SLOPE STABILITY ANALYSIS
ON
COAL REFUSE PILE
AT CASTLE GATE PREPARATION PLANT
PRICE RIVER COAL COMPANY

MARCH 1983

RECEIVED
APR 11 1983
DIVISION OF
OIL, GAS & MINING

REGISTERED PROFESSIONAL ENGINEER
No. 3535
HAROLD LEE
WIMMER
STATE OF UTAH

Prepared by [signature]
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Mine # C/007/004
File Incoming
Record #
Doc. Date
Recd. Date

SECTION I

At the request of Price River Coal Company, I reviewed the report prepared by Golder Associates dated January 18, 1978 regarding the design of the coal refuse disposal system, including the detailed design of the School House Canyon Refuse Dump facility. In particular I have reviewed the geometric considerations for the dump site, the material considerations, and comments relating to construction contained in said report.

SECTION II

CONSTRUCTION RECORDS

On January 28, 1983 I visited the site in conjunction with Rob Wiley, Environmental Engineer, and Frank Pero, of the Price River Coal Company, and reviewed in detail the provisions taken at the site during construction in accordance with the previously mentioned "Golder Report". I also reviewed with Mr. Pero (who was present during the construction), the construction records including construction pictures which enabled me to determine that the dump site was constructed in basic accordance with the plans to its present state.

In particular, large sandstone rocks from the diversion channel construction were bladed to the bottom of the existing canyon to provide for the draining of seepage waters from the refuse material.

SECTION III

MATERIAL TESTING

While at the site, using a Troxler 3411B nuclear density gauge, I determined the in-place density of the refuse material. I also obtained moisture density samples and samples of the refuse material, which I returned to the lab for additional testing. The results of these in-place determinations (attached in the Appendix) indicate that the average in-place density of the material varied from 84% to 110% of the laboratory obtained T-99 standard proctor.

When the coal refuse is thoroughly mixed and remolded the T-99 Proctor valve increases significantly due to additional breakdown of the "bedrock" characteristics of the material (see "Composite Coal Refuse Pile" T-99 Standard Proctor in Appendix).

I submitted a sample of the refuse material to Chen and Associates, a consulting soil and foundation engineering firm, to determine the relationship of the loading to the shear stress, and to determine the internal cohesion. These results are included in the Appendix. The material gradation results are also included in the Appendix. The gradation results indicate that the material is free draining, nonplastic, and falls within the gradation bands contained in the "Golder Report".

SECTION IV

OCCURRENCE OF GROUND WATER AND PORE PRESSURE BUILDUP

The results of the gradation analysis indicate that the material is free draining. This was further observed at the site through reviewing the existing material in place and by analizing the records kept on the ground water observation pipes in the refuse pile. The data (summarized) for the ground water observation records is contained in the Appendix.

Basically the records confirm that the material is free draining and no pore pressure build up is occurring. The maximum recorded depth of water (6') occurred during the wet portion of an above normal precipitation year.

SECTION V

FACTOR OF SAFETY

A computer model was constructed to analyze the stability of the refuse pile, and the following conditions were assumed.

1. Ground Water at six feet (the highest level recorded to date).
2. In-place densities of 90 pounds per cubic foot.
3. Geometric configuration to conform to the proposed site when completed.

A computer simulation was then applied to this situation to determine various failure planes. The "Method of Slices" is the basis for the modified Bishop method computer program. Various failure planes were investigated to determine a minimum factor of safety. The results of these computer runs and a copy of the computer listing is attached in the Appendix. The results of these computer simulations indicate that the minimum static factor of safety is 4.6, and the minimum factor of safety with a .1 g earthquake loading is 2.6.

SECTION VI

CONCLUSIONS

In conclusion the coal refuse disposal pile as now existing is:

1. Free draining.
2. The maximum water depth measured by monitoring has been six feet, and this occurred during an abnormal wet period of time. The monitoring wells show several inches of water or less during most of the year.
3. No movement of the refuse pile has been detected.
4. There is no water pore pressure buildup in the refuse pile.
5. The computer simulation on failure planes indicates that the factor of safety is at least 2.6 with a .1 g earthquake loading.

APPENDIX

PRICE RIVER COAL COMPANY

INTER-OFFICE MEMORANDUM

TO: R. L. Wiley DATE: 1-11-83

FROM: F. L. Pero C.C.:

SUBJECT: Refuse Pile Construction

Construction of this facility was begun in 1978 and completed in 1979. During this time close communication with the State Engineer's Office was maintained and the site was visited several times by representatives of that office.

The primary concerns of the regulators were the competency of the pond embankment and drainage of the pile itself. In an effort to allay these fears, the pond embankment was constructed with engineered backfill and tight contruction specifications were maintained.

The rock underdrain was constructed using material excavated from the diversion structure. The diversion was cut entirely in rock and runs parallel to the canyon floor for most of its length. The blasted rock was dozed into a blanket at least 4 ft. thick and is uniformly mixed rock ranging in size up to about 4 ft. There are larger pieces, but these occur only randomly. No less than 60% of the material is in the 2 ft. minus range, 25% is 2 ft. to 3 ft. range, 10% is 3 ft. to 4 ft. and no more than 5% is larger than about 5 ft. diameter. Also, a crushed rock underdrain was installed between the toe of the pond embankment and the trash rack inlet on the pond overflow ditch. This was designed to collect any ground water which might collect either at the abutments or beneath the pond embankment.

As mentioned before, very tight controls were exercised during the construction of this faility. This consisted partly of very comprehensive soil and compaction testing. Nuclear density tests were performed on every 6" compacted lift throughout the embankment height, with no less than 3 tests taken at random locations on every lift. Laboratory series tests were conducted several times during the construction to ensure that the correct proctor information was being used to determine in-place density. Copies of all test results were furnished to the State Engineer's Office.

Frank Pero

Frank L. Pero

FP:jp

TROXLER LABORATORIES

NUCLEAR RELATIVE COMPACTION TEST DATA

PROJECT

JOB NUMBER

DATE 1-28-83

TAKEN BY [illegible signature]

Price River Coal Co.
Schoolhouse Canyon Refuse Pile

TEST NUMBER	1	2	3	4	5	6	7	8	9	10
STATION										
OFFSET										
ELEVATION										
MODE & DEPTH	8"	12"	8"	12"	12"	12"				
DENSITY COUNT										
DENSITY COUNT RATIO										
WET DENSITY PCF										
AIR-GAP COUNT										
AIR-GAP RATIO										
AIR-GAP DENSITY										
MOISTURE COUNT										
MOISTURE COUNT RATIO										
MOISTURE PCF										
DRY DENSITY	72.3	76.4	79.8	82.6	81.6	78.3				
% MOISTURE										
MAX. OBTAINABLE DENSITY	74.4*	→	→	→	→	→				
OPTIMUM MOISTURE	5.9	→	→	→	→	→				
% RELATIVE COMPACTION	97.2	102.7	107.3	111.0	109.7	105.2				

STANDARD COUNT	
DENSITY	MOISTURE

REMARKS:
* T-99 standard Proctor

MATERIALS AND TESTS DIVISION

MOISTURE–DENSITY RELATIONS

PROJECT NAME Price River Coal Company DATE 2-14-83

PROJECT No. ______ SAMPLE No. 1 (COAL) Refuse Pile

METHOD OF COMPACTION T-99 PROCTOR

TEST NO.	1	2	3	4	5	6	7	8
CYL. & WET EARTH IN GRAMS	7859	7944	7979	7949	7929			
CYLINDER WT. IN GRAMS	5527	5527	5527	5527	5527			
WET EARTH IN GRAMS	2332	2417	2452	2422	2402			
WET DENSITY IN LBS/CU. FT.	68.5	71.0	72.1	71.2	70.6			
DISH NUMBER	108.3	101.7	107.4	181.2	180.8			
DISH & WET SOIL WT. IN GRAMS	396.0	430.6	466.1	690.2	657.4			
DISH & DRY SOIL WT. IN GRAMS	375.5	411.9	442.8	643.8	600.8			
WATER WT. IN GRAMS	20.5	18.7	23.3	46.4	56.6			
DISH & DRY SOIL WT. IN GRAMS	375.5	411.9	442.8	643.8	600.8			
DISH WT. IN GRAMS	108.0	101.1	107.2	180.6	180.0			
DRY SOIL WT. IN GRAMS	267.5	310.8	335.6	463.2	420.8			
MOISTURE IN % OF DRY WT.	4.8	6.0	6.9	10.0	13.5			
DRY DENSITY IN LBS./CU. FT.	65.4	67.0	67.4	64.7	62.2			

$$\text{DRY DENSITY} = \frac{\text{WET DENSITY}}{100 + \%\ \text{MOISTURE}} \times 100$$

TESTED BY: Mark W. Foster

____
MATERIALS ENGINEER

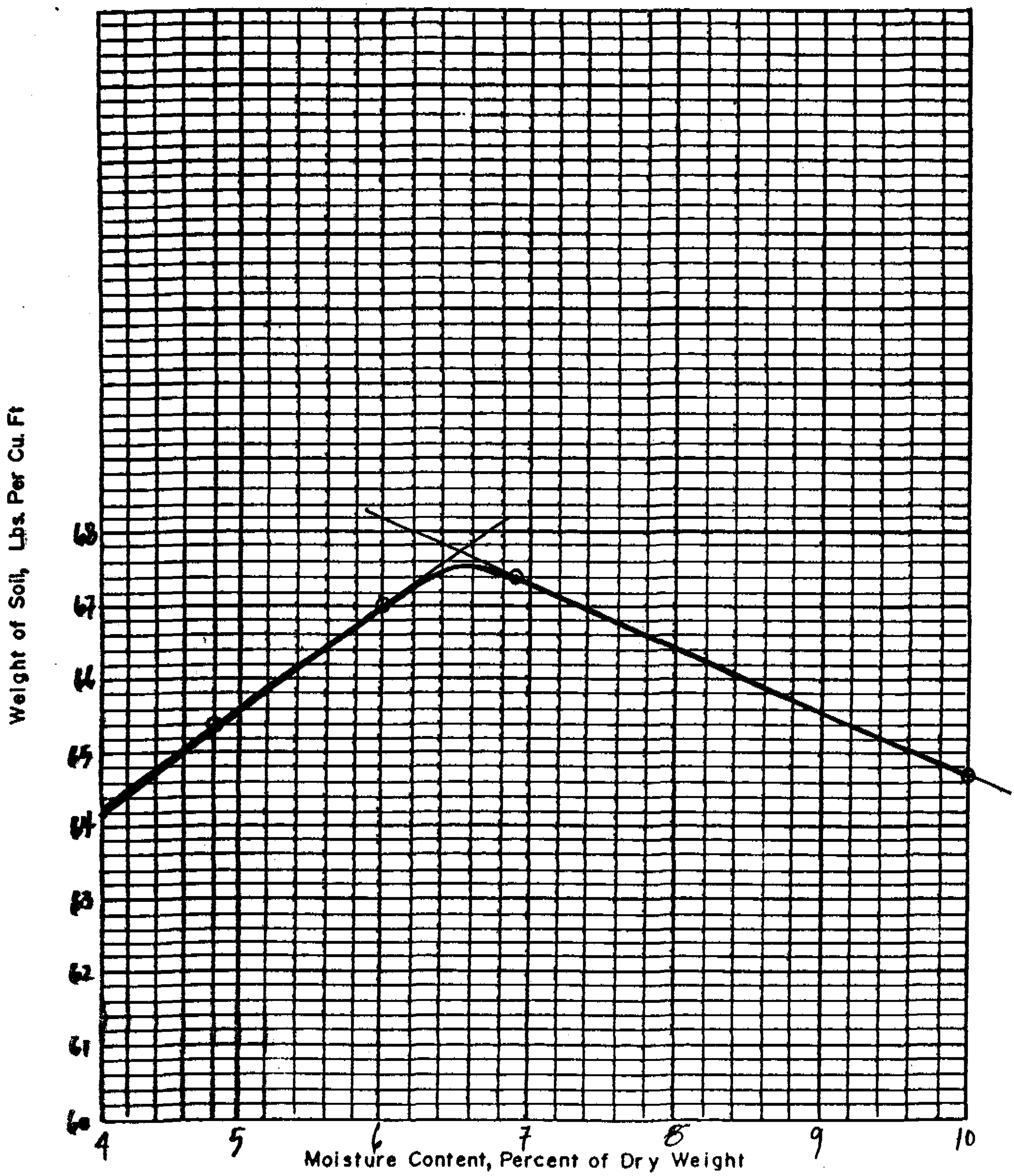
HORROCKS ENGINEERS

MOISTURE-DENSITY GRAPH

Project Name: Price River Coal- Refuse Pile Date: 2-13-83

Project No.: Sample No: 1 (COAL) Refuse pile

Method of Compaction: P.C.F.: 67.5 Optimum Moisture: 6.5%



HORROCKS ENGINEERS

Project Name: Price River Coal   Date: 2-13-83
Project No.: ______   Station or Pit Location: ______
Sample No: 1 (COAL) Refuse Pile   Requisted by: Lee Wimmer

AS RECEIVED GRADATION

Screen Size	Weight (g)	Percent Retained	Percent Passing	SPECS.
3"				
1½"	181.7	8.9	91.1	
1"	78.5	3.9	87.2	
3/4"	121.7	6.0	81.2	
1/2"	229.2	11.2	70.0	
3/8"	165.9	8.1	61.9	
#4	345.5	16.9	45.0	
Wet Wt. -#4				
Dry Wt. -#4				
Total Wt Dry				

WASHED GRADATION AFTER CRUSHING (2500 GM. DRY SAMPLE)

Screen Size	Weight Retained	Percent Retained	Percent Passing	Total % Passing	SPECS.
#8					
#10					
#16	331.6	16.3	28.7		
#20		L			
#30	100.7	4.9	23.8		
#40					
#50	101.8	5.0	18.8		
#100	86.5	4.2	14.6		
#200	38.9	1.9	12.7		
-#200	258.2	12.7	0.0		
Total Wt.	2040.2	100.0			

MOISTURE DETERMINATION

	-#4
Container & Wet Soil Weight (gm.)	110.86
Container & Dry Soil Weight (gm.)	102.81
H_2O Loss	8.05
% Moisture	10.00

A.A.S.H.O Classification: A-2-6 (4)

Wt. before washing 2042.9
Wt. after washing - 1784.7
-#200 from Wash: 243.4

COPIES TO:

Tested by ______

MATERIALS AND TESTS DIVISION

MOISTURE-DENSITY RELATIONS

PROJECT NAME PRICE RIVER COAL COMPANY DATE 2-21-83

PROJECT NO. ______ SAMPLE NO. 1 & 2 (COMPOSITE COAL) Refuse Pile

METHOD OF COMPACTION T-99 PROCTOR

TEST NO.	1	2	3	4	5	6	7	8
CYL. & WET EARTH IN GRAMS	9446	9616	9612	9572				
CYLINDER WT. IN GRAMS	5522	5522	5522	5522				
WET EARTH IN GRAMS	3924	4094	4090	4050				
WET DENSITY IN LBS/CU. FT.	115.3	120.3	120.2	119.0				
DISH NUMBER	101.7	137.0	5-G	4-G				
DISH & WET SOIL WT. IN GRAMS	444.9	404.3	337.4	321.4				
DISH & DRY SOIL WT. IN GRAMS	422.9	382.7	320.0	304.3				
WATER WT. IN GRAMS	22.0	21.6	17.4	17.1				
DISH & DRY SOIL WT. IN GRAMS	422.9	382.7	320.0	304.3				
DISH WT. IN GRAMS	100.1	131.7	138.4	140.0				
DRY SOIL WT. IN GRAMS	322.8	245.6	181.6	164.3				
MOISTURE IN % OF DRY WT.	6.8	8.8	9.6	10.4				
DRY DENSITY IN LBS/CU. FT.	108.0	110.6	109.7	107.8				

$$\text{DRY DENSITY} = \frac{\text{WET DENSITY}}{100 + \%\ \text{MOISTURE}} \times 100$$

TESTED BY: Mark W. Foster

MATERIALS ENGINEER

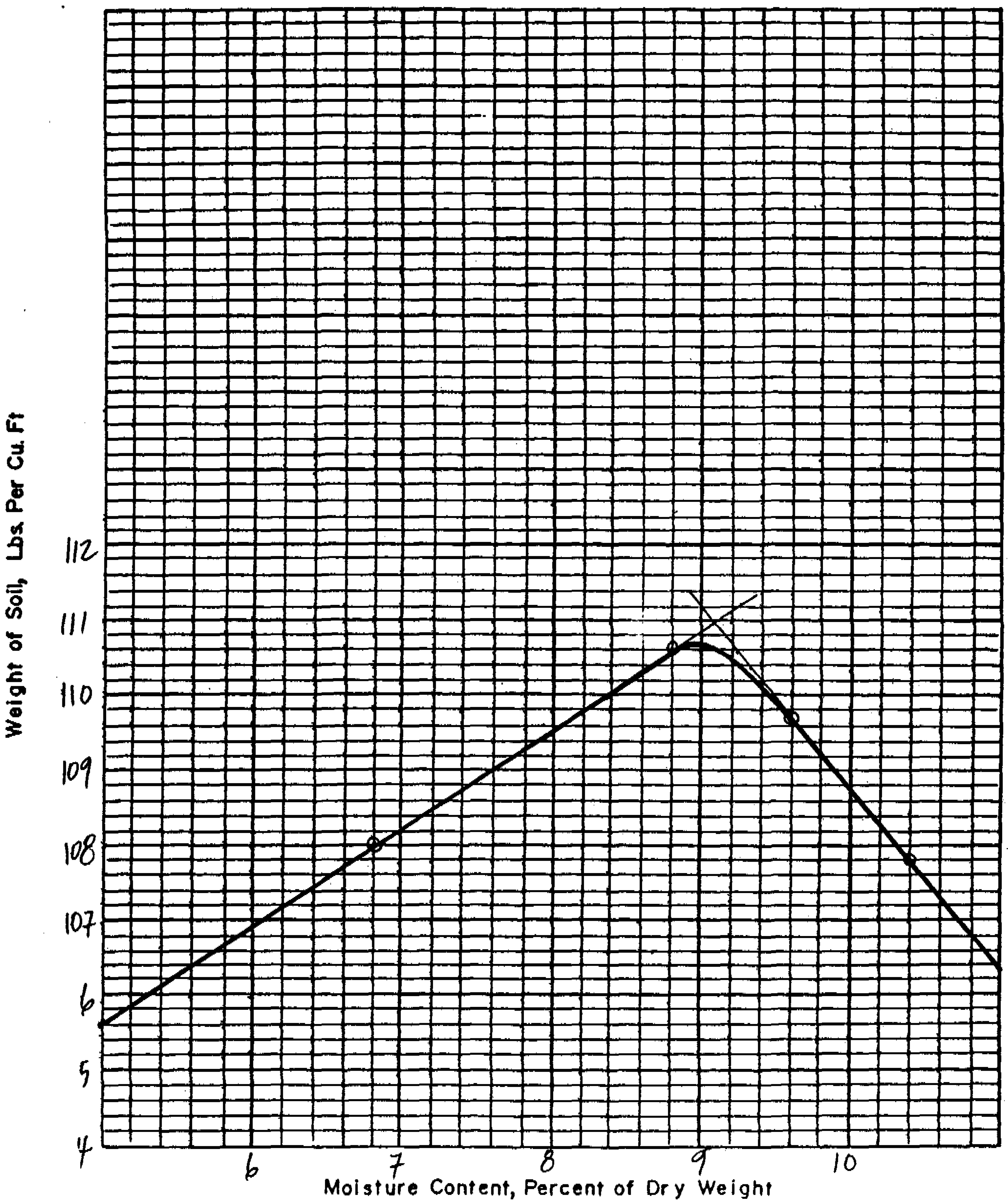
HORROCKS ENGINEERS

MOISTURE – DENSITY GRAPH

Project Name PRICE RIVER COAL COMPANY Date 2-21-83

Project No. ______ Sample No 1 & 2 (COMPOSITE COAL) Refuse

Method of Compaction T-99 PROCTOR P.C.F. 110.6 Optimum Moisture 9.0%



One West Main
P.O. Box 377
American Fork, Utah 84003
Telephone (801) 756-7628

LIQUID LIMIT AND PLASTICITY INDEX

PROJECT NAME Price River Coal Company DATE 2-13-83
PROJECT No. B104-81

SAMPLE No. 1 (COAL)

LIQUID LIMIT

CAN 5	WET 43.85	DRY 39.00		
TAPS 13	DRY 39.00	CAN 22.72		
	H_2O 4.85	DRY WT. 16.28	% H_2O 29.79 A	
CAN	WET	DRY		LL A 27.5
TAPS	DRY	CAN		LL B
	H_2O	DRY WT.	% H_2O B	LL C
CAN	WET	DRY		3) (27.5 L.L.
TAPS	DRY	CAN		17.3 P.L.
	H_2O	DRY WT.	% H_2O C	44.8 P.I.

PLASTIC LIMIT

CAN 10	WET 36.77	DRY 34.64	
	DRY 34.64	CAN 22.34	
	H_2O 2.13	DRY WT. 12.3	PL 17.32 (% H_2O)

SAMPLE No. 2 (COAL)

LIQUID LIMIT

CAN 12	WET 51.84	DRY 46.53		
TAPS 26	DRY 46.53	CAN 22.63		
	H_2O 5.31	DRY WT. 23.90	% H_2O 22.20 A	
CAN XX	WET 45.12	DRY 40.90		LL A 20.37
TAPS 24	DRY 40.90	CAN 22.33		LL B 22.61
	H_2O 4.22	DRY WT. 18.57	% H_2O 22.72 B	LL C 22.76
CAN C	WET 31.77	DRY 28.42		3) (21.9 L.L.
TAPS 14	DRY 28.42	CAN 14.72		14.9 P.L.
	H_2O 3.35	DRY WT. 13.70	% H_2O 24.45 C	36.8 P.I.

PLASTIC LIMIT

CAN B	WET 23.96	DRY 22.77	
	DRY 22.77	CAN 14.77	
	H_2O 1.19	DRY WT. 8.00	PL 14.88 (% H_2O)

SAMPLE No. 3 (SILTY SAND)

LIQUID LIMIT

CAN 2	WET 51.71	DRY 48.42		
TAPS 13	DRY 48.42	CAN 22.17		
	H_2O 3.29	DRY WT. 26.25	% H_2O 12.53 A	
CAN	WET	DRY		LL A 11.6
TAPS	DRY	CAN		LL B
	H_2O	DRY WT.	% H_2O B	LL C
CAN	WET	DRY		3) (11.6 L.L.
TAPS	DRY	CAN		18.4 P.L.
	H_2O	DRY WT.	% H_2O C	30.0 P.I.

PLASTIC LIMIT

CAN X	WET 41.15	DRY 39.54	
	DRY 39.54	CAN 30.80	
	H_2O 1.61	DRY WT. 8.74	PL 18.42 (% H_2O)

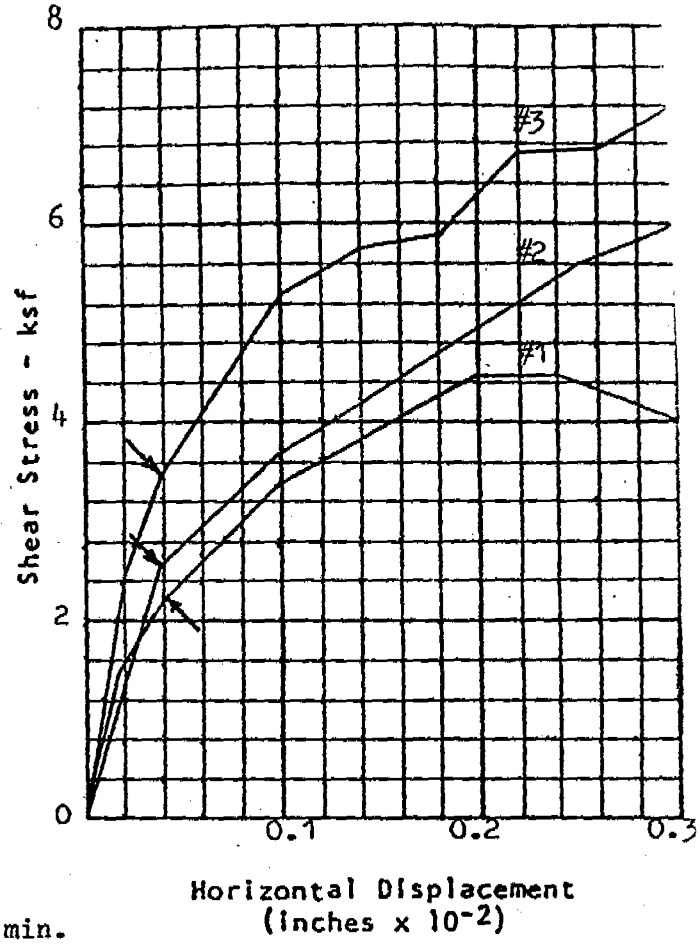
NO. OF TAPS	CORRECT FACTOR
16	0.947
17	0.95
18	0.961
19	0.967
20	0.973
21	0.979
22	0.985
23	0.990
24	0.995
25	1.00
26	1.00
27	1.00
28	1.01
29	1.01
30	1.02
31	1.02
32	1.03
33	1.03
34	1.03
35	1.04
36	1.04

TESTED BY: Mark W. Foster

CHEN AND ASSOCIATES

Consulting Soil and Foundation Engineers

TEST NUMBER	1	2	3	4
LOCATION	SAMPLE #2			
HEIGHT-INCH	1.00	1.00	1.00	
DIAMETER-INCH	1.93	1.93	1.93	
WATER CONTENT - %	12.7	13.4	13.3	
DRY DENSITY - pcf	98.3	93.4	95.1	
CONSOL. LOAD - ksf	---	---	---	
NORMAL LOAD - ksf	1.5	3.0	4.5	
SHEAR STRESS - ksf	2.3	2.6	3.5	



TYPE OF SPECIMEN Remolded

SOIL DESCRIPTION Coal Refuge

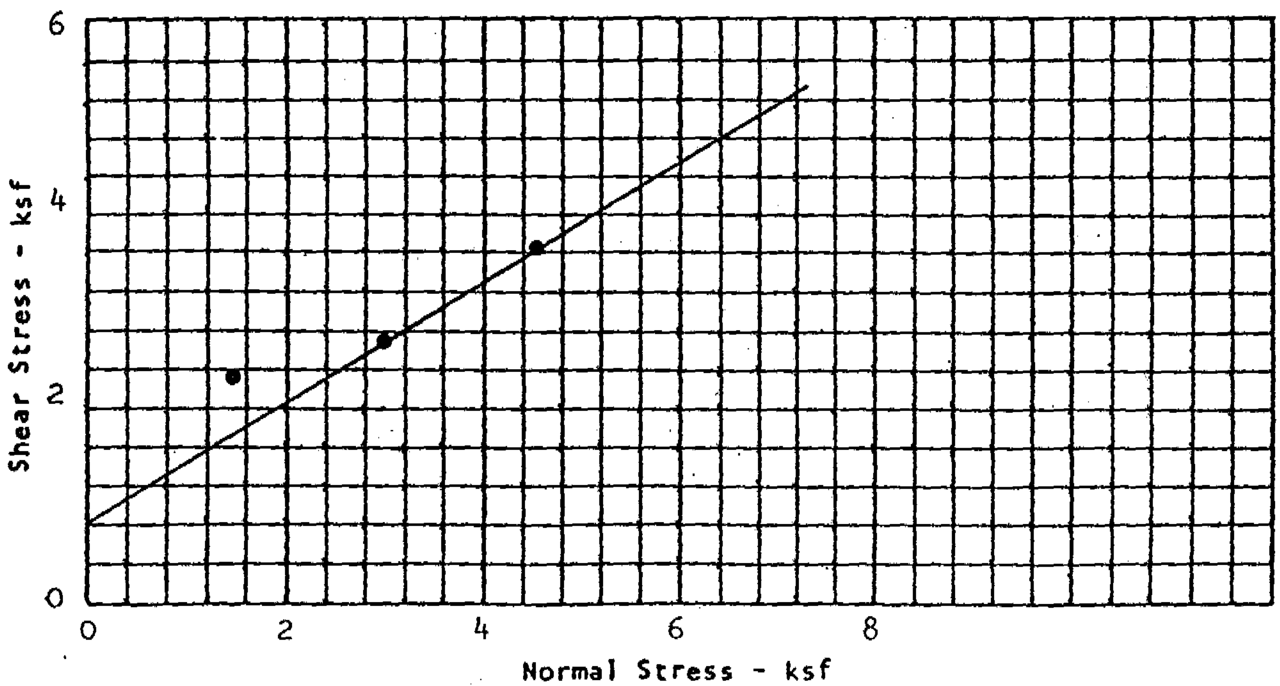
Non-plastic, -200=23%

TYPE OF TEST Quick

Strain rate 0.04 inches per min.

0.04 inches per min.

TAN Ø	0.60
Ø	31°
COHESION - ksf	0.8

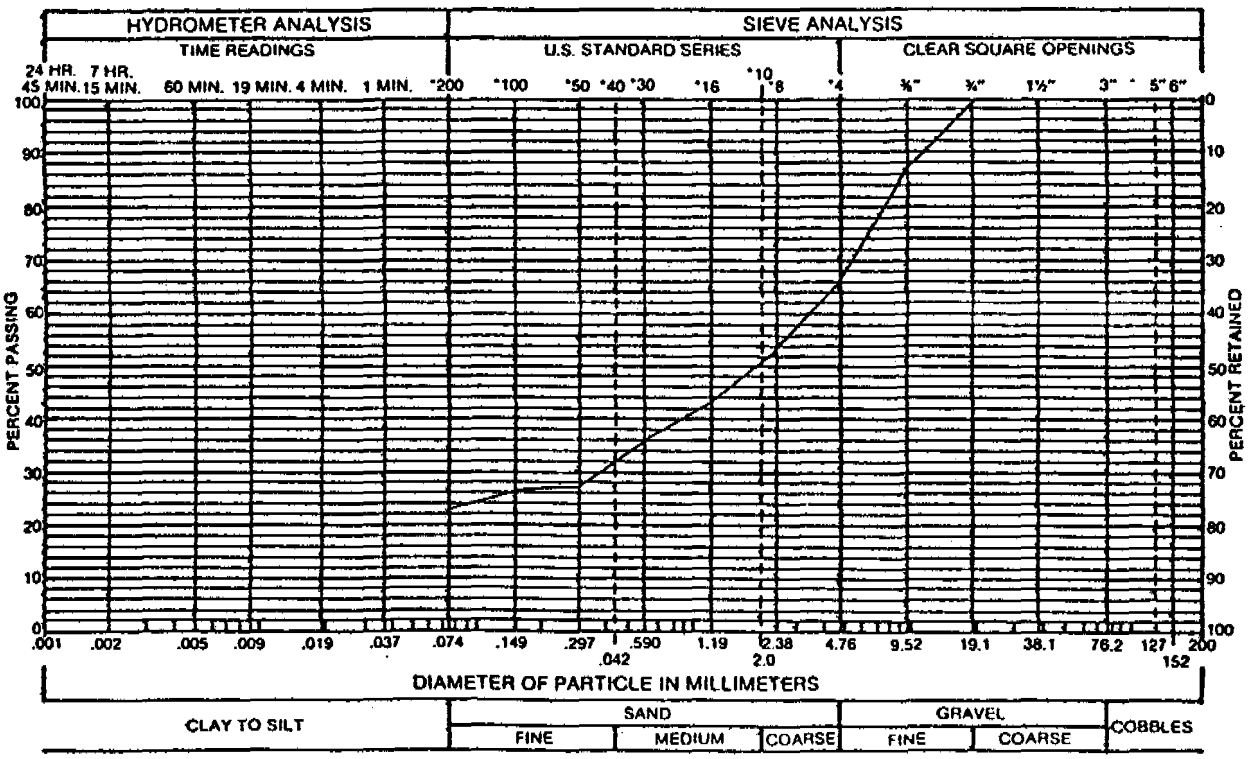


#498U

DIRECT SHEAR TEST RESULTS

Fig. 2

chen and associates, inc.



GRAVEL 34 % SAND 43 % SILT AND CLAY 23 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Coal Refuge FROM Sample #2

#498U GRADATION TEST RESULTS Fig. 3

MATERIALS AND TESTS DIVISION

MOISTURE–DENSITY RELATIONS

PROJECT NAME Price River Coal Company DATE 2-14-83

PROJECT NO. ______ SAMPLE NO. 2 (COAL) Refuse Pile

METHOD OF COMPACTION T-99 PROCTOR

TEST NO.	1	2	3	4	5	6	7	8
CYL. & WET EARTH IN GRAMS	8164	8204	8207	8209	8164			
CYLINDER WT. IN GRAMS	5527	5527	5527	5527	5527			
WET EARTH IN GRAMS	2637	2677	2680	2682	2637			
WET DENSITY IN LBS/CU. FT.	77.5	78.7	78.8	78.8	77.5			
DISH NUMBER	B	C	A	137.0	D			
DISH & WET SOIL WT. IN GRAMS	304.8	273.9	255.0	500.0	336.2			
DISH & DRY SOIL WT. IN GRAMS	292.5	261.3	243.1	475.7	319.3			
WATER WT. IN GRAMS	12.3	12.6	11.9	24.3	16.9			
DISH & DRY SOIL WT. IN GRAMS	292.5	261.3	243.1	475.7	319.3			
DISH WT. IN GRAMS	45.7	44.5	46.9	137.1	134.8			
DRY SOIL WT. IN GRAMS	246.8	216.8	196.2	338.6	184.5			
MOISTURE IN % OF DRY WT.	5.0	5.8	6.1	7.2	9.2			
DRY DENSITY IN LBS./CU. FT.	73.8	74.4	74.2	73.5	71.0			

$$\text{DRY DENSITY} = \frac{\text{WET DENSITY}}{100 + \%\ \text{MOISTURE}} \times 100$$

TESTED BY: Mark W. Foster

MATERIALS ENGINEER

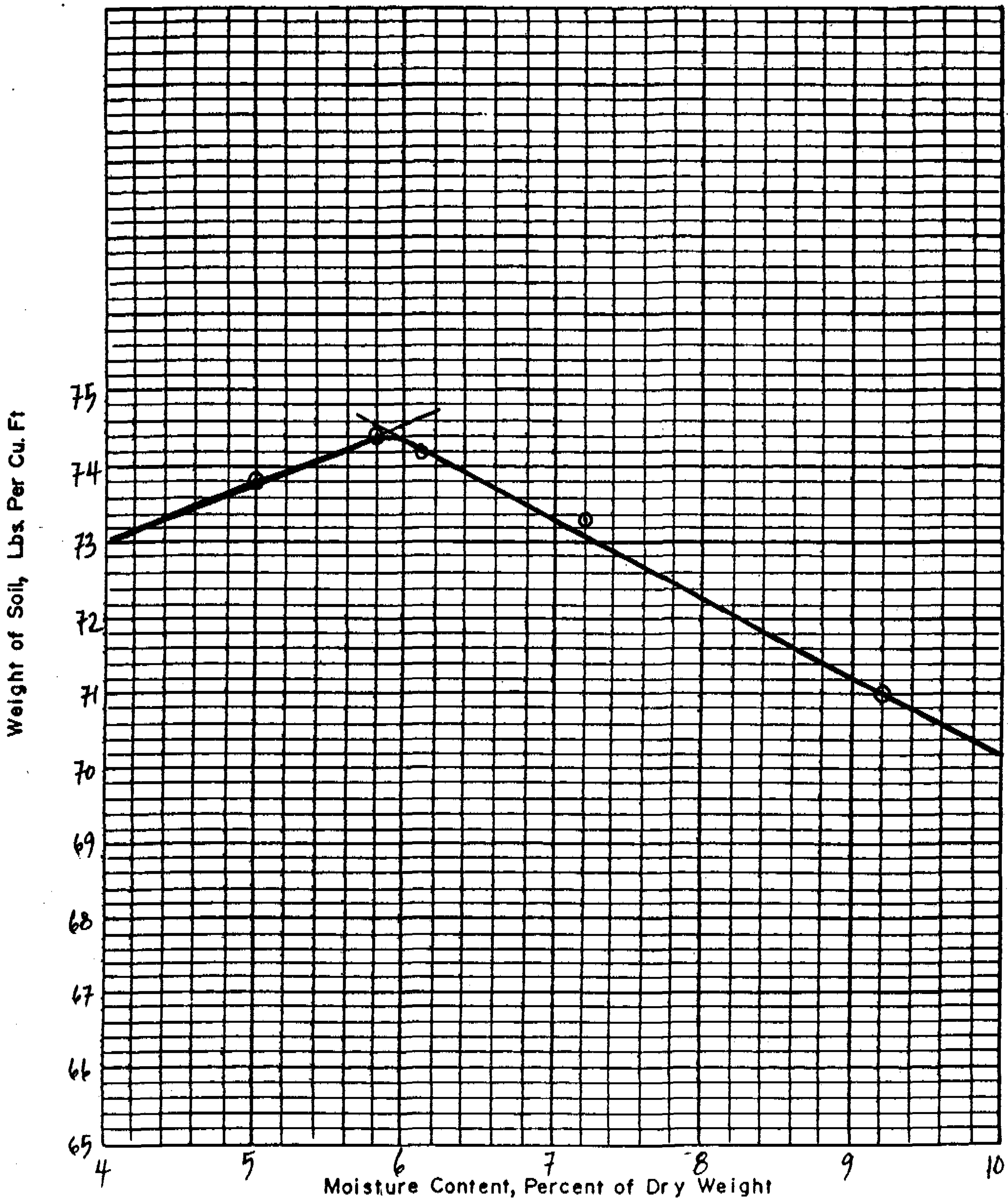
HORROCKS ENGINEERS

MOISTURE – DENSITY GRAPH

Project Name *Price River Coal - Refuse Pile* Date *2-13-83*

Project No. ______ Sample No *2 (COAL) Refuse Pile*

Method of Compaction ______ P.C.F. *74.4* Optimum Moisture *5.9 %*



HORROCKS ENGINEERS

Project Name: Price River Coal Date: 2-13-83
Project No.: Station or Pit Location:
Sample No: 2 (COAL) Refuse Pile Requisted by: Lee Wimmer

AS RECEIVED GRADATION

Screen Size	Weight (a)	Percent Retained	Percent Passing	SPECS.
3"				
1 1/2"	134.8	6.7	93.3	
1"	172.6	8.6	84.7	
3/4"	64.0	3.2	81.5	
1/2"	161.6	8.0	73.5	
3/8"	78.7	3.9	69.6	
#4	241.5	12.0	57.6	
Wet Wt. -#4				
Dry Wt. -#4				
Total Wt. Dry				

WASHED GRADATION AFTER CRUSHING (2500 GM. DRY SAMPLE)

Screen Size	Weight Retained	Percent Retained	Percent Passing	Total % Passing	SPECS.
#8					
#10					
#16	469.4	23.4	34.2		
#20					
#30	179.0	8.9	25.3		
#40					
#50	120.5	6.0	19.3		
#100	116.0	5.8	13.5		
#200	36.3	1.8	11.7		
-#200	235.9	11.7	0.0		
Total Wt.	2010.3	100.0			

MOISTURE DETERMINATION

	-#4
Container & Wet Soil Weight (gm.)	103.11
Container & Dry Soil Weight (gm.)	98.05
H_2O Loss	5.06
% Moisture	7.49

A.A.S.H.O Classification: A-2-6 (4)

Wt. before washing 2016.1
Wt. after washing 1799.9
-#200 from wash: 216.2

COPIES TO:

Tested by: Mark W. Foster

PRICE RIVER COAL COMPANY
SCHOOLHOUSE CANYON REFUSE DUMP
GROUNDWATER PIEZOMETER DATA SUMMARY

Date	OBSERVATION STATION NUMBER				
	#10	#11	#12	#13	#14
10-21-80	T	D	T	T	T
11-04-80	T	T	T	1"	T
12-02-80	T	T	T	2"	T
1-06-81	T	D	T	1"	T
2-02-81	T	T	T	1"	T
3-03-81	D	D	T	T	T
4-08-81	1"	T	1"	2"	T
5-06-81	T	D	T	1"	T
6-02-81	D	D	D	D	D
7-07-81	D	D	D	D	D
8-13-81	D	D	T	T	D
8-08-81	D	D	T	T	D
9-08-81	D	D	T	T	D
10-08-81	T	T	1"	2"	T
11-09-81	D	D	D	T	D
12-10-81	T	T	D	T	T
1-13-82	D	D	T	2"	T
2-11-82	D	D	T	8"	D
2-25-82	D	D	T	1'	T
3-03-82	D	D	2"	3'	D
3-12-82	D	D	18"	5'	D
3-18-82	D	D	2'	6'	T

D = Dry
T = Trace

HORROCKS ENGINEERS

3/16/83

SLOPE STABILITY ANALYSIS

for

PRICE RIVER COAL - SLOPE STABILITY

DATA FILE: "PRSLOP"

PROJECT NUMBER: 8301-28e

by: BMP

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1280.0	6322.0	100.0	98.39

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	16.5	2.9	800	1.9	5.0	31	1285.1
2	44.8	4.0	800	1.9	13.7	31	1287.0
3	66.9	5.1	800	1.9	20.5	31	1288.8
4	82.8	6.2	800	1.9	25.4	31	1290.7
5	92.5	7.3	800	1.9	28.4	31	1292.6
6	95.9	8.4	800	1.9	29.4	31	1294.5
7	93.0	9.5	800	1.9	28.5	31	1296.4
8	83.8	10.6	800	1.9	25.7	31	1298.3
9	68.0	11.7	800	1.9	20.9	31	1300.2
10	45.8	12.8	800	1.9	14.0	31	1302.1
11	16.9	13.9	800	1.9	5.2	31	1304.0

ITERATION	INITIAL	CALCULATED
1	1.0000	90.5289
2	90.5289	98.3824
3	98.3824	98.3901
4	98.3901	98.3901

FACTOR OF SAFETY= 98.39 AT X= 1280 Y= 6322 R= 100
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1300.0	6320.0	100.0	10.99

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	494.3	-8.9	800	5.9	151.6	31	1284.5
2	1342.5	-5.5	800	5.9	411.7	31	1290.4
3	2006.8	-2.2	800	5.9	615.4	31	1296.2
4	2489.4	1.2	800	5.9	763.4	31	1302.1
5	2790.5	4.6	800	5.9	855.7	31	1308.0
6	2908.5	7.9	800	5.9	891.9	31	1313.8
7	2839.8	11.4	800	5.9	870.9	31	1319.7
8	2578.6	14.8	800	5.9	790.8	31	1325.5
9	2116.7	18.3	800	5.9	649.1	31	1331.4
10	1442.8	21.9	800	5.9	442.5	31	1337.3
11	541.7	25.6	800	5.9	166.1	31	1343.1

ITERATION	INITIAL	CALCULATED
1	1.0000	10.2658
2	10.2658	10.9826
3	10.9826	10.9888
4	10.9888	10.9889

FACTOR OF SAFETY= 10.99 AT X= 1300 Y= 6320 R= 100
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1415.0	6340.0	100.0	22.90

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	152.8	-3.2	800	4.0	46.8	31	1409.4
2	415.6	-1.0	800	4.0	127.4	31	1413.3
3	621.6	1.3	800	4.0	190.6	31	1417.3
4	770.8	3.6	800	4.0	236.4	31	1421.3
5	862.9	5.9	800	4.0	264.6	31	1425.3
6	897.3	8.2	800	4.0	275.2	31	1429.3
7	873.2	10.5	800	4.0	267.8	31	1433.2
8	789.4	12.8	800	4.0	242.1	31	1437.2
9	644.3	15.2	800	4.0	197.6	31	1441.2
10	436.1	17.6	800	4.0	133.7	31	1445.2
11	162.3	20.0	800	4.0	49.8	31	1449.2

ITERATION	INITIAL	CALCULATED
1	1.0000	21.1985
2	21.1985	22.8931
3	22.8931	22.9003
4	22.9003	22.9003

FACTOR OF SAFETY= 22.90 AT X= 1415 Y= 6340 R= 100
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1286.0	6372.0	150.0	28.42

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	133.4	-.1	800	4.4	40.9	31	1285.8
2	362.9	1.6	800	4.4	111.3	31	1290.2
3	542.7	3.3	800	4.4	166.4	31	1294.6
4	672.6	4.9	800	4.4	206.3	31	1298.9
5	752.2	6.6	800	4.4	230.7	31	1303.3
6	781.1	8.3	800	4.4	239.5	31	1307.6
7	758.7	10.0	800	4.4	232.7	31	1312.0
8	684.4	11.7	800	4.4	209.9	31	1316.4
9	557.1	13.4	800	4.4	170.8	31	1320.7
10	375.8	15.1	800	4.4	115.3	31	1325.1
11	139.4	16.8	800	4.4	42.7	31	1329.4

ITERATION	INITIAL	CALCULATED
1	1.0000	26.2362
2	26.2362	28.4098
3	28.4098	28.4172
4	28.4172	28.4172

FACTOR OF SAFETY= 28.42 AT X= 1286 Y= 6372 R= 150
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1367.0	6350.0	150.0	2.60

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	9915.2	-28.1	800	17.4	3040.7	31	1296.5
2	26369.4	-20.8	800	17.4	8086.6	31	1313.9
3	38905.4	-13.8	800	17.4	11931.0	31	1331.4
4	47950.4	-7.0	800	17.4	14704.8	31	1348.8
5	53726.9	-.3	800	17.4	16476.3	31	1366.3
6	56307.5	6.4	800	17.4	17267.6	31	1383.7
7	55630.7	13.2	800	17.4	17060.1	31	1401.2
8	51488.2	20.2	800	17.4	15789.7	31	1418.6
9	43472.9	27.5	800	17.4	13331.7	31	1436.1
10	30857.9	35.3	800	17.4	9463.1	31	1453.5
11	12294.6	44.0	800	17.4	3770.3	31	1470.9

ITERATION	INITIAL	CALCULATED
1	1.0000	2.5673
2	2.5673	2.5976
3	2.5976	2.5982

FACTOR OF SAFETY= 2.60 AT X= 1367 Y= 6350 R= 150
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1372.0	6382.0	150.0	12.59

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	478.8	-4.6	800	6.7	146.8	31	1359.9
2	1302.2	-2.1	800	6.7	399.4	31	1366.6
3	1947.8	.5	800	6.7	597.3	31	1373.3
4	2415.7	3.0	800	6.7	740.8	31	1379.9
5	2705.4	5.6	800	6.7	829.7	31	1386.6
6	2815.0	8.1	800	6.7	863.3	31	1393.2
7	2741.6	10.7	800	6.7	840.7	31	1399.9
8	2480.9	13.3	800	6.7	760.8	31	1406.6
9	2027.6	16.0	800	6.7	621.8	31	1413.2
10	1374.4	18.6	800	6.7	421.5	31	1419.9
11	512.6	21.3	800	6.7	157.2	31	1426.6

ITERATION	INITIAL	CALCULATED
1	1.0000	11.7019
2	11.7019	12.5822
3	12.5822	12.5888
4	12.5888	12.5889

FACTOR OF SAFETY= 12.59 AT X= 1372 Y= 6382 R= 150
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1330.0	6412.0	200.0	3.78

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	4446.4	-14.4	800	15.2	1363.6	31	1280.3
2	12036.6	-9.9	800	15.2	3691.2	31	1295.5
3	17957.9	-5.5	800	15.2	5507.1	31	1310.8
4	22262.1	-1.1	800	15.2	6827.1	31	1326.0
5	24970.8	3.2	800	15.2	7657.7	31	1341.2
6	26077.4	7.6	800	15.2	7997.1	31	1356.5
7	25546.2	12.0	800	15.2	7834.2	31	1371.7
8	23309.8	16.6	800	15.2	7148.3	31	1387.0
9	19261.6	21.2	800	15.2	5906.9	31	1402.2
10	13244.6	25.9	800	15.2	4061.7	31	1417.4
11	5030.3	30.9	800	15.2	1542.6	31	1432.7

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6088
2	3.6088	3.7789
3	3.7789	3.7827

FACTOR OF SAFETY= 3.78 AT X= 1330 Y= 6412 R= 200
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1337.0	6428.0	200.0	14.32

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	447.9	-2.1	800	7.2	137.4	31	1329.7
2	1218.6	-.0	800	7.2	373.7	31	1336.9
3	1822.6	2.0	800	7.2	558.9	31	1344.1
4	2259.7	4.1	800	7.2	693.0	31	1351.3
5	2528.9	6.2	800	7.2	775.5	31	1358.5
6	2628.5	8.2	800	7.2	806.1	31	1365.6
7	2556.1	10.3	800	7.2	783.9	31	1372.8
8	2308.8	12.4	800	7.2	708.0	31	1380.0
9	1882.6	14.5	800	7.2	577.3	31	1387.2
10	1272.6	16.7	800	7.2	390.3	31	1394.4
11	473.0	18.8	800	7.2	145.1	31	1401.5

ITERATION	INITIAL	CALCULATED
1	1.0000	13.2787
2	13.2787	14.3157
3	14.3157	14.3226
4	14.3226	14.3227

FACTOR OF SAFETY= 14.32 AT X= 1337 Y= 6428 R= 200
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1272.0	6472.0	250.0	55.12

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	62.6	3.7	800	4.0	19.2	31	1288.3
2	170.2	4.7	800	4.0	52.2	31	1292.3
3	254.3	5.6	800	4.0	78.0	31	1296.3
4	314.7	6.5	800	4.0	96.5	31	1300.4
5	351.5	7.4	800	4.0	107.8	31	1304.4
6	364.3	8.4	800	4.0	111.7	31	1308.4
7	353.2	9.3	800	4.0	108.3	31	1312.4
8	317.8	10.2	800	4.0	97.4	31	1316.4
9	257.9	11.2	800	4.0	79.1	31	1320.4
10	173.5	12.1	800	4.0	53.2	31	1324.4
11	64.1	13.1	800	4.0	19.7	31	1328.5

ITERATION	INITIAL	CALCULATED
1	1.0000	50.7365
2	50.7365	55.1092
3	55.1092	55.1169
4	55.1169	55.1169

FACTOR OF SAFETY= 55.12 AT X= 1272 Y= 6472 R= 250
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1304.0	6470.0	250.0	7.91

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	1307.1	-4.5	800	11.0	400.8	31	1284.2
2	3555.0	-2.0	800	11.0	1090.2	31	1295.3
3	5317.3	.5	800	11.0	1630.6	31	1306.3
4	6594.8	3.1	800	11.0	2022.4	31	1317.3
5	7385.4	5.6	800	11.0	2264.9	31	1328.4
6	7684.3	8.1	800	11.0	2356.5	31	1339.4
7	7483.5	10.7	800	11.0	2294.9	31	1350.5
8	6771.7	13.3	800	11.0	2076.6	31	1361.5
9	5533.8	15.9	800	11.0	1697.0	31	1372.5
10	3750.8	18.6	800	11.0	1150.3	31	1383.6
11	1398.6	21.3	800	11.0	428.9	31	1394.6

ITERATION	INITIAL	CALCULATED
1	1.0000	7.3820
2	7.3820	7.9035
3	7.9035	7.9097
4	7.9097	7.9098

FACTOR OF SAFETY= 7.91 AT X= 1304 Y= 6470 R= 250
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1280.0	6322.0	100.0	165.20

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	16.5	2.9	800	1.9	5.0	31	1285.1
2	44.8	4.0	800	1.9	13.7	31	1287.0
3	66.9	5.1	800	1.9	20.5	31	1288.8
4	82.8	6.2	800	1.9	25.4	31	1290.7
5	92.5	7.3	800	1.9	28.4	31	1292.6
6	95.9	8.4	800	1.9	29.4	31	1294.5
7	93.0	9.5	800	1.9	28.5	31	1296.4
8	83.8	10.6	800	1.9	25.7	31	1298.3
9	68.0	11.7	800	1.9	20.9	31	1300.2
10	45.8	12.8	800	1.9	14.0	31	1302.1
11	16.9	13.9	800	1.9	5.2	31	1304.0

ITERATION	INITIAL	CALCULATED
1	1.0000	151.9435
2	151.9435	165.1905
3	165.1905	165.1982
4	165.1982	165.1983

FACTOR OF SAFETY= 165.20 AT X= 1280 Y= 6322 R= 100
EARTHQUAKE= 0.00

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1300.0	6320.0	100.0	18.65

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	494.3	-8.9	800	5.9	151.6	31	1284.5
2	1342.5	-5.5	800	5.9	411.7	31	1290.4
3	2006.8	-2.2	800	5.9	615.4	31	1296.2
4	2489.4	1.2	800	5.9	763.4	31	1302.1
5	2790.5	4.6	800	5.9	855.7	31	1308.0
6	2908.5	7.9	800	5.9	891.9	31	1313.8
7	2839.8	11.4	800	5.9	870.9	31	1319.7
8	2578.6	14.8	800	5.9	790.8	31	1325.5
9	2116.7	18.3	800	5.9	649.1	31	1331.4
10	1442.8	21.9	800	5.9	442.5	31	1337.3
11	541.7	25.6	800	5.9	166.1	31	1343.1

ITERATION	INITIAL	CALCULATED
1	1.0000	17.3680
2	17.3680	18.6469
3	18.6469	18.6536
4	18.6536	18.6536

FACTOR OF SAFETY= 18.65 AT X= 1300 Y= 6320 R= 100
EARTHQUAKE= 0.00

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1415.0	6340.0	100.0	38.62

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	152.8	-3.2	800	4.0	46.8	31	1409.4
2	415.6	-1.0	800	4.0	127.4	31	1413.3
3	621.6	1.3	800	4.0	190.6	31	1417.3
4	770.8	3.6	800	4.0	236.4	31	1421.3
5	862.9	5.9	800	4.0	264.6	31	1425.3
6	897.3	8.2	800	4.0	275.2	31	1429.3
7	873.2	10.5	800	4.0	267.8	31	1433.2
8	789.4	12.8	800	4.0	242.1	31	1437.2
9	644.3	15.2	800	4.0	197.6	31	1441.2
10	436.1	17.6	800	4.0	133.7	31	1445.2
11	162.3	20.0	800	4.0	49.8	31	1449.2

ITERATION	INITIAL	CALCULATED
1	1.0000	35.6891
2	35.6891	38.6083
3	38.6083	38.6157
4	38.6157	38.6157

FACTOR OF SAFETY= 38.62 AT X= 1415 Y= 6340 R= 100
EARTHQUAKE= 0.00

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1286.0	6372.0	150.0	47.81

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	133.4	-.1	800	4.4	40.9	31	1285.8
2	362.9	1.6	800	4.4	111.3	31	1290.2
3	542.7	3.3	800	4.4	166.4	31	1294.6
4	672.6	4.9	800	4.4	206.3	31	1298.9
5	752.2	6.6	800	4.4	230.7	31	1303.3
6	781.1	8.3	800	4.4	239.5	31	1307.6
7	758.7	10.0	800	4.4	232.7	31	1312.0
8	684.4	11.7	800	4.4	209.9	31	1316.4
9	557.1	13.4	800	4.4	170.8	31	1320.7
10	375.8	15.1	800	4.4	115.3	31	1325.1
11	139.4	16.8	800	4.4	42.7	31	1329.4

ITERATION	INITIAL	CALCULATED
1	1.0000	44.0878
2	44.0878	47.8061
3	47.8061	47.8136
4	47.8136	47.8136

FACTOR OF SAFETY= 47.81 AT X= 1286 Y= 6372 R= 150
EARTHQUAKE= 0.00

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1367.0	6350.0	150.0	4.60

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	9915.2	-28.1	800	17.4	3040.7	31	1296.5
2	26369.4	-20.8	800	17.4	8086.6	31	1313.9
3	38905.4	-13.8	800	17.4	11931.0	31	1331.4
4	47950.4	-7.0	800	17.4	14704.8	31	1348.8
5	53726.9	-.3	800	17.4	16476.3	31	1366.3
6	56307.5	6.4	800	17.4	17267.6	31	1383.7
7	55630.7	13.2	800	17.4	17060.1	31	1401.2
8	51488.2	20.2	800	17.4	15789.7	31	1418.6
9	43472.9	27.5	800	17.4	13331.7	31	1436.1
10	30857.9	35.3	800	17.4	9463.1	31	1453.5
11	12294.6	44.0	800	17.4	3770.3	31	1470.9

ITERATION	INITIAL	CALCULATED
1	1.0000	4.4918
2	4.4918	4.5940
3	4.5940	4.5957

FACTOR OF SAFETY= 4.60 AT X= 1367 Y= 6350 R= 150
EARTHQUAKE= 0.00

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1330.0	6412.0	200.0	6.50

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	4446.4	-14.4	800	15.2	1363.6	31	1280.3
2	12036.6	-9.9	800	15.2	3691.2	31	1295.5
3	17957.9	-5.5	800	15.2	5507.1	31	1310.8
4	22262.1	-1.1	800	15.2	6827.1	31	1326.0
5	24970.8	3.2	800	15.2	7657.7	31	1341.2
6	26077.4	7.6	800	15.2	7997.1	31	1356.5
7	25546.2	12.0	800	15.2	7834.2	31	1371.7
8	23309.8	16.6	800	15.2	7148.3	31	1387.0
9	19261.6	21.2	800	15.2	5906.9	31	1402.2
10	13244.6	25.9	800	15.2	4061.7	31	1417.4
11	5030.3	30.9	800	15.2	1542.6	31	1432.7

ITERATION	INITIAL	CALCULATED
1	1.0000	6.1468
2	6.1468	6.4977
3	6.4977	6.5026

FACTOR OF SAFETY= 6.50 AT X= 1330 Y= 6412 R= 200
EARTHQUAKE= 0.00

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1337.0	6428.0	200.0	24.16

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	447.9	-2.1	800	7.2	137.4	31	1329.7
2	1218.6	-.0	800	7.2	373.7	31	1336.9
3	1822.6	2.0	800	7.2	558.9	31	1344.1
4	2259.7	4.1	800	7.2	693.0	31	1351.3
5	2528.9	6.2	800	7.2	775.5	31	1358.5
6	2628.5	8.2	800	7.2	806.1	31	1365.6
7	2556.1	10.3	800	7.2	783.9	31	1372.8
8	2308.8	12.4	800	7.2	708.0	31	1380.0
9	1882.6	14.5	800	7.2	577.3	31	1387.2
10	1272.6	16.7	800	7.2	390.3	31	1394.4
11	473.0	18.8	800	7.2	145.1	31	1401.5

ITERATION	INITIAL	CALCULATED
1	1.0000	22.3388
2	22.3388	24.1488
3	24.1488	24.1561
4	24.1561	24.1561

FACTOR OF SAFETY= 24.16 AT X= 1337 Y= 6428 R= 200
EARTHQUAKE= 0.00

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1272.0	6472.0	250.0	92.55

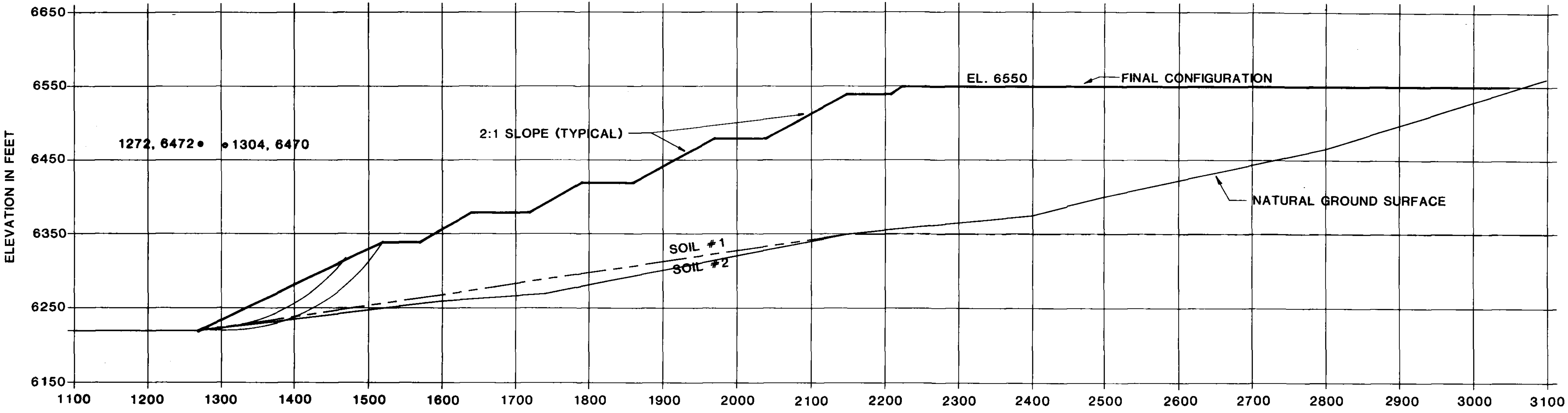
SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	62.6	3.7	800	4.0	19.2	31	1288.3
2	170.2	4.7	800	4.0	52.2	31	1292.3
3	254.3	5.6	800	4.0	78.0	31	1296.3
4	314.7	6.5	800	4.0	96.5	31	1300.4
5	351.5	7.4	800	4.0	107.8	31	1304.4
6	364.3	8.4	800	4.0	111.7	31	1308.4
7	353.2	9.3	800	4.0	108.3	31	1312.4
8	317.8	10.2	800	4.0	97.4	31	1316.4
9	257.9	11.2	800	4.0	79.1	31	1320.4
10	173.5	12.1	800	4.0	53.2	31	1324.4
11	64.1	13.1	800	4.0	19.7	31	1328.5

ITERATION	INITIAL	CALCULATED
1	1.0000	85.1348
2	85.1348	92.5376
3	92.5376	92.5454
4	92.5454	92.5454

FACTOR OF SAFETY= 92.55 AT X= 1272 Y= 6472 R= 250
EARTHQUAKE= 0.00

SCHOOLHOUSE CANYON REFUSE FACILITY

LONGITUDINAL SECTION THROUGH DUMP



RADIUS : 250'

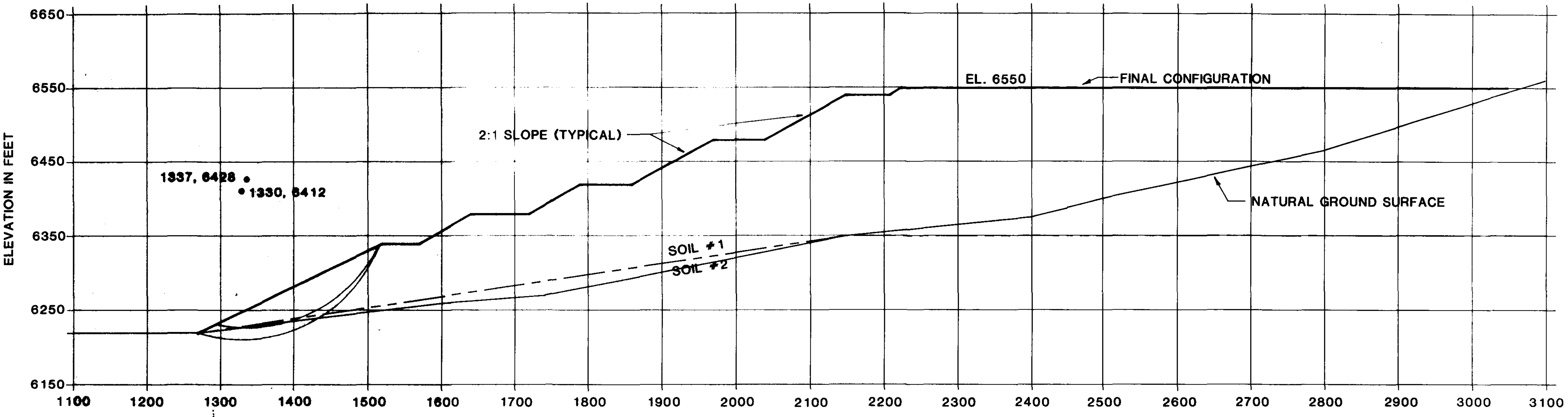
PRICE RIVER COAL COMPANY

SCALE 1":100'

HORROCKS ENGINEERS

SCHOOLHOUSE CANYON REFUSE FACILITY

LONGITUDINAL SECTION THROUGH DUMP



RADIUS : 200'

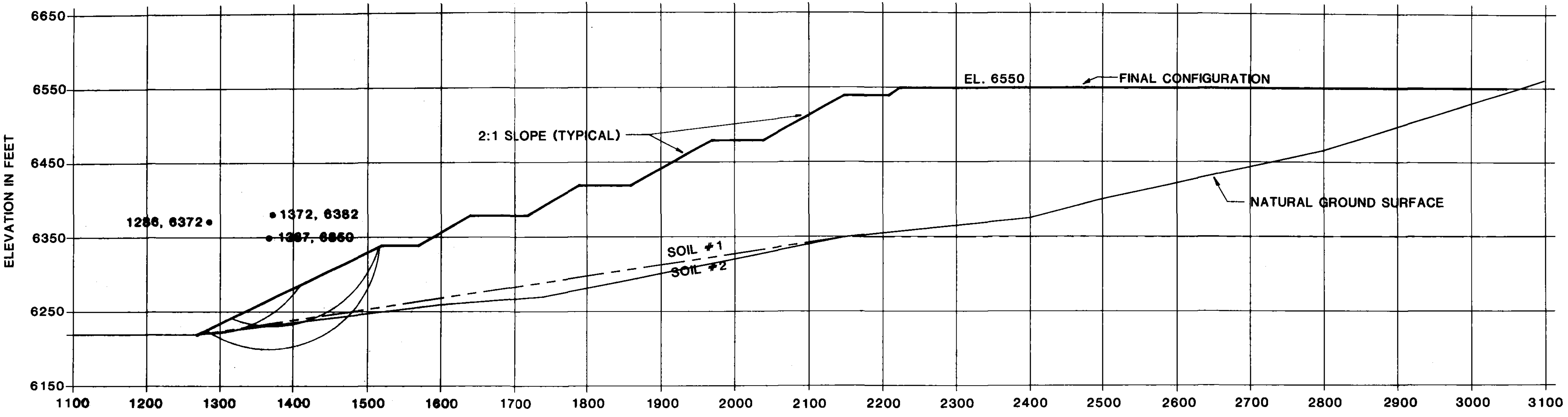
PRICE RIVER COAL COMPANY

SCALE 1":100'

HORROCKS ENGINEERS

SCHOOLHOUSE CANYON REFUSE FACILITY

LONGITUDINAL SECTION THROUGH DUMP



RADIUS : 150'

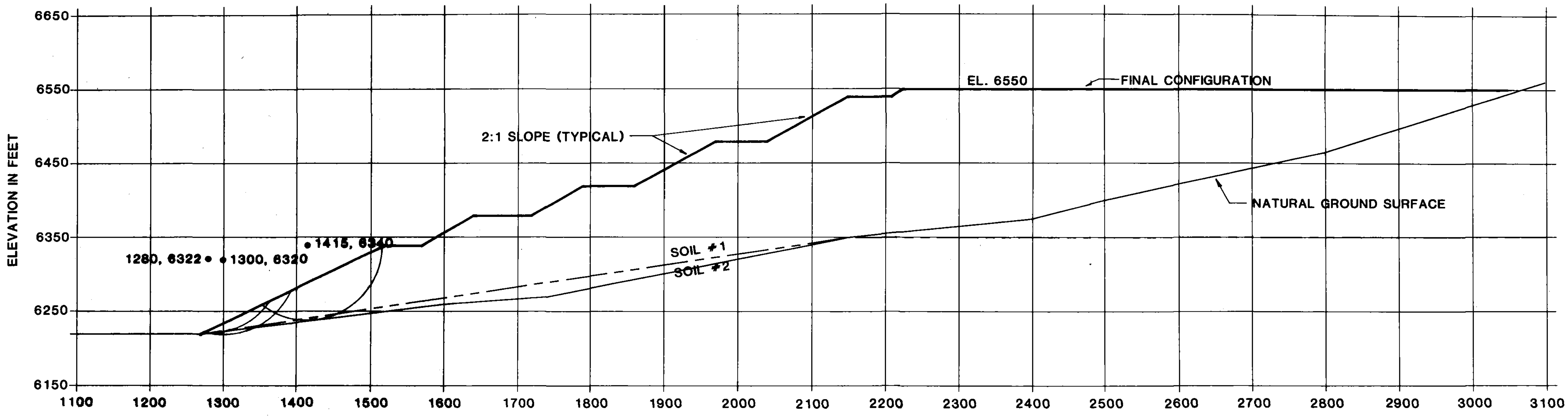
PRICE RIVER COAL COMPANY

SCALE 1":100'

HORROCKS ENGINEERS

SCHOOLHOUSE CANYON REFUSE FACILITY

LONGITUDINAL SECTION THROUGH DUMP



RADIUS : 100'

PRICE RIVER COAL COMPANY

SCALE 1":100'

HORROCKS ENGINEERS

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	6220.00
2	1270.00	6220.00
3	1520.00	6340.00
4	1570.00	6340.00
5	1640.00	6380.00
6	1720.00	6380.00
7	1790.00	6420.00
8	1860.00	6420.00
9	1970.00	6480.00
10	2040.00	6480.00
11	2150.00	6540.00
12	2210.00	6540.00
13	2225.00	6550.00
14	3050.00	6550.00
15	3100.00	6560.00
16	2150.00	6350.00
17	3100.00	6350.00

LINE	LEFT	RIGHT	SOIL
1	13	14	1
2	1	2	2
3	2	16	2
4	16	17	2

SOIL	UNIT WEIGHT	COHESION	Ø	SATURATED
1	90	800	31	NO
2	90	800	31	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	1304.0	6470.0	250.0	13.39

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	Ø	X
1	1307.1	-4.5	800	11.0	400.8	31	1284.2
2	3555.0	-2.0	800	11.0	1090.2	31	1295.3
3	5317.3	.5	800	11.0	1630.6	31	1306.3
4	6594.8	3.1	800	11.0	2022.4	31	1317.3
5	7385.4	5.6	800	11.0	2264.9	31	1328.4
6	7684.3	8.1	800	11.0	2356.5	31	1339.4
7	7483.5	10.7	800	11.0	2294.9	31	1350.5
8	6771.7	13.3	800	11.0	2076.6	31	1361.5
9	5533.8	15.9	800	11.0	1697.0	31	1372.5
10	3750.8	18.6	800	11.0	1150.3	31	1383.6
11	1398.6	21.3	800	11.0	428.9	31	1394.6

ITERATION	INITIAL	CALCULATED
1	1.0000	12.4399
2	12.4399	13.3835
3	13.3835	13.3903
4	13.3903	13.3903

FACTOR OF SAFETY= 13.39 AT X= 1304 Y= 6470 R= 250
EARTHQUAKE= 0.00

DATA FILE `PRSLOP´

```
5000  DATA PRICE RIVER COAL - SLOPE STABILITY ! FILE "PRSLOP"
5010  DATA 0,62.4,.1
5040  DATA 17,0,6220,1270,6220,1520,6340,1570,6340,1640,6380,1720,6380,1790,6420
5050  DATA 1860,6420,1970,6480,2040,6480,2150,6540,2210,6540,2225,6550,3050,6550
5060  DATA 3100,6560,2150,6350,3100,6350
5070  DATA 4,13,14,1,1,2,2,2,16,2,16,17,2
5080  DATA 2,90,800,31,1,90,800,31,0
```

"SLOPE"

A slope stability program utilizing the simplified or "modified Bishop" method.

The program was written by John P. Cross, P.E., Processing Manager of STS Consultants, Northbrook, Illinois. This program was printed in the October 1982 issue of "CIVIL ENGINEERING."

This version was copied from "CIVIL ENGINEERING" and edited for the Hewlett-Packard 9845 desk-top computer by Horrocks Engineers in March 1983. The format for the input and the output was changed from the original version, however, the program itself was not changed.

HORROCKS ENGINEERS
ONE WEST MAIN STREET
AMERICAN FORK, UTAH 83003
TELEPHONE (801)756-7628

```
42    OPTION BASE 1
44    OVERLAP
46    PRINTER IS 16
48    PRINT "SLOPE STABILITY ANALYSIS"
50    DIM P(50,2),L(50,3),S2(5,4),A(50),F(50,7),Z(50,4),H$[80],Sbit$(0:1)[3]
52    INTEGER Logo(2)
54    Sbit$(1)=" NO"
56    Sbit$(0)="YES"
58    S9=10
60    J6=0
62    OUTPUT 5;"R"
64    ENTER 5;M,D,Time$
66    Date$=VAL$(M)&"/"&VAL$(D)&"/83"
68    PRINTER IS 0
70    PRINT "",LIN(4),TAB(80-LEN(Date$));Date$,LIN(0);
72    GOSUB Logo    ! PRINT HORROCKS ENGINEERS' LOGO
74    PRINT LIN(5),TAB(28),"SLOPE STABILITY ANALYSIS",LIN(2),TAB(38),"for",LIN(2
);
```

*** INPUT OF PROGRAM VARIABLES ***

```
78    INPUT "ENTER THE DATA FILE NAME",File$
79    INPUT "ENTER THE PROJECT NUMBER",Pn$
82    INPUT "ENTER THE USER'S INITIALS",User$
186   LINK File$,5000
190   READ H$
191   PRINT TAB(40-LEN(H$)/2);H$
195   PRINT LIN(30),TAB(30),"DATA FILE: "&CHR$(34)&File$&CHR$(34),LIN(1)
200   PRINT TAB(25),"PROJECT NUMBER: "&Pn$,LIN(1)
201   PRINT TAB(37),"by: "&User$
203   PRINTER IS 16
210   READ S0
211   IF S0=0 THEN 270
230   READ S6
250   READ S7
270   READ W0
290   READ E1
310   READ P1
311   PRINTER IS 16
315   PRINT "POINT     X-ORD      Y-ORD"
320   FOR I=1 TO P1
331     PRINT SPA(2),I;
```

```
332     IMAGE 3X,2(7D.3D,2X)
350     READ P(I,1),P(I,2)
371     PRINT USING 332;P(I,1),P(I,2)
380   NEXT I
400   READ L1
401   PRINT LIN(1),"LINE    FROM      TO    SOIL BENEATH"
402   IMAGE 3X,2(4D,3X),2X,2D
410   FOR I=1 TO L1
421     PRINT I;
440     READ L(I,1),L(I,2),L(I,3)
480     PRINT USING 402;L(I,1),L(I,2),L(I,3)
490   NEXT I
510   READ S1
511   PRINT LIN(1),"SOIL   UNIT WEIGHT  COHESION    "&CHR$(210)&"   SATURATION"
512   IMAGE 3X,4D.DD,2X,9D,3X,3D,3X,3A
520   FOR I=1 TO S1
531     PRINT I;
550     READ S2(I,1),S2(I,2),S2(I,3),S2(I,4)
610     PRINT USING 512;S2(I,1),S2(I,2),S2(I,3),Sbit$(S2(I,4))
620   NEXT I
```

*** CIRCLE DEFINITION ***

```
640   F9=0
641   PRINTER IS 16
650   PRINT "CIRCLE DEFINITION"
660   INPUT "ENTER THE X-ORD, Y-ORD, AND RADIUS OF THE FAIL SURFACE  FORMAT X,Y,
R ",X,Y,R
```

*** CHECK TO SEE IF CIRCLE EXCEEDS TOP LINE END POINTS ***

```
730   U1=P1
740   FOR I=2 TO P1
750     IF (P(I,1)<P(I-1,1)) AND (U1=P1) THEN 770
760     GOTO 780
770     U1=I-1
780   NEXT I
790   J1=R*R-(P(1,2)-Y)^2
800   J2=R*R-(P(U1,2)-Y)^2
810   IF J1<=0 THEN 830
820   IF (J1>0) AND (P(1,1)>X-SQR(J1)) THEN 860
830   IF J2<=0 THEN 850
840   IF (J2>0) AND (P(U1,1)<X+SQR(J2)) THEN 860
850   GOTO 880
860   DISP "CIRCLE EXCEEDS TOP LINE END POINTS";
870   GOTO 4380
```

*** DEFINE INTERSECTION OF CIRCLE WITH LINES ***

```
890   FOR I=1 TO L1
900     X1=P(L(I,1),1)
910     Y1=P(L(I,1),2)
920     X2=P(L(I,2),1)
930     Y2=P(L(I,2),2)
940     IF X2=X1 THEN 960
950     GOTO 970
960     S=9.99E10
970     IF X2<>X1 THEN 990
980     GOTO 1000
990     S=(Y2-Y1)/(X2-X1)
1000    IF ABS(S)<1.0E-5 THEN 1150
```

```
1010    C1=X1-Y1/S
1020    C2=1/S^2+1
1030    C3=2*C1/S-2*X/S-2*Y
1040    C4=C1^2-2*X*C1+X^2+Y^2-R^2
1050    C5=C3^2-4*C2*C4
1060    IF C5<0 THEN 1080
1070    GOTO 1090
1080    Z(I,1)=0
1090    IF C5<0 THEN 1630
1100    Q1=(-C3+SQR(C5))/(2*C2)
1110    Q2=(-C3-SQR(C5))/(2*C2)
1120    Q3=Q1/S+C1
1130    Q4=Q2/S+C1
1140    GOTO 1240
1150    C5=R^2-(Y-Y1)^2
1160    IF C5<0 THEN 1180
1170    GOTO 1190
1180    Z(I,1)=0
1190    IF C5<0 THEN 1630
1200    Q3=X+SQR(C5)
1210    Q4=X-SQR(C5)
1220    Q1=Y1
1230    Q2=Y1
1240    J1=0
1250    J2=0
1260    IF (ABS(S)<=9.99E9) AND (Q3>=X1) AND (Q3<=X2) THEN 1280
1270    GOTO 1290
1280    J1=1
1290    IF (ABS(S)<=9.99E9) AND (Q4>=X1) AND (Q4<=X2) THEN 1310
1300    GOTO 1320
1310    J2=1
1320    IF (S<-9.99E9) AND (Q1>=Y2) AND (Q1<=Y1) THEN 1340
1330    GOTO 1350
1340    J1=1
1350    IF (S<-9.99E9) AND (Q2>=Y2) AND (Q2<=Y1) THEN 1370
1360    GOTO 1380
1370    J2=1
1380    IF (S>9.99E9) AND (Q1>=Y1) AND (Q1<=Y2) THEN 1400
1390    GOTO 1410
1400    J1=1
1410    IF (S>9.99E9) AND (Q2>=Y1) AND (Q2<=Y2) THEN 1430
1420    GOTO 1440
1430    J2=1
1440    Z(I,1)=J1+J2
1450    IF J1=1 THEN 1470
1460    GOTO 1480
1470    Z(I,2)=Q3
1480    IF J1=1 THEN 1500
1490    GOTO 1510
1500    Z(I,3)=Q1
1510    IF (J1=0) AND (J2=1) THEN 1530
1520    GOTO 1540
1530    Z(I,2)=Q4
1540    IF (J1=0) AND (J2=1) THEN 1560
1550    GOTO 1570
1560    Z(I,3)=Q2
1570    IF (J1=1) AND (J2=1) THEN 1590
1580    GOTO 1600
1590    Z(I,4)=Q4
1600    IF (J1=1) AND (J2=1) THEN 1620
1610    GOTO 1630
1620    Z(I,3)=Q2
1630  NEXT I
1640  X4=0
1650  X5=9.99E20
1660  I1=1
1670  FOR I=1 TO L1
```

```
1680     IF Z(I,1)>=1 THEN 1700
1690     GOTO 1710
1700     A(I1)=Z(I,2)
1710     IF Z(I,1)>=1 THEN 1730
1720     GOTO 1740
1730     I1=I1+1
1740     IF Z(I,1)=2 THEN 1760
1750     GOTO 1770
1760     A(I1)=Z(I,4)
1770     IF Z(I,1)=2 THEN 1790
1780     GOTO 1800
1790     I1=I1+1
1800   NEXT I
1810   IF I1=1 THEN 1830
1820   GOTO 1840
1830   PRINT "CIRCLE DOES NOT INTERSECT SLOPE"
1840   IF I1=1 THEN 4380


*** SET UP SLICE ARRAY ***

1860   FOR I=1 TO I1-1
1870     IF A(I)>X4 THEN 1890
1880     GOTO 1900
1890     X4=A(I)
1900     IF A(I)<X5 THEN 1920
1910     GOTO 1930
1920     X5=A(I)
1930   NEXT I
1940   FOR I=1 TO P1
1950     IF (P(I,1)<X4) AND (P(I,1)>X5) THEN 1970
1960     GOTO 1980
1970     A(I1)=P(I,1)
1980     IF (P(I,1)<X4) AND (P(I,1)>X5) THEN 2000
1990     GOTO 2010
2000     I1=I1+1
2010   NEXT I
2020   I1=I1-1
2030   FOR I=1 TO I1
2040     FOR J=1 TO I1-1
2050       IF A(J+1)>A(J) THEN 2090
2060       J1=A(J+1)
2070       A(J+1)=A(J)
2080       A(J)=J1
2090     NEXT J
2100   NEXT I
2110   U1=0
2120   FOR I=1 TO I1-1
2130     IF A(I)<A(I+1) THEN 2150
2140     GOTO 2160
2150     U1=U1+1
2160     IF A(I)<A(I+1) THEN 2180
2170     GOTO 2190
2180     A(U1)=A(I)
2190   NEXT I
2200   U1=U1+1
2210   A(U1)=A(I1)
2220   I1=U1


*** DEFINE SLICE BOUNDARIES ***

2240   Q1=A(I1)-A(1)
2250   Q2=Q1/S9
2260   U1=I1
```

```
2270  FOR I=1 TO U1-1
2280    Q3=A(I+1)-A(I)
2290    Q4=INT(Q3/Q2)+1
2300    C1=Q3/Q4
2310    C2=A(I)
2320    FOR J=1 TO Q4
2330      IF J<Q4 THEN 2350
2340      GOTO 2360
2350      I1=I1+1
2360      IF J<Q4 THEN 2380
2370      GOTO 2390
2380      A(I1)=C2+C1
2390      IF J<Q4 THEN 2410
2400      GOTO 2420
2410      C2=C2+C1
2420    NEXT J
2430  NEXT I
2440  FOR I=1 TO I1
2450    FOR J=1 TO I1-1
2460      IF A(J+1)>A(J) THEN 2500
2470      J1=A(J+1)
2480      A(J+1)=A(J)
2490      A(J)=J1
2500    NEXT J
2510  NEXT I
```

*** DEFINE SOIL PARAMETERS FOR EACH SLICE ***

```
2530  F1=I1-1
2540  FOR I=1 TO F1
2550    F(I,4)=A(I+1)-A(I)
2560    X6=F(I,4)
2570    F(I,7)=(A(I+1)+A(I))/2
2580    X3=F(I,7)
2590    Y1=Y-SQR(R^2-(A(I)-X)^2)
2600    Y2=Y-SQR(R^2-(A(I+1)-X)^2)
2610    A5=ATN(ABS(Y2-Y1)/F(I,4))
2620    IF Y2<Y1 THEN 2640
2630    GOTO 2650
2640    A5=-A5
2650    F(I,2)=A5
2660    IF A5=0 THEN 2680
2670    GOTO 2690
2680    F(I,2)=1.0E-5
2690    Y3=Y-SQR(R^2-(X3-X)^2)
2700    I4=0
2710    FOR J=1 TO L1
2720      L5=L(J,1)
2730      L6=L(J,2)
2740      IF (P(L5,2)<=Y3) AND (P(L6,2)<=Y3) THEN 2840
2750      IF (P(L5,1)<X3) AND (P(L6,1)<X3) THEN 2840
2760      IF (P(L5,1)>X3) AND (P(L6,1)>X3) THEN 2840
2770      Y6=P(L5,2)+(P(L5,2)-P(L6,2))/(P(L5,1)-P(L6,1))*(X3-P(L5,1))
2780      IF Y6<=Y3 THEN 2840
2790      I4=I4+1
2800      Z(I4,1)=Y6
2810      Z(I4,2)=L(J,3)
2820      W=0
2830      E=0
2840    NEXT J
2850    IF I4=1 THEN 2970
2860    FOR J=1 TO I4
2870      FOR J1=1 TO I4-1
2880        IF Z(J1,1)>=Z(J1+1,1) THEN 2950
2890        L5=Z(J1,1)
```

```
2900         L6=Z(J1,2)
2910         Z(J1,1)=Z(J1+1,1)
2920         Z(J1,2)=Z(J1+1,2)
2930         Z(J1+1,1)=L5
2940         Z(J1+1,2)=L6
2950       NEXT J1
2960     NEXT J
2970     I4=I4+1
2980     Z(I4,1)=Y3
2990     FOR J1=1 TO I4-1
3000       IF (I=1) AND (J1=1) AND (X3>=S6) THEN 3020
3010       GOTO 3030
3020       I6=S0-Y1
3030       IF (I=F1) AND (J1=1) AND (X3>=S6) AND (X3<=S7) THEN 3050
3040       GOTO 3060
3050       J6=S0-Y2
3060       W=W+(Z(J1,1)-Z(J1+1,1))*X6*S2(Z(J1,2),1)
3070       IF (Z(J1,1)<S0) AND (X3>=S6) AND (X3<=S7) THEN 3090
3080       GOTO 3100
3090       W=W+(S0-Z(J1,1))*X6*W0
3100       IF S2(Z(J1,2),4)>.95 THEN 3120
3110       GOTO 3130
3120       E4=S2(Z(J1,2),1)
3130       IF S2(Z(J1,2),4)<.95 THEN 3150
3140       GOTO 3160
3150       E4=S2(Z(J1,2),1)-W0
3160       E=E+(Z(J1,1)-Z(J1+1,1))*X6*E4
3170     NEXT J1
3180     F(I,1)=W
3190     F(I,5)=E
3200     F(I,3)=S2(Z(I4-1,2),2)
3210     F(I,6)=2*PI*(S2(Z(I4-1,2),3)/360)
3220   NEXT I
3221   NORMAL
3230   IF F9=0 THEN 3360
3240   PRINT USING 3250;CHR$(210)
3250   IMAGE "SLICE    WEIGHT   INCLINATION   COHESION   WIDTH    EFF WEIGHT    "A
"        X"
3280   O=360/(2*PI)
3290   FOR I=1 TO F1
3300     PRINT USING 3320;I,F(I,1),F(I,2)*O,F(I,3),F(I,4),F(I,5),F(I,6)*O,F(I,7)
3320     IMAGE 3D,10D.D,7D.D,12D,9D.D,11D.D,7D,7D.D
3340   NEXT I
3350   PRINT
3360   D=0
3361   PRINTER IS 0
3370   FOR I=1 TO F1
3380     D=D+F(I,1)*SIN(ABS(F(I,2)))*(F(I,2)/ABS(F(I,2)))
3390     D=D+E1*F(I,1)*COS(ABS(F(I,2)))
3400   NEXT I
3410   IF I6>0 THEN 3430
3420   GOTO 3440
3430   I7=W0*I6*I6*(R-I6/3)/(2*R)
3440   IF I6>0 THEN 3460
3450   GOTO 3470
3460   D=D-SGN(D)*I7
3470   IF (I6>0) AND (F9=1) THEN 3490
3480   GOTO 3510
3490   PRINT USING 3500;I7
3500   IMAGE "DRIVING FORCE COUNTER BALANCE OF",10D.2D
3510   IF J6>0 THEN 3530
3520   GOTO 3540
3530   I7=W0*J6*J6*(R-J6/3)/(2*R)
3540   IF J6>0 THEN 3560
3550   GOTO 3570
3560   D=D+SGN(D)*I7
3570   IF (J6>0) AND (F9=1) THEN 3590
```

```
3580  GOTO 3610
3590  PRINT USING 3600;I7
3600  IMAGE "DRIVING FORCE INCREASE OF",10D.2D
```

*** ITERATIVE SOLUTION FOR FACTOR OF SAFETY ***

```
3620  F0=1
3630  R4=0
3640  I6=0
3650  FOR I=1 TO F1
3660    R1=F(I,3)*F(I,4)+F(I,5)*TAN(F(I,6))
3670    R2=1/COS(ABS(F(I,2)))
3680    R3=1+TAN(F(I,6))*TAN(F(I,2))/F0
3690    R4=R4+R1*(R2/R3)
3700  NEXT I
3710  F2=R4/D
3720  I6=I6+1
3730  IF F9=1 THEN 3750
3740  GOTO 3820
3750  IF I6=1 THEN 3770
3760  GOTO 3800
3770  PRINT
3780  PRINT USING 3790
3790  IMAGE "ITERATION",11X,"INITIAL",10X,"CALCULATED"
3800  PRINT USING 3810;I6,F0,F2
3810  IMAGE 3X,3D,13X,3D.4D,12X,3D.4D
3820  IF I6>10 THEN 3840
3830  GOTO 3850
3840  PRINT "WILL NOT CLOSE"
3850  IF I6>10 THEN 3970
3860  IF ABS(ABS(F0)-ABS(F2))<.005 THEN 3900
3870  F0=ABS(F2)
3880  R4=0
3890  GOTO 3650
3900 !
3901  IF NOT F9 THEN
3902    PRINTER IS 16
3903  ELSE
3904    PRINTER IS 0
3905  END IF
3910  PRINT
3920  PRINT USING 3930;F2,X,Y,R
3930  IMAGE "FACTOR OF SAFETY= ",5D.2D,"  AT X= ",4D," Y= ",4D, " R= ",4D
3940  PRINT USING 3950;E1
3950  IMAGE "EARTHQUAKE= ",2D.2D
3951  IF F9 THEN 4380
3960  PRINT
3961  A$=""
3970  INPUT "DO YOU WISH A FORMAL PRINTOUT (Y/N)",A$
3990  IF UPC$(A$[1,1])="N" THEN 4320
3991  PRINTER IS 0
4030  IMAGE @"WATER UNIT WEIGHT=",3D.2D
4040  PRINT USING 4030;W0
4041  IF S0 THEN
4050    PRINT
4060    IMAGE "SUBMERGENCE AT "3D.2D,"  FROM  ",3D.1D,"  TO  ",3D.1D
4070    PRINT USING 4060;S0,S6,S7
4071  END IF
4080  PRINT
4090  PRINT " POINT   X-ORD     Y-ORD"
4100  IMAGE 4D,7D.2D,7D.2D
4110  FOR I=1 TO P1
4120    PRINT USING 4100;I,P(I,1),P(I,2)
4130  NEXT I
4140  PRINT
```

```
4150 PRINT "      LINE    LEFT   RIGHT    SOIL"
4160 IMAGE 4(8D)
4170 FOR I=1 TO L1
4180   PRINT USING 4160;I,L(I,1),L(I,2),L(I,3)
4190 NEXT I
4200 PRINT
4210 PRINT "SOIL       UNIT WEIGHT       COHESION     "&CHR$(210)&"     SATURAT
ED"
4220 IMAGE 3D,15D,17D,9D,7X,3A
4230 FOR I=1 TO S1
4240   PRINT USING 4220;I,S2(I,1),S2(I,2),S2(I,3),Sbit$(S2(I,4))
4250 NEXT I
4260 PRINT
4270 PRINT "CIRCLE   X-ORD    Y-ORD   RADIUS  FACTOR OF SAFETY"
4280 IMAGE 12D.D,7D.D,7D.D,8D.2D
4290 PRINT USING 4280;X,Y,R,F2
4300 PRINT
4310 PRINT
4311 A$=""
4320 INPUT "DO YOU WISH A DIAGNOSTIC RUN (Y/N)",A$
4340 IF UPC$(A$[1,1])="N" THEN 4370
4360 F9=1
4370 IF UPC$(A$[1,1])<>"N" THEN 720
4371 A$=""
4380 INPUT "DO YOU WANT TO CONTINUE (Y/N)",A$
4400 IF UPC$(A$[1,1])<>"N" THEN 630
4401 DISP " FINISHED "
4410 STOP
4520 Logo:PLOTTER IS 13,"GRAPHICS"
4530 GRAPHICS
4540 SCALE 0,559,0,454
4550 LORG 2
4560 FOR I=0 TO 5
4570   Logo(1)=-2175
4580   Logo(2)=-4352
4590   R=454-I
4600   GLOAD Logo(*),0,R
4610 NEXT I
4620 FOR I=6 TO 14
4630   Logo(1)=-2115
4640   Logo(2)=-4352
4650   R=454-I
4660   GLOAD Logo(*),0,R
4670 NEXT I
4680 FOR I=15 TO 21
4690   Logo(1)=-2175
4700   Logo(2)=-4352
4710   R=454-I
4720   GLOAD Logo(*),0,R
4730 NEXT I
4740 CSIZE 15/4.54,9/15
4750 MOVE 27,450
4760 LABEL "HORROCKS"
4770 MOVE 27,437
4780 CSIZE 15/4.54,8/15
4790 LABEL "ENGINEERS"
4800 DUMP GRAPHICS 430,454
4810 GCLEAR
4820 EXIT GRAPHICS
4830 RETURN
```

Slope stability program

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FOR NATURAL or man-made slopes, the index of stability with respect to a sudden failure is known as the safety factor of the slope. The safety factor may be defined as the ratio of the potential resisting forces to the drive forces tending to cause movement. A slope on the verge of failure would have a safety factor of 1.0. The analysis of slope stability is, therefore, the analytical procedure of determining the most critical, i.e., the lowest, factor of safety of given or proposed slope.

Manual methods of slope stability analysis were developed prior to the advent of the electronic computer. These approaches resulted in high analysis costs and conservative slope configurations. Repetitive calculations lended themselves to computerized methods and numerous programs exist that have been written for large computer systems to perform slope stability analysis according to a number of theoretical methods.

The simplified or modified Bishop method is reasonably accurate for most purposes where the slope under analysis can be assumed to fail along a circular failure surface. The factor of safety is defined as the ratio of the resisting moments to driving moments around the center of the failure arc. Initially, a cross-section of the slope is drawn detailing soil strata and piezometric surfaces. A center point is then chosen from which an arc is taken through the cross-section. This arc represents the failure surface under evaluation. This failure zone is broken down into a series of slices which can be individually evaluated for their weight and strength characteristics. An illustration of a slope cross-section being defined by a series of slices is shown in Figure 1.

The forces acting on each slice are illustrated in Figure 1, where ΔX is the width of the slice, W is the weight of the slice, T is the force acting along the failure surface at the bottom of the slice, $\overline{N}$ is the effective force acting normally to the base of the slice and Θ is the inclination of the failure surface or slice base. The factor of safety is defined as:

$$F = \frac{\sum \dfrac{(C \Delta X + \overline{N} \tan \Phi) \sec \Theta}{1 + \dfrac{\tan \Phi \tan \Theta}{F}}}{\sum W \sin \Theta}$$

Where C is the cohesion, Φ is the friction angle and the summation occurs over each slice of the failure zone. As the factor of safety, F, occurs on both sides of the equation. An interactive solution where F is initially estimated and then back substituted until the calculated F and estimated F close within a specified tolerance.

The equation can be modified to handle two additional conditions by adding additional factors to the term defining the driving force. These two conditions are standing pools, i.e., submergence of a portion of the slope, and earthquake loading. For submergence, the weight of water acting above the slice is added to the weight of the slice itself. The total driving force is increased or decreased by the weight of water above or below the exit of the failure surface from the slope. The second condition of earthquake loading can be handled by increasing the driving force calculated for each slice by $EW\cos\Theta$, where E is the earthquake loading factor. Similarly the resisting force is decreased by a decrease in the normal force due to the earthquake loading.

Following the calculation of the safety factor for this arc, the center or radius of the arc is modified to generate a new failure surface. The previously mentioned procedure is again followed with a new factor of safety being deter-

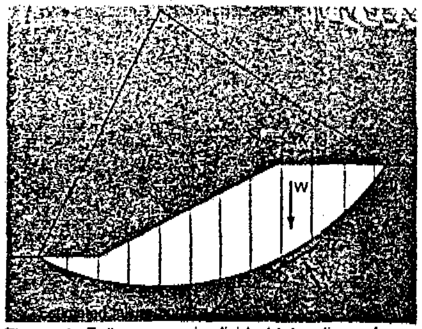


Figure 1. Failure zone is divided into slices; forces acting upon a slice are indicated.

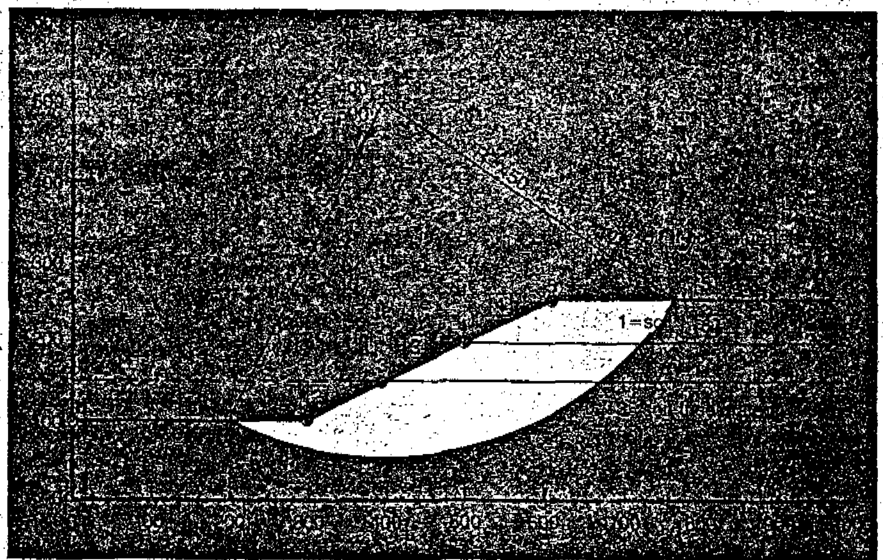


Figure 2. shows a typical cross-section and the input parameters required to define the cross-section for the program.

Table for Figure 2.

Point	X	Y	Line	Left	Right	Soil	Soil	α	Cohesion	Phi	Saturated
1	0	100	1	1	2	3	1	127	2000	20	No
2	300	100	2	2	3	3	2	130	1000	33	No
3	400	150	3	3	4	2	3	130	1000	33	Yes
4	500	200	4	4	5	1					
5	600	250	5	5	6	1					
6	1000	250	6	4	7	2					
7	1000	200	7	3	8	3					
8	1000	150									

0360-0556/82/0010-0071/$01.00

```
100 REM ************************************************
110 REM ** SIMPLIFIED BISHOP SLOPE STABILITY ANALYSIS
120 REM ************************************************
130 PRINT @40:"SLOPE STABILITY ANALYSIS"
140 DIM P(20,2),L(20,3),S2(5,4),A(20),F(20,7),Z(20,4)
150 S9=10
160 J6=0
170 REM *** INPUT@40: OF PROGRAM VARIABLES ***
180 PRINT @40:"HEADING ";
190 INPUT @40:H$
200 PRINT @40:"SUBMERGENCE ELEVATION (0 IF NO SUBMERGENCE) ";
210 INPUT @40:S0
220 PRINT @40:"FROM X-ORD ";
230 INPUT @40:S6
240 PRINT @40:"   TO X-ORD ";
250 INPUT @40:S7
260 PRINT @40:"WATER UNIT WEIGHT ";
270 INPUT @40:W0
280 PRINT @40:"EARTHQUAKE ";
290 INPUT @40:E1
300 PRINT @40:"NUMBER OF POINTS ";
310 INPUT @40:P1
320 FOR I=1 TO P1
330 PRINT @40:"POINT------> ";I
340 PRINT @40:"X-ORD ";
350 INPUT @40:P(I,1)
360 PRINT @40:"Y-ORD ";
370 INPUT @40:P(I,2)
380 NEXT I
390 PRINT @40:"NUMBER OF LINES ";
400 INPUT @40:L1
410 FOR I=1 TO L1
420 PRINT @40:"LINE------> ";I
430 PRINT @40:"LEFT PT ";
440 INPUT @40:L(I,1)
450 PRINT @40:"RIGHT PT ";
460 INPUT @40:L(I,2)
470 PRINT @40:"SOIL BENEATH ";
480 INPUT @40:L(I,3)
490 NEXT I
500 PRINT @40:"NUMBER OF SOILS ";
510 INPUT @40:S1
520 FOR I=1 TO S1
530 PRINT @40:"SOIL------> ";I
540 PRINT @40:"UNIT WEIGHT ";
550 INPUT @40:S2(I,1)
560 PRINT @40:"COHESION ";
570 INPUT @40:S2(I,2)
580 PRINT @40:"PHI ANGLE ";
590 INPUT @40:S2(I,3)
600 PRINT @40:"SATURATION (0=YES,1=NO) ";
610 INPUT @40:S2(I,4)
620 NEXT I
630 REM
640 F9=0
650 PRINT @40:"CIRCLE DEFINITION"
660 PRINT @40:"X-ORD OF CENTER ";
670 INPUT @40:X
680 PRINT @40:"Y-ORD OF CENTER ";
690 INPUT @40:Y
700 PRINT @40:"CIRCLE RADIUS ";
710 INPUT @40:R
720 REM *** CHECK TO SEE IF CIRCLE EXCEEDS TOP LINE END POI
730 U1=P1
740 FOR I=2 TO P1
750 IF P(I,1)<P(I-1,1) AND U1=P1 THEN 770
760 GO TO 780
770 U1=I-1
780 NEXT I
790 J1=R*R-(P(1,2)-Y)^2
800 J2=R*R-(P(U1,2)-Y)^2
810 IF J1<=0 THEN 830
820 IF J1>0 AND P(1,1)>X-SQR(J1) THEN 860
830 IF J2<=0 THEN 850
840 IF J2>0 AND P(U1,1)<X+SQR(J2) THEN 860
850 GO TO 880
860 PRINT @40:"CIRCLE EXCEEDS TOP LINE END POINTS"
870 GO TO 4380
880 REM *** DEFINE INTERSECTION OF CIRCLE WITH LINES ***
890 FOR I=1 TO L1
900 X1=P(L(I,1),1)
910 Y1=P(L(I,1),2)
920 X2=P(L(I,2),1)
930 Y2=P(L(I,2),2)
940 IF X2=X1 THEN 960
950 GO TO 970
960 S=9.99E+10
970 IF X2<>X1 THEN 990
980 GO TO 1000
990 S=(Y2-Y1)/(X2-X1)
1000 IF ABS(S)<1.0E-5 THEN 1150
1010 C1=X1-Y1/S
1020 C2=1/S^2+1
1030 C3=2*C1/S-2*X/S-2*Y
1040 C4=C1^2-2*X*C1+X^2+Y^2-R^2
1050 C5=C3^2-4*C2*C4
1060 IF C5<0 THEN 1080
1070 GO TO 1090
1080 Z(I,1)=0
1090 IF C5<0 THEN 1630
1100 Q1=(-C3+SQR(C5))/(2*C2)
1110 Q2=(-C3-SQR(C5))/(2*C2)
1120 Q3=Q1/S+C1
1130 Q4=Q2/S+C1
1140 GO TO 1240
1150 C5=R^2-(Y-Y1)^2
1160 IF C5<0 THEN 1180
1170 GO TO 1190
1180 Z(I,1)=0
1190 IF C5<0 THEN 1630
1200 Q3=X+SQR(C5)
1210 Q4=X-SQR(C5)
1220 Q1=Y1
1230 Q2=Y1
1240 J1=0
1250 J2=0
1260 IF ABS(S)<=9.99E+9 AND Q3=>X1 AND Q3<=X2 THEN 1280
1270 GO TO 1290
1280 J1=1
1290 IF ABS(S)<=9.99E+9 AND Q4=>X1 AND Q4<=X2 THEN 1310
1300 GO TO 1320
1310 J2=1
1320 IF S<-9.99E+9 AND Q1=>Y2 AND Q1<=Y1 THEN 1340
1330 GO TO 1350
1340 J1=1
1350 IF S<-9.99E+9 AND Q2=>Y2 AND Q2<=Y1 THEN 1370
1360 GO TO 1380
1370 J2=1
1380 IF S>9.99E+9 AND Q1=>Y1 AND Q1<=Y2 THEN 1400
1390 GO TO 1410
1400 J1=1
1410 IF S>9.99E+9 AND Q2=>Y1 AND Q2<=Y2 THEN 1430
1420 GO TO 1440
1430 J2=1
1440 Z(I,1)=J1+J2
1450 IF J1=1 THEN 1470
1460 GO TO 1480
1470 Z(I,2)=Q3
1480 IF J1=1 THEN 1500
1490 GO TO 1510
1500 Z(I,3)=Q1
1510 IF J1=0 AND J2=1 THEN 1530
1520 GO TO 1540
1530 Z(I,2)=Q4
1540 IF J1=0 AND J2=1 THEN 1560
1550 GO TO 1570
1560 Z(I,3)=Q2
1570 IF J1=1 AND J2=1 THEN 1590
1580 GO TO 1600
1590 Z(I,4)=Q4
1600 IF J1=1 AND J2=1 THEN 1620
1610 GO TO 1630
1620 Z(I,5)=Q2
1630 NEXT I
1640 X4=0
1650 X5=9.99E+20
1660 I1=1
1670 FOR I=1 TO L1
1680 IF Z(I,1)=>1 THEN 1700
1690 GO TO 1710
1700 A(I1)=Z(I,2)
1710 IF Z(I,1)=>1 THEN 1730
1720 GO TO 1740
1730 I1=I1+1
1740 IF Z(I,1)=2 THEN 1760
1750 GO TO 1770
1760 A(I1)=Z(I,4)
1770 IF Z(I,1)=2 THEN 1790
1780 GO TO 1800
1790 I1=I1+1
1800 NEXT I
1810 IF I1=1 THEN 1830
1820 GO TO 1840
1830 PRINT @40:"CIRCLE DOES NOT INTERSECT SLOPE"
1840 IF I1=1 THEN 4380
1850 REM *** SET UP OF SLICE ARRAY ***
1860 FOR I=1 TO I1-1
1870 IF A(I)>X4 THEN 1890
1880 GO TO 1900
1890 X4=A(I)
1900 IF A(I)<X5 THEN 1920
1910 GO TO 1930
1920 X5=A(I)
1930 NEXT I
1940 FOR I=1 TO P1
1950 IF P(I,1)<X4 AND P(I,1)>X5 THEN 1970
1960 GO TO 1980
1970 A(I1)=P(I,1)
1980 IF P(I,1)<X4 AND P(I,1)>X5 THEN 2000
1990 GO TO 2010
2000 I1=I1+1
2010 NEXT I
2020 I1=I1-1
2030 FOR I=1 TO I1
2040 FOR J=1 TO I1-1
```

mined. This entire sequence is repeated until the failure surface for the minimum factor of safety is determined.

The program included in this article follows the same general procedure as previously defined. The program can be broken down into nine segments. Lines 100-620 are input routines for the entry of data defining the cross-section, lines 630-710 define the circle that will generate the failure surface, lines 720-860 perform a verification that the failure arc falls fully within the cross-section and lines 880-1840 define the intersection points between the line segments and the failure arc. The slice array is set up between line 1850 and 2220, with slice boundaries defined in lines 2230-2510. Lines 2520-3600 include the definition of the soil parameters for each slice and the actual iterative solution for the factor of safety occurs between lines 3610 and 3950. The remainder of the program is the formal output of the results.

The program includes a diagnostic print-out where all the slice parameters can be displayed for any given failure surface. As currently configured the program can handle models including

```
2050 IF A(J+1)>A(J) THEN 2090
2060 J1=A(J+1)
2070 A(J+1)=A(J)
2080 A(J)=J1
2090 NEXT J
2100 NEXT I
2110 U1=0
2120 FOR I=1 TO I1-1
2130 IF A(I)<A(I+1) THEN 2150
2140 GO TO 2160
2150 U1=U1+1
2160 IF A(I)<A(I+1) THEN 2180
2170 GO TO 2190
2180 A(U1)=A(I)
2190 NEXT I
2200 U1=U1+1
2210 A(U1)=A(I1)
2220 I1=U1
2230 REM *** DEFINE SLICE BOUNDARIES ***
2240 O1=A(I1)-A(1)
2250 O2=O1/S9
2260 U1=I1
2270 FOR I=1 TO U1-1
2280 O3=A(I+1)-A(I)
2290 O4=INT(O3/O2)+1
2300 C1=O3/O4
2310 C2=A(I)
2320 FOR J=1 TO O4
2330 IF J<O4 THEN 2350
2340 GO TO 2360
2350 I1=I1+1
2360 IF J<O4 THEN 2380
2370 GO TO 2390
2380 A(I1)=C2+C1
2390 IF J<O4 THEN 2410
2400 GO TO 2420
2410 C2=C2+C1
2420 NEXT J
2430 NEXT I
2440 FOR I=1 TO I1
2450 FOR J=1 TO I1-1
2460 IF A(J+1)>A(J) THEN 2500
2470 J1=A(J+1)
2480 A(J+1)=A(J)
2490 A(J)=J1
2500 NEXT J
2510 NEXT I
2520 REM *** DEFINE SOIL PARAMETERS FOR EACH SLICE ***
2530 F1=I1-1
2540 FOR I=1 TO F1
2550 F(I,4)=A(I+1)-A(I)
2560 X6=F(I,4)
2570 F(I,7)=(A(I+1)+A(I))/2
2580 X3=F(I,7)
2590 Y1=Y-SQR(R^2-(A(I)-X)^2)
2600 Y2=Y-SQR(R^2-(A(I+1)-X)^2)
2610 A5=ATN(ABS(Y2-Y1)/F(I,4))
2620 IF Y2<Y1 THEN 2640
2630 GO TO 2650
2640 A5=-A5
2650 F(I,2)=A5
2660 IF A5=0 THEN 2680
2670 GO TO 2690
2680 F(I,2)=1.0E-5
2690 Y3=Y-SQR(R^2-(X3-X)^2)
2700 I4=0
2710 FOR J=1 TO L1
2720 L5=L(J,1)
2730 L6=L(J,2)
2740 IF P(L5,2)<=Y3 AND P(L6,2)<=Y3 THEN 2840
2750 IF P(L5,1)<X3 AND P(L6,1)<X3 THEN 2840
2760 IF P(L5,1)>X3 AND P(L6,1)>X3 THEN 2840
2770 Y6=P(L5,2)+(P(L5,2)-P(L6,2))/(P(L5,1)-P(L6,1))*(X3-P(L5,1))
2780 IF Y6<=Y3 THEN 2840
2790 I4=I4+1
2800 Z(I4,1)=Y6
2810 Z(I4,2)=L(J,3)
2820 W=0
2830 E=0
2840 NEXT J
2850 IF I4=1 THEN 2970
2860 FOR J=1 TO I4
2870 FOR J1=1 TO I4-1
2880 IF Z(J1,1)=>Z(J1+1,1) THEN 2950
2890 L5=Z(J1,1)
2900 L6=Z(J1,2)
2910 Z(J1,1)=Z(J1+1,1)
2920 Z(J1,2)=Z(J1+1,2)
2930 Z(J1+1,1)=L5
2940 Z(J1+1,2)=L6
2950 NEXT J1
2960 NEXT J
2970 I4=I4+1
2980 Z(I4,1)=Y3
2990 FOR J1=1 TO I4-1
3000 IF I=1 AND J1=1 AND X3=>S6 THEN 3020
3010 GO TO 3030
3020 I6=S0-Y1
3030 IF I=F1 AND J1=1 AND X3=>S6 AND X3<=S7 THEN 3050
3040 GO TO 3060
3050 J6=S0-Y2
3060 W=W+(Z(J1,1)-Z(J1+1,1))*X6*S2(Z(J1,2),1)
3070 IF Z(J1,1)<S0 AND X3=>S6 AND X3<=S7 THEN 3090
3080 GO TO 3100
3090 W=W+(S0-Z(J1,1))*X6*W0
3100 IF S2(Z(J1,2),4)>0.95 THEN 3120
3110 GO TO 3130
3120 E4=S2(Z(J1,2),1)
3130 IF S2(Z(J1,2),4)<0.95 THEN 3150
3140 GO TO 3160
3150 E4=S2(Z(J1,2),1)-W0
3160 E=E+(Z(J1,1)-Z(J1+1,1))*X6*E4
3170 NEXT J1
3180 F(I,1)=W
3190 F(I,5)=E
3200 F(I,3)=S2(Z(I4-1,2),2)
3210 F(I,6)=2*PI*(S2(Z(I4-1,2),3)/360)
3220 NEXT I
3230 IF F9=0 THEN 3360
3240 PRINT @40: USING 3250:
3250 IMAGE "SLICE  WEIGHT   INCLINATION ",S
3260 PRINT @40: USING 3270:
3270 IMAGE " COHESION  WIDTH  EFF WEIGTH      PHI    X"
3280 O=360/(2*PI)
3290 FOR I=1 TO F1
3300 PRINT @40: USING 3320:I,F(I,1),F(I,2)*O,F(I,3),F(I,4),F(I,5)
3310 PRINT @40: USING 3330:F(I,6)*O,F(I,7)
3320 IMAGE (3D,09D.1D,07D.1D,12D,07D.1D,,09D.1D),S
3330 IMAGE   7D.1D ,5D.2D
3340 NEXT I
3350 PRINT @40:
3360 D=0
3370 FOR I=1 TO F1
3380 D=D+F(I,1)*SIN(ABS(F(I,2)))*(F(I,2)/ABS(F(I,2)))
3390 D=D+E1*F(I,1)*COS(ABS(F(I,2)))
3400 NEXT I
3410 IF I6>0 THEN 3430
3420 GO TO 3440
3430 I7=W0*I6*I6*(R-I6/3)/(2*R)
3440 IF I6>0 THEN 3460
3450 GO TO 3470
3460 D=D-SGN(D)*I7
3470 IF I6>0 AND F9=1 THEN 3490
3480 GO TO 3510
3490 PRINT @40: USING 3500:I7
3500 IMAGE "DRIVING FORCE COUNTER BALANCE OF",10D.2D
3510 IF J6>0 THEN 3530
3520 GO TO 3540
3530 I7=W0*J6*J6*(R-J6/3)/(2*R)
3540 IF J6>0 THEN 3560
3550 GO TO 3570
3560 D=D+SGN(D)*I7
3570 IF J6>0 AND F9=1 THEN 3590
3580 GO TO 3610
3590 PRINT @40: USING 3600:I7
3600 IMAGE "DRIVING FORCE INCREASE OF",10D.2D
3610 REM *** ITERATIVE SOLUTION FOR FACTOR OF SAFETY ***
3620 F0=1
3630 R4=0
3640 I6=0
3650 FOR I=1 TO F1
3660 R1=F(I,3)*F(I,4)+F(I,5)*TAN(F(I,6))
3670 R2=1/COS(ABS(F(I,2)))
3680 R3=1+TAN(F(I,6))*TAN(F(I,2))/F0
3690 R4=R4+R1*(R2/R3)
3700 NEXT I
3710 F2=R4/D
3720 I6=I6+1
3730 IF F9=1 THEN 3750
3740 GO TO 3820
3750 IF I6=1 THEN 3770
3760 GO TO 3800
3770 PRINT @40:
3780 PRINT @40: USING 3790:
3790 IMAGE 1 T,"ITERATION",10X,"INITIAL",10X,"CALCULATED"
3800 PRINT @40: USING 3810:I6,F0,F2
3810 IMAGE  3T,3D,13X,3D.4D,12X,3D.4D
3820 IF I6>10 THEN 3840
3830 GO TO 3850
3840 PRINT @40:"WILL NOT CLOSE"
3850 IF I6>10 THEN 3970
3860 IF ABS(ABS(F0)-ABS(F2))<0.005 THEN 3900
3870 F0=ABS(F2)
3880 R4=0
3890 GO TO 3650
3900 REM
3910 PRINT @40:
3920 PRINT @40: USING 3930:F2,X,Y,R
3930 IMAGE "FACTOR OF SAFETY= ",2D.2D," AT X= ",4D," Y= ",4D," R= ",4D
3940 PRINT @40: USING 3950:E1
3950 IMAGE "EARTHQUAKE= ",2D.2D
3960 PRINT @40:
3970 PRINT @40:"DO YOU WISH A FORMAL PRINTOUT (Y OR N)";
3980 INPUT @40:A$
3990 IF A$="N" THEN 4320
4000 PRINT @40:
4010 PRINT @40:H$
4020 PRINT @40:
4030 IMAGE "WATER UNIT WEIGHT=",3D.2D," EARTHQUAKE=",1D.2D
4040 PRINT @40: USING 4030:W0,E1
4050 PRINT @40:
4060 IMAGE"SUBMERGENCE AT "3D.2D," FROM ",3D.1D," TO ",3D.1D
4070 PRINT @40: USING 4060:S0,S6,S7
4080 PRINT @40:
4090 PRINT @40:" POINT   X-ORD    Y-ORD"
4100 IMAGE 4D,7D.2D,7D.2D
4110 FOR I=1 TO P1
4120 PRINT @40: USING 4100:I,P(I,1),P(I,2)
4130 NEXT I
4140 PRINT @40:
4150 PRINT @40:"    LINE    LEFT    RIGHT    SOIL"
4160 IMAGE 4(8D)
4170 FOR I=1 TO L1
4180 PRINT @40: USING 4160:I,L(I,1),L(I,2),L(I,3)
4190 NEXT I
4200 PRINT @40:
4210 PRI @40:" SOIL     UNIT WEIGHT     COHESION     PHI    SATURATED"
4220 IMAGE 3D,15D,17D,9D,9D
4230 FOR I=1 TO S1
4240 PRINT @40: USING 4220:I,S2(I,1),S2(I,2),S2(I,3),S2(I,4)
4250 NEXT I
4260 PRINT @40:
4270 PRINT @40:"CIRCLE   X-ORD    Y-ORD   RADIUS  FACTOR OF SAFETY"
4280 IMAGE 12D.1D,7D.1D,7D.1D,8D.2D
4290 PRINT @40: USING 4280:X,Y,R,F2
4300 PRINT @40:
4310 PRINT @40:
4320 PRINT @40:"DO YOU WISH A DIAGNOSTIC RUN (Y OR N)";
4330 INPUT @40:A$
4340 IF A$="Y" THEN 4360
4350 GO TO 4370
4360 F9=1
4370 IF A$="Y" THEN 720
4380 PRINT @40:"CONTINUE (Y OR N)";
4390 INPUT @40:A$
4400 IF A$="Y" THEN 630
```

```
*SLOPE STABILITY ANALYSIS
 HEADING SAMPLE SLOPE STABILITY PROBLEM
 SUBMERGENCE ELEVATION (0 IF NO SUBMERGENCE) 150
          FROM X-ORD 0
            TO X-ORD 400
          WATER UNIT WEIGHT 62.4
          EARTHQUAKE 0.05
          NUMBER OF POINTS 8
          POINT------> 1
          X-ORD 0
          Y-ORD 100
          POINT------> 2
          X-ORD 300
          Y-ORD 100
          POINT------> 3
          X-ORD 400
          Y-ORD 150
          POINT------> 4
          X-ORD 500
          Y-ORD 200
          POINT------> 5
          X-ORD 600
          Y-ORD 250
          POINT------> 6
          X-ORD 1000
          Y-ORD 250
          POINT------> 7
          X-ORD 1000
          Y-ORD 200
          POINT------> 8
          X-ORD 1000
          Y-ORD 150
          NUMBER OF LINES 7
          LINE------> 1
          LEFT PT 1
          RIGHT PT 2
          SOIL BENEATH 3
          LINE------> 2
          LEFT PT 2
          RIGHT PT 3
          SOIL BENEATH 3
          LINE------> 3
          LEFT PT 3
          RIGHT PT 4
          SOIL BENEATH 2
          LINE------> 4
          LEFT PT 4
          RIGHT PT 5
          SOIL BENEATH 1
          LINE------> 5
          LEFT PT 5
          RIGHT PT 6
          SOIL BENEATH 1
          LINE------> 6
          LEFT PT 4
          RIGHT PT 7
          SOIL BENEATH 2
          LINE------> 7
          LEFT PT 3
          RIGHT PT 8
          SOIL BENEATH 3
          NUMBER OF SOILS 3
          SOIL------> 1
          UNIT WEIGHT 127
          COHESION 2000
          PHI ANGLE 20
          SATURATION (0=YES,1=NO) 1
          SOIL------> 2
          UNIT WEIGHT 130
          COHESION 1000
          PHI ANGLE 33
          SATURATION (0=YES,1=NO) 1
          SOIL------> 3
          UNIT WEIGHT 130
          COHESION 1000
          PHI ANGLE 33
          SATURATION (0=YES,1=NO) 0
          CIRCLE DEFINITION
          X-ORD OF CENTER 400
          Y-ORD OF CENTER 500
          CIRCLE RADIUS 450

          FACTOR OF SAFETY= 1.96  AT X= 400 Y= 500 R= 450
          EARTHQUAKE= 0.05

          DO YOU WISH A FORMAL PRINTOUT (Y OR N)Y

          SAMPLE SLOPE STABILITY PROBLEM

          WATER UNIT WEIGHT= 62.40  EARTHQUAKE=0.05

          SUBMERGENCE AT 150.00  FROM   0.0  TO  400.0

          POINT   X-ORD    Y-ORD
            1      0.00   100.00
            2    300.00   100.00
            3    400.00   150.00
            4    500.00   200.00
            5    600.00   250.00
            6   1000.00   250.00
            7   1000.00   200.00
            8   1000.00   150.00

             LINE    LEFT    RIGHT    SOIL
              1       1       2        3
              2       2       3        3
              3       3       4        2
              4       4       5        1
              5       5       6        1
              6       4       7        2
              7       3       8        3

          SOIL    UNIT WEIGHT       COHESION    PHI    SATURATED
           1         127             2000       20        1
           2         130             1000       33        1
           3         130             1000       33        0

          CIRCLE    X-ORD     Y-ORD    RADIUS   FACTOR OF SAFETY
                    400.0     500.0    450.0        1.96
```

up to 20 points, 20 lines, and 5 soil types. The minimum number of slices is set at 10, but can be changed by modifying the value of S9 at line 150 and changing the dimensioning of arrays A, F and Z.

A cross-section is drawn of the slope showing all soil strata and piezometric surfaces. Each intersect point between lines on the cross-section is numbered, with the constraint that all points along the top line must be numbered consecutively from left to right initiating with point 1. Points beneath the top line may be numbered in any order. These points are then defined with X and Y coordinates (the entire cross-section must fall in the first quadrant).

Lines are then specified by assigning line numbers for each line occurring between two end points. These lines are defined by a left point, a right point and the number of the soil type occurring beneath the line. Vertical lines are not allowed and should be modeled by offsetting the X coordinate of one end point by a small amount, i.e., .01. Piezometric surfaces within the cross-section are treated as any other soil strata interface with saturated soil beneath and unsaturated soil above the line segment. Soil types are defined by specifying a unit weight, cohesion, phi angle and an indication of whether the soil is saturated.

Additional information that must be supplied includes the unit weight of water, the earthquake loading factor and information defining any standing pool of water. This pool is specified by inputting the Y-coordinate of the pool elevation and the left and right X-coordinates defining the extent of the pool. The only remaining input parameters are the center coordinates and radius of the failure arc. The input can be in any consistent set of units.

Figure 2 shows a typical cross-section and the input parameters required to define the cross-section for the program. The sample execution in the box shows the typical input sequence and output formats. This result is not necessarily the minimum factor of safety for this slope, but the factor of safety for the specified failure surface. Additional runs should be made using different centers and radii until the minimum factor of safety is located.

The program presented here is the nucleus from which system specific enhancements should be made. These enhancements are not included in this version for the purpose of minimizing the size of the program presented. Particularly valuable enhancements include the ability to edit interactively, save input on a disc or tape and perform a search for the minimum factor of safety without manually inputting each circle definition. Additional enhancements could include plotting capabilities and more detailed diagnostic features.

A computerized evaluation of slope stability should never take place apart from a complete evaluation of the geophysical conditions involved. Likewise, the results should always be subjected to evaluation and interpretation based on current engineering practice and experience. ◻

Cross received his M.S. degree in civil engineering from Rose-Hulman Institute of Technology, Terre Haute, Indiana in 1972. Currently data processing manager/project engineer, Cross has been with STS (formerly Soil Testing Services) for 10 years. He holds a Master of Divinity from Trinity Evangelical Divinity School and is working on an MBA at the Keller Graduate School of Management.

```
DO YOU WISH A DIAGNOSTIC RUN (Y OR N)Y
SLICE  WEIGHT    INCLINATION  COHESION  WIDTH  EFF.WEIGHT   PHI    X
  1   252536.4     -23.6        1000     33.1    45205.8   33.0  220.38
  2   305318.3     -16.4        1000     33.1   114252.4   33.0  273.46
  3   482338.9      -9.6        1000     50.0   189276.2   33.0  325.00
  4   603232.6      -3.2        1000     50.0   293401.0   33.0  375.00
  5   726732.6       3.2        1000     50.0   416901.0   33.0  425.00
  6   852838.9       9.6        1000     50.0   560476.2   33.0  475.00
  7   939262.7      16.2        1000     50.0   682516.6   33.0  525.00
  8   982882.6      22.9        1000     50.0   781399.0   33.0  575.00
  9   759268.1      29.4        1000     41.4   650306.4   33.0  620.71
 10   617175.8      35.7        1000     41.4   576418.3   33.0  662.13
 11   518439.1      43.6        1000     52.6   518439.1   33.0  709.13
 12   131972.9      52.2        2000     38.8   131972.9   20.0  754.79

DRIVING FORCE COUNTER BALANCE OF    75(11,1)

ITERATION        INITIAL          CALCULATED
    1            1.0000             1.8106
    2            1.8106             1.9435
    3            1.9435             1.9570
    4            1.9570             1.9583

FACTOR OF SAFETY= 1.96  AT X= 400 Y= 500 R= 450
EARTHQUAKE= 0.05

DO YOU WISH A FORMAL PRINTOUT (Y OR N)N
DO YOU WISH A DIAGNOSTIC RUN (Y OR N)N
CONTINUE (Y OR N)N
```

PRICE RIVER COAL COMPANY
P.O. BOX 629 HELPER, UTAH 84526 (801) 472-3411

April 5, 1983

Mr. Tom Tetting
Engineering Geologist
Division of Oil, Gas and Mining
4241 State Office Building
Salt Lake City, UT 84114

Re: Submittal of Items Required by ACR

Dear Tom:

Price River Coal Company is now submitting a number of the items of additional information as required by the ACR. Please review the attached list and check off these items on the ACR.

Other additional items will be provided as quickly as possible. The following should be available shortly:

--UNDER 784.14

Chemical analysis of roof and floor data and discussion of seam similarity.

This information is not yet available. Samples submitted for testing during the first week of March, 1983, have not completed testing procedures.

--UNDER 783.15 AND 783.16

Ground and surface water information.

Vaughn Hansen Associates began actively working on these items on 3-21-83 and hope to provide a satisfactory report by 6-1-83.

--UNDER 783.25 AND 784.13

1. Stream channel and backfill area cross sections.

   Only now is the snow beginning to melt so as to allow necessary field work. About 2 weeks will be needed for surveying and 4 weeks for drafting.

2. Geologic Cross Sections

   Work has been under way on these since 2-21-83. They are extremely time consuming and may require an additional 3-4 weeks work.

--UNDER 784.12

Discussions of existing cut and fill sites and designation of present versus past surface effects of mining.

Snow has prevented necessary field work. These items can now proceed and will require about 4 weeks to complete.

--UNDER 784.14 AND 784.16

1. Rework and clarify pond sizing calculations.

   These are now complete but would be best attached to pond plans and cross sections.

2. Pond plans and cross sections.

   About 2 weeks of survey work and 4 weeks of drafting time is needed.

--UNDER 784.20

Discussion of subsidence, monitoring and installation of monitoring points.

This information is being assembled. An additional 2-3 weeks will be needed to assemble references.

--UNDER 784.22

Diversions.

Information relating to drainage control configuration and sizing to flow characteristics will require some field work. About 6 weeks are needed for surveying and drafting now that snow is disappearing.

--UNDER 805.11

Bonding.

Additional bonding calculations for removal of power lines is being developed. This should be available in 2-3 weeks.

--UNDER 817.43

Hydrologic balance - Outlet for School House Canyon diversion

This was discussed with Joe Lyons during his February visit. Drainage characteristics are still being evaluated. A plan will be developed by June 1, 1983.

--UNDER 771.23 AND 783.24

Permit Area - Permit Term.

Further in-house discussion is needed as well as some additional communication with the R.A. to decide on the usefulness of existing information versus the development of additional information as related to the concepts of permit area, permit term and right of successive renewal.

We will continue to work with you to provide all necessary information for mine plan review and approval. Please keep in close contact with us.

Sincerely,

PRICE RIVER COAL COMPANY

R. L. Wiley
Environmental Engineer

RW:jp

Enclosures

cc: Ben Young, OSM
Fred Hart Associates

ITEMS OF PRCC ACR TO BE SUPPLIED BY 4-15-83

1. Maps showing mining for No. 3 and No. 5 Mines before 8-3-77 and between 8-3-77 and 5-3-78.
2. Recapitulation and combined summation of reclamation costs and bonding estimates.
3. Commitment statement for UMS 817.131.
4. Portal seals, drawings and costs (included in bonding information).
5. Discussion of installation of sub-drain for School House refuse pile and refuse pile pond with past piezometric monitoring data.
6. Discussion of refuse pile drainage, stability and engineers certification of construction plans.
7. Development and implementation of refuse pile inspection plan.
8. Discussion of disposal and disposition of underground development waste.
9. Discussion of signs and markers.
10. Provide map showing locations of areas for past surveys for cultural, historic and archaeological resources. Also a listing (if available) of permit numbers held by the State of Utah and A.R.C.

ITEM 1

MINING DEVELOPMENT PERIODS

As required by comments relative to UMC 771.23(e)(2)

ITEM 2

BONDING

As required by comments under UMC 784.13 and 805.11.

RECLAMATION COSTS AND BONDING

Resulting from comments in the Apparent Completeness Review, we have re-evaluated our reclamation costs and bonding needs through use of standard construction cost manuals. We have used the 1983 edition "Dodge" guides for most earth work and a 1976 "Means" guide for building demolition costs. Some items of reclamation are either not addressed in construction guides (portal sealing) or are not reasonably comparable to the methods or materials needed (planting and seeding). For such items we have projected our own costs which are based on either actual completed project costs (in the preceding six months) or from courtesy supplier/contractor budget figures.

We have divided reclamation costs into five phases: Demolition and Disposal of Buildings, Portal Sealing, Grading, Topsoil Replacement and Re-vegetation. Each item is discussed and assumptions explained as follows:

(1) Demolition and Disposal of Buildings

Cost per cubic yard of building demolition and disposal - no salvage value, was arrived at as follows: Denver rates for labor and materials were taken from Dodge 1983 guide to heavy construction costs, and a factor of 1.92 for labor costs from 1976 to 1983, and a factor of 1.77 for material cost from 1976 to 1983, were derived therefrom.

Means building construction data for 1976 was used as a basis for labor and materials - for demolishing small or single buildings, no salvage included, steel, the labor was:

Crew	Daily, including Subsistence, Overhead and Profit	
(1) Foreman	$ 98.80	
(2) Building Laborers	186.40	
(1) Equip. Oper. (Med.)	123.20	
(2) Truck Drivers	190.40	
	$ 598.40 X 1.92 =	$1,148.93

Equipment, daily, including subsistence, O & P:

1 - Front end loader	251.70	
2 - Hvy dump trucks	258.70	
	$ 510.40 X 1.77 =	903.41
		$2,052.34

$$\frac{\$2,052.34}{12,300\ \text{cf/day}} = \$0.17/\text{cu.ft./steel}$$

$$\frac{\$2,052.34}{8,500\ \text{cf/day}} = \$0.25/\text{cu.ft./concrete}$$

Dump charges in 1976 were \$2.50/cu.yd X 1.92 = \$4.75/yd. in 1983; 4.75 ÷ 27 = \$0.18/cu.ft.

Then, \$0.17/ cu.ft. for demolition, steel
0.18 dump charge

\$0.35/cu.ft.

\$0.25/cu. ft. for demolition, concrete
0.18 dump charges

\$0.43/cu.ft.

(2) Portal Sealing

We have had to determine the cost based on costs of materials and labor to us. Both entry sealing and the equipment and materials to do so are common place on a mine site. Review the attached illustrations for the up dip and down dip portal seals.

(3) Grading

Cost figures for grading were obtained from the 1983 Dodge Guide for heavy construction. The assumptions made are:

1. That the equipment used would be two scrapers, moving 4,000 yds^3/day @ 34¢/yd^3 and one dozer, moving 700 yds^3/day @ 71¢/yd^3
2. That a one foot thickness of material will have to be moved over the entire disturbed area. (1,614 yds^3/acre)
3. All materials will have to be handled by the scrapers and the dozer, resulting in a cost per yd^3 = \$1.05 and the cost per acre = \$1,700.00.

(4) Re-soiling

Cost figures for topsoil placement, obtained from Dodge, 1983, include factors for loading, hauling, spreading and purchased material.

Loading:

A 5 yd^3 loader will be used which adds 24¢/yd^3.

Hauling:

The cost of hauling varies with distance. We will use over-the-road trucks. Materials will be either hauled from Gravel Canyon or from the local Helper area.

DRAWN Rhw 2/23/83 CHECKED

APPROVED FOR SAFETY

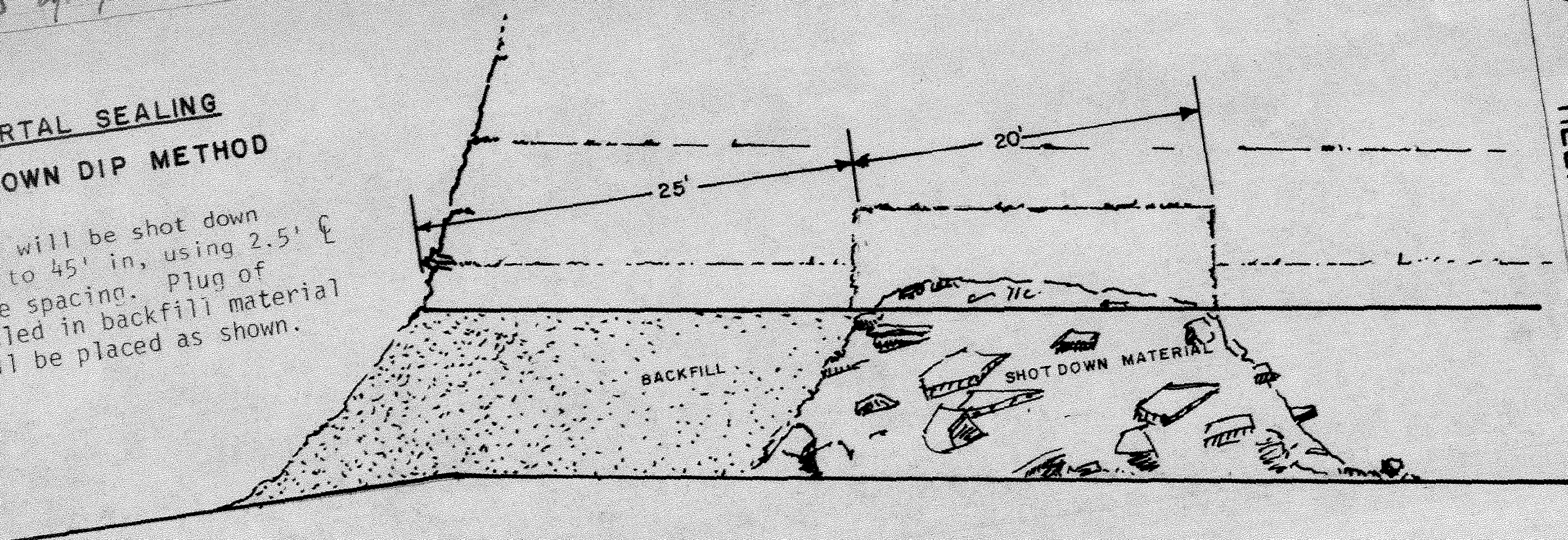
APPROVED

REVISIONS

PORTAL SEALING

DOWN DIP METHOD

Roof will be shot down 25' to 45' in, using 2.5' ℄ hole spacing. Plug of hauled in backfill material will be placed as shown.



LABOR AND MATERIALS

Blasting - 20' x 20' x 6' area
@ 2.5' ℄ hole pattern = 64 holes

Hole Drilling:	1 man, 1 shift =	$ 150.00
	Compressor & Stoper	300.00
Loading & Shooting:	1 man, 1 shift =	150.00
Powder		100.00
Caps		100.00
Shot Wire		2.50

Backfilling

250 yds^3 hauled and placed @ \$4.80/yd^3 = 1,200.00

TOTAL \$2,002.50

NOTE: There are 7 down dip portals on the permit area.

Total Cost: \$14,017.50

No. 4453

STATE OF UTAH

PRICE RIVER COAL COMPANY
ENGINEERING DEPARTMENT
HELPER, UTAH

DRAWING NUMBER A

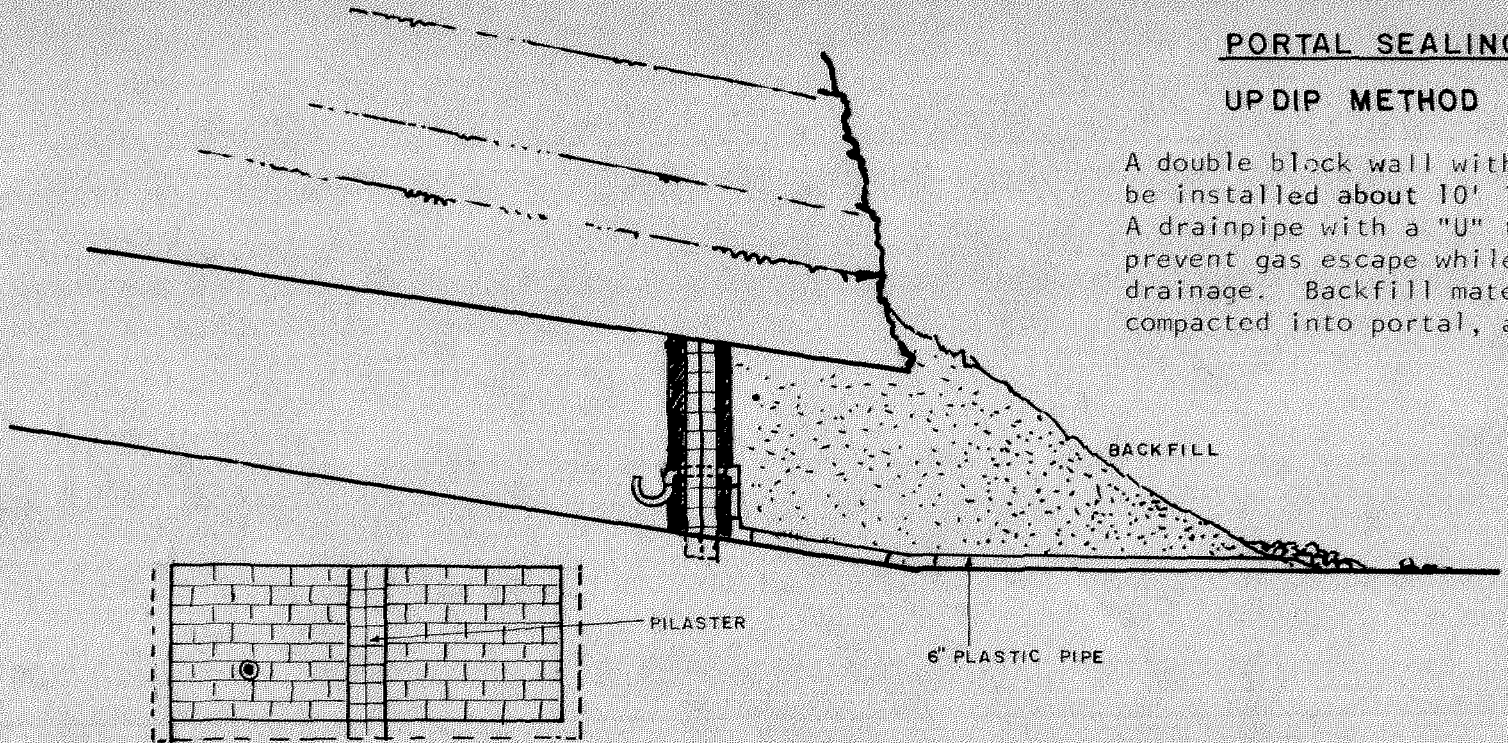
DRAWN RHW 4/20/83 CHECKED APPROVED FOR SAFETY APPROVED

REVISIONS

PORTAL SEALING

UPDIP METHOD

A double block wall with pilaster will be installed about 10' into portal. A drainpipe with a "U" tube inlet will prevent gas escape while allowing drainage. Backfill material will be compacted into portal, against wall.



COSTS

1. Build Wall - 9' X 22'

A. 520 blocks @ 76¢ ea. =	$ 390.00		
Labor - 2 men, 1 shift -	300.00		
B. Sealing Wall			
4 bags mortar @ $10/ea. =	40.00		
4 bags cement @ $20/ea. =	80.00		
Labor - 1 man, 1/2 shift =	75.00		
Subtotal			$ 885.00

2. Install "U" Tube and Discharge Pipe

35', 6" pipe @ $4.00/ft. installed =	140.00	
6" plastic "U" tube assembly =	150.00	
Installation: 1 man, 1/2 shift =	75.00	
Subtotal		365.00

3. Backfill

200 yds^3 of material hauled and pushed into place @ $4.80/yd^3$ =	960.00
TOTAL	$2,210.00

NOTE: Two up dip portal seals on property will cost $4,420.00.

PRICE RIVER COAL COMPANY
ENGINEERING DEPARTMENT
HELPER, UTAH

KENNETH A. HUTCHINSON

DRAWING NUMBER A

(4) Re-soiling (continued)

Distance (mi.)	HAULING COSTS $/yd^3	+ Loading Factor (Total Cost/yd^3)
1/2	$ 0.97	$1.21
1	1.20	1.44
2	1.49	1.73
3	1.81	2.05
5	2.43	2.67
8	3.25	3.50

Spreading:

Using landscaping figures from the Dodge Guide for spreading loam on slopes; the cost per yd^3 = 67¢ or $541.00/acre.

Purchase:

We currently have 45,000 - 50,000 yds^3 of soil stored at Gravel Canyon and about 8,000 yds^3 excess in Crandall Canyon; however, our total needs could be near 100,000 yds^3. Although we hope to fill out this need from new developments, we anticipate the potential for purchase. Should we purchase soil materials, we will strive to obtain a source in the immediate Helper area. We will purchase via a lump sum bid for material delivered to the site.

Dodge recommends about $8.70/yd^3 (with Utah materials adjustment factor - .94). We will use this figure.

Note: PRCC's topsoil needs may be significantly reduced in the near future. The R.A. has suggested that on-site materials be tested and utilized if satisfactory. We feel that No. 5 Mine site has potential for use of existing materials. Also, tests to date indicate that our refuse is non-toxic and could be exempt from the four-foot cover requirement. We will expect a bond reduction should tests favor our situation.

(5) Revegetation

Revegetation costs are primarily derived from recent experience and actual prices for material. Factors are considered for fertilizing, seeding and mulching, shrub or tree planting and evaluation of the plantation. Factors are explained in more detail on pages 555-557 in the MRP (Chapter IX).

Fertilizing: About $100.00/acre includes labor and materials

Seeding and Mulching:

Prices for seed mixes are derived from several local and regional native seed supply companies. For example, seed mix #3, page 540, MRP, was purchased last fall at a cost of $110.00/acre. Some species and mixes

(5) Revegetation (continued)

Seeding and Mulching: (continued)

will cost more. Dodge recommends $287.00 but with no discussion of mix. We will use $300.00/acre for seed cost.

Seed will be broadcast simultaneously with mulch, through use of a mulch blower. Cost for operation of a blower based on three-man crew is $60.00/hr. and three hours/acre = $180.00/acre.

Cost of straw varies locally from $1.25/bale to $3.50/bale; average $2.50. Twenty-two (22) bales needed per acre = $55.00/acre.

A tractor mounted crimping device will cost $35.00/hr and take two hours/acre = $70.00/acre.

Total Seeding and Mulching Cost = $605.00/acre.

Planting Trees and Shrubs:

Material costs, derived through comparison of State Forest Nursery prices and commercial grower/distributor prices, averages about 75¢/seedling. Total cost (see page 556, MRP) will be about $290.00 for labor and stock.

Evaluation of Success of Planatations:

Based on recent vegetation survey costs for this property we will use $40.00/acre for planting evaluation.

Total per acre revegetation costs = $1,035.00.

(6) Maintenance and Contingency

Fifteen (15%) percent of total cost will be added to cover post reclamation maintenance and unforseen problems.

SUMMATION OF PRCC BONDING/RECLAMATION COSTS

Site	No Variances Granted	4' Refuse Covering and Substitute Re-soiling
Sowbelly	$ 142,177.00	$ 96,515.00
Hardscrabble	346,339.00	312,962.00
Castle Gate	2,552,929.00	954,790.00
Willow Creek	132,377.00	132,377.00
Crandall Canyon *	350,000.00	350,000.00
TOTAL	$ 3,523,822.00	$ 1,846,644.00

* Bond Posted - 1980

COST OF RECLAMATION AND BONDING

ESTIMATE

SITE: Sowbelly Gulch - No. 5 Mine   ACRES: 13.5

DATE OF ESTIMATE: 3-14-83

LIFE OF FACILITY: Thru 1985

COSTS*

(1) Demolition	$ 40,000.00
(2) Portal Sealing	4,004.00
(3) Grading	22,950.00
(4) Re-soiling	42,706.00
(5) Revegetation	13,972.00
Subtotal	126,632.00
(6) Maintenance and Contingency (15%)	18,545.00
TOTAL COST AND PROPOSED BOND AMOUNT	$ 142,177.00

* See attached detailed breakdown forms for each phase of reclamation (1 through 5).

(1) DEMOLITION AND DISPOSAL COSTS FOR BUILDINGS AND STRUCTURES

* Type - construction materials of building

Steel = $0.35/ft^3$

Concrete = $0.43/ft^3$

Site: Sowbelly Gulch - No. 5 Mine

	Structure/Building	Type	Volume Standing (ft^3)	Cost
1.	Block Building	(C) 10 x 10 x 8	800	$ 344
2.	Block Building	(C) 10 x 10 x 8	800	344
3.	Arch	(S) 35 x Pi x $\bar{10}^2$	10,996	3,849
4.	Arch	(S) 30 x Pi x $\bar{10}^2$	9,425	3,299
5.	Arch	(S) 30 x Pi x $\bar{10}^2$	9,425	3,299
6.	Arch	(S) 30 x Pi x $\bar{10}^2$	9,425	3,299
7.	Steel Building	(S) 10 x 10 x 8	800	280
8.	Steel Building	(S) 10 x 10 x 8	800	280
9.	Steel Building	(S) 10 x 10 x 8	800	280
10.	Steel Building	(S) 15 x 20 x 6	1,800	630
11.	Shop	(S) 50 x 30 x 10	15,000	5,250
12.	Lean-to	(S) 50 x 8 x 8	3,200	1,120
13.	Steel Building	(S) 40 x 20 x 8	6,400	2,240
14.	Water Tank, 65,000 gal.	(S)	8,667	3,034
15.	Water Tank, 10,000 gal.	(S)	1,333	467
16.	Fan	(S)	1,000	350
17.	Lower Pump House	(C) 20 x 20 x 10	4,000	1,720
18.	Misc. Foundations	(C)	5,100	2,193
19.	Substation (move)	--	--	--
20.	5 Trailers and 1 Box Car (move)	--	--	--
21.	Misc. Power Poles, etc.	--	--	7,722
	TOTAL DEMOLITION AND DISPOSAL COST			$ 40,000

Site: Sowbelly Gulch - No. 5 Mine

(2) PORTAL SEALING

☐ UP DIP ($2,210/ea.) Number 2

☒ DOWN DIP ($2,002/ea.)

Total cost........................ $ 4,004.00

(3) GRADING COSTS

$1,700/Acre Acres to be Reclaimed 13.5

Total cost........................ $ 22,950.00

(4) RE-SOILING COSTS

I. Quantity of soil material needed 10,894 yds^3 (acres X 807)[1]

Where Obtained Gravel Canyon

Haul Distance 8 miles

Cost yd^3 delivered $ 3.25

Total cost...................... $ 35,407.00

II. Spreading Soil (67¢/yds^3 = $541.00/Acre)

Total cost...................... $ 7,299.00

Grand Total (I and II).......... $ 42,706.00

(1) For refuse pile covering specify acres of refuse -- and 6,456 yds^3/acre -- yds^3

(5) RE-VEGETATION - Seeding and Planting

Site: Sowbelly Gulch - #5 Mine Acres to be Reclaimed 13.5

Fertilizer $100.00 X Acres)	$ 1,350.00
Seeding & Mulching ($605.00 X Acres)	8,167.00
Tree & Shrub Planting ($290.00 X Acres)	3,915.00
Evaluation of Success ($40.00 X Acres)	540.00
Total Seeding & Planting Costs..............$	13,972.00

ALTERNATIVE COSTS

Native soil materials tested and found suitable for revegetation - No soil hauled in.

1. Delete $42,706.00 = $83,926.00 + 15% = $83,926.00
12,588.00 (15%)
$96,515.00

<u>SOWBELLY CANYON - BONDING ALTERNATIVE</u>

UMC 817.22(e) allows for the use of substitute re-soiling materials if chemical and physical tests demonstrate suitability of wuch materials. Tests of existing surface materials at the Sowbelly Canyon No. 5 Mine area will be performed during the spring or summer of 1983. Should materials prove suitable we will delete $42,706.00 of reclamation costs which included hauling and spreading of topsoil. About 11,000 yds^3 of soil materials at Gravel Canyon will be available for other uses (Castle Gate?).

The adjusted cost of reclamation for No. 5 Mine facilities will be:

	$ 126,632.00	
-	42,706.00	
	83,926.00	
+	12,588.00	(15%)
	$ 96,515.00	New Total

COST OF RECLAMATION AND BONDING

ESTIMATE

SITE: No. 3 and No. 4 Mines Hardscrabble Canyon ACRES: 24

DATE OF ESTIMATE: 3-10-83

LIFE OF FACILITY: 2 years (from March 1983)

COSTS*

(1)	Demolition	$ 150,000.00
(2)	Portal Sealing	10,010.00
(3)	Grading	40,800.00
(4)	Re-soiling	75,514.00
(5)	Revegetation	24,840.00
	Subtotal	301,164.00
(6)	Maintenance and Contingency (15%)	45,175.00
	TOTAL COST AND PROPOSED BOND AMOUNT	$ 346,339.00

* See attached detailed breakdown forms for each phase of reclamation (1 through 5).

(1) DEMOLITION AND DISPOSAL COSTS FOR BUILDINGS AND STRUCTURES

* Type - construction materials of building

Steel = $0.35/ft^3$

Concrete = $0.43/ft^3$

Site: Hardscrabble Canyon - No. 3 and No. 4 Mines

	Structure/Building	Type	Volume Standing (ft^3)	Cost
1.	Water Tanks	S	9,333	$ 3,267
2.	Fan Structures	S	3,000	1,050
3.	Substations	C	100	43
4.	Scalping Structure	S	2,000	700
5.	Loadout Structure	S	2,000	700
6.	Truck Building	S	3,000	1,050
7.	Motor Building	S	4,500	1,575
8.	Small Change House	C	7,000	3,010
9.	2 Sheds, Storage	S	2,000	700
10.	Quonset	S	6,400	2,240
11.	Storage	S	4,000	1,400
12.	Shop	S	75,000	26,250
13.	Scale House	C	3,600	1,548
14.	Warehouse	S	140,000	49,000
15.	Lean-to	C	2,250	968
16.	Large Change House	C	52,500	22,575
17.	Misc. - Conc. Dist. Lines, etc.	--	--	26,224
18.				
19.				
20.				

TOTAL DEMOLITION AND DISPOSAL COST........$ 150,000

Site: Hardscrabble Canyon - No. 3 and No. 4 Mines

(2) PORTAL SEALING

☐ UP DIP ($2,210/ea.) Number 5

☒ DOWN DIP ($2,002/ea.)

Total cost........................ $ 10,010.00

(3) GRADING COSTS

$1,700/Acre Acres to be Reclaimed 24

Total cost........................ $ 40,800.00

(4) RE-SOILING COSTS

I. Quantity of soil material needed 31,464 yds^3 (acres X 807)(1)

Where Obtained Gravel Canyon

Haul Distance 3 miles

Cost yd^3 delivered $ 1.73

Total cost........................ $ 54,433.00

II. Spreading Soil (67¢/yds^3 = $541.00/Acre)

Total cost........................ $ 21,081.00

Grand Total (I and II)........... $ 75,514.00

(1) For refuse pile covering specify acres of refuse 3.5 and 6,456 yds^3/acre 12,093 yds^3

(5) RE-VEGETATION - Seeding and Planting

Site: No. 3 and No. 4 Mines Hardscrabble Canyon   Acres to be Reclaimed 24

Fertilizer $100.00 X Acres)	$ 2,400.00
Seeding & Mulching ($605.00 X Acres)	14,520.00
Tree & Shrub Planting ($290.00 X Acres)	6,960.00
Evaluation of Success ($40.00 X Acres)	960.00
Total Seeding & Planting Costs..............	$ 24,840.00

ALTERNATE COSTS

If refuse pile is non-toxic and only 6" of material is needed -

Delete 12,093 yds^3 of soil hauled

X	$1.73	=	$ 20,921.00
X	0.67		8,102.00
			$ 29,023.00

Reclamation Cost	$ 301,164.00	
	- 29,023.00	
	$ 272,141.00	
	+ 40,821.00	(15%)
	$ 312,962.00	New Total

HARDSCRABBLE CANYON - No. 3 and No. 5 Mine Areas

BONDING ALTERNATIVE

Both UMC 817.83(iii) and UMC 817.85(d) consider the possibility of the existence of non-toxic refuse material and allow for a variance from the 4' cover requirement based on chemical and physical tests of materials which indicate suitability in reference to vegetational success. Tests will be performed shortly, which we feel will show non-toxicity of the old refuse material stored in Hardscrabble Canyon.

Some recent tests were performed in June of 1982 by Native Plants, Inc. under a Bureau of Mines grant. A copy is included.

Should our further test bear out the earlier Native Plants, Inc. findings, we feel a variance is in order. We would delete the hauling and spreading costs for 12,000 yds^3 of soil materials = $29,023.00.

The 12,000 yds^3 of soil would be available for other re-soiling needs.

The adjusted Hardscrabble Canyon reclamation costs would be:

$ 301.164.00	
- 29,023.00	
$ 272,141.00	
+ 40,821.00	(15%)
$ 312.962.00	New Cost

TESTS DONE BY NATIVE PLANTS INC. UNDER BUREAU MINES GRANT.

Table .

	pH	EC	SAR	K*	Na*	Ca*	Mg*	Cl*	SO_4*	HCO_3*
Topsoil	8.38	0.14	0.47	0.53	0.52	23.0	1.16	<.001	0.04	0.009
New refuse (School House)	7.89	1.76	3.62	0.44	4.26	26.4	1.23	0.31	1.6	0.014
New refuse	9.43	0.73								
Topsoil	8.99	0.11								
Old refuse (#3 Mine, Hardscrabble)										
0-15 cm	6.70	0.96								
15-30 cm	5.77	1.55								
#22										
0-15 cm	8.53	0.22	0.26	0.25	0.37	36.4	2.30	0.03	1.3	0.010
15-30 cm	8.38	0.37	0.22	0.19	0.31	37.9	2.06	<.001	1.48	0.012
#23										
0-30 cm	8.05	0.40								

	ppm B	%K	NO_3-N	P	% Organic Matter	% Sand	% Silt	% Clay	Texture
Topsoil	58.0	0.62	1.35	4.2	3.4	37	37	26	loam
New refuse (School House)	58.4	0.39				63	16	21	sandy clay loam
New refuse			0.90	2.0	6.3	63	17	20	sandy clay loam
Topsoil						35	32	33	clay loam
Old refuse (#3 Mine)									
0-15 cm						72	12	16	sandy loam
15-30 cm						70	12	18	sandy loam
#22									
0-15 cm	176.4	0.24	1.0	4.0	6.3	74	12	14	sandy loam
15-30 cm	224.4	0.18	0.7	4.2	4.5	67	19	14	sandy loam
#23									
0-30 cm						75	11	14	sandy loam

*expressed as meq/100g.

COST OF RECLAMATION AND BONDING

ESTIMATE

SITE: Castle Gate and Utah Fuel No. 1

ACRES: 58

35 - Facility Area
23 - Refuse Pile

DATE OF ESTIMATE: 3-14-83

LIFE OF FACILITY: 30 - 80 years

COSTS*

(1) Demolition...........................	$ 529,000.00
(2) Portal Sealing......................	4,420.00
(3) Grading.............................	98,600.00
(4) Re-soiling..........................	1,527,888.00
(5) Revegetation........................	60,030.00
Subtotal	2,219,938.00
(6) Maintenance and Contingency (15%).....	332,990.00
TOTAL COST AND PROPOSED BOND AMOUNT	$ 2,552,929.00

* See attached detailed breakdown forms for each phase of reclamation (1 through 5).

(1) DEMOLITION AND DISPOSAL COSTS FOR BUILDINGS AND STRUCTURES

* Type - construction materials of building

Steel = $0.35/ft^3$

Concrete = $0.43/ft^3$

Site: Castle Gate and Utah Fuel No. 1

	Structure/Building	Type	Volume Standing (ft^3)	Cost
1.	Preparation Plant	Steel	782,080	$ 273,728.00
2.	Bath House	Steel	182,695	63,944.00
3.	Div. 2 - U.F.	Steel	14,621	5,118.00
4.	Div. 4 - Transfer House	Steel	7,776	2,722.00
5.	Div. 5 - Truck Dump	Steel	5,814	2,035.00
6.	Div. 8 - Breaker Bldg.	Steel	82,800	28,980.00
7.	Div.10 - Raw Coal	Concrete	34,749	14,943.00
8.	Div.12A - Sample	Steel	21,924	7,674.00
9.	Div.13 - Clean Coal	Concrete	82,800	35,604.00
10.	940' Belt - Tube	Steel 940 x 4^2 x Pi	47,250	20,510.00
11.	Substation, Power Poles and Miscellaneous	--	--	--
12.	4540 Belt - Gallery	Steel 4540 x 6^2	163,440	57,204.00
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				

TOTAL DEMOLITION AND DISPOSAL COST........$ 529,000.00

Site: Castle Gate and Utah Fuel No. 1

(2) PORTAL SEALING

[X] UP DIP ($2,210/ea.) Number 2

[ ] DOWN DIP ($2,002/ea.)

Total cost........................ $ 4,420.00

(3) GRADING COSTS

$1,700/Acre Acres to be Reclaimed 58

Total cost........................ $ 98,600.00

(4) RE-SOILING COSTS (A) * See Also attached (B) and (C) re-soiling costs for total.

I. Quantity of soil material needed 176,733 yds^3 (acres X 807) (1)

Where Obtained Gravel Canyon 10,000 yds^3

Haul Distance 1/2 miles

Cost yd^3 delivered $ 1.21

Total cost........................ $ 12,100.00

A + B + 3 = $1,409,477.00

II. Spreading Soil (67¢/yds^3 = $541.00/Acre)

Total cost........................ $ 118,411.00

Grand Total (I and II)........... $ 1,527,888.00

(1) For refuse pile covering specify acres of refuse 23 and 6,456 yds^3/acre 148,488 yds^3

+ 28,245 yds^3 Facility Area

Site: Castle Gate and Utah Fuel No. 1

(4) RE-SOILING COSTS (B)

I. Quantity of soil material needed 166,733 yds^3 (acres X 807)

Where Obtained Crandall Canyon 8,000 yds^3

Haul Distance 3 miles

Cost yd^3 delivered $ 2.05

Total cost.......................... $ 16,400.00

(4) RE-SOILING COSTS (C)

I. Quantity of soil material needed 158,733 yds^3 (acres X 807)

Where Obtained Helper Area

Haul Distance 3 miles

Cost yd^3 delivered $ 8.70

Total cost.......................... $ 1,380,977.00

(5) RE-VEGETATION - Seeding and Planting

Site: Castle Gate and Utah Fuel No. 1 Acres to be Reclaimed 58

Fertilizer $100.00 X Acres)	$ 5,800.00
Seeding & Mulching ($605.00 X Acres)	35,090.00
Tree & Shrub Planting ($290.00 X Acres)	16,820.00
Evaluation of Success ($40.00 X Acres)	2,320.00
Total Seeding & Planting Costs.............$	60,030.00

CASTLE GATE AND UTAH FUEL NO. 1

ALTERNATE BONDING COSTS

Assuming that the refuse in Schoolhouse Canyon can demonstrate non-toxicity (see Hardscrabble Canyon alternative bonding discussion and attached tests), then we would apply for a variance to the 4' cover requirements. Should we prove successful the quantity of re-soiling material needed would be reduced from 176,733 yds^3 to 46,806 yds^3.

Haulage and purchase costs may also be reduced by the reduction of soil material needed at Hardscrabble and Sowbelly (see alternative bonding discussions). Some 33,000 yds^3 would be available from Gravel Canyon at a delivery cost of $2.21/$yd^3$ = $39,930.00. Eight thousand (8,000) yds^3 would still be available from the lower Crandall Canyon topsoil pile, leaving 5,806 yds^3 to be purchased.

Adjusted Reclamation Costs

33,000 yds^3 @ $1.21/$yds^3$	=	$ 39,930.00
8,000 yds^3 @ $2.05/$yds^3$	=	16,400.00
5,806 yds^3 @ $8.70/$yds^3$	=	50,512.00
Spreading 46,806 yds^3 @ $0.67/$yd^3$	=	31,360.00
TOTAL NEW RE-SOILING COSTS	=	$ 138,202.00
Other Factors		+692,050.00
		$ 830,252.00
15%		+124,538.00
		$ 954,790.00

TESTS DONE BY NATIVE PLANTS, INC, UNDER BU. MINES GRANT

Table .

	pH	EC	SAR	K*	Na*	Ca*	Mg*	Cl*	SO_4*	HCO_3*
Topsoil	8.38	0.14	0.47	0.53	0.52	23.0	1.16	<.001	0.04	0.009
New refuse (School House)	7.89	1.76	3.62	0.44	4.26	26.4	1.23	0.31	1.6	0.014
New refuse	9.43	0.73								
Topsoil	8.99	0.11								
Old refuse										
0-15 cm	6.70	0.96								
15-30 cm	5.77	1.55								
#22										
0-15 cm	8.53	0.22	0.26	0.25	0.37	36.4	2.30	0.03	1.3	0.010
15-30 cm	8.38	0.37	0.22	0.19	0.31	37.9	2.06	<.001	1.48	0.012
#23										
0-30 cm	8.05	0.40								

	ppm B	%K	NO_3-N	P	% Organic Matter	% Sand	% Silt	% Clay	Texture
Topsoil	58.0	0.62	1.35	4.2	3.4	37	37	26	loam
New refuse (School House)	58.4	0.39				63	16	21	sandy clay loam
New refuse			0.90	2.0	6.3	63	17	20	sandy clay loam
Topsoil						35	32	33	clay loam
Old refuse									
0-15 cm						72	12	16	sandy loam
15-30 cm						70	12	18	sandy loam
#22									
0-15 cm	176.4	0.24	1.0	4.0	6.3	74	12	14	sandy loam
15-30 cm	224.4	0.18	0.7	4.2	4.5	67	19	14	sandy loam
#23									
0-30 cm						75	11	14	sandy loam

*expressed as meq/100g.

LABORATORY ANALYSES REPORT

J. H. M. Laboratories

ANALYTICAL AND CONSULTING LABORATORIES

325 THIRTEENTH STREET
DUNBAR, W. VA. 25064
(304) 766-6283

ATTN: Frank L. Pero

Price River Coal Co.
P.O. Box 629
Helper, UT 84526

Analyst: Hehman

Lab No. See below
Date Sampled 10/29/80
Date Received 11/6/80
Date Analyzed 11/6/80

Lab Number	39086	39087	39088	
Identification	Thickener sludge	Lubricating oil	Hydraulic oil	
Arsenic	<0.03	<0.03	<0.03	mg/l
Barium	0.2	0.2	0.1	mg/l
Cadmium	0.01	0.32	0.22	mg/l
Chromium	< 0.01	0.08	0.09	mg/l
Lead	<0.1	2.2	1.3	mg/l
Mercury	<1	<1	<1	ug/l
Selenium	<1	<1	<1	ug/l
Silver	<0.01	0.14	0.05	mg/l

Samples prepared and analyzed according to RCRA EP Toxicity procedure 40CRR 261.

REC[illegible]
DEC 5 1980

WILLIAM B. MILLER
PRESIDENT
DAYTON CARPENTER
VICE PRESIDENT, CHEMIST
JOHN R. HART
SECRETARY-TREASURER

Submitted by *A. Dayton Carpenter /sm*
A. Dayton Carpenter

784.19 Underground Development Waste

LABORATORY ANALYSES REPORT

J. H. M. Laboratories

ANALYTICAL AND CONSULTING LABORATORIES

325 THIRTEENTH STREET
DUNBAR, W. VA. 25064
(304) 766-6283

ATTN: Frank Pero

Price River Coal Co.

P.O. Box 629

Helper, UT 84526

Analyst Wehrman - Villers

Lab No. See below

Date Sampled See below

Date Received 11/6/80

Date Analyzed 11/6/80

Lab Numbers	39084	39085	
Identification	Refuse Pile	Refuse Pile Retention Pond	
Date Sampled	10/29/80	10/10/80	
Arsenic	<0.03	<0.03	mg/l
Barium	0.3	0.1	mg/l
Cadmium	0.01	<0.01	mg/l
Chromium	<0.01	<0.01	mg/l
Lead	<0.1	<0.1	mg/l
Mercury	<1	<1	ug/l
Selenium	<1	2	ug/l
Silver	<0.01	<0.01	mg/l

Samples prepared and analyzed according to RCRA EP Toxicity procedure 40CFR 261.

RECEIVED
DEC 1 1980
FP

WILLIAM B. MILLER
PRESIDENT
DAYTON CARPENTER
VICE PRESIDENT, CHEMIST
JOHN R. HART
SECRETARY-TREASURER

Submitted by A. Dayton Carpenter
A. Dayton Carpenter

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 · AREA CODE 312 726-8434

WESTERN DIVISION MANAGER
LOYD W. TAYLOR, JR.

SINCE 1908

PLEASE ADDRESS ALL CORRESPONDENCE TO:
139 SOUTH MAIN, HELPER, UTAH 84526
OFFICE TEL. (801) 472-3537

PRICE RIVER COAL CO.
P.O. Box 629
Helper, Utah 84526

Jan. 25, 1980

Sample identification by
Price River Coal Co.
Refuse Pile
1211-UT-9-0027

Kind of sample reported to us: Coal

Sample taken at: Castle Gate Prep. Plant-Refuse Pile

Sample taken by: Price River Coal Co.

Date sampled: 1-16-80

Date received: 1-16-80

Analysis report no. 57-3329

TOXICITY- Following procedure as outlined in the Federal Register, Part IV. Dec. 18, 1978

Arsenic- 0.011 mg/l
Selenium- less than or = to 0.002 mg/l
Mercury- less than or = to 0.04 micrograms/l
Cadmium- less than or = to 0.004 mg/l
Lead- less than or = to 0.06 mg/l
Cromium- less than or = to 0.01 mg/l
Silver- less than or = to 0.01 mg/l
Barium- 0.8 mg/l

ACIDITY- Sample prepared 1:1 coal-water extraction, following procedures of the U.S. Dept. of Agriculture-Handbook 60. Acidity determined as directed in Standard Methods 14th Edition.

Acidity- 0

JB/gp

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.
Jack Blair,
Jack Blair
Manager, Helper Laboratory

Charter Member

COST OF RECLAMATION AND BONDING

ESTIMATE

SITE: Willow Creek ACRES: 11.0

DATE OF ESTIMATE: 3-14-83

LIFE OF FACILITY: 30 - 50 years

COSTS*

(1)	Demolition...........................	$ 1,849.00
(2)	Portal Sealing.......................	--
(3)	Grading..............................	18,700.00
(4)	Re-soiling...........................	83,177.00
(5)	Revegetation.........................	11,385.00
Subtotal		115,110.00
(6)	Maintenance and Contingency (15%).....	17,266.00
TOTAL COST AND PROPOSED BOND AMOUNT		$ 132,377.00

* See attached detailed breakdown forms for each phase of reclamation (1 through 5).

(1) DEMOLITION AND DISPOSAL COSTS FOR BUILDINGS AND STRUCTURES

* Type - construction materials of building

Steel = $0.35/ft^3

Concrete = $0.43/ft^3

Site: Willow Creek Storage Area

	Structure/Building	Type	Volume Standing (ft^3)	Cost
1.	Substation	C (Foundation)	800	$ 344.00
2.	Storage Building	Concrete Block	3,500	1,505.00
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				

TOTAL DEMOLITION AND DISPOSAL COST........$ 1,849.00

Site: Willow Creek

(2) PORTAL SEALING

☐ UP DIP ($2,210/ea.) Number NA

☐ DOWN DIP ($2,002/ea.)

Total cost...................... $ --

(3) GRADING COSTS

$1,700/Acre Acres to be Reclaimed 11

Total cost...................... $ 18,700.00

(4) RE-SOILING COSTS

I. Quantity of soil material needed 8,877 yds^3 (acres X 807)[(1)]

Where Obtained Purchase - Helper Area

Haul Distance 4 miles

Cost yd^3 delivered $ 8.70

Total cost...................... $ 77,230.00

II. Spreading Soil (67¢/yds^3 = $541.00/Acre)

Total cost...................... $ 5,948.00

Grand Total (I and II).......... $ 83,177.00

(1) For refuse pile covering specify acres of refuse -- and 6,456 yds^3/acre -- yds^3

(5) RE-VEGETATION - Seeding and Planting

Site: Willow Creek Storage Area   Acres to be Reclaimed 11

Fertilizer $100.00 X Acres)	$ 1,100.00
Seeding & Mulching ($605.00 X Acres)	6,655.00
Tree & Shrub Planting ($290.00 X Acres)	3,190.00
Evaluation of Success ($40.00 X Acres)	440.00
Total Seeding & Planting Costs..............$	11,385.00

ITEM 3

Price River Coal commits to the following regulatory requirements concerning temporary cessation of operations.

UMC 817.131 Cessation of Operations: Temporary

(a) Each person who conducts underground coal mining activities shall effectively support and maintain all surface access openings to underground operations, and secure surface facilities in areas in which there are no current operations, but operations are to be resumed under an approved permit. Temporary abandonment shall not relieve a person of his or her obligation to comply with any provision of the approved permit.

(b) Before temporary cessation of mining and reclamation operations for a period of thirty days or more, or as soon as it is known that a temporary cessation will extend beyond 30 days, each person who conducts underground mining activities shall submit to the Division a notice of intention to cease or abandon operations. This notice shall include a statement of the exact number of surface acres and the horizontal and vertical extent of sub-surface strata which have been in the permit area prior to cessation or abandonment, the extent and kind of reclamation of surface area which will have been accomplished, and identification of the backfilling, regrading, revegetation, environmental monitoring, underground opening closures and water treatment activites that will continue during the temporary cessation.

As required by comments under UMC 817.131.

ITEM 4

PORTAL SEALS

Drawing included as part of bonding information.

Down dip portals will have a drainpipe allowing discharge and preventing buildup of excess head. Recent water tests have shown that water quality is acceptable to discharge without treatment. Quantity will be discussed as part of the water information to be submitted at a later date.

As required by comments under UMC 784.13.

ITEM 5

DISCUSSIONS OF REFUSE PILE CONSTRUCTION, REFUSE PILE POND AND SCHOOLHOUSE CANYON DIVERSION

As required by comments under UMC 784.16 and 784.22.

PRICE RIVER COAL COMPANY

INTER-OFFICE MEMORANDUM

TO: R. L. Wiley DATE: 1-11-83

FROM: F. L. Pero C.C.:

SUBJECT: Refuse Pile Construction

Construction of this facility was begun in 1978 and completed in 1979. During this time close communication with the State Engineer's Office was maintained and the site was visited several times by representatives of that office.

The primary concerns of the regulators were the competency of the pond embankment and drainage of the pile itself. In an effort to allay these fears, the pond embankment was constructed with engineered backfill and tight contruction specifications were maintained.

The rock underdrain was constructed using material excavated from the diversion structure. The diversion was cut entirely in rock and runs parallel to the canyon floor for most of its length. The blasted rock was dozed into a blanket at least 4 ft. thick and is uniformly mixed rock ranging in size up to about 4 ft. There are larger pieces, but these occur only randomly. No less than 60% of the material is in the 2 ft. minus range, 25% is 2 ft. to 3 ft. range, 10% is 3 ft. to 4 ft. and no more than 5% is larger than about 5 ft. diameter. Also, a crushed rock underdrain was installed between the toe of the pond embankment and the trash rack inlet on the pond overflow ditch. This was designed to collect any ground water which might collect either at the abutments or beneath the pond embankment.

As mentioned before, very tight controls were exercised during the construction of this faility. This consisted partly of very comprehensive soil and compaction testing. Nuclear density tests were performed on every 6" compacted lift throughout the embankment height, with no less than 3 tests taken at random locations on every lift. Laboratory series tests were conducted several times during the construction to ensure that the correct proctor information was being used to determine in-place density. Copies of all test results were furnished to the State Engineer's Office.

Frank Pero

Frank L. Pero

FP:jp

PRICE RIVER COAL COMPANY

INTER-OFFICE MEMORANDUM

TO: Rob Wiley

DATE: 1-25-83

FROM: Frank Pero

c.c.: File

SUBJECT: Settling Pond Embankment Relief Wells and Diversion Ditch

Attached are detail and plan drawings of the relief wells. These relief wells were constructed as shown to help ensure the stability of the settling pond embankment.

The blanket drain consists of 4 ft. of 2 inch drain rock placed over a "proof-rolled" surface. This proof-rolled area was constructed by first ripping or scarifying the earth and then compacting to 95% relative density. The drain rock was then placed in 1 ft. thick lifts and the embankment construction begun.

Provision has been made in the relief wells for monitoring via the threaded caps on the 10" dia. pipe covering each well.

To reduce the capacity required for the settling pond itself, a diversion ditch was excavated to carry runoff water from the undisturbed upper portion of Schoolhouse Canyon (approximately 193 acres), to Barn Canyon. This "ditch" is actually a rather large channel having a cross-sectional area of 117 sq. ft. minimum. The diversion, which is some 1,400 ft. in length, was constructed by conventional blasting methods. Rock overburden was shot down to reach the designed grade, then the channel itself was excavated by blasting. Altogether, approximately 60,000 cubic yards of rock was excavated to form the diversion. This excavated rock was bulldozed into place to form the rock underdrain beneath the refuse pile. Small areas of unconsolidated material which was encountered were over-excavated and backfilled with rock.

The discharge end of the diversion was widened substantially in the bend area to reduce velocity before the effluent enters Barn Canyon.

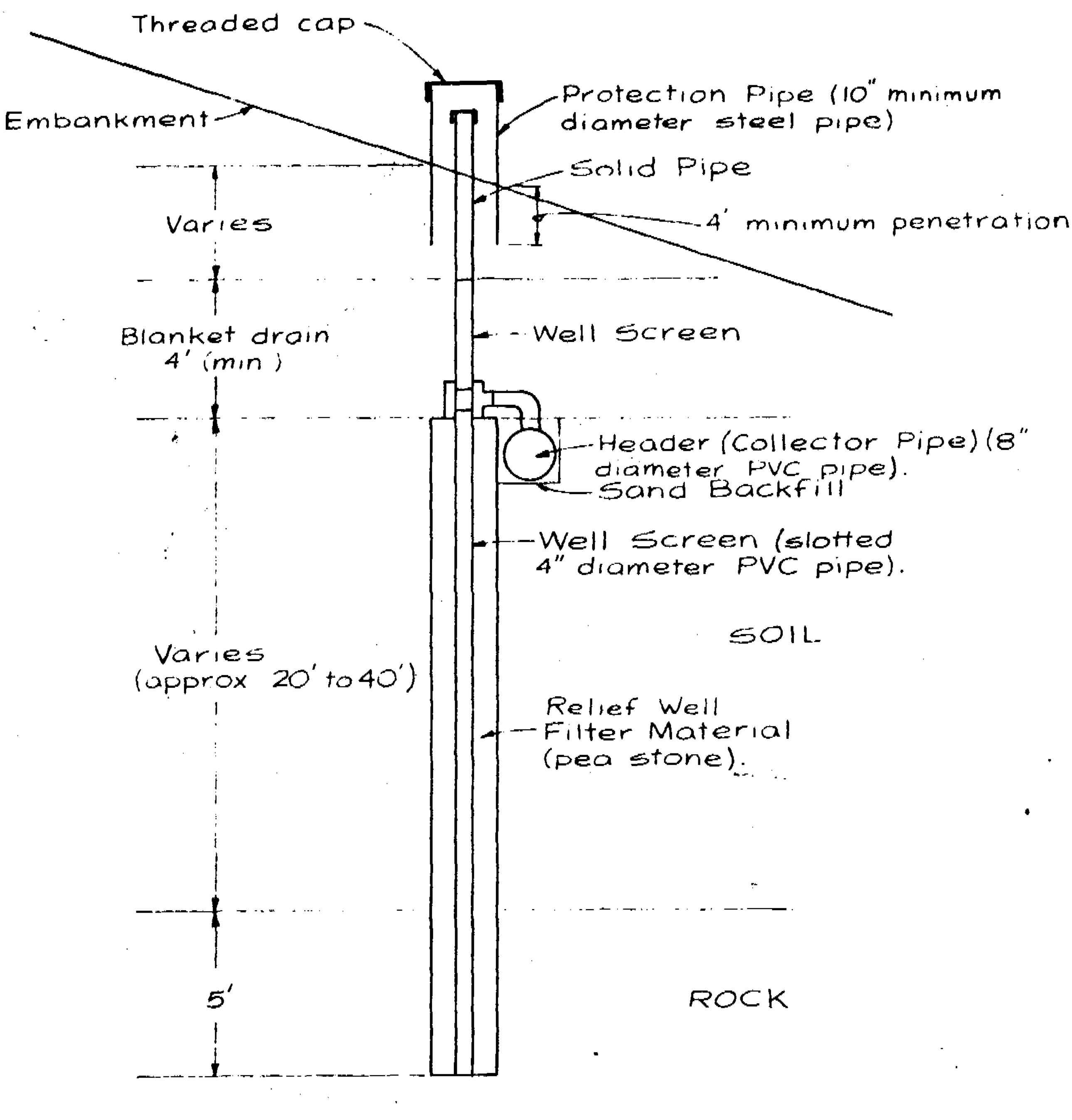
The outlet was angled to enter a small natural gulley, in an effort to reduce erosion down the Barn Canyon side, and a small basin built at the bottom where this flow enters the Barn Canyon drainage. In an effort to reduce surface disturbance as much as possible, the area occupied by the basin was not excavated but was formed by using a small dozer to push rock already in the area into a small natural depression. This was supplemented by dozing large boulders into rocky areas in the natural stream bed.

To date, there is little if any erosion noticeable in Barn Canyon that is attributable to the Schoolhouse Canyon diversion.

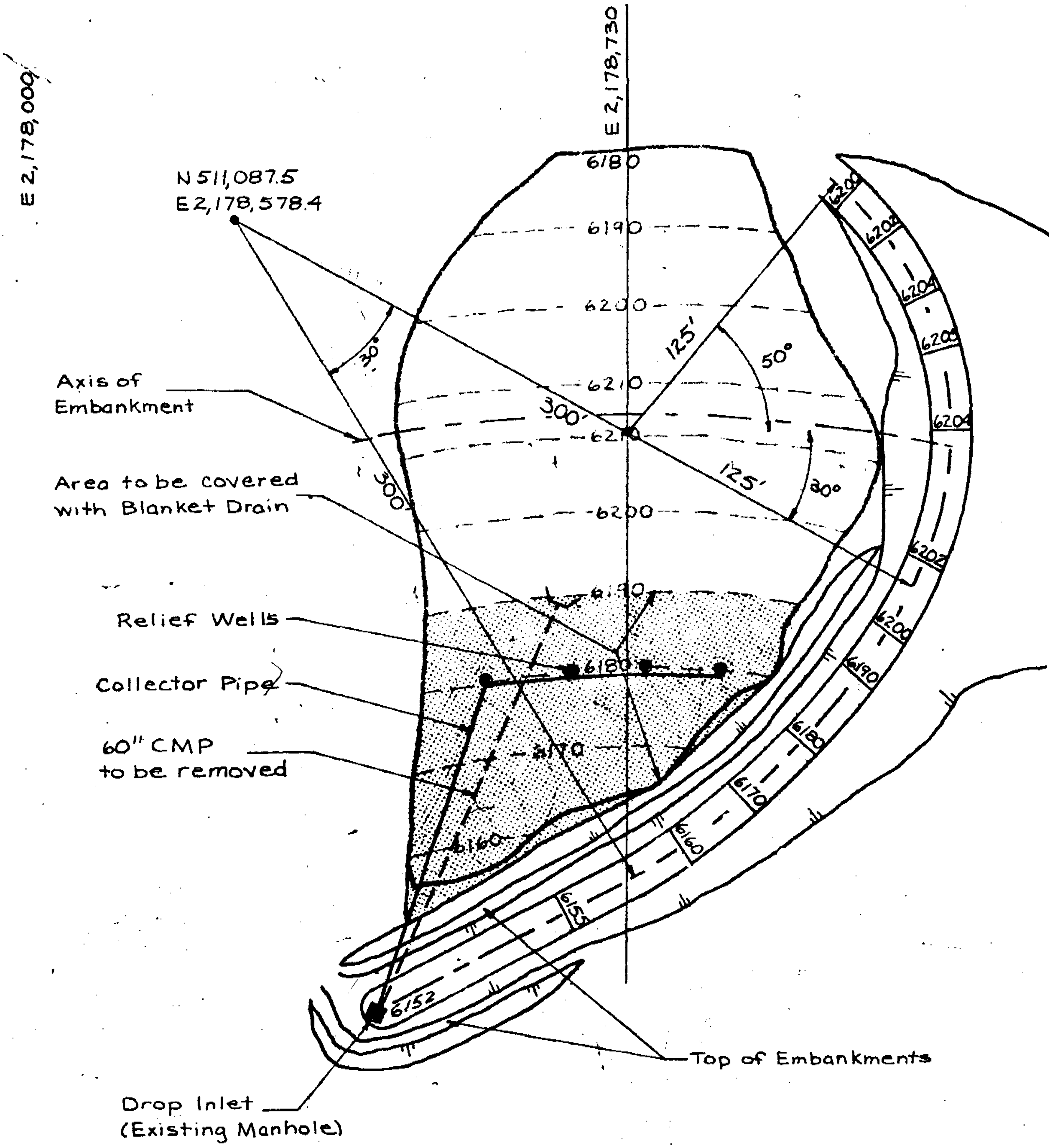
Frank Pero

Frank Pero

FP:jp



RELIEF WELL DETAIL



E 2,178,000
E 2,178,730
N 511,087.5
E 2,178,578.4
Axis of Embankment
Area to be covered with Blanket Drain
Relief Wells
Collector Pipe
60" CMP to be removed
Drop Inlet (Existing Manhole)
Top of Embankments
30°
50°
30°
125'
125'
300'
300'
6180
6190
6200
6210
6210
6200
6190
6180
6170
6160
6152
6155
6200
6202
6204
6206
6204
6202
6200
6190
6180
6170
6160

10-21-80

X	TRACE 49'	Dry 22'
TRACE 36'	TRACE 46'	TRACE 18'

10-28-80

X	TRACE 49'	TRACE 22'
TRACE 36'	TRACE 46'	TRACE 18'

11-4-80

X	TRACE 49'	TRACE 22'
TRACE 36'	1" 46'	TRACE 18'

11-12-80

	TRACE	TRACE
X	|	|
	49'	22'
1"	1"	TRACE
|	|	|
36'	46'	18'

11-18-80

	TRACE	TRACE
X	|	|
	49'	22'
TRACE	1"	TRACE
|	|	|
36'	46'	18'

11-25-80

	TRACE	TRACE
X	|	|
	49'	22'
TRACE	1"	TRACE
|	|	|
36'	46'	18'

12-2-80

X	TRACK | 49'	TRACK | 22'
TRACK | 36'	2" | 46'	TRACK | 18'

12-10-80

X	TRACK | 49'	TRACK | 22'
TRACK | 36'	2" | 46'	TRACK | 18'

12-11-80

X	TRACK | 49'	TRACK | 22'
TRACK | 36'	1" | 46'	TRACK | 18'

12-22-80

X	Trace 49'	Trace 22'
Trace 36'	1" 46'	Trace 18'

12-29-80

X	Trace 49'	Dry 22'
Trace 36'	Trace 46'	Trace 18'

1-6-81

X	Trace 49'	Dry 22'
Trace 36'	1" 46'	Trace 18'

1-14-81

X	TRACE 49'	TRACE 22'
TRACE 36'	1" 46'	TRACK 18'

1-21-81

X	TRACE 49'	TRACE 22'
1" 36'	1" 46'	TRACE 18'

1-27-81

X	TRACE 49'	TRACE 22'
1" 36'	2" 46'	TRACE 18'

2-2-81

X	Trace 49'	Trace 22'
Trace 36'	1" 46'	Trace 18'

2-11-81

X	Trace 49'	Dry 22'
Trace 36'	Trace 46'	Trace 18'

2-17-81

X	Trace 49'	Dry 22'
Trace 36'	1" 46'	Trace 18'

2-24-81

X	Dry | 49'	Dry | 22'
TRACE | 36'	TRACE | 46'	TRACE | 18'

3-3-81

X	Dry | 49'	Dry | 22'
TRACE | 36'	TRACE | 46'	TRACE | 18"

3-10-81

X	Dry | 49'	Dry | 22'
TRACE | 36'	1" | 46'	TRACE | 18'

3-16-81

X	Trace 49'	Dry 22'
Trace 36'	1" 46'	Trace 18'

3-24-81

X	Trace 49'	Dry 22'
Trace 36'	2" 46'	Trace 18'

3-30-81

X	Trace 49'	Trace 22'
1" 36'	2" 46'	Trace 18'

4-8-81

X	1"	TRACE
	49'	22'
1"	2"	TRACE
36'	46'	18'

4-15-81

X	TRACE	Dry
	49'	22'
TRACE	1"	TRACE
36'	46'	18'

4-21-81

X	TRACE	Dry
	49'	22'
TRACE	TRACE	Dry
36'	46'	18'

4-28-81

X	TRACE 49'	Dry 22'
TRACE 36'	TRACE 46'	Dry 18'

5-6-81

X	TRACE 49'	Dry 22'
TRACE 36'	1" 46'	TRACE 18'

5-12-81

X	TRACE 49'	Dry 22'
TRACE 36'	1" 46'	TRACE 18'

5-19-81

X	TRACE 49'	Dry 22'
TRACE 36'	TRACE 46'	Dry 18'

5-27-81

X	TRACE 49'	Dry 22'
TRACE 36'	TRACE 46'	Dry 18'

6-2-81

X	Dry 49'	Dry 22'
Dry 36'	Dry 46'	Dry 18'

6-9-81

X	Dry 49'	Dry 22'
Dry 36'	TRACE 46'	Dry 18'

6-16-81

X	Dry 49'	Dry 22'
Dry 36'	TRACE 46'	Dry 18'

6-23-81

X	Dry 49'	Dry 22'
Dry 36'	TRACE 46'	Dry 18'

6-30-81

X	Dry 49'	Dry 22'
Dry 36'	Dry 46'	Dry 18'

7-7-81

X	Dry 49'	Dry 22'
Dry 36'	Dry 46'	Dry 18'

7-14-81

X	Dry 49'	Dry 22'
Dry 36'	Trace 46'	Dry 18'

7-23-81

X	Dry 49'	Dry 22'
Dry 36'	Trace 46'	Dry 18'

8-13-81

X	Dry 49'	Dry 22'
Trace 36'	Trace 46'	Dry 18'

8-18-81

X	Dry 49'	Dry 22'
Dry 36'	Trace 46'	Dry 18'

8-26-81

X	Dry 49'	Dry 22'
Dry 36'	TRACE 46'	Dry 18'

9-2-81

X	Dry 49'	Dry 22'
Dry 36'	TRACE 46'	Dry 18'

9-8-81

X	Dry 49'	Dry 22'
TRACE 36'	TRACE 46'	Dry 18'

9-15-81

X	Dry 49'	Dry 22'
Trace 36'	1" 46'	Dry 18'

9-23-81

X	Trace 49'	Trace 22'
Trace 36'	1" 46'	Trace 18'

9-29-81

X	Trace 49'	Trace 22'
Trace 36'	2" 46'	Trace 18'

10-8-81

X	TRACE | 49'	TRACE | 22'
1" | 36'	2" | 46'	TRACE | 18'

10-12-81

X	TRACE | 49'	Dry | 22'
TRACE | 36'	1" | 46'	TRACE | 18'

10-20-81

X	Dry | 49'	Dry | 22'
TRACE | 36'	TRACE | 46'	Dry | 18'

10-26-81

X	Dry | 49'	Dry | 22'
TRACE | 36'	TRACE | 46'	Dry | 18'

11-3-81

X	Dry | 49'	Dry | 22'
Dry | 36'	TRACE | 46'	Dry | 18'

11-9-81

X	Dry | 49'	Dry | 22'
Dry | 36'	TRACE | 46'	Dry | 18'

11-17-81

X	DRY | 49'	DRY | 22'
TRACE | 36'	TRACE | 46'	DRY | 18'

11-25-81

X	TRACE | 49'	TRACE | 22'
TRACE | 36'	1" | 46'	TRACE | 18'

11-31-81

X	TRACE 49' |	TRACE 22' |
TRACE 36' |	1" 46' |	TRACE 18' |

12-10-81

	TRACE 49'	TRACE 18'
X	|	|
Dry 36'	TRACE 46'	TRACE 18'
|	|	|

12-14-81

	Dry 49'	Dry 22'
X	|	|
Dry 36'	TRACE 46'	Dry 18'
|	|	|

12-22-81

	Dry 49'	Dry 22'
X	|	|
TRACE 36'	1" 46'	Dry 18'
|	|	|

12-29-81

Dry 49'

Dry 22'

X

Dry 18'

1" 46'

TRACE 36'

1-5-82

TRACE 22'

TRACE 49'

X

TRACE 18'

2" 46'

1" 36'

1-13-82

Dry 22'

Dry 49'

X

TRACE 18'

2" 46'

TRACE 36'

1-20-82

X	Dry 49'	Dry 22'
2" 36'	2" 46'	Dry 18'

1-28-82

X	Dry 49'	Dry 22'
TRACE 36'	4" 46'	TRACE 18'

2-2-82

X	Dry 49'	Dry 22'
TRACE 36'	6" 46'	Dry 18'

2-11-82

X	Dry 49' 1	Dry 22' 1
Trace 36' 1	8" 46' 1	Dry 18' 1

2-17-82

X	Trace 49' 1	Trace 22' 1
Trace 36' 1	8" 46' 1	Trace 18' 1

2-25-82

X	Dry 49' 1	Dry 22' 1
Tracr 36' 1	1' 46' 1	Trace 18' 1

3-3-82

X	Dry 49'	Dry 22'
2" 36'	3' 46'	Dry 18'

3-12-82

X	Dry 49'	Dry 22'
1½' 36'	5' 46'	Dry 18'

3-18-82

X	Dry 49'	Dry 22'
2' 36'	6' 46'	TRACE 18'

3-26-82

	Trace	Trace
	49'	22'
X	1	1
1½'	3½'	2"
36'	46'	18'
1	1	1

3-27-82

	Dry	Dry
	49'	22'
X	1	1
1½'	3'	Trace
36'	46'	18'
1	1	1

4-9-82

	Dry	Dry
X	1	1
	49'	22'
18"	3'	Trace
1	1	1
35'	46'	18'

4-16-82

X	Dry | 49'	Dry | 22'
18" | 36'	3' | 46'	Trace | 18'

4-22-82

X	Dry | 49'	Dry | 22'
18" | 36'	3' | 46'	Trace | 18'

4-29-82

X	Dry | 49'	Dry | 22'
12" | 36'	3' | 41'	Trace | 18'

5-6-82

X	Dry / 49'	Dry / 22'
12" / 36'	3' / 46'	Trace / 18'

5 14 82

X	Dry / 49'	Dry / 22'
12" / 36'	3' / 46'	Trace / 18'

5 20 82

X	Dry / 49'	Dry / 22'
6" / 36'	3' / [illegible]	Trace / 18'

5-27-82

X	Dry | 44'	Dry | 22'
1" | 36'	3' | 46'	Trace | 18'

6-3-82

X	Dry | 49'	Dry | 22'
Dry | 36'	2' | 46'	Dry | 18'

6-10-82

X	Dry | 49'	Dry | 22'
Dry | 36'	2' | 46'	Dry | 18'

6-17-82

X	Dry | 48'	Dry | 22'
Dry | 36'	2' | 46'	Dry | 18'

7-12-82 no measurement made due to vacation.

7-15-82

X	Dry | 48'	Dry | 22'
Dry | 36'	1" | 46'	Dry | 18'

7-23-82

X	Dry 48'	Dry 22'
Dry 36'	1" 46'	Dry 18'

7-30-82

X	Dry 48'	Dry 22'
Dry 36'	TRACE 46'	Dry 18'

8-5-82

X	Dry 48'	Dry 22'
Dry 36'	TRACE 46'	Dry 18'

8-12-82

X	Dry / 48'	Dry / 22'
Dry / 36'	Trace / 46'	Dry / 18'

8-20-82

X	Dry / 48'	Dry / 22'
Dry / 36'	1' / 45'	Dry / 18'

8-26-82

X	Dry / 48'	Dry / 22'
Dry / 36'	1' / 45'	Trace / 18'

9-2-82

X	Dry / 1 / 49'	Dry / 1 / 22'
Dry / 1 / 36'	1' / 1 / 45'	Trace / 1 / 18'

9-9-82

X	Dry / 1 / 49'	Dry / 1 / 22'
Dry / 1 / 36'	1' / 1 / 45'	Trace / 1 / 18'

9-13-82

X	Dry / 1 / 49'	Dry / 1 / 22'
Dry / 1 / 36'	1' / 1 / 45'	Trace / 1 / 18'

9 24-82

X	Dry / 49'	Trace / 22'
Trace / 36'	1' / 45'	Trace / 18'

10-1-82

X	Dry / 49'	Trace / 22'
6" / 36'	2' / 44'	Trace / 18'

10-7-82

X	Dry / 49'	Trace / 22'
1' / 36'	2' / 44'	Trace / 18'

10-13-82

	Dry	Trace
X	/	/
	49'	22'
2'	3½'	1"
/	/	/
34'	46'	18'

10-19-82

	Dry	Trace
X	/	/
	49'	22'
2'	3½'	2"
/	/	/
34'	46'	18'

10-28-82

	Dry	Trace
X	/	/
	49'	22'
2'	3'	2"
/	/	/
34'	46'	18'

11-5-82

X	Dry / 49'	Trace / 22'
2' / 34'	3½' / 46'	3" / 18'

11-12-82

X	Dry / 49'	Trace / 22'
2' / 34'	3½' / 46'	3" / 18'

11-19-82

X	Trace / 49'	Trace / 22'
2' / 34'	3½' / 46'	3" / 18'

ITEM 6

DISCUSSION OF REFUSE PILE DRAINAGE,

STABILITY AND ENGINEERS CERTIFICATION

ITEM 7

REFUSE PILE INSPECTION PLAN AS PER UMC 817.82

The Schoolhouse Canyon refuse pile at Castle Gate will be inspected at least every three months. An inspection form will be completed and kept on file. A copy of the form is attached.

Compaction and density tests will be performed through use of a Troxler Nuclear Moisture Density Gauge, Model 3411-B.

Inspections will be performed by Frank Pero, Price River Coal Company Surface Construction Engineer.

As required by comments under UMC 784.16.

QUARTERLY INSPECTION REPORT

School House Canyon Refuse Disposal Site

Date ____________

Approximate Top Elevation ________________

Terrace No. ________

Slope of Face ______________ %

Removal of Organic Matter ______________________________

____

____

Distribution and Mixing of Materials ____________________

____

____

Overall Stability and Appearance ______________________

____

____

Average In-place Density __________

Average Rate of Compaction ____________

Number of Tests Performed _____________

Piezometer Levels

1st Terrace

North _____ Middle _____ South _____

2nd Terrace

North _____ Middle _____

REGISTERED PROFESSIONAL ENGINEER
No. 4453
KENNETH B. HUTCHINSON
STATE OF UTAH

_____________________ Inspector

_____________________ Engineer

ITEM 8

DISPOSITION OF UNDERGROUND DEVELOPMENT WASTE

Rock waste materials derived from construction of over/under casts is either placed in crosscuts and return entries or is sent out with the coal to be eventually placed in the active refuse pile. Large quantities of rock waste, as generated from rock tunnel development or station construction in a shaft, are sent primarily to the active refuse pile.

As required by comments under UMC 784.23.

ITEM 9

SIGNS AND MARKERS - UMC 817.11

Mine and Permit Identification Signs

Such signs are posted at entrances to all facilities. Signs have black lettering on white background and vary in size from about 2' square to about 4' square stating the name, address, phone number, MSHA Identification number and the 1977 DOGM permit number.

Perimeter Markers

Orange painted 3' roof bolts have been installed along the perimeter of all sites.

Buffer Zone Markers

18" square signs are posted along Willow Creek and the Price River which state: "Stream Buffer Zone, No Mining Activities Beyond This Point!"

Blasting Signs

No surface blasting occurs on operating sites. Should the need arise the required signs will be posted.

Topsoil Signs

Topsoil piles are marked with an 18" square sign reading: "Topsoil".

ITEM 10

Attached are three copies of new Exhibit 5-1, showing survey sites. State history was contacted on 2-22-83 and queried about the D01-PSAP permit. Discussions with Phil Notariann and Jim Dykeman revealed that no permit existed. Mr. Dykeman agreed to contact Foster Kirby of OSM and discuss the matter.

We have made unseccessful attempts to contact the Archaeological Research Corporation. It appears that they have moved or disbanded.

As required by comments under UMC 784.17.