September 24, 2014

Brown Oil and Gas
10481 CR 20.5
Sterling, Colorado 80751

Attn: Mr. Mark Brown
P: (970) 522-1072
E: brown_oil_and_gas@hotmail.com

Re: Geotechnical Engineering Report
Smith Estate No.1 Pit
About 1.25 miles east of CR 17, south of CR 70
Logan County, Colorado
Terracon Project No. 21145026

Dear Mr. Brown:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the project referenced above. These services were performed in general accordance with our Proposal No. P20140150 and signed Agreement for Services dated August 28, 2014. This report presents the results of our geotechnical engineering services performed for the Smith Estate No.1 Pit located about 1.25 miles east of CR 17, south of CR 70 in Logan County, Colorado. The purpose of these services is to provide information relative to:

- subsurface soil and bedrock conditions
- groundwater conditions
- field percolation rate

Our geotechnical engineering scope of work for this project included the advancement of two test borings to depths ranging from approximately 9 to 39 feet below existing site grades, laboratory testing for soil engineering properties, field percolation rate testing, and engineering analyses. Boring No. 2 was used to perform field percolation tests.

Logs of the borings along with an Exploration Plan (Exhibit A-2) are included in Appendix A. The results of the laboratory testing performed on soil and bedrock samples obtained from the site during the field exploration are included in Appendix B.

Typical Subsurface Profile

Specific conditions encountered at each boring location are indicated on the individual boring logs included in Appendix A. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be

gradual. Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Material Description	Approximate Depth to Bottom of Stratum (feet)	Consistency/Density/Hardness
Sandy silt	About 9 to 10 feet below existing site grades.	Medium stiff to stiff
Silty sand	About 19 feet below existing site grades.	Medium dense
Claystone bedrock	About 29 feet below existing site grades.	Firm
Shale bedrock	To the maximum depth of exploration of about 39.3 feet.	Firm to medium hard

Laboratory Testing

Samples of site soils and bedrock selected for plasticity testing exhibited low to medium plasticity with liquid limits ranging from 31 to 34 and plasticity indices ranging from 3 to 14. Laboratory test results are presented in Appendix B.

Groundwater

Groundwater was not observed in the test borings at the time of field exploration.

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed in the borings while drilling, or for the short duration that the borings were allowed to remain open. Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Based on our experience in the area of Colorado, groundwater is typically encountered very deep within the bedrock. Sites located near surface water features such as reservoirs, rivers, streams, or irrigation ditches may have comparatively shallower groundwater conditions typically perched on top of the bedrock. We do not believe perched groundwater conditions are present below this site as indicative by our field exploration.

During our site visit we did not observe any surface water in the vicinity of the pit or surface water depressions that would suggest dry stream beds, creeks, or other surface water pathways.

Field Percolation Rate Testing

Terracon performed field percolation rate testing in Boring No. 2 extended to a depth of about 9 feet below existing site grades outside of the recently constructed pit. The bottom of Boring No. 2 was at approximately the same elevation as the bottom of the adjacent pit. We performed field percolation rate testing by completing the borehole with slotted PVC pipe and silica sand

placed around the annulus of the pipe. We soaked the hole by filling the pipe with water multiple times to pre-soak the test hole. Three field percolation tests were performed with average percolation rates of 0.15 feet per minute (0.0762 cm/s). Our experience indicates percolation rates into the underlying bedrock is nearly negligible with hydraulic conductivity values less than $1X10^{-7}$cm/s.

General Comments

The information presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, and bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as described in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

We appreciate the opportunity to continue to be of service to you on this project. If you have any questions or concerns regarding the content of this report, please feel free to contact us.

Sincerely,
Terracon Consultants, Inc.

Bryce C. Reeves, E.I.
Geotechnical Staff Engineer

Eric D. Bernhardt, P.E.
Geotechnical Department Manager

Attachments:

Appendix A – FIELD EXPLORATION

Exhibit A-1	Site Location Map
Exhibit A-2	Exploration Plan
Exhibit A-3	Field Exploration Description
Exhibits A-4 to A-6	Boring Logs

Appendix B – LABORATORY TESTING

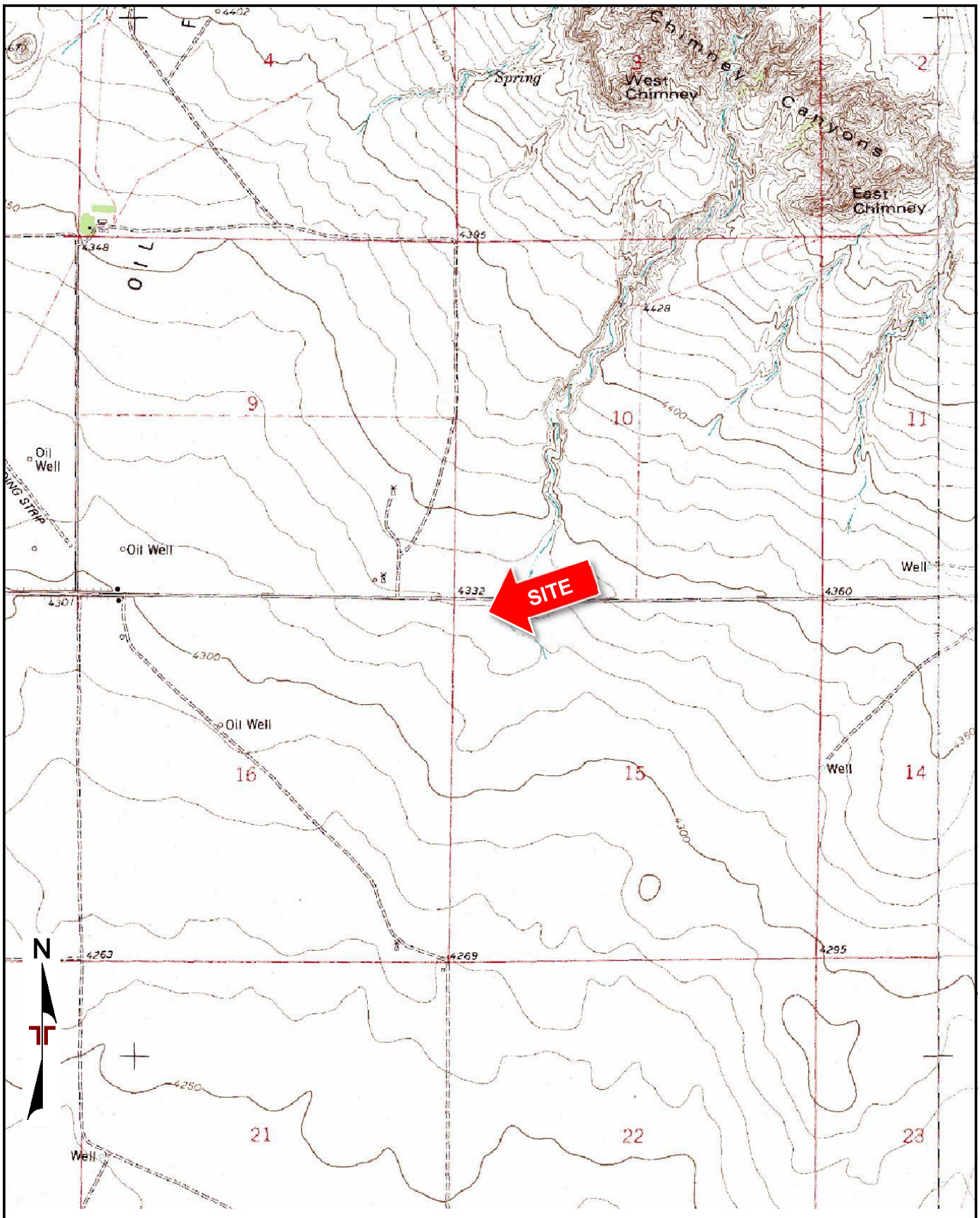
Exhibit B-1	Laboratory Testing Description
Exhibit B-2	Atterberg Limits Test Results
Exhibit B-3	Grain-size Distribution Test Results

Appendix C – SUPPORTING DOCUMENTS

Exhibit C-1	General Notes
Exhibit C-2	Unified Soil Classification System
Exhibit C-3	Description of Rock Properties
Exhibit C-4	Laboratory Test Significance and Purpose
Exhibits C-5 and C-6	Report Terminology

Copies to: Addressee (via e-mail)

APPENDIX A
FIELD EXPLORATION



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
QUADRANGLES INCLUDE: CHIMNEY CANYONS, CO (1/1/1978) and KIRCHNAVY BUTTE, CO (1/1/1978).

Project Manager: JRM	Project No. 21145026	Terracon 1289 First Ave. Greeley, CO	SITE LOCATION MAP	Exhibit
Drawn by: BCR	Scale: 1:24,000		Smith Estate No. 1 Pit **About 1.25 miles East of CR 17, South of CR 70** **Logan County, CO**	A-1
Checked by: EDB	File Name:			
Approved by: EDB	Date: 9/22/2014			

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager: JRM	Project No. 21145026	Terracon 1289 First Ave. Greeley, CO	EXPLORATION PLAN Smith Estate No. 1 Pit **About 1.25 miles East of CR 17, South of CR 70** **Logan County, CO**	Exhibit A-2
Drawn by: BCR	Scale: AS SHOWN			
Checked by: EDB	File Name:			
Approved by: EDB	Date: 9/22/2014			

Field Exploration Description

The locations of borings were based upon the development of the Smith Estates No.1 Pit. The borings were located in the field by measuring from existing site features. The ground surface elevation was surveyed at each boring location referencing the temporary benchmark shown on Exhibit A-2 using an engineer's level. The mapped locations of the borings shown on Exhibit A-2 were based on information provided to us by the client.

The borings were drilled with a CME-55 truck-mounted rotary drill rig with solid-stem augers. During the drilling operations, lithologic logs of the borings were recorded by the field engineer. Disturbed samples were obtained at selected intervals utilizing a 3-inch outside diameter ring-barrel sampler. Penetration resistance values were recorded in a manner similar to the standard penetration test (SPT). This test consists of driving the sampler into the ground with a 140-pound hammer free-falling through a distance of 30 inches. The number of blows required to advance the ring-barrel sampler 12 inches or the interval indicated, is recorded as a penetration resistance value. The blow count values are indicated on the boring logs at the respective sample depths. Ring-barrel sample blow counts are not considered N-values.

A manual SPT safety hammer was used to advance the samplers in the boring performed on this site. The standard penetration test provides a reasonable indication of the in-place density of sandy type materials, but only provides an indication of the relative stiffness of cohesive materials since the blow count in these soils may be affected by the soils moisture content. In addition, considerable care should be exercised in interpreting the blow counts in gravelly soils, particularly where the size of the gravel particle exceeds the inside diameter of the sampler.

Groundwater measurements were obtained in the borings at the time of site exploration. After completion of drilling, the borings were backfilled with auger cuttings. Some settlement of the backfill and/or patch may occur and should be repaired as soon as possible.

BORING LOG NO. 1

PROJECT: Smith Estate No.1 Pit

CLIENT: Brown Oil and Gas
Sterling, Colorado

SITE: 1.25 mile east of CR 17 and CR 70
Logan County, Colorado

LOCATION See Exhibit A-2

Latitude: 40.934609° Longitude: -103.398674°

Surface Elev.: 96.9 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SANDY SILT (ML), light brown, medium stiff to stiff									
						4-5	8	75		
			5							
						5-6	8	79	31-28-3	59
	10.0	87	10							
	SILTY SAND (SM), fine grained, light brown, medium dense									
						12-12	10	104	31-23-8	46
			15							
	19.0	78								
	SEDIMENTARY BEDROCK - CLAYSTONE, with sand, light brown, firm					19-19	9	115	34-20-14	75
			20							
						18-22	10	105		
			25							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4 inch solid-stem augers

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1901 Sharp Point Drive, Suite C
Fort Collins, Colorado

Boring Started: 9/8/2014 Boring Completed: 9/8/2014

Drill Rig: CME-55 Driller: Unlimited Access Drilling

Project No.: 21145026 Exhibit: A-4

BORING LOG NO. 1

PROJECT: Smith Estate No.1 Pit

CLIENT: Brown Oil and Gas
Sterling, Colorado

SITE: 1.25 mile east of CR 17 and CR 70
Logan County, Colorado

LOCATION See Exhibit A-2

Latitude: 40.934609° Longitude: -103.398674°

Surface Elev.: 96.9 (Ft.)

DEPTH	ELEVATION (Ft.)	GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
SEDIMENTARY BEDROCK - CLAYSTONE, with sand, light brown, firm *(continued)*										
29.0	68									
SEDIMENTARY BEDROCK - SHALE, brown, firm to medium hard			30			13-18	13	85		
			35							
39.3	57.5					50/4"	16	107		
Boring Terminated at 39.3 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4 inch solid-stem augers

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1901 Sharp Point Drive, Suite C
Fort Collins, Colorado

Boring Started: 9/8/2014 Boring Completed: 9/8/2014

Drill Rig: CME-55 Driller: Unlimited Access Drilling

Project No.: 21145026 Exhibit: A-5

BORING LOG NO. 2

PROJECT: Smith Estate No.1 Pit

CLIENT: Brown Oil and Gas
Sterling, Colorado

SITE: 1.25 mile east of CR 17 and CR 70
Logan County, Colorado

LOCATION See Exhibit A-2

Latitude: 40.934519° Longitude: -103.39866°

Surface Elev.: 96.4 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
			5							
	0.0	96.4								
SANDY SILT, light brown										
	9.0	87.5								
Boring Terminated at 9 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4 inch solid-stem augers

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1901 Sharp Point Drive, Suite C
Fort Collins, Colorado

Boring Started: 9/8/2014 Boring Completed: 9/8/2014

Drill Rig: CME-55 Driller: Unlimited Access Drilling

Project No.: 21145026 Exhibit: A-6

APPENDIX B
LABORATORY TESTING

Laboratory Testing Description

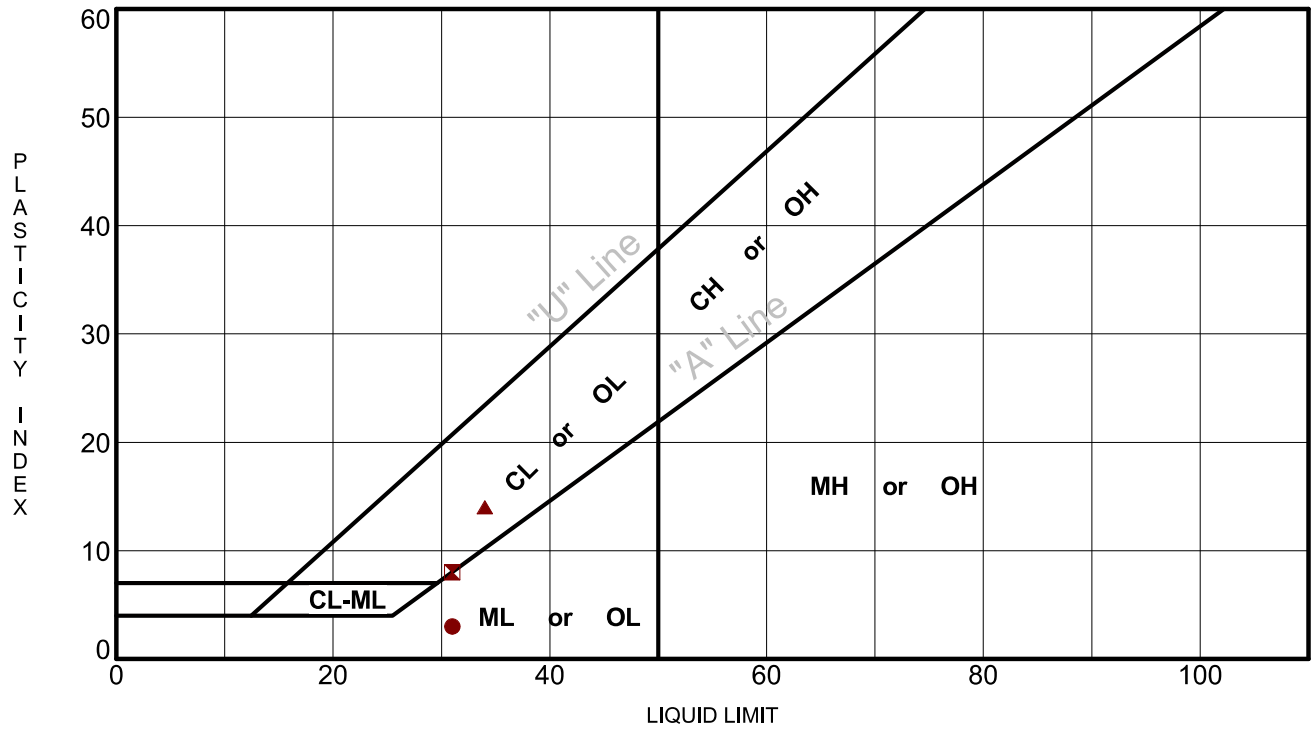
The soil and bedrock samples retrieved during the field exploration were returned to the laboratory for observation by the project geotechnical engineer. At that time, the field descriptions were reviewed and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil and bedrock samples. The results of these tests are presented on the boring logs and in this appendix. The laboratory tests were performed in general accordance with applicable locally accepted standards. Soil samples were classified in general accordance with the Unified Soil Classification System described in Appendix C. Rock samples were visually classified in general accordance with the description of rock properties presented in Appendix C. Procedural standards noted in this report are for reference to methodology in general. In some cases variations to methods are applied as a result of local practice or professional judgment.

- Water content
- Grain-size distribution
- Plasticity index
- Dry density

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID		Depth	LL	PL	PI	Fines	USCS	Description
●	1	9.0	31	28	3	59	ML	SANDY SILT
⊠	1	14.0	31	23	8	46	SM	SILTY SAND
▲	1	19.0	34	20	14	75	CL	LEAN CLAY with SAND

PROJECT: Smith Estate No.1 Pit

SITE: 1.25 mile east of CR 17 and CR 70
Logan County, Colorado

Terracon
1901 Sharp Point Drive, Suite C
Fort Collins, Colorado

PROJECT NUMBER: 21145026

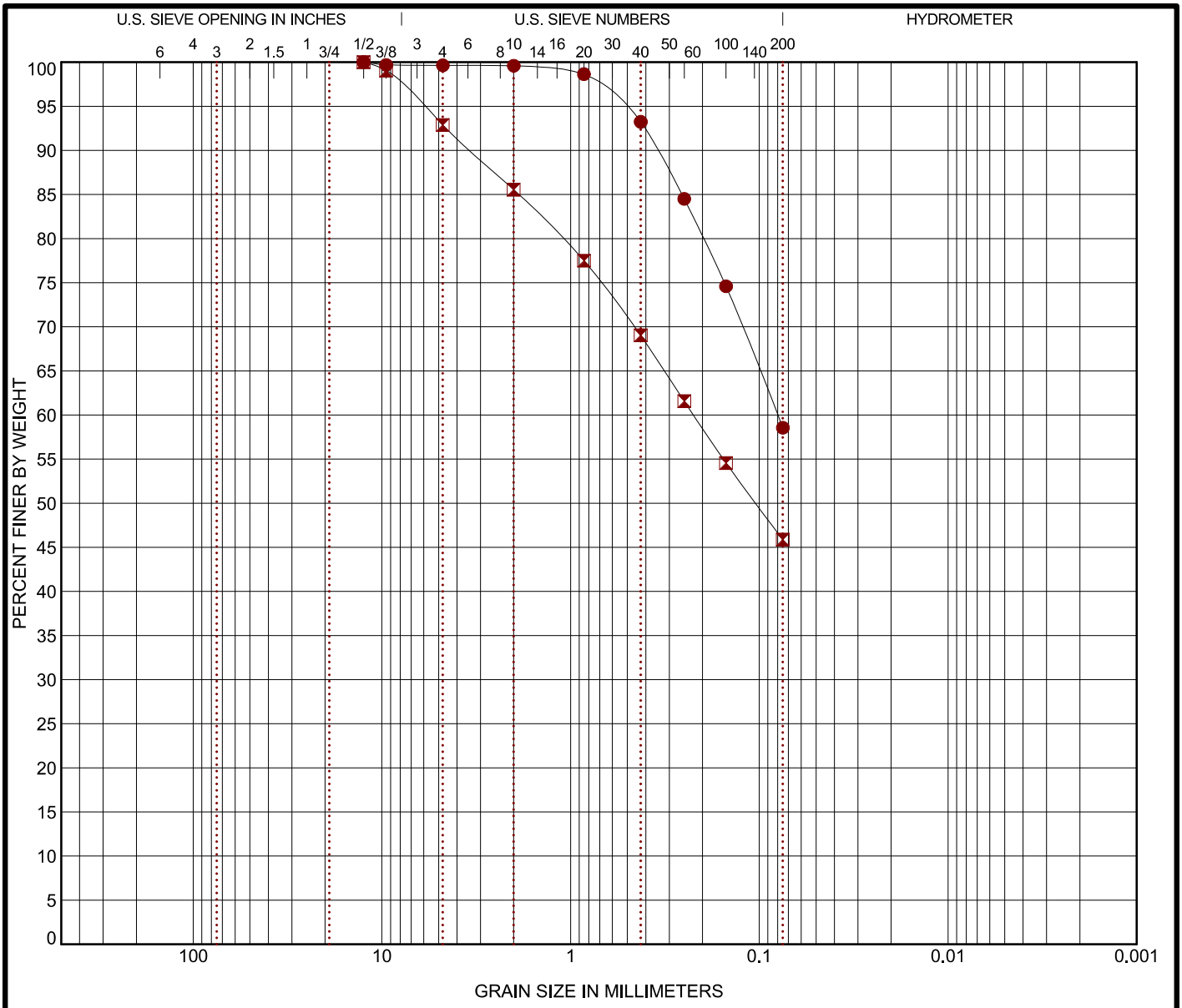
CLIENT: Brown Oil and Gas
Sterling, Colorado

EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 21145026.GPJ TERRACON2012.GDT 9/24/14

GRAIN SIZE DISTRIBUTION

ASTM D422



Boring ID		Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	1	9.0	SANDY SILT(ML)	31	28	3		
⊠	1	14.0	SILTY SAND(SM)	31	23	8		

Boring ID		Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	1	9.0	12.5	0.08			0.4	41.1	58.6	
⊠	1	14.0	12.5	0.223			7.1	47.0	45.9	

PROJECT: Smith Estate No.1 Pit

SITE: 1.25 mile east of CR 17 and CR 70
Logan County, Colorado

Terracon
1901 Sharp Point Drive, Suite C
Fort Collins, Colorado

PROJECT NUMBER: 21145026

CLIENT: Brown Oil and Gas
Sterling, Colorado

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 21145026.GPJ TERRACON2012.GDT 9/24/14

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING


Modified Dames & Moore Ring Sampler

WATER LEVEL


Water Initially Encountered


Water Level After a Specified Period of Time


Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance				BEDROCK		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**
Very Loose	0 - 3	0 - 6	Very Soft	less than 0.25	0 - 1	< 3	< 30	< 20	Weathered
Loose	4 - 9	7 - 18	Soft	0.25 to 0.50	2 - 4	3 - 4	30 - 49	20 - 29	Firm
Medium Dense	10 - 29	19 - 58	Medium-Stiff	0.50 to 1.00	4 - 8	5 - 9	50 - 89	30 - 49	Medium Hard
Dense	30 - 50	59 - 98	Stiff	1.00 to 2.00	8 - 15	10 - 18	90 - 119	50 - 79	Hard
Very Dense	> 50	≥ 99	Very Stiff	2.00 to 4.00	15 - 30	19 - 42	> 119	>79	Very Hard
			Hard	> 4.00	> 30	> 42			

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

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UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

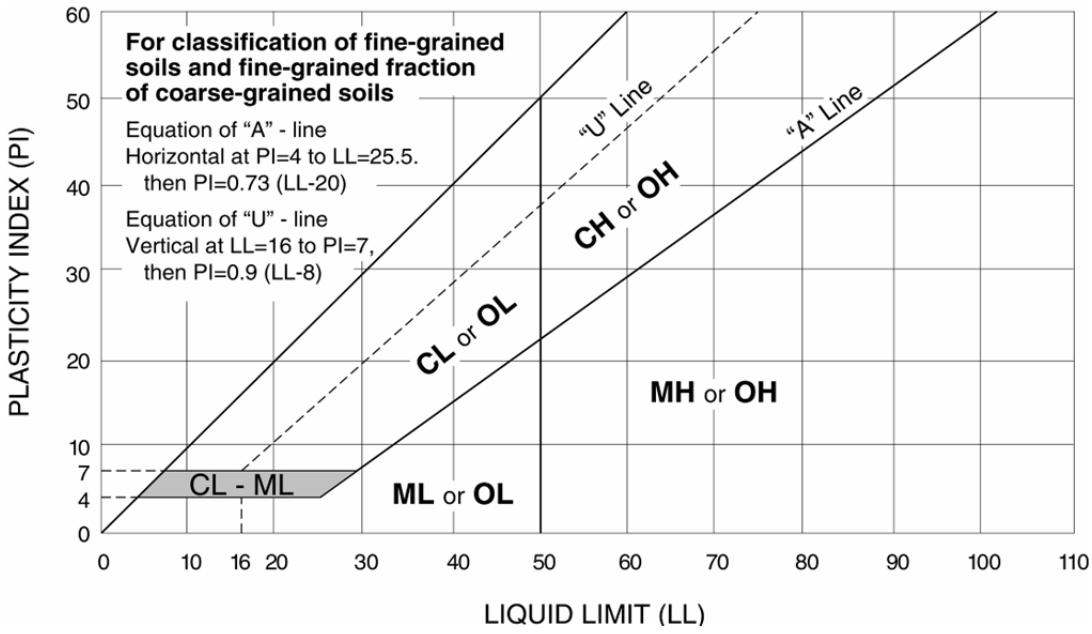
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Terracon

Exhibit C-2

DESCRIPTION OF ROCK PROPERTIES

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [a]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) a

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

a. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

LABORATORY TEST
SIGNIFICANCE AND PURPOSE

Test	Significance	Purpose
California Bearing Ratio	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	***Pavement Thickness Design***
Consolidation	Used to develop an estimate of both the rate and amount of both differential and total settlement of a structure.	***Foundation Design***
Direct Shear	Used to determine the consolidated drained shear strength of soil or rock.	***Bearing Capacity, Foundation Design, and Slope Stability***
Dry Density	Used to determine the in-place density of natural, inorganic, fine-grained soils.	***Index Property Soil Behavior***
Expansion	Used to measure the expansive potential of fine-grained soil and to provide a basis for swell potential classification.	***Foundation and Slab Design***
Gradation	Used for the quantitative determination of the distribution of particle sizes in soil.	***Soil Classification***
Liquid & Plastic Limit, Plasticity Index	Used as an integral part of engineering classification systems to characterize the fine-grained fraction of soils, and to specify the fine-grained fraction of construction materials.	***Soil Classification***
Permeability	Used to determine the capacity of soil or rock to conduct a liquid or gas.	***Groundwater Flow Analysis***
pH	Used to determine the degree of acidity or alkalinity of a soil.	***Corrosion Potential***
Resistivity	Used to indicate the relative ability of a soil medium to carry electrical currents.	***Corrosion Potential***
R-Value	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	***Pavement Thickness Design***
Soluble Sulfate	Used to determine the quantitative amount of soluble sulfates within a soil mass.	***Corrosion Potential***
Unconfined Compression	To obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state.	***Bearing Capacity Analysis for Foundations***
Water Content	Used to determine the quantitative amount of water in a soil mass.	***Index Property Soil Behavior***

REPORT TERMINOLOGY
(Based on ASTM D653)

Allowable Soil Bearing Capacity	The recommended maximum contact stress developed at the interface of the foundation element and the supporting material.
Alluvium	Soil, the constituents of which have been transported in suspension by flowing water and subsequently deposited by sedimentation.
Aggregate Base Course	A layer of specified material placed on a subgrade or subbase usually beneath slabs or pavements.
Backfill	A specified material placed and compacted in a confined area.
Bedrock	A natural aggregate of mineral grains connected by strong and permanent cohesive forces. Usually requires drilling, wedging, blasting or other methods of extraordinary force for excavation.
Bench	A horizontal surface in a sloped deposit.
Caisson (Drilled Pier or Shaft)	A concrete foundation element cast in a circular excavation which may have an enlarged base. Sometimes referred to as a cast-in-place pier or drilled shaft.
Coefficient of Friction	A constant proportionality factor relating normal stress and the corresponding shear stress at which sliding starts between the two surfaces.
Colluvium	Soil, the constituents of which have been deposited chiefly by gravity such as at the foot of a slope or cliff.
Compaction	The densification of a soil by means of mechanical manipulation
Concrete Slab-on-Grade	A concrete surface layer cast directly upon a base, subbase or subgrade, and typically used as a floor system.
Differential Movement	Unequal settlement or heave between, or within foundation elements of structure.
Earth Pressure	The pressure exerted by soil on any boundary such as a foundation wall.
ESAL	Equivalent Single Axle Load, a criteria used to convert traffic to a uniform standard, (18,000 pound axle loads).
Engineered Fill	Specified material placed and compacted to specified density and/or moisture conditions under observations of a representative of a geotechnical engineer.
Equivalent Fluid	A hypothetical fluid having a unit weight such that it will produce a pressure against a lateral support presumed to be equivalent to that produced by the actual soil. This simplified approach is valid only when deformation conditions are such that the pressure increases linearly with depth and the wall friction is neglected.
Existing Fill (or Man-Made Fill)	Materials deposited throughout the action of man prior to exploration of the site.
Existing Grade	The ground surface at the time of field exploration.

REPORT TERMINOLOGY
(Based on ASTM D653)

Expansive Potential	The potential of a soil to expand (increase in volume) due to absorption of moisture.
Finished Grade	The final grade created as a part of the project.
Footing	A portion of the foundation of a structure that transmits loads directly to the soil.
Foundation	The lower part of a structure that transmits the loads to the soil or bedrock.
Frost Depth	The depth at which the ground becomes frozen during the winter season.
Grade Beam	A foundation element or wall, typically constructed of reinforced concrete, used to span between other foundation elements such as drilled piers.
Groundwater	Subsurface water found in the zone of saturation of soils or within fractures in bedrock.
Heave	Upward movement.
Lithologic	The characteristics which describe the composition and texture of soil and rock by observation.
Native Grade	The naturally occurring ground surface.
Native Soil	Naturally occurring on-site soil, sometimes referred to as natural soil.
Optimum Moisture Content	The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.
Perched Water	Groundwater, usually of limited area maintained above a normal water elevation by the presence of an intervening relatively impervious continuous stratum.
Scarify	To mechanically loosen soil or break down existing soil structure.
Settlement	Downward movement.
Skin Friction (Side Shear)	The frictional resistance developed between soil and an element of the structure such as a drilled pier.
Soil (Earth)	Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.
Strain	The change in length per unit of length in a given direction.
Stress	The force per unit area acting within a soil mass.
Strip	To remove from present location.
Subbase	A layer of specified material in a pavement system between the subgrade and base course.
Subgrade	The soil prepared and compacted to support a structure, slab or pavement system.