PIT SLOPE MANUAL

supplement 5-3

FINANCIAL COMPUTER PROGRAMS

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THE PIT SLOPE MANUAL

The Pit Slope Manual consists of ten chapters, published separately. Most chapters have supplements, also published separately. The ten chapters are:

1. Summary
2. Structural Geology
3. Mechanical Properties
4. Groundwater
5. Design
6. Mechanical Support
7. Perimeter Blasting
8. Monitoring
9. Waste Embankments
10. Environmental Planning

The chapters and supplements can be obtained from the Publications Distribution Office, CANMET, Energy, Mines and Resources Canada, 555 Booth Street, Ottawa, Ontario, K1A 0G1, Canada.

Reference to this chapter should be quoted as follows:

ABSTRACT

The designer of an open pit attempts to minimize both the cost of waste excavation and the costs arising from instability associated with relatively steep slopes. The objective is to achieve an optimum geometry. The computer programs described in this supplement assist in reaching this goal.

The economic analysis is divided into two stages: one assesses economic benefits and costs associated with various slope angles, the second determines overall economic outcome. Performing the first is mandatory for every design.

The concepts incorporated in wall design are: (a) reliability of slopes, (b) integration of the reliabilities into a risk analysis, and (c) quantifying benefits and costs resulting from slope changes.

An example of the economic analysis of a pit wall based on a case study performed for an operating porphyry copper mine is provided. Appendices A and B contain program users' guides for both benefit-cost analyses and economic risk analyses.

ACKNOWLEDGEMENTS

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INTRODUCTION

Purpose and Scope

1. The purpose of this supplement is to provide the mine operator with guidance in selecting optimum wall angles consistent with his attitude toward risk. In other words, procedures are offered that will permit operators to select appropriate wall angles based on slope reliability or probability of stability.

2. Scope is limited to economic analysis and requires the availability of two or more layouts of the mine at different wall angles.

3. The main function of slope design is to specify the particular angles to be used at various locations at each of the three stages of development - feasibility, mine design and operating.

Review of Practice

4. A number of articles have appeared during the past decade which describe the economic impact of pit slope angles on the design and economics of open pits. One states that the ultimate pit slope angle should be as steep as possible to minimize overall waste stripping for a given ore reserve (1). If reduced waste stripping is the main concern, one could easily compute the effect of changes in slope angle on the stripping volume as shown in Fig 1. Reduced stripping means reduced costs; hence the economic benefit of a steeper ultimate slope can be readily obtained. However, this economic benefit can be wiped out if major instability develops.

5. Another consequence of a steeper ultimate slope is to increase the amount of ore that can be mined and hence to increase the life of the mine. Increasing the life of the mine can result in profits in later years, which may have little effect on the present value, particularly if the mine is in the early years of its life. (2,3). A counter argument can be made if the mine is at the feasibility study stage. Since a steeper ultimate slope means either increased ore reserves or reduced waste stripping, it can easily influence profitability of the proposed mining venture.

6. Regarding working slopes, it has already been stated that they should be as steep as possible to minimize stripping during the early years (1,2).

7. From the preceding views, it seems that slopes should be maintained as steep as possible. The economic impact is a function of: (1) type of slope angle, ie, ultimate, interim, etc.; (2) current stage of mine life; (3) size and life of the mine; (4) type of ore deposit, ie, tabular, massive, etc.; and (5) surrounding topography. Discussions are confined to the benefits only, without mention of potential costs. In other words, the possibility of slope instability has been ruled out, which implicitly assumes that only those slopes that are absolutely stable are to be considered.

8. The concept of slope reliability was introduced for the purpose of recognizing variations in strength (5). The cost of instability in determining the most economical slope angles was then added (6). The expected cost of instability for each year of mine life can then be computed.

9. An alternate approach has been proposed using the more conventional factor of safety concept (7). Here it is assumed that a slope will fail if the factor of safety falls below unity which, in reality, corresponds to a reliability of only 0.5 as shown in Fig 2(a). Even at a higher factor of safety, such as 2, there can be instability as indicated by the hatched area in Fig 2(b). The magnitude of the probability depends of the variability of the strength and stress parameters.

10. The above approaches do not include integration of the economic aspects of slope design with total mine design.

Economic Analysis

11. Economic analysis of slope design refers to the quantitative assessment of benefits and costs associated with different slopes. Design is concerned with ultimate and working slopes together with such other aspects as interim, interramp and bench slopes - all of which make up the actual wall geometry in a typical open pit mine.
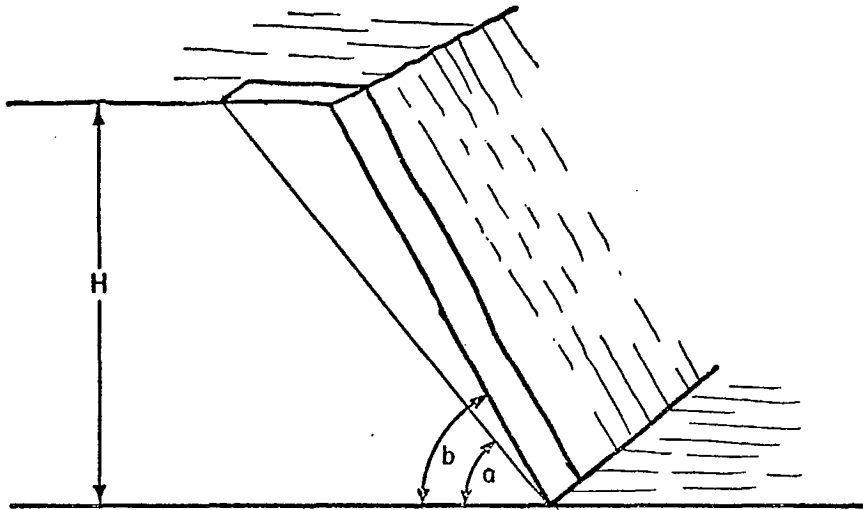
$$V = \frac{H^2 \, Sin \, (b - a)}{54 \, Sin \, a \, Sin \, b}$$

V = cubic yards per foot of face width
H = slope height (in feet)
a = initial slope angle
b = final slope angle

Fig 1 - Effect of changes in slope angle on stripping volume

Fig 3 shows typical geometries that can be encountered.

12. Although there is a tendency to represent pit slopes as being uniform and neat, the converse is more often true. A uniform slope is only one possibility among many. Some variability in slopes is being incorporated, in pit, as shown in Fig. 4.

13. The presence of haul roads, work benches and pushbacks, all complicate actual wall geometry. With the current trend of having relatively wide haul roads, over 100 ft (30 m) wide, slope instability problems are more frequently found in interramp slopes than in the overall slope. Therefore, economic analyses require information concerning the location of haul roads throughout the entire mining period.

14. Wall geometries at each design sector of a pit for the entire analysis period is needed.

15. Such mine planning data as presence of haul roads, annual mining sequence, associated stripping ratios and yearly ore grades become part of the input data for economic analysis of the slopes. In other words, slope design must incorporate such additional variables as: (1) amount of stripping to provide a minimum number of working faces, (2) mining rate and sequence, (3) other slope angles such as interim, interramp and bench angles, (4) definition of slope design sectors, (5) ore grades and (6) stripping ratios. These variables in turn are influenced by the choice of slope angles.

Development of Approach

16. Ignoring the probability aspects in the past made it difficult to include the cost aspect of instability. The deterministic approach requires that the future outcome be known with certainty. Pit wall instability cannot be predicted with certainty.

17. The two main difficulties associated with past procedures have been: (1) predicting if, when and how often there will be instability in each design sector and (2) quantifying costs of instability. It may not be realistic to assume there will be no instability at any stage in the life of a pit, even when the design appears reasonable. It may also be unrealistic to ignore this possibility when preparing the economic analysis.

18. New concepts are required to overcome some of the difficulties in slope design. Slope reliability rather than the more conventional safety factor, is one such concept. Simulated, or Monte Carlo, sampling is needed to determine if, when and how often there could be instability in each design sector. When instability occurs, an accounting of its cost through the use of various types of cost models becomes important. Risk analysis is needed to assess the economic impact of different slopes on the profitability of the mining operation (9).

19. Introduction of these concepts requires three assumptions to be made: (1) that it is possible to estimate the reliability of a slope, (2) that it is possible to estimate operational impact of instability, (3) that appropriate cost models can be established which adequately represent the specified operational impact.

20. The first assumption requires determining the following five items:

a. slope design sectors based on structurally homogeneous domains;

b. rock strength and density parameters for each sector;

c. the most probable modes of instability for each sector;

d. groundwater levels, and

e. detailed pit wall geometries.

21. The second assumption requires the following items:

a. detailed pit wall geometries;

b. planning data such as preproduction stripping, ore and waste tonnage for each period, etc., and

c. cost data for mining ore and waste, and for processing.

22. Regarding the third assumption, some generalized cost models for pit slope instability have been developed in the past (10). Some additional models are given below.

23. The recommended procedure is summarized in Fig 5. Performing the work elements described by

FREQUENCY

STRESS, σ

σ = S
F.S. = 1.0
P.I. = 0.5

STRENGTH, S

(A)

PSI

1500

σ = 1/2 S
F.S. = 2.0
P.I. $\geqq$ 0. (HATCHED AREA)

FREQUENCY   STRESS

STRENGTH

(B)

PSI

1000   2000
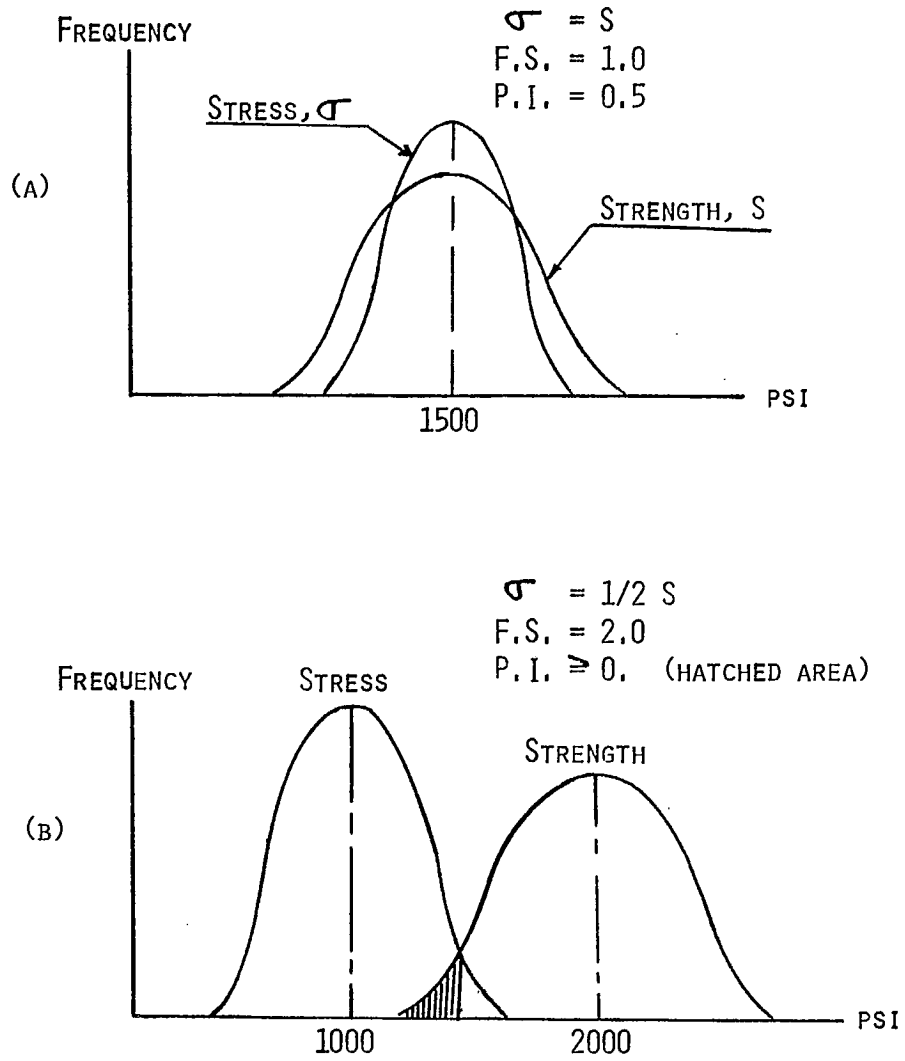
Fig 2 - Probability of instability compared with factor of safety
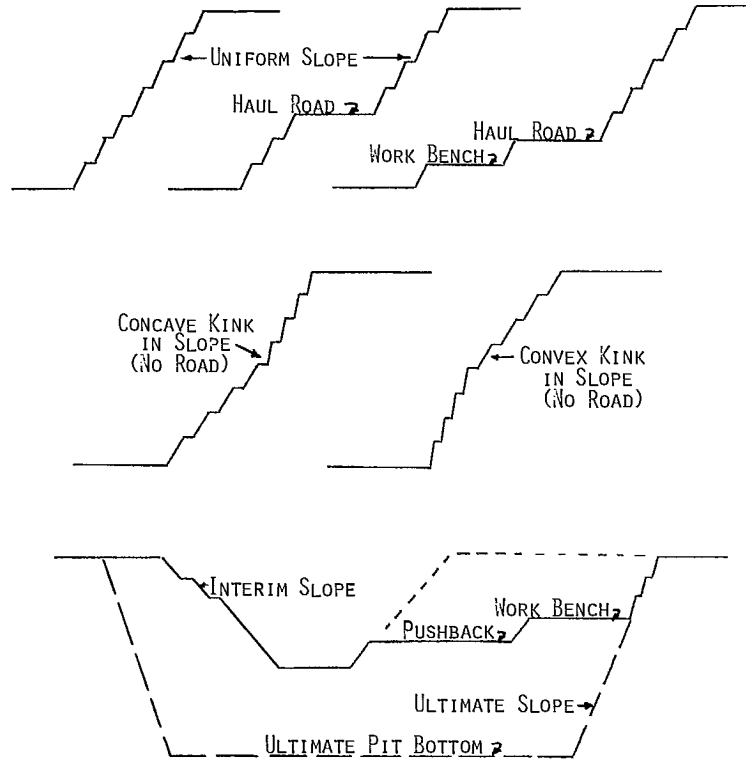
Fig 3 - Example of possible slope geometries
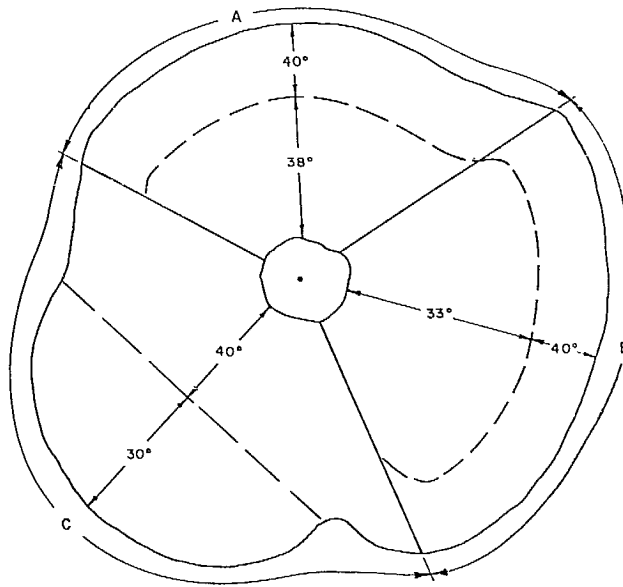
Fig 4 - A large open pit divided into slope design sectors

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                        ┌─────────┐
                        │  START  │
                        └─────────┘
                             │
                             ▼
        ┌────────────────────────────────────────┐
        │     A MODEL OF OPEN PIT OREBODY         │
        │ DIVIDED INTO STRUCTURALLY HOMOGENEOUS   │
        │              SECTORS.                   │
        └────────────────────────────────────────┘
                             │
                             ▼
        ┌────────────────────────────────────────┐
        │  A SET OF ULTIMATE PIT SLOPES* FOR      │
        │  DIFFERENT SECTORS OF THE PIT.          │
        │     COMPUTE THE TOTAL ORE RESERVE.      │
        └────────────────────────────────────────┘
                             │
                             ▼
        ┌────────────────────────────────────────┐
        │  SELECT WORKING SLOPES** AND DEVELOP    │
        │    ANNUAL MINING SEQUENCES              │
        │  ANNUAL ORE TONNAGES, GRADES, AND       │
        │           STRIPPING RATIOS.             │
        └────────────────────────────────────────┘
                             │
                             ▼
        ┌────────────────────────────────────────┐
        │  ALSO RECORD CHANGES IN PIT GEOMETRY    │
        │    AS A FUNCTION OF MINE LIFE.          │
        │  HIGHEST ELEVATION OF EACH SECTOR,      │
        │   PIT BOTTOM, HAUL ROAD LOCATION,       │
        │   ULTIMATE PIT WALL BOTTOM, ETC.        │
        └────────────────────────────────────────┘
                             │
                             ▼
        ┌────────────────────────────────────────┐
        │  ASSESS THE BENEFITS AND COSTS          │
        │    ASSOCIATED WITH EACH PIT DESIGN.     │
        │         OUTPUT THE RESULTS.             │
        └────────────────────────────────────────┘
                             │
                             ▼
                    ◇ OVERALL        ◇
                ◇ FINANCIAL RISK ANALYSIS ◇ ──NO──▶ ( RECOMMENDATION )
                    ◇  DESIRED?       ◇
                             │
                            YES
                             ▼
        ┌────────────────────────────────────────┐
        │  PERFORM FINANCIAL RISK ANALYSIS OF     │
        │         EACH PIT DESIGN.                │
        │         OUTPUT THE RESULTS.             │
        └────────────────────────────────────────┘
                             │
                             ▼
                   ( RECOMMENDATION. )
```

REPEAT AS MANY PIT DESIGN CASES AS THERE ARE TO BE TESTED.

Fig 5 - Required steps for pit slope economics analysis

BENCH WIDTH

BENCH HEIGHT

BENCH ANGLE (OR BANK ANGLE)

BANK WIDTH
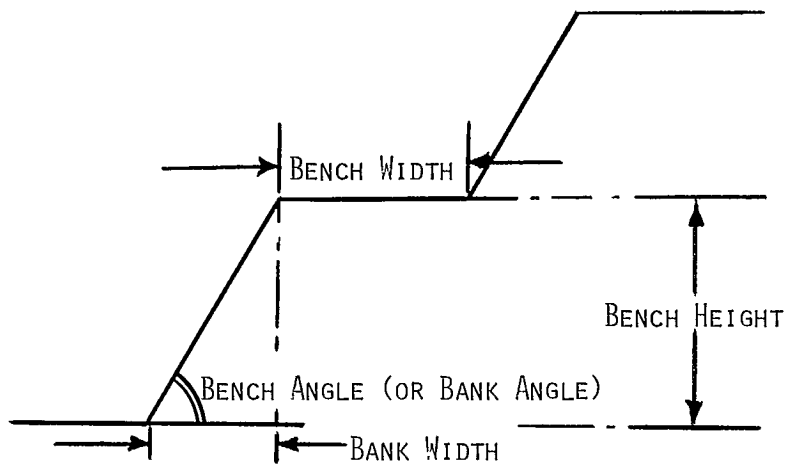
Fig 6 - The basic geometry of one bench

SURFACE

INTERRAMP

HAUL ROAD

FULL WALL HEIGHT

INTERRAMP WALL HEIGHT

WORK BENCH

INTERRAMP WALL HEIGHT

PIT (OR PUSHBACK) BOTTOM
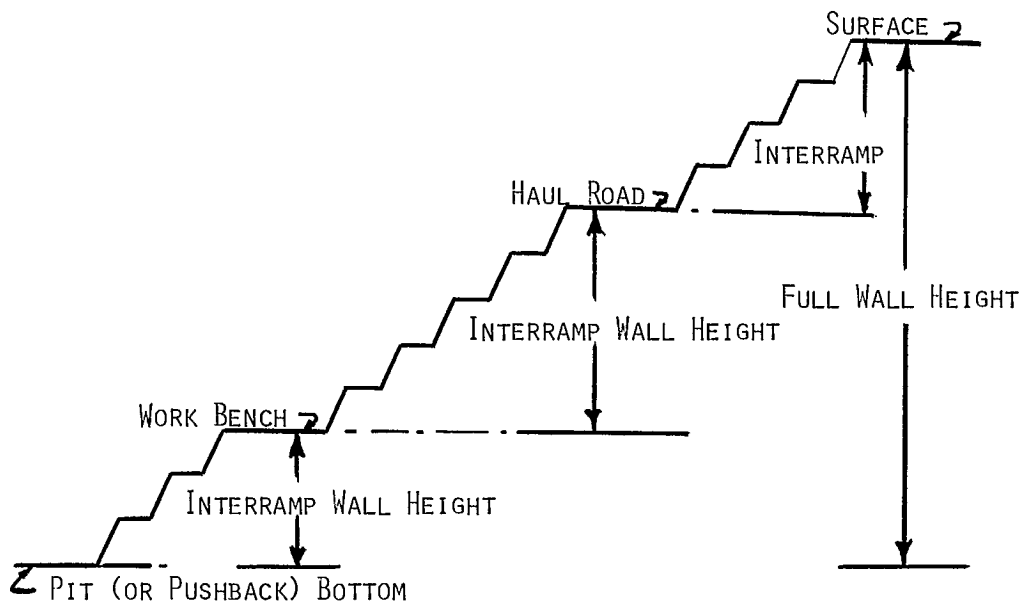
Fig 7 - Description of full wall and interramp wall heights

the first four blocks provides most of the input data for the economic analysis. Most mining companies routinely perform these work elements as part of mine planning activities. This part of the input therefore, demands very little additional effort on the part of company personnel.

24. On the other hand, many mining companies are not staffed to do detailed structural analyses to obtain estimates of the reliability of a pit wall. Hence, in some cases additional budget must be allocated by management to satisfy this portion of the input data requirement.

25. The analyses are represented by the two double-lined blocks in Fig 5. Benefit-cost, BNCST, assesses the benefits and costs associated with each pit design. Risk analysis INRISK, performs the overall analysis of the proposed or existing open pit mining venture. INRISK utilizes the benefits and costs of a given pit design as part of its input data. The benefit-cost analysis is required to determine optimum slopes. The risk analysis may or may not be performed, depending on the particular nature and extent of the design problem.

BENEFIT-COST ANALYSIS

Definitions

26. Since determining slope reliability as well as specifying various cost models require detailed pit geometries, some terminology used in the benefit-cost analysis are defined. These terms may not be in accordance with the common interpretation of the reader.

27. Pit Sector is a subdivision of the pit, limited by relatively vertical boundaries. This subdivision is usually based on slope design considerations; hence each sector is of necessity geologically and topographically homogeneous.

28. Bench Angle is the angle to the horizontal of a single bench face from toe to crest (Fig. 6).

29. Bench Width is the horizontal distance left between succeeding lifts. This is not necessarily the total horizontal distance between successive benches (Fig 6).

30. Full Pit Wall Height refers to the differ-ence in elevation between the uppermost crest and the pit bottom. In most instances there can be only one full pit wall in a given sector. The exception is when a pushback is in progress, in which case there will be two independent full walls, ie, the one above the pushback bottom and another below (Fig 7).

31. Interramp Wall Height refers to the difference in elevation between the uppermost crest of either (1) the ramp above, (2) the work bench above or (3) the ground surface above, and the elevation of either (1) the ramp, (2) the work bench, (3) the pit bottom, or (4) the pushback bottom (Fig 7). Note that a temporary haul road always exists on top of any work bench, thus making the distinction between interramp and inter work bench slopes irrelevant.

32. Interramp Slope Angle is the inclination of the interramp wall as defined above and as shown in Fig 8. Note that the interramp slope angle can vary within a sector.

33. Pit Wall Instability refers to unstable conditions that may exist in any portion of the pit wall. Three distinct concepts associated with instability are mode, scope, and cost.

34. Mode of Instability is used in the geomechanical sense. Four general modes have been identified: (1) rock fall, (2) rotational shear, (3) plane shear, and (4) block flow. (Fig 9) (11)

35. Scope of Instability, used in the cost analysis, is the physical scale or size associated with a case of instability. Four different scopes are defined: (1) full wall, (2) interramp, (3) single bench, and (4) weak stratum. Full wall instability involves a full wall as defined earlier. Interramp instability involves an interramp wall. Bench instability involves only a single bench. Weak stratum instability involves a particular part of a wall known to be considerably weaker than the remaining wall.

36. Cost Types of Instability are used in conjunction with scope in the cost analysis. Various cost types, such as shown in Fig 10, are used within each scope of instability to represent the operational impact. Various cost types are given numeric codes in BNCST. These codes are used to

SURFACE

HAUL ROAD A

INTERRAMP SLOPE ANGLE

WORK BENCH B

BOTTOM C
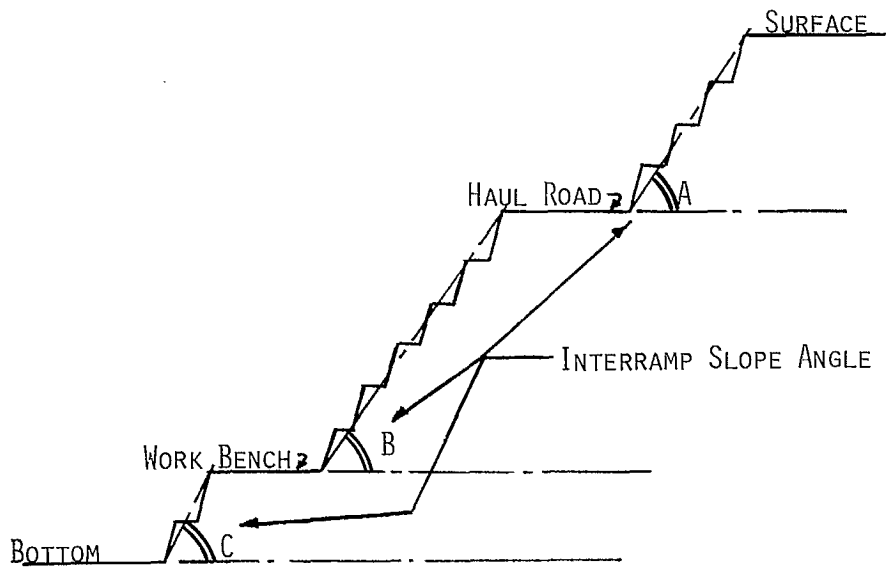
Fig 8 - Definition of interramp slope angle

(a) ROCK FALL

(b) ROTATIONAL SHEAR

(c) PLANE SHEAR

(d) BLOCK FLOW
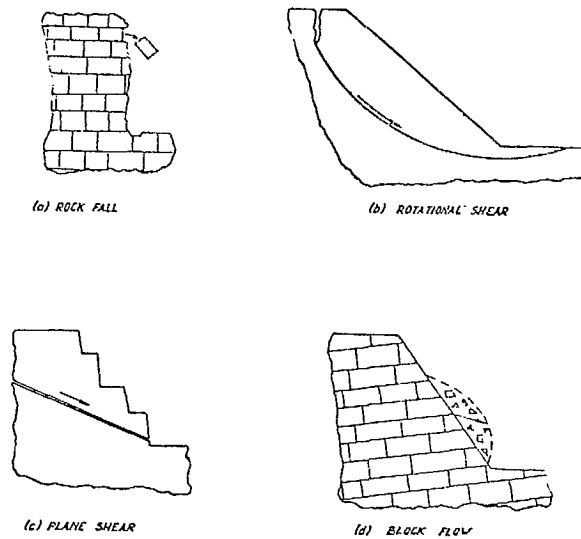
Fig 9 - Different modes of rock slope instability

0.2H

i

i

RESULTING PROFILE
OF SLIDE

H

LINE OF NEW
EXCAVATION

ψ   ψ

(A)   CLEANUP OF SLIDE MATERIAL

0.4H

MATERIAL TO BE
UNLOADED

0.2H

ψ
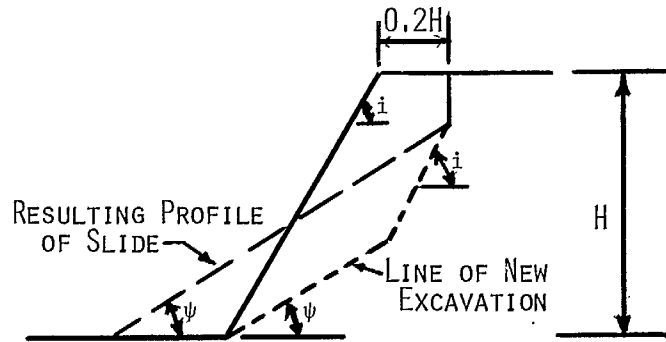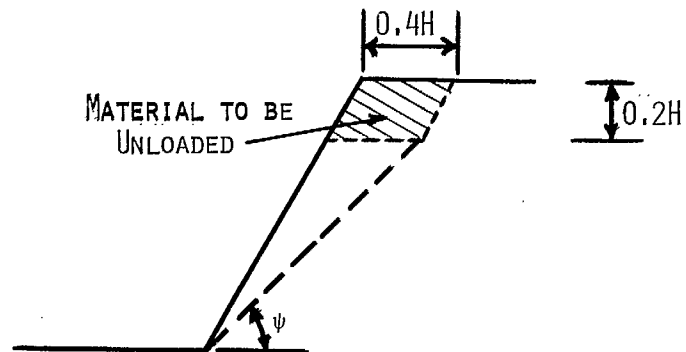
(B)   UNLOADING OF UNSTABLE AREA

Fig 10 - Generalized instability cost types

specify various models that determine the cost of a given instability. Therefore, cost types require specification by the mine engineer before the benefit-cost analysis.

37. Pushback is the mining back of a portion of pit wall, creating two distinct walls. The width of pushback is assumed to be several times that of the normal working bench width.

38. Top, Bottom, and Breadth of a Sector are the representative top and bottom elevations, and the horizontal circumferential length of the sector respectively. (The term "breadth" is used for a dimension parallel to strike and "width" for a dimension normal to strike similar to underground terminology for pillars (11)).

39. Ultimate Slope is the series of consecutive benches at the ultimate pit limit. Interim slopes will be subject to a pushback to either another interim slope or to the ultimate pit limit.

Reliability

40. Perhaps the most certain thing about pit slope design is the uncertainty values assigned to the geologic parameters affecting a given slope. The rock mass is a fractured complex of different rock types of varying strengths.

41. In recent years, various disciplines in science, engineering and business have accepted probability concepts to express degrees of uncertainty. Justification for use of the probability concept instead of the conventional factor of safety in slope design is that it is easier to express inherent uncertainty in design parameters in terms of probable ranges and associated probabilities than in a single value such as "the best guess".

42. Reliability can be defined as the relative frequency with which the computed ratio of strength/stress falls above unity when variability in the geological parameters is taken into account. A graphic representation of the probability of instability (ie, 1-R, where R = reliability) is given in Fig 11.

43. Reliability is a function of many variables. Some of these variables are: (1) the lateral extent and shape of the wall in plan, (2) the shape of the slope in elevation view, (3) rock quality, (4) location of groundwater table, and (5) time during which the slope is expected to remain unchanged. In mathematical terminology, reliability - the probability of stability is known as a joint probability of many variables.

44. Reliability, being a joint probability of many variables, creates certain difficulties in its estimation. To simplify the process, it is customary to divide a pit into different sectors which are substantially geologically and topographically homogeneous. This results in fewer number of variables to consider in probability estimation for a given design sector but requires separate estimations for each sector.

45. In the probability computation, the input parameters are varied in some manner, ie, usually according to probability distributions associated with each variable. The Monte Carlo sampling technique is used to obtain a sampled value from the population of each of these variables. These sampled values are used to obtain a single safety factor in the conventional manner. The above process is repeated 100 or more times to obtain a representative distribution of safety factors. This technique simulates the natural variability, or uncertainty, in input parameters and provides a picture of all possible outcomes.

46. Once the distribution of safety factors has been generated, the probability of instability can be estimated from the area under the distribution curve for which the factor of safety is less than one, as shown in Fig 11. This area can be estimated by fitting the distribution to a known distribution and numerically integrating, or by counting the number of times a safety factor less than one has occurred and dividing this by the total number of trials.

47. All of the above produces only one probability estimate for a specific combination of parameters such as slope height, slope angle, breadth of the design sector and groundwater level. This means that the computations must be repeated many times to obtain the probability distribution as a function of slope angle or slope

Prob. of Instability
= Shaded Area Under the Curve
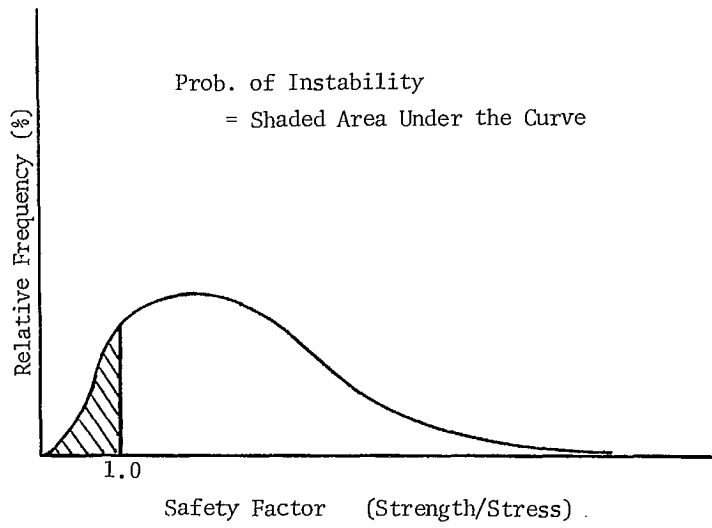
Fig 11 - Estimation of probability of instability from distribution of strength/stress
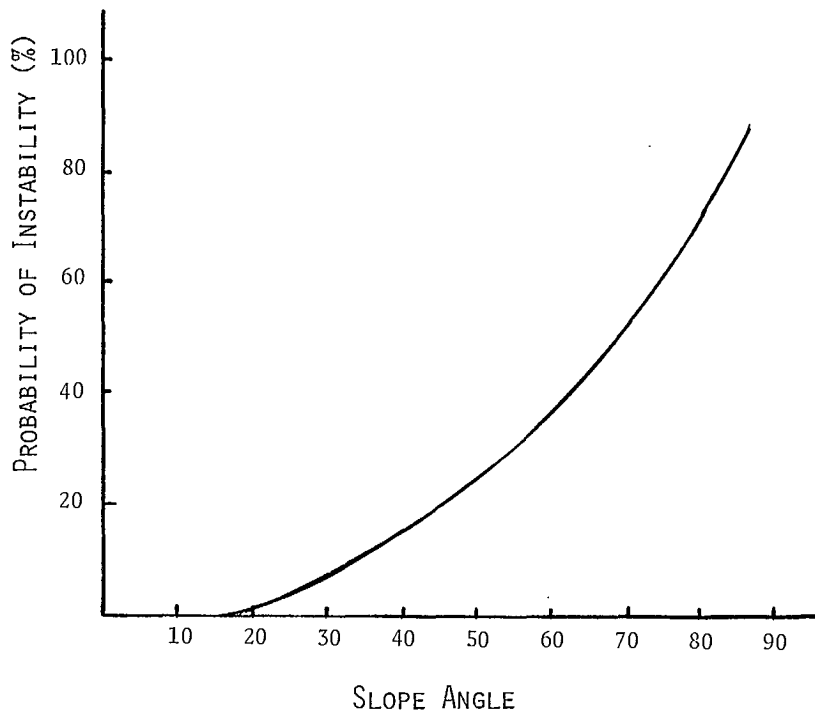
Fig 12 - Hypothetical cumulative probability of instability curve

height. A hypothetical probability distribution as a function of the slope angle with all other variables being fixed is shown in Fig 12.

48. The probablistic approach is nearly impossible without the help of a computer. The amount of computation required will certainly be 100 or more times that of the conventional deterministic approach. For this reason, computer programs for performing stability analyses for various modes of instability have been developed (Supplements 5-1 and 5-2).

49. This computed probability, as represented by Fig 11, provides one point on a cumulative probability distribution function. In other words, it represents a point on a curve such as in Fig 12. Thus, the cumulative probability, and not the more common probability density, should be considered as the probability of instability. This may be defined as the probability of having at least one or more cases of instability in the pit wall under specified conditions.

50. The probabilities used are statistical or objective and not intuitive or subjective. Frequently, however, not all input variables can be quantified. Under these circumstances, the objective probability is modified according to a subjective assessment of the questionable input.

51. There are some philosophical arguments against combining an objective with a subjective probability. However, they can and should be combined so as to utilize all available information in the analysis. A variable that cannot be fully quantified should not be ignored in the quantitative analysis, as can be seen in the subsequent case study.

52. The probability distribution function is usually displayed in terms of a single variable such as slope angle or slope height. The variable chosen for purposes of display and representation in the benefit-cost analysis is slope height (Fig 13).

53. Since the computed probabilities usually define several discrete points on the probability curve, these, in turn, are input to BNCST as a discrete cumulative function as shown in Fig 14. A maximum of ten discrete cumulative probabilities

associated with different slope heights can be input in the analysis for a given angle. In Fig 14 the largest probability can be much less than unity, because only the relevant portion of the cumulative probability function is required.

54. Within a given sector, several variables are of particular influence in the probability estimation. These are angle, height and breadth. In other words, wall geometry is important, and accurate specification of details for the entire pit is required.

55. The shape of walls is never one uniform, clear-cut slope. The actual shape is frequently made up of several different wall heights of varying slopes, interspersed by relatively wide horizontal areas of either an active work bench or haul road.

56. Because of sensitivity of probability estimates to wall geometry, some basic units are necessary to describe every possible wall geometry. These units are bench angle, bench height and unit cell. A unit cell is the square area in the pit wall face whose breadth is equal to its height. Figure 15 illustrates the concept of a unit cell; height and not breadth define it. For example, in this sector there is only one full height unit cell while there are several interramp unit cells for interramp walls no. 1 through no. 3.

57. Introducing the unit cell concept in the probability estimation has the effect of fixing the breadth, reducing the key variables to two, ie, angle and height of wall. This unit cell concept also plays an important role in the Monte Carlo sampling of instability. Throughout the remainder of the supplement, probability of instability will refer to the unit cell.

58. The anticipated slope geometries in the pit are usually obtained from the ongoing mine planning data. Other pertinent data that affect the geometry are: (1) average starting crest elevation, (2) breadth of each sector, (3) various widths of inactive benches, active benches and haul roads, and (4) current elevations of active benches, haul roads, pit bottom and pushback bottom.
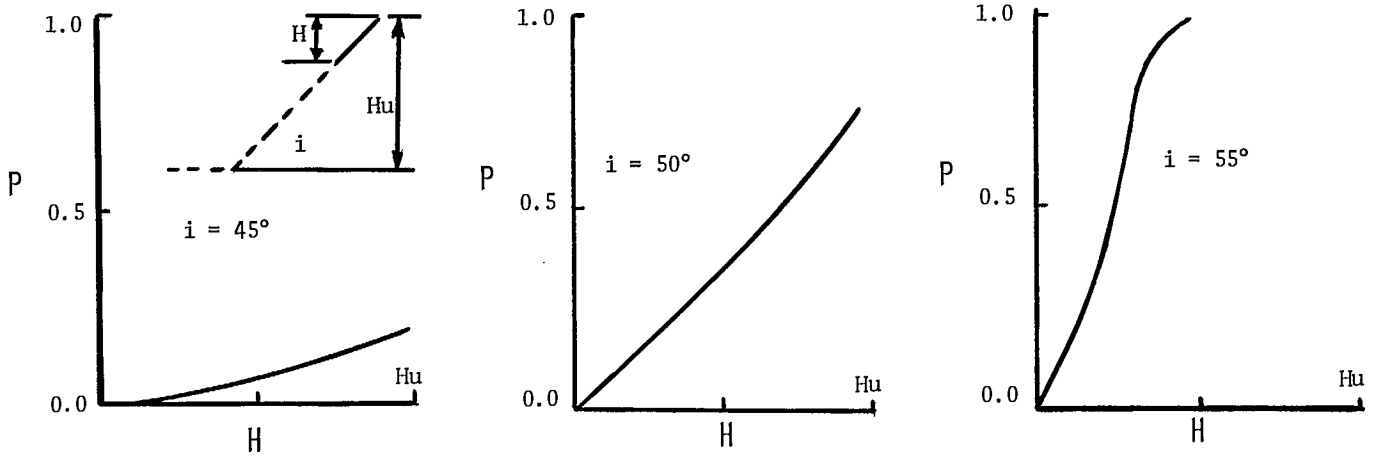
Fig 13 - Probability of instability as a function of slope height
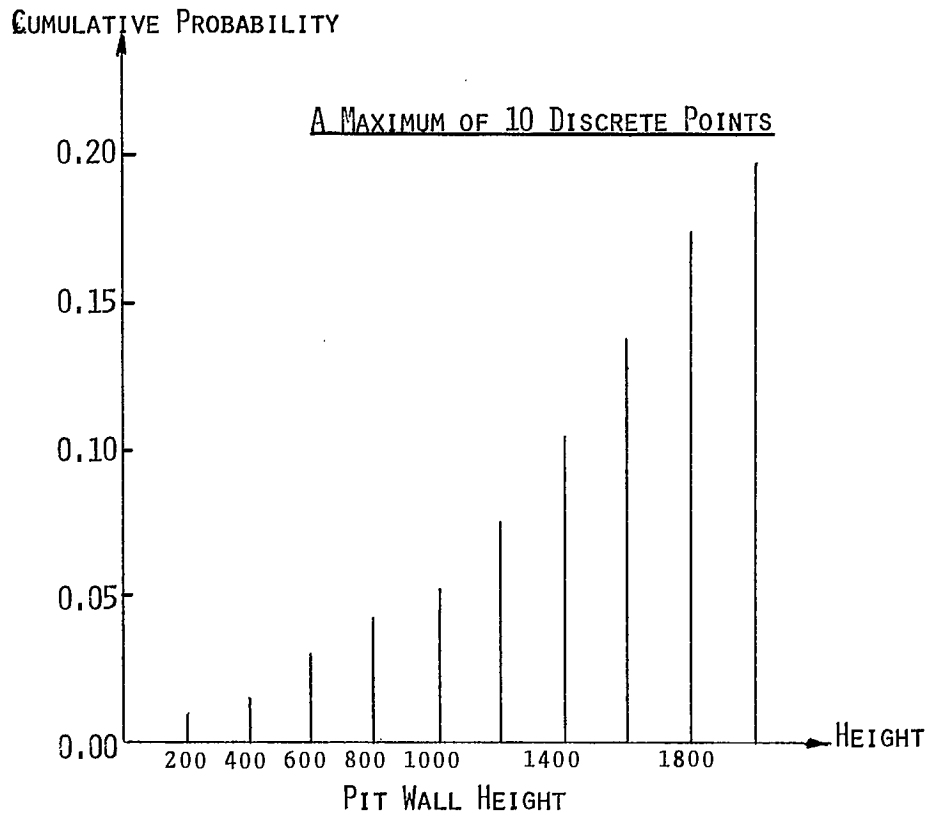
Fig 14 - Hypothetical cumulative pit wall instability probabilities as a function of pit wall height

SECTOR

2.5 CELLS	INTERRAMP WALL #1
1.5 CELLS	INTERRAMP WALL #2
3.5 CELLS	INTERRAMP WALL #3

FULL WALL
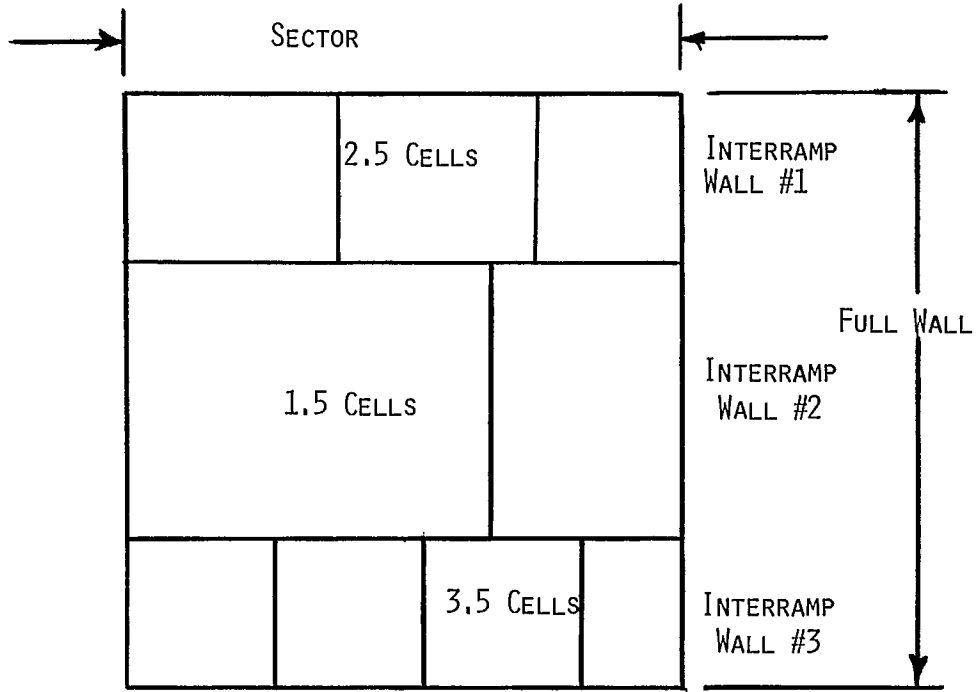
Fig 15 - Illustration of the unit cell concept

59. All conceivable geometries can thus be specified for the benefit-cost analysis. In Fig 14, the smallest height can be the bench height, whereas the largest value can be the maximum total depth of sector for the entire analysis period.

60. The range of average feasible slope angles must be examined for the full range of heights, ie, from that for the first year to the ultimate wall height. In BNCST six different slope angles or layouts can be used. The cumulative probabilities are given by a maximum of 60 discrete points (ie, 10 heights x 6 angles). Such points may not coincide exactly with the actual geometry of the wall when the analysis is being made. In such a case, the desired probability is obtained by a linear interpolation either for the actual angle or the actual height.

Simulated Sampling for Instability

61. The sampling for wall instability and for specifying the appropriate cost models is performed using the Monte Carlo technique. The schedules of probability of wall instability as a function of slope angle and slope height are used. The Monte Carlo method selects a value based on a generated random number.

62. The procedure requires that mining plans detailing the pit geometry and production of ore and waste be available for each time period. The mining plans are used to generate the slope geometry for each sector as well as net cash flows from mining operations.

63. Sampling is performed on a sector-by-sector basis for the entire pit throughout the analysis period. If sampling indicates instability in a given period, the cost of this instability is obtained from an appropriate cost model constructed on the basis of the expected operational impact.

64. Once all the benefits, or revenues, and costs for a sector for each period of the entire analysis have been determined, they are discounted to present values and combined to give a net present value (NPV) for that simulation. Such runs are repeated to determine the mean and standard deviation of NPV distributions for one

sector. Finally, the results for each sector are combined to obtain the desired results for the entire pit. For additional layouts, the process is repeated. Figure 16 gives the generalized logic for the benefit-cost analysis model, BNCST. Details and input requirements for the program are given in Appendix A.

65. Sampling is done for each time period in a given sector, starting with the greatest slope height which, in turn, determines the particular scope of instability. Thus, a full wall slope is sampled before an interramp slope, and an interramp slope is sampled before any bench slope or weak stratum. This avoids double counting since instability in a higher order slope involves instability in each of its lower order component slopes also. This manner of sampling results in bypassing the remaining lower order slopes whenever there is instability in the current order. This bypassing is done only for the current period and only for the affected portions of lower order slopes. In other words, the benches in a stable interramp slope will be sampled for possible instability although there may be instability in another interramp slope in that sector.

66. Sampling is done once per time period, such as a year, for each unit cell of the specified slope. In case the number of unit cells is 30 or more, sampling is replaced by the calculated expected value. The calculation is as follows:

$$\text{Cost of Instability} = P_f N C_f \qquad \text{eq 1}$$

where P_f is the probability of instability, N is the number of unit cells and C_f is the cost of instability of a unit cell.

67. Since the number of bench unit cells in a given sector can often be in the order of several hundreds, the expected value approach is almost always used for bench instability. Even though both P_f and N are not zero, the cost of instability can have a zero value if the instability cost of a unit cell, C_f, is zero.

68. A direct relationship exists between the frequency of sampling a unit cell in a period and the resultant cost of instability for that cell
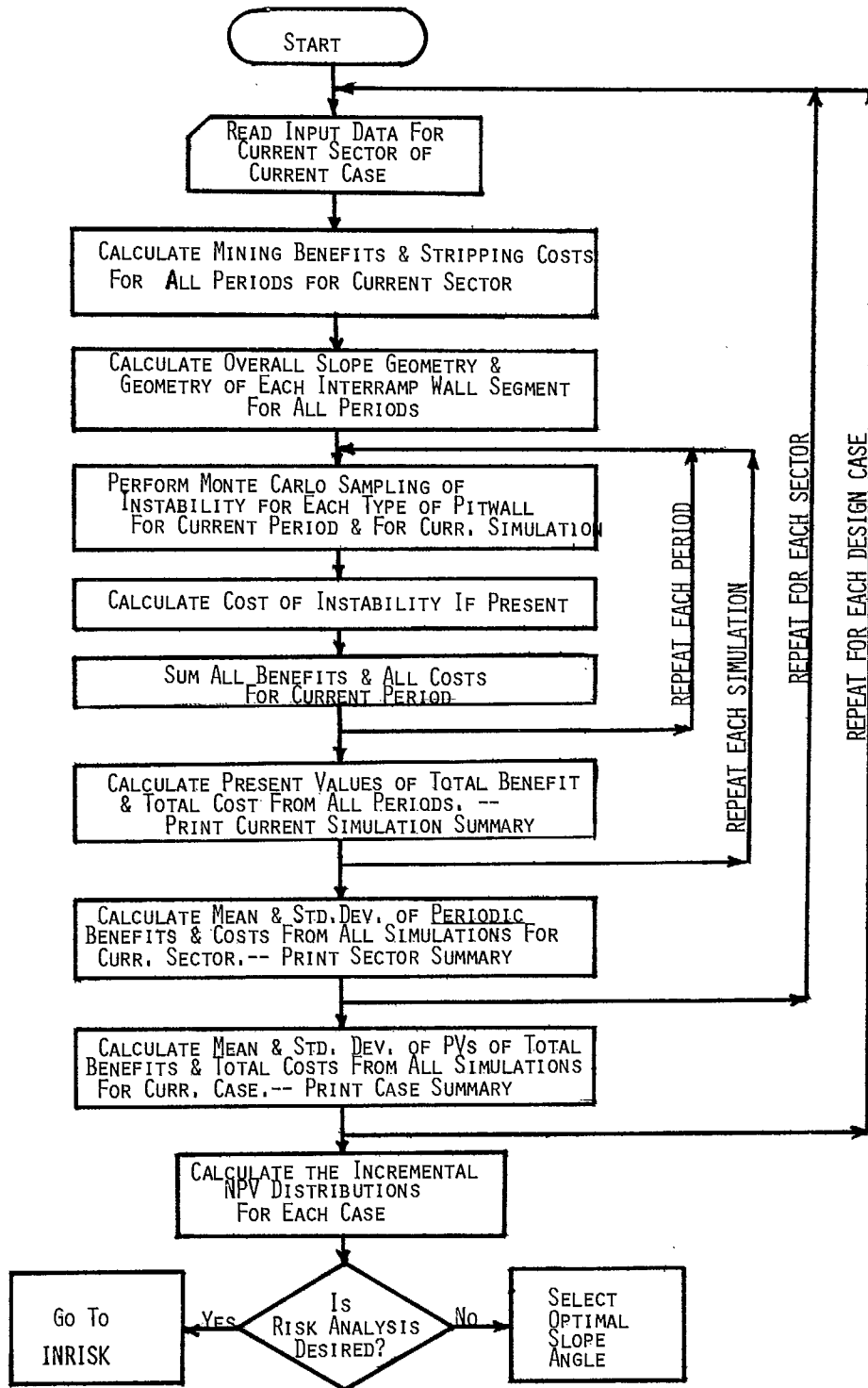
Fig 16 - Generalized logic of benefit-cost analysis model, BNCST

based on all the simulation runs. For instance, if each unit cell were sampled twice per period instead of once, the resultant cost would be double by virtue of the increased sampling frequency. For this reason, it is important to remember that the specified probabilities are for a unit cell and for sampling once per period.

69. Sometimes the common slope angle definition must be modified. In Fig 17, three different wall geometries are shown. Both in Fig 17(a) and (b), the common definition of the overall inclination between the crest to the toe is used to define the wall angle A. However, in the case depicted by Fig 17(c), the wall angle chosen for sampling is the angle B and not the angle A.

70. In obtaining the desired probability for a given slope angle and a given wall height, special care must be exercised to insure that the probability is determined from the correct portion of the probability distribution. This is particularly true in the extrapolation of various interramp slope probabilities. For example, assume that a full wall 1500 ft high contains three interramp walls of 500 ft each, as shown in Fig 18(a). Next, assume that the cumulative probability of instability curve as a function of wall height for the interramp wall angle of 50° is given by Fig 18(b). If stability of the first 500 ft affects stability of the second 500 ft, the desired probabilities for the second interramp slope is obtained by the incremental difference between the two successive probabilities, P_1 and P_2, ie, probability for interramp no. 1 = P_1, probability for interramp no. 2 = P_2 - P_1, and probability for interramp no. 3 = P_3 - P_2.

71. If the haul road or working bench is sufficiently wide that stability of the interramp wall is not affected by the amount of pit wall above it then the program should be modified to obtain the desired probability based on each interramp wall height alone. If there is no affect of one interramp wall on that below, the probability for each would be P_1.

72. In the event of instability, a cost type must be selected. In BNCST, a total of nine cost types are allowed for each scope of instability,
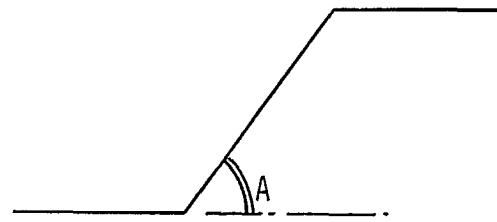
(A) A RELATIVELY UNIFORM FULL WALL
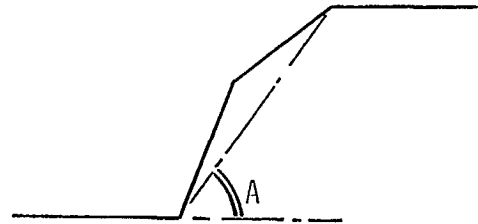
(B) A FULL WALL WITH CONVEX KINK
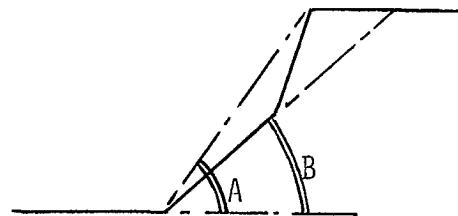
(C) A FULL WALL WITH CONCAVE KINK

Fig 17 - Three different full wall configurations
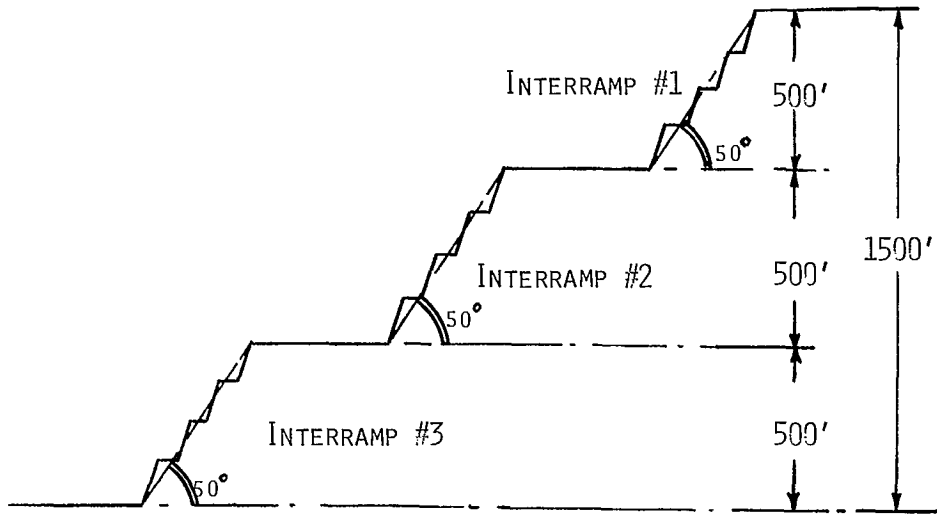
(A) A HYPOTHETICAL FULL WALL HAVING 3 INTERRAMP
WALLS OF IDENTICAL HEIGHT AND ANGLE
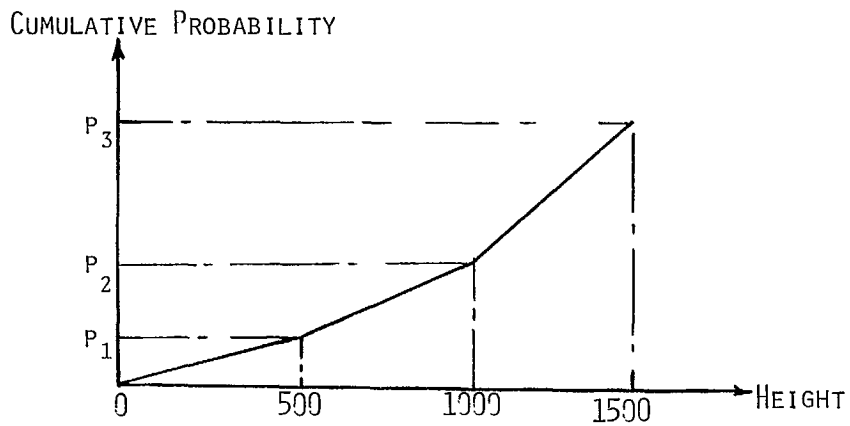
(B) PROBABILITY OF INSTABILITY FOR 50° SLOPE ANGLE

Fig 18 - Illustration of incremental probability determination

coded 1 to 9. The ith cost type for a full wall is likely to be different from the ith cost type for an interramp wall, and so forth. However, the ith cost type for one sector is the same as for another.

73. In making the analysis, each cost type corresponds to a cost model conceived or accepted by the mine planning engineer. The mine planning engineer must provide his best assessment of the operational impacts of a given instability, taking into account the pit geometry at that instant.

74. A limitation exists in the program. Only one cost type can be specified in each period regardless of the total number of unit cells present for a given scope of instability. Therefore, one cost type is allowed for a full wall, one each for interramp walls, and one each for bench and weak stratum walls in each period.

Assumptions

75. Two key assumptions are made in BNCST.
a. It is possible to estimate a representative reliability distribution in each design sector of the pit as a function of slope angle and wall height.
b. It is possible for the mine planning engineer to specify in dollars the operational impact of each case of instability.
Satisfying these key assumptions requires further assumptions of a lesser magnitude. In addition, there are implicit assumptions due to the particular manner of analytical procedure adopted. For the sake of clarity, these assumptions are grouped in terms of those required for cost type specification and those for cash-flow computations.

76. Assumptions used in instability sampling consist of the following:
a. Necessary mine planning data are available to determine mining sequences for the entire period.
b. Actual mining will proceed according to specified mining sequences.
c. The pit has been subdivided into different sectors, each of which has homogeneous geology and topography as well as being uniformly affected by instability.

d. The set of reliability distributions used is representative of the entire sector and is independent of time.
e. The schedule of probability of instability applies to the unit cell, sampled once per period.
f. The probability for a portion of wall height can be obtained by appropriate differences in two probabilities from a given probability distribution which assumes that the upper portion affects the lower.
g. Linear interpolation for probability is feasible between any two input values.
h. There are no boundary effects between sectors.
i. Cases of instability among unit cell areas are independent, thus requiring sampling for each unit cell.
j. Cases of instability occurring in successive time periods are independent.
k. No drastic change to the initially specified mining sequence due to instability will occur in a given year.
l. The average elevations and sector breadths for each period will accurately reflect pit geometry.
m. Bench angle, bench width, haul road width, working bench width all remain constant within each sector.
n. There will be only one pushback existing in a sector at any given instant.
o. If there exists a weak stratum, it will be exposed on the surface of the pit wall.
77. A few additional assumptions are required for the specifying instability costs.
a. The same operational impact of instability, or cost type, applies to each unit cell within a given slope.
b. Whenever there is instability, the cost is incurred in that period; in other words, the costs are independent between successive periods.
c. The operational impact of instability is entirely confined to that sector; hence, the "sectorized" approach is also valid for cost accounting.

d. Prior to the analysis, representative cost models are either available or can be developed.

78. Assumptions for cash-flow computations relevant to the benefit-cost model, BNCST, are:

a. The metal price, as well as ore recoveries, will remain constant.

b. When a steeper ultimate pit slope is adopted, the resulting benefit from increased ore reserves is realized at the end of the analysis period rather than being reflected in increased ore production during each period. On the other hand, the benefit from decreased waste stripping can be reflected immediately.

Cost Type Models

79. In the economic analysis of pit slopes, the operational impact of instability is of great concern. Instability is classified according to scope, or extent of impact on operations. The four classes of scope are: (a) full height, (b) interramp, (c) bench, and (d) weak stratum. Within each, there can be nine distinct cost types, each representing a unique impact. Instability involving an entire pit wall will probably interrupt operations more severely than one involving a single bench.

80. It has been suggested there are five possible reactions to slope instability: (1) ignoring the slide, (2) removing unstable material, (3) unloading an unstable zone, (4) living with the instability, and (5) improving the slope (12). The first reaction can be rejected. Others are discussed below in terms of individual cost models.

81. Some generalized cost models for slope instability based on operational impact were developed previously (10). These models have the form of volume of ground times unit cost. The volumes are determined as a function of slope height. The unit cost is the variable cost associated with the volume and should not include fixed costs. The accounting procedures at many mines produce mining costs that include both fixed and variable costs. Fixed costs, which are unaffected by the occurrence or magnitude of a slide, may include such items as equipment

depreciation, sales and administration. These indirect fixed charges should not be included in the unit costs.

82. Slide material may not require blasting, thus reducing unit costs; however, if it tends to break into large boulders, secondary blasting may be required which will increase costs. Limited working room may increase loading costs due to equipment interference and single truck spotting. Requirements for immediate action may necessitate an outside contractor at an increased rate or paying overtime to mine personnel. All the above factors should be considered in computing the direct unit cost.

83. Some of the possible cost types resulting from instability are: (a) removal of extra waste, (b) abandoning reserves or delaying ore production, (c) loss of haulage system, (d) loss of plant or equipment, (e) improvement of slope stability, and (f) living with the instability. These cost types need not be mutually exclusive, eg a lost haulage system may incur the removal of extra waste.

84. The removal of extra waste may arise from: (1) cleanup of slide material or (2) unloading of potentially unstable material (Fig 10).

85. For the cleanup of slide material, the volume to be removed can be estimated by assuming a backbreak of 0.2 times the slope height and a breadth of instability of 0.5 times the unit cell height. It is assumed that the excavation will be to the original slope toe and at the angle of repose of the slide material up to a point where this line intersects the line extending from the new crest at the designed slope angle. It is further assumed that the function (cot ψ - cot i) is constant for all slopes and equal to 0.5, where ψ is the angle of repose and i is the original slope angle. Under these assumptions, the cost of cleaning up slide material reduces to:

$$\text{Cost} = 0.08 \, H^3 C_f \qquad \text{eq 2}$$

where H is the slope height and C_f is the direct unit cost of removing the slide debris.

86. The volume of ground to be excavated to

unload a potentially unstable area can be estimated. If the depth of stripping is 0.2 times the slope height, the width of stripping into the face is 0.4 times the slope height, and the breadth of stripping parallel to the face is equal to the height of the slope, the cost of unloading reduces to eq 2 where C_f is the direct cost of excavating.

87. The actual dimensions of the extra excavation required may vary significantly from those given above. In one case, removal of both the failed material and unloading the slope to insure the mining of a high-grade ore zone was required (10). This resulted in a volume of increased excavation 13 times greater than that estimated by either of the above general models. Consequently, the mine planner must select dimension factors appropriate to the individual slope.

88. A possible alternate approach to estimating the volume of extra waste stripping would be to develop a conditional probability distribution of volume. This distribution could be sampled to give the volume of unstable material for each slide. This distribution would be determined concurrently with the probability of instability schedule since the volume of unstable material is included in the calculations for stability.

89. A difficulty arises if the slope in question is not a final slope, since extra material would be removed in the normal course of mining operations sometime in the future. In this case, the cost of the extra excavation consists of two items: (1) the time value of the money spent now for excavating earlier than originally planned and (2) possible increases in unit costs for handling slide debris rather than normal rock. The cost of extra stripping is now determined as:

$$\text{Cost} = 0.08H^3[C_f - C_n(1 + r)^{-t}] \qquad \text{eq 3}$$

where H is the slope height, r is the discount rate, t is the number of periods in the future from now when the waste stripping was originally scheduled, C_f is the direct unit cost of removing unstable material, and C_n is the direct unit cost of normal stripping.

90. Abandonment or delay of ore production is the proper course of action when the cost of slope stabilization exceeds the expected profit from mining the ore block. In this case, the cost would be the revenue lost from that ore block, ie, tonnage times net profit. If the lost production were scheduled for a period subsequent to the occurrence of instability, then the revenue must be discounted to reflect the time value of money.

91. If the ore block is not abandoned permanently but production only delayed until normal mining operations eliminate the instability, such as in a subsequent pushback, then the cost must reflect the time value of money due to the delay in receiving the revenue. In many cases, the delayed production will be made up by increased production from another ore zone, which may have a different unit profit due to different ore grades, recoveries, mining costs, etc. These differences should be reflected in the cost of delayed production which can be determined as follows:

$$\text{Cost} = V[(P_2 - P_1) - (P_1 - P_2)(1 + r)^{-t}] \qquad \text{eq 4}$$

where V is the volume of ore that is delayed, t is the number of periods for which the ore production is to be delayed, r is the discount rate, P is the net profit per unit of ore actually mined in this period and is equal to zero if no ore can be substituted for this period, and P is the anticipated net profit per unit of ore which was originally scheduled to be mined in this period.

92. The first term in eq 4 represents the difference in the profit due either to substitution or delay for the period in which the instability occurs. The second term, represents the discounted value of the delayed ore or of the reverse substitution which must occur "t" periods into the future.

93. The cost of a lost haulage system may be composed of three parts: (1) reestablishing the system, (2) increased haulage costs, and (3) temporary lost production.

94. A haulage ramp, as shown in Fig 19, could be reestablished by developing a new cut from the base of the slide affecting the old haulage ramp.
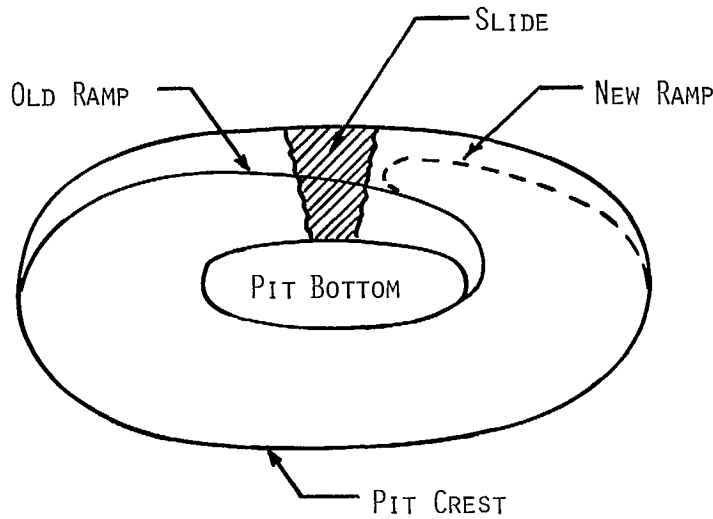
Fig 19 - Haulage ramp cut off by slide

The volume of extra excavation required is given approximately by (10):

$$V = WD^2/2G \qquad \text{eq 5}$$

where V is the volume of ground to be excavated, W is the ramp width, D is the depth of new cut required from the crest to the ramp elevation in the sector, and G is the grade of the ramp. The cost of this excavation can be calculated using eq 2.

95. A cheaper solution, where feasible, is to establish a temporary ramp. Costs for the temporary ramp would include the incremental cost of cut and fill material as well as increased road maintenance costs.

96. The reconstituted ramp may exit at a different point at the pit crest or may be at a steeper grade, thus increasing unit haulage costs. It may be necessary to use a longer haulage system either permanently or during construction of the new ramp. These increased haulage costs should be included in the instability costs, properly discounted to reflect the time value of charges occurring in years subsequent to the instability.

97. The cost of a temporary loss of production can be calculated using eq 4.

98. Living with slope instability is not uncommon, especially with minor bench instability. Several operations have been conducted successfully while major slides were in progress (12, 13).

99. In one case, a slide was maintained in balance by progressively unloading the unstable area and removing a similar amount of ore from the base. In the other case, ore beneath a slow-moving slide was recovered by excavating at the toe until the slide accelerated. Equipment was removed until the slide had stabilized and another cut could be taken. Costs of such a course of action would include the cost of a slope monitoring system, the movement of mobile equipment and possibly increased unit costs due to mining of slide material.

100. At another open pit mine, slides were stabilized by "stepping-out" a distance of 50-100 ft (15-30 m), leaving a shelf. The cut would then

proceed normally down from the step-out. Fortunately for this mine, sufficient ore was available so that increased stripping was not required, although this stepping-out procedure could not have been continued indefinitely. If the ore tied up in step-outs becomes excessive, then a stripping program must be initiated to uncover sufficient ore until the step-outs can be recovered in the next pushback. The cost of the step-out is the time value of the waste stripping which had exposed the ore tied up in the step-out. This cost is, in effect, a finance charge for prepaid stripping expense and can be calculated by:

$$\text{Cost} = V\,C_n\left[(1 + r)^t - 1\right]\left[\frac{SR}{SR + 1}\right] \quad \text{eq 6}$$

where V is the volume of material mined above the step-out, C_n is the waste mining cost per unit volume, r is the discount rate, t is the number of periods the step-out is tied up, and SR is the ratio of waste to ore above the step-out. Note that the above formula assumes no extra stripping will be required in 't' years when the ore tied up in the step-out is mined.

101. The stability of a pit slope can be improved in four ways: (1) flattening the slope, (2) drainage, (3) improved blasting, and (4) mechanical support.

102. The cost of the first option has been discussed. The costs of the other options consist of capital outlays in the initial installation of the system and operating costs due to system maintenance. These charges should be determined on an individual basis for each proposed system.

Benefit Models

103. The benefits from a change in pit slope angle are equivalent to increases in profitability of the mining venture resulting from changes in the mining plan. Consequently, benefits must be determined in the context of the total mining plan. In BNCST, these benefits will be reflected in the differential net present value between alternate plans.

104. The primary source of benefits will be in reduced cost - either through decreased stripping

due to a change in ultimate slope angle, through deferred stripping due to a change in ultimate slope angle, or through deferred stripping due to a change in interim or working slope angles. The savings from deferred stripping derive from the time value of money and can be more significant than the savings from decreased stripping, especially in pits of long life (2).

105. To illustrate the substantial effect of a change in working slope, a hypothetical example has been used to show a $4.72-million savings in a medium-sized open pit (14). This was due to delayed waste stripping arising from a change of 10 degrees in the working slope angle from 25 degrees to 35 degrees. In the same pit, a 10-degree change in ultimate slope angle will result in a reduction in waste stripping of approximately 55 million tons; however, the present value of this reduced stripping discounted at 15% is only $1.88 million. This is based on the assumption that the reduced stripping will occur in equal annual increments over the 20 years during which the ultimate slope is excavated.

106. Other benefits of a more direct nature accrue from decreased or deferred capital expenditures for mining equipment due to the changes in stripping requirements. The case study given below shows such a benefit since an additional haulage truck is required for the flatter slope angle due to a 2,000,000-ton per year in stripping requirements.

107. A change in ultimate slope angle will often result in a change in ore reserves. The present value of the increased ore reserve will be affected by the additional capital investment required to finance an expansion in capacity or by the time delay in production from the increased reserves if mine capacity is kept constant.

108. The final benefit from a change in slope angle is closely related to the delayed stripping benefit. If a change in working slope results in a change in ore production schedule, significant benefits may arise from an improved cash flow in the early years of production due to reduced pre-production stripping and selective mining.

CASE STUDY

Objectives

109. This section presents a summary of a slope design study at an operating mine. There were three objectives for this work. The first was to demonstrate the feasibility of the probabilistic design procedure under actual mine planning constraints. The second was to assess the acceptability of probabilistic results to mine management. The third objective was to provide guidance for engineers within the industry.

110. The exact details used in the study should not be considered as universally applicable since every pit wall is unique. It does show the types of approximations and the nature of the data required. Through application, further refinement of the procedure will occur.

111. The study was conducted in four stages: (1) estimation of schedules of probability of instability, (2) development of alternate mine plans, (3) estimation of costs of instability, and (4) use of the BNCST and INRISK computer programs. Two alternate ten-year mine plans were developed consisting of a series of yearly plans, schedules for production and estimates of mining costs and ore grades. The operating implications of each potential instability were discussed for each year of the mine life. Based on these implications, appropriate cost of instability models were developed for each sector.

112. The computer programs were run on the CDC 6400. The costs and benefits generated by the BNCST program were used in the INRISK program.

Description

113. The mine is a large copper deposit producing copper and molybdenum. Truck haulage is used exclusively within the pit, with a large fleet of 85-ton to 150-ton capacity trucks. Ore and waste loading is by 15-cubic yard electric shovels.

114. Currently, ore is hauled to a gyratory crusher located near the shop area at the 4100 elevation (feet above sea level) beyond the southern perimeter of the pit (Fig 20). A new crushing station is being constructed at the 3600 elevation to reduce the amount of lift required for ore haulage. After the new crusher is in operation, the present crusher will be used for waste, thereby significantly reducing the length of waste hauls.

115. There are six major rock types present within the pit. These are: (1) Harris Ranch porphyry, (2) Cretaceous volcanics, (3) biotite-quartz diorite, (4) Ruby Star granodiorite, (5) quartz-monzonite porphyry and (6) breccia. However, only the quartz-monzonite porphyry and the breccia are present within the study area as shown in the shaded portion of Fig 20.

116. The quartz-monzonite porphyry is fractured to massive with a high rock substance strength. Fracture planes in the quartz monzonite are well developed but lack the planarity found in the other lithologic units within the mine area. The breccia is a medium strength unit composed of lithic fragments from the other rock units. The amount of breccia in the study area decreases with depth.

117. The area of the pit included in this study is the NE corner of the pit, bounded by 94E on the west and 98N on the south (Fig 20). This corner contains three bench orientations: (1) a north face, (2) a NW face, and (3) a SW face. The rock in the area is predominantly fractured, quartz-monzonite porphyry with a minor amount of breccia.

118. All three faces are currently undergoing slow displacement. The instability is particularly noticeable on the NW face where most catch benches have been completely filled with rock falls and on the north face where a vertical scarp has formed parallel to the face behind the upper bench. Areas of the pit outside of the study area have experienced occasional wedge slides.

119. Two alternative ten-year plans were developed for equivalent annual ore production. The base case, using a 45° interramp slope angle, is the present mine plan. The second plan, using a 38° interramp slope angle, was developed as a possible response to current instability.

120. Additional stripping is required in the second design due to the flatter slope angle. This additional stripping is spread out over time

Fig 20 - Geologic map of pit area
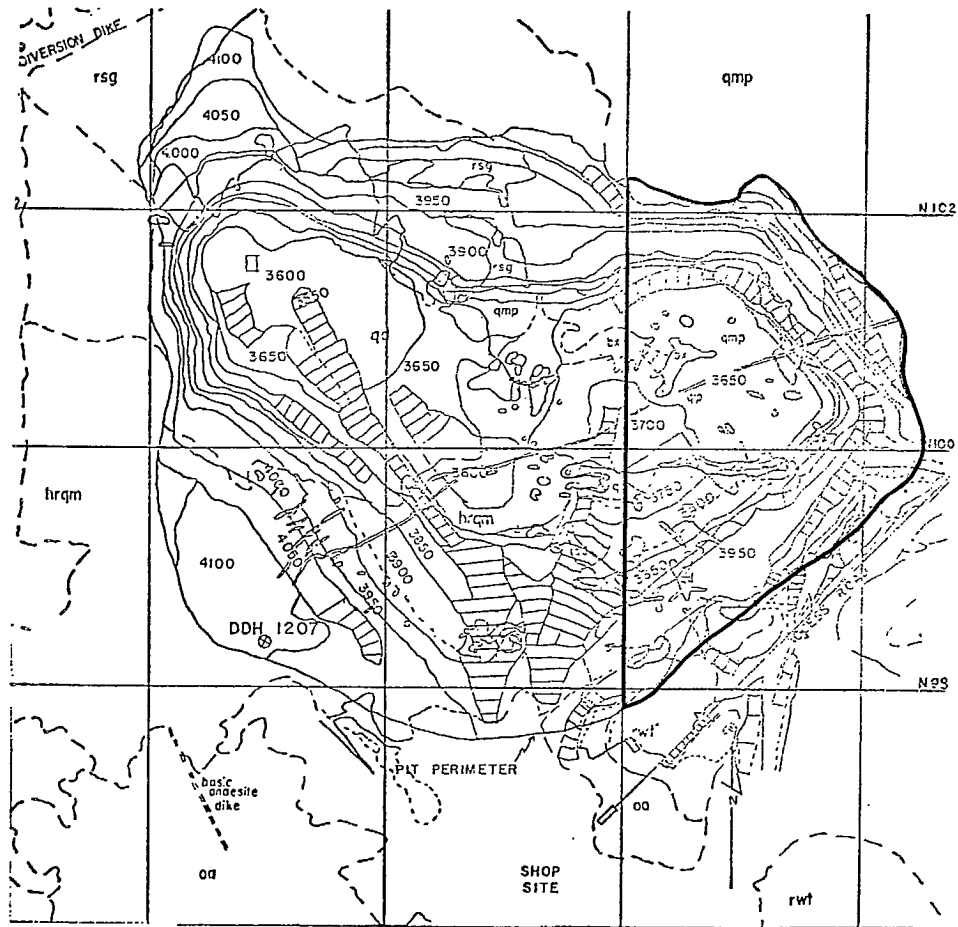
EXPLANATION

Qal	– Alluvium, waste dump, etc.		oa	–	Oxframe andesite
	– Aplite		qd	–	Biotite quartz diorite
bx	– Breccia Pipe		hrqm	–	Harris Ranch quartz monzonite
qlp	– Quartz latite porphyry		rwt	–	Oxframe rhyolite welded tuff
qmp	– Quartz monzonite porphyry		q	–	Quartzite
rsg	– Ruby Star granodiorite				

to give an additional 2.1 million tons per year of waste and requires the purchase of an additional truck. The second design also exposes an additional 3 million tons of ore; however, milling capacity constraints preclude mining of this additional ore during the ten-year period studied, and existing pit geometry prevents any compensating adjustments in layout.

121. In the first five years, the pit is to be deepened by a series of drop cuts with only the bottom bench being actively mined. After the fifth year, each of the three pit faces are to be pushbacked, thus expanding the pit perimeter.

122. Each layout attempts to maintain alternate access routes by developing two ramp systems, one on either side of the pit. This feature becomes extremely important when considering the operational impact of instability.

Design Sectors

123. Three design sectors were chosen on the basis of face orientation and operational use of each sector. All three fell within the same geologic domain. The sector boundaries, as shown on Fig 21, were kept constant throughout the life of the ten-year design. Although constant sector boundaries are not required in the analysis, they ease data gathering and interpretation.

124. The SW face was divided into two sectors (II and III) because of a ramp system contained in Sector III. This ramp gives two distinct wall geometries for the SW face as well as two different operational impacts of instability even though the two sectors have identical reliability schedules.

125. The north and NW faces were placed in Sector I. These two faces would normally define different sectors. They were examined separately in determining probability of instability schedules. However, they were found to have similar schedules, and the two faces contain a single haulage ramp system. Consequently, the slope geometry and operational impact of possible instability being similar, they were combined into a single design sector.

Structural Data

126. Structural data for the study area was gathered from two sources: (1) fracture set data gathered by the mine geologists in the course of regular pit mapping, and (2) detail line mapping done in the course of this study by mine personnel.

127. The fracture set data previously gathered were transferred from the mine geology maps to computer cards. These data were used to plot Schmidt equal area projections. The bulk of the structural features mapped in this phase were large-scale faults or shear zones.

128. The detail line study was undertaken to gather data on the individual sets of discontinuities. Ten detail lines were taken in various locations of the study area by recording all fractures greater than 1 ft (0.305 m) in length that intersected the line. Each detail line was terminated after 100 discontinuities were mapped.

129. The recorded information was attitude, length, spacing and roughness. The roughness of a structure was estimated by taking the difference between the average dip of the set and the minimum dip of each surface. The difference is a measure of the dilatancy factor for sliding.

130. The data from the detail lines were combined into ten sets, based on a visual examination of the Schmidt plot containing all data (Fig 22). An F-test statistic was applied to each of the sets to develop confidence intervals for the set boundaries (15). The results of the F-tests were inconclusive; consequently, the strike and dip limits of each joint set were determined by visual examination as shown in Fig 22. Table 1 gives a table of the limits used for each set. In Fig 22 each point represents the mean orientation of each set within a detail line. A separate Schmidt plot was made for each detail line (Fig 23-32). Since the plots were similar for each detail line, the study was treated as one structural domain (see Fig 33). A minor number of the discontinuities were faults and shears, which had substantially the same orientation as the joints (see Fig 34). A Schmidt plot of the structural data gathered prior to the detail line
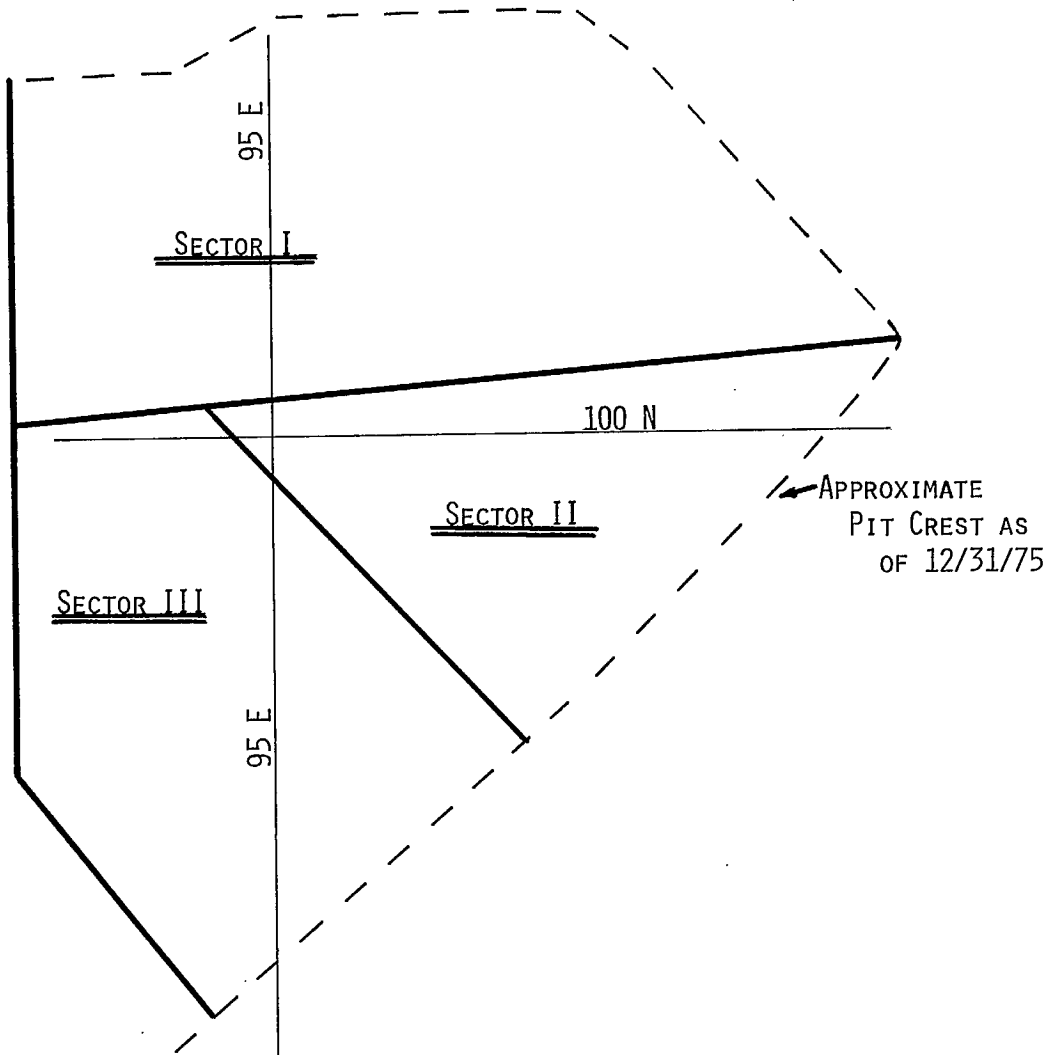
Fig 21 - Location of wall design sectors
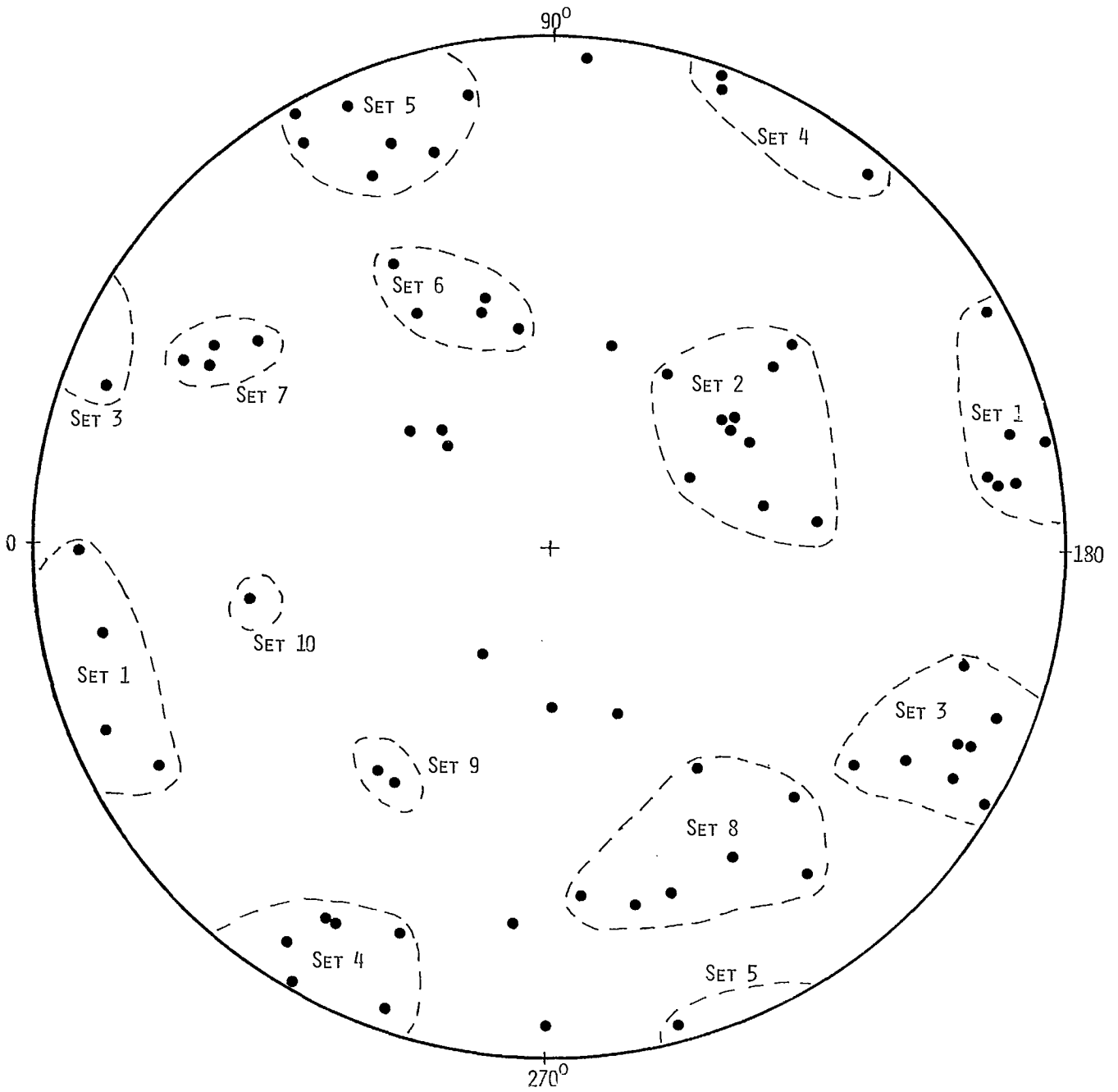
Fig 22 - Schmidt pole plot of fracture sets
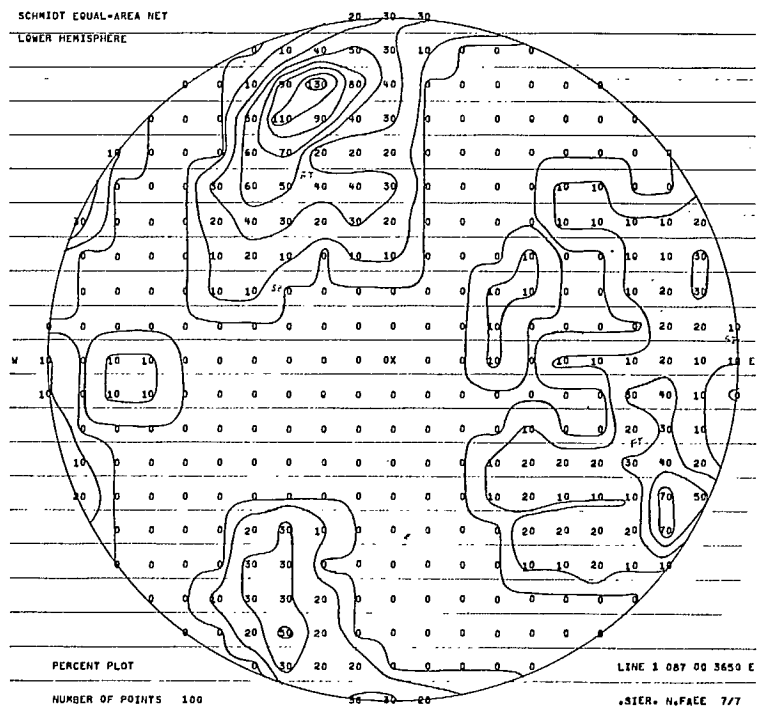
Fig 23 - Schmidt contour plot for line 1
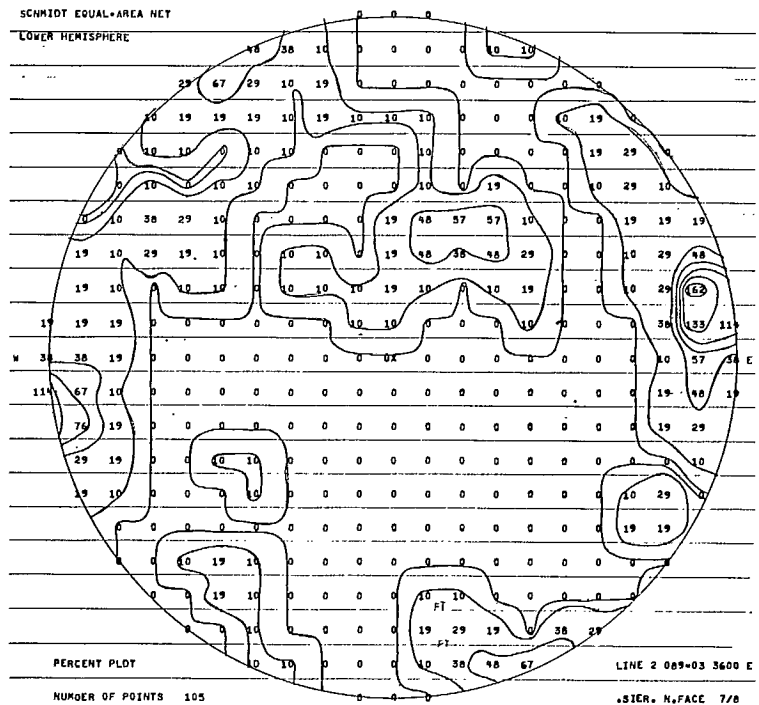
Fig 24 - Schmidt contour plot for line 2
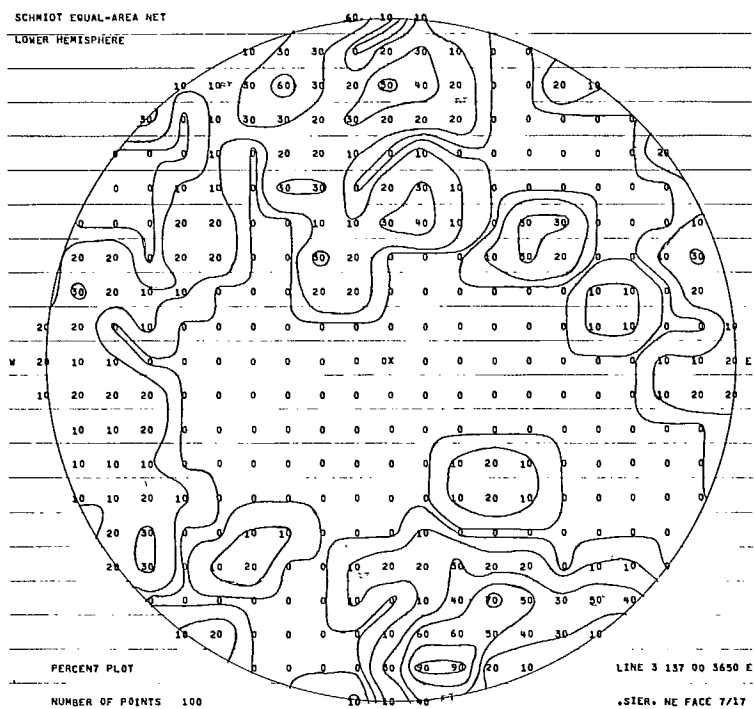
Fig 25 - Schmidt contour plot for line 3
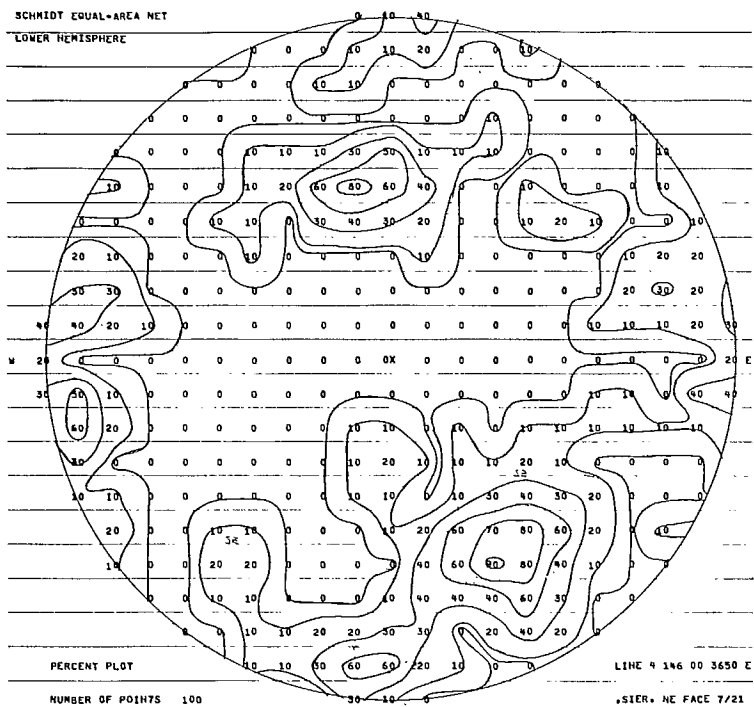
Fig 26 - Schmidt contour plot for line 4
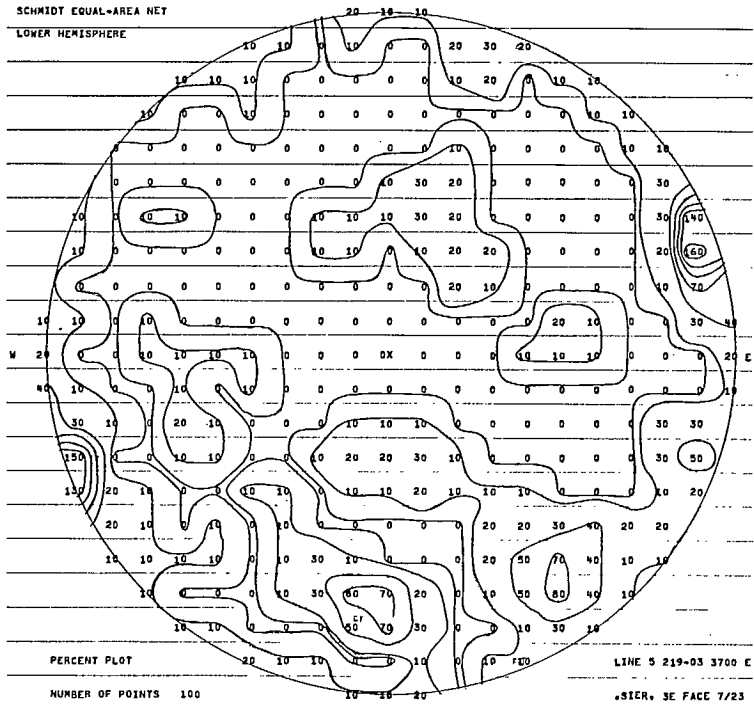
Fig 27 - Schmidt contour plot for line 5
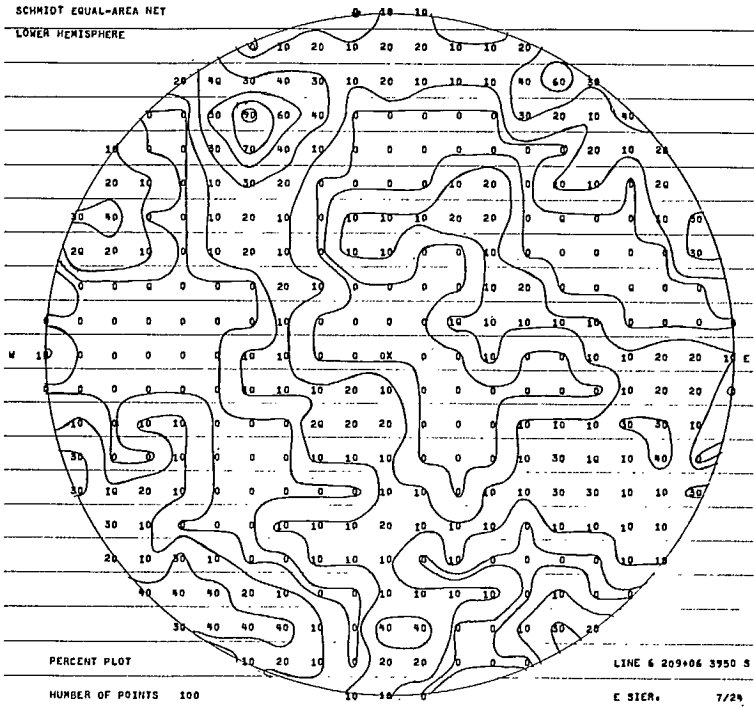
Fig 28 - Schmidt contour plot for line 6

33
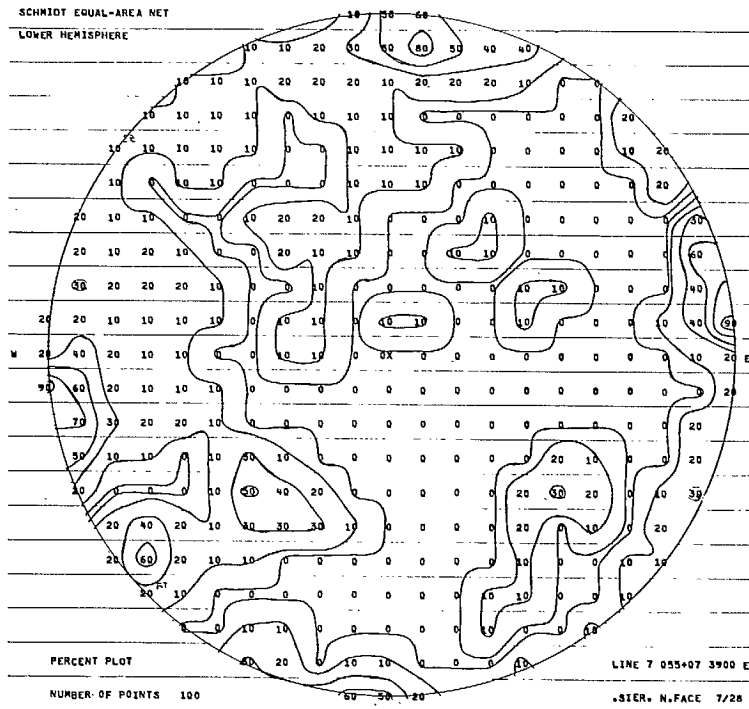
Fig 29 - Schmidt contour plot for line 7
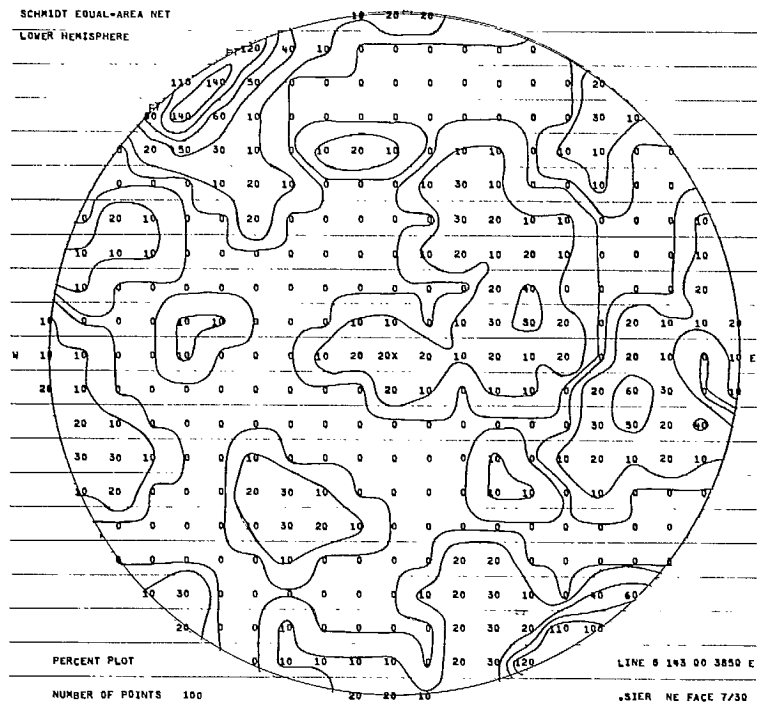
Fig 30 - Schmidt contour plot for line 8
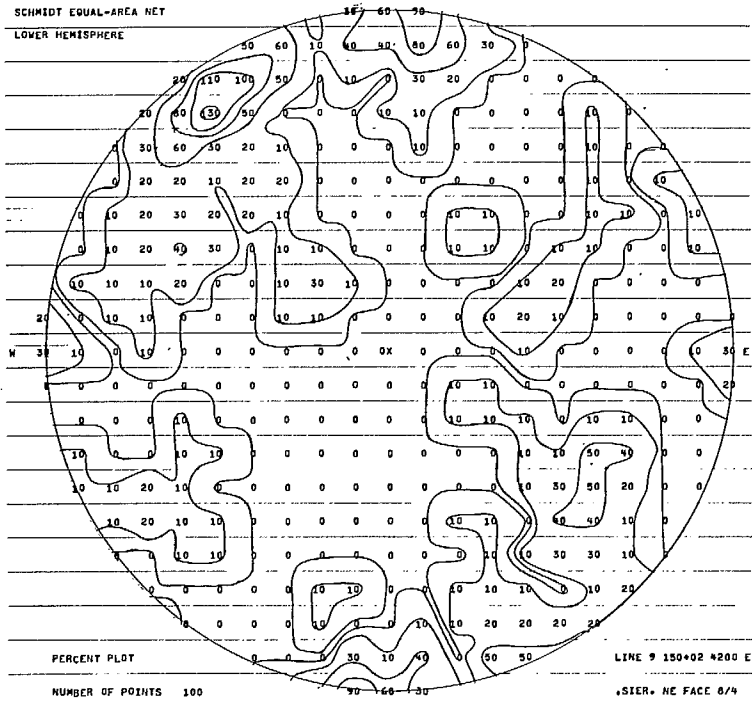
Fig 31 - Schmidt contour plot for line 9
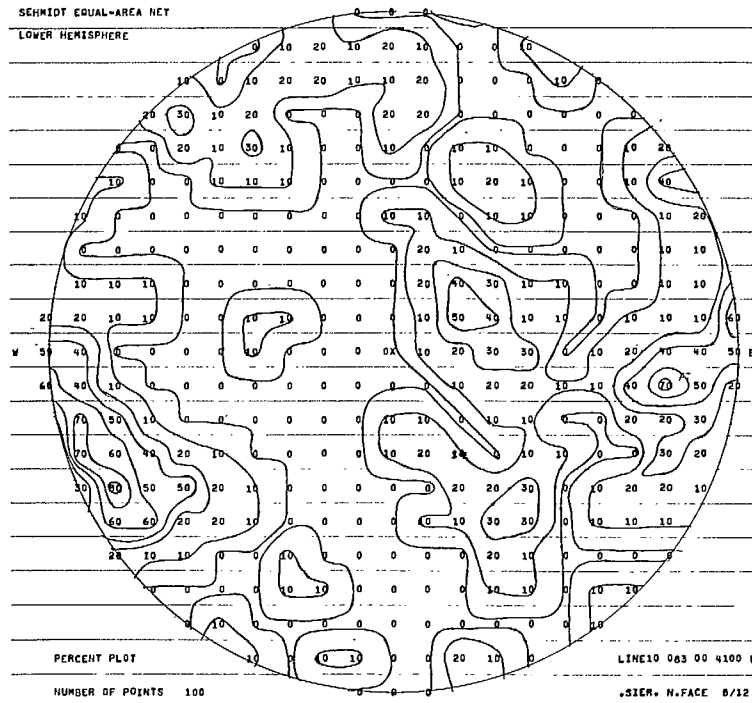
Fig 32 - Schmidt contour plot for line 10
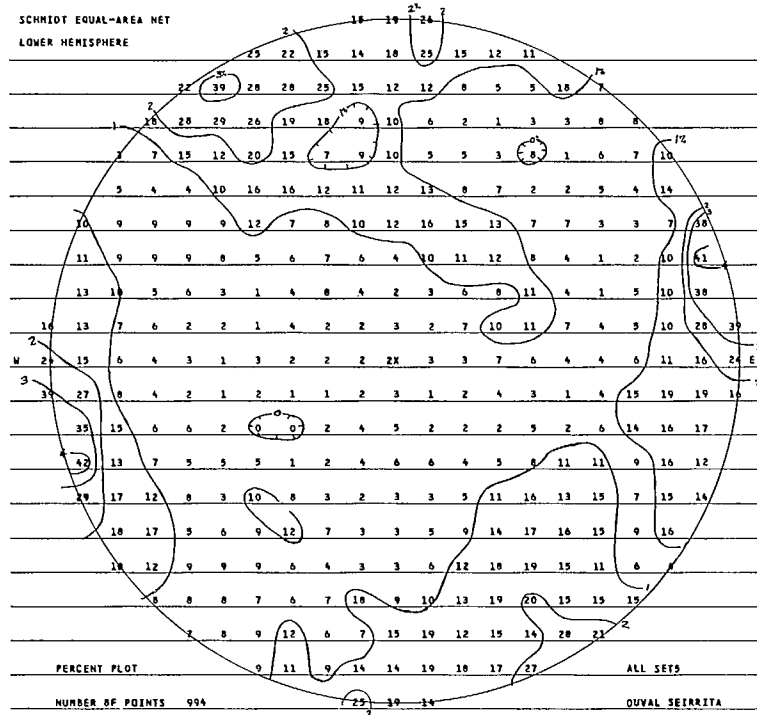
Fig 33 - Schmidt contour plot for all sets
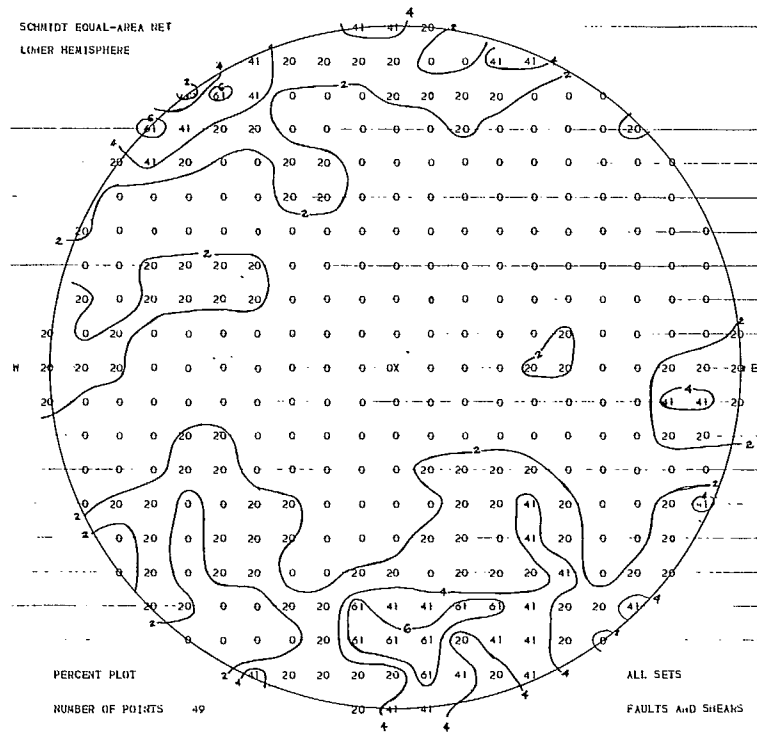
Fig 34 - Schmidt contour plot for faults and shears

survey showed essentially the same pattern as the detail line data. Consequently, only the structural data gathered in the detail line survey was used in the stability analyses.

Table 1: Summary of strike and dip ranges for each fracture set

	Strike Range		Dip Range	
Set	Maximum	Minimum	Maximum	Minimum
1	360°	325°	110°	70°
2	180°	120°	55°	20°
3	220°	195°	105°	60°
4	310°	285°	105°	65°
5	80°	55°	100°	65°
6	85°	55°	55°	30°
7	40°	25°	75°	55°
8	270°	220°	75°	40°
9	315°	295°	50°	40°
10	355°	345°	55°	45°

131. Estimates were made of the distribution of the structural parameters of dip, dip direction, spacing, length, and roughness. The dip and dip direction were fitted to a normal distribution curve. Table 2 gives the mean and standard deviation of the dip and dip direction for each set.

Table 2: Summary of dip direction and dip for each fracture set

Fracture Set	Dip Direction Mean	Dip Direction Standard Deviation	Dip Mean	Dip Standard Deviation
1	349.6°	91.1°	79.7°	9.0°
2	234.7°	25.5°	35.7°	9.8°
3	271.5°	64.8°	71.7°	12.8°
4	327.3°	86.7°	78.2°	9.6°
5	200.0°	78.8°	76.3°	10.1°
6	162.4°	19.2°	42.9°	8.1°
7	119.6°	8.7°	64.2°	8.1°
8	330.8°	14.6°	60.0°	12.1°
9	396.0°	9.9°	46.6°	5.1°
10	440.2°	10.7°	48.5°	10.2°

132. Cumulative exponential models were used for spacing, length and roughness. Table 3 gives the mean roughness, spacing, and length for each set. The cumulative exponential model has intuitive appeal for lengths in that there should be a large number of small fractures and few long fractures in the typical porphyry copper deposit. The function is given by:

$$F(x) = e^{-ax} \qquad \text{eq 7}$$

where F(x) is the cumulative frequency greater than x, x is the value of length or spacing, and a is the parameter for the mean length or spacing of the fracture set (16).

Table 3: Summary of length, roughness, and spacing for each fracture set

Fracture set	Number of fractures	Mean roughness	Mean spacing (feet)	Mean length (feet)
1	256	5.27°	1.55	7.57
2	68	3.37°	3.22	7.97
3	88	3.60°	1.67	6.09
4	82	4.58°	4.65	8.43
5	267	4.45°	1.07	11.27
6	70	1.80°	2.15	7.38
7	20	7.89°	5.46	8.37
8	79	3.74°	2.21	7.92
9	28	3.26°	2.50	7.35
10	4	6.50°	5.98	16.50

133. The exponential distribution requires that only one parameter, a, be estimated from sample data to specify the distribution. If the fracture length and spacing samples are unbiased, then "a" can be estimated by the reciprocal of the sample mean, m_x, ie, a = $1/m_x$. Unfortunately, detail line mapping gives a biased sample since small fractures of less than 1 ft (0.305 m) are not recorded and the full length of fractures extending beyond one bench, or 50 ft (15.2 m), cannot be observed due to lack of access.

134. In an attempt to adjust for sample truncation, a maximum likelihood estimate for "a" was developed for a truncated exponential distribution.

$$\bar{x} = \frac{1}{a} - \frac{x_1 \, e^{-ax_1} - x_0 \, e^{-ax_0}}{e^{-ax_0} - e^{-ax_1}} \qquad \text{eq 8}$$

where $\bar{x}$ is the mean calculated from observed data, x_1 is the upper truncation, x_0 is the lower truncation, and a is a parameter.

135. Eq 8 can be solved by trial and error to give the estimate of "a" for the cumulative exponential distribution (17). This procedure does not give a wholly satisfactory representation of the sampling bias and is cumbersome to apply. Furthermore, it gave estimates for "a" similar to eq 7. Consequently, the reciprocal of the mean estimate for "a" was used in the stability analysis.

136. Little information was available on groundwater levels and their variation. The one drill hole available within the pit area intersected the water table at the 3900 ft level; seven other drill holes, 2,000 to 3,000 ft beyond the pit perimeter, intersected water at the 4000 ft elevation. Visually, all three slope faces appeared to be dry. Hence taking into account the semi-arid climate, it was assumed that the groundwater level in the area around the pit did not vary from the 3900 elevation.

Mechanical Testing

137. The testing of rock samples consisted of direct shear tests on preexisting fractures. Samples were cut to the 11 3/4 in. by 11 3/4 in. (0.298 m x 0.298 m) dimensions of the shear box and placed in a fast-drying cement mixture. The samples were sheared under varying normal loads and a shear rate of 0.5 in./min (1.27 cm/min). Upon reaching the machine limit on sample displacement, the shearing direction was reversed with operations carried out similar to the forward run. The sample was cycled in this manner several times.

138. Five samples of preexisting fractures were taken from the mine study area and tested with the results shown in Table 4. Since the study area is predominantly of one rock type (quartz-monzonite porphyry). The results were combined, giving the mean friction angle of 30.76°, standard deviation of 3.15°, and a mean apparent cohesion of 10.06 psi (69.4 kPa) with a standard deviation of 6.12 psi (42.2 kPa). The cohesion is the y intercept and the friction angle is the slope of the straight line envelope on the Mohr diagram. These results were used for all fracture sets within the study area.

Table 4: Summary of direct shear test results

Sample	Friction angle	Cohesion psi	kPa
325/Forward/dry	36.08°	28.93	199.5
Reverse/dry	28.35°	5.27	36.3
326/Forward/dry	39.41°	11.50	79.3
Reverse/dry	26.38°	5.24	36.1
328/Forward/dry	26.19°	15.62	107.7
Reverse/dry	26.42°	-8.61	59.4
329/Forward/dry	36.78°	8.75	60.3
Reverse/dry	29.28°	2.18	15.0
330/Forward/wet	26.78°	20.27	139.8
Reverse/wet	30.89°	11.50	79.3

Reliability

139. The study area had been experiencing plane shear sliding, which was assumed to be the appropriate mode to use for analysis. For 3-d-wedge sliding, the following combination of joint sets were chosen as candidates for instability: Sector I Sets (2,6)(3,6)(2,7); Sectors II, III Sets (2,8).

140. The wedges could not be bounded by just two planar structures since there were no discontinuities within the study area long enough. The planes bounding the wedge had to be formed by combinations of smaller fractures. The planes would have a stepped appearance similar to the 2-d-wedge shown in Fig 35 (18). However, there is no developed analytical model for this instability mode. Supplement 5-1 provides analyses for
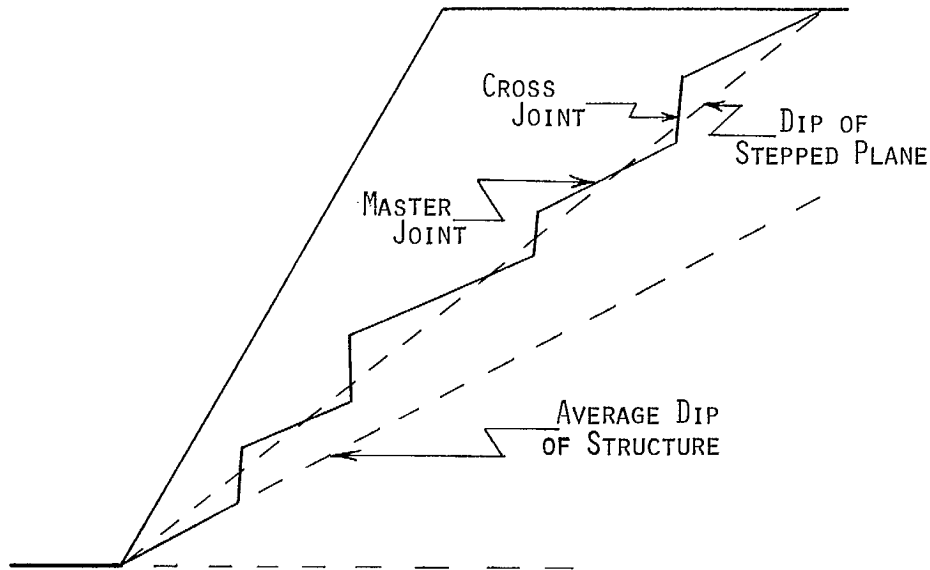
Fig 35 - Stepped-plane instability model

3-d-wedge sliding on two planes and 2-d plane shear sliding on a through-going plane and on a stepped path. These three types of analyses were made.

141. The WINTAM program was used to compute the probability of sliding given sufficiently long planes to produce 3-d wedges for each of the possible set combinations. This program uses a Monte Carlo simulation. Table 5 gives the input parameters and type of distribution specified. In an attempt to correct the assumption of through-going planes, the resultant probabilities were multiplied by the probability of occurrence of the required lengths of each discontinuity for each slope height increment. The probability of occurrence is estimated from the cumulative length distribution. Thus, the probability of obtaining a fracture of at least the requisite length is used. This converts the conditional probability of sliding into a joint probability, ie, $P_f = P_s \cdot P_o$, where P_f is the probability of instability, P_s is the probability of sliding given the required geometry and P_o is the probability of occurrence

of the requisite geometry.

Table 5: Summary of types of variables
supplied to Wintam computer program

Variable	Distribution
Dip direction	Truncated normal
Dip	Truncated normal
Cohesion	Truncated normal
Friction angle	Truncated normal
Roughness	Exponential
Water table	Constant
Slope face orientation	Constant
Slope angle	Constant
Slope height	Constant
Density of rock	Constant

142. A two-dimensional stepped-plane shear model was used to analyze two fracture set combinations - sets 5 and 6 in Sector I and sets 8 and 9 in Sectors II and III.   A Monte Carlo simulation

is used to generate the stepped-plane shown in Fig 34. Length and spacing of the master and cross joints are sampled to simulate the stepped plane. No length correction is required for this model.

143. The simple two-dimensional plane shear model was used to analyze sets 2 and 6 in Sector I. Each set was used for the appropriate part of the sector. Since length of the faces in the two directions were nearly equal and the probability of sliding for each set was similar, the probability schedules for the two sets were averaged. The resultant probabilities of sliding were multiplied by the probabilities of occurrence of a through-going discontinuity to give the probabilities of instability.

144. In using the above models it is normally assumed that the sliding plane passes through the toe of the slope. However, since pits are developed in discrete increments of depth, the sliding plane could be located anywhere within the increment. Thus, more than one location is possible for the plane within the depth increment. For purposes of this study, the relevant depth increment was taken to be the average annual increase in pit depth. The average number of fractures within this increment represents the number of potential sliding planes for each sampling period. This number is a function of the spacing and orientation of the fracture set. For the subsequent discussion only, the word "SET" is used to refer to both the single set of the simple plane shear mode and the combinations of sets in the 3-d-wedge and stepped-plane modes.

145. The probability of instability for each set can be found as follows:

$$P_m = 1 - P_f^\lambda \qquad \text{eq 9}$$

where P_m is the probability of instability for a given fracture set, P_f is the probability of instability for one discontinuity in the set, and λ is the mean number of potential sliding planes within the slope increment.

146. The probability of instability for the slope as a whole must be found by combining the probabilities for each individual set within the

slope as follows:

$$P = 1 - \prod_{m=1}^{n} (1 - P_m) \qquad \text{eq 10}$$

where P is the probability of instability for the slope at a given height and angle, P_m is the probability of instability for the slope affected by one set, and n is the number of critical sets within the slope. The symbol $\prod$ indicates the multiplication of a series and is analogous to the use of Σ to indicate the sum of a series.

147. The final probability of instability schedule for each sector was determined by repeating the computations for each slope height and angle required for the schedule. Table 6 gives the final schedule for Sector I. Table 7 gives the final schedule for Sectors II and III.

Table 6: Probability of instability schedule for Sector I

| Slope height | Slope angle | | | | Volume* |
	30°	38°	45°	55°	(1000 cu ft)
50 ft					
(15 m)	0.0	0.039	0.432	0.585	10
100 ft					
(30 m)	0.0	0.030	0.418	0.598	80
400 ft					
(122 m)	0.0	0.012	0.198	0.575	512
800 ft					
(244 m)	0.0	0.007	0.142	0.413	40,960
1200 ft					
(366 m)	0.0	0.002	0.086	0.251	138,240

* based on generalized model, $V = 0.08 H^3$

148. The schedules show decreasing probability of instability with slope height. This is due to the schedules representing the probability of full height instability rather than the probability of any instability within the given height. The probability of full height instability decreases with slope height since the chance of a through-

Table 7: Probability of instability schedule
for Sectors II and III

| Slope height | Slope angle | | | | Volume (1000 cu ft) |
	30°	38°	45°	55°	
50 ft (15 m)	0.0	0.001	0.016	0.106	10
100 ft (30 m)	0.0	0.002	0.019	0.115	80
400 ft (122 m)	0.0	0.003	0.033	0.130	512
800 ft (244 m)	0.0	0.004	0.040	0.150	40,960
1200 ft(366 m)	0.0	0.005	0.047	0.170	138,240

going discontinuity occurring decreases. The probability of less than full height instability is handled internally within the BNCST model by sampling for interramp and bench instabilities.

Benefit-Cost Analysis

149. The analyst must provide four basic types of information for BNCST. These are: (1) a schedule of probability of instability for each design sector, (2) pit wall geometry data for each design sector, (3) mining economic data, and (4) data on the cost impact of instability. Figures 36 and 37 show 80-80 listings of the input data used for each case. Exhibit A provides interpretation of the input data.

150. The pit wall geometry for each sector was obtained from yearly mine plan maps provided by the mine planning personnel. Although this process is relatively straightforward, some approximation is required of the actual pit geometry since the computer program assumes an identical, uniform cross-section for each sector.

151. Each layout was based on uniform bench dimensions. For both alternatives, the bench height was 50 ft (15 m) with a bench face angle of 60°. The bench width for the 45° design was 20 ft (6 m). For the 38° design, the bench width was 35 ft (11 m). Fig 38 shows the bench geometry for each design.

152. Pushbacks, work benches and haul roads were included annually as shown on the mine plans. The elevation of haulage ramps was taken as the midpoint of the ramp. These ramps have a 10% grade and a width of 120 ft (36.6 m). The width of work benches was taken as the average width of each work bench in the sector for each year. In some years, wide remnant benches were left to increase slope stability. These were treated as work benches although they were not actively mined.

153. The crest elevation of the cross-section for each sector was approximated by the average crest elevation in the sector. Similarly, the pit bottom elevation was approximated by the average pit bottom within the sector. Sector lengths were taken at the mid-elevation of each sector.

154. Although there was no ultimate slope encountered in any design sector, the BNCST program requires that the location of the ultimate slope be specified each year for each sector. For this reason, the ultimate slope bottom elevation each year was specified as the crest elevation for each sector. An elevation between the crest and pit bottom would have caused the program to include an ultimate pit slope, giving an erroneous analysis. An elevation below the pit bottom would have caused a computer error.

155. Information such as ore grade, recovery, ore and waste volumes and costs was provided. Ore production was scheduled for 32.85 million tons per year (29.86 million tonnes per year), with grade varying each year. Waste excavation volume was obtained from the volume of material removed in each annual cut, maintained as close as possible to 1.6:1 waste to ore stripping ratio. All production was lumped into the first sector to avoid breaking the production down by design sector.

156. The annual unit mining costs for ore and waste were modified. Fixed charges amounting to 12% of the total unit mining cost were deducted to give the variable unit mining cost. This variable cost was then used as the cost of waste mining for the BNCST program. The unit cost of mining the ore includes all costs associated with producing a marketable product - processing as well as mining.

157. It was not feasible to deduct fixed costs from the total ore costs since processing and

```
ANY PIT IN THE SOUTHWEST, 38 DEGREE INTERRAMP DESIGN
  ANY TIME
           15          30          1          1
           0.86         0       1280.         0      12.5      11.5      15.0      10
SECTOR               1           1          1
BENCH             50.0        36.0       60.0       120
PROB
                    50   100   400   800  1200

                                                              30.0
             .039 .030 .012 .007 .002                         38.0
             .432 .418 .198 .142 .086                         45.0
             .585 .598 .575 .413 .251                         55.0
                                                              90.0
INSTAB
     1           19     9999999999999999999999999999999999999
PUSH
     1           18     888888888888888888888888888888888888
HAUL
             1 3750     2 3675     3 3750     4 4050     5 4050     6 3975
             7 3975     8 3975     9 3975    10 3975
       END
                                   3 3750     4 3750     5 3725     6 3720
             7 3725     8 3700     9 3700
       END
                                   3 3280     4 3750     5 3300     6 3275
             7 3300     8 3300     9 3275
       END
                                              4 3250
       END
STELS
             1 3800     2 4000     3 4000     4 4150     5 4150     6 4150
             7 4150     8 4150     9 4150    10 4250
SWID
             1 2750     2 2800     5 2600     6 2900     9 2600    10 2300
PIT
             1 3550     2 3400     3 3150     4 3050     5 3050     6 2850
             7 2750     8 2750
       END
             1 3800     2 4000     3 4000     4 4150    10 4250
       END
             6 3800     7 3600     8 3400     9 3150    10 2950
ORF1
             132850
AVG1
             1 0.45     2 0.46     3 0.44     5 0.47     7 0.45     8 0.47
             9 0.52
WASTE
             146767    253300    353854    453104    556165    654743
             756000    854222    952706   1049350
CMNW
             1 0.35     8 0.29
CMN1
             1 3.81     2 3.85     3 3.70     4 3.90     5 3.90     6 3.83
             7 3.79     8 4.03     9 4.22
ULTIMATE
        45.04250.
END SECTOR
SECTOR               2           1          1
BENCH             50.0        36.0       60.0       120
PROB
                    50   100   400   800  1200

                                                              30.0
             .001 .002 .003 .004 .004                         38.0
             .016 .019 .030 .04  .040                         45.0
             .109 .118 .130 .150 .150                         55.0
                                                              90.0
```

Fig 36 - A listing of input data for 38° interramp design

```
INSTAB
      1        19     9999999999999999999999999999999999
PUSH
      1        18     888888888888888888888888888888888
HAUL
               2 3900      3 3825      4 3900      6 3150      7 3130
      END
               4 3130       699999      8 3100       999999
STELS
               1 3950      9 3900     10 3800
SWID
               1 2000      2 1750      3 1800      4 1500      8 1600      9 1450
              10 1500
PIT
               1 3550      2 3350      3 3200      4 3000      5 2950      6 2850
               7 2750
      END
               1 3950      9 3900     10 3800
      END
               5 3600       699999
WORK
               6 3350250.0    7 3200250.0     899999          9 3100250.0
              10 2950250.0
CMNW
               1 0.35      8 0.29
ULTIMATE
          45.04250.
END SECTOR
SECTOR            3           1.          1
BENCH          50.0        36.0        60.0        120
PROB
                 50    100    400    800   1200

                                                              30.0
             .001 .002 .003 .004 .004                         38.0
             .016 .019 .030 .04  .040                         45.0
             .109 .118 .130 .150 .150                         55.0
                                                              90.0
INSTAB
      1        19     9999999999999999999999999999999999
PUSH
      1        18     888888888888888888888888888888888
HAUL
               1 3850      2 3825      9 3850     10 3825
      END
               1 3650      2 3675      5 3300      6 3025      8 3170      9 3175
      END
               3 3325      4 3300       599999      8 3050      9 3025
      END
               4 3030       599999      8 3030       999999
STELS
               1 3950                  9 4150
SWID
               1 1400      5 1350      6 1300      7 1350      8 1300     10 1400
PIT
               1 3550      2 3350      3 3200      4 3050      6 2850      7 2750
      END
               1 3950      9 4150
      END
               5 3600      6 3350      7 3200       899999      9 3000     10 2900
WORK
               4 3900250.0     599999
CMNW
               1 0.35      8 0.29
ULTIMATE
          45.04250.
END SECTOR
STOP CASE
```

Fig 36 (cont) - A listing of input data for 38° interramp design

```
ANY PIT IN THE SCLTHWEST, 45 DEGREE INTERRAMP DESIGN
  ANY TIME
          15        30         1          1
         0.86        0       1280.        0       12.5      11.5      15.0         10
SECTOR              1          1          1
BENCH            50.0       20.0       60.0       120
PROB
                   50   100   400   800  1200

                                                           30.0
                 .039 .030 .012 .007 .002                  38.0
                 .432 .418 .198 .142 .086                  45.0
                 .585 .598 .575 .413 .251                  55.0
                                                           90.0
INSTAB
    1        19     999999999999999999999999999999999
PUSH
    1        18     888888888888888888888888888888888
HAUL
           1 3750    2 3675    3 3750    4 4050    5 4050    6 3975
           7 3975    8 3975    9 3975   10 3975
       END
                               3 3750    4 3750    5 3725    6 3720
           7 3725    8 3700    9 3700
       END
                               3 3280    4 3250    5 3300    6 3275
           7 3300    8 3300    9 3275
       END
                                                   5 3250
       END                      . —
STELS
           1 3800    2 4000    3 4000    4 4150    5 4150    6 4150
           7 4150    8 4150    9 4150   10 4250
SWID
           1 2750    2 2800    5 2600    6 2800    9 2600   10 2300
PIT
           1 3550    2 3400    3 3150    4 3050    5 3050    6 2850
           7 2750    8 2750
       END
           1 3800    2 4000    3 4000    4 4150   10 4250
       END
           6 3800    7 3600    8 3400    9 3150   10 2950
OPE1
          132850
AVG1
           1 0.45    2 0.46    3 0.44    5 0.47    7 0.45    8 0.47
           9 0.52
WASTE
          144667    251200    351754    451004    554065    652643
          753900    852122    950606   1047250
CMNW
           1 0.35    8 0.29
CMN1
           1 3.81    2 3.85    3 3.70    4 3.90    5 3.90    6 3.83
           7 3.79    8 4.03    9 4.22
ULTIMATE
          45.04250.
END SECTOR
SECTOR              2          1          1
BENCH            50.0       20.0       60.0       120
PROB
                   50   100   400   800  1200

                                                           30.0
                 .001 .002 .003 .004 .004                  38.0
                 .016 .019 .030 .04  .040                  45.0
                 .109 .118 .130 .150 .150                  55.0
                                                           90.0
```

Fig 37 - A listing of input data for 45° interramp design

```
INSTAB
     1       19    99999999999999999999999999999999
PUSH
     1       18    888888888888888888888888888888888
HAUL
             2 3900     3 3825     4 3900     6 3150     7 3130
     END
             4 3130     699999     8 3100     999999
STELS
             1 3950     9 3900    10 3800
SWID
             1 2000     2 1750     3 1800     4 1500     8 1600     9 1450
            10 1500
PIT
             1 3550     2 3350     3 3200     4 3000     5 2950     6 2850
             7 2750
     END
             1 3950     9 3900    10 3800
     END
             5 3600     699999
WORK
             6 3350250.0    7 3200250.0    899999          9 3100250.0
            10 2950250.0
CMNW
             1 0.35     8 0.29
ULTIMATE
        45.04250.
END SECTOR
SECTOR           3         1         1
BENCH         50.0      20.0      60.0        120
PROB
                50   100   400   800  1200
                                                            30.0
            .001 .002 .003 .004 .004                        38.0
            .016 .019 .030 .04  .040                        45.0
            .109 .118 .130 .150 .150                        55.0
                                                            90.0
INSTAB
     1       19    99999999999999999999999999999999
PUSH
     1       18    888888888888888888888888888888888
HAUL
             1 3850     2 3825     9 3850    10 3825
     END
             1 3650     2 3675     5 3300     6 3025     8 3170     9 3175
     END
             3 3325     4 3300     599999     8 3050     9 3025
     END
             4 3030     599999     8 3030     999999
STELS
             1 3950                9 4150
SWID
             1 1400     5 1350     6 1300     7 1350     8 1300    10 1400
PIT
             1 3550     2 3350     3 3200     4 3050     6 2850     7 2750
     END
             1 3950     9 4150
     END
             5 3600     6 3350     7 3200     899999     9 3000    10 2900
WORK
             4 3900250.0     599999
CMNW
             1 0.35     8 0.29
ULTIMATE
        45.04250.
END SECTOR
STOP CASE
```

Fig 37 (cont) - A listing of input data for 45° interramp design

(A) 38° INTERRAMP DESIGN

(B) 45° INTERRAMP DESIGN

Fig 38 - Bench geometries for each design

marketing charges were available only on an aggregate basis. The inclusion of fixed charges in this case would not introduce error into the analysis since both the total amount of ore mined and the ore production schedule were identical in both alternative designs studied. Thus, the fixed charges will cancel out when comparing the two designs. In the general case, however, the presence of fixed charges in unit cost data will result in some distortion when evaluating the merits of alternative designs.

158. The ore mined is a sulphide containing copper and molybdenum. Since the two products are not mined separately, the molybdenum was converted to an equivalent copper basis and added to the copper grade to give total ore grade. Similarly, the ore recovery figure reflects both the molybdenum and copper recovery. This sulphide ore is given in the computer output as Type 1 ore; there is no Type 2 produced.

159. A price of $0.64 per lb of copper was used in BNCST. Although the metal price is considered as a deterministic variable in BNCST, INRISK allows for the treatment of price as a stochastic variable.

160. The cost of instability would arise from the operation of stepping out at the toe. This procedure is consistent with the large amount of ore kept exposed (approximately one year's production in the first year of the study), the typical slow development of instability in the pit walls and the presence of alternate haulage ramps.

161. The step-out also alters the pit geometry in subsequent years by reducing the overall slope angle. This altering of pit geometry is handled by performing two-stage sampling. The process consists of sampling for instability each year based on the original wall geometry as if there had never been a step-out. Since the unaltered original geometry has a higher probability of instability compared with the altered geometry, the purpose of the first-stage sampling is to determine whether the second stage is required for this sampling period. The same random numbers are used in each stage of the two-stage sampling. Thus only the wall geometry is altered.

162. If instability occurs in the first stage, the altered wall geometry, including the effects of all previous step-outs, is sampled. If instability results in the second stage sampling, the step-out cost model is used to determine the cost of instability. If no instability occurs, zero cost is assessed, which is equivalent to stability. Although this process is cumbersome, it allows for the modification of pit wall geometry without altering the generalized nature of the BNCST program.

163. There must be a check on the accumulated amount of ore tied up beneath step-outs since a series of step-outs might easily tie up all available ore. In this analysis, a maximum of six months' delayed production of ore or waste tied up in step-outs was permitted. If either limit is exceeded, a cost model is called which simulates either the engaging of a contractor for a crash stripping program or increasing stripping by the company. If the excess material exceeds 10% of the scheduled waste production for the year, an outside contractor is called in at a charge of 200% of the normal unit mining cost, based on previous experience with contract stripping. If the excess is less than 10%, it is assumed the company will perform the stripping using existing equipment and overtime labour.

164. As can be seen from the annual ore grade schedule, there is some variation in ore grade within the pit although it is relatively constant, with a range of 0.44 to 0.52% copper equivalent. Consequently, variations in grade were ignored in developing the cost models. Any ore lost or delayed is assumed to be made up with a similar grade ore from another area of the pit.

165. The operating reaction to interramp instability will vary with time of occurrence and the particular haul road. In general, if there is an alternative haulage route, then the haul road is abandoned with possible charges due to increased haulage distance. If there is no alternative, the haul road must be reestablished, either by cutting a new ramp or excavating unstable material, with possible loss of production.

166. The operating reaction to bench insta-

bility was assumed to be that of cleaning up slide debris. Since the cost involved is minor, all bench instabilities in this case were assumed to have zero cost.

167. Certain cost subroutines were substituted for the corresponding subroutine given in Appendix A of this supplement. Exhibit 1 is a description of each cost model used in the study. The cost model names, such as FHSL6, are those used internally within the BNCST program. Exhibit 2 contains a tabulation of all cost models used each year.

168. The BNCST economic analysis program allows only one cost type per year for each type of instability. Thus, to allow multiple reactions to instability, eg, the reestablishment of a haul road and temporary production loss, a cost-model control routine must be used. This control routine, which calls on the appropriate cost models to perform the actual cost calculations, will use the cost type specified in the input data rather than the individual cost models. The use of control routines in this study is explained in Exhibit 1.

Risk Analysis

169. If there is no appreciable capital invest- ment required for the alternate mine design, then the BNCST analysis alone should be sufficient. The tax consequences of the alternatives will be relatively simple. The only key variables affecting the venture decision are the mining benefits and costs. Management can evaluate its risk position in the light of the BNCST analysis.

170. If there is a significant differential capital investment required, then further analysis will probably be required. Not only is management playing with higher stakes, but the nature of the problem has been altered. First, the number of key variables has increased due to the increased flexibility in operations engendered by a change in plant and to the inherent need to consider the capital expenditure sequence. Secondly, the tax picture becomes more complex. Thus, management needs a framework, such as given by the INRISK program, to consider the consequences of the joint

effects of the key variables in the venture decision.

171. In this study, there was only a minor difference between the two alternatives, the addition of one 150-ton haulage truck for the 38° interramp design. However, the INRISK program was used to illustrate the use of the total economic analysis. If this were a "real life" study, the INRISK program probably would not have been used for examining the effects of such a minor aspect.

172. Fig 39 and 40 are summaries of the values of key variables used for each of the two design cases. Depreciation was taken using the sum-of-the-year digit approach. The depletion allowance was taken as the minimum of either 15% of gross income from mining or half the net income.

173. The capital investment required in the 38° interramp design case was handled in a nonstandard manner in the INRISK program since acquisition of the haulage truck required no preproduction period. Consequently, the truck's capital cost was subtracted from the first period's cash flow. Since this outlay occurred at the beginning of the year rather than at the end, as assumed in the program, the capital cost was increased by the discount rate to reflect the earliest outlay when the cash flows were discounted back in the decision criteria models to present value. A listing of this subroutine is given in Fig 40.

Conclusions

174. As can be seen by an examination of Fig 42, 43, and 44, the BNCST simulation of the oper- ating results gives a decided advantage to the 38° interramp design (Case 1). This is due to the large differential in probability of instability between a 38° and a 45° slope angle. The reduced instability costs for the shallower slope angle outweighs the additional waste stripping costs. In addition, the variance of costs for the 45° interramp design is greater due to its greater proportion of instability costs than for the 38° interramp design.

175. When the additional investment is consid- ered, the 38° interramp design remains superior.

```
                    -- INPUT DATA FOR PIT DESIGN NUMBER  1 --
            ■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■

        ANY PIT IN THE SOUTHWEST, 38 DEGREE INTERRAMP DESIGN


    1. OPTION SWITCHES USED FOR THIS RUN.

                INPUT DATA PRINT OPTION              1
                DECISION CRITERIA OPTION             3
                INTERIM RESULTS PRINT OPTION         1
                USER SUPPLIED TAX ROUTINE OPT.       1


    2. INTEGER CONSTANTS.

                NUMBER OF SIMULATIONS               15
                NUMBER OF SECTORS IN THE PIT         3
                NUMBER OF WORKING DAYS /PERIOD     357
                NO. OF PERIODS FOR PRE-PROD.        -0
                NO. OF PERIODS FOR EXPLORATION      -0
                NO. OF PERIODS FOR LAND/WATER       -0
                NO. OF PERIODS FOR PLANT CONST      -0
                ACTUAL PROD. LIFE OF THE MINE       10
                TOTAL LIFE OF THE PROJECT           10


    3. FLOATING POINT CONSTANTS.

                REQUIRED RATE OF RETURN            .150
                FEDERAL INCOME TAX RATE          0.000
                PROVINCIAL MINING TAX RATE      -0.000
                PROVINCIAL INCOME TAX RATE      -0.000
                DEPLETION ALLOWANCE RATE        -0.000


    4. STOCHASTIC VARIABLES CONSTANT FOR ONE SIMULATION RUN.


                EXPLORATION EXPENSE      (IN 1000 DOLLAR            UNITS)
                        CONSTANT                   VALUE =       -0.000
                ROYALTY ( PERCENT           OF GROSS INCOME)
                        CONSTANT                   VALUE =       -0.000
                MINE CAPITAL EXPENDITURE (IN 1000 DOLLAR           UNITS)
                        RECTANGULAR             MINIMUM         MAXIMUM
                                                450.000         550.000
                MILL CAPITAL EXPENDITURE (IN 1000 DOLLAR           UNITS)
                        CONSTANT                   VALUE =       -0.000
                LEACH PLANT (OR TYPE2 ORE)
                            CAPIT. EXPEND(IN 1000 DOLLAR          UNITS)
                        CONSTANT                   VALUE =       -0.000
                WATER/LAND ACQUIS. COSTS.(IN 1000 DOLLAR          UNITS)
                        CONSTANT                   VALUE =       -0.000
                TOTAL SALVAGE VALUE       (IN 1000 DOLLAR         UNITS)
                        CONSTANT                   VALUE =       -0.000
                TOTAL WORKING CAPITAL     (IN 1000 DOLLAR         UNITS)
                        CONSTANT                   VALUE =       -0.000


    5. STOCHASTIC VARIABLES SAMPLED EVERY PERIOD DURING ONE SIMULATION RUN.


                OVERALL RECOVERY OF TYPE1 ORE-PERCENT
                        CONSTANT                   VALUE =         .860
                OVERALL RECOVERY OF TYPE2 ORE-PERCENT
                        CONSTANT                   VALUE =       -0.000
                SELLING PRICE OF THE METAL   (DOLLAR       /TON
                        CONSTANT                   VALUE =     1280.000
                MISCELLANEOUS COSTS          (DOLLAR       /TON               -ORE)
                        CONSTANT                   VALUE =       -0.000
```

Fig 39 - Summary of data for INRISK analysis of 38° interramp design

```
              -- INPUT DATA FOR PIT DESIGN NUMBER  2 --
         ■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■


        ANY PIT IN THE SOUTHWEST, 45 DEGREE INTERRAMP DESIGN



1. OPTION SWITCHES USED FOR THIS RUN.

                INPUT DATA PRINT OPTION          1
                DECISION CRITERIA OPTION         3
                INTERIM RESULTS PRINT OPTION    -0
                USER SUPPLIED TAX ROUTINE OPT.   1


2. INTEGER CONSTANTS.

                NUMBER OF SIMULATIONS           15
                NUMBER OF SECTORS IN THE PIT     3
                NUMBER OF WORKING DAYS /PERIOD 357
                NO. OF PERIODS FOR PRE-PROD.    -0
                NO. OF PERIODS FOR EXPLORATION  -0
                NO. OF PERIODS FOR LAND/WATER   -0
                NO. OF PERIODS FOR PLANT CONST  -0
                ACTUAL PROD. LIFE OF THE MINE   10
                TOTAL LIFE OF THE PROJECT       10


3. FLOATING POINT CONSTANTS.

                REQUIRED RATE OF RETURN         .150
                FEDERAL INCOME TAX RATE        0.000
                PROVINCIAL MINING TAX RATE    -0.000
                PROVINCIAL INCOME TAX RATE    -0.000
                DEPLETION ALLOWANCE RATE      -0.000


4. STOCHASTIC VARIABLES CONSTANT FOR ONE SIMULATION RUN.


        EXPLORATION EXPENSE      (IN 1000 DOLLAR              UNITS)
                     CONSTANT                 VALUE =       -0.000
        ROYALTY ( PERCENT                OF GROSS INCOME)
                     CONSTANT                 VALUE =       -0.000
        MINE CAPITAL EXPENDITURE (IN 1000 DOLLAR             UNITS)
                     CONSTANT                 VALUE =       -0.000
        MILL CAPITAL EXPENDITURE (IN 1000 DOLLAR             UNITS)
                     CONSTANT                 VALUE =       -0.000
        LEACH PLANT (OR TYPE2 ORE)
                     CAPIT. EXPEND(IN 1000 DOLLAR            UNITS)
                     CONSTANT                 VALUE =       -0.000
        WATER/LAND ACQUIS. COSTS.(IN 1000 DOLLAR             UNITS)
                     CONSTANT                 VALUE =       -0.000
        TOTAL SALVAGE VALUE      (IN 1000 DOLLAR             UNITS)
                     CONSTANT                 VALUE =       -0.000
        TOTAL WORKING CAPITAL    (IN 1000 DOLLAR             UNITS)
                     CONSTANT                 VALUE =       -0.000


5. STOCHASTIC VARIABLES SAMPLED EVERY PERIOD DURING ONE SIMULATION RUN.


        OVERALL RECOVERY OF TYPE1 ORE-PERCENT
                     CONSTANT                 VALUE =         .860
        OVERALL RECOVERY OF TYPE2 ORE-PERCENT
                     CONSTANT                 VALUE =       -0.000
        SELLING PRICE OF THE METAL  (DOLLAR          /TON
                     CONSTANT                 VALUE =     1700.000
        MISCELLANEOUS COSTS         (DOLLAR          /TON             -.4(1
                     CONSTANT                 VALUE =       -0.000
```

Fig 40 - Summary of data for INRISK analysis of 45° interramp design

```
      SUBROUTINE URTAX(K)
      CALL MNTAX (K)
      RETURN
      END
      SUBROUTINE MNTAX(K)

C     SUBROUTINE MNTAX DETERMINES THE APPROPRIATE AFTER TAX CASH FLOW

C     FOR THE STUDY AREA IN THE SOUTHWESTRN U.S. MNTAX IS TOO SIMPLE OF
C     A ROUTINE TO BE GENERALLY APPLICABLE TO U.S. TAX PROBLEMS. SUM OF
C     YEARS DIGITS DEPRECIATION IS USED. DEPLETION IS TAKEN AS THE
C     MINIMUM OF 15 PER CENT OF GROSS INCOME OR 50 PER CENT NET INCOME.
C     NO MINIMUM TAX IS INCLUDED.

C     FIT   = U S FEDERAL INCOME TAX
C     SIT   = STATE INCOME TAX
C     OPLTN = DEPLETION CLAIMED
C     DPRN  = DEPRECIATION CLAIMED
C     HNET  = ONE HALF OF NET INCOME
C     CAPIN = CAPITAL INVESTMENT
C     RATE  = DISCOUNT RATE
C     TAXIN = TAXABLE INCOME
C     FACTOR= ANNUAL FACTOR FOR SYD DEPPECIATION

      COMMON /REAC/ RRATE,FEDR, PMTR,PITR, DEPLR
      COMMON /VARI/ ORE1(30), ORE2(30), WASTE(30), AVG1(30), AVG2(30),
     .              CMN1(30), CMN2(30), CMNW(30),BENUA(30),BENUV(30),
     .              BENOA(30),BENOV(30),FAILA(30), FAILV(30),CSTUA(30),
     .              CSTUV(30)
      COMMON /MISC/ SVAR(12,14), CF(30) , BNTOT, CSTOT, BNNET,
     .              UNITS(7,5)
      CAPIN=SVAR(3,14)
      FACTOR=(11.0-K)/55.0
      DPRN=CAPIN*FACTOR
      IF(DPRN.LE.0) DPRN=0

C     CALCULATE PERCENTAGE DEPLETION

      OPLTN=ORE1(K)*AVG1(K)/100.*SVAR(9,14)*SVAR(11,14)*1000.*0.15
      HNET=0.5*(BNNET-OPRN)

C     DETERMINE WHETHER PERCENTAGE OR ONE HALF OF NET IS GREATER

      IF(OPLTN.GE.HNET) OPLTN=HNET
      IF(OPLTN.LT.0) OPLTN=0

C     DETERMINE TAXABLE INCOME

      TAXIN=BNNET-OPLTN-DPRN

C     DETERMINE FEDERAL AND STATE TAXES

      FIT=0.4542*TAXIN-5878
      SIT=0.0572*TAXIN+267.2
      IF(FIT.LT.0) FIT=0
      IF(SIT.LT.0) SIT=0

C     DETERMINE ANNUAL CASH FLOW

      CF(K)=TAXIN-FIT-SIT+OPLTN+DPRN

C     COMPOUND THE INITIAL INVESTMENT FOR ONE PERIOD TO COMPENSATE FOR
C     THE DIFFERENTIAL IN TIMING

      IF(K.EQ.1) CF(1)=CF(1)-SVAR(3,14)*(1.0+RRATE)

      RETURN
      END
```

Fig 41 - A listing of URTAX subroutine supplied for case study

```
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   15

```
        198034.      198034.      198034.      198034.      198034.
        198034.      198034.      198034.      198034.      198034.
        198034.      198034.      198034.      198034.      198034.
```

        PRESENT VALUE OF TOTAL COST   FOR SIMULATIONS 1 THRU   15

```
         91348.       90952.       94940.       90581.       91043.
         90986.       95061.       95086.       91253.       91022.
         91182.       91211.       90882.       92634.       95305.
```

            SUMMARY OF BENEFITS AND COSTS FOR CASE   1

                AVERAGE PRESENT VALUE OF BENEFITS   198034.

                STANDARD DEVIATION OF BENEFITS   0.

                AVERAGE PRESENT VALUE OF COSTS   92232.

                STANDARD DEVIATION OF COSTS   1844.

Fig 42 - Summary of BNCST results for 38° interramp slope design

```
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   15

```
        198034.      198034.      198034.      198034.      198034.
        198034.      198034.      198034.      198034.      198034.
        198034.      198034.      198034.      198034.      198034.
```

        PRESENT VALUE OF TOTAL COST   FOR SIMULATIONS 1 THRU   15

```
        102372.       95126.       94570.       96888.       95545.
         93071.       95463.       96527.      102061.       97051.
         96016.       96572.       95354.       97612.       93404.
```

            SUMMARY OF BENEFITS AND COSTS FOR CASE   2

                AVERAGE PRESENT VALUE OF BENEFITS   198034.

                STANDARD DEVIATION OF BENEFITS   0.

                AVERAGE PRESENT VALUE OF COSTS   96509.

                STANDARD DEVIATION OF COSTS   2640.

Fig 43 - Summary of BNCST results for 45° interramp slope design

```
SUMMARY OF INCREMENTAL CHANGE
IN NPV AMONG CASES (IN 1000 UNITS)
==================================
```

CASE NUMBER	TOTAL NPV	INCREMENTAL NPV	STD.DEV. OF INCREMENT
2	101526.	0.	0.
1	105802.	4276.	189.

Fig 44 - Summary of change in NPV between cases

```
---SUMMARY OF THE SIMULATION RESULTS FOR THE PIT DESIGN NO  1
=============================================================
```

ANY PIT IN THE SOUTHWEST, 38 DEGREE INTERRAMP DESIGN

```
NPV MEAN VALUE =   78745000. DOLLARS
NPV STD. DEV. =     1558000. DOLLARS
```

PROBABILITY OF ACHIEVING AT LEAST THE VALUE SHOWN	NPV VALUE
1.00	75500000
.93	75750000
.93	76000000
.87	76250000
.87	76500000
.87	76750000
.87	77000000
.87	77250000
.73	77500000
.73	77750000
.73	78000000
.57	78250000
.67	78500000
.67	78750000
.47	79000000
.33	79250000
.33	79500000
.27	79750000
.27	80000000
.20	80250000
.07	80500000
.07	80750000
0.00	81000000

Fig 45 - Summary of INRISK results for 38° interramp design

```
---SUMMARY OF THE SIMULATION RESULTS FOR THE PIT DESIGN NO  2
■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■

        ANY PIT IN THE SOUTHWEST, 45 DEGREE INTERRAMP DESIGN



                    NPV  MEAN VALUE  =    75291000.  DOLLARS
                    NPV  STD. DEV.  =     1628000.  DOLLARS


            PROBABILITY OF ACHIEVING    ●
            AT LEAST THE VALUE SHOWN    ●    NPV    VALUE
            ●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
                        1.00           ●       72000000
                         .93           ●       72250000
                         .93           ●       72500000
                         .93           ●       72750000
                         .87           ●       73000000
                         .80           ●       73250000
                         .80           ●       73500000
                         .73           ●       73750000
                         .73           ●       74000000
                         .73           ●       74250000
                         .73           ●       74500000
                         .73           ●       74750000
                         .67           ●       75000000
                         .60           ●       75250000
                         .60           ●       75500000
                         .47           ●       75750000
                         .47           ●       76000000
                         .33           ●       76250000
                         .27           ●       76500000
                         .20           ●       76750000
                         .20           ●       77000000
                         .00           ●       77250000
```

Fig 46 - Summary of INRISK results for 45° interramp design

An examination of the results from the INRISK simulation, Fig 45 and 46, shows that for a given level of net present value, the probability of achieving at least that level is greater for the 38° design than for the 45° interramp design. The 38° design gives a better risk to return ratio for any level of risk suitable to management. This is due to the higher average net present value of the 38° design offsetting the slightly increased variance in net present value.

176. The results of the two computer programs must be examined in the light of intangibles that are not included in the analysis. In this case study, the intangibles are primarily instability costs that have not been explicitly accounted for in the cost models. These intangible costs derive primarily from any disruption to pit operations due to the initial adjustment to instability, eg, repositioning mobile equipment. Since the 38° interramp design reduces the expected amount of instability, it follows that this design will also be more desirable for operating.

177. Since the 38° design gives a higher average net present value after tax, a better risk to return ratio, and reduced intangible costs, the 38° interramp angle design is the recommended alternative.

EXHIBIT I
SUMMARY OF COST OF INSTABILITY MODELS
USED IN THE CASE STUDY

1. This summary consists of a description of the individual cost models used in the case study. Although specific to the study area, these models should prove useful as a guide for using cost models.

FULL-WALL COST OF INSTABILITY MODELS

Subroutine FHSL6

2. This subroutine calculates the finance charge for the waste mined previously to expose ore that has been delayed due to a step-out. The following formula is used:

$$C = P[(1 + r)^t - 1]$$

where C is the cost of instability, P is the cost of excavation, t is the length of time for which mining of the step-out is delayed and r is the interest rate. Subroutine FHSL6 calls subroutine ADD to modify the wall geometry and subroutine FHSL7 to check for excessively delayed material.

3. The assumptions are as follows. (a) Mining of delayed ore will commence 6 years after the step-out for the first sector; in all other sectors, the mining of delayed ore will be 5 years after the step-out. This coincides with the push-back schedule for each sector. (b) All charges accrue at the end of the compounding period. (c) The ratio of ore to waste is a constant 1:1.6 on a volume basis throughout the section above the step-out, although this may be modified by the user. (d) The elevation of the base of the ore zone is at 2750 ft. (e) The step-out will always occur in ore. All material below the step-out will also be ore. (f) A step-out below a pushback will not affect the area above the pushback and vice versa. (g) A step-out will occur over the full width of a cell. The stability of the entire sector will be increased by a step-out in any cell of that sector. (h) The step-out distance is 50 ft (15.24 m).

Subroutine FHSL7

4. This subroutine calculates the cost of a crash stripping program necessitated by excessive delay in excavating ore or waste. The full cost of the stripping is charged since the value of income received more than 20 years in the future is minimal.

5. The assumptions are as follows. (a) There is a 10% excess stripping capacity with present equipment, and use of overtime labor is possible. (b) Stripping charge by the contractor is 200% of the normal waste mining cost. (c) Extra stripping will be performed by the mining company if it is less than 10% of the annual capacity. (d) Stripping by contractor will commence if the total combined delayed ore from one or more step-outs exceeds 6 months + 10% capacity, or the total delayed waste exceeds 6 months + 10% capacity. (e) For the case of delayed ore, the amount of stripping will be 1.6 x the amount of ore delayed. (f) Increased stripping caused by the crash program will be made up by decreased waste stripping at the end of mine life. This will be at least 20 years in the future.

Subroutine FHSL8

6. This is control subroutine for the cost model of full wall instability above a pushback. It calls the appropriate cost models to determine the cost of instability.

Subroutine FHSL9

7. This is the cost model control subroutine for full wall instability in the main pit wall. It calls the appropriate cost models to determine the cost of instability.

Subroutine ADD

8. This subroutine accounts for the reduction in overall slope angle caused as the result of a step-out. The routine performs a second-stage sampling on the wall geometry modified by all previous step-outs using the same random number generated in the first stage. The modified wall geometry represents the actual pit geometry as the result of prior step-outs; the original sampling

in the main portion of the BNCST is based on the original wall geometry. Since the occurrence of instability cannot be predicted, the original input geometry cannot reflect the presence of step-outs.

9. If the second stage results in instability, the step-out distance is recorded for subsequent years. The control returns to subroutine FHSL6 to compute the instability cost. If the second stage results in no instability, then the control returns to the main program and no instability is recorded.

INTERRAMP COST OF INSTABILITY MODELS

Subroutine IHWK1

10. This subroutine calculates the cost of reestablishing an unstable haul road by digging back to the next working bench of width greater than the haul road width. The instability cost is determined as the difference in present value between excavating material now compared to less excavation in the future, as given in the following formula.

$$C = C_u \times V \times [1 - (1 + r)^{-t}]$$

where C is the cost of instability, C_u is the unit cost of mining unstable material, V is the volume of material to be removed, r is the interest rate, and t is the time period until the amount of excavation is offset by less excavation in the future.

11. The assumptions are as follows. (a) In the 1st sector, the increased material that is mined now is assumed to be offset by a decrease in 6 years. Otherwise, the extra material is offset by reduced excavation occurring in 5 years from the instability. (b) The unit charge for this excavation will be at 115% of the current waste mining cost. (c) The full width of the ramp will be excavated. (d) The grade of the ramp is 10%. (e) The amount of excavation is assumed to be as if the ramp were cut at its mid-point, ie which is an average value.

Subroutine IHWK2

12. This subroutine determines the cost of cleaning up unstable material from an interramp wall above a haul road. The cost formula is similar to that of subroutine IHWK1 except the volume of excavation is replaced by the volume of unstable material.

13. The assumptions are as follows. (a) The material to be cleaned up is contained between the dip of the daylighted discontinuity and the slope angle. (b) The width of unstable material will be half the width of the interramp cell. (c) The unit cost of cleanup will be 115% of the normal waste mining cost. (d) The increased waste material cleaned up now will be offset by decreased waste stripped in 5 years.

Subroutine IHWK3

14. This subroutine determines the cost of increased haulage distance due to the loss of a haulage ramp. The cost is determined as the product of the increased distance, amount of material moved and the haulage cost per ton-mile. Each of these parameters are preset for each period and each haul road in the subroutine. Since the instability of any cell containing a haul road will result in the loss of the entire road, all instabilities in a period after the first instability for a given haul road are set to zero cost.

Subroutine IHWK4

15. This subroutine determines the cost of establishing a temporary haul road by dumping fill material. The cost is estimated as the cost of reloading the fill material when the temporary ramp is removed, either in the course of normal mining operations or in the course of establishing a new permanent ramp. The temporary ramp is assumed in the study to be removed in the period following its establishment.

Subroutine IHWK5

16. This subroutine determines the cost of lost production, based on the duration of the loss

and the unit profit from the ore.

17. The assumptions are as follows: (a) There is no ore stockpile or excess mill capacity. Consequently, any delay in ore production is immediately reflected in the mill. This lost production cannot be made up by increased mine output at some later date. (b) The unit profit on the lost ore will be the average unit profit for ore scheduled for production during the year in which the instability occurs.

Subroutine IHWK8

18. This subroutine is the control routine for interramp instability above a pushback. It is similar to subroutine FHSL8. It also assigns the proper haul road to the unstable interramp wall above the pushback. This is necessitated by storage of the data on haul roads and interramp walls in different arrays within the BNCST program.

Subroutine IHWK9

19. This routine is the user-supplied control routine for interramp instability in the main pit wall. It is similar to subroutine FHSL8. In addition, subroutine IHWK9 assigns the proper haul road to the unstable interramp wall in the main pit wall.

EXHIBIT 2

TABULATION OF COST MODELS
USED IN EACH YEAR OF CASE STUDY

SUMMARY OF COST OF INSTABILITY TYPES BY SUBROUTINE

Sector I

FULL WALL (all periods)
(a) Main pit wall - FHSL6
(b) Above pushback - FHSL6

INTERRAMP WALL
(a) Main pit wall

Period	Interramp Wall No. (between two ramps)		
	1	2	3
1,2,3	IHWK2	IHWK3	-
4	IHWK2	IHWK2	IHWK1
5	--	IHWK2	IHWK4
7	IHWK2, IHWK5	IHWK4, IHWK5	-
8	IHWK2	IHWK1	-

(b) Above pushback

Period	Interramp Wall No. (between two ramps)		
	1	2	3
6,7	1HWK2	IHWK1	

Sector II

FULL WALL (all periods)
(a) Main pit wall - FHSL6
(b) Above pushback - FHSL6

INTERRAMP WALL
(a) Main pit wall

Period	Interramp Wall No.		
	1	2	3
2,3,4	IHWK2	IHWK2	-
5	IHWK3	IHWK3	-
7	1HWK2	IHWK1	-

(b) Above pushback

Period	Interramp Wall No.		
	1	2	3
6	--	IHWK2	IHWK1

Sector III

FULL WALL (all periods)
(a) Main pit wall - FHSL6
(b) Above pushback -FHSL6

INTERRAMP WALL
(a) Main pit wall

Period	Interramp Wall No.				
	1	2	3	4	5&6
3	--	--	IHWK3	IWWK3	-
4	--	--	--	--	IHWK2
5	IHWK3	IHWK3			
6,7	IHWK3	IHWK3	--	--	--
8,9	--	IHWK3	--	--	-
10	IHWK3,IHWK5	IHWKL1,IHWK5	--	--	-

(b) Above pushback

Period	Wall No.	
	1	2
6,7	IHWK3	IHWK3

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APPENDIX A

USERS' GUIDE FOR BENEFIT-COST PROGRAM

BNCST - VERSION III

PROGRAM IDENTIFICATION

PROGRAM TITLE: Benefit-Cost Model for Pit-Slope Design

PROGRAM CODE NAME: BNCST, Version III

PROGRAM COORDINATOR: Y. C. Kim

PROGRAM WRITER: T. E. Hall

PROGRAM DOCUMENTATION: T. E. Hall, W. Cassun

ORGANIZATION: Department of Mining and Geological Engineering
                            University of Arizona
                            Tucson, Arizona

DATE: 15 March 1976

UPDATES: Version III is a revision of Version II,
                            completed on 15 March 1975.

SOURCE LANGUAGE: CDC 6400 FORTRAN Extended and DEC 10 FORTRAN 40

                            Nonstandard features of FORTRAN used in the
                            program include:

                            1. Nonstandard Hollerith field delimiters.

                            2. Mixed-Mode Arithmetic.

AVAILABILITY: Pit Slope Group, Mining Research Laboratories,
                            Canada Centre for Mineral and Energy Technology,
                            Department of Energy, Mines and Resources,
                            555 Booth Street,
                            Ottawa, Canada K1A 0G1

DISCLAIMER: Neither the authors nor the Mining Research Lab-
                            oratories can accept any responsibility for the
                            accuracy of results generated by this program.

ABSTRACT

BNCST assesses incremental benefits and costs associated with a change in pit geometry. Wall geometry is expressed in terms of any combination of ultimate, interim, working, interramp and bench slopes.

Design sectors divide the pit into homogeneous areas with respect to slope stability and operational impact of instability. These sectors are processed as independent units in the program.

Reliability schedules, mining plans and cost of instability schedules must be provided for each design sector.

Monte Carlo simulation is used to produce representative variations in expected benefits and costs. Resultant distributions are suitable for input into a risk analysis (INRISK).

The program can be used for either a massive-type ore body, such as porphyry copper, or a strata-bound type, such as a coal deposit.

ENGINEERING DOCUMENTATION

Narrative Description

1. A narrative description of the benefit-cost analysis is described in the text. Some additional definitions are as follows.

2. Design Case is one of the alternate mine layouts under examination. Thus for each design sector, a case will require a reliability schedule, a mining production sequence, a pit geometry schedule and an instability cost schedule.

3. Benefits are the net revenue from mining and processing, exclusive of waste stripping and instability costs. The cost of mining should include all mining, processing, and ancillary costs to obtain the product for which the price has been given. For example, if the price for refined copper is given, all production costs through refining plus marketing should be included. In addition to benefits from the two ore types, the program allows for miscellaneous and user benefits which may be given in a separate user-supplied subroutine called BENF2 in the program.

4. Bottom of Ultimate Slope is the base of the current portion of the pit wall which is at the ultimate or final pit limit. The bottom of the ultimate slope must always be at an elevation greater than or equal to the pit bottom elevation (Fig A-1).

5. Pit Bottom is the current pit bottom elevation in that sector (see Fig A-1).

6. Sector Bottom is the final pit bottom that will be reached in that sector (see Fig A-1).

7. Costs arise from waste stripping, instability and other sources that the user manual specifies. Stripping costs are computed from the input data, instability costs are derived from the cost of instability models, and specified user costs come from a separate user-supplied sub-routine (COST2).

8. Ore Types are the possible ore categories allowed in the program, (Type 1 and Type 2). Each of these is handled independently and requires separate input data. Examples of different ore types are leached and sulphide ore in copper mines.

9. Wall Above Pushback is the portion of the pit wall from the top of the design sector to the pushback elevation, when a pushback is present.

10. Wall Below Pushback is the portion of the pit wall from the pushback elevation to the pit bottom, when a pushback is present. If there is no pushback present, then the entire wall is referred to as "below pushback". This is also referred to as the pit wall.

Method of Solution

11. This section supplements the text discussion of the benefit-cost analysis and contains the specific mechanics of determining wall geometry and reliability or probability of instability calculations used within the BNCST model.

12. Rules for Slope Angle Determination. Definitions of various slope angles such as bench angle, interramp wall angle and full wall angle are given in the text. The following variables are used in slope angle determination in the BNCST model: WD is the total width of a wall, WU_i is the width of the i-th ultimate wall segment, WI is the width of either an interim wall or an active wall, HT is the total height of a wall, HU_i is the height of the i-th ultimate wall segment, HI is the height of either an interim wall or an active wall, BENHT is the height of one bench, BENWD is the width of one bench or berm, BNKWD is the bank width (Fig A-2), HALWD is the width of one haul road, and WRKBN is the width of one work bench.

13. First, an interramp wall slope, C, is calculated on the basis of the height of the interramp wall and the bench geometry (Fig A-2). Specifically, the angle, C, in Fig A-2 is calculated using eq A-1 below.

$$C = \tan^{-1} (HT/WD) \qquad \text{eq A-1}$$

In the above equation, HT is the height of an interramp wall as shown in Fig A-2. The total width WD, as shown in Fig A-2 can be computed using eq A-2.

$$WD = HT/BENHT \times (BENWD + BNKWD) - BENWD \qquad \text{eq A-2}$$

Sector Top

Ultimate Slope

Bottom of Ultimate
Slope (ULTBT)

Interim Slope

Pit Bottom

Sector Bottom
(SECBT)
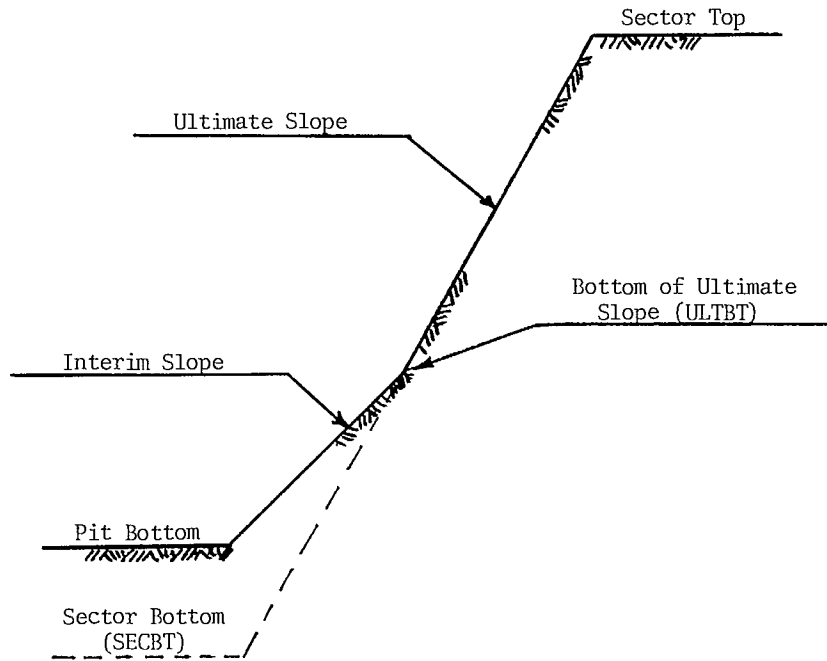
Fig A-1 - Definition of slope bottoms

Full Wall Top
or
Haul Road
or
Work Bench

Bench
Width

Bank
Width

Bench Angle

HT

Working Bench
or
Haul Road
or
Full Wall Bottom

Bench Height

C

WD
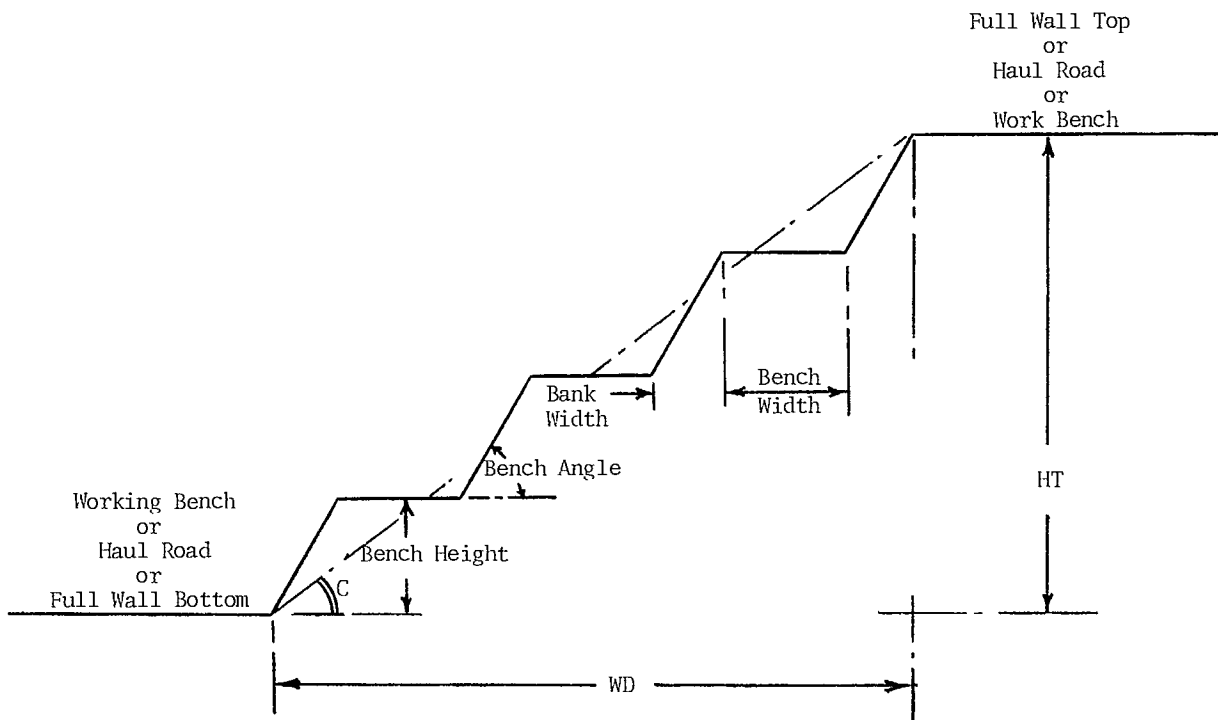
Fig A-2 - Components of interramp slope angle

14. In computing the full wall angle, there are three possible full wall slope configurations; namely, (1) no kink in the slope, (2) concave kink, and (3) convex kink. Although it is highly unlikely, a full wall may possess both concave and convex kinks. In such a situation, the lowest kink is the only one considered in the model for determining the full wall angle. When there is no possibility of a kink, the full wall angle can be computed using the geometry of the interramp walls with the addition of haul road and working bench widths. Eq A-3 below gives the desired width "WD" needed in the full wall angle computation.

$$WD = \frac{HT}{BENHT} \times (BENWD + BNKWD) + \sum HALWD + \sum WRKBN - BENWD \qquad \text{eq A-3}$$

The summations are for the wall under consideration, ie, full wall or interramp wall.

15. When there is a concave kink in the pit slope (Fig A-3), the full wall slope angle is the toe angle. The toe angle must be computed if the lowest segment of the wall is either an interim or an active wall having height HI (Fig A-3). Otherwise, the lowest segment of the wall is an ultimate wall, and the toe angle is obtained directly from the ultimate wall angle for that segment, ie, HU_i. Note that ultimate wall angles are input to the program at the beginning of program execution.

16. When there is a convex kink in the wall (Fig A-4), the resultant full wall slope angle must be computed using all the height and the width components shown in Fig A-4.

17. Hierarchical Sampling is done at each time period in a given sector. The sampling is based on slope height which, in turn, determines the particular scope of instability. Thus, a full wall slope is sampled before any interramp slope, and an interramp slope is sampled before any bench slope or weak stratum. The latter term refers to a particular part of a wall having a considerably weaker strength than the remainder.

18. This procedure avoids double counting since, by definition, instability in a higher order slope involves instability in each of its lower order components. It also has the desirable feature of sampling slopes in increasing order of slope angle.

19. Lower order slopes are bypassed when there is an instability in the current order. However, this bypassing is done only for the current period and only for the affected portions of lower order slopes. Benches in a stable interramp slope will be sampled, although there may be instability in another interramp slope in that sector.

20. Reliability or Probability of Instability for a given slope is determined by a linear interpolation between height and angle increments if the slope lies within the range of the schedule. If the slope lies beyond the range of the schedule, then a linear extrapolation is performed up to a limit of one increment beyond the range. If the schedule has 200 ft increments, with an upper bound of 1000 ft, then slope heights up to 1200 ft could be handled by extrapolation. For slopes beyond a one-increment extrapolation, a warning message is given.

Program Capabilities

21. The following is a list of the major program capabilities. If more than these capacities are required, the program can be redimensioned by the user.

Maximum periods	15
Maximum sectors	6
Maximum cases	5
Maximum haul roads/sectors	5
Maximum work benches/sector	1
Maximum number of instabilities/period (for each scope)	1
Maximum number of probability histograms	6
Maximum cost types/scope	9
Maximum number of ultimate wall angles	6

22. Production periods are usually one year; however, they may be of any interval, regular or irregular, convenient to the user. If nonannual periods are used, the model will sample for instability once per period for each input regardless of time elapsed. Reliability may have
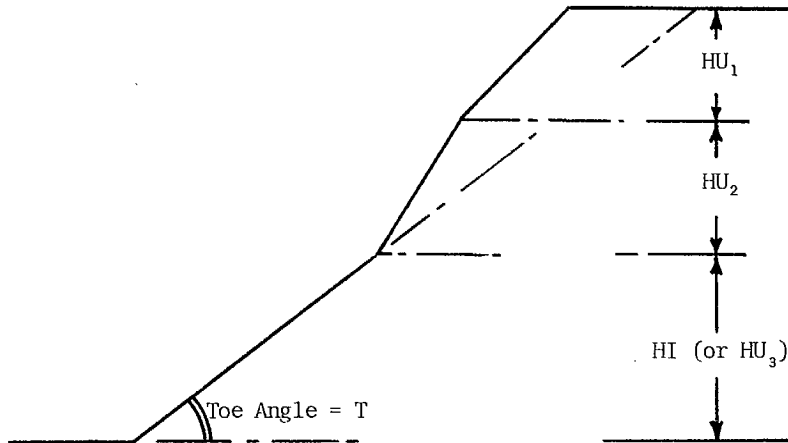
Full Wall Angle is Toe Angle

Fig A-3 - Full wall angle definition when there exists a concave kink in the slope (only the lowest kink is used for the determination)
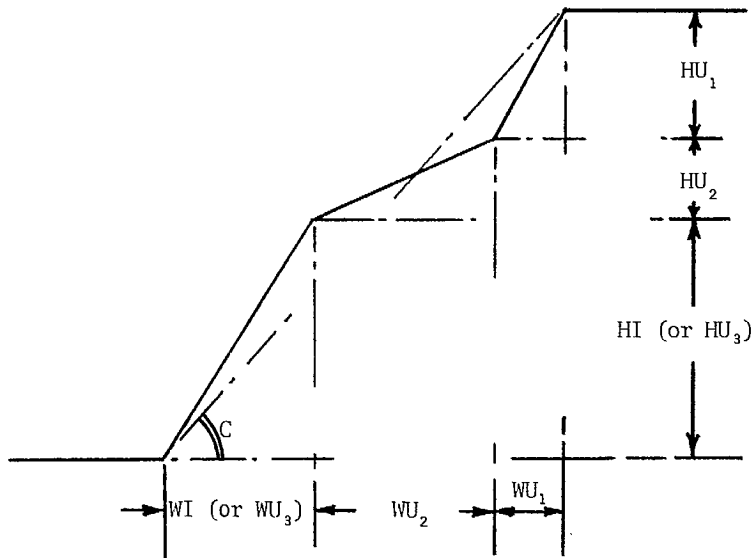
Full Wall Angle* is the Angle "C"

---

*It must be computed using all the height and width components shown above.

Fig A-4 - Full wall angle definition when there exists a convex kink in the slope (only the lowest kink is used for the determination)

to be adjusted to reflect the different sampling frequency. In addition, the discount rate must be adjusted to reflect non annual discounting.

23. Elevations may not be greater than 99998. The number 99999 is used to signify "no input value". Zero elevations as well as negative elevations are acceptable in the model.

24. Production tonnages in a given sector and period cannot exceed 99,999,000 tons; this constraint can be avoided by using a smaller sector or shorter time period.

25. It is emphasized that the program will handle any consistent set of units. If SI units are desired, all input data must be in SI units.

Data Input

26. The data required for the program is either common to all sectors or input for particular sectors. Data for each sector are required for each period, usually annually. A ditto feature is provided to eliminate the drudgery of repeating values which remain constant between periods. The program handles each separately in the READI routine. They must be input in the order shown although the data within each category may be in any order.

27. With the exception of stability probabilities and cost types, the data required for the model is that which would be determined in developing a mine plan - primarily annual production, grade, mining cost and pit configuration. Reliability data comes from stability analyses. The operational impact of any slope instability is required for the cost data.

28. The data input process can be greatly simplified if production figures for the entire pit can be aggregated into a single sector with corresponding values for the other sectors set at zero. This aggregation technique is valid only if one is interested in the total ore benefits and stripping costs for the pit as a whole. If for some reason, ore benefits and stripping costs must be localized, then the aggregation procedures cannot be used.

29. The cost of mining input should include all costs associated with production of the sale-able product in addition to the direct mining costs. These associated costs may include such items as milling, smelting, transportation, marketing and overhead.

30. Haulage ramps and work benches must be considered as being horizontal. Consequently, the midpoint elevation of a haulage ramp is used for specifying its location.

31. An 80-80 listing of input data for the Lucky Star deposit is shown in Fig A-5. Detailed descriptions of the input data are given in Exhibit A-1.

Program Options

32. The program provides a debugging option through the NDIAG variable which can provide the following results.

a. If NDIAG equals 0, then no intermediate results are output.

b. If NDIAG is greater than 0, then all full and interramp wall heights and angles are output.

c. If NDIAG is greater than or equal to 2, all wall geometry components are output in addition to the above intermediate results.

d. If NDIAG is greater than or equal to 3, all intermediate values for the probability of instability are given, in addition to the above intermediate results.

e. If NDIAG is greater than or equal to 4, then all haulage ramp and work bench elevations are given. The intermediate results printed are voluminous if NDIAG is equal to or greater than 4.

f. If NDIAG is greater than or equal to 6, then the values written on magnetic tape are output.

33. A ditto feature has been developed for data input to ease the chore of data preparation. For most input arrays, the value for any period before the first which is explicitly input is simply zeroed. Any period for which no value is input thereafter is given the previous period's value. This is done sequentially within each data storage array from the first period to the last. To have a zero value in the input data after a nonzero requires the explicit insertion of a zero.

AN 80-80 LISTING OF SAMPLE INPUT DATA
FOR THE BENEFIT COST MODEL BNCST, VERSION III

LUCKEY STAR DEPOSIT		BASE DESIGN 45 DEGREES ULTIMATE SLOPE				HIGH GRADE		INPUT COMMON TO ALL SECTORS
31 JULY 1977								
	30	30	1	3			0	
	0.45	0.70	120C.0	1200.0	31.5	12.2	12.0	12
SECTOR	1	2300						DATA SET TYPE 1
BENCH DIM.	40.0	40.0	60.0	120.0				
PROB								
1	0 200	400 600	800 1000	1200 3400	1600 1800			
1	0 .02	.04 .06	.09 .10	.105 .110	.115 .12	11.5		
1	0 .04	.14 .38	.22 .25	.27 .30	.335 .36	28.5		
1	0 .06	.17 .24	.29 .32	.35 .39	.445 .46	36.5		
1	0 .10	.26 .32	.36 .40	.45 .50	.58 .63	46.5		
	0 .13	.34 .41	.45 .49	.56 .62	.70 .76	60.0		
WEAK								
1	0 200	400 600	800 1000	1200 1400	1600 1800			
1	0 .02	.04 .06	.09 .10	.105 .330	.115 .12	11.5		
1	0 .04	.14 .18	.22 .25	.27 .30	.335 .36	28.5		
3	0 .06	.19 .24	.28 .32	.35 .39	.445 .46	36.5		
1	0 .10	.26 .32	.36 .40	.45 .50	.58 .63	46.5		
	0 .33	.34 .41	.45 .49	.56 .62	.70 .76	60.0		
PIT BOTTOM								
1	1 3420	2 3180	3 3020	4 2940	5 2820	6 2740	Active	
1	7 2700	8 2660	9 2540	10 2500	11 2340	12 2340		
ENO								
1	3 3420	7 3260	8 3060	9 2780	10 2740	11 2530	Ultimate	
1	12 2340							
END								
1	10 3100	11 3000	12 2900				Pushback	
WEAK								
	2 3320						Weak Strata Bottom	
INSTAB								
1	32 2	3 1	5 2			02 2		
1	43 2	3 4	2 2			02 2		
1DIT	5							
1	62 1	2 2	2			3 3		DATA SET TYPE 2
1	113 2	3 2	4 1			3 3		
1DIT	12							
PUSHBACK								
1	32 2	3 3	5 2			02 2		
1	43 2	3 4	2 2			02 2		
1DIT	5							
1	62 1	2 2	2			3 3		
1	113 2	3 2	4 1			3 3		
1DIT	12							
HAUL ROAD								
1	2 3220	3 3140	5 3020	6 2940			Highest	
ENO								
1	6 2760	7 2740	8 2700	9 2620			Next High Etc.	
ENO								
	11 2420							
WORK								
	2 3200	400						
ULTI								
	55.0 2800	45.0 2300						
STEES								
1	2 3420							
SWIO								
1	2 2000							
OPE2								
	2 480	3 1615	4 3811	6 4120	7 5048			
	8 5480	9 4472	10 5104	11 2061	12 231			
OPE1								
	2 420	3 5112	4 5590	5 5392	6 5336	7 5720		
	8 5592	9 5152	10 5192	11 4118	12 458			
WASTE TONS								
1	2 1597	3 5457	415435	514701	620913	728557		
1	834489	938467	1038072	1112430	12 0			
AVG2								
	2 0.25							
AVG1								
	2 0.34	3 0.51	4 0.58	5 0.65	6 0.74	7 0.67		
	8 0.53	9 0.47	10 0.46	11 0.55				
CMN2								
L 1	1 1.20	7 1.23	10 1.25					
CMN1								
S 1	1 2.55	7 2.60	10 2.65				BASE	
CMNW								
W 1	1 0.55	7 0.60	10 0.65				BASE	
MISC								
	2	144.55	244.55	344.55	444.55	544.55		
ENO SECTOR								
SECTOR	2	2300						DATA SET 1
BENCH DIM.	40.0	40.0	60.0	120.0				
PROB								
2DIT								
2DIT								
2DIT								
2DIT								
2DIT								
PIT BOT								
2	1 3180	3 3620						
2DIT	4	5	6	7	8	9		
2DIT	10	11						
2	32 2260							
ENO								
2	1 3380	5 3060	6 2980	7 2940	8 2820	9 2700	Active	
2	10 2580	11 2470	12 2360				Ultimate	
INSTAB								
1	32 2	3 1	5 2					
1	43 2	3 4	2 2					
1DIT	5							
1	62 1	2 2	2					DATA SET TYPE 2
1DIT	7							
1DIT	8							
1DIT	9							
1DIT	10							
1	113 2	3 2	4 1					
1DIT	12							
HAUL REG 2								
2	2 3220	3 3140	5 3020	8 2940				
ENO								
2	6 2760	7 2740	8 2700	9 2620				
STEES SEC 2								
	1 3400							
AVG2								
	2 0.25							
AVG1								
	2 0.34	3 0.51	4 0.58	5 0.65	6 0.74	7 0.67		
	8 0.53	9 0.47	10 0.46	11 0.55				
CMN2								
L 2	1 1.20	7 1.23	10 1.25					
CMN1								
S 2	1 2.55	7 2.60	10 2.65					
CMNW								
W 2	1 0.55	7 0.60	10 0.65				BASE	
END SECTOR								
STOP CASE								

SECTOR 1

CASE ONE – BASE DESIGN

SECTOR 2

Fig A-5 - A list of sample input data

A blank will not suffice.

34. Elevation data is handled in a special way. Any variable before the first value which is explicitly input for a period is set equal to the starting elevation of the sector (STELS) for that period. Exceptions from this rule are those elevation variable types which would not exist prior to the first period input; these are set to 99999. Thus, the value 99999 means there are no data. In particular, haul road and work bench elevations are assumed to exist only after the first input value has been read. If a haul road or work bench is removed from a sector during a period, this removal must be indicated by inserting 99999 in the input data for the period following immediately after. An example of the need for explicit zeroing of data is when no stripping occurs in the later years of the mine. These periods of no waste stripping must explicitly be set to zero; otherwise, the program will use the previous year's value.

35. All elevation data arrays are filled in the identical manner to that for other data arrays. That is, periods after the first for which a value is input are filled by, or set equal to, the previous period's value. To indicate the end of a road, 99999 must be inserted to avoid improper filling from the previous period.

36. In addition to the initializing and filling capabilities of the ditto feature, Type 2 data can be repeated from preceding sectors of the current case by use of either an ALL or DIT. It is left-justified in columns 6-8 of the record following the header card. An ALL signifies that all the data up to the next END or header card is to be repeated from the preceding sector's data, starting with the period on the ALL card through the last period of the design life. A DIT signifies that the data from the preceding sector is to be repeated for those periods (years) explicitly specified on the DIT card.

Printed Output

37. The BNCST program prints complete results for the first three simulations of each sector in a case. The results consist of the cost types which have occurred, instability costs by scope of instability, stripping costs and benefits of each period for the sector. A summary is printed for each sector, containing, (a) the number of unstable cells in each mode and, (b) the mean and standard deviation of the present value of all benefits and costs over all simulations.

38. A summary is also printed for each case considered, which consists of the present value of the benefits and the present value of the costs. The costs include both stripping and instability costs. The benefits are the net value from ore production less mining costs.

39. In addition to each case summary, a summary of the incremental change in net present value among cases is given. The increments are displayed in increasing order of the total net present value for the case.

40. The input data will be printed if the LPRT parameter equals 1. Typical output is shown in Exhibit A-2.

Special Files

41. An output file will be created on magnetic tape if the LWRT parameter equals 1. Structure of this file is discussed below.

Flow Charts

42. A macro flow chart for the BNCST routine is given in Fig A-6. Exhibit A-3 contains a micro flow chart of the COST1 and FCHK sub-routines.

Sample Runs

43. A sample run is given of a hypothetical porphyry copper deposit named the Lucky Star.

OPERATING SYSTEM DOCUMENTATION

Computer Equipment

44. The BNCST program was run on a CDC 6400 computer using 67K-core central memory. Approximate minimum central memory access time is 1.0μ sec. The program was also run on a DEC system 10 with a 256K-core memory. Only a few modifications are needed to change from the Control Data to the Digital Equipment machine, but the Digital machine
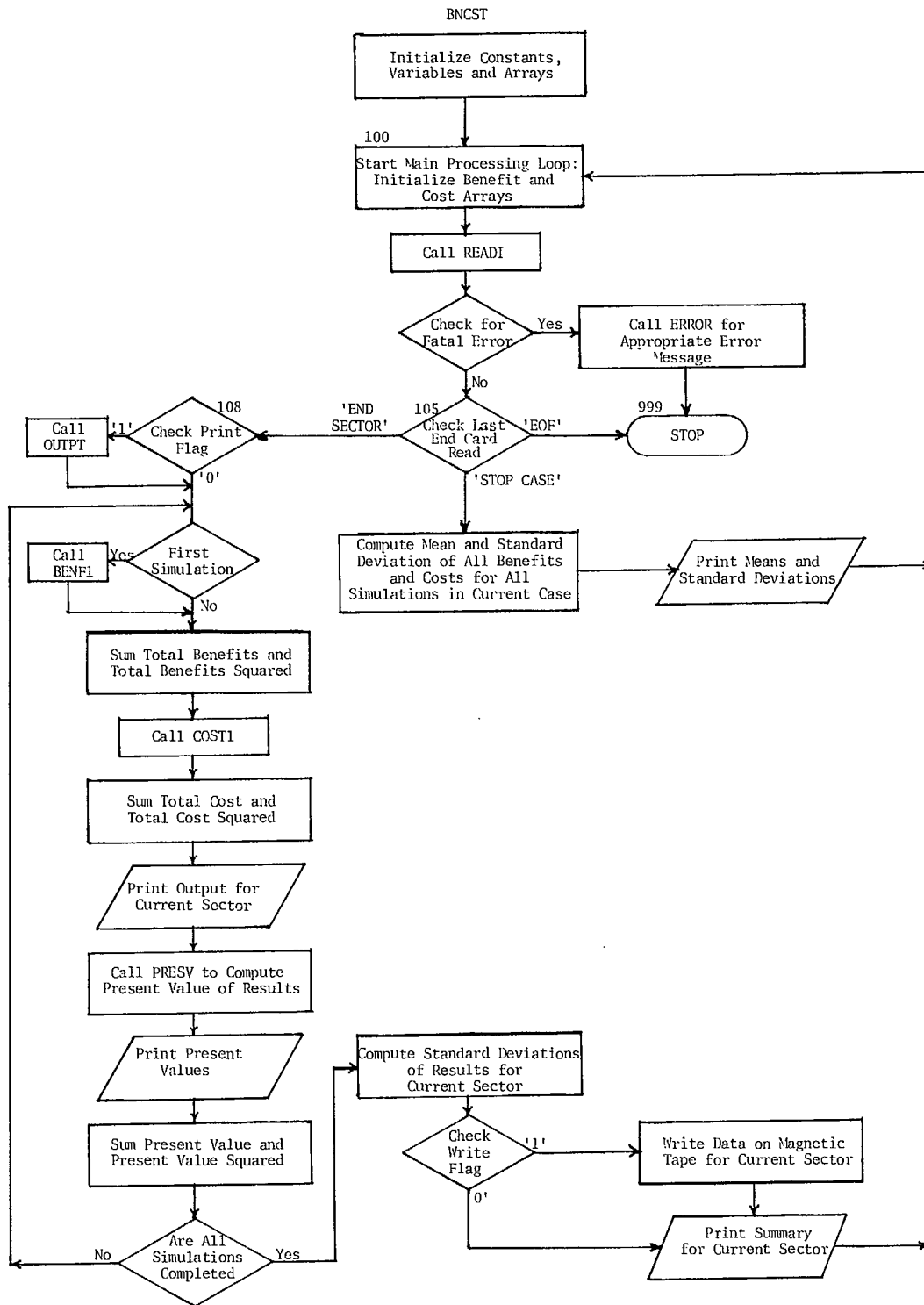
Fig A-6 - Macro-flow chart of BNCST program

maintains less mathematical accuracy because of a shorter word length.

Peripheral Equipment

45. The following peripheral equipment was used in the execution of the BNCST program: CDC 405 card reader, CDC 607 tape drive, CDC 512 line printer.

Source Program

46. Copies of the program listing and source card deck are available from:

Mining Research Laboratories
Canada Centre for Mineral & Energy Technology
Department of Energy, Mines & Resources
555 Booth Street
Ottawa, Canada   K1A 0G1

Variables and Subroutines

47. A listing of all variables used in the program is given in Exhibit A-4. The BNCST program consists of the following subroutines:

BNCST: main program for control of BNCST model.

READI: subroutine to read input data.

ERROR: subroutine to print error messages when errors occur in either input or execution.

OUTPT: subroutine to print input data if LPRT = 1.

COST1: subroutine to determine wall slope angles and wall heights, and to accumulate instability and stripping costs.

HWKCK: subroutine to add to the width of a full wall, the width of any haul road or work bench occurring within the wall. The subroutine is called only during full wall width computations.

FCHK: subroutine to sample for instabilities by Monte Carlo simulation and to compute the costs resulting from unstable cells in a wall.

FTYPE: subroutine to call the appropriate instability cost models.

PRESV: subroutine to determine Net Present Value of costs and benefits.

IDENT: function to identify header cards and return a numeric code.

FILL: subroutine to ditto prior period's data into missing periods, for two-dimensional array variables.

FILL1: subroutine to ditto prior period's data into missing periods, for one-dimensional array variables.

SORT: subroutine to sort net present value of each case for final summary of incremental NPV among cases.

48. In addition to the above subroutines, the program accesses the square root, tangent, arc tangent, random number and end of file functions provided by the CDC 6400 or DEC 10 system.

49. The relationship between subprograms is given in Fig A-7.

Data Structures

50. If the LWRT parameter is utilized to write on magnetic tape or any other device such as a disk, a file of data required for a financial risk analysis of the BNCST simulation is written on that device in a format compatible with the INRISK program. This data file serves as part of the input required by the INRISK program.

51. No other files are created or utilized by the BNCST program.

Storage Requirements

52. As presently structured, the BNCST program requires approximately 67 K storage on the CDC 6400.

Maintenance and Updates

53. BNCST, Version III, is an update of the BNCST, Version II program. The revision was undertaken to make a number of improvements in the model. A variable starting or top elevation and ultimate slopes were added. The number of haul roads per sector was increased to five. The option to input up to five work benches and their widths was added, both to make possible the definition of interramp walls and to account for the greatly varying widths of work benches. The haul roads and work benches together were used to define the limits of the interramp walls.

Name of Subprogram	Subprogram Used	Users of This Subprogram
BNCST	READI COST1 BENF1 ERROR PRESV OUTPT	NONE
READI	FILL FILL1 ERROR	BNCST
COST1	HWKCK FCHK	BNCST
BENF1	NONE	BNCST
ERROR	NONE	BNCST READI
OUTPT	NONE	BNCST
HWKCK	ERROR	COST1
FCHK	FTYPE	COST1
FTYPE	Cost-of-Instabilities Subroutines	FCHK
PRESV	NONE	BNCST
IDENT	NONE	READI
FILL	NONE	READI
FILL1	NONE	READI
SORT	NONE	BNCST

Fig A-7 - Subprograms used by main program BNCST and other subprograms

54. Each wall, whether full, interramp or bench, is now sampled for instability using the cell concept.

55. The number of probability schedules for a pit layout design was increased to six. Any part of the schedules may be used for any wall having the matching slope and height.

56. The number of ultimate wall slope angles was increased to six allowing greater flexibility in pit design.

57. The program was modified to make it independent of units used in the input data. It can therefore, accommodate any set of consistent units.

OPERATING DOCUMENTATION

Operating Instructions

58. The BNCST program is operated under the CDC 6400, SCOPE 3.4 operating system or the DEC System 10.

Operating Messages

59. Error messages produced by the program are self explanatory. In addition, normal system messages are produced.

Control Cards

60. The program may be executed with standard SCOPE 3.4 control cards. As run on the University of Arizona CDC 6400, the makeup of the input deck is as follows:

```
        Job card
        FTN.
        LGO.
        7/8/9 (end of file card)
        < SOURCE PROGRAM >
        7/8/9 (end of file card)
        < INPUT DATA >
        6/7/8/9 (end of job card)
```

61. The program may be compiled by DEC System 10 FORTRAN 40 and executed by the DEC 10 timeshare operating system by typing the following: .EXECUTE BNCST.

62. An example of an execution sequence for a pit containing three sectors is shown together with the DEC System 10 responses.

Printed on the Terminal	Explanation
.EXECUTE BNCST	Typed in by user
FORTRAN: BNCST	Compiling
LINK: LOADING	Loading
[LNKXCT BNCST EXECUTION]	
READING INPUT	Reading Sector 1 data
READING INPUT	Reading Sector 2 data
READING INPUT	Reading Sector 3 data
READING INPUT	Reading STOP CASE
READING INPUT	Reading EOF
END OF EXECUTION	DEC System 10
CPU TIME: 14:88	
ELAPSED TIME: 25.82	End message
EXIT	
.	

Error Recovery

63. If certain errors occur in the input data, the program will supply feasible values and continue execution of the program. A warning message will be printed giving cause of error and value supplied.

64. If a fatal error occurs in execution, there is no provision for restarting the program at an intermediate stage; consequently, the program must be rerun in its entirety after the error has been corrected.

Run Time

65. The sample run, consisting of the Lucky Star mine model, was completed in approximately 34 seconds on the CDC 6400 (13 seconds when run from object programs stored on disc files) and approximately 15 seconds on the DEC 10.

EXHIBIT A-1

INPUT DATA FOR THE BENEFIT COST MODEL--VERSION III

66. The input data required for the Benefit-Cost Program, version III, are grouped into three categories: (1) input data common to all sectors in a pit, (2) input data set Type 1 for each sector, and (3) input data set Type 2 for a sector. Fig A-8 shows the required sequence for data input. The model possesses many optional features intended to minimize the effort as well as the physical quantity of data input.

67. Refer to Exhibit A-4 for a description of the variables. A listing of typical data cards follows the description of input data.

Input Common to All Sectors

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

Title Card (1 Card - 20A4)

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

Date Card (1 Card - 5A4)

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

Fixed Variables (Card 1 - 8I10)

NSIM, MXCEL, LPRT, LWRT, LUSBN, LUSCT, NDIAG

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

REC1, REC2, PRICE, PRIC2, VOLO, VOLW, RATE, KLIFE

Input for Each Sector (Data Set Type 1)

69. 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 LD card and the Working Face card. These two cards may be in any order as long as each is present in the first sector's data set. Each card is read in with format (A4,6X,7F10.0).

Sector Card (1 Card)

1D, ISCN, SECBT

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

Working Face Card (1 Card)

ID, BENHT, BENWD, ANGBK, HALWD

70. 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.

Input for Each Sector (Data Set Type 2)

71. This second set of data cards follows the first for this sector. Within this set, input sequence is irrelevant for each kind of data, ie, probability distribution, haul road, etc. However, within each kind of data, a specific sequence must be followed as shown in the example, ie, 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.

Probability Distribution Cards

72. Format for all cards is (A4,1X,A3,2X, 11F5.0).

Header Card (1 Card)

PROB (the letters "PROB" punched in cols 1 to 4)

Numeric Data Cards (one height card followed by a
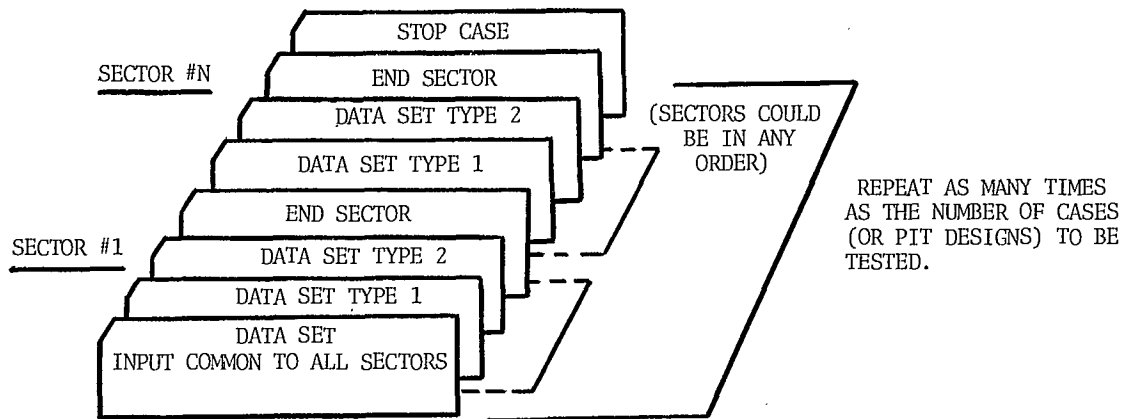
Fig A-8 - Input data deck arrangement

maximum of six probability cards).

ID, DIT, HEIT (J,1), J = 1, 10)

ID, DIT, (PROB (I,K,1), K = 1, 10), I = 1, MXPRB), PANG(I,1)

73. 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 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 there is none, the program ignores this field. It can therefore be used for the user's own identifications, ie, sector number and test case number. No special ending card is used.

74. 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 given under "PROB" above.

Header card
WEAK (the letters "WEAK" punched in cols 1 to 4)

Optional Ditto Feature

75. 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.

Instability Cost Type Cards

76. Format for all cards is (A4,1X,A3,2X,I5,I4 (I1,3X))

Header Card (1 Card)
INSTAB (the letters "INSTAB" punched in cols 1 to 6)

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

ID, DIT, KPD, MSTFH(KPD), (MSHWK(I,KPD), I = 1,12), MSBNB(KPD), MSWKB(KPD)

77. 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.

78. Periods prior to the earliest input will be zeroed, implying that no instability can occur during those periods. Any missing period that falls after the earliest 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.

Header Card (1 Card)
PUSHBACK (The letters "PUSHBACK" in cols 1 to 8)

Numeric Data Cards (as above)

79. If there is a pushback in the sector, the PUSHBACK header card must follow the last insta-bility card of this sector, followed by data containing instability types for the portion of wall above pushback bottom. In the program, whenever there is a pushback, the PUSHBACK header card is used to indicate the end of instability cost type data for the wall below pushback. The required numeric data for the pushback wall is the same as for a pit wall including Full Wall (MSTPB), Interramp Walls (MHWKP), Single Bench (MSBNA) and a Weak Stratum (MSWKA).

Optional Ditto Feature
80. DITTO in columns 6-10 means ditto instab-ility cost types of previous period for this period. It accomplishes the same purpose as the missing period in the input data stream.

Haul Road Election Cards
81. Format for all cards (A4,1X,A3,2X,6 (I5,F5.0)

Header Card (1 card)
HAUL ROADS (the letters "HAUL ROAD" punched

from col 1)

Numeric Data Cards (as many as required within each set).
ID, DIT, 6(KPD, HALEL(I,KPD))

End card
END (the letters "END" in cols 6 to 8)

Note that I in array HALEL corresponds to the number of the numeric data cards, ie, for card 1 in the set, I is 1, etc.

82. The first set of cards must contain ele-vations of the uppermost haul road in a sector by period during the mine life. Similarly, the second set of cards must contain elevations of the second highest haul road during each period. Therefore, the total number of sets required is the maximum number of haul roads present in that sector at any period of the 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.
83. Within each set of cards, one may contain elevations for up to six distinct periods. Missing periods are given the preceding period's value; if there is no preceding period elevations are set to 99999.
84. 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.

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

Header Card
WORK BENCH (from col 3)

Numeric Data Cards
ID, DIT, 4(KPD,WRKEL (I,KPD), WRKWD (I,KPD))

End card
END (from col 1)

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

Starting (Top) Elevation of Sector Cards

86. Format for all cards (A4,1X,A3,2X,6(I5, F5.0))

Header Card
    STELS (from col 1)

    ID, DIT, 6(KPD, STELS (KPD))

End card
    END (from col 1)

Each card may contain one to six periods. Missing periods are given the value for the preceding period; if there is no preceding period, the elevation for the period is set to 99999.

END after the last card is optional.

Sector Breadth Cards

87. Format for all cards (A4,1X,A3,2X,6(I5, F5.0))

Header Card
    SWID (from col 1)

Numeric data Cards
    ID, DIT, 6(KPD, SECWD(KPD))

Same as for Starting Elevations of Sector cards except if there is no preceding period the breadth is set to zero.

Pit Bottom Elevation Cards

88. Format for all cards (A4,1X,A3,2X,6(I5, F5.0))

Header Card
    PIT BOTTOM (from col 1)
Numeric data cards
    ID, DIT, 6(KPD,PITBT(KPD))

End card
    END (punched in cols 6 to 8)
Numeric data cards
    ID, DIT, 6(KPD,ULTBT(KPD))
End card
    END (punched in cols 6 to 8)
Numeric data cards
    ID, DIT, 6(KPD,ULTBT(KPD))

Weak stratum header card
    WEAK (punched in cols 1 to 4)
Numeric data cards
    ID, DIT, 6(KPD,WEKBT(KPD))

Three 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, and (3) pushback bottom elevations, if present. Each card may contain one to six periods for this sector. Missing periods are given the preceding period's input value; where there is no preceding period elevations are set to the corresponding Starting Elevation value.

89. If a weak stratum is to be tested, its bottom elevations must be given here following all other elevation cards and preceded by a WEAK Header card.

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

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

Ultimate Wall Angles and Elevations Card

92. Format for all cards (A4,1X,A3,2X,12F5.0)

Header card
    ULTIMATE (punched from col 1)

    LD, DIT, (ANGU(I),ULTDV(I)), I-1,6)

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.

Production Figures Cards

93. Format for all cards (A4,1X,A3,2X,6(I5, F5.0)). Values to be input in thousands. 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 for waste rock below.

Header card
  WASTE (punched from col 1)
Numeric data cards
  ID, DIT, 6(KPD, WASTE (1,KPD))
End card
  END (punched in cols 6 to 8)
Ore cards follow similarly, with the following header cards (punched from col 1)
  ORE1   Header card for Type 1 ore data
  ORE2   Header card for Type 2 ore data.

94. Each card may contain one to six periods for the sector. Missing periods are given the previous period's value, except where there was no previous period; its value is 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 mining ceases sooner than the life of the mine. In practice, it may be more convenient to lump production figures from the entire pit and assign these figures to one sector.

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

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

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

Mining Cost Cards (Cost/unit weight)

98. Format for all cards is (A4,1X,A3,2X,6 (I5,F5.0)). For each type of production figure that is 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. Header cards are as follows (punched from col 1):

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

Ore Grade Cards (Per cent)

99. Format for all cards (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. Header cards are as follows (punched from col 1):

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

Miscellaneous Data

100. Format for all cards (A4,1X,A3,2X,I10, 5E10.0)

Header card
  MISC (punched from col 1)

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

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

Names of Units Cards

101. Format for all cards is (A,1X,A3,A1,1X, 5A4); use of these cards is optional.

Header card

UNITS (punched from col 1)

Hollerith data card

ID, UID, EXT, (UNIT(I,J))J = 1,5)

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

UID	EXT	Default Name	Description
LEN	None	FOOT	Unit of linear measurement
VOL	None	CUBIC FT/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

End Control Cards

END SECTOR

Header or control card to signal the end of the 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.

EXHIBIT A-2

SAMPLE OUTPUT FROM BNCST, VERSION III

INPUT DATA SUMMARY FOR CASE NUMBER   1
===

ANY PIT IN THE SOUTHWEST, 38 DEGREE INTERRAMP DESIGN

STARTING DATE IS ANY TIME

        VARIABLES FIXED FOR ALL SECTORS.

                TYPE1 ORE PERCENT RECOVERY   .860

                TYPE2 ORE PERCENT RECOVERY   0.000

                PRICE PER TON   OF TYPE1   1280.00

                PRICE PER TON   OF TYPE2   1280.00

                VOLUME OF ORE   (CUBIC FEET PER TON)   12.50

                VOLUME OF WASTE (CUBIC FEET PER TON)   11.50

                TOTAL LIFE OF MINE (NUMBER OF PERIODS)   10

                INTEREST RATE PER PERIOD   .15

                NUMBER OF SIMULATIONS   15

            FLAGS

                USER BENEFIT ROUTINE FLAG   -0

                USER COST ROUTINE FLAG   -0

                MAGNETIC TAPE WRITE 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   FOOT

                VOLUME   CUBIC FEET PER TON

                WEIGHTS ORE/WASTE   TON

                    METAL/MINERAL   TON

                ANGLES   DEGREE

                INTEREST RATE   PERCENT

                MONEY   DOLLAR

```
SECTOR NUMBER        1
       OF CASE       1


    WORKING FACE.
        BENCHES ARE    50.0 UNITS HIGH
                AND    36.0 UNITS WIDE.
        ROADS   ARE   120.0 UNITS WIDE.


    BASIC WALL ANGLES.
        BENCH FACE ANGLE IS    60.0
        ULTIMATE WALL0 ANGLE  AND  BOTTOM ELEV.
                    45.0            4250.


    COUNT OF INPUT ITEMS.
        HAUL ROADS                4
        WORK BENCHES              0
        PROBABILITY DISTR.S       6
        PROB. DISTR.S (WEAK STRATUM)   0


PROBABILITY DISTRIBUTIONS

    PIT WALL DISTRIBUTION

                                    HEIGHTS.
      -0.    50.    100.   400.    800.  1200.    -0.     -0.     -0.     -0.

                              PROBABILITIES                              ANGLE
    -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000    0.00
    -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000   30.00
    -0.000  .039   .030   .012   .007   .002 -0.000 -0.000 -0.000 -0.000   38.00
    -0.000  .432   .418   .198   .142   .086 -0.000 -0.000 -0.000 -0.000   45.00
    -0.000  .585   .598   .575   .413   .251 -0.000 -0.000 -0.000 -0.000   55.00
    -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000   90.00


INSTABILITY COST TYPES FOR DIFFERENT WALLS.

    PERIOD   FULL HEIGHT        INTER RAMP WALLS        BENCH     WEAK STRATUM
      1          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0
      2          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0
      3          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0
      4          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0
      5          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0
      6          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0
      7          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0
      8          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0
      9          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0
     10          9          9 9 9 9 9 9 9 9 9 9-0-0       -0          -0

        PUSHBACK WALL INSTABILITY COST TYPES

    PERIOD   FULL HEIGHT        INTER RAMP WALLS        BENCH     WEAK STRATUM
      1          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
      2          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
      3          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
      4          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
      5          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
      6          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
      7          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
      8          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
      9          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
     10          8          8 8 8 8 8 8 8 8 8-0-0        -0          -0
```

```
PERIOO       SECTOR WIOTH
   1          275J.C
   2          28CJ.C
   3          2800.0
   4          2800.C
   5          2600.C
   6          28CJ.C
   7          280C.0
   8          28CC.C
   9          2600.C
  10          23CC.C
```

HAUL ROAO ELEVATIONS LISTEO FROM PIT TOP TO PIT BOTTOM.

PERIOO	ROAOO	1	2	3	4
1		3750.C	99999.0	99999.0	99999.C
2		3675.C	99999.0	99999.0	99999.U
3		375C.C	3750.C	328C.0	99999.U
4		4C5C.C	3750.0	3750.0	325J.0
5		4C5C.C	3725.0	33C0.0	3250.0
6		3975.0	3720.J	3275.0	3250.C
7		3975.C	3725.C	33CC.0	3250.C
8		3975.C	37JC.C	33CC.0	3250.0
9		3975.C	37CC.0	3275.0	3250.0
10		3975.C	37CC.0	3275.J	3250.0

PIT LIMIT ELEVATIONS.

PERIOO	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.	PUSHBACK BOTTOM ELEV.
1	38U0.	355C.	3800.	38JC.
2	4CCC.	340C.	4CCC.	4CCC.
3	4CCC.	315C.	4CCC.	4CCC.
4	415C.	305C.	415C.	415C.
5	415C.	305C.	415C.	415C.
6	415C.	285C.	415C.	38CC.
7	415C.	275C.	415C.	36CC.
8	415C.	275C.	415C.	34CC.
9	415C.	275C.	415C.	315C.
10	425C.	275C.	425C.	295C.

AMOUNT OF ROCK.

PERIOO	TYPE1 ORE	TYPE2 ORE	WASTE
1	3285000C.	0.	46767000.
2	3285CCCC.	0.	5330CuCC.
3	3285C0JC.	C.	53854uCC.
4	32853CCC.	u.	531C4CCC.
5	3285CCCC.	C.	56165CCC.
6	3285CC0C.	C.	54743CCC.
7	3285JCCC.	u.	56CCCCCC.
8	3285CCCC.	C.	54222CJC.
9	3285C0CC.	0.	527C6CCC.
10	3285CCCC.	C.	4935CCCC.

ORE GRADE AND COST OF MINING.

PERIOD	AVERAGE PERCENT ORE GRADE		COST OF MINING		
	TYPE1 ORE	TYPE2 ORE	TYPE1 ORE	TYPE2 ORE	WASTE
1	.450	0.000	3.810	0.000	.350
2	.460	0.000	3.850	0.000	.350
3	.440	0.000	3.700	0.000	.350
4	.440	0.000	3.900	0.000	.350
5	.470	0.000	3.900	0.000	.350
6	.470	0.000	3.830	0.000	.350
7	.450	0.000	3.790	0.000	.350
8	.470	0.000	4.030	0.000	.290
9	.520	0.000	4.220	0.000	.290
10	.520	0.000	4.220	0.000	.290

MISCELLANEOUS INPUT DATA.

PERIOD	VALUE 1	VALUE 2	VALUE 3	VALUE 4	VALUE 5
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

```
          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	37567.	0.	0.	0.	37567.
2	39869.	0.	0.	0.	39869.
3	37565.	0.	0.	0.	37565.
4	30995.	0.	0.	0.	30995.
5	41843.	0.	0.	0.	41843.
6	44143.	0.	0.	0.	44143.
7	38224.	0.	0.	0.	38224.
8	37573.	0.	0.	0.	37573.
9	49412.	0.	0.	0.	49412.
10	49412.	0.	0.	0.	49412.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	16368.	0.
2	18655.	0.
3	18849.	0.
4	18586.	0.
5	19658.	0.
6	19160.	0.
7	19600.	0.
8	15724.	0.
9	15285.	0.
10	14312.	0.

PERIOD	FULL WALL	COST OF INSTABILITY INTER RAMP	BENCH	WEAK STRATUM	TOTAL COST ALL TYPES
1	231.	0.	0.	0.	16599.
2	0.	2.	0.	0.	18657.
3	0.	0.	0.	0.	18849.
4	0.	132.	0.	0.	18719.
5	0.	0.	0.	0.	19658.
6	0.	282.	0.	0.	19442.
7	0.	1017.	0.	0.	21004.
8	0.	0.	0.	0.	16040.
9	0.	0.	0.	0.	15594.
10	0.	0.	0.	0.	14312.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	387.	0.	0.
8	0.	316.	0.	0.
9	0.	309.	0.	0.
10	0.	0.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS										BENCH	WEAK STRATUM
1	9	0	0	0	0	0	0	0	0	0	0	0	0
2	0	9	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	9	9	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	9	0	0	0	0	0	0	0	0	0	0
7	0	0	9	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES

													BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0		0	0
2	0	0	0	0	0	0	0	0	0	0	0		0	0
3	0	0	0	0	0	0	0	0	0	0	0		0	0
4	0	0	0	0	0	0	0	0	0	0	0		0	0
5	0	0	0	0	0	0	0	0	0	0	0		0	0
6	0	0	0	0	0	0	0	0	0	0	0		0	0
7	0	8	8	0	0	0	0	0	0	0	0		0	0
8	0	8	8	0	0	0	0	0	0	0	0		0	0
9	0	8	8	0	0	0	0	0	0	0	0		0	0
10	0	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	11	55	14	0	0	0	0	0	0	0	0	0	274
2	5	9	10	0	0	0	0	0	0	0	0	0	671
3	3	11	6	22	0	0	0	0	0	0	0	0	951
4	3	28	9	6	14	0	0	0	0	0	0	0	1231
5	2	26	8	6	52	13	0	0	0	0	0	0	1143
6	3	35	6	112	7	0	0	0	0	0	0	0	1455
7	3	9	56	6	0	0	0	0	0	0	0	0	1567
8	4	28	56	6	0	0	0	0	0	0	0	0	1567
9	7	7	0	0	0	0	0	0	0	0	0	0	1455
10	12	12	0	0	0	0	0	0	0	0	0	0	1379

PUSHBACK WALL CELLS

PERIOD													
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	16	16	0	0	0	0	0	0	0	0	0	0
7	0	16	11	22	0	0	0	0	0	0	0	0	0
8	0	16	10	9	0	0	0	0	0	0	0	0	0
9	0	15	9	6	104	26	0	0	0	0	0	0	0
10	0	8	8	5	92	8	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

PIT WALLS
FULL HEIGHT   3.
INTER RAMP   177.
SINGLE BENCH   4926.
WEAK STRATUM   0.

PUSHBACK WALLS
FULL HEIGHT   0.
INTER RAMP   151.
SINGLE BENCH   0.
WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
TOTAL BENEFIT =   198034.
TOTAL COST   =   90926.

RESULTS OF SIMULATION NUMBER   2
                    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	37567.	0.	0.	0.	37567.
2	39869.	0.	0.	0.	39869.
3	37565.	0.	0.	0.	37565.
4	30995.	0.	0.	0.	30995.
5	41843.	0.	0.	0.	41843.
6	44143.	0.	0.	0.	44143.
7	38224.	0.	0.	0.	38224.
8	37573.	0.	0.	0.	37573.
9	49412.	0.	0.	0.	49412.
10	49412.	0.	0.	0.	49412.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	16368.	0.
2	18655.	0.
3	18849.	0.
4	18586.	0.
5	19658.	0.
6	19160.	0.
7	19600.	0.
8	15724.	0.
9	15285.	0.
10	14312.	0.

PERIOD	FULL WALL	COST OF INSTABILITY INTER RAMP	BENCH	WEAK STRATUM	TOTAL COST ALL TYPES
1	0.	16.	0.	0.	16384.
2	0.	2.	0.	0.	18657.
3	0.	5.	0.	0.	18854.
4	0.	21.	0.	0.	18608.
5	0.	6.	0.	0.	19663.
6	0.	282.	0.	0.	19442.
7	0.	1017.	0.	0.	20636.
8	0.	0.	0.	0.	15743.
9	0.	0.	0.	0.	15594.
10	122.	0.	0.	0.	14434.

PUSHBACK WALL INSTABILITY COSTS

	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM
1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	19.	0.	0.
8	0.	18.	0.	0.
9	0.	309.	0.	0.
10	0.	0.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	9	0	0	0	0	0	0	0	0	0	0	0	0
2	0	9	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	9	0	0	0	0	0	0	0	0	0	0	0
4	0	9	0	9	0	0	0	0	0	0	0	0	0	0
5	0	0	0	9	0	0	0	0	0	0	0	0	0	0
6	0	0	9	0	0	0	0	0	0	0	0	0	0	0
7	0	0	9	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	9	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	8	0	0	0	0	0	0	0	0	0	0	0	0
8	0	8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	8	8	0	0	0	0	0	0	0	0	0	0	0
10	0	0	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	11	55	14	0	0	0	0	0	0	0	0	0	274
2	5	9	10	0	0	0	0	0	0	0	0	0	671
3	3	11	6	22	0	0	0	0	0	0	0	0	951
4	3	28	9	6	14	0	0	0	0	0	0	0	1231
5	2	26	8	6	52	13	0	0	0	0	0	0	1143
6	3	35	6	112	7	0	0	0	0	0	0	0	1455
7	3	9	56	6	0	0	0	0	0	0	0	0	1567
8	4	28	56	6	0	0	0	0	0	0	0	0	1567
9	7	7	0	0	0	0	0	0	0	0	0	0	1455
10	12	12	0	0	0	0	0	0	0	0	0	0	1379

PUSHBACK WALL CELLS

PERIOD														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	16	16	0	0	0	0	0	0	0	0	0	0	
7	0	16	11	22	0	0	0	0	0	0	0	0	0	
8	0	16	10	9	0	0	0	0	0	0	0	0	0	
9	0	15	9	6	104	26	0	0	0	0	0	0	0	
10	0	8	8	5	92	8	0	0	0	0	0	0	0	

COUNT OF UNSTABLE CELLS

PIT WALLS
    FULL HEIGHT   2.
    INTER RAMP   219.
    SINGLE BENCH   3747.
    WEAK STRATUM   0.

PUSHBACK WALLS
    FULL HEIGHT   0.
    INTER RAMP   148.
    SINGLE BENCH   0.
    WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
    TOTAL BENEFIT =   198034.
    TOTAL COST   =   90477.

```
RESULTS OF SIMULATION NUMBER          3
                    FOR SECTOR        1
                         CASE         1
```

BENEFITS (IN 1CCC DOLLAR   UNITS).
   BENEFIT FROM ORE IS NET AFTER COST OF MINING THE ORE

PERIOD	TYPE1 ORE	TYPE2 ORE	USER BENEFIT	MISC. BENEFIT	TOTAL
1	37567.	0.	0.	0.	37567.
2	39869.	0.	0.	0.	39869.
3	37565.	0.	0.	0.	37565.
4	30995.	0.	0.	0.	30995.
5	41843.	0.	0.	0.	41843.
6	44143.	0.	0.	0.	44143.
7	38224.	0.	0.	0.	38224.
8	37573.	0.	0.	0.	37573.
9	49412.	0.	0.	0.	49412.
1C	49412.	0.	0.	0.	49412.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	16368.	0.
2	18655.	0.
3	18849.	0.
4	18586.	0.
5	19658.	0.
6	19163.	0.
7	19600.	0.
8	15724.	0.
9	15285.	0.
10	14312.	0.

PERIOD	FULL WALL	COST OF INSTABILITY INTER RAMP	BENCH	WEAK STRATUM	TOTAL COST ALL TYPES
1	0.	16.	0.	0.	16384.
2	0.	2.	0.	0.	18657.
3	0.	5.	0.	0.	18854.
4	0.	29.	0.	0.	18616.
5	0.	4.	0.	0.	19662.
6	0.	282.	0.	0.	19442.
7	0.	1017.	0.	0.	20991.
8	0.	0.	0.	0.	15733.
9	0.	0.	0.	0.	15599.
10	122.	0.	0.	0.	15193.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	373.	0.	0.
8	0.	9.	0.	0.
9	0.	314.	0.	0.
10	0.	759.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	9	0	0	0	0	0	0	0	0	0	0	0	0
2	0	9	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	9	0	0	0	0	0	0	0	0	0	0	0
4	0	9	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	9	0	0	0	0	0	0	0	0	0	0	0
6	0	0	9	0	0	0	0	0	0	0	0	0	0	0
7	0	0	9	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	9	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	8	8	0	0	0	0	0	0	0	0	0	0	0
8	0	8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	8	8	0	0	0	0	0	0	0	0	0	0	0
10	0	8	8	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	11	55	14	0	0	0	0	0	0	0	0	0	274
2	5	9	10	0	0	0	0	0	0	0	0	0	671
3	3	11	6	22	0	0	0	0	0	0	0	0	951
4	3	28	9	6	14	0	0	0	0	0	0	0	1231
5	2	26	8	6	52	13	0	0	0	0	0	0	1143
6	3	35	6	112	7	0	0	0	0	0	0	0	1455
7	3	9	56	6	0	0	0	0	0	0	0	0	1567
8	4	28	56	6	0	0	0	0	0	0	0	0	1567
9	7	7	0	0	0	0	0	0	0	0	0	0	1455
10	12	12	0	0	0	0	0	0	0	0	0	0	1379

PUSHBACK WALL CELLS

PERIOD													
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	16	16	0	0	0	0	0	0	0	0	0	0
7	0	16	11	22	0	0	0	0	0	0	0	0	0
8	0	16	10	9	0	0	0	0	0	0	0	0	0
9	0	15	9	6	104	26	0	0	0	0	0	0	0
10	0	8	8	5	92	8	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

PIT WALLS
```
FULL HEIGHT      3.
INTER RAMP     227.
SINGLE BENCH  4080.
WEAK STRATUM     0.
```

PUSHBACK WALLS
```
FULL HEIGHT      0.
INTER RAMP     154.
SINGLE BENCH     0.
WEAK STRATUM     0.
```

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
```
TOTAL BENEFIT =   198034.
TOTAL COST    =    90600.
```

```
       SUMMARY OF ALL SIMULATIONS FOR SECTOR          1
                                    CASE             1
=======================================================

        AVERAGES AND STANDARD DEVIATIONS (IN 1000 DOLLAR    UNITS) FROM ALL SIMULATIONS.

    PERIOD     AVE. OF TOTAL BENEFITS     STD. DEV. OF TOTAL BENEFITS
      1           37567.26                              .00
      2           39869.39                              .00
      3           37564.63                              .00
      4           36994.63                              .00
      5           41843.02                              .00
      6           44142.52                              .00
      7           38224.26                              .00
      8           37572.52                              .00
      9           49411.66                              .00
     10           49411.66                              .00

    PERIOD     AVE. OF TOTAL COSTS       STD. DEV. OF TOTAL COSTS
      1           16427.18                            85.91
      2           18657.18                             2.41
      3           19028.20                           .664.39
      4           18690.08                            54.77
      5           19662.92                             2.84
      6           19310.63                           140.86
      7           20949.52                           123.46
      8           15978.93                           120.51
      9           15556.73                           102.73
     10           14968.51                           330.69


                         INPUT DATA SUMMARY FOR CASE NUMBER          1
                         =====================================================
    SECTOR NUMBER        2
          OF CASE        1


       WORKING FACE.
            BENCHES ARE     50.0 UNITS HIGH
                    AND     36.0 UNITS WIDE.
            ROADS   ARE    120.0 UNITS WIDE.


       BASIC WALL ANGLES.
            BENCH FACE ANGLE IS     60.0
            ULTIMATE WALL  ANGLE  AND  BOTTOM ELEV.
                         45.0               +250.


       COUNT OF INPUT ITEMS.
            HAUL ROADS                   2
            WORK BENCHES                 1
            PROBABILITY DISTR.S          6
            PROB. DISTR.S (WEAK STRATUM)    0
```

PROBABILITY DISTRIBUTIONS

PIT WALL DISTRIBUTION

				HEIGHTS					
-0.	50.	100.	400.	800.	1200.	-0.	-0.	-0.	-0.

				PROBABILITIES						ANGLE
-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.00
-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	30.00
-0.000	.001	.002	.003	.004	.004	-0.000	-0.000	-0.000	-0.000	38.00
-0.000	.016	.019	.030	.040	.040	-0.000	-0.000	-0.000	-0.000	45.00
-0.000	.109	.118	.130	.150	.150	-0.000	-0.000	-0.000	-0.000	55.00
-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	90.00

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
2	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
3	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
4	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
5	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
6	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
7	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
8	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
9	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
10	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0

PUSHBACK WALL INSTABILITY COST TYPES

PERIOD	FULL HEIGHT	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
2	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
3	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
4	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
5	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
6	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
7	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
8	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
9	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
10	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0

PERIOD	SECTOR WIDTH
1	2000.0
2	1750.0
3	1800.0
4	1500.0
5	1500.0
6	1500.0
7	1500.0
8	1600.0
9	1450.0
10	1500.0

HAUL ROAD ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	ROAD0 1	2
1	99999.0	99999.0
2	3900.0	99999.0
3	3825.0	99999.0
4	3900.0	3130.0
5	3900.0	3130.0
6	3150.0	99999.0
7	3130.0	99999.0
8	3130.0	3100.0
9	3130.0	99999.0
10	3130.0	99999.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1
1	99999.0	0.0
2	99999.0	0.0
3	99999.0	0.0
4	99999.0	0.0
5	99999.0	0.0
6	3350.0	250.0
7	3200.0	250.0
8	99999.0	-0.0
9	3100.0	250.0
10	2950.0	250.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.	PUSHBACK BOTTOM ELEV.
1	3950.	3550.	3950.	3950.
2	3950.	3350.	3950.	3950.
3	3950.	3200.	3950.	3950.
4	3950.	3000.	3950.	3950.
5	3950.	2950.	3950.	3600.
6	3950.	2850.	3950.	3950.
7	3950.	2750.	3950.	3950.
8	3950.	2750.	3950.	3950.
9	3900.	2750.	3900.	3900.
10	3800.	2750.	3800.	3800.

AMOUNT OF ROCK.

PERIOD	TYPE1 ORE	TYPE2 ORE	WASTE
1	0.	0.	0.
2	0.	0.	0.
3	0.	0.	0.
4	0.	0.	0.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	0.	0.	0.
9	0.	0.	0.
10	0.	0.	0.

ORE GRADE AND COST OF MINING.

	AVERAGE PERCENT ORE GRADE		COST OF MINING		
PERIOD	TYPE1 ORE	TYPE2 ORE	TYPE1 ORE	TYPE2 ORE	WASTE
1	0.00C	0.000	0.0C0	0.000	.350
2	0.000	C.000	C.000	0.000	.350
3	0.000	0.000	0.000	0.000	.350
4	0.000	0.000	0.000	0.000	.350
5	0.000	0.000	C.000	0.000	.350
6	0.000	0.000	0.000	0.000	.350
7	0.000	0.000	0.000	0.000	.350
8	0.000	0.000	0.000	0.000	.290
9	0.000	0.000	0.000	0.000	.290
10	0.000	0.000	0.000	0.000	.290

MISCELLANEOUS INPUT DATA.

PERIOD	VALUE 1	VALUE 2	VALUE 3	VALUE 4	VALUE 5
1	0.	0.	.376E+05	0.	0.
2	0.	0.	.399E+05	0.	0.
3	0.	0.	.376E+05	0.	0.
4	0.	0.	.310E+05	0.	0.
5	0.	0.	.418E+05	0.	C.
6	0.	0.	.441E+05	0.	0.
7	0.	0.	.382E+05	0.	0.
8	0.	0.	.376E+05	0.	0.
9	0.	0.	.494E+05	0.	0.
10	0.	0.	.494E+05	0.	0.

RESULTS OF SIMULATION NUMBER   1
FOR SECTOR   2
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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	C.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	C.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

| | COST OF INSTABILITY | | | | TOTAL COST |
PERIOD	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM	ALL TYPES
1	0.	0.	0.	0.	0.
2	0.	86.	0.	0.	86.
3	0.	0.	0.	0.	0.
4	0.	26.	0.	0.	26.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	9	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	9	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	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	5	0	0	0	5	0	0	0	0	0	0	0	319
2	3	35	0	0	3	0	0	0	0	0	0	0	419
3	2	14	0	0	3	0	0	0	0	0	0	0	539
4	2	30	2	12	0	0	0	0	0	0	0	0	569
5	2	3	8	0	0	0	0	0	0	0	0	0	599
6	1	3	8	5	0	0	0	0	0	0	0	0	659
7	1	2	21	4	0	0	0	0	0	0	0	0	719
8	1	2	53	5	0	0	0	0	0	0	0	0	767
9	1	2	48	4	0	0	0	0	0	0	0	0	666
10	1	2	8	8	0	0	0	0	0	0	0	0	629

PUSHBACK WALL CELLS

PERIOD

1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	30	5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

PIT WALLS
FULL HEIGHT   0.
INTER RAMP   15.
SINGLE BENCH   434.
WEAK STRATUM   0.

PUSHBACK WALLS
FULL HEIGHT   0.
INTER RAMP   3.
SINGLE BENCH   0.
WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
TOTAL BENEFIT =   0.
TOTAL COST   =   80.

RESULTS OF SIMULATION NUMBER   2
FOR SECTOR   2
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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

		COST OF INSTABILITY			TOTAL COST
PERIOD	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM	ALL TYPES
1	455.	0.	0.	0.	455.
2	0.	86.	0.	0.	86.
3	0.	0.	0.	0.	0.
4	0.	26.	0.	0.	26.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	9	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	9 9 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	9 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 0 0 0 0 0 0 0 0 0 0	0	0

PUSHBACK WALL COST TYPES

1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	0 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 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	5	0	0	0	5	0	0	0	0	0	0	0	319
2	3	35	0	0	3	0	0	0	0	0	0	0	419
3	2	14	0	0	3	0	0	0	0	0	0	0	539
4	2	30	2	12	0	0	0	0	0	0	0	0	569
5	2	3	8	0	0	0	0	0	0	0	0	0	599
6	1	3	8	5	0	0	0	0	0	0	0	0	659
7	1	2	21	4	0	0	0	0	0	0	0	0	719
8	1	2	53	5	0	0	0	0	0	0	0	0	767
9	1	2	48	4	0	0	0	0	0	0	0	0	666
10	1	2	8	8	0	0	0	0	0	0	0	0	629

PUSHBACK WALL CELLS

PERIOD														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	30	5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

PIT WALLS
    FULL HEIGHT   1.
    INTER RAMP   17.
    SINGLE BENCH   436.
    WEAK STRATUM   0.

PUSHBACK WALLS
    FULL HEIGHT   0.
    INTER RAMP   2.
    SINGLE BENCH   0.
    WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
    TOTAL BENEFIT =   0.
    TOTAL COST   =   476.

RESULTS OF SIMULATION NUMBER   3
FOR SECTOR   2
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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

PERIOD	FULL WALL	COST OF INSTABILITY INTER RAMP	BENCH	WEAK STRATUM	TOTAL COST ALL TYPES
1	0.	0.	0.	0.	0.
2	0.	86.	0.	0.	86.
3	0.	0.	0.	0.	0.
4	0.	7126.	0.	0.	7126.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0	0	0.	0
2	0	9	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	9	0	9	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	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	5	0	0	0	5	0	0	0	0	0	0	0	319
2	3	35	0	0	3	0	0	0	0	0	0	0	419
3	2	14	0	0	3	0	0	0	0	0	0	0	539
4	2	30	2	12	0	0	0	0	0	0	0	0	569
5	2	3	8	0	0	0	0	0	0	0	0	0	599
6	1	3	8	5	0	0	0	0	0	0	0	0	659
7	1	2	21	4	0	0	0	0	0	0	0	0	719
8	1	2	53	5	0	0	0	0	0	0	0	0	767
9	1	2	48	4	0	0	0	0	0	0	0	0	666
10	1	2	8	8	0	0	0	0	0	0	0	0	629

PUSHBACK WALL CELLS

PERIOD													
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	30	5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

    PIT WALLS
        FULL HEIGHT   0.
        INTER RAMP   19.
        SINGLE BENCH   430.
        WEAK STRATUM   0.

    PUSHBACK WALLS
        FULL HEIGHT   0.
        INTER RAMP   2.
        SINGLE BENCH   0.
        WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR UNITS)
        TOTAL BENEFIT =   0.
        TOTAL COST   =   4140.

```
        SUMMARY OF ALL SIMULATIONS FOR SECTOR          2
                                       CASE            1
===================================================================
```

AVERAGES AND STANDARD DEVIATIONS (IN 1000 DOLLAR   UNITS) FROM ALL SIMULATIONS.

PERIOD	AVE. OF TOTAL BENEFITS	STD. DEV. OF TOTAL BENEFITS
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	0.00	0.00
7	0.00	0.00
8	0.00	0.00
9	0.00	0.00
10	0.00	0.00

PERIOD	AVE. OF TOTAL COSTS	STD. DEV. OF TOTAL COSTS
1	30.31	113.40
2	86.32	.00
3	55.00	77.78
4	1914.47	3138.99
5	0.00	0.00
6	56.32	143.58
7	0.00	0.00
8	0.00	0.00
9	0.00	0.00
10	0.00	0.00

```
                    INPUT DATA SUMMARY FOR CASE NUMBER          1
                    ============================================
        SECTOR NUMBER          3
             OF CASE           1


        WORKING FACE.
             BENCHES ARE     50.0 UNITS HIGH
                    AND      36.0 UNITS WIDE.
             ROADS   ARE    120.0 UNITS WIDE.


        BASIC WALL ANGLES.
             BENCH FACE ANGLE IS    60.0
             ULTIMATE WALL ANGLE  AND  BOTTOM ELEV.
                         45.0            4250.


        COUNT OF INPUT ITEMS.
             HAUL ROADS                 4
             WORK BENCHES               1
             PROBABILITY DISTR.S        6
             PROB. DISTR.S (WEAK STRATUM)   0
```

PROBABILITY DISTRIBUTICNS

PIT WALL UISTRIBUTION

HEIGHTS

-0.	5J.	1CC.	4UC.	800.	1200.	-0.	-0.	-0.	-0.	

PROBABILITIES

										ANGLE
-0.000	-C.C00	-0.C00	-0.000	-C.000	-0.000	-0.000	-0.000	-0.000	-J.000	0.U0
-0.00C	-0.000	-0.C0C	-0.000	-0.00C	-0.000	-0.000	-0.003	-0.000	-0.C00	30.00
-C.000	.001	.002	.003	.004	.004	-0.000	-0.000	-0.330	-C.00J	38.00
-0.00C	.016	.019	.030	.040	.040	-0.000	-0.003	-0.000	-0.000	45.00
-0.000	.109	.118	.130	.150	.150	-0.000	-0.003	-0.000	-0.C00	55.00
-0.00C	-0.000	-0.000	-0.00C	-C.00C	-0.000	-0.000	-0.000	-0.000	-0.000	90.00

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
2	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
3	9	9 9 9 9 9 9 9 9 9-C-0	-0	-0
4	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
5	9	9 9 9 9 9 9 9 9 9-C-0	-0	-0
6	9	9 9 9 9 9 9 9 9 9-C-0	-0	-0
7	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
8	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
9	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
10	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0

PUSHBACK WALL INSTABILITY COST TYPES

PERIOD	FULL HEIGHT	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	8	8 8 8 8 8 8 8 8 8-C-0	-0	-0
2	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
3	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
4	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
5	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
6	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
7	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
8	8	8 8 8 8 8 8 8 8 8-C-0	-0	-0
9	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
10	8	8 8 8 8 8 8 8 8 8-C-0	-0	-0

PERIOD	SECTOR WIDTH
1	1405.0
2	1400.0
3	1400.C
4	1400.0
5	135J.C
6	1300.0
7	1350.0
8	1300.C
9	1300.3
10	1400.0

HAUL ROAD ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	ROADS 1	2	3	4
1	3850.0	3650.0	99999.0	99999.0
2	3825.0	3675.0	99999.0	99999.0
3	3825.0	3675.0	3325.0	99999.0
4	3825.0	3675.0	3300.0	3030.0
5	3825.0	3300.0	99999.0	99999.0
6	3825.0	3025.0	99999.0	99999.0
7	3825.0	3025.0	99999.0	99999.0
8	3825.0	3170.0	3050.0	3030.0
9	3850.0	3175.0	3025.0	99999.0
10	3825.0	3175.0	3025.0	99999.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1
1	99999.0	0.0
2	99999.0	0.0
3	99999.0	0.0
4	3940.0	250.0
5	99999.0	-0.0
6	99999.0	-0.0
7	99999.0	-0.0
8	99999.0	-0.0
9	99999.0	-0.0
10	99999.0	-0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.	PUSHBACK BOTTOM ELEV.
1	3950.	3550.	3950.	3950.
2	3950.	3350.	3950.	3950.
3	3950.	3200.	3950.	3950.
4	3950.	3050.	3950.	3950.
5	3950.	3050.	3950.	3600.
6	3950.	2850.	3950.	3350.
7	3950.	2750.	3950.	3200.
8	3950.	2750.	3950.	3950.
9	4150.	2750.	4150.	3000.
10	4150.	2750.	4150.	2900.

AMOUNT OF ROCK.

PERIOD	TYPE1 ORE	TYPE2 ORE	WASTE
1	0.	0.	0.
2	0.	0.	0.
3	0.	0.	0.
4	0.	0.	0.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	0.	0.	0.
9	0.	0.	0.
10	0.	0.	0.

ORE GRADE AND COST OF MINING.

PERIOD	AVERAGE PERCENT ORE GRADE		COST OF MINING		
	TYPE1 ORE	TYPE2 ORE	TYPE1 ORE	TYPE2 ORE	WASTE
1	0.000	0.000	0.000	0.000	.350
2	0.000	0.000	0.000	0.000	.350
3	0.000	0.000	0.000	0.000	.350
4	0.000	0.000	0.000	0.000	.350
5	0.000	0.000	0.000	0.000	.350
6	0.000	0.000	0.000	0.000	.350
7	0.000	0.000	0.000	0.000	.350
8	0.000	0.000	0.000	0.000	.290
9	0.000	0.000	0.000	0.000	.290
10	0.000	0.000	0.000	0.000	.290

MISCELLANEOUS INPUT DATA.

PERIOD	VALUE 1	VALUE 2	VALUE 3	VALUE 4	VALUE 5
1	0.	0.	.376E+05	0.	0.
2	0.	0.	.399E+05	0.	0.
3	0.	0.	.376E+05	0.	0.
4	0.	0.	.310E+05	0.	0.
5	0.	0.	.418E+05	0.	0.
6	0.	0.	.441E+05	0.	0.
7	0.	0.	.382E+05	0.	0.
8	0.	0.	.376E+05	0.	0.
9	0.	0.	.494E+05	0.	0.
10	0.	0.	.494E+05	0.	0.

RESULTS OF SIMULATION NUMBER   1
FOR SECTOR   3
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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

| | | COST OF INSTABILITY | | | TOTAL COST |
PERIOD	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM	ALL TYPES
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	165.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	1132.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	165.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	1132.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS										BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES

1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	8	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	8	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	4	14	7	14	0	0	0	0	0	0	0	0	223
2	2	11	9	4	0	0	0	0	0	0	0	0	335
3	2	11	9	4	11	0	0	0	0	0	0	0	419
4	2	28	19	9	4	6	0	0	0	0	0	0	503
5	2	5	5	0	0	0	0	0	0	0	0	0	485
6	3	4	7	0	0	0	0	0	0	0	0	0	571
7	3	8	5	0	0	0	0	0	0	0	0	0	647
8	1	10	2	11	65	5	0	0	0	0	0	0	623
9	5	5	0	0	0	0	0	0	0	0	0	0	727
10	9	9	0	0	0	0	0	0	0	0	0	0	783

PUSHBACK WALL CELLS

PERIOD

1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	11	6	0	0	0	0	0	0	0	0	0	0
6	0	10	3	0	0	0	0	0	0	0	0	0	0
7	0	11	2	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	4	2	9	52	0	0	0	0	0	0	0	0
10	0	4	2	9	11	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

PIT WALLS
    FULL HEIGHT   0.
    INTER RAMP   16.
    SINGLE BENCH   492.
    WEAK STRATUM   0.

PUSHBACK WALLS
    FULL HEIGHT   0.
    INTER RAMP   7.
    SINGLE BENCH   0.
    WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
    TOTAL BENEFIT =   0.
    TOTAL COST   =   342.

RESULTS OF SIMULATION NUMBER   2
            FOR SECTOR   3
                 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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

		COST OF INSTABILITY			TOTAL COST
PERIOD	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM	ALL TYPES
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	0 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 0 0 0 0 0 0 0 0 0 0	0	0

PUSHBACK WALL COST TYPES

1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	0 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 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	4	14	7	14	0	0	0	0	0	0	0	0	223
2	2	11	9	4	0	0	0	0	0	0	0	0	335
3	2	11	9	4	11	0	0	0	0	0	0	0	419
4	2	28	19	9	4	6	0	0	0	0	0	0	503
5	2	5	5	0	0	0	0	0	0	0	0	0	485
6	3	4	7	0	0	0	0	0	0	0	0	0	571
7	3	8	5	0	0	0	0	0	0	0	0	0	647
8	1	10	2	11	65	5	0	0	0	0	0	0	623
9	5	5	0	0	0	0	0	0	0	0	0	0	727
10	9	9	0	0	0	0	0	0	0	0	0	0	783

PUSHBACK WALL CELLS

PERIOD														
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	11	6	0	0	0	0	0	0	0	0	0	0
6	0	10	3	0	0	0	0	0	0	0	0	0	0
7	0	11	2	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	4	2	9	52	0	0	0	0	0	0	0	0
10	0	4	2	9	11	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

    PIT WALLS
        FULL HEIGHT   0.
        INTER RAMP   19.
        SINGLE BENCH   494.
        WEAK STRATUM   0.

    PUSHBACK WALLS
        FULL HEIGHT   0.
        INTER RAMP   5.
        SINGLE BENCH   0.
        WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
        TOTAL BENEFIT =   0.
        TOTAL COST   =   0.

        RESULTS OF SIMULATION NUMBER   3
                        FOR SECTOR   3
                             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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

		COST OF INSTABILITY			TOTAL COST
PERIOD	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM	ALL TYPES
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	0 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 0 0 0 0 0 0 0 0 0 0	0	0

PUSHBACK WALL COST TYPES

1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	0 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 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	4	14	7	14	0	0	0	0	0	0	0	0	223
2	2	11	9	4	0	0	0	0	0	0	0	0	335
3	2	11	9	4	11	0	0	0	0	0	0	0	419
4	2	28	19	9	4	6	0	0	0	0	0	0	503
5	2	5	5	0	0	0	0	0	0	0	0	0	485
6	3	4	7	0	0	0	0	0	0	0	0	0	571
7	3	8	5	0	0	0	0	0	0	0	0	0	647
8	1	10	2	11	65	5	0	0	0	0	0	0	623
9	5	5	0	0	0	0	0	0	0	0	0	0	727
10	9	9	0	0	0	0	0	0	0	0	1	0	783

PUSHBACK WALL CELLS

PERIOD													
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	11	6	0	0	0	0	0	0	0	0	0	0
6	0	10	3	0	0	0	0	0	0	0	0	0	0
7	0	11	2	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	4	2	9	52	0	0	0	0	0	0	0	0
10	0	4	2	9	11	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

```
    PIT WALLS
        FULL HEIGHT       0.
        INTER RAMP       17.
        SINGLE BENCH    494.
        WEAK STRATUM      0.

    PUSHBACK WALLS
        FULL HEIGHT       0.
        INTER RAMP        5.
        SINGLE BENCH      0.
        WEAK STRATUM      0.
```

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
```
        TOTAL BENEFIT =        0.
        TOTAL COST    =        0.
```

SUMMARY OF ALL SIMULATIONS FOR SECTOR   3
                                     CASE   1
==

                                            UNITS) FROM ALL SIMULATIONS.

AVERAGES AND STANDARD DEVIATIONS (IN 1000 DOLLAR

PERIOD	AVE. OF TOTAL BENEFITS	STD. DEV. OF TOTAL BENEFITS
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	0.00	0.00
7	0.00	0.00
8	0.00	0.00
9	0.00	0.00
10	0.00	0.00

PERIOD	AVE. OF TOTAL COSTS	STD. DEV. OF TOTAL COSTS
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	11.00	41.16
7	22.00	56.09
8	0.00	0.00
9	0.00	0.00
10	150.90	384.72

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 15

198034.	198034.	198034.	198034.	198034.
198034.	198034.	198034.	198034.	198034.
198034.	198034.	198034.	198034.	198034.

PRESENT VALUE OF TOTAL COST   FOR SIMULATIONS 1 THRU 15

91348.	90952.	94940.	90581.	91043.
90986.	95061.	95086.	91253.	91022.
91182.	91211.	90882.	92634.	95305.

SUMMARY OF BENEFITS AND COSTS FOR CASE   1

        AVERAGE PRESENT VALUE OF BENEFITS   198034.

        STANDARD DEVIATION OF BENEFITS   0.

        AVERAGE PRESENT VALUE OF COSTS   92232.

        STANDARD DEVIATION OF COSTS   1844.

```
        INPUT DATA SUMMARY FOR CASE NUMBER         2
        ==============================================
```

ANY PIT IN THE SOUTHWEST, 45 DEGREE INTERRAMP DESIGN

STARTING DATE IS ANY TIME

      VARIABLES FIXED FOR ALL SECTORS.

            TYPE1 ORE PERCENT RECOVERY   .860

            TYPE2 ORE PERCENT RECOVERY   0.000

            PRICE PER TON   OF TYPE1   1280.00

            PRICE PER TON   OF TYPE2   1280.00

            VOLUME OF ORE   (CUBIC FEET PER TON)   12.50

            VOLUME OF WASTE (CUBIC FEET PER TON)   11.50

            TOTAL LIFE OF MINE (NUMBER OF PERIODS)   10

            INTEREST RATE PER PERIOD   .15

            NUMBER OF SIMULATIONS   15

     FLAGS

            USER BENEFIT ROUTINE FLAG   -0

            USER COST ROUTINE FLAG   -0

            MAGNETIC TAPE WRITE 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   FOOT

            VOLUME   CUBIC FEET PER TON

            WEIGHT0 ORE/WASTE   TON

               METAL/MINERAL   TON

            ANGLES   DEGREE

            INTEREST RATE   PERCENT

            MONEY   DOLLAR

```
SECTOR NUMBER          1
      OF CASE          2


   WORKING FACE.
         BENCHES ARE      50.0 UNITS HIGH
                   AND    20.0 UNITS WIDE.
         ROADS    ARE    120.0 UNITS WIDE.


   BASIC WALL ANGLES.
         BENCH FACE ANGLE IS      60.0
         ULTIMATE WALL0 ANGLE  AND  BOTTOM ELEV.
                          45.0            4250.


   COUNT OF INPUT ITEMS.
         HAUL ROADS                      4
         WORK BENCHES                    C
         PROBABILITY DISTR.S             6
         PROB. CISTR.S (WEAK STRATUM)    0


   PROBABILITY DISTRIBUTIONS

         PIT WALL DISTRIBUTION

                                    HEIGHTS
         -C.    50.    1CC.    400.    80J.   12JJ.    -0.     -0.     -0.     -0.

                                    PROBABILITIES                                        ANGLE
    -0.000 -0.C00 -0.C70 -0.JJ0 -0.0U0 -0.003 -0.000 -0.000 -0.000 -0.J09       0.00
    -0.000 -0.000 -0.0C0 -0.0G0 -0.900 -0.303 -0.C00 -0.00C -0.J0C -0.L00      30.00
    -0.00C   .039   .030   .012   .0C7   .002 -0.003 -0.000 -0.000 -J.000      38.00
    -0.C0C   .432   .418   .196   .142   .C86 -0.000 -0.000 -0.000 -0.L00      45.0u
    -0.000   .585   .598   .575   .413   .251 -0.0C0 -C.0J0 -0.0J0 -0.C00      55.0C
    -C.00C -0.C00 -0.0u0 -C.006 -0.000 -0.800 -0.003 -J.0uu -0.000 -C.C00      9C.00


   INSTABILITY COST TYPES FOR DIFFERENT WALLS.

   PERIOD    FULL HEIGHT          INTER RAMP WALLS          BENCH    WEAK STRATUM
      1          9           9 9 9 9 9 9 9 9 9-0-0           -0          -0
      2          9           9 9 9 9 J 9 9 9 9-0-0           -J          -0
      3          9           9 9 9 9 9 9 9 9 9-0-0           -J          -0
      4          9           9 9 9 9 9 9 9 9 9-C-0           -0          -0
      5          9           9 9 9 9 9 9 9 9 9-0-0           -0          -0
      6          9           9 9 9 9 9 9 9 9 9-0-0           -0          -0
      7          9           9 9 9 9 J 9 9 9 9-0-0           -J          -0
      8          9           9 9 9 9 9 9 9 9 9-0-0           -9          -0
      9          9           9 9 9 9 9 9 9 9 9-C-0           -0          -J
     1C          9           9 9 9 9 J 9 9 9 9-0-0           -0          -J

         PUSHBACK WALL INSTABILITY COST TYPES

   PERIOD    FULL HEIGHT          INTER RAMP WALLS          BENCH    WEAK STRATUM
      1          8           8 8 8 8 8 8 8 8 8-0-0           -0          -0
      2          8           8 8 8 8 9 8 8 8 8-U-0           -C          -0
      3          8           8 8 8 8 8 8 8 8 8-0-J           -0          -0
      4          8           8 8 8 8 8 8 8 8 8-C-0           -J          -0
      5          8           8 8 8 8 8 8 8 8 8-0-u           -0          -0
      6          8           8 8 8 6 9 8 8 8 8-0-0           -0          -J
      7          8           8 8 3 8 8 8 8 8 8-C-J           -J          -0
      8          8           8 8 8 8 8 8 8 8 8-0-0           -0          -0
      9          8           8 8 8 8 8 8 8 8 8-0-0           -9          -0
     1C          8           8 8 3 8 8 8 8 8 8-C-0           -J          -0
```

```
PERIOD      SECTOR WIDTH
   1          2750.0
   2          2800.0
   3          2800.0
   4          2800.0
   5          2600.0
   6          2800.0
   7          2800.0
   8          2800.0
   9          2600.0
  10          2300.0
```

HAUL ROAD ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	ROAD 1	2	3	4
1	3750.0	99999.0	99999.0	99999.0
2	3675.0	99999.0	99999.0	99999.0
3	3750.0	3750.0	3280.0	99999.0
4	4050.0	3750.0	3250.0	99999.0
5	4050.0	3725.0	3300.0	3250.0
6	3975.0	3720.0	3275.0	3250.0
7	3975.0	3725.0	3300.0	3250.0
8	3975.0	3700.0	3300.0	3250.0
9	3975.0	3700.0	3275.0	3250.0
10	3975.0	3700.0	3275.0	3250.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.	PUSHBACK BOTTOM ELEV.
1	3800.	3550.	3800.	3800.
2	4000.	3400.	4000.	4000.
3	4000.	3150.	4000.	4000.
4	4150.	3050.	4150.	4150.
5	4150.	3050.	4150.	4150.
6	4150.	2850.	4150.	3800.
7	4150.	2750.	4150.	3600.
8	4150.	2750.	4150.	3400.
9	4150.	2750.	4150.	3150.
10	4250.	2750.	4250.	2950.

AMOUNT OF ROCK.

PERIOD	TYPE1 ORE	TYPE2 ORE	WASTE
1	32850000.	0.	44667000.
2	32850000.	0.	51200000.
3	32850000.	0.	51754000.
4	32850000.	0.	51904000.
5	32850000.	0.	54065000.
6	32850000.	0.	52643000.
7	32850000.	0.	53900000.
8	32850000.	0.	52122000.
9	32850000.	0.	50606000.
10	32850000.	0.	47250000.

ORE GRADE AND COST OF MINING.

PERIOD	AVERAGE PERCENT ORE GRADE		COST OF MINING		
	TYPE1 ORE	TYPE2 ORE	TYPE1 ORE	TYPE2 ORE	WASTE
1	.450	0.000	3.810	0.000	.350
2	.460	0.000	3.850	0.000	.350
3	.440	0.000	3.700	0.000	.350
4	.440	0.000	3.900	0.000	.350
5	.470	0.000	3.900	0.000	.350
6	.470	0.000	3.830	0.000	.350
7	.450	0.000	3.790	0.000	.350
8	.470	0.000	4.030	0.000	.290
9	.520	0.000	4.220	0.000	.290
10	.520	0.000	4.220	0.000	.290

MISCELLANEOUS INPUT DATA.

PERIOD	VALUE 1	VALUE 2	VALUE 3	VALUE 4	VALUE 5
1	0.	0.	.376E+05	0.	0.
2	0.	0.	.399E+05	0.	0.
3	0.	0.	.376E+05	0.	0.
4	0.	0.	.310E+05	0.	0.
5	0.	0.	.418E+05	0.	0.
6	0.	0.	.441E+05	0.	0.
7	0.	0.	.382E+05	0.	0.
8	0.	0.	.376E+05	0.	0.
9	0.	0.	.494E+05	0.	0.
10	0.	0.	.494E+05	0.	0.

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	37567.	0.	0.	0.	37567.
2	39869.	0.	0.	0.	39869.
3	37565.	0.	0.	0.	37565.
4	30995.	0.	0.	0.	30995.
5	41843.	0.	0.	0.	41843.
6	44143.	0.	0.	0.	44143.
7	38224.	0.	0.	0.	38224.
8	37573.	0.	0.	0.	37573.
9	49412.	0.	0.	0.	49412.
10	49412.	0.	0.	0.	49412.

COSTS (IN 1000 DOLLAR UNITS)

PERIOD	STRIPPING COST	USER COST
1	15633.	0.
2	17920.	0.
3	18114.	0.
4	17851.	0.
5	18923.	0.
6	18425.	0.
7	18865.	0.
8	15115.	0.
9	14676.	0.
10	13703.	0.

COST OF INSTABILITY

PERIOD	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM	TOTAL COST ALL TYPES
1	922.	0.	0.	0.	16556.
2	2656.	0.	0.	0.	20576.
3	0.	777.	0.	0.	18891.
4	0.	883.	0.	0.	18734.
5	0.	78.	0.	0.	19001.
6	0.	5455.	0.	0.	23880.
7	2665.	0.	0.	0.	22402.
8	2583.	0.	0.	0.	18089.
9	489.	0.	0.	0.	15568.
10	0.	0.	0.	0.	14604.

PUSHBACK WALL INSTABILITY COSTS

PERIOD				
1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	471.	0.	0.
8	0.	391.	0.	0.
9	0.	403.	0.	0.
10	0.	902.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	9	0 0 0 0 0 0 0 0 0 0 0	0	0
2	9	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 9 0 0 0 0 0 0 0 0 0	0	0
4	0	9 9 9 0 0 0 0 0 0 0 0	0	0
5	0	0 9 9 0 0 0 0 0 0 0 0	0	0
6	0	9 9 0 0 0 0 0 0 0 0 0	0	0
7	9	0 0 0 0 0 0 0 0 0 0 0	0	0
8	9	0 0 0 0 0 0 0 0 0 0 0	0	0
9	9	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 0 0 0 0 0 0 0 0 0 0	0	0

PUSHBACK WALL COST TYPES

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	0 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	8 8 0 0 0 0 0 0 0 0 0	0	0
8	0	8 8 0 0 0 0 0 0 0 0 0	0	0
9	0	8 8 0 0 0 0 0 0 0 0 0	0	0
10	0	8 8 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	11	55 0 0 0 14 0 0 0 0 0 0	274
2	5	9 0 0 0 10 0 0 0 0 0 0	671
3	3	11 6 0 22 0 0 0 0 0 0 0	951
4	3	28 9 6 14 0 0 0 0 0 0 0	1231
5	2	26 8 6 52 13 0 0 0 0 0 0	1143
6	3	35 6 112 7 0 0 0 0 0 0 0	1455
7	3	9 56 6 0 0 0 0 0 0 0 0	1567
8	4	28 56 6 0 0 0 0 0 0 0 0	1567
9	7	0 0 0 0 7 0 0 0 0 0 0	1455
10	12	0 0 0 0 12 0 0 0 0 0 0	1379

PUSHBACK WALL CELLS

```
PERIOD
   1        0      0  0  0  0   0  0  0  0  0  0  0        0
   2        0      0  0  0  0   0  0  0  0  0  0  0        0
   3        0      0  0  0  0   0  0  0  0  0  0  0        0
   4        0      0  0  0  0   0  0  0  0  0  0  0        0
   5        0      0  0  0  0   0  0  0  0  0  0  0        0
   6        0     16 16  0  3   0  0  0  0  0  0  0        0
   7        0     16 11 22  0   3  0  0  0  0  0  0        0
   8        0     16 10  9  0   0  0  0  0  0  0  0        0
   9        0     15  9  6 104  26  0  0  0  0  0  0       0
  1C        0      8  8  5  92  8  0  0  0  0  0  0        0
```

COUNT OF UNSTABLE CELLS

```
      PIT WALLS
          FULL HEIGHT        12.
          INTER RAMP        145.
          SINGLE BENCH      348.
          WEAK STRATUM        0.

      PUSHBACK WALLS
          FULL HEIGHT         0.
          INTER RAMP        189.
          SINGLE BENCH        0.
          WEAK STRATUM        0.
```

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
```
          TOTAL BENEFIT =    198034.
          TOTAL COST    =     95078.
```

```
      RESULTS OF SIMULATION NUMBER        2
                       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	37567.	0.	0.	0.	37567.
2	39869.	0.	0.	0.	39869.
3	37565.	0.	0.	0.	37565.
4	30995.	0.	0.	0.	30995.
5	41843.	0.	0.	0.	41843.
6	44143.	0.	0.	0.	44143.
7	38224.	0.	0.	0.	38224.
8	37573.	0.	0.	0.	37573.
9	49412.	0.	0.	0.	49412.
10	49412.	0.	0.	0.	49412.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	15633.	0.
2	17920.	0.
3	18114.	0.
4	17851.	0.
5	18923.	0.
6	18425.	0.
7	18865.	0.
8	15115.	0.
9	14676.	0.
10	13703.	0.

PERIOD	FULL WALL	COST OF INSTABILITY INTER RAMP	BENCH	WEAK STRATUM	TOTAL COST ALL TYPES
1	461.	0.	0.	0.	16095.
2	1328.	0.	0.	0.	19248.
3	0.	583.	0.	0.	18697.
4	0.	1100.	0.	0.	18951.
5	0.	42.	0.	0.	18965.
6	0.	5455.	0.	0.	23880.
7	2665.	0.	0.	0.	22017.
8	2583.	0.	0.	0.	18064.
9	1956.	0.	0.	0.	16985.
10	0.	0.	0.	0.	14488.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	487.	0.	0.
8	0.	365.	0.	0.
9	0.	353.	0.	0.
10	0.	786.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS .	BENCH	WEAK STRATUM
1	9	0 0 0 0 0 0 0 0 0 0 0	0	0
2	9	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 9 0 0 0 0 0 0 0 0 0	0	0
4	0	9 9 9 0 0 0 0 0 0 0 0	0	0
5	0	0 9 9 0 0 0 0 0 0 0 0	0	0
6	0	9 9 0 0 0 0 0 0 0 0 0	0	0
7	9	0 0 0 0 0 0 0 0 0 0 0	0	0
8	9	0 0 0 0 0 0 0 0 0 0 0	0	0
9	9	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 0 0 0 0 0 0 0 0 0 0	0	0

PUSHBACK WALL COST TYPES

1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	0 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	8 8 0 0 0 0 0 0 0 0 0	0	0
8	0	8 8 0 0 0 0 0 0 0 0 0	0	0
9	0	8 8 0 0 0 0 0 0 0 0 0	0	0
10	0	8 8 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	11	55	0	0	0	14	0	0	0	0	0	0	274
2	5	9	0	0	0	10	0	0	0	0	0	0	671
3	3	11	6	0	22	0	0	0	0	0	0	0	951
4	3	28	9	6	14	0	0	0	0	0	0	0	1231
5	2	26	8	6	52	13	0	0	0	0	0	0	1143
6	3	35	6	112	7	0	0	0	0	0	0	0	1455
7	3	9	56	6	0	0	0	0	0	0	0	0	1567
8	4	28	56	6	0	0	0	0	0	0	0	0	1567
9	7	0	0	0	0	7	0	0	0	0	0	0	1455
10	12	0	0	0	0	12	0	0	0	0	0	0	1379

PUSHBACK WALL CELLS

PERIOD													
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	16	16	0	0	0	0	0	0	0	0	0	0
7	0	16	11	22	0	0	0	0	0	0	0	0	0
8	0	16	10	9	0	0	0	0	0	0	0	0	0
9	0	15	9	6	134	26	0	0	0	0	0	0	0
10	0	8	8	5	92	8	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

```
    PIT WALLS
        FULL HEIGHT       10.
        INTER RAMP       143.
        SINGLE BENCH     348.
        WEAK STRATUM       0.

    PUSHBACK WALLS
        FULL HEIGHT        0.
        INTER RAMP       164.
        SINGLE BENCH       0.
        WEAK STRATUM       0.
```

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
```
        TOTAL BENEFIT =    198034.
        TOTAL COST    =     94022.
```

```
    RESULTS OF SIMULATION NUMBER        3
                    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	37567.	0.	0.	0.	37567.
2	39869.	0.	0.	0.	39869.
3	37565.	0.	0.	0.	37565.
4	30995.	0.	0.	0.	30995.
5	41843.	0.	0.	0.	41843.
6	44143.	0.	0.	0.	44143.
7	38224.	0.	0.	0.	38224.
8	37573.	0.	0.	0.	37573.
9	49412.	0.	0.	0.	49412.
10	49412.	0.	0.	0.	49412.

COSTS (IN 1000 DOLLAR   UNITS)

	STRIPPING	USER
PERIOD	COST	COST
1	15633.	0.
2	17920.	0.
3	18114.	0.
4	17851.	0.
5	18923.	0.
6	18425.	0.
7	18865.	0.
8	15115.	0.
9	14676.	0.
10	13703.	0.

	COST OF INSTABILITY				TOTAL COST
PERIOD	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM	ALL TYPES
1	1614.	0.	0.	0.	17247.
2	1328.	0.	0.	0.	19248.
3	0.	0.	0.	0.	18114.
4	0.	614.	0.	0.	18465.
5	0.	114.	0.	0.	19037.
6	3329.	0.	0.	0.	21754.
7	0.	1017.	0.	0.	20369.
8	1291.	0.	0.	0.	16797.
9	1467.	0.	0.	0.	16483.
10	0.	0.	0.	0.	14566.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	487.	0.	0.
8	0.	391.	0.	0.
9	0.	340.	0.	0.
10	0.	863.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	9	0	0	0	0	0	0	0	0	0	0	0	0	0
2	9	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	9	9	9	0	0	0	0	0	0	0	0	0	0
5	0	0	9	9	0	0	0	0	0	0	0	0	0	0
6	9	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	9	0	0	0	0	0	0	0	0	0	0	0
8	9	0	0	0	0	0	0	0	0	0	0	0	0	0
9	9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	8	8	0	0	0	0	0	0	0	0	0	0	0
8	0	8	8	0	0	0	0	0	0	0	0	0	0	0
9	0	8	8	0	0	0	0	0	0	0	0	0	0	0
10	0	8	8	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	11	55	0	0	0	14	0	0	0	0	0	0	274
2	5	9	0	0	0	10	0	0	0	0	0	0	671
3	3	11	6	0	22	0	0	0	0	0	0	0	951
4	3	28	9	6	14	0	0	0	0	0	0	0	1231
5	2	26	8	6	52	13	0	0	0	0	0	0	1143
6	3	35	6	112	7	0	0	0	0	0	0	0	1455
7	3	9	56	6	0	0	0	0	0	0	0	0	1567
8	4	28	56	6	0	0	0	0	0	0	0	0	1567
9	7	0	0	0	0	7	0	0	0	0	0	0	1455
10	12	0	0	0	0	12	0	0	0	0	0	0	1379

PUSHBACK WALL CELLS

PERIOD													
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	16	16	0	0	0	0	0	0	0	0	0	0
7	0	16	11	22	0	0	0	0	0	0	0	0	0
8	0	16	10	9	0	0	0	0	0	0	0	0	0
9	0	15	9	6	104	26	0	0	0	0	0	0	0
10	0	8	8	5	92	8	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

    PIT WALLS
        FULL HEIGHT   14.
        INTER RAMP   93.
        SINGLE BENCH   869.
        WEAK STRATUM   0.

    PUSHBACK WALLS
        FULL HEIGHT   0.
        INTER RAMP   170.
        SINGLE BENCH   0.
        WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
        TOTAL BENEFIT =   198034.
        TOTAL COST   =   92324.

SUMMARY OF ALL SIMULATIONS FOR SECTOR   1
                                    CASE   2
===

                                        UNITS) FROM ALL SIMULATIONS.
        AVERAGES AND STANDARD DEVIATIONS (IN 1000 DOLLAR

PERIOD	AVE. OF TOTAL BENEFITS	STD. DEV. OF TOTAL BENEFITS
1	37567.26	.00
2	39869.39	.00
3	37564.63	.00
4	30994.63	.00
5	41843.02	.00
6	44142.52	.00
7	38224.26	.00
8	37572.52	.00
9	49411.66	.00
10	49411.66	.00

PERIOD	AVE. OF TOTAL COSTS	STD. DEV. OF TOTAL COSTS
1	16786.22	366.96
2	19956.25	1069.75
3	18680.08	590.94
4	18476.90	284.95
5	19595.03	1487.77
6	23313.16	940.06
7	21698.88	1386.66
8	17217.79	770.26
9	15874.75	621.13
10	14487.52	187.58

```
                    INPUT DATA SUMMARY FOR CASE NUMBER          2
                    ======================================================
SECTOR NUMBER          2
        OF CASE        2


    WORKING FACE.
         BENCHES ARE    50.0 UNITS HIGH
                 AND    20.0 UNITS WIDE.
          ROADS  ARE   120.0 UNITS WIDE.


    BASIC WALL ANGLES.
          BENCH FACE ANGLE IS    60.0
          ULTIMATE WALL ANGLE   AND   BOTTOM ELEV.
                         45.0                  4250.


    COUNT OF INPUT ITEMS.
          HAUL ROADS                      2
          WORK BENCHES                    1
          PROBABILITY DISTR.S             6
          PROB. DISTR.S (WEAK STRATUM)    0


PROBABILITY DISTRIBUTIONS

    PIT WALL DISTRIBUTION


                                   HEIGHTS
       -0.    50.   100.   400.   800.  1200.    -0.     -0.    -0.    -0.


                               PROBABILITIES                              ANGLE
   -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000   0.00
   -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000  30.00
   -0.000   .031   .052   .003   .004   .004 -0.000 -0.000 -0.000 -0.000  38.00
   -0.000   .016   .019   .030   .040   .040 -0.000 -0.000 -0.000 -0.000  45.00
   -0.000   .109   .118   .130   .150   .150 -0.000 -0.000 -0.000 -0.000  55.00
   -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000  90.00


INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD     FULL HEIGHT           INTER RAMP WALLS          BENCH      WEAK STRATUM
   1            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0
   2            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0
   3            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0
   4            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0
   5            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0
   6            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0
   7            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0
   8            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0
   9            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0
  10            9          9 9 9 9 9 9 9 9 9 9-0-0          -0            -0

        PUSHBACK WALL INSTABILITY COST TYPES

PERIOD     FULL HEIGHT           INTER RAMP WALLS          BENCH      WEAK STRATUM
   1            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
   2            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
   3            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
   4            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
   5            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
   6            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
   7            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
   8            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
   9            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
  10            8          8 8 8 8 8 8 8 8 8 8-0-0          -0            -0
```

```
PERIOD      SECTOR WIDTH
  1           2000.0
  2           1750.0
  3           1800.0
  4           1500.0
  5           1500.0
  6           1500.0
  7           1500.0
  8           1600.0
  9           1450.0
 10           1500.0
```

HAUL ROAD ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

```
PERIOD    ROAD0    1              2
  1            99999.0        99999.0
  2             3900.0        99999.0
  3             3825.0        99999.0
  4             3900.0         3130.0
  5             3900.0         3130.0
  6             3150.0        99999.0
  7             3130.0        99999.0
  8             3130.0         3100.0
  9             3130.0        99999.0
 10             3130.0        99999.0
```

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

```
PERIOD    BENCH 1  WIDTH 1
  1       99999.0      0.0
  2       99999.0      0.0
  3       99999.0      0.0
  4       99999.0      0.0
  5       99999.0      0.0
  6        3350.0    250.0
  7        3200.0    250.0
  8       99999.0     -0.0
  9        3100.0    250.0
 10        2950.0    250.0
```

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.	PUSHBACK BOTTOM ELEV.
1	3950.	3550.	3950.	3950.
2	3950.	3350.	3950.	3950.
3	3950.	3200.	3950.	3950.
4	3950.	3000.	3950.	3950.
5	3950.	2950.	3950.	3600.
6	3950.	2850.	3950.	3950.
7	3950.	2750.	3950.	3950.
8	3950.	2750.	3950.	3950.
9	3900.	2750.	3900.	3900.
10	3800.	2750.	3800.	3800.

AMOUNT OF ROCK.

PERIOD	TYPE1 ORE	TYPE2 ORE	WASTE
1	0.	0.	0.
2	0.	0.	0.
3	0.	0.	0.
4	0.	0.	0.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	0.	0.	0.
9	0.	0.	0.
10	0.	0.	0.

ORE GRADE AND COST OF MINING.

PERIOD	AVERAGE PERCENT ORE GRADE		COST OF MINING		
	TYPE1 ORE	TYPE2 ORE	TYPE1 ORE	TYPE2 ORE	WASTE
1	0.000	0.000	0.000	0.000	.350
2	0.000	0.000	0.000	0.000	.350
3	0.000	0.000	0.000	0.000	.350
4	0.000	0.000	0.000	0.000	.350
5	0.000	0.000	0.000	0.000	.350
6	0.000	0.000	0.000	0.000	.350
7	0.000	0.000	0.000	0.000	.350
8	0.000	0.000	0.000	0.000	.290
9	0.000	0.000	0.000	0.000	.290
10	0.000	0.000	0.000	0.000	.290

MISCELLANEOUS INPUT DATA.

PERIOD	VALUE 1	VALUE 2	VALUE 3	VALUE 4	VALUE 5
1	0.	0.	.376E+05	0.	0.
2	0.	0.	.399E+05	0.	0.
3	0.	0.	.376E+05	0.	0.
4	0.	0.	.310E+05	0.	0.
5	0.	0.	.418E+05	0.	0.
6	0.	0.	.441E+05	0.	0.
7	0.	0.	.382E+05	0.	0.
8	0.	0.	.376E+05	0.	0.
9	0.	0.	.494E+05	0.	0.
10	0.	0.	.494E+05	0.	0.

RESULTS OF SIMULATION NUMBER   1
FOR SECTOR   2
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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

PERIOD	FULL WALL	COST OF INSTABILITY INTER RAMP	BENCH	WEAK STRATUM	TOTAL COST ALL TYPES
1	0.	0.	0.	0.	0.
2	0.	86.	0.	0.	86.
3	1598.	0.	0.	0.	1598.
4	0.	26.	0.	0.	26.
5	0.	0.	0.	0.	0.
6	0.	422.	0.	0.	422.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	2596.	0.	0.	0.	2596.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	9 0 0 0 0 0 0 0 0 0 0	0	0
3	9	0 0 0 0 0 9 0 0 0 0 0	0	0
4	0	9 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 9 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	9	0 0 0 0 0 0 0 0 0 0 0	0	0

PUSHBACK WALL COST TYPES

1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	0 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 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	5	0	0	0	5	0	0	0	0	0	0	0	319
2	3	35	0	0	3	0	0	0	0	0	0	0	419
3	2	14	0	0	3	0	0	0	0	0	0	0	539
4	2	30	2	0	12	0	0	0	0	0	0	0	569
5	2	3	8	0	0	0	0	0	0	0	0	0	599
6	1	3	8	5	0	0	0	0	0	0	0	0	659
7	1	2	21	4	0	0	0	0	0	0	0	0	719
8	1	2	53	5	0	0	0	0	0	0	0	0	767
9	1	2	48	4	0	0	0	0	0	0	0	0	666
10	1	2	3	8	0	0	0	0	0	0	0	0	629

PUSHBACK WALL CELLS

PERIOD														
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	30	5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

    PIT WALLS
        FULL HEIGHT   2.
        INTER RAMP   27.
        SINGLE BENCH   348.
        WEAK STRATUM   0.

    PUSHBACK WALLS
        FULL HEIGHT   0.
        INTER RAMP   3.
        SINGLE BENCH   0.
        WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
        TOTAL BENEFIT =   0.
        TOTAL COST   =   1955.

    RESULTS OF SIMULATION NUMBER   2
                    FOR SECTOR   2
                        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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

		COST OF INSTABILITY			TOTAL COST
PERIOD	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM	ALL TYPES
1	0.	0.	0.	0.	0.
2	0.	86.	0.	0.	86.
3	0.	0.	0.	0.	0.
4	0.	26.	0.	0.	26.
5	0.	0.	0.	0.	0.
6	0.	422.	0.	0.	422.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	9	0	0	0	0	0	0	0	0	0		0	0
3	0	0	0	0	0	0	0	0	0	0	0		0	0
4	0	9	0	0	0	0	0	0	0	0	0		0	0
5	0	0	0	0	0	0	0	0	0	0	0		0	0
6	0	9	0	0	0	0	0	0	0	0	0		0	0
7	0	0	0	0	0	0	0	0	0	0	0		0	0
8	0	0	0	0	0	0	0	0	0	0	0		0	0
9	0	0	0	0	0	0	0	0	0	0	0		0	0
10	0	0	0	0	0	0	0	0	0	0	0		0	0

PUSHBACK WALL COST TYPES

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0		0	0
3	0	0	0	0	0	0	0	0	0	0	0		0	0
4	0	0	0	0	0	0	0	0	0	0	0		0	0
5	0	0	0	0	0	0	0	0	0	0	0		0	0
6	0	0	0	0	0	0	0	0	0	0	0		0	0
7	0	0	0	0	0	0	0	0	0	0	0		0	0
8	0	0	0	0	0	0	0	0	0	0	0		0	0
9	0	0	0	0	0	0	0	0	0	0	0		0	0
10	0	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	5	0	0	0	5	0	0	0	0	0	0	0		319
2	3	35	0	0	3	0	0	0	0	0	0	0		419
3	2	14	0	0	3	0	0	0	0	0	0	0		539
4	2	30	2	0	12	0	0	0	0	0	0	0		569
5	2	3	8	0	0	0	0	0	0	0	0	0		599
6	1	3	8	5	0	0	0	0	0	0	0	0		659
7	1	2	21	4	0	0	0	0	0	0	0	0		719
8	1	2	53	5	0	0	0	0	0	0	0	0		767
9	1	2	48	4	0	0	0	0	0	0	0	0		666
10	1	2	8	8	0	0	0	0	0	0	0	0		629

PUSHBACK WALL CELLS

PERIOD														
1	0	0	0	0	0	0	0	0	0	0	0	0		0
2	0	0	0	0	0	0	0	0	0	0	0	0		0
3	0	0	0	0	0	0	0	0	0	0	0	0		0
4	0	0	0	0	0	0	0	0	0	0	0	0		0
5	0	30	5	0	0	0	0	0	0	0	0	0		0
6	0	0	0	0	0	0	0	0	0	0	0	0		0
7	0	0	0	0	0	0	0	0	0	0	0	0		0
8	0	0	0	0	0	0	0	0	0	0	0	0		0
9	0	0	0	0	0	0	0	0	0	0	0	0		0
10	0	0	0	0	0	0	0	0	0	0	0	0		0

COUNT OF UNSTABLE CELLS

PIT WALLS
    FULL HEIGHT   0.
    INTER RAMP   24.
    SINGLE BENCH   416.
    WEAK STRATUM   0.

PUSHBACK WALLS
    FULL HEIGHT   0.
    INTER RAMP   3.
    SINGLE BENCH   0.
    WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
    TOTAL BENEFIT =   0.
    TOTAL COST   =   263.

RESULTS OF SIMULATION NUMBER   3
          FOR SECTOR   2
              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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

PERIOD	FULL WALL	COST OF INSTABILITY INTER RAMP	BENCH	WEAK STRATUM	TOTAL COST ALL TYPES
1	0.	0.	0.	0.	0.
2	1023.	0.	0.	0.	1023.
3	0.	165.	0.	0.	165.
4	0.	26.	0.	0.	26.
5	0.	0.	0.	0.	0.
6	0.	422.	0.	0.	422.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	9	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	9 0 0 0 0 0 0 0 0 0 0	0	0
4	0	9 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 9 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 0 0 0 0 0 0 0 0 0 0	0	0

PUSHBACK WALL COST TYPES

1	0	0 0 0 0 0 0 0 0 0 0 0	0	0
2	0	0 0 0 0 0 0 0 0 0 0 0	0	0
3	0	0 0 0 0 0 0 0 0 0 0 0	0	0
4	0	0 0 0 0 0 0 0 0 0 0 0	0	0
5	0	0 0 0 0 0 0 0 0 0 0 0	0	0
6	0	0 0 0 0 0 0 0 0 0 0 0	0	0
7	0	0 0 0 0 0 0 0 0 0 0 0	0	0
8	0	0 0 0 0 0 0 0 0 0 0 0	0	0
9	0	0 0 0 0 0 0 0 0 0 0 0	0	0
10	0	0 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	5	0	0	0	5	0	0	0	0	0	0	0	319
2	3	35	0	0	3	0	0	0	0	0	0	0	419
3	2	14	0	0	3	0	0	0	0	0	0	0	539
4	2	36	2	0	12	0	0	0	0	0	0	0	569
5	2	3	8	0	0	0	0	0	0	0	0	0	599
6	1	3	8	5	0	0	0	0	0	0	0	0	659
7	1	2	21	4	0	0	0	0	0	0	0	0	719
8	1	2	53	5	0	0	0	0	0	0	0	0	767
9	1	2	48	4	0	0	0	0	0	0	0	0	666
10	1	2	8	8	0	0	0	0	0	0	0	0	629

PUSHBACK WALL CELLS

PERIOD													
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	70	5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

    PIT WALLS
        FULL HEIGHT   1.
        INTER RAMP   17.
        SINGLE BENCH   406.
        WEAK STRATUM   0.

    PUSHBACK WALLS
        FULL HEIGHT   0.
        INTER RAMP   4.
        SINGLE BENCH   0.
        WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
        TOTAL BENEFIT =   0.
        TOTAL COST   =   1080.

SUMMARY OF ALL SIMULATIONS FOR SECTOR   2
                                        CASE   2
==

                                                  UNITS) FROM ALL SIMULATIONS.

    AVERAGES AND STANDARD DEVIATIONS (IN 1000 DOLLAR

PERIOD	AVE. OF TOTAL BENEFITS	STD. DEV. OF TOTAL BENEFITS
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	0.00	0.00
7	0.00	0.00
8	0.00	0.00
9	0.00	0.00
10	0.00	0.00

PERIOD	AVE. OF TOTAL COSTS	STD. DEV. OF TOTAL COSTS
1	0.00	0.00
2	404.26	574.71
3	227.54	372.12
4	26.40	.00
5	160.06	408.07
6	253.42	206.92
7	0.00	0.00
8	0.00	0.00
9	415.12	1058.36
10	173.03	647.43

INPUT DATA SUMMARY FOR CASE NUMBER   2
===

SECTOR NUMBER   3
      OF CASE   2

WORKING FACE.
      BENCHES ARE   50.0 UNITS HIGH
              AND   20.0 UNITS WIDE.
      ROADS   ARE   120.0 UNITS WIDE.

BASIC WALL ANGLES.
      BENCH FACE ANGLE IS   60.0
      ULTIMATE WALL ANGLE   AND BOTTOM ELEV.
                    45.0   4250.

COUNT OF INPUT ITEMS.
      HAUL ROADS   4
      WORK BENCHES   1
      PROBABILITY DISTR.S   6
      PROB. DISTR.S (WEAK STRATUM)   0

PROBABILITY DISTRIBUTIONS

      PIT WALL DISTRIBUTION

                                   HEIGHTS
      -0.   50.   100.   400.   800.   1200.   -0.   -0.   -0.   -0.

                              PROBABILITIES   ANGLE
 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000   0.00
 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000   30.00
 -0.000   .001   .002   .003   .004   .005 -0.000 -0.000 -0.000 -0.000   38.00
 -0.000   .016   .019   .030   .040   .047 -0.000 -0.000 -0.000 -0.000   45.00
 -0.000   .109   .118   .130   .150   .170 -0.000 -0.000 -0.000 -0.000   55.00
 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000 -0.000   90.00

INSTABILITY COST TYPES FOR DIFFERENT WALLS.

PERIOD	FULL HEIGHT	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
2	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
3	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
4	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
5	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
6	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
7	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
8	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
9	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0
10	9	9 9 9 9 9 9 9 9 9-0-0	-0	-0

      PUSHBACK WALL INSTABILITY COST TYPES

PERIOD	FULL HEIGHT	INTER RAMP WALLS	BENCH	WEAK STRATUM
1	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
2	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
3	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
4	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
5	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
6	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
7	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
8	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
9	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0
10	8	8 8 8 8 8 8 8 8 8-0-0	-0	-0

PERIOD	SECTOR WIDTH
1	1400.0
2	1400.0
3	1400.0
4	1400.0
5	1350.0
6	1300.0
7	1350.0
8	1300.0
9	1300.0
10	1400.0

HAUL ROAD ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	ROAD 1	2	3	4
1	3850.0	3650.0	99999.0	99999.0
2	3825.0	3675.0	99999.0	99999.0
3	3825.0	3675.0	3325.0	99999.0
4	3825.0	3675.0	3300.0	3030.0
5	3825.0	3300.0	99999.0	99999.0
6	3825.0	3025.0	99999.0	99999.0
7	3825.0	3025.0	99999.0	99999.0
8	3825.0	3170.0	3050.0	3030.0
9	3850.0	3175.0	3025.0	99999.0
10	3825.0	3175.0	3025.0	99999.0

WORK BENCH ELEVATIONS LISTED FROM PIT TOP TO PIT BOTTOM.

PERIOD	BENCH 1	WIDTH 1
1	99999.0	0.0
2	99999.0	0.0
3	99999.0	0.0
4	3900.0	250.0
5	99999.0	-0.0
6	99999.0	-0.0
7	99999.0	-0.0
8	99999.0	-0.0
9	99999.0	-0.0
10	99999.0	-0.0

PIT LIMIT ELEVATIONS.

PERIOD	SECTOR TOP ELEV.	PIT BOTTOM ELEV.	ULTIMATE WALL BOTTOM ELEV.	PUSHBACK BOTTOM ELEV.
1	3950.	3550.	3950.	3950.
2	3950.	3350.	3950.	3950.
3	3950.	3200.	3950.	3950.
4	3950.	3050.	3950.	3950.
5	3950.	3950.	3950.	3600.
6	3950.	2850.	3950.	3350.
7	3950.	2750.	3950.	3200.
8	3950.	2750.	3950.	3950.
9	4150.	2750.	4150.	3000.
10	4150.	2750.	4150.	2900.

AMOUNT OF ROCK.

PERIOD	TYPE1 ORE	TYPE2 ORE	WASTE
1	0.	0.	0.
2	0.	0.	0.
3	0.	0.	0.
4	0.	0.	0.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	0.	0.	0.
9	0.	0.	0.
10	0.	0.	0.

ORE GRADE AND COST OF MINING.

PERIOD	AVERAGE PERCENT ORE GRADE		COST OF MINING		
	TYPE1 ORE	TYPE2 ORE	TYPE1 ORE	TYPE2 ORE	WASTE
1	0.000	0.000	0.000	0.000	.350
2	0.000	0.000	0.000	0.000	.350
3	0.000	0.000	0.000	0.000	.350
4	0.000	0.000	0.000	0.000	.350
5	0.000	0.000	0.000	0.000	.350
6	0.000	0.000	0.000	0.000	.350
7	0.000	0.000	0.000	0.000	.350
8	0.000	0.000	0.000	0.000	.290
9	0.000	0.000	0.000	0.000	.290
10	0.000	0.000	0.000	0.000	.290

MISCELLANEOUS INPUT DATA.

PERIOD	VALUE 1	VALUE 2	VALUE 3	VALUE 4	VALUE 5
1	0.	0.	.376E+05	0.	0.
2	0.	0.	.399E+05	0.	0.
3	0.	0.	.376E+05	0.	0.
4	0.	0.	.310E+05	0.	0.
5	0.	0.	.418E+05	0.	0.
6	0.	0.	.441E+05	0.	0.
7	0.	0.	.382E+05	0.	0.
8	0.	0.	.376E+05	0.	0.
9	0.	0.	.494E+05	0.	0.
10	0.	0.	.494E+05	0.	0.

RESULTS OF SIMULATION NUMBER   1
FOR SECTOR   3
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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOO	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

PERIOD	FULL WALL	COST OF INSTABILITY INTER RAMP	BENCH	WEAK STRATUM	TOTAL COST ALL TYPES
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	7992.	0.	0.	7992.
5	859.	0.	0.	0.	859.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	165.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	1132.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	165.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	1132.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	9	0	0	0	0	0	0	0	0
5	9	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	8	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	8	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	4	14	7	14	0	0	0	0	0	0	0	0	223
2	2	11	9	4	0	0	0	0	0	0	0	0	335
3	2	11	9	4	11	0	0	0	0	0	0	0	419
4	2	28	19	9	4	6	0	0	0	0	0	0	503
5	2	5	5	0	0	0	0	0	0	0	0	0	485
6	3	4	7	0	0	0	0	0	0	0	0	0	571
7	3	8	5	0	0	0	0	0	0	0	0	0	647
8	1	10	2	11	65	5	0	0	0	0	0	0	623
9	5	5	0	0	0	0	0	0	0	0	0	0	727
10	9	9	0	0	0	0	0	0	0	0	0	0	783

PUSHBACK WALL CELLS

PERIOD														
1	0	0	0	0	0	0	0	0	0	0	0	0		0
2	0	0	0	0	0	0	0	0	0	0	0	0		0
3	0	0	0	0	0	0	0	0	0	0	0	0		0
4	0	0	0	0	0	0	0	0	0	0	0	0		0
5	0	11	6	0	0	0	0	0	0	0	0	0		0
6	0	10	3	0	0	0	0	0	0	0	0	0		0
7	0	11	2	0	0	0	0	0	0	0	0	0		0
8	0	0	0	0	0	0	0	0	0	0	0	0		0
9	0	4	2	9	52	0	0	0	0	0	0	0		0
10	0	4	2	9	11	0	0	0	0	0	0	0		0

COUNT OF UNSTABLE CELLS

```
    PIT WALLS
        FULL HEIGHT        1.
        INTER RAMP        24.
        SINGLE BENCH     438.
        WEAK STRATUM       0.

    PUSHBACK WALLS
        FULL HEIGHT        0.
        INTER RAMP        13.
        SINGLE BENCH       0.
        WEAK STRATUM       0.
```

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR UNITS)
```
        TOTAL BENEFIT =        0.
        TOTAL COST    =     5339.
```

RESULTS OF SIMULATION NUMBER   2
FOR SECTOR   3
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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

| | | COST OF INSTABILITY | | | TOTAL COST |
PERIOD	FULL WALL	INTER RAMP	BENCH	WEAK STRATUM	ALL TYPES
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	859.	0.	0.	0.	859.
6	0.	0.	0.	0.	165.
7	0.	0.	0.	0.	165.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	1132.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	165.	0.	0.
7	0.	165.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	1132.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	9	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES

PERIOD		INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	8	0	0	0	0	0	0	0	0	0	0	0	0
7	0	8	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	8	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	4	14	7	14	0	0	0	0	0	0	0	0	223
2	2	11	9	4	0	0	0	0	0	0	0	0	335
3	2	11	9	4	11	0	0	0	0	0	0	0	419
4	2	28	19	9	4	6	0	0	0	0	0	0	503
5	2	5	5	0	0	0	0	0	0	0	0	0	485
6	3	4	7	0	0	0	0	0	0	0	0	0	571
7	3	8	5	0	0	0	0	0	0	0	0	0	647
8	1	10	2	11	65	5	0	0	0	0	0	0	623
9	5	5	0	0	0	0	0	0	0	0	0	0	727
10	9	9	0	0	0	0	0	0	0	0	0	0	783

PUSHBACK WALL CELLS

PERIOD													
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	11	6	0	0	0	0	0	0	0	0	0	0
6	0	10	3	0	0	0	0	0	0	0	0	0	0
7	0	11	2	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	4	2	9	52	0	0	0	0	0	0	0	0
10	0	4	2	9	11	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

    PIT WALLS
        FULL HEIGHT   2.
        INTER RAMP   24.
        SINGLE BENCH   451.
        WEAK STRATUM   0.

    PUSHBACK WALLS
        FULL HEIGHT   0.
        INTER RAMP   14.
        SINGLE BENCH   0.
        WEAK STRATUM   0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
        TOTAL BENEFIT =   0.
        TOTAL COST   =   840.

RESULTS OF SIMULATION NUMBER   3
               FOR SECTOR   3
                   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	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.

COSTS (IN 1000 DOLLAR   UNITS)

PERIOD	STRIPPING COST	USER COST
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

		COST OF INSTABILITY				TOTAL COST
PERIOD	FULL WALL	INTER RAMP	BENCH		WEAK STRATUM	ALL TYPES
1	0.	0.	0.		0.	0.
2	1023.	0.	0.		0.	1023.
3	0.	0.	0.		0.	0.
4	0.	0.	0.		0.	0.
5	0.	0.	0.		0.	0.
6	0.	0.	0.		0.	0.
7	0.	0.	0.		0.	165.
8	0.	0.	0.		0.	0.
9	0.	0.	0.		0.	0.
10	0.	0.	0.		0.	1339.

PUSHBACK WALL INSTABILITY COSTS

1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	165.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	1339.	0.	0.

INSTABILITY COST TYPES FOR WHICH INSTABILITY HAS OCCURRED.

PERIOD	FULL WALL	INTER RAMP WALLS											BENCH	WEAK STRATUM
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	9	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PUSHBACK WALL COST TYPES

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	8	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	8	8	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	4	14	7	14	0	0	0	0	0	0	0	0	223
2	2	11	9	4	0	0	0	0	0	0	0	0	335
3	2	11	9	4	11	0	0	0	0	0	0	0	419
4	2	28	19	9	4	6	0	0	0	0	0	0	503
5	2	5	5	0	0	0	0	0	0	0	0	0	485
6	3	4	7	0	0	0	0	0	0	0	0	0	571
7	3	8	5	0	0	0	0	0	0	0	0	0	647
8	1	10	2	11	65	5	0	0	0	0	0	0	623
9	5	5	0	0	0	0	0	0	0	0	0	0	727
10	9	9	0	0	0	0	0	0	0	0	0	0	783

PUSHBACK WALL CELLS

PERIOD

1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	11	6	0	0	0	0	0	0	0	0	0	0
6	0	10	3	0	0	0	0	0	0	0	0	0	0
7	0	11	2	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	4	2	9	52	0	0	0	0	0	0	0	0
10	0	4	2	9	11	0	0	0	0	0	0	0	0

COUNT OF UNSTABLE CELLS

PIT WALLS
FULL HEIGHT	1.
INTER RAMP	24.
SINGLE BENCH	463.
WEAK STRATUM	0.

PUSHBACK WALLS
FULL HEIGHT	0.
INTER RAMP	12.
SINGLE BENCH	0.
WEAK STRATUM	0.

PRESENT VALUE FOR THE SIMULATION (IN 1000 DOLLAR   UNITS)
TOTAL BENEFIT =   0.
TOTAL COST   =   1167.

SUMMARY OF ALL SIMULATIONS FOR SECTOR   3
CASE   2
==

UNITS) FROM ALL SIMULATIONS.

AVERAGES AND STANDARD DEVIATIONS (IN 1000 DOLLAR

PERIOD	AVE. OF TOTAL BENEFITS	STD. DEV. OF TOTAL BENEFITS
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	0.00	0.00
7	0.00	0.00
8	0.00	0.00
9	0.00	0.00
10	0.00	0.00

PERIOD	AVE. OF TOTAL COSTS	STD. DEV. OF TOTAL COSTS
1	0.00	0.00
2	204.57	409.14
3	0.00	0.00
4	1219.07	2717.34
5	343.79	421.06
6	346.77	405.72
7	285.42	257.99
8	0.00	0.00
9	0.00	0.00
10	706.72	580.90

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 15

```
    198034.      198034.      198034.      198034.      198034.
    198034.      198034.      198034.      198034.      198034.
    198034.      198034.      198034.      198034.      198034.
```

PRESENT VALUE OF TOTAL COST   FOR SIMULATIONS 1 THRU 15

```
    102372.       95126.        94570.       96888.       95545.
     93071.       95463.        96527.      102061.       97051.
     96016.       96572.        95354.       97612.       93404.
```

SUMMARY OF BENEFITS AND COSTS FOR CASE   2

AVERAGE PRESENT VALUE OF BENEFITS   198034.

STANDARD DEVIATION OF BENEFITS   0.

AVERAGE PRESENT VALUE OF COSTS   96509.

STANDARD DEVIATION OF COSTS   2640.

SUMMARY OF INCREMENTAL CHANGE
IN NPV AMONG CASES (IN 1000 UNITS)
==================================

CASE NUMBER	TOTAL NPV	INCREMENTAL NPV	STD.DEV. OF INCREMENT
2	101526.	0.	0.
1	105802.	4276.	189.

EXHIBIT A-3

MICRO FLOW CHARTS OF SUBROUTINES COST1 AND FCHK

COST1

First Simulation — No → 3A

Yes

Begin Primary Loop:

Compute stripping cost, wall heights, wall angles and number of cells in each wall.

This loop is executed only for the first simulation.

Abr.	Used Herein
Ult.	-- Ultimate
Pushb.	-- Pushback
I.R.	-- Interramp
Elev.	-- Elevation
Inst.	-- Instability

Compute Stripping Cost for this Period (Year)

Merge Haul Road and Work Bench Elevations into Array "HWKEL"

Determine Ult. Walls in which the Sector Top, Ultimate Wall Bottom and Pushback Bottom Elevations Lie.

Determine Interramp Wall in Which the Pushback Bottom Lies

200
Select First Interramp Wall

Compute Both Ultimate and Interim Wall Heights of All Interramp Walls Above and Below Pushback.

210
Wall Bottom ≥ Starting Elev. → 2B

1A →

<

Wall is All Below Pushback

230
Wall Top : Pushb. Bot. ← < Wall Bot. : Pushb. Bot. ≥ → Wall Bot. : Ult. Bot. ≥ →

Wall is All Above Pushback

Wall is all Ultimate. Compute and Store Height.

<

220
Wall Top : Ult. Bot.

Wall Top : Ult. Bot. ≤ → Wall is all Interim. Store Height.

>

Wall Bot : Ult. Bot. ≥ → Wall is all Ultimate. Store Height.

<

Wall Split between Ultimate & Interim. Store Heights.

Wall is all Interim Compute and store Height.

Wall is part Ultimate and Part Interim. Store Heights.

Wall is Both Above and Below Pushback

240
Store Ultimate Height Above Pushback ← < Ult. Bot. : Pushb. Bot. ≥ → Store Interim Height Below Pushback

Wall Bot : Ult. Bot. < → Store Heights Below Pushback

≥

Store Ultimate Height Below Pushback

Wall Top : Ult. Bot. > → Store Heights Above Pushback

≤

Store Interim Height Above Pushback

2

Determine Lowest Ultimate Wall

Compute full wall height, width, angle and number of cells for pit wall (wall below pushback) and pushback wall.

End Primary Loop, which computes the values needed for sampling.

FCHK

Check Wall Type Index

≠ 4 → Check Cell Count

= 4 Weak Stratum → Set Indices for Weak Stratum Wall Testing

Check Cell Count
= 0 → Set Cost to Zero → Return to Calling Program
≠ 0 → Set Loop Control Flag to Zero

50

100

Ang. : Prob. Ang
Wall Angle > Largest Prob. Angle → Compute Ratio of Wall Angle Minus Nearest Larger Probability Divided by Positive Difference of Largest Two Probability Angles
≥ ←
< → 120 Compute Ratio of Wall Angle Minus Nearest Larger Probability Angle Divided by Positive Difference of Largest and Next Lower Prob. Angles

130 Set Height (Ht) Variable to Height from Top Elevation to Bottom of Wall

140 Ht : Prob. Ht
Wall Height > Highest Prob. Height → Compute Ratio of Wall Height Minus Largest Probability Height Divided by Positive Difference of Largest Two Prob. Heights
> ←
≤ → Compute Ratio of Wall Height Minus Nearest Larger Probability Height Divided by the Positive Difference of Largest and Next Lower Probability Heights

Compute the Prob. of Instability from the Angle and Height Ratios

Check Loop Control Flag
1 → Compute Probability of Instability for the Wall Equal Difference between Probabilities to Wall Top and Bottom
0 → Set Loop Control Flag to One

Set Height Variable to Height from Top Elevation to Top of Wall

Save Probability for Height to Wall Bottom

Prob. Value
≠ 0 → Check Cell Count
= 0

Check Cell Count
≤ → 200
> MXCEL → Obtain Cost of a One-Cell Instability → Compute Cost of Instabilities for the Wall by Multiplying Cell Count Times Prob. Value Times One Cell Inst. Cost

200 Obtain a Pseudo Random Number between 0 and 1

Rand # : Prob. Val.
> ←
≤ → Obtain Cost of a One-Cell Instability → Sum Cost → Add One to Instability Count

Last Cell Sampled
No → (back to 200)
Yes → Return to Calling Prog.

Return to Calling Prog.

EXHIBIT A-4

LIST OF VARIABLES USED IN
BNCST - VERSION III

VARIABLES USED IN MAIN PROGRAM BNCST

A	AN ARRAY USED IN INPUTTING DATA BY THE "READI" ROUTINE.
ABENU	AN ARRAY USED IN "BNCST" FOR SUMMING BENEFITS FROM THE USER SUPPLIED ROUTINE BENF2 .
ABMSQ	ARRAY USED IN "BNCST" TO SUM SQUARE OF MISC. BENEFITS.
ABNMS	ARRAY USED IN "BNCST" TO SUM MISCELLANEOUS BENEFITS.
ABUSQ	ARRAY USED IN "BNCST" TO SUM SQUARE OF USER BENEFITS(ABENU SQUARED).
ACL	AVERAGE COST OF MINING TYPE2 ORE FOR ENTIRE PIT
ACS	AVERAGE COST OF MINING TYPE1 ORE FOR ENTIRE PIT
ACW	AVERAGE COST OF MINING WASTE FOR ENTIRE PIT
AGL	AVERAGE GRADE OF TYPE2 ORE FOR ENTIRE PIT
AGS	AVERAGE GRADE OF TYPE1 ORE FOR ENTIRE PIT
ANGBK	VARIABLE CONTAINING INPUT VALUE OF BANK ANGLE IN RADIANS.
ANGU	ARRAY CONTAINING INPUT VALUES OF ULTIMATE WALL ANGLES IN RADIANS.
AVG1	INPUT VALUE OF AVERAGE ORE GRADE FOR ORE TYPE 1.
AVG2	INPUT VALUE OF AVERAGE ORE GRADE FOR ORE TYPE 2.
B	ARRAY USED IN ROUTINE "READI" FOR READING INPUT DATA.
BEN	TEMPORARY VARIABLE USED IN PROGRAM "BNCST" TO SUM TOTAL BENEFIT OVER ALL SEGMENTS IN A SECTOR.
BENHT	INPUT VALUE OF BENCH HEIGHT.
BENMS	TEMP. VARIABLE USED IN "BNCST" TO SUM MISC. BENEFITS.
BENSQ	ARRAY USED IN "BNCST" TO SUM SQUARE OF TOTAL BENEFIT IN A SECTOR.
BENSV	ARRAY USED IN "BNCST" TO SUM TOTAL BENEFIT IN A SECTOR.
BENU	TEMPORARY VARIABLE USED IN "BNCST" FOR STORING USER BENEFITS.
BENWD	VARIABLE TO HOLD INPUT VALUE OF BENCH WIDTH.
BNMSC	ARRAY USED TO STORE MISCELLANEOUS BENEFITS.
BNTOT	ARRAY USED TO STORE TOTAL BENEFIT IN SECTOR.
BNTP1	AVERAGE BENEFIT OF TYPE 1 ORE
BNTP2	AVERAGE BENEFIT OF TYPE2 ORE
BOA	AVERAGE OTHER BENEFIT
BOV	VARIANCE OF OTHER BENEFITS
BPV	PRESENT VALUE OF BENEFITS
BS	USED IN COMPUTING STD. DEV. OF BENEFITS OVER ALL SIMULATIONS.
BSS	USED IN COMPUTING MEAN AND STD. DEV. OF BENEFITS OVER ALL SIMULATIONS.
BUA	AVERAGE USER BENEFITS
BUV	VARIANCE OF USER BENEFITS
C	ARRAY USED IN "READI" FOR READING INPUT DATA.
CFHT	ARRAY USED TO STORE COST OF FULL HEIGHT INSTABILITIES IN PIT WALL.
CFPB	ARRAY USED TO STORE COST OF FULL HEIGHT INSTABILITIES IN PUSHBACK WALL. WALL.
COCL	AVERAGE COST OF WASTE MINING IN CURRENT SECTOR
COFUS	AVERAGE USER COST
COMNW	ARRAY TO HOLD INPUT VALUE FOR COST OF MINING WASTE ROCK PER UNIT WEIGHT (TON).
COMN1	ARRAY TO HOLD INPUT VALUE FOR COST OF MINING AND PROCESSING ORE TYPE 1 PER UNIT WEIGHT (TON).
COMN2	SAME AS COMN1 BUT FOR ORE TYPE 2.
CPV	PRESENT VALUE OF COSTS
CS	USED IN COMPUTING STD. DEV. OF COSTS OVER ALL SIMULATIONS.
CSS	USED IN COMPUTING MEAN AND STD. DEV. OF COSTS OVER ALL SIMULATIONS.
CSTBA	ARRAY TO STORE COST OF BENCH INSTABILITIES IN PUSHBACK WALL.
CSTBB	ARRAY TO STORE COST OF BENCH INSTABILITIES IN PIT WALL.
CSTF	ARRAY CONTAINING INSTABILITY COSTS PER PERIOD
CSTFA	ARRAY USED TO STORE SUM OF INSTABILITY COSTS OVER ALL PERIODS

CSTF2	ARRAY CONTAINING SQUARE OF CSTFA
CSTIA	ARRAY,STORES COST OF INTERRAMP INSTABILITIES IN PUSHBACK WALL
CSTIB	ARRAY, STORES COST OF INTERRAMP INSABILITIES IN PIT WALL.
CSTSA	ARRAY, STORES COST OF WEAK STRATUM INSTABILITIES IN PUSHBACK WALL.
CSTSB	ARRAY, STORES COST OF WEAK STRATUM INSTABILITIES IN PIT WALL.
CSTSC	ARRAY, STORES SUM OF ALL COSTS IN SECTOR BY PERIOD.
CSTSQ	ARRAY, USED TO SAVE SQUARE OF TOTAL COST IN SECTOR FOR USE IN COMPUTING STD. DEV.
CSTSV	ARRAY, USED TO SUM TOTAL COST FROM ALL SIMULATIONS FOR USE IN COMPUTING MEAN AND STD. DEV. OVER SIMULATIONS BY PERIOD.
CSTUA	ARRAY CONTAINING SUM OF USER COSTS OVER ALL PERIODS
CSTU2	ARRAY CONTAINING SQUARE OF CSTUA
CUA	AVERAGE USER COST
CUSR	ARRAY, USED TO STORE COSTS FROM USER SUPPLIED ROUTINE COST2.
CUV	STANDARD DEVIATION OF USER COSTS
DATE	ARRAY TO STORE INPUT CALENDAR DATE (ANY 20 ALPHANUMERIC CHARACTERS).
DIT	USED IN "READI" TO HOLD THE DITTO FIELD WHEN READING INPUT DATA.
FAA	AVERAGE INSTABILITY COSTS FOR PERIOD
FAV	STANDARD DEVIATION OF FAA
FBEN	ARRAY TO STORE AVERAGE VALUE OF TOTAL BENEFITS FOR EACH CASE
FBENS	ARRAY TO STORE STD. DEV. OF TOTAL BENEFITS FOR EACH CASE
FCOSS	ARRAY TO STORE STD.DEV.OF TOTAL COSTS FOR EACH CASE
FCOST	ARRAY TO STORE AVERAGE VALUE OF TOTAL COSTS FOR EACH CASE
HALEL	ARRAY, STORES THE INPUT HAUL ROAD ELEVATIONS.
HALWD	STORES THE INPUT VALUE OF HAUL ROAD WIDTH FOR CURRENT SECTOR.
HEIT	ARRAY, STORES HEIGHT VALUES OF THE PROBABILITY DISTRIBUTION.
HWKEL	ARRAY, USED IN "COST1" TO STORE THE COLLATED HAUL ROAD AND WORK BENCH ELEVATIONS.
I	GENERAL ARRAY SUBSCRIPT AND LOOP CONTROL VARIABLE.
ID	USED TO HOLD CONTENTS OF ID FIELD DURING INPUT OF DATA.
IFLG	FLAG TO STOP SAMPLING PROCESS, USED ONLY IF USER SUPPLIED ROUTINE IS GIVEN TO TERMINATE INSTABILITY SAMPLING AFTER FIRST INSTABILITY
IHD1	ARRAY USED TO INDICATE WHAT TYPE 1 HEADER CARDS WERE READ
IHD2A	ARRAY USED TO INDICATE THAT CERTAIN TYPE 2 HEADER CARDS HAVE BEEN READ IN "READI".
IHD2B	ARRAY USED TO INDICATE THAT CERTAIN TYPE 2 HEADER CARDS HAVE BEEN READ IN "READI".
IHN	SUBSCRIPT USED IN INPUTTING HAUL ROADS AND WORK BENCHES TO SPECIFY TO THE "READI" AND "FILL" ROUTINES WHICH SURFACE IS BEING INPUT OR FILLED. ALSO IT MUST BE ZERO FOR OTHER CALLS TO THE "FILL" ROUTINE.
IHW	SUBSCRIPT USED TO SPECIFY WALL NUMBER FOR WALLS DELIMITED BY HAUL ROADS AND WORK BENCHES (INTER RAMP WALLS).
ISC	INTERNAL NUMBER USED TO INDICATE THE SECTOR, IT IS NOW ALWAYS ZERO.
INC	ARRAY TO STORE INCREMENTAL CHANGE IN NPV AMONG CASES
ISS	ARRAY TO STORE CASE NUMBERS, SORTED BY NPV
ISCN	STORES THE INPUT VALUE OF SECTOR NUMBER.
ISG	INTERNAL SEGMENT NUMBER, IT IS ALWAYS 1, 2 OR 3.
ISGN	ARRAY WHICH STORES THE INPUT VALUE(S) OF SEGMENT NUMBER(S).
K	GENERAL SUBSCRIPT AND LOOP CONTROL VARIABLE, USUALLY USED FOR PERIOD (YEAR) SUBSCRIPT.
KFLG	ARRAY TO HOLD USER DESIGNATED FLAGS WHICH ARE INITIALIZED ONLY AFTER EACH SIMULATION
KLIFE	USED TO STORE NUMBER OF PERIODS (YEARS) OF MINE DESIGN LIFE.
KPD	SUBSCRIPT AND LOOP CONTROL USED ONLY FOR PERIOD (YEAR) IN ARRAY REFERENCES
KSPD	ARRAY USED TO INDICATE WHAT PERIODS (YEARS) OF DATA LAST READ WERE ACTUALLY INPUT. IT IS USED IN FILLING INPUT DATA ARRAYS BY ROUTINES "FILL" AND "FILL1".

LERR   FLAG USED TO INDICATE WHETHER A FATAL ERROR HAS BEEN ENCOUNTE
IN READING THE INPUT DATA. FATAL ERROR IF LERR IS NONE ZERO.

LFINI   FLAG USED BY "READI" TO INDICATE TO "BNCST" WHAT TYPE OF END
HAS BEEN ENCOUNTERED. LFINI = 1 FOR END OF SECTOR INPUT
                                = 2 FOR STOP CASE CARD
                                = 3 FOR END OF INPUT FILE.

LINE   USED TO STORE COUNT OF PRINTED LINES SO THAT PAGES MAY BE
EJECTED AT PAGE END.

LPAGE   FLAG TO INDICATE WHETHER PAGES ARE TO EJECTED BY LINE COUNT
LPAGE   IS SET WHEN   LPRT .EQUALS 2.

LPRT   FLAG THAT CONTROLS PRINTING OF INPUT DATA AND PAGING.
IF   LPRT = 1 PRINT THE INPUT DATA

LPSH   FLAG USED IN INPUTTING INSTABILITY TYPES FOR THE PUSHBACK
WALL. LPSH = 1 INDICATES THAT PUSHBACK INSTABILITY TYPES ARE
BEING OR HAVE BEEN INPUT.

LPSHB   FLAG USED TO INDICATE THAT PUSHBACK ELEVATIONS HAVE BEEN INPUT
IF LPSHB = 1 ELEVATIONS WERE INPUT.

LSEG   FLAG INDICATING WHETHER SEGMENTS ARE TO BE USED. LSEG IS SET
BY INPUT.
LSEG = 0 FOR NO SEGMENTATION
          = 1 FOR SEGMENTATION USED.

LSTR   FLAG USED TO INDICATE THAT TITLE, DATE AND FIXED VARIABLES
HAVE BEEN READ FOR A NEW PIT DESIGN. 1 = YES.

LUNIT   SET =0 WHEN UNIT NAMES NOT FOUND IN INPUT DATA.
SET =1 WHEN UNIT NAMES FOUND IN INPUT DATA.

LUSBN   FLAG SET TO 1 WHEN A USER BENEFIT ROUTINE IS SUPPLIED.

LUSCT   FLAG SET TO 1 WHEN A USER COST ROUTINE IS SUPPLIED.

LW   FLAG USED WHILE READING WEAK STRATUM ELEVATIONS IN READI.

LWEK   FLAG USED WHILE READING THE WEAK STRATUM PROBABILITY
DISTRIBUTION IN READI.
SET AT END OF READI TO =1 IF WEAK STRATUM ELEV.S READ IN
                                    =0 IF NONE READ.

LWRT   FLAG SET TO 1 WHEN THE RESULTS OF SIMULATION ARE TO BE
WRITTEN TO A MAGNETIC TAPE OR OTHER STORAGE FILE FOR FURTHER
PROCESSING

L4   LOGICAL UNIT NUMBER OF FILE TO WRITE RESULTS ON WHEN IT
IS TO BE PROCESSED FURTHER BY OTHER PROGRAMS SUCH AS   INRISK

L5   LOGICAL UNIT NUMBER OF THE INPUT DATA FILE.

L6   LOGICAL UNIT NUMBER OF THE PRINTER OUTPUT FILE.

L7   LOGICAL UNIT NUMBER USED WITH DEBUG PRINT STATEMENTS.

MBNAS   ARRAY USED TO STORE THE BENCH INSTABILITY TYPES THAT HAVE
OCCURRED IN PUSHBACK WALL.

MBNBS   ARRAY USED TO STORE THE BENCH INSTABILITY TYPES THAT HAVE
OCCURRED IN THE PIT WALL (BELOW PUSHBACK).

MFHSV   ARRAY USED TO STORE THE FULL HEIGHT INSTABILITY TYPES THAT
HAVE OCCURRED IN THE PIT WALL (BELOW ANY PUSHBACK).

MHPSV   ARRAY USED TO STORE THE INTER RAMP INSTABILITIES WHICH HAVE
OCCURRED IN THE PUSHBACK WALL.
FOR THE PUSHBACK WALL.

MHWSV   ARRAY USED TO STORE THE INTER RAMP INSTABILITY TYPES WHICH

MHWKP   ARRAY USED TO STORE THE INPUT INTER RAMP INSTABILITY TYPES
HAVE OCCURRED IN THE PIT WALL.

MKHWK   ARRAY USED TO MARK THE HAUL ROAD AND WORK BENCH ENTRIES IN
ARRAY   HWKEL   SO THAT THEIR VARYING WIDTHS CAN BE USED IN
ROUTINE "HWKCK" .
MKHWK(IHW,KPD) = 0 FOR HAUL ROADS
                      = 1 FOR WORK BENCH.

MM   ARRAY USED FOR TEMP. STORAGE OF SOME INPUT DATA BY ROUTINE
"READI".

MN   ARRAY USED FOR TEMP. STORAGE OF SOME INPUT DATA BY ROUTINE
"READI".

MPBSV   ARRAY USED TO STORE THE FULL HEIGHT INSTABILITY TYPES WHICH
HAVE OCCURRED IN THE PUSHBACK WALL.

MS   ARRAY USED FOR TEMP. STORAGE OF SOME INPUT DATA BY ROUTINE
"READI".

MSBNA   ARRAY USED TO STORE THE INPUT BENCH INSTABILITIY TYPES FOR
THE PUSHBACK WALL.

MSBNB   ARRAY USED TO STORE THE INPUT BENCH INSTABILITY TYPES FOR
THE PIT WALL.

MSBNB   ARRAY USED TO STORE THE INPUT BENCH INSTABILITY TYPES FOR
THE PUSHBACK WALL.

MSHWK   ARRAY USED TO STORE THE INPUT INTER RAMP INSTABILITY TYPES
FOR THE PIT WALL (BELOW ANY PUSHBACK).

MSTFH   ARRAY USED TO STORE THE INPUT FULL HEIGHT INSTABILITY TYPES
FOR THE PIT WALL (BELOW ANY PUSHBACK).

MSTPB   ARRAY USED TO STORE THE INPUT FULL HEIGHT INSTABILITY TYPES
FOR THE PUSHBACK WALL.

MSWKA   ARRAY USED TO STORE THE INPUT WEAK STRATUM INSTABILITY TYPES
FOR THE PUSHBACK WALL.

MSWKB   ARRAY USED TO STORE THE INPUT WEAK STRATUM INSTABILITY TYPES
FOR THE PIT WALL.

MWKAS   ARRAY USED TO STORE THE WEAK STRATUM INSTABILITY TYPES WHICH
HAVE OCCURED IN THE PUSHBACK WALL.

MWKBS   ARRAY USED TO STORE THE WEAK STRATUM INSTABILITY TYPES WHICH
HAVE OCCURRED IN THE PIT WALL.

MXCEL   STORES THE INPUT CELL COUNT ABOVE WHICH INDIVIDUAL SAMPLING IS
NOT PERFORMED IN ROUTINE "FCHK" .

MXERR   STORES THE MAXIMUM NUMBER OF PROBABILITY RELATED ERRORS THAT
MAY BE PRINTED BY ROUTINE "ERROR"

MXHAL   MAXIMUM NUMBER OF HAUL ROADS WHICH MAY BE READ IN.

MXHWK   SUM OF MXHAL AND MXWRK.

MXHWK1   MXHWK+1

MXPRB   MAXIMUM NUMBER OF PROBABILITY HISTOGRAMS WHICH MAY BE READ IN

MXWRK   MAXIMUM NUMBER OF WORK BENCHES WHICH MAY BE READ IN.

NBCL   TEMP. VARIABLE FOR NUMBER OF BENCH CELLS IN AN INTERRAMP WALL

NBCLA   ARRAY STORING NUMBER OF BENCH CELLS IN PUSHBACK WALL FOR
EACH PERIOD.

NBCLB   ARRAY STORING NUMBER OF BENCH CELLS IN PIT WALL FOR EACH
PERIOD.

NCAS   TEMPORARY VARIABLE FOR STORING THE CASE NUMBER.

NCASE   VARIABLE USED TO STORE THE DESIGN CASE NUMBER.

NCELA   ARRAY STORING THE NUMBER OF FULL WALL HEIGHT CELLS FOR THE
PUSHBACK WALL.

NCELB   ARRAY STORING THE NUMBER OF FULL WALL HEIGHT CELLS FOR THE
PIT WALL.

NDIAG   VARIABLE SET BY INPUT DATA TO CONTROL PRINTING OF DIAGNOSTIC
MESSAGES BY THE PROGRAM.

NERR   ARRAY TO STORE THE COUNTS OF ERRORS ASSOCIATED WITH THE
PROBABILITY DISTRIBUTIONS. THE CONTENTS IS PRINTED WHENEVER
A VALUE IS GREATER THAN MXERR .

NHAUL   COUNT OF MAXIMUM NUMBER OF HAUL ROADS INPUT FOR ANY PERIOD
IN THE SECTORS DATA.

NHWK   THE SUM OF NHAUL AND NWORK .

NPROB   COUNT OF THE PROBABILITY HISTOGRAMS INPUT FOR THE SECTOR.

NPRBW   COUNT OF PROB. HISTOGRAMS(CARDS) INPUT FOR WEAK STRATUM
IN SECTOR.

NPV   ARRAY TO STORE AVERAGE NET PRESENT VALUE FOR EACH CASE

NRCLA   ARRAY STORING THE NUMBER OF CELLS IN EACH INTER RAMP WALL
IN THE PUSHBACK WALL FOR EACH PERIOD (YEAR).

NRCLB   ARRAY STORING THE NUMBER OF CELLS IN EACH INTER RAMP WALL
IN THE PIT WALL FOR EACH PERIOD (YEAR).

NSC   COUNT OF SECTORS READ IN THUS FAR IN PROCESSING THE DESIGN
CASE.

NSEG   NUMBER OF SEGMENTS IN CURRENT SECTOR. IS NOW ALWAYS =1.

NSIM   STORES INPUT VALUE FOR NUMBER OF SIMULATIONS TO BE RUN FOR
THE CURRENT DESIGN CASE.

NSM   LOOP CONTROL VARIABLE USED IN "BNCST" TO CONTROL THE
SIMULATION LOOP.

NWORK   COUNT OF THE MAXIMUM NUMBER OF WORK BENCHES INPUT FOR ANY
PERIOD OF THE CURRENT SECTOR.

NULT   NUMBER OF ULTIMATE WALLS INPUT. MAX VALUE IS 6.

N1   FLAG TO INDICATE THAT A PRIOR INSTABILITY HAS OCCURRED

ORE1	ARRAY USED TO STORE THE INPUT VALUES FOR TONNAGE OF ORE TYPE 1.
ORE2	ARRAY USED TO STORE THE INPUT VALUES FOR TONNAGE OF ORE TYPE 2.
PANG	ARRAY USED TO STORE THE WALL ANGLES ASSOCIATED WITH THE PROBABILITY HISTOGRAMS.
PITBT	ARRAY USED TO STORE THE INPUT VALUES OF ELEVATION FOR THE PIT BOTTOM.
PRICE	THE PRICE PER POUND OF FINISHED MATERIAL FROM ORE TYPE 1.
PRIC2	THE PRICE PER POUND OF FINISHED MATERIAL FROM ORE TYPE 2.
PROB	ARRAY USED TO STORE THE INPUT PROBABILITY DISTRIBUTIONS.
PSHBT	ARRAY USED TO STORE THE INPUT ELEVATIONS OF THE PUSHBACK WALL BOTTOM.
PVB	PRESENT VALUE OF BENEFIT COMPUTED IN ROUTINE "PRESV" .
PVC	PRESENT VALUE OF COST COMPUTED IN ROUTINE "PRESV" .
RATE	THE INPUT VALUE OF DISCOUNT RATE.
REC1	THE INPUT VALUE OF RECOVERY RATE FOR ORE TYPE 1.
REC2	THE INPUT VALUE OF RECOVERY RATE FOR ORE TYPE 2.
SCOST	ARRAY USED TO STORE THE COMPUTED VALUE OF STRIPPING COST FOR THE CURRENT SECTOR.
SAVE1	ARRAY TO HOLD USER DESIGNATED INFORMATION WHICH IS ZEROED ONLY AFTER THE COMPLETION OF EACH CASE
SAVE2	ARRAY TO HOLD USER DESIGNATED INFORMATION WHICH IS ZEROED ONLY AFTER THE COMPLETION OF EACH CASE
SDINC	ARRAY TO STORE STD.DEV.OF INCREMENTAL NPV
SECBT	TEMP. VARIABLE USED IN READI TO READ INPUT VALUES OF ELEVATION FOR SECTOR BOTTOM FOR EACH PERIOD.
SECWD	ARRAY USED TO STORE THE INPUT VALUES FOR SECTOR WIDTH FOR EACH PERIOD (YEAR) FOR THE CURRENT SECTOR.
SEGBT	ARRAY USED TO STORE THE INPUT VALUES OF ELEVATION FOR THE SEGMENT BOTTOMS. ONE VALUE FOR EACH SEGMENT.
SEGTP	ARRAY USED TO STORE THE INPUT VALUES OF ELEVATION FOR THE SEGMENT TOPS. ONE VALUE FOR EACH SEGMENT.
SFREQ	ARRAY USED TO STORE THE COUNT OF CELL INSTABILITIES OF EACH MODE WHICH HAVE OCCURRED.
SMISC	ARRAY USED TO STORE THE INPUT VALUES OF MISCELLANEOUS TYPE DATA.
STELS	ARRAY USED TO STORE THE INPUT VALUES OF PIT TOP ELEVATION FOR EACH PERIOD IN THE CURRENT SECTOR.
TITLE	ARRAY USED TO HOLD THE INPUT PIT DESIGN NAME.
TMP	TEMPORARY STORAGE ARRAY USED IN ROUTINE "READI" .
TTNWA	TOTAL TONNAGE OF WASTE MATERIAL IN THIS SECTOR
TTN1	TOTAL TONNAGE OF TYPE1 ORE IN THIS SECTOR
TTN2	TOTAL TONNAGE OF TYPE2 ORE IN THIS SECTOR
ULTBT	ARRAY USED TO STORE INPUT ELEVATIONS FOR ULTIMATE WALL BOTTOM
UND	ARRAY USED TO STORE UNDERLINING CHARACTERS USED IN PRINTING RESULTS.
USRBN	ARRAY USED TO STORE THE VALUES OF BENEFIT SUPPLIED BY THE USER BENEFIT ROUTINE BENF2 .
VOLO	VOLUME OF ORE PER TON.
VOLW	VOLUME OF WASTE PER TON.
WALHT	TEMPORARY VARIABLE FOR WALL HEIGHT USED BY SOME COST MODELS.
WASTE	ARRAY USED TO STORE THE INPUT VALUES FOR WEIGHT OF WASTE ROCK MOVED DURING EACH PERIOD (YEAR) OF MINE LIFE.
WRKEL	ARRAY USED TO STORE INPUT ELEVATIONS OF WORK BENCHES.
WEKPB	USED TO STORE THE PROBABILITY OF A WEAK STRATUM INSTABILITY IN THE PUSHBACK WALL.
WEKPP	USED TO STORE THE PROBABILITY OF A WEAK STRATUM INSTABILITY IN THE PIT WALL.
WRKWD	ARRAY USED TO STORE INPUT WIDTHS FOR EACH WORK BENCH.

ULTOV   ARRAY USED TO STORE BOTTOM ELEVATION LIMIT OF EACH ULTIMATE
        WALL.

        VARIABLES USED IN SUBROUTINES FILL AND FILL1

ARRAY   AN ARRAY USED IN ROUTINE "FILL" TO REPRESENT ANY INPUT ARRAY
        DIMENSIONED 1 BY 15, IN "FILL1" FOR ARRAYS DIMENSIONED 15.
ARRY2   AN ARRAY USED IN ROUTINE "FILL" TO REPRESENT ANY INPUT ARRAY
        DIMENSIONED 5 BY 15.
IDM   INDEX SUPPLIED TO ROUTINE "FILL" TO INDICATE WHETHER ARRAY
        OR ARRY2 SHOULD BE REFERENCED. IDM = 3 OR 5.
IERR   ERROR NUMBER TO BE CALLED FOR BY "FILL" OR "FILL1" IF NO
        VALUES ARE FOUND IN THE ARRAY TO BE FILLED.
ITYP   INDICATES TYPE OF INITIALIZING TO BE USED IN ROUTINE "FILL"
        AND IN ROUTINE "FILL1" . ITYP=0 INITIALIZE WITH ZEROS,
        ITYP=9 INITIALIZE WITH NINES.

        VARIABLES IN SUBROUTINE ERROR

HEAD   ARRAY USED IN ROUTINE "ERROR" TO STORE HEADINGS FOR CERTAIN
        PRINT LINES.
IM   STORES VARIOUS INDEX INFORMATION SUPPLIED THROUGH THE CALL
        PARAMETERS IN CALLS TO ROUTINE "ERROR" .
INIT   A TWO WORD ARRAY USED TO INITIALIZE FATAL ERROR MESSAGE PRINT
        LINES IN ROUTINE "ERROR" .
IPB   INDEX INTO ARRAY WCAT IN ROUTINE "ERROR" TO REFERENCE
        EITHER "PIT WALL" OR "PUSHBACK WALL" FOR ERROR MESSAGES.
N   USED IN ROUTINE "ERROR" FOR THE ERROR MESSAGE NUMBER SUPPLIED
        BY THE CALLING ROUTINE.
NAM   ARRAY USED IN ROUTINE "ERROR" TO STORE GENERAL ROCK TYPE
        NAMES USED USED IN PRINT LINES.
PTNAM   ARRAY USED IN ROUTINE "ERROR" TO STORE NAMES FOR PRINTING.
TYP1   ARRAY USED IN ROUTINE "ERROR" TO STORE NAMES FOR PRINT LINES.
TYP2A   ARRAY USED IN ROUTINE "ERROR" TO STORE NAMES FOR PRINTING.
WARNG   ARRAY USED IN ROUTINE "ERROR" TO INITIALIZE NONFATAL ERROR
        MESSAGES.
WCAT   ARRAY USED IN ROUTINE "ERROR" TO STORE NAMES FOR PRINTING.
WNAM   ARRAY USED IN ROUTINE "ERROR" TO STORE NAMES FOR PRINTING.

VARIABLES IN SUBROUTINE READI

IBR   VARIABLE SET BY OUTPUT FROM ROUTINE "IDENT" AND BRANCHED ON
BY COMPUTED GOTO STATEMENTS OR USED AS AN INDEX INTO ARRAYS.
USED IN ROUTINES "READI" AND "FTYPE" .

J   GENERAL SUBSCRIPT AND LOOP CONTROL VARIABLE.

JCAT   SUBSCRIPT USED TO SPECIFY THE POSITION OF A HISTOGRAM IN THE
PROBABILITY DISTRIBUTIONS ARRAY PROB . IT IS USED BY
ROUTINE "READI".

JVAL   SUBSCRIPT USED IN "READI" TO SPECIFY THE POSITION OF A
PROBABILITY VALUE IN A HISTOGRAM.

KF   FIRST PERIOD(YEAR) OF A RANGE OF PERIODS TO BE FILLED WITH
SOME VALUE.

KL   LAST PERIOD (YEAR) OF A RANGE OF PERIODS TO BE FILLED WITH
SOME VALUE.

KPDD   SUBSCRIPT VARIABLE USED TO TEMPORARILY STORE THE PREVIOUS
INPUT PERIOD (YEAR) DURING DATA INPUT PROCESSING BY "READI"

LEXC   FLAG SET TO 1 IN "READI" WHEN MORE THAN MXPRB PROBABILITY
HISTOGRAMS ARE FOUND IN THE INPUT DATA. AN ERROR MESSAGE
IS PRINTED.

LFRST   FLAG SET TO 1 TO INDICATE THAT THE FIRST PROBABILITY
DISTRIBUTION CARD HAS BEEN READ AND STORED. THE FIRST CARD
(RECORD) CONTAINS HEIGHTS, ALL OTHERS CONTAIN PROBABILITY
HISTOGRAMS.

LWEK   FLAG USED IN "READI" TO INDICATE THAT THE WEAK STRATUM
HEADER CARD HAS BEEN READ AND THAT WEAK STRATUM PROBABILITIES
WILL FOLLOW.

MAX   A DO LOOP CONTROL VARIABLE EQUAL TO MXHWK+1 USED IN "READI"

NSEG1   TEMPORARY STORAGE VARIABLE USED IN "READI" TO SET NSEG.

PSH   USED IN ROUTINE "READI" TO SET LPSH DURING INPUT OF INSTA-
BILITY TYPES.

VARIABLES IN SUBROUTINE OUTPUT

AVG1T   TEMPORARY VARIABLE USED IN PRINTING AVG1*100 IN "OUTPT" .

AVG2T   TEMPORARY VARIABLE USED IN PRINTING AVG2*100 IN "OUTPT".

IU   SUBSCRIPT VARIABLE USED IN UNDERLINING PRINTED LINES.

NUM   ARRAY USED IN ROUTINE "OUTPT" TO STORE NUMBERS 1 THROUGH
11 FOR USE IN COMPOSING PRINT LINES.

VARIABLES IN SUBROUTINE COST1

ANG	TEMPORARY STORAGE VARIABLE FOR ANGLES USED IN ROUTINE "COST1"
ANGA	ARRAY USED TO STORE THE COMPUTED VALUES OF INTER RAMP WALL ANGLES FOR THE PUSHBACK WALL.
ANGB	ARRAY USED TO STORE THE COMPUTED VALUES OF INTER RAMP WALL ANGLES FOR THE PIT WALL.
ANGIA	TEMPORARY VARIABLE FOR THE INTERIM ANGLE IN AN INTER RAMP WALL LOCATED IN THE PUSHBACK WALL.
ANGIB	TEMPORARY VARIABLE FOR THE INTERIM ANGLE IN AN INTER RAMP WALL LOCATED IN THE PIT WALL.
ANGLI	TEMPORARY VARIABLE USED IN DETERMINING THE WALL ANGLE IN ROUTINE "COST1".
BOTEL	VARIABLE USED FOR ELEV OR THE PUSHBACK BOTTOM WHEN DETERMINING WALL WIDTHS OF INTER RAMP WALLS IN "COST1".
BOTS	TEMPORARY STORAGE FOR BOTEL IN "COST1".
ELEV	VARIABLE USED FOR THE BOTTOM ELEVATION OF AN INTERRAMP PAIR, EITHER A HAUL ROAD, A WORK BENCH OR THE FULL WALL BOTTOM ELEVATION. USE IS DURING HEIGHT AND ANGLE DETERMINATIONS IN ROUTINE "COST1".
HBNFA	ARRAY USED IN ROUTINE "COST1" TO STORE THE FULL HEIGHT OF THE WALL ABOVE THE AVERAGE BENCH BOTTOM IN THE PUSHBACK WALL.
HBNFB	ARRAY USED IN ROUTINE "COST1" TO STORE THE FULL HEIGHT OF THE WALL ABOVE THE AVERAGE BENCH BOTTOM IN THE PIT WALL.
HIFLA	ARRAY USED IN "COST1" TO STORE THE FULL HEIGHTS OF THE WALLS ABOVE INTER RAMP BOTTOM ELEVATIONS IN THE PUSHBACK WALL.
HIFLB	ARRAY USED IN "COST1" TO STORE THE FULL HEIGHTS OF THE WALLS ABOVE INTER RAMP BOTTOM ELEVATIONS IN THE PIT WALL.
HIWLA	ARRAY USED IN "COST1" TO STORE THE HEIGHT OF INTER RAMP WALLS WHICH ARE IN THE PUSHBACK WALL.
HIWLB	ARRAY USED IN "COST1" TO STORE THE HEIGHT OF INTER RAMP WALLS WHICH ARE IN THE PIT WALL (BELOW ANY PUSHBACK IN THE SECTOR).
HT	VARIABLE USED FOR VALUES OF HEIGHT.
HTFLA	ARRAY USED IN "COST1" TO STORE THE FULL WALL HEIGHTS FOR THE PUSHBACK WALL.
HTFLB	ARRAY USED IN "COST1" TO STORE THE FULL WALL HEIGHTS FOR THE PIT WALL.
HTI	VARIABLE USED IN ROUTINE "COST1" FOR INTERIM HEIGHT VALUES.
HTIA	ARRAY USED IN "COST1" TO STORE INTERIM WALL HEIGHT VALUES IN EACH INTER RAMP WALL FOR THE PUSHBACK WALL.
HTIB	ARRAY USED IN "COST1" TO STORE INTERIM WALL HEIGHT VALUES IN EACH INTER RAMP WALL FOR THE PIT WALL.
HTS	ARRAY USED IN "COST1" TO STORE HEIGHT OF EACH SEGMENT.
HTUA	ARRAY USED IN "COST1" TO STORE THE ULTIMATE WALL HEIGHTS IN EACH INTER RAMP WALL FOR THE PUSHBACK WALL.
HTUB	ARRAY USED IN "COST1" TO STORE THE ULTIMATE WALL HEIGHTS IN EACH INTER RAMP WALL FOR THE PIT WALL.
IANG	FLAG USED IN "COST1" IN DETERMINING INTER RAMP ANGLES. IF IANG=1 THE INTER RAMP ANGLE IS COMPUTED FROM INTER RAMP HEIGHTS AND WIDTHS. IF IANG=0 ANGLE WILL BE THE INTERIM WALL ANGLE OR THE ULTIMATE ANGLE OF THE WALL BOTTOM.
IBOT	VARIABLE USED IN "COST1" FOR THE SEGMENT NUMBER OF THE WALL BOTTOM. ALWAYS 1 NOW THAT SEGMENTATION HAS BEEN DELETED.
IBOT1	IBOT-1
IBOT2	IBOT1-1
IHWB	THE NUMBER OF THE FIRST HAUL ROAD OR WORK BENCH BELOW THE PUSHBACK BOTTOM OR ELSE NHWK+1.
ILOC	FLAG USED IN "COST1" TO INDICATE WHETHER THE INTER RAMP WALL WIDTH BEING COMPUTED IS IN THE PUSHBACK WALL OR PIT WALL.
IRZA	ARRAY USED IN ROUTINE "COST1" TO STORE WALL NUMBERS OF ZERO HEIGHT INTER RAMP WALLS IN THE PUSHBACK WALL.
IRZB	ARRAY USED IN ROUTINE "COST1" TO STORE INTER RAMP WALL NUMBERS OF ZERO HEIGHT WALLS IN THE PIT WALL.

ITOP	ALWAYS =1 SINCE SEGMENTATION WAS REMOVED.
ITOPU	INDICATES THE ULTIMATE WALL IN WHICH THE I. R. WALL TOP LIES (FOR THE INTER RAMP WALL CURRENTLY BEING PROCESSED).
IU	SUBSCRIPT VARIABLE USED IN ROUTINE "COST1" FOR THE ULTIMATE WALL ANGLE SEGMENT NUMBER.
IULB	CONTAINS THE ULT. WALL DIVISION NUMBER OF THE DIVISION IN WHICH THE ULT. WALL BOTTOM ELEV. FOR THIS PERIOD IS LOCATED.
IULWP	THE ULTIMATE WALL DIVISION IN WHICH THE PUSHBACK OCCURS.
JBOT	VARIABLE USED TO STORE IBOT TEMPORARILY DURING PROCESSING OF THAT INTER RAMP PAIR WHICH INCLUDES THE PUSHBACK BOTTOM.
JH	SUBSCRIPT FOR THE NEXT HAUL ROAD IN THE FORTRAN CODE FOR MERGING HAUL ROADS WITH WORK BENCHES INTO ARRAY HWKEL .
JW	SUBSCRIPT FOR THE NEXT WORK BENCH IN WKKEL TO BE MERGED WITH THE HAUL ROADS INTO ARRAY HWKEL .
LOOP	LOOP CONTROL VARIABLE USED IN "COST1" TO INDICATE WHEN A PUSHBACK LIES BETWEEN AN INTER RAMP PAIR. IF LOOP=1 A PUSHBACK LIES BETWEEN AND THE ANGLE DETERMINATION LOOP MUST BE EXECUTED TWICE.
PUSHB	TEMPORARY VARIABLE USED FOR THE PUSHBACK BOTTOM ELEVATION DURING WALL HEIGHT AND ANGLE DETERMINATIONS IN "COST1" .
TOP	TEMPORARY VARIABLE USED FOR THE TOP ELEVATION OF A WALL. IT MAY CONTAIN THE TOP ELEVATION OF THE EXCAVATION OR THE TOP OF AN INTER RAMP PAIR. IT IS USED IN ROUTINE "COST1" DURING WALL HEIGHT AND ANGLE DETERMINATIONS.
TOPEL	TEMPORARY VARIABLE USED FOR THE TOP ELEVATION OF THE WALL CURRENTLY BEING PROCESSED. IT MAY CONTAIN TOP OF THE PUSH-BACK BOTTOM (WHEN THE TOP OF A WALL) OR OTHER TOP ELEVATION.
ULTB	TEMPORARY VARIABLE USED FOR THE ULTIMATE WALL BOTTOM ELEVATION DURING WALL HEIGHT AND ANGLE DETERMINATIONS IN ROUTINE "COST1" .
WO	VARIABLE USED FOR WALL WIDTH IN VARIOUS ROUTINES.
WOFLA	ARRAY USED IN "COST1" TO STORE THE WIDTH OF FULL HEIGHT WALLS LOCATED IN THE PUSHBACK WALL.
WOFLB	ARRAY USED IN "COST1" TO STORE THE WIDTH OF FULL HEIGHT WALLS LOCATED IN THE PIT WALL.
WOI	VARIABLE USED IN "COST1" FOR THE WIDTH OF AN INTERIM WALL.
WOIA	ARRAY USED IN "COST1" TO STORE THE WIDTHS OF INTERIM WALLS IN INTER RAMP WALLS LOCATED IN THE PUSHBACK WALL FOR THE CURRENT PERIOD (YEAR).
WOIB	ARRAY USED IN "COST1" TO STORE THE WIDTHS OF INTERIM WALLS IN INTER RAMP WALLS LOCATED IN THE PIT WALL FOR THE CURRENT PERIOD (YEAR).
WOUA	ARRAY USED IN "COST1" TO STORE THE ULTIMATE WALL WIDTHS IN INTER RAMP WALLS LOCATED IN THE PUSHBACK WALL FOR THE CURRENT PERIOD (YEAR).
WOUB	ARRAY USED IN "COST1" TO STORE THE ULTIMATE WALL WIDTHS IN INTER RAMP WALLS LOCATED IN THE PIT WALL FOR THE CURRENT PERIOD (YEAR).

VARIABLES IN SUBROUTINE FCHK

APAT   THE PROBABILITY DISTRIBUTION INTERPOLATION RATIO COMPUTED IN
        ROUTINE "FCHK" FOR THE GIVEN WALL ANGLE.
CCST   THE COST OF A ONE CELL INSTABILITY IN ROUTINE "FCHK" .
COST   VARIABLE USED TO SUM OR RETURN COST BY VARIOUS ROUTINES.
HRAT   THE PROBABILITY DISTRIBUTION INTERPOLATION RATIO COMPUTED IN
        ROUTINE "FCHK" FOR THE GIVEN WALL HEIGHT.
HTF   VARIABLE USED IN ROUTINE "FCHK" TO STORE THE HEIGHT FROM PIT
        TOP ELEVATION TO WALL BOTTOM ELEVATION.
IS   SUBSCRIPT VARIABLE SET TO INDEX THE PROBABILITY DISTRIBUTION
        NEAREST TO BUT LARGER THAN THE GIVEN WALL ANGLE.
ISL   SUBSCRIPT USED IN THE INSTABILITY COUNTING ARRAY SFREQ
        TO REFERENCE THE CORRECT MODE.
JOST   PROBABILITY DISTRIBUTION SUBSCRIPT. =2 FOR WEAK STRATUM.
JS   SUBSCRIPT VARIABLE SET TO INDEX THE PROBABILITY DISTRIBUTION
        HEIGHT NEAREST TO BUT LARGER THAN THE GIVEN WALL HEIGHT.
LHT   SET IN ROUTINE "FCHK" TO GREATEST NUMBER OF PROB. POINTS
        IN A HISTOGRAM (10).
LPB   PUSHBACK FLAG INPUT TO ROUTINE "FCHK" . 1 = PUSHBACK.
PA   USED TO STORE COMPUTED PROBABILITY FOR THE WALL FROM PIT TOP
        TO GIVEN WALL BOTTOM.
PB   USED TO STORE COMPUTED PROBABIITY FOR THE WALL FROM PIT TOP
        TO GIVEN WALL TOP.
PROBV   THE COMPUTED PROBABILITY OF INSTABILITY OF THE GIVEN WALL,
        PROBV = PA-PB.
R   USED TO STORE THE CURRENT RANDOM NUMBER.
WALL   VARIABLE USED TO STORE THE GIVEN VALUE OF WALL HEIGHT.
XANG   VARIABLE USED TO STORE ANGLE IN DEGREES FOR PRINTING IN
        ROUTINE "FCHK" .

APPENDIX B

USERS' GUIDE FOR RISK ANALYSIS PROGRAM

INRISK - VERSION III

PROGRAM IDENTIFICATION

PROGRAM TITLE: Economic Risk Analysis Model for Pit-Slope Design

PROGRAM CODE NAME: INRISK, VERSION III

PROGRAM WRITER: Y. C. Kim

ORGANIZATION: Department of Mining & Geological Engineering
The University of Arizona Tucson, Arizona

DATED: 15 March 1976

UPDATED: Version III is a revision of Version II, completed on 15 March 75

SOURCE LANGUAGE: CDC 6400 FORTRAN Extended

AVAILABILITY: Pit Slope Group, Mining Research Laboratories,
Canada Centre for Mineral and Energy Technology,
Department of Energy, Mines and Resources,
555 Booth Street,
Ottawa, Canada K1A 0G1

DISCLAIMER: Neither the authors nor the Mining Research Laboratories can accept any responsibility for the accuracy of results generated by this program.

ABSTRACT

INRISK performs risk analyses for open pit mine investments, with particular emphasis on slope economics. In performing the risk analysis, the model uses the output from BNCST, as part of its input data. Therefore, BNCST must be run prior to using INRISK.

The program can perform the desired analysis, whether the mine is at the feasibility stage, mine design stage, or operating stage.

ENGINEERING DOCUMENTATION

Narrative Description

1. The objective of the program is to perform the risk analysis of open pit mining ventures with particular emphasis on slope economics. First, the program is designed to make full use of information concerning the benefits and costs of a particular slope design, as generated by BNCST, Version III. Secondly, it is designed to display the overall financial impact of this design on the mine investment decisions.

2. Although the program is designed to perform a full-scale risk analysis, it can also be used for performing conventional economic analyses by making all input variables constant. Such simulations are called deterministic and are frequently used to verify financial computations. The program can be used where the decision to mine or invest is of a "go" or "no go" nature.

3. There is one critical requirement that must be met to execute this program. BNCST must be run earlier and its output of benefits, costs, and other pit design data such as ore and waste figures by period, must be stored on magnetic tape or any other data file. Thus, output from the benefit-cost model becomes input data to this program, in addition to those input data on cards whose format is given in the subsequent section of this guide.

Method of Solution

4. For the input of data generated by BNCST, the same number of sectors as in BNCST must be specified in INRISK, although these divisions are later aggregated into a single pit during the financial computations. The reason for this aggregation is that the capital investments associated with a mining venture are seldom on a sector basis in a pit.

5. However, the model can analyze a pit sector of an ongoing operation. Such a sector can be undergoing a study for possible future expansion. In this case, only the incremental investments associated with this sector expansion are used in the risk analysis program.

6. For convenience in programming, the key variables in the risk analysis model are not classified according to state or decision variables. Instead, they are classified either as constants (ie, integer or floating point) or as stochastic variables.

7. A stochastic variable is, by definition, subject to variation according to some probability distribution associated with the variable. Whether a key variable should be classified as a constant or as a stochastic variable in a risk analysis is quite arbitrary. The classification is usually dictated by the objective of the analysis as well as the situation.

8. For INRISK, the values of key variables regarded as constants remain unchanged for all simulations. One simulation refers to computation of one sample point of the investment decision criteria such as the net present value of the venture. The values of key variables regarded as stochastic will vary from simulation to simulation.

9. Stochastic variables are further divided into: (1) those whose values vary between simulations but remain unchanged from period to period during the mine's life within the current simulations and (2) those whose values not only vary between simulations but also vary from period to period.

10. Fig B-1 is a printout of all the input data required in running the risk analysis model. As can be seen, the last portion of input data is obtained from the benefit-cost model, which is assumed to have been run earlier.

11. A portion of data from the benefit-cost model is also treated as constant between simulation runs. These data are the periodic (such as annual) figures for ore and waste, grades and costs of mining for the entire pit. These data are obtained for the entire pit by weighting corresponding figures from each sector of the pit by the associated production figures for each period.

12. The remaining portion of data from the benefit-cost model, namely the user and miscellaneous benefits as well as instability and user

```
      -- INPUT DATA FOR PIT DESIGN NUMBER  1 --
   ==================================================
```

LUCKEY STAR DEPOSIT   BASE DESIGN 45 DEGREES ULTIMATE SLOPE   HIGH GRADE

1. OPTION SWITCHES USED FOR THIS RUN.

```
              INPUT DATA PRINT OPTION           1
              DECISION CRITERIA OPTION          0
              INTERIM RESULTS PRINT OPTION      0
              USER SUPPLIED TAX ROUTINE OPT.    0
```

2. INTEGER CONSTANTS.

```
              NUMBER OF SIMULATIONS            30
              NUMBER OF SECTORS IN THE PIT      2
              NUMBER OF WORKING DAYS /PERIOD  350
              NO. OF PERIODS FOR PRE-PROD.      2
              NO. OF PERIODS FOR EXPLORATION    0
              NO. OF PERIODS FOR LAND/WATER     0
              NO. OF PERIODS FOR PLANT CONST    2
              ACTUAL PROD. LIFE OF THE MINE    10
              TOTAL LIFE OF THE PROJECT        12
```

3. FLOATING POINT CONSTANTS.

```
              REQUIRED RATE OF RETURN          .150
              FEDERAL INCOME TAX RATE        0.000
              PROVINCIAL MINING TAX RATE       .100
              PROVINCIAL INCOME TAX RATE       .150
              DEPLETION ALLOWANCE RATE         .330
```

4. STOCHASTIC VARIABLES CONSTANT FOR ONE SIMULATION RUN.

```
              EXPLORATION EXPENSE      (IN 1000 DOLLAR              UNITS)
                        CONSTANT                 VALUE =        500.000
              ROYALTY ( PERCENT            OF GROSS INCOME)
                        CONSTANT                 VALUE =           .050
              MINE CAPITAL EXPENDITURE (IN 1000 DOLLAR              UNITS)
                        RECTANGULAR              MINIMUM           MAXIMUM
                                                6000.000         10000.000
              MILL CAPITAL EXPENDITURE (IN 1000 DOLLAR              UNITS)
                        RECTANGULAR              MINIMUM           MAXIMUM
                                               10000.000         30000.000
              LEACH PLANT (OR TYPE2 ORE)
                        CAPIT. EXPEND(IN 1000 DOLLAR                UNITS)
                        CONSTANT                 VALUE =        5000.000
              WATER/LAND ACQUIS. COSTS.(IN 1000 DOLLAR              UNITS)
                        CONSTANT                 VALUE =           1.000
              TOTAL SALVAGE VALUE      (IN 1000 DOLLAR              UNITS)
                        CONSTANT                 VALUE =           0.000
              TOTAL WORKING CAPITAL    (IN 1000 DOLLAR              UNITS)
                        CONSTANT                 VALUE =           0.000
```

Fig B-1 - Input data required in the INRISK model

5. STOCHASTIC VARIABLES SAMPLED EVERY PERIOD DURING ONE SIMULATION RUN.

```
OVERALL RECOVERY OF TYPE1 ORE-PERCENT
        RECTANGULAR              MINIMUM         MAXIMUM
                                  .800            .900
OVERALL RECOVERY OF TYPE2 ORE-PERCENT
        TRIANGULAR              MINIMUM      MOST LIKELY     MAXIMUM
                                  .500          .700          .900
SELLING PRICE OF THE METAL   (DOLLAR         /TON                )
        NORMAL                   MEAN         STD. DEV.
                               1600.000       160.000
MISCELLANEOUS COSTS          (DOLLAR         /TON             -ORE)
        CONSTANT               VALUE =         0.000
```

6. INPUT DATA OBTAINED FROM THE BENEFIT-COST MODEL.

PERIOD	WEIGHTS (1000 TON UNITS)			AVE. GRADES (PERCENT)		COST OF MINING (COST/UNIT WEIGHT)		
	TYPE1 ORE	TYPE2 ORE	WASTE	TYPE1	TYPE2	TYPE1 ORE	TYPE2 ORE	WASTE
1	0.	0.	0.	0.000	0.000	0.000	0.000	0.000
2	920.	480.	1587.	.340	.250	2.550	1.200	.550
3	5112.	1615.	5452.	.510	.250	2.550	1.200	.550
4	5896.	3811.	15435.	.580	.250	2.550	1.200	.550
5	5392.	3811.	14701.	.650	.250	2.550	1.200	.550
6	5336.	4120.	20913.	.740	.250	2.550	1.200	.550
7	5720.	5048.	28557.	.670	.250	2.600	1.230	.600
8	5592.	5460.	34499.	.530	.250	2.600	1.230	.600
9	5192.	4472.	38907.	.470	.250	2.600	1.230	.600
10	5192.	5104.	38072.	.460	.250	2.650	1.250	.650
11	4118.	2081.	12430.	.550	.250	2.650	1.250	.650
12	458.	231.	0.	.550	.250	2.650	1.250	0.000

PERIOD	USER BENEFITS(THOUSANDS)		MISC..BENEFITS(THOUSANDS)		INSTAB. COSTS(THOUSANDS)		USER COSTS(THOUSANDS)	
	AVE.	STD.DEV.	AVE.	STD.DEV.	AVE.	STD.DEV.	AVE.	STD.DEV.
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	543.	176.	0.	0.
4	0.	0.	0.	0.	926.	460.	0.	0.
5	0.	0.	0.	0.	965.	546.	0.	0.
6	0.	0.	0.	0.	1265.	650.	0.	0.
7	0.	0.	0.	0.	1490.	934.	0.	0.
8	0.	0.	0.	0.	1676.	1025.	0.	0.
9	0.	0.	0.	0.	2080.	1541.	0.	0.
10	0.	0.	0.	0.	1714.	436.	0.	0.
11	0.	0.	0.	0.	2312.	1291.	0.	0.
12	0.	0.	0.	0.	2287.	912.	0.	0.

Fig B-1 (continued) - Input data required in the INRISK model

costs, are treated as stochastic variables, all of which are assumed to be normally distributed. They are sampled for each period from the corresponding period's normal distribution for the current simulation and also between simulation runs.

13. Just as the weighting of certain data from the different sectors of a pit is required, the means and standard deviations of stochastic variables from the benefit-cost model must be combined in the risk analysis model. In other words, the probability distributions that have been obtained in the benefit-cost model must be combined into a single composite probability distribution.

14. All stochastic variables whose distributions require combining or adding together are assumed to be normally distributed. Under this assumption, the means and the variances ie, square of the standard deviation, can both be added (18). Furthermore it is also proven that the resulting distribution is normally distributed. In other words, X_1, X_2, ..., X_n are mutually stochastically independent random variables having, respectively, the normal functions $n(\mu_1, \sigma_1^2)$, $n(\mu_2, \sigma_2^2)$, ..., and $n(\mu_n, \sigma_n^2)$ where μ_i and σ_i are the mean and variance of X_i. The random variable $Y = k_1X + k_2X + ... + k_nX_n$, where k_1, k_2, ..., k_n are real constants, is

$$n(\sum_{i=1}^{n} k_i\mu_i, \sum_{i=1}^{n} k_i\sigma_i^2)$$

15. The types of probability density functions that may be input for the stochastic variables are: (1) normal, (2) triangular, (3) uniform (or rectangular), (4) histogram, and (5) single-point (or constant).

16. The first three functions are continuous whereas the last two are discrete. A brief description of each is given below.

17. A normal density function is completely specified by its mean and standard deviation. This function is used most frequently to describe the probabilistic outcomes of some natural phenomena, when the outcomes are shown to be spread equally about some expected value, ie, the mean. The extent of spread or dispersion is

usually described in terms of magnitude of the standard deviation. An estimate of the mean and standard deviation is required in the model.

18. A triangular density function requires specification of the minimum, the most likely, and the maximum values of the variable. The minimum and the maximum are considered as the lower and upper limits on the value, with the most likely value having the greatest probability of occurrence. The model requires these three estimates for the variables.

19. A uniform function is specified when the minimum and the maximum values are given. In a uniform function, there is an equal probability of obtaining any value between those two extremes, including the minimum and the maximum.

20. A histogram function refers to a special discrete function. The range of values are estimated and divided into classes. The probabilities associated with each class are specified, making certain that the sum of all probabilities adds up to exactly 1.0. A histogram is useful for empirical data or for approximating any probability distribution. The model requires the beginning class limit, the class interval and the probability for each class. The program allows a maximum of nine class intervals.

21. The final alternative is to assume the stochastic variables as constants. Such an alternative can be useful in performing deterministic or conventional sensitivity analysis on key input variables. A point estimate is required for the model equivalent to a probability of one for this value.

22. The cash flow computations in the model cover both the preproduction and production periods of the mine.

23. During the preproduction period, negative cash flow occurs due to the following activities: (1) exploration, (2) water and land acquisition, and (3) plant construction and preproduction stripping. The model requires that the three activities occur in the above sequence.

24. The total number of periods allowed in the model for cash flow computations is 15. This number includes both preproduction and production

periods. The length of a period need not correspond to one year in time. Fifteen periods are not likely to be sufficient in many cases. If more than 15 periods are required, the user can redimension the arrays. The corresponding change in the number of periods must be made to BNCST because this number must match both programs.

25. INRISK makes certain explicit assumptions some of which are related to executing the program. (1) BNCST is run earlier, and its output is stored in the specified data file. (2) Project titles used for the risk analysis and the benefit-cost analysis match columns for the entire 80 columns of an input data record for each case representing a particular pit design. (3) For each case, the total number of simulations, the total life of the pit and the number of sectors in the current pit is the same between the risk analysis and the previously run benefit-cost analysis. (4) The total number of periods specified for preproduction are equal to the sum of periods required for conducting exploration, water and land acquisition, and plant construction and preproduction stripping. (5) The total number of periods specified for mine life is equal to the sum of periods required for preproduction plus operating periods.

26. Other assumptions are related to the cash-flow computations. (1) Cash flow computation is to be performed for the entire pit and not only for a sector in the pit. (2) Those stochastic variables such as "User Benefits" and "Instability Costs" whose values are generated in the benefit-cost model are normally distributed. This assumption permits combining several distributions into a single composite distribution. (3) The work involving exploration, water and land acquisition, plant construction and preproduction stripping is conducted in that sequential order. Expenditures for each category of work are made uniformly over the specified number of periods for that category. (4) The same mining sequence as used in the benefit-cost model will be followed. The production figures, grades and mining costs associated with each period will not vary between simula-

tion runs. (5) All the ore mined in a given period will be processed in that period. This assumption applies even to the preproduction period, thus creating a possibility of some revenue during the preproduction period. (6) Applicable royalty is always given as some percentage of the gross revenue. In other words, there is no minimum royalty, irrespective of the gross revenue for the period.

27. The assumptions included in the risk analysis are as follows. (1) All key variables used in the risk analysis are independent of each other. (2) The periodic variations of those stochastic variables sampled in each period are independent. (3) No trend, either increasing or decreasing, exists in the value of the stochastic variables, as a function of mine life.

Program Capabilities

28. At present, the program has the following capabilities:

Maximum number of pit layouts to be tested (less than or equal to those tested in BNCST program) = 9

Maximum number of sectors in the pit = 6

Maximum number of periods in mine's life (including the preproduction period) = 15

Maximum number of simulations for each layout = 100

Maximum number of stochastic variables allowed = 12

Maximum number of class intervals in input histogram = 9

The period array has been dimensioned at 15 to conserve core space. If more than 15 periods are required, the array can be redimensioned by the user. Cash flows are computed for each period in the model and are discounted to the present. If the period in the model is a year, then the discount rate is the annual rate. If a nonannual period is used, then an appropriate discount rate should be input. The program is capable of performing risk analysis for all types of deposits with two distinct ore types.

```
0      10      20      30      40      50      60      70      80   Master
1                                                                    - Run
LUCKEY STAR DEPOSIT      BASE DESIGN 45 DEGREES ULTIMATE SLOPE   HIGH GRADE  - Type 0
                  1           0         0         0                  - Type 1
    30     2  350  2     0    0     2  10    12                      - Type 2
0.15      0.21      0.1      0.15      0.33                          - Type 3
5.0  500.
5.0  .05
3.0  6000.   10000.
3.0  15000.  30000.                                                 - Type 4
5.0  5000.
5.0  1.
5.0  0.0
5.0  0.0
3.0   .80     0.90
2.0   .50      .70      .90                                         - Type 5
1.0  1600.0  160.0
5.0  0.0
0      10      20      30      40      50      60      70      80
```

Fig B-2 - An 80-80 listing of the sample input data cards

Data Input

29. The data required for the program comes from both the data cards and the benefit-cost output data file. The data cards contain information needed for the economic risk analysis, whereas the data file contains output from the benefit-cost model, BNCST-Version III. The subsequent description of input data applies only to those belonging to the first category. A sample of the input data required for the program is shown in Fig B-2.

30. Besides the project headings for the pit layout, five types of information are input to the model through data cards in the sequence:

a. program run control parameters,

b. integer constants that remain the same for the entire simulation,

c. floating point constants that remain the same for the entire simulation,

d. key stochastic variables and their probability distributions that remain constant for one simulation run but vary between simulation runs,

e. key stochastic variables and their probability distributions that vary from one period to the next within each simulation run as well as between simulation runs.

This set of data must be repeated for each pit layout to be tested during the model run. The particular format used to input these five types of data is described in Exhibit B-1 of this Appendix. Fig B-2 is an 80-80 listing of the input data cards used for the sample problem, ie, the Lucky Star deposit with the base design of the pit.

31. The input data may be in any consistent set of units. However, those used in the INRISK program must correspond to those in the prior run of the BNCST program.

Program Options

32. All the options available in running the program are controlled by the values assumed by variables NOUT, NDE, NBUG, NTAX.

33. NOUT is used for controlling printout of input data. When NOUT = 0, the input data for each case is not printed. When NOUT = 1, input data and also the sorted values of the simulation

SORTED VALUES FOR THE PIT DESIGN NO   1

SIMULATION NO.	NPV
11	14340000.
17	14508000.
23	15531000.
28	18249000.
3	18631000.
24	20257000.
27	21151000.
6	21152000.
4	23743000.
15	25058000.
8	26249000.
10	26531000.
2	26736000.
12	26762000.
21	26977000.
9	27246000.
26	28048000.
18	30480000.
25	30496000.
16	31350000.
29	31686000.
30	32487000.
13	34011000.
19	35401000.
1	37347000.
22	38100000.
20	38447000.
5	39119000.
7	41042000.
14	44937000.

Fig B-3 - Typical printout of sorted results of simulations

results are printed.

34. NDE is used to select the desired financial decision criteria during the risk analysis for each case. When NDE = 0, all three criteria of DCFROY, NPV, WGR are used. When NDE = 1, DCFROY and NPV are used. When NDE = 2, DCFROY only used. When NDE = 3, NPV only used. When NDE = 4, WGR only used.

35. NBUG is used to control printout of intermediate results that can be used both to debug the program logic through comparative calculations and to obtain additional information such as annual figures on production, taxes, depreciation, etc., as well as the sampled values of stochastic variables. When NBUG = 0, intermediate results are not printed. When NBUG = 1, intermediate results are printed. Because of the voluminous amount of information that could be printed when NBUG switch is 1, only the values used during the first two simulation runs are output in the model.

36. NTAX is the option switch for calling the program user's tax laws instead of the tax laws supplied in the model. The user's tax laws must be programmed into a subroutine named URTAX in the program. At present, URTAX in the program is simply a dummy subroutine. When NTAX = 0, the given tax laws are used. When NTAX = 1, other tax laws are used by calling subroutine URTAX.

Printed Output

37. Printed output consists of input data summary, intermediate results during the simulation and the final results for each pit design. A summary of input data, as shown in Fig B-1, is printed if the NOUT value is greater than zero. Intermediate results during the first two simulations are printed if the NBUG value is greater than zero.

38. At the conclusion of the risk analysis for each pit design, the program prints out the sorted values of decision criteria if the NOUT value is greater than zero (see Fig B-3). Finally, it prints out the cumulative probability distribution, which represents all possible outcomes of the decision criteria (see Fig B-4).

---SUMMARY OF THE SIMULATION RESULTS FOR THE PIT DESIGN NO 1

LUCKEY STAR DEPOSIT   BASE DESIGN 45 DEGREES ULTIMATE SLOPE   HIGH GRADE

             NPV MEAN VALUE =   28202000. DOLLARS
             NPV STD. DEV. =   9683000. DOLLARS

PROBABILITY OF ACHIEVING   .
AT LEAST THE VALUE SHOWN   .   NPV VALUE
....
            1.00   .   14000000
             .93   .   15000000
             .90   .   16000000
             .90   .   17000000
             .90   .   18000000
             .83   .   19000000
             .83   .   20000000
             .80   .   21000000
             .73   .   22000000
             .73   .   23000000
             .70   .   24000000
             .70   .   25000000
             .67   .   26000000
             .50   .   27000000
             .47   .   28000000
             .43   .   29000000
             .43   .   30000000
             .37   .   31000000
             .30   .   32000000
             .27   .   33000000
             .27   .   34000000
             .23   .   35000000
             .20   .   36000000
             .20   .   37000000
             .17   .   38000000
             .10   .   39000000
             .07   .   40000000
             .07   .   41000000
             .03   .   42000000
             .03   .   43000000
             .03   .   44000000
             .00   .   45000000

Fig B-4 - A typical summary of the risk analysis results

Other Outputs

39. None.

Flow Chart

40. A flow chart of the INRISK main program is given in Fig B-5. Fig B-6 contains a micro-flow chart of DCFROI, the most complicated subroutine.

Sample Runs

41. A sample run is given in Exhibit B-2 of this Appendix. It corresponds to the one described in BNCST-Version III. In other words, the output from BNCST was used as part of the overall input data.

42. The case represents a pit design for a hypothetical porphyry copper deposit called Lucky Star. The numerical values such as the capital investment, mining cost, etc, input for this sample run are arbitrary. The numerical results are not necessarily realistic.

43. The case was tested using the printout option switch NOUT and the debug switch NBUG at the value of 0, thus obtaining the input data summary without the intermediate results.

OPERATING SYSTEM DOCUMENTATION

Computer Equipment

44. The INRISK, Version III program was run on a CDC 6400 computer with a 50K-core central memory. Approximate minimum central memory access time is 1.0 micro second.

Peripheral Equipment

45. The following peripheral equipment is necessary in the execution of the INRISK program: 405 card reader, 607 tape driver, 512 line printer.

Source Program

46. A complete source program listing is available on request. System unit Number 1 is the card reader, Number 3 is the line printer, and Number 4 is the physical unit containing BNCST output data. Copies of the program source card deck are available from:

Canada Centre for Mineral and Energy
   Technology
Department of Energy, Mines and Resources
555 Booth Street
Ottawa, Canada K1A OG1

Variables and Subroutines

47. The program consists of the main program "INRISK" and 19 subroutines.

48. **Main Program INRISK** - This program performs the following tasks. (a) Reads in all input data at the beginning of a run. (b) Calls various subroutines in a proper sequence to perform risk analysis simulations in accordance with the specified options. (c) Prints out certain input data and intermediate results, if requested, by calling appropriate subroutines.

49. **Subroutines**

a. INOUT: Prints out all the input data required by the program.

b. ERROR: Prints out appropriate error messages if the program detects any error in input data. The routine also terminates the run.

c. GENER: Generates sample values for all stochastic variables.

d. CASHFL: Computes cash flows for each preproduction and production years.

e. DEPRN: Computes accelerated write-off capital investment.

f. DEPL: Computes annual depletion allowance and various taxes.

g. DCFROI: Computes the net present value of cash flows using the specified discount rate.

h. NETPRV: Computes the net present value of cash flows using the specified discount rate.

i. WELGR: Computes the wealth growth rate of investment.

j. OUTINT: Sorts the results of different financial criteria in increasing order, and prints the sorted values if requested.

k. SORT: Sorts one-dimensional array values into increasing order.

l. OTPUT: Controls the final result printout.
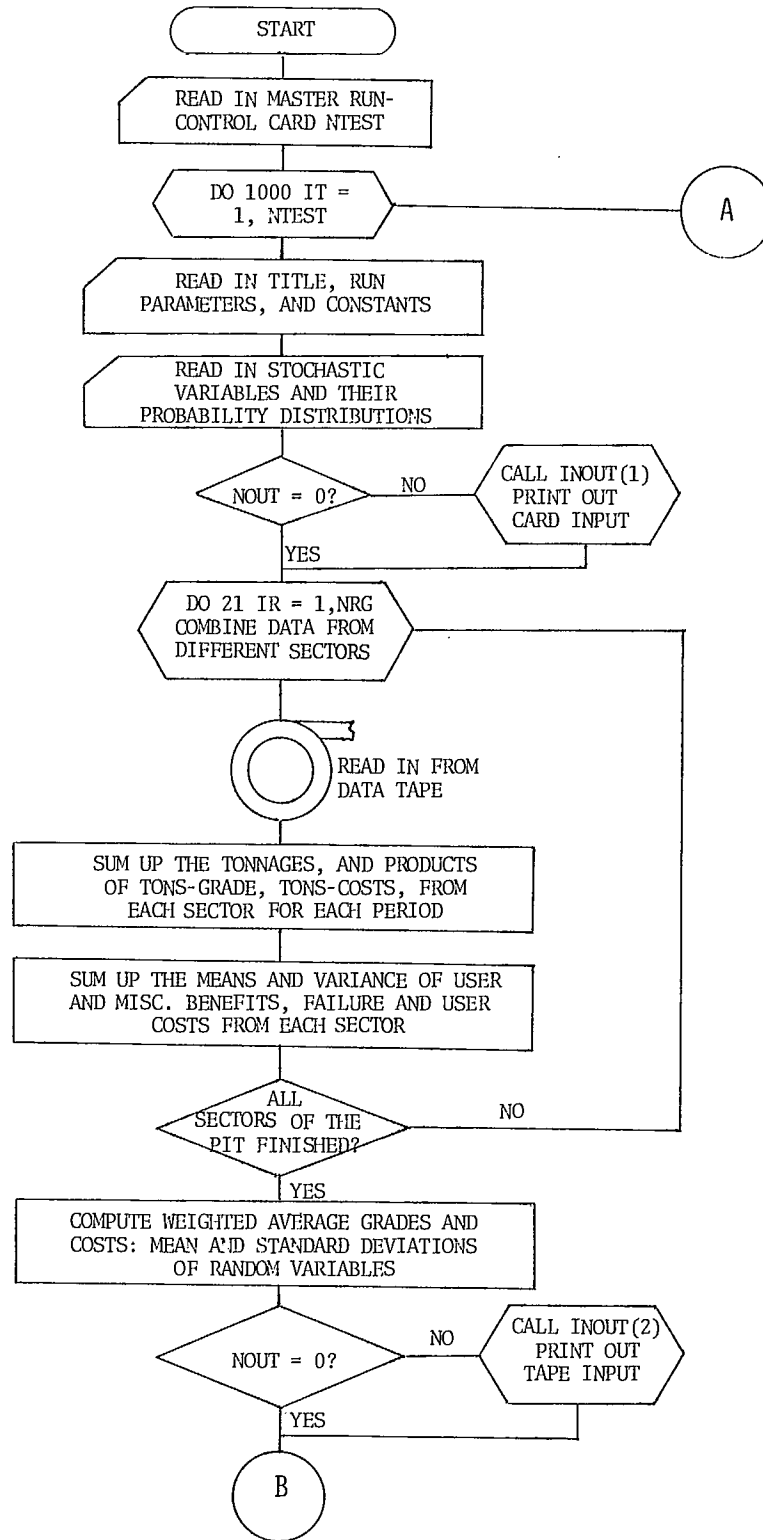
Fig B-5 - Flow chart of the INRISK main program
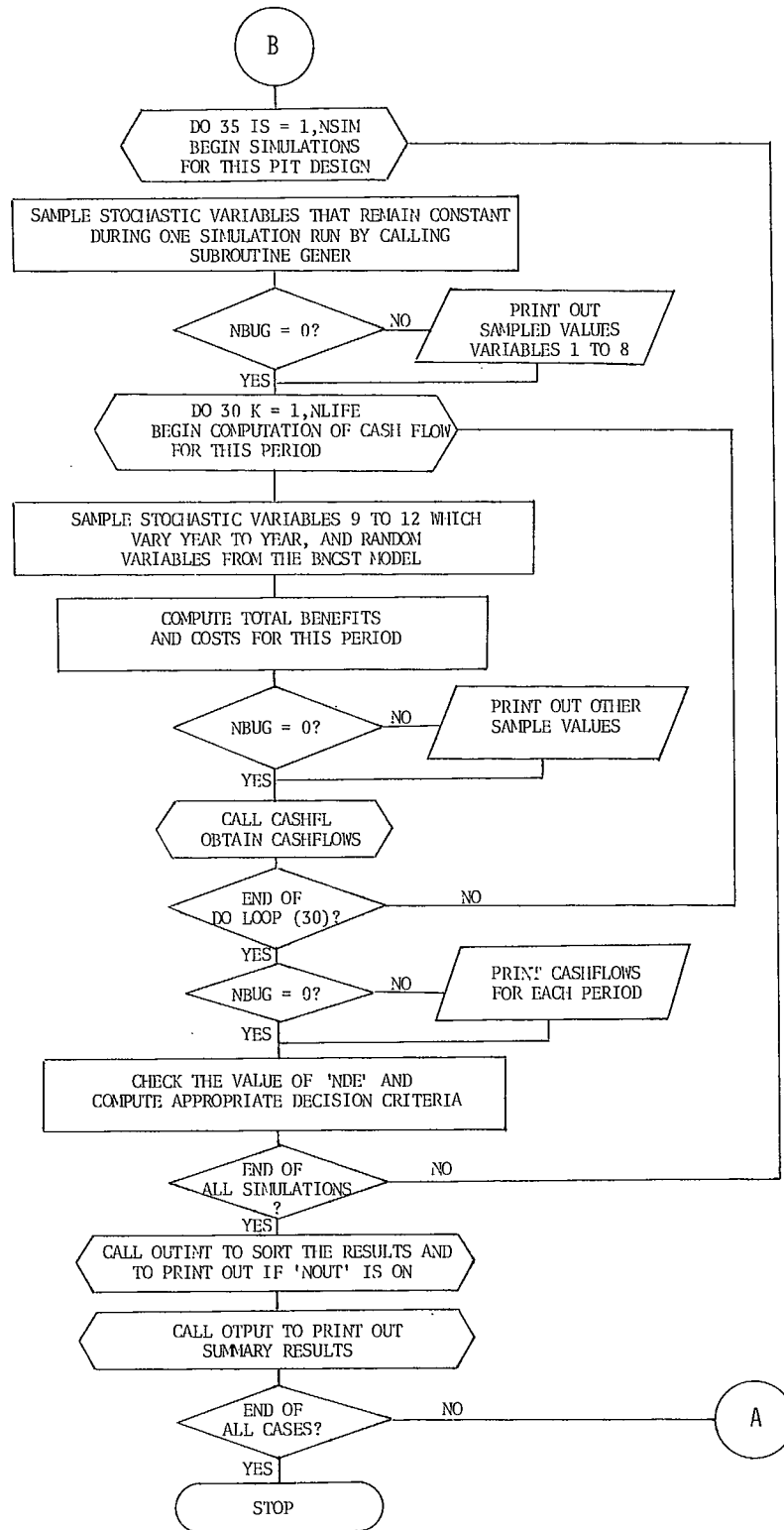
Fig B-5 (continued) - Flow chart of the INRISK main program

170

START

OBTAIN ANNUAL
POSITIVE & NEGATIVE
CASH FLOWS

IS
SPIN > SPOUT
?

NO(2) → PRINT ERROR MESSAGE → CALL RETURN

YES(3)

SET TRIAL DISCOUNT
RATE ' 15%
NKEY = 1
KEY = 1

⑦

YES(32) ← IS DISCOUNT RATE >150% ← POSITIVE(47) ← THE DISCOUNT RATE IS → NEGATIVE(45) → PRINT ERROR MESSAGE → CALL RETURN

PRINT ERROR MESSAGE

CALL RETURN

NO(31)

ZERO(46)

NKEY = 2? → NO(48) → KEY = 1? → NO(45) → PRINT ERROR MESSAGE

YES(50)

COMPUTE POSITIVE &
NEGATIVE DISCOUNTED
CASH FLOWS @ TRIAL
RATE

THE RATE LIES
BETWEEN ZERO AND
5%--COMPUTE
CASH FLOWS 4 MORE
TIMES

YES(49)

SET THE RATE
@ ZERO--
LOWEST POSSIBLE

CALL RETURN

⑬

CALL RETURN

PCASH >
TNCASH (13)

IS TOTAL
DISCOUNTED POS:
CASH FLOW ≥
NEG. CASH
FLOW

PCASH =
TNCASH

⑲

DISCOUNT RATE
= TRIAL RATE

WORTH (1) = PCASH
TVEST (1) = TNCASH
CDMP (1)= INT

YES(14) ← (KEY+NKEY) = 2?

SET KEY = 2
FIRST TIME
AROUND

(15)

NO(15)

PCASH < TNCASH
(12)

CALL RETURN

COMPUTE TOTAL POSITIVE
& NEGATIVE CASH
FLOWS FOR 4
DIFFERENT RATES
AND STORE FOR COMPARISON

NKEY = 1? → NO(17) → IADD = 1

YES(16)

⑬

NARROW THE RATE
TO THE NEAREST
ONE PERCENT

INCREASE THE RATE
BY 5 PERCENT

⑦

APPROXIMATE TO
THE NEAREST TENTH
OF ONE PERCENT
BY DIRECT PROPORTION

NO(20)

NOT FIRST
TIME

(KEY+NKEY)
= 2?

CORRESPONDING RATE
IS THE INTERNAL
R.O.I.

YES(14)

CALL RETURN

(20)

SET NKEY = 2
FIRST TIME
AROUND

NO(22)

KEY = 1?

YES(21)

IADD = -1

REDUCE THE RATE
BY 5 PERCENT

⑬

⑦

Fig B-6 - Micro flow chart of the subroutine DCFROI

m. STAT: Computes the mean and standard devia-
              tion of the final simulation results,
              and determines the cumulative
              probabilities.

n. TABLE: Prints out the cumulative probabili-
              ties of the results in a tabular form.

o. XNORM: Samples normal distribution.

p. TRIANG: Samples triangular distribution.

q. RECT: Samples uniform distribution.

r. HISTO: Samples histogram distribution.
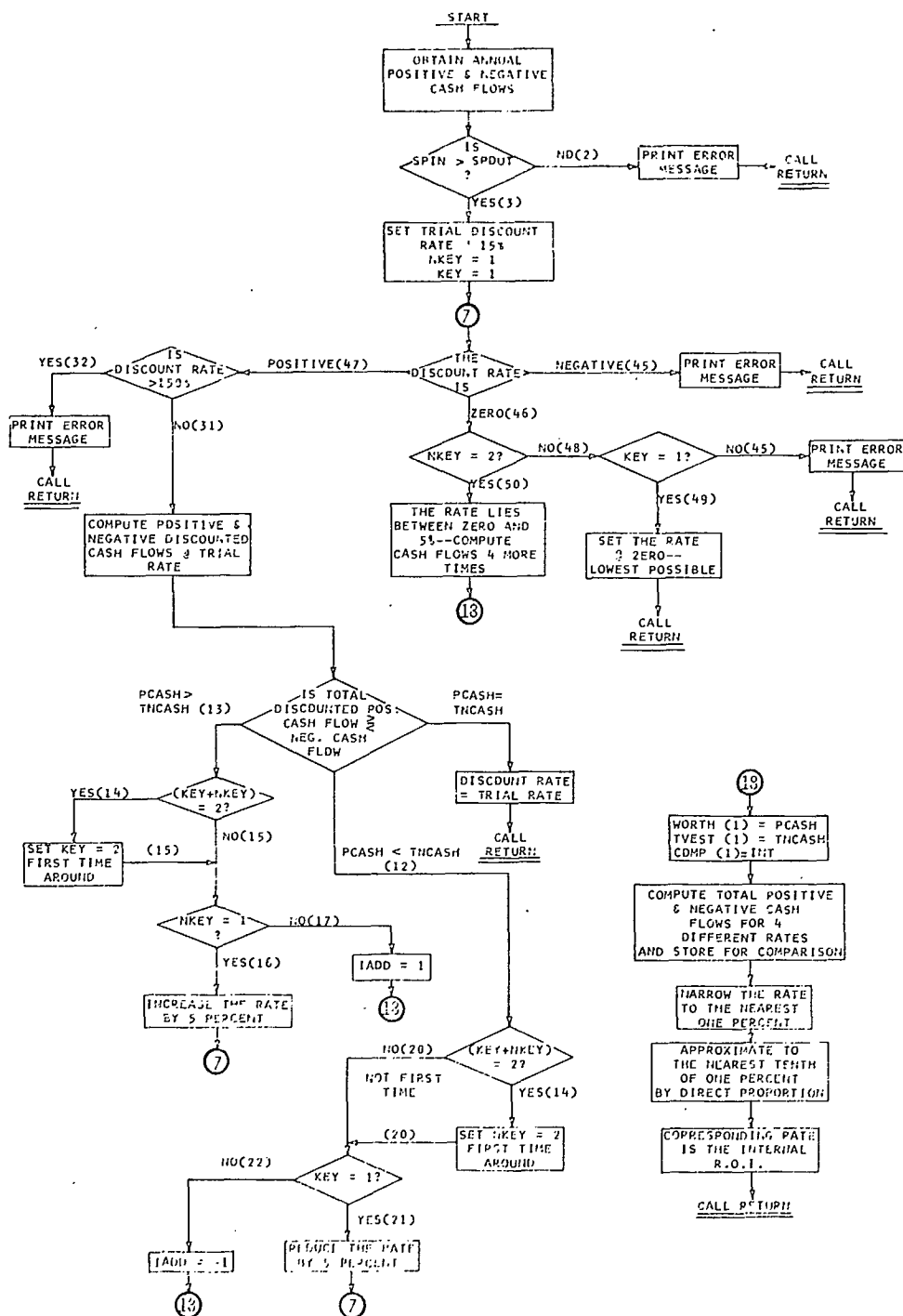
s. URTAX: Optional subroutine which the user
              must supply if he wishes to follow his
              own financial analysis schedules.

Data Structures

50. A narrative description of the input data structure is given in the sections on Method of Solution and Data Input. Exhibit B-1 contains the format for input data cards. Part of the input data generated from the BNCST, Version III, program is read in from an auxiliary data file media, which is system unit Number 4.

Storage Requirements

51. As presently structured, the INRISK program requires approximately 50K storage.

Maintenance and Updates

52. INRISK, Version III, is an update of INRISK, Version II program. The revision was necessary to accommodate results from the revised benefit-cost model, BNCST-Version III.

OPERATING DOCUMENTATION

Operating Instructions

53. INRISK is operated under the CDC 6400, SCOPE 3.4 operating system.

Operating Messages

54. Error messages produced by the program are self-explanatory. In addition, normal system messages are produced.

Control Cards

55. The program is executed with standard SCOPE 3.4 control cards. As run on the University of Arizona CDC 6400, the makeup of the input deck is as follows:

    Job card
    FTN.
    LGO.
    7/8/9 end of file card
    < SOURCE PROGRAM >
    7/8/9 end of file card
    < INPUT DATA >
    6/7/8/9 end of job card.

Error Recovery

56. If certain errors occur in execution, the program will supply feasible values and continue execution of the program. A warning message will be printed.

57. If a fatal error occurs in the input data, there is no provision for restarting the program at an intermediate stage. The program must be rerun in its entirety upon error.

Run Time

58. The sample run of 30 simulations, consisting of one pit design described in the text, was completed in approximately 10 seconds. Each run would take between 10 to 30 seconds depending on the number of simulations to be performed.

EXHIBIT B-1

FORMAT FOR INPUT DATA CARDS

MASTER RUN-CONTROL CARD (one card)

Contents	Columns	Remarks
NTEST	1 (A1)	Number of pit designs to be tested in this run.

TYPE 0. TITLE CARD (one card)

Contents	Columns	
NAME	1-80 (20A4)	Project Headings, ie, the name of mine, etc.

TYPE 1. RUN PARAMETER CARD (one card)

Contents	Columns	
NOUT	1-10 (I10)	Option for printing input data.

= 0, do not print.

$\geq$ 1, print.

NDE   11-20 (I10)   Option switch for selecting particular financial decision criteria during the risk analysis run.

= 0, all three criteria of DCFROI, NPV, WGR.

= 1, DCFROI and NPV.

= 2, DCFROI only.

= 3, NPV only.

= 4, WGR only.

NBUG   21-30 (I10)   Intermediate results printout option

= 0, do not print.

$\geq$ 1, print.

NTAX   31-40 (I10)   Option for using other tax laws.

= 0, no - not used in the program.

$\geq$ 1, yes - used in the program. If yes, the user must provide a subroutine called URTAX to compute depreciation, depletion and taxes.

TYPE 2. INTEGER CONSTANTS CARD (one card)

Contents	Columns	Remarks
NSIM	1-5 (I5)	Number of simulations for the current pit design.
NRG	5-10 (I5)	Number of sectors in the pit.
NDAY	11-15 (I5)	Number of working days/year.
NN	16-20 (I5)	Number of preproduction periods.
NEXP	21-25 (I5)	Number of periods required for exploration (starting from the first period).
NOC	26-30 (I5)	Number of periods required for acquisition of land and water starting immediately after completion of exploration.
NMML	31-35 (I5)	Number of periods required for mine, mill and leaching plant construction.
NPROD	36-40 (I5)	Production periods of the mine's life.
NLIFE	41-45 (I5)	Total periods of the mine's life including preproduction periods.

TYPE 3. FLOATING POINT CONSTANTS CARD (one card)

Contents	Columns	Remarks
RRATE	1-10 (F10.0)	Required rate of return, cost of capital or internal discount rate.
FEDR	11-20 (F10.0)	Federal income tax rate.
PMTR	21-30 (F10.0)	Provincial mining tax rate.
PITR	31-40 (F10.0)	Provincial income tax rate.
DEPLR	41-50 (F10.0)	Depletion rate.

TYPES 4 and 5. STOCHASTIC VARIABLES CARD (12 Cards - One/variable)

There are twelve stochastic variables. They must be read consecutively from Variable No. 1 through Variable No. 12. The variable number identification is given first, followed by the input format used to accommodate various probability distributions that each variable can assume in the model.

A two-dimensional array named SVAR (K,N) is used in the program to store all 12 stochastic variables and their attributes. The value of K corresponds to the variable number. The value of N corresponds to various parameters used to describe the type of distribution and its parameters.

a) Description of Variables (Value of the Index K):

Variable Number	Description
SVAR (1,N)	Exploration expense
2	Royalty (% of gross revenue in fractions)
3	Mine capital expenditure
4	Mill capital expenditure
5	Leach plant capital expenditure
6	Water and land acquisition cost
7	Total salvage value
SVAR (8,N)	Total working capital

Note: The values of the above 8 variables remain constant during one simulation but vary between simulation runs.

Variable Number	Descriptions
SVAR (9,N)	Overall recovery of Type 1 ore (% in decimals)
10	Overall recovery of Type 2 ore (% in decimals)
11	Selling price of metal (value/weight unit)
SVAR (12,N)	Miscellaneous charges (value/weight-ore)

Note: The values of the above 4 variables vary from one period to the next as well as between simulation runs.

b) Description of Variable Attributes (Value of the Index N)

Contents	Columns Formats	Remarks
SVAR (K,1)	1-5 (F5.2)	Code designating the type of probability distribution for the K th stochastic variable. 1.0 = Normal 2.0 = Triangular 3.0 = Uniform (or Rectangular) 4.0 = Histogram 5.0 = Constant (or Single Point)
SVAR (K,2)	6-15 (F10.3)	The first parameter value for the specified probability distribution associated with K th variable. (See below for parameter descriptions).
SVAR (K,3)	16-25 (F10.3)	The second parameter value for the specified probability distribution.
SVAR (K,4)	26-35 (F10.3)	The third parameter value.
SVAR (K,6)	36-40 (F5.3)	
SVAR (K,7)	41-45 (F5.3)	
SVAR (K,8)	46-50 (F5.3)	Used for Histogram only.
SVAR (K,9)	51-55 (F5.3)	SVAR (K,6) contains the probability of the first class interval, whereas SVAR (K,14) contains that of the last (ie, the 9th) class interval.
SVAR (K,10)	56-60 (F5.3)	
SVAR (K,11)	61-65 (F5.3)	
SVAR (K,12)	66-70 (F5.3)	
SVAR (K,13)	71-75 (F5.3)	
SVAR (K,14)	76-80 (F5.3)	

Note: Parameter Descriptions [SVAR (K,2), SVAR (K,3), SVAR (K,4)]

For <u>Normal Distribution</u>, parameter 2 is the mean, parameter 3 is the standard deviation, and
the remaining parameters are not used.

For <u>Triangular Distribution</u>, 2, 3, and 4 represent minimum, most likely and maximum values re-
spectively. The remaining parameters are not used.

For <u>Uniform Distribution</u>, parameters 2 and 3 represent the lower and upper limit values re-
spectively.

For <u>Histogram</u>, 2 contains the value of the beginning class and 3 is the width of class inter-
val. Parameter 4 is not used. The histogram is assumed to consist of a total of
9 class intervals, starting from the beginning class as given in parameter 2 and
the succeeding class value increased by the specified interval width.

For <u>Constant</u>, 2 contains the value; 3 and 4 are not used.

EXHIBIT B-2

SAMPLE OUTPUT FROM

INRISK - VERSION III

-- INPUT DATA FOR PIT DESIGN NUMBER 1 --
===

ANY PIT IN THE SOUTHWEST, 38 DEGREE INTERRAMP DESIGN

1. OPTION SWITCHES USED FOR THIS RUN.

           INPUT DATA PRINT OPTION   1
           DECISION CRITERIA OPTION   3
           INTERIM RESULTS PRINT OPTION   1
           USER SUPPLIED TAX ROUTINE OPT.   1

2. INTEGER CONSTANTS.

           NUMBER OF SIMULATIONS   15
           NUMBER OF SECTORS IN THE PIT   3
           NUMBER OF WORKING DAYS /PERIOD   357
           NO. OF PERIODS FOR PRE-PROD.   -0
           NO. OF PERIODS FOR EXPLORATION   -0
           NO. OF PERIODS FOR LAND/WATER   -0
           NO. OF PERIODS FOR PLANT CONST   -0
           ACTUAL PROD. LIFE OF THE MINE   10
           TOTAL LIFE OF THE PROJECT   10

3. FLOATING POINT CONSTANTS.

           REQUIRED RATE OF RETURN   .150
           FEDERAL INCOME TAX RATE   0.000
           PROVINCIAL MINING TAX RATE   -0.000
           PROVINCIAL INCOME TAX RATE   -0.000
           DEPLETION ALLOWANCE RATE   -0.000

4. STOCHASTIC VARIABLES CONSTANT FOR ONE SIMULATION RUN.

           EXPLORATION EXPENSE   (IN 1000 DOLLAR   UNITS)
                    CONSTANT   VALUE =   -0.000
           ROYALTY (PERCENT   OF GROSS INCOME)
                    CONSTANT   VALUE =   -0.000
           MINE CAPITAL EXPENDITURE (IN 1000 DOLLAR   UNITS)
                       RECTANGULAR   MINIMUM   MAXIMUM
                                                  450.000   550.000
           MILL CAPITAL EXPENDITURE (IN 1000 DOLLAR   UNITS)
                    CONSTANT   VALUE =   -0.000
           LEACH PLANT (OR TYPE2 ORE)
                    CAPIT. EXPEND(IN 1000 DOLLAR   UNITS)
                    CONSTANT   VALUE =   -0.000
           WATER/LAND ACQUIS. COSTS.(IN 1000 DOLLAR   UNITS)
                    CONSTANT   VALUE =   -0.000
           TOTAL SALVAGE VALUE   (IN 1000 DOLLAR   UNITS)
                    CONSTANT   VALUE =   -0.000
           TOTAL WORKING CAPITAL   (IN 1000 DOLLAR   UNITS)
                    CONSTANT   VALUE =   -0.000

5. STOCHASTIC VARIABLES SAMPLED EVERY PERIOD DURING ONE SIMULATION RUN.

```
OVERALL RECOVERY OF TYPE1 ORE-PERCENT
          CONSTANT              VALUE =            .860
OVERALL RECOVERY OF TYPE2 ORE-PERCENT
          CONSTANT              VALUE =          -0.000
SELLING PRICE OF THE METAL  (DOLLAR          /TON              )
          CONSTANT              VALUE =        1280.000
MISCELLANEOUS COSTS          (DOLLAR          /TON           -ORE)
          CONSTANT              VALUE =          -0.000
```

6. INPUT DATA OBTAINED FROM THE BENEFIT-COST MODEL.

PERIOD	WEIGHTS (1000 TON UNITS)			AVE. GRADES (PERCENT)		COST OF MINING (COST/UNIT WEIGHT)		
	TYPE1 ORE	TYPE2 ORE	WASTE	TYPE1	TYPE2	TYPE1 ORE	TYPE2 ORE	WASTE
1	32850.	0.	46767.	.450	0.000	3.810	0.000	.350
2	32850.	0.	53300.	.460	0.000	3.850	0.000	.350
3	32850.	0.	53864.	.440	0.000	3.700	0.000	.350
4	32850.	0.	53104.	.440	0.000	3.900	0.000	.350
5	32850.	0.	56165.	.470	0.000	3.900	0.000	.350
6	32850.	0.	54743.	.470	0.000	3.830	0.000	.350
7	32850.	0.	56000.	.450	0.000	3.790	0.000	.350
8	32850.	0.	54222.	.470	0.000	4.030	0.000	.290
9	32850.	0.	52706.	.520	0.000	4.220	0.000	.290
10	32850.	0.	49350.	.520	0.000	4.220	0.000	.290

PERIOD	USER BENEFITS(THOUSANDS)		MISC..BENEFITS(THOUSANDS)		INSTAB. COSTS(THOUSANDS)		USER COSTS(THOUSANDS)	
	AVE.	STD.DEV.	AVE.	STD.DEV.	AVE.	STD.DEV.	AVE.	STD.DEV.
1	0.	0.	0.	0.	89.	147.	0.	0.
2	0.	0.	0.	0.	88.	2.	0.	0.
3	0.	0.	0.	0.	234.	693.	0.	0.
4	0.	0.	0.	0.	2018.	3249.	0.	0.
5	0.	0.	0.	0.	5.	3.	0.	0.
6	0.	0.	0.	0.	218.	213.	0.	0.
7	0.	0.	0.	0.	1372.	141.	0.	0.
8	0.	0.	0.	0.	255.	125.	0.	0.
9	0.	0.	0.	0.	272.	106.	0.	0.
10	0.	0.	0.	0.	808.	525.	0.	0.

SIMULATION NO. = 1

```
SAMPLE VALUES
   -0.          -0.         .4920E+03    -0.        -0.         -0.        -0.          -0.

SAMPLE VALUES
   .8600E+00    -0.         .1280E+04    -0.        .3285E+05   0.         .4677E+05    .4500E+00
   0.           .3810E+01   0.           .3500E+00  .3757E+08   0.         .1637E+08    .2118E+08
SAMPLE VALUES
   .8600E+00    -0.         .1280E+04    -0.        .3285E+05   0.         .5330E+05    .4600E+00
   0.           .3850E+01   0.           .3500E+00  .3987E+08   0.         .1866E+08    .2113E+08
SAMPLE VALUES
   .8600E+00    -0.         .1280E+04    -0.        .3285E+05   0.         .5385E+05    .4400E+00
   0.           .3700E+01   0.           .3500E+00  .3756E+08   0.         .1885E+08    .1827E+08
SAMPLE VALUES
   .8600E+00    -0.         .1280E+04    -0.        .3285E+05   0.         .5310E+05    .4400E+00
   0.           .3900E+01   0.           .3500E+00  .3099E+08   0.         .1859E+08    .1270E+08
SAMPLE VALUES
```

```
     .8530E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5617E+05     .4700E+00
SAMPLE VALUES   .3900E+01    0.           .3500E+00      .4184E+08      0.           .1966E+08     .2218E+08
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5474E+05     .4700E+00
C.              .3870E+01    0.           .3500E+00      .4414E+08      0.           .1916E+08     .2469E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5600E+05     .4500E+00
0.              .3790E+01    0.           .3500E+00      .3922E+08      0.           .1960E+08     .1734E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5422E+05     .4700E+00
C.              .4030E+01    0.           .2900E+00      .3757E+08      0.           .1572E+08     .2170E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5271E+05     .5200E+00
L.              .4220E+01    0.           .2900E+00      .4941E+08      0.           .1528E+08     .3397E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .4935E+05     .5200E+00
0.              .4220E+01    0.           .2900E+00      .4941E+08      0.           .1431E+08     .3466E+08
```

CASH FLOWS FCR PERIODS 1 THROUGH 10

15767311.   15730787.   13607667.   9457165.   16515056.   18381796.   12908891.   16160315.   25289236.   25355930.

NET PRESENT VALUE =   79710000.

SIMULATION NO. = 2

```
SAMPLE VALUES
    -0.           -0.           .5030E+03      -0.           -0.           -0.           -0.             -0.
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .4677E+05     .4500E+00
0.              .3810E+01    0.                    .3500E+00      .3757E+08      0.           .1637E+08     .2129E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5330E+05     .4600E+00
0.              .3850E+01    0.           .3500E+00      .3987E+08      0.           .1866E+08     .2113E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5385E+05     .4400E+00
0.              .3700E+01    0.           .3500E+00      .3756E+08      0.           .1885E+08     .1827E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5310E+05     .4400E+00
0.              .3900E+01    0.           .3500E+00      .3099E+08      0.           .1859E+08     .9252E+07
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5617E+05     .4700E+00
0.              .3900E+01    0.           .3500E+00      .4184E+08      0.           .1966E+08     .2218E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5474E+05     .4700E+00
0.              .3830E+01    0.           .3500E+00      .4414E+08      0.           .1916E+08     .2488E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5600E+05     .4500E+00
0.              .3790E+01    0.           .3500E+00      .3822E+08      0.           .1960E+08     .1703E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5422E+05     .4700E+00
0.              .4030E+01    0.           .2900E+00      .3757E+08      0.           .1572E+08     .2167E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .5271E+05     .5200E+00
0.              .4220E+01    0.           .2900E+00      .4941E+08      0.           .1528E+08     .3398E+08
SAMPLE VALUES
     .8600E+00      -0.           .1280E+04      -0.           .3285E+05      0.           .4935E+05     .5200E+00
0.              .4220E+01    0.           .2900E+00      .4941E+08      0.           .1431E+08     .3324E+08
```

CASH FLOWS FCR PERIODS 1 THROUGH 10

15849083.   15731783.   13607480.   6891977.   16516644.   18523933.   12684690.   16132684.   25295437.   24743465.

NET PRESENT VALUE =   78134000.

SORTED VALUES FOR THE PIT DESIGN NO   1

SIMULATION NO.	NPV
9	75619000.
10	76046000.
14	77424000.
15	77493000.
2	78134000.
8	78853000.
11	78899000.
12	78927000.
4	79099000.
6	79173000.
1	79710000.
5	80116000.
13	80330000.
7	80498000.
3	80854000.

---SUMMARY OF THE SIMULATION RESULTS FOR THE PIT DESIGN NO   1
==

ANY PIT IN THE SOUTHWEST, 38 DEGREE INTERRAMP DESIGN

NPV MEAN VALUE =   78745000. DOLLARS
NPV STD. DEV. =   2110300O. DOLLARS

PROBABILITY OF ACHIEVING AT LEAST THE VALUE SHOWN	NPV VALUE
1.00	75500000
.93	75750000
.93	76000000
.87	76250000
.87	76500000
.87	76750000
.87	77000000
.87	77250000
.73	77500000
.73	77750000
.73	78000000
.67	78250000
.67	78500000
.67	78750000
.47	79000000
.33	79250000
.33	79500000
.27	79750000
.27	80000000
.20	80250000
.07	80500000
.07	80750000
0.00	81000000

-- INPUT DATA FOR PIT DESIGN NUMBER 2 --
==

ANY PIT IN THE SOUTHWEST, 45 DEGREE INTERRAMP DESIGN

1. OPTION SWITCHES USED FOR THIS RUN.

INPUT DATA PRINT OPTION	1
DECISION CRITERIA OPTION	3
INTERIM RESULTS PRINT OPTION	1
USER SUPPLIED TAX ROUTINE OPT.	1

2. INTEGER CONSTANTS.

NUMBER OF SIMULATIONS	15
NUMBER OF SECTORS IN THE PIT	3
NUMBER OF WORKING DAYS /PERIOD	357
NO. OF PERIODS FOR PRE-PROD.	-0
NO. OF PERIODS FOR EXPLORATION	-0
NO. OF PERIODS FOR LAND/WATER	-0
NO. OF PERIODS FOR PLANT CONST	-0
ACTUAL PROD. LIFE OF THE MINE	10
TOTAL LIFE OF THE PROJECT	10

3. FLOATING POINT CONSTANTS.

REQUIRED RATE OF RETURN	.150
FEDERAL INCOME TAX RATE	0.000
PROVINCIAL MINING TAX RATE	-0.000
PROVINCIAL INCOME TAX RATE	-0.000
DEPLETION ALLOWANCE RATE	-0.000

4. STOCHASTIC VARIABLES CONSTANT FOR ONE SIMULATION RUN.

EXPLORATION EXPENSE	(IN 1000 DOLLAR	UNITS)
CONSTANT	VALUE =	-0.000
ROYALTY (PERCENT	OF GROSS INCOME)	
CONSTANT	VALUE =	-0.000
MINE CAPITAL EXPENDITURE	(IN 1000 DOLLAR	UNITS)
CONSTANT	VALUE =	-0.000
MILL CAPITAL EXPENDITURE	(IN 1000 DOLLAR	UNITS)
CONSTANT	VALUE =	-0.000
LEACH PLANT (OR TYPE2 ORE)		
CAPIT. EXPEND (IN 1000 DOLLAR		UNITS)
CONSTANT	VALUE =	-0.000
WATER/LAND ACQUIS. COSTS.(IN 1000 DOLLAR		UNITS)
CONSTANT	VALUE =	-0.000
TOTAL SALVAGE VALUE	(IN 1000 DOLLAR	UNITS)
CONSTANT	VALUE =	-0.000
TOTAL WORKING CAPITAL	(IN 1000 DOLLAR	UNITS)
CONSTANT	VALUE =	-0.000

5. STOCHASTIC VARIABLES SAMPLED EVERY PERIOD DURING ONE SIMULATION RUN.

```
OVERALL RECOVERY OF TYPE1 ORE-PERCENT
              CONSTANT              VALUE =              .860
OVERALL RECOVERY OF TYPE2 ORE-PERCENT
              CONSTANT              VALUE =           -0.000
SELLING PRICE OF THE METAL    (DOLLAR         /TCN              )
              CONSTANT              VALUF =         1280.000
MISCELLANEOUS COSTS          (DOLLAR         /TON            -ORE)
              CONSTANT              VALUE =           -0.000
```

6. INPUT DATA OBTAINED FROM THE BENEFIT-COST MODEL.

| PERIOD | WEIGHTS (1000 TON | UNITS) | AVE. GRADES (PERCENT | COST OF MINING (COST/UNIT WEIGHT) |
	TYPE1 ORE	TYPE2 ORE	WASTE	TYPE1	TYPE2	TYPE1 ORE	TYPE2 ORE	WASTE
1	32850.	0.	44667.	.450	0.000	3.810	0.000	.350
2	32850.	0.	51200.	.460	0.000	3.850	0.000	.350
3	32850.	0.	51754.	.440	0.000	3.700	0.000	.350
4	32850.	0.	51004.	.440	0.000	3.900	0.000	.350
5	32850.	0.	54065.	.470	0.000	3.900	0.000	.350
6	32850.	0.	52643.	.470	0.000	3.830	0.000	.350
7	32850.	0.	53900.	.450	0.000	3.790	0.000	.350
8	32850.	0.	52122.	.470	0.000	4.030	0.000	.290
9	32850.	0.	50606.	.520	0.000	4.220	0.000	.290
10	32850.	0.	47250.	.520	0.000	4.220	0.000	.290

| PERIOD | USER BENEFITS(THOUSANDS) | | MISC..BENEFITS(THOUSANDS) | | INSTAB. COSTS(THOUSANDS) | | USER COSTS(THOUSANDS) | |
	AVE.	STD.DEV.	AVE.	STD.DEV.	AVE.	STD.DEV.	AVE.	STD.DEV.
1	0.	0.	0.	0.	1153.	380.	0.	0.
2	0.	0.	0.	0.	2645.	1326.	0.	0.
3	0.	0.	0.	0.	794.	723.	0.	0.
4	0.	0.	0.	0.	1871.	2828.	0.	0.
5	0.	0.	0.	0.	1176.	1655.	0.	0.
6	0.	0.	0.	0.	5488.	1081.	0.	0.
7	0.	0.	0.	0.	7119.	1460.	0.	0.
8	0.	0.	0.	0.	2102.	797.	0.	0.
9	0.	0.	0.	0.	1614.	1271.	0.	0.
10	0.	0.	0.	0.	1665.	921.	0.	0.

SIMULATION NO. = 1

```
SAMPLE VALUES
    -0.          -0.          -0.          -0.          -0.          -0.          -0.          -0.

SAMPLE VALUES
    .8600E+00    -0.          .1280E+04    -0.          .3285E+05    0.           .4467E+05    .4500E+00
    0.           .3810E+01    0.           .3500E+00    .3757E+08    0.           .1563E+08    .2106E+08
SAMPLE VALUES
    .8600E+00    -0.          .1280E+04    -0.          .3285E+05    0.           .5120E+05    .4600E+00
    0.           .3850E+01    0.           .3500E+00    .3987E+08    0.           .1792E+08    .1869E+08
SAMPLE VALUES
    .8600E+00    -0.          .1280E+04    -0.          .3285E+05    0.           .5175E+05    .4400E+00
    0.           .3700E+01    0.           .3500E+00    .3756E+08    0.           .1811E+08    .1768E+08
SAMPLE VALUES
    .8600E+00    -0.          .1280E+04    -0.          .3285E+05    0.           .5100E+05    .4400E+00
    0.           .3900E+01    0.           .3500E+00    .3099E+08    0.           .1785E+08    .1038E+08
SAMPLE VALUES
    .8600E+00    -0.          .1280E+04    -0.          .3285E+05    0.           .5407E+05    .4700E+00
```

0.	.3900E+01	0.	.3500E+00	.4184E+08	3.	.1892E+08	.2113E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	3.	.5264E+05	.4703E+00
0.	.3830E+01	0.	.3500E+00	.4414E+08	0.	.1847E+08	.2149E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5390E+05	.4500E+00
0.	.3790E+01	0.	.3500E+00	.3922E+08	0.	.1887E+08	.1792E+08

SAMPLE VALUES

.9600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5212E+05	.4700E+00
0.	.4030E+01	0.	.2900E+00	.3757E+08	0.	.1512E+08	.2006E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5061E+05	.5200E+00
0.	.4220E+01	0.	.2900E+00	.4941E+08	0.	.1469E+08	.3374E+08

SAMPLE VALUES

.8500E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.4725E+05	.5200E+00
0.	.4220E+01	0.	.2900E+00	.4941E+08	0.	.1370E+08	.3566E+08

CASH FLOWS FOR PERIODS 1 THROUGH 10

15679489. 14061913. 13166980. 7729130. 15731312. 16004071. 13346365. 14936168. 25118390. 26101358.

NET PRESENT VALUE = 75576000.

SIMULATION NO. = 2

SAMPLE VALUES

-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.4467E+05	.4500E+00
0.	.3810E+01	0.	.3500E+00	.3757E+08	0.	.1563E+08	.2101E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5120E+05	.4600E+00
0.	.3850E+01	0.	.3500E+00	.3987E+08	0.	.1792E+08	.2055E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5175E+05	.4400E+00
0.	.3700E+01	0.	.3500E+00	.3756E+08	0.	.1811E+08	.1762E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5100E+05	.4400E+00
0.	.3900E+01	0.	.3500E+00	.3099E+08	0.	.1785E+08	.1084E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5407E+05	.4700E+00
0.	.3900E+01	0.	.3500E+00	.4184E+08	0.	.1892E+08	.2356E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5264E+05	.4700E+00
0.	.3830E+01	0.	.3500E+00	.4414E+08	0.	.1843E+08	.1983E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5390E+05	.4500E+00
0.	.3790E+01	0.	.3500E+00	.3822E+08	0.	.1887E+08	.1800E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5212E+05	.4700E+00
0.	.4030E+01	0.	.2900E+00	.3757E+08	0.	.1512E+08	.2009E+08

SAMPLE VALUES

.8600E+00	-0.	.1280E+04	-0.	.3285E+05	0.	.5061E+05	.5200E+00
0.	.4220E+01	0.	.2900E+00	.4941E+08	0.	.1468E+08	.3397E+08

SAMPLE VALUES

.8600E+00	-0.	.1290E+04	-0.	.3285E+05	0.	.4725E+05	.5200E+00
0.	.4220E+01	0.	.2900E+00	.4941E+08	0.	.1370E+08	.3513E+08

CASH FLOWS FOR PERIODS 1 THROUGH 10

15641566. 15301437. 13120739. 8074128. 17543699. 14763668. 13404684. 14961946. 25288554. 26153602.

NET PRESENT VALUE = 77104000.

SORTED VALUES FOR THE PIT DESIGN NO   2

SIMULATION NO.	NPV
3	72172000.
14	72309000.
7	73203000.
9	73645000.
4	74756000.
12	75244000.
1	75576000.
5	75640000.
6	76042000.
11	76046000.
8	76442000.
13	76536000.
15	77022000.
2	77104000.
10	77125000.

---SUMMARY OF THE SIMULATION RESULTS FOR THE PIT DESIGN NO   2
==

ANY PIT IN THE SOUTHWEST, 45 DEGREE INTERRAMP DESIGN

NPV MEAN VALUE =   75291000. DOLLARS
NPV STD. DEV. =   2018800 0. DOLLARS

PROBABILITY OF ACHIEVING AT LEAST THE VALUE SHOWN	NPV VALUE
1.00	72000000
.93	72250000
.93	72500000
.93	72750000
.87	73000000
.80	73250000
.80	73500000
.73	73750000
.73	74000000
.73	74250000
.73	74500000
.73	74750000
.67	75000000
.60	75250000
.60	75500000
.47	75750000
.47	76000000
.33	76250000
.27	76500000
.20	76750000
.20	77000000
.00	77250000