECL = RECL(II+7)
C .EMPLOYMENT INSURANCE RATE  -  $/$100 OF PAYROLL COST
      XFINS = XINSS
C .YIELD OC CLEAN TONS  -  FRACTION OF RAW TONS
      YIELD = YIELDS
      FED=FEDS
C .CALCULATE SEVT$ HERE
      SEVT$ = SEVT * 1000. * SZ * YIELD
C
      KK=KK+1
      NAMELIST/DBUG8/ KK,OB,SZ,PROD
C     WRITE(6,DBUG8)
C    CALCULATE ALL COSTS FOR STRIP MINE.
      DO 42 J=1,2
 42   C(J.KK)=SF(J)
      D(1,KK)=SZ
      D(2,KK)=OB
      D(3,KK)=0.
      D(4,KK)=0.
      IF(SZ.LT.1.) GO TO 47
C .MINES WITH CAPACITY OF 1 MILLION TONS OR MORE.
      IC=(XICBS+1.20*(OB-10.)*1000)*SZ*(1.-(SZ-1.)/20)
      DC=(DCBS+0.25*(OB-10.)*1000)*SZ*(1.-(SZ-1.)/20)
      GO TO 49
C .MINES WITH CAPACITY OF LESS THAN 1 MILLION TONS.
C47    IC=(XICBS+1.20*(OB-10.)*1000)*(1.-0.08*(1.-SZ)/0.1)
C      DC=(DCBS+0.25*(OB-10.)*1000)*(1.-0.08*(1.-SZ)/0.1)
 47    IC=(XICBS+1.20*(OB-10.)*1000)*(1.-0.05*(1.-SZ)/0.1)
       DC=(DCBS+0.25*(OB-10.)*1000)*(1.-0.05*(1.-SZ)/0.1)
 49    CONTINUE
       TPMD=(TPMDBS+3*(SZ-1.0)/0.1)*(1.-0.1*(OB-10.)/5)
       LAB=(SZ*1000/TPMD)*SLAB
       POW=400.
       PAS=(PASBS+30.*(OB-10.))*SZ
```

```
      WEL=SWEL
      WPD=SWELD
      SURF=1.0
C
C    FILL OUT REST OF BUFFER ITEMS,  ALL MINES
C                                    --- -----
C
  800 CONTINUE
C
C DEFERRED CAPITAL = 0, IF MINE LIFE =< 10 YEARS,
C                  = 2 * VALUE OF 20 YEARS, IF MINE LIFE = 30 YEARS,
C                  = LINEAR INTERPOLATED VALUE, IF MINE LIFE > 10 YEARS,
C                                                      BUT < 30 YEARS.
C
      DC = DC * (FLOAT(MYR-10)/10.)
      IF(MYR .LE. 10) DC = 0.0
C   NOTE HERE THAT THE CALCULATION OF PVFAC IN SUBROUTINE PRVAL IGNORES
C  INFLATION,REAL CAPITAL ESCALATION , AND ASSUMES THAT THE THE
C    DISCOUNT RATE ,ROR, IS REAL
C
      B(1,KK)=IC
      B(2,KK)=DC
      B(3,KK)=IC+PVFAC*DC
      XXX=(1.-(1.+ROR)**(-MYR))/ROR
      MDIV=110
      IF(XXX.LT.SMAL) WRITE(6,BUGDC)
      B(4,KK)=B(3,KK)/XXX
      B(13,KK)=LAB
      B(14,KK)=PAS
      B(15,KK)=0.2*LAB
C MIT CORRECTION
C  ORIGINAL VERSION :
C      B(16,KK)=1000.*SZ*(WEL+WPD/TPMD)*YIELD
       B(16,KK)= 1000.*SZ*(WEL*YIELD+WPD/TPMD)
C      B(16,KK)=WEL*1000.*SZ*YIELD
      B(17,KK)=ROY*1000*SZ   * YIELD
      B(18,KK)=XLIC*1000*SZ  * YIELD
      POW=POW*SZ
      SUP=PAS-POW
      B(19,KK)=0.15*(LAB+SUP)
      B(20,KK)=0.02*IC
      B(21,KK)=(IC+DC)/MYR
      B(22,KK)=0.
      DO 810 J=13,21
  810 B(22,KK)=B(22,KK)+B(J,KK)
C
C
      B(23,KK)=TPMD
      B(24,KK)=PROD
C    TEST IF DEPL GT 1/2*GROSS PROFIT.
      SALES=(B(22,KK)/2.0+B(4,KK)-B(21,KK))/0.55
      DEPL=0.1*SALES
      GROPR=SALES-B(22,KK)
      XX=GROPR/2.
      IF(DEPL.LE.XX) GO TO 900
```

```
      GROPR=(B(4,KK)-B(21,KK))*4./3.
      SALES=GROPR+B(22,KK)
      DEPL=0.5*GROPR
 900  CONTINUE
C
C
      B(5,KK)=SALES
      B(6,KK)=B(22,KK)
      B(7,KK)=GROPR
      B(8,KK)=DEPL
      B(9,KK)=B(7,KK)-B(8,KK)
      B(10,KK)=B(9,KK)*CTAX
      B(11,KK)=B(9,KK)-B(10,KK)
      MDIV=120
      IF(SZ.LT.SMAL) WRITE(6,BUGDC)
C  CALCULATE THE MINIMUM ACCEPTABLE SELLING PRICE (MASP) FOR
C   THE MINE'S FIRST YEAR. THIS IS A CASE -YEAR PRICE IN
C    BASE-YEAR DOLLARS, NOT ANNUATIZED OVER MINE LIFETIME
      B(12,KK)=B(5,KK)/(SZ*1000.)
      NYR=ICASYR-IBASYR
C
C
CC    XNYR=NYR
CC     NNN=NYR/2
      Y(3,1) = 0.
CCC   FILL UP Y FOR EACH OF CONTRACT YEARS UP TO A TOTAL OF MCYR.
C  FILL UP Y FOR EACH OF CONTRACT YEARS UP TO A TOTAL OF MYR.
CC    DO 1102 JJ=1,MCYR
      DO 1102 JJ=1,MYR
CC    LL=JJ+NNN
C  MIT CORRECTION
C   ORIGINAL VERSION:
C      LL=JJ+NYR-1
       LL=JJ+NYR
CC   NYR/2 IS TIME IC IS ASSUMED SUNK-HALFWAY FROM 1975 TO CASE YR.
CC    Y(1,JJ)=IC*(1+ECAP)**(NYR/2)
C
C .INITIAL CAPITAL IS INFLATED @ CAPITAL INFLATION RATE UPTO 8
C    MONTHS PRIOR TO THE YEAR MINE IS OPENED.  (I.E., FOR
C    CASE YEAR-BASE YEAR-1-4/12  YEARS)
C
C  MIT CORRECTION
C   ORIGINAL VERSION
C      Y(1,JJ)=IC*(1+ECAP)**(NYR-5./3.)
       Y(1,1)=IC*((1+ECAP)**(NYR-2./3.))*((1+EPAS)**(2./3.))
      Y(2,JJ)=DC*DCFRAC(JJ)*(1+ECAP)**LL
      Y(6,1)=Y(2,1)
      IF(JJ.EQ.1) GO TO 1102
      Y(6,JJ)=Y(6,JJ-1)+Y(2,JJ)
 1102 Y(3,1)=Y(3,1)+Y(2,JJ)*(1+ROR)**(-JJ)
C
C
      Y(3,1)=Y(3,1)+Y(1,1)
      PTOT=0.
C  Y(6,JJ) CONTAIN THE CUMULATIVE ACTUAL DEFERRED CAPITAL
```

```
C  EXPENSES TO BE USED TO CALCULATE CURRENT DEPRECIATION.
C  Y(3,1) NOW CONTAINS P.V. OF ALL CAPITAL FLOWS
CC     DO 1104 JJ=1,MCYR
       DO 1104 JJ=1,MYR
C      MIT CORRECTION
C       OIGINAL VERSION
C       LL=JJ+NYR-1
        LL=JJ+NYR
       Y(4,JJ)=Y(3.1)/XXX
       Y(13,JJ)=LAB*(1+EMP)**LL
       Y(14,JJ)=PAS*(1+EPAS)**LL
       Y(15,JJ)=0.20*Y(13,JJ)
      3          + XPINS*Y(13,JJ)*.01
       CAPTL = (1+ECAP)**LL
       Y(16,JJ)=B(16.KK)      *(1+EMP)**LL
       Y(17,JJ)=B(17,KK)      *CAPTL
       Y(18,JJ)=B(18,KK)      *CAPTL
       XSUP=Y(14,JJ)-POW*(1.+EPAS)**LL
       Y(19,JJ)=.15*(Y(13,JJ)+XSUP)
C  MIT CORRECTION
C    ORIGINAL VERSION
C       Y(20,JJ)=.02*Y(1,JJ)  *CAPTL
C  DEPRECIATION IS CALCD. AS STRAIGHT LINE
         Y(20,JJ)=.02*(Y(1,1)/((1+EPAS)**(2./3.)))*(1+ECAP)**
      &  (JJ+2./3.)
C  BASED ON ACTUAL CURRENT DOLLARS SPENT.
CCC    Y(21,JJ)=(Y(6,JJ)+Y(1,1))/MYR
C  MIT CORRECTION
C   ORIGINAL VERSION
C       Y(21,JJ)=(Y(6,MYR)+Y(1,1))/MYR
        Y(21,JJ)=(Y(6,MYR)+(Y(1,1)/((1+EPAS)**(2./3.))))/MYR
       Y(22,JJ)=0.
       DO 1105 MM=13,21
 1105  Y(22,JJ)=Y(22,JJ)+Y(MM,JJ)
C
C ADD RECLAMATION AND CLEANING COSTS DULY INFLATED
C   AT CAPITAL AND LABOR OR POWER & SUPPLY ESCALATION RATES.
C   ALSO ADD EXPOSURE INSURANCE COST.
C
C   MIT CORRECTION
C  ORIGINAL       ...(1+ECAP)**NYR+...
       Y(22,JJ) = Y(22,JJ) + ((XRECL+CLEAN(1))*(1+ECAP)**(NYR+1) +
      2          YRECL*(1.+EMP)**LL + CLEAN(2)*(1.+EPAS)**LL
      3           +AMR+BLUNG)*SZ*1000*YIELD
C
       Y(23,JJ)=B(23.KK)
       XSALES=(Y(22,JJ)/2.+Y(4,JJ)-Y(21,JJ))/
      1(.55*(1.-SEVTR-FED))
      2+SEVTS/(2.*.55)
       XDEPL=0.1*XSALES
       XGROPR=XSALES-Y(22,JJ)-XSALES*(SEVTR+FED)-SEVTS
       XYX=XGROPR/2.
       IF(XDEPL.LE.XYX) GO TO 1202
       XSALES=((Y(4,JJ)-Y(21,JJ))*4./3.+Y(22,JJ))/(1.-(SEVTR+FED))+SEVTS
       XGROPR=XSALES-Y(22,JJ)-XSALES*(SEVTR+FED)-SEVTS
```

```
      XDEPL=0.5*XGROPR
 1202  CONTINUE
      Y(5,JJ)=XSALES
C
C ADJUST FOR SEVERANCE TAX.
C
      Y(12,JJ)=Y(5,JJ)/(SZ*1000.*YIELD)
C  Y(12,JJ) CONTAIN THE UNADJUSTED PRICES FOR YEAR JJ, EXCEPT FOR
C   UTILITY DISCOUNT RATE -  ADDED BELOW
      PTOT=PTOT+Y(12,JJ)*(1+RUT)**(-JJ)
 1104  CONTINUE
C  CAULATE FINAL PRICE.
      MDIV=130
      IF(ABS(1-SEVT).LT.SMAL) WRITE(6,BUGDC)
      MDIV=140
      IF(ABS(APFAC).LT.SMAL) WRITE(6,BUGDC)
      B(25,KK)=PTOT/APFAC
C
C PRINT VALUES FOR ALL YEARS FOR SENSITIVILY ANALYSIS,
C    IF SENSITIVITY SWITCH IS SET = 1.
C
      IF(ISENS .EQ. 1) WRITE(MPRT,1145) RMINE, B(25,KK),
     2                  ((JKJ,Y(12,JKJ)),JKJ=1,MYR)
C
 1145 FORMAT(/,'0   MINE TYPE -',A8,'- WITH ANNUITY PRICE = ',F10.2,
     2       ', HAS FOLLOWING ANNUAL NOMINAL PRICES OVER THE',
     3       ' LIFE OF THE MINE:',/,5(I5,')',2X,F12.2))
C
C
      B(26,KK) = SURF
      IF (ISENS.EQ.1) WRITE (MPRT,1234) NYR,Y(1,1),(Y(K,1),K=3,6),
     1(Y(K2,1),K2=12,22),XRECL,CLEAN(1),ECAP,YRECL,EMP,CLEAN(2),
     2EPAS,XPINS,SEVT$,SEVTR
 1234 FORMAT(' NYR Y 1 3-6 12-22 XRECL CLEAN(1) ECAP NYR YRECL EMP ',
     1'CLEAN(2) EPAS XPINS SEVT$ SEVTR',/I5,10E12.5/(5X,10E12.5))
      GO TO 10
C
C    MAKE CALCS FOR DEEP MINES
C                   ---- -----
C
 200  READ(KIO,305) ST,DP,SZ,PROD,RMINE
      DP=DP*100.
C
C MINE LIFE IN YEARS.
C
      MYR = MLIFE(2,2)
      IF(SZ .LT. 10.0) MYR = MLIFE(1,2)
      CALL PRVAL(MYR,ROR,PVFAC,DCFRAC)
C
      SZ=SZ/10.
      DR=0
      SURF=0.
      XRECL=0.
      YRECL=0.
C .EXPOSURE INSURANCE $/$100 OF PAYROLL COST
```

```
      XPINS = XINSD
C .CLEAN TONS YIELD  -  FRACTION OF RAW TONS
      YIELD = YIELDD
      FED=FEDD
      AMR=.15
      BLUNG=BLACKL(2)
C .CALCULATE SEVT$ HERE
      SEVT$ = SEVT * 1000. * SZ * YIELD
C
      IF(DP.LE.0.1) DR=1
      KK=KK+1
      NAMELIST/DBUG9/ KK,ST,DP,SZ,PROD
C     WRITE(6,DBUG9)
C  MIT CORRECTION: NEXT LINE COMMENTED OUT
C       IF(ST.EQ.28.) ST=24.
      IF(DR.GT.0.5) GO TO 208
      DO 204 J=1,2
 204  C(J,KK)=DS(J)
      GO TO 210
 208  DO 209 J=1,2
 209  C(J,KK)=DD(J)
 210   CONTINUE
      D(1,KK)=SZ
      D(2,KK)=0.
      D(3,KK)=ST
      IF(D(3,KK).EQ.24.) D(3,KK)=28.
      D(4,KK)=DP
C    CALC IC,DC,LAB,PAS FOR DEEP MINES
      IF(SZ.LT.1.) GO TO 260
      IC=(XICBD+500*(DP-700.)/100.-6000*DR)*(1+.06*(72.-ST)/12)*
     C  (1.+0.30*(SZ-1.))
      DC=(DCBD-3000*DR)*(1.+0.06*(72.-ST)/12)*(1.+0.15*(SZ-1.))
      GO TO 280
 260  CS=500*DP/100.
      CSB=3500.
      IC1=(XICBD+CS-CSB-6000*DR)*(1.+.06*(72.-ST)/12)
      IC=(IC1-CS)*SZ+CS
      DC=(DCBD-3000*DR)*(1.+.06*(72.-ST)/12)*SZ
 280  CONTINUE
      TPMD=(TPMDBD-1.0*(72.-ST)/12+0.5*(SZ-1.)/0.1)
      MDIV=150
      IF(TPMD.LT.SMAL) WRITE(6,BUGDC)
      LAB=(SZ*1000/TPMD)*DLAB
      PAS=(PASBD+0.15*1000.*(72-ST)/12)*SZ
      POW=500.
      WEL=DWEL
      WPD=DWELD
      GO TO 800
 999  CONTINUE
C    PRINT ALL PAGES
      MINTOT=KK
      IF(KSW.EQ.0) GO TO 701
      KPAGE=KK/6 +1
      DO 700 KP=1,KPAGE
      K1=KP*6-5
```

```
      K2=K1+5
C     WRITE(MPRT,1310) Y
      NAMELIST /DBUG1/ KPAGE,KK,K1,K2,KP,D
C     WRITE(6,DBUG1)
      WRITE(MPRT,321) T,KP,KPAGE
      WRITE(MPRT,322)
      WRITE(MPRT,324)
      WRITE(MPRT,326) ((C(J,I),J=1,2),I=K1,K2)
      WRITE(MPRT,327) (D(1,I),I=K1,K2)
      WRITE(MPRT,328) (D(2,I),I=K1,K2)
      WRITE(MPRT,329) (D(3,I),I=K1,K2)
      WRITE(MPRT,330) (D(4,I),I=K1,K2)
      DO 650 KQ=1,4
 650  WRITE(MPRT,332) (A(J,KQ),J=1,4),(B(KQ,I),I=K1,K2)
      WRITE(MPRT,340)
      DO 660 KQ=5,11
 660  WRITE(MPRT,332) (A(J,KQ),J=1,4),(B(KQ,I),I=K1,K2)
      WRITE(MPRT,341)
      WRITE(MPRT,362) (A(J,12),J=1,4),(B(12,I),I=K1,K2)
      DO 670 KQ=13,22
 670  WRITE(MPRT,332) (A(J,KQ),J=1,4),(B(KQ,I),I=K1,K2)
      WRITE(MPRT,341)
      WRITE(MPRT,372) (A(J,23),J=1,4),(B(23,I),I=K1,K2)
 700  CONTINUE
 701  CONTINUE
 353  FORMAT(1H ,5X,'S',2A2,2X,7F7.2)
 354  FORMAT(1H ,5X,'D',3A2,7F7.2)
 888  FORMAT(6X,A1,3A2,7F7.2)
 889  FORMAT(1H ,'         N',A1,A2,'  NEW.',A1,3A2,3X,F7.3,1X,
     C  5(F6.2,1X))
  890 FORMAT('                  NEW.',A1,3A2,3X,F7.3,4(F7.2,2X))
C
C  NOW LOOP THRU B AND D AND STACK UP UNSORTED MINE DATA
C
 1310 FORMAT(3(1H ,6(F10.2,1X)/),1H ,F10.2,1X,F10.2,1X,F10.2,1X,
     C  F10.2,1X,F10.2,1X,//)
      COMMON /COEFS/COEF1,COEF2,IPIES
      DO 970 N=1,MINTOT
      MDIV=200+N
      IF(D(1,N).LT.SMAL) WRITE(6,BUGDC)
               IF (D(1,N).LT.SMAL) WRITE (6,7983) D(1,N)
7983      FORMAT (F7.4)
      IF(C(1,N).NE.SF(1)) GO TO 997
C   IT'S A SURFACE MINE.      WRITE INFO TO KO.
      XOB= BLK
      XSZ= BLK
      PRC=0.
      PROD=0.
      DO 720 J=1,7
      IF(D(2,N).EQ.AOB(1,J)) XOB=AOB(2,J)
       IF (J.EQ.7) GO TO 720
      IF(ABS(D(1,N)-ASZ(1,J)).LE..001) XSZ=ASZ(2,J)
  720  CONTINUE
      PRC=B(25,N)
      PROD=B(24,N)
```

```
      SURF=B(26,N)
      YIC$=((B(1,N)/1000.)/D(1,N))
      YDC$=((B(2,N)/1000.)/D(1,N))
C  RECALL THAT THE USE OF COEF1 & COEF2 RELATE TO AN OLDER
C    VERSION OF THE RAMC CODE
      SCAP=YIC$*COEF1 +YDC$*COEF2
CC    SCAP=YIC$*(1+ECAP)**(NYR/2) + YDC$*(NYR/40)*(1+ECAP)**(NYR/4)
      SDRAG=0.0
      IF(D(1,N).GT.0.99) SDRAG=D(2,N)
      WRITE(KSC,353) XOB,XSZ,PROD,PRC,SURF,YIC$,YDC$,SDRAG,SCAP
      GO TO 970
C   IT'S A DEEP MINE.     WRITE INFO TO KO.
 997  XDP=ZRO
      PRC=0.
      PROD=0.
      XST=BLK
      XSZ=BLK
      DO 920 J=1,7
      IF (J.EQ.7)GO TO 921
      IF(ABS(D(1,N)-ASZ(1,J)).LE..001) XSZ=ASZ(2,J)
  921 IF(ABS(D(3,N)-AST(1,J)).LT.0.001) XST=AST(2,J)
      IF(ABS(D(4,N)-ADP(1,J)).LT.0.001) XDP=ADP(2,J)
 920  CONTINUE
      PROD=B(24,N)
      PRC=B(25,N)
      SURF=B(26,N)
      YIC$=((B(1,N)/1000.)/D(1,N))
      YDC$=((B(2,N)/1000.)/D(1,N))
      DCAP=YIC$*COEF1+YDC$*COEF2
CC    DCAP=YIC$*(1+ECAP)**(NYR/2) + YDC$*(NYR/40)*(1+ECAP)**(NYR/4)
      WRITE(KSC,354) XST,XDP,XSZ,PROD,PRC,SURF,YIC$,YDC$,DDRAG,DCAP
 970  CONTINUE
      NAMELIST/D1BUG/ Y
C     WRITE(6,D1BUG)
      REWIND KSC
      READ(KSC,888,END=733) BUF
      WRITE(6,222)
 222  FORMAT(1H ,'I GOT THERE...')
 733  CONTINUE
C  BUF(6,*) IS PRICE KEY
      MMM=MINTOT
      CALL SHELLR(BUF,MMM,MMM,11,6,1)
      MM=MMM
      IF(MM.GT.35) MM=35
      DO 1300 J=1,MM
      IF (IPIES.NE.0) WRITE(KOUT,889) ORD(J),CT,(BUF(I,J),I=1,10)
      IF (IPIES.EQ.0) WRITE(KOUT,889) ORD(J),CT,(BUF(I,J),I=1,7),
     X  BUF(11,J),BUF(10,J)
C
      IF(PRNTR .NE. 1) GO TO 1300
      CUMUL = CUMUL + BUF(5,J)
      BUF(7,J) = CUMUL
      WRITE(IPRT,890) (BUF(I,J),I=1,7)
 1300  CONTINUE
C
```

```
      RETURN
      END
      SUBROUTINE  SHELLR(A,NR,N,NC,NK,NS)
C SEE C EVERETT FOR SOURCE OF THIS SORT ROUTINE
      DIMENSION A(NC,NR)
      M=N
 104   M=M/2
      IF(M.LE.0) RETURN
      L=N-M
      DO 109 J=1,L
      I=J+M+NS-1
 106  I=I-M
      IF(I-NS+1.LE.0) GO TO 109
      IF(A(NK,I+M).GE.A(NK,I)) GO TO 109
      DO 200 JJ=1,NC
      X=A(JJ,I)
      A(JJ,I)=A(JJ,I+M)
 200  A(JJ,I+M)=X
      GO TO 106
 109   CONTINUE
      GO TO 104
      END
      SUBROUTINE PRVAL(MYR, ROR, PVFAC, DCFRAC)
C
      DIMENSION    DCFRAC(1)
C
C .PVFAC - PRESENT VALUE FACTOR IS DERIVED TO CALCULATE
C          DEFERRED CAPITAL ON THE FOLLOWING BASES
C   NOTE HERE THAT THE CALCULATION OF PVFAC IN THIS SUBROUTINE
C   IGNORES INFLATION ,REAL CAPITAL ESCALATION, AND ASSUMES THAT
C    THE DISCOUNT RATE , ROR, IS REAL
C
C  FIRST 25% OF MINE LIFE   =  5% OF DEFERRED CAPITAL
C  NEXT  50% OF MINE LIFE   = 90% OF DEFERRED CAPITAL
C  LAST  25% OF MINE LIFE   =  5% OF DEFERRED CAPITAL
C  LAST YEAR OF MINE LIFE   =  0.
C
      M25 = MYR/4
      M50 = MYR/2
      M75 = M25 + M50
      M99 = M25 - 1
C  MIT INSERT
        IF ((MYR-(M75+M99)).NE.2) GO TO 120
        M50=M50+1
        M75=M75+1
         GO TO 130
 120      IF((MYR-(M75+M99)).NE.3) GO TO 130
        M25=M25+1
          M75=M75+1
         M99=M99+1
 130         CONTINUE
C
C   END MIT INSERT
C
C
```

```
      PVFAC = (.05/M25)*(1-(1+ROR)**(-M25))/ROR +
     2        (.9/M50)*((1-(1+ROR)**(-M50))/ROR)*((1+ROR)**(-M25)) +
     3        (.05/M99)*((1-(1+ROR)**(-M99))/ROR)*((1+ROR)**(-M75))
C
      A = .05/M25
C
      DO 25 I = 1, M25
   25     DCFRAC(I) = A
C
      A = .9/M50
      NEXT = M25 + 1
C
      DO 50 I = NEXT, M75
   50     DCFRAC(I) = A
C
      A = .05/M99
      NEXT = M75 + 1
      LAST = MYR - 1
C
      DO 75 I = NEXT, LAST
   75     DCFRAC(I) = A
C
      DCFRAC(MYR) = 0.0
C
      RETURN
C
      END
```