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OPTIMIZATION OF COAL RECOVERY FROM OPEN PITS

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OPTIMIZATION OF COAL RECOVERY FROM OPEN PITS

by

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FOREWORD

From 1972 to 1977 CANMET together with industry, consultants and universities engaged in the Pit Slope Project. The result of the project was a 25-volume Manual concerned with the various aspects of field investigation and design. The project was a reflection that some 70% of Canada's ore and coal production comes from surface mining.

In the Manual, it was recognized that the objective of design is to achieve optimum financial returns; consequently, in the design of slopes, not only were analytical procedures supplied for investigating stability but also a method was established for including the economic impact of instability. The practicability of this approach was demonstrated in cooperation with Duval Sierrita Corp. by redesigning one quadrant of its pit. This case history was documented in Supplement 5-3 of the Pit Slope Manual.

In face of the fuel problem in Canada and the policy to replace petroleum wherever possible with coal, it was recognized that improved design and operating procedures would be particularly valuable in coal mining. Accordingly, a search was made for an industrial partner to undertake a design trial in a coal mine where slope stability was critical. After discussions with domestic companies, the Kemmerer Coal Co. of Wyoming was approched and the present case history was produced through a contract made with the University of Arizona. It is, in effect, a supplement to the Pit Slope Manual, demonstrating its application in coal mining.

CANMET is most grateful to Kemmerer Coal Co. for the opportunity it provided and for its openness with information. As coal production in Canada triples or quadruples during the next 20 years, the investment in this study will be returned manyfold.

D.F. Coates
Director-General

AVANT-PROPOS

De 1972 à 1977, le CANMET, en collaboration avec l'industrie, les consultants et les universités, a entrepris un projet sur la pente des mines à ciel ouvert. Suite à ce projet, un manuel en 25 volumes a été publié traitant de divers sujets d'étude de chantier et de conception. On peut en conclure que 70% de la production de minerais et de charbon au Canada provient d'exploitations en surface.

D'après le manuel, les objectifs de la conception sont d'atteindre un revenu optimal sur l'investissement; par conséquent, à l'étape de conception des pentes, on doit non seulement tenir compte des procédures analytiques fournies pour étudier la stabilité mais aussi de la méthode élaborée pour analyser les répercussions économiques de l'instabilité. La réalisation de cette méthode a été démontrée avec la collaboration de Duval Sierrita Corp. en modifiant la conception de un des quadrants de la fosse. On retrouve cette étude de cas dans le supplément 5-3 du Manuel sur la pente des mines à ciel ouvert.

Face au problème de carburant au Canada et à la politique de remplacer le plus possible le pétrole par le charbon, on a reconnu les bienfaits d'améliorer la conception et les procédés opérationels de l'exploitation du charbon. En conséquence, on a recherché un partenaire industriel désireux d'entreprendre un essai de conception sur une mine de charbon dont la stabilité des pentes est un facteur primordial. Après un entretien avec plusieurs compagnies du pays, la compagnie Kemmerer Coal Co. du Wyoming a été consultée. La présente étude est le fruit d'un contrat entrepris par l'université de l'Arizona. Cette étude consiste d'un supplément au Manuel sur la pente des mines à ciel ouvert et démontre l'application de celui-ci dans les mines de charbon.

Le CANMET remercie la Kemmerer Coal Co. de son offre et de sa candeur en ce qui a trait à l'information. Durant les prochains 20 ans, lorsque la production du charbon au Canada augmentera trois ou quatre fois, les investissements consacrés à cette étude seront recompensés maintes fois.

D.F. Coates
Directeur général

OPTIMIZATION OF COAL RECOVERY FROM OPEN PITS

by

Y.C. Kim, S.F. Wolff, E.Y. Baafi and J.A. Cervantes*

SUMMARY

The design techniques of the Pit Slope Manual (1) were successfully applied in a case study concerned with optimizing the design of coal mines. A steeply dipping multiple seam deposit, being mined by the truck-shovel combination, was selected for the study.

The criterion for optimum slopes was based on the financial consequences of each design, i.e., the resultant benefits and costs. Three alternative designs were analyzed. The first had an average highwall slope angle of 28° and a final height of 290 m. The second had a 35° slope angle and a 305-m wall height. The third had a 45° slope angle and a 320-m wall height.

Trade-off between benefits and increased cost of slope instability inherent in steeper slope angles was analyzed for the entire mine life through computer simulation of actual mining operations. Hence it was necessary to have: (1) year by year mine planning data for each design; (2) probability of instability schedules for various wall heights and angles; and (3) representative cost models to be used at appropriate times and places during simulation.

The cost models developed were: (1) No Cost, (2) Clean-up, (3) Lost Coal, (4) Early Mining, (5) Mine Abandonment, (6) Increased Haulage, and (7) Haul Road Re-establishment.

Without including the cost of instability, the 45° design is superior to either the 28° or 35° designs, having a net present value, NPV, of $71,049,000 with the 28° and 35° designs having $58,571,000 and $63,397,000, respectively. However, with inclusion of instability costs, the 35° design is optimum with an NPV of $58,948,000 versus $57,021,000 and $51,130,000 for 28° and 45° designs, respectively. All of these results are based on the assumption that the slopes would be drained dry. If this assumption is not met, then the optimum slope angle lies between 28° and 35°.

From this study several observations can be made:

(1) The recently developed design procedures of the Pit Slope Manual can be applied to operations.

(2) The required data under real-life conditions is available largely as a result of normal mine planning and cost accounting practices.

(3) The study was more difficult than was originally anticipated due to complex lithology.

(4) When an instability occurs in such a mine, some coal is lost due to intermingling with overburden.

(5) The rationalization of results from each sector, post processing, was necessary in this case to be able to deduce the correct consequences of some instabilities.

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*See inside title page for affiliation

RECUPERATION OPTIMALE DU CHARBON PAR EXPLOITATION DES MINES A CIEL OUVERT

par

Y.C. Kim, S.F. Wolf, E.Y. Baafi et J.A. Cervantes*

SOMMAIRE

Les techniques de conception du Manuel sur la pente des mines à ciel ouvert (1) ont été appliquées à bonne fin à une étude de cas concernant l'optimisation de la conception des mines de charbon. On a choisi, pour les besoins de l'étude, un dépôt à couches multiples à paroi abrupte exploité à l'aide d'une combinaison camion-pelle.

Les critères pour une pente optimale sont basés sur les répercussions financières de chacun des concepts, i.e. les bénéfices et les coûts qui en résultent. Trois concepts différents ont été analysés. Le premier avait une pente ayant un angle moyen de 28° et une hauteur définitive de 290 m. Le deuxième avait une pente ayant un angle de 35° et une hauteur de 305 m. Le troisième avait une pente ayant un angle de 45° et une hauteur de 320 m. La pondération entre les bénéfices et les coûts supplémentaires de l'instabilité des pentes propre à des pentes plus abruptes a été analysée sur toute la vie de la mine en simulant par ordinateur les opérations véritables d'exploitation minière. Il était donc nécessaire d'avoir en main: (1) les données annuelles de planification de la mine pour chacun des concepts; (2) un barême de probabilités d'instabilité selon différentes hauteurs et angles des parois et (3) des modèles-types de coûts à employer selon le temps et l'emplacement durant la simulation.

Les modèles de coût élaborés sont: (1) aucun coût, (2) nettoyage, (3) perte de charbon, (4) exploitation précoce, (5) abandon de la mine, (6) accroissement de l'extraction et (7) réétablissement des routes pour le transport.

Si on ne tient pas compte du coût des instabilités, le concept à 45° ayant une valeur actuelle nette (VAN) de $71,049,000 est supérieur à celui de 28° et celui de 35° ayant des VAN de $58,571,000 et $63,397,000 respectivement. Si par contre on tient compte des coûts des instabilités, le concept à 35° aura une valeur optimale avec une VAN de $58,948,000 tandis que les concepts à 28° et 45° seront de $57,021,000 et 51,130,000 respectivement. Les résultats sont basés sur une exploitation complète des pentes. Si ce critère n'est pas respecté, l'angle optimal de la pente se situe entre 28° et 35°.

Plusieurs observations ont été faites à la suite de cette étude:

(1) Les procédures de conception récemment mises au point dans le Manuel sur la pente des mines à ciel ouvert peuvent être appliquées aux opérations.
(2) Les données requises dans des conditions véritables sont disponibles principalement en obtenant les résultats de la planification normale d'une mine et de la comptabilité des prix de revient.
(3) L'étude était plus compliquée que prévue à cause de la complexité de la lithologie.
(4) Lorsque une instabilité se produit dans cette mine, une certaine quantité de charbon est perdue à cause de l'entremêlement avec les morts-terrains.
(5) La rationalisation des résultats provenant de chaque secteur, après le traitement, s'est avérée nécessaire dans le cas présent afin de pouvoir déceler les vraies conséquences de certaines instabilités.

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CONTENTS

	Page
FOREWORD	i
AVANT-PROPOS	ii
SUMMARY	iii
SOMMAIRE	iv
INTRODUCTION	1
Historical Background	1
Objective and Scope	1
SOURCES OF INPUT DATA	1
Description of the Deposit	1
Sources of Existing Data	1
MINE PLANNING	2
Modeling the Deposit	2
Choice of 2-D Variable Block Model	4
Steps in Building the Variable Block Model	4
Alternative Ultimate Pit Designs	6
Mining Sequences	7
PROBABILITY OF INSTABILITY SCHEDULE DEVELOPMENT	9
Background	9
Geology	9
Hydrology	14
Material Properties	14
Stability Analysis	14
FINANCIAL DATA	16
Procedure	16
COST OF INSTABILITY MODELS	23
BENEFIT COST ANALYSIS	26
Wall Geometry	26
Financial Data	26
Probability of Instability	27
Cost Impact Specification	28
BNCST Execution	30
RESULTS	32
Base Case Results	32
RESULTS INCLUDING FAILURE COSTS BUT NO POST PROCESSING	34
Post Processing Results	36
Sensitivity of Results to Cost Assumptions	40
CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY	43
Conclusions	43
ACKNOWLEDGEMENTS	44
REFERENCES	44

TABLES

1. Summary of mining sequence development for the 28°, 35°, and 45° designs	9

CONTENTS (cont'd)

		Page
2.	Summary of geologic parameters for the highwall	13
3.	Summary of geologic parameters for the north wingwall	13
4.	Summary of geologic parameters for the south wingwall	14
5.	Uniaxial and triaxial test results	15
6.	Shear strengths and total unit weights	15
7.	Probability of a continuous failure path longer than 15 m	15
8.	Material properties used for highwall rotational shear analyses	17
9.	Probability of instability schedule, highwall sector I, 28° design, drained	17
10.	Probability of instability schedule, wingwall sectors II and IV, 28° design, drained	18
11.	Probability of instability schedule, highwall sector I, 35° design, drained	18
12.	Probability of instability schedule, wingwall sectors II and IV, 35° design, drained	18
13.	Probability of instability schedule, highwall sector I, 45° design, drained	19
14.	Probability of instability schedule, wingwall sectors II and IV, 45° design, drained	19
15.	Probability of instability schedule, highwall sector I, 28° design, undrained	19
16.	Probability of instability schedule, wingwall sectors II and IV, 28° design, undrained	20
17.	Probability of instability schedule, highwall sector I, 35° design, undrained	20
18.	Probability of instability schedule, wingwall sectors II and IV, 35° design, undrained	20
19.	Probability of instability schedule, highwall sector I, 45° design, undrained	21
20.	Probability of instability schedule, wingwall sectors II and IV, 45° design, undrained	21
21.	Financial data for BNCST program	23
22.	Cost models and associated numeric codes	23
23.	Typical output of computed wall heights and associated angles	27
24.	Example of cost model assignments for sectors I and II of 28° design	29
25.	Base case results	32
26.	Results including failure costs but prior to post processing	34

CONTENTS (cont'd)

Page

27. Summary of results before post processing 36

28. Final post processing results 37

29. Post processing results (first step) 39

30. Summary of results including post processing 41

31. Cost model statistics 42

FIGURES

1. Steps for financial design analysis 1

2. Existing pit 2

3. Regular 3-D fixed block model 3

4. Typical cross section of correlated coal seams 4

5. Variable block model 4

6. Gridded seam model is composed of a 2-dimensional matrix for each seam 5

7. Geometric interpolation method for top of seam elevations 5

8. Completed variable block model 6

9. Ultimate pit cross section for 28° and 45° 7

10. Plan of mining cuts 7

11. Design of mining cuts for the 45° pit 8

12. 28° design E-W cross section showing pit scheduling 10

13. 45° design E-W cross section showing pit scheduling 10

14. Plan for year 12 of the 45° design 10

15. Delineation of design sectors 10

16. Typical E-W cross section showing lithologic units 11

17. Schmidt pole plot of fractures for the highwall sector ... 12

18. Schmidt contour plot for the highwall sector 12

19. Instability modes 16

20. Location of permanent dual haul roads in the pit 22

21. Composite cross section of sector II, looking west, for the 45° design 28

22. Coal seam templates used in cost impact specification 28

23. Illustration of mining method 30

24. Flow chart of benefit-cost analysis 31

25. The hierarchy of steps in the benefit-cost analysis 31

CONTENTS (cont'd)

Page

26. The hierarchy of steps in post processing 31

27. Summary of results 38

APPENDIX A - INPUT DATA LOADING SHEETS FOR THE BNCST MODEL A-45

APPENDIX B - 80-80 LISTINGS OF ALL INPUT DATA FOR ALL SECTORS OF THREE DESIGNS B-57

APPENDIX C - COMPUTED WALL HEIGHTS AND ANGLES FOR ALL SECTORS OF THREE DESIGNS C-71

APPENDIX D - A CONCISE SUMMARY OF INPUT GEOMETRIES AS OUTPUT BY BNCST D-85

APPENDIX E - COMPLETE COST MODEL ASSIGNMENTS FOR THREE DESIGNS E-99

APPENDIX F - SIMULATION RESULTS BEFORE POST PROCESSING F-109

APPENDIX G - SIMULATION RESULTS AFTER POST PROCESSING G-123

APPENDIX H - IMPROVEMENTS MADE TO BNCST-VERSION III FOR VERSION IV H-131

COST1 Subroutine Modularization H-133

Printout Options in BNCST-Version IV H-133

Geometry Information of Interramp Walls H-135

Elimination of Pushback Capability H-135

Table H-1 - Print control numbers H-134

Figure H-1 - Modularization of COST1 subroutine H-133

APPENDIX I - COST MODEL PROGRAM LISTINGS I-137

APPENDIX J - POST PROCESSING PROGRAM LISTINGS J-175

INTRODUCTION

HISTORICAL BACKGROUND

The Pit Slope Manual of CANMET was introduced as a practical working tool for mine staff. Some new procedures were introduced, one being the integration of slope design with mine design, through optimizing benefits and costs or net present value (NPV) (1).

This approach is shown in Fig. 1. Unlike the conventional factor of safety approach to pit design, the new approach is probabilistic which requires more detailed analyses.

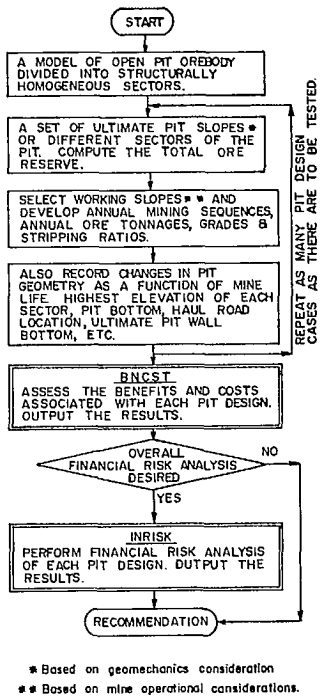


Fig. 1 - Steps for financial design analysis

OBJECTIVE AND SCOPE

The objective of the study was to demonstrate one application of the Pit Slope Manual to the mining of coal. It was felt that such a case study would promote optimum design of open pit coal mines in Canada.

The scope of this study was confined to performing the benefit-cost analyses associated with three different pit designs - one having an overall slope of 45° and the other two with slopes of 28° and 35°.

SOURCES OF INPUT DATA

DESCRIPTION OF THE DEPOSIT

It was desired to have the case study made of a Canadian operation. Discussions with several companies did not result in being able to make appropriate arrangements at the time. Consequently, advantage was taken of an opportunity in the U.S.A. The coal deposit used for this study is located in the western part of the state of Wyoming, and is very similar to those found in Canada. It is owned by the Kemmerer Coal Company, Frontier. The deposit is currently being mined by truck and shovel, see Fig. 2.

The deposit is within the lower part of the Adaville formation of upper Cretaceous age. This formation, consisting of interbedded sandstone, siltstone, claystone, and coal, is the product of cyclic deposition. The landscape consists of rolling plains with an escarpment running north and south in the mine area. The greatest difference in elevation is 150 m. Multiple coal seams dip approximately 18° to the west with a strike of 8°.

Seam geometry is complex with seams pinching out and reappearing, and branching into two or more seams. The thickness of seams is highly variable along any cross section.

The bottom three seams are fairly continuous. The bottom seam has an average thickness of 27 m, and the two above average 13.5 m. Eighty per cent of the coal comes from these three seams, although 15 seams are to be mined.

In 1978, the highwall was approximately 105 m and the ultimate highwall will be more than 300 m. At the present mining rate, life expectancy is approximately 24 years.

SOURCES OF EXISTING DATA

In the early part of 1975, Kemmerer Coal Co. engaged a consultant to do a slope stability analysis (7). For data, the company drilled one

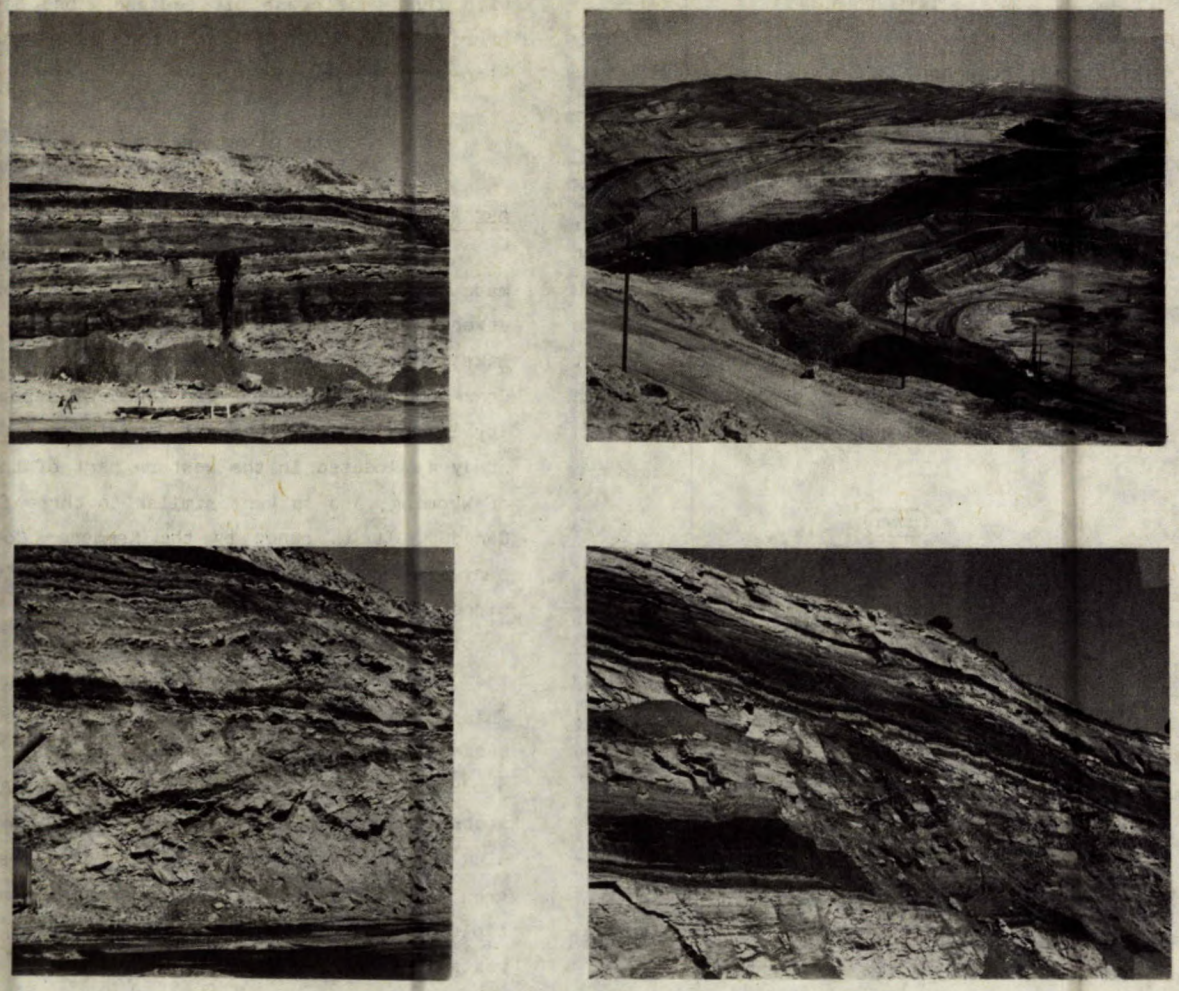


Fig. 2 - Existing pit

457-m deep hole near the final pit perimeter as part of the above stability analysis.

Consequently, some information was available for the case study structure and stratigraphy as well as on some strength properties of various strata. Management of the Kemmerer Coal Co. kindly provided the information obtained from this stability analysis together with other data such as topography maps, drill hole logs and cross sections.

They engaged MINTEC Inc, Tucson, to develop a computerized mine planning system in 1976 and permitted use of the programs in modeling the deposit (3).

Use was also permitted of computer programs that simulate mining operations (4) and a consultant's report on adjacent property (5).

MINE PLANNING

MODELING THE DEPOSIT

The various types of open pit mine models in use today can be classified into at least five categories: (1) regular 3-D fixed block model, (2) 3-D variable block model, (3) gridded seam model, (4) 2-D irregular block model, and (5) 3-D

irregular block model (6).

In the regular 3-D fixed block model, the orebody is divided into fixed size blocks. The vertical dimension of each block usually corresponds to the bench height or a multiple of it. Horizontal dimensions of the blocks are fixed. In the 3-D variable block model, at least one dimension of each block on the horizontal plane is not fixed. However, the vertical dimension is usually fixed at bench height. In the gridded seam model, a regular 2-dimensional grid in plan is superimposed onto each seam. Consequently, the vertical dimensions at each grid point are variable both for ore and overburden. In the 2-D irregular block-model, irregular shapes are defined by polygons on a number of vertical cross sections. Vertical sections can be regularly or irregularly spaced depending on the continuity of the deposit. In the 3-D irregular block model, irregular and spotty mineralization is defined by polygons on each level. The bench dimension, however, remains fixed.

Among the models mentioned, only the regular 3-D fixed block model (which is best suited for massive porphyry type deposits) is widely in use today both in Canada and in the U.S.A. A typical illustration of the regular 3-D fixed block model is given in Fig. 3.

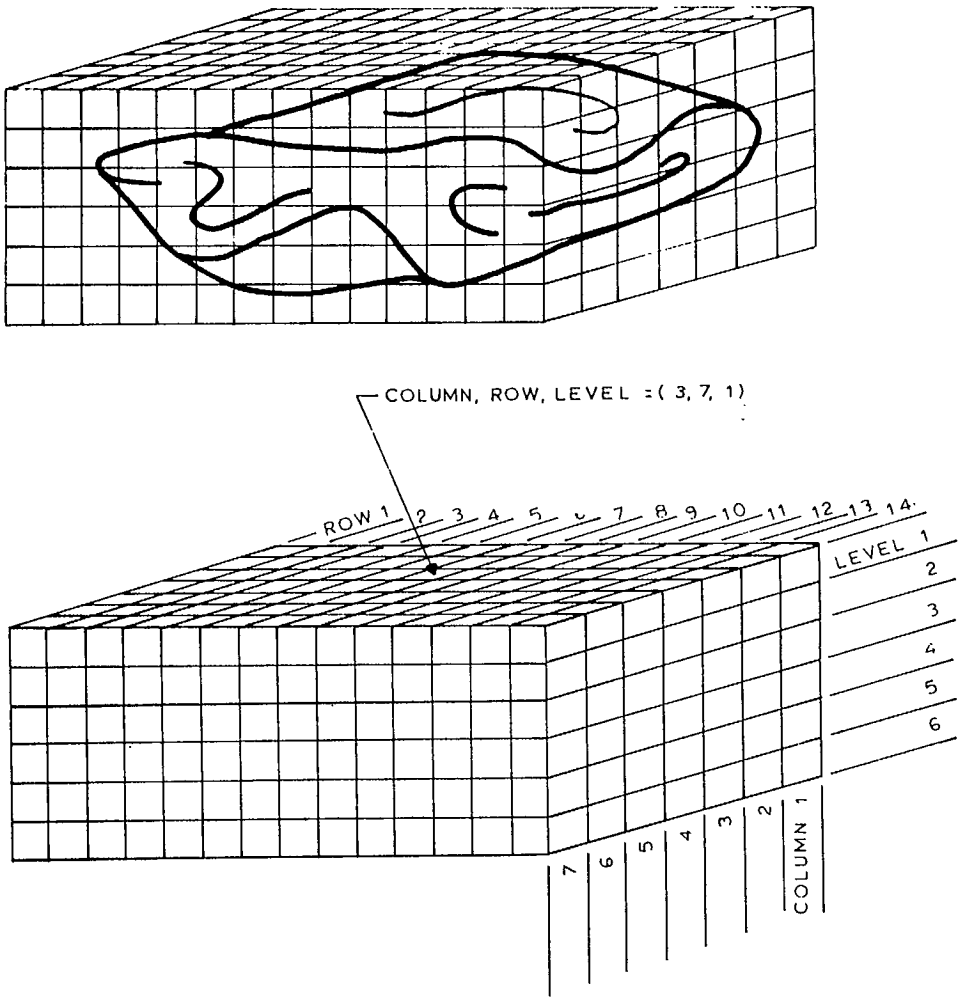


Fig. 3 - Regular 3-D fixed block model

CHOICE OF 2-D VARIABLE BLOCK MODEL

Figure 4 shows a typical cross section of the deposit. In spite of variability in seam geometry on any cross section, a continuity does exist along the strike. This makes it possible to use either the gridded seam model or 2-D irregular (or variable) block model.

The latter was adopted in the study. Illustration of one model as given by MINTEC Inc is shown in Fig. 5 (3).

In this model, the seams are defined by a series of equally spaced cross sections perpendicular to the strike. Each section has a zone of influence equal to the spacing between sections; that is, the influence extends halfway to the nearest section on either side. In the cross section, variable sized blocks define the ore and waste. Coordinates of points which delineate the coal block or overburden block need to be stored only where the border line of the block changes direction.

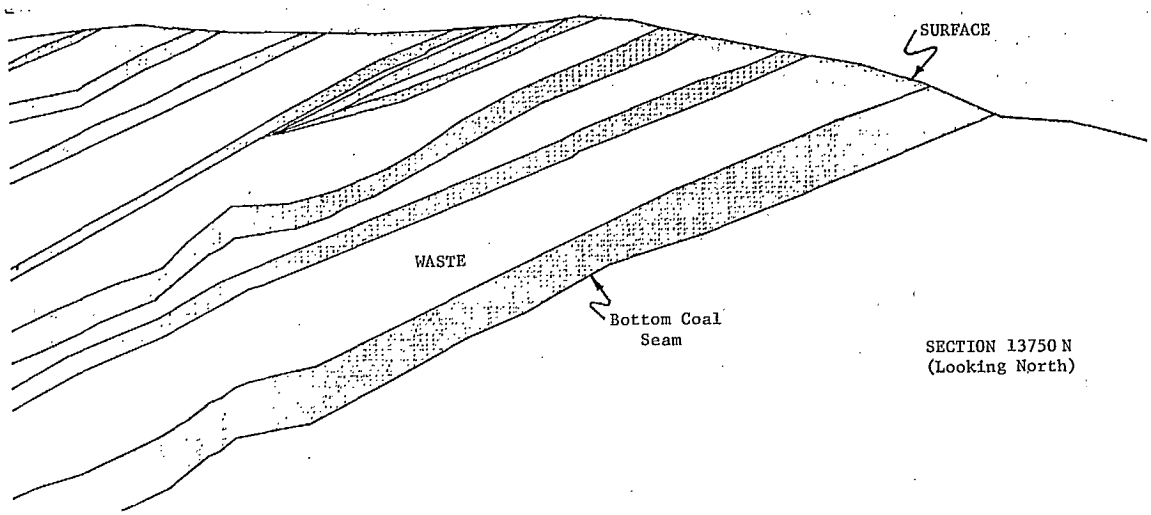


Fig. 4 - Typical cross section of correlated coal seams

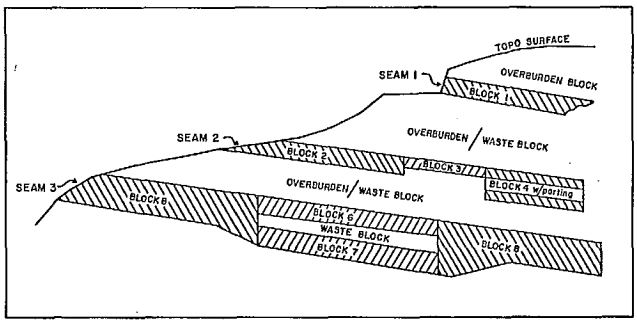


Fig. 5 - Variable block model (3)

STEPS IN BUILDING THE VARIABLE BLOCK MODEL

The variable block model was built in two steps. First, a gridded seam model, GSM, as shown in Fig. 6 was created, and then the variable block model, VBM, was extracted from the GSM.

There are several reasons for incorporating the GSM in building the VBM. The VBM with various cross sectional spacings can be created with relative ease from the GSM. If a large area is being modeled where more than one pit is to be designed, the GSM makes it possible to design all pits differently. The GSM makes backtracking possible and inexpensive. Good records are available for review as well as display.

Prior to building the GSM, the drill hole data was coded. The drill hole lithologies were plotted in cross sections. The drill holes at the property were drilled along uniform sections of 150-m spacing.

Coal intersections were correlated between drill holes for each cross section. As much as possible, seam correlation was performed using the computer. However, the final seam correlation had to be performed manually because of the complex geometry.

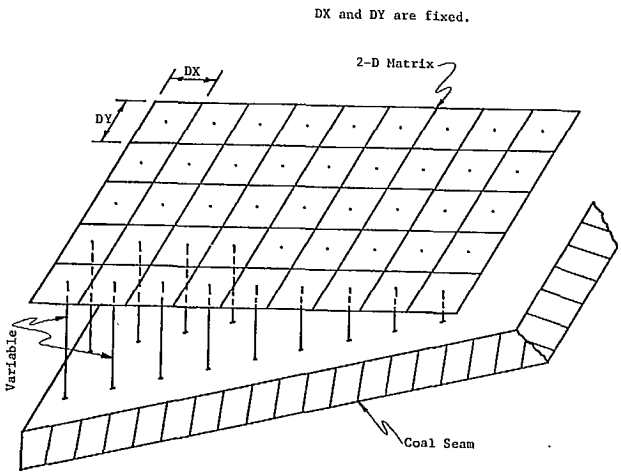
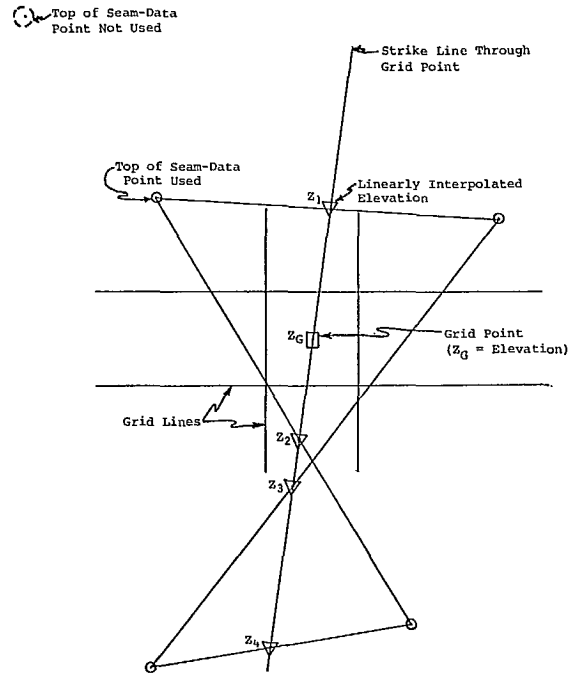


Fig. 6 - Gridded seam model (3) is composed of a 2-dimensional matrix for each seam; grid spacing west to east is DX, and grid spacing south to north is DY

Next, the coal intersections had to be composited for each seam. If a seam split and had more than one intersection in the drill hole defining it, the total thickness of coal and the total thickness of partings had to be calculated and stored, i.e., composited. Quality data were stored by computing a weighted average.

One step in building the GSM was the creation of a model matrix, which was initialized and zeroed. This matrix has fixed dimensions in horizontal directions and varies in the vertical direction (Fig. 6).

Using the composited drill hole data, the seam geometry (i.e., the top of coal seam elevations) had to be interpolated between drill holes for each grid point. The method of interpolation was a type of weighted averaging which could take into account the trend of a seam. This method was chosen because of sparse data. First, a line is drawn through the grid point in the strike direction. Elevations of the top of the coal seam are determined along this line by linear interpolation between pairs of points on either side of the line. Then, the grid point elevation is determined by taking a weighted average of the calculated points on this strike line as shown in Fig. 7.



$$Z_G = \frac{W_1Z_1 + W_2Z_2 + W_3Z_3 + W_4Z_4}{W_1 + W_2 + W_3 + W_4}$$ where W_i = weight of elevation Z_i

Fig. 7 - Geometric interpolation method for top of seam elevations (3)

The quality data were interpolated using the inverse distance weighting method since these types of data were not assumed to be related to strike. Since the drill hole data were particularly sparse near the model limits, the geometry and quality data had to be extrapolated linearly to the model limits. Finally, the topography was added to the model. Unfortunately, the original topography data were not on the same grid as the model. Consequently, it had to be interpolated to the model's grid system. Entry of topography at this point was primarily for display purposes.

In the completed GSM, coal seams were on a uniform grid extending up and down dip to the model limits. The topography truncated the seams by the surface.

The development of the VBM followed. The first step was to extract geometry and quality data from each cross section of the GSM. Geom-

etry and quality data were stored on equally spaced cross sections across the deposit with the coal seam and overburden geometries stored as ore and waste polygons. Coal polygons were divided into blocks where each coal block represented constant coal thicknesses or constant coal quality.

Quality data were stored separately for each block and were calculated from the GSM. This information included the coal and parting thicknesses and the quality parameters of BTU, water, ash, and sulphur.

The final step in creating the variable block model was to truncate the coal and burden blocks by the topography. Included in this step was the deletion of the oxidized coal near the surface from the coal blocks. The top portion of the coal was henceforth designated as a waste block. A sample cross section of the completed variable block model can be seen in Fig. 8.

Utilizing the just completed variable block model, three alternative ultimate pit designs were developed, using overall ultimate slope angles of 45°, 35° and 28°.

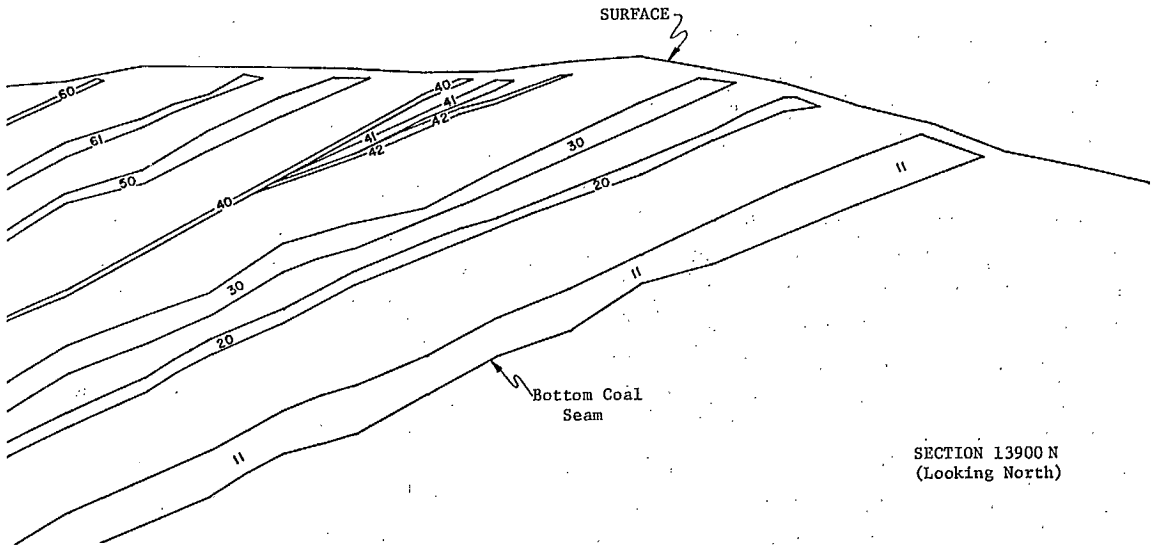


Fig. 8 - Completed variable block model. Numbers indicate coal seam designations from bottom to top, 40 is top branch of Seam No. 4; 41 is next lower branch of Seam No. 4; and so forth

ALTERNATIVE ULTIMATE PIT DESIGNS

In designing the three ultimate pits, the philosophy was to follow the lowest seam to a depth where it is no longer economically attractive to continue further. Under this design criterion, the final highwall was about 320 m using the 45° slope angle.

As the basis for comparison, it was decided to hold the reserves equal for all three designs (Fig. 9). This suggests that the deepest pit would be the 45° design while the shallowest pit would be the 28° design. It also implies that more stripping would be required for the flatter ultimate slope design, i.e., the 28° design. The highwall bench dimensions for the three pits were as follows (Fig. 9):

	28°	35°	45°
bench width	39.7 m	25.9 m	12.9 m
bench height	30.5 m	30.5 m	30.5 m
bench slope	60.0°	60.0°	60.0°

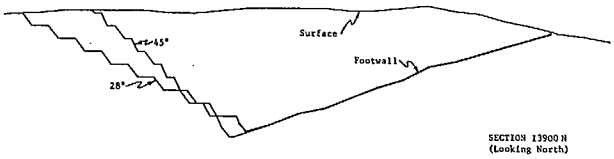


Fig. 9 - Ultimate pit cross section for 28° and 45°

Since the ultimate pit limit for the 28° slopes would lie outside of the 35° and the 45° pit limits, the 28° pit was designed first. The overall stripping ratio for this pit was 3.4:1. The pit was then smoothed from section to section.

After the pit was smoothed, the reserves were calculated. Next, the 45° pit and finally the 35° pit were designed and smoothed in the same manner while keeping the reserves equal to the previously obtained 28° design reserves. This had to be done on a trial and error basis. The calculations for the three designs gave the following:

	28°	35°	45°
tonnes of coal	52,377,000	52,379,000	52,377,000
cubic metres of stripping	149,134,000	143,236,000	123,235,000

Consequently, the 28° design required an additional 26 x 10^6 m^3 of extra stripping over the mine life of approximately 24 years in comparison with the 45° design.

MINING SEQUENCES

The philosophy adopted in designing mining sequences was to advance the pit toward its ultimate limit in cuts of 120 to 180 m (Fig. 10 and 11). Cuts refer to dividing the pit into a number of approximately equal segments each of which approximates the working bench width. The cuts are made on each cross section and consist of a set of highwalls parallel to the ultimate pit highwall. Generally, there were three to four working benches exposed at any one time, and this fact determined the rate of growth of the pit.

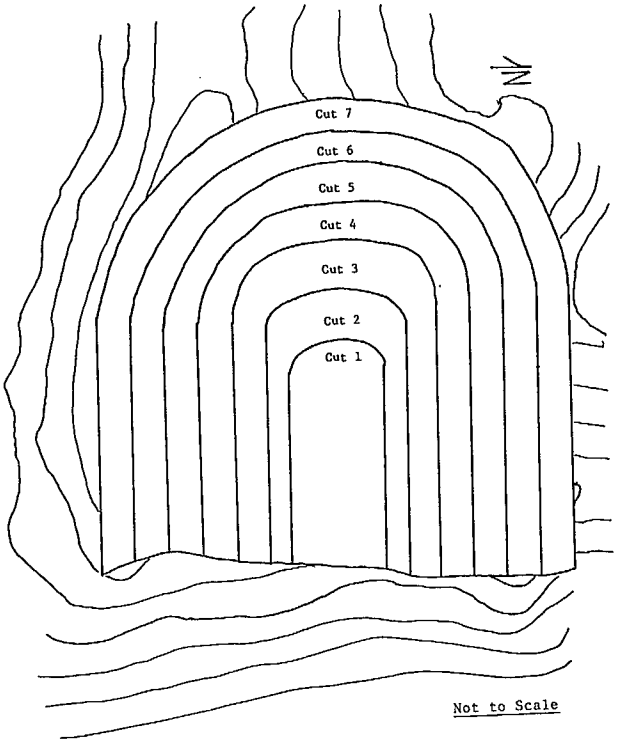


Fig. 10 - Plan of mining cuts

In the computer model, the pit was divided into equal cuts on each cross section to approximate the 120- to 180-m slices that were to be mined in reality. Each cut paralleled the highwall (for the three designs) and extended from the surface to the bottom of the lowest seam. The smallest unit the computer model was designed to mine was a unit block with width equal to the width of the slice i.e., 120 to 240 m, the height equal to the bench height, i.e., 30.5 m, and the depth equal to the distance of influence of the given cross section i.e., 120 m.

In developing the mining sequences, it was necessary to specify the yearly coal production desired. The program then attempted to obtain this tonnage, while at the same time removing as much of the overburden as required. Specific-

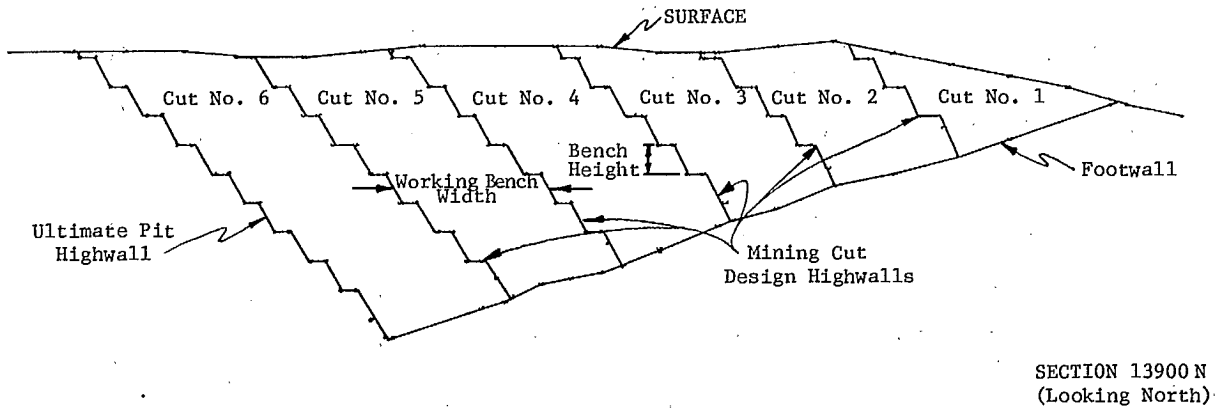


Fig. 11 - Design of mining cuts for the 45° pit

ally, the coal was mined in the following manner: 1. The area of coal in a unit block was calculated for the current bench on the current section. The tonnage of coal was determined by multiplying the area times the zone of influence of this section times the coal density. 2. The number of benches to be mined on one section was determined by the input lag, which reflected the number of working benches to be open at any time in any given section. 3. Sections were mined from south to north through all the sections, and then mining commenced againon the south and continued until the yearly production was met. 4. Mining continued in this fashion for the entire mine life.

The results included production tonnage, waste volume, and the resultant stripping ratio for each year of the mine life. Table 1 below summarizes the results in imperial units. It can be seen that the actual coal mined in a given year did not correspond exactly to the tonnage figure previously specified. This was due to the program mining a unit block in its entirety. In other words, the program was not capable of mining a partial block.

Since the benefit-cost analysis requires the input or detailed pit geometry associated with each design for the entire period, the mining sequences had to be plotted both in cross section and plan. Figure 12 is a typical E-W cross section showing bi-annual mining sequences for the 28° design. Similarly, Fig. 13 shows the mining sequences for the 45° design. Figure 14 shows the wall geometries in plan associated with the 45° design at the end of Year 12.

Considerable effort is required in generating these cross sections as well as plans, even using the computer. A typical cross section for each design sector had to be plotted, as well as a total of 24 annual bench plans such as shown in Fig. 14 to specify the wall geometries.

In addition to the mining sequences, the correlated coal seams have also been superimposed in Fig. 12 and 13. These figures show that exposed lithology is constantly changing along the wall face for each mining sequence. Stability of the face is dependent on the particular lithology. Similarly, the cost impact of instability also depends on lithology mainly because the amount of lost coal is dependent on which coal seams daylight at the face.

For these reasons, the information given in Fig. 12, 13, and 14 played a key role in the development of instability schedules as well as in the cost impact specifications.

Table 1 - Summary of mining sequence development for the 28°, 35°, and 45° designs

AMOUNT OF ROCK. 28 DEGREE DESIGN.

PERIOD	TYPE1 ORE	TYPE2 ORE	WASTE
1	2726000.	0.	10670000.
2	2306000.	0.	8273000.
3	2580000.	0.	8191000.
4	2547000.	0.	9792000.
5	2366000.	0.	8065000.
6	2576000.	0.	9162000.
7	2598000.	0.	10801000.
8	2486000.	0.	7959000.
9	2345000.	0.	8846000.
10	2523000.	0.	10100000.
11	2498000.	0.	11346000.
12	2481000.	0.	7573000.
13	2476000.	0.	7894000.
14	2565000.	0.	10827000.
15	2461000.	0.	9713000.
16	2585000.	0.	8145000.
17	2422000.	0.	7266000.
18	2515000.	0.	8397000.
19	2478000.	0.	8357000.
20	2552000.	0.	7136000.
21	2425000.	0.	5950000.
22	2617000.	0.	6800000.
23	2546000.	0.	3803000.
24	74000.	0.	0.

AMOUNT OF ROCK. 35 DEGREE DESIGN.

PERIOD	TYPE1 ORE	TYPE2 ORE	WASTE
1	2501000.	0.	8419000.
2	2526000.	0.	5740000.
3	2547000.	0.	10341000.
4	2719000.	0.	8931000.
5	2212000.	0.	5947000.
6	2653000.	0.	9469000.
7	2431000.	0.	10833000.
8	2615000.	0.	10231000.
9	2299000.	0.	13214000.
10	2653000.	0.	7247000.
11	2421000.	0.	6183000.
12	2564000.	0.	9221000.
13	2563000.	0.	11417000.
14	2384000.	0.	7164000.
15	2490000.	0.	9071000.
16	2508000.	0.	7915000.
17	2607000.	0.	10059000.
18	2416000.	0.	3820000.
19	2707000.	0.	8986000.
20	2256000.	0.	7167000.
21	2526000.	0.	4577000.
22	2667000.	0.	6609000.
23	2342000.	0.	4563000.
24	143000.	0.	113000.

AMOUNT OF ROCK. 45 DEGREE DESIGN.

PERIOD	TYPE1 ORE	TYPE2 ORE	WASTE
1	2636000.	0.	8991000.
2	2453000.	0.	6862000.
3	2421000.	0.	7448000.
4	2515000.	0.	8370000.
5	2769000.	0.	9605000.
6	2378000.	0.	8449000.
7	2394000.	0.	6463000.
8	2443000.	0.	7792000.
9	2551000.	0.	7982000.
10	2525000.	0.	8087000.
11	2746000.	0.	8206000.
12	2224000.	0.	6657000.
13	2472000.	0.	8138000.
14	2484000.	0.	8975000.
15	2689000.	0.	6617000.
16	2528000.	0.	6664000.
17	2407000.	0.	6497000.
18	2426000.	0.	7462000.
19	2586000.	0.	6352000.
20	2405000.	0.	3738000.
21	2485000.	0.	4957000.
22	2403000.	0.	3163000.
23	1404000.	0.	2808000.
24	1404000.	0.	808000.

PROBABILITY OF INSTABILITY SCHEDULE DEVELOPMENT (7)

by

P.J. Visca*, R.D. Call*, S.M. Miller*, Y.C. Kim

BACKGROUND

The benefit-cost analysis requires a comprehensive set of probability of instability schedules for all wall heights and angles that are to be encountered. As there were three alternative designs - 28° , 35° and 45° overall slopes - three sets of schedules were required and a separate schedule was required for each design sector. For this study, the pit was divided into four different design sectors, the boundaries of which are shown in Fig. 15.

In general, the following steps are required: (1) gather geologic and hydrologic information; (2) determine strength properties of rocks; (3) assess possible modes of instability; (4) calculate degree of instability for each mode; (5) compile probability of instability schedules.

GEOLOGY

Most field data and laboratory results were obtained from other sources (2,5). One report (2) was for the study pit whereas the second report (5) was for an adjacent property although much of the data were collected in the study pit. As the purpose of the case study was to demonstrate application of the Pit Slope Manual no additional data were generated other than from the new one cited above.

The lithologic sequence consists of interbedded coal, sandstone, siltsone, and fine-grained material which could be described as

*Pincock, Allen & Holt, Inc.

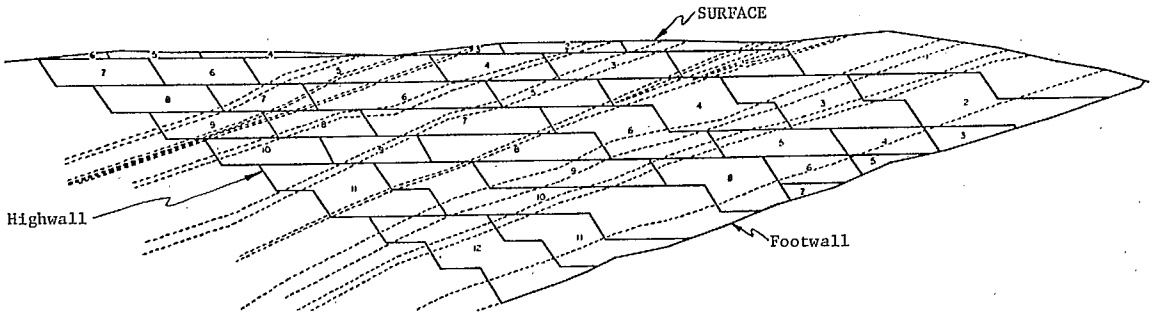


Fig. 12 - 28° Design E-W cross section showing pit scheduling (dashed lines indicate coal seams)

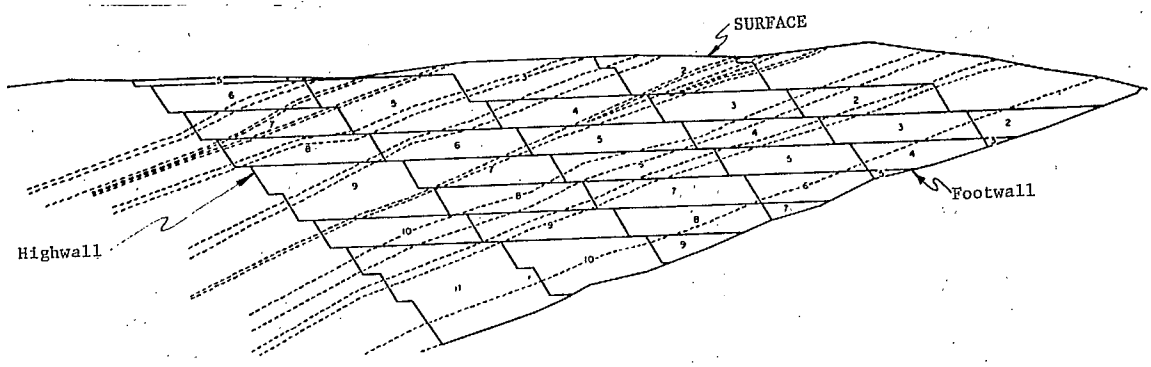


Fig. 13 - 45° Design E-W cross section showing pit scheduling (dashed lines indicate coal seams)

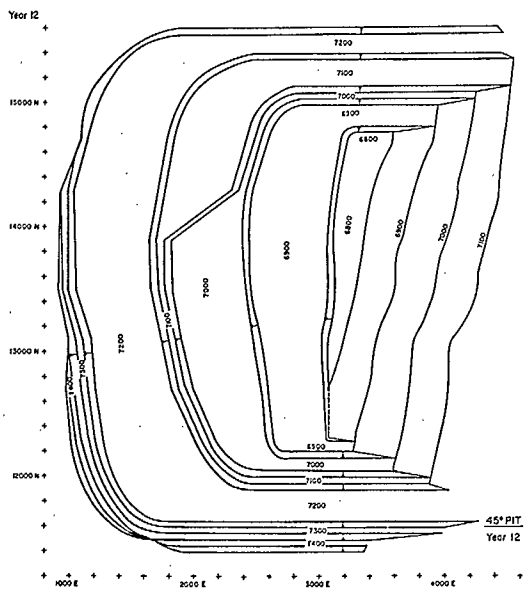


Fig. 14 - Plan for year 12 of the 45° design

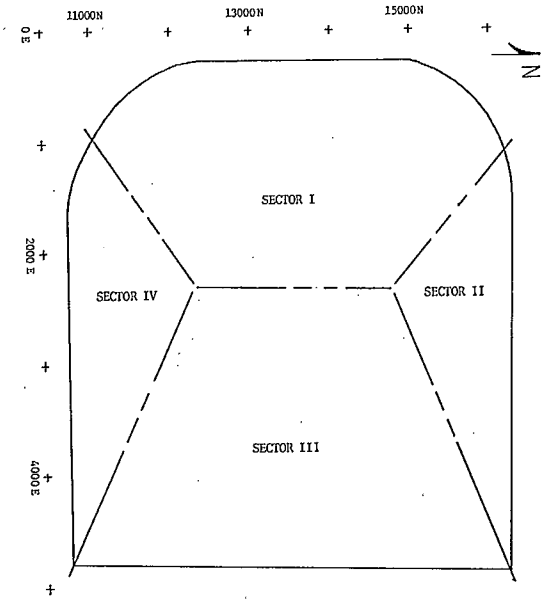


Fig. 15 - Delineation of design sectors

claystone, mudstone, or shale. The coal seams appear to be the thickest units, with the basal coal having an approximate thickness of 27 m. A layer of clay is apparent beneath the basal coal member, but the thickness of this material is unknown.

The percentage of each lithologic unit was estimated for the inter-coal strata and are presented in Fig. 16. This was to facilitate stability analysis.

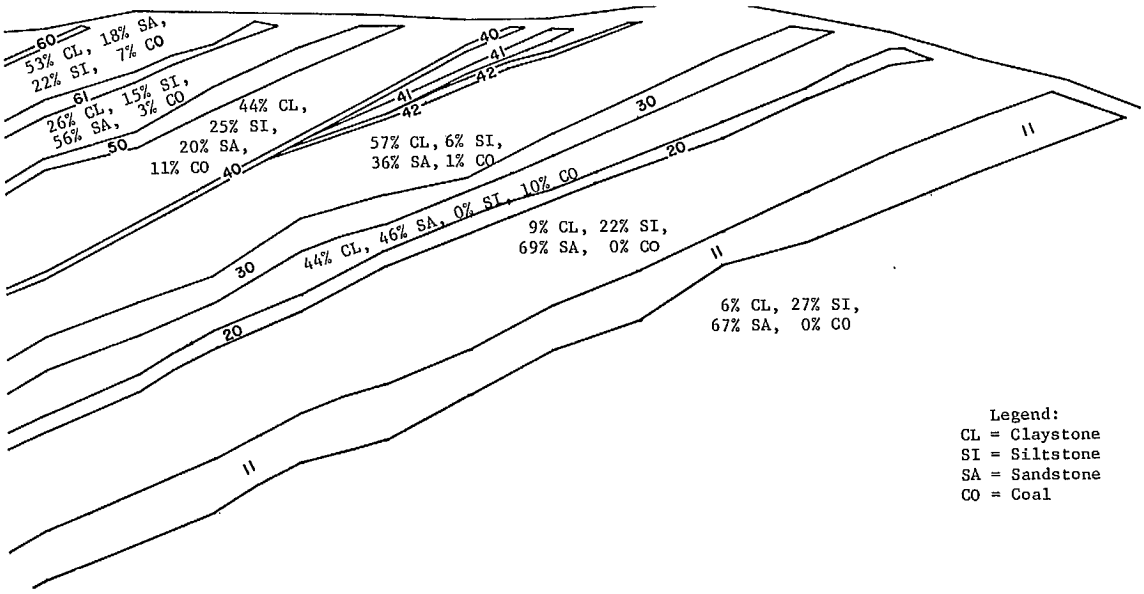


Fig. 16 - Typical E-W cross section showing lithologic units

Visual observations indicated that the bedding was folded into a series of gentle east-west striking synclines and anticlines. The amplitude of these features was minor, and the impact upon stability was expected to be minimal. Bedding deviations in the upper sections of the north wingwall (Fig. 14) appeared to be more severe but the limited extent of these features, coupled with practical constraints, precluded a detailed examination.

Quantified information on the geologic structure was obtained by analyzing the mapping data collected at 13 sites within and adjacent to the pit. Linear sampling techniques were utilized. The vertical and horizontal dispersion of the above 13 locations appeared to be sufficient to ensure that representative samples of the geologic structure had been obtained.

The initial step in the structure analysis consisted of obtaining lower hemisphere Schmidt plots of the poles to the geologic structures. Although the general trends apparently deviated spatially, the vertical deviation was not great enough to preclude combining the plots in each sector. Consequently, combined plots for the highwall and wingwall sectors were generated. The point and percentage plots for the highwall sector are shown in Fig. 17 and 18. The percentage plots were examined, and individual observations were assigned to sets on the basis of orientation.

Statistical analyses of each set were then performed by sector. During this process, the means, standard deviations, and distributions of dip direction, dip, length, and spacing were examined. Tables 2 to 4 show the results of these analyses. Histograms of dip direction and dip were also generated and the negative exponential distribution was fitted to the length and spacing observations.

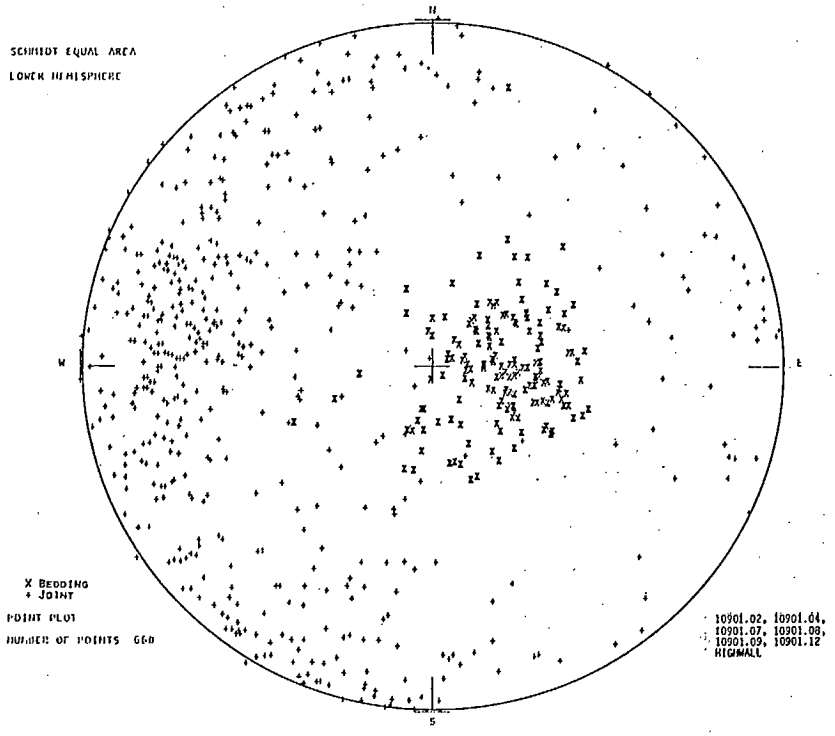


Fig. 17 - Schmidt pole plot of fractures for the highwall sector

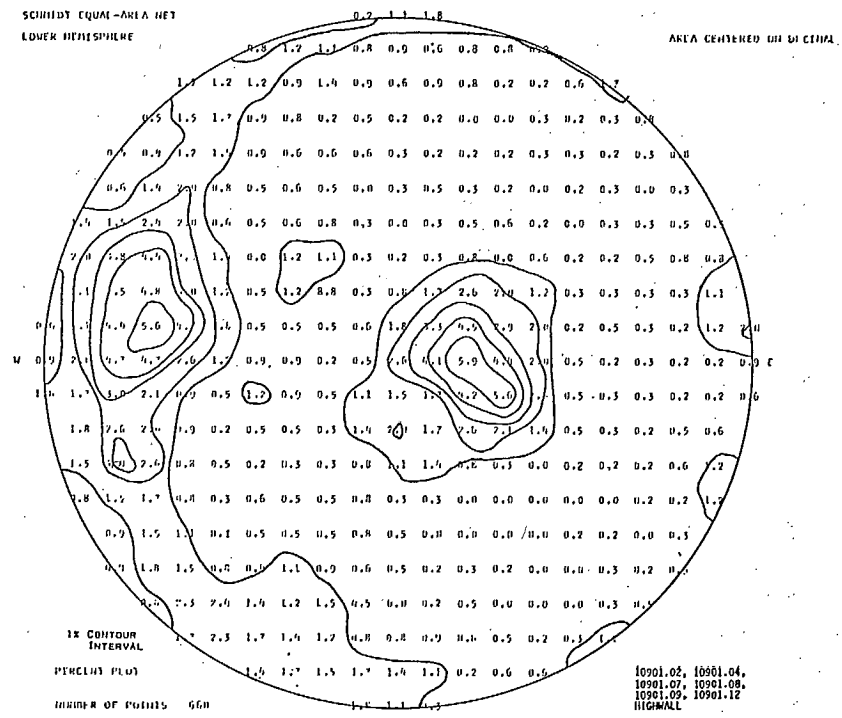


Fig. 18 - Schmidt contour plot for the highwall sector

Table 2 - Summary of geologic parameters for the highwall

Set		Dip (°)	Dip dir (°)	Length (m)	Spacing (m)
1	mean	23.9	269.1	2.24	0.13
	stan dev	9.9	81.4	2.16	0.16
	no.	216	216	216	215
2	mean	87.7	5.6	0.64	0.25
	stan dev	20.2	22.8	0.95	0.25
	no.	148	148	148	147
3	mean	72.9	93.9	1.41	0.25
	stan dev	17.0	24.3	1.77	0.25
	no.	298	298	298	297

Table 3 - Summary of geologic parameters for the north wingwall

Set		Dip (°)	Dip dir (°)	Length (m)	Spacing (m)
1	mean	24.1	291.9	0.76	0.11
	stan dev	7.8	49.2	0.91	0.16
	no.	72	72	72	71
2	mean	81.2	192.1	0.70	0.17
	stan dev	15.0	23.9	2.21	0.16
	no.	82	82	82	81
3	mean	86.2	106.7	0.51	0.19
	stan dev	23.2	23.3	0.81	0.16
	no.	68	68	68	67

Table 4 - Summary of geologic parameters for the south wingwall

Set		Dip (°)	Dip dir (°)	Length (m)	Spacing (m)
1	mean	23.8	270.2	1.03	0.10
	stan dev	10.0	71.0	0.93	0.13
	no.	173	173	173	172
2	mean	89.0	3.5	0.62	0.12
	stan dev	15.8	22.8	0.60	0.11
	no.	131	131	131	130
3	mean	83.8	89.2	0.67	0.13
	stan dev	20.3	24.6	0.81	0.13
	no.	138	138	138	137

HYDROLOGY

A steady state null pressure piezometric surface was assumed to exist at the 2135-m elevation. For stability analyses, two different hydrologic models were used. The first model assumed a drained condition in which the steady state surface would be lowered by an artificial drainage system such that a dry condition would occur in the slope. The second hydrologic model assumed an undrained condition in which the null pressure surface was modeled with a parabolic drawdown from the steady state surface to an exit point at the toe of the slope. It was realized that perched water tables probably existed throughout the stratigraphic sequence.

MATERIAL PROPERTIES

The uniaxial and triaxial compression test data were reduced using a method that related the confining stress to the maximum applied stress. Statistical analysis of this relationship was used to calculate the mean and standard deviation of the unconfined compressive strength, a mean cohesion, and a mean coefficient of friction for each material type. The results obtained are given in Table 5.

Due to the lateral and vertical variability within sedimentary formations such as the Adaville, specimens that have been assigned the same generic classification for engineering purposes may possess variable strength properties. The test results from each specimen reflected the particular composition of that specimen. Consequently, pairs of normal and shear stresses derived from the same specimen were not independent. Their dependence had to be accounted for by analyzing each specimen separately before combining results by rock types. The mean and standard deviation for the cohesion and coefficient used in the slope stability analysis are presented in Table 6. The test data were averaged by rock type and the standard deviations were calculated. Table 7 gives the resultant total unit weight values used.

STABILITY ANALYSIS

Six modes of instability are depicted in Fig. 19. Since folding was minor, the stratigraphic wedge was rejected as a probable sliding mode. The structurally controlled sliding mechanisms that are kinematically possible are simple plane shear in all sectors and in addition struc-

Table 5 - Uniaxial and triaxial test results

Rock type	Unconf comp mean	Strength (psi) Stan dev	Cohesion (psi)	Coeff of friction	No.	(ref)
	3248	713	928	0.589	10	(2)
Claystone	3276	2117	3025	-0.653	5	(5)
	3015	253	2567	-0.557	5	(5)
Siltstone	7000	896	2130	0.518	6	(2)
	2136	962	721	0.404	16	(5)
Sandstone	4191	864	1016	0.790	11	(2)
	4048	1416	1368	0.402	13	(5)
Coal	1317	-	-	-	2	(2)
	1414	433	390	0.630	18	(5)

Table 6 - Shear strengths and total unit weights

	Cohesion (psi)		Coeff of friction		Total unit weights (pcf)		
Rock Type	Mean	Stan dev	Mean	Stan dev	Mean	Stan dev	No. of samples
Claystone	13.32	0.63	0.3544	0.0502	141.7	9.4	22
Siltstone	9.32	0.31	0.5517	0.1006	147.0	4.5	13
Sandstone	6.47	2.26	0.6975	0.0796	145.7	10.6	14
Coal	10.27	3.01	0.5968	0.1119	80.2	9.2	63

Table 7 - Probability of a continuous failure path longer than 15 m

Sector	Mechanism	Probability
Highwall	Simple plane shear	2×10^{-5}
North wingwall	Simple plane shear	3×10^{-10}
	Structural wedge	5×10^{-14}
South wingwall	Simple plane shear	2×10^{-11}
	Structural wedge	8×10^{-18}

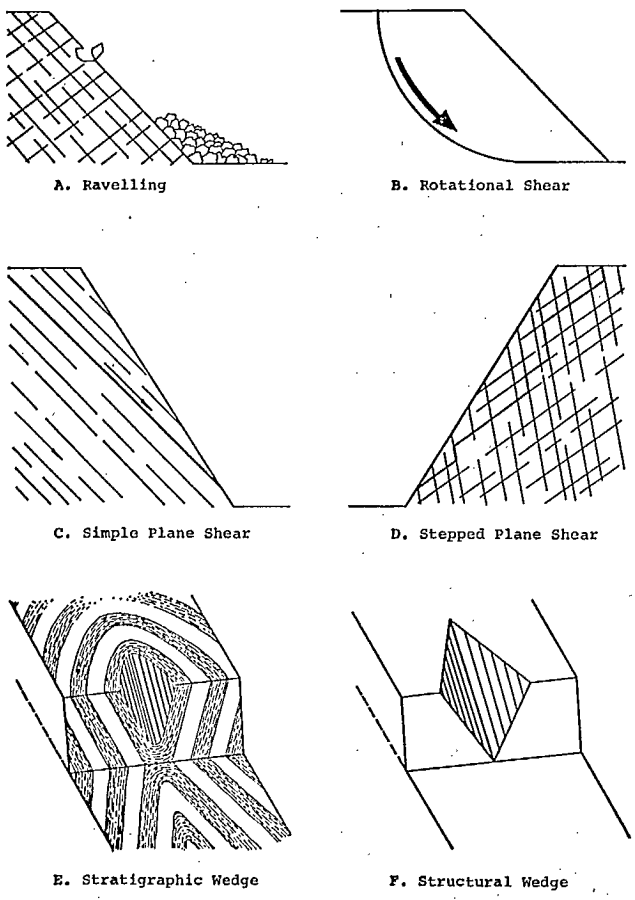


Fig. 19 - Instability modes

turally controlled wedges in the wingwalls.

The occurrence of small percentages of intact rock along a potential failure surface increases the effective shear resistance considerably by an unknown amount. Consequently, sliding by simple plane shear and a structural wedge is assumed to be for continuous structures.

Using mean length values, the probabilities of encountering continuous sliding paths 15 m or longer were calculated. The results of these calculations are listed in Table 7.

The low probabilities of encountering continuous sliding surfaces for the highwall and both wingwall sectors, combined with the low probability of daylighting, eliminated structurally controlled failure mechanisms in those sectors from further analysis.

Since no length data were available for the footwall bedding, further analyses of this sector were performed. The results of the analyses indicated that the probability of failure from plane shear was negligible for the footwall sector also.

Most of the instability was expected to be due to rotational shear. To produce probabilities, a Monte Carlo sampling procedure was incorporated into the stability analysis. The material properties were weighted according to the lithologic percentage, and new means and standard deviations were obtained for the intercoal units as listed in Table 8.

In the wingwall sectors, the positions of the bedding contacts are not constant. Consequently, it was not possible to generate a typical north-south lithologic section. To account for this variability, the percentages of each rock type expected within the wingwall sectors were randomized in the stability analyses.

For this study, the pit wall configurations shown in Fig. 12, 13 and 14 were utilized for the highwall and the wingwall sectors. To produce probability of instability schedules, the stability of the pit wall configurations expected during each year of the mine life for each design sector had to be sampled and analyzed. The results are tabulated in Tables 9 through 20. Tables 9 through 14 contain the probability schedules for drained pits whereas Tables 15 through 20 are for undrained pits. The probability of instablility in the footwall sector, Sector III, was negligible.

FINANCIAL DATA

PROCEDURE

Financial data include the benefits of mining according to a given pit design and the costs of possible slope instabilities (8). Benefit is defined as the net profit before taxes from sale of the commodity. The costs associated with a given design are: (1) the costs incurred under any normal mining operation and (2) the unusual costs resulting from slope instability.

Table 8 - Material properties used for highwall rotational shear analyses

Layer	Cohesion (psf) Mean	Cohesion (psf) Stan dev	Coeff of friction Mean	Coeff of friction Stan dev	Total unit weight (pcf) Mean	Total unit weight (pcf) Stan dev
1	1470	80	0.4997	0.0421	139.9	4.7
2	1479	433	0.5968	0.1119	80.2	9.2
3	1152	239	0.6225	0.0592	142.4	8.0
4	1479	433	0.5968	0.1119	80.2	9.2
5	1551	82	0.4765	0.0383	139.3	5.5
6	1479	433	0.5968	0.1119	80.2	9.2
7	1245	184	0.5834	0.0490	142.9	6.5
8	1479	433	0.5968	0.1119	80.2	9.2
9	1492	91	0.4990	0.0391	137.1	4.9
10	1479	433	0.5968	0.1119	80.2	9.2
11	1515	128	0.4922	0.0410	142.8	6.6
12	1479	433	0.5968	0.1119	80.2	9.2
13	1420	161	0.5365	0.0442	137.4	6.5
14	1479	433	0.5968	0.1119	80.2	9.2
15	1079	225	0.6345	0.0594	145.6	7.4
16	1479	433	0.5968	0.1119	80.2	9.2
17			fire clay		141.7	9.4
18	1063	218	0.6375	0.0599	145.8	7.2

Table 9 - Probability of instability schedule, highwall sector I, 28° design, drained

Slope angle	Slope height (ft) 50	100	200	300	500	600	700	800	950
	Probability of failure								
20.9°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
22.1°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
28°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003
60°	0.001	0.031	0.515	0.999	0.999	0.999	0.999	0.999	0.999

Note: double underline indicates the probability value was computed for the specified slope height and angle; single underline indicates the value was interpolated using computed values for slope angles within ±3° and slope heights within ±50 ft of those specified; other values result from linear interpolations or extrapolations.

Table 10 - Probability of instability schedule, wingwall sectors II & IV, 28° design, drained

Slope angle	Slope height (ft) 50	100	200	300	400	600	700	800	950
	Probability of failure								
13°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
20°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
28°	0.001	0.001	0.001	0.003	0.003	0.005	0.008	0.011	0.020
60°	0.001	0.031	0.515	0.999	0.999	0.999	0.999	0.999	0.999

Table 11 - Probability of instability schedule, highwall sector I, 35° design, drained

Slope angle	Slope height (ft) 100	200	300	400	500	600	700	800	1000
	Probability of failure								
10.1°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
23°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.108	0.224
35°	0.001	0.001	0.010	0.003	0.029	0.079	0.143	0.233	0.432
44.9°	0.018	0.052	0.157	0.397	0.413	0.443	0.841	0.999	0.999
60°	0.043	0.521	0.999	0.999	0.999	0.999	0.999	0.999	0.999

Table 12 - Probability of instability schedule, wingwall sectors II & IV, 35° design, drained

Slope angle	Slope height (ft) 50	150	250	350	450	550	650	750	850
	Probability of failure								
13.3°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
24°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
35°	0.001	0.045	0.018	0.063	0.076	0.114	0.231	0.339	0.418
44.9°	0.001	0.035	0.157	0.325	0.441	0.662	0.831	0.999	0.999
60°	0.001	0.085	0.760	0.999	0.999	0.999	0.999	0.999	0.999

Table 13 - Probability of instability schedule, highwall sector I, 45° design, drained

Slope angle	Slope height (ft) 80	100	180	200	280	380	480	580	1000
	Probability of failure								
10°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
25°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
35°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.367	0.800
45°	0.001	0.001	0.092	0.313	0.569	0.874	0.893	0.999	0.999
60°	0.001	0.031	0.150	0.515	0.900	0.999	0.999	0.999	0.999

Table 14 - Probability of instability schedule, wingwall sectors II & IV, 45° design, drained

Slope angle	Slope height (ft) 100	200	300	400	500	600	700	800	900
	Probability of failure								
13°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
30°	0.001	0.001	0.001	0.001	0.001	0.001	0.117	0.190	0.350
37°	0.001	0.001	0.001	0.134	0.145	0.491	0.890	0.950	0.999
45°	0.001	0.314	0.647	0.766	0.844	0.921	0.959	0.996	0.999
51.7°	0.014	0.404	0.750	0.999	0.999	0.999	0.999	0.999	0.999
60°	0.031	0.515	0.999	0.999	0.999	0.999	0.999	0.999	0.999

Table 15 - Probability of instability schedule, highwall sector I, 28° design, undrained

Slope angle	Slope height (ft) 50	100	200	750	800	850	900	950
	Probability of failure							
20.9°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
22.1°	0.001	0.001	0.001	0.001	0.008	0.041	0.001	0.001
28.0°	0.001	0.001	0.001	0.001	0.008	0.010	0.030	0.035
60.0°	0.001	0.031	0.515	0.999	0.999	0.999	0.999	0.999

Table 16 - Probability of instability schedule, wingwall sectors II & IV, 28° design, undrained

Slope angle	Slope height (ft) 50	100	200	300	400	500	600	700	800	950
	Probability of failure									
13°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
20°	0.001	0.001	0.001	0.001	0.005	0.001	0.010	0.117	0.124	0.231
28°	0.001	0.031	0.001	0.012	0.006	0.035	0.064	0.204	0.217	0.402
60°	0.001	0.031	0.515	0.999	0.999	0.999	0.999	0.999	0.999	0.999

Table 17 - Probability of instability schedule, highwall sector I, 35° design, undrained

Slope angle	Slope height (ft) 100	200	300	400	500	600	700	800	1000
	Probability of failure								
10.1°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
16°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
23°	0.001	0.001	0.001	0.002	0.051	0.101	0.150	0.179	0.179
35°	0.001	0.001	0.010	0.003	0.088	0.432	0.826	0.999	0.999
44.9°	0.018	0.052	0.157	0.397	0.577	0.788	0.999	0.999	0.999
60°	0.043	0.521	0.999	0.999	0.999	0.999	0.999	0.999	0.999

Table 18 - Probability of instability schedule, wingwall sectors II & IV, 35° design, undrained

Slope angle	Slope height (ft) 50	150	250	350	450	550	650	750	850
	Probability of failure								
13.3°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
19°	0.001	0.001	0.001	0.001	0.001	0.030	0.002	0.169	0.238
24°	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.314	0.446
35°	0.001	0.045	0.018	0.063	0.162	0.536	0.802	0.812	0.904
44.9°	0.001	0.035	0.157	0.368	0.493	0.719	0.999	0.999	0.999
60°	0.001	0.085	0.760	0.999	0.999	0.999	0.999	0.999	0.999

Table 19 - Probability of instability schedule, highwall sector I, 45° design, undrained

Slope angle	Slope height (ft) 80	100	180	200	280	380	480	580	1000
	Probability of failure								
10°	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
25°	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
35°	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.900	0.999
45°	0.0001	0.001	0.092	0.313	0.569	0.976	0.985	0.999	0.999
60°	0.0001	0.031	0.150	0.515	0.900	0.999	0.999	0.999	0.999

Table 20 - Probability of instability schedule, wingwall sectors II & IV, 45° design, undrained

Slope angle	Slope height (ft) 100	200	300	400	500	600	650	700	800	900
	Probability of failure									
13°	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
30°	0.001	0.001	0.001	0.005	0.050	0.001	0.150	0.210	0.220	0.400
37°	0.001	0.001	0.001	0.243	0.180	0.703	0.965	0.970	0.999	0.999
45°	0.001	0.313	0.647	0.832	0.900	0.959	0.965	0.970	0.999	0.999
51.7°	0.014	0.404	0.750	0.999	0.999	0.999	0.999	0.999	0.999	0.999
60°	0.031	0.515	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999

The assumptions used estimating future mining costs were as follows:

1. Throughout the 24 years of mine life, similar equipment would be used for mining both coal and overburden.
2. The equipment would be: (a) several 16-cy front-end loaders for loading coal (b) an adequate number of 50-ton coal haulers for hauling coal to two distinct destinations (c) several 15-cy shovels for removing overburden and (d) a sufficient number of 85-ton trucks hauling overburden to the dumps located due east from the pit.
3. Two separate haul roads would be maintained in the pit.
4. A maximum uniform grade of 8% would be maintained for all inclined haul roads and passing would be allowed in the haul road.
5. For safety reasons, the following maximum speed limits would be observed: (a) 16 miles per hour on -8% grade (b) 22 miles per hour on level haul in the pit and on the dumps (c) 28 miles per hour on level haul on the main haul road to the tipples, and (d) 5 miles per hour to negotiate switch-backs.
6. The average time to load an 85-ton truck with coal is 4 min by the 16-cy front-end loader, whereas for the 15-cy shovels it is 2 min.
7. The mine would be operated 3 shifts/day, 5 days/week. Each operating shift would be 350 min.
8. Other basic data required for mining costs

estimation such as the availability and the estimated life of major equipment would be based on generally accepted industry averages.

9. Purchase price of major equipment was as given by the company (13).

Figure 20 shows typical haul road profiles in the pit which were used to compute the cycle times of various trucks at a particular point in time and thereby determines the fleet mix or composition. Other miscellaneous costs such as (a) tipple operation (b) reclamation (c) supporting equipment and (d) general overhead and administration were included.

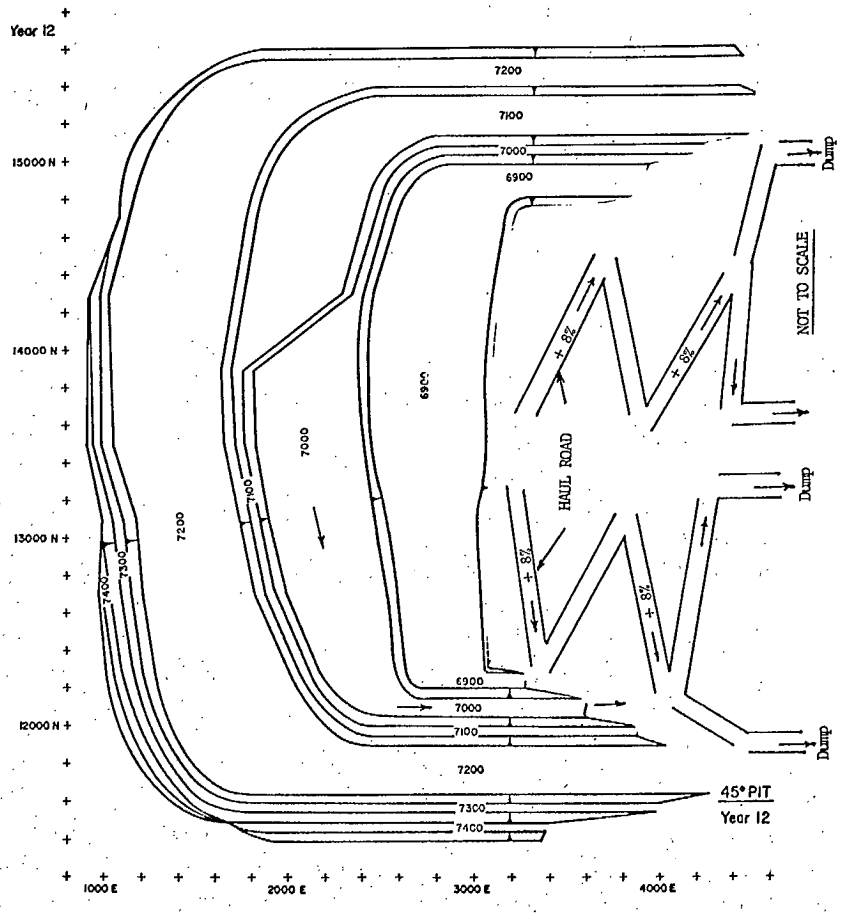


Fig. 20 - Location of permanent dual haul roads in the pit

Simulation of the 24-year mine life indicated that the average haul cycle time would increase approximately 150% from the present. However, the total unit mining costs were not varied to reflect the increased haulage costs for the reasons given below.

As selling price of the coal was fixed during the benefit-cost analysis at $13.22/tonne for the entire mine life, it was felt that the mining costs should also be fixed at the current level. In other words, to maintain the current profit margin it was implicitly assumed that the selling price of the coal would be increased to reflect the future increase in all costs.

The financial data used in the benefit-cost analysis are shown in Table 21.

Table 21 - Financial data for BNCST program

Selling price/ton of coal	13.22/t
Mining, processing and transportation, cost/ton of coal	4.96/t
Overburden mining cost	1.63/m^3 (in place)
Drilling and blasting cost	0.11/t (coal and OB)
Increased haulage cost due to slide	0.15/t - km (coal and OB)

COST OF INSTABILITY MODELS

Slope instability is classified into different scopes based on operational impact. Instability involving an entire pit wall will probably interrupt operations more severely than one involving a single bench. The three classes used are: (a) full wall, (b) interramp, and (c) bench.

In addition, there are other factors which influence the cost of a given instability: (a) location of the instability within the pit (b) time of occurrence and (c) mine strategy in using stockpiles.

In performing the benefit-cost analysis using the BNCST model (Fig. 1), the impact of each instability must be quantified using one or more cost models having numeric codes from 0 to 9. These codes are unique within each scope of instabilities. Hence, a code of 9 in a full wall is different from the same code in an interramp wall, as far as the operational impact is concerned.

For this case study, the following basic cost models were assessed to be adequate to cover all instabilities. One model, or a combination of models, was used to specify the cost of the various instabilities throughout the life of the pit. Table 22 shows the particular cost models selected for this case study under each scope of instability. It also gives the associated numeric code for each cost model.

In subsequent discussions on cost models, some such as the clean-up model and the mine abandonment model are identical under different scopes. In other words, the cost of instability

Table 22 - Cost models and associated numeric codes

Code	Cost type
	Full Wall (FHSL)
0	No Cost
1	Clean-up
2	Lost Coal
3	Lost Coal + Clean-up
4	Lost Coal + Early Mining
5	Mine Abandonment
6	Re-establish Haul Road
7	Clean-up + Early Mining + Lost Coal
8	Increased Haul + Clean-up
9	Mine Abandonment or Clean-up
	Interramp (IHWK)
0	No Cost
1	Clean-up
2	Lost Coal No. 1
3	Lost Coal No. 2
4	Lost Coal No. 3
5	Mine Abandonment
6	Early Mining
7	(None)
8	Increased Haul + Clean-up
9	Mine Abandonment or Clean-up
	Bench (BENS)
0	No Cost
1	Clean-up

is computed using the same relationship although the total magnitude does vary depending on its scope, i.e., full wall or interramp wall. On the other hand, some other models are unique to the given scope of instability.

In nearly all cost models, the costs are computed by multiplying the volume of material involved times the unit cost associatd with this volume. The volume is the volume of instability, and Coates gives a generalized equation for computing this volume as a function of the pit wall height (1):

$$V = 0.08\ H^3 \qquad \text{Eq 1}$$

For this case study, the volume of material to be cleaned due to instability was computed using Eq 1. Similarly, the volume of material that had to be mined earlier than originally planned was also computed using the same equation. The remainder of this section discusses the individual cost models used and the associated assumptions of these models.

No Cost Model. As the name implies, this cost model was used whenever the cost of instability was negligible such as the cost involved in a small bench-scale failure.

Clean-up Model. This model was called whenever the slide material had to be cleaned up. As can be seen from Table 22, this model was used for instability occurring in all three wall types: (1) full wall (2) interramp wall and (3) bench wall. It is assumed: (i) volume required for clean-up is that given by Eq 1; (ii) the unit cost of clean-up is equal to the cost of waste mining less drilling and blasting; (iii) the same clean-up cost is applicable in all sectors; (iv) all the necessary clean up will be performed by the company and no outside contractor will be called in; (v) there is no limit to clean-up capacity in a given period; and (vi) coal mined in the process of clean-up will be discarded as overburden.

Lost Coal Model. As the coal which had intermingled with overburden material would be discarded, this model was used to compute the amounts and the values of coal lost due to instability. As can be seen in Fig. 12 and 13, various amounts of coal could be lost depending on: (1) the exposed wall height (2) the location of coal seams along this exposed wall and (3) the total thickness of these seams. For this study, four distinct types of lost coal models were used, in which one type differs from the other only in the total thickness of lost coal seams. The assumptions included: (i) the total volume of the instability, a portion of which consists of lost coal, is computed using Eq 1; (ii) the volume of lost coal can be calculated as a simple proportion of total volume given in (i), where the total thickness of coal seams over the total wall height gives the proportional factor; (iii) the cost of lost coal is simply the net lost revenue of the lost coal; the net lost revenue is given by the difference between the sales price minus all the costs applicable in mining and selling of this coal, including the required stripping cost; the amount of lost coal in each period is, however, assumed to be made up from outside sources such as some other pits in the area; (iv) the total volume of slide material will also be cleaned up in this model, under similar assumptions given in the clean-up model; in computing clean-up cost, coal is treated as overburden; and (v) the total thicknesses used for coal seams for the above four distinct types of lost coal models would be:

	lost coal	41.0 m
	lost coal No. 1	22.7 m
	lost coal No. 2	13.6 m
and	lost coal No. 3	4.5 m

Early Mining Model. This model was used to account for the cost of mining the overburden material earlier than originally scheduled, mainly due to wall instabilities. The cost component primarily consists of the time value of money which is the difference between two costs; i.e., one that would be incurred in the future under the original mine plan (discounted to the present) and the other that is actually incurred now due to instability.

No consideration was given to early min-

ing of coal in this model. Therefore, it was called only when the instability was in waste material. Whenever any amount of coal was involved, the lost coal model was used instead of the early mining model. The early mined overburden would be in addition to the normally scheduled overburden stripping in that period. Hence, the amount would be subtracted from the planned future overburden tonnages. The number of years to be discounted would be the time required to mine a cut (Fig. 11). It is assumed to be 4 years during the first 20 years in the mine life of 24 years. For the remaining 4 years, the discount period is assumed to be equal to the years remaining in the mine life after the current period. The annual discount rate used is 12%. The total volume of an instability and the cost of minimg are computed in the same manner as given in the clean-up cost model, except that the drilling and blasting costs are included in the future planned mining costs.

Mine Abandonment. Due to one or more successive slides in the pit, it can become more economical to abandon the pit than to continue mining. Of course, the decision to abandon the pit, particularly when it is the only mining operation, may not be entirely based on economics alone. Since the company owns many other coal properties in the neighborhood, it is a reason for it to abandon a pit and to mine in another area.

In this case study, the decision to abandon the pit was based entirely on economic considerations. The pit was abandoned when the cost of instability would exceed the net present value of the remaining coal to be mined. The net value of coal that would be mined in each subsequent year is revenue minus all expenses of mining the coal including stripping. The net values for each year were discounted to the current year for the purpose of comparison with the required clean-up cost.

If the results of comparison indicated that it was cheaper to clean up, the clean-up cost as computed from the clean-up model was detemined to be the cost of instability. On the other hand, if pit abandonment was found to be cheaper, the switch was set which indicated that the pit was to be abandoned in the current period of the current design sector. The benefit-cost analysis continued for all the remaining design sectors in the pit.

Since each design sector was analyzed independently of other sectors and since the impact of the decision to abandon the pit transcended any single design sector, post processing had to be performed in which the total cost of pit abandonment could be assessed. Post processing is the next step in the benefit-cost analysis in which the results of analysis for all design sectors are combined and any necessary adjustments are made to reflect the impact on the entire pit.

Increased Haulage. Whenever instability results in cutting off a haul road, trucks must be re-routed. This results in an increased haulage cost equal to the increased distance times the cost of hauling the material for that distance. It is assumed that: (i) only the material from sectors II and IV is subjected to such increased haulage; (ii) the increased haulage distance during each period of analysis is known; and (iii) the unit cost of haulage is the same in all periods.

Haul Road Re-establishment. This model can be used to compute the cost of re-establishing either a permanent or a temporary haul road in the pit. There are many alternatives available for re-establishing a haul road. The cost can vary greatly depending on the particular alternative selected.

The factors which determine the total cost of re-establishing a haul road are: (a) width of the haul road (b) length of the haul road to be re-established and (c) availability of working room for either cutting out or backfilling. Only the permanent haul road located in the footwall section of the pit, i.e., Sector III, needed to be considered for this reaction. Consequently, this cost model was specified only in Sector III.

The assumptions included in this cost

model are: (i) no loss of production would occur during a haul road re-establishment period because of the presence of the dual haulage system in Sector III; (ii) the total length of haul road to be repaired would be, on the average, 30% of the total haul road length existing in that sector at that moment; and (iii) the estimated cost for repairing the haul road is $164/m.

Due to the small probability of instability in this sector, the overall cost impact of this model was negligible for all three designs.

BENEFIT COST ANALYSIS

WALL GEOMETRY

Wall geometry data for each sector for the three designs were transferred from the yearly mine plans such as in Fig. 14. Since the total life of the mine was 24 years, altogether 72 plans were utilized.

Although the process of transferring geometry data from the plans to the program is relatively straightforward, some approximation is required of the actual pit geometry as it is assumed in the program that an identical, uniform geometry exists during each year.

Specifically, the following data were transferred for each sector: (1) sector width for each year; (2) working bench elevations and widths for each year; (3) haul road elevations and the basic width of a haul road (all temporary haul roads were located on working benches; therefore, no haul roads were treated separately from the working benches); (4) pit limit elevations for each year consisting of sector top elevation, pit bottom elevation and ultimate wall bottom elevation; (5) bench dimensions and bench face angle; and (6) ultimate wall angle.

The sector width was an average value that generally increased for all sectors as the pit expanded. The largest number of working benches open at any one time for any sector of the three designs was four. This occurred in Sectors I and II of the 28° design, Sectors I, II and IV of the 35° design, and in Sector IV of the 45° design. The width of a working bench averaged about 190 m in Sector I of the three designs and appproximately 95 m in Sectors II and IV. Sector III did not contain any working benches.

The top elevation in each sector was approximated by the average pit top elevation in the sector for that period. The sector top elevation can vary from one period to another as the pit expands outward. Similarly, the pit bottom elevation was approximated by the average pit bottom within the sector. Prior to reaching the ultimate pit limit, the ultimate wall bottom elevation was set equal to the sector top elevation. Only when the ultimate pit limits were reached, did the ultimate wall bottom elevation proceed downward to create the ultimate wall height at the specified ultimate wall angle.

The maximum pit depths for each sector of each pit design at the end of the mine life were:

	28°	35°	45°
Sector I	290 m	305 m	320 m
Sector II	245 m	260 m	275 m
Sector III	245 m	245 m	245 m
Sector IV	215 m	245 m	275 m

FINANCIAL DATA

The financial data of Table 21 were next input to the BNCST model. Yearly coal and overburden production figures, shown in Table 1, were also input. Yearly production was lumped into Sector I mainly to eliminate the need to break the production down by design sector. The lumping procedure also minimized the data input without changing any of the results.

The unit cost of mining included all costs associated with producing a marketable coal, except that of overburden removal. In the BNCST model, the stripping cost is specifically treated as one of the costs associated with a given design mainly due to probable variations in the overall stripping under different slopes.

Appendix A contains input data loading sheets. The BNCST model provides the ditto feature (or DIT) as well as the filling capabilities. The ditto capability simply allows the user to ditto the previously input data, thus

minimizing the physical quantity of data input. In the same manner, the filling capability allows the user to input only those data that are different from the preceding ones.

The BNCST was executed first without probability schedules and the cost model specification to obtain the computed wall heights and angles for each design sector, to obtain a summary of input geometries such as the elevations and working widths of benches and to obtain the base case results which excludes any cost of instability. Some dummy probabilities and cost models must, however, be supplied.

A typical output of computed wall heights and associated angles for the first 12 periods only is shown in Table 23 for Sector I or the 28° design. This output was obtained by setting one of the diagnostic switches, NDIAG, to 1 during the BNCST Version IV execution. For the final run, the switch should be set to 0. Remaining heights and angles for all other sectors of the three designs are given in Appendix C. A summary of input geometries such as the pit limit elevations and the widths of working benches is shown in Appendix D.

This information is of value to the overall analysis. Each wall height at the associated slope angle is used to determine the appropriate probability of instability and is used to sample for a failure. If instability occurs, the cost impact depends on its size. This, in turn, is directly proportional to the wall height. Hence, the pit wall configurations are also needed in specifying the cost impact, i.e., assigning the appropriate cost model, to each wall in a given sector.

Table 23 - Typical output of computed wall heights and associated angles

28 DEGREE DESIGN.

		PIT WALL HEIGHTS AND ANGLES					
		FULL	INTERRAMP WALLS				
PERIOD		WALL	1	2	3	4	5
1	HEIGHT	300.0	100.0	200.0	0.0	0.0	0.0
	ANGLE	20.5	60.0	39.1	0.0	0.0	0.0
2	HEIGHT	300.0	100.0	100.0	100.0	0.0	0.0
	ANGLE	13.3	60.0	60.0	60.0	0.0	0.0
3	HEIGHT	400.0	100.0	200.0	100.0	0.0	0.0
	ANGLE	16.4	60.0	39.1	60.0	0.0	0.0
4	HEIGHT	400.0	100.0	100.0	200.0	0.0	0.0
	ANGLE	14.4	60.0	60.0	39.1	0.0	0.0
5	HEIGHT	400.0	100.0	200.0	100.0	0.0	0.0
	ANGLE	14.4	60.0	39.1	60.0	0.0	0.0
6	HEIGHT	500.0	100.0	100.0	200.0	100.0	0.0
	ANGLE	14.6	60.0	60.0	39.1	60.0	0.0
7	HEIGHT	500.0	100.0	100.0	100.0	100.0	100.0
	ANGLE	11.8	60.0	60.0	60.0	60.0	60.0
8	HEIGHT	500.0	100.0	100.0	200.0	100.0	0.0
	ANGLE	13.6	60.0	60.0	39.1	60.0	0.0
9	HEIGHT	500.0	200.0	100.0	100.0	100.0	0.0
	ANGLE	13.6	39.1	60.0	60.0	60.0	0.0
10	HEIGHT	550.0	100.0	100.0	200.0	100.0	50.0
	ANGLE	12.7	60.0	60.0	39.1	60.0	60.0
11	HEIGHT	600.0	200.0	100.0	100.0	100.0	100.0
	ANGLE	13.1	39.1	60.0	60.0	60.0	60.0
12	HEIGHT	600.0	100.0	100.0	100.0	200.0	100.0
	ANGLE	12.3	28.0	60.0	60.0	39.1	60.0
13	HEIGHT	600.0	100.0	100.0	200.0	100.0	100.0
	ANGLE	12.3	28.0	60.0	39.1	60.0	60.0

PROBABILITY OF INSTABILITY

The probability of instability schedules as given in Tables 9 through 20 were next input to the BNCST model.

Careful comparison of the schedules for drained conditions among the three designs for a given sector shows several aspects. For example, comparison of Tables 9, 11 and 13 shows that the probabilities of instability for Sector I are lower for the 35° pit than the 45° pit. Also, the probabilities for Sector I are lower for the 35° pit than the 45°. The highest attainable probability for the 28° pit, i.e., 28° at 288 m, is 0.003 which is negligible. On the contrary, the highest attainable probability for the 35° and the 45° pit is 0.999 which is practically certain failure.

Another aspect is that the probability of instability schedules for Sector II are identical to those for Sector IV, for the three designs, due to the symmetry of these two sectors (see Tables 10, 12 and 14). The largest probability for sampled wall height and angle combinations for the 28° pit is 0.515, while the largest sampled probability for either the 35° or 45° pit is 0.999, for all the feasible wall height and angle combinations.

Finally, no probability of instability schedules for Sector III are given in these tables. The probability of instability was negligible due to the flat slope of 18°. For this reason, a probability of 0.001 was input to the model for all wall heights in all designs.

COST IMPACT SPECIFICATION

The cost impact specifications were made by viewing particular wall geometry at a given moment and also by considering the overall mine operations.

Sector I cost model assignments were made for both designs by using Section 13900N as the typical cross section for this sector. Sectors II and IV required composite cross sections such as shown in Fig. 21. For each design, these com-

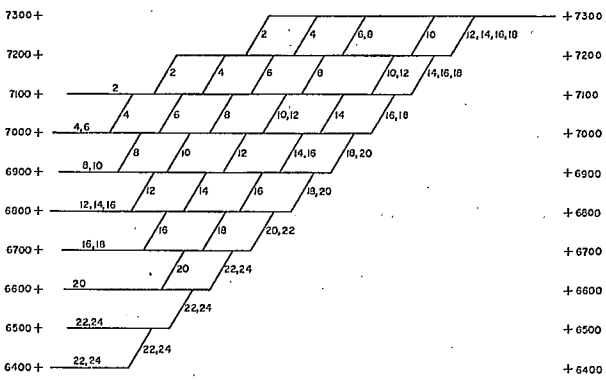


Fig. 21 - Composite cross section of sector II, looking west, for the 45° design

posite cross sections had to be constructed from the year-by-year pit geometries as calculated by BNCST for two reasons. First, the variable block model cross sections were east-west sections, whereas a north-south cross section was required for the wingwalls to depict their pit wall geometries. Secondly, a fixed cross section, as opposed to a composite or shifting cross section, would not reflect the average or typical wingwall cross section, since the pertinent geometry and geology did shift each period. Pertinent geometry and geology refer to the lithology at the face. Thus, the composite wingwall cross section reflected the expansion of the pit.

Two coal seam templates (Fig. 22), one for Sector II and the other for Sector IV, were also required to quantify the total thickness of the lost coal due to instabilities. These templates were required only in Sectors II and IV because these sectors had composite cross sections. It was also determined that one template could not serve for both sectors due to the variation in coal seam lithology between the north and south extremes of the deposit. These templates gave the apparent thickness and the position of various coal seams from the existing pit bottom, as seen in the composite cross section.

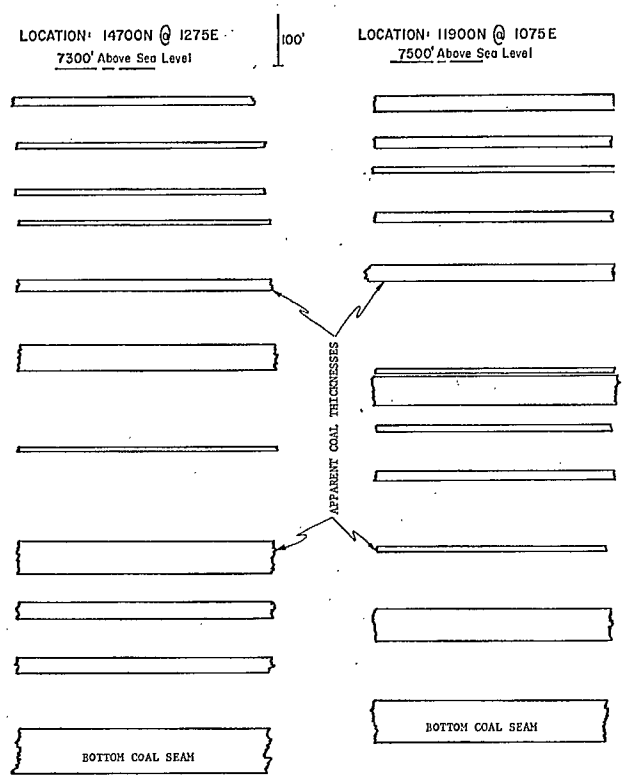


Fig. 22 - Coal seam templates used in cost impact specification

Table 22 shows all the cost models that were required for this study for each scope of instability: (1) full wall (2) interramp wall and

(3) bench. It also shows the particular numeric codes that were assigned to each cost model. Table 24 below gives an example of actual cost model assignments for Sectors I and II of the 28° design. The complete cost model assignments for all sectors of the three designs are given in Appendix E.

Table 24 - Example of cost model assignments for sectors I and II of 28° design

PERIOD	FULL WALL	INTERRAMP WALLS WALL #1	#2	#3	#4	#5	BENCH
		DESIGN SECTOR I					
1	0	0	3	0	0	0	1
2	0	0	4	6	0	0	1
3	2	0	3	0	0	0	1
4	2	0	4	3	0	0	1
5	2	0	3	6	0	0	1
6	2	0	4	3	0	0	1
7	2	0	4	4	3	0	1
8	2	0	4	3	6	0	1
9	2	0	4	0	6	0	1
10	2	0	0	3	3	0	1
11	2	0	4	0	3	0	1
12	3	0	0	4	3	6	1
13	3	0	0	3	4	6	1
14	3	0	0	4	3	4	1
15	3	0	4	4	3	0	1
16	3	1	4	4	3	0	1
17	3	1	4	4	0	0	1
18	3	1	0	4	0	0	1
19	9	9	0	3	0	0	1
20	9	9	3	0	0	0	1
21	9	9	0	4	0	0	1
22	9	9	0	0	0	0	1
23	9	9	0	0	0	0	1
24	9	9	0	0	0	0	1
		DESIGN SECTOR II					
1	0	0	0	0	0	0	1
2	4	0	0	0	0	0	1
3	4	3	0	0	0	0	1
4	4	3	0	0	0	0	1
5	4	3	0	0	0	0	1
6	4	4	4	0	0	0	1
7	4	4	4	0	0	0	1
8	4	3	3	0	0	0	1
9	4	2	0	0	0	0	1
10	4	3	3	3	0	0	1
11	4	3	4	0	0	0	1
12	4	2	3	3	3	0	1
13	4	3	3	0	0	0	1
14	4	0	3	4	0	0	1
15	4	0	2	0	0	0	1
16	7	1	4	0	0	0	1
17	7	1	0	0	0	0	1
18	7	1	0	0	0	0	1
19	8	8	0	0	0	0	1
20	8	8	0	0	0	0	1
21	9	9	0	0	0	0	1
22	9	9	0	0	0	0	1
23	9	9	0	0	0	0	1
24	9	9	0	0	0	0	1

From the assignments certain observations can be made. For the interramp wall No. 1, i.e., the uppermost interramp wall in Sector I, the no-cost model, i.e., code No. 1, is widely used due to the particular relationship existing between the uppermost coal seam and the overburden lying above this seam, prior to reaching the ultimate pit limit. The most common cost models involve a certain amount of lost coal, i.e., codes No. 2, 3, and 4). The model for mine abandonment is done on a comparison basis, code No. 9, instead of an outright abandonment, code No. 5. That is, mine abandonment is called only if it is cheaper than the cost of clean-up. One exception is in Sector III (Appendix E).

In assigning various cost models for this case study, specification of the lost coal model was somewhat simpler for Sector I than for Sectors II and IV. For Sector I, the wall was viewed in the typical cross section shown in Fig. 12 and 13 for both designs, and the total thickness of all coal seams daylighting in the wall face was determined.

For Sectors II and IV, determination of lost coal required the use of templates for the reasons given earlier (Fig. 22). The pit bottom in the composite cross section always coincided with the bottom of the lowest seam. Therefore, to determine the amount of lost coal, the template was positioned next to the composite cross section such that the bottom seam on the template matched the pit bottom for the year in question. Then, the total coal thicknesses that daylighted for each pit wall were observed and the appropriate lost coal models were assigned to each wall.

It was assumed that little, if any, coal would be lost from No. 1 seam. Overburden never covered the seam during ongoing mining as can be seen from Fig. 23. Therefore, no failed waste could mix with the seam during instability to cause a loss of coal.

The increased haulage cost model was not used in Sector I since haulage could be re-routed through Sector II or Sector IV depending on the location of instability in Sector I. On the other hand, increased haulage was not required in

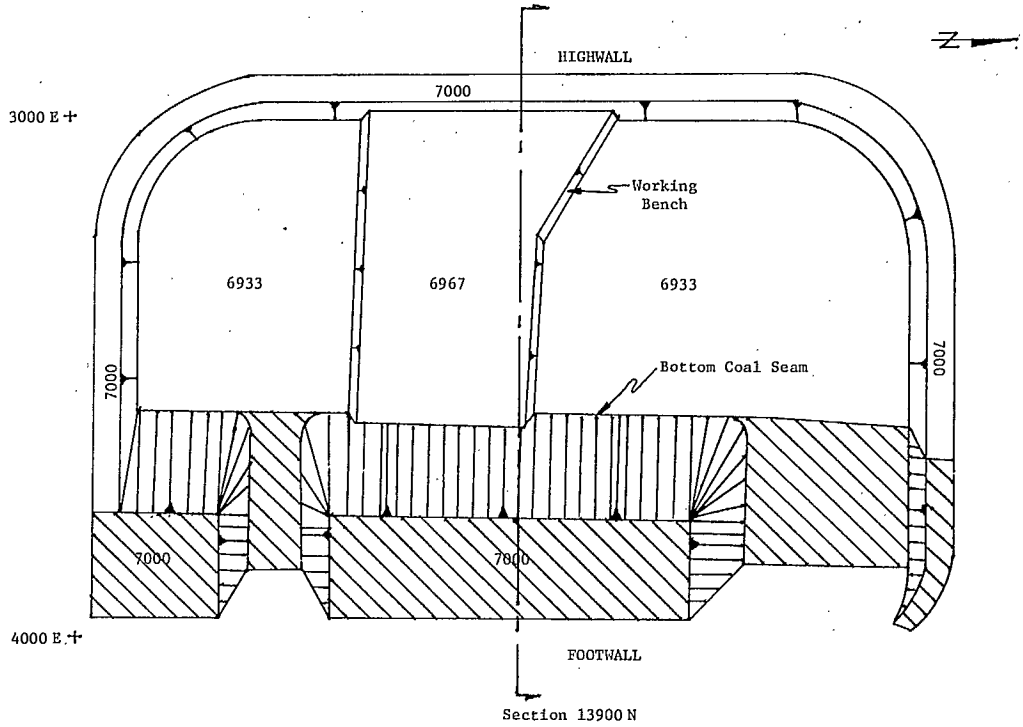


Fig. 23 - Illustration of mining method

Sector III since there were alternate haul road routes out of this sector (Fig. 20). In Sectors II or IV, however, instability of sufficient extent could block all haul roads in that sector requiring traffic to be re-routed to the other side of the pit. Consequently, this model was used only in Sectors II and IV.

BNCST EXECUTION

This case study was performed on the BNCST Version IV. The form of data input is identical to Version III, which makes the program user's guide given in Supplement 5-3 of the Pit Slope Manual entirely applicable. The potential user need only be aware of the additional capabilities provided in Version IV, which includes post processing.

Appendix H at the end of this report describes those improvements made to Version III and hence the added capabilities of Version IV.

The need for post processing can be seen by examining Fig. 24. Figure 25 re-emphasizes the hierarchy of the analysis as described by the loops in Fig. 24, i.e., analyses of each period followed by each simulation, then each sector and finally each design case.

This sequence allows each design sector to be analyzed on its own without considering the overall pit. However, it includes an implicit assumption that the cost impact of an instability in a given sector would be confined to that sector.

Certain cost impacts such as mine abandonment or excessive cumulative clean-ups from all sectors required in a given year do transcend the sector. Figure 26 illustrates the procedure of post processing. Here, the results from the normal benefit-cost analysis are reprocessed using a different analysis hierarchy, i.e., each sector in a given year followed by each year and then by each simulation. Consequently, post processing allows the analysis to be performed

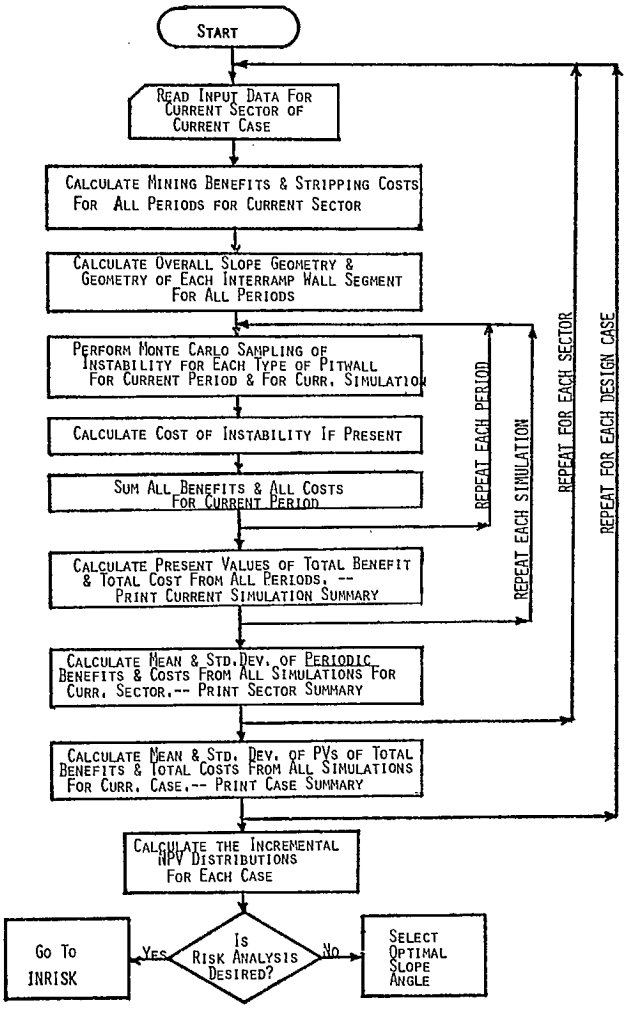


Fig. 24 - Flow chart of benefit-cost analysis

for the entire pit as a whole, while accounting for inter-dependencies.

In the benefit-cost analysis model, all the required number of simulations for each design sector is first performed in the normal manner without consideration of overall impact on the entire pit. Afterwards, the results from each sector are analyzed jointly by period basis and for each simulation. Depending on the results from post processing, the previously obtained results from the normal benefit-cost model run may be modified to account for the overall impact on the entire pit.

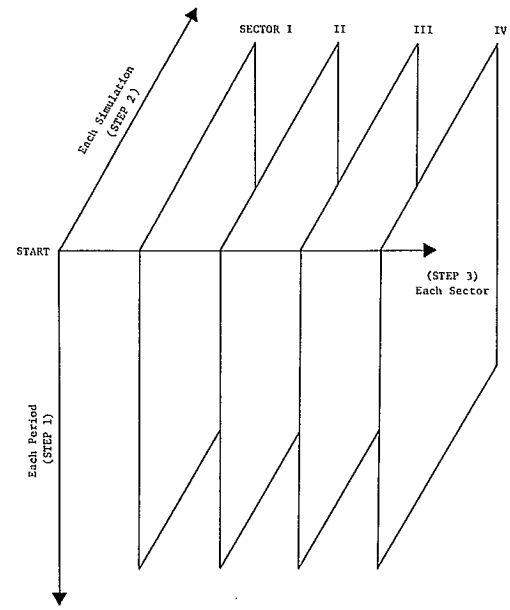


Fig. 25 - The hierarchy of steps in the benefit-cost analysis

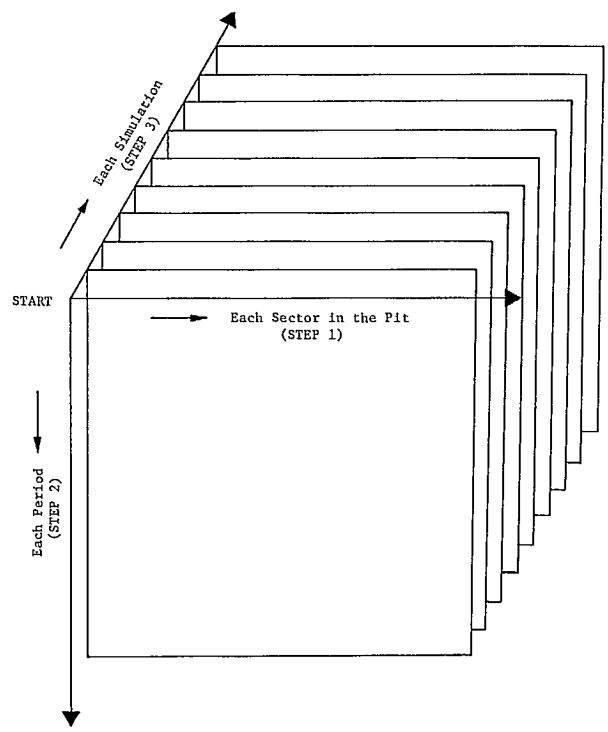


Fig. 26 - The hierarchy of steps in post processing

RESULTS

The results for the benefit-cost analysis were obtained in three stages: (1) The benefit cost program (BNCST-Version IV) was run without the cost of instability included; only coal revenue and stripping costs were calculated. These results formed the base case for each slope design. (2) The program was next run with the costs of instabilities included. These results were then compared with the base case results to see what effect instability had on the net present values for each design. (3) Finally, post processing was performed to determine the true cost impacts which transgress the normal sectorized analysis. Post processing was performed using a program distinct from BNCST and was supplied by the user. The post processing program used for this case study is listed in Appendix J.

A partial output of the final Stage 2 run is given in Appendix F including Simulation No. 1 of Sector 1 for the three designs and the final case results. Also, the Stage 3 final run is shown in Appendix G. For all figures and tables in this chapter, Case No. 1 refers to the 28° design, Case No. 2 refers to the 35° design, and Case No. 3 refers to the 45° design.

BASE CASE RESULTS

The results of the base case are given in Table 25. Even though the total coal reserves are nearly the same for the three designs, the present values of the benefits for each design are not exactly the same. The 28° design resulted in benefits of $145,471,000 while the 35° and 45° designs resulted in benefits of $145,483,000 and $145,411,000, respectively. There is a significant difference among the associated costs, i.e., the stripping costs incurred in the three designs. The 28° design resulted in $86,900,000 without including failure costs, whereas the 35° and 45° designs indicated $82,086,000 and $74,362,000, respectively. Flatter slope angles require more waste stripping.

Table 25 - Base case results

CASE SUMMARY FOR CASE NUMBER 1 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

86900.	86900.	86900.	86900.	86900.
86900.	86900.	86900.	86900.	86900.
86900.	86900.	86900.	86900.	86900.
86900.	86900.	86900.	86900.	86900.
86900.	86900.	86900.	86900.	86900.
86900.	86900.	86900.	86900.	86900.

SUMMARY OF BENEFITS AND COSTS FOR CASE 1

AVERAGE PRESENT VALUE OF BENEFITS	145471.
STANDARD DEVIATION OF BENEFITS	0.
AVERAGE PRESENT VALUE OF COSTS	86900.
STANDARD DEVIATION OF COSTS	0.

Table 25 cont'd.

CASE SUMMARY FOR CASE NUMBER 2 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

82086.	82086.	82086.	82086.	82086.
82086.	82086.	82086.	82086.	82086.
82086.	82086.	82086.	82086.	82086.
82086.	82086.	82086.	82086.	82086.
82086.	82086.	82086.	82086.	82086.
82086.	82086.	82086.	82086.	82086.

SUMMARY OF BENEFITS AND COSTS FOR CASE 2

AVERAGE PRESENT VALUE OF BENEFITS 145483.

STANDARD DEVIATION OF BENEFITS 0.

AVERAGE PRESENT VALUE OF COSTS 82086.

STANDARD DEVIATION OF COSTS 0.

CASE SUMMARY FOR CASE NUMBER 3 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

74362.	74362.	74362.	74362.	74362.
74362.	74362.	74362.	74362.	74362.
74362.	74362.	74362.	74362.	74362.
74362.	74362.	74362.	74362.	74362.
74362.	74362.	74362.	74362.	74362.
74362.	74362.	74362.	74362.	74362.

SUMMARY OF BENEFITS AND COSTS FOR CASE 3

AVERAGE PRESENT VALUE OF BENEFITS 145411.

STANDARD DEVIATION OF BENEFITS 0.

AVERAGE PRESENT VALUE OF COSTS 74362.

STANDARD DEVIATION OF COSTS 0.

RESULTS INCLUDING FAILURE COSTS BUT NO POST PROCESSING

The results including the costs due to instability are given in Table 26 for the three design cases. See Appendix F for a sample output illustrating the costs of sampled failures. The benefits for all three designs remain nearly the same as for the base case - $145,471,000 for the 28° design, $145,483,000 for the 35° design and $145,411,000 for the 45° design. However, the cost for each increases when the cost of instability is incorporated. The costs for the 28° design increase to $88,274,000, the costs of the 35° design increase to $83,944,000 and the costs of the 45° design increase to $84,407,000, an increase of over $10 million.

The high cost of failure for the 45° design is a direct result of the instability. The degree of difference in stability among the three designs can be traced to the much higher probabilities of failure associated with the 45° pit walls. For instance, compare the probability schedules for Sector 1 of the three cases in Tables 9, 11, and 13. The probabilities for the 28° schedule are all negligible. The probability for a wall height of 228.6 m at 60° is 0.999, but a pit wall with this geometry does not occur in the 28° pit, nor will it ever occur if one is to have an overall slope of 28°. On the other hand, the probabilities in the 45° schedule increase rapidly after the wall height reaches 177 m at 35° (probability = 0.367) and 85 m at 45° (probability = 0.569). These wall geometries

Table 26 - Results including failure costs but prior to post processing

CASE SUMMARY FOR CASE NUMBER 1 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

88120.	88265.	88170.	88144.	88091.
88509.	88404.	88239.	88362.	88513.
88274.	88124.	88068.	88861.	88392.
88629.	88556.	88051.	87897.	88160.
88083.	87928.	88235.	88242.	88061.
88357.	88223.	88443.	88621.	88203.

SUMMARY OF BENEFITS AND COSTS FOR CASE 1

AVERAGE PRESENT VALUE OF BENEFITS	145471.
STANDARD DEVIATION OF BENEFITS	0.
AVERAGE PRESENT VALUE OF COSTS	88274.
STANDARD DEVIATION OF COSTS	222.

Table 26 cont'd.

CASE SUMMARY FOR CASE NUMBER 2 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

84058.	83858.	83944.	83684.	84154.
84180.	83885.	83826.	84229.	84510.
83715.	84073.	83814.	83882.	84230.
84391.	83800.	84035.	83786.	84383.
84070.	83742.	83495.	84352.	83629.
83423.	83869.	84159.	83996.	84660.

SUMMARY OF BENEFITS AND COSTS FOR CASE 2

AVERAGE PRESENT VALUE OF BENEFITS 145483.

STANDARD DEVIATION OF BENEFITS 0.

AVERAGE PRESENT VALUE OF COSTS 83994.

STANDARD DEVIATION OF COSTS 294.

CASE SUMMARY FOR CASE NUMBER 3 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
AFTER POST PROCESSING
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

84677.	84306.	84448.	84209.	84125.
83644.	84358.	84399.	84530.	84256.
84103.	85041.	84482.	84876.	84930.
84317.	84141.	84463.	84888.	84823.
84581.	84193.	84565.	84813.	83908.
84382.	84769.	84419.	83961.	83614.

SUMMARY OF BENEFITS AND COSTS FOR CASE 3

AVERAGE PRESENT VALUE OF BENEFITS 145411.

STANDARD DEVIATION OF BENEFITS 0.

AVERAGE PRESENT VALUE OF COSTS 84407.

STANDARD DEVIATION OF COSTS 361.

are likely to occur in any 45° design and do occur for this case study as shown in Appendix C.

With the cost of instability included in the benefit-cost analysis, the 35° pit provides the highest NPV (Table 27). The NPV of the 28° and 35° designs were $57,197,000 and $61,489,000, respectively, while that of the 45° design was $61,004,000.

Table 27 - Summary of results before post processing

		28°	35°	45°
A.	Benefits	$145,471,000	$145,483,000	$145,411,000
	Costs	86,900,000	82,086,000	74,362,000
	NPV	58,571,000	63,397,000	71,049,000
B.	Benefits	$145,471,000	$145,483,000	$145,411,000
	Costs	88,274,000	83,994,000	84,407,000
	NPV	57,197,000	61,489,000	61,004,000

A. excludes cost of instability

B. includes cost of instability and excludes post processing

POST PROCESSING RESULTS

Post processing was performed in two steps. First, the earliest period in which the mine was abandoned had to be determined. To do this, the earliest period of mine abandonment (if any) in each sector had to be compared to find the first abandonment period for the entire pit. Next, the possibility of pit abandonment due to combined cost impacts from all sectors had to be investigated. Such a possibility existed if the combined clean-up from all sectors exceeded the total excess clean-up capacity available. For this purpose, a total excess clean-up capacity above the normal stripping rate was assumed to be 30%.

Having determined the earliest year of pit abandoment for either of the above two reasons, this year was then used to adjust the benefits and costs obtained during the BNCST runs. Specifically, the benefits and costs for all sectors were reduced to zero from this year to the end of the mine life. Afterwards, the cost associated with pit abandonment was assigned for that period, where the cost primarily consisted of total net lost profit. All these steps were performed using the post processing program, KPOSTP, listed in Appendix J.

In order to perform post processing, the results from the normal benefit-cost analysis, e.g., the benefits and costs for each simulation of all sectors for the three designs, had to be written to a tape. The tape was then read by the post processing program and results were compared across the sectors for the three pit designs.

The results from post processing are given in Table 28. After post processing, the NPV of the 28° design is $57,021,000 and the NPV of the 35° design is $58,948,000. In the case of the 45° design, the NPV is $51,130,000 after post processing. This is an additional reduction of approximately $10,000,000 due to post processing. The 35° pit unquestionably becomes the most economical.

As a matter of curiosity, a study was conducted on undrained pits. Results obtained are shown in Fig. 27 with those of drained pits. The results suggest that the optimum slope angle for undrained pits lies between 28° and 35°.

Table 28 - Final post processing results

CASE SUMMARY FOR CASE NUMBER 1 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
AFTER POST PROCESSING
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145471.	145435.	145435.	145435.	145471.
145471.	145471.	145435.	145471.	144026.
145435.	145435.	145471.	145435.	145471.
145471.	144026.	145471.	145435.	145471.
145471.	145471.	145471.	145435.	145471.
145471.	145471.	145435.	145471.	145471.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

88120.	88300.	88205.	88180.	88091.
88509.	88404.	88275.	88362.	89349.
88311.	88159.	88068.	88897.	88392.
88629.	89390.	88051.	87932.	88160.
88083.	87928.	88235.	88278.	88061.
88357.	88223.	88479.	88621.	88203.

SUMMARY OF BENEFITS AND COSTS FOR CASE 1

AVERAGE PRESENT VALUE OF BENEFITS 145363.

STANDARD DEVIATION OF BENEFITS 364.

AVERAGE PRESENT VALUE OF COSTS 88342.

STANDARD DEVIATION OF COSTS 350.

CASE SUMMARY FOR CASE NUMBER 2 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
AFTER POST PROCESSING
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

142463.	144116.	144116.	144116.	144116.
145412.	144116.	144116.	142463.	140710.
144116.	142463.	144116.	142463.	140710.
144116.	144116.	144116.	144116.	142463.
144116.	145412.	144116.	142463.	145412.
144116.	144116.	140710.	144116.	142463.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

84627.	84454.	84540.	84281.	84751.
84237.	84480.	84423.	84762.	85510.
84312.	84642.	84409.	84651.	85320.
84986.	84397.	84631.	84383.	84697.
84667.	83799.	84091.	84811.	83686.
84020.	84466.	85377.	84593.	85137.

SUMMARY OF BENEFITS AND COSTS FOR CASE 2

AVERAGE PRESENT VALUE OF BENEFITS 143519.

STANDARD DEVIATION OF BENEFITS 1291.

AVERAGE PRESENT VALUE OF COSTS 84571.

STANDARD DEVIATION OF COSTS 419.

Table 28 cont'd.

CASE SUMMARY FOR CASE NUMBER 3 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
AFTER POST PROCESSING
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

83610.	83035.	83073.	83040.	82955.
82519.	83159.	83068.	83380.	83137.
82850.	83535.	83159.	83579.	83662.
83095.	82736.	83145.	83615.	83459.
83007.	82869.	82991.	83495.	82743.
82957.	83094.	83048.	82990.	82228.

SUMMARY OF BENEFITS AND COSTS FOR CASE 3

AVERAGE PRESENT VALUE OF BENEFITS	134238.
STANDARD DEVIATION OF BENEFITS	0.
AVERAGE PRESENT VALUE OF COSTS	83108.
STANDARD DEVIATION OF COSTS	332.

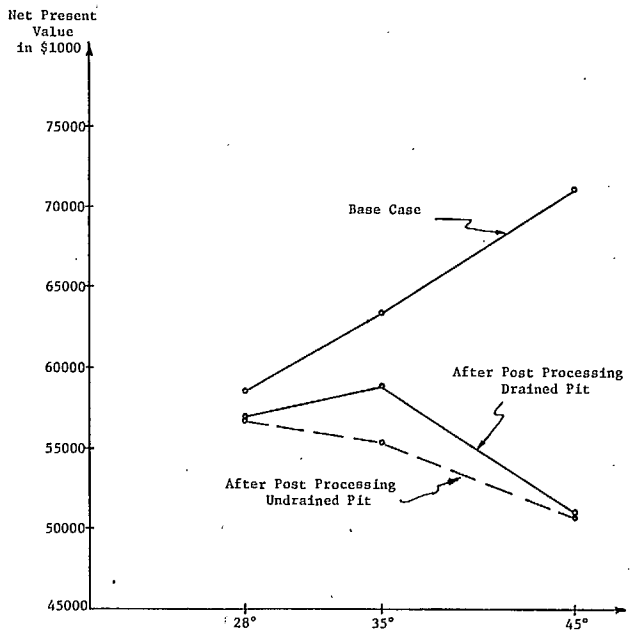


Fig. 27 - Summary of results

The reason for the change in the results from the regular benefit-cost analysis can be traced by examining the two steps performed in post processing. The results from testing for the earliest period of pit abandonment in any sector (see Table 29) are very similar to the results from the run including instability costs but prior to post processing (Table 27). The NPV for this first step in the post processing run is $57,171,000 for the 28° pit, $61,361,000 for the 35° pit, and $61,004,000 for the 45° pit. For the 28° pit, this NPV is only $26,000 less than the NPV from the prior BNCST run. The NPV for the 45° pit is exactly the same. The NPV for the 35° pit decreased by $128,000 from the prior BNCST run.

The run including the above test plus an additional test to determine if adjustments were required when the clean-up became too excessive produced the final results as given in Table 28 earlier.

Table 29 - Post processing results (first step)

CASE SUMMARY FOR CASE NUMBER 1 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
AFTER POST PROCESSING
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145471.	145435.	145435.	145435.	145471.
145471.	145471.	145435.	145471.	145435.
145435.	145435.	145471.	145435.	145471.
145471.	145471.	145471.	145435.	145471.
145471.	145471.	145471.	145435.	145471.
145471.	145471.	145435.	145471.	145471.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

88120.	88300.	88205.	88180.	88091.
88509.	88404.	88275.	88362.	88550.
88311.	88159.	88068.	88897.	88392.
88629.	88556.	88051.	87932.	88160.
88083.	87928.	88235.	88278.	88061.
88357.	88223.	88479.	88621.	88203.

SUMMARY OF BENEFITS AND COSTS FOR CASE 1

AVERAGE PRESENT VALUE OF BENEFITS 145458.

STANDARD DEVIATION OF BENEFITS 18.

AVERAGE PRESENT VALUE OF COSTS 88287.

STANDARD DEVIATION OF COSTS 223.

CASE SUMMARY FOR CASE NUMBER 2 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
AFTER POST PROCESSING
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145412.	145412.	145412.	145412.	145412.
145412.	145412.	145412.	145412.	145412.
145412.	145412.	145412.	145412.	145412.
145412.	145412.	145412.	145412.	145412.
145412.	145412.	145412.	145412.	145412.
145412.	145412.	145412.	145412.	145412.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

84112.	83914.	84001.	83741.	84211.
84237.	83940.	83883.	84285.	84564.
83772.	84127.	83871.	83937.	84286.
84448.	83857.	84091.	83842.	84439.
84127.	83799.	83552.	84408.	83686.
83479.	83926.	84216.	84053.	84716.

SUMMARY OF BENEFITS AND COSTS FOR CASE 2

AVERAGE PRESENT VALUE OF BENEFITS 145412.

STANDARD DEVIATION OF BENEFITS 0.

AVERAGE PRESENT VALUE OF COSTS 84051.

STANDARD DEVIATION OF COSTS 294.

Table 29 cont'd.

CASE SUMMARY FOR CASE NUMBER 3 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

84677.	84306.	84448.	84209.	84125.
83644.	84358.	84399.	84530.	84256.
84103.	85041.	84482.	84876.	84930.
84317.	84141.	84463.	84888.	84823.
84581.	84193.	84565.	84813.	83908.
84382.	84769.	84419.	83961.	83614.

SUMMARY OF BENEFITS AND COSTS FOR CASE 3

AVERAGE PRESENT VALUE OF BENEFITS	145411.
STANDARD DEVIATION OF BENEFITS	0.
AVERAGE PRESENT VALUE OF COSTS	84407.
STANDARD DEVIATION OF COSTS	361.

In Table 30, all the results obtained before and after post processing have been tabulated. By comparing the results from the first and the second steps in post processing, it can be seen that the NPV of the 28° design decreased by only $150,000, implying that there was no pit abandonment due to excessive clean-up for this design. The NPV of the 35° design, however, decreased by $2,413,000, while the NPV of the 45° design decreased by $9,874,000, due to pit abandonment from excessive clean-up.

This earlier pit abandonment can be further substantiated by observing cost model statistics gathered during the normal benefit-cost run and later output during post processing. Table 31 is the output of these statistics which include the number of subroutine calls made to each cost model, the average cost of a call, and the standard deviation of the costs. It is quite apparent that all subroutine calls, particularly those involving clean-up of any type, occurred more frequently for the 45° design than for the 28° and 35° designs. Since each call represented a sampled instability, those requiring clean-up were greater for the 45° design.

The NPV of the 35° design is $1,927,000 larger than the NPV of the 28° design at the conclusion of the analysis. It also exceeds the NPV of the 45° design by $7,818,000 at the final analysis. All these results are based on the assumption that the pit would be drained dry.

SENSITIVITY OF RESULTS TO COST ASSUMPTIONS

The sensitivity of this case study to the cost assumptions can be illustrated by comparing the results of the previous two sections of this chapter. The change of the slope from 45° to 35°, shows the dependence of the results on the cost model assumptions with particular emphasis on the clean-up cost model. Two clean-up assumptions that had a direct bearing on the results are: the amount of excessive clean-up allowed per

Table 30 - Summary of results including post processing

	28°	35°	45°
A. Excluding instability costs			
Benefits	$145,471,000	$145,483,000	$145,411,000
Costs	86,900,000	82,086,000	74,362,000
NPV	58,571,000	63,397,000	71,049,000
B. Including instability costs and excluding post processing			
Benefits	145,471,000	145,483,000	145,411,000
Costs	88,274,000	83,994,000	84,407,000
NPV	57,197,000	61,489,000	61,004,000
C. Post processing results (first step)			
Benefits	145,458,000	145,412,000	145,411,000
Costs	88,287,000	84,051,000	84,407,000
NPV	57,171,000	61,361,000	61,004,000
D. Post processing results (second step)			
Benefits	145,363,000	143,519,000	134,238,000
Costs	88,342,000	84,571,000	83,108,000
NPV	57,021,000	58,948,000	51,130,000

year was 30% and no outside contractor was used to perform any clean-up.

Specified clean-up capacity had a direct impact on the results as this figure, 30%, was the only criterion used to determine when to abandon the pit. If this number were changed, the period of pit abandonment could be affected, which would result in changes to the calculated benefits and cost.

The use of an outside contractor would affect results in the same manner. This effect could be to increase the life of the 45° pit and thus would increase the NPV.

Another cost model assumption that could affect the results is that the total amount of coal in a pit wall failure is lost. If this assumption is correct, then the 28° pit should be chosen over the 35° and 45° pits from a conservation of energy standpoint, as the amount of coal lost is least for the 28° design. However, if all coal were not lost, the benefits would be increased, assuming that the cost of recovering this coal is less than the value to be gained. Since the volume of clean-up involving lost coal is greater for the 45° pit than for either the 28° or 35° pit, the gain in benefits would affect the 45° pit more than either the 28° or the 35° pit.

Generally, any of the assumptions made in assigning a cost to a particular instability that acts differentially on the three designs would have an effect on the analysis results, as the above discussion indicates.

In addition, it was assumed that cost

impact specifications could be made from a typical cross section. The outcome could change if cost impacts were determined from the exact pit wall lithologies for all areas in the pit. The results of this case study are sensitive to the assumptions made involving cost models.

Table 31 - Cost model statistics

28 DEGREE DESIGN.

COST MODEL STATISTICS FOR CASE NUMBER 1
(VALUES AVERAGED OVER 30 SIMULATIONS)

MODEL NAME	TOT. NO. OF CALLS	AVERAGE COST	STD. DEV. OF COST
CLEAN-UP--FW	0	0.00	0.00
LOST COAL-FW	2	1272.06	790.29
LSTC+CLNP-FW	2	1077.84	167.21
LSTC+ERMN-FW	2	641.76	515.03
MN ABDNMT-FW	0	0.00	0.00
RE-EST HR-FW	3	81.51	10.86
CL+LC+EM--FW	0	0.00	0.00
INCHL+CLN-FW	1	747.67	0.00
CL(VS MA)-FW	4	778.02	199.41
CLEAN-UP--IR	2	84.79	.00
LST CL NO. 1	182	69.09	40.22
LST CL NO. 2	1213	58.92	46.45
LST CL NO. 3	755	17.94	15.59
MN ABDNMT-IR	0	0.00	0.00
ERLY MNG--IR	132	1.35	.00
INCHL+CLN-IR	0	0.00	0.00
CL(VS MA)-IR	12	1462.34	369.84
CLEAN-UP-BEN	3036	3.14	.00
MA(VS CL)-FW	3	165.18	286.10
MA(VS CL)-IR	13	419.30	186.09

35 DEGREE DESIGN.

COST MODEL STATISTICS FOR CASE NUMBER 2
(VALUES AVERAGED OVER 30 SIMULATIONS)

MODEL NAME	TOT. NO. OF CALLS	AVERAGE COST	STD. DEV. OF COST
CLEAN-UP--FW	0	0.00	0.00
LOST COAL-FW	1	837.20	0.00
LSTC+CLNP-FW	14	526.18	98.39
LSTC+ERMN-FW	13	385.94	88.20
MN ABDNMT-FW	0	0.00	0.00
RE-EST HR-FW	1	94.05	0.00
CL+LC+EM--FW	33	595.30	116.10
INCHL+CLN-FW	0	0.00	0.00
CL(VS MA)-FW	192	993.87	292.58
CLEAN-UP--IR	110	184.24	93.68
LST CL NO. 1	83	71.52	22.88
LST CL NO. 2	845	24.32	45.93
LST CL NO. 3	1144	16.49	26.66
MN ABDNMT-IR	0	0.00	0.00
ERLY MNG--IR	75	1.35	.00
INCHL+CLN-IR	0	0.00	0.00
CL(VS MA)-IR	100	985.48	459.83
CLEAN-UP-BEN	3660	3.14	.00
MA(VS CL)-FW	199	405.29	416.65
MA(VS CL)-IR	64	415.74	419.02

45 DEGREE DESIGN.

COST MODEL STATISTICS FOR CASE NUMBER 3
(VALUES AVERAGED OVER 30 SIMULATIONS)

MODEL NAME	TOT. NO. OF CALLS	AVERAGE COST	STD. DEV. OF COST
CLEAN-UP--FW	0	0.00	0.00
LOST COAL-FW	0	0.00	0.00
LSTC+CLNP-FW	2	710.70	72.98
LSTC+ERMN-FW	64	365.03	172.52
MN ABDNMT-FW	0	0.00	0.00
RE-EST HR-FW	3	62.70	28.73
CL+LC+EM--FW	144	371.40	120.08
INCHL+CLN-FW	201	1003.79	302.73
CL(VS MA)-FW	853	1705.93	775.97
CLEAN-UP--IR	1437	229.19	235.46
LST CL NO. 1	242	148.16	103.19
LST CL NO. 2	1533	59.93	20.54
LST CL NO. 3	1346	34.45	18.78
MN ABDNMT-IR	0	0.00	0.00
ERLY MNG--IR	375	5.24	4.20
INCHL+CLN-IR	35	300.17	123.31
CL(VS MA)-IR	18	1526.07	292.85
CLEAN-UP-BEN	1240	3.14	.00
MA(VS CL)-FW	150	0.00	0.00
MA(VS CL)-IR	0	0.00	0.00

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

CONCLUSIONS

Coal is lost whenever instability occurs due to intermingling of waste with coal. Therefore, maintaining steeper slopes will not necessarily result in more coal recovered if the number and size of slides are excessive.

The three cases had different degrees of stability. The total NPV costs of instability for all simulations are $46,500,000 for the 28° pit, $239,820,000 for the 35° pit, and $597,570,000 for the 45° pit. The difference is over one order of magnitude greater for the 45° pit than either the 28° or 35° pit. The average number of calls per simulation were calculated for 28°, 35° and 45° respectively as: 78, 96 and 213, and the average cost per simulation was $1.5M, $8.0M and $19.9M.

Taking into account the cost of stripping led to the conclusion that the optimum slope angle is 35°. This conclusion is based on the assumption that the pit would be drained dry. If this assumption is not met, the optimum slope angle would be between 28° and 35°.

The benefit-cost analysis was difficult to perform due to the lithology of the strata. Correlation of coal seams was difficult. Composite cross sections also had to be constructed for wingwalls to assist in specifying cost models.

ACKNOWLEDGEMENTS

The management of the Kemmerer Coal Company, Frontier, Wyoming, provided the geologic and mining data and permitted the use of proprietary computer programs in the modeling of the deposit and mine sequencing. MINTEC Inc., Tucson, Arizona, cooperated during modeling of the deposits and mine sequencing.

D.F. Coates, R. Sage and G. Herget of CANMET established specifications for the work and reviewed the draft report. R.D. Call, P.J. Visca and S.M. Miller, Pincock, Allen and Holt, Inc. determined the probability of instability schedules used in the case study. H. Geslin, Kemmerer Coal Co. provided information for the cost models. T.E. Hall, University of Arizona, developed Version IV of the BNCST programs which were used in this study.

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APPENDIX A

INPUT DATA LOADING SHEETS FOR THE BNCST MODEL

A DETAILED DESCRIPTION OF INPUT DATA FORMATS

Input Common to All Sectors

This set of data must come first in the data deck for each test case (or each design).

0.1 Title Card (1 Card -20A4)

(TITLE(I), I = 1, 20)

```
LUCKY STAR DEPOSIT      BASE DESIGN 45 DEGREES ULTIMATE SLOPE      HIGH GRADE
```

0.2 Date Card (1 Card - 5A4)

(DATE(I), I = 1, 5)

```
31 JULY 1977
```

0.3 Fixed Variables (Card #1 - 8I10)

NSIM	MXCEL	LPRT	LWRT	LUSBN	LUSCT	NDIAG
30	30	1	0	0	0	0

Fixed Variables (Card #2 - 7F10.0, I10)

REC1	REC2	PRICE	PRIC2	VOLO	VOLW	RATE	KLIFE
0.85	0.70	1400.0	4780.0	11.5	12.2	12.0	12

Input for Each Sector (Data Set Type 1)

This first set of data cards must come first for each sector followed by the second set of input data for this sector. This first set consists of the sector ID card, Working Face Card. These two cards may be in any order as long as each of them is present in the first sector's data set. Each card is read in with a format (A4,6X,7F10.0).

1.1 Sector Card (1 Card)

ID	ISCN	SECBT[1]
SECTOR	1	2300

1.2 Working Face Card (1 Card)

ID	BENHT	BENWD	ANGBK	HALWD
BENCH DIM.	40.0	50.0	60.0	120

The ID columns (first 10 columns) of each card must contain its ID words as given by the above examples, starting from column 1. In the program, however, only the first 4 columns are used to identify the card type.

[1] Note: SECBT is the final, expected pit bottom of the sector.

Input for Each Sector (Data Set Type 2)

This second set of data cards follows the first set for this sector. Within this set, input sequence is irrelevant for each kind of data, i.e., probability distribution, haul road, etc. However, within each kind of data, a specific sequence must be followed as shown in the example, i.e., a header card followed by the actual numeric data. All the data for one kind must follow the header card, prior to reading in the next header card. The input data formats for each kind of data are variable and they are given in the example.

2.1 Probability Distributions Deck. Format (A4,1X,A3,2X,11F5.0)

Header Card (1 Card)

```
PROB
```

Numeric Data Cards (one height card followed by a maximum of six probability cards).

```
ID    DIT    (HEIT (J,1), J = 1, 10)
   1        0   200  400  600  800 1000 1200 1400 1600 1800
```

```
ID    DIT    (PROB (I,K,1), K = 1, 10), 1 = 1, MXPRB)          PANG(I,1)
   1        0.0  0.02  .04  .06  .09  .10  .10  .11  .12  .12  11.5
```

Distributions are expected to be in ascending order of wall angle. The first distribution must be for the smallest wall angle and the last for the largest wall angle planned for by the pit designer. Each distribution is represented by one probability card. The program checks the ID field for a header name only, and if the field does not contain a header name, the program ignores this field. Therefore, it can be used for user's own identifications, i.e., sector number and test case number. No special ending card is used.

```
WEAK
```

If there is a weak stratum in the sector, probability distributions associated with this stratum are input following the header card WEAK which can only follow the last probability data card under header card PROB. The format is the same as that given under "PROB" above.

**Optional Input Features -- Ditto Field -- Instability Probability

"DITTO" punched in the ditto field (columns 6-10) causes the program to use the immediately preceding sector's input data for this sector. If "DITTO" appears on a card in the nth distribution position, the probabilities from the preceding sector for the nth position are used. Obviously, the ditto capability cannot be used for the first sector of each case.

2.2 Instability Cost Type Cards. Format (A4,1X,A3,2X,I5,14(I1,3X))

Header Card (1 Card)

INSTAB														

Numeric Data Cards (One card for each period during which there can be an instability).

ID	DIT	KPD	MSTFH (KPD)	MSHWK (1,KPD)								MSHWK (11,KPD)	MSBNB (KPD)	MSWKB (KPD)
1			32	2										
1	DIT		5											

Note that instability cost type cards are an exception to the standard Type 2 data formats. Only four columns are allowed for each instability cost type variable. Each type entry must be a left justified digit.

Periods prior to the earliest period that is input will be zeroed, implying that no instability can occur during those periods. Any missing period that falls after the earliest period will be filled with the preceding period's input, until a later period appears in the data stream. This filling process continues until the last period of the mine's life. Instability cost types may be input here for Full Wall (MSTFH), Interramp Walls (MSHWK), Single Bench (MSBNB) and a Weak Stratum (MSWKB) wall in the pit wall (not pushback wall). Only one cost type for each wall is read in during each period.

** Optional Input Features -- Ditto Field -- Instability Cost Types

"DITTO" in columns 6-10 means ditto instability cost types of previous period for this period. It accomplishes the same purpose as the missing period in the input data stream.

2.3 Haul Road Elevation Cards. Format (A4,1X,A3,2X,6(I5,F5.0))

```
HAUL ROADS
```

Numeric Data Cards (as many as required within each set).

```
                    HELEL       HELEL       HALEL                       HALEL
 ID   DIT   KPD (I,KPD) KPD (I,KPD) KPD (I,KPD)                   KPD (I,KPD)
            2 3220      3 3140      5 3020      8 2940
      END
```

The first set of cards must contain the elevations of the uppermost haul road by period, among one or more haul roads that may be present in a sector during the mine life. Similarly, the second set of cards must contain the elevations of the second highest haul road during each period. Therefore, the total number of the sets required is equal to the maximum number of haul roads that are present in that sector, at any period of mine life. Each set of cards is terminated by an "END" card. The "END" card after the set containing the lowest haul road elevations is optional, however.

Within each set of cards, one card may contain the elevations for up to six distinct periods. Missing periods are given preceding period's value, except elevations before first input period are set to 99999.

Up to five haul road sets may be input. If there are fewer haul roads than the maximum number specified for the sector in a given period, the missing lower haul roads must be indicated by inserting an elevation of 99999 for that period.

2.4 Working Bench Elevation and Width Cards. Format (A4,1X,A3,2X,4(I5,2F5.0))

```
WORK BENCH
                    WRKEL  WRKWD       WRKEL  WRKWD                    WRKEL  WRKWD
 ID   DIT   KPD (I,KPD) (I,KPD) KPD (I,KPD) (I,KPD)        ...     KPD (I,KPD) (I,KPD)
      END
```

Input data procedures are identical to those of Haul Roads, except that corresponding width must be entered for each elevation.

2.5 Starting (Top) Elevation of Sector Cards. Format (A4,IX,A3,2X,6(I5,F5.0))

STELS													
ID	DIT	KPD	STELS (KPD)	KPD	STELS (KPD)	KPD	STELS (KPD)		...	KPD	STELS (KPD)		

Each card may contain one to six periods. Missing periods are given preceding period's value except values before first input period are set to 99999.

"END" after the last card is optional.

2.6 Sector Width Cards. Format (A4,1X,A3,2X,6(I5,F5.0))

SWID													
ID	DIT	KPD	SECWD (KPD)	KPD	SECWD (KPD)				...	KPD	SECWD (KPD)		

Same as for Starting Elevations of Sector cards except widths before first input period are set to zero.

2.7 Pit Bottom Elevation Cards. Format (A4,1X,A3,2X,6(I5,F5.0))

PIT BOTTOM													
ID	DIT	KPD	PITBT (KPD)	KPD	PITBT (KPD)				...	KPD	PITBT (KPD)		
1			1 34.20		2 318.0		3 302.0		4 294.0		5 28.20		6 274.0
1			7 27.00		8 266.0		9 254.0		10 240.0		11 23.40		
	END												
ID	DIT	KPD	ULTBT (KPD)	KPD	ULTBT (KPD)				...	KPD	ULTBT (KPD)		
1			1 34.20		7 326.0		8 306.0		10 278.0		11 25.80		12 23.40
	END												

ID	DIT	KPD	WEKBT (KPD)	KPD	WEKBT (KPD)	...
			1 33 20			

Two different sets of elevation cards may be input under "PIT BOTTOM" header card, separated by a card with "END" left justified in the ditto field. These sets must be in the following sequence of (1) pit bottom elevations, (2) ultimate wall bottom elevations. Each card may contain one to six periods for this sector. Missing periods are given preceding period's input value, except periods before the first input period are set to the corresponding Starting Elevation value.

If a weak stratum is to be tested its bottom elevations must be given here following all other elevation cards.

**Optional Features -- Ditto Field -- Pit Bottom Elevations

"ALL" in columns 6-8 causes the program to ditto this period and all the remaining periods for this sector from the previous sector. Therefore, the next card should be an "END" card or next header card.

"DITTO" in columns 6-8 means ditto only those periods given on this card from the corresponding periods of the previous sector.

2.8 Ultimate Wall Angles and Elevations Card. (A4,1X,A3,2X,12F5.0)

ULTIMATE											
ID	DIT	ANGU (I)	ULTDV (I)								

A total of six sets of ultimate wall values, each consisting of an ultimate wall angle and the corresponding ultimate wall bottom elevation, may be input on the card. Only one such card is accepted.

2.9 Production Figures Cards (Values in thousands). Format (A4,1X,A3,2X,6(I5,F5.0))

Three different header cards may be input for three different types of production figures. These are for Type 1 ore, Type 2 ore, and waste (or stripping). Each header card must be immediately followed by the numeric data cards as shown by the example below. The example is for waste rock.

WASTE								
ID	DIT	KPD	WASTE (1,KPD)	KPD	WASTE (1,KPD)	...	KPD	WASTE (1,KPD)
1		2	15.87	3	54.52	4	154.35	5	147.01	6	20.91	3	7.28	8.57
1		8	3.44	8	9	9	38.90	7	10.38	0	7.2	1	112.43	0	12	0
	END															

ORE1		Header card for Type 1 ore data.
ORE2		Header card for Type 2 ore data.

Each card may contain one to six periods for the sector.[2] Missing periods are given previous period's value, except periods before the first input period are set to zero. It is important to input the last active year's value for the sector, followed by a "ZERO" value for the immediately following period, if the mining ceases sooner than the life of the mine.

"END" in columns 6-8 of a card following the data cards is optional.

**Optional Features -- Ditto Field -- Production Figures

"ALL" in columns 6-8 causes the program to ditto this period and all the remaining periods for this sector from the previous sector.

"DITTO" in columns 6-10 means ditto only those periods given on this card from the corresponding periods of the previous sector.

[2] Note: In practice, however, it may be more convenient to lump production figures from the entire pit and assign these figures to one sector.

2.10 Mining Cost Cards (Cost/unit weight). Format (A4,1X,A3,2X,6(I5,F5.0))

For each type of production figure that was input, its associated total mining costs (including the processing costs in case of ore) must be input. Again, three different header cards as shown below may be used to distinguish each type of cost. Each header card must be immediately followed by the numeric data cards. Input formats for the numeric data as well as the optional features are identical to those given for the PRODUCTION DATA CARDS (see 2.9).

CMNW	Header card for the cost of mining the waste -- in cost/unit weight.
CMN1	Header card for the cost of mining and processing the Type 1 ore -- in cost/unit weight.
CMN2	Header card for the cost of mining and processing the Type 2 ore -- in cost/unit weight.

2.11 Ore Grade Cards (Percent). Format (A4,1X,A3,2X,6(I5,F5.0))

Two header cards are used to separate the grades between two types of ore as shown below. Same comments and features apply for this set of data as for the PRODUCTION DATA CARDS.

AVG1	Header card for the grade of Type 1 ore in percent.
AVG2	Header card for the grade of Type 2 ore in percent.

2.12 Miscellaneous Data. Format (A4,1X,A3,2X,I10,5E10.0)

MISC									
	ID	DIT	KPD	SMISC (1,KPD)		...		SMISC (5,KPD)	

Five miscellaneous values may be input each year. No filling or ditto capability is provided.

2.13 Names of Units Cards. Format (A4,1X,A3,A1,1X,5A4) (Use of these cards is optional in the program.)

```
UNITS
          EXT
ID    UID↓    (UNIT(I,J), J = 1,5)
      ANGR RADIANS
```

The names appropriate for the system of units used by the user for the input data may be entered, one per card with the following unit identification and extension. A maximum of 20 characters may be in each name. Note that these names are used only for labeling the output. Hence, it is the user's responsibility to input data that are consistent with the unit names employed.

UID	EXT	Default Name	Description
LEN	None	FOOT	Unit of linear measurement
VOL	None	CUBIC FEET PER TON	Unit of volume
WTO	None	TON	Unit of weight for ore
WTM	None	TON	Unit of weight for end product
ANG	R	DEGREE	Unit of input angles R extension -- Radians must be input Otherwise -- Degrees must be input
INT	F	PERCENT	Form of input percentages F extension -- Fractions must be input Otherwise -- Percentages must be input
MON	None	DOLLAR	Unit of money

2.14 Ending Control Cards. (2 Cards)

END SECTOR Header or control card to signal the end of one sector data. This card is required at the end of each sector input data.

STOP CASE Header or control card to signal the end of one design case. This card is required at the end of each design case.

APPENDIX B

80-80 LISTINGS OF ALL INPUT DATA FOR ALL SECTORS OF THREE DESIGNS

CASE 1

```
BIG PIT - 28 DEGREE DESIGN  - CANADAIAN TEST CASE- DRAINED PIT
JULY 1978
      30        30         1         0         0         0         1         1
     1.0         0      12.0         0      25.3      14.2      12.0        24
SECTOR           1      6400
BENCH DIM.     100.0     130.3      60.0      60.0
PROB
   1        50  100  200  300  500  600  700  800  950
   1      0000000000000000000000000000000000000000000        5.0
   1      .0010.0010.0010.0010.0010.0010.0010.0010.0010       20.9
   1      .0010.0010.0010.0010.0010.0010.0010.0010.0010       22.1
   1      .0010.0010.0010.0010.0010.0010.0010.0020.0030       28.0
   1      .0010.0310.5150.9990.9990.9990.9990.9990.9990       60.0
INSTAB
            10   0   3   0   0   0   0   0   0   0   0   0   1   0
            20   0   4   6   0   0   0   0   0   0   0   0   1   0
            32   0   3   0   0   0   0   0   0   0   0   0   1   0
            42   0   4   3   0   0   0   0   0   0   0   0   1   0
            52   0   3   6   0   0   0   0   0   0   0   0   1   0
            62   0   4   3   0   0   0   0   0   0   0   0   1   0
            72   0   4   4   3   0   0   0   0   0   0   0   1   0
            82   0   4   3   6   0   0   0   0   0   0   0   1   0
            92   0   4   0   6   0   0   0   0   0   0   0   1   0
           102   0   0   3   3   0   0   0   0   0   0   0   1   0
           112   0   4   0   3   0   0   0   0   0   0   0   1   0
           123   0   0   4   3   6   0   0   0   0   0   0   1   0
           133   0   0   3   4   6   0   0   0   0   0   0   1   0
           143   0   0   4   3   4   0   0   0   0   0   0   1   0
           153   0   4   4   3   0   0   0   0   0   0   0   1   0
           163   1   4   4   3   0   0   0   0   0   0   0   1   0
           173   1   4   4   0   0   0   0   0   0   0   0   1   0
           183   1   0   4   0   0   0   0   0   0   0   0   1   0
           199   9   0   3   0   0   0   0   0   0   0   0   1   0
           209   9   3   0   0   0   0   0   0   0   0   0   1   0
           219   9   0   4   0   0   0   0   0   0   0   0   1   0
           229   9   0   0   0   0   0   0   0   0   0   0   1   0
     BIT   23
     DIT   24
WORK BENCH
            1 7400  500    2 7300  550    3 7300  600    6 7300  500
            9 7200  500   10 7300  450   11 7200  500   12 7300  500
           14 7200  500   16 7100  500   18 7000  500   19 6900  500
           21 6800  500   22 6600  500   2399999  000
     END
            1 7300  500    2 7200  550    3 7100  400    4 7200  600
            5 7100  600    6 7200  600    7 7200  550    9 7100  550
           10 7200  600   11 7100  600   12 7200  500   14 7100  500
           15 7000  450   18 6900  450   19 6800  450   20 6700  400
           2299999  000
     END
            6 7000  400    7 7100  600    8 7000  600   10 7000  500
           11 7000  550   12 7100  600   13 7000  600   15 6900  600
           17 6800  600   19 6700  500   2099999  000
     END
            7 7000  450    899999  000   10 6900  450   12 6900  550
           15 6800  450   1699999  000
     END
STELS
            1 7400
SWID
            1 1400    2 1800    4 2000    8 2200   14 2400   19 2600
PIT BOTTOM
            1 7100    3 7000    6 6900   10 6850   11 6800   14 6750
           16 6700   19 6650   20 6600   21 6550   22 6500   23 6450
     END
            1 7400   12 7300   14 7200   16 7100   18 7000   19 6900
           21 6800   22 6700   23 6500   24 6450
     END
ULTIMATE
           28 6400
WASTE
            110670    2 8273    3 8191    4 9792    5 8065    6 9162
            710801    8 7959    9 8840   1010100   1111346   12 7573
           13 7894   1410827   15 9713   16 8145   17 7266   18 8397
           19 8357   20 7136   21 5950   22 6800   23 3803   24   00
ORE1
            1 2726    2 2306    3 2580    4 2547    5 2366    6 2576
            7 2598    8 2486    9 2345   10 2523   11 2498   12 2481
           13 2476   14 2565   15 2461   16 2585   17 2422   18 2515
           19 2478   20 2552   21 2425   22 2617   23 2546   24   74
CHNW
            1 1.25
CHN1
            1 4.50
AVG1
            1 100.
UNITS
     LEN  FEET
     VOL  CUBIC FEET
     WTO  TON
     WTM  TON
     MON  DOLLAR
END SECTOR
```

CASE 1

```
SECTOR              2      6400
BENCH DIM.      100.0     130.3      60.0      60.0
PROB
    1          50  100  200  300  400  600  700  800  950
    1       .0010.0010.0010.0010.0010.0010.0010.0010.0010      13.0
    1       .0010.0010.0010.0010.0010.0010.0010.0010.0010      20.0
    1       .0010.0010.0010.0030.0030.0050.0080.0110.0200      28.0
    1       .0010.0310.5150.9990.9990.9990.9990.9990.9990      60.0
INSTAB
                10   0   0   0   0   0   0   0   0   0   0   0   1   0
                24   0   0   0   0   0   0   0   0   0   0   0   1   0
                34   3   0   0   0   0   0   0   0   0   0   0   1   0
     DIT        4
     DIT        5
                64   4   4   0   0   0   0   0   0   0   0   0   1   0
     DIT        7
                84   3   3   0   0   0   0   0   0   0   0   0   1   0
                94   2   0   0   0   0   0   0   0   0   0   0   1   0
               104   3   3   3   0   0   0   0   0   0   0   0   1   0
               114   3   4   0   0   0   0   0   0   0   0   0   1   0
               124   2   3   3   3   0   0   0   0   0   0   0   1   0
               134   3   3   0   0   0   0   0   0   0   0   0   1   0
               144   0   3   4   0   0   0   0   0   0   0   0   1   0
               154   0   2   0   0   0   0   0   0   0   0   0   1   0
               167   1   4   0   0   0   0   0   0   0   0   0   1   0
               177   1   0   0   0   0   0   0   0   0   0   0   1   0
     DIT       18
               198   8   0   0   0   0   0   0   0   0   0   0   1   0
     DIT       20
               219   9   0   0   0   0   0   0   0   0   0   0   1   0
     DIT       22
     DIT       23
     DIT       24
WORK BENCH
                2 7200  250    3 7100  250    4 7200  350    5 7100  350
                6 7200  350    7 7200  270    9 7100  270   10 7200  370
               11 7200  300   14 7200  330   16 7100  320   18 7000  320
               19 6900  320   21 6800  320   22 6700  320  2399999  000
     END
                4 7100  200    599999  000    7 7100  350    8 7000  300
               10 7100  270   11 7100  370   13 7000  370   14 7100  300
               15 7000  300   16 7000  320   18 6900  320   19 6800  320
               2199999  000
     END
               11 7000  250   13 6900  250   14 7000  370   15 6900  370
               16 6900  350   1799999  000
     END
               14 6900  250   1599999  000
     END
STELS
                2 7300
SWID
                2  800    5 1000    7 1200    9 1400   13 1600   15 1800
               18 2000
PIT BOTTOM
                2 7100    3 7050    5 7000    8 6900   12 6850   13 6800
               19 6700   22 6600   23 6500
     END
               14 7200   16 7100   18 7000   19 6900   21 6800   22 6700
               23 6600   24 6500
     END
ULTIMATE
               28 6500
CMNW
     ALL
CMN1
     ALL
END SECTOR
```

CASE 1

```
SECTOR              3       6400
BENCH DIM.      100.0        0.0       18.0       60.0
PROB
    1           0  200  400  600  800 1000 1200
    1      00000.0010.0010.0010.0010.0010                    30.
    1      00000.0010.0010.0010.0010.0010                    64.
    1      00000.0010.0010.0010.0010.0010                    90.
INSTAB
                16   0   0   0   0   0   0   0   0   0   0   0   0   0
     DIT         2
     DIT         3
     DIT         4
     DIT         5
     DIT         6
     DIT         7
     DIT         8
     DIT         9
     DIT        10
     DIT        11
     DIT        12
     DIT        13
     DIT        14
     DIT        15
     DIT        16
     DIT        17
     DIT        18
     DIT        19
     DIT        20
               215   0   0   0   0   0   0   0   0   0   0   0   0   0
     DIT        22
     DIT        23
     DIT        24
STELS
                1 7200
SWID
                1 1200    2 1600
PIT BOTTOM
                1 7100    3 7000    6 6900   10 6800   14 6700   19 6600
               21 6500   23 6400
     END
                1 7100    3 7000    6 6900   10 6800   14 6700   19 6600
               21 6500   23 6400
     END
ULTIMATE
               18 6360
CMNW
     ALL
CMN1
     ALL
END SECTOR
```

CASE 1

```
SECTOR              4       6400
BENCH DIM.      100.0      130.3       60.0       60.0
PROB
    1          50  100  200  300  400  600  700  800  950
    1       .0010.0010.0010.0010.0010.0010.0010.0010.0010        13.0
    1       .0010.0010.0010.0010.0010.0010.0010.0010.0010        20.0
    1       .0010.0010.0010.0030.0030.0050.0080.0110.0200        28.0
    1       .0010.0310.5150.9990.9990.9990.9990.9990.9990        60.0
INSTAB
                10   0   0   0   0   0   0   0   0   0   0   0   1   0
                24   0   0   0   0   0   0   0   0   0   0   0   1   0
                34   3   0   0   0   0   0   0   0   0   0   0   1   0
     DIT        4
     DIT        5
                64   4   4   0   0   0   0   0   0   0   0   0   1   0
     DIT        7
                84   3   3   0   0   0   0   0   0   0   0   0   1   0
                94   2   0   0   0   0   0   0   0   0   0   0   1   0
               104   3   3   3   0   0   0   0   0   0   0   0   1   0
               114   3   4   0   0   0   0   0   0   0   0   0   1   0
               124   2   3   3   3   0   0   0   0   0   0   0   1   0
               134   3   3   0   0   0   0   0   0   0   0   0   1   0
               144   0   3   4   0   0   0   0   0   0   0   0   1   0
               154   0   2   0   0   0   0   0   0   0   0   0   1   0
               167   1   4   0   0   0   0   0   0   0   0   0   1   0
               177   1   0   0   0   0   0   0   0   0   0   0   1   0
     DIT       18
               198   8   0   0   0   0   0   0   0   0   0   0   1   0
     DIT       20
               219   9   0   0   0   0   0   0   0   0   0   0   1   0
     DIT       22
     DIT       23
     DIT       24
WORK BENCH
                1 7400  350    2 7300  350    3 7400  350    4 7400  250
                6 7400  200    7 7400  350   10 7300  370   14 7200  370
               16 7100  350   18 7000  350   19 6900  350   21 6800  350
               2299999  000
     END
                1 7300  250    2 7200  250    3 7200  300    4 7300  250
                5 7200  250    6 7300  200    7 7200  220    9 7100  220
               1099999  000   11 7200  350   14 7100  350   15 7000  350
               17 6900  300   1999999  000
     END
                4 7200  300    599999  000    6 7200  230    7 7100  200
                899999  000
     END
STELS
                1 7430   10 7400
SWID
                1  600    2  800    4 1200    8 1400   13 1600
PIT BOTTOM
                1 7100    6 7000   10 6900   15 6850   16 6800   21 6750
               22 6700
     END
                7 7400   11 7300   14 7200   16 7100   18 7000   19 6900
               21 6800   22 6700
     END
ULTIMATE
               28 6560
CMNW
     ALL
CMN1
     ALL
END SECTOR
STOP CASE
```

CASE 2

```
BIG PIT - 35 DEGREE DESIGN  - CANADAIAN TEST CASE- DRAINED PIT
JULY 1978
        30        30         1         0         0         0         1         2
       1.0         0      12.0         0      25.3      14.2      12.0        24
SECTOR             1      6400
BENCH DIM.     100.0      85.0      60.0      60.0
PROB
    1       100  200  300  400  500  600  700  800 1000
    1      .0010.0010.0010.0010.0010.0010.0010.0010.0010      10.1
    1      .0010.0010.0010.0010.0010.0010.0010.1080.2240      23.0
    1      .0010.0010.0100.0030.0290.0790.1430.2330.4320      35.0
    1      .0180.0520.1570.3970.4130.4430.8410.9990.9990      44.9
    1      .0430.5210.9990.9990.9990.9990.9990.9990.9990      60.0
INSTAB
              10   0   4   0   0   0   0   0   0   0   0   0   1   0
              20   0   4   4   0   0   0   0   0   0   0   0   1   0
              32   0   4   0   0   0   0   0   0   0   0   0   1   0
              42   4   4   0   0   0   0   0   0   0   0   0   1   0
              52   4   3   0   0   0   0   0   0   0   0   0   1   0
     DIT      6
              72   4   4   2   0   0   0   0   0   0   0   0   1   0
              84   0   4   4   3   0   0   0   0   0   0   0   1   0
              93   0   4   0   3   0   0   0   0   0   0   0   1   0
     DIT     10
             113   0   4   0   0   0   0   0   0   0   0   0   1   0
             123   0   3   0   0   0   0   0   0   0   0   0   1   0
             133   4   4   4   0   0   0   0   0   0   0   0   1   0
             143   4   3   4   0   0   0   0   0   0   0   0   1   0
             153   4   4   3   0   0   0   0   0   0   0   0   1   0
             163   4   3   0   0   0   0   0   0   0   0   0   1   0
             173   3   4   0   0   0   0   0   0   0   0   0   1   0
             183   1   2   0   0   0   0   0   0   0   0   0   1   0
             199   9   3   0   0   0   0   0   0   0   0   0   1   0
             209   9   4   0   0   0   0   0   0   0   0   0   1   0
             219   9   4   0   0   0   0   0   0   0   0   0   1   0
             229   9   0   0   0   0   0   0   0   0   0   0   1   0
     DIT     23
     DIT     24
WORK BENCH
              1 7200  700    2 7300  600    3 7200  600    4 7200  700
              6 7100  700    7 7200  700    8 7300  800    9 7200  800
             13 7100  800   15 7000  800   17 6900  800   19 6800  800
             20 6700  800   22 6600  800   23 6500  600   2499999  000
     END
              1 7100  500    2 7200  800    3 7100  800    4 7100  800
              5 7000  800    7 7100  700    8 7200  700    9 7100  700
             12 7000  700   14 6900  700   15 6900  600   16 6800  650
             18 6700  600   2099999  000
     END
              8 7000  700   11 6900  650   1399999  000
     END
STELS
              1 7400
SWID
              1 2400    2 2800    4 2900    8 3000
PIT BOTTOM
              1 7000    4 6900   10 6800   15 6700   18 6600   21 6500
             23 6400
     END
              8 7300    9 7200   13 7100   15 7000   17 6900   19 6800
             20 6700   22 6600   23 6500   24 6400
     END
ULTIMATE
             35 6400
WASTE
              1 8419    2 5740    310341    4 8931    5 5947    6 9469
              710833    810231    913214   10 7247   11 6183   12 9221
             1311417   14 7164   15 9071   16 7915   1710059   18 3820
             19 8986   20 7167   21 4577   22 6609   23 4563   24  113
ORE1
              1 2501    2 2526    3 2547    4 2719    5 2212    6 2653
              7 2431    8 2615    9 2299   10 2653   11 2421   12 2564
             13 2563   14 2384   15 2490   16 2508   17 2607   18 2416
             19 2707   20 2256   21 2526   22 2667   23 2342   24  143
CMNW
              1 1.25
CMN1
              1 4.50
AVG1
              1 100.
UNITS
     LEN  FEET
     VOL  CUBIC FEET
     WTO  TON
     WTM  TON
     MON  DOLLAR
END SECTOR
```

CASE 2

```
SECTOR              2       6400
BENCH DIM.      100.0       85.0       60.0       60.0
PROB
    1          50  150  250  350  450  550  650  750  850
    1       .0010.0010.0010.0010.0010.0010.0010.0010.0010        13.3
    1       .0010.0010.0010.0010.0010.0010.0010.0010.0010        24.0
    1       .0010.0450.0180.0630.0760.1140.2310.3390.4180        35.0
    1       .0010.0350.1570.3250.4410.6620.8310.9990.9990        44.9
    1       .0010.0850.7600.9990.9990.9990.9990.9990.9990        60.0
INSTAB
                10   0   0   0   0   0   0   0   0   0   0   0   1   0
                24   4   0   0   0   0   0   0   0   0   0   0   1   0
     DIT        3
     DIT        4
                54   3   4   0   0   0   0   0   0   0   0   0   1   0
                64   2   0   0   0   0   0   0   0   0   0   0   1   0
                74   3   4   0   0   0   0   0   0   0   0   0   1   0
     DIT        8
     DIT        9
               104   3   3   4   0   0   0   0   0   0   0   0   1   0
               114   3   3   3   0   0   0   0   0   0   0   0   1   0
               124   3   2   0   0   0   0   0   0   0   0   0   1   0
               137   2   4   4   0   0   0   0   0   0   0   0   1   0
               147   2   4   0   0   0   0   0   0   0   0   0   1   0
               157   1   0   0   0   0   0   0   0   0   0   0   1   0
               167   1   4   0   0   0   0   0   0   0   0   0   1   0
               177   1   6   0   0   0   0   0   0   0   0   0   1   0
               187   1   4   0   0   0   0   0   0   0   0   0   1   0
               197   1   6   0   0   0   0   0   0   0   0   0   1   0
               209   9   4   0   0   0   0   0   0   0   0   0   1   0
               219   9   0   0   0   0   0   0   0   0   0   0   1   0
     DIT       22
     DIT       23
     DIT       24
WORK BENCH
                1 7200  350     2 7100  250     3 7200  300     4 7200  210
                5 7200  210     6 7100  220     7 7200  200     8 7200  440
                9 7200  200    10 7200  600    13 7100  450    15 7000  400
               17 6900  400    19 6800  350    21 6700  260   2299999  000
     END
                3 7100  210     4 7100  300     5 7000  150     6 7000  150
                7 7100  200     8 7000  250    10 7100  500    12 7000  400
               13 7000  250    14 6900  350    16 6800  360    19 6700  400
               20 6600  250   2199999  000
     END
                7 7000  200    899999  000    10 7000  250    11 6900  150
              1299999  000    13 6900  185   1499999  000
     END
STELS
                1 7250
SWID
                1 1100     2 1200     4 1700     8 2000    10 2600
PIT BOTTOM
                1 7100     2 7000     5 6900    10 6800    16 6700    18 6600
               20 6500    24 6400
     END
               10 7200    13 7100    15 7000    17 6900    19 6800    21 6700
               22 6600    23 6500    24 6400
     END
ULTIMATE
               35 6400
CMNW
     ALL
CMN1
     ALL
END SECTOR
```

CASE 2

```
SECTOR              3       6400
BENCH DIM.      100.0        0.0       18.0       60.0
PROB
    1           0  200  400  600  800 1000 1200
    1      00000.0010.0010.0010.0010.0010                      30.
    1      00000.0010.0010.0010.0010.0010                      64.
    1      00000.0010.0010.0010.0010.0010                      90.
INSTAB
                16   0   0   0   0   0   0   0   0   0   0   0   0   0
     DIT        2
     DIT        3
     DIT        4
     DIT        5
     DIT        6
     DIT        7
     DIT        8
     DIT        9
     DIT       10
     DIT       11
     DIT       12
     DIT       13
     DIT       14
     DIT       15
     DIT       16
     DIT       17
     DIT       18
     DIT       19
     DIT       20
     DIT       21
               225   0   0   0   0   0   0   0   0   0   0   0   0   0
     DIT       23
     DIT       24
STELS
                1 7200
SWID
                1 1900    2 2200   11 2500   13 2800
PIT BOTTOM
                1 7100    2 7000    4 6900   10 6800   13 6700   18 6600
               21 6500   22 6400
     END
                1 7100    2 7000    4 6900   10 6800   13 6700   18 6600
               21 6500   22 6400
     END
ULTIMATE
               18 6400
CMNW
     ALL
CMN1
     ALL
END SECTOR
```

CASE 2

```
SECTOR              4       6400
BENCH DIM.      100.0       85.0       60.0       60.0
PROB
    1          50  150  250  350  450  550  650  750  850
    1       .0010.0010.0010.0010.0010.0010.0010.0010.0010        13.3
    1       .0010.0010.0010.0010.0010.0010.0010.0010.0010        24.0
    1       .0010.0450.0180.0630.0760.1140.2310.3390.4180        35.0
    1       .0010.0350.1570.3250.4410.6620.8310.9990.9990        44.9
    1       .0010.0850.7600.9990.9990.9990.9990.9990.9990        60.0
INSTAB
                10   0   0   0   0   0   0   0   0   0   0   0   1   0
                24   0   4   0   0   0   0   0   0   0   0   0   1   0
                34   0   0   0   0   0   0   0   0   0   0   0   1   0
                44   3   4   0   0   0   0   0   0   0   0   0   1   0
      DIT       5
                64   4   3   0   0   0   0   0   0   0   0   0   1   0
                74   0   3   0   0   0   0   0   0   0   0   0   1   0
      DIT       8
                94   4   3   0   0   0   0   0   0   0   0   0   1   0
      DIT      10
      DIT      11
               124   3   3   4   0   0   0   0   0   0   0   0   1   0
               137   3   3   4   0   0   0   0   0   0   0   0   1   0
               147   1   4   0   0   0   0   0   0   0   0   0   1   0
               157   1   3   4   0   0   0   0   0   0   0   0   1   0
               167   1   4   0   0   0   0   0   0   0   0   0   1   0
      DIT      17
      DIT      18
      DIT      19
               209   9   0   0   0   0   0   0   0   0   0   0   1   0
               219   9   0   0   0   0   0   0   0   0   0   0   1   0
      DIT      22
      DIT      23
      DIT      24
WORK BENCH
                1 7350  450    4 7350  350    6 7300  450    7 7300  510
                9 7200  505   12 7100  450   14 7000  450   17 6900  300
               19 6800  240   20 6700  150   2299999  000
      END
                1 7300  400    2 7300  350    3 7200  250    4 7300  350
                6 7200  250    8 7100  300   10 7000  300   12 7000  350
               14 6900  350   16 6800  350   17 6800  300   1899999  000
      END
                1 7200  340    299999  000    4 7200  350    6 7100  300
                7 7100  300    8 7000  245   1099999  000   12 6900  150
               1399999  000
      END
STELS
                1 7350
SWID
                1  900    2 1700    4 2400
PIT BOTTOM
                1 7100    4 7100    6 7000    8 6900   12 6800   15 6700
               19 6600   22 6500
      END
                7 7300    9 7200   12 7100   14 7000   17 6900   19 6800
               20 6700   22 6600   23 6550
      END
ULTIMATE
               35 6550
CMNW
      ALL
CMN1
      ALL
END SECTOR
STOP CASE
```

CASE 3

```
BIG PIT - 45 DEGREE DESIGN  - CANADAIAN TEST CASE- DRAINED PIT
JULY 1978
       30        30         1         0         0         0         1         3
      1.0         0      12.0         0      25.3      14.2      12.0        24
SECTOR            1      6350
BENCH DIM.     100.0     42.26      60.0      60.0
PROB
    1        20  100  180  200  280  380  480  580 1000
    1     0.001.0010.0010.0010.0010.0010.0010.0010.0010      10.
    1     0.001.0010.0010.0010.0010.0010.0010.0010.0010      25.
    1     0.001.0010.0010.0010.0010.0010.0010.3670.8000      35.
    1     0.001.0010.0920.3130.5690.8740.8930.9990.9990      45.
    1     0.001.0310.1500.5150.9000.9990.9990.9990.9990      60.
INSTAB
              10   0   0   0   0   0   0   0   0   0   0   0   1   0
              20   0   0   0   0   0   0   0   0   0   0   0   1   0
              32   0   0   6   0   0   0   0   0   0   0   0   1   0
              42   3   3   6   0   0   0   0   0   0   0   0   1   0
              52   0   3   3   0   0   0   0   0   0   0   0   1   0
              62   0   4   4   3   0   0   0   0   0   0   0   1   0
              72   0   4   2   6   0   0   0   0   0   0   0   1   0
              82   0   3   4   6   0   0   0   0   0   0   0   1   0
              93   1   3   3   3   0   0   0   0   0   0   0   1   0
             103   1   4   4   3   0   0   0   0   0   0   0   1   0
             113   1   0   4   3   0   0   0   0   0   0   0   1   0
             123   1   4   6   6   0   0   0   0   0   0   0   1   0
             133   1   4   4   6   0   0   0   0   0   0   0   1   0
             143   1   4   4   0   0   0   0   0   0   0   0   1   0
             153   1   0   4   0   0   0   0   0   0   0   0   1   0
             163   1   4   6   0   0   0   0   0   0   0   0   1   0
             173   1   0   6   0   0   0   0   0   0   0   0   1   0
             183   1   3   6   0   0   0   0   0   0   0   0   1   0
             199   9   0   0   0   0   0   0   0   0   0   0   1   0
     DIT     20
     DIT     21
     DIT     22
     DIT     23
     DIT     24
WORK BENCH
              1 7400  500    2 7300  500    4 7200  500    5 7300  500
              8 7300  550   11 7200  550   13 7100  550   14 7100  600
             15 7000  600   17 6900  600   18 6800  600   19 6700  550
             20 6600  550   2199999  000
     END
              1 7300  450    2 7200  500    4 7100  500    6 7200  500
              8 7100  550    9 7200  500   10 7100  500   11 7100  550
             12 7000  550   14 6900  550   16 6800  550   18 6700  550
             1999999  000
     END
              6 7100  500    7 7000  500    9 7100  550   10 7000  550
             12 6900  550   14 6800  550   1699999  000
     END
STELS
              1 7420    9 7450
SWID
              1  800    2 1800    3 2000    7 2200   11 2400
PIT BOTTOM
              1 7100    3 7000    7 6900   11 6800   13 6750   14 6700
             17 6650   18 6625   19 6600   20 6500   22 6400
     END
              1 7420    9 7300   11 7200   13 7100   15 7000   17 6900
             18 6800   19 6700   20 6600   21 6500
     END
ULTIMATE
             45 6360
WASTE
              1 8991    2 6862    3 7448    4 8370    5 9605    6 8449
              7 6463    8 7792    9 7982   10 8087   11 8206   12 6657
             13 8138   14 8975   15 6617   16 6664   17 6497   18 7462
             19 6352   20 3738   21 4957   22 3163   23 2808   24  808
ORE1
              1 2636    2 2453    3 2421    4 2515    5 2769    6 2378
              7 2394    8 2443    9 2551   10 2525   11 2746   12 2224
             13 2472   14 2484   15 2689   16 2528   17 2407   18 2426
             19 2586   20 2405   21 2485   22 2403   23 1404   24 1404
CMNW
              1 1.25
CMN1
              1 4.50
AVG1
              1 100.
UNITS
     LEN  FEET
     VOL  CUBIC FEET
     WTO  TON
     WTM  TON
     MON  DOLLAR
END SECTOR
```

CASE 3

```
SECTOR              2      6400
BENCH DIM.      100.0     42.26       60.0       60.0
PROB
    1        100  200  300  400  500  600  700  800  900
    1      .0010.0010.0010.0010.0010.0010.0010.0010.0010      13.
    1      .0010.0010.0010.0010.0010.0010.1170.1900.3500      30.
    1      .0010.0010.0010.1340.1450.4910.8900.9500.9990      37.
    1      .0010.3140.6470.7660.8440.9210.9590.9960.9990      45.
    1      .0140.4040.7500.9990.9990.9990.9990.9990.9990      51.7
    1      .0310.5150.9990.9990.9990.9990.9990.9990.9990      60.
INSTAB
                10   0   0   0   0   0   0   0   0   0   0   0   1   0
                24   0   0   0   0   0   0   0   0   0   0   0   1   0
                34   0   3   0   0   0   0   0   0   0   0   0   1   0
     DIT        4
                54   0   0   0   0   0   0   0   0   0   0   0   1   0
                64   0   3   0   0   0   0   0   0   0   0   0   1   0
                74   0   3   4   0   0   0   0   0   0   0   0   1   0
                84   3   4   0   0   0   0   0   0   0   0   0   1   0
                94   3   4   3   0   0   0   0   0   0   0   0   1   0
               104   3   4   0   0   0   0   0   0   0   0   0   1   0
               114   4   4   4   0   0   0   0   0   0   0   0   1   0
               124   4   4   3   0   0   0   0   0   0   0   0   1   0
               134   2   4   0   0   0   0   0   0   0   0   0   1   0
               147   1   3   0   0   0   0   0   0   0   0   0   1   0
               157   1   0   0   0   0   0   0   0   0   0   0   1   0
               167   1   3   0   0   0   0   0   0   0   0   0   1   0
               178   8   0   0   0   0   0   0   0   0   0   0   1   0
     DIT       18
               199   9   0   0   0   0   0   0   0   0   0   0   1   0
     DIT       20
     DIT       21
     DIT       22
     DIT       23
     DIT       24
WORK BENCH
                2 7200  170    5 7100  170    6 7200  170    8 7100  170
                9 7200  210   10 7100  210   11 7200  150   13 7100  170
               15 7000  160   17 6900  160   18 6800  160   20 6700  160
               2199999  000
     END
                4 7100  170   599999  000    6 7100  170    8 7000  170
                9 7100  180   10 7000  180   11 7100  210   13 7000  210
               14 6900  180   16 6800  180   1899999  000
     END
               11 7000  170   12 6900  170   1499999  000
     END
STELS
                2 7300
SWID
                2  900    4 1100    6 1250    9 1400   14 1800   21 1600
PIT BOTTOM
                2 7100    3 7000    7 6900   11 6800   16 6700   19 6600
               21 6500   22 6400
     END
               11 7200   13 7100   15 7000   17 6900   18 6800   20 6700
               21 6600   22 6500
     END
ULTIMATE
               45 6360
CMNW
     ALL
CMN1
     ALL
END SECTOR
```

CASE 3

```
SECTOR              3      6400
BENCH DIM.      100.0       0.0      18.0      60.0
PROB
    1           0  200  400  600  800 1000 1200
    1      00000.0010.0010.0010.0010.0010                    30.
    1      00000.0010.0010.0010.0010.0010                    64.
    1      00000.0010.0010.0010.0010.0010                    90.
INSTAB
               16   0   0   0   0   0   0   0   0   0   0   0   0   0
     DIT        2
     DIT        3
     DIT        4
     DIT        5
     DIT        6
     DIT        7
     DIT        8
     DIT        9
     DIT       10
     DIT       11
     DIT       12
     DIT       13
     DIT       14
     DIT       15
     DIT       16
     DIT       17
     DIT       18
     DIT       19
     DIT       20
     DIT       21
     DIT       22
               235   0   0   0   0   0   0   0   0   0   0   0   0   0
     DIT       24
STELS
                1 7200
SWID
                1 1200    2 1600
PIT BOTTOM
                1 7100    3 7000    6 6900   10 6800   14 6700   19 6600
               21 6500   23 6400
     END
                1 7100    3 7000    6 6900   10 6800   14 6700   19 6600
               21 6500   23 6400
     END
ULTIMATE
               18 6360
CMNW
     ALL
CMN1
     ALL
END SECTOR
```

CASE 3

```
SECTOR              4       6400
BENCH DIM.      100.0      42.26       60.0       60.0
PROB
    1        100  200  300  400  500  600  700  800  900
    1       .0010.0010.0010.0010.0010.0010.0010.0010.0010        13.
    1       .0010.0010.0010.0010.0010.0010.1170.1900.3500        30.
    1       .0010.0010.0010.1340.1450.4910.8900.9500.9990        37.
    1       .0010.3140.6470.7660.8440.9210.9590.9960.9990        45.
    1       .0140.4040.7500.9990.9990.9990.9990.9990.9990        51.7
    1       .0310.5150.9990.9990.9990.9990.9990.9990.9990        60.
INSTAB
                10   0   0   0   0   0   0   0   0   0   0   0   1   0
                24   0   0   0   0   0   0   0   0   0   0   0   1   0
                34   0   3   0   0   0   0   0   0   0   0   0   1   0
      DIT       4
                54   0   0   0   0   0   0   0   0   0   0   0   1   0
                64   0   3   0   0   0   0   0   0   0   0   0   1   0
                74   0   3   4   0   0   0   0   0   0   0   0   1   0
                84   3   4   0   0   0   0   0   0   0   0   0   1   0
                94   3   4   3   0   0   0   0   0   0   0   0   1   0
               104   3   4   0   0   0   0   0   0   0   0   0   1   0
               114   4   4   4   0   0   0   0   0   0   0   0   1   0
               124   4   4   3   0   0   0   0   0   0   0   0   1   0
               134   2   4   0   0   0   0   0   0   0   0   0   1   0
               147   1   3   0   0   0   0   0   0   0   0   0   1   0
               157   1   0   0   0   0   0   0   0   0   0   0   1   0
               167   1   3   0   0   0   0   0   0   0   0   0   1   0
               178   8   0   0   0   0   0   0   0   0   0   0   1   0
      DIT      18
               199   9   0   0   0   0   0   0   0   0   0   0   1   0
      DIT      20
      DIT      21
      DIT      22
      DIT      23
      DIT      24
WORK BENCH
                2 7300  450    3 7400  300    5 7400  200    6 7400  300
                7 7400  250    9 7300  250   11 7200  250   13 7100  250
               15 7000  250   16 6900  250   18 6800  210   1999999  000
      END
                2 7200  400    3 7300  450    4 7200  450    5 7200  120
                6 7300  150    7 7300  130    8 7200  100   10 7100  100
               12 7000  100   14 6900   90   1699999  000
      END
                3 7200  350    4 7100  250    6 7200  120    7 7200  100
                8 7100  120    9 7000  120   1299999  000
      END
                6 7100  200    799999  000
      END
STELS
                2 7430    8 7450
SWID
                2  500    5  800    6 1000    7 1300    8 1500   14 1700
               16 1500   20 1300
PIT BOTTOM
                2 7100    4 7000    9 6900   14 6850   16 6800   18 6700
               20 6600   21 6550
      END
                6 7400    9 7300   11 7200   13 7100   15 7000   16 6900
               18 6800   19 6700   20 6600   21 6550
      END
ULTIMATE
               45 6360
CMNW
      ALL
CMN1
      ALL
END SECTOR
STOP CASE
```

APPENDIX C

COMPUTED WALL HEIGHTS AND ANGLES FOR ALL SECTORS OF THREE DESIGNS

28 DEGREE DESIGN. SECTOR I.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1	2	3	4	5
1	HEIGHT	300.0	100.0	200.0	0.0	0.0	0.0
	ANGLE	20.5	60.0	39.1	0.0	0.0	0.0
2	HEIGHT	300.0	100.0	100.0	100.0	0.0	0.0
	ANGLE	13.3	60.0	60.0	60.0	0.0	0.0
3	HEIGHT	400.0	100.0	200.0	100.0	0.0	0.0
	ANGLE	16.4	60.0	39.1	60.0	0.0	0.0
4	HEIGHT	400.0	100.0	100.0	200.0	0.0	0.0
	ANGLE	14.4	60.0	60.0	39.1	0.0	0.0
5	HEIGHT	400.0	100.0	200.0	100.0	0.0	0.0
	ANGLE	14.4	60.0	39.1	60.0	0.0	0.0
6	HEIGHT	500.0	100.0	100.0	200.0	100.0	0.0
	ANGLE	14.6	60.0	60.0	39.1	60.0	0.0
7	HEIGHT	500.0	100.0	100.0	100.0	100.0	100.0
	ANGLE	11.8	60.0	60.0	60.0	60.0	60.0
8	HEIGHT	500.0	100.0	100.0	200.0	100.0	0.0
	ANGLE	13.6	60.0	60.0	39.1	60.0	0.0
9	HEIGHT	500.0	200.0	100.0	100.0	100.0	0.0
	ANGLE	13.6	39.1	60.0	60.0	60.0	0.0
10	HEIGHT	550.0	100.0	100.0	200.0	100.0	50.0
	ANGLE	12.7	60.0	60.0	39.1	60.0	60.0
11	HEIGHT	600.0	200.0	100.0	100.0	100.0	100.0
	ANGLE	13.1	39.1	60.0	60.0	60.0	60.0
12	HEIGHT	600.0	100.0	100.0	100.0	200.0	100.0
	ANGLE	12.3	28.0	60.0	60.0	39.1	60.0
13	HEIGHT	600.0	100.0	100.0	200.0	100.0	100.0
	ANGLE	12.3	28.0	60.0	39.1	60.0	60.0
14	HEIGHT	650.0	200.0	100.0	100.0	100.0	150.0
	ANGLE	12.8	28.0	60.0	60.0	60.0	44.7
15	HEIGHT	650.0	200.0	200.0	100.0	100.0	50.0
	ANGLE	13.2	28.0	39.1	60.0	60.0	60.0
16	HEIGHT	700.0	300.0	100.0	100.0	200.0	0.0
	ANGLE	15.8	28.0	60.0	60.0	39.1	0.0
17	HEIGHT	700.0	300.0	100.0	200.0	100.0	0.0
	ANGLE	15.8	28.0	60.0	39.1	60.0	0.0
18	HEIGHT	700.0	400.0	100.0	100.0	100.0	0.0
	ANGLE	15.8	28.0	60.0	60.0	60.0	0.0
19	HEIGHT	750.0	500.0	100.0	100.0	50.0	0.0
	ANGLE	16.5	28.0	60.0	60.0	60.0	0.0
20	HEIGHT	800.0	500.0	200.0	100.0	0.0	0.0
	ANGLE	20.5	28.0	39.1	60.0	0.0	0.0
21	HEIGHT	850.0	600.0	100.0	150.0	0.0	0.0
	ANGLE	20.8	28.0	60.0	44.7	0.0	0.0
22	HEIGHT	900.0	800.0	100.0	0.0	0.0	0.0
	ANGLE	25.0	30.2	60.0	0.0	0.0	0.0
23	HEIGHT	950.0	950.0	0.0	0.0	0.0	0.0
	ANGLE	28.0	28.9	0.0	0.0	0.0	0.0
24	HEIGHT	950.0	950.0	0.0	0.0	0.0	0.0
	ANGLE	28.0	28.0	0.0	0.0	0.0	0.0

28 DEGREE DESIGN. SECTOR II.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1	2	3	4	5
1	HEIGHT	0.0	0.0	0.0	0.0	0.0	0.0
	ANGLE	0.0	0.0	0.0	0.0	0.0	0.0
2	HEIGHT	200.0	100.0	100.0	0.0	0.0	0.0
	ANGLE	28.0	60.0	60.0	0.0	0.0	0.0
3	HEIGHT	250.0	200.0	50.0	0.0	0.0	0.0
	ANGLE	25.5	39.1	60.0	0.0	0.0	0.0
4	HEIGHT	250.0	100.0	100.0	50.0	0.0	0.0
	ANGLE	19.8	60.0	60.0	60.0	0.0	0.0
5	HEIGHT	300.0	200.0	100.0	0.0	0.0	0.0
	ANGLE	24.7	39.1	60.0	0.0	0.0	0.0
6	HEIGHT	300.0	100.0	200.0	0.0	0.0	0.0
	ANGLE	24.7	60.0	39.1	0.0	0.0	0.0
7	HEIGHT	300.0	100.0	100.0	100.0	0.0	0.0
	ANGLE	20.7	60.0	60.0	60.0	0.0	0.0
8	HEIGHT	400.0	100.0	200.0	100.0	0.0	0.0
	ANGLE	23.2	60.0	39.1	60.0	0.0	0.0
9	HEIGHT	400.0	200.0	100.0	100.0	0.0	0.0
	ANGLE	23.2	39.1	60.0	60.0	0.0	0.0
10	HEIGHT	400.0	100.0	100.0	200.0	0.0	0.0
	ANGLE	21.8	60.0	60.0	39.1	0.0	0.0
11	HEIGHT	400.0	100.0	100.0	100.0	100.0	0.0
	ANGLE	19.2	60.0	60.0	60.0	60.0	0.0
12	HEIGHT	450.0	100.0	100.0	100.0	150.0	0.0
	ANGLE	19.9	60.0	60.0	60.0	44.7	0.0
13	HEIGHT	500.0	100.0	200.0	100.0	100.0	0.0
	ANGLE	20.5	60.0	39.1	60.0	60.0	0.0
14	HEIGHT	500.0	100.0	100.0	100.0	100.0	100.0
	ANGLE	16.7	28.0	60.0	60.0	60.0	60.0
15	HEIGHT	500.0	100.0	200.0	100.0	100.0	0.0
	ANGLE	17.9	28.0	39.1	60.0	60.0	0.0
16	HEIGHT	500.0	200.0	100.0	100.0	100.0	0.0
	ANGLE	18.0	28.0	60.0	60.0	60.0	0.0
17	HEIGHT	500.0	200.0	100.0	200.0	0.0	0.0
	ANGLE	20.8	28.0	60.0	39.1	0.0	0.0
18	HEIGHT	500.0	300.0	100.0	100.0	0.0	0.0
	ANGLE	20.8	28.0	60.0	60.0	0.0	0.0
19	HEIGHT	600.0	400.0	100.0	100.0	0.0	0.0
	ANGLE	21.7	28.0	60.0	60.0	0.0	0.0
20	HEIGHT	600.0	400.0	100.0	100.0	0.0	0.0
	ANGLE	21.7	28.0	60.0	60.0	0.0	0.0
21	HEIGHT	600.0	500.0	100.0	0.0	0.0	0.0
	ANGLE	24.5	28.0	60.0	0.0	0.0	0.0
22	HEIGHT	700.0	600.0	100.0	0.0	0.0	0.0
	ANGLE	24.9	28.0	60.0	0.0	0.0	0.0
23	HEIGHT	800.0	800.0	0.0	0.0	0.0	0.0
	ANGLE	28.0	30.2	0.0	0.0	0.0	0.0
24	HEIGHT	800.0	800.0	0.0	0.0	0.0	0.0
	ANGLE	28.0	28.0	0.0	0.0	0.0	0.0

28 DEGREE DESIGN. SECTOR III.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1
1	HEIGHT	100.0	100.0
	ANGLE	18.0	18.0
2	HEIGHT	100.0	100.0
	ANGLE	18.0	18.0
3	HEIGHT	200.0	200.0
	ANGLE	18.0	18.0
4	HEIGHT	200.0	200.0
	ANGLE	18.0	18.0
5	HEIGHT	200.0	200.0
	ANGLE	18.0	18.0
6	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
7	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
8	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
9	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
10	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
11	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
12	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
13	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
14	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
15	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
16	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
17	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
18	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
19	HEIGHT	600.0	600.0
	ANGLE	18.0	18.0
20	HEIGHT	600.0	600.0
	ANGLE	18.0	18.0
21	HEIGHT	700.0	700.0
	ANGLE	18.0	18.0
22	HEIGHT	700.0	700.0
	ANGLE	18.0	18.0
23	HEIGHT	800.0	800.0
	ANGLE	18.0	18.0
24	HEIGHT	800.0	800.0
	ANGLE	18.0	18.0

28 DEGREE DESIGN. SECTOR IV.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1	2	3	4
1	HEIGHT	330.0	30.0	100.0	200.0	0.0
	ANGLE	19.7	60.0	60.0	39.1	0.0
2	HEIGHT	330.0	130.0	100.0	100.0	0.0
	ANGLE	21.7	48.7	60.0	60.0	0.0
3	HEIGHT	330.0	30.0	200.0	100.0	0.0
	ANGLE	18.8	60.0	39.1	60.0	0.0
4	HEIGHT	330.0	30.0	100.0	100.0	100.0
	ANGLE	18.4	60.0	60.0	60.0	60.0
5	HEIGHT	330.0	30.0	200.0	100.0	0.0
	ANGLE	21.9	60.0	39.1	60.0	0.0
6	HEIGHT	430.0	30.0	100.0	100.0	200.0
	ANGLE	23.1	60.0	60.0	60.0	39.1
7	HEIGHT	430.0	30.0	200.0	100.0	100.0
	ANGLE	19.9	28.0	39.1	60.0	60.0
8	HEIGHT	430.0	30.0	200.0	200.0	0.0
	ANGLE	21.0	28.0	39.1	39.1	0.0
9	HEIGHT	430.0	30.0	300.0	100.0	0.0
	ANGLE	21.0	28.0	34.7	60.0	0.0
10	HEIGHT	500.0	100.0	400.0	0.0	0.0
	ANGLE	25.5	60.0	32.8	0.0	0.0
11	HEIGHT	500.0	100.0	100.0	300.0	0.0
	ANGLE	19.7	28.0	60.0	34.7	0.0
12	HEIGHT	500.0	100.0	100.0	300.0	0.0
	ANGLE	19.7	28.0	60.0	34.7	0.0
13	HEIGHT	500.0	100.0	100.0	300.0	0.0
	ANGLE	19.7	28.0	60.0	34.7	0.0
14	HEIGHT	500.0	200.0	100.0	200.0	0.0
	ANGLE	19.7	28.0	60.0	39.1	0.0
15	HEIGHT	550.0	200.0	200.0	150.0	0.0
	ANGLE	20.2	28.0	39.1	44.7	0.0
16	HEIGHT	600.0	300.0	100.0	200.0	0.0
	ANGLE	20.9	28.0	60.0	39.1	0.0
17	HEIGHT	600.0	300.0	200.0	100.0	0.0
	ANGLE	21.6	28.0	39.1	60.0	0.0
18	HEIGHT	600.0	400.0	100.0	100.0	0.0
	ANGLE	21.6	28.0	60.0	60.0	0.0
19	HEIGHT	600.0	500.0	100.0	0.0	0.0
	ANGLE	24.0	28.0	60.0	0.0	0.0
20	HEIGHT	600.0	500.0	100.0	0.0	0.0
	ANGLE	24.0	28.0	60.0	0.0	0.0
21	HEIGHT	650.0	600.0	50.0	0.0	0.0
	ANGLE	23.3	28.0	60.0	0.0	0.0
22	HEIGHT	700.0	700.0	0.0	0.0	0.0
	ANGLE	28.0	28.0	0.0	0.0	0.0
23	HEIGHT	700.0	700.0	0.0	0.0	0.0
	ANGLE	28.0	28.0	0.0	0.0	0.0
24	HEIGHT	700.0	700.0	0.0	0.0	0.0
	ANGLE	28.0	28.0	0.0	0.0	0.0

35 DEGREE DESIGN. SECTOR I.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1	2	3	4
1	HEIGHT	400.0	200.0	100.0	100.0	0.0
	ANGLE	14.8	44.9	60.0	60.0	0.0
2	HEIGHT	400.0	100.0	100.0	200.0	0.0
	ANGLE	13.1	60.0	60.0	44.9	0.0
3	HEIGHT	400.0	200.0	100.0	100.0	0.0
	ANGLE	13.1	44.9	60.0	60.0	0.0
4	HEIGHT	500.0	200.0	100.0	200.0	0.0
	ANGLE	14.3	44.9	60.0	44.9	0.0
5	HEIGHT	500.0	200.0	200.0	100.0	0.0
	ANGLE	14.3	44.9	44.9	60.0	0.0
6	HEIGHT	500.0	300.0	100.0	100.0	0.0
	ANGLE	14.3	41.2	60.0	60.0	0.0
7	HEIGHT	500.0	200.0	100.0	200.0	0.0
	ANGLE	15.1	44.9	60.0	44.9	0.0
8	HEIGHT	500.0	100.0	100.0	200.0	100.0
	ANGLE	10.7	35.0	60.0	44.9	60.0
9	HEIGHT	500.0	200.0	100.0	100.0	100.0
	ANGLE	10.7	35.0	60.0	60.0	60.0
10	HEIGHT	600.0	200.0	100.0	100.0	200.0
	ANGLE	12.1	35.0	60.0	60.0	44.9
11	HEIGHT	600.0	200.0	100.0	200.0	100.0
	ANGLE	12.3	35.0	60.0	44.9	60.0
12	HEIGHT	600.0	200.0	200.0	100.0	100.0
	ANGLE	12.3	35.0	44.9	60.0	60.0
13	HEIGHT	600.0	300.0	100.0	200.0	0.0
	ANGLE	15.3	35.0	60.0	44.9	0.0
14	HEIGHT	600.0	300.0	200.0	100.0	0.0
	ANGLE	15.3	35.0	44.9	60.0	0.0
15	HEIGHT	700.0	400.0	100.0	200.0	0.0
	ANGLE	17.4	35.0	60.0	44.9	0.0
16	HEIGHT	700.0	400.0	200.0	100.0	0.0
	ANGLE	17.1	35.0	44.9	60.0	0.0
17	HEIGHT	700.0	500.0	100.0	100.0	0.0
	ANGLE	17.1	35.0	60.0	60.0	0.0
18	HEIGHT	800.0	500.0	200.0	100.0	0.0
	ANGLE	18.6	35.0	44.9	60.0	0.0
19	HEIGHT	800.0	600.0	100.0	100.0	0.0
	ANGLE	18.6	35.0	60.0	60.0	0.0
20	HEIGHT	800.0	700.0	100.0	0.0	0.0
	ANGLE	23.3	35.0	60.0	0.0	0.0
21	HEIGHT	900.0	700.0	200.0	0.0	0.0
	ANGLE	24.2	35.0	44.9	0.0	0.0
22	HEIGHT	900.0	800.0	100.0	0.0	0.0
	ANGLE	24.2	35.0	60.0	0.0	0.0
23	HEIGHT	1000.0	900.0	100.0	0.0	0.0
	ANGLE	27.2	35.0	60.0	0.0	0.0
24	HEIGHT	1000.0	1000.0	0.0	0.0	0.0
	ANGLE	35.0	35.0	0.0	0.0	0.0

35 DEGREE DESIGN. SECTOR II.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1	2	3	4
1	HEIGHT	150.0	50.0	100.0	0.0	0.0
	ANGLE	19.0	60.0	60.0	0.0	0.0
2	HEIGHT	250.0	150.0	100.0	0.0	0.0
	ANGLE	29.8	49.3	60.0	0.0	0.0
3	HEIGHT	250.0	50.0	100.0	100.0	0.0
	ANGLE	20.9	60.0	60.0	60.0	0.0
4	HEIGHT	250.0	50.0	100.0	100.0	0.0
	ANGLE	20.9	60.0	60.0	60.0	0.0
5	HEIGHT	350.0	50.0	200.0	100.0	0.0
	ANGLE	28.4	60.0	44.9	60.0	0.0
6	HEIGHT	350.0	150.0	100.0	100.0	0.0
	ANGLE	29.7	49.3	60.0	60.0	0.0
7	HEIGHT	350.0	50.0	100.0	100.0	100.0
	ANGLE	23.6	60.0	60.0	60.0	60.0
8	HEIGHT	350.0	50.0	200.0	100.0	0.0
	ANGLE	19.7	60.0	44.9	60.0	0.0
9	HEIGHT	350.0	50.0	200.0	100.0	0.0
	ANGLE	25.4	60.0	44.9	60.0	0.0
10	HEIGHT	450.0	50.0	100.0	100.0	200.0
	ANGLE	14.5	35.0	60.0	60.0	44.9
11	HEIGHT	450.0	50.0	100.0	200.0	100.0
	ANGLE	15.4	35.0	60.0	44.9	60.0
12	HEIGHT	450.0	50.0	200.0	200.0	0.0
	ANGLE	17.0	35.0	44.9	44.9	0.0
13	HEIGHT	450.0	150.0	100.0	100.0	100.0
	ANGLE	19.5	35.0	60.0	60.0	60.0
14	HEIGHT	450.0	150.0	200.0	100.0	0.0
	ANGLE	19.5	35.0	44.9	60.0	0.0
15	HEIGHT	450.0	250.0	100.0	100.0	0.0
	ANGLE	20.2	35.0	60.0	60.0	0.0
16	HEIGHT	550.0	250.0	200.0	100.0	0.0
	ANGLE	21.8	35.0	44.9	60.0	0.0
17	HEIGHT	550.0	350.0	100.0	100.0	0.0
	ANGLE	21.8	35.0	60.0	60.0	0.0
18	HEIGHT	650.0	350.0	100.0	200.0	0.0
	ANGLE	23.2	35.0	60.0	44.9	0.0
19	HEIGHT	650.0	450.0	100.0	100.0	0.0
	ANGLE	23.3	35.0	60.0	60.0	0.0
20	HEIGHT	750.0	450.0	200.0	100.0	0.0
	ANGLE	26.6	35.0	44.9	60.0	0.0
21	HEIGHT	750.0	550.0	200.0	0.0	0.0
	ANGLE	31.0	35.0	44.9	0.0	0.0
22	HEIGHT	750.0	750.0	0.0	0.0	0.0
	ANGLE	35.0	37.3	0.0	0.0	0.0
23	HEIGHT	750.0	750.0	0.0	0.0	0.0
	ANGLE	35.0	35.0	0.0	0.0	0.0
24	HEIGHT	850.0	850.0	0.0	0.0	0.0
	ANGLE	35.0	35.0	0.0	0.0	0.0

35 DEGREE DESIGN. SECTOR III.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1
1	HEIGHT	100.0	100.0
	ANGLE	18.0	18.0
2	HEIGHT	200.0	200.0
	ANGLE	18.0	18.0
3	HEIGHT	200.0	200.0
	ANGLE	18.0	18.0
4	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
5	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
6	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
7	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
8	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
9	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
10	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
11	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
12	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
13	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
14	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
15	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
16	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
17	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
18	HEIGHT	600.0	600.0
	ANGLE	18.0	18.0
19	HEIGHT	600.0	600.0
	ANGLE	18.0	18.0
20	HEIGHT	600.0	600.0
	ANGLE	18.0	18.0
21	HEIGHT	700.0	700.0
	ANGLE	18.0	18.0
22	HEIGHT	800.0	800.0
	ANGLE	18.0	18.0
23	HEIGHT	800.0	800.0
	ANGLE	18.0	18.0
24	HEIGHT	800.0	800.0
	ANGLE	18.0	18.0

35 DEGREE DESIGN. SECTOR IV.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1	2	3	4
1	HEIGHT	250.0	50.0	100.0	100.0	0.0
	ANGLE	15.8	60.0	60.0	60.0	0.0
2	HEIGHT	250.0	50.0	200.0	0.0	0.0
	ANGLE	23.3	60.0	44.9	0.0	0.0
3	HEIGHT	250.0	150.0	100.0	0.0	0.0
	ANGLE	29.8	49.3	60.0	0.0	0.0
4	HEIGHT	250.0	50.0	100.0	100.0	0.0
	ANGLE	16.5	60.0	60.0	60.0	0.0
5	HEIGHT	250.0	50.0	100.0	100.0	0.0
	ANGLE	16.5	60.0	60.0	60.0	0.0
6	HEIGHT	350.0	50.0	100.0	100.0	100.0
	ANGLE	16.2	60.0	60.0	60.0	60.0
7	HEIGHT	350.0	50.0	100.0	100.0	100.0
	ANGLE	15.0	35.0	60.0	60.0	60.0
8	HEIGHT	450.0	50.0	200.0	100.0	100.0
	ANGLE	17.3	35.0	44.9	60.0	60.0
9	HEIGHT	450.0	150.0	100.0	100.0	100.0
	ANGLE	17.4	35.0	60.0	60.0	60.0
10	HEIGHT	450.0	150.0	200.0	100.0	0.0
	ANGLE	19.4	35.0	44.9	60.0	0.0
11	HEIGHT	450.0	150.0	200.0	100.0	0.0
	ANGLE	19.4	35.0	44.9	60.0	0.0
12	HEIGHT	550.0	250.0	100.0	100.0	100.0
	ANGLE	20.4	35.0	60.0	60.0	60.0
13	HEIGHT	550.0	250.0	100.0	200.0	0.0
	ANGLE	21.2	35.0	60.0	44.9	0.0
14	HEIGHT	550.0	350.0	100.0	100.0	0.0
	ANGLE	21.2	35.0	60.0	60.0	0.0
15	HEIGHT	650.0	350.0	100.0	200.0	0.0
	ANGLE	22.6	35.0	60.0	44.9	0.0
16	HEIGHT	650.0	350.0	200.0	100.0	0.0
	ANGLE	22.6	35.0	44.9	60.0	0.0
17	HEIGHT	650.0	450.0	100.0	100.0	0.0
	ANGLE	25.6	35.0	60.0	60.0	0.0
18	HEIGHT	650.0	450.0	200.0	0.0	0.0
	ANGLE	29.6	35.0	44.9	0.0	0.0
19	HEIGHT	750.0	550.0	200.0	0.0	0.0
	ANGLE	31.5	35.0	44.9	0.0	0.0
20	HEIGHT	750.0	650.0	100.0	0.0	0.0
	ANGLE	33.4	35.0	60.0	0.0	0.0
21	HEIGHT	750.0	650.0	100.0	0.0	0.0
	ANGLE	33.4	35.0	60.0	0.0	0.0
22	HEIGHT	850.0	850.0	0.0	0.0	0.0
	ANGLE	35.0	37.0	0.0	0.0	0.0
23	HEIGHT	850.0	850.0	0.0	0.0	0.0
	ANGLE	35.0	36.0	0.0	0.0	0.0
24	HEIGHT	850.0	850.0	0.0	0.0	0.0
	ANGLE	35.0	36.0	0.0	0.0	0.0

45 DEGREE DESIGN. SECTOR I.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1	2	3	4
1	HEIGHT	320.0	20.0	100.0	200.0	0.0
	ANGLE	15.2	60.0	60.0	51.7	0.0
2	HEIGHT	320.0	120.0	100.0	100.0	0.0
	ANGLE	15.0	57.1	60.0	60.0	0.0
3	HEIGHT	420.0	120.0	100.0	200.0	0.0
	ANGLE	18.0	57.1	60.0	51.7	0.0
4	HEIGHT	420.0	220.0	100.0	100.0	0.0
	ANGLE	18.0	51.1	60.0	60.0	0.0
5	HEIGHT	420.0	120.0	200.0	100.0	0.0
	ANGLE	18.0	57.1	51.7	60.0	0.0
6	HEIGHT	420.0	120.0	100.0	100.0	100.0
	ANGLE	13.5	57.1	60.0	60.0	60.0
7	HEIGHT	520.0	120.0	100.0	200.0	100.0
	ANGLE	15.7	57.1	60.0	51.7	60.0
8	HEIGHT	520.0	120.0	200.0	100.0	100.0
	ANGLE	14.9	57.1	51.7	60.0	60.0
9	HEIGHT	550.0	150.0	100.0	100.0	200.0
	ANGLE	15.2	45.0	60.0	60.0	51.7
10	HEIGHT	550.0	150.0	200.0	100.0	100.0
	ANGLE	15.2	45.0	51.7	60.0	60.0
11	HEIGHT	650.0	250.0	100.0	100.0	200.0
	ANGLE	16.7	45.0	60.0	60.0	51.7
12	HEIGHT	650.0	250.0	200.0	100.0	100.0
	ANGLE	16.7	45.0	51.7	60.0	60.0
13	HEIGHT	700.0	350.0	100.0	100.0	150.0
	ANGLE	17.5	45.0	60.0	60.0	54.3
14	HEIGHT	750.0	350.0	200.0	100.0	100.0
	ANGLE	17.9	45.0	51.7	60.0	60.0
15	HEIGHT	750.0	450.0	100.0	100.0	100.0
	ANGLE	17.9	45.0	60.0	60.0	60.0
16	HEIGHT	750.0	450.0	200.0	100.0	0.0
	ANGLE	22.4	45.0	51.7	60.0	0.0
17	HEIGHT	800.0	550.0	100.0	150.0	0.0
	ANGLE	23.2	45.0	60.0	54.3	0.0
18	HEIGHT	825.0	650.0	100.0	75.0	0.0
	ANGLE	23.5	45.0	60.0	60.0	0.0
19	HEIGHT	850.0	750.0	100.0	0.0	0.0
	ANGLE	32.0	45.0	60.0	0.0	0.0
20	HEIGHT	950.0	850.0	100.0	0.0	0.0
	ANGLE	33.1	45.0	60.0	0.0	0.0
21	HEIGHT	950.0	950.0	0.0	0.0	0.0
	ANGLE	45.0	45.0	0.0	0.0	0.0
22	HEIGHT	1050.0	1050.0	0.0	0.0	0.0
	ANGLE	45.0	46.2	0.0	0.0	0.0
23	HEIGHT	1050.0	1050.0	0.0	0.0	0.0
	ANGLE	45.0	46.2	0.0	0.0	0.0
24	HEIGHT	1050.0	1050.0	0.0	0.0	0.0
	ANGLE	45.0	46.2	0.0	0.0	0.0

45 DEGREE DESIGN. SECTOR II.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1	2	3	4
1	HEIGHT	0.0	0.0	0.0	0.0	0.0
	ANGLE	0.0	0.0	0.0	0.0	0.0
2	HEIGHT	200.0	100.0	100.0	0.0	0.0
	ANGLE	35.0	60.0	60.0	0.0	0.0
3	HEIGHT	300.0	100.0	200.0	0.0	0.0
	ANGLE	37.9	60.0	51.7	0.0	0.0
4	HEIGHT	300.0	100.0	100.0	100.0	0.0
	ANGLE	30.3	60.0	60.0	60.0	0.0
5	HEIGHT	300.0	200.0	100.0	0.0	0.0
	ANGLE	37.9	51.7	60.0	0.0	0.0
6	HEIGHT	300.0	100.0	100.0	100.0	0.0
	ANGLE	30.3	60.0	60.0	60.0	0.0
7	HEIGHT	400.0	100.0	100.0	200.0	0.0
	ANGLE	33.1	60.0	60.0	51.7	0.0
8	HEIGHT	400.0	200.0	100.0	100.0	0.0
	ANGLE	33.1	51.7	60.0	60.0	0.0
9	HEIGHT	400.0	100.0	100.0	200.0	0.0
	ANGLE	31.1	60.0	60.0	51.7	0.0
10	HEIGHT	400.0	200.0	100.0	100.0	0.0
	ANGLE	31.1	51.7	60.0	60.0	0.0
11	HEIGHT	500.0	100.0	100.0	100.0	200.0
	ANGLE	29.0	45.0	60.0	60.0	51.7
12	HEIGHT	500.0	100.0	100.0	200.0	100.0
	ANGLE	29.0	45.0	60.0	51.7	60.0
13	HEIGHT	500.0	200.0	100.0	100.0	100.0
	ANGLE	28.4	45.0	60.0	60.0	60.0
14	HEIGHT	500.0	200.0	200.0	100.0	0.0
	ANGLE	33.2	45.0	51.7	60.0	0.0
15	HEIGHT	500.0	300.0	100.0	100.0	0.0
	ANGLE	33.5	45.0	60.0	60.0	0.0
16	HEIGHT	600.0	300.0	200.0	100.0	0.0
	ANGLE	35.0	45.0	51.7	60.0	0.0
17	HEIGHT	600.0	400.0	100.0	100.0	0.0
	ANGLE	35.0	45.0	60.0	60.0	0.0
18	HEIGHT	600.0	500.0	100.0	0.0	0.0
	ANGLE	39.9	45.0	60.0	0.0	0.0
19	HEIGHT	700.0	500.0	200.0	0.0	0.0
	ANGLE	40.6	45.0	51.7	0.0	0.0
20	HEIGHT	700.0	600.0	100.0	0.0	0.0
	ANGLE	40.6	45.0	60.0	0.0	0.0
21	HEIGHT	800.0	800.0	0.0	0.0	0.0
	ANGLE	45.0	46.6	0.0	0.0	0.0
22	HEIGHT	900.0	900.0	0.0	0.0	0.0
	ANGLE	45.0	46.4	0.0	0.0	0.0
23	HEIGHT	900.0	900.0	0.0	0.0	0.0
	ANGLE	45.0	46.4	0.0	0.0	0.0
24	HEIGHT	900.0	900.0	0.0	0.0	0.0
	ANGLE	45.0	46.4	0.0	0.0	0.0

45 DEGREE DESIGN. SECTOR III.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1
1	HEIGHT	100.0	100.0
	ANGLE	18.0	18.0
2	HEIGHT	100.0	100.0
	ANGLE	18.0	18.0
3	HEIGHT	200.0	200.0
	ANGLE	18.0	18.0
4	HEIGHT	200.0	200.0
	ANGLE	18.0	18.0
5	HEIGHT	200.0	200.0
	ANGLE	18.0	18.0
6	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
7	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
8	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
9	HEIGHT	300.0	300.0
	ANGLE	18.0	18.0
10	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
11	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
12	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
13	HEIGHT	400.0	400.0
	ANGLE	18.0	18.0
14	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
15	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
16	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
17	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
18	HEIGHT	500.0	500.0
	ANGLE	18.0	18.0
19	HEIGHT	600.0	600.0
	ANGLE	18.0	18.0
20	HEIGHT	600.0	600.0
	ANGLE	18.0	18.0
21	HEIGHT	700.0	700.0
	ANGLE	18.0	18.0
22	HEIGHT	700.0	700.0
	ANGLE	18.0	18.0
23	HEIGHT	800.0	800.0
	ANGLE	18.0	18.0
24	HEIGHT	800.0	800.0
	ANGLE	18.0	18.0

45 DEGREE DESIGN. SECTOR IV.

PIT WALL HEIGHTS AND ANGLES

PERIOD		FULL WALL	INTERRAMP WALLS 1	2	3	4	5
1	HEIGHT	0.0	0.0	0.0	0.0	0.0	0.0
	ANGLE	0.0	0.0	0.0	0.0	0.0	0.0
2	HEIGHT	330.0	130.0	100.0	100.0	0.0	0.0
	ANGLE	17.4	56.0	60.0	60.0	0.0	0.0
3	HEIGHT	330.0	30.0	100.0	100.0	100.0	0.0
	ANGLE	14.3	60.0	60.0	60.0	60.0	0.0
4	HEIGHT	430.0	30.0	200.0	100.0	100.0	0.0
	ANGLE	18.4	60.0	51.7	60.0	60.0	0.0
5	HEIGHT	430.0	30.0	200.0	100.0	100.0	0.0
	ANGLE	26.6	60.0	51.7	60.0	60.0	0.0
6	HEIGHT	430.0	30.0	100.0	100.0	100.0	100.0
	ANGLE	22.6	45.0	60.0	60.0	60.0	60.0
7	HEIGHT	430.0	30.0	100.0	100.0	200.0	0.0
	ANGLE	28.8	45.0	60.0	60.0	51.7	0.0
8	HEIGHT	450.0	50.0	200.0	100.0	100.0	0.0
	ANGLE	29.6	45.0	51.7	60.0	60.0	0.0
9	HEIGHT	550.0	150.0	100.0	200.0	100.0	0.0
	ANGLE	31.6	45.0	60.0	51.7	60.0	0.0
10	HEIGHT	550.0	150.0	200.0	100.0	100.0	0.0
	ANGLE	31.6	45.0	51.7	60.0	60.0	0.0
11	HEIGHT	550.0	250.0	100.0	100.0	100.0	0.0
	ANGLE	31.6	45.0	60.0	60.0	60.0	0.0
12	HEIGHT	550.0	250.0	200.0	100.0	0.0	0.0
	ANGLE	34.0	45.0	51.7	60.0	0.0	0.0
13	HEIGHT	550.0	350.0	100.0	100.0	0.0	0.0
	ANGLE	34.0	45.0	60.0	60.0	0.0	0.0
14	HEIGHT	600.0	350.0	200.0	50.0	0.0	0.0
	ANGLE	34.4	45.0	51.7	60.0	0.0	0.0
15	HEIGHT	600.0	450.0	100.0	50.0	0.0	0.0
	ANGLE	34.4	45.0	60.0	60.0	0.0	0.0
16	HEIGHT	650.0	550.0	100.0	0.0	0.0	0.0
	ANGLE	37.2	45.0	60.0	0.0	0.0	0.0
17	HEIGHT	650.0	550.0	100.0	0.0	0.0	0.0
	ANGLE	37.2	45.0	60.0	0.0	0.0	0.0
18	HEIGHT	750.0	650.0	100.0	0.0	0.0	0.0
	ANGLE	39.3	45.0	60.0	0.0	0.0	0.0
19	HEIGHT	750.0	750.0	0.0	0.0	0.0	0.0
	ANGLE	45.0	45.0	0.0	0.0	0.0	0.0
20	HEIGHT	850.0	850.0	0.0	0.0	0.0	0.0
	ANGLE	45.0	45.0	0.0	0.0	0.0	0.0
21	HEIGHT	900.0	900.0	0.0	0.0	0.0	0.0
	ANGLE	45.0	45.0	0.0	0.0	0.0	0.0
22	HEIGHT	900.0	900.0	0.0	0.0	0.0	0.0
	ANGLE	45.0	45.0	0.0	0.0	0.0	0.0
23	HEIGHT	900.0	900.0	0.0	0.0	0.0	0.0
	ANGLE	45.0	45.0	0.0	0.0	0.0	0.0
24	HEIGHT	900.0	900.0	0.0	0.0	0.0	0.0

APPENDIX D

A CONCISE SUMMARY OF INPUT GEOMETRIES AS OUTPUT BY BNCST

CASE 1 - SECTOR I

PERIOD	SECTOR WIDTH
1	1400.0
2	1800.0
3	1800.0
4	2000.0
5	2000.0
6	2000.0
7	2000.0
8	2200.0
9	2200.0
10	2200.0
11	2200.0
12	2200.0
13	2200.0
14	2400.0
15	2400.0
16	2400.0
17	2400.0
18	2400.0
19	2600.0
20	2600.0
21	2600.0
22	2600.0
23	2600.0
24	2600.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1	2	2	3	3	4	4
1	7400.0	500.0	7300.0	500.0	99999.0	0.0	99999.0	0.0
2	7300.0	550.0	7200.0	550.0	99999.0	0.0	99999.0	0.0
3	7300.0	600.0	7100.0	400.0	99999.0	0.0	99999.0	0.0
4	7300.0	600.0	7200.0	600.0	99999.0	0.0	99999.0	0.0
5	7300.0	600.0	7100.0	600.0	99999.0	0.0	99999.0	0.0
6	7300.0	500.0	7200.0	600.0	7000.0	400.0	99999.0	0.0
7	7300.0	500.0	7200.0	550.0	7100.0	600.0	7000.0	450.0
8	7300.0	500.0	7200.0	550.0	7000.0	600.0	99999.0	0.0
9	7200.0	500.0	7100.0	550.0	7000.0	600.0	99999.0	0.0
10	7300.0	450.0	7200.0	600.0	7000.0	500.0	6900.0	450.0
11	7200.0	500.0	7100.0	600.0	7000.0	550.0	6900.0	450.0
12	7300.0	500.0	7200.0	500.0	7100.0	600.0	6900.0	550.0
13	7300.0	500.0	7200.0	500.0	7000.0	600.0	6900.0	550.0
14	7200.0	500.0	7100.0	500.0	7000.0	600.0	6900.0	550.0
15	7200.0	500.0	7000.0	450.0	6900.0	600.0	6800.0	450.0
16	7100.0	500.0	7000.0	450.0	6900.0	600.0	99999.0	0.0
17	7100.0	500.0	7000.0	450.0	6800.0	600.0	99999.0	0.0
18	7000.0	500.0	6900.0	450.0	6800.0	600.0	99999.0	0.0
19	6900.0	500.0	6800.0	450.0	6700.0	500.0	99999.0	0.0
20	6900.0	500.0	6700.0	400.0	99999.0	0.0	99999.0	0.0
21	6800.0	500.0	6700.0	400.0	99999.0	0.0	99999.0	0.0
22	6600.0	500.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
23	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
24	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7400.	7100.	7400.
2	7400.	7100.	7400.
3	7400.	7000.	7400.
4	7400.	7000.	7400.
5	7400.	7000.	7400.
6	7400.	6900.	7400.
7	7400.	6900.	7400.
8	7400.	6900.	7400.
9	7400.	6900.	7400.
10	7400.	6850.	7400.
11	7400.	6800.	7400.
12	7400.	6800.	7300.
13	7400.	6800.	7300.
14	7400.	6750.	7200.
15	7400.	6750.	7200.
16	7400.	6700.	7100.
17	7400.	6700.	7100.
18	7400.	6700.	7000.
19	7400.	6650.	6900.
20	7400.	6600.	6900.
21	7400.	6550.	6800.
22	7400.	6500.	6700.
23	7400.	6450.	6500.
24	7400.	6450.	6450.

CASE 1 - SECTOR II

PERIOD	SECTOR WIDTH
1	0.0
2	800.0
3	800.0
4	800.0
5	1000.0
6	1000.0
7	1200.0
8	1200.0
9	1400.0
10	1400.0
11	1400.0
12	1400.0
13	1600.0
14	1600.0
15	1800.0
16	1800.0
17	1800.0
18	2000.0
19	2000.0
20	2000.0
21	2000.0
22	2000.0
23	2000.0
24	2000.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1	2	2	3	3	4	4
1	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
2	7200.0	250.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
3	7100.0	250.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
4	7200.0	350.0	7100.0	200.0	99999.0	0.0	99999.0	0.0
5	7100.0	350.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
6	7200.0	350.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
7	7200.0	270.0	7100.0	350.0	99999.0	0.0	99999.0	0.0
8	7200.0	270.0	7000.0	300.0	99999.0	0.0	99999.0	0.0
9	7100.0	270.0	7000.0	300.0	99999.0	0.0	99999.0	0.0
10	7200.0	370.0	7100.0	270.0	99999.0	0.0	99999.0	0.0
11	7200.0	300.0	7100.0	370.0	7000.0	250.0	99999.0	0.0
12	7200.0	300.0	7100.0	370.0	7000.0	250.0	99999.0	0.0
13	7200.0	300.0	7000.0	370.0	6900.0	250.0	99999.0	0.0
14	7200.0	330.0	7100.0	300.0	7000.0	370.0	6900.0	250.0
15	7200.0	330.0	7000.0	300.0	6900.0	370.0	99999.0	0.0
16	7100.0	320.0	7000.0	320.0	6900.0	350.0	99999.0	0.0
17	7100.0	320.0	7000.0	320.0	99999.0	0.0	99999.0	0.0
18	7000.0	320.0	6900.0	320.0	99999.0	0.0	99999.0	0.0
19	6900.0	320.0	6800.0	320.0	99999.0	0.0	99999.0	0.0
20	6900.0	320.0	6800.0	320.0	99999.0	0.0	99999.0	0.0
21	6800.0	320.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
22	6700.0	320.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
23	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
24	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7300.	7300.	7300.
2	7300.	7100.	7300.
3	7300.	7050.	7300.
4	7300.	7050.	7300.
5	7300.	7000.	7300.
6	7300.	7000.	7300.
7	7300.	7000.	7300.
8	7300.	6900.	7300.
9	7300.	6900.	7300.
10	7300.	6900.	7300.
11	7300.	6900.	7300.
12	7300.	6850.	7300.
13	7300.	6800.	7300.
14	7300.	6800.	7200.
15	7300.	6800.	7200.
16	7300.	6800.	7100.
17	7300.	6800.	7100.
18	7300.	6800.	7000.
19	7300.	6700.	6900.
20	7300.	6700.	6900.
21	7300.	6700.	6800.
22	7300.	6600.	6700.
23	7300.	6500.	6600.
24	7300.	6500.	6500.

CASE 1 - SECTOR III

PERIOD	SECTOR WIDTH
1	1200.0
2	1600.0
3	1600.0
4	1600.0
5	1600.0
6	1600.0
7	1600.0
8	1600.0
9	1600.0
10	1600.0
11	1600.0
12	1600.0
13	1600.0
14	1600.0
15	1600.0
16	1600.0
17	1600.0
18	1600.0
19	1600.0
20	1600.0
21	1600.0
22	1600.0
23	1600.0
24	1600.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7200.	7100.	7100.
2	7200.	7100.	7100.
3	7200.	7000.	7000.
4	7200.	7000.	7000.
5	7200.	7000.	7000.
6	7200.	6900.	6900.
7	7200.	6900.	6900.
8	7200.	6900.	6900.
9	7200.	6900.	6900.
10	7200.	6800.	6800.
11	7200.	6800.	6800.
12	7200.	6800.	6800.
13	7200.	6800.	6800.
14	7200.	6700.	6700.
15	7200.	6700.	6700.
16	7200.	6700.	6700.
17	7200.	6700.	6700.
18	7200.	6700.	6700.
19	7200.	6600.	6600.
20	7200.	6600.	6600.
21	7200.	6500.	6500.
22	7200.	6500.	6500.
23	7200.	6400.	6400.
24	7200.	6400.	6400.

CASE 1 - SECTOR IV

PERIOD	SECTOR WIDTH
1	600.0
2	800.0
3	800.0
4	1200.0
5	1200.0
6	1200.0
7	1200.0
8	1400.0
9	1400.0
10	1400.0
11	1400.0
12	1400.0
13	1600.0
14	1600.0
15	1600.0
16	1600.0
17	1600.0
18	1600.0
19	1600.0
20	1600.0
21	1600.0
22	1600.0
23	1600.0
24	1600.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1	2	2	3	3
1	7400.0	350.0	7300.0	250.0	99999.0	0.0
2	7300.0	350.0	7200.0	250.0	99999.0	0.0
3	7400.0	350.0	7200.0	300.0	99999.0	0.0
4	7400.0	250.0	7300.0	250.0	7200.0	300.0
5	7400.0	250.0	7200.0	250.0	99999.0	0.0
6	7400.0	200.0	7300.0	200.0	7200.0	230.0
7	7400.0	350.0	7200.0	220.0	7100.0	200.0
8	7400.0	350.0	7200.0	220.0	99999.0	0.0
9	7400.0	350.0	7100.0	220.0	99999.0	0.0
10	7300.0	370.0	99999.0	0.0	99999.0	0.0
11	7300.0	370.0	7200.0	350.0	99999.0	0.0
12	7300.0	370.0	7200.0	350.0	99999.0	0.0
13	7300.0	370.0	7200.0	350.0	99999.0	0.0
14	7200.0	370.0	7100.0	350.0	99999.0	0.0
15	7200.0	370.0	7000.0	350.0	99999.0	0.0
16	7100.0	350.0	7000.0	350.0	99999.0	0.0
17	7100.0	350.0	6900.0	300.0	99999.0	0.0
18	7000.0	350.0	6900.0	300.0	99999.0	0.0
19	6900.0	350.0	99999.0	0.0	99999.0	0.0
20	6900.0	350.0	99999.0	0.0	99999.0	0.0
21	6800.0	350.0	99999.0	0.0	99999.0	0.0
22	99999.0	0.0	99999.0	0.0	99999.0	0.0
23	99999.0	0.0	99999.0	0.0	99999.0	0.0
24	99999.0	0.0	99999.0	0.0	99999.0	0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7430.	7100.	7430.
2	7430.	7100.	7430.
3	7430.	7100.	7430.
4	7430.	7100.	7430.
5	7430.	7100.	7430.
6	7430.	7000.	7430.
7	7430.	7000.	7400.
8	7430.	7000.	7400.
9	7430.	7000.	7400.
10	7400.	6900.	7400.
11	7400.	6900.	7300.
12	7400.	6900.	7300.
13	7400.	6900.	7300.
14	7400.	6900.	7200.
15	7400.	6850.	7200.
16	7400.	6800.	7100.
17	7400.	6800.	7100.
18	7400.	6800.	7000.
19	7400.	6800.	6900.
20	7400.	6800.	6900.
21	7400.	6750.	6800.
22	7400.	6700.	6700.
23	7400.	6700.	6700.
24	7400.	6700.	6700.

CASE 2 - SECTOR I

35 DEGREE DESIGN. SECTOR I.

PERIOD	SECTOR WIDTH
1	2400.0
2	2800.0
3	2800.0
4	2900.0
5	2900.0
6	2900.0
7	2900.0
8	3000.0
9	3000.0
10	3000.0
11	3000.0
12	3000.0
13	3000.0
14	3000.0
15	3000.0
16	3000.0
17	3000.0
18	3000.0
19	3000.0
20	3000.0
21	3000.0
22	3000.0
23	3000.0
24	3000.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1	2	2	3	3
1	7200.0	700.0	7100.0	500.0	99999.0	0.0
2	7300.0	600.0	7200.0	800.0	99999.0	0.0
3	7200.0	600.0	7100.0	800.0	99999.0	0.0
4	7200.0	700.0	7100.0	800.0	99999.0	0.0
5	7200.0	700.0	7000.0	800.0	99999.0	0.0
6	7100.0	700.0	7000.0	800.0	99999.0	0.0
7	7200.0	700.0	7100.0	700.0	99999.0	0.0
8	7300.0	800.0	7200.0	700.0	7000.0	700.0
9	7200.0	800.0	7100.0	700.0	7000.0	700.0
10	7200.0	800.0	7100.0	700.0	7000.0	700.0
11	7200.0	800.0	7100.0	700.0	6900.0	650.0
12	7200.0	800.0	7000.0	700.0	6900.0	650.0
13	7100.0	800.0	7000.0	700.0	99999.0	0.0
14	7100.0	800.0	6900.0	700.0	99999.0	0.0
15	7000.0	800.0	6900.0	600.0	99999.0	0.0
16	7000.0	800.0	6800.0	650.0	99999.0	0.0
17	6900.0	800.0	6800.0	650.0	99999.0	0.0
18	6900.0	800.0	6700.0	600.0	99999.0	0.0
19	6800.0	800.0	6700.0	600.0	99999.0	0.0
20	6700.0	800.0	99999.0	0.0	99999.0	0.0
21	6700.0	800.0	99999.0	0.0	99999.0	0.0
22	6600.0	800.0	99999.0	0.0	99999.0	0.0
23	6500.0	600.0	99999.0	0.0	99999.0	0.0
24	99999.0	0.0	99999.0	0.0	99999.0	0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7400.	7000.	7400.
2	7400.	7000.	7400.
3	7400.	7000.	7400.
4	7400.	6900.	7400.
5	7400.	6900.	7400.
6	7400.	6900.	7400.
7	7400.	6900.	7400.
8	7400.	6900.	7300.
9	7400.	6900.	7200.
10	7400.	6800.	7200.
11	7400.	6800.	7200.
12	7400.	6800.	7200.
13	7400.	6800.	7100.
14	7400.	6800.	7100.
15	7400.	6700.	7000.
16	7400.	6700.	7000.
17	7400.	6700.	6900.
18	7400.	6600.	6900.
19	7400.	6600.	6800.
20	7400.	6600.	6700.
21	7400.	6500.	6700.
22	7400.	6500.	6600.
23	7400.	6400.	6500.
24	7400.	6400.	6400.

CASE 2 - SECTOR II

35 DEGREE DESIGN. SECTOR II.

PERIOD	SECTOR WIDTH
1	1100.0
2	1200.0
3	1200.0
4	1700.0
5	1700.0
6	1700.0
7	1700.0
8	2000.0
9	2000.0
10	2600.0
11	2600.0
12	2600.0
13	2600.0
14	2600.0
15	2600.0
16	2600.0
17	2600.0
18	2600.0
19	2600.0
20	2600.0
21	2600.0
22	2600.0
23	2600.0
24	2600.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1	2	2	3	3
1	7200.0	350.0	99999.0	0.0	99999.0	0.0
2	7100.0	250.0	99999.0	0.0	99999.0	0.0
3	7200.0	300.0	7100.0	210.0	99999.0	0.0
4	7200.0	210.0	7100.0	300.0	99999.0	0.0
5	7200.0	210.0	7000.0	150.0	99999.0	0.0
6	7100.0	220.0	7000.0	150.0	99999.0	0.0
7	7200.0	200.0	7100.0	200.0	7000.0	200.0
8	7200.0	440.0	7000.0	250.0	99999.0	0.0
9	7200.0	200.0	7000.0	250.0	99999.0	0.0
10	7200.0	600.0	7100.0	500.0	7000.0	250.0
11	7200.0	600.0	7100.0	500.0	6900.0	150.0
12	7200.0	600.0	7000.0	400.0	99999.0	0.0
13	7100.0	450.0	7000.0	250.0	6900.0	185.0
14	7100.0	450.0	6900.0	350.0	99999.0	0.0
15	7000.0	400.0	6900.0	350.0	99999.0	0.0
16	7000.0	400.0	6800.0	360.0	99999.0	0.0
17	6900.0	400.0	6800.0	360.0	99999.0	0.0
18	6900.0	400.0	6800.0	360.0	99999.0	0.0
19	6800.0	350.0	6700.0	400.0	99999.0	0.0
20	6800.0	350.0	6600.0	250.0	99999.0	0.0
21	6700.0	260.0	99999.0	0.0	99999.0	0.0
22	99999.0	0.0	99999.0	0.0	99999.0	0.0
23	99999.0	0.0	99999.0	0.0	99999.0	0.0
24	99999.0	0.0	99999.0	0.0	99999.0	0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7250.	7100.	7250.
2	7250.	7000.	7250.
3	7250.	7000.	7250.
4	7250.	7000.	7250.
5	7250.	6900.	7250.
6	7250.	6900.	7250.
7	7250.	6900.	7250.
8	7250.	6900.	7250.
9	7250.	6900.	7250.
10	7250.	6800.	7200.
11	7250.	6800.	7200.
12	7250.	6800.	7200.
13	7250.	6800.	7100.
14	7250.	6800.	7100.
15	7250.	6800.	7000.
16	7250.	6700.	7000.
17	7250.	6700.	6900.
18	7250.	6600.	6900.
19	7250.	6600.	6800.
20	7250.	6500.	6800.
21	7250.	6500.	6700.
22	7250.	6500.	6600.
23	7250.	6500.	6500.
24	7250.	6400.	6400.

CASE 2 - SECTOR III

35 DEGREE DESIGN. SECTOR III.

PERIOD	SECTOR WIDTH
1	1900.0
2	2200.0
3	2200.0
4	2200.0
5	2200.0
6	2200.0
7	2200.0
8	2200.0
9	2200.0
10	2200.0
11	2500.0
12	2500.0
13	2800.0
14	2800.0
15	2800.0
16	2800.0
17	2800.0
18	2800.0
19	2800.0
20	2800.0
21	2800.0
22	2800.0
23	2800.0
24	2800.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7200.	7100.	7100.
2	7200.	7000.	7000.
3	7200.	7000.	7000.
4	7200.	6900.	6900.
5	7200.	6900.	6900.
6	7200.	6900.	6900.
7	7200.	6900.	6900.
8	7200.	6900.	6900.
9	7200.	6900.	6900.
10	7200.	6800.	6800.
11	7200.	6800.	6800.
12	7200.	6800.	6800.
13	7200.	6700.	6700.
14	7200.	6700.	6700.
15	7200.	6700.	6700.
16	7200.	6700.	6700.
17	7200.	6700.	6700.
18	7200.	6600.	6600.
19	7200.	6600.	6600.
20	7200.	6600.	6600.
21	7200.	6500.	6500.
22	7200.	6400.	6400.
23	7200.	6400.	6400.
24	7200.	6400.	6400.

CASE 2 - SECTOR IV

35 DEGREE DESIGN. SECTOR IV.

PERIOD	SECTOR WIDTH
1	900.0
2	1700.0
3	1700.0
4	2400.0
5	2400.0
6	2400.0
7	2400.0
8	2400.0
9	2400.0
10	2400.0
11	2400.0
12	2400.0
13	2400.0
14	2400.0
15	2400.0
16	2400.0
17	2400.0
18	2400.0
19	2400.0
20	2400.0
21	2400.0
22	2400.0
23	2400.0
24	2400.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1	2	2	3	3
1	7350.0	450.0	7300.0	400.0	7200.0	340.0
2	7350.0	450.0	7300.0	350.0	99999.0	0.0
3	7350.0	450.0	7200.0	250.0	99999.0	0.0
4	7350.0	350.0	7300.0	350.0	7200.0	350.0
5	7350.0	350.0	7300.0	350.0	7200.0	350.0
6	7300.0	450.0	7200.0	250.0	7100.0	300.0
7	7300.0	510.0	7200.0	250.0	7100.0	300.0
8	7300.0	510.0	7100.0	300.0	7000.0	245.0
9	7200.0	505.0	7100.0	300.0	7000.0	245.0
10	7200.0	505.0	7000.0	300.0	99999.0	0.0
11	7200.0	505.0	7000.0	300.0	99999.0	0.0
12	7100.0	450.0	7000.0	350.0	6900.0	150.0
13	7100.0	450.0	7000.0	350.0	99999.0	0.0
14	7000.0	450.0	6900.0	350.0	99999.0	0.0
15	7000.0	450.0	6900.0	350.0	99999.0	0.0
16	7000.0	450.0	6800.0	350.0	99999.0	0.0
17	6900.0	300.0	6800.0	300.0	99999.0	0.0
18	6900.0	300.0	99999.0	0.0	99999.0	0.0
19	6800.0	240.0	99999.0	0.0	99999.0	0.0
20	6700.0	150.0	99999.0	0.0	99999.0	0.0
21	6700.0	150.0	99999.0	0.0	99999.0	0.0
22	99999.0	0.0	99999.0	0.0	99999.0	0.0
23	99999.0	0.0	99999.0	0.0	99999.0	0.0
24	99999.0	0.0	99999.0	0.0	99999.0	0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7350.	7100.	7350.
2	7350.	7100.	7350.
3	7350.	7100.	7350.
4	7350.	7100.	7350.
5	7350.	7100.	7350.
6	7350.	7000.	7350.
7	7350.	7000.	7300.
8	7350.	6900.	7300.
9	7350.	6900.	7200.
10	7350.	6900.	7200.
11	7350.	6900.	7200.
12	7350.	6800.	7100.
13	7350.	6800.	7100.
14	7350.	6800.	7000.
15	7350.	6700.	7000.
16	7350.	6700.	7000.
17	7350.	6700.	6900.
18	7350.	6700.	6900.
19	7350.	6600.	6800.
20	7350.	6600.	6700.
21	7350.	6600.	6700.
22	7350.	6500.	6600.
23	7350.	6500.	6550.
24	7350.	6500.	6550.

CASE 3 - SECTOR I

PERIOD	SECTOR WIDTH
1	800.0
2	1800.0
3	2000.0
4	2000.0
5	2000.0
6	2000.0
7	2200.0
8	2200.0
9	2200.0
10	2200.0
11	2400.0
12	2400.0
13	2400.0
14	2400.0
15	2400.0
16	2400.0
17	2400.0
18	2400.0
19	2400.0
20	2400.0
21	2400.0
22	2400.0
23	2400.0
24	2400.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1	2	2	3	3
1	7400.0	500.0	7300.0	450.0	99999.0	0.0
2	7300.0	500.0	7200.0	500.0	99999.0	0.0
3	7300.0	500.0	7200.0	500.0	99999.0	0.0
4	7200.0	500.0	7100.0	500.0	99999.0	0.0
5	7300.0	500.0	7100.0	500.0	99999.0	0.0
6	7300.0	500.0	7200.0	500.0	7100.0	500.0
7	7300.0	500.0	7200.0	500.0	7000.0	500.0
8	7300.0	550.0	7100.0	550.0	7000.0	500.0
9	7300.0	550.0	7200.0	500.0	7100.0	550.0
10	7300.0	550.0	7100.0	500.0	7000.0	550.0
11	7200.0	550.0	7100.0	550.0	7000.0	550.0
12	7200.0	550.0	7000.0	550.0	6900.0	550.0
13	7100.0	550.0	7000.0	550.0	6900.0	550.0
14	7100.0	600.0	6900.0	550.0	6800.0	550.0
15	7000.0	600.0	6900.0	550.0	6800.0	550.0
16	7000.0	600.0	6800.0	550.0	99999.0	0.0
17	6900.0	600.0	6800.0	550.0	99999.0	0.0
18	6800.0	600.0	6700.0	550.0	99999.0	0.0
19	6700.0	550.0	99999.0	0.0	99999.0	0.0
20	6600.0	550.0	99999.0	0.0	99999.0	0.0
21	99999.0	0.0	99999.0	0.0	99999.0	0.0
22	99999.0	0.0	99999.0	0.0	99999.0	0.0
23	99999.0	0.0	99999.0	0.0	99999.0	0.0
24	99999.0	0.0	99999.0	0.0	99999.0	0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7420.	7100.	7420.
2	7420.	7100.	7420.
3	7420.	7000.	7420.
4	7420.	7000.	7420.
5	7420.	7000.	7420.
6	7420.	7000.	7420.
7	7420.	6900.	7420.
8	7420.	6900.	7420.
9	7450.	6900.	7300.
10	7450.	6900.	7300.
11	7450.	6800.	7200.
12	7450.	6800.	7200.
13	7450.	6750.	7100.
14	7450.	6700.	7100.
15	7450.	6700.	7000.
16	7450.	6700.	7000.
17	7450.	6650.	6900.
18	7450.	6625.	6800.
19	7450.	6600.	6700.
20	7450.	6500.	6600.
21	7450.	6500.	6500.
22	7450.	6400.	6500.
23	7450.	6400.	6500.
24	7450.	6400.	6500.

CASE 3 - SECTOR II

PERIOD	SECTOR WIDTH
1	0.0
2	900.0
3	900.0
4	1100.0
5	1100.0
6	1250.0
7	1250.0
8	1250.0
9	1400.0
10	1400.0
11	1400.0
12	1400.0
13	1400.0
14	1800.0
15	1800.0
16	1800.0
17	1800.0
18	1800.0
19	1800.0
20	1800.0
21	1600.0
22	1600.0
23	1600.0
24	1600.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1	2	2	3	3
1	99999.0	0.0	99999.0	0.0	99999.0	0.0
2	7200.0	170.0	99999.0	0.0	99999.0	0.0
3	7200.0	170.0	99999.0	0.0	99999.0	0.0
4	7200.0	170.0	7100.0	170.0	99999.0	0.0
5	7100.0	170.0	99999.0	0.0	99999.0	0.0
6	7200.0	170.0	7100.0	170.0	99999.0	0.0
7	7200.0	170.0	7100.0	170.0	99999.0	0.0
8	7100.0	170.0	7000.0	170.0	99999.0	0.0
9	7200.0	210.0	7100.0	180.0	99999.0	0.0
10	7100.0	210.0	7000.0	180.0	99999.0	0.0
11	7200.0	150.0	7100.0	210.0	7000.0	170.0
12	7200.0	150.0	7100.0	210.0	6900.0	170.0
13	7100.0	170.0	7000.0	210.0	6900.0	170.0
14	7100.0	170.0	6900.0	180.0	99999.0	0.0
15	7000.0	160.0	6900.0	180.0	99999.0	0.0
16	7000.0	160.0	6800.0	180.0	99999.0	0.0
17	6900.0	160.0	6800.0	180.0	99999.0	0.0
18	6800.0	160.0	99999.0	0.0	99999.0	0.0
19	6800.0	160.0	99999.0	0.0	99999.0	0.0
20	6700.0	160.0	99999.0	0.0	99999.0	0.0
21	99999.0	0.0	99999.0	0.0	99999.0	0.0
22	99999.0	0.0	99999.0	0.0	99999.0	0.0
23	99999.0	0.0	99999.0	0.0	99999.0	0.0
24	99999.0	0.0	99999.0	0.0	99999.0	0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7300.	7300.	7300.
2	7300.	7100.	7300.
3	7300.	7000.	7300.
4	7300.	7000.	7300.
5	7300.	7000.	7300.
6	7300.	7000.	7300.
7	7300.	6900.	7300.
8	7300.	6900.	7300.
9	7300.	6900.	7300.
10	7300.	6900.	7300.
11	7300.	6800.	7200.
12	7300.	6800.	7200.
13	7300.	6800.	7100.
14	7300.	6800.	7100.
15	7300.	6800.	7000.
16	7300.	6700.	7000.
17	7300.	6700.	6900.
18	7300.	6700.	6800.
19	7300.	6600.	6800.
20	7300.	6600.	6700.
21	7300.	6500.	6600.
22	7300.	6400.	6500.
23	7300.	6400.	6500.
24	7300.	6400.	6500.

CASE 3 - SECTOR III

PERIOD	SECTOR WIDTH
1	1200.0
2	1600.0
3	1600.0
4	1600.0
5	1600.0
6	1600.0
7	1600.0
8	1600.0
9	1600.0
10	1600.0
11	1600.0
12	1600.0
13	1600.0
14	1600.0
15	1600.0
16	1600.0
17	1600.0
18	1600.0
19	1600.0
20	1600.0
21	1600.0
22	1600.0
23	1600.0
24	1600.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7200.	7100.	7100.
2	7200.	7100.	7100.
3	7200.	7000.	7000.
4	7200.	7000.	7000.
5	7200.	7000.	7000.
6	7200.	6900.	6900.
7	7200.	6900.	6900.
8	7200.	6900.	6900.
9	7200.	6900.	6900.
10	7200.	6800.	6800.
11	7200.	6800.	6800.
12	7200.	6800.	6800.
13	7200.	6800.	6800.
14	7200.	6700.	6700.
15	7200.	6700.	6700.
16	7200.	6700.	6700.
17	7200.	6700.	6700.
18	7200.	6700.	6700.
19	7200.	6600.	6600.
20	7200.	6600.	6600.
21	7200.	6500.	6500.
22	7200.	6500.	6500.
23	7200.	6400.	6400.
24	7200.	6400.	6400.

CASE 3 - SECTOR IV

PERIOD	SECTOR WIDTH
1	0.0
2	500.0
3	500.0
4	500.0
5	800.0
6	1000.0
7	1300.0
8	1500.0
9	1500.0
10	1500.0
11	1500.0
12	1500.0
13	1500.0
14	1700.0
15	1700.0
16	1500.0
17	1500.0
18	1500.0
19	1500.0
20	1300.0
21	1300.0
22	1300.0
23	1300.0
24	1300.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1	2	2	3	3	4	4
1	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
2	7300.0	450.0	7200.0	400.0	99999.0	0.0	99999.0	0.0
3	7400.0	300.0	7300.0	450.0	7200.0	350.0	99999.0	0.0
4	7400.0	300.0	7200.0	450.0	7100.0	250.0	99999.0	0.0
5	7400.0	200.0	7200.0	120.0	7100.0	250.0	99999.0	0.0
6	7400.0	300.0	7300.0	150.0	7200.0	120.0	7100.0	200.0
7	7400.0	250.0	7300.0	130.0	7200.0	100.0	99999.0	0.0
8	7400.0	250.0	7200.0	100.0	7100.0	120.0	99999.0	0.0
9	7300.0	250.0	7200.0	100.0	7000.0	120.0	99999.0	0.0
10	7300.0	250.0	7100.0	100.0	7000.0	120.0	99999.0	0.0
11	7200.0	250.0	7100.0	100.0	7000.0	120.0	99999.0	0.0
12	7200.0	250.0	7000.0	100.0	99999.0	0.0	99999.0	0.0
13	7100.0	250.0	7000.0	100.0	99999.0	0.0	99999.0	0.0
14	7100.0	250.0	6900.0	90.0	99999.0	0.0	99999.0	0.0
15	7000.0	250.0	6900.0	90.0	99999.0	0.0	99999.0	0.0
16	6900.0	250.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
17	6900.0	250.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
18	6800.0	210.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
19	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
20	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
21	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
22	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
23	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0
24	99999.0	0.0	99999.0	0.0	99999.0	0.0	99999.0	0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.
1	7430.	7430.	7430.
2	7430.	7100.	7430.
3	7430.	7100.	7430.
4	7430.	7000.	7430.
5	7430.	7000.	7430.
6	7430.	7000.	7400.
7	7430.	7000.	7400.
8	7450.	7000.	7400.
9	7450.	6900.	7300.
10	7450.	6900.	7300.
11	7450.	6900.	7200.
12	7450.	6900.	7200.
13	7450.	6900.	7100.
14	7450.	6850.	7100.
15	7450.	6850.	7000.
16	7450.	6800.	6900.
17	7450.	6800.	6900.
18	7450.	6700.	6800.
19	7450.	6700.	6700.
20	7450.	6600.	6600.
21	7450.	6550.	6550.
22	7450.	6550.	6550.
23	7450.	6550.	6550.
24	7450.	6550.	6550.

APPENDIX E

COMPLETE COST MODEL ASSIGNMENTS FOR THREE DESIGNS

COST MODELS AND ASSOCIATED NUMERIC CODES USED IN THIS CASE STUDY

CODE	COST TYPE
	Full Wall (FHSL)
0	No Cost
1	Clean-up
2	Lost Coal
3	Lost Coal + Clean-up
4	Lost Coal + Early Mining
5	Mine Abandonment
6	Re-establish Haul Road
7	Clean-up + Early Mining + Lost Coal
8	Increased Haul + Clean-up
9	Mine Abandonment or Clean-up
	Interramp (IHWK)
0	No Cost
1	Clean-up
2	Lost Coal No. 1
3	Lost Coal No. 2
4	Lost Coal No. 3
5	Mine Abandonment
6	Early Mining
7	(None)
8	Increased Haul + Clean-up
9	Mine Abandonment or Clean-up
	Bench (BENS)
0	No Cost
1	Clean-up

CASE 1

SECTOR I

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	0	0	3	0	0	0	0	0	0	0	0	1
2	0	0	4	6	0	0	0	0	0	0	0	1
3	2	0	3	0	0	0	0	0	0	0	0	1
4	2	0	4	3	0	0	0	0	0	0	0	1
5	2	0	3	6	0	0	0	0	0	0	0	1
6	2	0	4	3	0	0	0	0	0	0	0	1
7	2	0	4	4	3	0	0	0	0	0	0	1
8	2	0	4	3	6	0	0	0	0	0	0	1
9	2	0	4	0	6	0	0	0	0	0	0	1
10	2	0	0	3	3	0	0	0	0	0	0	1
11	2	0	4	0	3	0	0	0	0	0	0	1
12	3	0	0	4	3	6	0	0	0	0	0	1
13	3	0	0	3	4	6	0	0	0	0	0	1
14	3	0	0	4	3	4	0	0	0	0	0	1
15	3	0	4	4	3	0	0	0	0	0	0	1
16	3	1	4	4	3	0	0	0	0	0	0	1
17	3	1	4	4	0	0	0	0	0	0	0	1
18	3	1	0	4	0	0	0	0	0	0	0	1
19	9	9	0	3	0	0	0	0	0	0	0	1
20	9	9	3	0	0	0	0	0	0	0	0	1
21	9	9	0	4	0	0	0	0	0	0	0	1
22	9	9	0	0	0	0	0	0	0	0	0	1
23	9	9	0	0	0	0	0	0	0	0	0	1
24	9	9	0	0	0	0	0	0	0	0	0	1

SECTOR II

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	0	0	0	0	0	0	0	0	0	0	0	1
2	4	0	0	0	0	0	0	0	0	0	0	1
3	4	3	0	0	0	0	0	0	0	0	0	1
4	4	3	0	0	0	0	0	0	0	0	0	1
5	4	3	0	0	0	0	0	0	0	0	0	1
6	4	4	4	0	0	0	0	0	0	0	0	1
7	4	4	4	0	0	0	0	0	0	0	0	1
8	4	3	3	0	0	0	0	0	0	0	0	1
9	4	2	0	0	0	0	0	0	0	0	0	1
10	4	3	3	3	0	0	0	0	0	0	0	1
11	4	3	4	0	0	0	0	0	0	0	0	1
12	4	2	3	3	3	0	0	0	0	0	0	1
13	4	3	3	0	0	0	0	0	0	0	0	1
14	4	0	3	4	0	0	0	0	0	0	0	1
15	4	0	2	0	0	0	0	0	0	0	0	1
16	7	1	4	0	0	0	0	0	0	0	0	1
17	7	1	0	0	0	0	0	0	0	0	0	1
18	7	1	0	0	0	0	0	0	0	0	0	1
19	8	8	0	0	0	0	0	0	0	0	0	1
20	8	8	0	0	0	0	0	0	0	0	0	1
21	9	9	0	0	0	0	0	0	0	0	0	1
22	9	9	0	0	0	0	0	0	0	0	0	1
23	9	9	0	0	0	0	0	0	0	0	0	1
24	9	9	0	0	0	0	0	0	0	0	0	1

CASE 1

SECTOR III

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS											BENCH
1	6	0	0	0	0	0	0	0	0	0	0	0	0
2	6	0	0	0	0	0	0	0	0	0	0	0	0
3	6	0	0	0	0	0	0	0	0	0	0	0	0
4	6	0	0	0	0	0	0	0	0	0	0	0	0
5	6	0	0	0	0	0	0	0	0	0	0	0	0
6	6	0	0	0	0	0	0	0	0	0	0	0	0
7	6	0	0	0	0	0	0	0	0	0	0	0	0
8	6	0	0	0	0	0	0	0	0	0	0	0	0
9	6	0	0	0	0	0	0	0	0	0	0	0	0
10	6	0	0	0	0	0	0	0	0	0	0	0	0
11	6	0	0	0	0	0	0	0	0	0	0	0	0
12	6	0	0	0	0	0	0	0	0	0	0	0	0
13	6	0	0	0	0	0	0	0	0	0	0	0	0
14	6	0	0	0	0	0	0	0	0	0	0	0	0
15	6	0	0	0	0	0	0	0	0	0	0	0	0
16	6	0	0	0	0	0	0	0	0	0	0	0	0
17	6	0	0	0	0	0	0	0	0	0	0	0	0
18	6	0	0	0	0	0	0	0	0	0	0	0	0
19	6	0	0	0	0	0	0	0	0	0	0	0	0
20	6	0	0	0	0	0	0	0	0	0	0	0	0
21	6	0	0	0	0	0	0	0	0	0	0	0	0
22	6	0	0	0	0	0	0	0	0	0	0	0	0
23	5	0	0	0	0	0	0	0	0	0	0	0	0
24	5	0	0	0	0	0	0	0	0	0	0	0	0

SECTOR IV

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS											BENCH
1	0	0	0	0	0	0	0	0	0	0	0	0	1
2	4	0	0	0	0	0	0	0	0	0	0	0	1
3	4	3	0	0	0	0	0	0	0	0	0	0	1
4	4	3	0	0	0	0	0	0	0	0	0	0	1
5	4	3	0	0	0	0	0	0	0	0	0	0	1
6	4	4	4	0	0	0	0	0	0	0	0	0	1
7	4	4	4	0	0	0	0	0	0	0	0	0	1
8	4	3	3	0	0	0	0	0	0	0	0	0	1
9	4	2	0	0	0	0	0	0	0	0	0	0	1
10	4	3	3	3	0	0	0	0	0	0	0	0	1
11	4	3	4	0	0	0	0	0	0	0	0	0	1
12	4	2	3	3	3	0	0	0	0	0	0	0	1
13	4	3	3	0	0	0	0	0	0	0	0	0	1
14	4	0	3	4	0	0	0	0	0	0	0	0	1
15	4	0	2	0	0	0	0	0	0	0	0	0	1
16	7	1	4	0	0	0	0	0	0	0	0	0	1
17	7	1	0	0	0	0	0	0	0	0	0	0	1
18	7	1	0	0	0	0	0	0	0	0	0	0	1
19	8	8	0	0	0	0	0	0	0	0	0	0	1
20	8	8	0	0	0	0	0	0	0	0	0	0	1
21	9	9	0	0	0	0	0	0	0	0	0	0	1
22	9	9	0	0	0	0	0	0	0	0	0	0	1
23	9	9	0	0	0	0	0	0	0	0	0	0	1
24	9	9	0	0	0	0	0	0	0	0	0	0	1

CASE 2

SECTOR I

INSTABILITY COST TYPES FOR DIFFERENT WALLS. SECTOR I.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	0	0	4	0	0	0	0	0	0	0	0	1
2	0	0	4	4	0	0	0	0	0	0	0	1
3	2	0	4	0	0	0	0	0	0	0	0	1
4	2	4	4	0	0	0	0	0	0	0	0	1
5	2	4	3	0	0	0	0	0	0	0	0	1
6	2	4	3	0	0	0	0	0	0	0	0	1
7	2	4	4	2	0	0	0	0	0	0	0	1
8	4	0	4	4	3	0	0	0	0	0	0	1
9	3	0	4	0	3	0	0	0	0	0	0	1
10	3	0	4	0	3	0	0	0	0	0	0	1
11	3	0	4	0	0	0	0	0	0	0	0	1
12	3	0	3	0	0	0	0	0	0	0	0	1
13	3	4	4	4	0	0	0	0	0	0	0	1
14	3	4	3	4	0	0	0	0	0	0	0	1
15	3	4	4	3	0	0	0	0	0	0	0	1
16	3	4	3	0	0	0	0	0	0	0	0	1
17	3	3	4	0	0	0	0	0	0	0	0	1
18	3	1	2	0	0	0	0	0	0	0	0	1
19	9	9	3	0	0	0	0	0	0	0	0	1
20	9	9	4	0	0	0	0	0	0	0	0	1
21	9	9	4	0	0	0	0	0	0	0	0	1
22	9	9	0	0	0	0	0	0	0	0	0	1
23	9	9	0	0	0	0	0	0	0	0	0	1
24	9	9	0	0	0	0	0	0	0	0	0	1

SECTOR II

INSTABILITY COST TYPES FOR DIFFERENT WALLS. SECTOR II.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	0	0	0	0	0	0	0	0	0	0	0	1
2	4	4	0	0	0	0	0	0	0	0	0	1
3	4	4	0	0	0	0	0	0	0	0	0	1
4	4	4	0	0	0	0	0	0	0	0	0	1
5	4	3	4	0	0	0	0	0	0	0	0	1
6	4	2	0	0	0	0	0	0	0	0	0	1
7	4	3	4	0	0	0	0	0	0	0	0	1
8	4	3	4	0	0	0	0	0	0	0	0	1
9	4	3	4	0	0	0	0	0	0	0	0	1
10	4	3	3	4	0	0	0	0	0	0	0	1
11	4	3	3	3	0	0	0	0	0	0	0	1
12	4	3	2	0	0	0	0	0	0	0	0	1
13	7	2	4	4	0	0	0	0	0	0	0	1
14	7	2	4	0	0	0	0	0	0	0	0	1
15	7	1	0	0	0	0	0	0	0	0	0	1
16	7	1	4	0	0	0	0	0	0	0	0	1
17	7	1	6	0	0	0	0	0	0	0	0	1
18	7	1	4	0	0	0	0	0	0	0	0	1
19	7	1	6	0	0	0	0	0	0	0	0	1
20	9	9	4	0	0	0	0	0	0	0	0	1
21	9	9	0	0	0	0	0	0	0	0	0	1
22	9	9	0	0	0	0	0	0	0	0	0	1
23	9	9	0	0	0	0	0	0	0	0	0	1
24	9	9	0	0	0	0	0	0	0	0	0	1

CASE 2

SECTOR III

INSTABILITY COST TYPES FOR DIFFERENT WALLS. SECTOR III.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	6	0	0	0	0	0	0	0	0	0	0	0
2	6	0	0	0	0	0	0	0	0	0	0	0
3	6	0	0	0	0	0	0	0	0	0	0	0
4	6	0	0	0	0	0	0	0	0	0	0	0
5	6	0	0	0	0	0	0	0	0	0	0	0
6	6	0	0	0	0	0	0	0	0	0	0	0
7	6	0	0	0	0	0	0	0	0	0	0	0
8	6	0	0	0	0	0	0	0	0	0	0	0
9	6	0	0	0	0	0	0	0	0	0	0	0
10	6	0	0	0	0	0	0	0	0	0	0	0
11	6	0	0	0	0	0	0	0	0	0	0	0
12	6	0	0	0	0	0	0	0	0	0	0	0
13	6	0	0	0	0	0	0	0	0	0	0	0
14	6	0	0	0	0	0	0	0	0	0	0	0
15	6	0	0	0	0	0	0	0	0	0	0	0
16	6	0	0	0	0	0	0	0	0	0	0	0
17	6	0	0	0	0	0	0	0	0	0	0	0
18	6	0	0	0	0	0	0	0	0	0	0	0
19	6	0	0	0	0	0	0	0	0	0	0	0
20	6	0	0	0	0	0	0	0	0	0	0	0
21	6	0	0	0	0	0	0	0	0	0	0	0
22	5	0	0	0	0	0	0	0	0	0	0	0
23	5	0	0	0	0	0	0	0	0	0	0	0
24	5	0	0	0	0	0	0	0	0	0	0	0

SECTOR IV

INSTABILITY COST TYPES FOR DIFFERENT WALLS. SECTOR IV.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	0	0	0	0	0	0	0	0	0	0	0	1
2	4	0	4	0	0	0	0	0	0	0	0	1
3	4	0	0	0	0	0	0	0	0	0	0	1
4	4	3	4	0	0	0	0	0	0	0	0	1
5	4	3	4	0	0	0	0	0	0	0	0	1
6	4	4	3	0	0	0	0	0	0	0	0	1
7	4	0	3	0	0	0	0	0	0	0	0	1
8	4	0	3	0	0	0	0	0	0	0	0	1
9	4	4	3	0	0	0	0	0	0	0	0	1
10	4	4	3	0	0	0	0	0	0	0	0	1
11	4	4	3	0	0	0	0	0	0	0	0	1
12	4	3	3	4	0	0	0	0	0	0	0	1
13	7	3	3	4	0	0	0	0	0	0	0	1
14	7	1	4	0	0	0	0	0	0	0	0	1
15	7	1	3	4	0	0	0	0	0	0	0	1
16	7	1	4	0	0	0	0	0	0	0	0	1
17	7	1	4	0	0	0	0	0	0	0	0	1
18	7	1	4	0	0	0	0	0	0	0	0	1
19	7	1	4	0	0	0	0	0	0	0	0	1
20	9	9	0	0	0	0	0	0	0	0	0	1
21	9	9	0	0	0	0	0	0	0	0	0	1
22	9	9	0	0	0	0	0	0	0	0	0	1
23	9	9	0	0	0	0	0	0	0	0	0	1
24	9	9	0	0	0	0	0	0	0	0	0	1

CASE 3

SECTOR I

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0	1
3	2	0	0	6	0	0	0	0	0	0	0	1
4	2	3	3	6	0	0	0	0	0	0	0	1
5	2	0	3	3	0	0	0	0	0	0	0	1
6	2	0	4	4	3	0	0	0	0	0	0	1
7	2	0	4	2	6	0	0	0	0	0	0	1
8	2	0	3	4	6	0	0	0	0	0	0	1
9	3	1	3	3	3	0	0	0	0	0	0	1
10	3	1	4	4	3	0	0	0	0	0	0	1
11	3	1	0	4	3	0	0	0	0	0	0	1
12	3	1	4	6	6	0	0	0	0	0	0	1
13	3	1	4	4	6	0	0	0	0	0	0	1
14	3	1	4	4	0	0	0	0	0	0	0	1
15	3	1	0	4	0	0	0	0	0	0	0	1
16	3	1	4	6	0	0	0	0	0	0	0	1
17	3	1	0	6	0	0	0	0	0	0	0	1
18	3	1	3	6	0	0	0	0	0	0	0	1
19	9	9	0	0	0	0	0	0	0	0	0	1
20	9	9	0	0	0	0	0	0	0	0	0	1
21	9	9	0	0	0	0	0	0	0	0	0	1
22	9	9	0	0	0	0	0	0	0	0	0	1
23	9	9	0	0	0	0	0	0	0	0	0	1
24	9	9	0	0	0	0	0	0	0	0	0	1

SECTOR II

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	0	0	0	0	0	0	0	0	0	0	0	1
2	4	0	0	0	0	0	0	0	0	0	0	1
3	4	0	3	0	0	0	0	0	0	0	0	1
4	4	0	3	0	0	0	0	0	0	0	0	1
5	4	0	0	0	0	0	0	0	0	0	0	1
6	4	0	3	0	0	0	0	0	0	0	0	1
7	4	0	3	4	0	0	0	0	0	0	0	1
8	4	3	4	0	0	0	0	0	0	0	0	1
9	4	3	4	3	0	0	0	0	0	0	0	1
10	4	3	4	0	0	0	0	0	0	0	0	1
11	4	4	4	4	0	0	0	0	0	0	0	1
12	4	4	4	3	0	0	0	0	0	0	0	1
13	4	2	4	0	0	0	0	0	0	0	0	1
14	7	1	3	0	0	0	0	0	0	0	0	1
15	7	1	0	0	0	0	0	0	0	0	0	1
16	7	1	3	0	0	0	0	0	0	0	0	1
17	8	8	0	0	0	0	0	0	0	0	0	1
18	8	8	0	0	0	0	0	0	0	0	0	1
19	9	9	0	0	0	0	0	0	0	0	0	1
20	9	9	0	0	0	0	0	0	0	0	0	1
21	9	9	0	0	0	0	0	0	0	0	0	1
22	9	9	0	0	0	0	0	0	0	0	0	1
23	9	9	0	0	0	0	0	0	0	0	0	1
24	9	9	0	0	0	0	0	0	0	0	0	1

CASE 3

SECTOR III

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	6	0	0	0	0	0	0	0	0	0	0	0
2	6	0	0	0	0	0	0	0	0	0	0	0
3	6	0	0	0	0	0	0	0	0	0	0	0
4	6	0	0	0	0	0	0	0	0	0	0	0
5	6	0	0	0	0	0	0	0	0	0	0	0
6	6	0	0	0	0	0	0	0	0	0	0	0
7	6	0	0	0	0	0	0	0	0	0	0	0
8	6	0	0	0	0	0	0	0	0	0	0	0
9	6	0	0	0	0	0	0	0	0	0	0	0
10	6	0	0	0	0	0	0	0	0	0	0	0
11	6	0	0	0	0	0	0	0	0	0	0	0
12	6	0	0	0	0	0	0	0	0	0	0	0
13	6	0	0	0	0	0	0	0	0	0	0	0
14	6	0	0	0	0	0	0	0	0	0	0	0
15	6	0	0	0	0	0	0	0	0	0	0	0
16	6	0	0	0	0	0	0	0	0	0	0	0
17	6	0	0	0	0	0	0	0	0	0	0	0
18	6	0	0	0	0	0	0	0	0	0	0	0
19	6	0	0	0	0	0	0	0	0	0	0	0
20	6	0	0	0	0	0	0	0	0	0	0	0
21	5	0	0	0	0	0	0	0	0	0	0	0
22	5	0	0	0	0	0	0	0	0	0	0	0
23	5	0	0	0	0	0	0	0	0	0	0	0
24	5	0	0	0	0	0	0	0	0	0	0	0

SECTOR IV

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS										BENCH
1	0	0	0	0	0	0	0	0	0	0	0	1
2	4	0	0	0	0	0	0	0	0	0	0	1
3	4	0	3	0	0	0	0	0	0	0	0	1
4	4	0	3	0	0	0	0	0	0	0	0	1
5	4	0	0	0	0	0	0	0	0	0	0	1
6	4	0	3	0	0	0	0	0	0	0	0	1
7	4	0	3	4	0	0	0	0	0	0	0	1
8	4	3	4	0	0	0	0	0	0	0	0	1
9	4	3	4	3	0	0	0	0	0	0	0	1
10	4	3	4	0	0	0	0	0	0	0	0	1
11	4	4	4	4	0	0	0	0	0	0	0	1
12	4	4	4	3	0	0	0	0	0	0	0	1
13	4	2	4	0	0	0	0	0	0	0	0	1
14	7	1	3	0	0	0	0	0	0	0	0	1
15	7	1	0	0	0	0	0	0	0	0	0	1
16	7	1	3	0	0	0	0	0	0	0	0	1
17	8	8	0	0	0	0	0	0	0	0	0	1
18	8	8	0	0	0	0	0	0	0	0	0	1
19	9	9	0	0	0	0	0	0	0	0	0	1
20	9	9	0	0	0	0	0	0	0	0	0	1
21	9	9	0	0	0	0	0	0	0	0	0	1
22	9	9	0	0	0	0	0	0	0	0	0	1
23	9	9	0	0	0	0	0	0	0	0	0	1
24	9	9	0	0	0	0	0	0	0	0	0	1

APPENDIX F

SIMULATION RESULTS BEFORE POST PROCESSING

INPUT DATA SUMMARY FOR CASE NUMBER 1

BIG PIT - 28 DEGREE DESIGN - CANADAIAN TEST CASE

STARTING DATE IS JAN 1978

VARIABLES FIXED FOR ALL SECTORS.

TYPE1 ORE PERCENT RECOVERY		1.000
TYPE2 ORE PERCENT RECOVERY		0.000
PRICE PER TON	OF TYPE1	12.00
PRICE PER TON	OF TYPE2	12.00
VOLUME OF ORE (CUBIC FEET	)	25.30
VOLUME OF WASTE (CUBIC FEET	)	14.20
INTEREST RATE PER PERIOD		.1200
TOTAL LIFE OF MINE (NUMBER OF PERIODS)		24
NUMBER OF SIMULATIONS		30

FLAGS

USER BENEFIT ROUTINE FLAG	0
USER COST ROUTINE FLAG	0
MAGNETIC TAPE WRITE FLAG	0
PRINT CONTROL FLAG	1

UNITS OF MEASURE USED IN PRINTING OUTPUT.
NOTE.....IT IS INCUMBENT UPON THE USER TO INPUT DATA IN A CONSISTENT SYSTEM OF UNITS. THE UNIT NAMES LISTED HERE ARE USED ONLY FOR LABELING PRINTED OUTPUT.

LINEAR MEASURE	FEET
VOLUME	CUBIC FEET
WEIGHT: ORE/WASTE	TON
METAL/MINERAL	TON
ANGLES	DEGREE
INTEREST RATE	PERCENT
MONEY	DOLLAR

1 RESULTS OF SIMULATION NUMBER 1
FOR SECTOR 1
CASE 1

BENEFITS (IN 1000 DOLLAR UNITS).
BENEFIT FROM ORE IS NET AFTER COST OF MINING THE ORE

PERIOD	TYPE1 ORE	TYPE2 ORE	USER BENEFIT	MISC. BENEFIT	TOTAL
1	20445.	0.	0.	0.	20445.
2	17295.	0.	0.	0.	17295.
3	19350.	0.	0.	0.	19350.
4	19103.	0.	0.	0.	19103.
5	17745.	0.	0.	0.	17745.
6	19320.	0.	0.	0.	19320.
7	19485.	0.	0.	0.	19485.
8	18645.	0.	0.	0.	18645.
9	17588.	0.	0.	0.	17588.
10	18923.	0.	0.	0.	18923.
11	18735.	0.	0.	0.	18735.
12	18608.	0.	0.	0.	18608.
13	18570.	0.	0.	0.	18570.
14	19238.	0.	0.	0.	19238.
15	18458.	0.	0.	0.	18458.
16	19388.	0.	0.	0.	19388.
17	18165.	0.	0.	0.	18165.
18	18863.	0.	0.	0.	18863.
19	18585.	0.	0.	0.	18585.
20	19140.	0.	0.	0.	19140.
21	18188.	0.	0.	0.	18188.
22	19628.	0.	0.	0.	19628.
23	19095.	0.	0.	0.	19095.
24	555.	0.	0.	0.	555.

COSTS (IN 1000 DOLLAR UNITS)

PERIOD	STRIPPING COST	USER COST
1	13338.	0.
2	10341.	0.
3	10239.	0.
4	12240.	0.
5	10081.	0.
6	11453.	0.
7	13501.	0.
8	9949.	0.
9	11050.	0.
10	12625.	0.
11	14183.	0.
12	9466.	0.
13	9868.	0.
14	13534.	0.
15	12141.	0.
16	10181.	0.
17	9083.	0.
18	10496.	0.
19	10446.	0.
20	8920.	0.
21	7438.	0.
22	8500.	0.
23	4754.	0.
24	0.	0.

PERIOD	COST OF INSTABILITY FULL WALL	INTER RAMP	BENCH	TOTAL COST ALL TYPES
1	0.	68.	3.	13408.
2	0.	7.	0.	10348.
3	0.	136.	3.	10378.
4	0.	136.	0.	12376.
5	0.	206.	0.	10287.
6	0.	7.	16.	11476.
7	0.	7.	3.	13511.
8	0.	68.	3.	10020.
9	0.	7.	7.	11064.
10	0.	82.	3.	12710.
11	0.	21.	7.	14210.
12	0.	137.	3.	9606.
13	0.	211.	6.	10085.
14	0.	21.	8.	13562.
15	0.	131.	14.	12287.
16	0.	142.	10.	10334.
17	0.	118.	13.	9214.
18	0.	0.	16.	10512.
19	0.	0.	19.	10465.
20	0.	68.	22.	9010.
21	0.	0.	22.	7459.
22	0.	0.	23.	8523.
23	0.	0.	24.	4778.
24	0.	0.	24.	24.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH
1	0	0 3 0 0 0 0 0 0 0 0 0	1
2	0	0 4 0 0 0 0 0 0 0 0 0	0
3	0	0 3 0 0 0 0 0 0 0 0 0	1
4	0	0 0 3 0 0 0 0 0 0 0 0	0
5	0	0 3 6 0 0 0 0 0 0 0 0	0
6	0	0 4 0 0 0 0 0 0 0 0 0	1
7	0	0 0 4 0 0 0 0 0 0 0 0	1
8	0	0 0 3 0 0 0 0 0 0 0 0	1
9	0	0 4 0 0 0 0 0 0 0 0 0	1
10	0	0 0 3 3 0 0 0 0 0 0 0	1
11	0	0 4 0 3 0 0 0 0 0 0 0	1
12	0	0 0 0 3 6 0 0 0 0 0 0	1
13	0	0 0 3 4 6 0 0 0 0 0 0	1
14	0	0 0 4 3 0 0 0 0 0 0 0	1
15	0	0 4 4 0 0 0 0 0 0 0 0	1
16	0	0 0 4 3 0 0 0 0 0 0 0	1
17	0	0 0 4 0 0 0 0 0 0 0 0	1
18	0	0 0 0 0 0 0 0 0 0 0 0	1
19	0	0 0 0 0 0 0 0 0 0 0 0	1
20	0	0 3 0 0 0 0 0 0 0 0 0	1
21	0	0 0 0 0 0 0 0 0 0 0 0	1
22	0	0 0 0 0 0 0 0 0 0 0 0	1
23	0	0 0 0 0 0 0 0 0 0 0 0	1
24	0	0 0 0 0 0 0 0 0 0 0 0	1

NUMBER OF CELLS IN EACH WALL

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH
1	5	14	7	0	0	0	0	0	0	0	0	0	41
2	6	18	18	18	0	0	0	0	0	0	0	0	53
3	5	18	9	18	0	0	0	0	0	0	0	0	71
4	5	20	20	10	0	0	0	0	0	0	0	0	79
5	5	20	10	20	0	0	0	0	0	0	0	0	79
6	4	20	20	10	20	0	0	0	0	0	0	0	99
7	4	20	20	20	20	20	0	0	0	0	0	0	99
8	4	22	22	11	22	0	0	0	0	0	0	0	109
9	4	11	22	22	22	0	0	0	0	0	0	0	109
10	4	22	22	11	22	44	0	0	0	0	0	0	120
11	4	11	22	22	22	22	0	0	0	0	0	0	131
12	4	22	22	22	11	22	0	0	0	0	0	0	131
13	4	22	22	11	22	22	0	0	0	0	0	0	131
14	4	12	24	24	24	16	0	0	0	0	0	0	155
15	4	12	12	24	24	48	0	0	0	0	0	0	155
16	3	8	24	24	12	0	0	0	0	0	0	0	167
17	3	8	24	12	24	0	0	0	0	0	0	0	167
18	3	6	24	24	24	0	0	0	0	0	0	0	167
19	3	5	26	26	52	0	0	0	0	0	0	0	194
20	3	5	13	26	0	0	0	0	0	0	0	0	207
21	3	4	26	17	0	0	0	0	0	0	0	0	220
22	3	3	26	0	0	0	0	0	0	0	0	0	233
23	3	3	0	0	0	0	0	0	0	0	0	0	246
24	3	3	0	0	0	0	0	0	0	0	0	0	246

COUNT OF UNSTABLE CELLS

PIT WALLS

FULL HEIGHT	0.
INTER RAMP	65.
SINGLE BENCH	80.
WEAK STRATUM	0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR UNITS)

TOTAL BENEFIT = 145471.
TOTAL COST = 87539.

CASE SUMMARY FOR CASE NUMBER 1 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.
145471.	145471.	145471.	145471.	145471.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

88120.	88265.	88170.	88144.	88091.
88509.	88404.	88239.	88362.	88513.
88274.	88124.	88068.	88861.	88392.
88629.	88556.	88051.	87897.	88160.
88083.	87928.	88235.	88242.	88061.
88357.	88223.	88443.	88621.	88203.

SUMMARY OF BENEFITS AND COSTS FOR CASE 1

AVERAGE PRESENT VALUE OF BENEFITS	145471.
STANDARD DEVIATION OF BENEFITS	0.
AVERAGE PRESENT VALUE OF COSTS	88274.
STANDARD DEVIATION OF COSTS	222.

INPUT DATA SUMMARY FOR CASE NUMBER 2

BIG PIT - 35 DEGREE DESIGN - CANADAIAN TEST CASE- DRAINED PIT
STARTING DATE IS JULY 1978

VARIABLES FIXED FOR ALL SECTORS.

TYPE1 ORE PERCENT RECOVERY		1.000
TYPE2 ORE PERCENT RECOVERY		0.000
PRICE PER TON	OF TYPE1	12.00
PRICE PER TON	OF TYPE2	12.00
VOIUME OF ORE (CUBIC FEET	)	25.30
VOLUME OF WASTE (CUBIC FEET	)	14.20
INTEREST RATE PER PERIOD		.1200
TOTAL LIFE OF MINE (NUMBER OF PERIODS)		24
NUMBER OF SIMULATIONS		30

FLAGS

USER BENEFIT ROUTINE FLAG	0
USER COST ROUTINE FLAG	0
MAGNETIC TAPE WRITE FLAG	0
PRINT CONTROL FLAG	1
DIAGNOSTIC MESSAGE CONTROL	1

UNITS OF MEASURE USED IN PRINTING OUTPUT.
NOTE.....IT IS INCUMBENT UPON THE USER TO INPUT DATA IN A CONSISTENT SYSTEM OF UNITS. THE UNIT NAMES LISTED HERE ARE USED ONLY FOR LABELING PRINTED OUTPUT.

LINEAR MEASURE	FEET
VOLUME	CUBIC FEET
WEIGHT: ORE/WASTE	TON
METAL/MINERAL	TON
ANGLES	DEGREE
INTEREST RATE	PERCENT
MONEY	DOLLAR

1 RESULTS OF SIMULATION NUMBER 1
FOR SECTOR 1
CASE 2

BENEFITS (IN 1000 DOLLAR UNITS).
BENEFIT FROM ORE IS NET AFTER COST OF MINING THE ORE

PERIOD	TYPE1 ORE	TYPE2 ORE	USER BENEFIT	MISC. BENEFIT	TOTAL
1	18758.	0.	0.	0.	18758.
2	18945.	0.	0.	0.	18945.
3	19103.	0.	0.	0.	19103.
4	20393.	0.	0.	0.	20393.
5	16590.	0.	0.	0.	16590.
6	19898.	0.	0.	0.	19898.
7	18233.	0.	0.	0.	18233.
8	19613.	0.	0.	0.	19613.
9	17243.	0.	0.	0.	17243.
10	19898.	0.	0.	0.	19898.
11	18158.	0.	0.	0.	18158.
12	19230.	0.	0.	0.	19230.
13	19223.	0.	0.	0.	19223.
14	17880.	0.	0.	0.	17880.
15	18675.	0.	0.	0.	18675.
16	18810.	0.	0.	0.	18810.
17	19553.	0.	0.	0.	19553.
18	18120.	0.	0.	0.	18120.
19	20303.	0.	0.	0.	20303.
20	16920.	0.	0.	0.	16920.
21	18945.	0.	0.	0.	18945.
22	20003.	0.	0.	0.	20003.
23	17565.	0.	0.	0.	17565.
24	1073.	0.	0.	0.	1073.

COSTS (IN 1000 DOLLAR UNITS)

PERIOD	STRIPPING COST	USER COST
1	10524.	0.
2	7175.	0.
3	12926.	0.
4	11164.	0.
5	7434.	0.
6	11836.	0.
7	13541.	0.
8	12789.	0.
9	16518.	0.
10	9059.	0.
11	7729.	0.
12	11526.	0.
13	14271.	0.
14	8955.	0.
15	11339.	0.
16	9894.	0.
17	12574.	0.
18	4775.	0.
19	11233.	0.
20	8959.	0.
21	5721.	0.
22	8261.	0.
23	5704.	0.
24	141.	0.

COST OF INSTABILITY

PERIOD	FULL WALL	INTER RAMP	BENCH	ALL TYPES
1	0.	7.	9.	10540.
2	0.	39.	3.	7217.
3	0.	7.	11.	12944.
4	0.	59.	8.	11231.
5	0.	147.	9.	7590.
6	0.	261.	0.	12097.
7	0.	317.	0.	13859.
8	0.	21.	8.	12817.
9	0.	13.	14.	16545.
10	0.	68.	21.	9147.
11	0.	7.	16.	7751.
12	0.	68.	24.	11618.
13	0.	46.	12.	14329.
14	0.	7.	20.	8982.
15	0.	20.	24.	11383.
16	0.	68.	16.	9978.
17	0.	20.	23.	12617.
18	573.	0.	0.	5348.
19	0.	14.	27.	11274.
20	1077.	0.	0.	10036.
21	0.	1077.	8.	6806.
22	1608.	0.	0.	9869.
23	3.	0.	0.	5707.
24	1.	0.	0.	142.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH
1	0	0 4 0 0 0 0 0 0 0 0 0	1
2	0	0 0 4 0 0 0 0 0 0 0 0	1
3	0	0 4 0 0 0 0 0 0 0 0 0	1
4	0	4 4 0 0 0 0 0 0 0 0 0	1
5	0	4 3 0 0 0 0 0 0 0 0 0	1
6	0	4 3 0 0 0 0 0 0 0 0 0	0
7	0	4 4 2 0 0 0 0 0 0 0 0	0
8	0	0 4 0 3 0 0 0 0 0 0 0	1
9	0	0 4 0 0 0 0 0 0 0 0 0	1
10	0	0 0 0 3 0 0 0 0 0 0 0	1
11	0	0 4 0 0 0 0 0 0 0 0 0	1
12	0	0 3 0 0 0 0 0 0 0 0 0	1
13	0	0 4 4 0 0 0 0 0 0 0 0	1
14	0	0 0 4 0 0 0 0 0 0 0 0	1
15	0	0 4 0 0 0 0 0 0 0 0 0	1
16	0	0 3 0 0 0 0 0 0 0 0 0	1
17	0	0 4 0 0 0 0 0 0 0 0 0	1
18	3	0 0 0 0 0 0 0 0 0 0 0	0
19	0	0 3 0 0 0 0 0 0 0 0 0	1
20	9	0 0 0 0 0 0 0 0 0 0 0	0
21	0	9 0 0 0 0 0 0 0 0 0 0	1
22	9	0 0 0 0 0 0 0 0 0 0 0	0
23	9	0 0 0 0 0 0 0 0 0 0 0	0
24	9	0 0 0 0 0 0 0 0 0 0 0	0

NUMBER OF CELLS IN EACH WALL

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH
1	6	12	24	24	0	0	0	0	0	0	0	0	95
2	7	28	28	14	0	0	0	0	0	0	0	0	111
3	7	14	28	28	0	0	0	0	0	0	0	0	111
4	6	15	29	15	0	0	0	0	0	0	0	0	144
5	6	15	15	29	0	0	0	0	0	0	0	0	144
6	6	10	29	29	0	0	0	0	0	0	0	0	144
7	6	15	29	15	0	0	0	0	0	0	0	0	144
8	6	30	30	15	30	0	0	0	0	0	0	0	149
9	6	15	30	30	30	0	0	0	0	0	0	0	149
10	5	15	30	30	15	0	0	0	0	0	0	0	179
11	5	15	30	15	30	0	0	0	0	0	0	0	179
12	5	15	15	30	30	0	0	0	0	0	0	0	179
13	5	10	30	15	0	0	0	0	0	0	0	0	179
14	5	10	15	30	0	0	0	0	0	0	0	0	179
15	4	8	30	15	0	0	0	0	0	0	0	0	209
16	4	8	15	30	0	0	0	0	0	0	0	0	209
17	4	6	30	30	0	0	0	0	0	0	0	0	209
18	4	6	15	30	0	0	0	0	0	0	0	0	239
19	4	5	30	30	0	0	0	0	0	0	0	0	239
20	4	4	30	0	0	0	0	0	0	0	0	0	239
21	3	4	15	0	0	0	0	0	0	0	0	0	269
22	3	4	30	0	0	0	0	0	0	0	0	0	269
23	3	3	30	0	0	0	0	0	0	0	0	0	299
24	3	3	0	0	0	0	0	0	0	0	0	0	299

COUNT OF UNSTABLE CELLS

PIT WALLS

FULL HEIGHT	7.
INTER RAMP	59.
SINGLE BENCH	81.
WEAK STRATUM	0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR UNITS)

TOTAL BENEFIT = 145483.
TOTAL COST = 83105.

CASE SUMMARY FOR CASE NUMBER 2 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.
145483.	145483.	145483.	145483.	145483.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

84058.	83858.	83944.	83684.	84154.
84180.	83885.	83826.	84229.	84510.
83715.	84073.	83814.	83882.	84230.
84391.	83800.	84035.	83786.	84383.
84070.	83742.	83455.	84352.	83629.
83423.	83869.	84159.	83996.	84660.

SUMMARY OF BENEFITS AND COSTS FOR CASE 2

AVERAGE PRESENT VALUE OF BENEFITS	145483.
STANDARD DEVIATION OF BENEFITS	0.
AVERAGE PRESENT VALUE OF COSTS	83994.
STANDARD DEVIATION OF COSTS	294.

INPUT DATA SUMMARY FOR CASE NUMBER 3

BIG PIT - 45 DEGREE DESIGN - CANADAIAN TEST CASE

STARTING DATE IS JAN 1978

VARIABLES FIXED FOR ALL SECTORS.

TYPE1 ORE PERCENT RECOVERY		1.000
TYPE2 ORE PERCENT RECOVERY		0.000
PRICE PER TON	OF TYPE1	12.00
PRICE PER TON	OF TYPE2	12.00
VOLUME OF ORE (CUBIC FEET	)	25.30
VOLUME OF WASTE (CUBIC FEET	)	14.20
INTEREST RATE PER PERIOD		.1200
TOTAL LIFE OF MINE (NUMBER OF PERIODS)		24
NUMBER OF SIMULATIONS		30

FLAGS

USER BENEFIT ROUTINE FLAG	0
USER COST ROUTINE FLAG	0
MAGNETIC TAPE WRITE FLAG	0
PRINT CONTROL FLAG	1

UNITS OF MEASURE USED IN PRINTING OUTPUT.
NOTE.....IT IS INCUMBENT UPON THE USER TO INPUT DATA IN A CONSISTENT SYSTEM OF UNITS. THE UNIT NAMES LISTED HERE ARE USED ONLY FOR LABELING PRINTED OUTPUT.

LINEAR MEASURE	FEET
VOLUME	CUBIC FEET
WEIGHT: ORE/WASTE	TON
METAL/MINERAL	TON
ANGLES	DEGREE
INTEREST RATE	PERCENT
MONEY	DOLLAR

1 RESULTS OF SIMULATION NUMBER 1
FOR SECTOR 1
CASE 3

BENEFITS (IN 1000 DOLLAR UNITS).
BENEFIT FROM ORE IS NET AFTER COST OF MINING THE ORE

PERIOD	TYPE1 ORE	TYPE2 ORE	USER BENEFIT	MISC. BENEFIT	TOTAL
1	19770.	0.	0.	0.	19770.
2	18398.	0.	0.	0.	18398.
3	18158.	0.	0.	0.	18158.
4	18863.	0.	0.	0.	18863.
5	20768.	0.	0.	0.	20768.
6	17835.	0.	0.	0.	17835.
7	17955.	0.	0.	0.	17955.
8	18323.	0.	0.	0.	18323.
9	19133.	0.	0.	0.	19133.
10	18938.	0.	0.	0.	16938.
11	20595.	0.	0.	0.	20595.
12	16680.	0.	0.	0.	16680.
13	18540.	0.	0.	0.	18540.
14	18630.	0.	0.	0.	18630.
15	20168.	0.	0.	0.	20168.
16	18960.	0.	0.	0.	18960.
17	18053.	0.	0.	0.	18053.
18	18195.	0.	0.	0.	18195.
19	19395.	0.	0.	0.	19395.
20	18038.	0.	0.	0.	18038.
21	18638.	0.	0.	0.	18638.
22	18023.	0.	0.	0.	18023.
23	10530.	0.	0.	0.	10530.
24	10530.	0.	0.	0.	10530.

COSTS (IN 1000 DOLLAR UNITS)

PERIOD	STRIPPING COST	USER COST
1	11239.	0.
2	8578.	0.
3	9310.	0.
4	10463.	0.
5	12006.	0.
6	10561.	0.
7	8079.	0.
8	9740.	0.
9	9978.	0.
10	10109.	0.
11	10258.	0.
12	8321.	0.
13	10173.	0.
14	11219.	0.
15	8271.	0.
16	8330.	0.
17	8121.	0.
18	9328.	0.
19	7940.	0.
20	4673.	0.
21	6196.	0.
22	3954.	0.
23	3510.	0.
24	1010.	0.

COST OF INSTABILITY

PERIOD	FULL WALL	INTER RAMP	BENCH	ALL TYPES
1	0.	0.	3.	11242.
2	0.	0.	0.	8578.
3	0.	65.	3.	9378.
4	0.	255.	0.	10718.
5	0.	271.	6.	12284.
6	0.	41.	0.	10602.
7	0.	386.	3.	8468.
8	0.	205.	0.	9945.
9	0.	448.	3.	10429.
10	0.	89.	9.	10207.
11	0.	621.	0.	10879.
12	0.	474.	0.	8796.
13	0.	815.	3.	10990.
14	0.	1061.	6.	12286.
15	0.	1431.	6.	9708.
16	0.	979.	0.	9309.
17	0.	2094.	3.	10219.
18	0.	3450.	0.	12778.
19	1325.	0.	0.	9265.
20	1929.	0.	0.	6601.
21	8077.	0.	0.	14274.
22	5385.	0.	0.	9339.
23	5385.	0.	0.	8895.
24	2.	0.	0.	1012.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH
1	0	0 0 0 0 0 0 0 0 0 0	1
2	0	0 0 0 0 0 0 0 0 0 0	0
3	0	0 0 6 0 0 0 0 0 0 0	1
4	0	3 0 0 0 0 0 0 0 0 0	0
5	0	0 3 0 0 0 0 0 0 0 0	1
6	0	0 4 4 3 0 0 0 0 0 0	0
7	0	0 0 2 6 0 0 0 0 0 0	1
8	0	0 3 0 6 0 0 0 0 0 0	0
9	0	0 3 3 3 0 0 0 0 0 0	1
10	0	1 4 0 0 0 0 0 0 0 0	1
11	0	1 0 4 3 0 0 0 0 0 0	0
12	0	1 4 6 6 0 0 0 0 0 0	0
13	0	1 0 4 0 0 0 0 0 0 0	1
14	0	1 4 0 0 0 0 0 0 0 0	1
15	0	1 0 0 0 0 0 0 0 0 0	1
16	0	1 4 6 0 0 0 0 0 0 0	0
17	0	1 0 6 0 0 0 0 0 0 0	1
18	0	1 0 6 0 0 0 0 0 0 0	0
19	9	0 0 0 0 0 0 0 0 0 0	0
20	9	0 0 0 0 0 0 0 0 0 0	0
21	9	0 0 0 0 0 0 0 0 0 0	0
22	9	0 0 0 0 0 0 0 0 0 0	0
23	9	0 0 0 0 0 0 0 0 0 0	0
24	9	0 0 0 0 0 0 0 0 0 0	0

NUMBER OF CELLS IN EACH WALL

PERIOD	FULL WALL					INTER RAMP WALLS						BENCH
1	3	40	8	4	0	0	0	0	0	0	0	25
2	6	15	18	18	0	0	0	0	0	0	0	57
3	5	17	20	10	0	0	0	0	0	0	0	83
4	5	9	20	20	0	0	0	0	0	0	0	83
5	5	17	10	20	0	0	0	0	0	0	0	83
6	5	17	20	20	20	0	0	0	0	0	0	83
7	4	18	22	11	22	0	0	0	0	0	0	114
8	4	18	11	22	22	0	0	0	0	0	0	114
9	4	15	22	22	11	0	0	0	0	0	0	120
10	4	15	11	22	22	0	0	0	0	0	0	120
11	4	10	24	24	12	0	0	0	0	0	0	155
12	4	10	12	24	24	0	0	0	0	0	0	155
13	3	7	24	24	16	0	0	0	0	0	0	167
14	3	7	12	24	24	0	0	0	0	0	0	179
15	3	5	24	24	24	0	0	0	0	0	0	179
16	3	5	12	24	0	0	0	0	0	0	0	179
17	3	4	24	16	0	0	0	0	0	0	0	191
18	3	4	24	32	0	0	0	0	0	0	0	197
19	3	3	24	0	0	0	0	0	0	0	0	203
20	3	3	24	0	0	0	0	0	0	0	0	227
21	3	3	0	0	0	0	0	0	0	0	0	227
22	2	2	0	0	0	0	0	0	0	0	0	251
23	2	2	0	0	0	0	0	0	0	0	0	251
24	2	2	0	0	0	0	0	0	0	0	0	251

COUNT OF UNSTABLE CELLS

PIT WALLS

FULL HEIGHT	11.
INTER RAMP	119.
SINGLE BENCH	15.
WEAK STRATUM	0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR UNITS)

TOTAL BENEFIT = 145411.
TOTAL COST = 79033.

CASE SUMMARY FOR CASE NUMBER 3 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.
145411.	145411.	145411.	145411.	145411.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

84677.	84306.	84448.	84209.	84125.
83644.	84358.	84399.	84530.	84256.
84103.	85041.	84482.	84876.	84930.
84317.	84141.	84463.	84888.	84823.
84581.	84193.	84565.	84813.	83908.
84382.	84769.	84419.	83961.	83614.

SUMMARY OF BENEFITS AND COSTS FOR CASE 3

AVERAGE PRESENT VALUE OF BENEFITS	145411.
STANDARD DEVIATION OF BENEFITS	0.
AVERAGE PRESENT VALUE OF COSTS	84407.
STANDARD DEVIATION OF COSTS	361.

APPENDIX G

SIMULATION RESULTS AFTER POST PROCESSING

COST MODEL STATISTICS FOR CASE NUMBER 1
(VALUES AVERAGED OVER 30 SIMULATIONS)

MODEL NAME	TOT. NO. OF CALLS	AVERAGE COST	STD. DEV. OF COST
CLEAN-UP--FW	0	0.00	0.00
LOST COAL-FW	2	1272.06	790.29
LSTC+CLNP-FW	2	1077.84	167.21
LSTC+ERMN-FW	2	641.76	515.03
MN ABDNMT-FW	0	0.00	0.00
RE-EST HR-FW	3	81.51	10.86
CL+LC+EM--FW	0	0.00	0.00
INCHL+CLN-FW	1	747.67	0.00
CL(VS MA)-FW	4	778.02	199.41
CLEAN-UP--IR	2	84.79	.00
LST CL NO. 1	182	69.09	40.22
LST CL NO. 2	1213	58.92	46.45
LST CL NO. 3	755	17.94	15.59
MN ABDNMT-IR	0	0.00	0.00
ERLY MNG--IR	132	1.35	.00
INCHL+CLN-IR	0	0.00	0.00
CL(VS MA)-IR	12	1462.34	369.84
CLEAN-UP-BEN	3036	3.14	.00
MA(VS CL)-FW	3	165.18	286.10
MA(VS CL)-IR	13	419.30	186.09

```
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   2 OF SIMULATION   2 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   2 OF SIMULATION   3 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   2 OF SIMULATION   4 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   1 OF SIMULATION   8 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  10 CLEAN-UP VOLUME EXCEEDED: VOL=   3042963.
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   1 OF SIMULATION  11 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   1 OF SIMULATION  12 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   2 OF SIMULATION  14 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  17 CLEAN-UP VOLUME EXCEEDED: VOL=   3042963.
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   2 OF SIMULATION  19 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   2 OF SIMULATION  24 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   2 OF SIMULATION  28 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
```

CASE SUMMARY FOR CASE NUMBER 1 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
AFTER POST PROCESSING
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

145471.	145435.	145435.	145435.	145471.
145471.	145471.	145435.	145471.	144026.
145435.	145435.	145471.	145435.	145471.
145471.	144026.	145471.	145435.	145471.
145471.	145471.	145471.	145435.	145471.
145471.	145471.	145435.	145471.	145471.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

88120.	88300.	88205.	88180.	88091.
88509.	88404.	88275.	88362.	89349.
88311.	88159.	88068.	88897.	88392.
88629.	89390.	88051.	87932.	88160.
88083.	87928.	88235.	88278.	88061.
88357.	88223.	88479.	88621.	88203.

SUMMARY OF BENEFITS AND COSTS FOR CASE 1

AVERAGE PRESENT VALUE OF BENEFITS	145363.
STANDARD DEVIATION OF BENEFITS	364.
AVERAGE PRESENT VALUE OF COSTS	88342.
STANDARD DEVIATION OF COSTS	350.

35 DEGREE DESIGN.

COST MODEL STATISTICS FOR CASE NUMBER 2
(VALUES AVERAGED OVER 30 SIMULATIONS)

MODEL NAME	TOT. NO. OF CALLS	AVERAGE COST	STD. DEV. OF COST
CLEAN-UP--FW	0	0.00	0.00
LOST COAL-FW	1	837.20	0.00
LSTC+CLNP-FW	14	526.18	98.39
LSTC+ERMN-FW	13	385.94	88.20
MN ABDNMT-FW	0	0.00	0.00
RE-EST HR-FW	1	94.05	0.00
CL+LC+EM--FW	33	595.30	116.10
INCHL+CLN-FW	0	0.00	0.00
CL(VS MA)-FW	192	993.87	292.58
CLEAN-UP--IR	110	184.24	93.68
LST CL NO. 1	83	71.52	22.88
LST CL NO. 2	845	24.32	45.93
LST CL NO. 3	1144	16.49	26.66
MN ABDNMT-IR	0	0.00	0.00
ERLY MNG--IR	75	1.35	.00
INCHL+CLN-IR	0	0.00	0.00
CL(VS MA)-IR	100	985.48	459.83
CLEAN-UP-BEN	3660	3.14	.00
MA(VS CL)-FW	199	405.29	416.65
MA(VS CL)-IR	64	415.74	419.02

```
** THE PIT WAS ABANDONED IN PERIOD  21 OF SIMULATION   1 CLEAN-UP VOLUME EXCEEDED: VOL=   3139630.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION   2 CLEAN-UP VOLUME EXCEEDED: VOL=   3580741.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION   3 CLEAN-UP VOLUME EXCEEDED: VOL=   3583704.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION   4 CLEAN-UP VOLUME EXCEEDED: VOL=   6197037.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION   5 CLEAN-UP VOLUME EXCEEDED: VOL=   7297778.
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   1 OF SIMULATION   6 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION   7 CLEAN-UP VOLUME EXCEEDED: VOL=   5097778.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION   8 CLEAN-UP VOLUME EXCEEDED: VOL=   3580741.
** THE PIT WAS ABANDONED IN PERIOD  21 OF SIMULATION   9 CLEAN-UP VOLUME EXCEEDED: VOL=   3136667.
** THE PIT WAS ABANDONED IN PERIOD  20 OF SIMULATION  10 CLEAN-UP VOLUME EXCEEDED: VOL=   3871481.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  11 CLEAN-UP VOLUME EXCEEDED: VOL=   3580741.
** THE PIT WAS ABANDONED IN PERIOD  21 OF SIMULATION  12 CLEAN-UP VOLUME EXCEEDED: VOL=   3668889.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  13 CLEAN-UP VOLUME EXCEEDED: VOL=   4394444.
** THE PIT WAS ABANDONED IN PERIOD  21 OF SIMULATION  14 CLEAN-UP VOLUME EXCEEDED: VOL=   4158889.
** THE PIT WAS ABANDONED IN PERIOD  20 OF SIMULATION  15 CLEAN-UP VOLUME EXCEEDED: VOL=   3472222.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  16 CLEAN-UP VOLUME EXCEEDED: VOL=   7767037.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  17 CLEAN-UP VOLUME EXCEEDED: VOL=   5103704.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  18 CLEAN-UP VOLUME EXCEEDED: VOL=   3764815.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  19 CLEAN-UP VOLUME EXCEEDED: VOL=   5272963.
** THE PIT WAS ABANDONED IN PERIOD  21 OF SIMULATION  20 CLEAN-UP VOLUME EXCEEDED: VOL=   4128519.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  21 CLEAN-UP VOLUME EXCEEDED: VOL=   5653333.
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   1 OF SIMULATION  22 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  23 CLEAN-UP VOLUME EXCEEDED: VOL=   3755926.
** THE PIT WAS ABANDONED IN PERIOD  21 OF SIMULATION  24 CLEAN-UP VOLUME EXCEEDED: VOL=   3160370.
** THE PIT WAS ABANDONED IN PERIOD  23 IN SECTOR   1 OF SIMULATION  25 CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  26 CLEAN-UP VOLUME EXCEEDED: VOL=   4150370.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  27 CLEAN-UP VOLUME EXCEEDED: VOL=   3583704.
** THE PIT WAS ABANDONED IN PERIOD  20 OF SIMULATION  28 CLEAN-UP VOLUME EXCEEDED: VOL=   3727407.
** THE PIT WAS ABANDONED IN PERIOD  22 OF SIMULATION  29 CLEAN-UP VOLUME EXCEEDED: VOL=   4830741.
** THE PIT WAS ABANDONED IN PERIOD  21 OF SIMULATION  30 CLEAN-UP VOLUME EXCEEDED: VOL=   3136667.
```

CASE SUMMARY FOR CASE NUMBER 2 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
AFTER POST PROCESSING
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

142463.	144116.	144116.	144116.	144116.
145412.	144116.	144116.	142463.	140710.
144116.	142463.	144116.	142463.	140710.
144116.	144116.	144116.	144116.	142463.
144116.	145412.	144116.	142463.	145412.
144116.	144116.	140710.	144116.	142463.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

84627.	84454.	84540.	84281.	84751.
84237.	84480.	84423.	84762.	85510.
84312.	84642.	84409.	84651.	85320.
84986.	84397.	84631.	84383.	84697.
84667.	83799.	84091.	84811.	83686.
84020.	84466.	85377.	84593.	85137.

SUMMARY OF BENEFITS AND COSTS FOR CASE 2

AVERAGE PRESENT VALUE OF BENEFITS	143519.
STANDARD DEVIATION OF BENEFITS	1291.
AVERAGE PRESENT VALUE OF COSTS	84571.
STANDARD DEVIATION OF COSTS	419.

45 DEGREE DESIGN.

COST MODEL STATISTICS FOR CASE NUMBER 3
(VALUES AVERAGED OVER 30 SIMULATIONS)

MODEL NAME	TOT. NO. OF CALLS	AVERAGE COST	STD. DEV. OF COST
CLEAN-UP--FW	0	0.00	0.00
LOST COAL-FW	0	0.00	0.00
LSTC+CLNP-FW	2	710.70	72.98
LSTC+ERMN-FW	64	365.03	172.52
MN ABDNMT-FW	0	0.00	0.00
RE-EST HR-FW	3	62.70	28.73
CL+LC+EM--FW	144	371.40	120.08
INCHL+CLN-FW	201	1003.79	302.73
CL(VS MA)-FW	853	1705.93	775.97
CLEAN-UP--IR	1437	229.19	235.46
LST CL NO. 1	242	148.16	103.19
LST CL NO. 2	1533	59.93	20.54
LST CL NO. 3	1346	34.45	18.78
MN ABDNMT-IR	0	0.00	0.00
ERLY MNG--IR	375	5.24	4.20
INCHL+CLN-IR	35	300.17	123.31
CL(VS MA)-IR	18	1526.07	292.85
CLEAN-UP-BEN	1240	3.14	.00
MA(VS CL)-FW	150	0.00	0.00
MA(VS CL)-IR	0	0.00	0.00

```
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION   1 CLEAN-UP VOLUME EXCEEDED: VOL=   5376667.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION   2 CLEAN-UP VOLUME EXCEEDED: VOL=   4245185.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION   3 CLEAN-UP VOLUME EXCEEDED: VOL=   4171111.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION   4 CLEAN-UP VOLUME EXCEEDED: VOL=   4239259.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION   5 CLEAN-UP VOLUME EXCEEDED: VOL=   4245185.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION   6 CLEAN-UP VOLUME EXCEEDED: VOL=   4245185.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION   7 CLEAN-UP VOLUME EXCEEDED: VOL=   4242222.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION   8 CLEAN-UP VOLUME EXCEEDED: VOL=   3431481.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION   9 CLEAN-UP VOLUME EXCEEDED: VOL=   4705556.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  10 CLEAN-UP VOLUME EXCEEDED: VOL=   5522222.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  11 CLEAN-UP VOLUME EXCEEDED: VOL=   4882222.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  12 CLEAN-UP VOLUME EXCEEDED: VOL=   4171111.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  13 CLEAN-UP VOLUME EXCEEDED: VOL=   4239259.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  14 CLEAN-UP VOLUME EXCEEDED: VOL=   4879259.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  15 CLEAN-UP VOLUME EXCEEDED: VOL=   4242222.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  16 CLEAN-UP VOLUME EXCEEDED: VOL=   4242222.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  17 CLEAN-UP VOLUME EXCEEDED: VOL=   3425556.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  18 CLEAN-UP VOLUME EXCEEDED: VOL=   4242222.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  19 CLEAN-UP VOLUME EXCEEDED: VOL=   4708519.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  20 CLEAN-UP VOLUME EXCEEDED: VOL=   4245185.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  21 CLEAN-UP VOLUME EXCEEDED: VOL=   4239259.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  22 CLEAN-UP VOLUME EXCEEDED: VOL=   3431481.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  23 CLEAN-UP VOLUME EXCEEDED: VOL=   4369630.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  24 CLEAN-UP VOLUME EXCEEDED: VOL=   4553333.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  25 CLEAN-UP VOLUME EXCEEDED: VOL=   3981481.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  26 CLEAN-UP VOLUME EXCEEDED: VOL=   3431481.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  27 CLEAN-UP VOLUME EXCEEDED: VOL=   4239259.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  28 CLEAN-UP VOLUME EXCEEDED: VOL=   4879259.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  29 CLEAN-UP VOLUME EXCEEDED: VOL=   3547037.
** THE PIT WAS ABANDONED IN PERIOD  17 OF SIMULATION  30 CLEAN-UP VOLUME EXCEEDED: VOL=   3357407.
```

CASE SUMMARY FOR CASE NUMBER 3 FOR THE ENTIRE PIT FOR ALL SIMULATIONS
AFTER POST PROCESSING
(AMOUNT IN THOUSAND DOLLAR UNITS)

PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS 1 THRU 30

134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.
134238.	134238.	134238.	134238.	134238.

PRESENT VALUE OF TOTAL COST FOR SIMULATIONS 1 THRU 30

83610.	83035.	83073.	83040.	82955.
82519.	83159.	83068.	83380.	83137.
82850.	83535.	83159.	83579.	83662.
83095.	82736.	83145.	83615.	83459.
83007.	82869.	82991.	83495.	82743.
82957.	83094.	83048.	82990.	82228.

SUMMARY OF BENEFITS AND COSTS FOR CASE 3

AVERAGE PRESENT VALUE OF BENEFITS	134238.
STANDARD DEVIATION OF BENEFITS	0.
AVERAGE PRESENT VALUE OF COSTS	83108.
STANDARD DEVIATION OF COSTS	332.

APPENDIX H

IMPROVEMENTS MADE TO BNCST-VERSION III FOR VERSION IV

IMPROVEMENTS MADE TO THE BNCST-VERSION III FOR THE VERSION IV

The benefit-cost analysis was performed using BNCST-Version IV program because several useful changes were incorporated into the prior version (2). Four improvements were made: (1) The COST1 subroutine, which contains many complicated logics as well as many different functions, was modularized. (2) Complete flexibility in selecting diagnostic messages during program execution was provided. (3) A means was provided for gaining access to the pit wall geometry information of interramp walls during cost model programming and instability schedule development. (4) The pushback capability was eliminated.

COST1 SUBROUTINE MODULARIZATION

The COST1 subroutine was broken down into six different subroutines. The modularization is shown in Fig. H-1 with the new subroutines being:

(1) GEOM computes the pit walls geometries.
(2) STRIP computes the yearly stripping ratios.
(3) SAMPL controls the sampling of pit wall slope instabilities.
(4) SFULL samples for full wall failures.
(5) SINTR samples for interramp wall failures.
(6) SBNCH samples for bench wall failures.

PRINTOUT OPTIONS IN BNCST-VERSION IV

Use of the print control variables LPRT and NDIAG are designed to give the user of BNCST complete flexibility in selecting diagnostic messages and combinations of messages to be

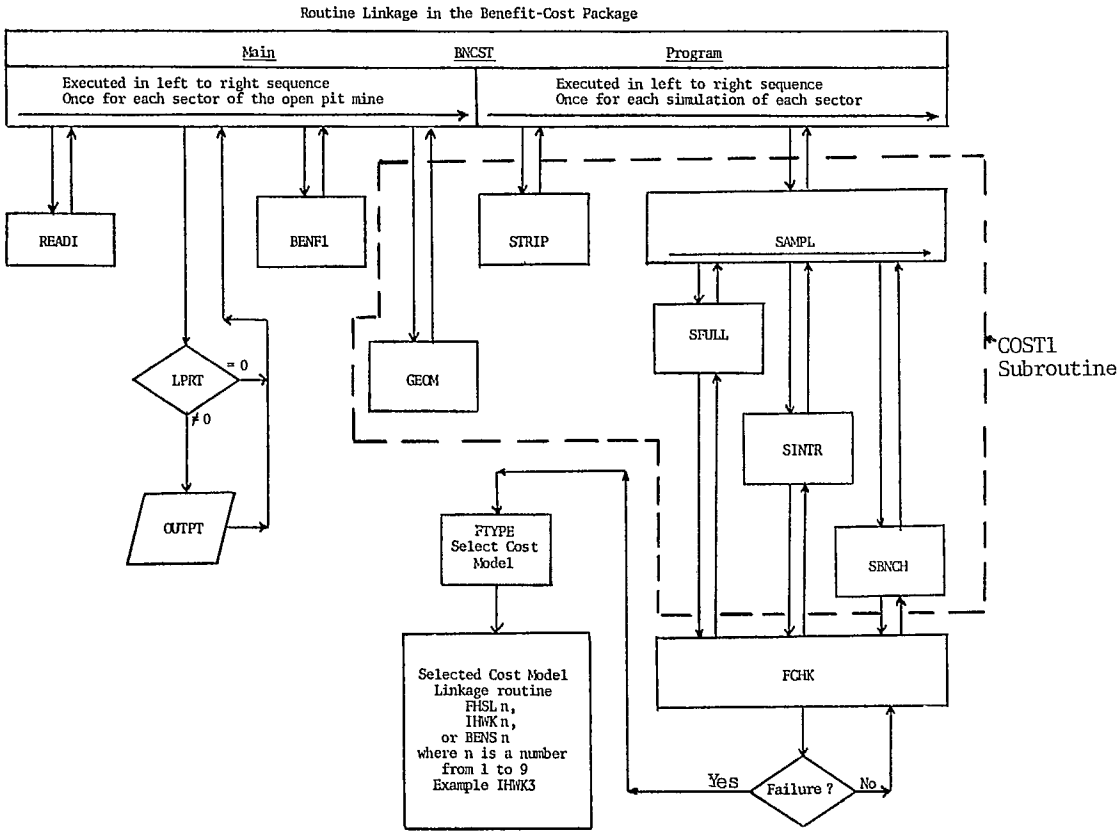

Fig. H-1 - Modularization of COST1 subroutine

printed. When full flexibility is not of interest, the user should set the value of data printout switch LPRT to 2 for printing the input data and the final results only, or 3 for printing the final results only (see Table H-1). Also for this case, the value of the diagnostic switch NDIAG should be set to 0. If some diagnostic printing is desired, NDIAG should be set to either 1 or 2. These values are sufficient to print out the pit geometry computed by BNCST using input data.

However, the additional flexibility is provided to allow greater print detail when it is needed or desired. To facilitate this flexibility, rather large decimal numbers are used for NDIAG in many cases. These numbers when converted to computer internal numbers, provide unique on-off control for all diagnostic types. The input value to be used for NDIAG is arrived at by adding the unique numbers given for each of the desired diagnostic messages (see Table H-1). For example, diagnostic messages for all the geometry information can be obtained by setting NDIAG = 3,

Table H-1 - Print control numbers

LPRT	Printed Output
0	Print final results only.
1	Print the input data, the results of the first three simulations, and the final results of Benefit-Cost analysis.
2	Print the input data and the final results only.
3	Same as 0.

Diagnostic Number	Diagnostic Output
1	Print wall heights and angles. If weak stratum data was input, then print weak stratum geometry.
2	Print all wall heights and widths and the interim wall angle. This includes printing the arrays containing the elevation levels in the pit. These arrays which contain pit top (STELS), ramps (HWKEL) and pit bottom (PITBT) are printed left to right in decreasing elevation sequence for each period of mine life.
	The following are meant for debugging various Benefit-Cost programs and are not normally needed by the user.
4	Print full wall angle determination index and angles in GEOM.
8	Print flags used in determining the heights of ultimate walls within interramp walls.
16	The packed HWKEL array is printed in octal.
32	The value of arguments supplied in calls to the HWKCK routine are printed.
64	The elevation and width values of ramps in the current full wall are printed in the HWKCK routine.
128	Arguments input to routine FCHK and the probability and instability cost values resulting from the call are printed.
256	Probability determination ratios and intermediate values computed in subroutine FCHK.
512	The values written on mass storage for later analysis by routine INRISK are printed.
n	Any combination of the above diagnostics may be selected by setting NDIAG to the sum of the diagnostic numbers given. Examples: NDIAG = 3 Diagnostics 1 and 2 are printed. NDIAG = 259 Diagnostics 1, 2 and 256 are printed.

i.e., 1 + 2. Similarly, to print the geometry values and those values written on mass storage for later analysis by INRISK, set NDIAG = 1 + 2 + 256 = 259.

GEOMETRY INFORMATION OF INTERRAMP WALLS

The HWKEL array contains haul road and work bench geometry information. It is packed in routine GEOM so as to save computer memory space and still supply ramp elevation and width information for each interramp wall for each period of the mine life in an easily accessible form. The information consists of each ramp elevation packed with the corresponding ramp width and a flag indicating the type of ramp stored. The pit bottom elevation is packed in the lowest ramp elevation position, and the pit bottom width is set to zero. The ramp type flag is set to 0 for a haul road, 1 for a work bench or 2 for the pit bottom.

Unpacking a desired value can be accomplished by calling the unpack routine UN12: CALL UN12 [WKEL(IHW,KPD), N, M, IP]. IHW is the interramp wall number. It is numbered sequentially from top to bottom. KPD is the current period of mine life. N contains the unpacked integer value returned by UN12. M normally M = 1; in general, M is the number of array elements to be unpacked by one call to UN12. IP is the position of a value in a packed HWKEL word.

The desired value at position IP in a HWKEL word, for interramp wall IHW in period KPD, is returned in N. The returned variable, N, must be of integer type. In the case of an elevation, N must be subtracted from REFEL after unpacking.

The positions of packed data are: IP = 3 for ramp width, IP = 4 for ramp elevation, and IP = 5 for ramp type flag.

An example of unpacking the ramp elevation for interramp wall number 2 in period 7 is as follows:

```
CALL UN12 [HWKEL (2,7), N, 1, 4]
ELEV = REFEL - N
IF (ELEV.EQ.0) ELEV = 99999.0
```

An elevation can be packed in the HWKEL array in a similar fashion by using the subroutine PK12. CALL PK12 [HWKEL(IHW, KPD), N, M, IP].

The elevation in the above example was packed by

```
IF (ELEV.GE.99999.0) ELEV - 0
N - REFEL - ELEV
CALL PK12[HWKEL(2,7), N, 1, 4]
```

Note that the value packed, N, must be of integer type. The IF statements are required to allow for undefined elevation values which are set to 99999.0 in the BNCST package.

Unpacking and packing the ramp width of the above example is done by:

```
CALL UN12[HWKEL(2,7), NWD, 1, 3]
WD = NWD
NWD = WD
CALL PK12[HWKEL(2,7), NWD, 1, 3]
```

UN12 and PK12 can be used to pack and unpack any integer value which will fit into 12 bits. These are values up to 4095. A total of five positions can be packed in one CDC-6400 word (5 x 12 = 60 bits).

ELIMINATION OF PUSHBACK CAPABILITY

The capability to analyze the special pit wall geometry resulting from the presence of a pushback was initially incorporated into the BNCST-Version I, mainly because the program could not handle variable widths in the bench. The current version, however, allows the specification of variable bench widths in a form of working benches. Since the pushback is like a wide working bench the pushback capability can now be handled through working bench specification. Hence, the pushback capability has been eliminated so as to reduce the amount of duplication that existed in the program logic.

APPENDIX I

COST MODEL PROGRAM LISTINGS

```
00010
00020          SUBROUTINE SAMPL
00030    C
00040    C     ROUTINE -SAMPI- CONTROLS SAMPLING OF PIT WALL FAILURES FOR
00050    C       VARIOUS PIT WALL TYPES, I.E., FULL WALL, INTERRAMP WALL, &
00060    C       BENCH WALL.
00070    C       ROUTINE -FCHK- IS CALLED IN FOLLOWING ROUTINES TO SAMPLE FOR
00080    C       INSTABILITIES IN THE FULL WALL HEIGHT, INTERRAMP WALL, BENCH
00090    C       WALL AND WEAK STRATUM MODES.
00100    C       COSTS ARE SUMMED FOR THE SECTOR IN ARRAY  CSTSC.
00110
00120          COMMON /ANGLE/ ANGDK,ANGO(6)
00130          COMMON /BNFIT/ BNTP1(30),BNTP2(30),OSBEN(30),BNMSC(30),
00140         .               BNTOT(30)
00150          COMMON /CELL/  NCELB(30),NRCLE(11,30),NECLB(30)
00160          COMMON /COFL/  VOLO,VOLW,WALH1,CCCL
00170          COMMON /COST/  CFHT(30),CSTIB(30),CSTBF(30),CSTSB(30),
00180         .               CUSR(30),CSTSC(30),SCOST(30),MXCEL
00190          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
00200          COMMON /FAIL/  MSIFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
00210         .               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
00220          COMMON /FLAGS/ LOSBN,LOSCT,LWRI,LPRT,LFINI,LSTR,LPSH,LERR,
00230         .               NDIAG,LPSHE,LWBK,LMISC,LRAD,LONIT
00240          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
00250         .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
00260         .               EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
00270          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
00280         .               NHAOL,NWORK,MXHWK,MXBWK1,NHWK,NHWK1,
00290         .               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IBK,REFEL
00300          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,K1(10),TMP(10),MM(5),
00310         .               MS(11,4),MN(2,4),KSED(30),IHN,IHD2A(9)
00320          COMMON /INRSK/ ITN1(30),ITN2(30),TINWA(30),AGS(30),AGL(30),
00330         .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
00340          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
00350         .               BENWD,BENHT,NOLT
00360          COMMON /LOGIC/ L5,L6,L7
00370          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
00380         .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
00390          COMMON /OTPUT/ UND
00400          COMMON /PITBL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
00410         .               ULTDV(6),WEKB1(30)
00420          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),BEIT(10,2),MXPRB,NPROB,NPRBW
00430          COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
00440         .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
00450         .               COMNW(30)
00460          COMMON /TIME/  KLIFE,KPD
00470          COMMON     IBG,LABN,IHW,SUMC(20),SSOC(20),NOMC(20),CLMTL(30)
00480          COMMON /MABDN/ COAL1(30),COAL2(30),BRDN1(30),BRDN2(30),COAL3(30),
00490         .               BRDN3(30)
00500
00510          DIMENSION SANGB(11,30),SEANGB(30),SANGWB(30)
00520
00530          DATA IFST,NCSTM /0,20/
00540
00550    C
00560    C     INITIALIZE TEMPORARY PRODUCTION STORAGE ARRAYS:
00570    C       COAL1 = CASE 1 COAL PRODUCTION
00580    C       COAL2 = CASE 2 COAL PRODUCTION
00590    C       COAL3 = CASE 3 COAL PRODUCTION
00600    C       BRDN1 = CASE 1 WASTE PRODUCTION
00610    C       BRDN2 = CASE 2 WASTE PRODUCTION
00620    C       BRDN3 = CASE 3 WASTE PRODUCTION
00630    C
```

```
00640          GO TO (6,5,9) NCASE
00650    6       IF(NSM.NE.1 .OR. NSC.NE.1) GO TO 10
00660          DO 1 I=1,30
00670          COAL1(I) = 0.0
00680          COAL2(I) = 0.0
00690          COAL3(I) = 0.0
00700          BRDN1(I) = 0.0
00710          BRDN2(I) = 0.0
00720        1 BRDN3(I) = 0.0
00730    C
00740    C     SAVE PRODUCTION FIGURES FOR USE IN COST MODELS
00750    C
00760          DO 3 I=1,KLIFE
00770          COAL1(I) = ORE1(I)
00780        3 BRDN1(I) = WASTE(I)
00790          GO TO 10
00800    9     IF(NSC.NE.1 .OR. NSM.NE.1) GO TO 10
00810          DO 11 I=1,KLIFE
00820          COAL3(I) = ORE1(I)
00830   11     BRDN3(I) = WASTE(I)
00840          GO TO 10
00850        5 IF(NSC.NE.1 .OR. NSM.NE.1) GO TO 10
00860          DO 7 I=1,KLIFE
00870          COAL2(I) = ORE1(I)
00880        7 BRDN2(I) = WASTE(I)
00890
00900
00910    C      **** TEST ALL WALLS FOR INSTABILITIES ****
00920
00930    C    THE ORDER OF TESTING
00940    C       1. SAMPLE THE FULL WALL FOR INSTABILITY COST.
00950    C       2. IF THERE IS NO FULL WALL INSTABILITY COST THEN SAMPLE ALL
00960    C          INTERRAMP WALLS IN THE FULL WALL.
00970    C       3. IF THERE IS NO INSTABILITY COST IN AN INTERRAMP WALL THEN
00980    C          TEST THAT WALL FOR BENCH INSTABILITIES.
00990    C       4. IF A WEAK STRATUM LIES IN AN INTERRAMP WALL OR WALLS WITH
01000    C          NO INSTABILITY COST THEN SAMPLE THE WEAK STRATUM.
01010    C
01020    C    SAVE FULL WALL , INTRRAMP AND WEAK STRATUM ANGLES.
01030       10 IF(NSM.NE.1) GO TO 700
01040
01050            DO 100 K=1,KLIFE
01060            SEANGB(K) = EANGB(K)
01070            SANGWB(K) = ANGWB(K)
01080            DO 100 I=1,NHWK1
01090   100      SANGB(I,K) = ANGB(I,K)
01100            DO 200 K = 1,NCSTM
01110            SUMC(K) = 0.
01120            SSQC(K) = 0.
01130            NUMC(K) = 0
01140   200      CONTINUE
01150    C
01160    C     ZERO ARRAY FOR STORING TOTAL MATERIAL TO BE CLEANED
01170    C       UP EACH PERIOD, FOR USE IN POST PROCESSING.
01180    C
01190      700 DO 50 K=1,30
01200       50 CLMTL(K) = 0.0
01210    C
01220          DO 800 KPD=1,KLIFE
01230            CFHT(KPD)=0.0
01240            CSTIB(KPD)=0.0
01250            CSTBB(KPD)=0.0
01260            CSTSB(KPD)=0.0
```

```
C*****************************************
C    TEST FULL HEIGHT WALL FOR INSTABILITY.  *
C*****************************************

      CALL SFULL

        IF( CFHT(KPD).NE.0 ) GOTO 780

C*************************************************
C    TEST PIT WALL  FOR INTER RAMP INSTABILITIES. *
C*************************************************

      CALL SINTR

C*****************************************
C    TEST PIT WALL FOR BENCH INSTABILITIES.  *
C*****************************************

C      TEST EACH STABLE INTERRAMP WALL SEPARATELY.

      CALL SBNCH

C*****************************************
C    TEST FOR WEAK STRATUM INSTABILITY.      *
C*****************************************

      ELEV = STELS(KPD)
      DO 776 IHW=1,NHWK1
      II = IHW-1
      IF(II .LE. 0) GOTO 774
      CALL UN12(HWKEL(II,KPD),N,1,4)
      ELEV = REFEL-N
774   IF(ELEV.LE.WEKBT(KPD)) GOTO 776
      IF(MHWSV(IHW,KPD).NE.0)GOTO 780
776   CONTINUE

      CALL SWEAK

C    DIVIDE INSTABILITY COSTS BY 1000.

780   CFHT(KPD) =CFHT(KPD) /1000.
      CSTIB(KPD)=CSTIB(KPD)/1000.
      CSTEB(KPD)=CSTEB(KPD)/1000.
      CSTSB(KPD)=CSTSB(KPD)/1000.

C    SUM COSTS

      CSTSC(KPD)=CFHT(KPD)+CSTIB(KPD)+CSTEB(KPD)+CSTSB(KPD)
      CSTSC(KPD)=CSTSC(KPD)+CUSR(KPD)+SCOST(KPD)
C     IF(NDIAG.GE.3)WRITE(L7,4005)KPD,CSTSC(KPD)
4005  FORMAT(10X"SECTOR COST:  YEAR"I3," ="F15.2)
      SUMST=0
      SUMUS=0
      TCUSR=0
      COFUS(KPD)=SUMUS+CUSR(KPD)
      SUMUS=COFUS(KPD)
      TCUSR=TCUSR+CUSR(KPD)
```

```
01900          SUMST=SUMST+SCOST(KPD)
01910          CSTF(KPD)=CSTSC(KPD)-(TCUSR+SUMST)
01920
01930    800   CONTINUE
01940
01950    C*************************************************************
01960    C    WRITE OUT SAVED VALUES FROM COST MODELS FOR LATER READ     *
01970    C    BACK AND ANALYSIS BY POST PROCESSING.                      *
01980    C*************************************************************
01990
02000          IF(NSC.NE.1.OR.NSM.NE.1)GOTO 900
02010          IBG = 0
02020          IF((NDIAG.A.2048).NE.0) IBG = 1
02030          IRAMP = 5
02040          IBNCH = 10
02050
02060    C    REWIND FILE FOR POST PROCESSING IF FIRST TIME.
02070          IF(IFST.EQ. 0)  REWIND 2
02080          IFST = 1
02090
02100    C***** NOTE: ORE1 IS WRITTEN ONLY FOR SECTOR 1.
02110    C        DEFINE THE TOTAL NO. OF DESIGN SECTORS IN THE PIT FOR
02120    C        THE USER PROBLEM, USING VARIABLE NSEC.
02130    C
02140            NSEC = 4
02150
02160          WRITE(2) KLIFE,NSEC,NSIM,NCAS,RATE,UNITS,(ORE1(K),WASTE(K),
02170     .                COMN1(K),COMNW(K),K=1,KLIFE)
02180
02190    900   WRITE(2) NSM,NSC,LABN,(BNTOT(K),CSTSC(K),K=1,KLIFE)
02200    C    WRITE COST MODEL STATISTICS FOR LATER ANALYSIS IN POST PROCESSING.
02210
02220    C    THESE VALUES MUST BE SAVED IN THE COST MODELS BY THE MODEL DESIGNER.
02230    C     SAVING IS DONE WITH THE ARRAYS AND INDEX VARIABLES DESCRIBED
02240    C     BELOW.
02250    C    ARRAYS:
02260    C        NOTE A "COST" IS THE VALUE RETURNED FROM A COST MODEL LINK ROUTINE.
02270    C    SUMC(I) = SUM OF MODEL I COSTS.  EACH MODELS COSTS MUST BE SUMMED AT ONE
02280    C    LOCATION IN SUMC(I).  SUMC(I) = SUMC(I) + COST
02290    C     FOR EXAMPLE: SUMC(2) = SUM OF COSTS COMPUTED BY THE BACKFILL MODEL.
02300    C                  SUMC(2) = SUMC(2) + COST  FOR EACH ENTRY TO THE COST MODEL.
02310    C    SSQC(I) = SUM OF THE SQUARES OF COSTS COMPUTED IN A MODEL.
02320    C              SSQC(I) = SSQC(I) + COST**2
02330    C    NUMC(I) = THE COUNT OF COST VALUES COMPUTED AND SUMMED IN MODEL I.
02340    C              THIS IS THE NUMBER OF TIMES THE MODEL WAS CALLED.
02350    C              NUMC(I) = NUMC(I) + 1
02360    C    INDEXES:
02370    C      IRAMP = START OF RAMP MODEL COSTS IN THE ARRAYS.
02380    C      IBNCH = START OF BENCH MODEL COSTS IN THE ARRAYS.
02390    C    ALL COST MODEL COST VALUES ARE SUMMED INTO THE ABOVE ARRAYS. FULL HEIGHT
02400    C    MODELS ARE SUMMED STARTING AT LOCTION ONE (1) IN SUMC, SSQC AND NUMC.
02410    C    INTERRAMP MODELS ARE SUMMED STARTING AT IRAMP AND BENCH MODELS AT IBNCH.
02420    C    THE VALUES FOR IRAMP AND IBNCH BE SELECTED AND SET BY THE USER.
02430    C    FOR EXAMPLE: IRAMP = 4 AND IBNCH = 9.
02440
02450    C     A DEFAULT VALUE OF ONE HAS BEEN SET FOR EACH INDEX AND NEED NOT
02460    C     BE CHANGED.
02470
02480            WRITE(2) IRAMP,IBNCH,NCSTM,(SUMC(I),SSQC(I),NUMC(I),I=1,NCSTM)
02490    C
02500    C      WRITE CLEAN-UP MATERIAL TO TAPE FOR POST PROCESSING--PERIOD
02510    C        BY PERIOD FOR EACH SIMULATION.
02520    C
```

```
02530          WRITE(2)  (CLMTL(I),I=1,KLIFE)
02540    C
02550    C**** DEBUG PRINTOUT *****
02560            IF (IBG.EQ.1)   WRITE(L6,4030)  IRAMP,IENCH,NCSTM
02570    4030    FORMAT(10X"IRAMP, IBNCH, NCSTM",3I6)
02580            IF (IBG.EQ.1) WRITE(L6,5020)  (SUMC(L),L=1,NCSTM)
02590    5020    FORMAT(5X,8F12.0)
02600    C
02610    C    ZERO ABANDONMENT FLAG.
02620          LABN = 0
02630
02640          DO 920 I=1,NCSTM
02650          SUMC(I)  = 0.0
02660          SSQC(I)  = 0.0
02670    920   NUMC(I)  = 0
02680
02690    C    RESTORE FULL WALL, INTERRAMP AND WEAK STRATUM ANGLES.
02700
02710            DO 930 K=1,KLIFE
02720            EANGB(K)  =  SEANGB(K)
02730            ANGWB(K)  =  SANGWB(K)
02740            DO 930 I=1,NHWK1
02750    930     ANGB(I,K)  =  SANGB(I,K)
02760
02770
02780          RETURN
02790          END
02800
02810            SUBROUTINE SFULL
02820    C
02830    C    THIS ROUTINE SAMPLES FOR FULL WALL INSTABILITIES.
02840    C
02850          COMMON /ANGLE/ ANGBK,ANGU(6)
02860          COMMON /BNFIT/ ENTP1(30),ENTP2(30),USREN(30),BNMSC(30),
02870         .               BNTOT(30)
02880          COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
02890          COMMON /CGFL/  VOLC,VOLW,WALHT,CCCL
02900          COMMON /COST/  CFHT(30),CSTIB(30),CSTEB(30),CSTSB(30),
02910         .               CUSR(30),CSTSC(30),SCOST(30),MXCEL
02920          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
02930          COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
02940         .               MFHSV(30),MHWSV(11,30),MENBS(30),MWKBS(30),SFREQ(8)
02950          COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
02960         .               NDIAG,LPSHB,LWEK,LMISC,IRAD,LUNIT
02970          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
02980         .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
02990         .               EANGB(30),HIWKB(30),ANGWB(30),NCLWB(30)
03000          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
03010         .               NHAUL,NWCRK,MXHWK,MXHWK1,NHWK,NHWK1,
03020         .               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
03030          COMMON /INPUT/ A(7),B(11),C(85),ID,DIT,KI(10),TMP(10),MM(5),
03040         .               MS(11,4),MN(2,4),KSED(30),IHN,IHD2A(9)
03050          COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
03060         .               ACS(30),ACL(30),ACW(30),CSTF(30),CCFUS(30)
03070          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
03080         .               BENWD,BENWT,NULT
03090          COMMON /LOGIC/ L5,L6,L7
03100          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
03110         .               EVB,EVC,NERR(4),MXERR,UNITS(7,5)
03120          COMMON /OTPUT/ UND
03130          COMMON /PITEL/ PITBT(30),ULTBT(30),STEIS(30),SECBT,
03140         .               ULTDV(6),WEKDT(30)
03150          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
```

```
      COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
     -               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     -               COMNW(30)
      COMMON /TIME/  KLIFE,KPD
      COMMON     IBG,LABN,IHW,SUMC(20),SSCC(20),NUMC(20),CLMTL(30)
      COMMON /MABDN/ COAL1(30),COAL2(30),BRDN1(30),BRDN2(30),COAL3(30),
     -               BRDN3(30)


C     TEST FULL HEIGHT WALL FOR INSTABILITY.

      WALHT=HTFLB(KPD)
      CALL FCHK(1,0,0,HTFLB(KPD),HTFLE(KPD),EANGB(KPD),NCELB(KPD),
     -CFHT(KPD))
      IF(CFHT(KPD).NE.0)MFHSV(KPD)=MSTFH(KPD)

      RETURN
      END


        SUBROUTINE SINTR
C
C   THIS ROUTINE SAMPLES FOR INTER-RAMP WALL INSTABILIES.
C
      COMMON /ANGLE/ ANGBK,ANGU(6)
      COMMON /BNFIT/ ENTP1(30),ENTP2(30),USREN(30),BNMSC(30),
     -               BNTOT(30)
      COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
      COMMON /COFL/  VOLC,VOLW,WALHT,COCL
      COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
     -               CUSR(30),CSTSC(30),SCOST(30),MXCEL
      COMMON /DIVSN/ ISC,ISCW,NSC,NCASE,NCAS
      COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
     -               MFHSV(30),MHWSV(11,30),MENBS(30),MWKBS(30),SFREQ(8)
      COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
     -               NDIAG,LPSHB,LWEK,LMISC,IRAD,LUNIT
      COMMON /GMTRY/ ANGB(11,30),HTIE(11),HTUB(11),WDLB(11),WDUB(11),
     -               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
     -               EANGB(30),HTWKB(30),ANGWB(30),NCLWD(30)
      COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
     -               NHAUL,NWCRK,MXHWK,MXHWK1,NHWK,NHWK1,
     -               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
      COMMON /INPUT/ A(7),B(11),C(65),IL,DIT,KT(10),TMP(10),MM(5),
     -               MS(11,4),MN(2,4),KSPD(30),IBN,IHD2A(9)
      COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
     -               ACS(30),ACL(30),ACW(30),CSIF(30),COFUS(30)
      COMMON /LIMIT/ NSIM,NSM,SECWD(30),
     -               BENWD,BENHT,NULT
      COMMON /LOGIC/ I5,L6,L7
      COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
     -               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
      COMMON /OTPUT/ UND
      COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
     -               ULTDV(6),WEKBT(30)
      COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
      COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
     -               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     -               COMNW(30)
      COMMON /TIME/  KLIFE,KPD
      COMMON     IBG,LABN,IHW,SUMC(20),SSCC(20),NUMC(20),CLMTL(30)
      COMMON /MABDN/ COAL1(30),COAL2(30),BRDN1(30),BRDN2(30),COAL3(30),
     -               BRDN3(30)
```

```
03790
03800   C     TEST PIT WALL  FOR INTER RAMP INSTABILITIES.
03810
03820          IHW=0
03830   730    IHW=IHW+1
03840          IF(IHW.GT.NHWK1)GOTO 999
03850          HT=HIWLB(IHW,KPD)
03860          IF(HT.LE.0)GOTO 730
03870          HTF=HIFLB(IHW,KPD)
03880          CALL FCHK(2,0,IHW,HT,HTF,ANGE(IHW,KPD),NRCLB(IHW,KPD),CST)
03890          IF(CST.NE.0)MHWSV(IHW,KPD)=MSHWK(IHW,KPD)
03900          CSTIB(KPD)=CSTIB(KPD)+CST
03910          GOTO 730
03920
03930   999    RETURN
03940          END
03950
03960
03970            SUBROUTINE SBNCH
03980   C
03990   C    THIS ROUTINE SAMPLES FOR BENCH INSTABILITIES.
04000   C
04010          COMMON /ANGLE/ ANGBK,ANGU(6)
04020          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USRBN(30),BNMSC(30),
04030         -               BNTCT(30)
04040          COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
04050          COMMON /COFL/  VOLO,VOLW,WALHT,CCCL
04060          COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
04070         -               CUSR(30),CSTSC(30),SCOST(30),MXCEL
04080          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
04090          COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
04100         -               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
04110          COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
04120         -               NDIAG,LPSHE,LWEK,LMISC,IRAD,LUNIT
04130          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
04140         -               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
04150         -               EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
04160          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
04170         -               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
04180         -               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
04190          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
04200         -               MS(11,4),MN(2,4),KSED(30),IHN,IHD2A(9)
04210          COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
04220         -               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
04230          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
04240         -               BENWD,BENHT,NULT
04250          COMMON /LOGIC/ L5,L6,L7
04260          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
04270         -               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
04280          COMMON /OTPUT/ OND
04290          COMMON /PITEL/ PITBE(30),ULTET(30),STELS(30),SECBT,
04300         -               ULTDV(6),WEKBT(30)
04310          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),BEIT(10,2),MXPRB,NPROB,NPRBW
04320          COMMON /PROD/  CRE1(30),CRE2(30),WASTE(30),AVG1(30),
04330         -               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
04340         -               COMNW(30)
04350          COMMON /TIME/  KLIFE,KPD
04360          COMMON     IBG,LABN,IHW,SUMC(20),SSCC(20),NUMC(20),CLMTL(30)
04370          COMMON /MABDN/ COAL1(30),COAL2(30),BRDN1(30),BRDN2(30),COAL3(30),
04380         -               BRDN3(30)
04390
04400
04410   C     TEST PIT WALL FOR BENCH INSTABILITIES.
```

```
C       TEST EACH STABLE INTERRAMP WALL SEPARATELY.
        DO 758 IHW=1,NHWK1
        IF(MHWSV(IHW,KPD).NE.0)GOTO 758
        HTF=HIFLB(IHW,KPD)-(HIWLB(IHW,KPD)/2.0)
        IF(HTF.LE.0)GOTO 758
        NBCL=NBCLB(KPD)*HIWLB(IHW,KPD)/ HTFLB(KPD)
        CALL FCHK(3,0,0,BENHT,HTF,ANGEK,NECL,CST)
        CSTBB(KPD)=CSTBB(KPD)+CST
758     CONTINUE
        IF(CSTBB(KPD).NE.0)MBNBS(KPD)=MSENE(KPD)

999     RETURN
        END


          SUBROUTINE SWEAK
C
C     THIS ROUTINE SAMPLES FOR WEAK STRATUM INSTABILITIES.
C
        COMMON /ANGLE/  ANGBK,ANGU(6)
        COMMON /BNFIT/  BNTP1(30),BNTP2(30),USRBN(30),BNMSC(30),
       .                BNTCT(30)
        COMMON /CELL/   NCELB(30),NRCLE(11,30),NECLB(30)
        COMMON /COFL/   VOLO,VOLW,WALHT,COCL
        COMMON /COST/   CFHT(30),CSTLE(30),CSTEE(30),CSTSB(30),
       .                CUSE(30),CSTSC(30),SCOST(30),MXCEL
        COMMON /DIVSN/  ISC,ISCN,NSC,NCASE,NCAS
        COMMON /FAIL/   MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
       .                MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
        COMMON /FLAGS/  IUSBN,LUSCT,LWRT,LERT,LFINI,LSTR,LPSH,LERR,
       .                NDIAG,LPSHL,LWEK,LMISC,LRAD,LUNIT
        COMMON /GMTRY/  ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
       .                HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
       .                EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
        COMMON /HALWK/  HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
       .                NHAUL,NWCRK,MXHWK,MXEWK1,NHWK,NHWK1,
       .                HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
        COMMON /INPUT/  A(7),B(11),C(65),IL,DIT,KT(10),TMP(10),MM(5),
       .                MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
        COMMON /INRSK/  TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
       .                ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
        COMMON /LIMIT/  NSIM,NSM,SECWD(30),
       .                BENWD,BENHT,NULT
        COMMON /LOGIC/  L5,L6,L7
        COMMON /MISC/   TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
       .                PVB,PVC,NERR(4),MXERR,UNITS(7,5)
        COMMON /OTPUT/  UND
        COMMON /PITEL/  BITBT(30),ULTET(30),STELS(30),SECBT,
       .                ULTDV(6),WEKBT(30)
        COMMON /PROBF/  PROB(6,10,2),PANG(6,2),BEIT(10,2),MXPRB,NPROB,NPRBW
        COMMON /PROD/   ORE1(30),ORE2(30),WASTE(30),AVG1(30),
       .                AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
       .                COMNW(30)
        COMMON /TIME/   KLIFE,KPD
        COMMON      IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
        COMMON /MABDN/  COAL1(30),COAL2(30),BRDN1(30),BRDN2(30),COAL3(30),
       .                BRDN3(30)

C     TEST FOR WEAK STRATUM INSTABILITY.
        CALL FCHK(4,0,0,HTWKB(KPD),HTWKB(KPD),ANGWB(KPD),NCLWB(KPD),
       .CSTSB(KPD))
        IF(CSTSB(KPD).NE.0)MWKBS(KPD)=MSWKE(KPD)
```

```
05050
05060          RETURN
05070          END
05080            SUBROUTINE PK12(IA,IB,N,IP)
05090   C**********
05100   C     THE PK12 ROUTINE PACKS 12 BITS FROM IA INTO THE POSITION IP
05110   C     IN IB. POSITIONS ARE NUMBERED FROM THE RIGHT END OF A WORD.
05120   C**********
05130
05140            DIMENSION IA(1),IB(1)
05150            DATA MK/7777B/,MF/12/,NS/5/
05160
05170
05180            L6 = 6
05190            IF(IP.LE.NS) GOTO 50
05200            WRITE(L6,2000) IP,NS
05210   2000     FORMAT(5X"*** ERROR. PACKING POSITION ="I6"  MAXIMUM POSSIBLE IS"
05220       *I4".")
05230            GOTO 999
05240
05250   50       ISH = MF * (IP-1)
05260            MSK = SHIFT(MK,ISH)
05270
05280            DO 100 I=1,N
05290            ITMP = SHIFT(IA(I),ISH)
05300            ITMP = MSK.A.ITMP
05310            IB(I) = .N.MSK.A.IB(I)
05320   100      IB(I) = IB(I).O.ITMP
05330
05340   999      RETURN
05350            END
05360
05370
05380            SUBROUTINE UN12(IA,IB,N,IP)
05390
05400   C*********
05410   C     THE UN12 ROUTINE UNPACKS AN ITEM PACKED BY PK12 FROM 12 BITS OF
05420   C     IA AT POSITION IP. POSITION IP OF FIRST N WORDS OF IA ARRAY
05430   C     IS UNPACKED INTO ARRAY IB.
05440   C*********
05450
05460            DIMENSION IA(1),IB(1)
05470            DATA  MK/7777B/,MF/12/,NA/5/,NS1/6/
05480
05490            L6 = 6
05500            IF(IP.LE.NA) GOTO 50
05510            WRITE(L6,2000) IP,NA
05520   2000     FORMAT(5X"*** ERROR. POSTION OF UNPACK ="I6
05530       * "  MAXIMUM POSSIBLE IS"I4".")
05540            GOTO 999
05550
05560   50       ISH = MF * (IP-1)
05570            JSH = MF * (NS1 - IP)
05580            IF(IP.EQ.1) JSH = 0
05590            MSK = SHIFT(MK,ISH)
05600
05610   C**********
05620   C        WRITE(6,4010) IP,ISH,JSH,MSK
05630   4010     FORMAT(5X"IP,ISH,JSH,MSK ="3I6,O22)
05640   C***********
05650
05660            DO 100 I=1,N
05670            ITMP = MSK.A.IA(I)
```

```
05680              IB(I) = SHIFT(ITMP,JSH)
05690      C******
05700      C       WRITE(6,4000) ITMP,IA(I),IB(I)
05710      4000    FORMAT(5X"ITMP IA IB"J022)
05720      C******
05730      100     CONTINUE
05740
05750
05760      999     RETURN
05770              END
```

```
C0010
00020          SUBROUTINE FHSL1 (COST)
C0030
C0040   C*********************************
C0050   C   CLEAN - UP   --   FULL WALL
00060   C*********************************
C0070
00080          COMMON /ANGLE/ ANGBK,ANGU(6)
C0090          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
00100         .               BNTOT(30)
00110          COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
C0120          COMMON /COFL/  VOLO,VOLW,WALHT,COCL
00130          COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
00140         .               CUSR(30),CSTSC(30),SCOST(30),MXCEL
00150          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
00160          COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
00170         .               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
00180          COMMON /FLAGS/ LUSBN,LUSC1,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
00190         .               NDIAG,LPSHB,LWEK,LMISC,IRAD,LUNIT
00200          COMMON /GMTRY/ ANGB(11,30),HTLE(11),HTUB(11),WDIB(11),WDUB(11),
00210         .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
00220         .               EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
00230          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
00240         .               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
00250         .               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
00260          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
00270         .               MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
00280          COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
00290         .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
C0300          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
00310         .               BENWD,BENHT,NULT
00320          COMMON /LOGIC/ L5,L6,L7
00330          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
00340         .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
C0350          COMMON /OTPUT/ UND
00360          COMMON /PITEL/ PITBT(30),ULTBT(30),STEIS(30),SECBT,
C0370         .               ULTDV(6),WEKBT(30)
00380          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
C0390          COMMON /PROD/  CRE1(30),CRE2(30),WASTE(30),AVG1(30),
00400         .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
00410         .               COMNW(30)
00420          COMMON /TIME/  KLIFE,KPD
00430          COMMON /USER/  N1,IFLG
00440          COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
00450
00460          DATA CSTDB /0.10/
00470            CALL CLNUP(1,COST,0)
C0480   C
00490   C      KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
C0500   C        FOR POST PROCESSING.
00510   C
00520          CLMTL(KPD) = CLMTL(KPD) + COST/(COMNW(KPD)-CSTDB*27/VOLW)
00530
00540   C
00550   C      SUM COST VALUE STATISTICS
C0560   C
00570            SUMC(1) = SUMC(1) + COST
00580            SSQC(1) = SSQC(1) + COST**2
00590            NUMC(1) = NUMC(1) + 1
C0600   C
00610            RETURN
00620            END
00630            SUBROUTINE FHSL2 (COST)
```

```
C***********************************
C   LOST COAL    --    FULL WALL
C***********************************

      COMMON /ANGLE/ ANGBK,ANGU(6)
      COMMON /BNFIT/ BNTP1(30),BNTP2(30),USRBN(30),BNMSC(30),
     .               BNTOT(30)
      COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
      COMMON /COPL/  VOLC,VOLW,WALHT,COCL
      COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
     .               CUSR(30),CSTSC(30),SCOST(30),MXCEL
      COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
      COMMON /FAIL/  MSIFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
     .               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
      COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
     .               NDIAG,LPSHE,LWEK,LMISC,IRAD,LUNIT
      COMMON /GMTRY/ ANGB(11,30),HTIE(11),HTUE(11),WDIB(11),WDUB(11),
     .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
     .               EANGB(30),HTWKE(30),ANGWB(30),NCLWB(30)
      COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
     .               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
     .               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
      COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
     .               MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
      COMMON /INRSK/ TTN1(30),TTN2(30),TINWA(30),AGS(30),AGL(30),
     .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
      COMMON /LIMIT/ NSIN,NSM,SECWD(30),
     .               BENWD,BENHT,NULT
      COMMON /LOGIC/ L5,L6,L7
      COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
     .               EVB,EVC,NERR(4),MXERR,UNITS(7,5)
      COMMON /OTPUT/ UND
      COMMON /PITEL/ PITBT(30),ULTBT(30),STEIS(30),SECBT,
     .               ULTDV(6),WEKBT(30)
      COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
      COMMON /PROD/  CRE1(30),CRE2(30),WASTE(30),AVG1(30),
     .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     .               COMNW(30)
      COMMON /TIME/  KLIFE,KPD
      COMMON /USER/  N1,IFLG
      COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
       IF(NCASE.LE.2) NIP=1
        IF(NCASE.EQ.3) NIP=2
      CALL LSTCI(NIP,1,COAL,BURDN,COST)

C
C     SUM COST VALUE STATISTICS
C
        SUMC(2) = SUMC(2) + COST
        SSQC(2) = SSQC(2) + COST**2
        NUMC(2) = NUMC(2) + 1
C
        RETURN
        END
        SUBROUTINE FHSL3 (COST)

C*********************************************
C   LOST COAL + CLEAN-UP    --    FULL WALL
C*********************************************

      COMMON /ANGLE/ ANGBK,ANGU(6)
      COMMON /BNFIT/ BNTP1(30),BNTP2(30),USRBN(30),BNMSC(30),
```

```
     .                    BNTOT(30)
      COMMON /CELL/       NCELB(30),NBCLE(11,30),NBCLB(30)
      COMMON /COFL/       VOLO,VOLW,WALHT,CCCL
      COMMON /COST/       CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
     .                    CUSR(30),CSTSC(30),SCOST(30),MXCEL
      COMMON /DIVSN/      ISC,ISCN,NSC,NCASE,NCAS
      COMMON /FAIL/       MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
     .                    MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
      COMMON /FLAGS/      LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
     .                    NDIAG,LPSHE,LWEK,LMISC,LRAD,LUNIT
      COMMON /GMTRY/      ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
     .                    HTFLB(30),HIWLE(11,30),HIFLB(11,30),HBNFB(30),
     .                    EANGB(30),HTWKE(30),ANGWB(30),NCLWB(30)
      COMMON /HALWK/      HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
     .                    NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
     .                    HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
      COMMON /INPUT/      A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
     .                    MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
      COMMON /INRSK/      TIN1(30),TIN2(30),TINWA(30),AGS(30),AGL(30),
     .                    ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
      COMMON /LIMIT/      NSIM,NSM,SECWD(30),
     .                    BENWD,BENHT,NULT
      COMMON /LOGIC/      L5,L6,L7
      COMMON /MISC/       TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
     .                    PVB,PVC,NERR(4),MXERR,UNITS(7,5)
      COMMON /OTPUT/      UND
      COMMON /PITEL/      PITBT(30),ULTBT(30),STELS(30),SECBT,
     .                    ULTDV(6),WEKBT(30)
      COMMON /PROBF/      PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
      COMMON /PROD/       ORE1(30),ORE2(30),WASTE(30),AVG1(30),
     .                    AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     .                    COMNW(30)
      COMMON /TIME/       KLIFE,KPD
      COMMON /USER/       N1,IFLG
      COMMON      IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
      DATA CSTDB /0.10/
       IF(NCASE.LE.2) NIP=1
       IF(NCASE.EQ.3) NIP=3
        CALL LSTCL(NIP,1,COAL,BURDN,CST1)
        CALL CLNUP(1,CST2,0)
        COST = CST1 + CST2
C
C     KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
C       FOR POST PROCESSING.
C
      CLMTL(KPD) = CLMTL(KPD) + CST2/(COMNW(KPD)-CSTDB*27/VOLW)

C
C***** DEBUG *****
C
      IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,CST1,CST2,COST
 1000 FORMAT(10X,"LSTCL+CLNUP-FW",3I5,3F15.2)
C
C     SUM COST VALUE STATISTICS
C
        SUMC(3) = SUMC(3) + COST
        SSQC(3) = SSQC(3) + COST**2
        NUMC(3) = NUMC(3) + 1
C
        RETURN
        END
        SUBROUTINE FHSL4 (COST)
```

```
01900   C*************************************************
01910   C   LOST COAL + EARLY MINING    --    FULL WALL
01920   C*************************************************
01930
01940         COMMON /ANGLE/ ANGBK,ANGU(6)
01950         COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
01960        .               BNTOT(30)
01970         COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
01980         COMMON /COFL/  VOLC,VOLW,WALHT,COCL
01990         COMMON /COST/  CFHT(30),CSIIB(30),CSTEB(30),CSTSB(30),
02000        .               CUSB(30),CSTSC(30),SCOST(30),MXCEL
02010         COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
02020         COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
02030        .               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
02040         COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTB,LPSH,LERR,
02050        .               NDIAG,LPSHB,LWEK,LMISC,IRAD,LUNIT
02060         COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTOB(11),WDIB(11),WDUB(11),
02070        .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
02080        .               EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
02090         COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
02100        .               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
02110        .               HWREL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
02120         COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,RT(10),TMP(10),MM(5),
02130        .               MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
02140         COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
02150        .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
02160         COMMON /LIMIT/ NSIM,NSM,SECWD(30),
02170        .               BENWD,BENHI,NULT
02180         COMMON /LOGIC/ L5,L6,L7
02190         COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
02200        .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
02210         COMMON /OTPUT/ UND
02220         COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
02230        .               ULTDV(6),WEKBT(30)
02240         COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
02250         COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
02260        .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
02270        .               COMNW(30)
02280         COMMON /TIME/  KLIFE,KPD
02290         COMMON /USER/  N1,IFLG
02300         COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
02310
02320         NTYPE = 0
02330           IF(NCASE.EQ.2) GO TO 100
02340         IF(NCASE.EQ.3.AND.NSEC.EQ.2)GO TO 202
02350         IF(NCASE.EQ.3.AND.NSEC.EQ.4)GO TO 404
02360          IF(NCASE.EQ.1)GO TO 606
02370   C     THIS IS THE 35 DEGREE DESIGN,SECTOR II.
02380   C
02390   202   IF(KPD.LE.4)NTYPE=4
02400         IF(KPD.GE.5.AND.KPD.LE.10)NTYPE=2
02410         IF(KPD.GE.11)NTYPE=1
02420         GOTO 50
02430   C
02440   C     THIS IS THE 35 DEGREE DESIGN,SECTOR IV.
02450   C
02460   404   IF(KPD.LE.8)NTYPE=3
02470         IF(KPD.GE.9)NTYPE=2
02480         GO TO 50
02490   C
02500   C     THIS IS THE 28 DEGREE DESIGN
02510   C
02520   606    IF(KPD.EQ.2)  NTYPE=4
```

```
02530          IF(KPD.GE.3.AND.KPD.LE.7)  NTYPE=3
02540          IF(KPD.GE.8.AND.KPD.LE.11)  NTYPE=2
02550          IF(KPD.EQ.12.OR.KPD.EQ.13)  NTYPE=1
02560          IF(KPD.EQ.14.OR.KPD.EQ.15)  NTYPE=2
02570  C
02580  C     CALCULATE COST OF LOST COAL, WHICH IS NET REVENUE LOST.
02590  C
02600     50 IF(NTYPE.EQ.0) GO TO 9999
02610        CALL LSTCL(NTYPE,1,COAL,BURDN,CST1)
02620  C
02630  C     CALCULATE EARLY MINING COST
02640  C
02650          CALL ERMNG(1,CST2)
02660  C
02670  C     TOTAL COST
02680  C
02690          COST = CST1 + CST2
02700  C
02710  C*****DEBUG*****
02720  C
02730        IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,NTYPE,COAL,BURDN,
02740     .                              CST1,CST2,COST
02750   1000 FORMAT(10X,"LSTCL+ERMNG",4I5,2F15.2,3F10.2)
02760  C
02770  C     SUM COST VALUE STATISTICS
02780  C
02790        SUMC(4) = SUMC(4) + COST
02800        SSQC(4) = SSQC(4) + COST**2
02810        NUMC(4) = NUMC(4) + 1
02820  C
02830        GO TO 10000
02840  C
02850  C***** ASSIGNMENT OR PROGRAMMING ERROR FOR COST MODELS *****
02860  C
02870   9999 WRITE(L6,99999) NCASE,NSC,KPD
02880  99999 FORMAT(10X,"ASSIGNMENT ERROR--NTYPE IS NOT SPECIFIED
02890     .              IN FHSL4, FOR CASE",I5," SECTOR",I5,
02900     .              " IN PERIOD",I5)
02910  C
02920  10000 RETURN
02930  C
02940  C     THIS IS THE 45 DEGREE DESIGN
02950  C
02960    100 IF(KPD.EQ.2) NTYPE=4
02970          IF(KPD.GE.3.AND.KPD.LE.6)    NTYPE=3
02980          IF(KPD.GE.7.AND.KPD.LE.10)   NTYPE=2
02990          IF(KPD.GE.11.AND.KPD.LE.13)  NTYPE=1
03000          GO TO 50
03010          END
03020          SUBROUTINE FHSL5 (COST)
03030
03040  C************************
03050  C   MINE ABANDONMENT
03060  C************************
03070
03080        COMMON /ANGLE/ ANGBK,ANGU(6)
03090        COMMON /BNFIT/ BNTP1(30),BNTP2(30),USRBN(30),BNMSC(30),
03100     .                 BNTCT(30)
03110        COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
03120        COMMON /COFL/  VOLC,VOLW,WALHT,CCCL
03130        COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
03140     .                 CUSR(30),CSISC(30),SCOST(30),MXCEL
03150        COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
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```
      COMMON /FAIL/   MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
     .                MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
      COMMON /FLAGS/  LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
     .                NDIAG,LPSHE,LWEK,LMISC,LRAD,LUNIT
      COMMON /GMTRY/  ANGB(11,30),HTIB(11),HTUB(11),WDUB(11),
     .                HTFLB(30),HIWLE(11,30),EIFLB(11,30),HBNFB(30),
     .                EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
      COMMON /HALWK/  HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
     .                NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
     .                HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
      COMMON /INPUT/  A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
     .                MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
      COMMON /INRSK/  TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
     .                ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
      COMMON /LIMIT/  NSIM,NSM,SECWD(30),
     .                BENWD,BENHT,NULT
      COMMON /LOGIC/  L5,L6,L7
      COMMON /MISC/   TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
     .                PVB,PVC,NERR(4),MXERR,UNITS(7,5)
      COMMON /OTPUT/  UND
      COMMON /PITEL/  PITBT(30),ULTBT(30),STELS(30),SECBT,
     .                ULTDV(6),WEKBT(30)
      COMMON /PROBF/  PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
      COMMON /PROD/   ORE1(30),ORE2(30),WASTE(30),AVG1(30),
     .                AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     .                COMNW(30)
      COMMON /TIME/   KLIFE,KPD
      COMMON /USER/   N1,IFLG
      COMMON      IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)

      COST = 0.0
      IF(LABN.NE.0) GO TO 10
        LABN = KPD
        COST = 1000.
C
C***** DEBUG *****
C
   10 IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,LABN,COST
 1000 FORMAT(10X,"MABDN-FW",4I5,F15.2)
C
C     SUM COST VALUE STATISTICS
C
      SUMC(5) = SUMC(5) + COST
      SSQC(5) = SSQC(5) + COST**2
      NUMC(5) = NUMC(5) + 1
C
      RETURN
        END
        SUBROUTINE FHSL6 (COST)

C*****************************************
C   RE-ESTABLISH HAUL ROAD COST MODEL
C*****************************************

      COMMON /ANGLE/  ANGBK,ANGU(6)
      COMMON /BNFIT/  BNTP1(30),BNTP2(30),USBEN(30),BNMSC(30),
     .                BNTOT(30)
      COMMON /CELL/   NCELB(30),NRCLE(11,30),NBCLB(30)
      COMMON /COFL/   VOLO,VOLW,WALHT,COCL
      COMMON /COST/   CFHT(30),CSTIE(30),CSTBB(30),CSTSB(30),
     .                CUSR(30),CSTSC(30),SCOST(30),MXCEL
      COMMON /DIVSN/  ISC,ISCN,NSC,NCASE,NCAS
      COMMON /FAIL/   MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
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03790          .                 MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
03800          COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
03810          .                 NDIAG,LPSHE,LWRK,LMISC,LRAD,LUNIT
03820          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
03830          .                 HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
03840          .                 EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
03850          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
03860          .                 NHAUL,NWCRK,MXHWK,MXBWK1,NHWK,NHWK1,
03870          .                 HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
03880          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
03890          .                 MS(11,4),MN(2,4),KSED(30),IHN,IHD2A(9)
03900          COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
03910          .                 ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
03920          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
03930          .                 BENWD,BENHT,NULT
03940          COMMON /LOGIC/ L5,L6,L7
03950          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
03960          .                 PVB,PVC,NERR(4),MXERR,UNITS(7,5)
03970          COMMON /OTPUT/ UND
03980          COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
03990          .                 ULTDV(6),WERBT(30)
04000          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),BEIT(10,2),MXPRB,NPROB,NPRBW
04010          COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
04020          .                 AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
04030          .                 COMNW(30)
04040          COMMON /TIME/  KLIFE,KPD
04050          COMMON /USER/  N1,IFLG
04060          COMMON      IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
04070
04080            DATA CORPR,PROP/50.00,0.30/
04090    C
04100    C     COST = UNIT COST * HAUL ROAD LENGTH * PROPORTION DAMAGED
04110    C     ---AN 8 PER CENT HAUL ROAD IS ASSUMED
04120    C
04130            HLNTH = HTFLB(KPD) * 12.54
04140            COST = CORPR * HLNTH * PROP
04150    C
04160    C***** DEBUG *****
04170    C
04180            IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,HTFLB(KPD),
04190          .                             HLNTH,COST
04200     1000 FORMAT(10X,"RE-ESTABLISH H.R.",3I5,3F15.2)
04210    C
04220    C     SUM COST VALUE STATISTICS
04230    C
04240          SUMC(6) = SUMC(6) + COST
04250          SSQC(6) = SSQC(6) + COST**2
04260          NUMC(6) = NUMC(6) + 1
04270    C
04280            RETURN
04290            END
04300            SUBROUTINE FHSL7 (COST)
04310
04320    C*****************************************
04330    C   CLEAN-UP + LOST COAL + EARLY MINING
04340    C*****************************************
04350
04360          COMMON /ANGLE/ ANGBK,ANGU(6)
04370          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
04380          .                 BNTOT(30)
04390          COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
04400          COMMON /COFL/  VOLO,VOLW,WALHT,COCL
04410          COMMON /COST/  CFHT(30),CSTIB(30),CSTEB(30),CSTSB(30),
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04420          .                    CUSR(30),CSTSC(30),SCOST(30),MXCEL
04430          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
04440          COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
04450          .              MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
04460          COMMON /FLAGS/ IUSBN,LUSCT,LWRT,LPRT,LFIN1,LSTR,LPSH,LERR,
04470          .              NDIAG,LPSHB,LWEK,LMISC,LRAD,LUNIT
04480          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
04490          .              HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
04500          .              EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
04510          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
04520          .              NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
04530          .              HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
04540          COMMON /INPUT/ A(7),B(11),C(65),ID,DI1,KT(10),TMP(10),MM(5),
04550          .              MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
04560          COMMON /INRSK/ TIN1(30),TIN2(30),TINWA(30),AGS(30),AGL(30),
04570          .              ACS(30),ACL(30),ACR(30),CSTF(30),COFUS(30)
04580          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
04590          .              BENWD,BENNT,NULT
04600          COMMON /LOGIC/ I5,I6,L7
04610          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
04620          .              PVB,PVC,NERR(4),MXERR,UNITS(7,5)
04630          COMMON /OTPUT/ UND
04640          COMMON /PITEL/ PITBT(30),ULTBT(30),STBIS(30),SECBT,
04650          .              ULTDV(6),WERBT(30)
04660          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPRCB,NPRBW
04670          COMMON /PROD/  CRE1(30),CRE2(30),WASTE(30),AVG1(30),
04680          .              AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
04690          .              COMNW(30)
04700          COMMON /TIME/  KLIFE,KPD
04710          COMMON /USER/  N1,IFLG
04720          COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
04730          DATA CSTDB /0.10/
04740
04750          NTYPE = 0
04760           IF(NCASE.EQ.3)GO TO 202
04770            IF(NCASE.EQ.2) GO TO 100
04780    C
04790    C     THIS IS THE 28 DEGREE DESIGN
04800    C
04810            IF(KPD.EQ.16.OR.KPD.EQ.17) NTYPE=3
04820            IF(KPD.EQ.18) NTYPE=4
04830    C
04840    C     CALCULATE AND SUM THE COSTS
04850    C
04860       50 IF(NTYPE.EQ.0) GO TO 9999
04870          CALL LSTCL(NTYPE,1,COAL,BURDN,CST1)
04880            CALL CLNUP(1,CST2,0)
04890            CALL ERMNG(1,CST3)
04900    C
04910            COST = CST1 + CST2 + CST3
04920    C
04930    C     KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
04940    C       FOR POST PROCESSING.
04950    C
04960          CLMTL(KPD) = CLMTL(KPD) + CST2/(COMNW(KPD)-CSTDB*27/VOLW)
04970
04980    C
04990    C***** DEBUG *****
05000    C
05010          IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,CST1,CST2,CST3,COST
05020     1000 FORMAT(10X,"CLNUP+LSTCL+ERMNG",3I5,4F15.2)
05030    C
05040    C     SUM COST VALUE STATISTICS
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05050   C
05060         SUMC(7)  = SUMC(7)  + COST
05070         SSQC(7)  = SSQC(7)  + COST**2
05080         NUMC(7)  = NUMC(7)  + 1
05090           GO TO 10000
05100   C
05110   C***** ASSIGNMENT OR PROGRAMMING ERROR - FOR COST MODELS *****
05120   C
05130    9999 WRITE(L6,99999) NCASE,NSC,KPD
05140   99999 FORMAT(10X,"ASSIGNMENT ERROR--NTYPE IS NOT SPECIFIED
05150        .              IN FHSL7, FOR CASE",I5," SECTOR",I5,
05160        .              " IN PERIOD",I5)
05170   10000 RETURN
05180   C
05190   C     THIS IS THE 45 DEGREE DESIGN.
05200   C
05210     100 IF(KPD.EQ.14)  NTYPE=2
05220           IF(KPD.EQ.15)  NTYPE=3
05230           IF(KPD.EQ.16)  NTYPE=4
05240           GO TO 50
05250   C
05260   C      THIS IS THE 35 DEGREE DESIGN
05270   C
05280   202     NTYPE=1
05290           GO TO 50
05300            END
05310            SUBROUTINE FHSL8 (COST)
05320
05330   C*************************************
05340   C   INCREASED HAULAGE AND CLEAN-UP
05350   C*************************************
05360
05370
05380          COMMON /ANGLE/ ANGBK,ANGU(6)
05390          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
05400        .                BNTOT(30)
05410          COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
05420          COMMON /COFL/  VOLO,VOLW,WALHT,COCL
05430          COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
05440        .                CUSR(30),CSTSC(30),SCOST(30),MXCEL
05450          COMMON /DIVSN/ ISC,ISCW,NSC,NCASE,NCAS
05460          COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
05470        .                MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
05480          COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
05490        .                NDIAG,LPSHB,LWEK,LMISC,IRAD,LUNIT
05500          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HIUB(11),WDIB(11),WDUB(11),
05510        .                HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
05520        .                EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
05530          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
05540        .                NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
05550        .                HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IHK,KEFEL
05560          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
05570        .                MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
05580          COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
05590        .                ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
05600          COMMON /LIMIT/ NSIN,NSM,SECWD(30),
05610        .                BENWD,BENHT,NULT
05620          COMMON /LOGIC/ L5,L6,L7
05630          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
05640        .                PVB,PVC,NERR(4),MXERR,UNITS(7,5)
05650          COMMON /OTPUT/ UND
05660          COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
05670        .                ULTDV(6),WEKBT(30)
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      COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
      COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
     -               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     -               COMNW(30)
      COMMON /TIME/  KLIFE,KPD
      COMMON /USER/  N1,IFLG
      COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
      DATA CSTDB /0.10/

        CALL INCHL(1,CST1)

        CALL CLNUP(1,CST2,1)

        COST = CST1 + CST2
C
C     KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
C       FOR POST PROCESSING.
C
      CLMTL(KPD) = CLMTL(KPD) + CST2/(COMNW(KPD)-CSTDB*27/VOLW)

C
C***** DEBUG *****
C
      IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,CST1,CST2,COST
 1000 FORMAT(10X,"INCHL+CLNUP-FW",3I5,3F15.2)
C
C     SUM COST VALUE STATISTICS
C
      SUMC(8) = SUMC(8) + COST
      SSQC(8) = SSQC(8) + COST**2
      NUMC(8) = NUMC(8) + 1
C
        RETURN
        END
        SUBROUTINE FHSL9 (COST)

C*********************************
C   CLEAN-UP OR MINE ABANDONMENT
C*********************************

      COMMON /ANGLE/ ANGBK,ANGU(6)
      COMMON /BNFIT/ BNTP1(30),BNTP2(30),USRBN(30),BNMSC(30),
     -               BNTOT(30)
      COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
      COMMON /COFL/  VOLO,VOLW,WALHT,COCL
      COMMON /COST/  CFHT(30),CSTIB(30),CSTBE(30),CSTSB(30),
     -               CUSE(30),CSTSC(30),SCOST(30),MXCEL
      COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
      COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
     -               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
      COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
     -               NDIAG,LPSHB,LWEK,LMISC,IRAD,LUNIT
      COMMON /GMTRY/ ANGE(11,30),HTIE(11),HTUE(11),WDIB(11),WDUB(11),
     -               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
     -               EANGB(30),HTWKE(30),ANGWB(30),NCLWB(30)
      COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
     -               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
     -               BWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
      COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
     -               MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
      COMMON /INRSK/ TTN1(30),TTN2(30),TINWA(30),AGS(30),AGL(30),
     -               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
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      COMMON /LIMIT/ NSIM,NSM,SECWD(30),
     -               BENWD,BENHT,NULT
      COMMON /LOGIC/ L5,L6,L7
      COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
     -               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
      COMMON /OTPUT/ UND
      COMMON /PITEL/ PITBT(30),ULTET(30),STELS(30),SECBT,
     -               ULTDV(6),WEKBT(30)
      COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
      COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
     -               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     -               COMNW(30)
      COMMON /TIME/  KLIFE,KPD
      COMMON /USER/  N1,IFLG
      COMMON      IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
      DATA CSTDB /0.10/

C
C***** IF PIT ABANDONMENT HAS BEEN CALLED EARLIER, KEEP THE RECORD OF THE
C       TOTAL NUMBER OF CALLS TO THIS SUBROUTINE AND RETURN.
C
        CALL CLNUP(1,CST1,0)
        CALL MABDN(CST2)
        IF(LABN.NE.0) GO TO 10
C
C     IF THE COST OF CLEAN-UP IS GREATER THAN THE VALUE OF
C     THE REMAINING COAL, ABANDON THE PIT.
C
        IF(CST1.GE.CST2) GO TO 10
        COST = CST1
C
C     KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
C       FOR POST PROCESSING.
C
      CLMTL(KPD) = CLMTL(KPD) + COST/(COMNW(KPD)-CSTDB*27/VOLW)

C
C***** DEBUG *****
C
      IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,CST1,CST2,COST
 1000 FORMAT(10X,"CLNUP OR MABDN--FW",3I5,3F15.2)
C
C     SUM COST VALUE STATISTICS
C
        SUMC(9) = SUMC(9) + COST
        SSQC(9) = SSQC(9) + COST**2
        NUMC(9) = NUMC(9) + 1
C
        RETURN
C
C***** KEEP STATISTICS FOR POST PROCESSING.
C
10      COST = 1000.
      SUMC(19) = SUMC(19) + CST2
      SSQC(19) = SSQC(19) + CST2**2
      NUMC(19) = NUMC(19) + 1
C
C***** DEBUG *****
C
      IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,CST1,CST2,COST
C
      IF(LABN.NE.0) GO TO 20
        LABN = KPD
```

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06940        20 RETURN
06950           END
06960           SUBROUTINE IHWK1 (COST)
06970
06980   C****************
06990   C   CLEAN-UP
07000   C****************
07010
07020          COMMON /ANGLE/ ANGBK,ANGU(6)
07030          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
07040         .               BNTOT(30)
07050          COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
07060          COMMON /COFL/  VOLO,VOLW,WALHT,COCL
07070          COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
07080         .               CUSB(30),CSTSC(30),SCOST(30),MXCEL
07090          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
07100          COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
07110         .               MFHSV(30),MHWSV(11,30),MENBS(30),MWKBS(30),SFREQ(8)
07120          COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
07130         .               NDIAG,LPSHB,LWRK,LMISC,LRAD,LUNIT
07140          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
07150         .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
07160         .               EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
07170          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
07180         .               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
07190         .               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
07200          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
07210         .               MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
07220          COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
07230         .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
07240          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
07250         .               BENWD,BENHT,NULT
07260          COMMON /LOGIC/ L5,L6,L7
07270          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
07280         .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
07290          COMMON /OTPUT/ UND
07300          COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
07310         .               ULTDV(6),WEKBT(30)
07320          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
07330          COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
07340         .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
07350         .               COMNW(30)
07360          COMMON /TIME/  KLIFE,KPD
07370          COMMON /USER/  N1,IFLG
07380          COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
07390          DATA CSTDB /0.10/
07400
07410            CALL CLNUP(2,COST,0)
07420   C
07430   C      KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
07440   C        FOR POST PROCESSING.
07450   C
07460          CLMTL(KPD) = CLMTL(KPD) + COST/(COMNW(KPD)-CSTDB*27/VOLW)
07470
07480
07490   C
07500   C      SUM COST VALUE STATISTICS
07510   C
07520            SUMC(10) = SUMC(10) + COST
07530            SSQC(10) = SSQC(10) + COST**2
07540            NUMC(10) = NUMC(10) + 1
07550   C
07560            RETURN
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07570          END
07580          SUBROUTINE IHWK2 (COST)
07590
07600   C**********************
07610   C   LOST COAL NO. 1
07620   C**********************
07630
07640         COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
07650
07660          CALL LSTCL(2,2,COAL,BURDN,COST)
07670
07680   C
07690   C     SUM COST VALUE STATISTICS
07700   C
07710          SUMC(11) = SUMC(11) + COST
07720          SSQC(11) = SSQC(11) + COST**2
07730          NUMC(11) = NUMC(11) + 1
07740   C
07750          RETURN
07760          END
07770          SUBROUTINE IHWK3 (COST)
07780
07790   C**********************
07800   C   LOST COAL NO. 2
07810   C**********************
07820
07830         COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
07840
07850          CALL LSTCL(3,2,COAL,BURDN,COST)
07860
07870   C
07880   C     SUM COST VALUE STATISTICS
07890   C
07900          SUMC(12) = SUMC(12) + COST
07910          SSQC(12) = SSQC(12) + COST**2
07920          NUMC(12) = NUMC(12) + 1
07930   C
07940          RETURN
07950          END
07960          SUBROUTINE IHWK4 (COST)
07970
07980   C**********************
07990   C   LOST COAL NO. 3
08000   C**********************
08010
08020         COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
08030
08040          CALL LSTCL(4,2,COAL,BURDN,COST)
08050   C
08060   C     SUM COST VALUE STATISTICS
08070   C
08080          SUMC(13) = SUMC(13) + COST
08090          SSQC(13) = SSQC(13) + COST**2
08100          NUMC(13) = NUMC(13) + 1
08110   C
08120          RETURN
08130          END
08140          SUBROUTINE IHWK5 (COST)
08150
08160   C**********************
08170   C   MINE ABANDONMENT
08180   C**********************
08190
```

```
08200          COMMON /ANGLE/ ANGBK,ANGU(6)
08210          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
08220         .               BNTOT(30)
08230          COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
08240          COMMON /COFL/  VOLO,VOLW,WALHT,CCCI
08250          COMMON /COST/  CFHT(30),CSTIB(30),CSTLB(30),CSTSB(30),
08260         .               CUSR(30),CSTSC(30),SCOST(30),MXCEL
08270          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
08280          COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
08290         .               MFHSV(30),MHWSV(11,30),MENBS(30),MWKBS(30),SFREQ(8)
08300          COMMON /FLAGS/ LUSLN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
08310         .               NDIAG,LPSHE,LWEK,LMISC,LRAD,LUNIT
08320          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),
08330         .               HTFLB(30),HIWLB(11,30),BIFLB(11,30),HBNFB(30),
08340         .               EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
08350          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
08360         .               NHAUL,NWCHK,MXHWK,MXHWK1,NHWK,NHWK1,
08370         .               HWKLL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
08380          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
08390         .               MS(11,4),MN(2,4),KSED(30),IHN,IHD2A(9)
08400          COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
08410         .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
08420          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
08430         .               BENWD,BENHT,NULT
08440          COMMON /LOGIC/ I5,L6,L7
08450          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
08460         .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
08470          COMMON /OTPUT/ UND
08480          COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
08490         .               ULTDV(6),WEKBT(30)
08500          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
08510          COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
08520         .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
08530         .               COMNW(30)
08540          COMMON /TIME/  KLIFE,KPD
08550          COMMON /USER/  N1,IFLG
08560          COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
08570
08580          COST = 1000.
08590          IF(LABN.NE.0) GO TO 10
08600          LABN = KPD
08610
08620    C
08630    C***** DEBUG *****
08640    C
08650       10 IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,LABN,COST
08660     1000 FORMAT(10X,"MABDN-IR",4I5,F15.2)
08670    C
08680    C     SUM COST VALUE STATISTICS
08690    C
08700          SUMC(14) = SUMC(14) + COST
08710          SSQC(14) = SSQC(14) + COST**2
08720          NUMC(14) = NUMC(14) + 1
08730    C
08740          RETURN
08750            END
08760            SUBROUTINE IHWK6 (COST)
08770
08780    C********************
08790    C   EARLY MINING
08800    C********************
08810
08820          COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
```

```
08830
08840          CALL ERMNG(2,COST)
08850   C
08860   C      SUM COST VALUE STATISTICS
08870   C
08880          SUMC(15) = SUMC(15) + COST
08890          SSQC(15) = SSQC(15) + COST**2
08900          NUMC(15) = NUMC(15) + 1
08910   C
08920          RETURN
08930          END
08940          SUBROUTINE IHWK7 (COST)
08950
08960          RETURN
08970          END
08980          SUBROUTINE IHWK8 (COST)
08990
09000   C*********************************
09010   C   INCREASED HAUL + CLEAN-UP
09020   C*********************************
09030
09040          COMMON /ANGLE/ ANGBK,ANGU(6)
09050          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USRBN(30),BNMSC(30),
09060         .               BNTOT(30)
09070          COMMON /CELL/  NCELB(30),NBCLB(11,30),NBCLB(30)
09080          COMMON /COFL/  VOLO,VOLW,WALHT,CCCL
09090          COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
09100         .               CUSR(30),CSTSC(30),SCOST(30),MXCEL
09110          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
09120          COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
09130         .               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
09140          COMMON /FLAGS/ LUSLN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
09150         .               NDIAG,LPSHB,LWEK,LMISC,LRAD,LUNIT
09160          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
09170         .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
09180         .               BANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
09190          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
09200         .               NHAUL,NWORK,MXHWK,MXBWK1,WHWK,NHWK1,
09210         .               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
09220          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
09230         .               MS(11,4),MN(2,4),KSED(30),IHN,IHD2A(9)
09240          COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
09250         .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
09260          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
09270         .               BENWD,BENHT,NOLT
09280          COMMON /LOGIC/ L5,L6,L7
09290          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
09300         .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
09310          COMMON /OTPUT/ UND
09320          COMMON /PITEL/ PITLT(30),ULTLT(30),STELS(30),SECBT,
09330         .               ULTDV(6),WEKBT(30)
09340          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
09350          COMMON /PROD/  CRE1(30),CRE2(30),WASTE(30),AVG1(30),
09360         .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
09370         .               COMNW(30)
09380          COMMON /TIME/  KLIFE,KPD
09390          COMMON /USER/  N1,IFLG
09400          COMMON      IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMIL(30)
09410          DATA CSTDB /0.10/
09420
09430          CALL INCHI(2,CST1)
09440          CALL CLNUP(2,CST2,1)
09450
```

```
09460          COST = CST1 + CST2
09470    C
09480    C     KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
09490    C       FOR POST PROCESSING.
09500    C
09510          CLMTL(KPD) = CLMTL(KPD) + CST2/(COMNW(KPD)-CSTDB*27/VOLW)
09520
09530    C
09540    C     SUM COST VALUE STATISTICS
09550    C
09560          SUMC(16) = SUMC(16) + COST
09570          SSQC(16) = SSQC(16) + COST**2
09580          NUMC(16) = NUMC(16) + 1
09590    C
09600    C
09610    C***** DEBUG *****
09620    C
09630          IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,CST1,CST2,COST
09640     1000 FORMAT(10X,"INCHL+CLNUP-IR",3I5,3F15.2)
09650
09660            RETURN
09670            END
09680            SUBROUTINE IHWK9 (COST)
09690
09700    C*************************************
09710    C   CLEAN-UP OR MINE ABANDONMENT
09720    C*************************************
09730
09740          COMMON /ANGLE/ ANGBK,ANGU(6)
09750          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
09760         .               BNTOT(30)
09770          COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
09780          COMMON /COFL/  VOLC,VOLW,WALHT,COCL
09790          COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
09800         .               CUSF(30),CSTSC(30),SCOST(30),MXCEL
09810          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
09820          COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
09830         .               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
09840          COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
09850         .               NDIAG,LPSHB,LWEK,LMISC,LRAD,LUNIT
09860          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
09870         .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
09880         .               EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
09890          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
09900         .               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
09910         .               HWKEL(11,30),MXHAL,MXWBK,IWD,IEL,IMK,REFEL
09920          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KI(10),TMP(10),MM(5),
09930         .               MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
09940          COMMON /INRSK/ TTN1(30),TIN2(30),I1NWA(30),AGS(30),AGL(30),
09950         .               ACS(30),ACL(30),ACW(30),CSIF(30),COFUS(30)
09960          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
09970         .               BENWD,BENHT,NULT
09980          COMMON /LOGIC/ L5,L6,L7
09990          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
10000         .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
10010          COMMON /OTPUT/ UND
10020          COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
10030         .               ULTDV(6),WEKBT(30)
10040          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
10050          COMMON /PROD/  GRE1(30),GRE2(30),WASTE(30),AVG1(30),
10060         .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
10070         .               COMNW(30)
10080          COMMON /TIME/  KLIFE,KPD
```

```
      COMMON /USER/  N1,IFLG
      COMMON      IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
      DATA CSTDB /0.10/

C
C***** IF PIT ABANDONMENT HAS BEEN CALLED EARLIER, KEEP THE RECORD OF THE
C       TOTAL NUMBER OF CALLS TO THIS SUBROUTINE AND RETURN.
C
        CALL CLNUP(2,CST1,0)
        CALL MABDN(CST2)
        IF(LABN.NE.0) GO TO 10
C
C     ABANDON THE PIT IF THE CLEAN-UP COST EXCEEDS THE VALUE
C     OF THE COAL REMAINING
C
        IF(CST1.GE.CST2) GO TO 10
        COST = CST1
C
C     KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
C       FOR POST PROCESSING.
C
      CLMTL(KPD) = CLMTL(KPD) + COST/(COMNW(KPD)-CSTDB*27/VOLW)

C
C***** DEBUG *****
C
      IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,CST1,CST2,COST
 1000 FORMAT(10X,"CLNUP OR MABDN-IB",3I5,3F15.2)

C
C     SUM COST VALUE STATISTICS
C
        SUMC(17) = SUMC(17) + COST
        SSQC(17) = SSQC(17) + COST**2
        NUMC(17) = NUMC(17) + 1
C
        RETURN
C
C***** KEEP STATISTICS FOR POST PROCESSING.
C
10      COST = 1000.
        SUMC(20) = SUMC(20) + CST2
        SSQC(20) = SSQC(20) + CST2**2
        NUMC(20) = NUMC(20) + 1
C
C***** DEBUG *****
C
      IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,CST1,CST2,COST
C
      IF(LABN.NE.0) GO TO 20
        LABN = KPD
   20 RETURN
        END
        SUBROUTINE BENS1 (COST)

C****************
C   CLEAN-UP
C****************

      COMMON /ANGLE/ ANGBK,ANGU(6)
      COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
                     BNTOT(30)
      COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
```

```
      COMMON /COFL/  VOLO,VOLW,WALHT,COCL
      COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
     .               CUSB(30),CSTSC(30),SCOST(30),MXCEL
      COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
      COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
     .               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
      COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
     .               NDIAG,LPSHB,LWEK,LMISC,IRAD,LUNIT
      COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
     .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
     .               EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
      COMMON /HALWK/ HALWD,HALEL(5,30),WBKWD(5,30),WBKEL(5,30),
     .               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
     .               HWKEL(11,30),MXHAL,MXWBK,IWD,IEL,IMK,REFEL
      COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
     .               MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
      COMMON /INRSK/ TTN1(30),TTN2(30),TINWA(30),AGS(30),AGL(30),
     .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
      COMMON /LIMIT/ NSIM,NSM,SECWD(30),
     .               BENWD,BENHT,NULT
      COMMON /LOGIC/ L5,L6,L7
      COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
     .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
      COMMON /OTPUT/ UND
      COMMON /PITEL/ PITBT(30),ULTBT(30),STEIS(30),SECBT,
     .               ULTDV(6),WEKBT(30)
      COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
      COMMON /PROD/  CRE1(30),CRE2(30),WASTE(30),AVG1(30),
     .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     .               COMNW(30)
      COMMON /TIME/  KLIFE,KPD
      COMMON /USER/  N1,IFLG
      COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
      DATA CSTDB /0.10/

        CALL CLNUP(3,COST,0)
C
C     KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
C       FOR POST PROCESSING.
C
      CLMTL(KPD) = CLMTL(KPD) + COST/(COMNW(KPD)-CSTDB*27/VOLW)

C
C     SUM COST VALUE STATISTICS
C
        SUMC(18) = SUMC(18) + COST
        SSQC(18) = SSQC(18) + COST**2
        NUMC(18) = NUMC(18) + 1
C
        RETURN
        END
        SUBROUTINE BENS2 (COST)
        COST = 1000.
        RETURN
        END
        SUBROUTINE BENS3 (COST)
        COST = 1000.
        RETURN
        END
        SUBROUTINE BENS4 (COST)
        COST = 1000.
        RETURN
        END
```

```
      SUBROUTINE BENS5 (COST)
      COST = 1000.
      RETURN
      END
      SUBROUTINE BENS6 (cost)
      COST = 1000.
      RETURN
      END
      SUBROUTINE BENS7 (COST)
      COST = 1000.
      RETURN
      END
      SUBROUTINE BENS8 (COST)
      COST = 1000.
      RETURN
      END
      SUBROUTINE BENS9 (cost)
      COST = 1000.
      RETURN
      END
      SUBROUTINE CLNUP(NWALL,COST,ISWCH)

C*********************************************************
C    SUBROUTINE CLNUP CALCULATES THE CLEAN-UP COST FOR:
C      1)  FULL WALL FAILURES
C      2)  INTER RAMP FAILURES
C     &3)  BENCH FAILURES
C*********************************************************

      COMMON /ANGLE/  ANGBK,ANGU(6)
      COMMON /BNFIT/  BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
     .                BNTCT(30)
      COMMON /CELL/   NCELB(30),NBCLB(11,30),NBCLB(30)
      COMMON /COFL/   VOLO,VOLW,WALHT,CCCL
      COMMON /COST/   CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
     .                CUSR(30),CSTSC(30),SCOST(30),MXCEL
      COMMON /DIVSN/  ISC,ISCN,NSC,NCASE,NCAS
      COMMON /FAIL/   MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
     .                MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
      COMMON /FLAGS/  LUSBN,LUSCT,LWRT,LPRT,LFINI,LSTR,LPSH,LERR,
     .                NDIAG,LPSHB,LWEK,LMISC,LRAD,LUNIT
      COMMON /GMTRY/  ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
     .                HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
     .                EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
      COMMON /HALWK/  HALWD,HALEL(5,30),WBKWD(5,30),WBKEL(5,30),
     .                NHAUL,NWORK,MXHWK,MXBWK1,NHWK,NHWK1,
     .                HWKEL(11,30),MXHAL,MXWBK,IWD,IEL,IMK,REFEL
      COMMON /INPUT/  A(7),B(11),C(65),IL,DI1,KT(10),TMP(10),MM(5),
     .                MS(11,4),MN(2,4),KSED(30),IHN,IHD2A(9)
      COMMON /INRSK/  TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
     .                ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
      COMMON /LIMIT/  NSIM,NSM,SECWD(30)
     .                BENWD,BENHT,NULT
      COMMON /LOGIC/  L5,L6,L7
      COMMON /MISC/   TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
     .                PVB,PVC,NERR(4),MXERR,UNITS(7,5)
      COMMON /OTPUT/  UND
      COMMON /PITEL/  PITBT(30),ULTBT(30),STELS(30),SECBT,
     .                ULTDV(6),WEKBT(30)
      COMMON /PROBF/  PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRDW
      COMMON /PROD/   CRE1(30),OBL2(30),WASTE(30),AVG1(30),
     .                AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     .                COMNW(30)
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11980          COMMON /TIME/  KLIFE,KPD
11990          COMMON /USER/  N1,IFLG
12000          COMMON      IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
12010
12020            DATA CSTDB/0.10/
12030          COST = 0.0
12040            IF(NWALL-2) 100,200,300
12050    C
12060    C     CALCULATE THE FULL WALL COST
12070    C     -- THE AMOUNT OF FAILED MATERIAL IS CALCULATED USING DON
12080    C        COATE'S SLIDE FAILURE MODEL
12090    C
12100      100 HT = STELS(KPD) - ULTBT(KPD)
12110          IF(ISWCH.EQ.1) HT = HTFLB(KPD)
12120            TNNGE = 0.08 * HT**3 /VOLW
12130    C
12140    C     COST OF MINING IS IN $/CUYD, SO MATERIAL MUST BE IN CU. YDS.
12150    C
12160      150 IF(HT.LE.0.0) GO TO 999
12170          COST = TNNGE*(VOLW/27) * (COMNW(KPD)-CSTDB*(27/VOLW))
12180    C
12190    C***** DEBUG *****
12200    C
12210      999 IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,NWALL,HT,TNNGE,COST
12220     1000 FORMAT(10X,"CLNUP",4I5,3F15.2)
12230
12240            RETURN
12250    C
12260    C   CALCULATE INTER RAMP CLEAN-UP COSTS
12270    C
12280      200 HT = HIWLB(IHW,KPD)
12290          TNNGE = 0.08 * HT**3 / VOLW
12300            GO TO 150
12310    C
12320    C     CALCULATE BENCH CLEAN-UP COSTS
12330    C
12340      300 HT = BENHT
12350          TNNGE = 0.08 * HT**3 / VOLW
12360            GO TO 150
12370            END
12380            SUBROUTINE LSTCL(NTYPE,NWALL,COAL,BURDN,COST)
12390
12400    C*****************************************************************
12410    C   THIS SUBROUTINE CALCULATES THE COSTS ASSOCIATED WITH LOSING
12420    C     VARIOUS AMOUNTS OF COAL ALONG WITH THE TONNAGES OF COAL AND
12430    C     WASTE THAT ARE INVOLVED.
12440    C*****************************************************************
12450
12460          COMMON /ANGLE/ ANGBK,ANGU(6)
12470          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
12480         -               BNTOT(30)
12490          COMMON /CELL/  NCELB(30),NBCLE(11,30),NBCLB(30)
12500          COMMON /COFL/  VOLO,VOLW,WALHT,CCCI
12510          COMMON /COST/  CFHT(30),CSTIB(30),CSTEB(30),CSTSB(30),
12520         -               CUSR(30),CSTSC(30),SCOST(30),MXCEL
12530          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
12540          COMMON /FAIL/  MSTFB(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
12550         -               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
12560          COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPR1,LFINI,LSTR,LPSH,LERR,
12570         -               NDIAG,LPSHE,LWEK,LMISC,LRAD,LUN11
12580          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
12590         -               HTFLB(30),HIWLE(11,30),BIFLB(11,30),HBNFB(30),
12600         -               EANGB(30),HTWKE(30),ANGWB(30),NCLWB(30)
```

```
      COMMON /HALWK/ HALWD,HALEL(5,30),WEKWD(5,30),WEKEL(5,30),
     -               NHAUL,NWCRK,MXHWK,MXHWK1,NHWK,NHWK1,
     -               HWKEL(11,30),MXHAL,MXWEK,IWD,IEL,IMK,REFEL
      COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,AT(10),TMP(10),MM(5),
     -               MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
      COMMON /INRSK/ TTN1(30),TTN2(30),TINWA(30),AGS(30),AGL(30),
     -               ACS(30),ACL(30),ACW(30),CSTF(30),CCFUS(30)
      COMMON /LIMIT/ NSIM,NSM,SECWD(30),
     -               BENWD,BENH1,NULT
      COMMON /LOGIC/ I5,I6,L7
      COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
     -               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
      COMMON /OTPUT/ UND
      COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
     -               ULTDV(6),WEKBT(30)
      COMMON /PROBF/ PROB(6,10,2),RANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
      COMMON /PROD/  CRE1(30),CRE2(30),WASTE(30),AVG1(30),
     -               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     -               COMNW(30)
      COMMON /TIME/  KLIFE,KPD
      COMMON /USER/  N1,IFLG
      COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)

        DIMENSION THKLC(4)
        DATA THKLC,CSTDB/135.,75.,45.,15.,0.10/
C
C   GO TO APPROPRIATE LOST COAL MODEL.  SET COST = 0 FIRST.
C
        COST = 0.0
        GO TO (100,200,300,400) NTYPE
C
C   LOST COAL NO. 0 -- FULL WALL ONLY -- IF AT ULTIMATE WALL, HEIGHT
C     IS FULL WALL HEIGHT MINUS HEIGHT OF WALL AT ULTIMATE PIT LIMIT.
C
  100 HT = HTFLB(KPD) - (STELS(KPD)-ULTBT(KPD))
        IF(HT.LE.0.0) GO TO 999
        RATIO = THKLC(1)/HT
C
  150 SLIDE = 0.08 * HT**3
        COAL = RATIO * SLIDE / VOLO
        BURDN = (SLIDE-RATIO*SLIDE) / VOLW
C
C     CLEAN-UP COST
C
      TMATL = COAL*(VOLO/27) + BURDN*(VOLW/27)
        CST1 = TMATL * (COMNW(KPD)-CSTDB*(27/VOLW))
C
C     KEEP TOTAL CLEAN-UP VOLUME OF MATERIAL FOR EACH PERIOD
C       FOR POST PROCESSING.
C
      CLMTL(KPD) = CLMTL(KPD) + TMATL


C
C     COST OF LOST COAL = NET VALUE OF COAL LOST
C
      CMNG = COAL * COMN1(KPD)
        RVLST = COAL * PRICE
        CST2 = RVLST - CMNG
        IF(CST2.LT.0.0) CST2 = 0.0

C
C     TOTAL COST
```

```
13240   C
13250         COST = CST1 + CST2
13260   C
13270   C***** DEBUG *****
13280   C
13290     999 IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,NWALL,NTYPE,HT,
13300       -                             RATIO,COAL,BURDN,RVLST,CMNG,COST,
13310       -                             THKLC(NTYPE)
13320    1000 FORMAT(10X,"LSTCL",5I5,2F8.2,2F15.2,3F12.2,F5.0)
13330
13340           RETURN
13350   C
13360   C   LOST COAL NO. 1
13370   C
13380     200 HT = HIWLB(IHW,KPD)
13390           IF(NWALL.EQ.1) HT=HTFLB(KPD)-(STELS(KPD)-ULTBT(KPD))
13400           IF(HT.LE.0.0) GO TO 999
13410           RATIO = THKLC(2) /HT
13420           GO TO 150
13430   C
13440   C   LOST COAL NO. 2
13450   C
13460     300 HT = HIWLB(IHW,KPD)
13470           IF(NWALL.EQ.1) HT=HTFLB(KPD)-(STELS(KPD)-ULTBT(KPD))
13480           IF(HT.LE.0.0) GO TO 999
13490           RATIO = THKLC(3) /HT
13500           GO TO 150
13510   C
13520   C   LOST COAL NO. 3
13530   C
13540     400 HT = HIWLB(IHW,KPD)
13550           IF(NWALL.EQ.1) HT=HTFLB(KPD)-(STELS(KPD)-ULTBT(KPD))
13560           IF(HT.LE.0.0) GO TO 999
13570           RATIO = THKLC(4) /HT
13580           GO TO 150
13590           END
13600           SUBROUTINE ERMNG(NWALL,COST)
13610
13620   C*************************************************************************
13630   C   THIS SUBROUTINE CALCULATES THE COST OF MINING MATERIAL BEFORE IT WAS
13640   C     SCHEDULED TO BE MINED.
13650   C*************************************************************************
13660   C
13670   C     MYRS IS THE ASSUMED NUMBER OF YEARS THAT MATERIAL IS MINED EARLY.
13680   C
13690         COMMON /ANGLE/ ANGBK,ANGU(6)
13700         COMMON /BNFIT/ ENTP1(30),ENTP2(30),USREN(30),BNMSC(30),
13710       -                BNTOT(30)
13720         COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
13730         COMMON /COFL/  VOLO,VOLW,WALHT,COCL
13740         COMMON /COST/  CFHT(30),CSTIB(30),CSTEB(30),CSTSB(30),
13750       -                CUSB(30),CSTSC(30),SCOST(30),MXCEL
13760         COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
13770         COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
13780       -                MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
13790         COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LFRT,LFINI,LSTR,LPSH,LERR,
13800       -                NDLAG,LPSHB,LWRK,LMISC,IRAD,LUNIT
13810         COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
13820       -                HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
13830       -                EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
13840         COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
13850       -                NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
13860       -                HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
```

```
      COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
     -               MS(11,4),MN(2,4),KSED(30),IHN,IHD2A(9)
      COMMON /INRSK/ TIN1(30),TIN2(30),TINWA(30),AGS(30),AGL(30),
     -               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
      COMMON /LIMIT/ NSIM,NSM,SECWD(30),
     -               BENWD,BENHT,NULT
      COMMON /LOGIC/ L5,L6,L7
      COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
     -               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
      COMMON /OTPUT/ UND
      COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
     -               ULTDV(6),WEKBT(30)
      COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
      COMMON /PROD/  CRE1(30),CRE2(30),WASTE(30),AVG1(30)
     -               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
     -               COMNW(30)
      COMMON /TIME/  KLIFE,KPD
      COMMON /USER/  N1,IFLG
      COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)

        DATA MYRS/4/
        COST = 0.0
C
C   THE COST OF EARLY MINING IS THE DIFFERENCE BETWEEN THE CURRENT MINING
C     COST AND THE FUTURE COST DISCCUNTED TO THE PRESENT TIME.
C
        K = KPD+MYRS
      N = MYRS
        IF(K.LE.KLIFE) GO TO 50
        K = KLIFE
        N = KLIFE - KPD
50      CCOST = COMNW(KPD) - COMNW(K) / (1.0 + RATE)**N
C
C***** DEBUG *****
C
      IF(IBG.EQ.1) WRITE(L6,1100) CCMNW(KPD),COMNW(K),CCOST,K,N
 1100 FORMAT(10X,"PRINT MINING COSTS FOR CURRENT AND FUTURE PERIOD",
     -       3F10.2,2I5)
        IF(NWALL.EQ.2) GO TO 100
C
C   CALCULATE FULL WALL COST
C
        HT = HTFLB(KPD)-(STELS(KPD)-ULTBT(KPD))
        IF(HT.LE.0.0) GO TO 999
        COST = CCOST * (0.08*HT**3) * (1./27.)
C
        GO TO 999

C
C   CALCULATE INTER RAMP COST
C
  100 HT = HIWLB(IHW,KPD)
        IF(HT.LE.0.0) GO TO 999
        COST = CCOST * (0.08*HT**3) * (1./27.)
C
C***** DEBUG *****
C
  999 IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,NWALL,HT,CCOST,COST,
     -                            RATE,MYRS
 1000 FORMAT(10X,"ERMNG",4I5,3F15.2,F10.5,I5)

        RETURN
        END
```

```
14500          SUBROUTINE MABDN(COST)
14510
14520   C*********************************************************************
14530   C    THIS ROUTINE CALCULATES THE COST OF ABANDONING THE MINE BEFORE THE
14540   C      RESERVES ARE EXHAUSTED.
14550   C*********************************************************************
14560
14570         COMMON /ANGLE/ ANGBK,ANGU(6)
14580         COMMON /BNFIT/ ENTP1(30),ENTP2(30),USBBN(30),BNMSC(30),
14590        .               BNTOT(30)
14600         COMMON /CELL/  NCELB(30),NRCLB(11,30),NBCLB(30)
14610         COMMON /COFL/  VOLO,VOLW,WALHT,COCL
14620         COMMON /COST/  CFHT(30),CSTIB(30),CSTBE(30),CSTSB(30),
14630        .               CUSR(30),CSTSC(30),SCOST(30),MXCEL
14640         COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
14650         COMMON /FAIL/  MSTFH(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
14660        .               MFHSV(30),MHWSV(11,30),MBNBS(30),MWKBS(30),SFREQ(8)
14670         COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LERT,LPINI,LSTR,LPSH,LERR,
14680        .               NDIAG,LPSHB,LWRK,LMISC,IRAD,LUNIT
14690         COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTOB(11),WDIB(11),WDOB(11),
14700        .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
14710        .               BANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
14720         COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
14730        .               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
14740        .               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
14750         COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),MM(5),
14760        .               MS(11,4),MN(2,4),KSPD(30),IHN,IHD2A(9)
14770         COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
14780        .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
14790         COMMON /LIMIT/ NSIM,NSM,SECWD(30),
14800        .               BENWD,BENHT,NULT
14810         COMMON /LOGIC/ I5,I6,L7
14820         COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
14830        .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
14840         COMMON /OTPUT/ UND
14850         COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
14860        .               ULTDV(6),WEKBT(30)
14870         COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
14880         COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
14890        .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
14900        .               COMNW(30)
14910         COMMON /TIME/  KLIFE,KPD
14920         COMMON /USER/  N1,IFLG
14930         COMMON      IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
14940         COMMON /MABDN/ COAL1(30),COAL2(30),BRDN1(30),BRDN2(30),COAL3(30),
14950        .               BRDN3(30)
14960
14970   C
14980   C    CALCULATE NET REVENUE LOST FOR EACH PERIOD (AFTER FAILURE) AND SUM.
14990   C
15000           COST = 0.0
15010           K= KPD + 1
15020           IF(K.GT.KLIFE) GO TO 999
15030           J = KLIFE
15040           DO 100 I=K,KLIFE
15050           J = J-1
15060         GO TO(5,10,15) NCASE
15070   5     ORE = COAL1(I)
15080           WSTE = BRDN1(I)
15090           GO TO 50
15100      10   ORE = COAL2(I)
15110           WSTE = BRDN2(I)
15120         GO TO 50
```

```
15130     15   ORE = COAL3(I)
15140          WSTE = BRDN3(I)
15150       50   REV = ORE * PRICE
15160            CSTMN = ORE*COMN1(I) + WSTE*COMNW(I)
15170            REVNT = REV - CSTMN
15180            N = KLIFE - J
15190      100 COST = COST + REVNT/(1.+RATE)**N
15200    C
15210    C***** DEBUG *****
15220    C
15230      999 IF(IBG.EQ.1) WRITE(16,1000) NCASE,NSC,KPD,CSTMN,REVNT,COST,RATE,
15240     .                 ORE,WSTE,PRICE
15250     1000 FORMAT(10X,"MABDN",3I5,3F15.2,F10.5,3F10.2)
15260            RETURN
15270            END
15280            SUBROUTINE INCHL(NWALL,CCST)
15290
15300    C*********************************
15310    C   INCREASED HAUL COST MODEL
15320    C*********************************
15330
15340          COMMON /ANGLE/ ANGBK,ANGU(6)
15350          COMMON /BNFIT/ BNTP1(30),BNTP2(30),USREN(30),BNMSC(30),
15360         .               BNTOT(30)
15370          COMMON /CELL/  NCELB(30),NBCLB(11,30),NBCLB(30)
15380          COMMON /COFL/  VOLC,VOLW,WALHT,CCCL
15390          COMMON /COST/  CFHT(30),CSTIB(30),CSTBB(30),CSTSB(30),
15400         .               CUSR(30),CSTSC(30),SCOST(30),MXCEL
15410          COMMON /DIVSN/ ISC,ISCN,NSC,NCASE,NCAS
15420          COMMON /FAIL/  MSTFB(30),MSHWK(11,30),MSBNB(30),MSWKB(30),
15430         .               MFHSV(30),MHWSV(11,30),MBKBS(30),MWKBS(30),SFREQ(8)
15440          COMMON /FLAGS/ LUSBN,LUSCT,LWRT,LPRT,LPINT,LSTR,LPSH,LERR,
15450         .               NDIAG,LPSHB,LWEK,LMISC,IBAD,LUNIT
15460          COMMON /GMTRY/ ANGB(11,30),HTIB(11),HTUB(11),WDIB(11),WDUB(11),
15470         .               HTFLB(30),HIWLB(11,30),HIFLB(11,30),HBNFB(30),
15480         .               EANGB(30),HTWKB(30),ANGWB(30),NCLWB(30)
15490          COMMON /HALWK/ HALWD,HALEL(5,30),WRKWD(5,30),WRKEL(5,30),
15500         .               NHAUL,NWORK,MXHWK,MXHWK1,NHWK,NHWK1,
15510         .               HWKEL(11,30),MXHAL,MXWRK,IWD,IEL,IMK,REFEL
15520          COMMON /INPUT/ A(7),B(11),C(65),ID,DIT,KT(10),TMP(10),ME(5),
15530         .               MS(11,4),MN(2,4),KSED(30),IHN,IHD2A(9)
15540          COMMON /INRSK/ TTN1(30),TTN2(30),TTNWA(30),AGS(30),AGL(30),
15550         .               ACS(30),ACL(30),ACW(30),CSTF(30),COFUS(30)
15560          COMMON /LIMIT/ NSIM,NSM,SECWD(30),
15570         .               BENWD,BENHT,NULT
15580          COMMON /LOGIC/ I5,I6,I7
15590          COMMON /MISC/  TITLE(20),DATE(5),RATE,PRICE,PRIC2,SMISC(5,30),
15600         .               PVB,PVC,NERR(4),MXERR,UNITS(7,5)
15610          COMMON /OTPUT/ UND
15620          COMMON /PITEL/ PITBT(30),ULTBT(30),STELS(30),SECBT,
15630         .               ULTDV(6),WEKBT(30)
15640          COMMON /PROBF/ PROB(6,10,2),PANG(6,2),HEIT(10,2),MXPRB,NPROB,NPRBW
15650          COMMON /PROD/  ORE1(30),ORE2(30),WASTE(30),AVG1(30),
15660         .               AVG2(30),REC1,REC2,COMN1(30),COMN2(30),
15670         .               COMNW(30)
15680          COMMON /TIME/  KLIFE,KPD
15690          COMMON /USER/  N1,IFLG
15700          COMMON     IBG,LABN,IHW,SUMC(20),SSQC(20),NUMC(20),CLMTL(30)
15710
15720            DATA HLCST,HLDST/0.10,0.57/
15730            COST = 0.0
15740    C
15750    C   COST IS SIMPLY THE INCREASED DISTANCE(MILES) * COST($/TON-MILE) * TONNAGE
```

```
C
          IF(NWALL.EQ.2) GO TO 10
C
C   FULL WALL
C
          HT = HTFLB(KPD)
          GO TO 50
C
C   INTER RAMP WALL
C
   10 HT = HIWLB(IHW,KPD)

   50 IF(HT.LE.0.0) GO TO 999
          TONS = 0.08 * HT**3 / VOLW
          COST = HLDST * HLCST * TONS
C
C***** DEBUG *****
C
  999 IF(IBG.EQ.1) WRITE(L6,1000) NCASE,NSC,KPD,HT,TONS,COST
 1000 FORMAT(10X,"INCHL",3I5,3F15.2)

          RETURN
          END
```

APPENDIX J

POST PROCESSING PROGRAM LISTINGS

```
00010
00020          PROGRAM KPOSTP(OUTPUT,TAPE6=OUTPUT,TAPE2)
00030    C
00040    C    ROUTINE -POSTP- IS USED TO PROCESS STATISTICS GENERATED BY
00050    C     EXECUTING THE BENEFIT-COST MODEL -BNCST-. ANALYSIS OF THESE
00060    C     STATISTICS ALLOWS THE USER TO EVALUATE THE OPEN PIT MINE AS A
00070    C     WHOLE RATHER THAN IN SECTORS. THIS IS REQUIRED, FOR EXAMPLE, IN
00080    C     HANDLING THE STOCKPILING OF ORE THAT IS TO BE USED THROUGHOUT
00090    C     THE MINE. SIMILARLY, POST PROCESSING IS REQUIRED IF PIT IS ABANDONED
00100    C     IN ANY ONE DESIGN SECTOR DUE TO EXTENSIVE FAILURE.
00110
00120
00130    C     BLANK COMMON VARIABLES ARE CURRENTLY SET UP TO HOLD DATA
00140    C     FOR 9 SECTORS, 31 SIMULATIONS AND 30 PERIODS(YEARS) OR
00150    C     10 COST MODELS.
00160    C      IF GREATER NUMBERS OF THESE ITEMS ARE USED IN AN ASSOCIATED
00170    C     -BNCST- RUN THEN THEY SHOULD BE INCREASED HERE IN -POSTP-.
00180    C*****************************************************************
00190    C
00200          COMMON LABN(9,31),BNTOT(9,31,30),CSTSC(9,31,30),ORE1(30),
00210         *       WASTE(30),COMN1(30),COMNW(30),BPV(31),CPV(31),
00220         *       SUMC(20),SSQC(20),NUMC(20),TSUM(20),TSQC(20),NUMT(20),
00230         *       AVE(20),VAR(20),SD(20),CLMTL(9,31,30)
00240
00250          DIMENSION UNITS(7,5) ,NAME(3,20)
00260          DATA UND/1H=/
00270          DATA ((NAME(I,J),I=1,3),J=1,20) /4HCLEA,4HN-UP,4H--FW,
00280         .     4HLOST,4H COA,4HL-FW,4HLSTC,4H+CLN,4HP-FW,4HLSTC,
00290         .     4H+ERM,4HN-FW,4HMN A,4HBDNM,4HT-FW,4HRE-E,4HST H,
00300         .     4HR-FW,4HCL+L,4HC+EM,4H--FW,4HINCH,4HL+CL,4HN-FW,
00310         .     4HCL(V,4HS MA,4H)-FW,4HCLEA,4HN-UP,4H--IR,4HLST ,
00320         .     4HCL N,4HO. 1,4HLST ,4HCL N,4HO. 2,4HLST ,4HCL N,
00330         .     4HO. 3,4HMN A,4HBDNM,4HT-IR,4HERLY,4H MNG,4H--IR,
00340         .     4HINCH,4HL+CL,4HN-IR,4HCL(V,4HS MA,4H)-IR,4HCLEA,
00350         .     4HN-UP,4H-BEN,4HMA(V,4HS CL,4H)-FW,4HMA(V,4HS CL,
00360         .     4H)-IR/
00370    C
00380    C*****************************************************************
00390    C      IBUG = 0 MEANS NO DEBUG PRINTOUT.
00400    C      IBUG = 1 MEANS PRINT MODIFIED BENEFITS AND COSTS BY PERIOD FOR
00410    C                THE FIRST THREE SIMULATIONS.
00420    C      IBUG = 2 MEANS PRINT MEANS AND STD. DEVIATIONS OF FAILURE COSTS
00430    C                FOR ALL SIMULATIONS
00440    C      IBUG = 5 MEANS PRINT INPUT DATA COMING FROM EXTERNAL STORAGE
00450    C                FOR CHECKING.
00460    C      RATE = DISCOUNT RATE FOR EACH PERIOD.
00470    C      NCSTM = TOTAL NO. OF COST MODEL STATISTICS THAT HAVE BEEN GATHERED
00480    C        EARLIER DURING THE BENEFIT COST ANALYSIS.
00490    C      IPHAS = FLAG THAT CONTROLS THE CAUSE OF PIT ABANDONMENT
00500    C      IF IPHAS IS 1 THE COST OF CLEAN UP EXCEEDS THE VALUE OF ABANDONED COAL
00510    C                  2 THE MAXIMUM CLEAN UP CAPACITY IS EXCEEDED
00520    C*****************************************************************
00530    C
00540           IBUG = 5
00550           L2 = 2
00560           L6 = 6
00570           RATE = 0.12
00580    5      NCSTM = 20
00590
00600           DO 10 L=1,NCSTM
00610           TSUM(L) = 0.0
00620           TSQC(L) = 0.0
00630    10     NUMT(L) = 0.0
```

```
00640   C
00650   C**** READ IN RESULTS OF THE BENEFIT COST ANALYSIS FROM EXTERNAL DATA
00660   C        STORAGE DEVICE (TAPE2).
00670   C        NOTE: ORE1 IS READ ONLY FOR SECTOR NUMBER 1, BECAUSE IT IS
00680   C        ASSUMED THAT ALL ORE AND WASTE TONNAGES FROM THE ENTIRE PIT
00690   C        HAVE BEEN INPUT INTO SECTOR NO. 1 FOR CONVENIENCE ONLY.
00700   C
00710   20     READ(L2) KLIFE,NSEC,NSIM,NCAS,RATE,UNITS,(ORE1(K),WASTE(K),
00720        * COMN1(K),COMNW(K),K=1,KLIFE)
00730          IF(EOF(L2).NE.0) GOTO 999
00740   C
00750   C **** DEBUG PRINTOUT FOR IBUG = 5 ******
00760          IF(IBUG.EQ.5) WRITE(L6,5000) NCAS,NSEC,NSIM,KLIFE
00770   5000   FORMAT(10X"POSTP(5000)",4I6)
00780          IF(IBUG.EQ.5) WRITE(L6,5010) (ORE1(K),WASTE(K),COMN1(K),
00790        * COMNW(K),K=1,KLIFE)
00800   5010   FORMAT(5X,4F15.2)
00810   C
00820          DO 50 I=1,NSEC
00830          DO 50 J=1,NSIM
00840   C
00850   C**** READ TOTAL BENEFITS AND TOTAL COSTS BY PERIODS, FOR CURRENT
00860   C        SIMULATION AND CURRENT SECTOR
00870   C
00880          READ(L2) NSM,NSC,LABN(I,J),(BNTOT(I,J,K),
00890        *          CSTSC(I,J,K),K=1,KLIFE)
00900   C
00910   C****READ COST MODEL COST STATISTICS THAT WERE KEPT DURING THE BENEFIT-
00920   C        COST ANALYSIS.
00930   C
00940          READ(L2) IRAMP,IBNCH,NCSTM,(SUMC(L),SSQC(L),NUMC(L),L=1,NCSTM)
00950   C
00960   C***** DEBUG PRINTOUT FOR IBUG= 5 ****
00970   C
00980          IF(IBUG.EQ.5.AND.J.LE.3) WRITE(L6,4030) IRAMP,IBNCH,NCSTM
00990   4030   FORMAT(//10X"IRAMP, IBNCH, NCSTM",3I6)
01000          IF(IBUG.EQ.5.AND.J.LE.3) WRITE(L6,5020) I,J,(SUMC(L),NUMC(L),
01010                                                  L=1,NCSTM)
01020   5020 FORMAT(5X,"SECTOR NO.=",I3,"  NSIM =",I3,/(5X,6(F12.0,I7)))
01030   C
01040   C
01050   C**** SUM COST VALUES RESULTING FROM CALLS TO SELECTED COST MODELS FOR
01060   C        FOR THE ENTIRE SIMULATIONS AND FOR ALL DESIGN SECTORS IN THE PIT
01070   C
01080          DO 40 L=1,NCSTM
01090          TSUM(L) = TSUM(L) + SUMC(L) / 1000.
01100          TSQC(L) = TSQC(L) + SSQC(L) /1000000.
01110   40     NUMT(L) = NUMT(L) + NUMC(L)
01120
01130   C
01140   C    READ CLEAN-UP VOLUME-- VOLUME IS IN CUBIC YARDS.  IT IS THE
01150   C        TOTAL FOR EACH PERIOD OF THE CURRENT SIMULATION.
01160   C
01170          READ(L2) (CLMTL(I,J,K),K=1,KLIFE)
01180
01190          IF(IBUG.EQ.5.AND.J.LE.3) WRITE(L6,455) (CLMTL(I,J,K),
01200        *K=1,KLIFE)
01210     455 FORMAT(1X,"CLEANUP FOR EACH PERIOD",(/25X,6F15.2))
01220
01230   50     CONTINUE
01240   C
01250   C****COMPUTE MEAN AND STANDARD DEVIATION OF COSTS BY EACH COST MODEL
01260   C        TYPE.
```

```
01270   C
01280           DO 55 L=1,NCSTM
01290           SNT = NUMT(L)
01300           SD(L) = 0.0
01310           AVE(L) = 0.0
01320           IF (SNT.LE.0) GO TO 55
01330           AVE(L) = TSUM(L)/SNT
01340           IF (SNT.EQ.1) GO TO 55
01350           VAR(L) = (TSQC(L)/SNT - AVE(L)*AVE(L))*(SNT/(SNT-1))
01360           IF(VAR(L).NE.0) SD(L) = SQRT(ABS(VAR(L)))
01370   55      CONTINUE
01380   C
01390   C***** DEBUG PRINTOUT FOR IBUG = 2 *****
01400   C
01410           IF(IBUG.EQ.2) WRITE(L6,4040) (AVE(L),VAR(L),SD(L),L=1,NCSTM)
01420   4040    FORMAT(10X"TAVE"12X"VAR"13X"SD"/(4X,3F15.2))
01430   C
01440   C
01450   C**** WRITE COST MODEL STATISTICS FOR EACH COST TYPE.
01460   C
01470           WRITE(L6,2000) NCAS,NSIM,(UND,IU=1,46)
01480   2000    FORMAT(1H1,11X"COST MODEL STATISTICS FOR CASE NUMBER"I4
01490        */14X"(VALUES AVERAGED OVER"I3,"  SIMULATIONS)"
01500        *//11X"MODEL"6X"TOT. NO."5X"AVERAGE"6X"STD. DEV."
01510        */11X"NAME"7X"OF CALLS"6X"COST"9X"OF COST"/6X,14A1,2X,8A1,
01520        *2(2X,12A1))
01530
01540           WRITE(L6,2010) ((NAME(I,L),I=1,3),NUMT(L),AVE(L),SD(L),
01550                          L=1,NCSTM)
01560   2010    FORMAT(7X,3A4,3X,I6,2X,2F13.2)
01570   C
01580   C**** BEGIN POST PROCESSING AS REQUIRED. THIS PART OF LOGIC IS UNIQUE
01590   C       TO EACH USER. HENCE, MAY REQUIRE MODIFICATIONS.
01600   C
01610           DO 420 J=1,NSIM
01620   C
01630   C****CHECK TO SEE IF ANY SECTOR HAS CALLED FOR ABANDONMENT OF PIT.
01640   C
01650   C
01660           ND = 0
01670           KLABN = 0
01680           KSMAL = 100
01690           PRICE = 12.5
01700           IPHAS = 0
01710   C
01720           DO 280 I=1,NSEC
01730           IF(LABN(I,J).EQ.0)GO TO 280
01740           IF(LABN(I,J) .GE. KSMAL)  GO TO 280
01750           KSMAL = LABN (I,J)
01760           KLABN = KSMAL
01770           ISC = I
01780           IPHAS = 1
01790   280     CONTINUE
01800   C
01810
01820
01830   C ***     SUM CLEAN UP VOLUME.
01840   C *** DETERMINE IF CLEAN UP VOL. EXCEEDS THE ALLOWABLE CAPACITY
01850
01860           CLRAT = 3.0E6
01870           DO 310 K=1,KLIFE
01880           EXCLN = 0
01890           DO 300 I=1,NSEC
```

```
01900   300      EXCLN = EXCLN + CLMTL(I,J,K)
01910   C
01920   C*** CHECK IF CLEAN UP CAPACITY IS EXCEEDED FOR THIS PERIOD.
01930   C
01940          IF(EXCLN.LE.CLRAT)GO TO 310
01950          IF(K.LT.KLABN)IPHAS = 2
01960          IF(K.LT.KLABN) KLABN = K
01970          GO TO 320
01980   310      CONTINUE
01990   320      IF(KLABN.EQ.0) GO TO 420
02000
02010   C**** MODIFY BENEFITS AND COSTS FOR CURRENT SIMULATION, IF PIT IS
02020   C        ABANDONED.
02030   C        INSERT USER SPECIFIC COSTS OF PIT ABANDONMENT BELOW.
02040   C
02050            KK = KLABN + 1
02060            IF(KK.GT.KLIFE) GO TO 420
02070   C
02080            DO 400 K=KK,KLIFE
02090            DO 390 I=1,NSEC
02100            BNTOT(I,J,K) = 0.0
02110            CSTSC(I,J,K) = 0.0
02120            IF(I.GT.1) GO TO 390
02130   C
02140            CSTSC(I,J,K) = ORE1(K)*PRICE - ORE1(K)*COMN1(K) - WASTE(K)
02150            *COMNW(K)
02160            CSTSC(I,J,K) = CSTSC(I,J,K) / 1000.0
02170   C
02180   C**** REDUCE TO 1000 DOLLARS.
02190   C**** IF THE COST IS NEGATIVE, IT IS A BENEFIT.
02200            IF(CSTSC(I,J,K).LT.0.) BNTOT(I,J,K) = - CSTSC(I,J,K)
02210            IF(CSTSC(I,J,K).LT.0.) CSTSC(I,J,K) = 0.
02220            IF(IBUG.NE.1) GO TO 390
02230   C
02240   C*** PRINT ONLY THE FIRST THREE SIMULATION RESULTS.
02250   C
02260            IF(I.EQ.1.AND.J.LE.3) WRITE(L6,5050) K, CSTSC(I,J,K)
02270   5050     FORMAT(5X," THE NPV OF LOST ORE IN PERIOD",I3,2X,F15.0)
02280   390      CONTINUE
02290   400      CONTINUE
02300   C
02310   C*** PRINT TIME OF ABANDONMENT
02320   C
02330          IF( IPHAS. GT .1)GO TO 305
02340          IF( IPHAS. EQ .1)WRITE(L6,2080)KLABN,ISC,J
02350          GO TO 420
02360     305  WRITE(L6,2082)KLABN,J,EXCLN
02370    2082  FORMAT(10X"** THE PIT WAS ABANDONED IN PERIOD"I4" OF SIMULATION"I4
02380         *" CLEAN-UP VOLUME EXCEEDED: VOL= "F10.0)
02390    2080   FORMAT(10X"** THE PIT WAS ABANDONED IN PERIOD"I4" IN SECTOR"I4" O
02400         *F SIMULATION"I4" CLEAN-UP COST EXCEEDS ABANDONED COAL VALUE **")
02410
02420   420      CONTINUE
02430   C
02440   C**** THE ABOVE COMPLETES THE USER SPECIFIC PIT ABANDONMENT COST ADJUST-
02450   C        MENTS.
02460   C
02470            IF(IBUG.NE.5) GO TO 474
02480   C
02490   C***** DEBUG PRINTOUT FOR IBUG = 5 ****
02500   C   PRINT COST AND BENEFIT TOTALS FOR EACH PERIOD FOR THE FIRST THREE
02510   C                SIMULATIONS ONLY.
02520            MPRT = 3
```

```
02530          DO 470 J = 1,NSIM
02540          IF(J.GT.MPRT) GO TO 474
02550          WRITE(L6,2062) J
02560   2062   FORMAT(//10X"SIMULATION"I4/13X"BENEFIT"6X"COST")
02570          DO 470 K = 1,KLIFE
02580          COST = 0.0
02590          BENF = 0.0
02600          DO 460 I = 1,NSEC
02610          IF(J.LE.3) WRITE(L6,5040) K,I,BNTOT(I,J,K),CSTSC(I,J,K)
02620   5040   FORMAT(5X," PERIOD =",I3," SECTOR =",I3," TOTAL BEN. & COSTS",
02630        * 2F10.0)
02640          BENF = BENF + BNTOT(I,J,K)
02650   460    COST = COST + CSTSC(I,J,K)
02660
02670          WRITE(L6,2064) BENF,COST
02680   2064   FORMAT(10X,2F16.0)
02690   470    CONTINUE
02700   C
02710   C**** COMPUTE AND SUM PRESENT VALUE OF BENEFIT AND COST OVER
02720   C          PIT LIFE AND ALL SECTORS FOR EACH SIMULATION.
02730   C
02740   474    DO 500 J=1,NSIM
02750   C
02760          PVB = 0.0
02770          PVC = 0.0
02780          DO 480 I=1,NSEC
02790          DO 480 K=1,KLIFE
02800          PVB = PVB + BNTOT(I,J,K)/(1.0+RATE)**K
02810   480    PVC = PVC + CSTSC(I,J,K)/(1.0+RATE)**K
02820
02830          BPV(J) = PVB
02840   500    CPV(J) = PVC
02850
02860
02870   C   DO FINAL PROCESSING FOR CURRENT CASE.
02880     600 BPVSV = 0.0
02890         CPVSV = 0.0
02900         BPVSQ = 0.0
02910         CPVSQ = 0.0
02920
02930   C     WRITE CASE SUMMARY.
02940
02950          WRITE(L6,2009)NCAS,(UNITS(7,J),J=1,5),(UND, IU=1,71)
02960    2009  FORMAT(1H1, 7X,"CASE SUMMARY FOR CASE NUMBER",I3," FOR THE ENTI",
02970         ."RE PIT FOR ALL SIMULATIONS"/ 31X,"AFTER POST PROCESSING"
02980         ./22X,"(AMOUNT IN THOUSAND "5A4" UNITS)"/ 7X,100A1,/)
02990          WRITE(L6,2038)NSIM
03000   2038   FORMAT(//13X,"PRESENT VALUE OF TOTAL BENEFIT FOR SIMULATIONS",
03010         ." 1 THRU"I4/)
03020          DO 630 I=1,NSIM,5
03030          IEND = I + 4
03040          WRITE(L6,2070) (BPV( NSM), NSM=I,IEND)
03050     630  CONTINUE
03060   2070   FORMAT(10X,5F12.0)
03070
03080          WRITE(L6,2042)NSIM
03090   2042   FORMAT(//13X,"PRESENT VALUE OF TOTAL  COST   FOR SIMULATIONS",
03100         ." 1 THRU"I4/)
03110          DO 640 I=1,NSIM,5
03120          IEND = I + 4
03130          WRITE(L6,2070) (CPV( NSM), NSM=I,IEND)
03140     640  CONTINUE
03150
```

```
03160
03170          DO 610 NSM = 1, NSIM
03180          BPVSV = BPVSV + BPV(NSM)
03190          BPVSQ = BPVSQ + BPV(NSM) ** 2
03200          CPVSV = CPVSV + CPV(NSM)
03210          CPVSQ = CPVSQ + CPV(NSM) ** 2
03220      610 CONTINUE
03230          BPVSV=BPVSV/NSIM
03240          BS=0
03250          CPVSV=CPVSV/NSIM
03260          CS=0
03270          IF(NSIM.EQ.1)GOTO 625
03280          BSS=(BPVSQ-BPVSV*BPVSV*NSIM)/(NSIM-1)
03290          CSS=(CPVSQ-CPVSV*CPVSV*NSIM)/(NSIM-1)
03300          IF(BSS.NE.0)BS=SQRT(ABS(BSS))
03310          IF(CSS.NE.0)CS=SQRT(ABS(CSS))
03320
03330    C     PRINT SUMMARY OF BENEFITS AND COSTS.
03340
03350    625   WRITE(L6,2026)NCAS,BPVSV,BS,CPVSV,CS
03360     2026 FORMAT(///16X,"SUMMARY OF BENEFITS AND COSTS FOR CASE"I8 /
03370         ./20X"AVERAGE PRESENT VALUE OF BENEFITS"F10.0//20X"STANDARD DEVIATI
03380         .ON OF BENEFITS"F13.0//20X"AVERAGE PRESENT VALUE OF COSTS"3X,F10.0/
03390         ./20X"STANDARD DEVIATION OF COSTS"3X,F13.0/)
03400
03410    C   GO READ DATA FOR NEXT PIT DESIGN CASE.
03420          GOTO 5
03430
03440    999   STOP
03450          END
```

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