Appendix 5-5

Lila Canyon Mine

Safety Factor Analyses
for
Portal Access Road, Sediment Pond and Reclaimed Slope

UTAH REGISTERED PROFESSIONAL ENGINEER
#152606
R. Jay Marshall

Appendix 5-5
Safety Factor Analyses
for
Portal Access Road, Sediment Pond and Reclaimed Slope

General

The soils information used in these calculations is taken from the data provided by Earthfax Engineering, Inc. for a slope stability analysis of a previously proposed access road. The access road location has been changed, reducing the height and angle of cut and fill slopes; however, the soils data is still representative of the new location. The data was compiled from 3 test pits located on the proposed mine site. (See Table 1) Parameters utilized in this report are based on the "worst-case" soils test for conservancy.

Safety factors in this report were determined by using Geo-Slope Slope/W Version 5 software. The "Spencer's Method" was used within Slope/W. Spencer's method considers both normal and shear inter-slice forces, and satisfies both force and moment equilibrium. Spencer's method is unique in that the ratio of shear to normal inter-slice forces is a constant, and is therefore the same for each slice. The safety factors are calculated using a given set of parameters, including slope height, slope angle, soil density, cohesion and internal friction angles.

The following assumptions are used in these calculations:

(1) The material forming the slope is assumed to be homogeneous;

(2) The sheer strength of the material is characterized by a cohesion (c) and a friction angle ϕ;

(3) Failure is assumed to occur on a circular failure surface which passes through the toe of the slope;

(4) A vertical tension crack is assumed to occur in the upper surface of the face of the slope;

(5) The location of the tension crack and failure surface are such that the factor of safety of the slope is a minimum for the slope geometry and groundwater conditions considered.

Portal Access Road

This road is shown on Plate 5-2, and will provide access from the bathhouse area to the rock slope portals. The road is approximately 1600' in length, with a maximum grade of 12.5%. The road will be constructed using standard cut/fill techniques. Cut slopes are expected to be no steeper than 1H:1V with a maximum height of 23'. Fill slopes will not be steeper than 2H:1V with a maximum height of 50'.

Mine Facilities Access Road

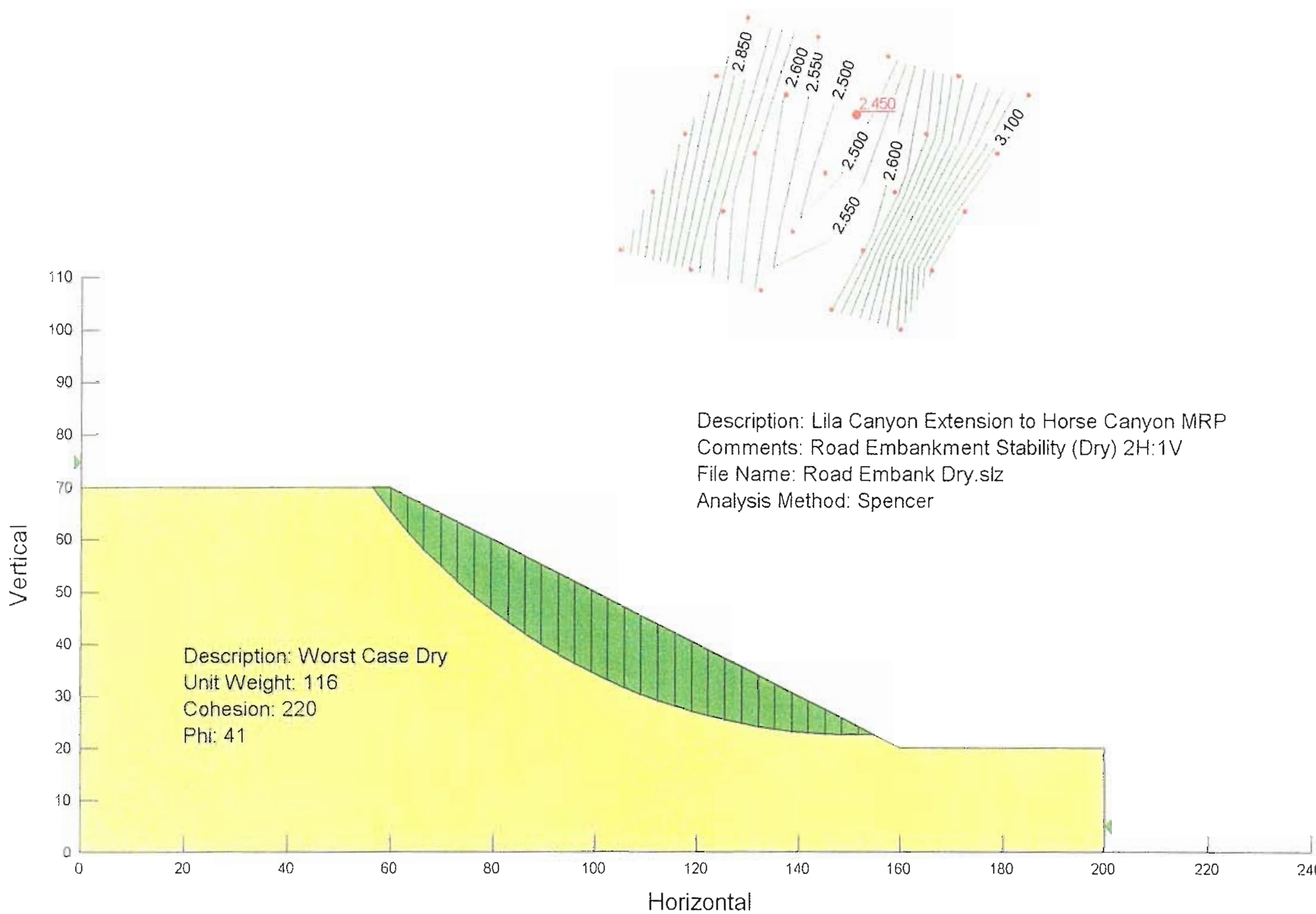
The mine facility road shown on Plate 5-2 begins at the edge of County Road 164 and allows for access to the various surface facilities. The road has been located in the most practical location taking into consideration grade, stability, and alignment. Employees will use this road to access the office & bathhouse facilities. Coal haul trucks will use this road to access the scales and truck loadout. All supplies will be hauled on a short portion of this road from the supply storage area to the slope access road. The road will be constructed using standard cut/fill techniques. Cut slopes are expected to be no steeper than 1H:1V with a maximum height of 5'. Fill slopes will not be steeper than 2H:1V with a maximum height of 5'. The road is relatively flat. Safety factors were not calculated for this road since the most severe conditions are found on the Portal Access Road. Since the Portal Access Road meets or exceeds the minimum safety standard of 1.3 of the Utah Coal Rules, then it should be intuitive that the much flatter mine facility access road will exceed the minimum 1.3 stability standard.

Road Embankment Stability

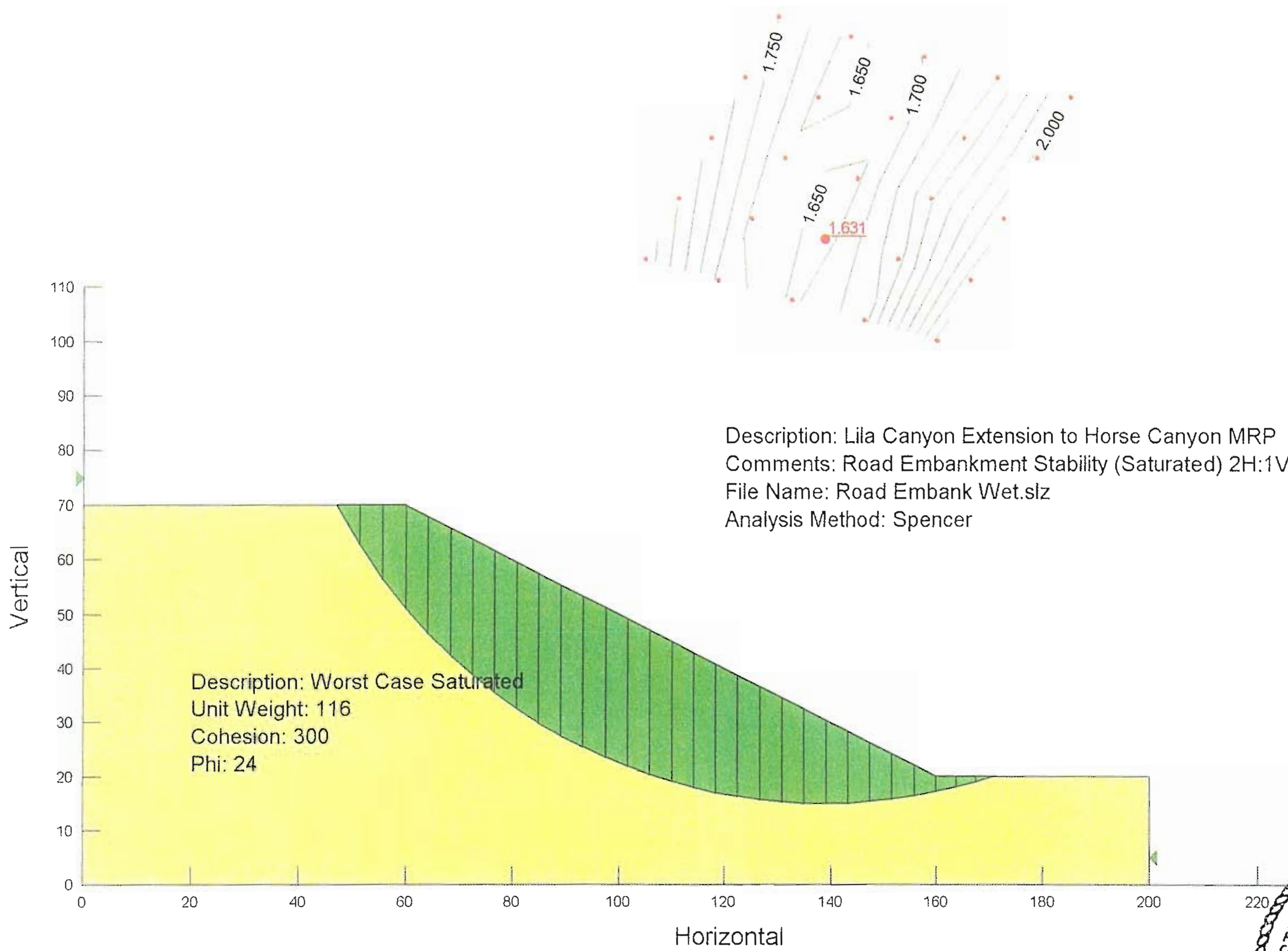
The following parameters were used for input for the proposed road embankment:

Slope Height	-	50'
Slope Angle	-	26.5° (2H:1V)
Soil Density	-	116 lbs/ft^3
Soil Cohesion	-	220 psf dry / 300psf saturated
Internal Friction Angle	-	41° dry / 24° saturated

The calculated Factor of Safety using the above parameters is 2.45 for dry conditions and 1.63 for saturated conditions. This exceeds the required 1.30 Factor of Safety required by the regulations.



REGISTERED PROFESSIONAL ENGINEER
152606
R. JAY
MARSHALL
6/9/08
STATE OF UTAH



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152606
R. JAY
MARSHALL
6/9/05
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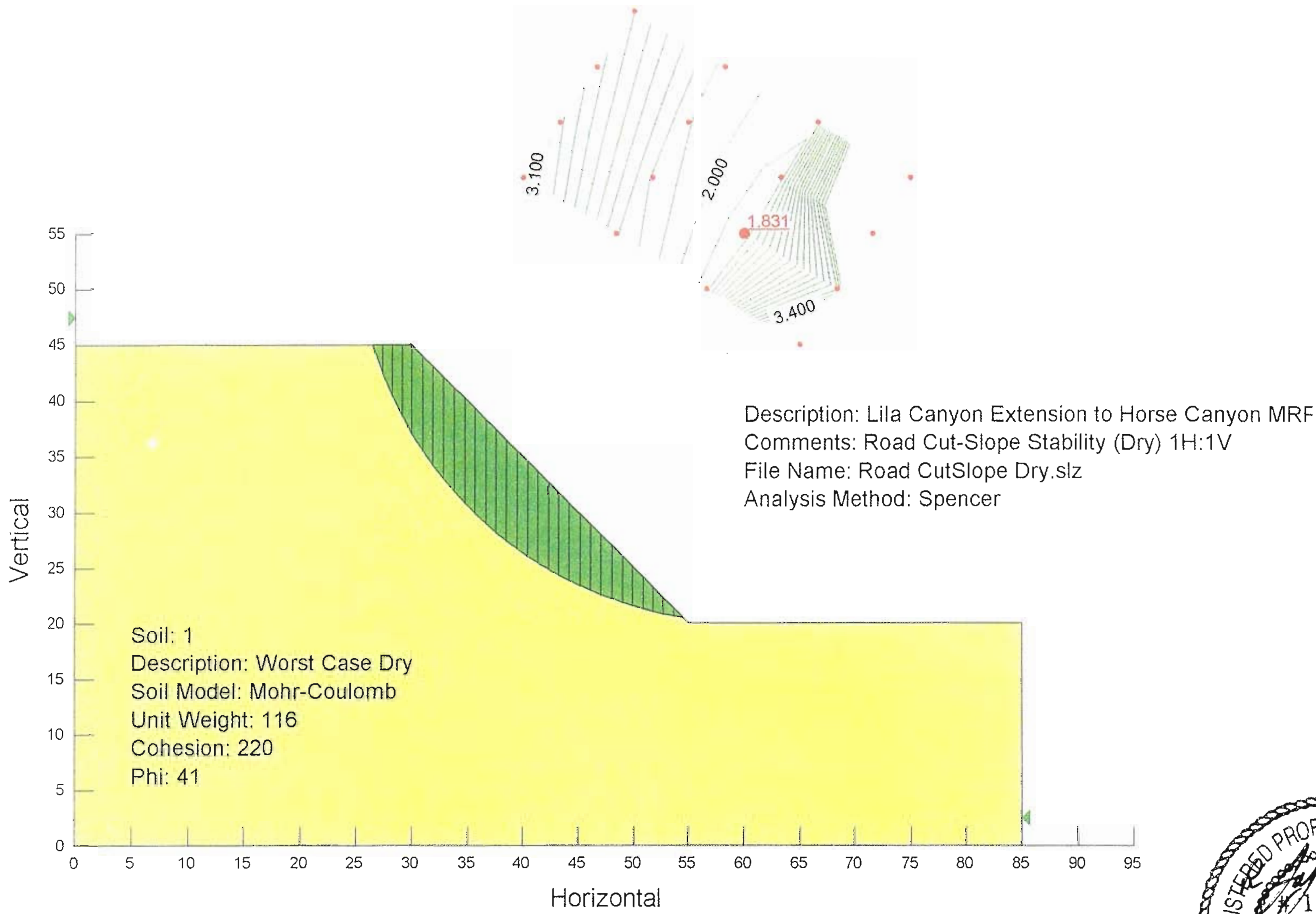
Road Cut-Slope Stability

The following parameters were used for the proposed road cut slopes:

Slope Height	-	23'
Slope Angle	-	45° (1H:1V)
Soil Density	-	116 lbs/ft^3
Soil Cohesion	-	220 psf dry / 300psf saturated
Internal Friction Angle	-	41° dry / 24° saturated

The calculated Factor of Safety for the cut slopes is 1.83 for dry conditions and 1.46 for saturated conditions. This also exceeds the 1.30 requirement of the regulations.

For non-circular failure the slip surface shape follow the arc of a circle through the soil until it intersects the bedrock layer. It then follows the bedrock surface until it again interests the slip circle. The soil strength used along the bedrock surface is the strength of the soil immediately above the bedrock. As can be seen on page 7-A, the safety factor for a worse case non-circular slip failure analysis is 1.51 for saturated conditions. This exceeds the 1.3 requirement of the regulations.



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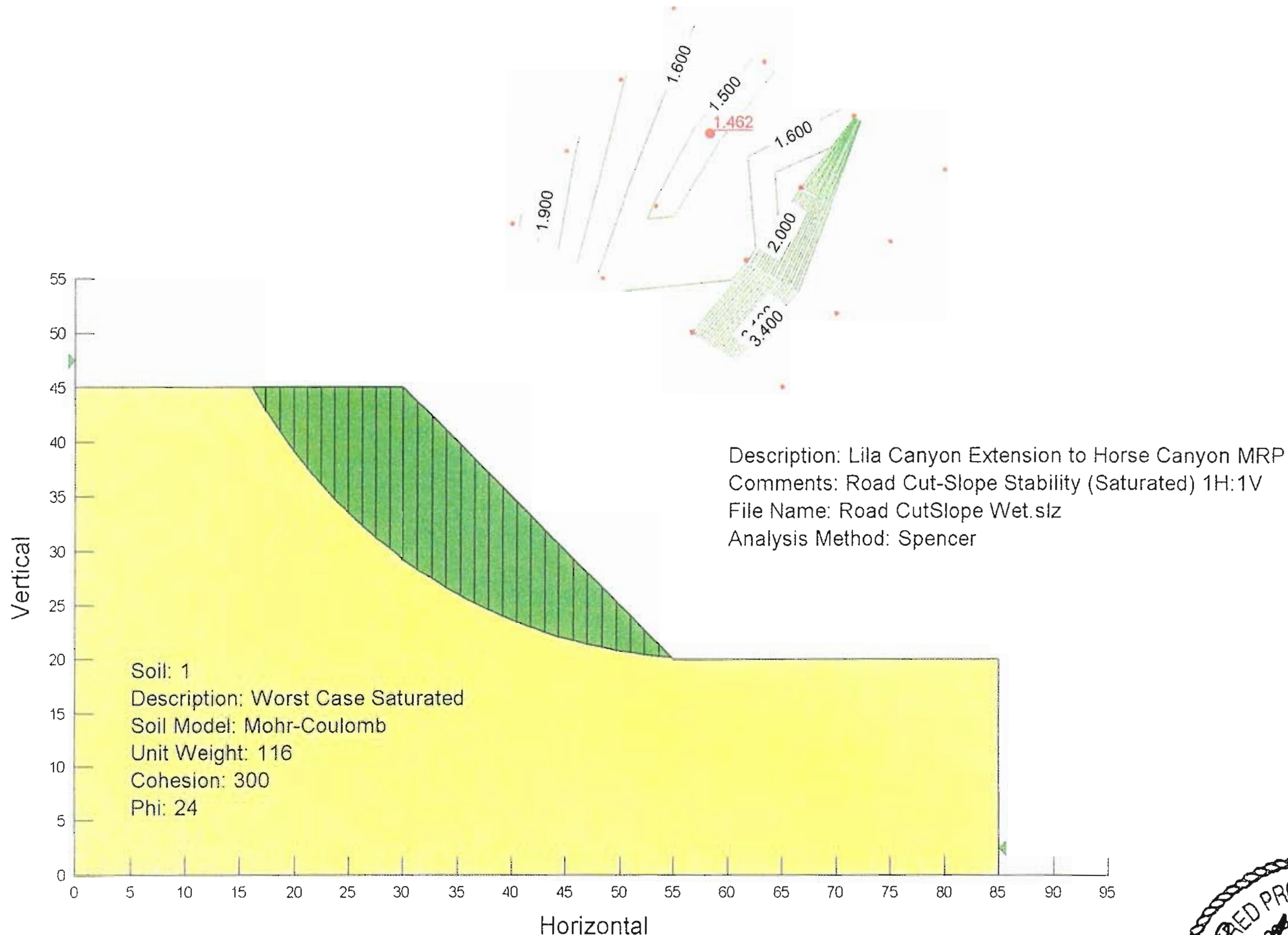

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152606
R. JAY MARSHALL
6/9/05
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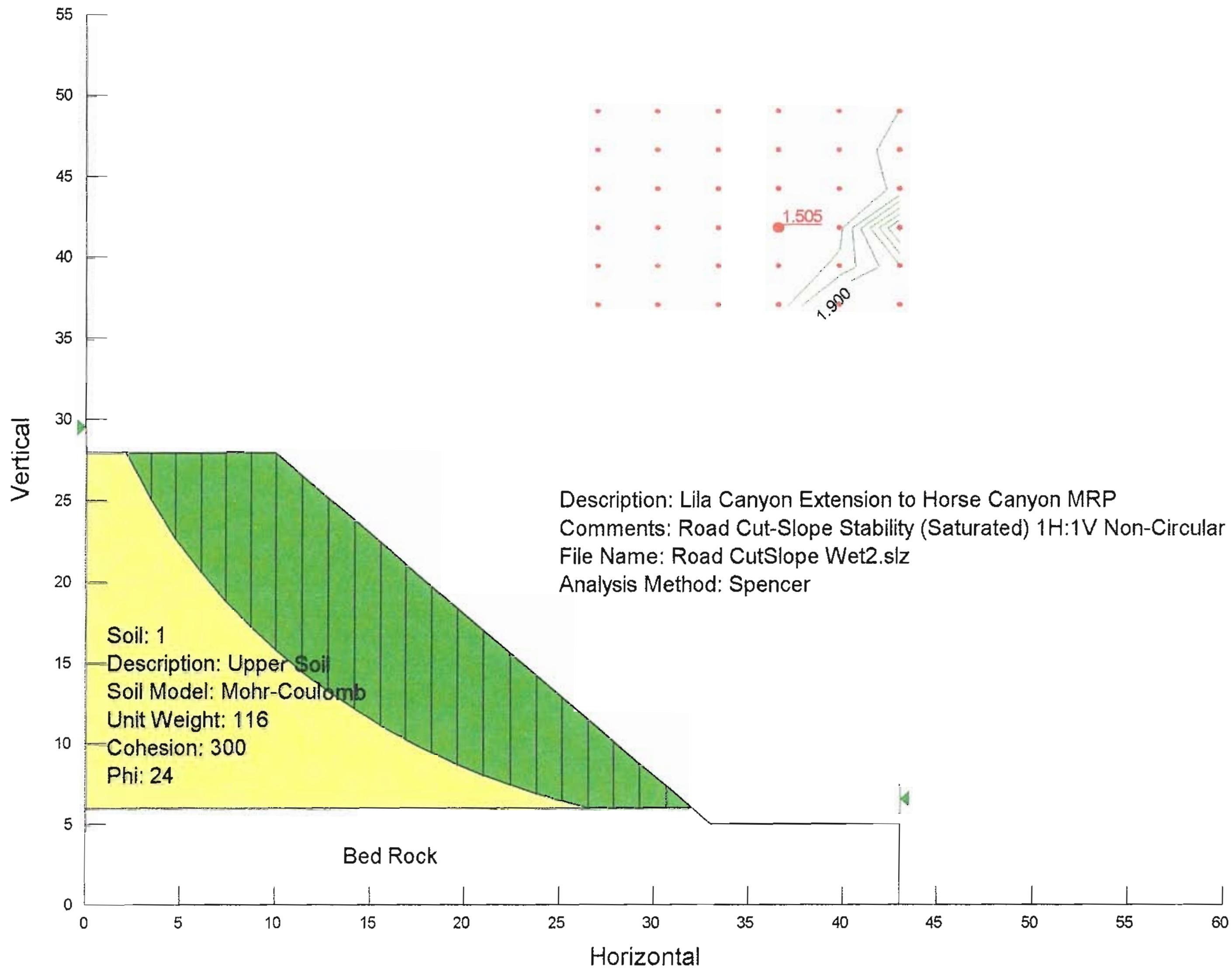
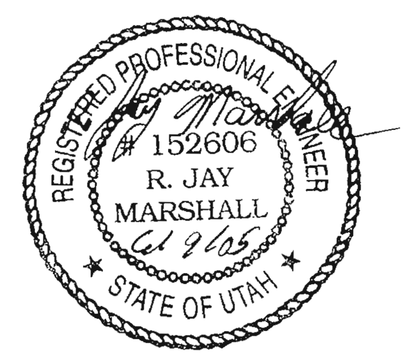


Description: Lila Canyon Extension to Horse Canyon MRP
Comments: Road Cut-Slope Stability (Saturated) 1H:1V Non-Circular Failure
File Name: Road CutSlope Wet2.slz
Analysis Method: Spencer



Sediment Pond Stability

The proposed sediment pond is shown on Plates 5-2, 7-2 and 7-6. The pond will be located in an existing drainage and will therefore be mostly incised into natural ground. The pond dam embankment will also be a reconstructed portion of the county road, with a top width of approximately 25'.

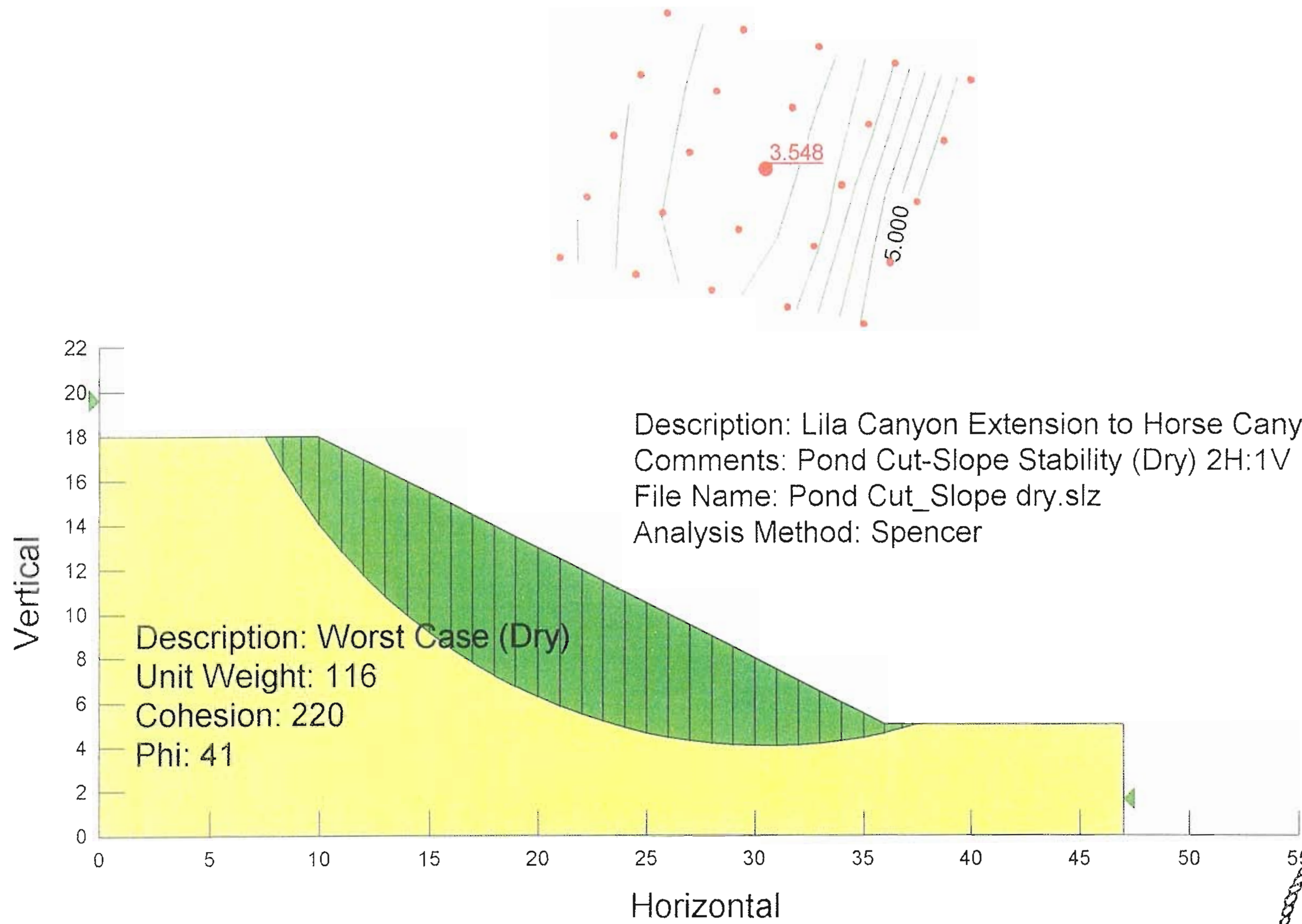
The proposed pond bottom will be a maximum of 13' below the top of the embankment. Slopes within the pond are proposed to be a maximum of 2H:1V for the incised portion and 3H:1V for the embankment. (See Sections C-C' and D-D')

Pond Cut-Slope Stability

The following parameters were used for the proposed pond incised slopes:

Slope Height	-	13'
Slope Angle	-	26.5° (2H:1V)
Soil Density	-	113 lbs/ft^3
Soil Cohesion	-	220 psf dry / 300psf saturated
Internal Friction Angle	-	41° dry / 24° saturated

The calculated Factor of Safety for the pond cut slopes is 3.55 for dry conditions and 2.80 for saturated conditions. This exceeds the 1.30 requirements of the regulations.


3.548
5.000
22
20
18
16
14
12
10
8
6
4
2
0
Vertical
Description: Lila Canyon Extension to Horse Canyon MRP
Comments: Pond Cut-Slope Stability (Dry) 2H:1V
File Name: Pond Cut_Slope dry.slz
Analysis Method: Spencer
Description: Worst Case (Dry)
Unit Weight: 116
Cohesion: 220
Phi: 41
0 5 10 15 20 25 30 35 40 45 50 55
Horizontal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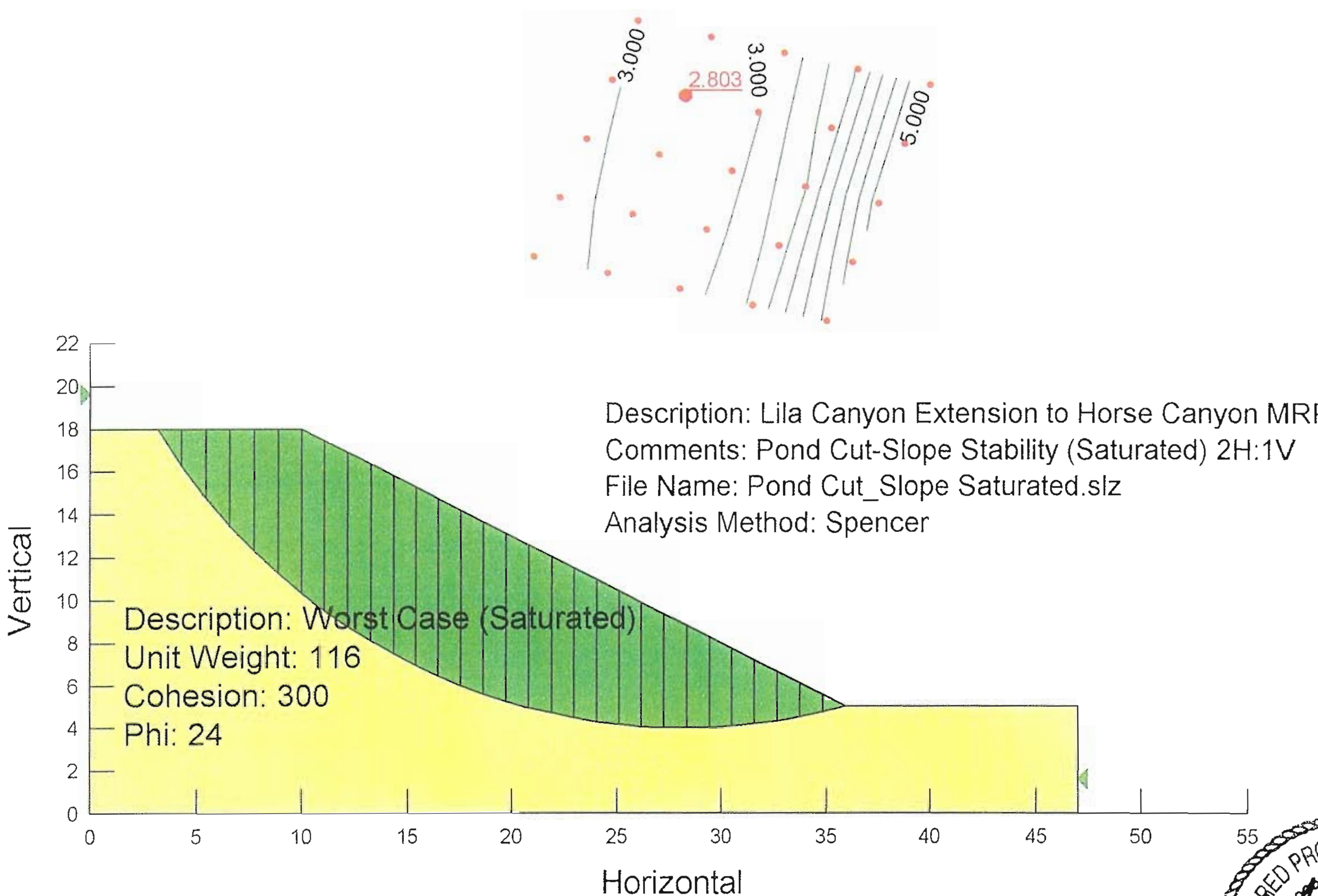

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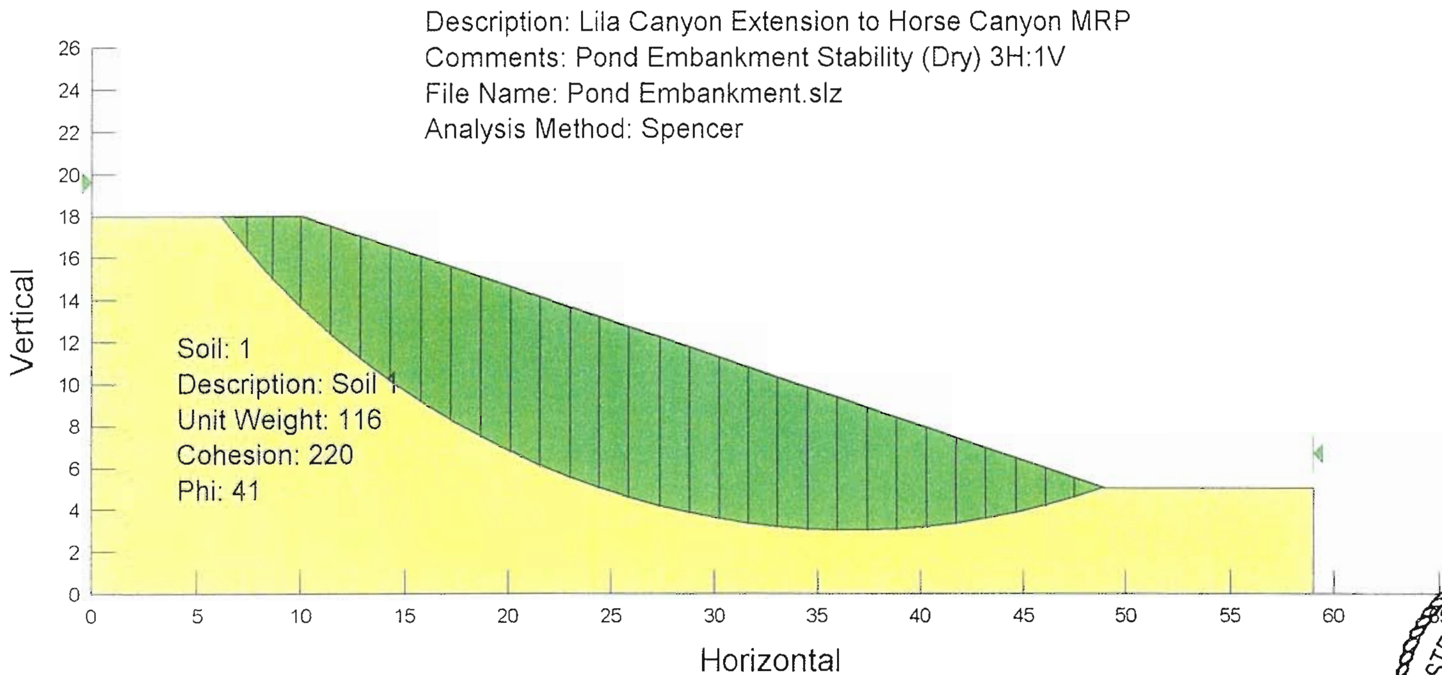
Pond Embankment Stability

The following parameters were used for the proposed pond embankment:

Slope Height	-	13'
Slope Angle	-	18.4° (3H:1V)
Soil Density	-	113 lbs/ft^3
Soil Cohesion	-	220 psf dry / 300psf saturated
Internal Friction Angle	-	41° dry / 24° saturated

The calculated Factor of Safety for the pond embankment is 4.35 for dry conditions and 3.10 for saturated conditions. This also exceeds the regulatory requirement of 1.30.



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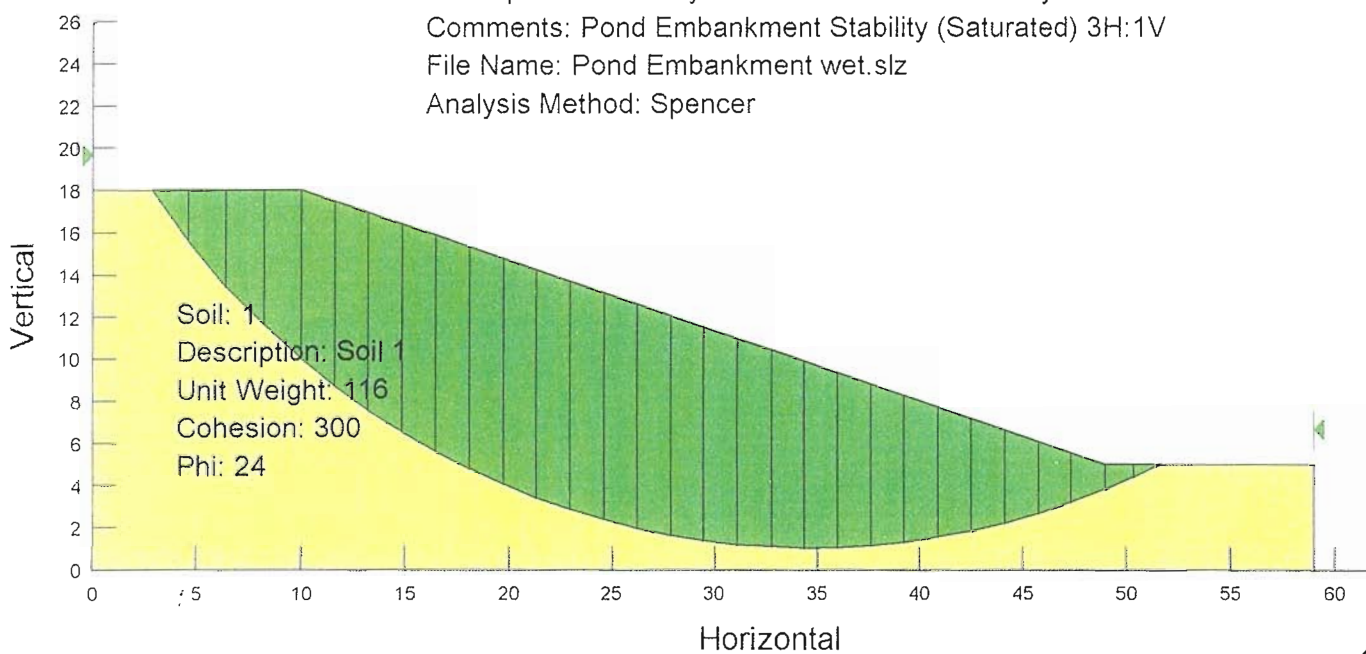
Description: Lila Canyon Extension to Horse Canyon MRP
Comments: Pond Embankment Stability (Saturated) 3H:1V
File Name: Pond Embankment wet.slz
Analysis Method: Spencer



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152606
R. JAY MARSHALL
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Sudden Drawdown Protection

The sediment pond will be protected from failure from sudden drawdown by the following primary measures:

(1) Proper construction/compaction of the embankment as per engineering requirements in Appendix 7-4;

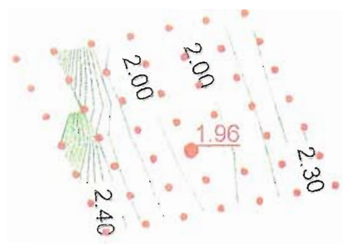
(2) Majority of pond is incised and therefore cut into natural ground with 2H:1V slopes for stability;

(3) Safety Factor calculations show the pond to be stable under both saturated and dry conditions; therefore, transition from one state to the other should not affect stability to the extent to cause failure;

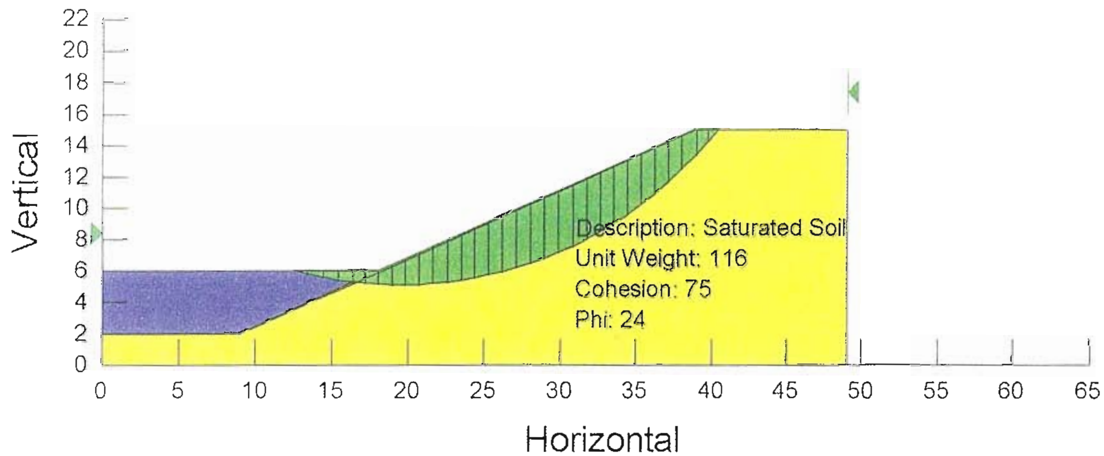
(4) Pond embankment will be vegetated wherever feasible;

(5) It should also be noted that the pond design has been reviewed and approved by the State Engineers Office.

Using Geosystems Software SB-Slope Version 3.0 stability analysis for sudden drawdown conditions were run. Assuming a 10 foot sudden drop in water elevation, and a soil cohesion value one fourth of the measured value, the Factor of Safety would be 1.96. This reduced cohesion value was used for conservative purposes. The actual factor of safety would be considerably higher.



Description: Lila Canyon Extension to Horse Canyon MRP
Comments: Pond Embankment Stability (Sudden Draw Down) 3H:1V
File Name: Pond Sudden Draw Down.stz.slz
Analysis Method: Spencer



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152606
R. JAY
MARSHALL
6/9/05
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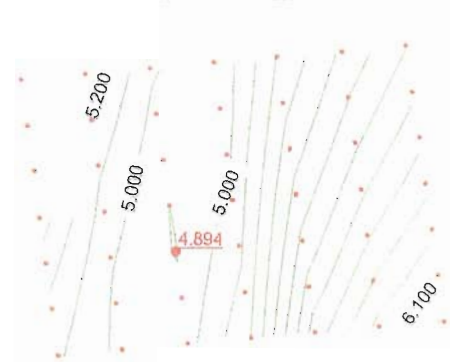
Reclaimed Slope

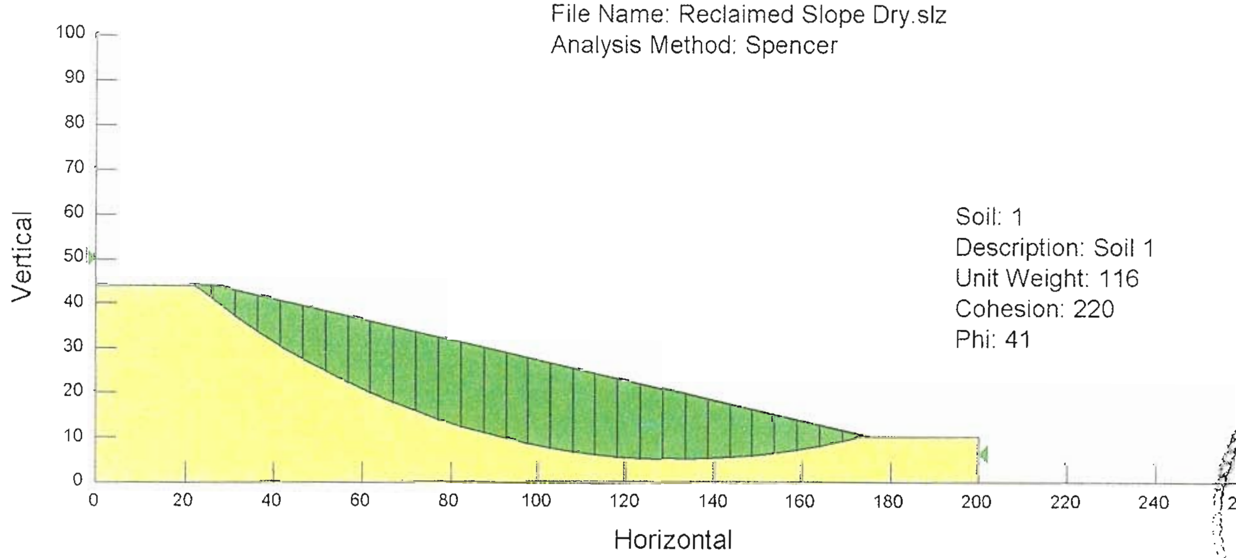
The proposed reclamation profile is shown on Plate 5-7C. A section of this profile, approximately 260' in length was selected for the stability calculation. This section is designated E-E' on Plate 5-7C and in Figure 3 of this Appendix. The section shows a maximum slope height of 34 feet at a slope angle of 12.8°. Density, cohesion and internal friction angles were assumed to be the same as the native soil for these calculations.

The calculated Factor of Safety for the reclaimed slope is <u>4.89</u> for dry conditions and <u>3.12</u> for saturated conditions. This also exceeds the regulatory requirement of 1.30.

NOTE: All slopes will have a maximum steepness of 1H : 1V. All such slopes will have a safety factor of 1.3 or greater as shown above.



Description: Lila Canyon Extension to Horse Canyon MRP
Comments: Reclaimed Slope Stability (Dry) 12.8 degrees
File Name: Reclaimed Slope Dry.slz
Analysis Method: Spencer



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#152606
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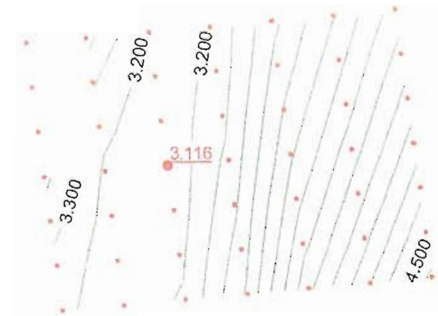
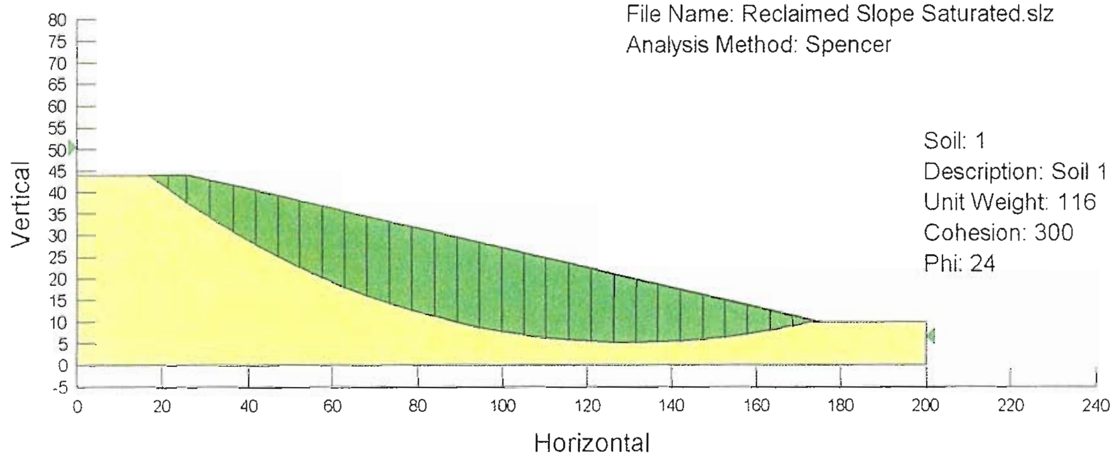


Description: Lila Canyon Extension to Horse Canyon MRP
Comments: Reclaimed Slope Stability (Saturated) 12.8 degrees
File Name: Reclaimed Slope Saturated.slz
Analysis Method: Spencer



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#152606
R. JAY
MARSHALL
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Summary

Factors of Safety have been calculated for the proposed portal access road, sediment pond and reclaimed slope, using the most conservative soil parameters taken from test pits on the proposed site.

Road cut safety factors range from 1.83 for dry conditions to 1.46 for saturated conditions. Road embankment factors of safety are 2.45 for dry and 1.63 for saturated conditions. These calculations show the proposed road design will exceed the 1.30 Factor of Safety required by the regulations.

The sediment pond incised (cut) slopes were shown to have a Factor of Safety of 3.34 for dry conditions and 2.80 for saturated conditions. Embankment stability shows a safety factor of 4.58 for dry conditions and 3.42 for saturated conditions. These calculated safety factors also exceed the regulatory requirement.

In addition to the Safety Factor calculations, discussion was also provided for methods of protecting the sediment pond from failure due to sudden or rapid draw down.

The reclaimed slope was shown to have a Factor of Safety of 4.89 for dry conditions and 3.12 for saturated conditions. These safety factors exceed the 1.30 regulatory requirements for reclaimed slopes.

Table 1

SUMMARY OF LABORATORY TEST RESULTS

Test Pit	Standard Proctor Values		Direct Shear Test Values			
	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Moist Conditions [a]		Saturated Conditions [b]	
TP-1	113.0	14.5	38	510	25	490
TP-3	116.0	15.0	41	220	24	300
TP-4	113.5	13.5	43	450	41	300

(a) Samples compacted to 92% of the Standard Proctor dry density at the optimum moisture content and tested under consolidated-undrained (CU) unsaturated conditions with vertical effective pressures of 500, 1000, and 2000 psf.

(b) Samples compacted to 92% of the Standard Proctor dry density at the optimum moisture content and tested under consolidated-undrained (CU) saturated conditions with vertical effective pressures of 500, 1000, and 2000 psf.

App 5-5

Applied Geotechnical Engineering Consultants, Inc.

July 2, 1998

Earthfax Engineering
7324 South 1300 East, Suite 100
Midvale, UT 84047

Attention: Rhett Brooks

Subject: Soils Laboratory Testing
Basic Management Services, Lila Canyon
AGEC Project No. 973301

Gentlemen:

Applied Geotechnical Engineering Consultants, Inc. was requested to provide laboratory testing on three samples received May 22, 1998. We understand that the samples came from the Basic Management Services site in Lila Canyon. The following tests have been performed in general accordance with the test method listed.

Test	Test Method
Direct Shear	ASTM D-3080
Standard Proctor	ASTM D-698

The results of the laboratory testing are shown graphically in Figures 1-9. The direct shear test specimens were remolded to approximately 92% of the standard proctor maximum dry density near optimum moisture content. Only material passing the #4 sieve was used in direct shear testing.

If you have any questions, or if we can be of further service, please call.

Sincerely,

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

Stephanie Francom

Stephanie Francom
Rev. SDA, E.I.T.

Applied Geotechnical Engineering Consultants, Inc.

Sample from: TP-1

Description: Basic Management Services
Lila Canyon

Test Method ASTM D-698 Method A

Maximum Dry Density 113.0 pcf

Optimum Moisture Content 14.5 %

Atterberg Limits

Liquid Limit ____ %

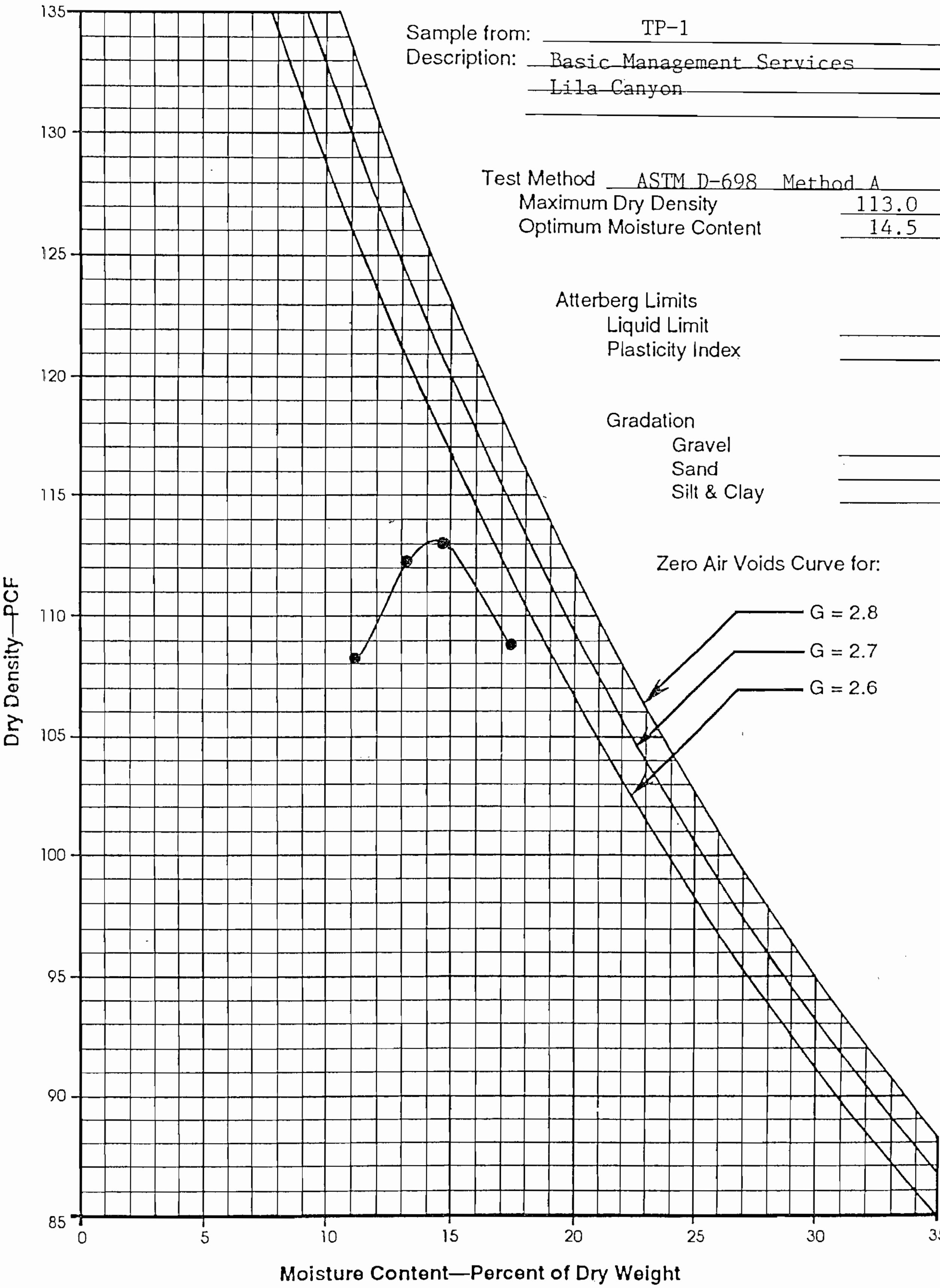
Plasticity Index ____ %

Gradation

Gravel ____ %

Sand ____ %

Silt & Clay ____ %



Project No. 973301

COMPACTION TEST RESULTS

Figure 1

Applied Geotechnical Engineering Consultants, Inc.

Sample from: TP-3

Description: Basic Management Services

Lila Canyon

Test Method ASTM D-698 Method C

Maximum Dry Density 116.0 pcf

Optimum Moisture Content 15.0 %

Atterberg Limits

Liquid Limit ______ %

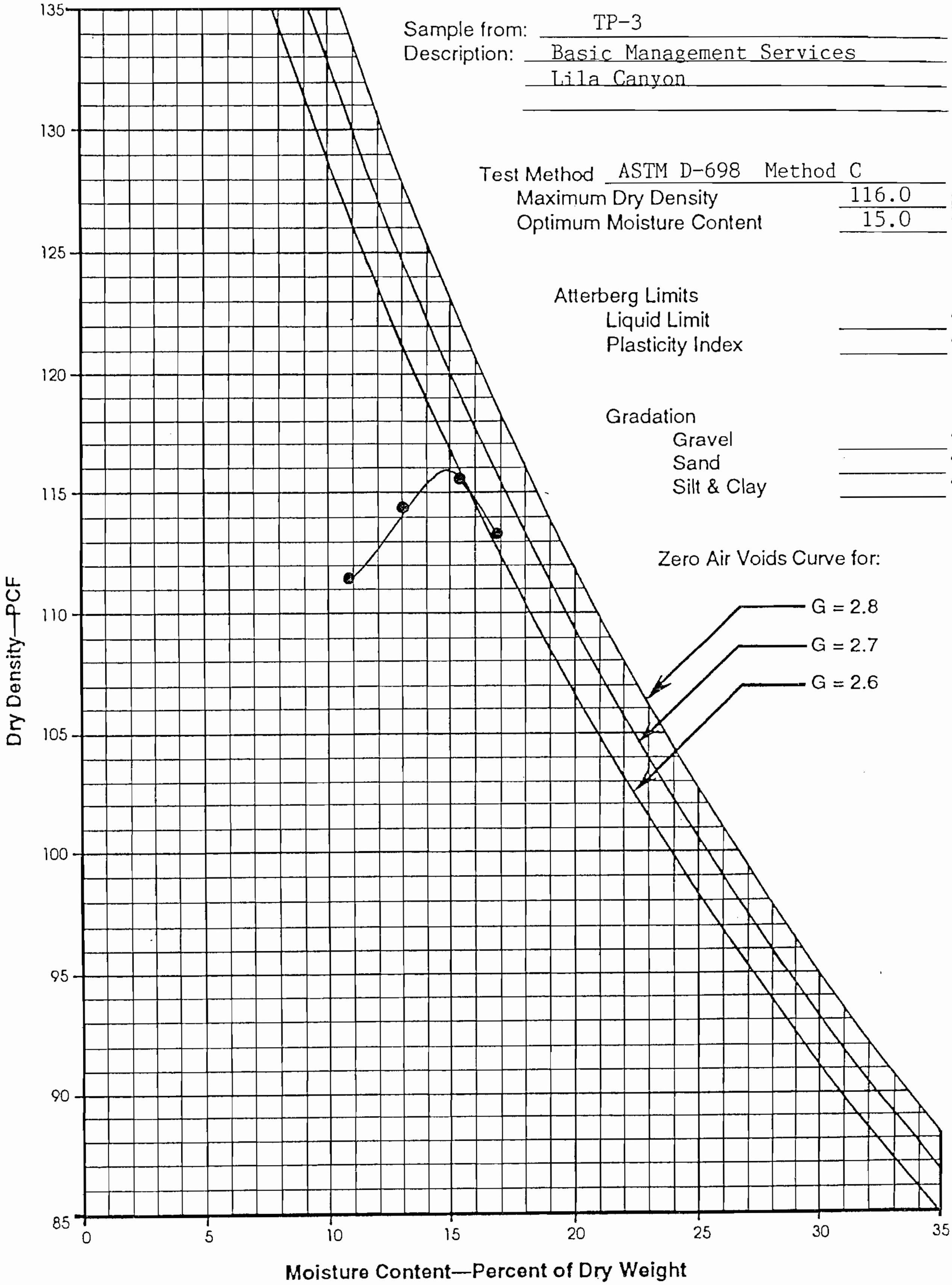
Plasticity Index ______ %

Gradation

Gravel ______ %

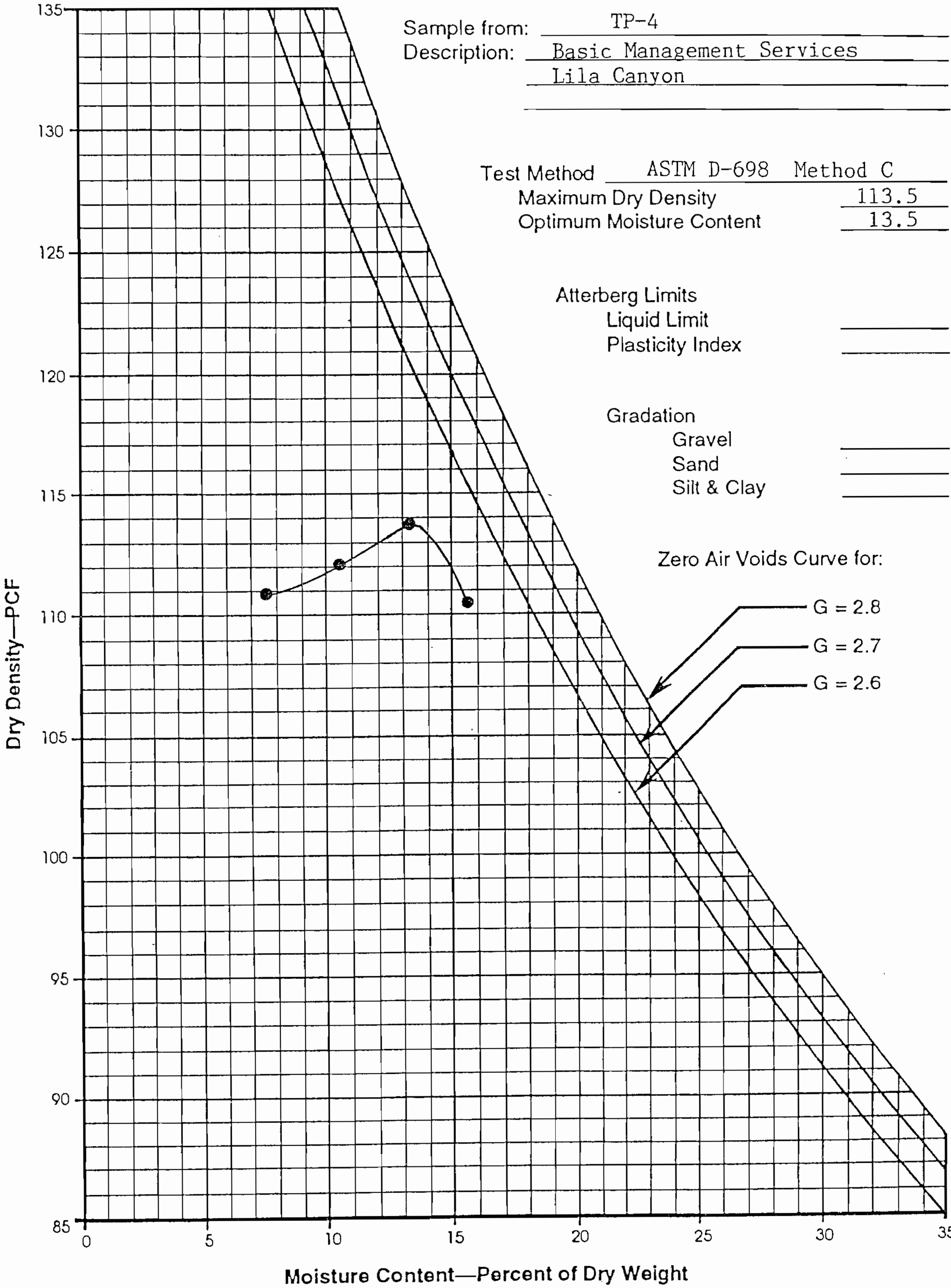
Sand ______ %

Silt & Clay ______ %



Project No. 973301 **COMPACTION TEST RESULTS** Figure 2

Applied Geotechnical Engineering Consultants, Inc.



Sample from: TP-4

Description: Basic Management Services
Lila Canyon

Test Method ASTM D-698 Method C

Maximum Dry Density 113.5 pcf

Optimum Moisture Content 13.5 %

Atterberg Limits

Liquid Limit ______ %

Plasticity Index ______ %

Gradation

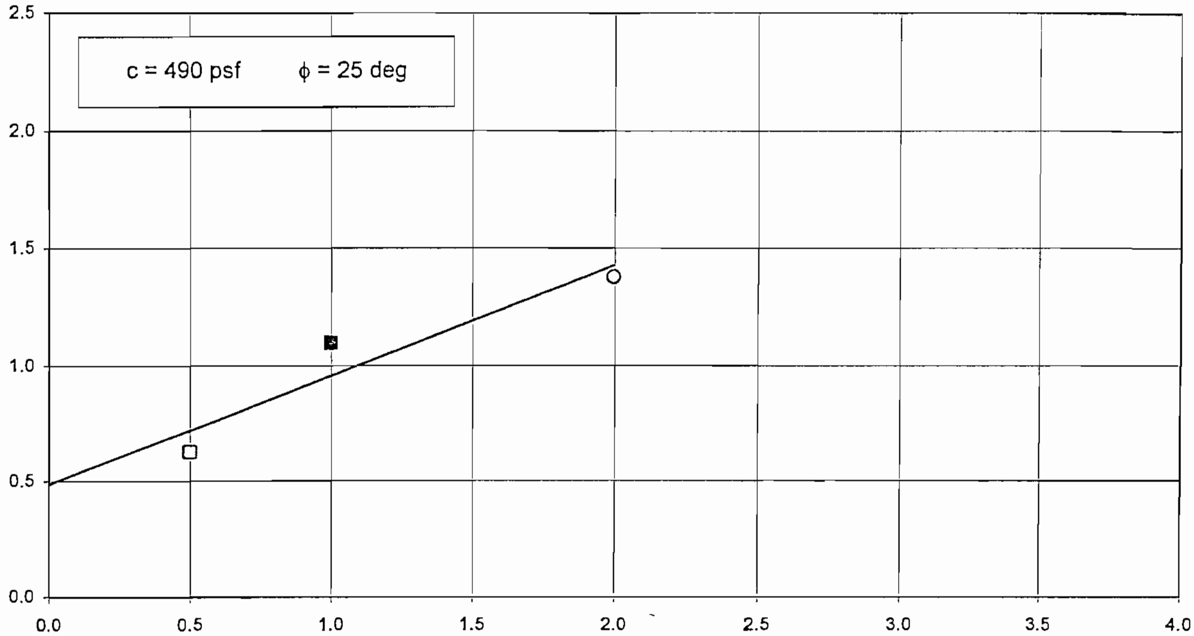
Gravel ______ %

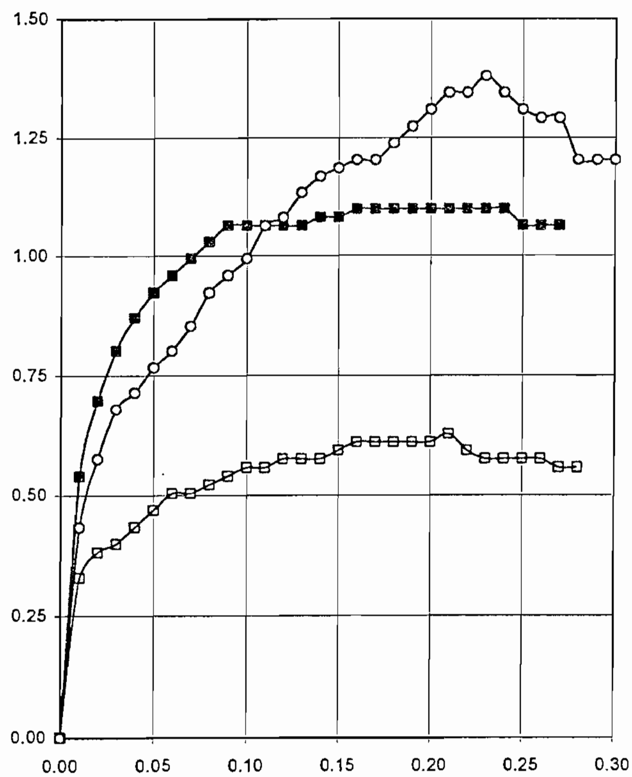
Sand ______ %

Silt & Clay ______ %

Project No. 973301 **COMPACTION TEST RESULTS** Figure 3

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Remolded		
Length, in.	1.00	1.00	1.00
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	113	113	113
Moisture Content, %	14.5	14.5	14.5
Consolidation Load, ksf	0.5	1.0	2.0
Normal Load, ksf	0.5	1.0	2.0
Shear Stress, ksf	0.63	1.10	1.38
Remarks	Strain Rate 0.05 in/min. Sample remolded to 92% of the standard proctor value near the optimum moisture content.		

Sample Index Properties	
Dry Density, pcf	N/A
Moisture Content, %	N/A
Liquid Limit, %	N/A
Plasticity Index, %	N/A
Percent Gravel	N/A
Percent Sand	N/A
Percent Passing No. 200 Sieve	N/A

Type of Test: Consolidated Undrained/Saturated

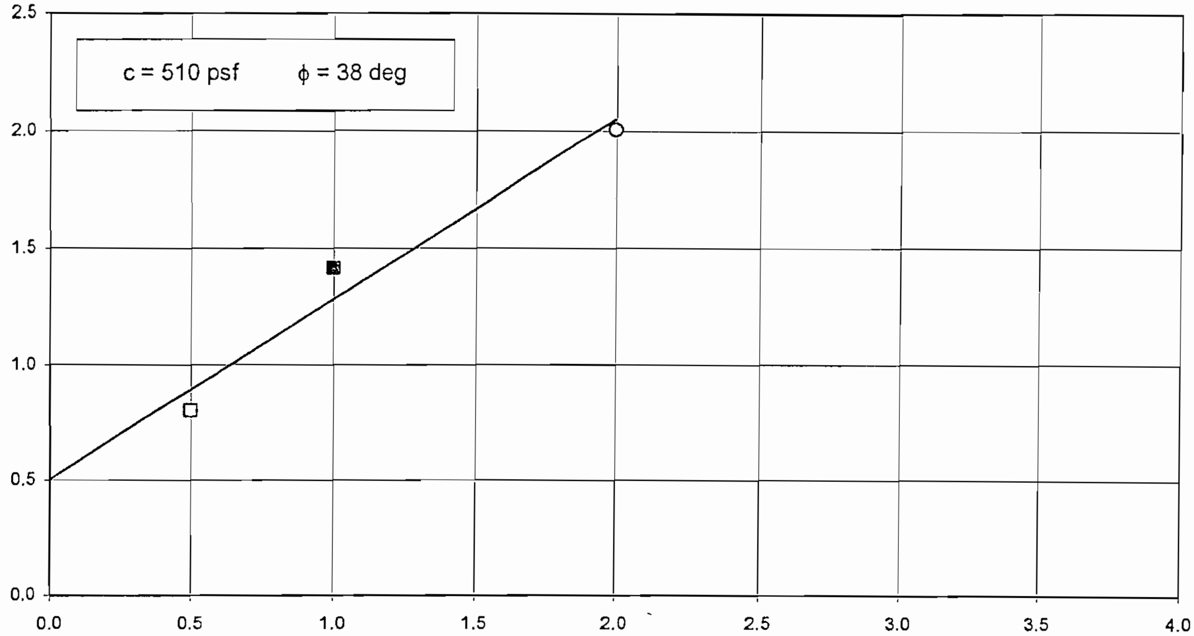
Sample Description: ______ From: TP-1

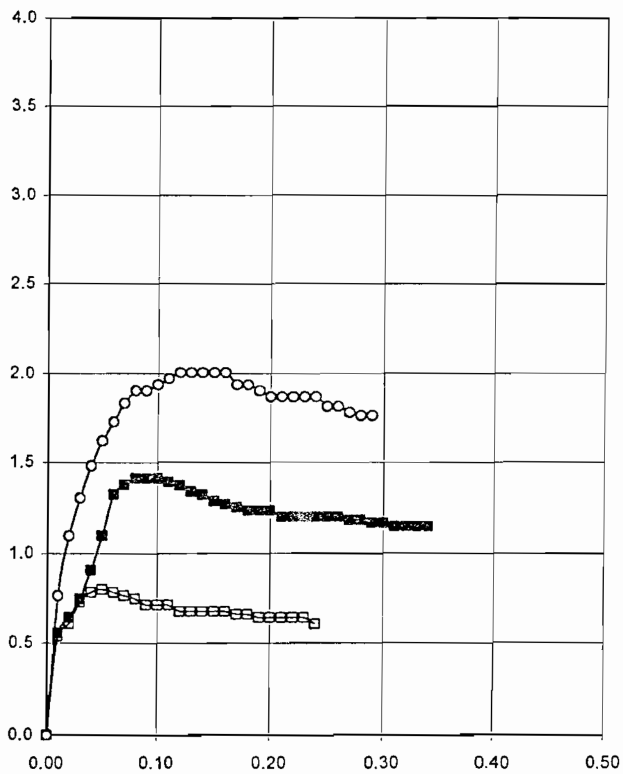
Project No. 973301

DIRECT SHEAR TEST RESULTS

Figure 4

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Remolded		
Length, in.	0.75	0.75	0.75
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	104	104	104
Moisture Content, %	14	14	14
Consolidation Load, ksf	0.5	1.0	2.0
Normal Load, ksf	0.5	1.0	2.0
Shear Stress, ksf	0.80	1.41	2.01
Remarks	Strain Rate 0.05 in/min. Sample remolded to 92% of standard proctor value near the optimum moisture content.		

Sample Index Properties	
Dry Density, pcf	N/A
Moisture Content, %	N/A
Liquid Limit, %	N/A
Plasticity Index, %	N/A
Percent Gravel	N/A
Percent Sand	N/A
Percent Passing No. 200 Sieve	N/A

Type of Test: Consolidated Undrained/Unsaturated

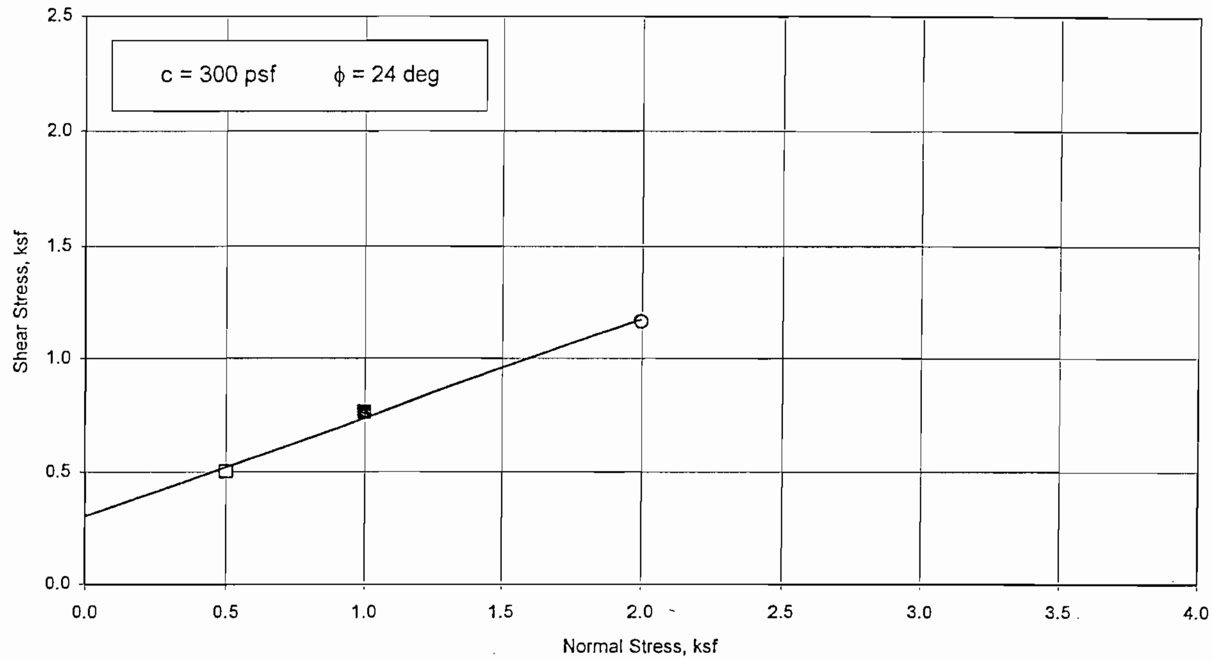
Sample Description: ______ From: TP-1

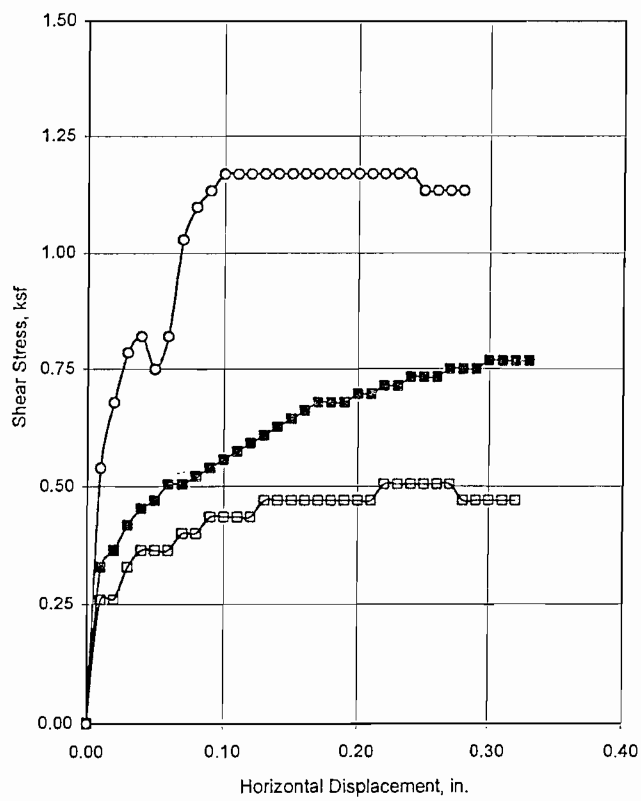
Project No. 973301

DIRECT SHEAR TEST RESULTS

Figure 5

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(O)
Sample Type	Remolded		
Length, in.	0.75	0.75	0.75
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	107	107	107
Moisture Content, %	15	15	15
Consolidation Load, ksf	0.5	1.0	2.0
Normal Load, ksf	0.5	1.0	2.0
Shear Stress, ksf	0.50	0.77	1.17
Remarks	Strain Rate 0.05 in/min. Sample remolded to 92% of the standard proctor value near optimum moisture content.		

Sample Index Properties	
Dry Density, pcf	N/A
Moisture Content, %	N/A
Liquid Limit, %	N/A
Plasticity Index, %	N/A
Percent Gravel	N/A
Percent Sand	N/A
Percent Passing No. 200 Sieve	N/A

Type of Test: Consolidated Undrained/Saturated

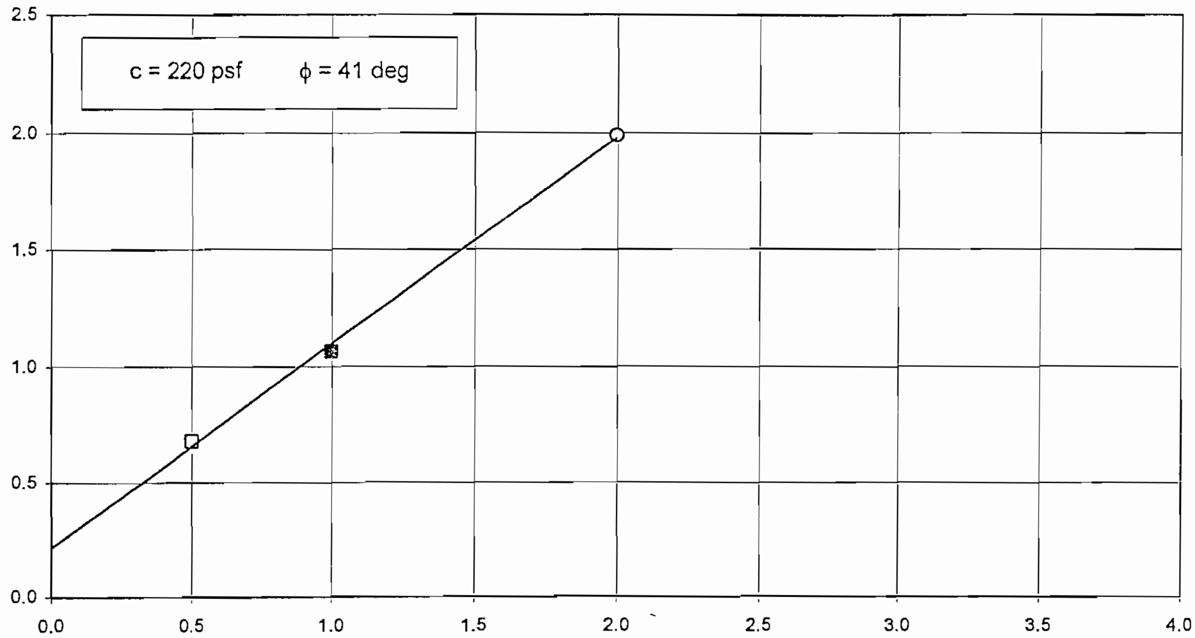
Sample Description: ____ From: TP-3

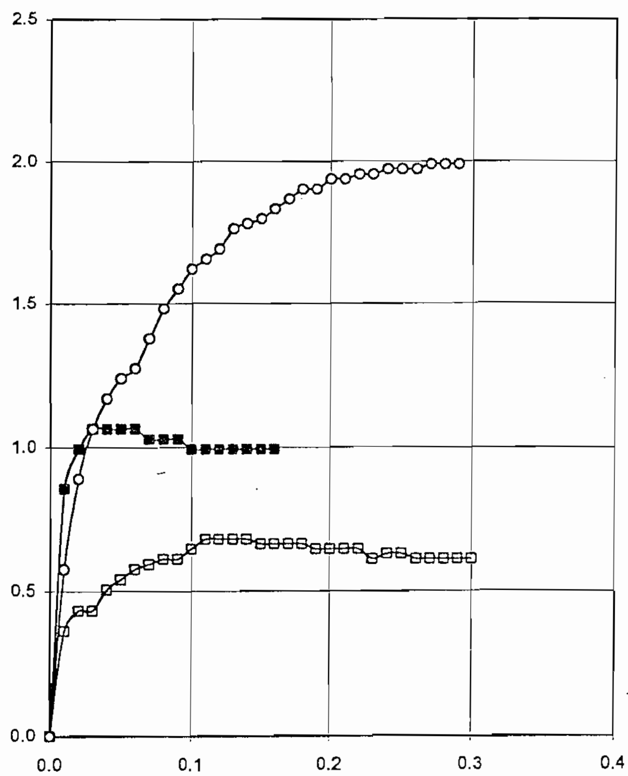
Project No. 973301

DIRECT SHEAR TEST RESULTS

Figure 6

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Remolded		
Length, in.	0.75	0.75	0.75
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	107	107	107
Moisture Content, %	15	15	15
Consolidation Load, ksf	0.5	1.0	2.0
Normal Load, ksf	0.5	1.0	2.0
Shear Stress, ksf	0.68	1.06	1.99
Remarks	Strain Rate 0.05 in/min.		
	Sample remolded to 92% of the standard		
	proctor value near optimum moisture		
	content.		

Sample Index Properties	
Dry Density, pcf	N/A
Moisture Content, %	N/A
Liquid Limit, %	N/A
Plasticity Index, %	N/A
Percent Gravel	N/A
Percent Sand	N/A
Percent Passing No. 200 Sieve	N/A

Type of Test: Consolidated Undrained/Unsaturated

Sample Description: ____ From: TP-3

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DIRECT SHEAR TEST RESULTS

Figure 7

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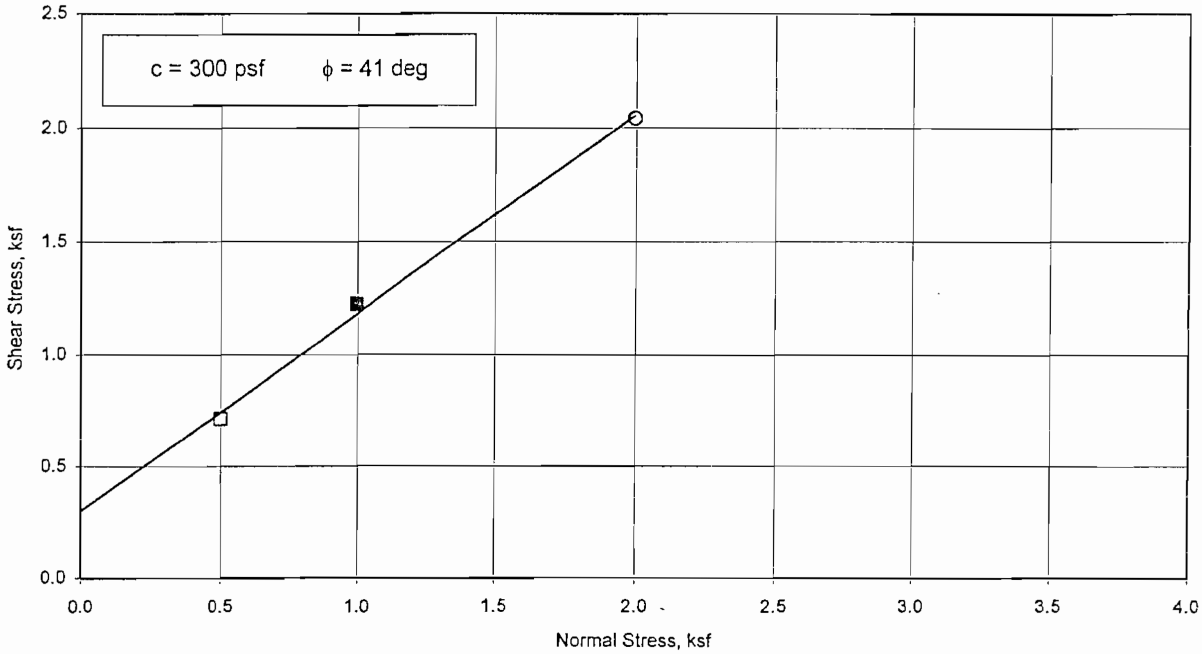
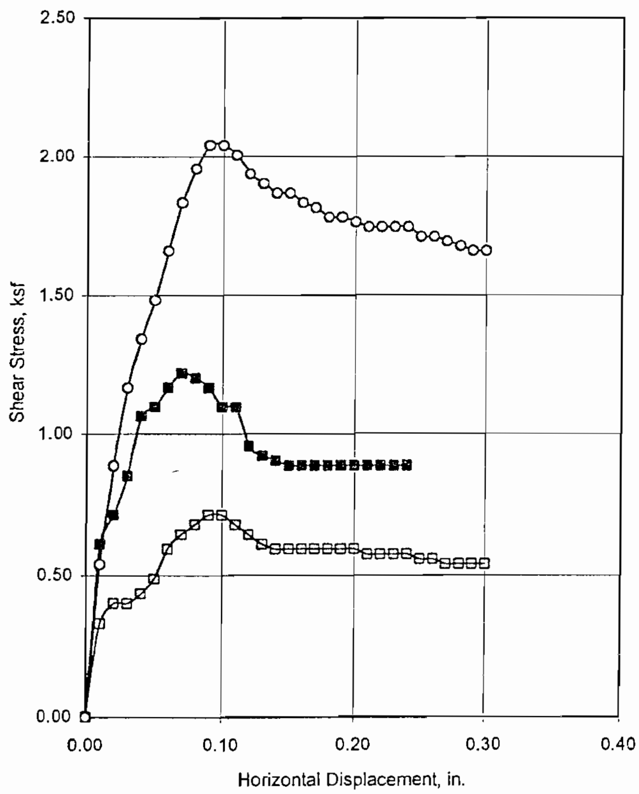




Test No. (Symbol)	1(□)	2(■)	3(O)
Sample Type	Remolded		
Length, in.	0.75	0.75	0.75
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	104	104	104
Moisture Content, %	14	14	14
Consolidation Load, ksf	0.5	1.0	2.0
Normal Load, ksf	0.5	1.0	2.0
Shear Stress, ksf	0.71	1.22	2.04
Remarks	Strain Rate 0.05 in/min.		
	Sample remolded to 92% of the standard		
	proctor value near optimum moisture		
	content.		

Sample Index Properties	
Dry Density, pcf	N/A
Moisture Content, %	N/A
Liquid Limit, %	N/A
Plasticity Index, %	N/A
Percent Gravel	N/A
Percent Sand	N/A
Percent Passing No. 200 Sieve	N/A

Type of Test Consolidated Undrained/Saturated

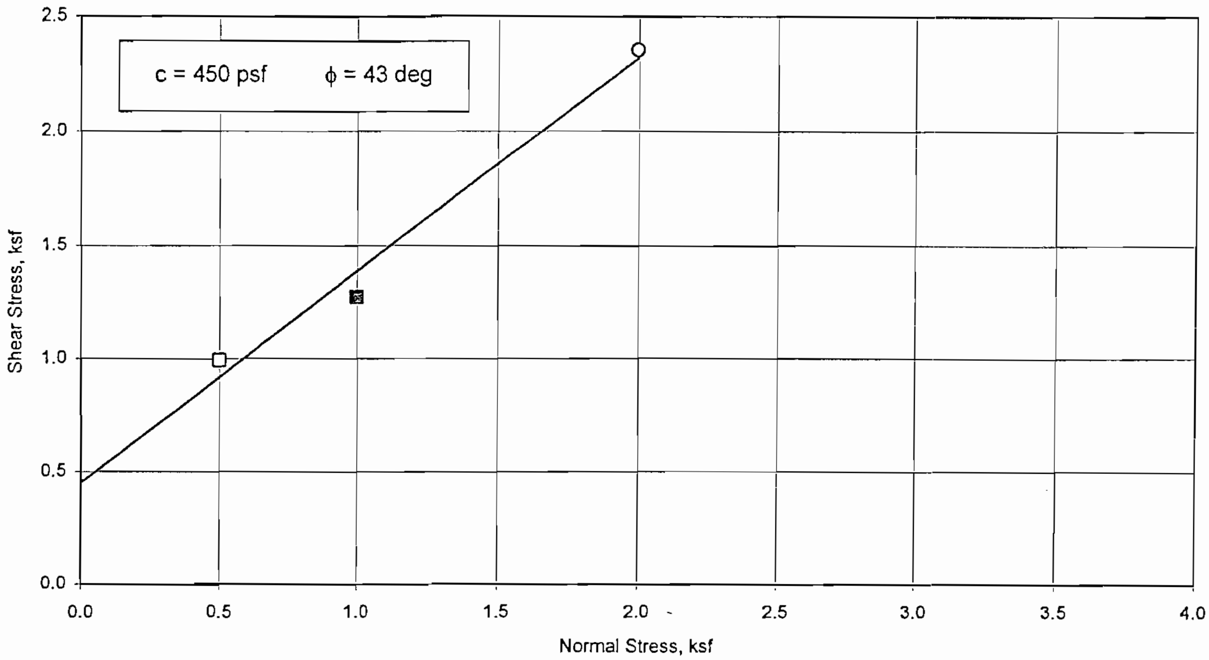
Sample Description ______ From TP-4

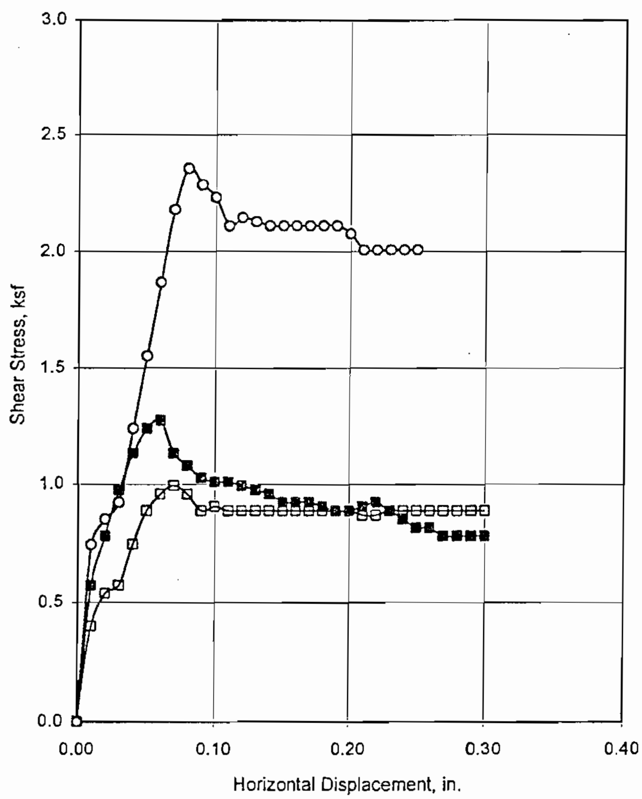
Project No. 973301

DIRECT SHEAR TEST RESULTS

Figure 8

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Remolded		
Length, in.	0.75	0.75	0.75
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	104	104	104
Moisture Content, %	14	14	14
Consolidation Load, ksf	0.5	1.0	2.0
Normal Load, ksf	0.5	1.0	2.0
Shear Stress, ksf	0.99	1.27	2.36
Remarks	Strain Rate 0.05 in/min. Sample remolded to 92% of the standard proctor value near optimum moisture content.		

Sample Index Properties	
Dry Density, pcf	N/A
Moisture Content, %	N/A
Liquid Limit, %	N/A
Plasticity Index, %	N/A
Percent Gravel	N/A
Percent Sand	N/A
Percent Passing No. 200 Sieve	N/A

Type of Test: Consolidated Undrained/Unsaturated

Sample Description: ______ From TP-4

Project No. 973301

DIRECT SHEAR TEST RESULTS

Figure 9