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PROVO, UT 84601-1343
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COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY

Emery County, Utah

October 1992

STABILITY ANALYSIS

9201.139

PACIFICORP
ELECTRIC OPERATIONS

ONE UTAH CENTER

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October 28, 1992

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NOV 0 2 1992
DIVISION OF
OIL GAS & MINING

Ms. Pamela Grubaugh-Littig
Permit Supervisor
Division of Oil, Gas and Mining
3 Triad Center, Suite 350
Salt Lake City, UT 84180-1203

Re: Division Order DO-91B, PacifiCorp
Cottonwood/Wilberg Waste Rock Site,
ACT/015/019-DO-91B, Folder #2, Emery County, Utah

Dear Ms. Littig:

In response to follow-up action in Issue #5 of my letter to you dated September 24, 1992 a report from Rollins, Brown and Gunnell is included herewith. This submittal fulfills the response required for the above referenced Division Order. We hope this will resolve the matter.

Respectfully,

Val Payne

Val Payne
Senior Environmental Engineer

cc: Blake Webster
Larry Lafrentz
file

RB&G
ENGINEERING
INC.

October 27, 1992

Greg Cowan
Energy West Mining Co.
P.O. Box 310
Huntington, UT 84528

Dear Greg:

During our recent investigation of the Waste Rock Pile at the Cottonwood/Wilberg Coal Mine in Emery County, Utah, it was concluded that the rock pile should have a slope of 2.5 horizontal to 1 vertical to provide an adequate factor of safety for the water level in both the sedimentation pond and in the rock pile elevation 6770.

An overall slope of 2.5 horizontal to 1 vertical can be achieved if the width of the berm above the elevation of the rock pile at the present time is increased from 3 to 8 feet. The profile of the upstream face of the waste rock pile would have the shape as shown in the attached figure. Since the increase in the horizontal distance in each berm is 5 feet, and there are six berms above the present elevation, the total increase in the horizontal length of the slope would be 30 feet. It should also be noted that the upstream face between berms is 2 horizontal to 1 vertical. We recommend that in order to have a satisfactory factor of safety for the waste rock pile that the rock pile face conform to the shape shown in Figure 1.

Sincerely,

RB&G ENGINEERING, INC.

Ralph L. Rollins

Ralph L. Rollins, Ph.D., P.E.

rlr/jag

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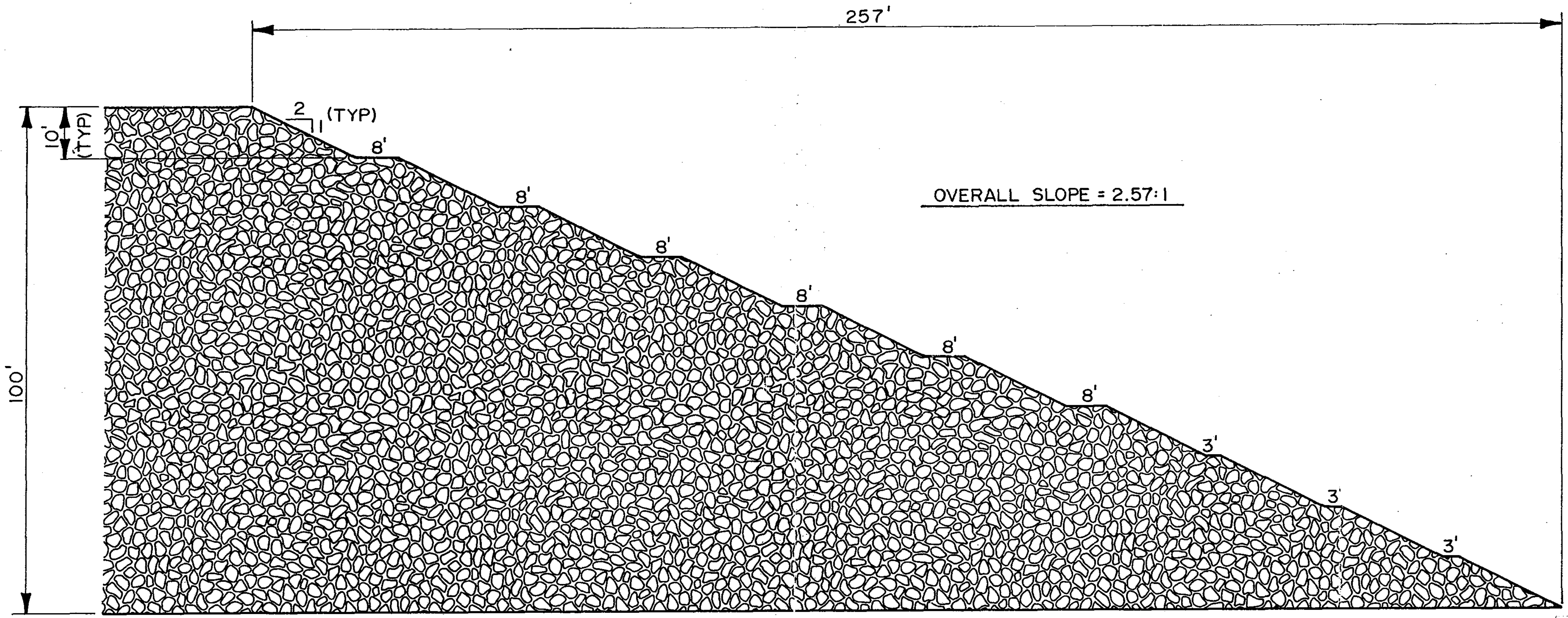

Figure

RB&G ENGINEERING INC.
Provo, Utah

COTTONWOOD/WILBERG COAL MINE
WASTE ROCK STORAGE FACILITY
EMERY COUNTY, UTAH

PROPOSED CROSS SECTION

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COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY

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STABILITY ANALYSIS

COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY

Emery County, Utah

October 1992

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Professional Engineers

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October 2, 1992

Greg Cowan
Energy West Mining Co.
P.O. 310
Huntington, UT 84528

Dear Greg:

In accordance with your request, we have completed a slope stability study for the Waste Rock Pile at the Cottonwood/Wilberg Coal Mine in Emery County, Utah. The purpose of the investigation was to determine the stability of the proposed rock fill slope when the structure has reached the finished height. The investigation has been performed in accordance with a written proposal submitted to you for the work, and the results of the investigation are outlined in the following sections of this report. The information contained in the report is discussed under the following headings: (1) Existing Site Conditions, (2) Subsurface Soil and Water Conditions, (3) The Results of Laboratory Tests, (4) Slope Stability Considerations, and (5) Summary and Conclusions.

1. *EXISTING SITE CONDITIONS*

The existing waste rock pile is located several miles down slope from the existing Cottonwood/Wilberg Coal Mine. Figure 1 is a contour map showing the area where the waste rock pile is located. This map defines the topography of the area as it presently exists. A steep cliff is located on the north and northwest of the site. A ridge is located along the easterly side of the site, and a sedimentation pond is located downstream from the face of the waste rock pile. It will be observed that the embankment on the downstream side of the sedimentation pond is approximately 20 feet high, and that at the present time, the face of the existing rock pile is about 25 feet high. The location of drainage ditches directing the water towards the sedimentation pond is shown in Figure 1. It appears that the maximum depth of refuse in the rock pile at the present time is about 25 feet.

Figure 2 shows the contours defining the finished rock pile, and it will be observed that the rock pile reaches an elevation of 6855 feet with respect to the site datum. The bottom of the sedimentation pond is at approximately elevation 6755. This means that when the rock pile is finished, the total height of the embankment at the sedimentation pond will be about 100 feet. The contour map also indicates that the slope of the waste rock pile near the sedimentation pond is about 2 horizontal to 1 vertical. The material within the refuse pile consists of coal intermixed with angular rock fragments. The coal breaks down rapidly to form a significant percentage of fine grained material intermixed with the gravel size particles. From a textural standpoint, the coal refuse classifies as SM- or GM-type materials.

Water accumulated in the sedimentation pond from time to time from the drainage system, and some small amount of saturation of the rock pile may occur when water backs up in the sedimentation pond. The drainage ditches around the pond appear to intercept any water flowing off of the high ground to the north and northwest so that the only water which reaches the surface of the waste rock pile is the natural precipitation.

2. *SUBSURFACE SOIL AND WATER CONDITIONS*

A subsurface investigation was performed to define the characteristics of the existing rock pile material. Four test pits extending to depths of approximately 12 feet were excavated throughout the area at the locations shown in Figure 1. The logs for these four test pits are presented in Figures 3 and 4. During the subsurface investigation, sampling was performed at 3- to 4-foot intervals at locations shown on the test pit logs. The in-place unit weight and the natural moisture content was determined at each sampling location and the results of these tests are shown on the test pit logs. It will be observed that considerable variation occurred in the in-place unit weight of the refuse material. The dry unit weight varied from about 77.5 to 100.5 pcf. Weathered shale was encountered in Test Pit 1 at a depth of 11 feet below the existing ground surface. Previous drilling in the waste rock pile area by our organization indicates that the shale extends to a substantial depth below the original ground surface.

The test pits were supplemented by drilling three test holes to depths varying from 25 to 31.5 feet. The logs for the three test borings are presented in Figures 5 and 6. The location where the three test holes are located are presented in Figure 1. It should be noted that at the time the drilling was performed, the entire area near the downstream face of the rock pile was covered with large piles of coal refuse. This condition generally necessitated clearing a road through the refuse material to provide access to drilling and test pit sites. It will be observed that Drill Holes 1, 2 and 3 nearly form a straight line. Based upon the three test borings, it appears that the hard gray shale was encountered at a depth of about 18 to 20 feet below the surface of the waste rock pile at the time the drilling was performed.

During the drilling operations, field permeability tests were performed in the bore holes at five to ten-foot intervals. The field permeability tests were performed in accordance with Designation E-18 of the U.S. Bureau of Reclamation Earth Manual. The results of these tests are shown in Figures 5 and 6. It will be observed that the permeability of the coal material was relatively high; however, the shale underlying the waste coal material was essentially impervious. This means that any water accumulating in the waste rock pile will move towards the sedimentation pond. Since the main source of water reaching the surface of the waste rock pile will be natural precipitation, it appears unlikely that the waste rock pile will ever be saturated. It is our opinion that the amount of water existing above the shale surface will not be more than a few feet.

During the subsurface investigation, sampling in the drill holes was performed at three-foot intervals throughout the depth investigated. Samples were obtained by driving a 2-inch split spoon sampling tube through a distance of 18 inches using a 140-pound weight dropped from a distance of 30 inches. The number of blows to drive the sampling spoon through each 6 inches of penetration is shown on the boring logs. The sum of the last two blow counts, which represents the number of blows to drive the sampling spoon through 12 inches, is defined as the standard penetration value. The standard penetration value provides a good indication of the in-place density of sandy material; however, it only provides an indication of the relative stiffness of the cohesive material, since the penetration resistance of materials of this type is a function of the moisture content. Considerable care must be exercised in interpreting the standard penetration value in gravelly-type soils, particularly where the size of the granular particle exceeds the inside diameter of the sampling spoon. If the spoon can be driven through the full 18 inches with a reasonable core recovery, the standard penetration value provides a good indication of the in-place density of gravelly-type material. The results of the standard penetration tests indicate that considerable variation occurs in the in-place density of the refuse material.

Each sample of the refuse material obtained in the field was classified texturally according to the Unified Soil Classification System. The symbol designating the type of material according to this system, is presented on the boring logs. A description of the Unified Soil Classification System is presented in Figure 7, and the meaning of the various symbols shown on the boring logs can be obtained from this figure. From a textural standpoint, the refuse material classifies as either SM- or GM-type materials. It should be noted that a thin layer of weathered shale material existed on top of the hard shale. Undisturbed samples of the weathered shale were obtained for laboratory testing.

No groundwater was encountered in any of the test holes or test pits throughout the waste rock pile at the time the investigation was performed, and it is our opinion that the accumulation of water above the shale will only occur to a significant extent when water accumulates in the sedimentation pond downstream from the rock pile slope.

3. THE RESULTS OF LABORATORY TESTS

Laboratory tests performed on the refuse material included mechanical analyses, direct shear tests and triaxial shear tests.

A. MECHANICAL ANALYSIS

Two bulk samples of the coal refuse were obtained from Test Pits 1 and 3. Each sample weighed several hundred pounds, and the large size particles were separated by hand in the field. A sample of the minus #4 material was obtained by partial sieving in the field followed by a complete sieve analysis in the laboratory. The results of the particle size distribution analyses for the bulk samples are presented in Figures 8 and 9, and it will be observed that over one-half of the sample consisted of material in the gravel and cobble size range. About one-third of the sample consisted of materials in the sand size range and only 5 to 11% of the material passed a 200 sieve. Mechanical analyses were also performed on small size samples of the refuse material. The results of these tests are shown on Table 1, Summary of Test Data. It should be noted that the particle size distribution performed for the bulk samples is a much better representation of the characteristics of the refuse material than the particle size distribution data obtained from the small samples.

B. DIRECT SHEAR TESTS

Three consolidated drained direct shear tests were performed on the thin clay layer overlying the shale to obtain an indication of the shearing strength characteristics of this material. The undisturbed samples in the clay layer were obtained by cutting a block sample of this material in one of the test pits. The results of the direct shear tests plotted in a form of a Mohr Envelope is presented in Figure 10. The stress strain curves associated with the three direct shear tests are also presented in this figure. It will be observed that the subsurface material had a friction angle of 32° and no cohesion. The results of the direct shear tests performed on the clay layer was used in the stability analysis.

C. TRIAXIAL SHEAR TESTS

The results of the mechanical analyses performed on the bulk samples of the subsurface material taken from the test pits indicate that the amount of material in the sand size range was only about 30% of the total sample. In order to obtain an indication of the shearing strength of the coal refuse material, three triaxial shear tests were performed on the minus #4 material obtained from the bulk samples. Since the coal refuse appears to break down quite easily under the use of mechanical equipment, it is our opinion that the triaxial shear tests will provide a reasonable indication of the shearing strength of the coal refuse. The triaxial shear tests were performed under consolidated drained conditions. The permeability characteristics of the refuse material is relatively high and drainage occurs quite quickly. The results of the triaxial shear tests are plotted in the form of a Mohr Envelope in Figure 11, and it will be noted that a friction angle of 32° and no cohesion was obtained for the refuse material.

4. SLOPE STABILITY CONSIDERATIONS

As indicated earlier in this report, Figure 2 represents the contours throughout the waste rock pile when the proposed facility has been completed. A profile through the rock pile slope along line A-A is presented in Figure 12. It will be observed that the waste rock pile has a slope of about 2 horizontal to 1 vertical, and that a thin layer of clay exists between the waste pile refuse and the underlying shale. Field permeability tests performed during the drilling indicate that the coal refuse is relatively pervious, while the shale is relatively impervious.

Stability computations were performed for the waste rock pile at its full height and with (1) no water in either the sediment pond or the waste rock pile, (2) water in both the sedimentation pond and the waste rock pile at elevation 6770, and (3) water in the sedimentation pond at elevation 6770 and with water in the coal refuse pile at elevation 6805. The results of the stability computations are presented in Figures 13 through 15.

Figure 13 indicates that the waste rock pile material had a friction angle of 30° and a cohesion of zero, and that the dry unit weight of the waste rock material was 90 pcf and that the moisture content was 8.9%. Laboratory tests also indicate that the thin clay layer beneath the coal refuse material had a friction angle of 32°, a cohesion of zero, a dry unit weight of 109 pcf and a moisture content of 15.3%. The critical failure surface for each of the three assumed water level conditions are shown in this figure. Factors of safety of 1.21, 1.00 and <1.00 were obtained for the three water levels. It will be observed from Figure 13 that the failure surfaces indicate thin failure zones on the surface of the embankment. This condition frequently occurs in performing stability analyses for granular material, since the normal stress of the subsurface material near the face of the slope is very low resulting in lower resisting forces.

In order to obtain an indication of the effect of the cohesion on the location of the failure surface, a thin surface layer having a vertical depth of 8 feet and a cohesion of 400 psf was assumed to exist on the slope of the waste rock pile. This condition is presented in Figure 14. The factors of safety along with the critical failure surface for each of the water level conditions indicated above are shown in this figure. It will be observed that all of the failure surfaces lie well below the thin surface layer shown in this figure. Factors of safety obtained from each of the failure surfaces are 1.41, 1.31 and <1.00.

In order to obtain an indication of the effect of the slope of the rock pile on the stability of the rock pile material, stability computations were performed assuming a slope of 2.5 horizontal to 1 vertical and with no thin cohesive layer on the upstream slope. The results of the analysis are presented in Figure 15 for each of the water level conditions previously discussed. It will be observed that a factor of safety of 1.656 was obtained for no water in the sedimentation pond, 1.47 was obtained for the water level at elevation 6770, and <1.00 was obtained when the water level was at elevation 6805.

5. SUMMARY AND CONCLUSIONS

The subsurface material in the waste rock pile area was characterized by excavating four test pits and drilling three test borings in the vicinity of the existing waste rock pile slope near the sedimentation pond. An indication of the dry unit weight, along with the shearing strength parameters of the existing material was obtained for the waste rock pile zone.

A stability analysis was performed for side slopes of 2 horizontal to 1 vertical and 2.5 horizontal to 1 vertical using the shear strength parameters determined during the investigation for water levels in the sedimentation pond of zero, 6770, and 6805. For side slopes of 2 horizontal to 1 vertical, the factor of safety for the sedimentation pond emptied was 1.21. For the water levels at elevations 6770 and 6805, the factor of safety was equal to or less than 1.00.

For side slopes of 2.5 horizontal to 1 vertical, the factor of safety for the sedimentation pond empty and for the water level at elevation 6770 was 1.656 and 1.47 respectively. With the water level at elevation 6805, the factor of safety was less than 1.00.

A stability analysis was also performed for a side slope of 2 horizontal to 1 vertical assuming that the cohesion of a surface layer along the slope had a value of 400 psf. The results of this analysis indicated a factor of safety of 1.41 for the sedimentation pond empty, and 1.31 for the water level in both the sedimentation pond and the waste rock pile at elevation 6770. With the water level at elevation 6805, the factor of safety was <1.00.

Based upon the information obtained above, it is our opinion that the following conclusions can be made:

A. The proposed rock pile slope will be unstable for side slopes of 2 horizontal to 1 vertical and 2.5 horizontal to 1 vertical if the water level in the rock pile rises to elevation 6805.

B. For side slopes of 2 horizontal to 1 vertical, the rock pile will have a factor of safety of 1.21 if the sedimentation pond is empty. The proposed rock pile slope will likely experience slumping for side slopes of 2 horizontal to 1 vertical if the water level in the sedimentation pond and the rock pile reach elevation 6770.

C. The proposed rock pile slope will be stable for side slopes of 2.5 horizontal to 1 vertical if the sedimentation pond is either empty or rises to elevation 6770.

D. If the side slopes of the rock pile are 2 horizontal to 1 vertical, and if a surface layer having a vertical depth of 8 feet, a friction angle of 32°, and a cohesion of 400 psf exists on the slope, the factor of safety for the slope will be 1.41 for the sedimentation pond empty, and 1.31 with the water level in the sedimentation pond and the rock pile at elevation 6770.

The cohesion in a surface layer placed on the face of the existing facility could be obtained by placing a layer of earth materials on the surface having the desired characteristics. Figure 16 is a cross-section indicating how the proposed facility will be constructed. If at least half of the berm material consisted of a clayey gravel, and if the clayey gravel was densified to 95% of the maximum laboratory density as determined by ASTM D 1557-91, the surface layer would have sufficient strength to provide a stable structure for the water level in the sedimentation pond and in the waste rock pile at or below elevation 6770.

Cohesion could also be imparted to the surface layer along the slope by using plastic grids extending into the embankment for a horizontal distance of about 16 feet and located at periodic intervals up the slope of the rock pile. The exact spacing of the plastic grids in a vertical dimension would have to be determined.

The results of the field investigations indicate that the coal refuse has moderately high permeability characteristics, and it is our opinion that it is extremely unlikely that water would ever accumulate in the waste rock pile to an elevation greater than 6770, which corresponds to the depth to which water may accumulate in the sedimentation pond.

In the absence of any measures to increase the cohesion of a surface layer of material along the slope, we recommend that the rock pile slope be flattened to 2.5 horizontal to 1 vertical.

Sincerely,

RB&G ENGINEERING, INC.

Ralph L. Rollins

Ralph L. Rollins, Ph.D., P.E.

Bradford E. Price

Bradford E. Price, P.E.

rlr/jag

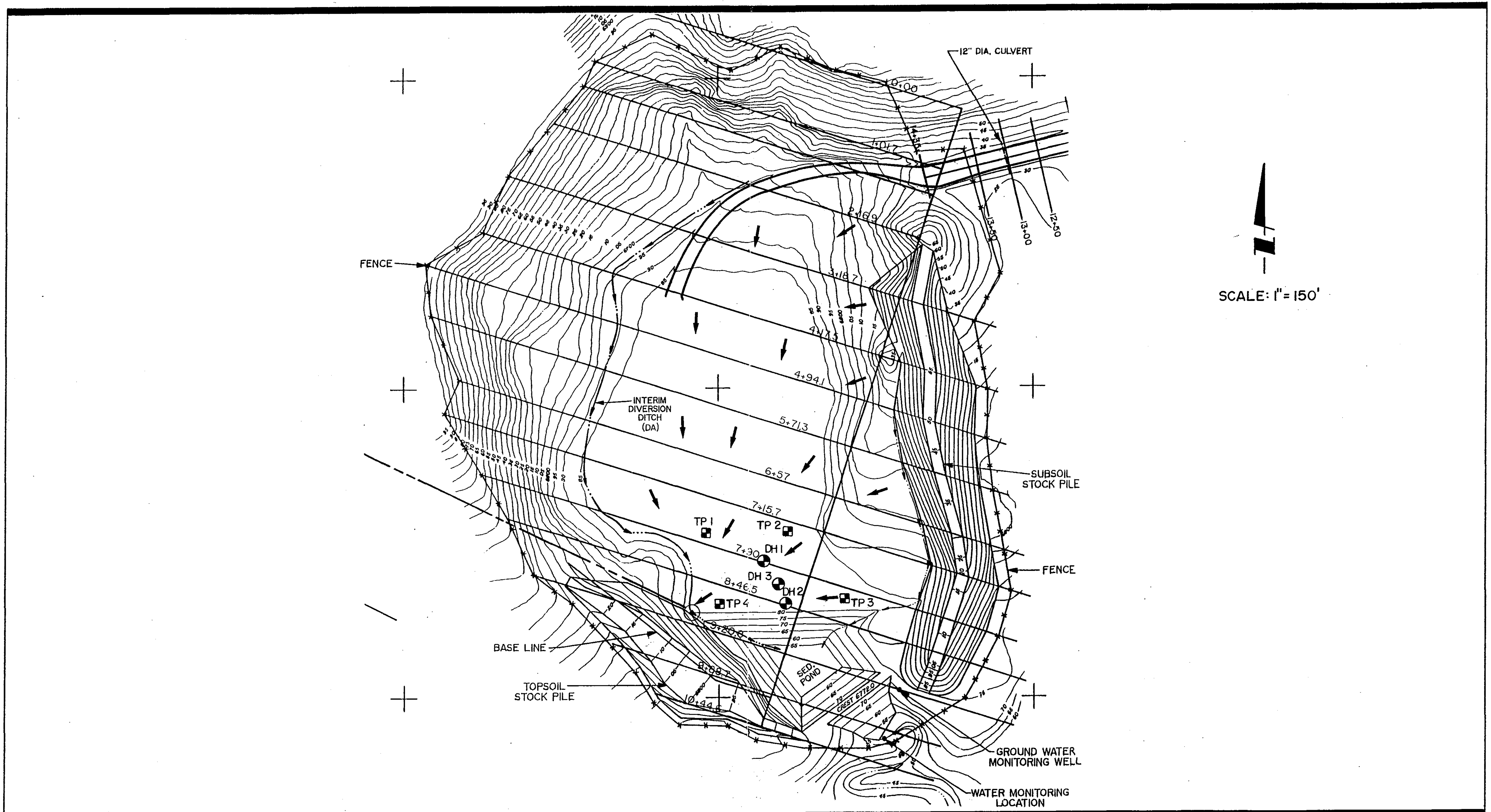

Figure 1

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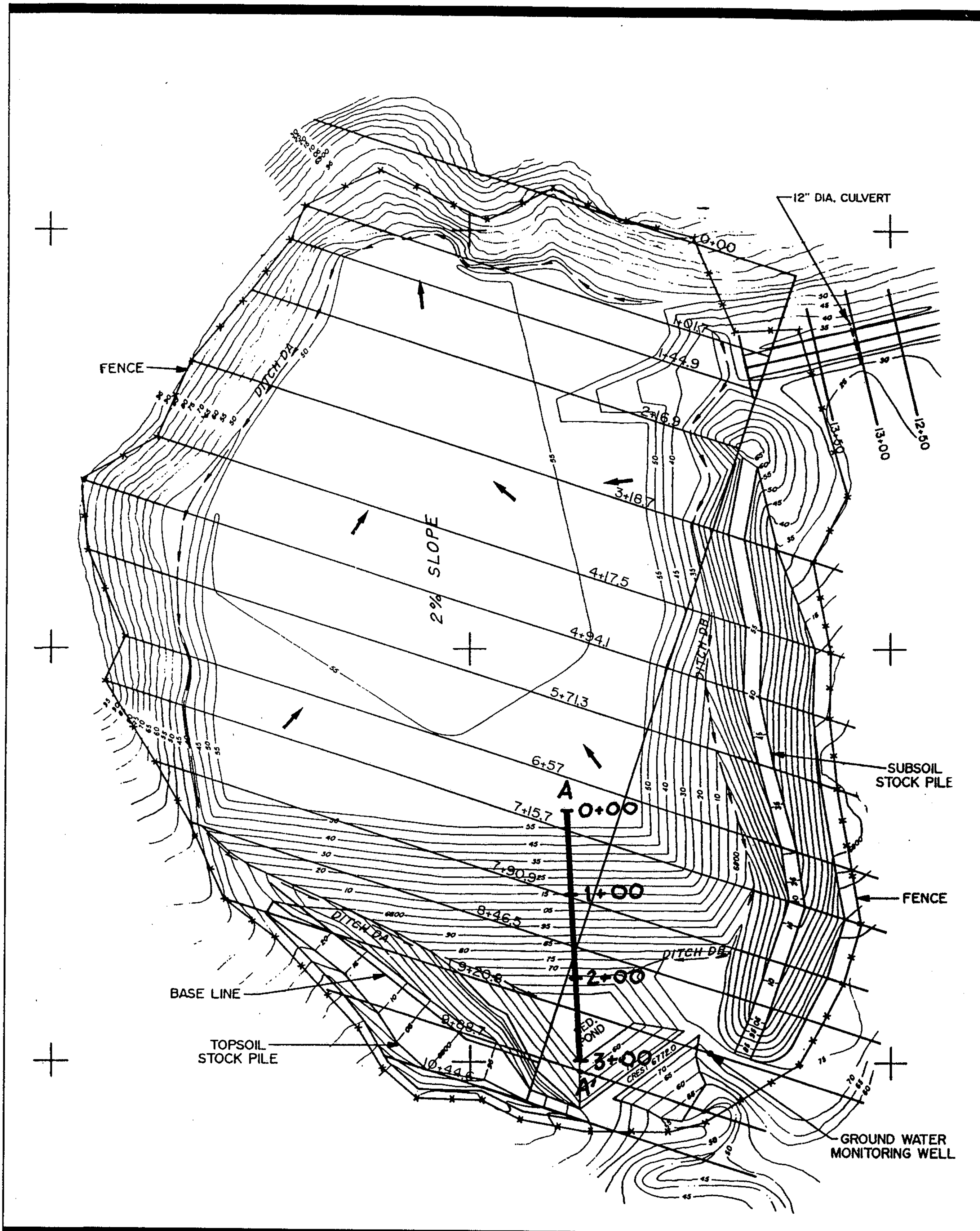
Provo, Utah

Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah

PLAN VIEW OF EXISTING WASTE ROCK PILE, AND TEST PIT AND BORING LOCATIONS



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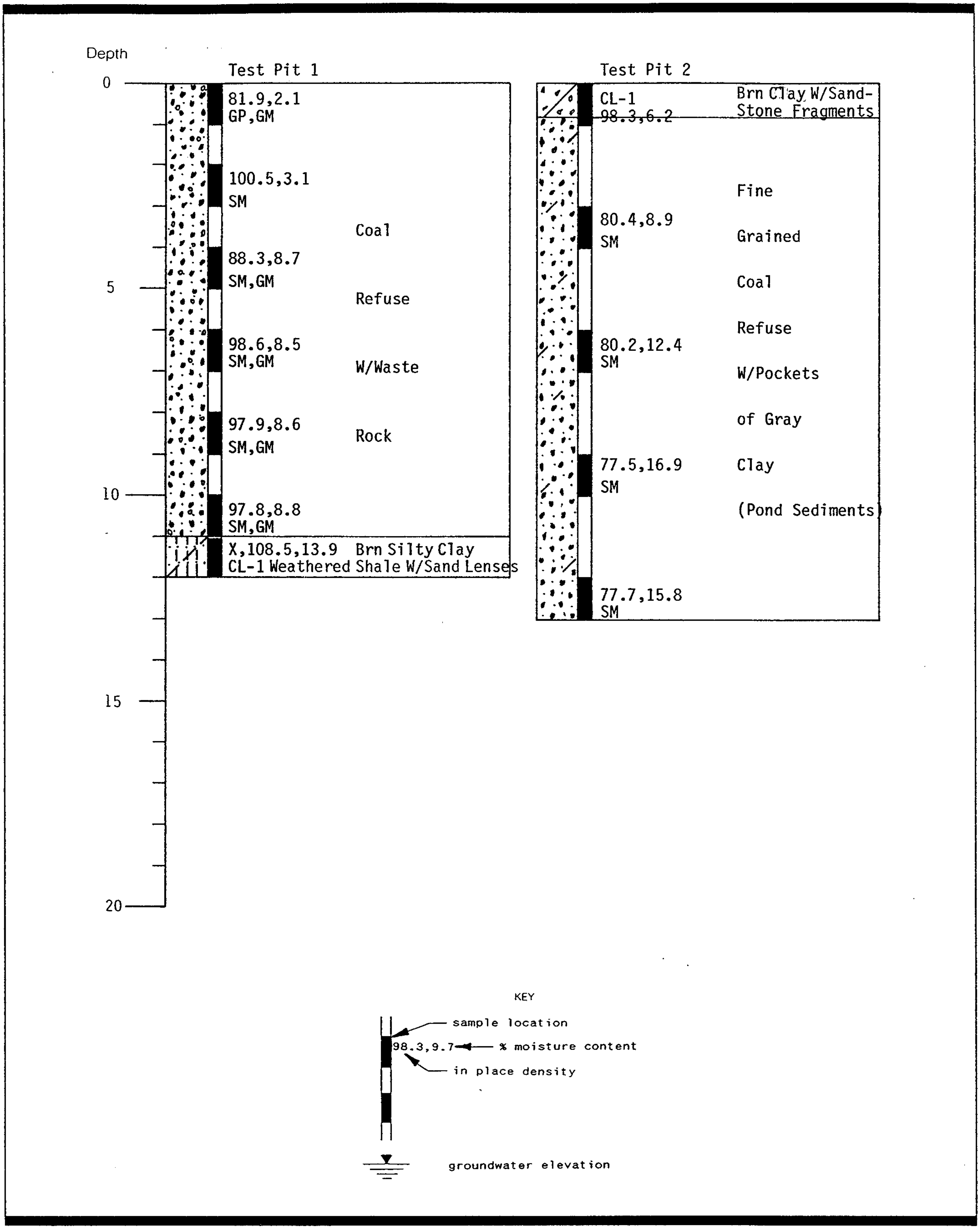
Provo, Utah

Figure 2. PLAN VIEW OF WASTE ROCK PILE

Cottonwood/Wilberg Mine
Waste Rock Pile Stability Analysis



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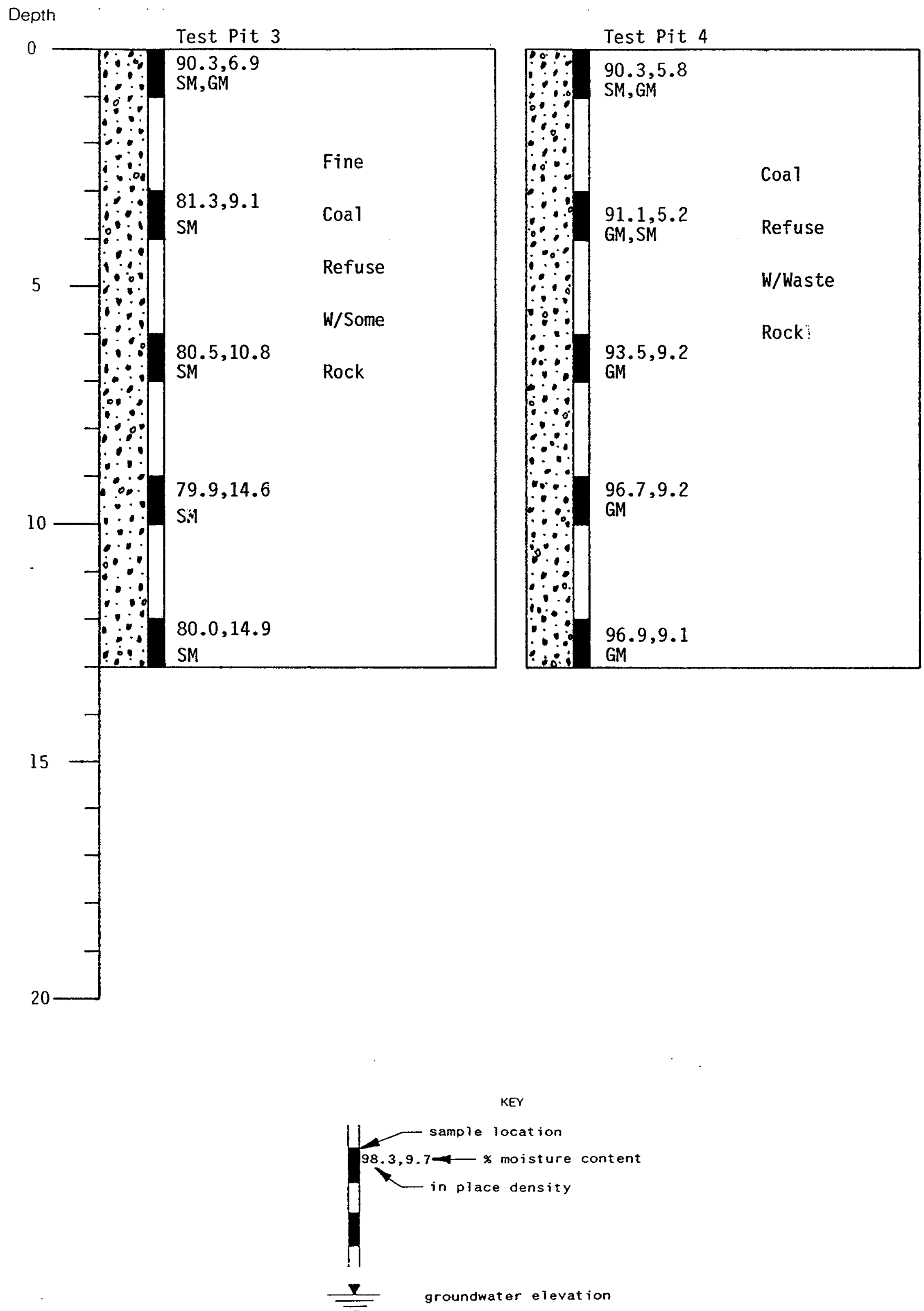
Provo, Utah

Figure 3 **TEST PIT LOGS**
Cottonwood/Wilberg Coal Mine Waste Storage Facility
Emery County, Utah



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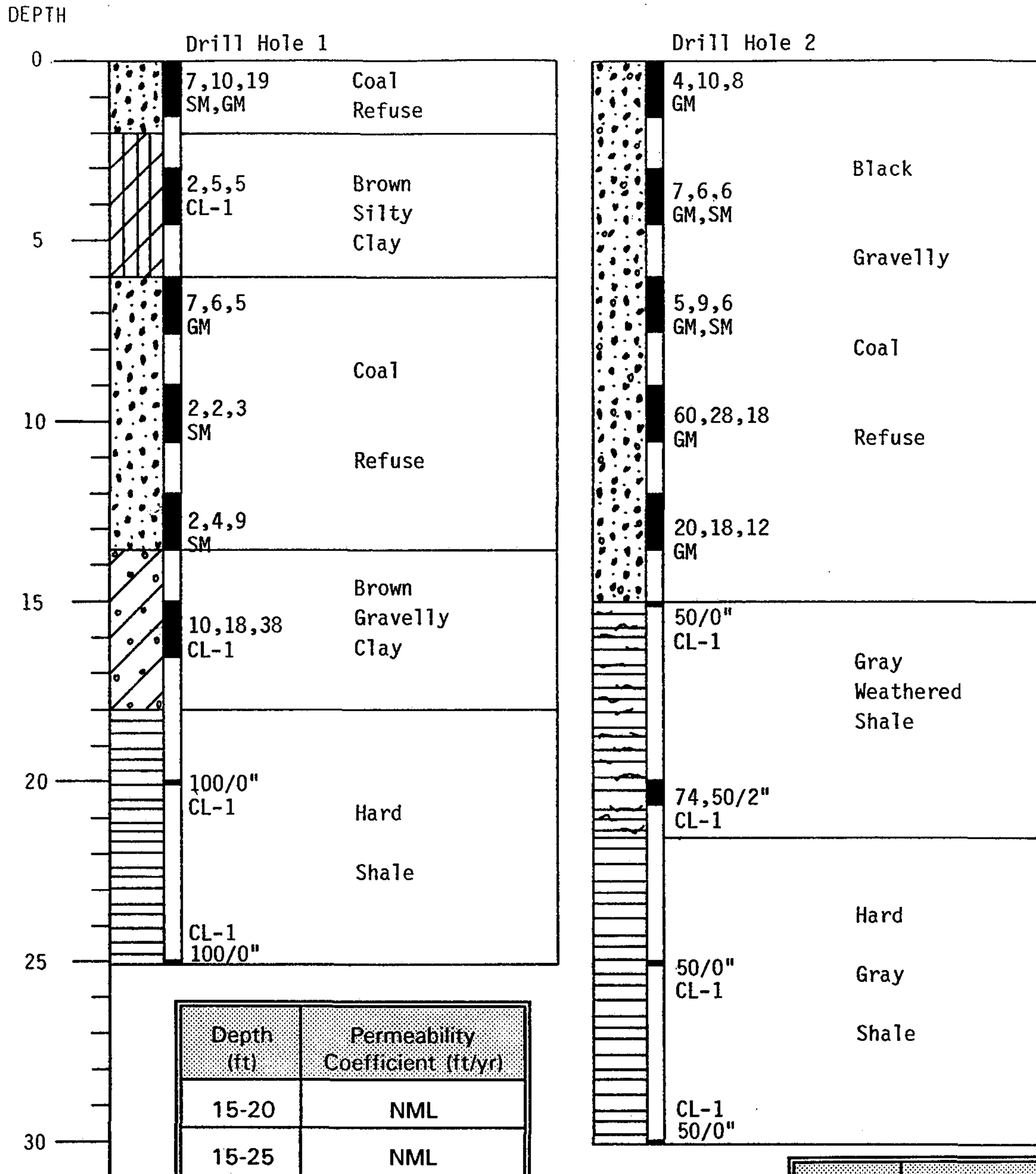
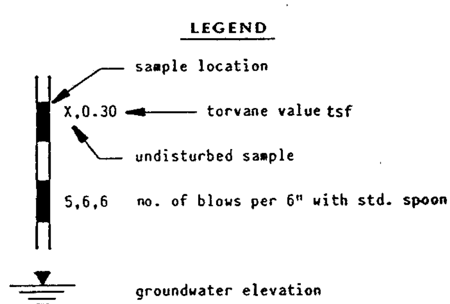
Provo, Utah

Figure 4 **TEST PIT LOGS**
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah



Depth (ft)	Permeability Coefficient (ft/yr)
15-20	NML
15-25	NML

NML = No measurable loss



Depth (ft)	Permeability Coefficient (ft/yr)
0-6	1200
5-10.5	>22,700
15-16	>66,500
20-25	NML
25-30	NML

NML = No measurable loss

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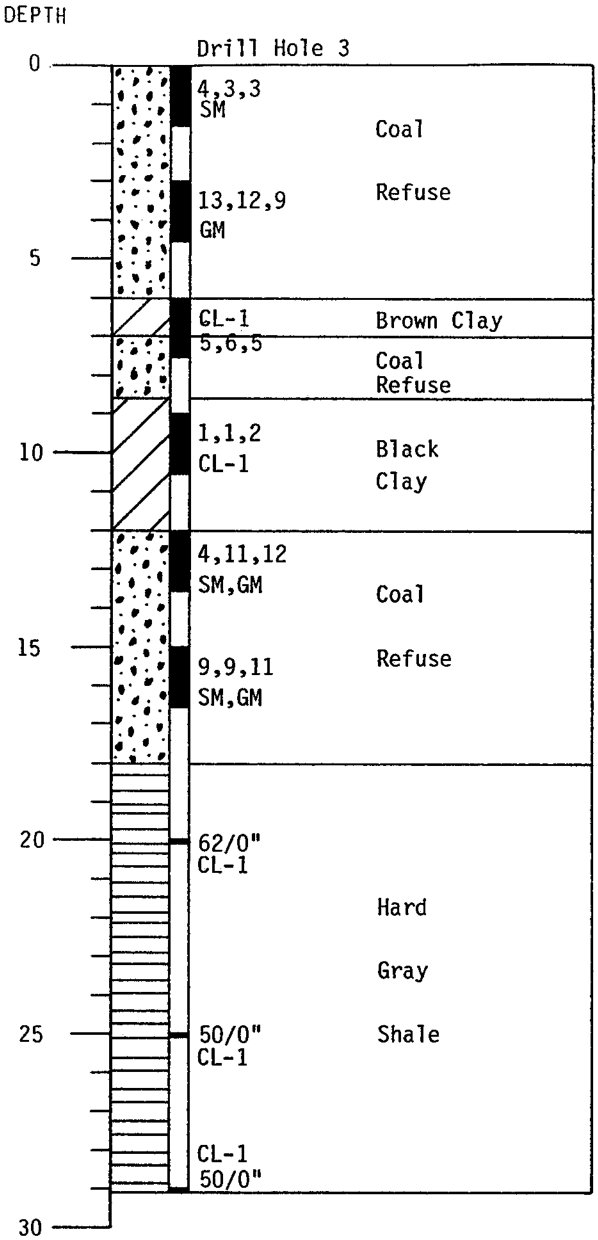
Provo, Utah

Figure 5 **DRILL HOLE LOGS**
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah



Depth (ft)	Permeability Coefficient (ft/yr)
0-6	206
0-10.5	583
15-20	1562
20-25	NML
25-30	NML

NML = No measurable loss

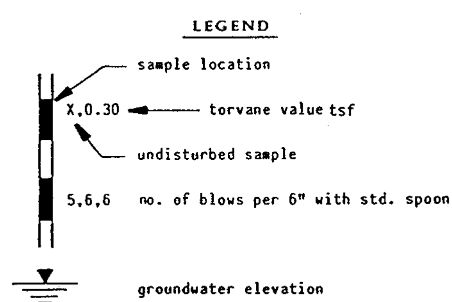


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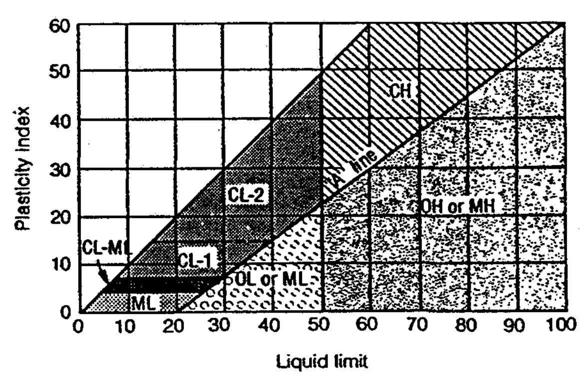
Figure 6 **DRILL HOLE LOGS**
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah

Unified Soil Classification System

Major Divisions			Group Symbols		Typical Names	Laboratory Classification Criteria		
Course-grained Soils More than half of material is *larger* than No. 200 sieve	Gravels More than half of coarse fraction is larger than No. 4 sieve size	Clean Gravels (Little or no fines)	GW		Well graded gravels, gravel-sand mixtures, little or no fines.	Determine percentage of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5% .... GW, GP, SW, SP More than 12% .... GM, GC, SM, SC 5% to 12% .... *Borderline cases requiring use of dual symbols***	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM*	d	Silty gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits below "A" line, or *PI* less than 4	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring uses of dual symbols
				u				
			GC		Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, or *PI* greater than 7	
	Sands More than half of coarse fraction is smaller than No. 4 sieve size	Clean Sands (Little or no fines)	SW		Well graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines.		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM*	d	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line, or *PI* less than 4	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring uses of dual symbols
				u				
			SC		Clayey sands, poorly graded sand-clay mixtures		Atterberg limits above "A" line, or *PI* greater than 7	
Fine-grained Soils More than half of material is *smaller* than No. 200 sieve	Silt and Clays Liquid limit less than 50		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity			
			CL	1	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
				2				
			OL		Organic silts and organic silt-clays of low plasticity			
	Silts and Clays Liquid limit greater than 50		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
Highly Organic Soils			Pt		Peat and other highly organic soils			

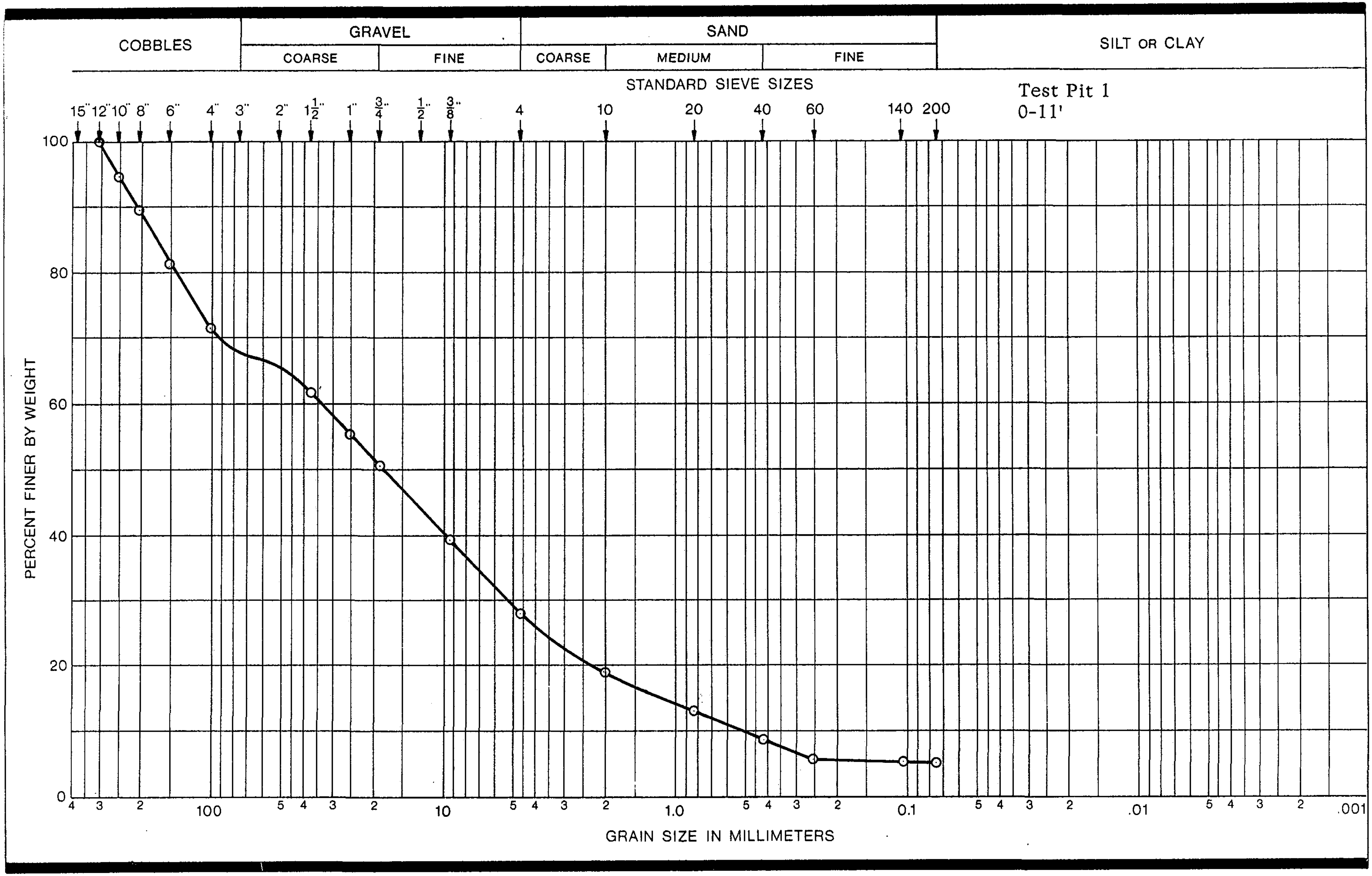


Plasticity Chart
For laboratory classification of fine-grained soils

*Division of *GM* and *SM* groups into subdivisions of d and u for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when liquid limit is 28 or less and the *PI* is 6 or less, the suffix u used when liquid limit is greater than 28.

***Borderline classification:* Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.

Figure No. 7



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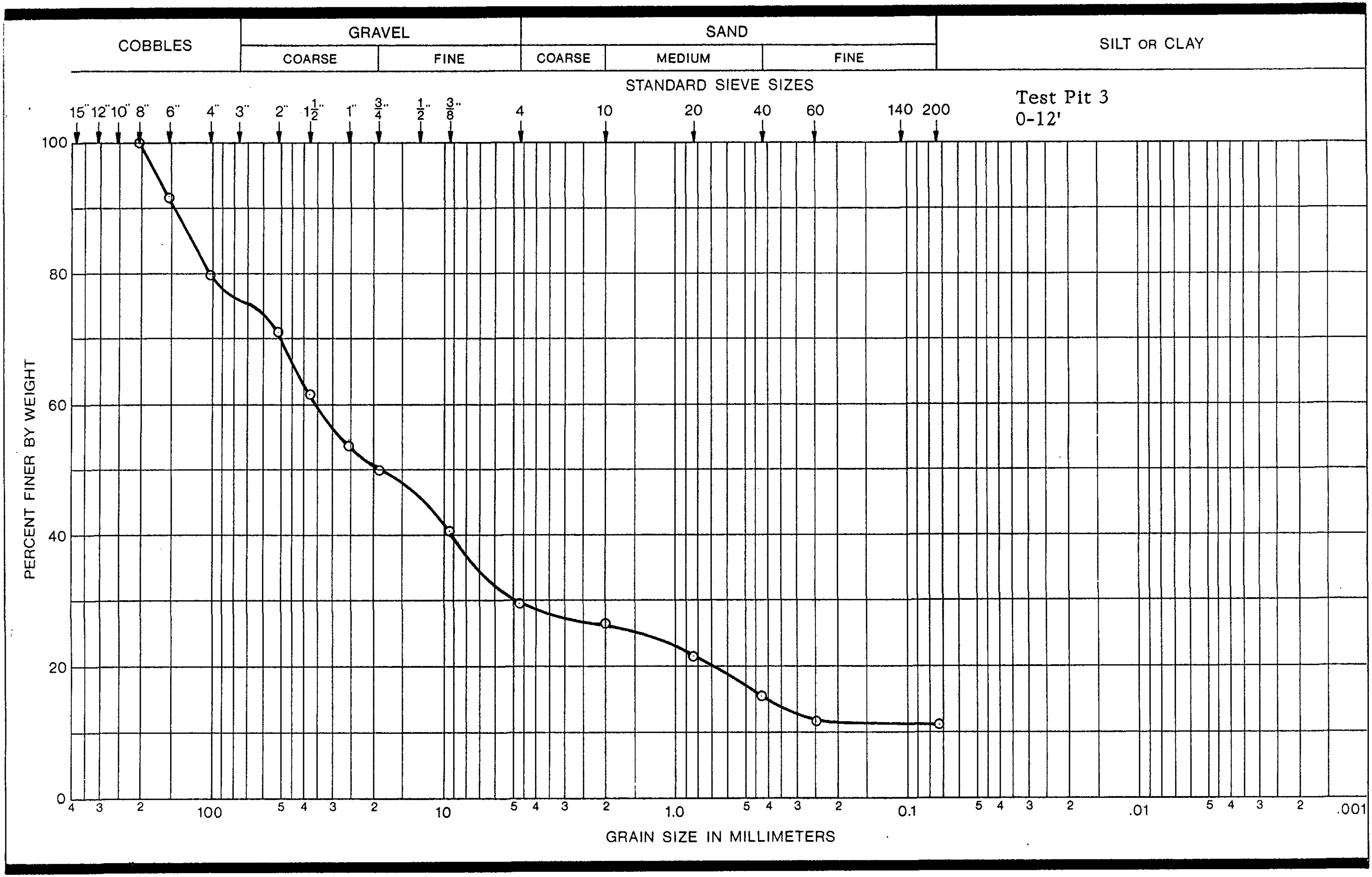
Provo, Utah

Figure 8 **SIEVE ANALYSIS**
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah



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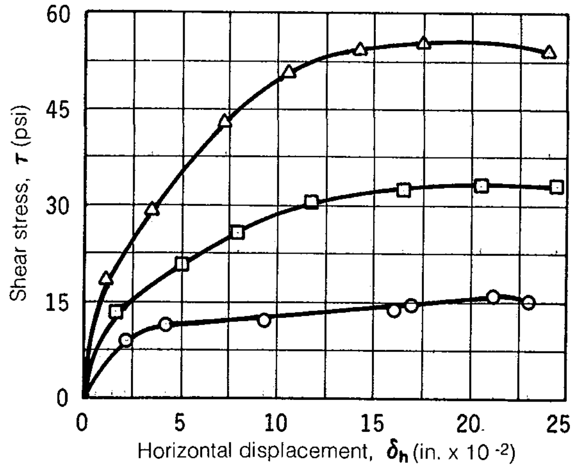
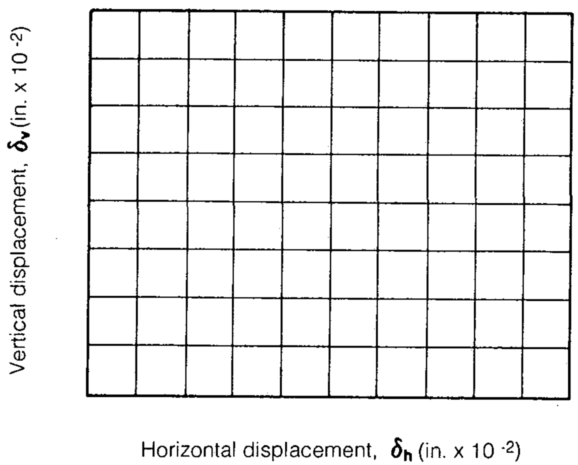
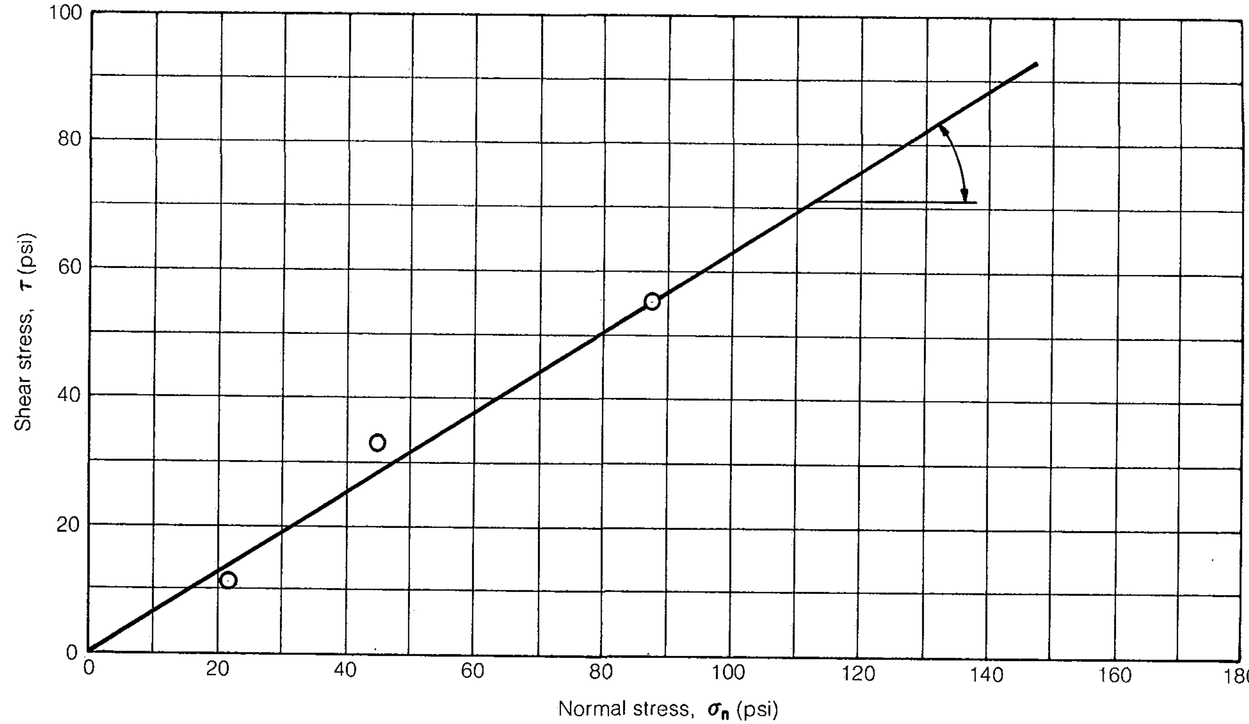
Provo, Utah

Figure 9 **SIEVE ANALYSIS**
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah

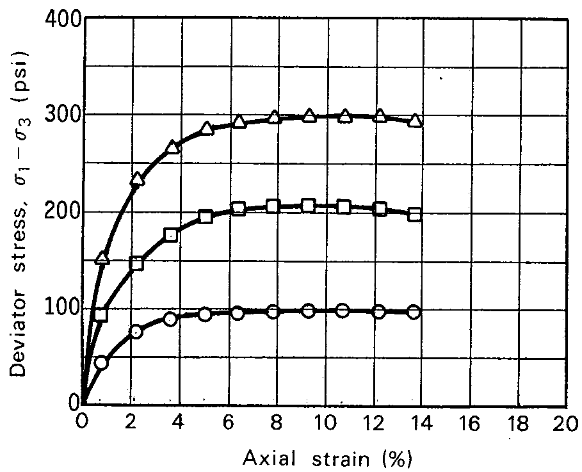


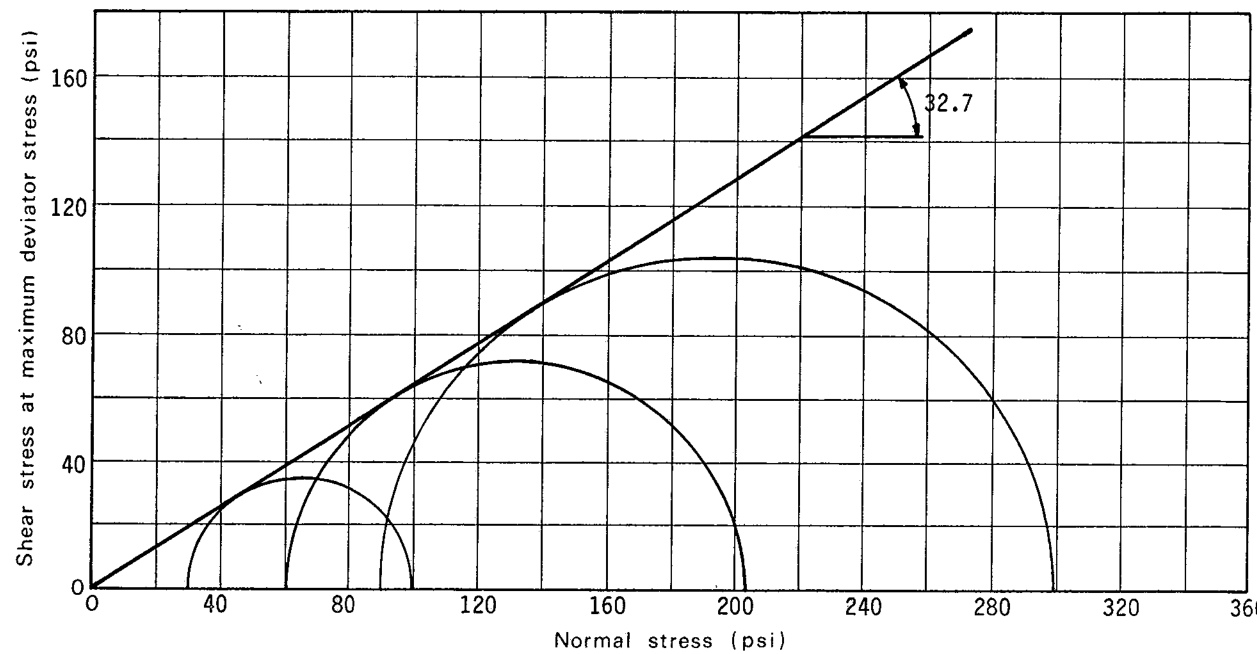


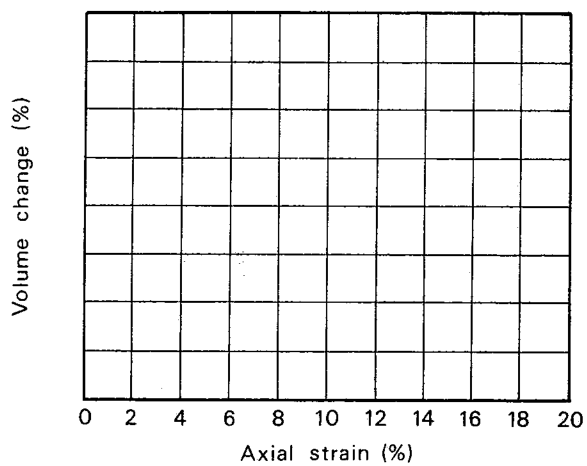


Test no. or symbol	Sample size (inches)	Sample data		Degree of saturation (%)	Normal stress σ_n (psi)	Maximum shear stress τ (psi)	Strain rate (inches / minute)	Shear strength parameters	
		Dry density (pcf)	Moisture content (%)					Friction angle ϕ (degrees)	Cohesion (c / psi)
○	2.35	108.8	15.3	~100	21.7	16.1	.001	32.2	0
□	2.35	109.3	13.4	~100	44.6	33.1.	.001		
△	2.35	108.5	13.9	~100	87.6	55.2	.001		

ROLLINS, BROWN AND GUNNELL, INC. PROFESSIONAL ENGINEERS	DIRECT SHEAR TEST Project: Cottonwood/Wilberg Coal Mine Waste Rock Pile Stability Analysis	HOLE NO. TP1 DEPTH: 11'	FIGURE NO. 10







Test no. or symbol	Boring no. or depth	Sample data: Dry density (pcf)	Sample data: Moisture content (%)	Degree of saturation (%)	Confining pressure (psi)	Maximum deviator stress (psi)	Strength values at failure: Friction angle ϕ (degrees)	Strength values at failure: Cohesion (c/psi)	Sample size, L/D (inches)	Strain rate (inches/minute)
○		90.9	8.6	~100	30	99.9	32.7	0	2.8/1.32	.001
□		91.1	8.5	~100	60	203.6			2.8/1.32	.001
△		90.2	8.9	~100	90	299.3			2.8/1.32	.001

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

TRIAXIAL SHEAR TEST

Project: Cottonwood/Wilberg Coal Mine
Waste Rock Pile Stability Analysis

HOLE NO. TP1
DEPTH: 0-11'

FIGURE NO. 11

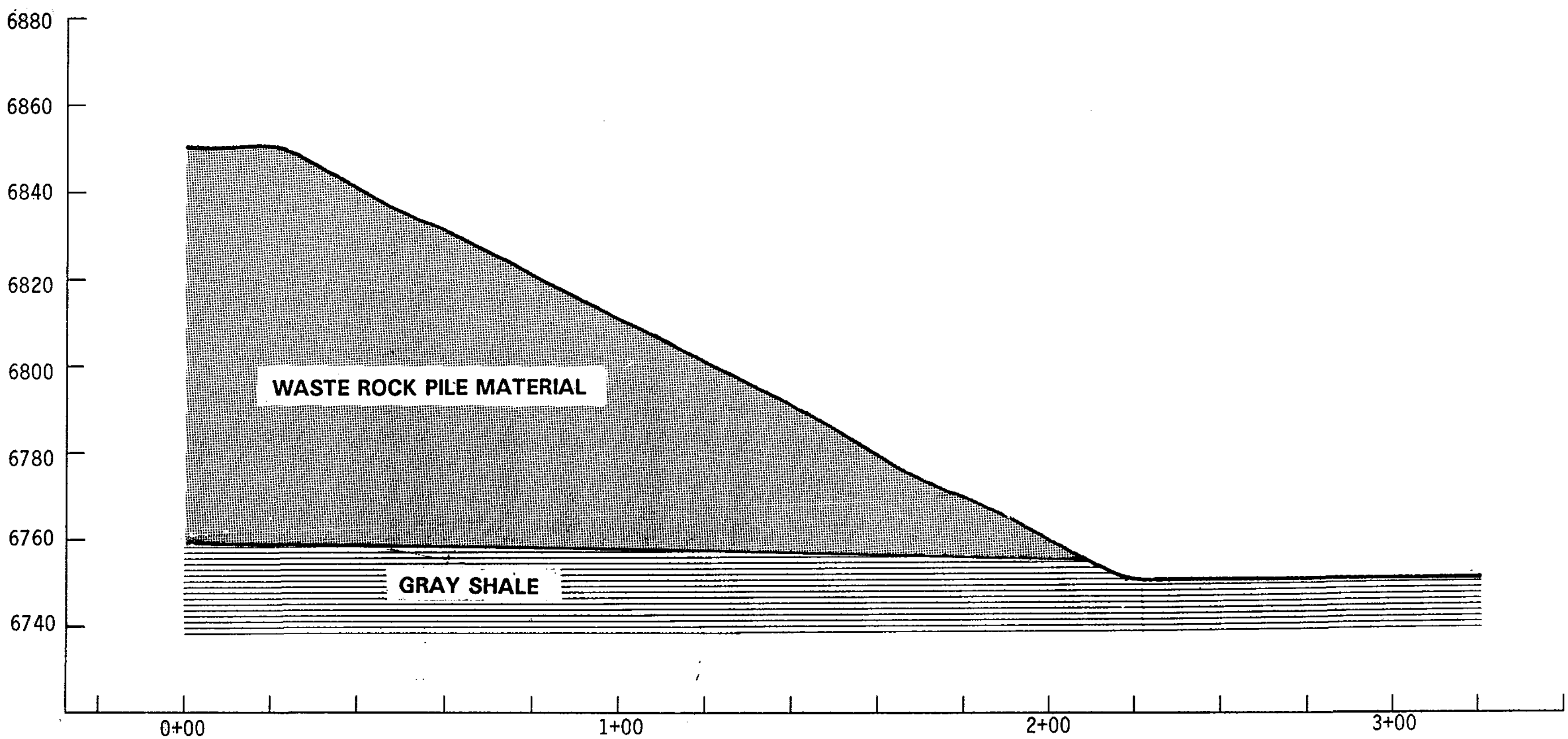


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Figure 12. PROFILE THROUGH SECTION A-A'

Cottonwood/Wilberg Mine
Waste Rock Pile Stability Analysis

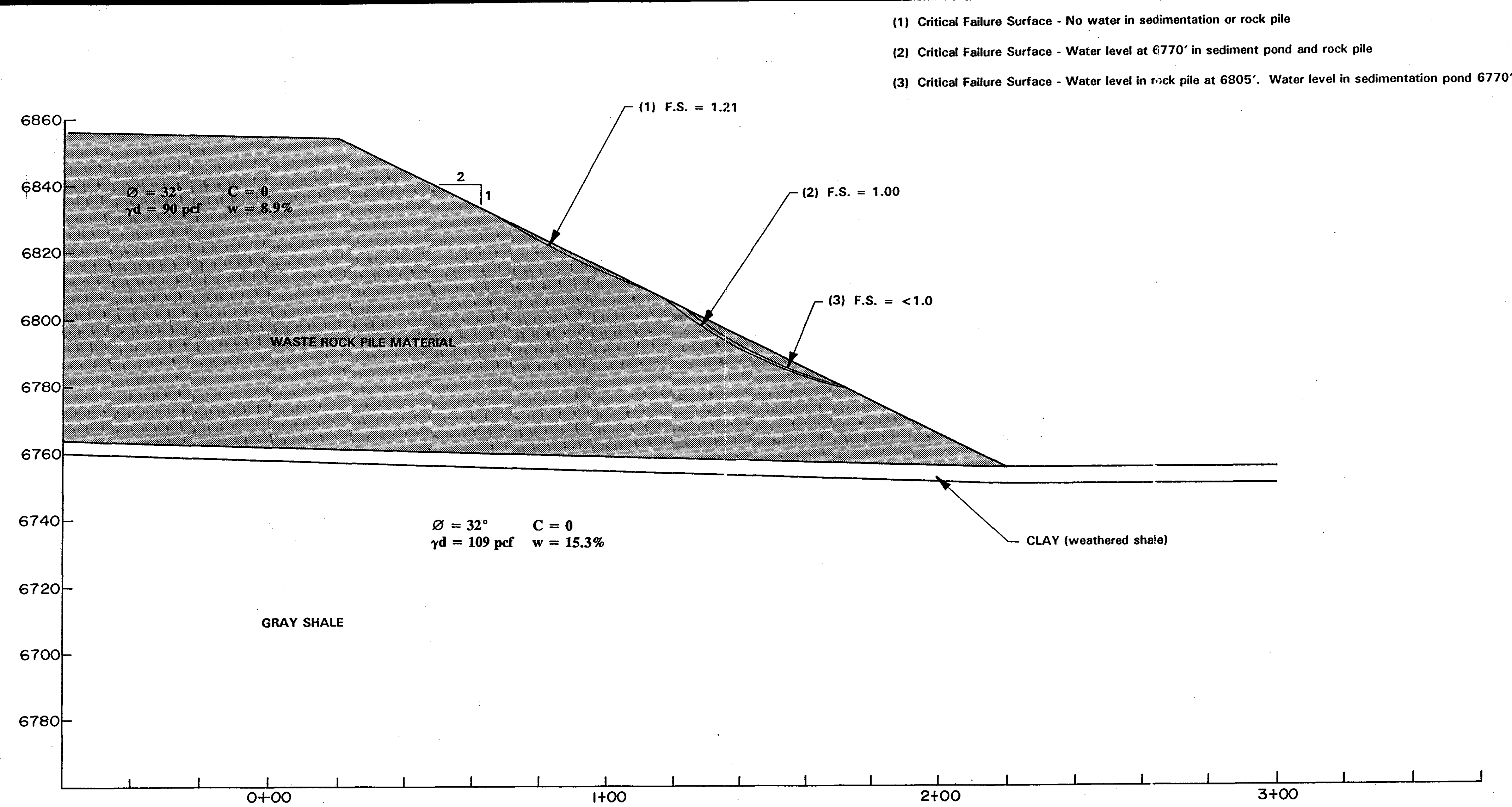
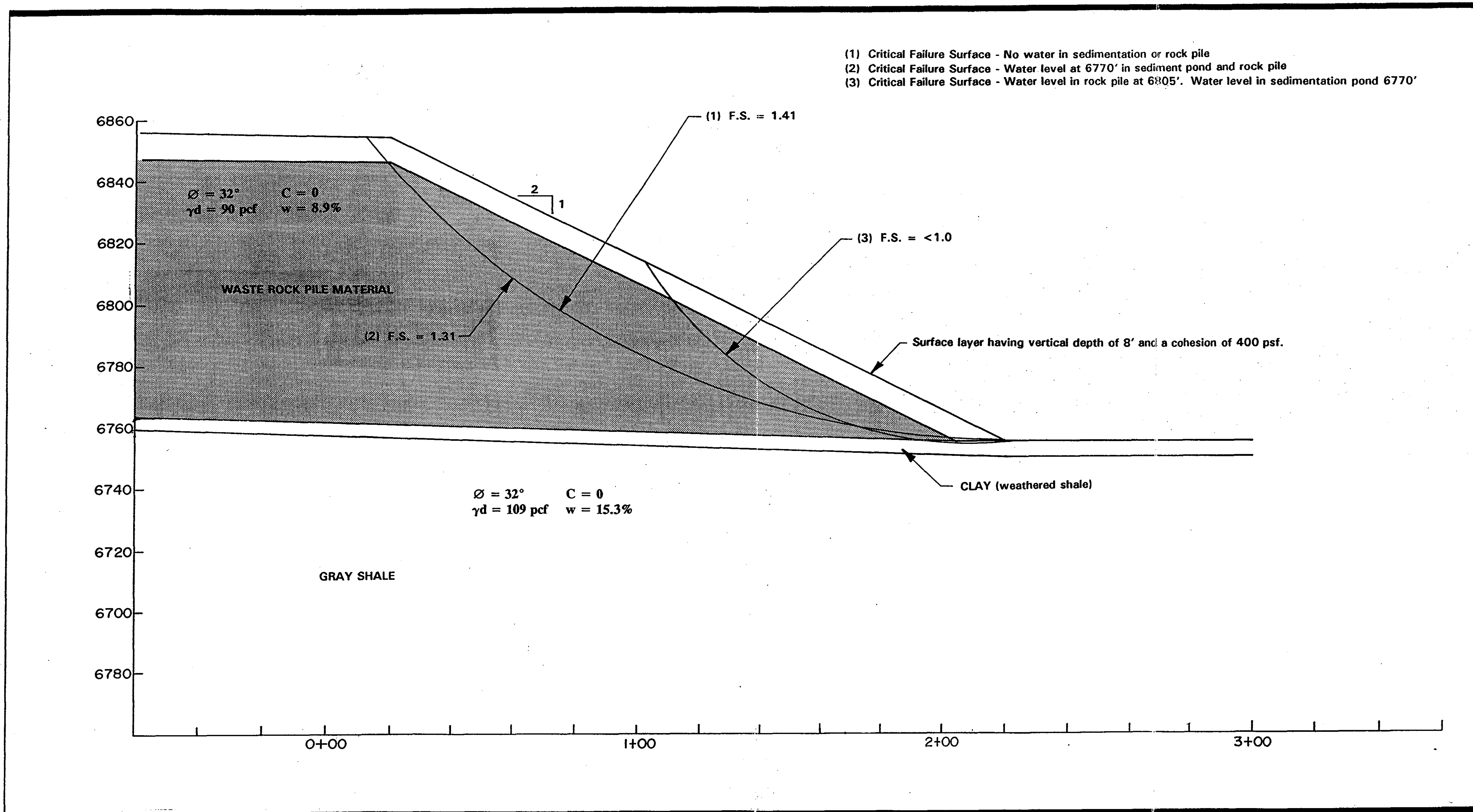


Figure 13

RB&G ENGINEERING INC.
Provo, Utah

COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY
EMERY COUNTY, UTAH

Location of Failure Surfaces and the Factors of Safety for Various Conditions of Saturation and no Cohesion - Side Slope = 2:1



RB&G ENGINEERING INC.
Provo, Utah

COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY
EMERY COUNTY, UTAH

Location of Failure Surfaces and the Factors of Safety for Various Conditions of Saturation and a Surface Zone Having 400 psf Cohesion - Side Slope = 2:1

Figure 14

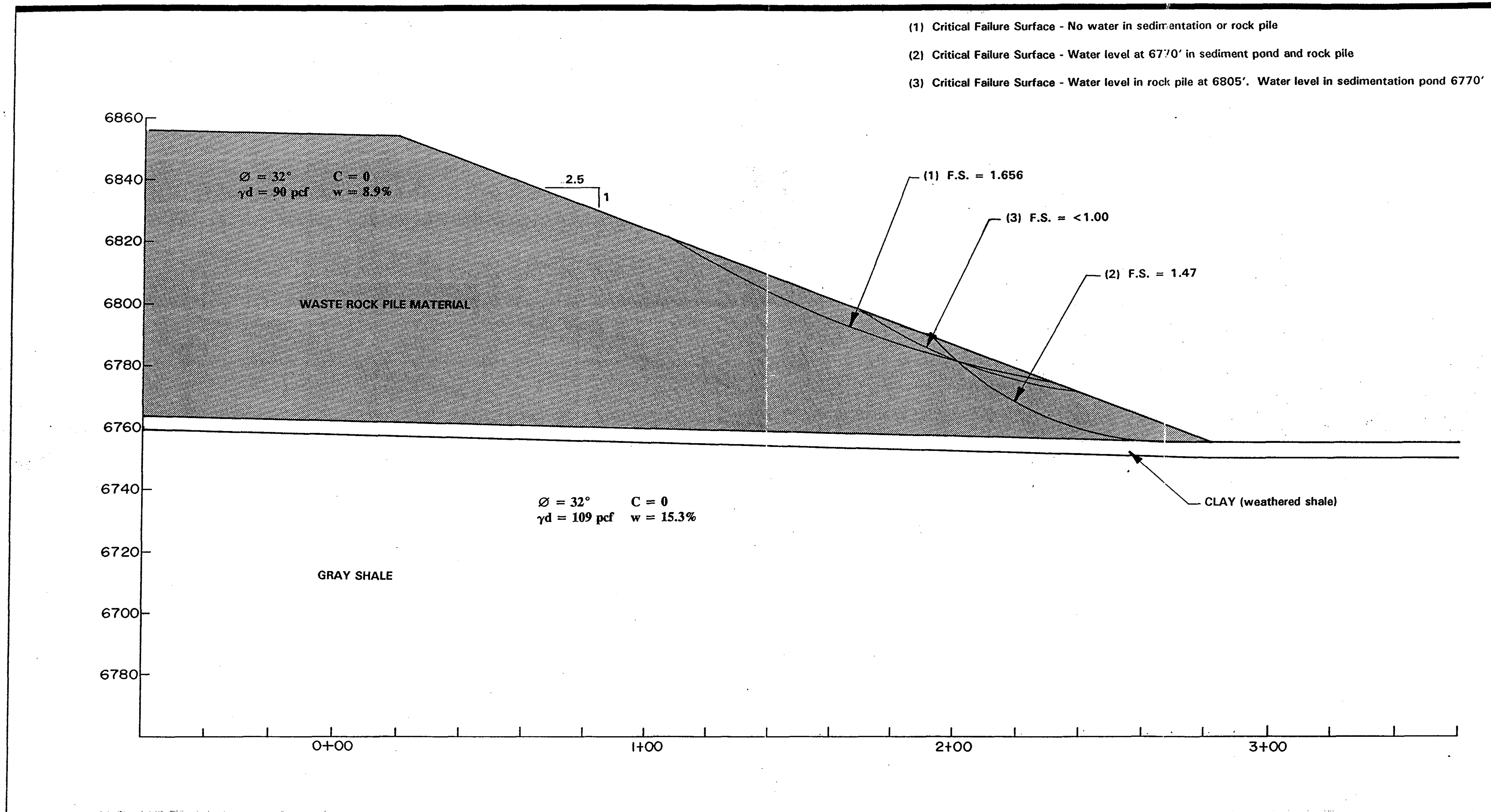
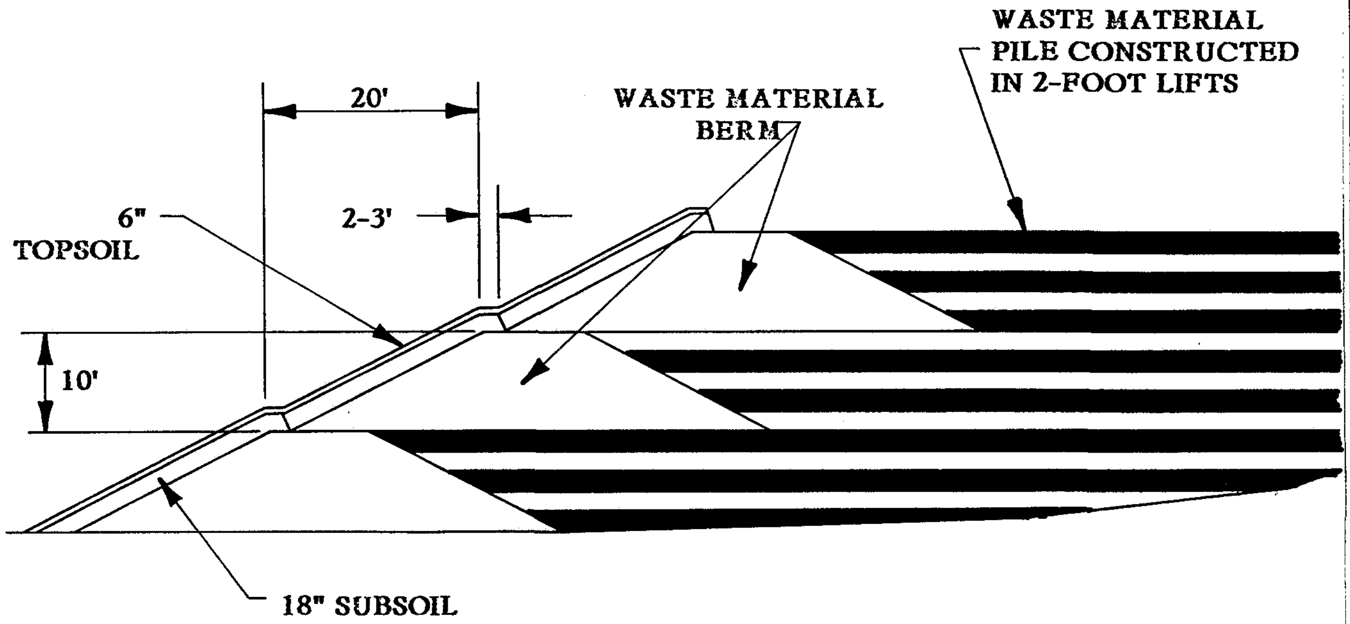


Figure 15

RB&G ENGINEERING INC.
Provo, Utah

COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY
EMERY COUNTY, UTAH

Location of Failure Surfaces and the Factors of Safety for Various Conditions of Saturation - Side Slope = 2.5:1



SEQUENCE

1. CONSTRUCT BERM WITH WASTE ROCK MATERIAL FROM MINING OPERATION.
2. COVER OUTSIDE SLOPE OF BERM WITH 18" OF SUBSOIL AND 6" OF TOPSOIL.
3. REVEGETATE OUTSIDE SLOPE.
4. PLACE WASTE MATERIAL INSIDE OF BERM AND COMPACT IN 2' LIFTS.
5. WHEN WASTE MATERIAL LEVEL REACHES TOP OF BERM CONSTRUCT THE NEXT BERM WITH 2' TO 3' OFFSET AT TOE OF NEW BERM.

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Provo, Utah

Figure 16 CONSTRUCTION SEQUENCE
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah

Table 1

SUMMARY OF TEST DATA

PROJECT Cottonwood/Wilberg Coal Mine
Waste Rock Storage Facility

LOCATION Emery County, Utah FEATURE Foundations

TEST PIT NO.	DEPTH BELOW GROUND SURFACE (ft)	STANDARD PENETRATION BLOWS PER FOOT	IN-PLACE		UNCONFINED COMPRESSIVE STRENGTH (psf)	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			UNIFIED SOIL CLASSIFICATION SYSTEM (modified)
			DRY UNIT WEIGHT (pcf)	MOISTURE (%)		LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT & CLAY	
1	0-1		81.9	2.1					47.5	44.5	8.0	GP,GM
	2-3		100.5	3.1					29.0	53.8	17.2	SM
	4-5		88.3	8.7					35.1	48	16.9	SM,GM
	6-7		98.6	8.5					27.8	49.4	22.8	SM,GM
	8-9		97.9	8.6					31.0	45.1	23.9	SM,GM
	10-11		97.8	8.8					32.7	42.8	24.5	SM,GM

NP=Nonplastic