PETTIGREW
& ASSOCIATES PA

ENGINEERING | SURVEYING | TESTING

DEFINING QUALITY SINCE 1965

[redacted]

[redacted]

Debra P. Hicks, PE/LSI
NM 10871

PREPARED FOR:

R. T. Hicks Consultants, Ltd.
Attn: Randall Hicks
910 Rio Grande Boulevard, STE F-142
Albuquerque, New Mexico 87104

LAB No. 14 7043
PROJECT No. 2014.1120

September 23, 2014

This report is generated specifically for the purpose of providing design criteria for the All Thorn Multi-Well Fluid Management (MWFM) Pit – Section 36 T17S R27E, Eddy County, New Mexico. Under no circumstances shall it be used for any other project on or off the site. This report is meant to provide information that will inform Lime Rock Resources II-A, LP (LRRII) of appropriate design criteria for the planned use. The conditions encountered in field exploration and reported herein are accurate for the test location(s), time and conditions. It is not meant to eliminate the uncertainty regarding the potential for variation or changes in subsurface conditions at the site. Subsurface descriptions contained herein are of a generalized nature to provide highlights of major strata and conditions revealed in the soil samples, however, it represents only the conditions at the actual boring locations.

Debra P. Hicks, PE/LSI

NM 10871

[illegible]

Lime Rock Resources proposes to construct the All Thorn MWFM Pit in Section 36, T17S R27E, Eddy County, NM. The site is approximately 2.6 acres. This investigation was performed at the direction and authorization of Mr. Randall Hicks of R.T. Hicks Consultants, Ltd.

The purpose of this investigation is to determine the characteristics of the subsoils and provide recommendations for foundation design. This report provides an overview of existing geotechnical/geologic conditions at the proposed demonstration site and geotechnical design parameters for the proposed facilities. The geotechnical site conditions presented herein are based on our field exploration as well as literature review from available geotechnical/geologic reports in the project vicinity. This report does not include environmental site characterization, hazardous materials testing, or other environmental services.

[illegible]

The proposed development includes construction of one multi-well fluid management pit to facilitate the re-use of produced water for well stimulation and well drilling.

[illegible]

Four (4) exploratory borings were drilled on July 29, 2014. The exploratory borings were drilled to approximate depths listed in Table 1 of this Report. Boring locations are shown on the Boring Location Map. Drilling was carried out using a truck-mounted drill rig contracted with Enviro-Drill, Inc. – Albuquerque, New Mexico.

TABLE – 1 Boring Dates and Depths

[illegible]	[illegible]	[illegible]	[illegible]
BH-1	7/29/14	3684.05	41’9”
BH-2	7/29/14	3684.45	41’10”
BH-3	7/29/14	3682.83	51’0”
BH-4	7/29/14	3683.73	36’5”

Subsurface materials were sampled at varying intervals by split spoon sampler and/or drill cuttings where applicable.

Air-rotary/auger drilling methods were employed to cut the test borings. During the drilling, the soils encountered were continuously examined, visually classified and, where applicable, sampled.

Standard penetration tests (SPT) were performed at varying depths. Penetration resistance was measured in accordance with ASTM D 1586 by driving a standard 2" split tube sampler having a 30" free fall drop hammer weighing 140 pounds. The penetration resistance value is a useful index in estimating the consistency, relative density or hardness of the materials encountered.

[redacted]

Representative samples were tested in the laboratory to determine certain engineering properties of the soils. Mechanical analysis and soil constant determinations were performed for classification and identification of each soil type encountered. Classifications are in accordance with the Unified Soil Classification System ASTM D 2487. The results of the laboratory tests are presented on the Logs.

The following tests were conducted on selected soil samples:

- Moisture Content
- Sieve Analysis
- Atterberg Limits

[redacted]

As previously described, the project site is located near the intersection of Arco and Hilltop Road, approximately 1.7 miles south of Highway 82, Eddy County, New Mexico. The topography of the site slopes mildly to the north. The vegetation consists of tall brush and short grasses.

[illegible]

The proposed MWFM pit location is between the Mescalero rim, the western edge of the Ogallala formation, and the Pecos River. The above mentioned development of the Pecos Drainage removed and reworked the remnants of the Ogallala formation between the Mescalero rim and the Pecos River. This surface is called the Mescalero Plain and is composed of relatively thin pediment deposits and alluvium of fluvial and eolian origins deposited on top of weathered Triassic and Permian formations[1].

[illegible]

[illegible]

[illegible] – Stratum 1 is classified as silty sand (SM). These surface soils are very loose to medium dense. This stratum is present at approximately 0'0" to 0'6" +/- below ground surface (bgs). Soils are typically brown and moist.

[illegible] – Stratum 2 is classified as silty sand with gravel (SM). For engineering purposes Stratum 2 was defined to include medium dense to very dense soils. This stratum is appears at a depth of 0'6" to 20'0" +/- bgs. The determination of the thickness was based mostly upon SPT blow count data, degree of cementation, plasticity and color of the soil samples. Soils in Stratum 2 are moist, non-plastic and tan in color.

[illegible] – Stratum 3 is classified as clayey sand (SC) and fat clay (CL) interbedded with gypsum. Some gypsum layers are up to 3' thick. For engineering purposes Stratum 3 was defined to include very soft to hard soils in relative firmness. This stratum is appears at a depth of 20'0" to 51'0" +/- bgs. The determination of the thickness was based mostly upon SPT blow count data, degree of cementation, plasticity and color of the soil samples. Soils in Stratum 3 are moist, plastic and red in color.

[1] Hicks, RT, 2014, C-144 Permit Package for All Thorn MWFM Pit Section 36 T17S R27E Eddy County, pg.2.

TABLE – 2 Soil Parameters

[illegible]	[illegible]	[illegible]	[illegible] γ (pcf)	[illegible]	[illegible] Φ (°)	[illegible]
S-1	SM	0'0"	131.2	0.80	30.8	445.6
S-2	SM	0'6"	136.9	0.00	42.1	355.1
S-3	SC/CL	20'0"	140.2	7.50	0.00	2906.0

[illegible]

Groundwater was not encountered in any of the borings.

[illegible]

In accordance with the 2009 International Building Code - Section 1803.5.3 Soil Classification in the bearing strata (Stratum 2) is not considered expansive.

[illegible]

Soils to depths explored of up to 51' +/- are damp to moist ranging from 1.7 to 12.4 percent in the samples tested. Subsurface soil and current groundwater conditions indicate that there is minimal potential for liquefaction to occur within the confined bearing stratum.

[illegible]

The following discussion and recommendations are based upon the results of field and laboratory testing, engineering analyses, experience with similar soil conditions, and our understanding of the proposed project.

[illegible]

In accordance with the 2009 International Building Code®, Section 1613.5.5, Site Class D is applicable.

In general, field test results indicate that the silty sands and clayey sands vary from very loose to very dense in relative density as indicated by measured SPT-N Values of 2 blows in 12" to 50 blows per 1". Very dense materials (N>30) were encountered at various depths.

Frost penetration approximates 15" to 18".

The MWFM Pit is anticipated to be below 10' to 15' below ground. The general contractor will excavate the insitu soils to the depths and grades shown on the construction plans. This material will be stockpiled for use in construction of roads, pads, etc.

1) All vegetation and other deleterious materials should be removed from the construction site prior to construction activities. Stripped materials consisting of vegetation and organic materials (estimated depth of 8") should be wasted from the site, or stockpiled for reuse during pit closure. Deleterious material should be removed from the site.

2) The MWFM Pit is anticipated to be approximately 10' to 15' below ground. The general contractor will excavate the insitu soils to the depths and grades shown on the construction plans. This material (caliche) will be stockpiled for use in construction of roads, pads, etc.

3) All soils that are to receive foundation elements including primary liner and dike should be scarified a minimum of 10" and compacted, at approximately optimum moisture (plus 2% to minus 2%), to not less than 95% of Laboratory Density as determined by ASTM D 698. The entire site should then be proofrolled to observe for unsuitable or weak soils. At least five passes with a heavy vibratory roller should be made during proofrolling. Soft materials or loose soils indicated during proofrolling should be stripped or further compacted. Areas of subgrade in which pumping or significant deflections are observed should be removed or stabilized. Use of lime, fly ash, kilm dust, cement or geotextiles could be considered as a stabilization technique.

4) All fill and/or backfill be placed in lifts not to exceed 8" (loose), and compacted at approximately optimum moisture (plus 2% to minus 2%), to not less than 95% of Laboratory Density as determined by ASTM D 698.

5) [illegible] Materials for Engineered Fill shall be composed of an appropriate combination of crushed stone, crushed or screened gravel, caliche, and/or sand to meet the specifications contained herein. Materials shall be free from vegetable matter and all other deleterious materials, including silt and clay balls.

[illegible]	[illegible]
2″	100
½″	30-80
#4	20-60
#200	5-20

Liquid Limit	35 max
Plasticity Index	4 min to 15 max

6) All imported fill material shall be from same source.

7) [illegible] Unless otherwise provided for in the specifications, materials to be used for non-load bearing dike embankment (controlled fill) shall be constructed with moisture and density control as specified herein. Materials for controlled fill shall have a maximum particle size of two and one-half (2-1/2) inches, and a plasticity index of four (4) minimum to fifteen (15) maximum. The liquid limit shall not exceed thirty-five (35).

8) [illegible]: Upon completion of pit excavation and subgrade preparation, a site inspection shall be conducted to determine the need for bedding beneath the liner. In accordance with liner installation guidelines, subgrade shall be free of rocks, roots, and other protruding objects. All loose or disturbed material soil shall be removed from bearing surface. If bedding is required, a minimum of 12″ of Engineered Fill shall be placed in accordance with these Recommendations.

[illegible] At the request of the contractor, suitability of existing soils may be determined based upon laboratory test results and the intended use.

10) [illegible] Positive drainage should be established away from the pit during and after construction. The ground immediately adjacent to the pit shall be sloped away from the dike at a slope not less than 5% for a minimum of 10′. In no case should long-term ponding of water be allowed around the perimeter of the dike.

11) □□□□□□□ □□□ □□□ □□□□□□□□ Portland Cement Concrete shall be proportioned in accordance with ACI 211.1-81; all portland cement shall be an approved American (USA) brand conforming to ASTM C150, Type II, or Type V with Class F flyash, where concrete is to be placed against high sulfate content soils, low alkali; and, all exposed Portland Cement Concrete or Portland Cement Concrete slabs on grade shall be air entrained.

[illegible]

Pettigrew & Associates shall perform construction observation and testing of the following:

- Subgrade preparation and proof-rolling;
- Suitability of Engineered fill and controlled fill;
- Backfill and compaction of excavations;
- Fill placement and compaction; and
- Compliance with the geotechnical recommendations.

[illegible]

Subgrade (Insitu soils) - One (1) soil density every 5,000 square feet of prepared surface for dike or pit bottom and side slopes (ASTM D 698 and ASTM D 2922)

Engineered Fill/Primary Liner Bedding - One (1) soil density every 5,000 square feet of prepared pit surface including bottom and side slopes per compacted lift (ASTM D 698 and ASTM D 2922)

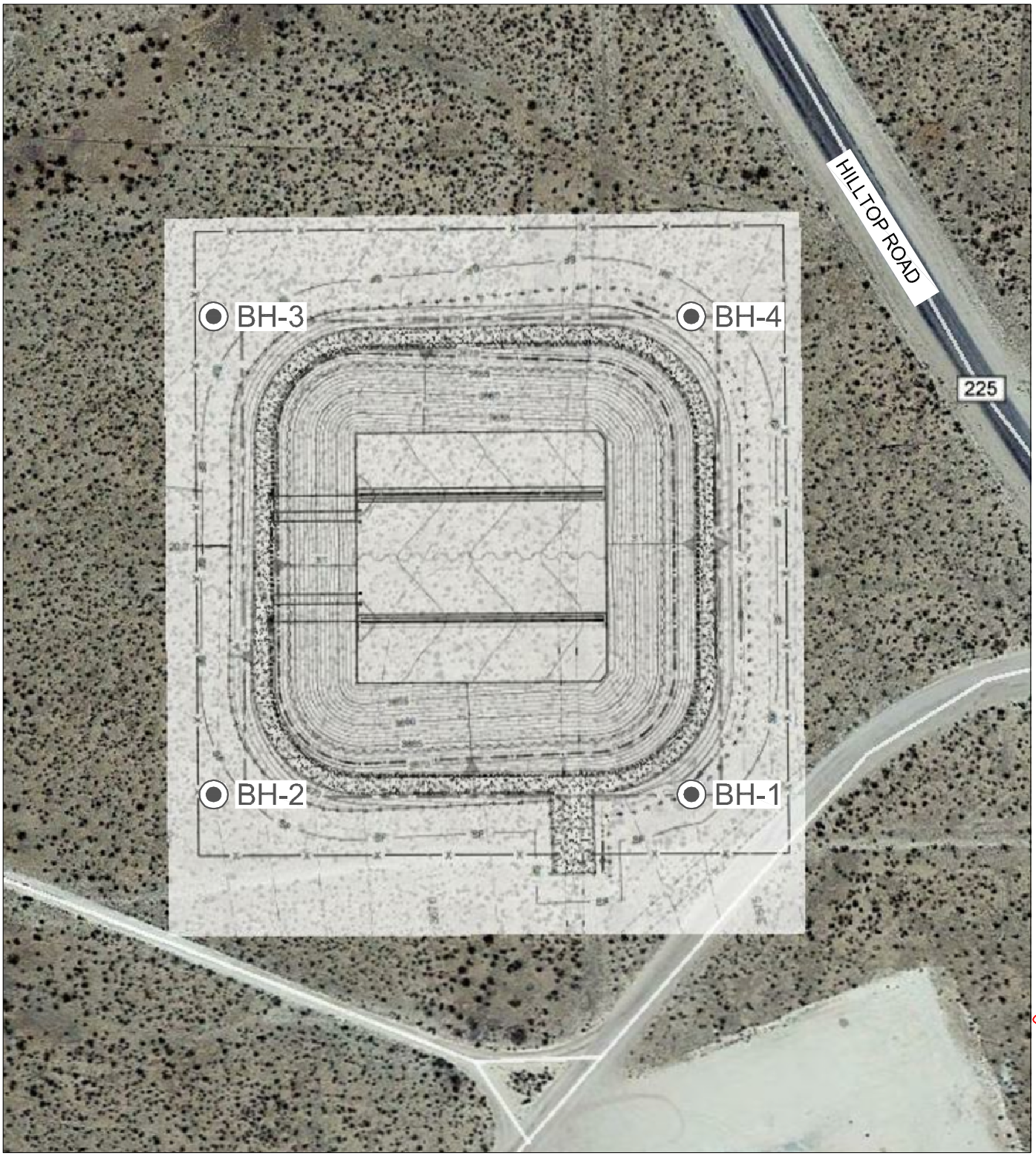
Controlled Fill - One (1) soil density every 300 lineal feet of dike per lift of compacted material (ASTM D 698 and ASTM D 2922)

One (1) sieve analysis and plasticity index per material (subgrade, engineered fill, controlled fill) (ASTM C 136 and ASTM D 4318)

One (1) moisture density determination (proctor) per each type of material (ASTM D 698)

[illegible]

Our conclusions, recommendations and opinions presented herein are based upon our evaluation and interpretation of the findings of the field and laboratory investigation. [illegible] Pettigrew & Associates, P.A appreciates the opportunity to provide our services on this project and looks forward to working with you during construction and on future projects. Should you have any questions, please do not hesitate to contact us.



BOREHOLE MAP

PROJECT NAME:	ALL THORN MWFM PIT
CLIENT:	RT HICKS CONSULTANTS LTD
PROJECT NUMBER:	2014.1120
PROJECT MANAGER:	EH/DPH

PETTIGREW & ASSOCIATES PA
ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965
100 E. Navajo Drive Suite 100 Hobbs New Mexico 88240
T 575 393 9827 | F 575 393 1543 | Pettigrew.us

PETTIGREW & ASSOCIATES PA

ENGINEERING | SURVEYING | TESTING

DEFINING QUALITY SINCE 1965

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3	Dry Brown Silty Sand (Topsoil)	--	3.6	94	80	75	71	50.0	--	--	--	0
	24	Dry Tan Silty Sand with Gravel (Caliche)		1.7									4,500
	15			4.0									2,510
	15			5.7									2,510
	24			8.9									4,500
	23			8.9									4,280
	29			--									5,600
	57			--									>8,000
	51		SM	7.3	84	60	47	35	18.8	SNP	SNP	SNP	>8,000
	60			7.3									>8,000
	47			7.4									>8,000
	46			7.4									>8,000

PETTIGREW
& ASSOCIATES PA
ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			60/11"												>8,000	
[redacted]			50/9"	Moist Red Sandy Fat Clay with Gypsum		6.4									>8,000	
						11.9										

37	--	>8,000
60/9"	--	>8,000
50/3"	--	>8,000

PETTIGREW
& ASSOCIATES PA
ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965

			22		CH	11.5	100	90	81	73	68.5	60	29	31	5,410		
			51			--									>8,000		
			40			--									>8,000		
			74/9"			--									>8,000		

10/6"	Dry Brown Silty Sand (Topsoil)	--	--	94	80	75	71	50.0	--	--	--	3,620		
45/6"	Dry Tan Silty Sand with Gravel (Caliche)		--									>8,000		
72			--									>8,000		
27			9.1									5,160		
16			9.1									2,730		
18			9.2									3,180		
27			9.2									5,160		
41			10.6									>8,000		
50/6"			10.6									>8,000		
67/11"			9.3									>8,000		
80/11"			8.8									>8,000		
		SM		84	60	47	35	18.8	SNP	SNP	SNP			

75/8"			8.7									>8,000		
50/3"			--									>8,000		
50/1"	Dry to Moist Red Clayey Sand with Gravel and Gypsum		2.6									>8,000		

PETTIGREW
& ASSOCIATES PA

ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965

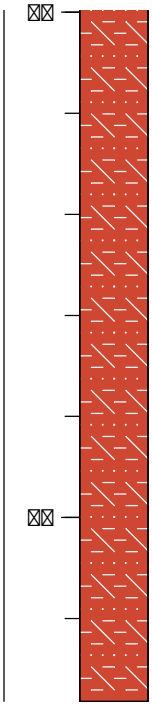
[redacted]

[redacted]

[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]												
[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			35/3"			SC	--	95	79	68	48	31.4	32	18	14	>8,000		
[redacted]			50/4"				--									>8,000		
[redacted]																		

PETTIGREW
& ASSOCIATES PA

ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965



			50/3"			9.8									>8,000				
			17			--									3,940				
			59/10"			--									>8,000				

8/6"	Dry Brown Silty Sand (Topsoil)	2.6	94	80	75	71	50.0	--	--	--	2,730
32	Dry Tan Silty Sand with Gravel (Caliche)	4.3									6,260
50/6"		4.3									>8,000
37		3.6									7,360
29		3.6									5,600
23		4.5	84	60	47	35	18.8	SNP	SNP	SNP	4,280
24		4.5									4,500
63		5.3									>8,000
61		7.6									>8,000
39		6.7									7,800
71		6.7									>8,000
83		4.2									>8,000
50/6"		--									>8,000

PETTIGREW
& ASSOCIATES PA
ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965

[redacted]

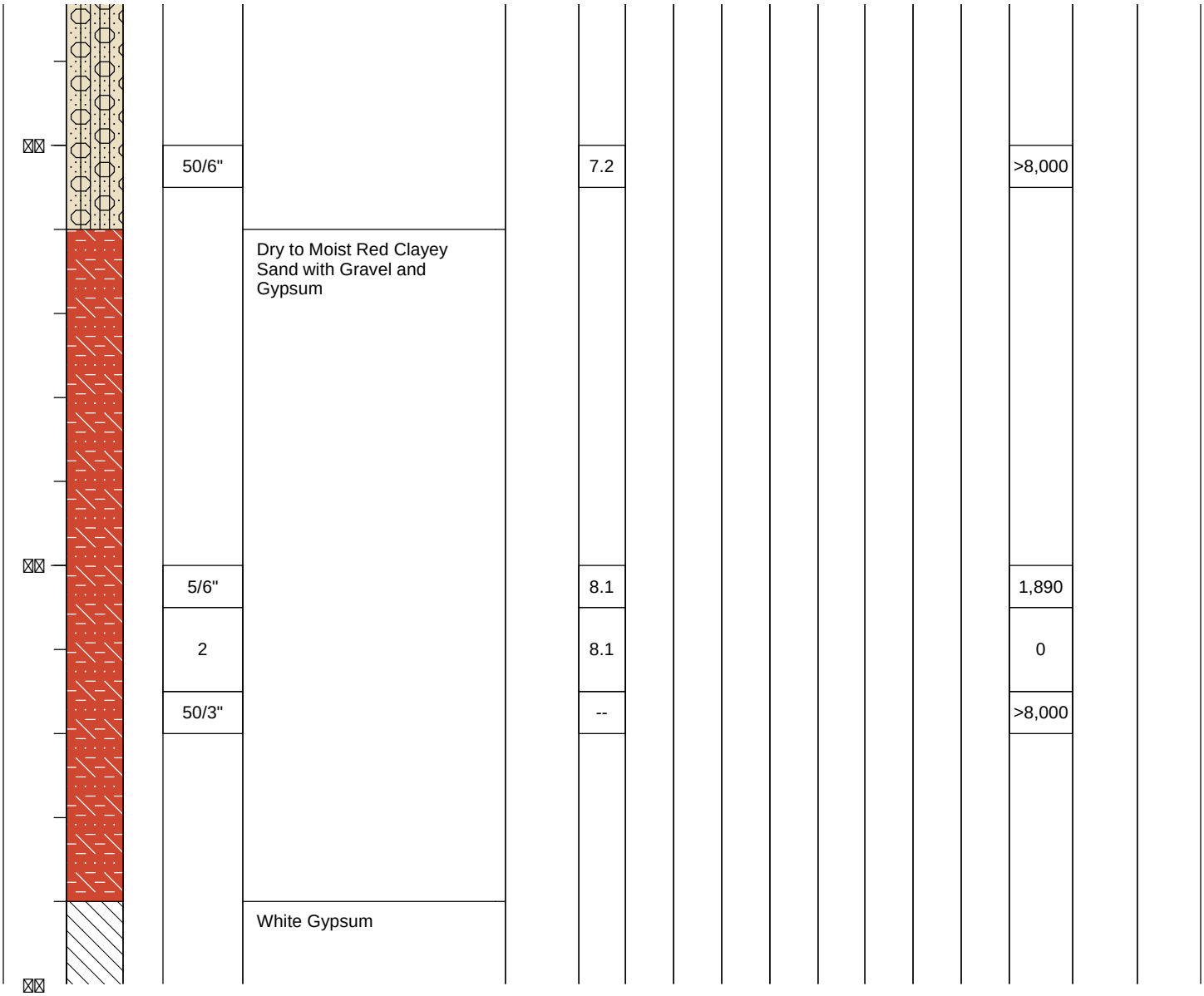
[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]																
[redacted]			50/6"			5.2									>8,000	
[redacted]			50/4"			8.4									>8,000	
			75/3"			5.5									>8,000	

PETTIGREW
& ASSOCIATES PA

ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965



PETTIGREW
& ASSOCIATES PA
ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		23			--									4,280	
[redacted]		73			--									>8,000	
[redacted]			Moist Red Sandy Fat Clay with Gypsum												
[redacted]		50/6"			10.3	100	90	81	73	68.5	60	29	31	>8,000	
[redacted]		50/6"			--									>8,000	

PETTIGREW & ASSOCIATES PA

ENGINEERING | SURVEYING | TESTING

DEFINING QUALITY SINCE 1965

			67			11.9								>8,000		

PETTIGREW & ASSOCIATES PA

ENGINEERING | SURVEYING | TESTING

DEFINING QUALITY SINCE 1965

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	7/6"	Dry Brown Silty Sand (Topsoil)	--	2.8	94	80	75	71	50.0	--	--	--	2,290		
[redacted]	70	Dry Tan Silty Sand with Gravel (Caliche)		1.9									>8,000		
[redacted]															
[redacted]	29			6.9									5,600		
[redacted]	19			6.9									3,400		
[redacted]	54			8.7	84	60	47	35	18.8	SNP	SNP	SNP	>8,000		
[redacted]	92			8.7									>8,000		
[redacted]	50/6"			6.9									>8,000		
[redacted]															
[redacted]	66		SM	12.4									>8,000		
[redacted]	50/4"			12.4									>8,000		
[redacted]															
[redacted]	50/5"			9.6									>8,000		
[redacted]															

PETTIGREW
& ASSOCIATES PA

ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965

			50/3"			--										>8,000		
			50/6"	Dry to Moist Red Clayey Sand with Gravel and Gypsum		7.1	95	79	68	48	31.4	32	18	14		>8,000		

PETTIGREW & ASSOCIATES PA

ENGINEERING | SURVEYING | TESTING

DEFINING QUALITY SINCE 1965

50/5"	--	>8,000
35	--	>8,000
60	--	>8,000

PETTIGREW
& ASSOCIATES PA
ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965

			52			SC	10.3									>8,000			
			50/5"				10.3									>8,000			

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE-GRAINED SOILS (major portions retained on No. 200 sieve): includes (1) clean gravel and sands and (2) silty or clayey gravels and sands. Condition is rated according to relative density as determined by laboratory tests or standard penetration resistance tests.

Descriptive Terms	Relative Density	SPT Blow Count
Very loose	0 to 15 %	< 4
Loose	15 to 35 %	4 to 10
Medium dense	35 to 65 %	10 to 30
Dense	65 to 85 %	30 to 50
Very dense	85 to 100 %	> 50

FINE-GRAINED SOILS (major portions passing on No. 200 sieve): includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings, SPT blow count, or unconfined compression tests.

Descriptive Terms	Unconfined Compressive Strength kPa	SPT Blow Count
Very soft	< 25	< 2
Soft	25 to 50	2 to 4
Medium stiff	50 to 100	4 to 8
Stiff	100 to 200	8 to 15
Very Stiff	200 to 400	15 to 30
Hard	> 400	> 30

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.

2. Surface elevations are based on topographic maps and estimated locations.

3. Descriptions on these boring logs apply only at the specific boring locations and at the time the borings were made. they are not guaranteed to be representative of subsurface conditions at other locations or times.

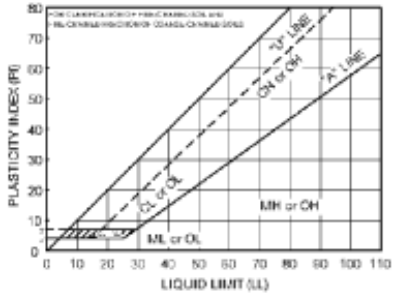
Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria
Coarse-Grained soils (more than half the material is larger than No. 200 sieve size)	Gravels (more than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ 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
		Gravel with fines (Appreciable amount of fines)	GM* d u	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4
			GC	Clayey gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. 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 u	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4
			SC	Clayey sands, sand-clay mixtures	Atterberg limits below "A" line or P.I. greater than 7
Fine-Grained soils (more than half the material is smaller than No. 200 sieve size)	Silts 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	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
			OL	Organic silts and organic silty clays of low plasticity	
	Silts and Clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, organic 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	

Determine percentages of sand and gravel from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows:

Less than 5 percent..... GW, GP, SW, SP
More than 12 percent..... GM, GC, SM, SC
5 to 12 percent..... Borderline cases requiring dual symbols**

Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols

Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols



Plasticity Chart

Particle Size	Material	mm	Sieve
	Silt or Clay	< 0.074	< #200
	Sand	0.074 to 4.76	#200 to #4
	Fine	0.42 to 2.00	#40 to #10
	Medium	2.00 to 4.75	#10 to #4
	Coarse	4.76 to 19.1	#4 to 3/4 in.
	Gravel	19.1 to 76.2	3/4 in. to 3 in.
	Fine	4.76 to 19.1	#4 to 3/4 in.
	Coarse	19.1 to 76.2	3/4 in. to 3 in.
	Cobble	76.2 to 304.8	3 in. to 12 in.
	Boulders	304.8 to 914.4	12 in. to 36 in.

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

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

TERMINOLOGY USED TO DESCRIBE THE RELATIVE DENSITY,
CONSISTENCY, OR FIRMNESS OF SOILS

The terminology used on the boring logs to describe the relative density, consistency, or firmness of soils relative to the standard penetration resistance is presented below. The standard penetration resistance (N) in blows per foot is obtained by ASTM D1586 procedure using 2" O.D., 1-3/8" I.D. samplers.

1. Relative Density. Terms for description of relative density of cohesionless, uncemented sands and sand-gravel mixtures.

[illegible]	[illegible]
0 - 4	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
50+	Very Dense

2. Relative Consistency. Terms for the description of clays which are saturated or near saturation.

[illegible]	[illegible]	[illegible]
0 - 2	Very Soft	Easily penetrated several inches with fist
3 - 4	Soft	Easily penetrated several inches
5 - 8	Medium Stiff	Can be penetrated several inches with thumb with moderate effort
9 - 15	Stiff	Readily indented with thumb, but penetrated only with great effort
16 - 30	Very Stiff	Readily indented with thumbnail
30+	Hard	Indented only with difficulty with thumbnail

3. Relative Firmness. Terms for the description of partially saturated and/or cemented soils which commonly occur in the Southwest including clays cemented granular materials, silts, and silty and clayey granular soils.

[illegible]	[illegible]
0 - 4	Very Soft
5 - 8	Soft
9 - 15	Moderately Firm
16 - 30	Firm
31 - 50	Very Firm
50+	Hard