APPENDIX L

Geotechnical Investigation of Cut Slopes at the Belina Mine Complex and Haul Road Carbon County, Utah

Prepared for

Valley Camp of Utah, Inc.
Helper, Utah

Prepared by

Morrison-Knudsen Co., Inc.
Boise, Idaho

October, 1983

TABLE OF CONTENTS

SECTION		PAGE
1.0	INTRODUCTION	1
	1.1 General	1
	1.2 Scope of Work	1
2.0	FIELD INVESTIGATION	2
	2.1 General	2
	2.2 Backslope Drilling Program	2
	2.3 Fill Pad Boring	3
	2.4 Boring Logs	3
	2.5 Composite Logs of Cut Slopes	4
	2.6 Detail Line Maps	4
	2.7 General Reconnaissance of Mine Facilities Area	4
	2.8 Reconnaisance of Cut Slopes on the Haul Road	4
3.0	GEOLOGY AND SITE CONDITIONS	6
	3.1 Geology of the Area	6
	3.2 Backslope Above the Upper Portals	6
	3.3 Backslope Above the Office/Changehouse	8
	3.4 Cut Slope Near the Coal Loadout Chute	8
	3.5 Cut Slopes on the Haul Road	9
4.0	LABORATORY TESTING	
	4.1 Moisture and Density Determination	10
	4.2 Atterberg Limits Test Data	10
	4.3 Unconfined Compression Tests	10
	4.4 Triaxial Compression Tests	10
	4.5 Direct Shear Tests	11
5.0	SLOPE STABILITY ANALYSIS	12
	5.1 General	12

5.2 Analysis of Backslope Above Upper Portals 13
5.3 Analysis of Backslope Above The Office/ Changehouse 13
5.4 Analysis of the Cut Slope Near the Coal Loadout Chute 13
5.5 Analysis of the Haul Road Cut Slopes 13

6.0 CONCLUSIONS AND RECOMMENDATIONS 15
6.1 General Conclusions 15
6.2 General Recommendations 15
6.2.1 Backslope Above the Upper Portals 15
6.2.2 Backslope Above the Office/ Changehouse 15
6.2.3 Cut Slope Near the Coal Loadout Chute 16
6.2.4 Haul Road Cut Slopes 16

LIST OF TABLES

TITLE	TABLE NUMBER
Moisture and Density Determinations	1
Atterberg Limits Test Data	2
Unconfined Compression Test Results	3
Direct Shear Test Data	4

LIST OF FIGURES

TITLE	FIGURE NUMBER
Geotechnical Investigation Site Plan	1
Boring Logs	2-6
Logs of Cut Slopes	7-8
Detail Line Data Sheets	9-10
Descriptions of Haul Road Cut Slopes	11-13
Geologic Cross Sections	14-17
Direct Shear Test Results	18-20
Computer Geologic Models for Stability Analyses	21-23
Stereographic Projections	24-26

1.0 INTRODUCTION

1.1 GENERAL: At the request of Valley Camp of Utah, Inc.(Valley Camp), a geotechnical investigation was initiated on September 13, 1983 at the Belina Mine located in Carbon County near Helper, Utah. The purpose of this investigation was to evaluate the stability of cut slopes in the mine facilities area and on the 1.4 mile long haul road leading to the mine from Eccles Canyon.

1.2 SCOPE OF WORK: The geotechnical investigation consisted of a drilling and sampling program, field reconnaissance and mapping, laboratory testing, and computer assisted slope stability analyses. This report presents the data obtained during the course of the investigation, as well as conclusions and recommendations formulated from that data base and other information furnished by Valley Camp.

2.0 FIELD INVESTIGATION

2.1 GENERAL: The field investigation was directed toward evaluating the stability of cut slopes steeper than 2 horizontal:1 vertical. At the mine facilities site, three major cut areas were investigated: the backslope above the upper coal stratum portals; the backslope above the office/changehouse, and the cut slope near the coal loadout chute. Numerous cut slopes on the haul road were also examined and/or mapped which were steeper than 2H:1V.

2.2 BACKSLOPE DRILLING PROGRAM: Soil and rock samples were required to evaluate the stability of the backslope above the upper portals and the office/changehouse. To obtain these samples, four exploratory borings were drilled to depths ranging from 49 feet to 61 feet below existing grade at location shown on the Geotechnical Investigation Site Plan (Figure 1).

Drilling was performed using a CME-750 drill machine mounted on an all-terrain vehicle and equipped with 6.0 inch diameter continuous flight hollowstem auger and NX-size coring tools. Disturbed samples of soil and soft rock were obtained for laboratory testing and logging purposes using a Standard Penetration Test (SPT) sampler, which is driven into soil or soft rock by a 140 pound hammer with a free-fall of 18 inches. The number of blows required to drive the sampler one foot (known as the "N-Value") is a measure of the relative density of cohesionless soils and the consistency of cohesive materials. Relatively undisturbed soil and soft rock samples for laboratory testing were extracted using a 3-inch o.d. Dames and Moore sampler with inner-liner brass rings, which serve to protect the samples during shipment to the laboratory.

The hollowstem auger was used as casing for NX coring tools. A 10 foot long double tube core barrel with a split inner barrel and carbide or diamond bits was utilized to obtain rock samples for logging and laboratory testing. Water was used as a drilling medium. Excessive water loss into pervious rock strata was experienced at all boring locations. Additives such as bentonite, cellulose, nut shell and DE-7 polymer did not significantly reduce the water loss. Only in borings in the vicinity of a 12,000 gallon water storage tank, automatically resupplied by pumped water, could sufficient quantities of siphoned water be obtained to allow continuous coring operations.

Soil and soft rock samples were immediately sealed in plastic bags, placed in airtight containers, and stored in special foam-padded aluminum boxes. Rock samples were placed in standard cardboard core boxes; samples selected for laboratory testing were wrapped in plastic, sealed, wrapped in paper, and stored in a padded box.

All borings were thoroughly backfilled with soil after groundwater readings were taken. In the spring, Valley Camp personnel should check the bore holes and refill them if necessary.

2.3 FILL PAD BORING: At the request of Valley Camp an exploratory boring was drilled on the existing earth fill pad to obtain soil samples for later testing, which will determine the suitability of the fill for reclamation purposes. Valley Camp provided burlap bags with plastic inner bags for sample collection at 2.5-foot intervals. Samples were identified for location and depth. It is our understanding that sample shipment and subsequent laboratory testing will be performed under the direction of Valley Camp. The location of this boring is shown in Figure 1. It was backfilled in the same manner as the four backslope borings.

2.4 BORING LOGS: Boring logs were prepared for the four backslope exploratory borings, and are included in the report as boring nos. 1 through 4 (Figures 2 through 5). The fill pad boring was logged and is contained herein as boring no. 5 (Figure 6). Locations and top ground elevations of the borings were determined by Valley Camp personnel and are referenced to Belina Mine survey data points.

The boring logs include: the depths and elevations of major changes in soil and rock stratigraphic units; classification and description of natural soils in accordance with the Unified Soil Classification System; locations of disturbed, undisturbed, and cored soil and(or) rock samples; core sample data, including the percentage of total core recovered and the percentage of core greater than 4 inches in length (rock quality designation, RQD); pertinent drilling information; and, groundwater data.

2.5 COMPOSITE LOGS OF CUT SLOPES: Two cut slopes in the mine facilities area exposed subsurface stratigraphic rock units and the orientation of fractures within those rock units. These cut slopes were logged in the same manner as an exploratory boring would be logged. The depths were estimated and fracture orientations were inferred from the same stratigraphic unit at several locations in the cut slope.

The composite log for the cut slope behind the office/changehouse building is included in this report as "B-6" (Figure 7), and the log of the cut slope near the coal loadout chute is included as "B-7" (Figure 8).

2.6 DETAIL LINE MAPS: Two detail line maps or detailed mappings of fracture orientations along a measured straight line were made in the cut slope near the loadout chute. The purpose of this mapping was to determine the orientation of primary and secondary joint sets and the nature of any infillings. These detail line maps are shown in Figures 9 and 10. The locations mapped are identified on the Geotechnical Investigation Site Plan (Figure 1), as "D1" and "D2".

Fracture orientations were determined using a hand-held Brunton compass.

2.7 GENERAL RECONNAISSANCE OF MINE FACILITIES AREA: Cut slopes in the mine facilities area were visually examined for evidence of tension cracks related to past and(or) potential slope movements, erosion or ravelling problems, and abnormal vegetation growth above the cut slopes that may indicate slope creep. The results of this reconnaissance are included in site descriptions contained in Section 3.0 of this report, Geology and Site Conditions.

2.8 RECONNAISSANCE OF CUT SLOPES ON THE HAUL ROAD: Detailed descriptions of cut slopes on the haul road were prepared in the field. They are presented in this report as Figures 11 through 13, which are organized as an odometer mileage log that begins at the beginning of the road in Eccles Canyon. Specific references to these cut slope descriptions are contained in other parts of this report.

Joint and other fracture orientations were measured by Brunton compass, and in most cases, the strikes and dips recorded are actually averages of readings taken on four or more different rock surfaces.

3.0 GEOLOGY AND SITE CONDITIONS

3.1 GEOLOGY OF THE AREA: It is not the purpose of this report to present detailed geologic data of the Belina Mine Complex. However, the following brief overview of the regional geology does provide data pertinent to the geotechnical investigation of the Belina Mine cut slopes.

The Belina Mine lies within the Wasatch Plateau Coal Field, in an area in which all of the coal mined lies within 400 feet of the base of the Blackhawk Formation of Upper Cretaceous geologic age. Other than several coal strata, the lithology is predominately composed of yellow and gray sandstones and siltstones with some interbedded shales.

Structurally the mine lies between two northward striking, vertical displacement faults, on the upthrown block of a graben-like geologic feature. The nearer of the two faults passes less than one-half mile to the west, which may have determined the gentle southwestward dip of stratigraphic rock units at and near the Belina Mine. According to Valley Camp personnel and the observations made for this investigation, the magnitude of the dip is about 4°. Undoubtedly, other less significant faulting has occurred that affects site-specific geology. The approximate location of a possible strike-slip fault passing through the area is indicated in Figure 1 of this report. Mining personnel have indicated that at least one fault with minor vertical displacement has been encountered underground.

Two coal strata are mined at Belina and outcrops of each stratum are located on the enclosed site plan (Figure 1). Separate sets of portals penetrate the two strata.

A generalized backslope lithologic section is presented in this report as Figure 14, which represents data obtained from the four backslope borings.

3.2 BACKSLOPE ABOVE THE UPPER PORTALS: Boring nos. 1 and 2 were drilled in an area in which some slide activity has been experienced. The boring logs indicate that 13.5 to 26.5 feet of colluvium and talus overlie competent bedrock strata, predominately composed of gray siltstones that exhibit various degrees of differential weathering. Permeability of the bedrock strata is quite high up to the depths penetrated by the borings. However, 20 hours after drilling, a static groundwater level was measured at 12.5 feet below existing grade at the location of boring no. 1. This boring could not be continuously cored because of excessive water loss into the formations at many different depths. Therefore, it is believed that the water level reading is the result of a zone of seepage water, noted on the log at 12.5 feet, filling a hole that was finally sealed with a layer of drilling mud. The sealing occurred after the hollowstem auger was pulled (i.e., rotated up and down to clear the augers) from the bottom of the hole. It does not appear that the backslope above the upper portals has a static phreatic surface within the depths penetrated by boring nos. 1 and 2.

Several tension cracks, approximately one inch wide and 3 to 5 feet long, were observed in an area about 50 feet southwest of boring no. 1. A water seep was trickling from the slope, before drilling began, about 10 to 15 feet below boring no. 1. Evidence of some slope erosion from this seep could be seen. In the vicinity of boring no. 2 there is a distinct lack of tree growth and evidence of recent slide activity, including some erosional scour. No tension cracks or water seeps were noted. An overview of the area suggests that a fault may pass through the natural drainageway in the vicinity of boring no. 2. This conjecture is based only on surface characteristics, the unusual thickness of colluvium and talus in boring no. 2, and conversations with Valley Camp mining personnel. The exploration borings were not deep enough to confirm the fault presence. Vertical displacement of the fault should not be significant, based upon visual observation of the upper coal stratum outcrop.

In general, the backslope above the upper portals appears to be in a nearly natural condition. The slide area seems to be more the result of natural weathering processes on a daylighting fault zone than a condition caused by mining activities.

Sections A-A' and B-B' (Figures 15 and 16) present simplified geologic cross sections through boring nos. 1 and 2, respectively. The sections also show sample locations and types, as well as the existing slope configurations above and below the borings.

3.3 BACKSLOPE ABOVE THE OFFICE/CHANGEHOUSE: Boring logs 3 and 4 indicate that about 11 feet of colluvium and(or) talus overlie predominately gray siltstones, shales, and sandstones. The bedrock strata are quite pervious, and in some instances a ten foot core run required about 1000 gallons of water to complete. In most cases, core runs were made with water loss of 75 to 100%.

Tension cracks, erosional scour, or seepage zones were not observed in the vicinity of boring nos. 3 and 4. Surface vegetation was lush, and numerous large trees indicated no evidence of slope creep. Except for the steep cut slope behind the office/changehouse, the backslope appears to be virtually natural.

The composite log of the cut slope behind the office/changehouse (Figure 7) shows a section of competent bedrock units. The strike of the slope is approximately parallel to the regional dip direction (to the southwest at 4°±), which is a favorable cut slope orientation. The same cut slope continues to the northeast, and at a point above the waste water treatment plant some potential for ravelling of the upper coal stratum may exist which could precipitate a minor, shallow slide of overlying colluvium. Some ravelling of the coal stratum above the office/changehouse may also occur.

Section C-C' (Figure 17) presents the generalized geologic section of this slope.

3.4 CUT SLOPE NEAR THE COAL LOADOUT CHUTE: The log of this nearly vertical cut slope is referred to herein as "B-7" (Figure 8). Detail line maps (Figures 9 and 10) present further data on fracture orientations. The sandstone exposed in this cut is massive and extremely competent. The overlying coal, however, has been cut quite steeply for about a 3-foot thickness. The coal ravels from this portion of the section even in a light wind. The gentler slope above the coal appears to be nearly natural to the elevation of the existing tree line, although some evidence of erosional scour can be observed.

3.5 <u>CUT SLOPES ON THE HAUL ROAD:</u> The haul road from Eccles Canyon traverses the east side of the ridge on which the Belina Mine is located. The regional bedding plane dip direction to the southwest presents a favorable orientation for the haul road cuts. Neither cut slopes perpendicular to the dip direction nor cut slopes parallel to the dip directions, have downdip bedding planes daylighting into the slope faces.

Primary and secondary joint sets are prominent in many of the cut slope faces and dips of the joints are generally quite steep, steeper than the inclination of the cut slopes. The steep dip in itself often precludes the possibility of plane shear failure because unfavorable joint planes do not daylight in the slope face.

The primary joint set generally strikes north-south (±10°) and has an average dip of about 80° to the east. The secondary joint set generally strikes east-west (±10°) and has an average dip of 75° to the north.

The descriptions of cut slopes contained in this report (Figures 11 through 13) indicate only four relatively minor areas in which regular maintenance or remedial measures may be required to stabilize cut slopes. These areas will be further discussed in sections 5.0 and 6.0 of this report.

4.0 LABORATORY TESTING

A laboratory testing program was established to determine the engineering properties of soil masses and jointed and intact rock masses. Test results were utilized to properly classify material types and to provide strength parameters for use in slope stability analyses.

4.1 MOISTURE AND DENSITY DETERMINATION: Moisture and density determinations were performed on thirteen specimens. These data, found in Table 1, provide information relative to the degree of saturation, compressibility characteristics, and the mass weight of various stratigraphic soil and rock units. These data are required for slope stability analysis.

4.2 ATTERBERG LIMITS TEST DATA: To properly classify soils in accordance with the Unified Soil Classification System, the liquid and plastic limits (two of the Atterberg limits) of seven representative soil samples were determined. These data also provide indications of the susceptibility of the soils to volume changes with changes in moisture content. Some references (e.g. NAVFAC, DM-7, Department of the Navy, 1972) also correlate these data with the angle of internal friction, ϕ, of a soil, and with certain consolidation characteristics.

Table 2 contains the results of these Atterberg limits tests.

4.3 UNCONFINED COMPRESSION TESTS: Nine specimens of soil and rock were tested in unconfined compression to determine the shear strength parameter, c (unit cohesion), of those materials when ϕ (angle of friction) is assumed to be 0. This is a quick, relatively inexpensive test method for obtaining values of c.

4.4 TRIAXIAL COMPRESSION TESTS: Three samples were subjected to lateral confining pressures before an axial load was applied. These triaxial tests (unconsolidated, undrained) require a high degree of specimen homogeneity before the data points may be combined to provide accurate values for both ϕ and c. In this case, the samples did not prove to be sufficiently homogeneous to provide such data, although ranges may be established for ϕ and c.

Test results are shown in tabulated form in Table 3. The modulus of elasticity is included, which is a function of the stress-strain curve, dependent on the sample stress history, moisture content, density and other factors. These data are also used in slope stability analyses.

4.5 DIRECT SHEAR TESTS: Three multi-stage direct shear tests were performed on jointed rock specimens to evaluate the shear strength parameters Ø and c of the rock joints. In a rock slope stability analysis, these data provide parameters for a probable failure surface that would primarily follow existing joint patterns.

Test data are shown in Table 4, and more detailed direct shear test results are contained in Figures 18 through 20 of this report.

5.0 SLOPE STABILITY ANALYSIS

5.1 GENERAL: Recognized potential modes of slope instability consist of plane shear, wedge, circular, and toppling failures. Such failures are dependent upon many factors including the slope configuration, geologic discontinuities, and physical characteristics of the stratigraphic units.

Laboratory data and(or) stratigraphic information from exploratory borings, field reconnaissance, and field mapping were utilized to establish computer models or stereographic projections by which the stability of various cut slopes could be evaluated.

A computer program based on a limiting equilibrium analysis method (STABL, Siegel, 1977) was used to evaluate the two major Belina Mine slopes: the backslopes above the upper portals and the backslope above the office/changehouse. Stereographic projection techniques were used to evaluate the cut slope near the coal loadout chute and the major cuts along the haul road.

For the computer analysis the most important consideration is the selection of correct soil and rock shear strength parameters for each stratigraphic unit. For the backslopes, the worst-case unconfined compression test result of 8.5 psi was utilized for the colluvium/talus. A significant ϕ angle was estimated to be 18° from NAVFAC, DM-7. This ϕ value was used to calculate the value of c from the unconfined compressive strength test results. For the weathered siltstones, direct shear test results on jointed rock, along with unconfined compression tests of intact rock, were utilized to estimate the shear strength. Since rock joints were noticeably absent in the rock cores extracted in the drilling program, it was assumed that a potential failure surface would have to pass through some intact rock. Therefore, c was estimated to be a midrange value of 34.7 psi and ϕ was estimated to be 38°. Groundwater and earthquake factors were not assumed to be significant factors in the analyses. Moist unit weights were used for both soil and rock.

5.2 <u>ANALYSIS OF BACKSLOPE ABOVE UPPER PORTALS:</u> The computer-generated geologic models of the A-A' and B-B' sections are included in this report as Figures 21 and 22. The most critical failure paths passed through the colluvium and(or) talus interface with the underlying bedrock surface. For section A-A', the corresponding factor of safety against slope instability was 1.4. For section B-B' the factor of safety was 1.15 at the steepest portion of the slope, just below boring no. 2. Failure surfaces extending into bedrock materials had very high factors of safety, in excess of 2.5.

5.3 <u>ANALYSIS OF BACKSLOPE ABOVE THE OFFICE/CHANGEHOUSE:</u> Figure 23 presents the computer-generated geologic model of the C-C' section. As in the analysis for the adjacent backslope described above, the most critical failure path passed through the colluvium and(or) talus interface with the bedrock. The lowest factor of safety obtained was 1.9.

5.4 <u>ANALYSIS OF THE CUT SLOPE NEAR THE COAL LOADOUT CHUTE:</u> Stereographic projections are long recognized methods of presenting kinematic tests for various modes of slope instability. Using the cut slope log "B-7" and detail line data, stereographic projections were prepared for potential shear plane, wedge and toppling failures (Figures 24 through 26). The massive sandstone in this cut is extremely competent and joint orientations generally appear to be favorable. Only that portion of the cut slope striking S25°W shows a slight potential for failure in a toppling mode. However, the adjacent portion of the cut confines theis potential toppling section, causing the entire slope to be safe.

5.5 <u>ANALYSIS OF THE HAUL ROAD CUT SLOPES:</u> The potential failure plane described between odometer mileage readings 0.14 to 0.17 on Figure 11 does not pass the kinematic test for stability because the slope face is 3° steeper than the 65° dip of the secondary joint set. Relatively minor quantities of rock are found above the daylighting joint set.

The colluvium/talus described between odometer mileage readings 0.69 to 0.72 on Figure 12 indicates that the colluvium/talus is cut in the steepest portion of the slope to an angle of about 65°. The thickness of this stratum is not known, but a stable slope configuration should be flatter, as evidenced by the results of the backslope analysis.

The potential failure surface described at the 0.86 odometer reading on Figure 12 is located on a "nose", or peninsula-like rock feature. This type of rock mass is the most susceptible to natural weathering processes, and it is likely that the potential failure surface is a naturally occuring phenomenon than a result of "blast damage." In any case, the potential failure surface does not pass the kinematic test for stability.

At odometer reading 0.92 on Figure 12, highly fractured rock may be cut to a slope that is slightly steeper than long-term stability would dictate. There is no laboratory data available to substantiate this possibility.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 GENERAL CONCLUSIONS: Slope stability analyses have indicated that the cut slopes in the area of mine facilities are, in general, stable. The steeper portion of the backslope above the upper portals, represented by section B-B', is the only backslope that does not meet the required 1.3 minimum factor of safety established by the State of Utah for cut slopes steeper than 2 horizontal to 1 vertical. It should be reiterated that this so-called "unstable" condition may not be related to mining operations and may rather be associated with natural geologic discontinuities.

The vertical 3-foot high section of coal above the massive sandstone exposed in the cut slope by the coal loadout chute is too speep, and will probably ravel or weather to an angle of about 34°.

For the most part, the haul road cuts were found to be stable. Four haul road cut slopes described in section 5.5 appear to be too steep for long-term stability, although the cut slope at the 0.86 odometer reading may have had the potential failure surface develop long before the haul road was constructed.

6.2 GENERAL RECOMMENDATIONS

6.2.1 BACKSLOPE ABOVE THE UPPER PORTALS: In the vicinity of boring no. 2 (section B-B') the steep portion of the slope should be excavated to a flatter configuration, perhaps 23°, which is the slope angle of the more stable section A-A'.

Positive surface drainage must be directed away from the slope face, and the slope should be smoothed and revegetated. Seepage water should be controlled, possibly by gravel-lined diversion ditches.

In lieu of the above-mentioned remedial actions, seasonal maintenance of slope or slide debris should be anticipated.

6.2.2 BACKSLOPE ABOVE THE OFFICE/CHANGEHOUSE: Some ravelling may occur from the coal and siltstone strata, and maintenance provisions should be anticipated.

6.2.3 <u>CUT SLOPE NEAR THE COAL LOADOUT CHUTE:</u> The coal stratum above the massive sandstone should be flattened to a slope angle of about 34°. The gentler slope above the coal should be smoothed and revegetated to more properly control surface water runoff. A diversion ditch on the trail above the slope may further reduce the runoff erosion potential.

6.2.4 <u>HAUL ROAD CUT SLOPES:</u> Major cut slope failures on the haul road are not likely. More probably, natural weathering processes will remedy most of the stability problems over a period of years, during which time seasonal maintenance should be anticipated. However, flattening of the slopes identified in section 5.5 should alleviate much of the scheduled road maintenance. In any case, the identified slopes should be carefully observed with monthly regularity, and more often during the spring thaw period.

T A B L E S

Table 1

Moisture and Density Determinations

Boring No.	Depth (ft.)	Sample No.	Moisture (% of dry wt)	Wet Density (PCF)	Dry Density (PCF)
1	5.0-6.5	1-1*	18.7	146.6	123.5
1	11.5-11.8	1-3*	10.5	136.9	123.9
1	16.0-16.5	CORE	5.7	152.9	144.7
2	4.0-4.5	2-1	17.6	125.0	106.3
2	9.5-10.0	2-2	20.0	130.3	108.6
2	14.3-14.5	2-3	14.5	130.1	113.6
2	29.0-29.5	2-6	5.4	139.6	132.4
3	5.0-5.5	3-1	12.3	126.4	112.6
3	17.0-17.5	3-4	16.1	133.2	114.7
3	21.7-22.3	CORE	7.6	152.8	142.0
3	25.0-25.5	CORE	10.6	156.6	141.6
3	30.5-30.9	CORE	8.2	147.5	136.3
4	9.5-10.0	4-2	15.4	132.6	114.9

*Represents disturbed samples, and wet/dry density results may not be accurate.

Table 2

Atterberg Limits Test Data

Boring No.	Depth (ft.)	Sample No.	Liquid Limit (%)	Plastic Limit (%)	Plasticity* Index (%)	Group Classi-fication
1	5.0-6.5	1-1	38	27	11	ML
2	4.0-4.5	2-1	28	19	9	CL
2	9.5-10.0	2-2	35	19	16	CL
2	14.3-14.5	2-3	35	20	15	CL
3	5.0-5.5	3-1	36	18	18	CL
3	17.0-17.5	3-3	31	19	12	CL
4	9.5-10.0	4-2	29	18	11	CL

*Liquid Limit - Plastic Limit = Plasticity Index

Table 3

Unconfined Compression Tests

Boring No.	Depth (ft.)	Lithology	Density (pcf)	Compressive Strength (psi)	Young's Modulus (psi)
1	16.0-16.5	SILTSTONE	152.9	68*	7.3×10^3
2	4.0-4.5	SANDY CLAY	125.0	8.5	-
2	9.5-10.0	SILTY CLAY	130.3	48	1.3×10^3
2	29.0-29.5	SILTSTONE	139.6	120	5.2×10^3
3	5.0-5.5	SILTY CLAY	126.4	42	2.2×10^3
3	17.0-17.5	SHALE	133.2	90[1]	1.5×10^3
3	21.7-22.3	SHALE	152.8	428[2]	2.3×10^4
3	25.0-25.5	SHALE	156.6	130[3]	2.2×10^3
3	30.5-30.9	SHALE	147.5	61	1.1×10^3
3	59.6-60.0	COAL	76.8	1,540	1.3×10^5
4	9.5-10.0	SANDY CLAY	132.6	37	8.1×10^2
4	57.0-57.5	SANDSTONE	159.2	20,640	-

*Failure across healed fracture

[1]Confining pressure of 20 psi (triaxial test - uu)

[2]Confining pressure of 50 psi (triaxial test - uu)

[3]Confining pressure of 80 psi (triaxial test - uu)

Table 4

Direct Shear Test Results*

Boring No.	Depth (ft.)	Lithology	Type of Joint	Friction Angle, Ø (degrees)	Unit Cohesion c (psi)
3	49.7-50.2	SILTSTONE	70°, OPEN	25.6°	28.3
4	20.5-21.0	SHALE	0°, OPEN	22.3°	30.7
4	37.5-38.0	SILTSTONE	77°, OPEN	38.0°	15.5

*Shear strength parameters for each sample were determined by multi-stage tests, using five different normal stresses.

F I G U R E S

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 1
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer / 30-in. Fall / 2-in. o.d. Split-barrel Sampler		Sheet 1 of 3
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 9-13-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9139.6	0	CL	Silty Clay: dark brown; 15-20% fine sand; very wet; medium plasticity; medium stiff. Some organics. (Topsoil zone)			Location - N: 7,226.26 W: 10,102.57 (on slope above ventilation fan)
9138.1	1.5	CL	Silty Clay: dark yellowish-brown; 20% fine sand; wet to very wet; medium plasticity; medium stiff.			
9136.1	3.5	CL	As above but mottled with dark grayish-brown and wet.			Hole cased to 13.5' with hollowstem auger.
9134.1	5.5	CL-CH & ML	Silty Clay: dark brownish-gray and dark gray; wet; medium to high plasticity; stiff. Some thin (1/8") coal seams, and zones of sandy silt.	SPT 1-1	3 / 4 / 7	N=11
9132.1	7.5	CH	Silty Clay: dark gray and gray; moist; high plasticity; very stiff.			
9130.1	9.5	CL	Silty and sandy clay: dark gray, yellowish brown, and brown; up to 25% fine sand; moist; low to medium plasticity; hard to very hard. Last 2-3" saturated from groundwater perched on sandstone stringer from 12.5 to 12.7'. (Weathered rock)	D&M 1-2 / SPT 1-3	35 / 38 / 23 / 47	N=70 Groundwater @ 12.3' after 20 hours.
9126.1	13.5		Shale and Siltstone: silty and sandy clay; gray mottled with brownish-yellow; up to 25% fine sand; partings every 8"±; soft rock.	NX core Run #1		94% Recovery (diamond bit; bentonite and D7-E polymer) 94% RQD (10 pieces)
9119.6	20					

601

Figure 2

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in continuous flight auger	Standard Penetration Test			Boring No. 1
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 2 of 3
w=Moisture Content, % · D=Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 9-13-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9119.6	20					
9113.3	20.3		As before (shale and siltstone)			
			Badly weathered sandstones and shales: brown and brownish yellow; very soft rock.	NX Core Run #2		56% Recovery (carbide bit; bentonite and D7-E; lost circulation at 21.5") 0% RQD
						Added cellulose, nut shell and more bentonite to drilling water: began drilling w/ tricone bit at 23.9' lost circulation; continued drilling with hollowstem auger; tried tricone bit again at 29.0' and lost circulation immediately.
				D&M 1-4	72 in 3'	
9107.6	32					
9107.1	32.5		Zone of broken sandstone.			
		CL-ML	Shale and siltstone: silty clay;' gray and dark gray; moist; low to medium plasticity; soft rock.			
				SPT 1-5	100	in 3" N=100+
9102.6	37					
9102.1	37.5		Possible sandstone			
		ML	Siltstone: sandy silt; dark brown and grayish brown; dry; slight plasticity; moderately soft rock.			
9099.6	40					

Figure 2a

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT

Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger		Standard Penetration Test		Boring No. 1
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler		140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 3 of 3
w = Moisture Content, %	D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 9-13-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9099.6	40		As before (siltstone) D&M	1-6	100	in 1"
9095.1	44.5		Sandstone (poor recovery with hollowstem auger); soft to moderately hard rock.			
9093.6	46		Siltstone, as before.			
9091.6	48		Sandstone: hard rock.			
9090.6	49		(Refusal of hollowstem auger with carbide teeth, using CME-750 rig)			

Figure 2b

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 2
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 3
w=Moisture Content, % / D=Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 9-14-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9230.1	0	CL	Silty Clay: very dark brown; 15-20% fine sand; moist; medium plasticity; medium stiff.			Location - N: 7,561.28 W: 10,196.59 (Active slide area)
9227.6	2.5	CL	Sandy Clay: dark yellowish brown; some pieces of weathered sandstone (¼" diameter).			
9226.6	3.5	CL	Sandy Clay: brownish yellow mottled with brownish gray; 20-25% fine sand; pieces of weathered sandstone; medium plasticity; soft to medium stiff.	D&M 2-1	5 9 10	(33% recovered)
9224.1	6	CL& CH	Silty Clay: gray and dark gray becoming dark brownish gray; some pieces of weathered sandstone; medium and high plasticity; very stiff to hard.	D&M 2-2	7 13 19	No groundwater 38 hours after drilling.
9218.8	11.3		Weathered sandstone			
9218.1	12	CL& CH	As before but more zones of weathered sandstone.	D&M 2-3	5 6 10	
9214.1	16		Weathered sandstone pieces.			
9213.1	17	CL, CH, &SM	Silty and sandy clay: brownish yellow; wet; 5-35% fine sand; low (sandy clay) & high (silty clay) plasticity; stiff. Zones of badly weathered sandstone (SM).	SPT 2-4	3 11 8	N=19
9210.1	20					

Figure 3

MORRISON KNUDSEN **Mining Group**

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger	Standard Penetration Test: 140-lb. Hammer, 30-in. Fall, 2-in. o.d. Split-barrel Sampler		Boring No. 2
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler			Sheet 2 of 3
w=Moisture Content, %	D=Dry Density, pcf	Penetration Resistance: N=Blows per foot	Date: 9-14-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9210.1	20	CL, CH, &SM	As before (silty and sandy clay with badly weathered sandstone)			
9206.1	24		Siltstone or sandstone: moderately hard rock; possible talus (no samples).			
9204.6	25.5	CL, CH, SM	As before with thin seams of siltstone	SPT 2-5	9 10 50	in 5" N=60+
9203.6	26.5		Weathered siltstone: sandy silt; gray; moist; 15-20% fine sand; soft to moderately hard rock.	D&M 2-6	16 29 40	
9197.6	32.5		As above but moderately hard to hard rock (harder than above)			
9194.6	35.5	SM& ML	Badly weathered siltstone & sandstone: brownish yellow and yellowish gray; wet; very soft rock.	SPT 2-7	39 18 46	N=64
9191.1	39		Siltstone or sandstone: moderately hard rock (no recovery).			

Figure 3a

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina MIne, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 2
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer	30-in. Fall / 2-in. o.d. Split-barrel Sampler	Sheet 3 of 3
w=Moisture Content, % / D=Dry Density, pcf	Penetration Resistance: N=Blows per foot		Date: 9-14-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9190.1	40		As before.			
9189.6	40.5		Weathered siltstone: sandy silt; gray; moist; soft to moderately hard rock.	D&M 2-8	100 in 2"	Hollowstem auger used as casing at 44.0'; tried to hold water head with bentonite and cellulose to see if coring was possible; lost head of water within 30 seconds.
9182.1	48		Weathered siltstone: as above but mottled with yellowish brown and yellowish gray; somewhat harder.	SPT 2-9	50	in 2" N=50+
9175.8	54.3		End of Boring	SPT 2-10	100	in 3.5" N=100+

Figure 3b

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 3
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 3
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot			Date: 9-15-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9129.3	0	CL	Silty Clay: dark brown to brown; 15 to 20% fine sand; moist; low to medium plasticity; organics upper 12".			Location - N: 7,786.38 W: 9,745.67 (on slope above changehouse)
9125.8	3.5	CL& CH w/ SM	Silty/sandy clay with sandstone: grayish brown; zones of hard weathered sand compose ≃ 20% of stratum; wet; medium and high plasticity; up to 30% fine sand in zones of sandy clay; very stiff t to hard.	D&M 3-1	14 / 21 / 25	Hollowstem auger set as casing at 18.5' No groundwater data-hole plugged at 18' 24 hours after drilling.
9121.3	8	CL, SM &ML	Badly weathered siltstone&sandstone: sandy clay matrix with pieces of moderately soft rock; brownish yellow and brownish gray.	SPT 3-2	8 / 23 / 19	N=42
9118.8	10.5		Weathered siltstone: gray; moist; moderately soft rock.			
9117.3	12	CL	Silty Clay: brownish yellow; wet; low to medium plasticity; stiff. Zones of claystone ≃ 3-4" thick; hard.	SPT 3-3	7 / 11 / 19	N=30
9113.8	15.5	CL-CH	Weathered shale: brownish yellow becoming gray at 17.5'; moist; medium to high plasticity; very soft to soft rock.	D&M 3-4	25 / 29 / 23	in 2"
				NX Core Run#1		See following page for core data
9109.3	20					

601

Figure 4

MORRISON KNUDSEN Mining Group — BORING LOG	PROJECT: Valley Camp of Utah, Inc. Belina Mine, Carbon County. Upper Portal Backslope

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 3
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer	30-in. Fall; 2-in. o.d. Split-barrel Sampler	Sheet 2 of 3
w = Moisture Content, %; D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 9-15-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9109.3	20	CL-CH	As before			
9108.8	20.5		Weathered shale: gray and brownish yellow; some interbedded sandstone strata ≃ 1-2" thick; partings at 2-3"; soft rock. Joints: 20.5', moderately smooth, open, 10° dip; 21.7-22.3', closed 90° dip; 23.1-23.2' moderately smooth; 30° dip.	Cont. NX Core Run #1		97% Recovery 12% RQD (1 piece) (Carbide bit; "unlimited" water supply by siphon from 12,000 gal. potable water storage tank; water did not recirculate
9105.3	24		Sandstone: brownish yellow; moderately hard rock. Joints: 24.2-24.4' moderately rough, open, 80° dip; 24.6-24.7' moderately smooth, 45&60°; 24.7'24.9', open, moderately smooth, 90° dip.			
9104.4	24.9					
9103.5	25.8		Weathered shale: gray and brownish yellow; moist; soft rock.	NX Core Run #2		52% Recovery 15% RQD (1 piece)
			Badly weathered sandstone & shale: brownish yellow and gray; partings every ½ to 2". Joints: 26.0', open, rough, 75° dip.			
9101.3	28		Lost sample: very soft rock.			
9099.3	30		Weathered shale, siltstone&sandstone: gray and brownish yellow; soft rock partings ½-3".	NX Core Run #3		78% Recovery 14% RQD (2 pieces)
9096.3	33		Sandstone: brownish yellow; hard; thin-bedded (1.5-3").			
9095.3	34		Weathered shale and siltstone: gray and brownish yellow; soft rock; partings ½ to 2". Joints: 39.2', closed, 90°.	NX Core Run #4		87% Recovery 0% RQD
				NX Core Run #5		80% Recovery 23% RQD (2 pieces)
9089.8	39.5		As below			

Figure 4a

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 3
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 3 of 3
w=Moisture Content, %	D=Dry Density, pcf	Penetration Resistance: N=Blows per foot	Date: 9-15-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9089.3	40		Weathered shale: gray and brownish yellow; soft rock. Joints: 40.7 & 41.3', open, rough, 20° dip. Partings every 2 to 12".	Cont. NX Core Run #5		As before
				NX Core Run #6		100% Recovery 46% RQD (8 pieces)
9083.8	45.5		Siltstone: gray and brownish yellow; moist; moderately hard rock. Joints: 48.5', open, rough, 0°; 49.5-49.8', 3 pieces, rough, 70°; 50.0', open, moderately smooth, 20°. Partings every 2 to 7".			
9078.3	51		Very soft weathered shale			
9077.3	52		Coal: thin bedded, moderately soft. Partings every 1 to 3"; highly fractured from 55.5' to 56.5'.	NX Core Run #7		82% Recovery 0% RQD
9068.3	61		End of Boring			

601

Figure 4b

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger		Standard Penetration Test			Boring No. 4
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler		140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 3
w=Moisture Content, %	D=Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 9-16-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9176.1	0	CL	Fill: silty and sandy clays; dark gray and dark grayish brown; medium stiff.			Location - N: 8,031.57 W: 9,605.70
9174.6	1.5	CL	Sandy Clay: dark brown to brown; 25-30% fine sand; moist; low plasticity; stiff.			(on jeep trail east of potable water tank)
9171.6	4.5	SM	Sandstone cobble: top 6" badly weathered.	SPT 4-1	32 45	N=50+
9169.6	6.5	CL	Silty Clay: brownish yellow; 15-20% fine sand; wet; medium plasticity; stiff.			No groundwater 24 hrs. after drilling
9168.1	8	SM	Silty Sand: brownish yellow; 40-45% nonplastic fines; moist; dense (badly weathered sandstone cobble).			
9167.1	9	CL, ML, &SM	Silty/sandy clay, sandy silt, and silty sand: hard soil colluvium with pieces of rock.	D&M 4-2	16 25 50	in 2"
9165.6	10.5	ML	Weathered siltstone cobble: brownish gray; moderately soft rock.			
9164.6	11.5		Weathered siltstone with some sandstone: gray mottled with brownish gray and brownish yellow; soft rock.	SPT 4-3	34 50	in 5" N=80+
9160.1	16		Weathered shale & sandstone: brownish yellow and gray w/ brownish red; highly fractured; moderately hard rock. Joints(all open): 17.5-17.7', moderately smooth, 80°; 18.3-18.4', moderately rough, 90°, 19.1-19.3', moderately smooth, 20°&90°; (4 pieces).	NX Core Run #1		89% Recovery 34% RQD (4 pieces between 19.5' & 25')
9156.6	19.5		As below			

Figure 5

MORRISON KNUDSEN **Mining Group**

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 4
Undisturbed Soil Sampler: 3-in.o.d. D&M sampler	140-lb. Hammer / 30-in. Fall	2-in.o.d. Split-barrel Sampler	Sheet 2 of 3
w=Moisture Content, % / D=Dry Density, pcf	Penetration Resistance: N=Blows per foot		Date: 9-16-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9156.1	20		Weathered shale: gray, brownish gray, very dark gray and very dark grayish brown; moist; medium and high plasticity; zones of siltstone; soft rock. 2" thick highly fractured sandstone at 20.8'. Partings every 2 to 9".	Cont. NX Core Run #1		As before
9151.9	24.2		Siltstone: gray; moderately hard rock.			
9151.1	25		Sandstone: brownish yellow, gray and yellowish red; thin shale seams (1/8"); highly fractured in part; parts moderately hard.	NX Core Run #2		96% Recovery 9% RQD (1 piece, below 27')
9149.7	26.4		Badly weathered shale & siltstone: gray mottled with brownish yellow; highly fractured in part; very soft rock. Partings every ½ to 3" (some coal in partings). Joint: 29.6-29.8', open, smooth, 90°.			
				NX Core Run #3		100% Recovery 39% RQD (8 pieces, between 33 & 38')
9143.9	32.2		Siltstone: yellowish gray mottled with brownish yellow; up to 35% fine sand; moderately hard rock. Partings every 2-8" with leaf fossils. Parting with slickensides at 34': variable dip of partings above 34', 20° dip below 34'.			
9138.1	38		Weathered siltstone: dark gray and gray mottled with brownish yellow; many multi-piece irregular joints; cont....			
9136.1	40					

Figure 5a

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County

Upper Portal Backslope

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 4
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 3 of 3
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot			Date: 9-16-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9136.1	40		Weathered siltstone, cont.. soft rock with zones of very soft rock. Partings every ½ to 3". Joints: 39.5-39.6', open, irregular, moderately smooth, 70-90° dip, 4 pieces.			
9133.1	43		Siltstone: yellowish gray; moderately hard rock. Partings every 2 to 5".	NX Core Run #4		95% Recovery 32% RQD (7 pieces, between 43-44' & 45-50')
9132.1	44	ML				
9131.1	45		Badly weathered siltstone: yellowish brown; weathered to soil in part; very soft rock. Partings every ¼ to 2".			
			Weathered siltstone: yellowish brown and gray; badly fractured from 47.5 to 48.0 and 49.0-49.4'. Partings every 2-10".			
9126.7	49.4		Claystone: dark gray; hard rock.			
				NX Core Run #5		100% Recovery 50% RQD (5 pieces)
9124.4	51.7		Weathered clay parting			
9124.3	51.8		Siltstone: gray and brownish yellow; moderately hard rock becoming softer. Partings generally every 2-3".			
9120.4	55.7		Siltstone: brownish yellow; zones of fine sandstone, badly fractured from 59.5 to 60.0'. Partings every 2-12". Joint: 57.5-57.8', open, rough, 60°, 4 pieces.			
911.61	60		End of Boring			

Figure 5b

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT

Valley Camp of Utah, Inc.
Belina Mine, Carbon County
Boring to Sample Fill on Pad

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 5
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 2
w=Moisture Content, % / D=Dry Density, pcf	Penetration Resistance: N=Blows per foot		Date: 9-17-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
8923.3	0	CL w/ coal	Fill: silty clay with coal; very dark grayish brown.	1		Location - N: 7526.24 W: 9092.96 Purpose of hole was to obtain bag samples at 2.5' intervals for testing by Valley Camp to determine potential use of the fill for reclamation. Boring log is necessarily rough because of variations within the fill. No groundwater 24 hours after drilling.
8921.3	2	SM w/ CL	Fill: silty sand with silty clay; brownish yellow.	2		
8917.3	6	CL	Fill: sandy clay; dark yellowish brown.	3		
8916.3	7	SM& CL	Fill: pieces of sandstone and sandy clay; brownish yellow.	4		
8912.3	11	CL	Fill: silty clay; dark yellowish brown.	5, 6		
8908.3	15	CL	Fill: silty and sandy clay with pieces of wood and roots; very dark grayish brown.	7, 8		
8903.3	20					

601

Figure 6

MORRISON KNUDSEN Mining Group

BORING LOG

PROJECT

Valley Camp of Utah, Inc.
Belina Mine, Carbon County
Boring to Sample Fill on Pad

Boring Method: 6-in. continuous flight auger	Standard Penetration Test	Boring No. 5
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer / 30-in. Fall / 2-in. o.d. Split-barrel Sampler	Sheet 2 of 2
w=Moisture Content, % / D=Dry Density, pcf	Penetration Resistance: N=Blows per foot	Date: 9-17-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
8903.3	20		As before	9		
8901.3	22	CL w/ coal	Fill: silty clay with coal and coal tailings; very dark grayish brown.	10		
8897.3	26	CL	Fill: sandy clay; very dark grayish brown.	11		
				12		
8893.3	30					

Figure 6a

MORRISON KNUDSEN **Mining Group**

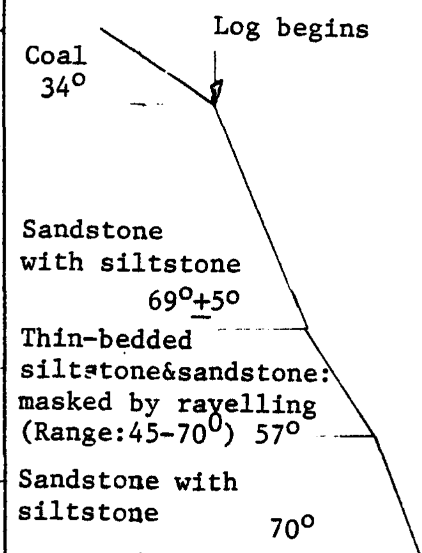
LOG OF CUT SLOPE

PROJECT

Valley Camp of Utah, Inc.
Belina Mine, Carbon County
Composite Log of Cut Slope
Behind Changehouse

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 6
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler	140-lb. Hammer / 30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 2
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 9-17-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9042*	0		Sandstone: hard; fractured in part.			Composite log of cut slope behind the changehouse, at the center of the building. Depths shown in log are estimated only, from the base of the coal stratum.
9040.5	1.5		Siltstone			
9039.5	2.5		Sandstone: hard; joints strike N80W with dip 70-90°N.			
9038	4		Siltstone			
9037.5	4.5		Sandstone: hard, as before.			
9036	6		Shale and siltstone: hard.			
9034.5	7.5		Sandstone: as before, but secondary joint system strikes N20E and dips 80°E.			
9033	9		Alternating zones of sandstone and siltstone.			
9030	12		Coal			
9029.5	12.5		Sandstone: hard, as before.			
9028.5	13.5		Siltstone: thin-bedded (½ to 2"); soft rock. Source of erosion, ravelling, and undercut.			
9025	17		Sandstone and siltstone: 1-6" thick bedding; joints strike N10E, dipping 85°E.			
9022	20					



Generalized section

*Elevation estimated from topographic map

601

Figure 7

MORRISON KNUDSEN Mining Group

LOG OF CUT SLOPE

PROJECT

Valley Camp of Utah, Inc.
Belina Mine, Carbon County
Composite Log of Cut Slope
Behind Changehouse

Boring Method: 6-in. continuous flight auger		Standard Penetration Test		Boring No. 6
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler		140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 2 of 2
w = Moisture Content, %	D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 9-17-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
9022	20		Sandstone with some siltstone: massive in part (bedding 1-3" thick, and up to 24" thick); primary joints strike N10E, dipping 85°E; secondary joints strike E-W with dip 85°N. The 24" thick bedding is actually very tight thin-bedded sandstone.			
9016	26		Bottom of slope cut			

Figure 7b

601

MORRISON KNUDSEN Mining Group

LOG OF CUT SLOPE

PROJECT
Valley Camp of Utah, Inc.
Belina Mine, Carbon County
Composite Log of Cut Slope
East of Loadout Chute

Boring Method: 6-in. continuous flight auger		Standard Penetration Test		Boring No. 7
Undisturbed Soil Sampler: 3-in. o.d. D&M sampler		140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, %	D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 9-17-83

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
8949*	0		Coal: cut almost vertically, ravels in light wind.			Composite log of vertical cut slope (at the center of the cut) near the coal loadout chute. Depths shown in log are estimated only, from the top of the "vertical" section. Log of cut was made at point D1 of the first detail line (see boring location plan).
8947	2		Weathered shale: dark yellowish brown.			
8945.5	3.5		Sandstone: massive; hard rock; yellowish brown.			
8938	11					
8937.8	11.2		Bedding plane filled with weathered sandstone.			
			Sandstone: massive, as before.			
8924	25		Base of cut			

*Elevation estimated from topographic map

Figure 8

MORRISON-KNUDSEN, INC.

DATA SHEET FOR DETAIL LINE MAPPING

W.O. NO. 1630-02 PAGE 1 OF 1

PROJECT Valley Camp BY B.(le

LINE NO. D1 TREND S55°W PLUNGE 0° ELEV. 8929 LOCATION Belina DATE 9-17-83

LINE INTERCEPT (ft.)	ROCK TYPE	STRUCTURE TYPE	STK	DIP	GEOMETRY MD	P	LENGTH	± OVERLAP	T_L	T_U	R	WIDTH ( )	FILLING	W	REMARKS
D1(NE end)															
0	MASSIVE SANDSTONE (OVERLAIN BY LOWER COAL STRATUM)	SJ	S60W	90		PL	5'		R	N	SM				
5		SJ	S25W	84E		PL	4'		N	R	SM	1.5"	Clay		
9		SJ	W	75N		WV	2"		R	N	RH				
11		SJ	S65W	80E		PL	14'		N	N	SM				
25		SJ	S	90		PL	3'		N	R	SM				
28		SJ	W	83N		PL	16'		N	N	SM	becoming RH			
39		SJ	-	58E		--	--		R	R	--				
44		SJ	S15W	87W		PL	1'		N	R	SM				
45			BLAST DAMAGED JOINT												
45.5		SJ	S35W	86E		WV	1.5'		N	R	RH				
47			BLAST DAMAGED MASSIVE ROCK TO 62'												
62		SJ	S75W	54S		PL	2'		R	N	SM				
63			BLAST DAMAGED MASSIVE ROCK TO 83'												
83		SJ	S	84E		PL	2'		N	R	SM				
85			BLAST DAMAGED MASSIVE ROCK TO 90'												
90 (D1', SW End: at a point 14' NE of ℄ of loadout chute drive, perpendicular to ℄)															

ROCK TYPE ABBREVIATIONS	STRUCTURE TYPE	GEOMETRY
	SJ SINGLE JOINT	MD = MINIMUM DIP
	FT FAULT	P = PLANARITY: PL, WV R = ROUGHNESS: SM, RH
	CT CONTACT	
		T_L, T_U = TERMINATIONS
WATER: D = DRY, W = WET, F = FLOWING		H >20° / R IN ROCK
FILLING ABBREVIATIONS		L <20° / N NONE
N NONE		E ENECHELON

Figure 9

MORRISON-KNUDSEN, INC.

TA SHEET FOR DETAIL LINE MAPPING

W.O. NO. 1630-02 PAGE 1 OF 1

PROJECT Valley Camp BY B ale

LINE NO. D2 TREND S25°W PLUNGE 0° ELEV. 8929 LOCATION Belina DATE 9-17-83

LINE INTERCEPT (ft.)	ROCK TYPE	STRUCTURE TYPE	STK	DIP	GEOMETRY MD	P	LENGTH	± OVERLAP	T_L	T_U	R	WIDTH ( )	FILLING	W	REMARKS
D2 (N end)															
0	SANDSTONE, AS BEFORE ON D1	SJ	--	70N		PL	--		N	R	SM				
0		SJ	S25W	76W		PL	21'		N	N	SM				
21		SJ	N85E	73S		PL	--		N	R	SM	1.5"	Open		
21		SJ	S20W	80W		PL	7'		N	N	SM				
28		SJ	E	78S		WV	1'		N	R	SM	12"	Clay		
29		SJ	S15W	83E		PL	23'		N	R	SM				
51			BLAST DAMAGED FACE 2'LONG												
52		SJ	S15W	75E		PL	8'		N	R	SM				
60 (D2', S End; at a point 10' from D1 on the same slope)															

ROCK TYPE ABBREVIATIONS	STRUCTURE TYPE	GEOMETRY
	SJ SINGLE JOINT	MD = MINIMUM DIP
	FT FAULT	P = PLANARITY: PL, WV R = ROUGHNESS: SM, RH
	CT CONTACT	
		T_L, T_U = TERMINATIONS

WATER: D = DRY, W = WET, F = FLOWING

FILLING ABBREVIATIONS	
N	NONE

T_L, T_U			
H	>20°	R	IN ROCK
L	<20°	N	NONE
		E	ENECHELON

Figure10

Geotechnical Mileage Log of Cut Slopes
Valley Camp of Utah, Inc.
Belina Mine Haul Road
Section 19, R7E, T13S, Carbon County, Utah

Odometer Mileage	Description
0.0	Road begins on north side of Eccles Canyon.
0.14-0.17	*Evidence of movement along secondary joint set on 20-25' high 68° cut slope. Secondary set strikes E-W with dip to N @ 65° (Primary N-S ± 10°, dip to E @ 75-90°) Strike of slope S53°E at this point. Bedding dips into slope (SW dip direction & 4° dip)
0.21	40' high cut (above slide area) with 65° slope angle. Upper portion has some overhanging rock, and cobble zone at top will produce some rockfall. Primary joints strike N-S ± 10°, dip to E 75-90° Secondary joints strike E-W ± 10°, dip to N 70-90° Bedding dips into slope
0.32	Same cut as above, but 30' high "nose" with weathered sandstone and siltstone cut at 45° to depth of 10', and competent sandstone cut to 60°. Primary joints of competent sandstone strike N10°W to N20°E, dip 72-78°E Secondary joints strike E-W ± 10°, dip N 60-65°. Bedding dips into slope
0.37	Center of 20' high 45-50° cut in competent sandstones.
0.42	10' high "nose" (with same joint sets as described below at mile 0.52) will weather/ravel to smoother slope.
0.44	Beginning of cut described at mile 0.52.
0.52	Center of 70°, 25' high (500' ± long) cut with 6' weathered rock on top of competent sandstone and siltstone. Parts of weathered rock section may be cut too steep, but natural weathering will remedy. Primary joints of sandstone strike N3°W, dip 84°E Secondary joints strike N80°W with dip 90° ± 5° Bedding dip is into the slope.

*Indicates areas that may require regular maintenance and (or) remedial work.

Figure 11

Geotechnical Mileage Log of Cut Slopes, cont.

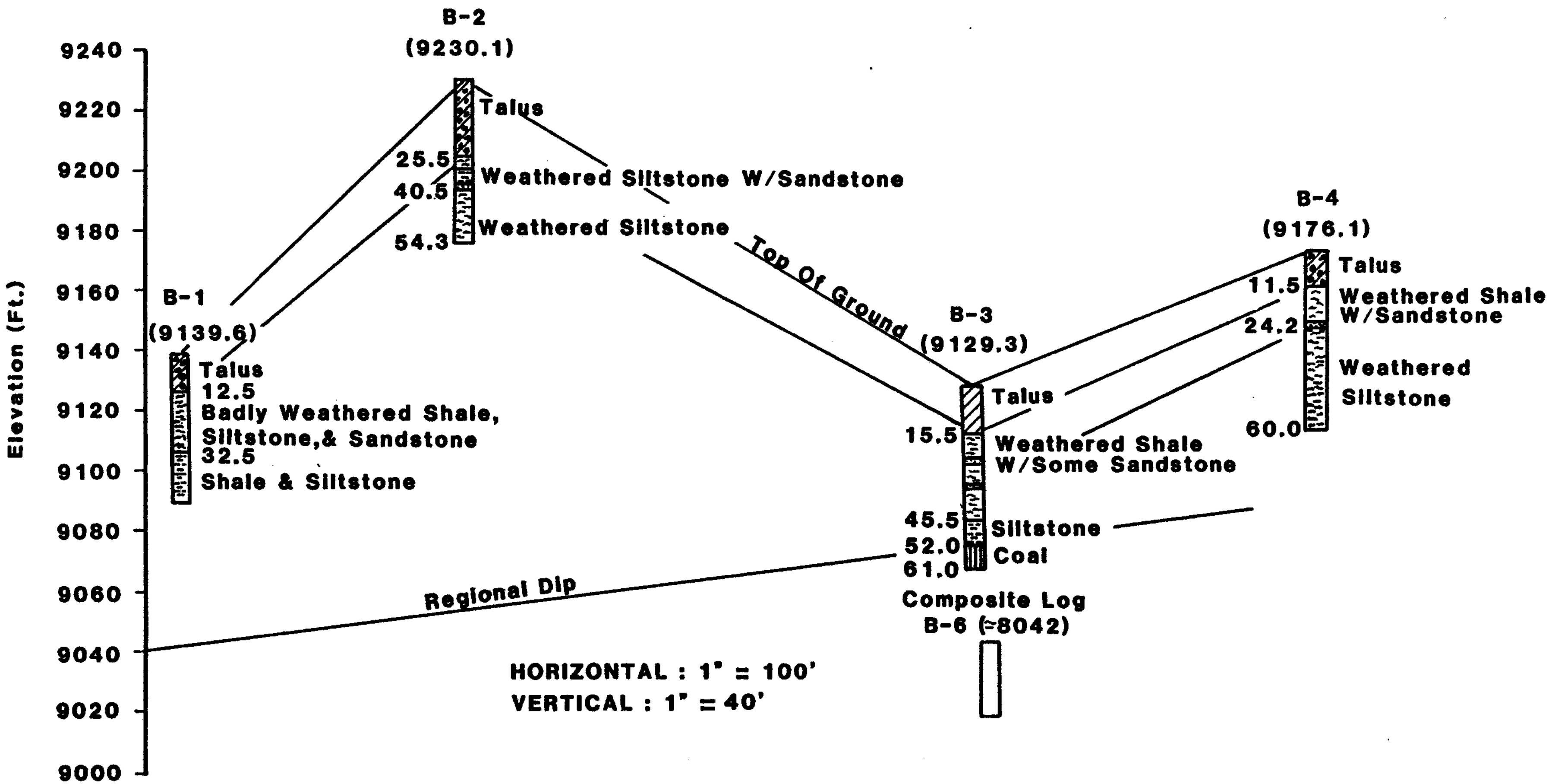
Odometer Mileage	Description
0.57	Drainageway
0.61	65^{o}, 12' high cut in competent rock with dip into the slope.
0.69-0.72	*25' high cut in possible colluvium/talus on 65^{o} slope with concave face. May be a potential slide area: top of slope could be flattened but revegetation would be essential.
0.74	Major drainageway
0.86	*Possible blast damaged "nose" rock section. 15' high that may creep on an open, potential failure surface (which might continue beneath the road section) with a strike of S60^{o}W and a dip of 42^{o}E.
0.87	20' high cut in very competent sandstone. Strike of cut parallels primary joint set (N-S $\pm$ 5^{o} with dip of 82^{o}E). Secondary set strikes E-W with 90^{o} dip.
0.92	*Possible fault? Rock is highly fractured in 40-45^{o}, 20' high cut. Evidence of soil creep and erosion. Soil cover will continue moving (perhaps 3-4' thickness)
0.97	Heavy soil cover on slope described at mile 1.02, but some competent rock strata still visible. Cut is 48^{o}.
1.02	20' high, 60^{o} cut in rock composed of sandstones and siltstones with 1-8" thick bedding. Most of cut is perpendicular to SW dip direction.
1.06	Drainageway
1.07	15' high, 55^{o} cut in competent rock.
1.12	15' cut with weathered rock (top 5') over competent rock with dip into the slope.
1.23	Some ravelling evident at beginning of slope described at mile 1.32.

*Indicates areas that may require maintenance and (or) remedial work.

Figure 12

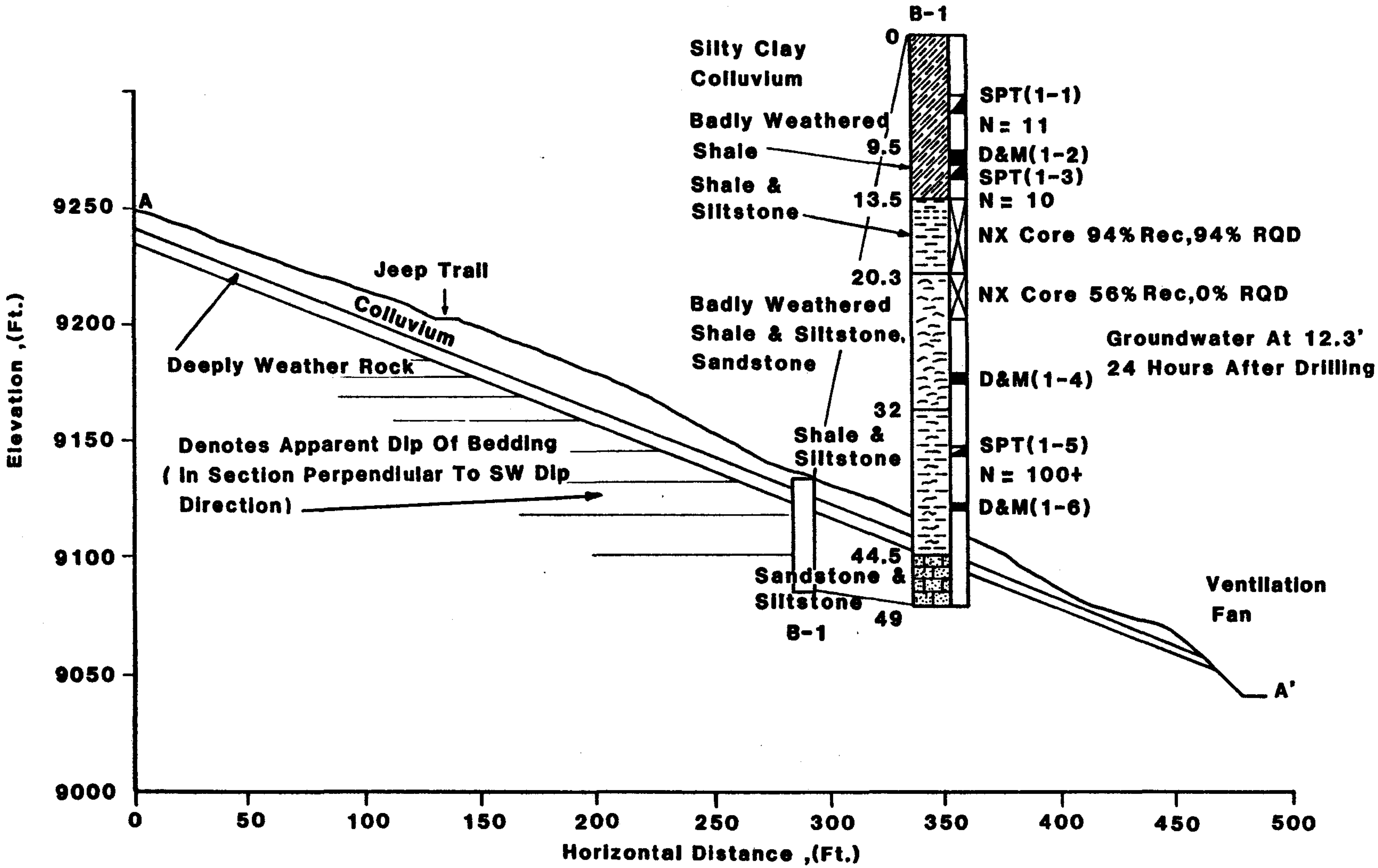
Odometer Mileage	Description
1.32	15' cut, 42^{o} in weathered rock (top 6') and competent rock with dip into slope. Some ravelling will occur from the top of the cut. At mile 1.28, primary joint set strikes N10^{o}E with dip of 85^{o}E.
1.40	20' high cut, 35^{o} in weathered rock, 55^{o} in competent rock (sandstone/siltstone) with primary joint set striking parallel to the haul road (≃N-S) dipping at 85^{o}E.
1.42	Fork in haul road leading to upper and lower portals of the Belina mine.

Figure 13



VALLEY CAMP OF UTAH , INC.
BELINA MINE . CARBON COUNTY
GENERALIZED BACKSLOPE SECTION

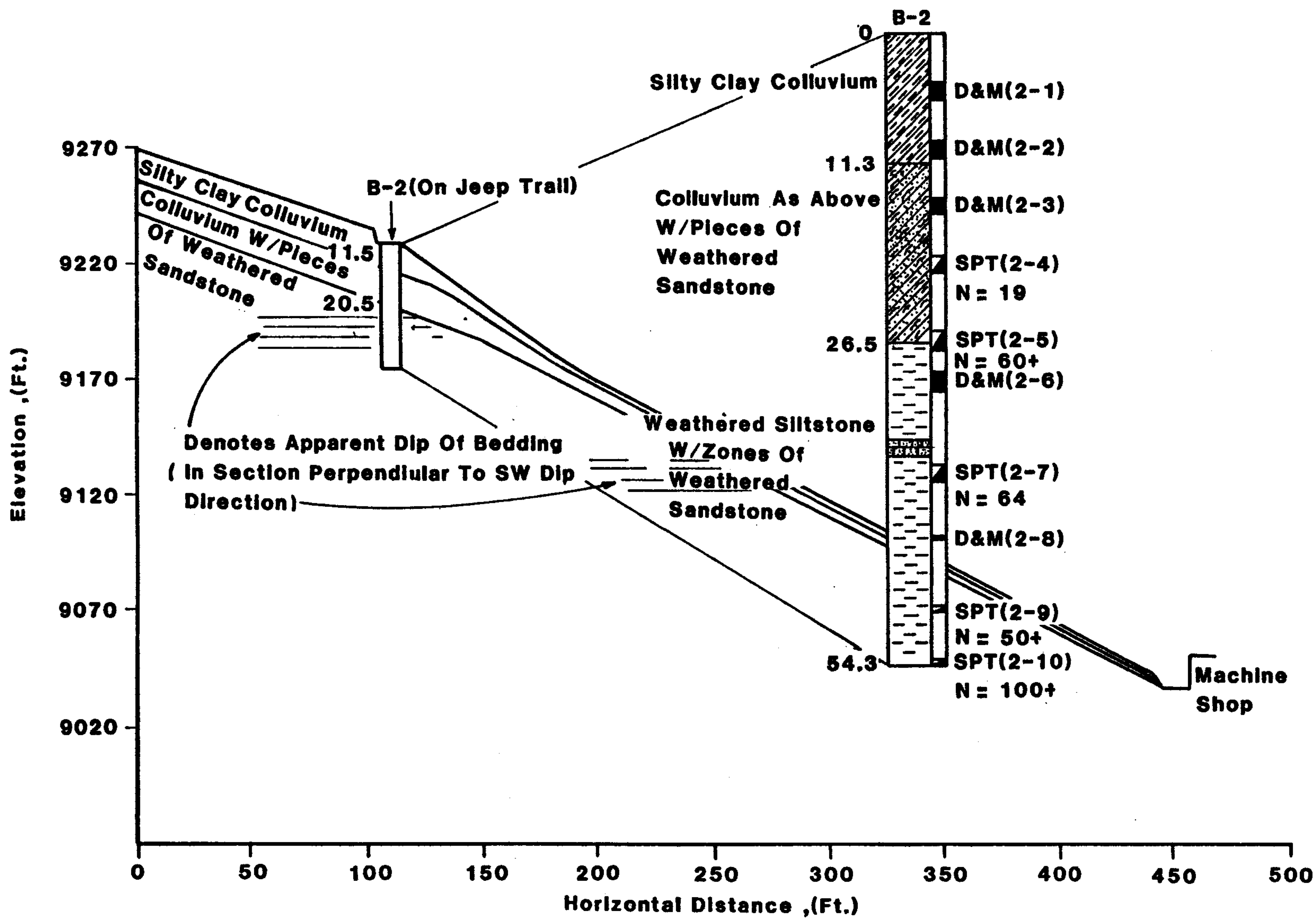
FIGURE 14



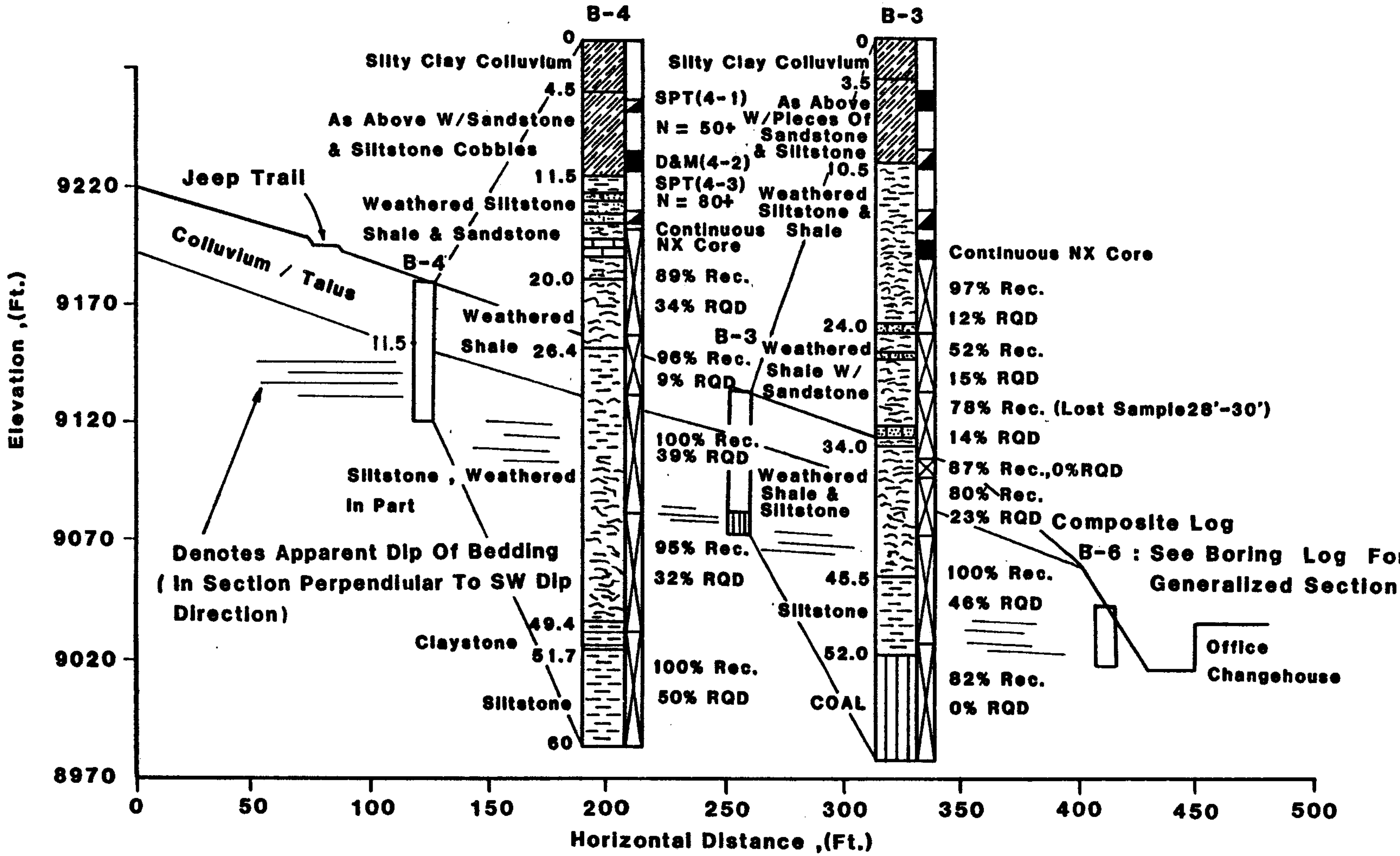
VALLEY CAMP OF UTAH, INC.
BELINA MINE, CARBON COUNTY

UPPER PORTAL BACKSLOPE SECTION A - A'

FIGURE 15



VALLEY CAMP OF UTAH , INC.
BELINA MINE , CARBON COUNTY
UPPER PORTAL BACKSLOPE SECTION B - B'
(ACTIVE SLIDE AREA)
FIGURE 16

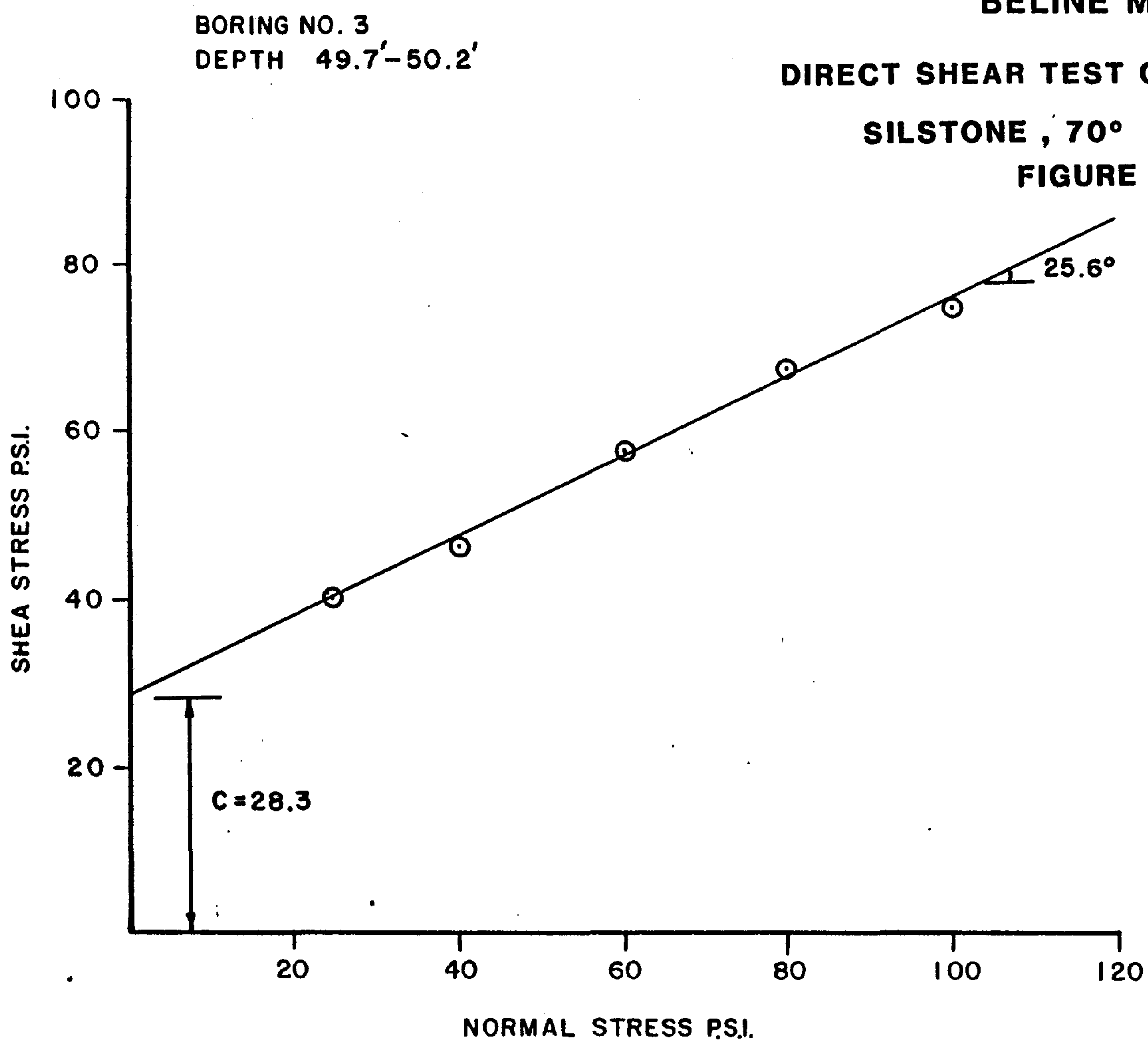


VALLEY CAMP OF UTAH, INC.
BELINA MINE, CARBON COUNTY
UPPER PORTAL BACKSLOPE SECTION C - C'
FIGURE 17

VALLEY CAMP OF UTAH , INC.
BELINE MINE

DIRECT SHEAR TEST ON DISCONTIUITY :

SILSTONE , 70° OPEN JOINT
FIGURE 18

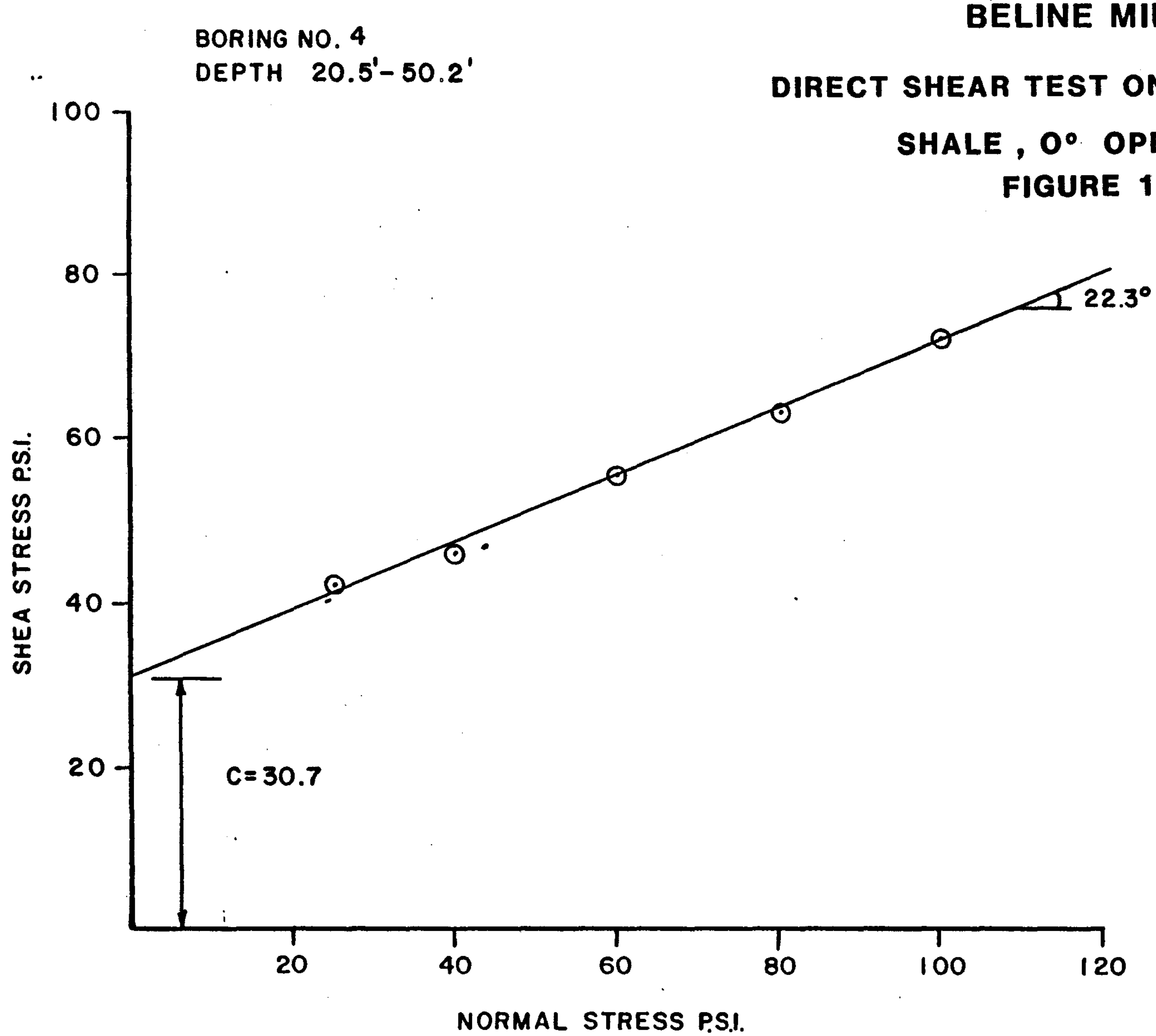


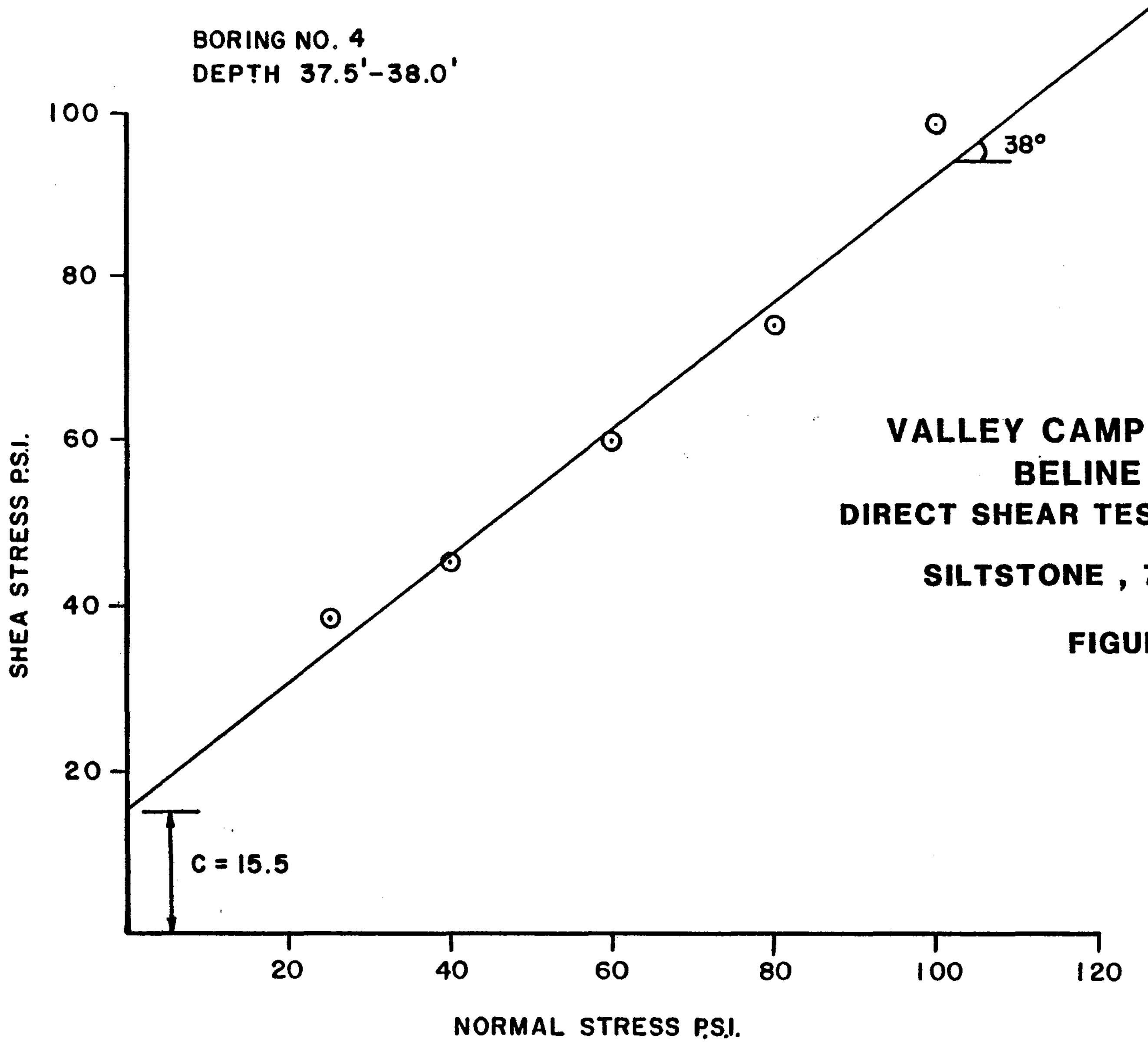
VALLEY CAMP OF UTAH , INC.
BELINE MINE

DIRECT SHEAR TEST ON DISCONTIUITY :

SHALE , 0° OPEN JOINT

FIGURE 19

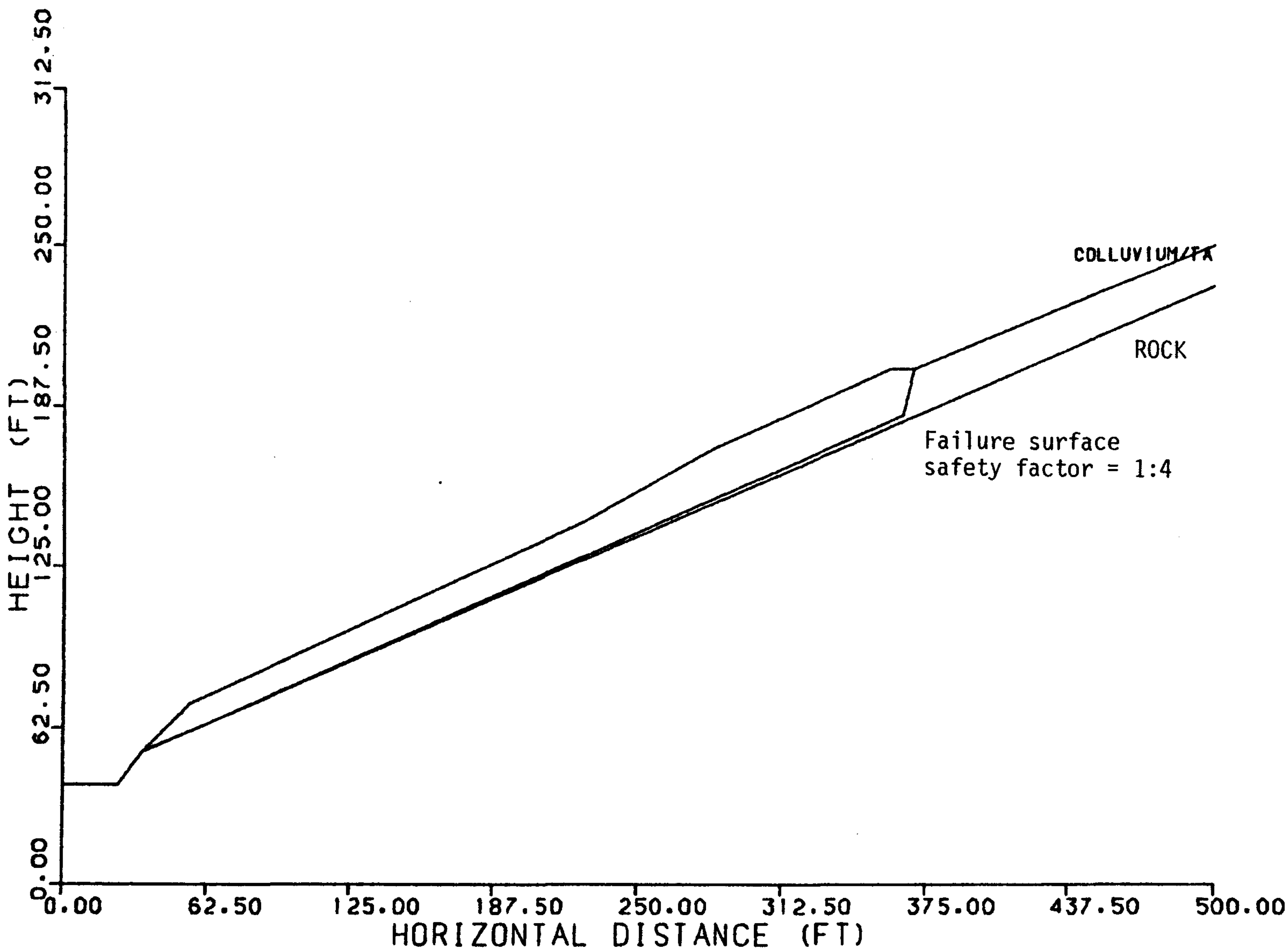




VALLEY CAMP OF UTAH , INC.
BELINE MINE
DIRECT SHEAR TEST ON DISCONTIUITY :

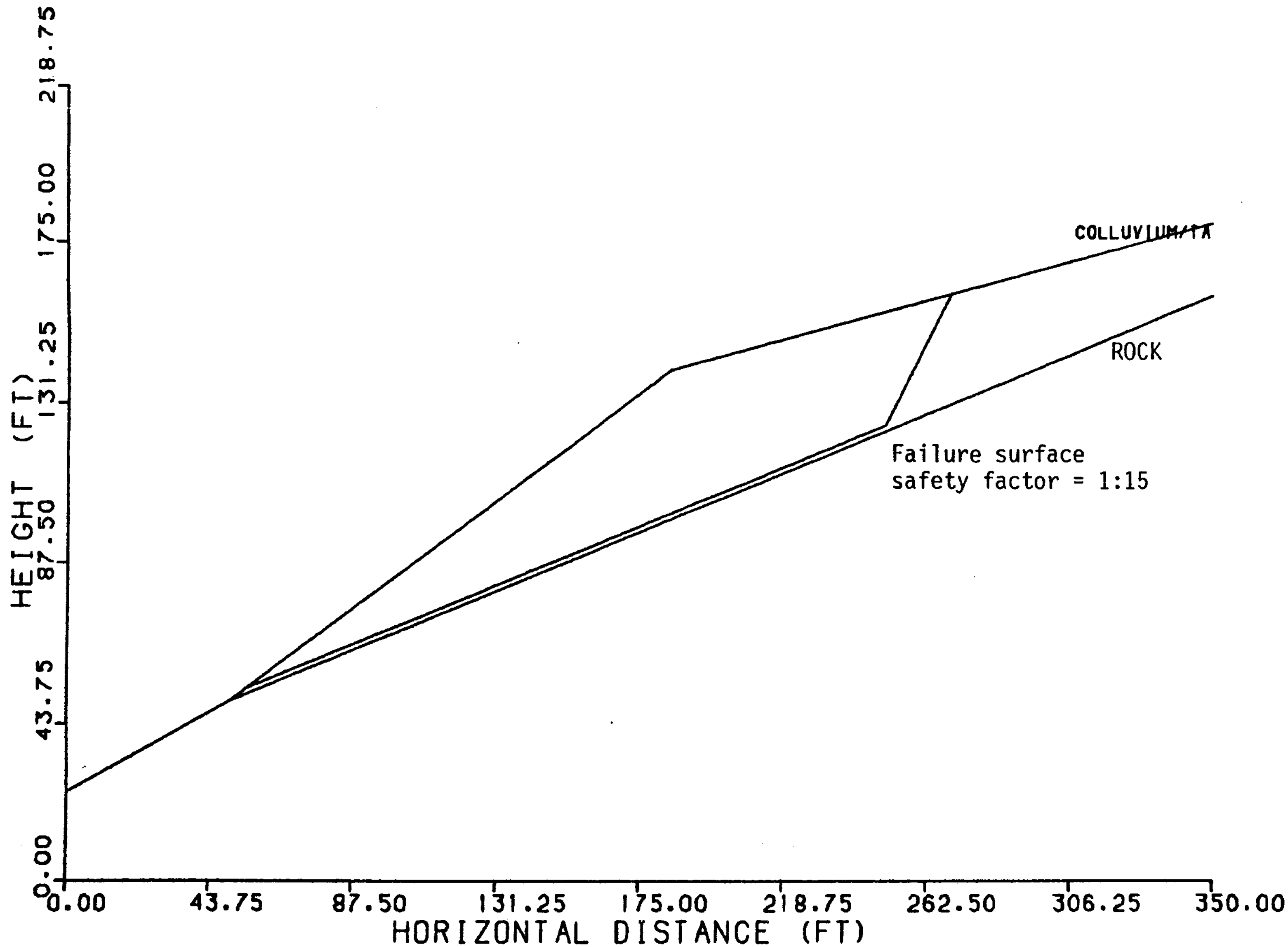
SILTSTONE , 77% OPEN JOINT

FIGURE 20



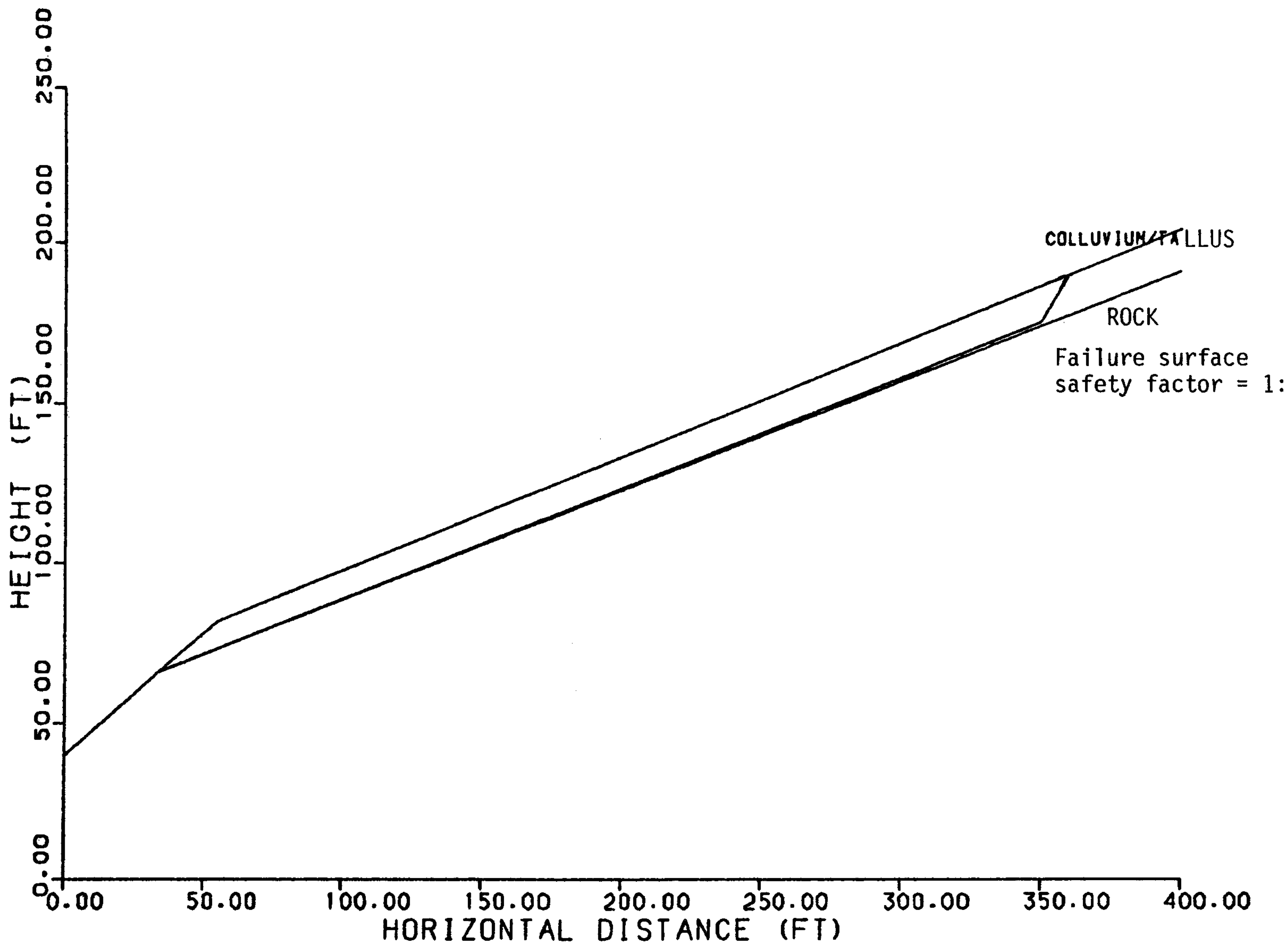
Valley Camp of Utah, Inc.
Belina Mine
Computer Generated Geologic
Model of Section A-A

Figure 21



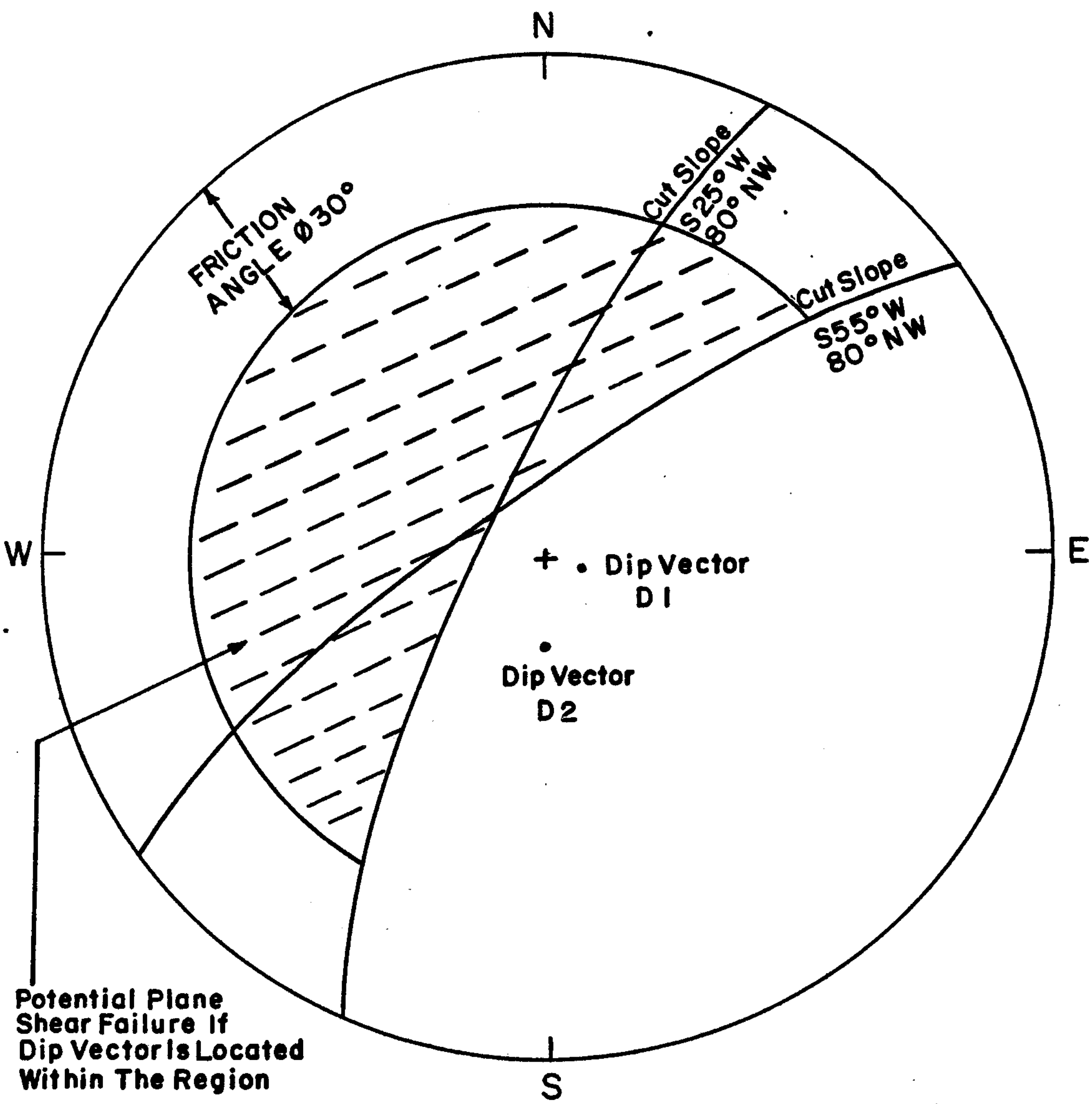
Valley Camp of Utah, Inc.
Belina Mine
Computer Generated Geologic
Model of Section B-B (most critical portion)

Figure 22



Valley Camp of Utah, Inc.
Belina Mine
Computer Generated Geologic
Model of Section C-C

Figure 23

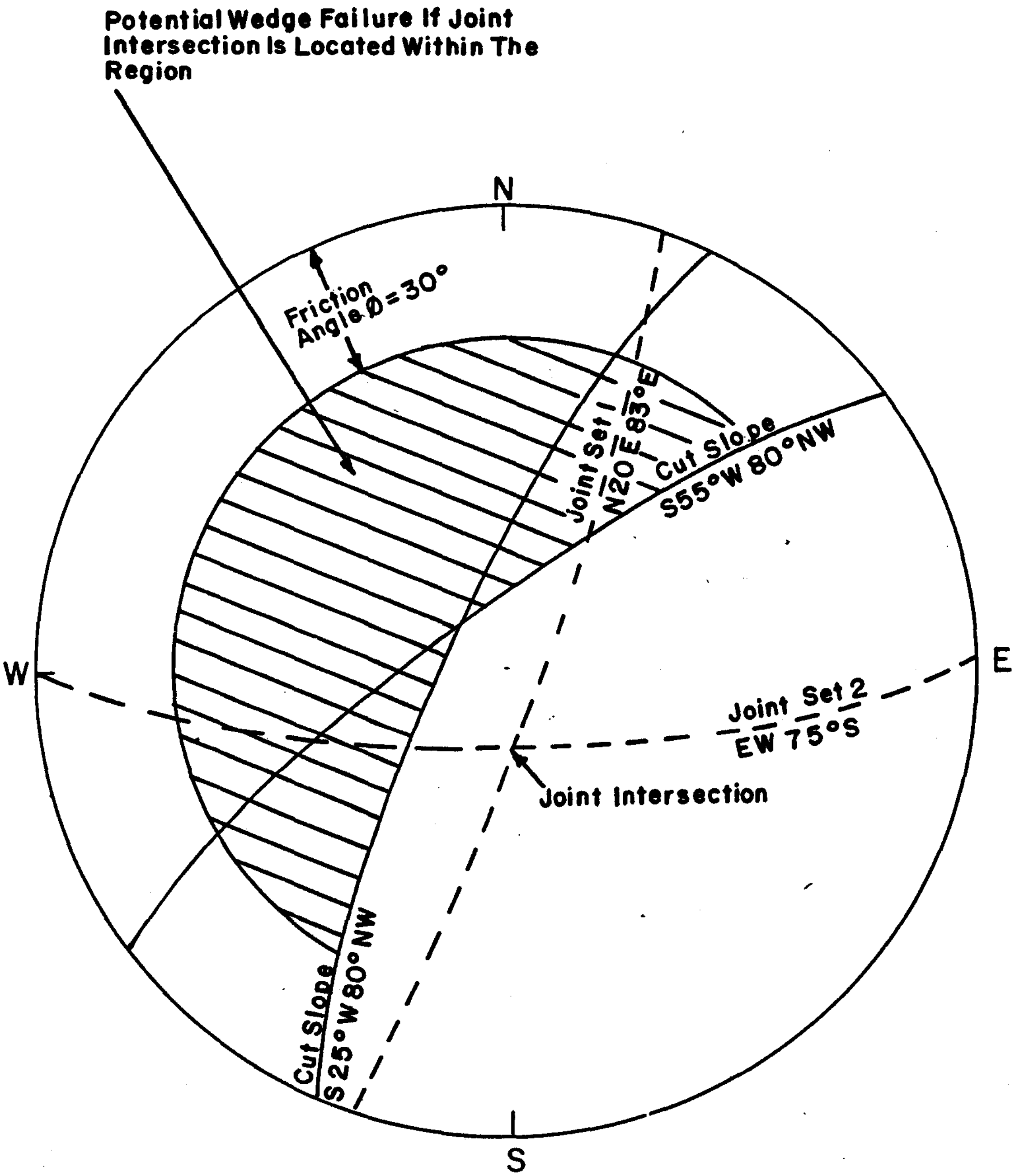


VALLEY CAMP OF UTAH , INC.

BELINA MINE

STEREOPLOT FOR PLANE SHEAR ANALYSIS FOR CUT SLOPE NEAR COAL LOADOUT CHUTE

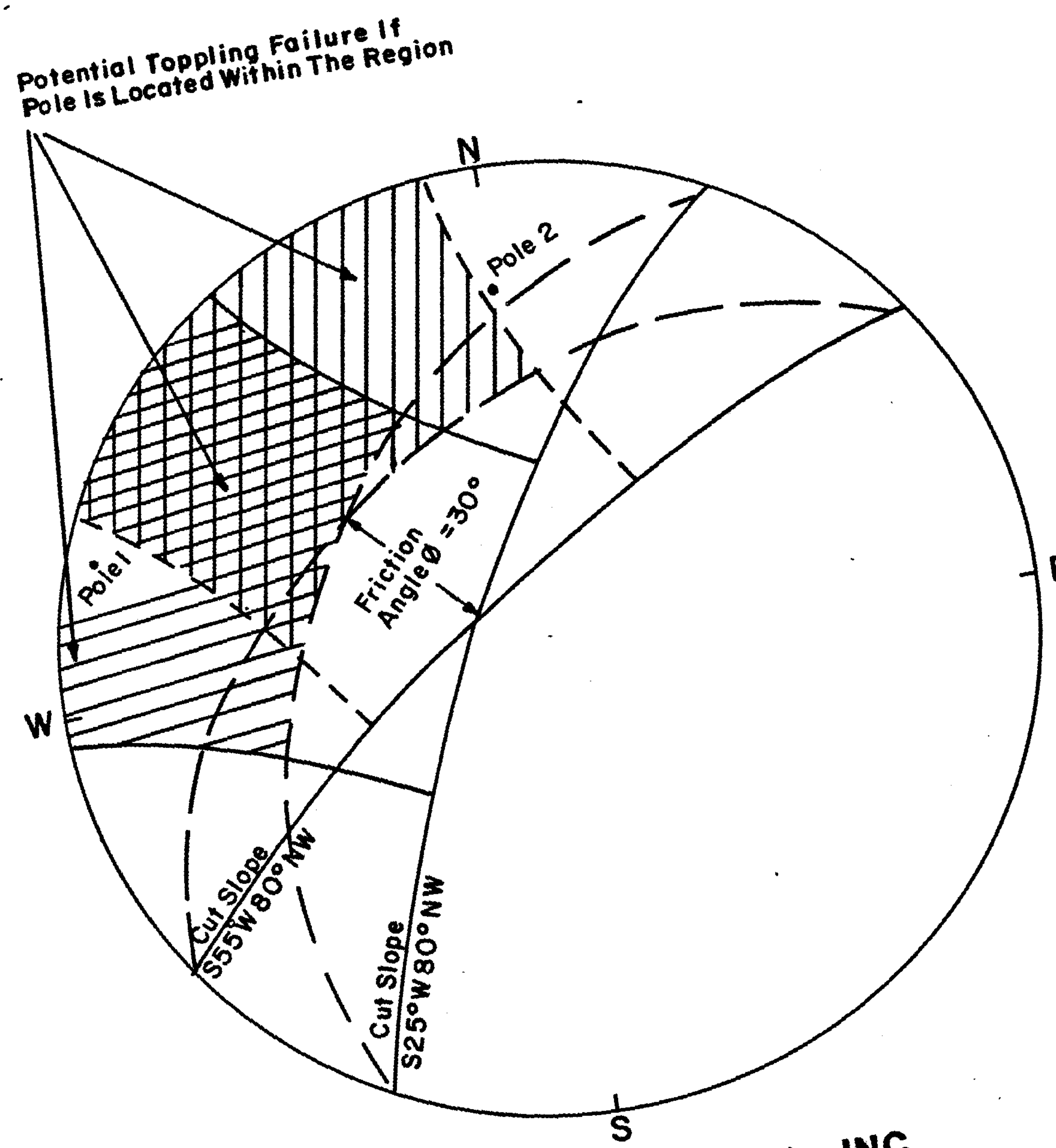
FIGURE 24



VALLEY CAMP OF UTAH , INC.
BELINA MINE

STEREOPLOT FOR WEDGE FAILURE ANALYSIS FOR CUT SLOPE NEAR COAL LOADOUT CHUTE

FIGURE 25



VALLEY CAMP OF UTAH , INC.
BELINA MINE

STEREOPLOT FOR POTENTIAL TOPPLING FAILURE FOR CUT SLOPE NEAR COAL LOADOUT CHUTE

FIGURE 26