0005

Golder Associates

CONSULTING MINING AND GEOTECHNICAL ENGINEERS

February 13, 1978
E/78/124

RECEIVED
MAR 23 1978
DIVISION OF OIL, GAS, & MINING

American Electric Power
Service Corporation
P.O. Box 629
Helper, Utah 84526

RECEIVED
FEB 17 1977
A.E.P. SERVICE CORP.
HELPER, UTAH

ATTN: MR. LEE MC CLOSKEY

RE: SCHOOLHOUSE CANYON REFUSE DISPOSAL FACILITY SETTLING POND EMBANKMENT STABILITY

Gentlemen:

On February 8, 1978 we were contacted by Gene Hoab who had been reviewing the Proposed Settling Pond design with Mr. Bill Denning of the MESA regional office in Denver. Mr. Denning asked for some computer stability analysis which would support the following statement made in our final Phase II report regarding embankment stability:

> "Given the flat slopes recommended for the embankment, it is considered that the embankment will be stable under all conditions of operation."

The above engineering judgement was made in the light of extensive experience gathered by Golder Associates personnel in this field, and after appropriate manual stability analysis using circular failure charts which have been developed within the company.

As indicated to you on the telephone on February 10th, it was our opinion that this statement was adequate considering the conservatism in design. However, to quantitatively justify the conclusion, we have utilized an in-house stability analysis program as requested, on both the upstream and downstream embankment slopes. The simplified Bishop Method of slope stability analysis was used for the embankment section shown on the attachment. This section also gives the shear strength parameters which were used (from our laboratory test results), the material densities and phreatic surface assumed. An earthquake loading of 0.1g was also adopted.

The computer output obtained is also attached for the various runs which were made to search for critical failure surfaces. From these results, it is our opinion that the downstream embankment slope should have a factor of safety of not less than 1.4, while the upstream slope under a rapid drawdown situation, should have a factor of safety of not less than 1.5. The downstream slope analysis was made assuming steady state seepage conditions which are unlikely to occur in practice, and without consideration to three-dimensional effects. The computed factor of safety is therefore considered to be conservative.

We trust that this additional analysis meets with Mr. Denning's approval. Should any further questions arise, please do not hesitate to contact the undersigned.

Yours sincerely,

GOLDER ASSOCIATES, INC.

Graham Mathieson
Project Engineer

GM:mm
77212
Encl.

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*          GOLDER ASSOCIATES LTD. -  PROGRAM MSLOPE         *
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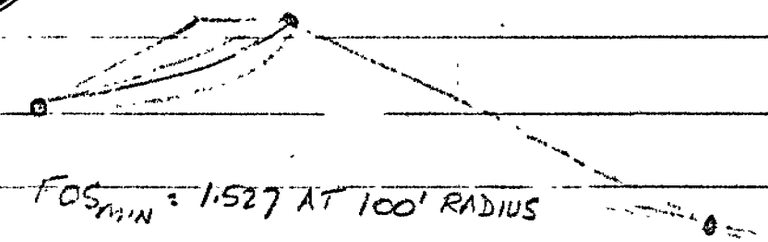
$ AEP SETTLING POND EMBANKMENT
$ UPSTREAM SLOPE ANALYSIS BISHOP METHOD



FOS_{MIN} = 1.527 AT 100' RADIUS

POINTS

NO	X	Y	F
1	0.00	6182.00	
2	20.00	6180.00	
3	24.00	6179.00	
4	115.00	6210.00	
5	119.00	6210.00	
6	135.00	6210.00	
7	284.00	6160.00	
8	320.00	6156.00	
9	101.00	6204.00	
10	164.00	6159.00	
11	192.00	6180.00	
12	204.00	6166.00	

REGIONS

NO.	SOIL	POINTS DEFINING THE TOP SURFACE OF THE REGION							
1	1	2	4	5					
2	2	1	2	3	5	6	7	8	

PIEZOMETRIC SURFACES

NO.	POINTS DEFINING SURFACE							
1	1	3	9	10	11	12	7	8

SOIL TYPES

NO	DENSITY WET	DENSITY SATURATED	SOIL TYPE	FRICTION ANGLE	COHESION	EARTHQUAKE FACTOR	RU FACTOR OR PIEZOMETRIC LINE
1	145.00	145.00		60.000	0.00	.100	1
2	125.00	140.00		34.000	0.00	.100	1

*****BISHOP SOLUTION*****

BISECTOR ANALYSIS-BISHOP SOLUTION

POINT 1% X = 20.00 Y = 6180.50 POINT 2% X = 135.00 Y = 6210.50

CENTRE X	CENTRE Y	RADIUS	SLICES	DEPTH	FELLENIUS FACTOR	FACTOR OF SAFETY
57.2	6273.3	100.0	14	23.3	1.602	1.835
42.7	6328.8	150.0	14	15.7	1.642	1.730
29.3	6380.3	200.0	14	12.4	1.701	1.748
16.2	6430.5	250.0	14	10.5	1.758	1.785

****MINIMUM FACTOR OF SAFETY = 1.730

SOIL TYPES

NO	DENSITY WET	DENSITY SATURATED	SOIL TYPE	FRICTION ANGLE	COHESION	EARTHQUAKE FACTOR	RU FACTOR OR PIEZOMETRIC LINE
1	145.00	145.00		60.000	0.00	.100	1
2	125.00	140.00		22.000	200.00	.100	1

*****BISHOP SOLUTION*****

BISECTOR ANALYSIS-BISHOP SOLUTION

POINT 1% X = 20.00 Y = 6130.50 POINT 2% X = 135.00 Y = 6210.50

CENTRE X	CENTRE Y	RADIUS	SLICES	DEPTH	FELLENIUS FACTOR	FACTOR OF SAFETY
57.2	6273.3	100.0	14	23.3	1.381	1.527
42.7	6328.8	150.0	14	15.7	1.537	1.592
29.3	6350.3	200.0	14	12.4	1.692	1.720
16.2	6430.5	250.0	14	10.5	1.833	1.846

****MINIMUM FACTOR OF SAFETY = 1.527

** END-OF-JOB **

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*          GOLDER ASSOCIATES LTD. -  PROGRAM MSLOPE         *
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*                 10/02/78            08:10:11              *
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$ AEP SETTLING POND EMBANKMENT
$ UPSTREAM SLOPE ANALYSIS BISHOP METHOD

POINTS

NO	X	Y	F
1	0.00	6182.00	
2	20.00	6180.00	
3	24.00	6179.00	
4	115.00	6210.00	
5	119.00	6210.00	
6	135.00	6210.00	
7	284.00	6160.00	
8	320.00	6154.00	
9	100.00	6204.00	
10	164.00	6189.00	
11	192.00	6180.00	
12	204.00	6168.00	

REGIONS

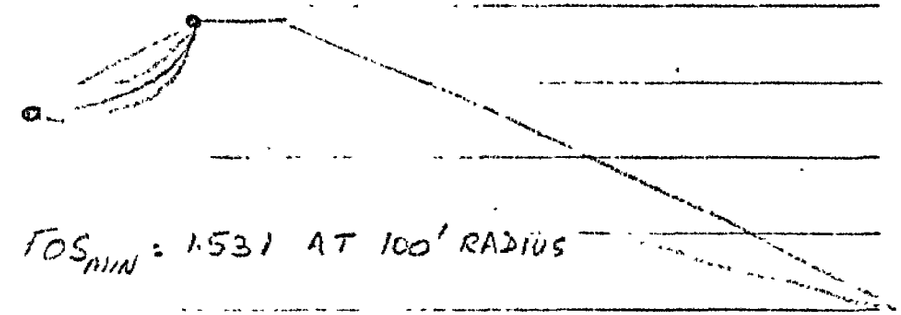
NO.	SOIL	POINTS DEFINING THE TOP SURFACE OF THE REGION						
1	1	2	4	5				
2	2	1	2	3	5	6	7	8

PIEZOMETRIC SURFACES

NO.	POINTS DEFINING SURFACE							
1	1	3	9	10	11	12	7	8

SOIL TYPES

NO	DENSITY WET	DENSITY SATURATED	SOIL TYPE	FRICTION ANGLE	COHESION	EARTHQUAKE FACTOR	RU FACTOR OR PIEZOMETRIC LINE
1	145.00	145.00		60.000	0.00	.100	1
2	125.00	140.00		34.000	0.00	.100	1



FOS_{MIN} = 1.531 AT 100' RADIUS

*****BISHOP SOLUTION*****

BISECTOR ANALYSIS-BISHOP SOLUTION

POINT 1* X = 22.00 Y = 6180.50 POINT 2* X = 115.00 Y = 6210.50

CENTRE X	CENTRE Y	RADIUS	SLICES	DEPTH	FELLENIUS FACTOR	FACTOR OF SAFETY
41.4	6278.2	100.0	13	13.4	1.397	1.546
9.2	6380.2	200.0	13	6.0	1.679	1.701

****MINIMUM FACTOR OF SAFETY = 1.546

SOIL TYPES

NO	DENSITY WET	DENSITY SATURATED	SOIL TYPE	FRICTION ANGLE	COHESION	EARTHQUAKE FACTOR	RU FACTOR OR PIEZOMETRIC LINE
1	145.00	145.00		60.000	0.00	.100	1
2	125.00	140.00		22.000	200.00	.100	1

*****BISHOP SOLUTION*****

BISECTOR ANALYSIS-BISHOP SOLUTION

POINT 1% X = 20.00 Y = 6180.50 POINT 2% X = 115.00 Y = 6210.50

CENTER X	CENTER Y	RADIUS	SLICES	DEPTH	FELLENIUS FACTOR	FACTOR OF SAFETY
41.4	6278.2	100.0	13	13.4	1.443	1.531
9.2	6380.2	200.0	13	6.0	2.147	2.152

****MINIMUM FACTOR OF SAFETY = 1.531

** END-OF-JOB **

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*          GOLDER ASSOCIATES LTD. -  PROGRAM MSLOPE         *
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*                 10/02/78            08:14:25              *
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$ AEP SETTLING POND EMBANKMENT
$ DOWNSTREAM SLOPE ANALYSIS BISHOP METHOD

POINTS

NO	X	Y	F
1	0.00	6152.00	
2	20.00	6150.00	
3	24.00	6179.00	
4	115.00	6210.00	
5	119.00	6210.00	
6	135.00	6210.00	
7	284.00	6160.00	
8	320.00	6156.00	
9	100.00	6204.00	
10	164.00	6189.00	
11	192.00	6180.00	
12	204.00	6168.00	

REGIONS

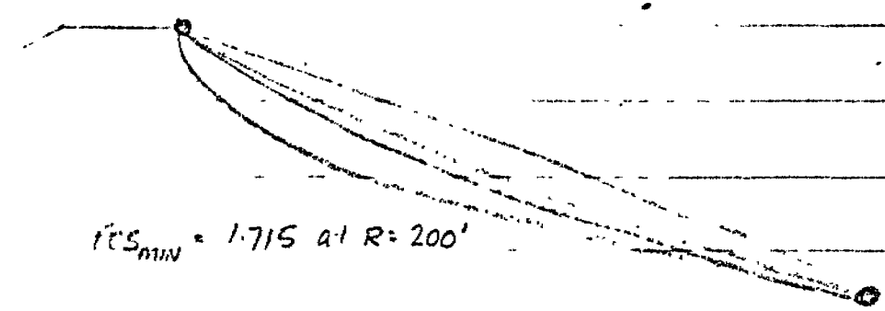
NO.	SOIL	POINTS DEFINING THE TOP SURFACE OF THE REGION						
1	1	2	4	5				
2	2	1	2	3	5	6	7	8

PIEZOMETRIC SURFACES

NO.	POINTS DEFINING SURFACE							
1	1	3	9	10	11	12	7	8

SOIL TYPES

NO	DENSITY WET	DENSITY SATURATED	SOIL TYPE	FRICTION ANGLE	COHESION	EARTHQUAKE FACTOR	RU FACTOR OR PIEZOMETRIC LINE
1	145.00	145.00		60.000	0.00	.100	1
2	125.00	140.00		34.000	0.00	.100	1



*****BISHOP SOLUTION*****

BISECTOR ANALYSIS-BISHOP SOLUTION

POINT 1% X = 135.00 Y = 6210.50 POINT 2% X = 284.00 Y = 6160.50

CENTRE X	CENTRE Y	RADIUS	SLICES	DEPTH	FELLENIUS FACTOR	FACTOR OF SAFETY
268.0	6359.9	200.0	15	16.5	1.936	2.007
301.6	6460.0	300.0	11	10.5	2.041	2.071
334.3	6557.3	400.0	11	7.7	2.027	2.043
366.6	6653.6	500.0	11	6.1	2.020	2.031

****MINIMUM FACTOR OF SAFETY = 2.007

SOIL TYPES

NO	DENSITY WET	DENSITY SATURATED	SOIL TYPE	FRICTION ANGLE	COHESION	EARTHQUAKE FACTOR	RU FACTOR OR PIEZOMETRIC LINE
1	145.00	145.00		60.000	0.00	.100	1
2	125.00	140.00		22.000	200.00	.100	1

*****BISHOP SOLUTION*****

BISECTOR ANALYSIS-BISHOP SOLUTION

POINT 1% X = 135.00 Y = 6210.00 POINT 2% X = 284.00 Y = 6160.50

CENTRE X	CENTRE Y	RADIUS	SLICES	DEPTH	FELLENIUS FACTOR	FACTOR OF SAFETY
268.0	6359.9	250.0	15	16.5	1.674	1.715
301.6	6460.0	300.0	11	10.5	2.005	2.022
334.3	6557.3	400.0	11	7.7	2.269	2.279
366.6	6653.6	500.0	11	6.0	2.548	2.554

****MINIMUM FACTOR OF SAFETY = 1.715

** END-OF-JOB **

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*        GOLDER ASSOCIATES LTD. -  PROGRAM MSLOPE           *
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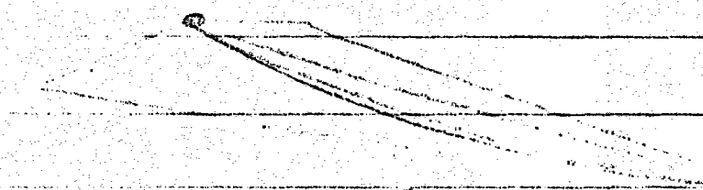
$ AEP SETTLING POND EMBANKMENT
$ DOWNSTREAM SLOPE ANALYSIS BISHOP METHOD



FOS_{min} = 1.394 at R = 150'

POINTS

NO	X	Y	F
1	0.00	6182.00	
2	20.00	6180.00	
3	24.00	6179.00	
4	115.00	6210.00	
5	119.00	6210.00	
6	135.00	6210.00	
7	284.00	6160.00	
8	320.00	6156.00	
9	100.00	6204.00	
10	164.00	6169.00	
11	192.00	6160.00	
12	204.00	6168.00	

REGIONS

NO.	SOIL	POINTS DEFINING THE TOP SURFACE OF THE REGION						
1	1	2	4	5				
2	2	1	2	3	5	6	7	8

PIEZOMETRIC SURFACES

NO.	POINTS DEFINING SURFACE							
1	1	3	9	10	11	12	7	8

SOIL TYPES

NO	DENSITY WET	DENSITY SATURATED	SOIL TYPE	FRICTION ANGLE	COHESION	EARTHQUAKE FACTOR	RU FACTOR OR PIEZOMETRIC LINE
1	145.00	145.00		60.000	0.00	.100	1
2	125.00	140.00		34.000	0.00	.100	1

*****BISHOP SOLUTION*****

BISECTOR ANALYSIS-BISHOP SOLUTION

POINT 1% X = 115.00 Y = 6210.50 POINT 2% X = 284.00 Y = 6160.50

CENTRE X	CENTRE Y	RADIUS	SLICES	DEPTH	FELLENIUS FACTOR OF SAFETY
212.9	6230.8	100.0			FAILURE SURFACE TOO DEEP
233.9	6301.9	150.0	15	33.0	1.663
250.4	6357.7	200.0	15	24.5	1.782
					1.869
					1.887

****MINIMUM FACTOR OF SAFETY = 1.869

SOIL TYPES

NO	DENSITY WET	DENSITY SATURATED	SOIL TYPE	FRICTION ANGLE	COHESION	EARTHQUAKE FACTOR	RU FACTOR OR PIEZOMETRIC LINE
1	145.00	145.00		60.000	0.00	.100	1
2	125.00	140.00		22.000	200.00	.100	1

Moore Business Forms, Inc. 14121

*****BISHOP SOLUTION*****

BISECTOR ANALYSIS-BISHOP SOLUTION

POINT 1% X = 115.00 Y = 6210.50 POINT 2% X = 264.00 Y = 6160.50

CENTRE X	CENTRE Y	RADIUS	SLICES	DEPTH	FELLENIUS FACTOR	FACTOR OF SAFETY
212.9	6230.8	100.0			FAILURE SURFACE TOO DEEP	
233.9	6301.9	150.0	15	33.0	1.271	1.394
250.4	6357.7	200.0	15	24.5	1.412	1.475

****MINIMUM FACTOR OF SAFETY = 1.394

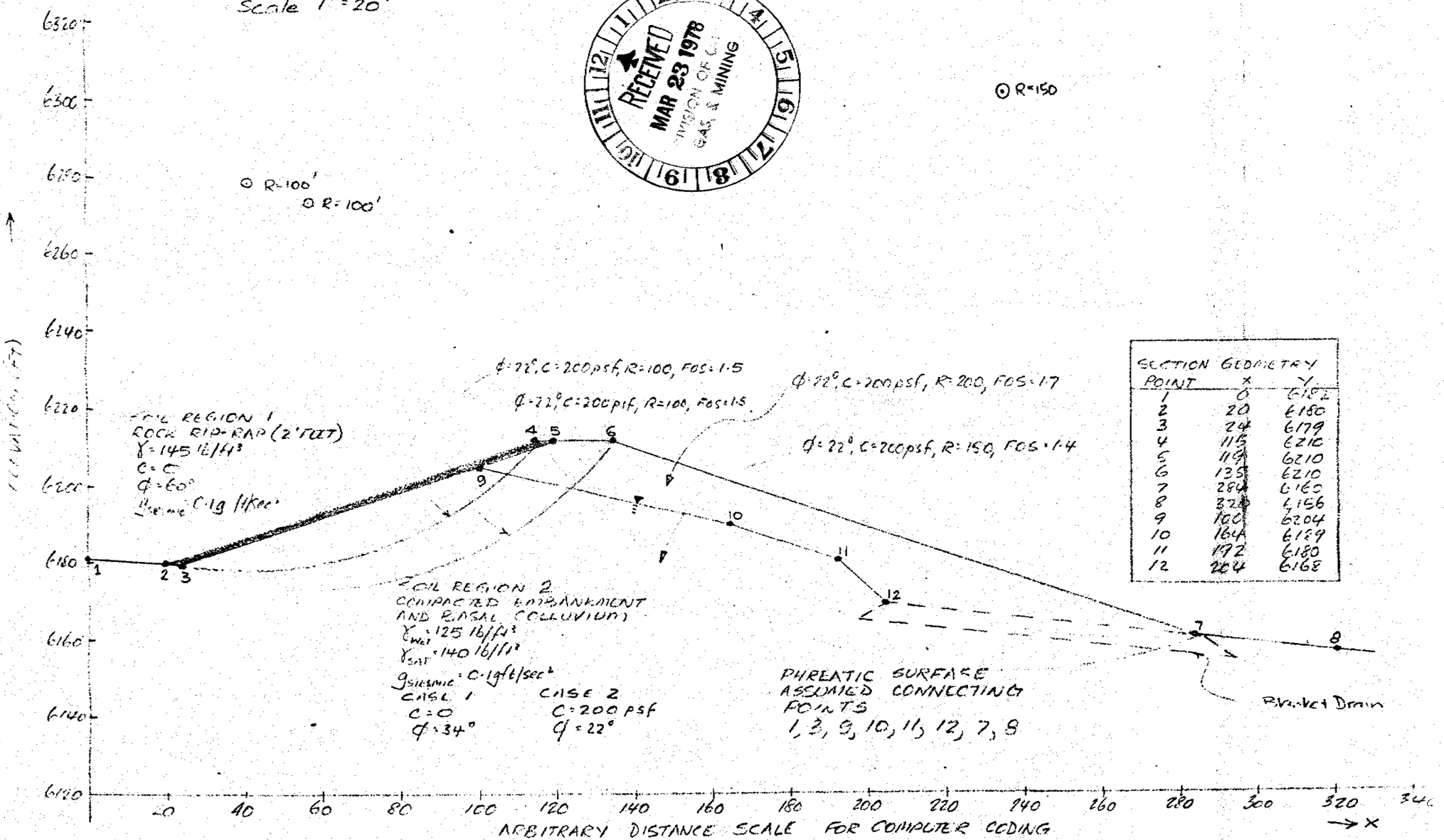
** END-OF-JOB **

Moore Business Forms, Inc. 14127

Golder Associates Inc
GAM 2/10/78

AMERICAN ELECTRIC POWER
SETTLING POND EMBANKMENT
SLOPE STABILITY SECTION "BB"
Scale 1" = 20'

RECEIVED
MAR 23 1978
DIVISION OF OIL, GAS & MINING



SECTION GEOMETRY

POINT	X	Y
1	0	6181
2	20	6180
3	24	6179
4	115	6210
5	119	6210
6	135	6210
7	284	6160
8	324	6156
9	100	6204
10	164	6189
11	192	6180
12	204	6168