December 5, 2007

Mr. Brett Middleton
EnCana Oil and Gas (USA), Inc.
2717 County Road 215, Suite 100
Parachute, CO 81635

Subject: Geotechnical Evaluation of Water Impoundments, High Mesa and Hunter Mesa Water Parks, Piceance Basin, Colorado

Dear Mr. Middleton,

ENSR Corporation (dba The RETEC Group, Inc. [RETEC]) was contracted by EnCana Oil and Gas (USA), Inc. (EnCana) to conduct a geotechnical evaluation of its two water parks, High Mesa and Hunter Mesa, located south of Interstate I-70 in the Piceance Basin of Colorado. The purpose of this evaluation was twofold: to collect data to provide a geotechnical assessment of the stability of the water impoundments and to evaluate groundwater conditions and quality beneath the water impoundments, if groundwater is present. This letter documents a field investigation, geotechnical laboratory analysis, and recommendations for the water impoundment structures located at High Mesa and Hunter Mesa.

Field Activities

RETEC contracted Drilling Engineers, Inc. of Fort Collins, Colorado to drill and abandon exploratory boreholes, collect soil samples for analysis, and install monitoring wells, if necessary. Field work was supervised by Mr. Doug Brannan of RETEC and was performed on August 28 through August 30, 2007. The field work included the installation of one exploratory boring at High Mesa (SB-01) and two exploratory borings at Hunter Mesa (SB-02 and SB-03). The borings locations were established in the field by Mr. Brett Middleton of EnCana.

The exploratory borings were advanced with a hollow stem auger drilling rig, unless auger refusal was encountered. If auger refusal was encountered prior to completing a minimum depth of 20 feet below the bottom of the water impoundments, the drill rig was converted from hollow stem auger to air rotary drilling to continue advancing the borehole through rocky conditions. Air rotary drilling tools were required to complete SB-01 after a boulder was encountered at approximately 12.5 feet below ground surface (bgs).

Split spoon samples were collected continuously during drilling, with lithologic description, and geotechnical standard penetration test blow count data recorded on boring/well logs (provided as Attachment A) in accordance with Standard Operating Procedures (SOPs) 7115, 7510, and 7600 (provided as Attachment B). Volatile organic compound (VOC) headspace analysis equipment was present on site to conduct readings in accordance with SOP 310 (Attachment B), if impacted material was encountered.

Soil samples were identified from selected depths in each boring for laboratory geotechnical analysis of moisture content (ASTM[1] Method D 2216), grain size distribution (ASTM Method D 6913), and Atterberg limits (ASTM Method D 4318). The lack of visual observation of staining in samples indicated that there was no hydrocarbon contamination of soils; therefore, no headspace analyses for VOCs were measured and no samples were collected for laboratory analysis of hydrocarbon contaminants. Upon completion of drilling, the exploratory borings were abandoned by backfilling with native material to 10 feet bgs followed by plugging with bentonite chips to the ground surface.

Site Conditions

The High Mesa location has a moderate slope dipping to the northwest, with the grade dropping off dramatically approximately 200 yards to the northwest. The site consists of sage brush, sparse juniper trees, and native grasses surrounding the water impoundments and a compressor station to the south. Drainage from the facility and surrounding area flows to the northwest. High Mesa impoundment construction details were developed based on discussions with EnCana personnel and construction drawings provided by EnCana. The water impoundments were established in 2005, and are constructed such that the bottoms and most of the separating berms of the impoundments are excavated into the native material. The details are shown on the construction drawings in Attachment C. The upper portions of the berms and the parking pads that are outside of the ponds appear to be constructed by compacting the natural material that was produced during excavation of the ponds. The interior berms between the ponds are sloped at an inclination of 2H:1V (2 Horizontal: 1 Vertical), while exterior pond berms are sloped at an inclination of 4H:1V. The top width of both interior and exterior berm is reportedly 20 feet. The maximum design water depth in the ponds varies from 12.5 to 13.5 feet, and the ponds were designed such that the water level would be controlled by a series of siphons between the ponds. Currently, water is pumped between the ponds. A parking pad at the downgradient end of the ponds is built up in order to allow vehicle access around the lower pond. There has been no instability reported at the site, and no indications of berm instability were identified during our work on the site. The boring at High Mesa was drilled off the western, downgradient edge of the fill area in the native material, as shown in Figure 1 and in Photo 1 (Attachment D). The conditions in the boring are expected to be representative of the natural material that makes up the majority of the berms that separate and retain the pond water.

The Hunter Mesa site is relatively flat with a gradual slope dipping to the north. The site consists of sage brush and native grasses surrounding the water impoundments and a compressor station. Drainage from the facility and surrounding area flows to the north. Hunter Mesa impoundment construction details were developed based on discussions with EnCana personnel and construction drawings provided by EnCana. The water impoundments are constructed such that the bottoms of the impoundments are excavated into the native material and the associated fill material is used to create the berms and parking pads around the outside of the ponds. The as-built drawing for Hunter Mesa is provided in Attachment C. The upper portions of the berms and the parking pads that are outside of the ponds appear to be constructed by compacting the natural material that was produced during excavation of the ponds. The maximum design water depth in the ponds varies from 13 to 28 feet. A parking pad at the downgradient end of the ponds is built up in order to allow vehicle access around the lower pond. Each boring at Hunter Mesa was drilled off the fill area in the native material, with the

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[1] American Society of Testing and Materials, ASTM International, www.ASTM.org

upgradient boring installed near the southwest corner of the impoundment and the downgradient boring installed off the northern end of the water impoundments and parking lot downgradient of the ponds, as shown in Figure 2 and Photos 2 and 3, respectively.

Site Geology

The site is located within the Piceance Basin. The Piceance Basin is a large, deep structural basin formed during the Laramide orogenic event of late Cretaceous age. Present structural relief between the Piceance Basin and the White River uplift is about 30,000 feet. The site is located on what has been termed the Ohio Creek Formation (Ogden, 1979) by various authors. The Ohio Creek Formation occurs stratigraphically between the underlying Upper Cretaceous Mesaverde Group and the overlying Paleocene Wasatch Formation. An unconformity separates the two. The Ohio Creek formation has been placed either just above or just below this unconformity, depending on the worker. As reported by Tweto (1980), the white, slightly pebbly sandstone of the Ohio Creek is a deeply weathered zone in Mesaverde rocks beneath the unconformity. Overlying conglomerate, which has been mapped as Ohio Creek by some workers, is a basal conglomerate of the Wasatch Formation in some places. The Tertiary claystone, mudstone, sandstone, siltstone and shales of the Wasatch and Ohio Creek formations are the dominant formations at the High and Hunter Mesa locations.

Site subsurface conditions at the High Mesa site were identified by logging the soil encountered in boring SB-01, and consist of stiff to very stiff tan, dry, silty clay with some gravel from ground surface to approximately 12.5 feet bgs. A white/tan, dry layer of stiff silty clay was encountered from 8 to 10 feet. Standard penetration test blow count values in the upper 12.5 feet ranged from a low of 17 to a high of 50 for 5", with the average blow count being 28. A basalt boulder (estimated at 3.5 feet in diameter) stopped advancement of the hollow stem auger at 12.5 feet bgs. Examples of these types of boulders are present at the site, as shown in Photo 4 (Attachment D). Once the boulder was encountered, the drillers were forced to convert to air rotary methods in order to advance through the boulder. Air rotary drilling techniques break up the formation and force the highly disturbed soil/rock cuttings to the ground surface in a stream of air, so logging is completed by visual observation of the soil/rock cuttings. This method makes identification of small soil layers difficult, and requires that identification be completed based on an overall general soil type. From approximately 16 feet bgs until sandstone bedrock was encountered at 39 feet bgs the dominant material was a silty clay. Tan, dry, silty clay with some coarse sand (possible interbeds) was encountered from approximately 16 to 25 feet bgs. A tan, slightly moist silty clay with some coarse sand and gravel extended to 30 feet bgs. A tan brown, slightly moist silty clay with some interbedded fine-grained sand grading to a coarser sand after 35 feet bgs was encountered down to bedrock at 39 feet. Bedrock encountered in the boring at High Mesa consisted of a tan sandstone. Although the borehole was left open for 30 minutes, no groundwater was encountered during drilling to the top of the sandstone bedrock.

The borings at Hunter Mesa were advanced through various layers of clay mixed with silt, gravel and fine grained sand to approximately 40 feet bgs until a sandstone bedrock was encountered. Tan, inorganic clay with some intermixed sandstone gravel was encountered at the upgradient boring location from the ground surface to approximately 4.5 feet bgs. Increasing moisture content was observed in the samples as the boring was advanced to approximately 6.5 feet bgs. From 6.5 to 10 feet a layer of reddish, weathered sandstone was layered within the clay. A dry, tan, hard, sandy clay was the predominant soil observed from approximately 10 feet bgs until the sandstone bedrock was encountered at approximately 40 feet bgs. Occasional sandstone and gravel and cobbles were encountered throughout the zone.

The geology encountered in the boring drilled downgradient of the Hunter Mesa water impoundments was similar to the upgradient location with the dominant material being a silty clay. From ground surface to approximately 2 feet bgs a tan brown, dry, inorganic clayey silt was found above a white, dry, silty clay layer that continued to 6 feet bgs. At 6 feet bgs, a tan, dry, hard silty clay was encountered down to approximately 40 feet bgs, where a tan sandstone bedrock was encountered. The silty clay encountered from approximately 6 feet bgs to bedrock at approximately 40 feet bgs included some interbedded sandstone between 16 and 18 feet bgs. Although the borehole was left open for 30 minutes, no groundwater was encountered during drilling to the top of the sandstone bedrock.

Physical Laboratory Test Results

Three soil samples each were collected at High Mesa and Hunter Mesa and submitted to Advanced Terra Testing, Inc. for soil index testing that included moisture content, grain size distribution analysis, and Atterberg limits testing.

Soil samples were collected from SB-01 at High Mesa from approximately 0–12.5 feet bgs, 16–30 feet bgs, and 30–39 feet bgs. Soil samples were collected from boring SB-02 at Hunter Mesa (upgradient location) from approximately 0–4.5 feet bgs and 8–40 feet bgs. A sample was collected from SB-03 (downgradient location) from 6–18 feet bgs. Test results are summarized in Table 1 and the physical lab report is included as Attachment E.

Five samples were analyzed using ASTM Method D2216 for moisture content[2]. Soil boring SB-01 from 0–12.5 feet bgs had a moisture content of 9.7%, from 16–30 feet bgs 4.8% and from 30 to 39 ft bgs 5.8%. Soil boring SB-02 from 8–40 feet bgs had a moisture content of 4.8% and soil boring SB-03 from 6–18 feet bgs had a moisture content of 7.9%.

Six samples where analyzed using ASTM Method D4318 for Atterberg limits analysis. Soil samples from boring SB-01 from 0–12.5 feet, 16–30 feet, and 30–39 feet are classified as clay (CL) with low to medium plasticity with some gravel, sand, and silts. Soil samples from boring SB-02 from 0–4.5 feet and from 8–40 feet are also classified as a CL. Soil boring SB-03 from 6-18 feet is also classified as a CL.

Six samples where analyzed using ASTM Method D6913 for mechanical sieve test data analysis. Soil samples from boring SB-01 from 0–12.5 feet and 30–39 feet had 62.7% and 61.6% by weight pass through the #200 sieve, respectively, whereas the sample from 16–30 feet contained approximately 32.7% by weight passing the #200 sieve. Soil samples from boring SB-02 from 0–4.5 feet had 45.4% and from 8–40 feet had 57.3% by weight pass through the #200 sieve. The soil sample from boring SB-03 from 6–18 feet had 64.3% by weight pass through the #200 sieve.

[2] Insufficient material was available to conduct a moisture content analysis on the sample from SB-02 from 0-4.5 feet bgs.

Recommendations

Geotechnical

High Mesa

The High Mesa site ponds were constructed by excavating the majority of the three ponds out of the natural soil found on the slope and placing some of the excavated material as the upper portions of the pond berms. The ponds were excavated into a gently sloping hillside that has a natural slope of around 4 degrees. The three adjacent ponds were constructed with interior side slopes of 2H:1V (about 26 degrees), and exterior side slopes (for the perimeter berms) that are 4H:1V (about 14 degrees). The ponds contain a synthetic liner to minimize leakage. The design drawings indicate that the water in the ponds is a maximum of 13.5 feet deep, and that the design water surface provides between 2 and 3 feet of freeboard when compared to the elevation of the top of the berms. The cross section shows that the upper 2 to 4 feet of the berms were constructed with backfilled soil with the remainder of the berms being constructed in an excavation into the natural hillside.

The boring completed at the High Mesa site was completed outside of the berms and in the natural hillside next to the downhill berm. The configuration of the berms and the synthetic lining on the berms made drilling down through the berms unrealistic while keeping the ponds operating. Based on observations made at the site, the material encountered in the borings, and discussions with EnCana, our review of the pond stability assumes that the fill portion of the pond berms is comprised of soil that was excavated from the natural hillside to form the lower portions of the ponds. Natural soil on the site was found to be composed of silty clay with varying amounts of gravel and cobbles. Blow counts recorded during the drilling indicated that it was stiff to hard, and primarily very stiff to hard, indicating that the soil has a relatively high intact strength. No groundwater was encountered. This soil placed as backfill to form the upper portions of the berms will have a relatively lower strength that is somewhat dependant on the compactive effort utilized during berm construction.

Given the configuration of the berms, the stability of the berms is primarily a function of the intact strength of the natural soils found on the site. A cursory stability analysis was performed using the geometry of the site, the soil conditions identified in the borings as described herein, and soil strength parameters based on the soil index testing completed for this study. The results indicate that the factor of safety of the interior berm slopes is lower than exterior berm slopes. This result is to be expected given that the interior berm slopes are steeper (2H:1V) than the exterior berm slopes (4H:1V). The interior berm safety factor was determined to be around 1.5, and the exterior berm safety factor was determined to be around 2.0. Both factors of safety are considered satisfactory, and show a stable berm system. It should be noted that the factors of safety were calculated using what are considered to be relatively conservative soil strength parameters given the soil conditions encountered in the borings at the site. A more detailed study including detailed laboratory strength testing of the soil would likely result in factors of safety higher than reported in this preliminary study.

Hunter Mesa

Subsurface conditions in the borings completed at the uphill and downhill sides of the ponds consist of very stiff to hard fine-grained clay, siltstone, and fine-grained sandstone. This unit is considered to be of relatively high internal strength, and very stable at the slopes presently on the site. Construction details of the berms at Hunter Mesa were not available, so commenting on the stability of the berms is not possible. However, portions of the ponds constructed within the intact natural soil on the site would be considered to be stable given the relatively high internal strength of the intact soil.

Groundwater

The Colorado Oil and Gas Conservation Commission (COGCC) rules include requirements for groundwater beneath Centralized E&P Waste Management Facilities. The COGCC rules also utilize the depth to groundwater as one determining factor regarding a Sensitive Area Determination. Section 908 (9) of the COGCC rules specify groundwater monitoring at Centralized E&P Waste Management Facilities to ensure compliance with allowable concentrations and levels. In addition, a location may be defined as a Sensitive Area if groundwater is encountered less than 20 feet below the pit bottom. To evaluate compliance with these regulatory conditions, one of the objectives of the work was to evaluate the presence of groundwater beneath the High Mesa and Hunter Mesa water parks.

The soil borings drilled as part of this work were advanced to sandstone bedrock. Bedrock was encountered at 39 feet bgs at High Mesa and at 40 feet bgs at Hunter Mesa. These depths are greater than 20 feet below the respective bottoms of the ponds. No groundwater was encountered in any of the borings. These conditions indicate that there should be no need to monitor groundwater quality at either water park and that the water parks do not appear to be within Sensitive Areas, with respect to depth to groundwater.

Sincerely yours,

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Senior Engineer and Reviewer

COLORADO REGISTERED THOMAS MICHAEL KREUTZ 28362 PROFESSIONAL ENGINEER

References:

Ogden, 1979. Geological Map of Colorado. Prepared in cooperation with The U.S. Geological Survey of Colorado

Tweto, Ogden, 1980. Summary of Laramide Orogeny in Colorado, in Colorado Geology, ed. H.C. Kent and K.W. Porter, RMAG, Denver, CO

Table 1 Summary of Soil Analysis
EnCana Oil and Gas (USA), Inc.
Hunter and High Mesa
August 28 - 30, 2007

Sample ID	Sample Depth ft	Moisture Content %	Liquid Limit %	Plastic Limit	Grain Size			USCS Designation
					% Gravel	% Sand	% Passing #200 Seive	
High Mesa								
SB-01	0-12.5	9.7	39.6	18.8	14.1	23.2	62.7	CL
	16-30	4.8	33.7	16.4	11.5	55.8	32.7	CL
	30-39	5.8	32.0	14.6	2.1	36.3	61.6	CL
Hunter Mesa								
SB-02	0-4.5	NA	26.4	14.4	11.6	43.0	45.4	CL
	8-40	4.8	25.6	13.5	14.2	28.5	57.3	CL
SB-03	6-18	7.9	30.3	14.3	5.7	30.0	64.3	CL

File: W:\Encana\High and Hunter Mesa Drilling\HIGH AND HUNTER MESA FIGURES.dwg Layout: FIGURE 1 User: dbrannan Plotted: Nov 02, 2007 - 11:29am Xref's:

ENSR | AECOM

RETEC

LEGEND

▲ SOIL BORING

ENCANA 10331-007-0200	HIGH MESA SOIL BORING LOCATION
DATE: 11/02/07 DRWN: D.B./UKN	FIGURE 1

File: W:\Encana\High and Hunter Mesa Drilling\HIGH AND HUNTER MESA FIGURES.dwg Layout: FIGURE 2 User: dbrannan Plotted: Nov 02, 2007 - 11:28am Xref's:

ENSR | AECOM

RETEC

LEGEND

▲ SOIL BORING

ENCANA

10831-007-0200

HUNTER MESA
SOIL BORING LOCATIONS

DATE: 04/10/07	DRAWN: EJF/SEA			**FIGURE 2**

Attachment A

Soil Boring Logs

ENSR | AECOM

Boring/Well Log

Boring ID:SB-01
Sheet 1 of 3

Client: EnCana	Monument:	Stick Up:
Project #:10331-007-0200	Northing: 4365832 Easting:753530	Ground Elevation: 10,707'
Location:High Mesa	Drill Rig Type:	MP Elevation:
Project:	Method:HSA / Air Rotary	Total Depth:
Start Date & Time:8/28/07	Casing ID:	Filter Pack:
Finish Date & Time: 8/29/07 10:20	Boring ID: 6.75"/4"	Seal:
Contractor: Drilling Engineers	Bit Type:	Grout:
Weather:Partly cloudy-clear, 80 degrees F	Logged By: Doug Brannan	Screen:

Sample				Graphic	Depth (ft.)	MATERIALS: Color, size, range, MAIN COMPONENT, minor compoenent(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)	Elevation (ft.)	Comments
% Rec (in)	Depth Range	PID	Blows per 6"					
					0	CL: Tan, silty clay with some gravel, dry, moisture = 9.7 %	0	
24"	0-2'		4-11-20-20		1			
					2		-2	
12"	2-4'		11-17-12-50		3			
					4		-4	
20"	4-6'		9-11-12-13		5			
					6		-6	
10"	6-8'		6-8-9-12		7			
					8	CL: White/tan, silty clay, dry, moisture = 9.7 %	-8	
18"	8-10'		13-13-16-20		9			
					10	CL: Tan, silty clay with some gravel, dry, moisture = 9.7 %	-10	
10"	10-12'		16-24-17-12		11			
					12		-12	
	12-14'		50 for 0.5'		13	CL: Large coble, dark gray, porous, with reflective material, basalt		
					14		-14	
	14-16'				15			
					16	CL: Tan, silty clay, with coarse sand, angular, very slightly moist, moisture = 4.8%	-16	
	16-18'				17			

Remarks and Datum Used: SB-01 (0-12.5')

Switched to air rotary at 12.5'

SB-01 (16'-30') SB-01 (30'-39')

Checked for water 30 min. later, no water

ENSR Corporation
2409 Research Blvd., Suite 106
Fort Collins, CO 80526
Phone: (970) 493-3700
Fax: (970) 493-2328

Sample Type
N = SPT
DP = Direct Push
GS = Grab Sample
C = Core

Groundwater		
Date	Time	Depth (ft.)

ENSR | AECOM

Boring/Well Log

Boring ID:SB-01

Client: EnCana	Monument:	Stick Up:
Project #:10331-007-0200	Northing: 4365832 Easting:753530	Ground Elevation: 10,707'
Location:High Mesa	Drill Rig Type:	MP Elevation:
Project:	Method:HSA / Air Rotary	Total Depth:
Start Date & Time:8/28/07	Casing ID:	Filter Pack:
Finish Date & Time: 8/29/07 10:20	Boring ID: 6.75"/4"	Seal:
Contractor: Drilling Engineers	Bit Type:	Grout:
Weather:Partly cloudy-clear, 80 degrees F	Logged By: Doug Brannan	Screen:

Sample: % Rec (in)	Sample: Depth Range	Sample: PID	Sample: Blows per 6"	Graphic	Depth (ft.)	MATERIALS: Color, size, range, MAIN COMPONENT, minor compoenent(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)	Elevation (ft.)	Comments
24"	0-2'		4-11-20-20		0	CL: Tan, silty clay with some gravel, dry, moisture = 9.7 %	0	
12"	2-4'		11-17-12-50					
20"	4-6'		9-11-12-13					
10"	6-8'		6-8-9-12					
18"	8-10'		13-13-16-20		8	CL: White/tan, silty clay, dry, moisture = 9.7 %	-8	
10"	10-12		16-24-17-12		10	CL: Tan, silty clay with some gravel, dry, moisture = 9.7 %	-10	
	12-14		50 for 0.5'		12.5	CL: Large coble, dark gray, porous, with reflective material, basalt		
	14-16							
	16-18				16	CL: Tan, silty clay, with coarse sand, angular, very slightly moist, moisture = 4.8%	-16	

Remarks and Datum Used: SB-01 (0-12.5')

Switched to air rotary at 12.5'

SB-01 (16'-30') SB-01 (30'-39')

Checked for water 30 min. later, no water

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Sample Type
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C = Core

Groundwater: Date	Time	Depth (ft.)

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Boring/Well Log

Sample (inRec)	Depth Range	PID	Blows per 6"	Graphic	Depth (ft.)	MATERIALS: Color, size, range, MAIN COMPONENT, minor compoenent(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)	Elevation (ft.)	Comments
					40 41 42	BEDROCK: Sandstone, tan	-40 -42	

So

Remarks and Datum Used: SB-01 (0-12.5')

Switched to air rotary at 12.5'

SB-01 (16'-30') SB-01 (30'-39')

Checked for water 30 min. later, no water

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Sample Type
N = SPT
DP = Direct Push
GS = Grab Sample
C = Core

Groundwater		
Date	Time	Depth (ft.)

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Boring/Well Log

Boring ID:SB-02
Sheet 1 of 2

Client: **EnCana**	Monument:	Stick Up:
Project #:**10331-007-0200**	Northing: **4372368** Easting:**266297**	Ground Elevation: **6070'**
Location:**Hunter Mesa**	Drill Rig Type:	MP Elevation:
Project:	Method:**HSA, continuous split spoon**	Total Depth:
Start Date & Time:**8/29/07 14:00**	Casing ID:	Filter Pack:
Finish Date & Time:	Boring ID: **6.75"**	Seal:
Contractor: **Drilling Engineers**	Bit Type:	Grout:
Weather: **Cloudy - sunny, 80 degrees F**	Logged By: **Doug Brannan**	Screen:

Sample: % Rec (In)	Sample: Depth Range	Sample: PID	Sample: Blows per 6"	Graphic	Depth (ft.)	MATERIALS: Color, size, range, MAIN COMPONENT, minor compoenent(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)	Elevation (ft.)	Comments
20"	2-4'		7-9-22-20		2	2-4' CL, tan, clay silt with some gravel, dry, sanstone rocks	-2	
20"	4-5'		6-10-20-20		4	4-6' CL, tan, clay silt with some gravel, very slightly moist	-4	
12"	5-7.5'		10-23-(50 for 3")		6.5	6.5-7.5' SANDSTONE, brown-red-tan, color changing with depth, weathered, dry		
17"	7.5-10'		21-23-(50 for 5")		7.5	7.5-10 CL, tan, clay silt with some gravel, moisture = 4.8%		
15"	10-12'		16-19-30-17		10	10-13.5 CL, tan claystone, finely layered, very slightly moist	-10	
24"	12-14'		12-17-16-17		13.5	13.5-14 SANDSTONE, tan, dry		
18"	14-16'		19-31-36-35		14	14-16 CL, tan claystone, finely layered, very slightly moist	-14	
20"	16-18'		34-34-29-21		16	16-24 CL, tan claystone with interbedded sandstone, dry, moisture = 4.8%	-16	

Remarks and Datum Used:
SB-02 (0-4.5')
SB-02 (8-40')
Boulder at 0-2'

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Fort Collins, CO 80526
Phone: (970) 493-3700
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Sample Type
N = SPT
DP = Direct Push
GS = Grab Sample
C = Core

Groundwater		
Date	Time	Depth (ft.)

Boring/Well Log

ENSR | AECOM RETEC

So

% Rec (in)	Depth Range	PID	Blows per 6"	Depth (ft.)	MATERIALS: Color, size, range, MAIN COMPONENT, minor compoenent(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)	Elevation (ft.)	Comments
18"	18-21		11-9-20-(50 for 5")	20		-20	
				21	21-22 Rock, dark gray		
				22	22-26 CL, claystone with sandstone intermixed, tan, dry	-22	
5"	22-24		31-(50 for 3")	23			
				24		-24	
12"	24-26		38-37-(50 for 6")	25			
				26	26-28 CL, claystone with some sandstone intermixed, tan, dry, granite like rock encountered	-26	
7"	26-28		45-(50 for 1")	27			
				28	28-40 CL, claystone with sandstone intermixed, tan, moisture = 4.8%	-28	
	28-30		24-25-(50 for 6")	29			
				30		-30	
			50 for 2"	31			
				32		-32	
				33			
				34		-34	
				35			
				36		-36	
				37			
				38		-38	
				39			
				40		-40	

Remarks and Datum Used:

SB-02 (0-4.5')

SB-02 (8-40')

Boulder at 0-2'

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Sample Type
N = SPT
DP = Direct Push
GS = Grab Sample
C = Core

Groundwater		
Date	Time	Depth (ft.)

ENSR | AECOM

Boring/Well Log

Client: **EnCana**	Monument:	Stick Up:
Project #: **10331-007-0200**	Northing: **4372623** Easting: **266413**	Ground Elevation: **6050'**
Location: **Hunter Mesa**	Drill Rig Type:	MP Elevation:
Project:	Method: **HSA, continuous split spoon**	Total Depth:
Start Date & Time: **8-30-07 08:00**	Casing ID:	Filter Pack:
Finish Date & Time:	Boring ID: **6.75"**	Seal:
Contractor: **Drilling Engineers**	Bit Type:	Grout:
Weather: **Partly cloudy, 60-80 degrees F**	Logged By: **Doug Brannan**	Screen:

Sample: % Rec (In)	Sample: Depth Range	Sample: PID	Sample: Blows per 6"	Graphic	Depth (ft.)	MATERIALS: Color, size, range, MAIN COMPONENT, minor compoenent(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)	Elevation (ft.)	Comments
10"	0-2		7-8-19-21		0	0-2' Tanish brown, clay (silty), dry, layers	0	
20"	2-4		18-13-18-20		2	2-6' Tanish white, silty clay, dry	-2	
20"	4-6		18-19-31-28		4		-4	
8"	6-8		18-13-16-19		6	6-8' CL, tanish brown, claystone, dry, moisture = 7.9%	-6	
20"	8-10		10-10-14-12		8	8-10' CL, tan, clay silt, very slightly moist, moisture = 7.9%	-8	
	10-12		11-12-16-20		10	10-16' CL, tanish brown, claystone, very slightly moist, moisture = 7.9%	-10	
24"	12-14		12-11-13-8		12		-12	
12"	14-16		19-18-27-24		14		-14	
19"	16-18		9-14-		16	16-18' CL, tan, silty clay with some sandstone gravel, dry, moisture = 7.9%	-16	

Remarks and Datum Used: SB-03 (6-18')

Top of pond - 6066ft, ponds are 13 ft deep

After 30 min. check for GW in boring, it was dry

Cave in @ 34'2"

ENSR Corporation
2409 Research Blvd., Suite 106
Fort Collins, CO 80526
Phone: (970) 493-3700
Fax: (970) 493-2328

Sample Type
N = SPT
DP = Direct Push
GS = Grab Sample
C = Core

Groundwater: Date	Time	Depth (ft.)

% Rec (in)	Depth Range	PID	Blows per 6"	Depth (ft.)	MATERIALS: Color, size, range, MAIN COMPONENT, minor compoenent(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)	Elevation (ft.)	Comments
			19-14				
				18	18-22', tan silt stone, dry, layered	-18	
11"	18-20		18-(50 fo 5")	19			
				20		-20	
1"	20-22		50 for 1"	21			
				22	22-24', tan silt stone, dry, layered, 2" shale layer	-22	
	22-24		39-40-40-(50 for 2")	23			
				24	24-39' tan silt stone, dry, layered	-24	
	24-26		50 for 1"	25			
				26		-26	
				27			
				28		-28	
				29			
				30		-30	
				31			
				32		-32	
				33			
				34		-34	
				35			
				36		-36	
				37			
				38		-38	
				39	Sandstone		
				40		-40	

Remarks and Datum Used: SB-03 (6-18')

Top of pond - 6066ft, ponds are 13 ft deep

After 30 min. check for GW in boring, it was dry

Cave in @ 34'2"

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Sample Type
N = SPT
DP = Direct Push
GS = Grab Sample
C = Core

Groundwater		
Date	Time	Depth (ft.)

ENSR | AECOM

Boring/Well Log

Well #: SB-03

Sample % Rec (in)	Sample Depth Range	Sample PID	Sample Blows per 6"	Graphic	Depth (ft.)	MATERIALS: Color, size, range, MAIN COMPONENT, minor compoenent(s), moisture content, structure, angularity, maximum grain size, odor, and Geologic Unit (If Known)	Elevation (ft.)	Comments
	39-41		18-20-21-(50 for 5")		40–41		-40	

Remarks and Datum Used:	SB-03 (6-18')
ENSR Corporation 2409 Research Blvd., Suite 106 Fort Collins, CO 80526 Phone: (970) 493-3700 Fax: (970) 493-2328	Top of pond - 6066ft, ponds are 13 ft deep After 30 min. check for GW in boring, it was dry Cave in @ 34'2"

Sample Type
- N = SPT
- DP = Direct Push
- GS = Grab Sample
- C = Core

Groundwater		
Date	Time	Depth (ft.)

Attachment B

Standard Operating Procedures

SOP NUMBER: 7115

Subsurface Soil Sampling by Split Spoon	Date:	3rd Qtr. 1994
	Revision Number:	3
	Author:	Charles Martin
	Discipline:	Geosciencies

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) describes the methods used in obtaining subsurface soil samples for physical and/or chemical analysis. Subsurface soil samples are obtained in conjunction with soil boring programs and provide information as to the physical and/or chemical makeup of the subsurface environment.

The purpose of this SOP is to provide a description of a specific method or procedure to be used in the collection of subsurface soil samples. Subsurface soil is defined as unconsolidated material which may consist of one or a mixture of the following materials: sand, gravel, silt, clay, peat (or other organic soils), and fill material. Subsurface soil sampling, conducted in accordance with this SOP will promote consistency in sampling and provide a basis for sample representativeness.

This SOP covers subsurface soil sampling by split-spoon only, as this is the means most often used for obtained samples of unconsolidated deposits. Other types of equipment are available for use in subsurface soil sampling, including thin-wall tube samplers (Shelby tubes), piston samplers, and continuous core barrel samplers. Information on the use of these other sampling devices may be found in several available drilling handbooks and respective state and/or federal agency technical guidance documents. The American Society for Testing and Materials (ASTM) also provides procedures for use of split-spoon and other sampling devices.

Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.2 General Principles

Split-spoon subsurface soil sampling generally requires use of a drilling rig and typically the hollow-stem auger or other common drilling method to generate a borehole in which to use the split-spoon sampler. The split-spoon sampler is inserted through the augers (or other type of drill casing) then is driven into the subsurface soil with a weighted hammer. The sampler is then retrieved and opened to reveal the recovered soil sample. Soil samples may be collected at a continuous interval or at pre-selected vertically spaced intervals within the borehole.

1.3 Quality Assurance Planning Considerations

Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific Quality Assurance Project Plan (QAPP). Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements outlined in the QAPP typically suggest the collection of a sufficient quantity of field duplicate, field blank, and other samples.

1.4 Health and Safety Considerations

Subsurface soil sampling may involve chemical hazards associated with the types of contaminants potentially encountered and will always involve potential physical hazards associated with use of drilling equipment. When sampling is performed in materials which may contain hazardous constituents, or when the quality assurance objectives of the project require the use of hazardous solvents, adequate Health and Safety measures must be taken to protect sampling personnel. These measures must be addressed in the project Health and Safety Plan (HASP). This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing sampling, and must be adhered to as field activities are performed.

2.0 RESPONSIBILITIES

2.1 Drilling Subcontractor

It will be the responsibility of the drilling subcontractor to provide the necessary materials for obtaining subsurface soil samples. This generally includes one or more split-spoon samplers in good operating condition and sample containers used for stratigraphic characterization samples (sample containers for environmental samples should be provided by the designated analytical laboratory). It is the drilling subcontractor's responsibility to provide and maintain their own boring logs if desired. Equipment decontamination materials should also be supplied by the subcontractor and should meet project specifications.

2.2 Project Geologist/Sampling Engineer

It will be the responsibility of the project geologist/sampling engineer to conduct subsurface soil sampling in a manner which is consistent with this SOP. The project geologist/sampling engineer will observe all activities pertaining to subsurface soil sampling to ensure that the SOP is followed, and to record all pertinent data onto a boring log. It is also the project geologist/sampling engineer's responsibility to indicate the specific targeted sampling depth or sampling interval to the drilling subcontractor. The project geologist/sampling engineer is also responsible for the collection of representative environmental or stratigraphic characterization samples once the sampling device has been retrieved and opened. Additional sample collection responsibilities include labeling, handling, and storage of samples until further chain-of-custody procedures are implemented.

3.0 REQUIRED MATERIALS

In addition to those materials provided by the subcontractor, the project geologist/sampling engineer will require:

- Project Sampling Plan, QAPP, and HASP
- Boring logs
- Teaspoon or spatula (stainless steel is recommended)
- Sample kit (bottles, labels, custody records and tape, cooler)
- Sample collection pen
- Folding rule or tape measure
- Equipment decontamination materials
- Health and safety equipment (as required by HASP)
- Field project notebook/pen

4.0 METHOD

4.1 General Method Description

Split-spoon sampling devices are typically constructed of steel and are most commonly available in lengths of 18 and 24 inches and diameters of 1.5 to 3 inches. The split-spoon consists of a tubular body with two halves that split apart lengthwise, a drive head on the upper end with a ball-check valve for venting, and a hardened steel cutting shoe at the bottom. The soil sample enters the split-spoon through the cutting shoe as the device is driven into the ground. A replaceable plastic or metal basket is often inserted into the shoe to assist with retaining samples. Once the sampler is retrieved, the drive head and cutting shoes are removed and the split-spoon halves are then separated, revealing the sample.

Sample depth intervals are usually defined on a project-specific basis with these requirements specified in the project sampling plan. Sampling intervals typically range from one (1) sample per five (5) feet of drilling to continuous sampling where the entire drilled interval is sampled.

Subsurface soil sampling is usually accomplished as part of a drilling program where a soil boring is advanced with drilling equipment to the designated depth prior to collection of a representative sample. The general procedures outlined briefly in the following section provide requirements for advancing drill casing/augers in preparation for sampling.

4.2 General Procedures - Borehole Preparation

4.2.1 Advancing Casing/Augers

Soil borings that are completed for soil sampling purposes are typically advanced using hollow-stem augers and sometimes drive-and-wash or other casing methods. The casing/augers must be of sufficient diameter to allow for soil sampling at a minimum. The casing/augers will be advanced according to project requirements to the required depth for sampling. If hollow-stem augers are used, a temporary plug shall be used in the lead auger to prevent the auger from becoming filled with drill cuttings while drilling is in progress.

4.2.2 Obstructions

For those borings which encounter obstructions, the casing/augers will be advanced past or through the obstruction if possible. Caution should be exercised when obstructions are encountered and an effort made to identify the obstruction before drilling is continued. If the obstruction is not easily drilled through or removed, the boring should be relocated to an adjacent location.

4.2.3 Use of Added Water

The use of added or recirculated water during drilling is permitted when necessary. Use of extraneous water should be minimized or avoided if possible as it may impact sample quality. Water usage should be documented in the field notebook. Sampling and analysis of added or recirculated water may be required for quality assurance purposes (refer to QAPP). If a well is installed within the completed borehole, removal of the added water may be required.

4.3 Sampling Procedure

4.3.1 Equipment Decontamination

Each split-spoon must be decontaminated prior to its initial use and following collection of each soil sample. Site-specific requirements for equipment decontamination should be outlined within the Project Sampling Plan. Equipment decontamination procedures are also outlined within SOP 7600 - Decontamination of Equipment.

4.3.2 Standard Penetration Test

The drilling subcontractor will lower the split-spoon into the borehole. Samples are generally obtained using the Standard Penetration Test (SPT) in accordance with ASTM standards (ASTM D 1586-84). Following this method, the sampler will be driven using the 140-pound hammer with a vertical free drop of 30 inches using two turns of the rope on the cathead. The number of hammer blows required for every 6 inches of penetration will be recorded on the boring log. Blowcount information is used as an indicator of soil density for geotechnical as well as stratigraphic logging purposes. Once the split-spoon has been driven to its fullest extent, or to refusal, it will be removed from the borehole.

4.3.3 Sample Recovery

The split-spoon will be immediately opened upon removal from the casing/auger. The open sampler shall then be screened for volatile organics with a photoionization device (PID) if required by the Project Sampling Plan. If the Sampling Plan also requires individual soil sample headspace screening for volatile organic compounds, then a small portion of the split-spoon sample shall be removed and properly contained for that purpose.

Sample recovery will be determined by the project geologist/sampling engineer who will examine the soil core once the sampler is opened. The length of sample shall then be measured with a folding rule or tape measure. Any portion of the split-spoon contents which are not considered part of the true sample (i.e., heaved soils) will be discarded. If the sample recovery is considered inadequate for sample characterization or analytical testing purposes, another sample should be collected from the next vertical interval if possible before drilling is reinitiated.

Adequate sample recovery for stratigraphic logging purposes and/or headspace organic vapor testing purposes should be approximately 6 inches. Adequate sample recovery for analytical testing purposes should be a minimum of 12 inches and is somewhat dependent on the type of analytical testing required. In some cases, continuous sampling over a short interval, and compositing of the sample, may be required to satisfy analytical testing requirements. Larger diameter samplers may be used if large volumes of soil are required for analytical testing.

4.3.4 Sample Containment - General

Once retrieved, the sample will be removed from the split-spoon with a teaspoon or spatula and placed into the appropriate sample container. The sample will be split if necessary to meet sampling program requirements. Sample splitting may be necessary to provide individual samples for headspace testing, visual characterization, physical testing, analytical testing, or simply for archiving purposes. In general, most sampling programs are structured around environmental characterization needs; therefore, sample portions required for analytical testing should be collected first. The Project Sampling Plan and QAPP provides specific sample container requirements for each type of sample and should be referred to for guidance.

Once filled, the sample containers should be properly capped, cleaned, and labeled, and chain-of-custody and sample preservation procedures initiated. Sampling equipment should then be properly decontaminated.

4.3.5 Sample Containment - Volatile Organic Analyses

Collection of subsurface soil samples for volatile organic analysis (VOA) is slightly more complex than collection of samples for other routine chemical or physical testing primarily because of the concern for the potential loss of volatiles during the sample collection procedure. To limit the potential for loss of volatiles, the soil sample needs to be obtained as quickly and as directly as possible from the split-spoon. This generally means that the VOA sample is to be collected and placed into the appropriate sample container first. The VOA sample should also be obtained from a discrete portion of the entire sample interval and not composited or homogenized. The remainder of the recovered sample can then be composited, homogenized or split to meet the other testing requirements. The boring log and/or sample logbook should be filled out to indicate actual sample collection depths for both VOA samples and other portions of the sample which may have been composited over a larger vertical interval.

5.0 QUALITY CONTROL

Quality control requirements are dependent on project-specific sampling objectives. The QAPP will provide requirements for sample preservation and holding times, sample container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

6.0 DOCUMENTATION

Various forms are required to ensure that adequate documentation is made of sample collection activities. These forms include:

- Boring logs
- Field log books
- Sample collection records
- Chain-of-custody records
- Shipping labels

Boring logs (Figure 1) will provide visual and descriptive information for each sample collected and are often the most critical form of documentation generated during a sampling program. The field log book is kept as a general log of activities. Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes. Shipping labels are required if sample coolers are to be transported to the laboratory by a third party (courier service). Original copies of these records should be maintained in the appropriate project files.

7.0 REFERENCES

ASTM D 1586-84

ENSR

Figure 1

R:\pubs\mw97\SOPs\7115\fig-1.doc

Sheet 1 of __

BORING LOG

Project No. ________ Date – Start ________ Finish ________ Boring ________

Project Name ________ Drilling Co. ________

Location ________ Drilling Method ________

Total Depth ________ Inspector ________ Reviewer ________

Remarks ________

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			

SOP NUMBER: 7510

Packaging and Shipment of Environmental Samples

Date:	4th Qtr. 1999
Revision Number:	4
Author:	Charles Martin
Discipline:	Geosciences

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) describes the procedures associated with the packaging and shipment of environmental samples. Two general categories of samples exist: environmental samples consisting of water and soil submitted for routine environmental testing, and waste material samples which include non-hazardous solid wastes and/or hazardous wastes as defined by 40 CFR Part 261 submitted for environmental testing or bench/pilot-scale treatability testing. Packaging and shipping procedures will differ for the two sample categories.

This SOP is applicable to packaging and shipment of environmental samples submitted for routine environmental testing. Environmental samples are not considered a hazardous waste by definition; therefore, more stringent Department of Transportation (DOT) regulations regarding sample transportation do not apply. Environmental samples do, however, require fairly stringent packaging and shipping measures to ensure sample integrity as well as safety for those individuals handling and transporting the samples.

This SOP is designed to provide a high degree of certainty that environmental samples will arrive at their destination intact. This SOP assumes that samples will often require shipping overnight by a commercial carrier service, therefore, the procedures are more stringent than may be necessary if a laboratory courier is used or if samples are transported directly to their destination by a sampling team member. Should the latter occur, the procedures may be modified to reflect a lesser degree of packaging requirements.

Respective state or federal agency (regional offices) protocols may require or recommend specific types of equipment for use in sample packaging or a specific method of shipment that may vary from the indicated procedures. Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.2 General Principles

Sample packaging and shipment generally involves the placement of individual sample containers into a cooler or other similar shipping container and placement of packing materials and coolant in such a manner as to isolate the samples, maintain the required temperature, and to limit the potential for damage to sample containers when the cooler is transported.

1.3 Quality Assurance Planning Considerations

Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific work plan or Quality Assurance Project Plan (QAPP). Proper quality assurance requirements should be provided which will specify sample packaging and shipment requirements if variations to the indicated procedures are necessary on a particular project.

1.4 Health and Safety Considerations

Sampling personnel should be aware that packaging and shipment of samples involves potential physical hazards primarily associated with handling of occasional broken sample containers and lifting of heavy objects. Adequate health and safety measures must be taken to protect sampling personnel from these potential hazards. The project Health and Safety Plan (HASP) generally addresses physical and other potential hazards. This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing sampling, and must be adhered to as field activities are performed. In the absence of a HASP, work will be conducted according to the ENSR Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

2.0 RESPONSIBILITIES

2.1 Sampling Technician

It is the responsibility of the sampling technician to be familiar with the procedures outlined within this SOP and with specific sampling, quality assurance, and health and safety requirements outlined within the project-specific plans. The sampling technician is responsible for proper packaging and shipment of environmental samples and for proper documentation of sampling activities for the duration of the sampling program.

2.2 Sampling Coordinator

Large sampling programs may require additional support personnel such as a sampling coordinator. The sampling coordinator is responsible for providing management support such as maintaining an orderly sampling process, providing instructions to sampling technicians regarding sampling locations, and fulfilling sample documentation requirements, thereby allowing sampling technicians to collect samples in an efficient manner.

2.3 Project Manager

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the activities in accordance with the project plan and this SOP. The project manager is also responsible for ensuring that proper arrangements have been made with the designated analytical laboratory. These arrangements include, but are not necessarily limited to, subcontractor agreements, analytical scheduling, and bottle/cooler orders. The project manager may delegate some of these responsibilities to other project staff.

3.0 REQUIRED MATERIALS

- Sample coolers
- Sample containers
- Shipping labels
- Chain-of-custody records, custody seals
- Bubble wrap
- Vermiculite (granular), or styrofoam pellets
- "Blue Ice" refreezable ice packs, or ice cubes
- Transparent tape, or rubber bands
- Fiber tape
- Duct tape
- Zipper-lock plastic bags

- Trash bags
- Health and Safety supplies
- Equipment decontamination materials
- Field project notebook/pen

4.0 METHOD

4.1 General Information

4.1.1 Regulatory Information

The extent and nature of sample containerization will be governed by the type of sample, and the most reasonable projection of the sample's hazardous nature and constituents. The EPA regulations (40 CFR Section 261.4(d)) specify that samples of solid waste, water, soil or air, collected for the sole purpose of testing, are exempt from regulation under the Resource Conservation and Recovery Act (RCRA) when any of the following conditions are applicable:

- Samples are being transported to a laboratory for analysis;
- Samples are being transported to the collector from the laboratory after analysis;
- Samples are being stored (1) by the collector prior to shipment for analyses, (2) by the analytical laboratory prior to analyses, (3) by the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case.

4.1.2 Sample Information:

The following information must accompany each shipment of samples on a chain-of-custody form (Figure 1) where each sample has an individual entry:

- Sample collector's name, mailing address and telephone number,
- Analytical laboratory's name, mailing address and telephone number,
- A unique identification of each sample,

- Sample description (matrix),
- Number and type of sample containers,
- Container size,
- Preservative,
- Type and method of analysis requested, and
- Date and time that the samples were collected and prepared for shipping,
- Special handling instructions, including notation of suspected high concentration samples.

4.1.3 Laboratory Notifications:

Prior to sample collection, the Project Manager, or designated alternative must notify the laboratory manager of the number, type and approximate collection and shipment dates for the samples. If the number, type or date of sample shipment changes due to program changes which may occur in the field, the Project Manager or alternate must notify the laboratory of the changes. Additional notification from the field is often necessary when shipments are scheduled for weekend delivery.

4.2 General Site Preparation

4.2.1 Small Projects

Small projects of one or two days duration may require packaging and shipment of samples using the field vehicle as the sample preparation area. If sample coolers will be sent via third party commercial carrier service, adequate sample packaging materials should be sent to the project location in advance of sampling or purchased from stores located near the site.

4.2.2 Large Projects

Multi-day or week sampling programs usually require rental of an office trailer or use of existing office/storage facilities for storage of equipment as well as for sample preparation. If possible, a designated area should be selected for storage of unused sample containers/coolers and another area for sample handling, packaging, and shipment. Handling of environmental samples should preferably be conducted in a clean area and away from unused sample containers to minimize the potential for cross contamination. Large quantities of packaging materials may require advance special ordering. Shipping forms/labels may be preprinted to facilitate shipping.

4.2.3 Cooler Inspection and Decontamination

Laboratories will often re-use coolers. Every cooler received at a project location should be inspected for condition and cleanliness. Any coolers that have cracked interior or exterior linings/panels or hinges should be discarded as their insulating properties are now compromised. Any coolers missing one or both handles should also be discarded if replacement handles (i.e., knotted rope handles) can not be fashioned in the field. Replacement coolers may be purchased in the field if necessary.

The interior and exterior of each cooler should be inspected for cleanliness before using it. Excess strapping tape and old shipping labels should be removed. If the cooler interior exhibits visible contamination or odors it should be decontaminated in accordance with ENSR SOP-7600 (Decontamination of Equipment) prior to use. Drain plugs should be sealed on the inside with duct tape.

4.2.4 Other Considerations

VOC Samples - Sample containers used for VOC analysis may be grouped into a single cooler, with separate chain-of-custody record, to limit the number of trip blanks required for transportation and analysis. Individual VOC samples may also be placed into Zipper-lock bags to further protect the samples.

Contaminated Samples - Sample containers with presumed high contaminant concentrations should be isolated within their own cooler with each sample container placed into a Zipper-lock bag.

4.3 Sample Packaging Method

Sample packaging should be conducted in the following manner:

4.3.1 Place plastic bubble wrap matting over the base of each cooler or shipping container as needed. A 2- to 3-inch thickness layer of vermiculite may be used as a substitute base material.

4.3.2 Insert a clean trash bag into the cooler to serve as a liner.

4.3.3 Check that each sample container is sealed, labelled legibly, and is externally clean. Re-label and/or wipe bottles clean if necessary. Clear tape should be placed over the labels to protect them. Wrap each sample bottle individually with bubble wrap secured with tape or rubber bands. Place bottles into the cooler in an upright single layer with approximately one inch of space between each bottle. Do not stack bottles or place them in the cooler lying on their side. If plastic and glass sample containers are used, alternate the placement of each type of container within the cooler so that glass bottles are not placed side by side.

4.3.4 Insert cooler temperature blanks if required.

4.3.5 Place additional vermiculite, bubble wrap, and/or styrofoam pellet packing material throughout the voids between sample containers within each cooler to a level which meets the approximate top of the sample containers. Packing material may require tamping by hand to reduce the potential for settling.

4.3.6 Place cubed ice or cold packs in heavy duty Zip-lock type plastic bags, close the bags, and distribute the packages in a layer over the top of the samples. Cubed ice should be double-bagged to prevent leakage. Loose ice should never be used. Cold packs should be used only if the samples are chilled before being placed in the cooler.

4.3.7 Add additional bubble wrap/styrofoam pellets or other packing materials to fill the balance of the cooler or container.

4.3.8 Obtain two pieces of chain of custody tape as shown in Figure 2 and enter the custody tape numbers in the appropriate place on the chain-of-custody form. Sign and date the chain-of-custody tape.

4.3.9 Complete the chain-of-custody form. If shipping the samples involves use of a third party commercial carrier service, sign the chain-of-custody record thereby relinquishing custody of the samples. Shippers should not be asked to sign chain of custody records. If a laboratory courier is used, or if samples are transported to the laboratory, the receiving party should accept custody and sign the chain-of-custody records. Remove the last copy from the form and retain it with other field notes. Place the original (with remaining copies) in a Zipper-lock type plastic bag and tape the bag to the inside lid of the cooler or shipping container.

4.3.10 Close the top or lid of the cooler or shipping container.

4.3.11 Place the chain of custody tape at two different locations (i.e., one tape on each side) on the cooler or container lid and overlap with transparent packaging tape.

4.3.12 Packaging tape should be placed entirely around the sample shipment containers. A minimum of two full wraps of packaging tape will be placed at least two places on the cooler.

4.3.13 Repeat the above steps for each cooler or shipping container.

4.4 Sample Shipping Method

Packaged sample coolers should be shipped using one of the following options:

4.4.1 Hand Delivery

When a project member is transporting samples by automobile to the laboratory, the cooler should only be sealed with tape. In these cases, chain-of-custody will be maintained by the person transporting the sample and chain-of-custody tape need not be used. Chain-of-custody records should be relinquished upon delivery and a copy of the record retained in the project file.

4.4.2 Laboratory Courier

Laboratory couriers are usually employees of the analytical laboratory receiving the samples. As such, they will accept custody of the samples and must be asked to sign the chain-of-custody records. Chain-of-custody records do not need to be sealed in the cooler although it is recommended that the coolers be sealed with tape. All other packaging requirements generally apply unless otherwise specified in the QAPP.

If the laboratory courier is not authorized to accept custody of the samples, or if the requirements of the project plan preclude transfer to the laboratory courier, samples will be handled as described below in Section 4.4.3.

4.4.3 Third Party Courier

If overnight shipment is required, a third party package delivery service should be used. Transport the cooler to the package delivery service office or arrange for package pick-up at the site. Fill out the appropriate shipping form or airbill and affix it to the cooler. Some courier services may use multi-package shipping forms where only one form needs to be filled out for all packages going to the same destination. If not, a separate shipping form should be used for each cooler. Keep the receipt for package tracking purposes should a package become lost. Please note that each cooler also requires a shipping label which indicates point of origin and destination. This will aid in recovery of a lost cooler if a shipping form gets misplaced. Never leave coolers unattended while waiting for package pick-up. Airbills or waybills will be maintained as part of the custody documentation.

4.5 Sample Receipt

Upon receipt of the samples, the analytical laboratory will open the cooler or shipping container and will sign "received by laboratory" on each chain-of-custody form. The laboratory will verify that the chain-of-custody tape has not been broken previously and that the tape number corresponds with the number on the chain-of-custody record. The laboratory will note the condition of the samples upon receipt and will identify any discrepancies between the contents of the cooler and chain-of-custody. The analytical laboratory will then forward the back copy of the chain-of-custody record to the project manager to indicate that sample transmittal is complete.

5.0 QUALITY CONTROL

The potential for samples to break during transport increases greatly if individual containers are not snugly packed into the cooler. Completed coolers may be lightly shake-tested to check for any loose bottles. The cooler should be repacked if loose bottles are detected.

Environmental samples are generally shipped so that the samples are maintained at a temperature of approximately 4°C. Temperature blanks may be required for some projects as a quality assurance check on shipping temperature conditions. These blanks usually are supplied by the laboratory and consist of a 40-ml vial or plastic bottle filled with tap water. Temperature blanks should be placed near the center of the cooler.

6.0 DOCUMENTATION

Documentation supporting sample packaging and shipment generally consists of chain-of-custody records and shipping records. In addition, a description of sample packaging procedures will be written in the field project notebook. All documentation will be retained in the project files following project completion.

7.0 TRAINING/QUALIFICATIONS

Sample packaging and shipment is a relatively simple procedure requiring minimal training and a minimal amount of equipment. It is, however, recommended that initial attempts be supervised by more experienced personnel. Sampling technicians should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials are considered to be present.

Figure 1. Chain of Custody Form

CHAIN OF CUSTODY RECORD

8CLHQW3URMHFW1DPH	3URMHFW3FDWLRQ	$QDO\WLVHVTXHVWHG
3URMHFWXPEHU	)LHOG/RJERRN1R	
6DPSOHU	&KDLQRI&XVWRG\7DSH1R	
6LJQDWXUH	6HQGHVXOWVHSRUWWR	

)LHOG6DPSOH1R ,GHQWLILFDWLRQ	'DWH	7LPH	*UDE	&RPS	6DPSOH&RQWDLQHU 6L]H	6DPSOHHSH	3UHVHUYDWLYH	)LHOG)LOWHUHG							/DE	5HPDUNV

5HOLQTXLVKHG E\ 6LJQDWXUH	'DWH 7LPH	5HFHLYHG E\ 6LJQDWXUH	'DWH 7LPH	$QDO\WLFDO/DERUDWRU\ 'HVWLQDWLRQ (165 3RUWHU\$YH)RUW&ROOLQV&2
5HOLQTXLVKHG E\ 6LJQDWXUH	'DWH 7LPH	5HFHLYHG E\ 6LJQDWXUH	'DWH 7LPH	
5HOLQTXLVKHG E\ 6LJQDWXUH	'DWH 7LPH	5HFHLYHG E\ 6LJQDWXUH	'DWH 7LPH	6HULDO1R

Figure 2. Chain of Custody Tape

SOP NUMBER: 7600

Decontamination of Field Equipment

Date:	4th Qtr. 1994
Revision Number:	4
Author:	Charles Martin
Discipline:	Geosciences

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This SOP describes the methods to be used for the decontamination of field equipment used in the collection of environmental samples. The list of field equipment may include a variety of items used in the collection of soil and/or water samples, such as split-spoon samplers, trowels, scoops, spoons, bailers and pumps. Heavy equipment such as drill rigs and backhoes also require decontamination, usually in a specially constructed temporary decontamination area.

Decontamination is performed as a quality assurance measure and a safety precaution. Improperly decontaminated sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination. Decontamination protects field personnel from potential exposure to hazardous materials. Decontamination also protects the community by preventing transportation of contaminants from a site.

This SOP emphasizes decontamination procedures to be used for decontamination of reusable field equipment. Occasionally, dedicated field equipment such as well construction materials (well screen and riser pipe) or disposable field equipment (bailers or other general sampling implements) may also require decontamination prior to use. The project-specific work plan should indicate the specific decontamination requirements for a particular project.

Respective state or federal agency (regional offices) regulations may require specific types of equipment or procedures for use in decontamination of field equipment. The project manager should review the applicable regulatory requirements, if any, prior to the start of the field investigation program.

1.2 General Principles

Decontamination is accomplished by manually scrubbing, washing, or spraying equipment with detergent solutions, tap water, distilled/deionized water, steam and/or high pressure water, or solvents. The decontamination method and agents are generally determined on a project-specific basis and must be stated in the Quality Assurance Project Plan (QAPP).

Generally, decontamination of equipment is accomplished at each sampling site between collection points. Waste decontamination materials such as spent liquids and solids will be collected and managed as investigation-derived waste for later disposal. All decontamination materials, including wastes, should be stored in a central location so as to maintain control over the quantity of materials used or produced throughout the investigation program.

1.3 Quality Assurance Planning Considerations

1.3.1 General Considerations

Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific QAPP. The QAPP guidelines typically require collection of equipment blank samples in order to determine the effectiveness of the decontamination procedure.

The decontamination method, solvent, frequency, location on site and the method of containment and disposal of decontamination wash solids and solutions are dependent on site logistics, site-specific chemistry, and nature of the contaminated media to be studied and the objectives of the study. Each topic must be considered and addressed during development of a decontamination strategy and should be outlined in the Quality Assurance Project Plan (QAPP).

1.3.2 Solvent Selection

There are several factors which need to be considered when deciding upon a decontamination solvent. The solvent should not be an analyte of interest. The sampling equipment must be resistant to the solvent. The solvent must be evaporative or water soluble or preferably both. The applicable regulatory agency may have specific requirements regarding decontamination solvents. The QAPP should specify the type of solvent to be used for a particular project.

The analytical objectives of the study must also be considered when deciding upon a decontamination solvent. Pesticide-grade methanol is the solvent of choice for general organic analyses. It is relatively safe and effective. Hexane, acetone, and isopropanol are sometimes used as well. A 10% nitric acid in deionized water solution is the solvent of choice for general metals analyses. Nitric acid can be used only on Teflon, plastics and glass. If used on metal equipment, nitric acid will eventually corrode the metal and lead to the introduction of metals to the collected samples. Dilute hydrochloric acid is usually preferred over nitric acid when cleaning metal sampling equipment.

Equipment decontamination should be performed a safe distance away from the sampling area so as not to interfere with sampling activities but close enough to the sampling area to maintain an efficient working environment. If heavy equipment such as drill rigs or backhoes are to be decontaminated, then a central decontamination station should be constructed with access to a power source and water supply.

1.4 Health and Safety Considerations

Decontamination procedures may involve chemical exposure hazards associated with the type of contaminants encountered or solvents employed and may involve physical hazards associated with decontamination equipment. When decontamination is performed on equipment which has been in contact with hazardous materials or when the quality assurance objectives of the project require decontamination with chemical solvents, the measures necessary to protect personnel must be addressed in the project Health and Safety Plan (HASP). This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing equipment decontamination, and must be adhered to as field activities are performed.

2.0 RESPONSIBILITIES

2.1 Sampling Technician

It is the responsibility of the sampling technician to be familiar with the decontamination procedures outlined within this SOP and with specific quality assurance, and health and safety requirements outlined within project-specific work plans (HASP, QAPP). The sampling technician is responsible for decontamination of field equipment and for proper documentation of decontamination activities. The sampling technician is also responsible for ensuring that decontamination procedures are followed by subcontractors when heavy equipment requires decontamination.

2.2 Field Project Manager

The field project manager is responsible for ensuring that the required decontamination procedures are followed at all times. The project manager is also responsible for ensuring that subcontractors construct and operate their decontamination facilities according to project specifications. The project manager is responsible for collection and control of IDW in accordance with project specifications.

3.0 REQUIRED MATERIALS

- Decontamination agents (per work plan requirements):
    - LIQUI-NOX, ALCONOX, or other phosphate-free biodegradable detergent,
    - Tap water,
    - Distilled/deionized water,
    - Nitric acid and/or hydrochloric acid,
    - Methanol and/or hexane, acetone, isopropanol.
- Health and Safety equipment
- Chemical-free paper towels
- Waste storage containers: drums, 5-gallon pails w/covers, plastic bags
- Cleaning containers: plastic buckets or tubs, galvanized steel pans, pump cleaning cylinder
- Cleaning brushes
- Pressure sprayers
- Squeeze bottles
- Plastic sheeting
- Aluminum foil
- Field project notebook/pen

4.0 METHODS

4.1 General Preparation

4.1.1 It should be assumed that all sampling equipment, even new items, are contaminated until the proper decontamination procedures have been performed on them or unless a certificate of analysis is available which demonstrates the items cleanliness.

Field equipment that is not frequently used should be wrapped in aluminum foil, shiny side out, and stored in a designated "clean" area. Small field equipment can also be stored in plastic bags to eliminate the potential for contamination. Field equipment should be inspected and decontaminated prior to use if the equipment appears contaminated and/or has been stored for long periods of time. Unless customized procedures are stated in the QAPP for decontamination of equipment, the standard procedures specified in this SOP shall be followed.

4.1.2 Establish the decontamination station within an area that is convenient to the sampling location. If single samples will be collected from multiple locations, then a centralized decontamination station, or a portable decontamination station should be established.

4.1.3 An investigation-derived waste (IDW) containment station should be established at this time also. The project-specific work plan should specify the requirements for IDW containment. In general, decontamination solutions are discarded as IDW between sampling locations. Solid waste is disposed of as it is generated.

4.2 Decontamination for Organic Analyses

4.2.1 This procedure applies to soil sampling and groundwater sampling equipment used in the collection of environmental samples submitted for organic constituents analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, bailers, and other small items. Submersible pump decontamination procedures are outlined in Section 4.4.

4.2.2 Decontamination is to be performed before sampling events and between sampling points.

4.2.3 After a sample has been collected, remove all gross contamination from the equipment or material by brushing and then rinsing with available tap water.

This initial step may be completed using a 5-gallon pail filled with tap water. Steam or a high-pressure water rinse may also be conducted to remove solids and/or other contamination.

4.2.4 Wash the equipment with a phosphate-free detergent and tap water solution. This solution should be kept in a 5-gallon pail with its own brush.

4.2.5 Rinse with tap water or distilled/deionized water until all detergent and other residue is washed away. This step can be performed over an empty bucket using a squeeze bottle or pressure sprayer.

4.2.6 Rinse with methanol or other appropriate solvent using a squeeze bottle or pressure sprayer. Rinsate should be collected in a waste bucket.

4.2.7 Rerinse with deionized water to remove any residual solvent. Rinsate should be collected in the solvent waste bucket.

4.2.8 Allow the equipment to air-dry in a clean area or blot with chemical-free paper towels before reuse. Wrap the equipment in tin foil and/or seal it in a plastic bag if it will not be reused for a while.

4.2.9 Dispose of soiled materials and spent solutions in the designated IDW disposal containers.

4.3 Decontamination for Inorganic (Metals) Analyses

4.3.1 This procedure applies to soil sampling equipment used primarily in the collection of environmental samples submitted for inorganic constituents analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, bailers, and other small items.

4.3.2 For plastic and glass sampling equipment, follow the steps outlined in 4.2 above, however, use a 10% nitric acid solution (acid in water) in place of the solvent rinse in Section 4.2.6.

4.3.3 For metal sampling equipment, follow the steps outlined in 4.2 above, however, use a 10% hydrochloric acid solution (acid in water) in place of the solvent rinse in Section 4.2.6.

4.4 Decontamination of Submersible Pumps

4.4.1 This procedure will be used to decontaminate submersible pumps before and between ground-water sample collection points. This procedure applies to both electric submersible and bladder pumps. This procedure also applies to discharge tubing if it will be reused between sampling points.

4.4.2 Prepare the decontamination area if pump decontamination will be conducted next to the sampling point. If decontamination will occur at another location, the pump and tubing may be removed from the well and placed into a clean trash bag for transport to the decontamination area. Pump decontamination is easier with the use of 3-foot tall pump cleaning cylinders (i.e., Nalgene cylinder) for the various cleaning solutions, although the standard bucket rinse equipment may be used.

4.4.3 Once the decontamination station is established, the pump should be removed from the well and the discharge tubing and power cord coiled by hand as the equipment is removed. If any of the equipment needs to be put down temporarily, place it on a plastic sheet (around well) or in a clean trash bag. If a disposable discharge line is used it should be removed and discarded at this time.

4.4.4 As a first step in the decontamination procedure, use a pressure sprayer with tap water to rinse the exterior of the pump, discharge line, and power cord as necessary. Collect the rinsate and handle as IDW.

4.4.5 Place the pump into a pump cleaning cylinder or bucket containing a detergent solution (detergent in tap water). Holding the tubing/power cord, pump solution through the pump system. A minimum of one gallon of detergent solution should be pumped through the system. Collect the rinsate and handle as IDW.

4.4.6 Place the pump into another cylinder/bucket containing a 10% solution of solvent (methanol, or other designated solvent) in distilled/deionized water. Pump until the detergent solution is removed. Collect the rinsate and handle as IDW.

4.4.7 Place the pump into another cylinder/bucket containing distilled/deionized water. Pump a minimum of 3 to 5 pump system volumes (pump and tubing) of water through the system. Collect the rinsate and handle as IDW.

4.4.8 Remove the pump from the cylinder/bucket and if the pump is reversible, place the pump in the reverse mode to discharge all removable water from the system. If the pump is not reversible the pump and discharge line should be drained by hand as much as possible. Collect the rinsate and handle as IDW.

4.4.9 Using a pressure sprayer with distilled/deionized water, rinse the exterior of the pump, discharge line, and power cord thoroughly, shake all excess water, then place the pump system into a clean trash bag for storage. If the pump system will not be used again right away, the pump itself should also be wrapped with aluminum foil before placing it into the bag.

4.5 Decontamination of Large Equipment

4.5.1 Consult the QAPP for instruction on the location of the decontamination station and the method of containment of the wash solutions. On large projects usually a temporary decontamination facility (decontamination pad) is required which may include a membrane-lined and bermed area large enough to drive heavy equipment (drill rig, backhoe) onto with enough space to spread other equipment and to contain overspray. Usually a small sump with pump is necessary to collect and contain rinsate. A water supply and power source is also necessary to run steam cleaning and/or pressure washing equipment.

4.5.2 Upon arrival and prior to leaving a sampling site, all heavy equipment such as drill rigs, trucks, and backhoes should be thoroughly cleaned and then the parts of the equipment which come in contact or in close proximity to sampling activity should be decontaminated. This can be accomplished in two ways, steam cleaning or high pressure water wash and manual scrubbing. Following this initial cleaning, only those parts of the equipment which come in close proximity to the sampling activities (i.e., auger stems, rods, backhoe bucket) must be decontaminated in between sampling events.

Occasionally, well construction materials such as well screen and riser pipe may require decontamination before the well materials are used. These materials may be washed in the decontamination pad, preferably on a raised surface above the pad (i.e., on sawhorses), with clean plastic draped over the work surfaces. Well materials usually do not require a multistep cleaning process as they generally arrive clean from the manufacturer. Usually, a thorough steam-cleaning of the interior/exterior of the well materials will be sufficient. The QAPP should provide specific guidance regarding decontamination of well materials.

5.0 QUALITY CONTROL

5.1 Field Blank Sample Collection

General guidelines for quality control check of field equipment decontamination usually require the collection of one field blank from the decontaminated equipment per day. The QAPP should specify the type and frequency of collection of each type of quality assurance sample.

Field blanks are generally made by pouring laboratory-supplied deionized water into, over, or through the freshly decontaminated sampling equipment and then transferring this water into a sample container. Field blanks should then be labeled as a sample and submitted to the laboratory to be analyzed for the same parameters as the associated sample. Field blank sample numbers, as well as collection method, time and location should be recorded in the field notebook.

6.0 DOCUMENTATION

Specific information regarding decontamination procedures should be documented in the project-specific field notebook. Documentation within the notebook should thoroughly describe the construction of each decontamination facility and the decontamination steps implemented in order to show compliance with the project work plan. Decontamination events should be logged when they occur with the following information documented:

- Date, time and location of each decontamination event
- Equipment decontaminated
- Method
- Solvents
- Noteable circumstances
- Identification of field blanks and decontamination rinsates
- Method of blank and rinsate collection
- Date, time and location of blank and rinsate collection
- Disposition of IDW

Repetitive decontamination of small items of equipment does not need to be logged each time the item is cleaned.

7.0 TRAINING/QUALIFICATIONS

All sampling technicians performing decontamination must be properly trained in the decontamination procedures employed, the project data quality objectives, health and safety procedures and the project QA procedures. Specific training or orientation will be provided for each project to ensure that personnel understand the special circumstances and requirements of that project. Field personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

8.0 REFERENCES

Not applicable.

RETEC Standard Operating Procedure (SOP) 310 Headspace Screening

1.0 Purpose and Applicability

ENSR Corporation (dba The RETEC Group, Inc. [RETEC]) SOP 310 describes the basic techniques for using headspace analysis to screen for volatile organics in contaminated soils using a portable Photo Ionization Detector (PID) or Flame Ionization Detector (FID).

Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, Job Hazard Analysis (JHA), Safety Task Analysis Review (STAR), or Site-Specific Health and Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

The project manager/task manager is responsible for overseeing work activities to ensure that field screening is performed and documented in accordance with the methods described here and in the project-specific sampling plan. In addition, a STAR will be conducted to assess any potential hazards associated with headspace screening. Copies of STAR forms are available in the Site-Specific HASP.

3.0 Health and Safety

This section presents the generic hazards associated with headspace screening and is intended to provide general guidance in preparing site-specific health and safety documents. The Site-Specific HASP, JHAs, and STARs will address additional requirements and will take precedence over this document. Note that headspace screening usually requires Level D personal protection unless there is a potential for airborne exposure to site contaminants. Under circumstances where potential airborne exposure is possible respiratory protective equipment may be required based on personal air monitoring results. Upgrades to Level C will be coordinated with your Site Safety and Health Officer (SSHO) or Environment, Health, and Safety (EHS) Coordinator.

Health and safety hazards and corresponding precautions include, but are not limited to, the following:

- Dermal contact with contaminated soil. Personnel should treat all soil as potentially contaminated and wear chemically impervious gloves. Minimize skin contact with soil by using sampling instruments such as stainless steel spades or spoons. Do not touch any exposed skin with contaminated gloves.

- Inhalation hazards. Appropriate air monitoring should be conducted to ensure that organic vapor concentrations in the breathing zone do not exceed action levels as specified in the Site-Specific HASP. When ambient temperatures are low enough to require warming samples using the vehicle heater, the vehicle's windows should be opened enough to prevent the build-up of any organic vapors. Use the PID or FID to verify the airborne concentrations in the vehicle remain below applicable action levels. Note that many volatile organic compounds (VOCs) are flammable and all precautions must be observed to eliminate any potential ignition sources.

- Shipping limitations. Follow applicable regulations when shipping FID/PID equipment. When shipping an FID by air, the hydrogen tank must be bled dry. Calibration gas canisters are considered dangerous goods and must be shipped according to IATA and DOT regulations. Consult your EHS Coordinator and check with your shipping company to determine the correct shipping procedures.

4.0 Supporting Materials

The following materials must be on hand in good operating condition and/or in sufficient quantity to ensure that proper field analysis procedures may be followed.

- Calibrated PID/FID instrument
- Top-sealing "Zip-Loc" type plastic bags – *or* – 16 ounces of soil or "mason-" type glass jars and aluminum foil
- Project field book and/or boring logs
- PPE as specified in the Site-Specific HASP
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants
- A copy of the Site-Specific HASP

5.0 Methods and Procedures

5.1 Preparation

Review available project information to determine the types of organic vapors that will likely be encountered to select the right instrument. The two basic types of instruments are FIDs and PIDs.

FIDs work well with organic compounds that have relatively lightweight molecules, but may have problems detecting halogenated compounds or heavier organic compounds; FIDs can detect methane for example. Since the FID uses a flame to measure organic compounds, ensure that work is conducted in an atmosphere, which is free of combustible vapors. If ambient temperatures are below 40°F, the flame of the FID may be difficult to light.

When using a PID, select an instrument that can measure the ionization potential of the anticipated contaminants of concern. PIDs work well with a range of organic compounds and can detect some halogenated hydrocarbons; PIDs cannot detect methane. The correct ultraviolet (UV) light bulb must be selected according to the types of organic vapors that will likely be encountered. The energy of the UV light must equal or exceed the ionization potential of the organic molecules that the PID will measure. The NIOSH *Pocket Guide to Chemical Hazards* is one source for determining ionization potentials for different chemicals. Bulbs available for PIDs include 9.4 eV, 10.6 (or 10.2) eV, and 11.7 eV bulbs. The 10.6 eV bulb is most commonly used as it detects a fairly large range of organic molecules and does not burn out as easily as the 11.7 eV bulb. The 9.4 eV bulb is the most rugged, but detects only a limited range of compounds. Under very humid or very cold ambient conditions, the window covering the UV light may fog up, causing inaccurate readings. Ask your EHS coordinator about correction factors when high humidity conditions exist.

After selecting the correct instrument, calibrate the PID/FID according to the manufacturer's instructions. Record background/ambient levels of organic vapors measured on the PID/FID after calibration and make sure to subtract the background concentration (if any) from your readings. Check the PID/FID readings against the calibration standard every 20 readings or at any time when readings are suspected to be inaccurate, and recalibrate, if necessary. Be aware that, after measuring highly contaminated soil samples, the PID/FID may give artificially high readings for a time.

5.2 Top-Sealing Plastic Bag

Place a quantity of soil in a top-sealing plastic bag and seal the bag immediately. The volume of soil to be used should be determined by the project manager or field task manager. The volume of soil may vary between projects but should be consistent for all samples collected for one project. Ideally, the bag should be at least 1/10th-filled with soil and no more than half-filled with soil. Once the bag is sealed, shake the bag to distribute the soil evenly. If the soil is hard or clumpy, use your fingers to gently work the soil (through the bag) to break up the clumps. Do not use a sampling instrument or a rock hammer since this may create small holes in the plastic bag and allow organic vapors to escape. Alternatively, the sample may be broken up before it is placed in the bag. Use a permanent marker to record the following information on the outside of the bag:

- Site identification information (i.e., borehole number)
- Depth interval
- Time the sample was collected
- For example: "SS-12, 2-4 ft, @1425"

Headspace should be allowed to develop before organic vapors are measured with a PID/FID. The amount of time required for sufficient headspace development will be determined by the project-specific sampling plan and the ambient temperature. Equilibration time should be the same for all samples to allow an accurate comparison of organic vapor levels between samples. However, adjustments to equilibration times may be necessary when there are large variations in ambient temperature from day to day. When ambient temperatures are below 32°F, headspace development should be within a heated building or vehicle. When heating samples, be sure there is adequate ventilation to prevent the build-up or organic vapors above action levels.

Following headspace development, open a small opening in the seal of the plastic bag. Insert the probe of a PID/FID and seal the bag back up around the probe as tightly as possible. Alternatively, the probe can be inserted through the bag to avoid loss of volatiles. Since PIDs and FIDs are sensitive to moisture, avoid touching the probe to the soil or any condensation that has accumulated inside of the bag. Since the PID/FID consumes organic vapors, gently agitate the soil sample during the reading to release fresh organic vapors from the sample. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case, headspace data should be discounted. Record the highest reading on the field form or in the field notebook as described in Section 7.

5.3 Jar and Aluminum Foil (Alternate Method)

Half-fill a clean glass jar with the soil sample to be screened. Quickly cover the jar's opening with one to two sheets of clean aluminum foil and apply the screw cap to tightly seal the jar. Allow headspace development for at least ten minutes. Vigorously shake the jar for 15 seconds, both at the beginning and at the end of the headspace development period. Where ambient temperatures are below 32°F (0°C), headspace development should be within a heated area. When heating samples be sure there is adequate ventilation to prevent the build-up of organic vapors above action levels.

Subsequent to headspace development, remove the jar lid and expose the foil seal. Quickly puncture the foil seal with the instrument sampling probe, to a point about one-half of the headspace depth. Exercise care to avoid uptake of water droplets or soil particulates. As an alternative, use a syringe to withdraw a headspace sample, and then inject the sample into the instrument probe or septum-fitted inlet. This method is acceptable contingent upon verification of methodology accuracy using a test gas standard. Following probe insertion through the foil seal or sample injection to probe, record the highest meter response on the field form or in the field notebook. Using foil seal/probe insertion method, maximum response should occur between two and five seconds. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case, headspace data should be discounted.

6.0 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) will include the collection of duplicate samples. In general, one duplicate will be collected per 20 samples. Organic vapor concentrations measured in the primary and duplicate samples should be similar within plus or minus 20 percent. The frequency of headspace duplicate collection will be determined by the project manager/task manager. The PID/FID instrument must be calibrated according to the manufacturer's instructions before beginning screening, and checked or recalibrated every 20 analyses or when readings are suspected to be inaccurate. Record ambient organic vapor levels in the field notebook and on the field form. Periodically check ambient organic vapor levels. If ambient levels have changed more than 20 percent, recalibrate the PID/FID. Make sure readings are not collected near a vehicle exhaust or downwind of the drill rig exhaust. If grossly contaminated soil is encountered, decontaminate sampling instruments between samples and/or change contaminated gloves to avoid cross contaminating less contaminated samples.

7.0 Documentation

All data generated (results and duplicate comparisons) will be recorded in the field notebook and/or on the field form. Any deviation from the outlined procedure will also be noted. Field conditions (ambient temperature, wind, etc.) should also be recorded in the field notebook.

Readings may be recorded in a field notebook, on a boring log, or on an appropriate form specific to the project. The form should include the following information:

- When the PID/FID was calibrated (date/time) and calibration standard used
- Background/ambient concentrations measured after PID/FID calibration
- Location of sample (i.e., bore-hole number)
- Depth interval of sample measured
- Lithology of material measured
- PID/FID reading and units of measure

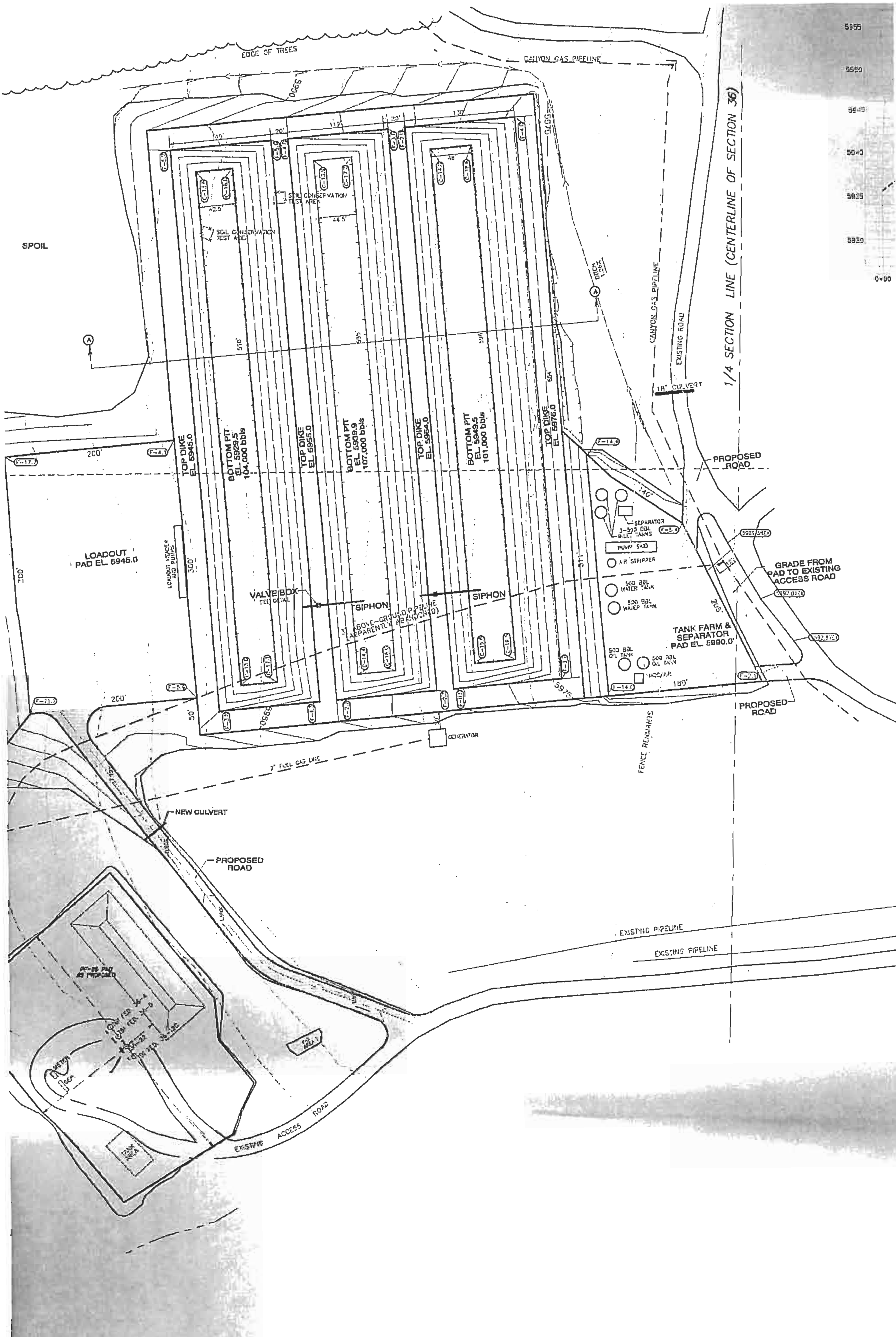
Note that if PID/FID measurements are recorded on a boring log, it is not necessary to duplicate information in the column where the PID/FID readings are recorded (e.g., borehole number, depth interval, lithology type).

All documentation will be stored in the project files and retained following completion of the project.

Attachment C

Construction Drawings

High Mesa

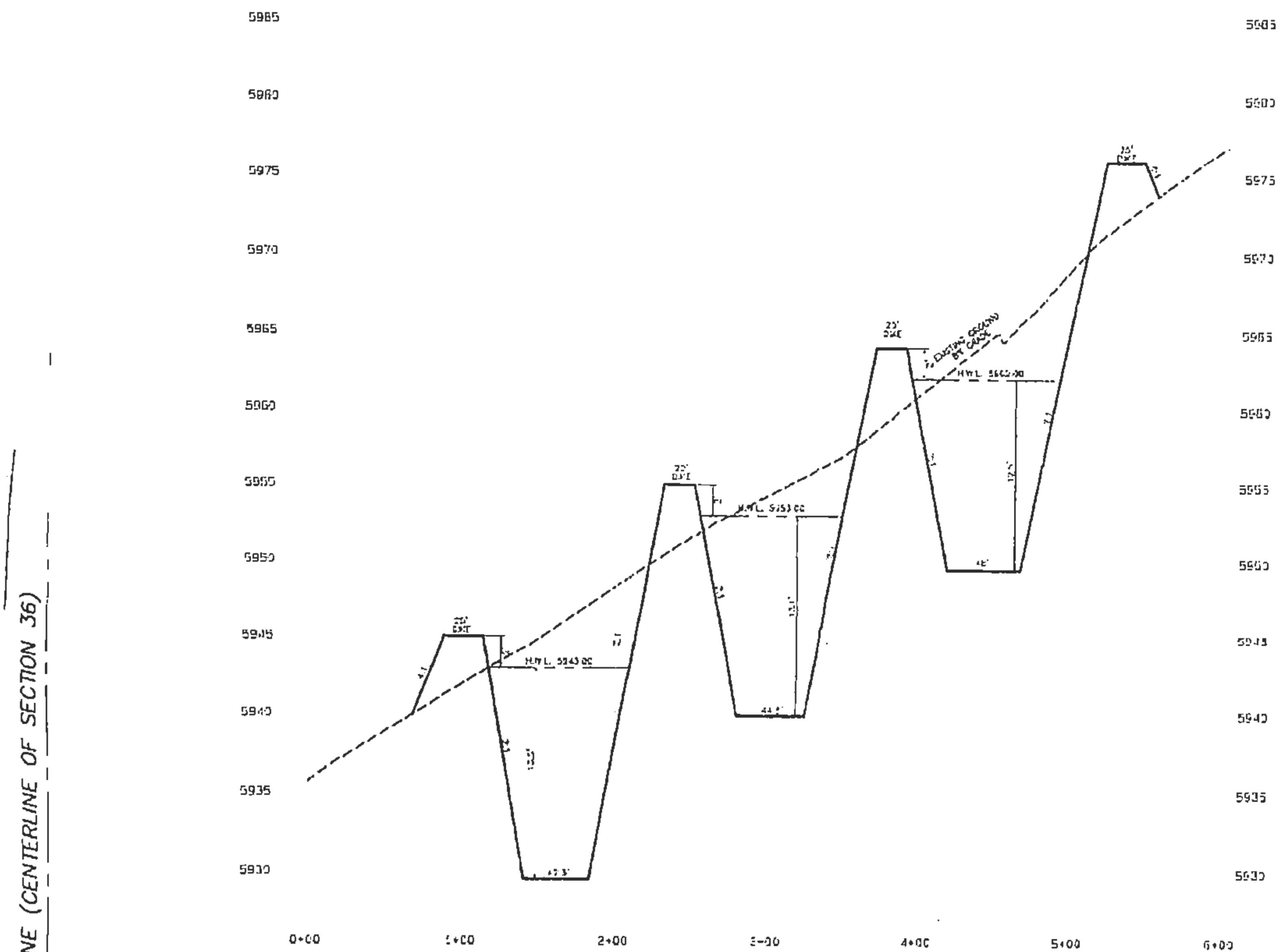


1	02/17/05	ASD CLIENT'S INFO. TO BOTTOM PIT, TOP BERM AND PAD CORNERS	

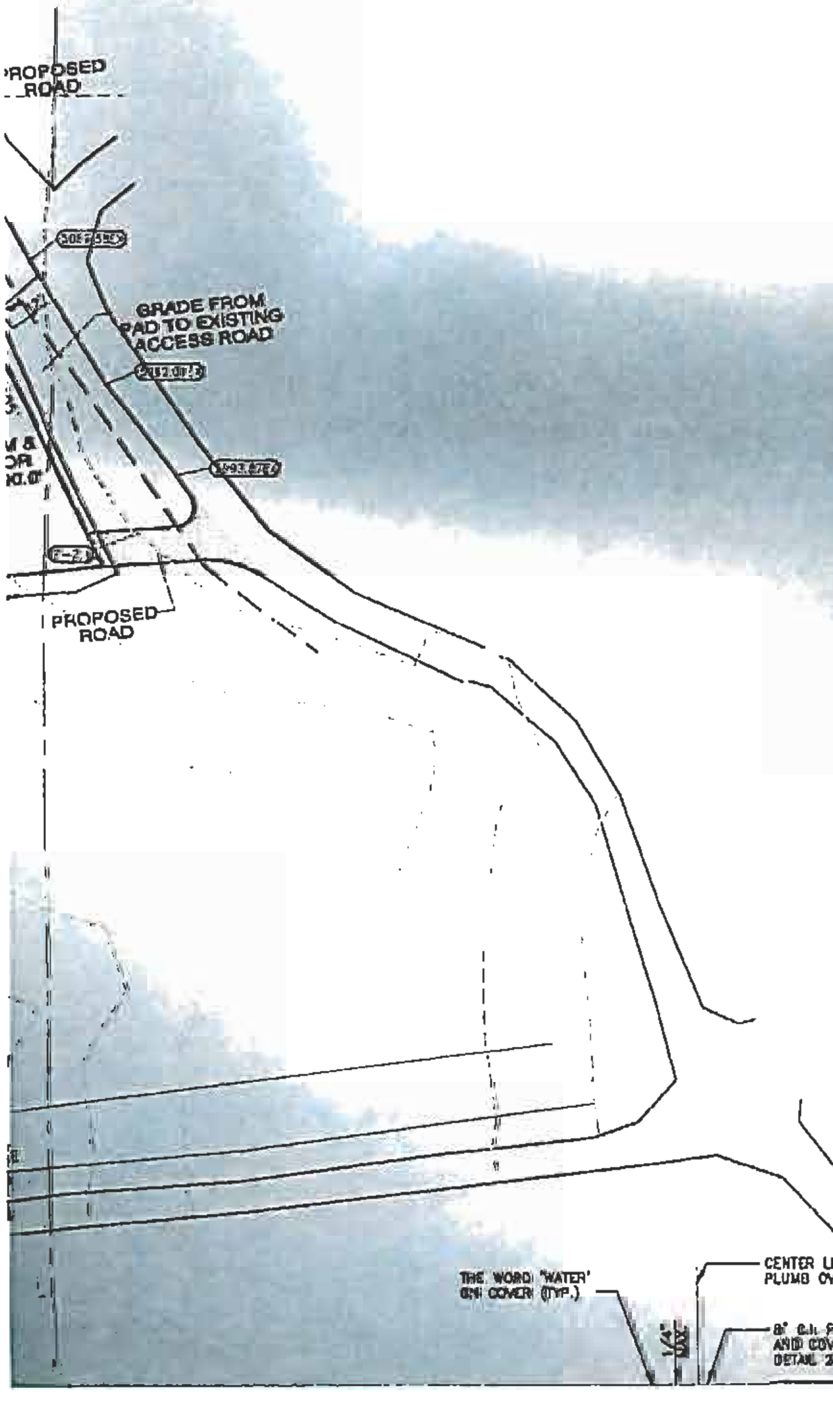
SHEET TITLE

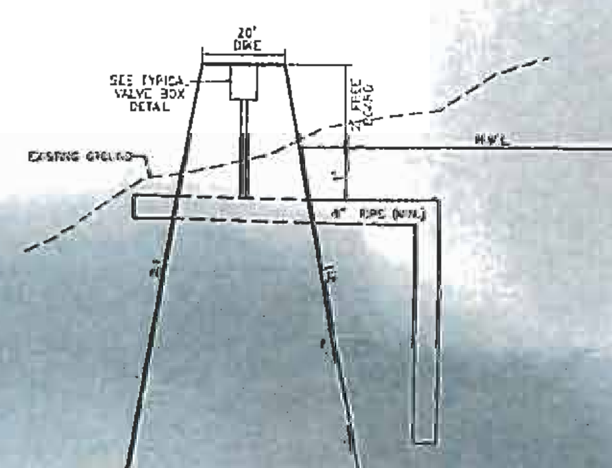
EVAPORA

PROJECT



SECTION A-A





SIPHON DETAIL

GRADING NOTES

ESTIMATED EARTHWORK QUANTITIES @ FINISH SUB-GRADE

UNCLASSIFIED EXCAVATION........... 66,930 cy

COMPACTED FILL........................73,960 cy

(ESTIMATED SHRINKAGE AT 0%)

NOTE: EARTHWORK QUANTITIES ARE ESTIMATES BASED ON THE BEST INFORMATION AVAILABLE. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO DETERMINE EXACT QUANTITIES. IF THE CONTRACTOR BELIEVES THERE IS A DISCREPANCY IN THE QUANTITIES SHOWN HEREON, HE SHALL NOTIFY THE ENGINEER AND THE OWNER PRIOR TO BIDDING.

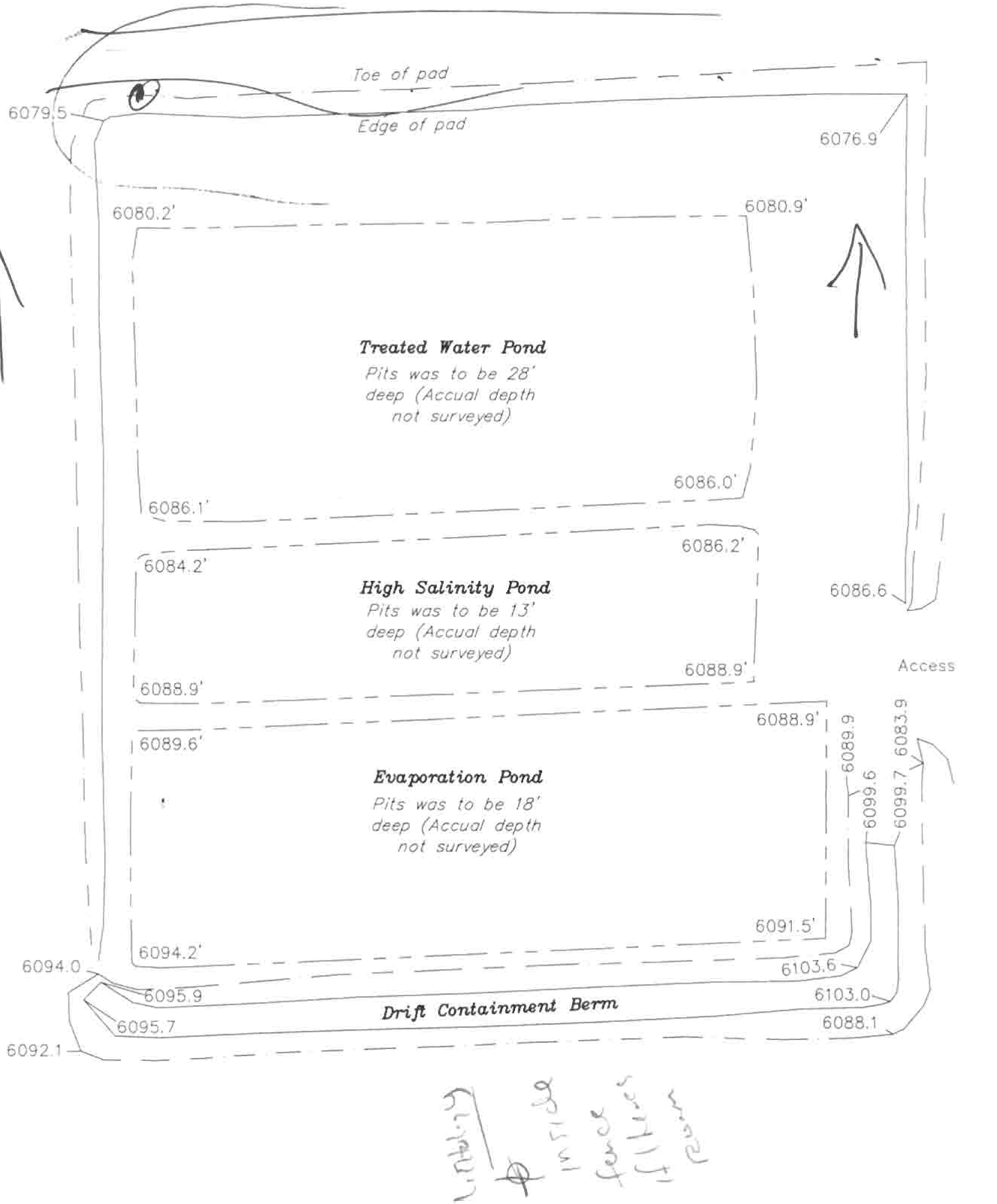
NOTE

NO GEOTECHNICAL INFORMATION WAS AVAILABLE FOR THESE EARTHWORK CALCULATIONS THEREFORE NO FACTOR FOR EARTHWORK SHRINKAGE WAS CONSIDERED.

Hunter Mesa

ENCANA OIL & GAS (USA) INC

HUNTER MESA STATION EVAPORATION PIT SITE
AS-BUILT



		SCALE:	1" = 100'
DRAWN BY:	R.V.C.	DATE:	8-19-05

Tri State Land Surveying, Inc.
(435) 781-2501
100 NORTH VERNAL AVE. VERNAL, UTAH 84078

Attachment D

Photographs

Photo 1 - Location of the High Mesa soil boring location SB-01 from on top of the filled parking lot area downgradient of the water impoundment.

Photo 2 - Location of the Hunter Mesa soil boring location SB-02 upgradient of the water impoundment. The water impoundment is to the left of the picture behind the berm and fence.

Photo 3 - Location of the Hunter Mesa soil boring location SB-03 downgradient of the water impoundment. The water impoundment is in the background behind the parking pad, which looks like a berm.

Photo 4 - Example of the Basalt boulders at High Mesa

Attachment E

Lab Reports

MECHANICAL ANALYSIS
ASTM 6913

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 6913

CLIENT	Retec	JOB NO.	2570-21
BORING NO.	SB-02	SAMPLED	
DEPTH	0-4.5'	DATE+#4 WASHED	09-19-07 SR
SAMPLE NO.		DATE -#4 WASHED	09-26-07 WAR
SOIL DESCR.	#10331-007-0200	WASH SIEVE	Yes
LOCATION	High/Hunter Mesa	DRY SIEVE	No

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	55.21
Wt. Dry Soil & Pan (g)	54.59
Wt. Lost Moisture (g)	0.62
Wt. of Pan Only (g)	3.11
Wt. of Dry Soil (g)	51.48
Moisture Content %	1.2
Wt. Partial -#4 Sample Wet (g)	226.74
Wt. Partial Sample Dry (g)	224.04

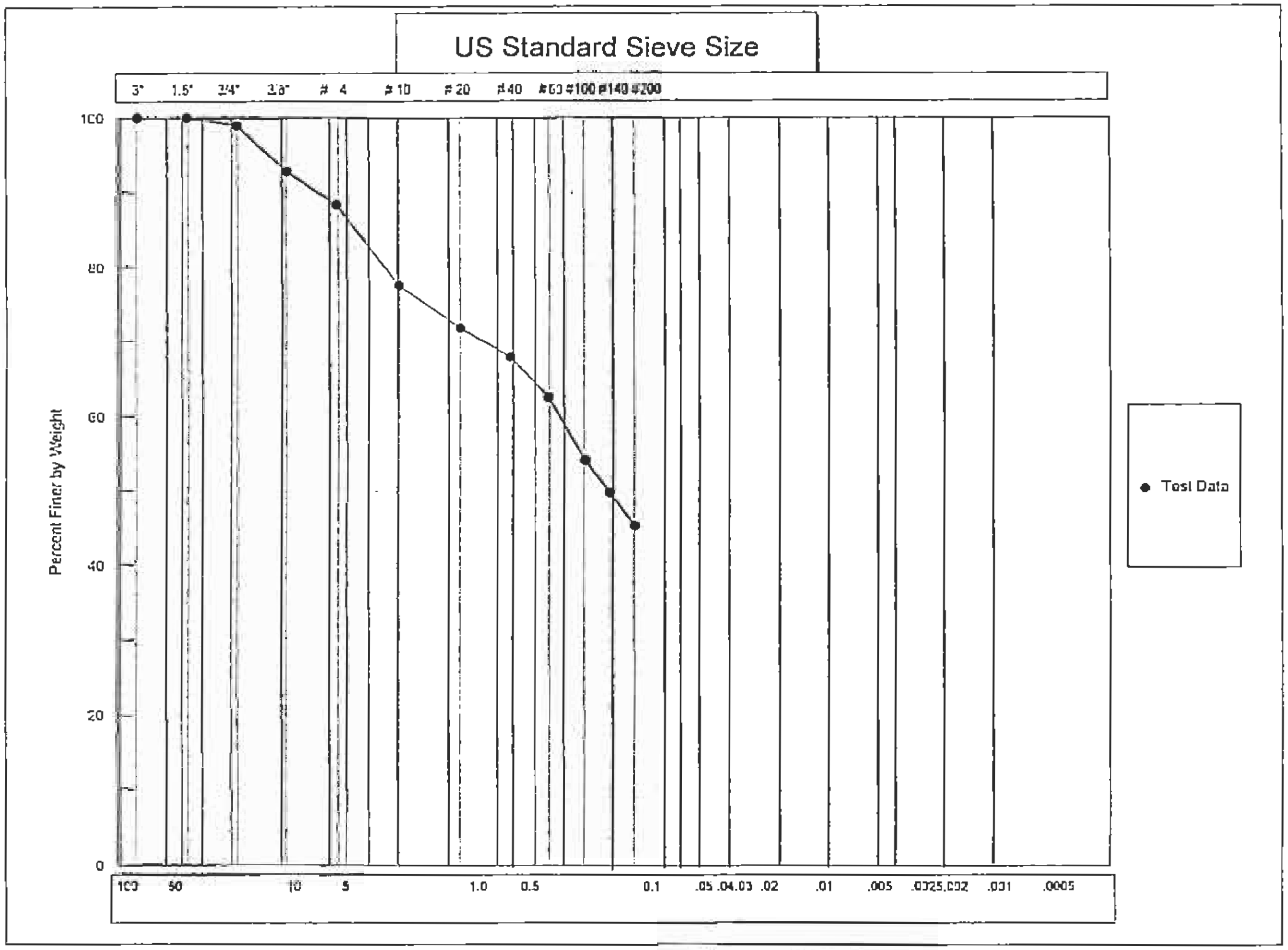
WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	1984.30
Weight of + #4 Before Washing (g)	241.80
Weight of + #4 After Washing (g)	227.11
Weight of - #4 Wet (g)	1742.50
Weight of - #4 Dry (g)	1736.28
Wt. Total Sample Dry (g)	1963.39
Calc. Wt. "W" (g)	253.35
Calc. Mass + #4	29.31

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	20.79	20.79	20.79	1.1	98.9
3/8"	0.00	119.72	119.72	140.51	7.2	92.8
#4	0.00	86.60	86.60	227.11	11.6	88.4
#10	3.14	30.68	27.54	27.54	22.4	77.6
#20	3.08	17.51	14.43	41.97	28.1	71.9
#40	3.09	12.93	9.84	51.81	32.0	68.0
#60	3.09	16.88	13.79	65.60	37.5	62.5
#100	3.11	24.70	21.59	87.19	46.0	54.0
#140	3.12	13.81	10.69	97.88	50.2	49.8
#200	3.13	14.37	11.24	109.12	54.6	45.4

Data entered by: SR Date: 09/27/2007
Data checked by: BKL Date: 9-28-07
FileName: RGM00045

ADVANCED TERRA TESTING, INC.



COBBLES	GRAVEL		SAND			SILT OR CLAY	USCS
	COARSE	FINE	CRS	MEDIUM	FINE		

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY	WENTWORTH
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE			

Client: Relec
Job Number: 2570-21
Classification: Classification Not Performed

Boring No.: SB-02
Depth: 0-4.5'

Sample No.:

Advanced Terra Testing, Inc.

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 6913

CLIENT	Retec	JOB NO.	2570-21
BORING NO.	SB-01	SAMPLED	
DEPTH	16-30'	DATE+#4 WASHED	09-19-07 SR
SAMPLE NO.		DATE -#4 WASHED	09-26-07 WAR
SOIL DESCR.	#10331-007-0200	WASH SIEVE	Yes
LOCATION	High/Hunter Mesa	DRY SIEVE	No

MOISTURE DATA

HYGROSCOPIC	Yes	
NATURAL	No	
Wt. Wet Soil & Pan (g)		67.82
Wt. Dry Soil & Pan (g)		66.97
Wt. Lost Moisture (g)		0.85
Wt. of Pan Only (g)		3.19
Wt. of Dry Soil (g)		63.78
Moisture Content %		1.3
Wt. Partial -#4 Sample Wet (g)		212.91
Wt. Partial Sample Dry (g)		210.11

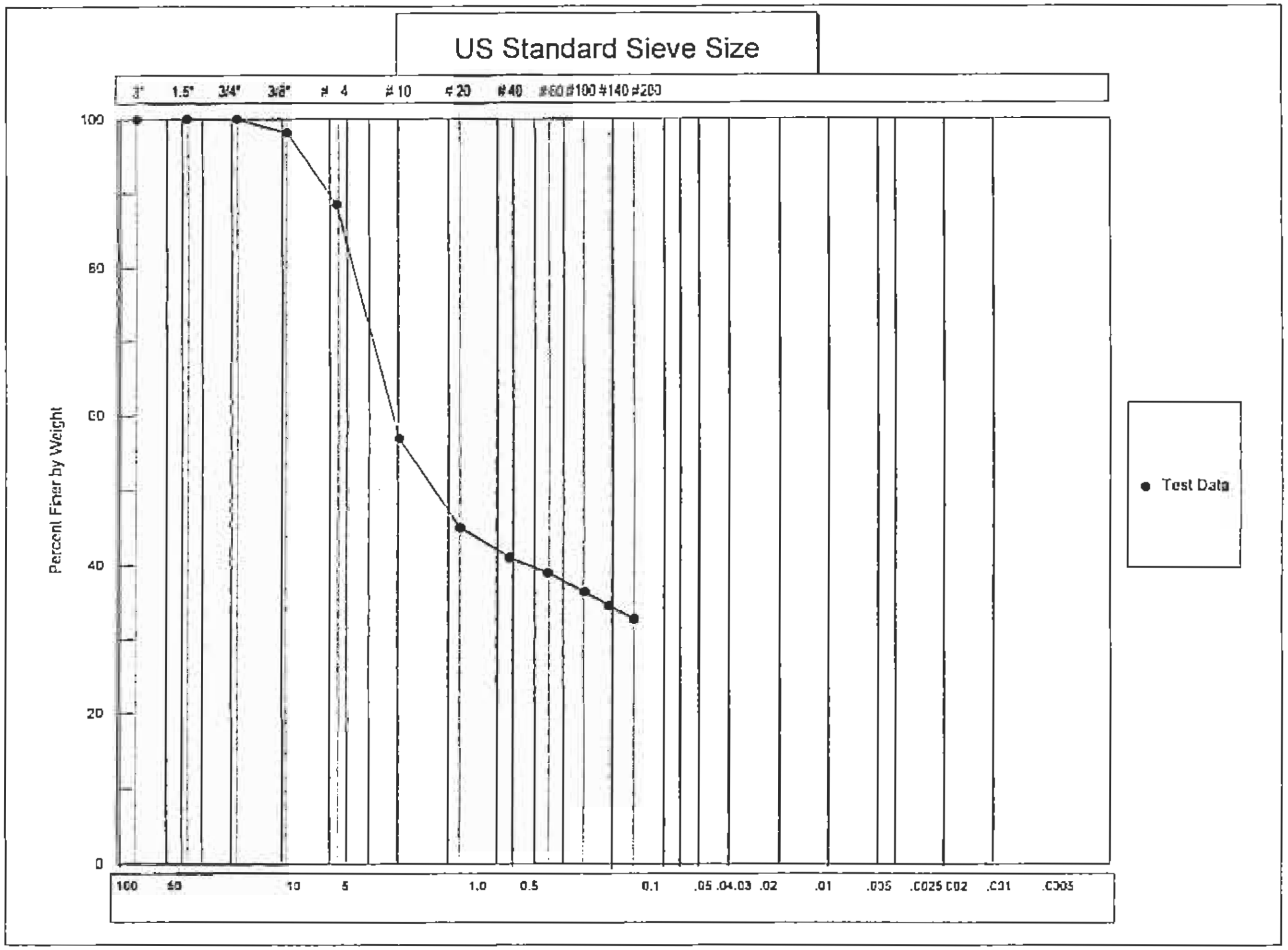
WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	631.76
Weight of + #4 Before Washing (g)	80.23
Weight of + #4 After Washing (g)	71.75
Weight of - #4 Wet (g)	551.53
Weight of - #4 Dry (g)	552.64
Wt. Total Sample Dry (g)	624.39
Calc. Wt. "W" (g)	237.39
Calc. Mass + #4	27.28

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	11.51	11.51	11.51	1.8	98.2
#4	0.00	60.24	60.24	71.75	11.5	88.5
#10	3.12	78.23	75.11	75.11	43.1	56.9
#20	3.71	32.04	28.33	103.45	55.1	44.9
#40	3.22	12.62	9.40	112.85	59.0	41.0
#60	3.20	8.21	5.01	117.86	61.1	38.9
#100	3.14	9.12	5.98	123.84	63.7	36.3
#140	3.17	7.50	4.33	128.17	65.5	34.5
#200	3.16	7.55	4.39	132.56	67.3	32.7

Data entered by: SR Date: 09/27/2007
Data checked by: *[initials]* Date: *9.28.07*
FileName: RGM01630

ADVANCED TERRA TESTING, INC.



COBBLES	GRAVEL		SAND			SILT OR CLAY	USCS
	COARSE	FINE	CRS	MEDIUM	FINE		

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY	WENTWORTH
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE			

Client: Retec
Job Number: 2570-21
Classification: Classification Not Performed

Boring No.: SB-01
Depth: 16-30'

Sample No.:

Advanced Terra Testing, Inc.

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 6913

CLIENT	Retec	JOB NO.	2570-21
BORING NO.	SB-01	SAMPLED	
DEPTH	0-12.5'	DATE+#4 WASHED	09-19-07 SR
SAMPLE NO.		DATE -#4 WASHED	09-23-07 SR
SOIL DESCR.	#10331-007-0200	WASH SIEVE	Yes
LOCATION	High/Hunter Mesa	DRY SIEVE	No

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	55.77
Wt. Dry Soil & Pan (g)	54.43
Wt. Lost Moisture (g)	1.34
Wt. of Pan Only (g)	3.71
Wt. of Dry Soil (g)	50.72
Moisture Content %	2.6
Wt. Partial -#4 Sample Wet (g)	220.67
Wt. Partial Sample Dry (g)	214.99

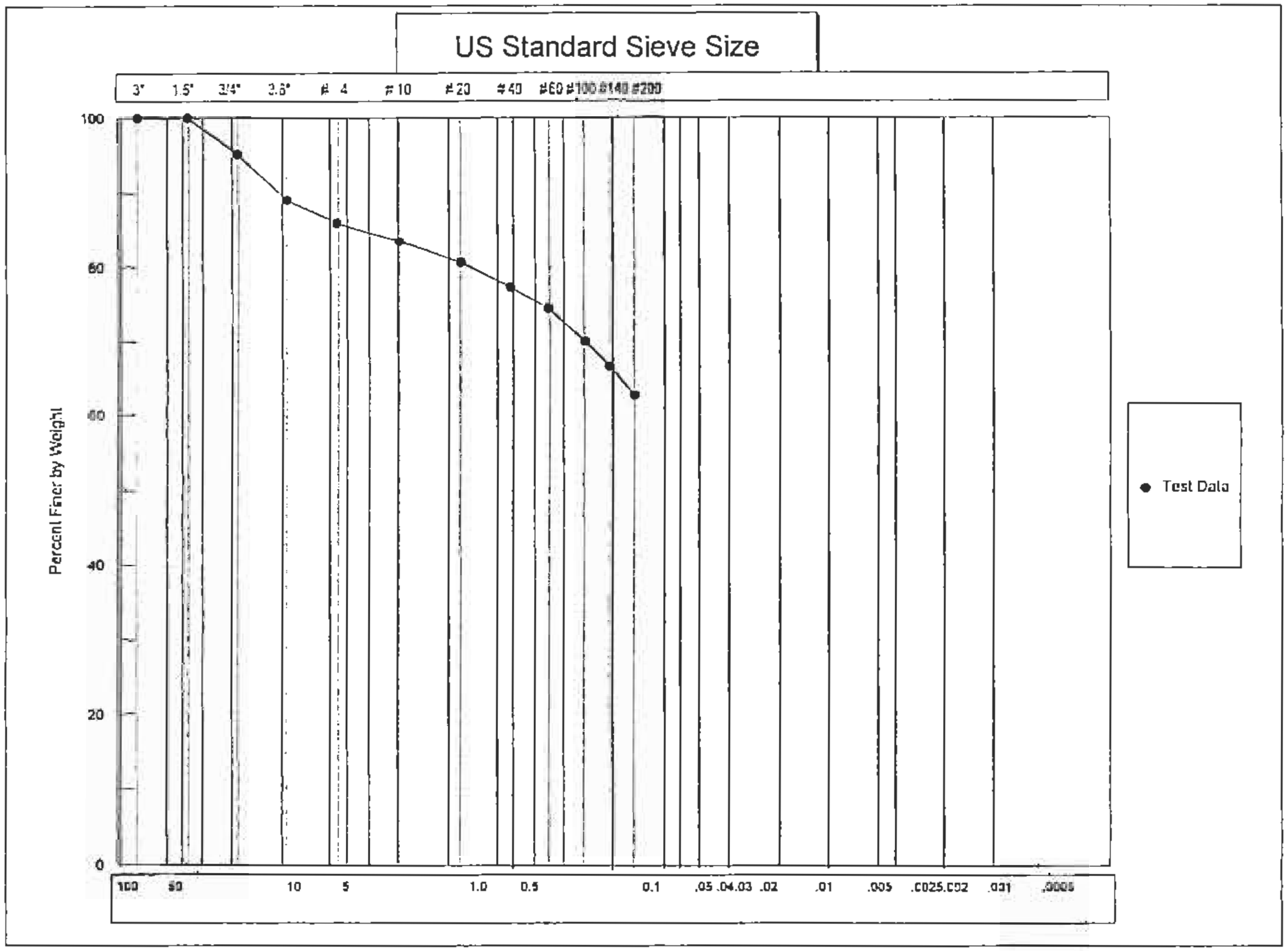
WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	1063.97
Weight of + #4 Before Washing (g)	154.76
Weight of + #4 After Washing (g)	146.18
Weight of - #4 Wet (g)	909.21
Weight of - #4 Dry (g)	894.17
Wt. Total Sample Dry (g)	1040.35
Calc. Wt. "W" (g)	250.14
Calc. Mass + #4	35.15

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	50.30	50.30	50.30	4.8	95.2
3/8"	0.00	63.56	63.56	113.86	10.9	89.1
#4	0.00	32.32	32.32	146.18	14.1	85.9
#10	3.11	9.19	6.08	6.08	16.5	83.5
#20	3.77	10.86	7.09	13.17	19.3	80.7
#40	3.06	11.21	8.15	21.32	22.6	77.4
#60	3.16	10.51	7.35	28.67	25.5	74.5
#100	3.15	14.26	11.11	39.78	30.0	70.0
#140	3.18	11.66	8.48	48.26	33.3	66.7
#200	3.09	13.10	10.01	58.27	37.3	62.7

Data entered by: SR Date: 09/25/2007
Data checked by:______ Date:________
FileName: RGM0SB01

ADVANCED TERRA TESTING, INC.



COBBLES	GRAVEL		SAND			SILT OR CLAY	USCS
	COARSE	FINE	CRS	MEDIUM	FINE		

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY	WENTWORTH
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE			

Client: Ratec Boring No.: SB-01 Sample No.:
Job Number: 2570-21 Depth: 0-12.5'
Classification: <u>Classification Not Performed</u>

Advanced Terra Testing, Inc.

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 6913

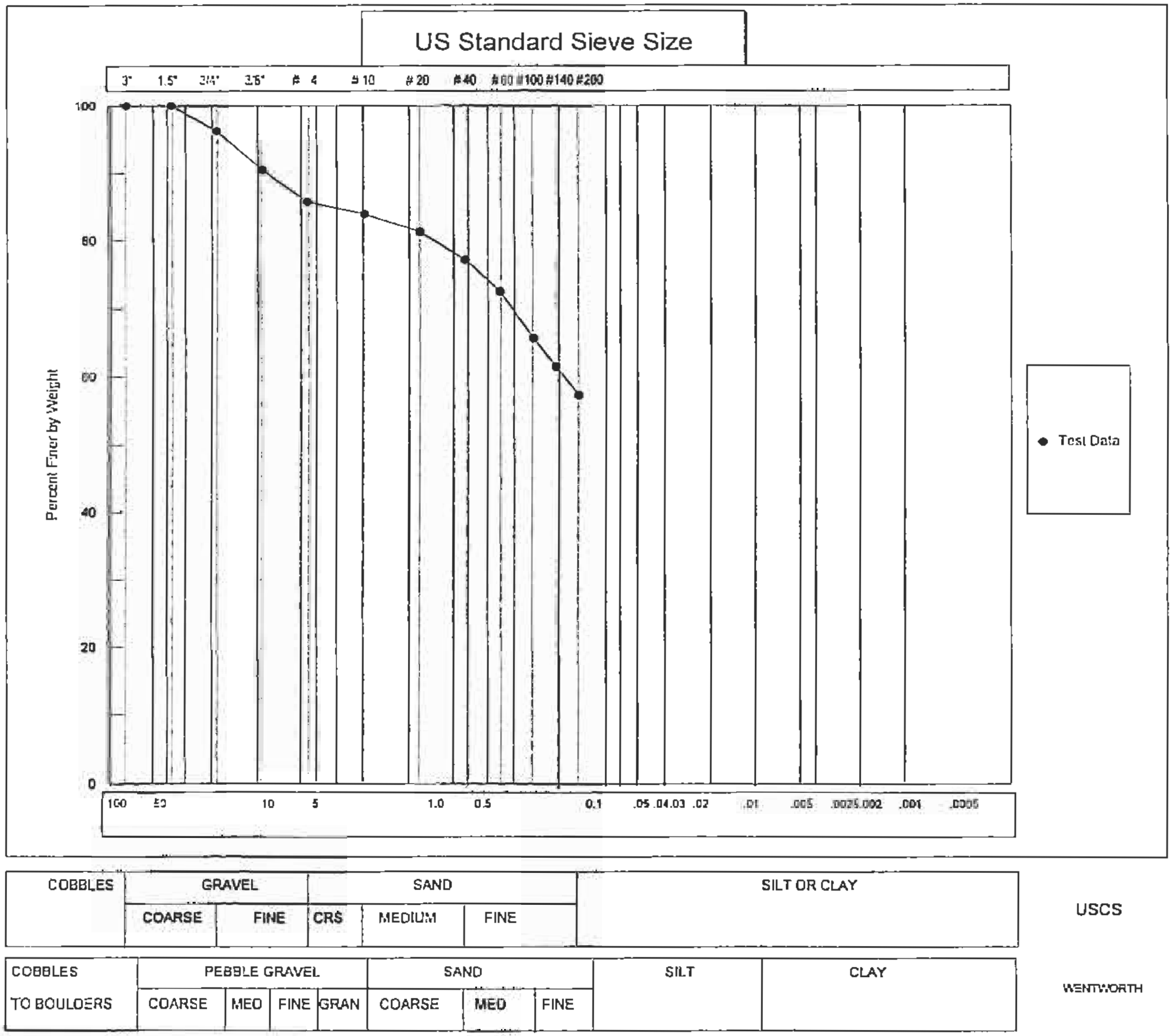
CLIENT	Retec		JOB NO.	2570-21
BORING NO.	SB-02		SAMPLED	
DEPTH	8-40'		DATE+#4 WASHED	09-19-07 SR
SAMPLE NO.			DATE -#4 WASHED	09-23-07 SR
SOIL DESCR.	#10331-007-0200		WASH SIEVE	Yes
LOCATION	High/Hunter Mesa		DRY SIEVE	No

MOISTURE DATA		WASH SIEVE ANALYSIS	
HYGROSCOPIC	Yes	Wt. Total Sample Wet (g)	1053.25
NATURAL	No	Weight of + #4 Before Washing (g)	158.40
		Weight of + #4 After Washing (g)	148.54
Wt. Wet Soil & Pan (g)	56.01		
Wt. Dry Soil & Pan (g)	55.38	Weight of - #4 Wet (g)	894.85
Wt. Lost Moisture (g)	0.63		
Wt. of Pan Only (g)	3.19	Weight of - #4 Dry (g)	893.92
Wt. of Dry Soil (g)	52.19		
Moisture Content %	1.2	Wt. Total Sample Dry (g)	1042.46
Wt. Partial -#4 Sample Wet (g)	218.90	Calc. Wt. "W" (g)	252.23
Wt. Partial Sample Dry (g)	216.29	Calc. Mass + #4	35.94

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	39.03	39.03	39.03	3.7	96.3
3/8"	0.00	59.91	59.91	98.94	9.5	90.5
#4	0.00	49.60	49.60	148.54	14.2	85.8
#10	3.70	8.38	4.68	4.68	16.1	83.9
#20	3.67	10.39	6.72	11.40	18.8	81.2
#40	3.19	13.55	10.36	21.76	22.9	77.1
#60	3.19	15.03	11.84	33.60	27.6	72.4
#100	3.14	20.28	17.14	50.74	34.4	65.6
#140	3.12	13.74	10.62	61.36	38.6	61.4
#200	3.14	13.56	10.42	71.78	42.7	57.3

Data entered by: SR Date: 09/24/2007
Data checked by: BKL Date: 9.24.07
FileName: RGM0SB02

ADVANCED TERRA TESTING, INC.



Client: Retec
Job Number: 2570-21
Classification: Classification Not Performed
Boring No.: SB-02
Depth: 8-40'
Sample No.:

Advanced Terra Testing, Inc.

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 6913

CLIENT Retec

JOB NO. 2570-21

BORING NO. SB-03
DEPTH 6-18'
SAMPLE NO.
SOIL DESCR. #10331-007-0200
LOCATION High/Hunter Mesa

SAMPLED
DATE+#4 WASHED 09-19-07 SR
DATE -#4 WASHED 09-23-07 SR
WASH SIEVE Yes
DRY SIEVE No

MOISTURE DATA

HYGROSCOPIC Yes

NATURAL No

Wt. Wet Soil & Pan (g)	53.87
Wt. Dry Soil & Pan (g)	52.96
Wt. Lost Moisture (g)	0.91
Wt. of Pan Only (g)	3.70
Wt. of Dry Soil (g)	49.26
Moisture Content %	1.8
Wt. Partial -#4 Sample Wet (g)	213.71
Wt. Partial Sample Dry (g)	209.83

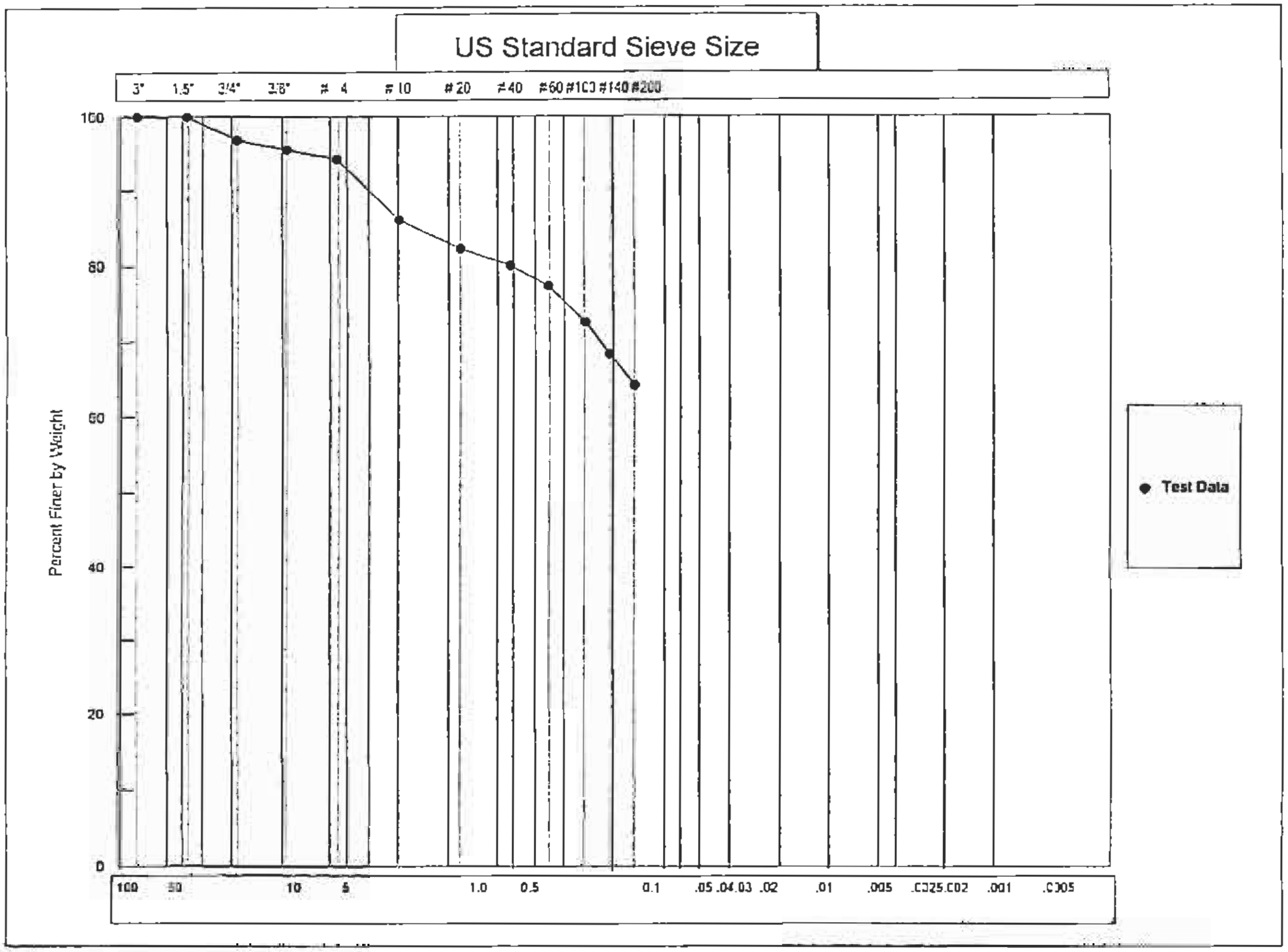
WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	1712.51
Weight of + #4 Before Washing (g)	101.41
Weight of + #4 After Washing (g)	96.39
Weight of - #4 Wet (g)	1611.10
Weight of - #4 Dry (g)	1586.81
Wt. Total Sample Dry (g)	1683.20
Calc. Wt. "W" (g)	222.58
Calc. Mass + #4	12.75

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	53.79	53.79	53.79	3.2	96.8
3/8"	0.00	21.07	21.07	74.86	4.4	95.6
#4	0.00	21.53	21.53	96.39	5.7	94.3
#10	3.07	21.24	18.17	18.17	13.9	86.1
#20	3.11	11.67	8.56	26.73	17.7	82.3
#40	3.11	7.83	4.72	31.45	19.9	80.1
#60	3.68	9.86	6.18	37.63	22.6	77.4
#100	3.24	13.82	10.58	48.21	27.4	72.6
#140	3.08	12.46	9.38	57.59	31.6	68.4
#200	3.08	12.28	9.20	66.79	35.7	64.3

Data entered by: SR Date: 09/24/2007
Data checked by: BKL Date: 9.24.07
FileName: RGM0SB03

ADVANCED TERRA TESTING, INC.



COBBLES	GRAVEL		SAND			SILT OR CLAY	USCS
	COARSE	FINE	CRS	MEDIUM	FINE		

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY	WENTWORTH
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE			

Client: Retec
Boring No.: SB-03
Sample No.:
Job Number: 2570-21
Depth: 6-18'
Classification: <u>Classification Not Performed</u>

Advanced Terra Testing, Inc.

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 6913

CLIENT	Retec	JOB NO.	2570-21
BORING NO.	SB-01	SAMPLED	
DEPTH	30-39'	DATE+#4 WASHED	09-19-07 SR
SAMPLE NO.		DATE -#4 WASHED	09-23-07 SR
SOIL DESCR.	#10331-007-0200	WASH SIEVE	Yes
LOCATION	High/Hunter Mesa	DRY SIEVE	No

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No
Wt. Wet Soil & Pan (g)	61.11
Wt. Dry Soil & Pan (g)	60.22
Wt. Lost Moisture (g)	0.89
Wt. of Pan Only (g)	3.17
Wt. of Dry Soil (g)	57.05
Moisture Content %	1.6
Wt. Partial -#4 Sample Wet (g)	219.32
Wt. Partial Sample Dry (g)	215.95

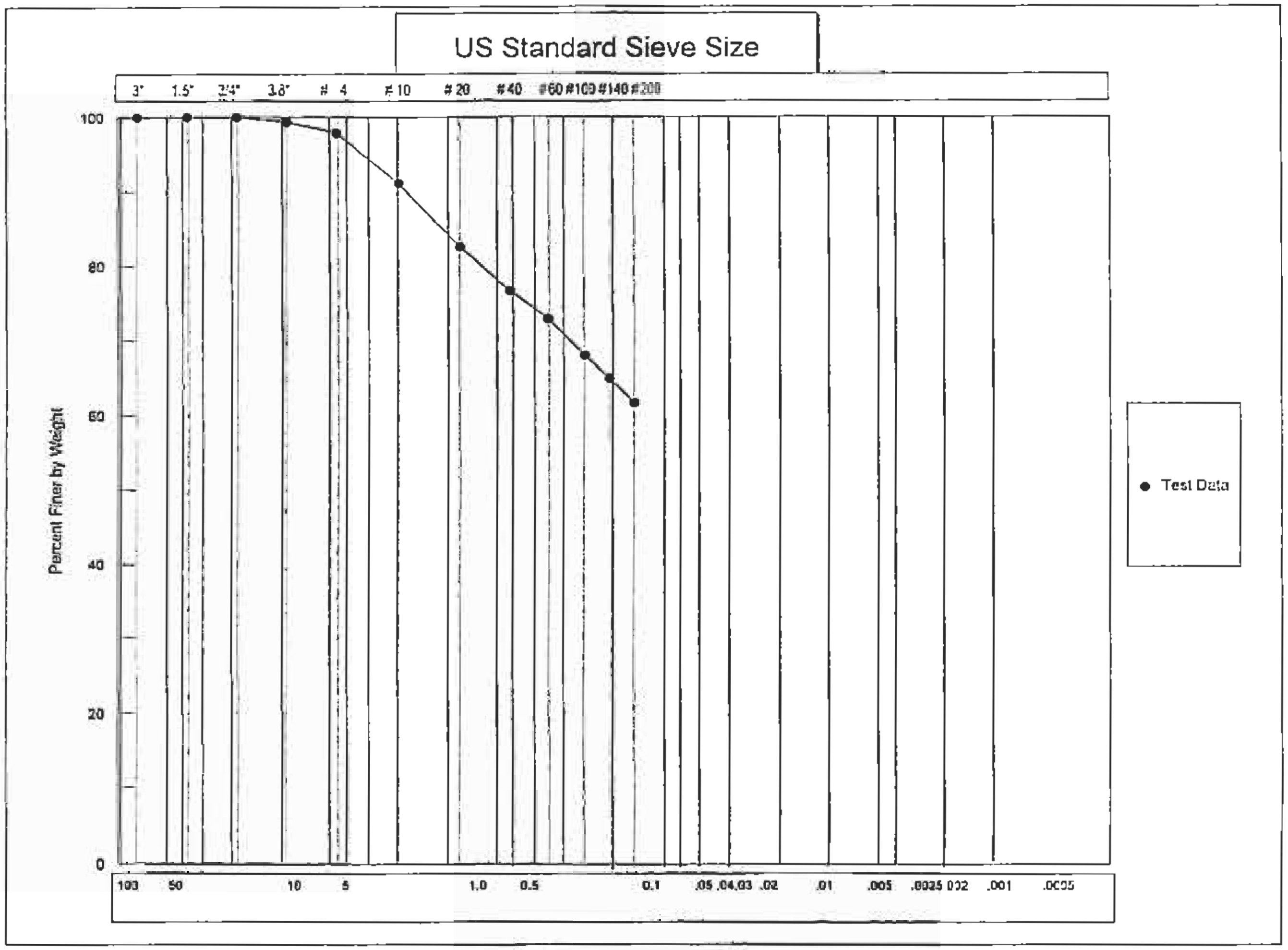
WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	556.83
Weight of + #4 Before Washing (g)	12.48
Weight of + #4 After Washing (g)	11.44
Weight of - #4 Wet (g)	544.35
Weight of - #4 Dry (g)	537.01
Wt. Total Sample Dry (g)	548.45
Calc. Wt. "W" (g)	220.55
Calc. Mass + #4	4.60

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	3.64	3.64	3.64	0.7	99.3
#4	0.00	7.80	7.80	11.44	2.1	97.9
#10	3.08	17.98	14.90	14.90	8.8	91.2
#20	3.07	21.80	18.73	33.63	17.3	82.7
#40	3.07	16.28	13.21	46.84	23.3	76.7
#60	3.08	11.33	8.25	55.09	27.1	72.9
#100	3.67	14.59	10.92	66.01	32.0	68.0
#140	3.17	10.05	6.88	72.89	35.1	64.9
#200	3.12	10.26	7.14	80.03	38.4	61.6

Data entered by: SR Date: 09/24/2007
Data checked by: BKL Date: 9.24.07
FileName: RGM03039

ADVANCED TERRA TESTING, INC.



COBBLES	GRAVEL		SAND			SILT OR CLAY	USCS
	COARSE	FINE	CRS	MEDIUM	FINE		

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY	WENTWORTH
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE			

Client: Retec
Job Number: 2570-21
Classification: Classification Not Performed.

Boring No.: SB-01
Depth: 30-39'

Sample No.:

Advanced Terra Testing, Inc.

ATTERBERG LIMITS
ASTM D 4318

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	Retec		JOB NO.	2570-21
BORING NO.	SB-02		DATE SAMPLED	
DEPTH	0-4.5'		DATE TESTED	09-20-07 MLM
SAMPLE NO.				
SOIL DESCR.	#10331-007-0200			
LOCATION	High/Hunter Mesa			

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	10.94	9.36	11.14
Wt Dish & Dry Soil	9.68	8.32	9.87
Wt of Moisture	1.26	1.04	1.27
Wt of Dish	1.04	1.01	1.11
Wt of Dry Soil	8.64	7.31	8.76
Moisture Content	14.58	14.23	14.50

Liquid Limit Determination — Device Number 0860

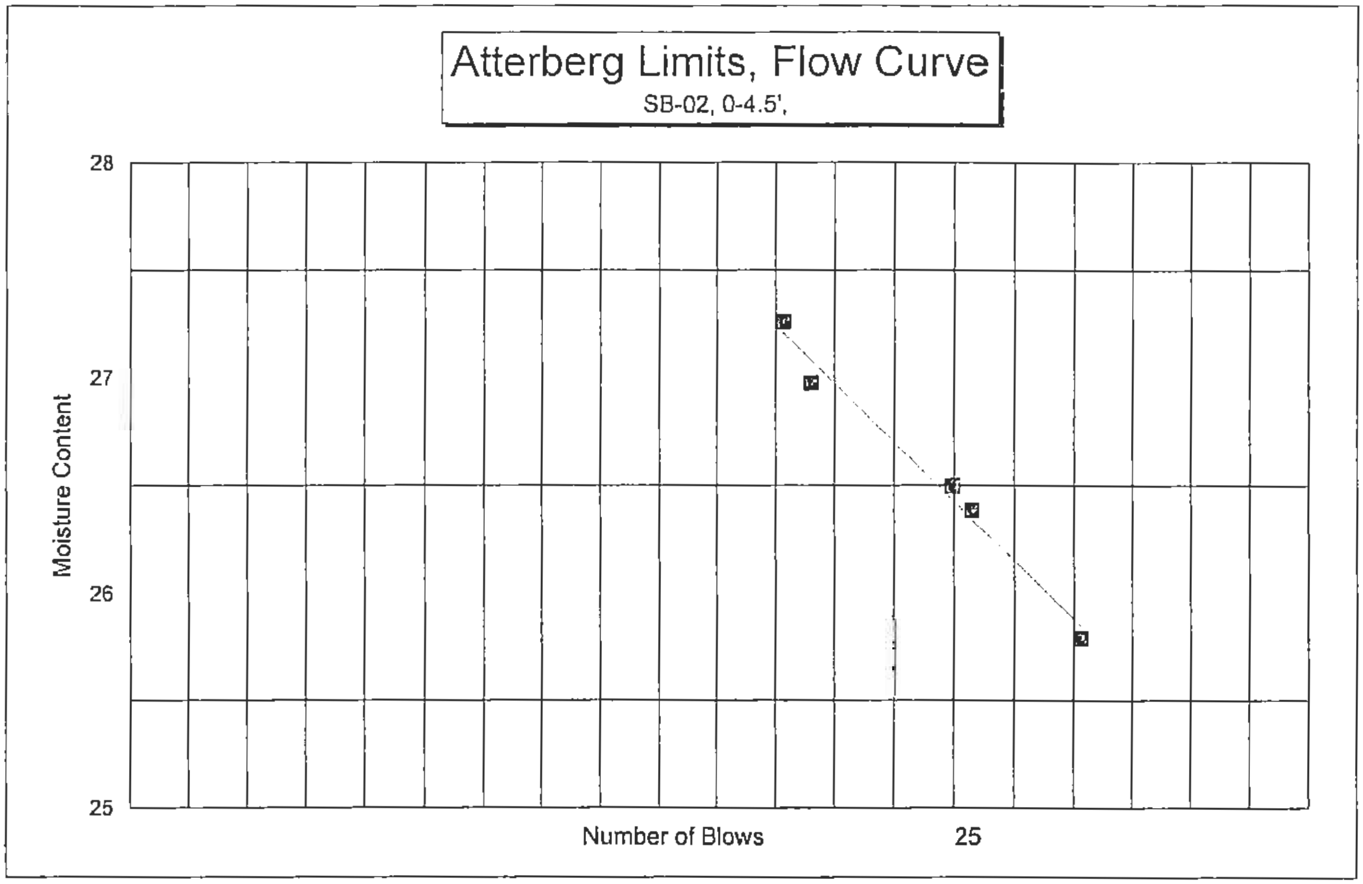
	1	2	3	4	5
Number of Blows	32	26	25	18	19
Wt Dish & Wet Soil	12.64	10.86	10.17	11.75	11.17
Wt Dish & Dry Soil	10.28	8.81	8.27	9.46	9.02
Wt of Moisture	2.36	2.05	1.90	2.29	2.15
Wt of Dish	1.13	1.04	1.10	1.06	1.05
Wt of Dry Soil	9.15	7.77	7.17	8.40	7.97
Moisture Content	25.79	26.38	26.50	27.26	26.98

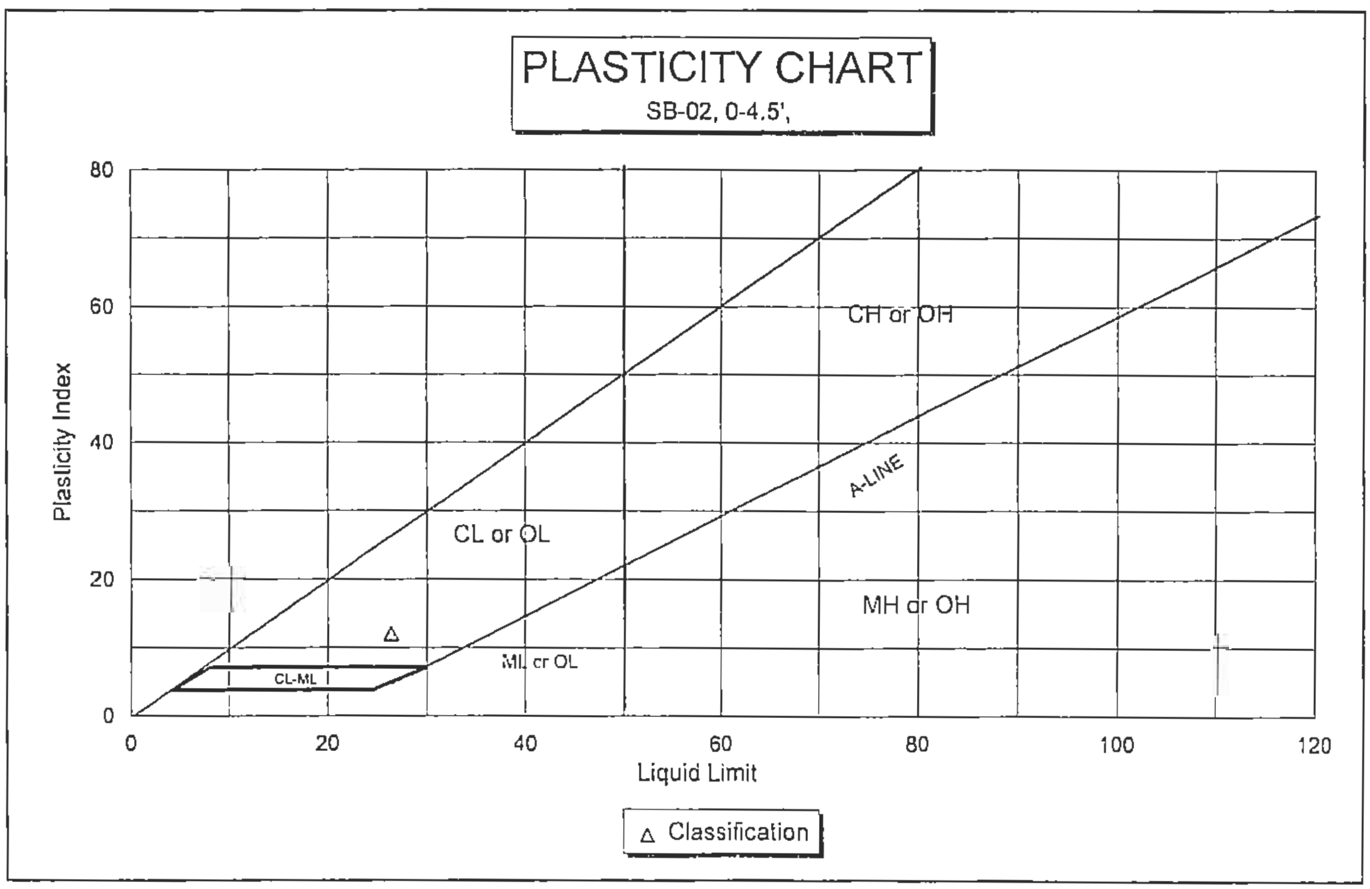
Liquid Limit	26.4
Plastic Limit	14.4
Plasticity Index	12.0

Atterberg Classification CL

Data entry by: SR Date: 09/21/2007
Checked by: RB Date: 9/23/07
FileName: RGG0SB02

ADVANCED TERRA TESTING, INC.


Atterberg Limits, Flow Curve
SB-02, 0-4.5',
28
27
26
25
Moisture Content
Number of Blows
25


PLASTICITY CHART
SB-02, 0-4.5',
80
60
40
20
0
Plasticity Index
0
20
40
60
80
100
120
Liquid Limit
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	Retec	JOB NO.	2570-21
BORING NO.	SB-02	DATE SAMPLED	
DEPTH	8-40'	DATE TESTED	09-26-07 WAR
SAMPLE NO.			
SOIL DESCR.	#10331-007-0200		
LOCATION	High/Hunter Mesa		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	7.77	8.84	9.09
Wt Dish & Dry Soil	6.98	7.92	8.15
Wt of Moisture	0.79	0.92	0.94
Wt of Dish	1.14	1.14	1.15
Wt of Dry Soil	5.84	6.78	7.00
Moisture Content	13.51	13.59	13.49

Liquid Limit Determination   Device Number   0860

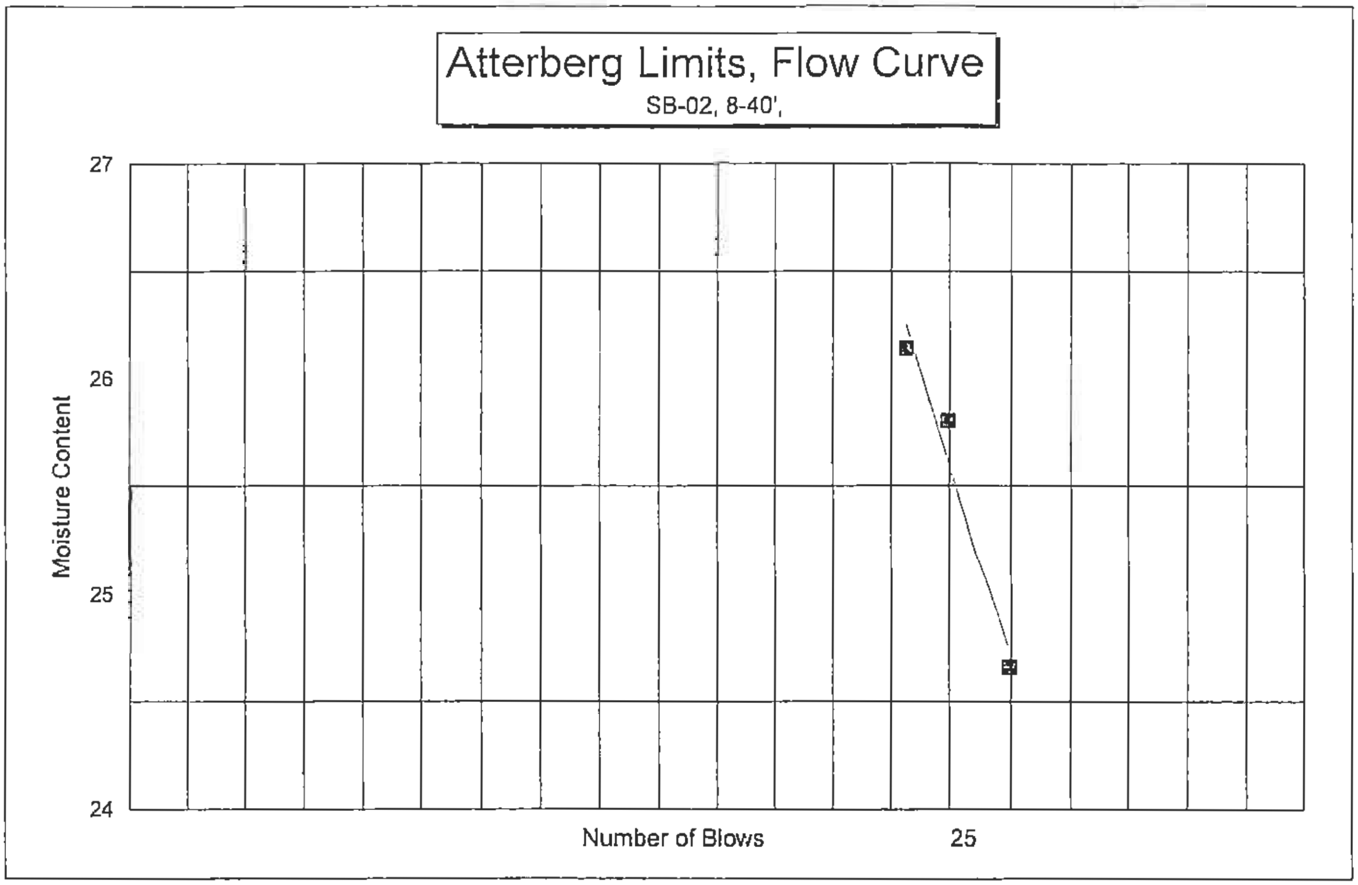
	1	2	3
Number of Blows	28	25	23
Wt Dish & Wet Soil	11.70	12.12	13.57
Wt Dish & Dry Soil	9.61	9.87	10.99
Wt of Moisture	2.09	2.25	2.58
Wt of Dish	1.14	1.15	1.13
Wt of Dry Soil	8.47	8.72	9.86
Moisture Content	24.66	25.80	26.14

Liquid Limit	25.6
Plastic Limit	13.5
Plasticity Index	12.1

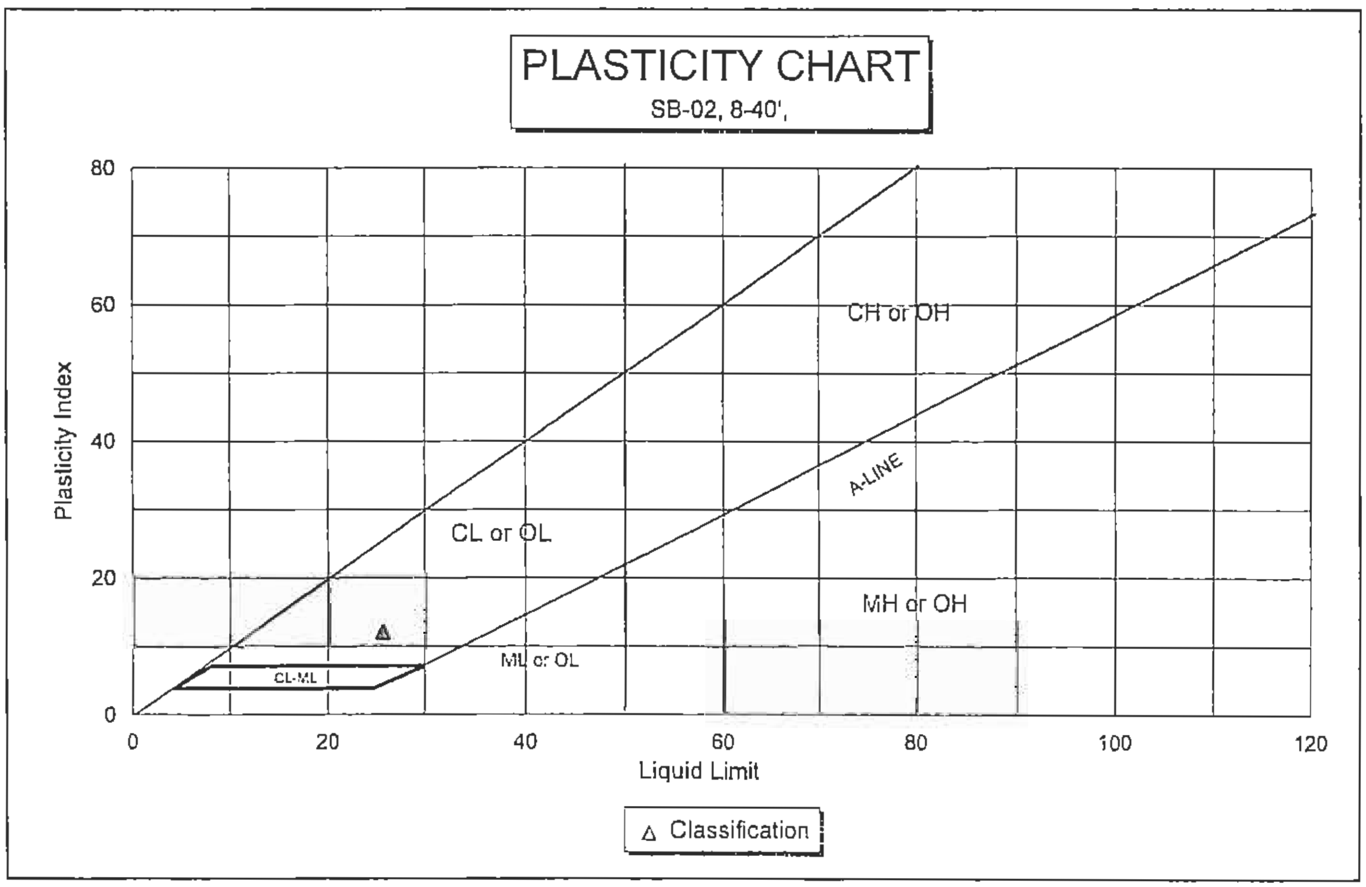
Atterberg Classification   CL

Data entry by: SR   Date: 09/27/2007
Checked by: BKL   Date: 9.28.07
FileName: RGG0840

ADVANCED TERRA TESTING, INC.



Atterberg Limits, Flow Curve
SB-02, 8-40',
27
26
25
24
Moisture Content
Number of Blows
25



PLASTICITY CHART
SB-02, 8-40',
80
60
40
20
0
Plasticity Index
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT Retec JOB NO. 2570-21

BORING NO. SB-01 DATE SAMPLED
DEPTH 0-12.5' DATE TESTED 09-26-07 MLM
SAMPLE NO.
SOIL DESCR. #10331-007-0200
LOCATION High/Hunter Mesa

Plastic Limit
Determination

	1	2	3
Wt Dish & Wet Soil	8.39	8.80	6.97
Wt Dish & Dry Soil	7.28	7.58	6.07
Wt of Moisture	1.11	1.22	0.90
Wt of Dish	1.14	1.32	1.31
Wt of Dry Soil	6.14	6.26	4.76
Moisture Content	18.00	19.47	18.96

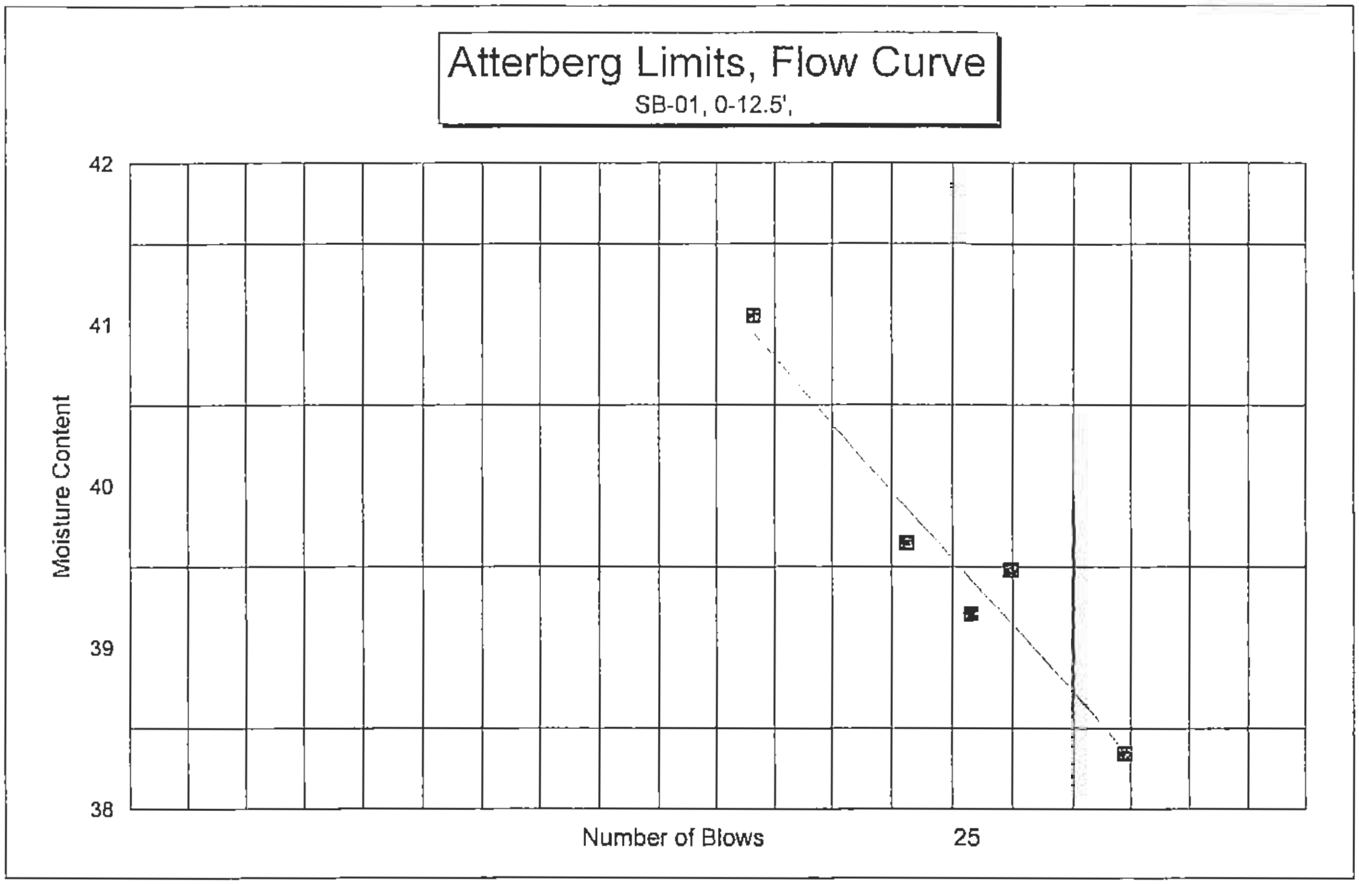
Liquid Limit Device Number 0860
Determination

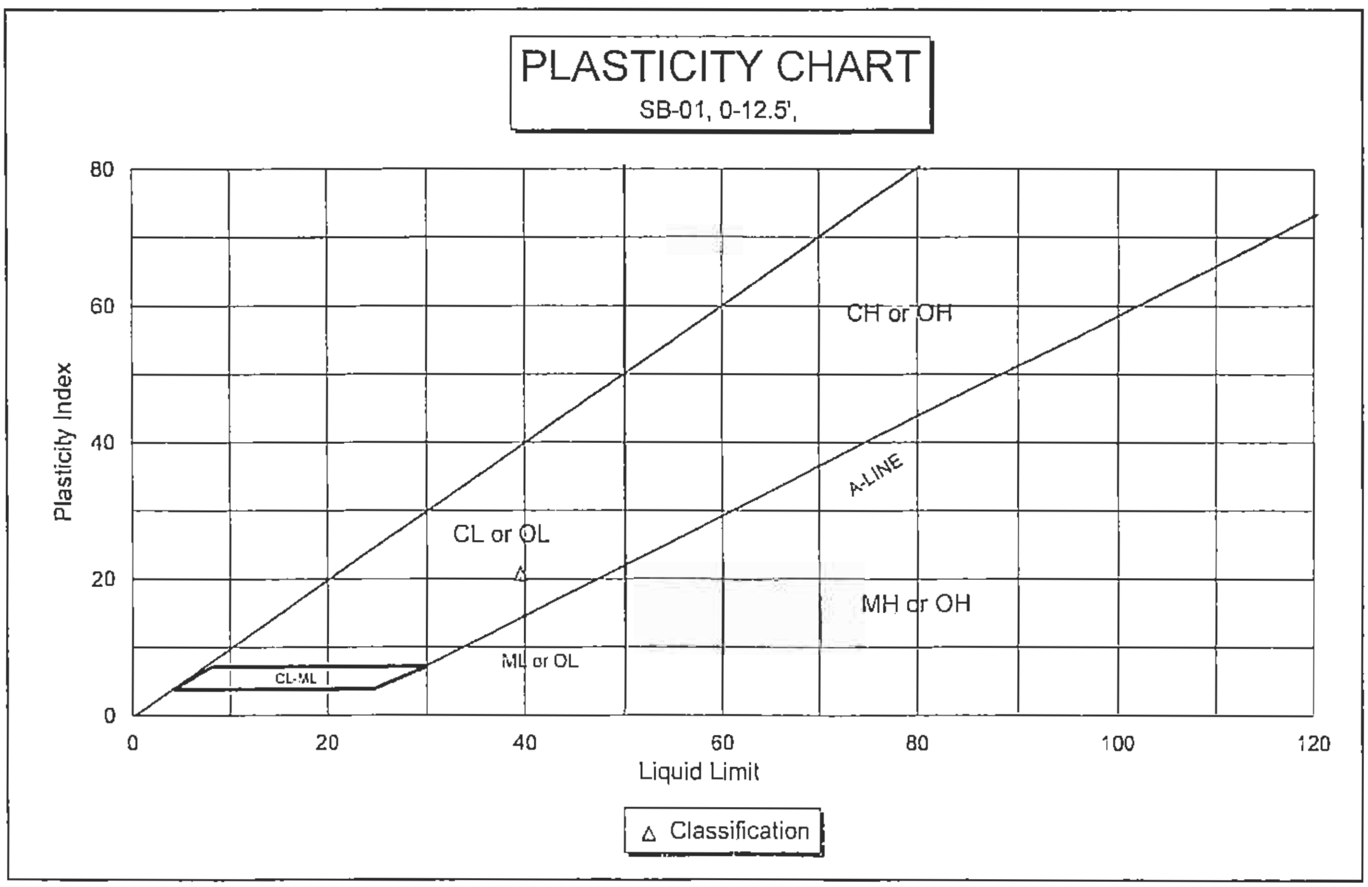
	1	2	3	4	5
Number of Blows	26	28	23	35	17
Wt Dish & Wet Soil	10.81	11.44	10.58	11.16	10.02
Wt Dish & Dry Soil	8.06	8.50	7.88	8.43	7.49
Wt of Moisture	2.75	2.94	2.70	2.73	2.54
Wt of Dish	1.05	1.05	1.07	1.31	1.31
Wt of Dry Soil	7.01	7.45	6.81	7.12	6.18
Moisture Content	39.21	39.48	39.65	38.34	41.05

Liquid Limit 39.6
Plastic Limit 18.8
Plasticity Index 20.8

Atterberg Classification CL

Data entry by: SR Date: 09/27/2007
Checked by: BKL Date: 9-28-07
FileName: RGG00125 ADVANCED TERRA TESTING, INC.


Atterberg Limits, Flow Curve
SB-01, 0-12.5',
Moisture Content
42
41
40
39
38
Number of Blows
25


PLASTICITY CHART
SB-01, 0-12.5',
Plasticity Index
80
60
40
20
0
0
20
40
60
80
100
120
Liquid Limit
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	Retec	JOB NO.	2570-21
BORING NO.	SB-01	DATE SAMPLED	
DEPTH	16-30'	DATE TESTED	09-25-07 WAR
SAMPLE NO.			
SOIL DESCR.	#10331-007-0200		
LOCATION	High/Hunter Mesa		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	8.00	6.73	7.28
Wt Dish & Dry Soil	7.02	5.96	6.40
Wt of Moisture	0.98	0.77	0.88
Wt of Dish	1.14	1.12	1.14
Wt of Dry Soil	5.88	4.84	5.26
Moisture Content	16.67	15.91	16.73

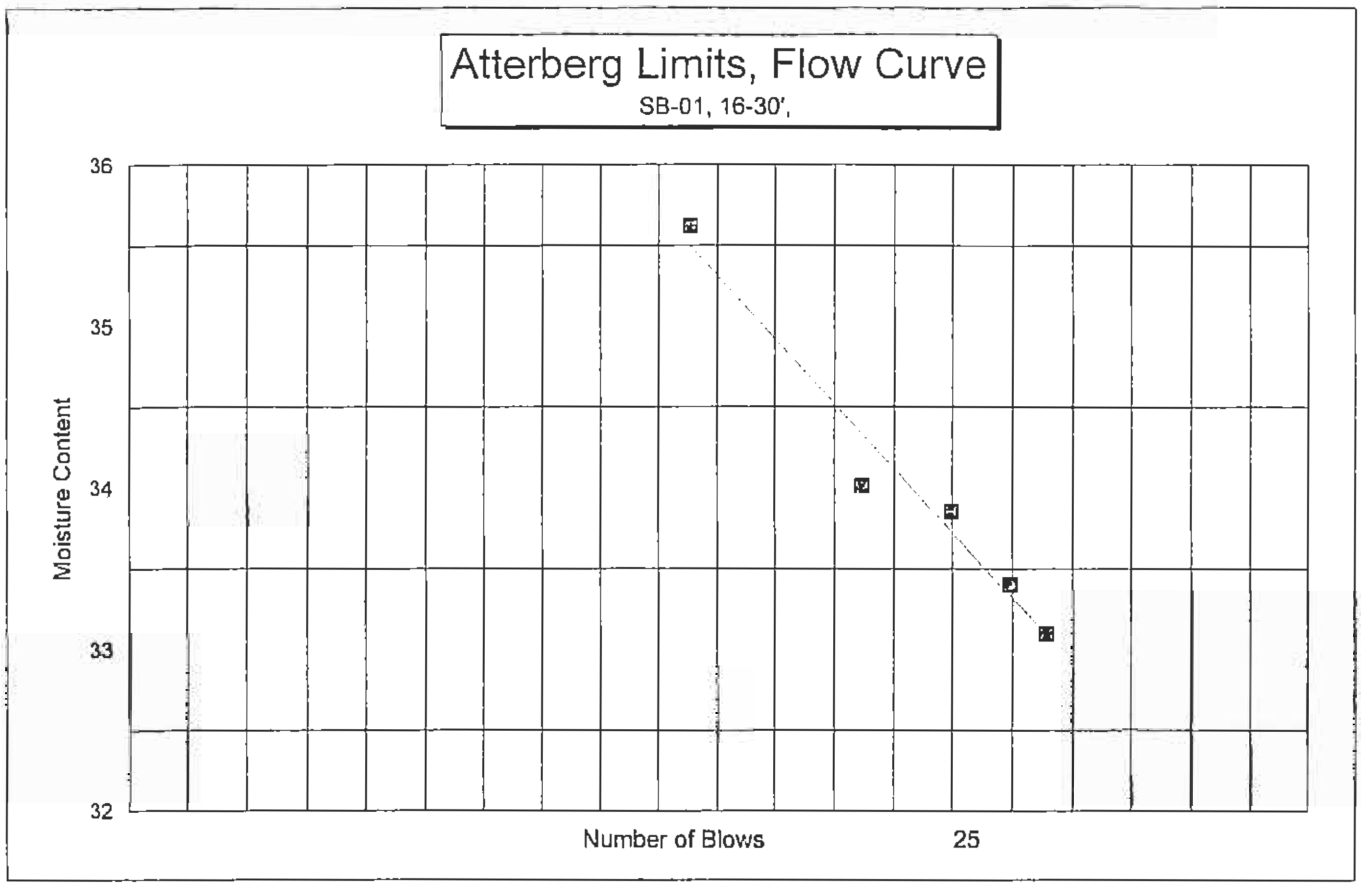
Liquid Limit Determination   Device Number 0860

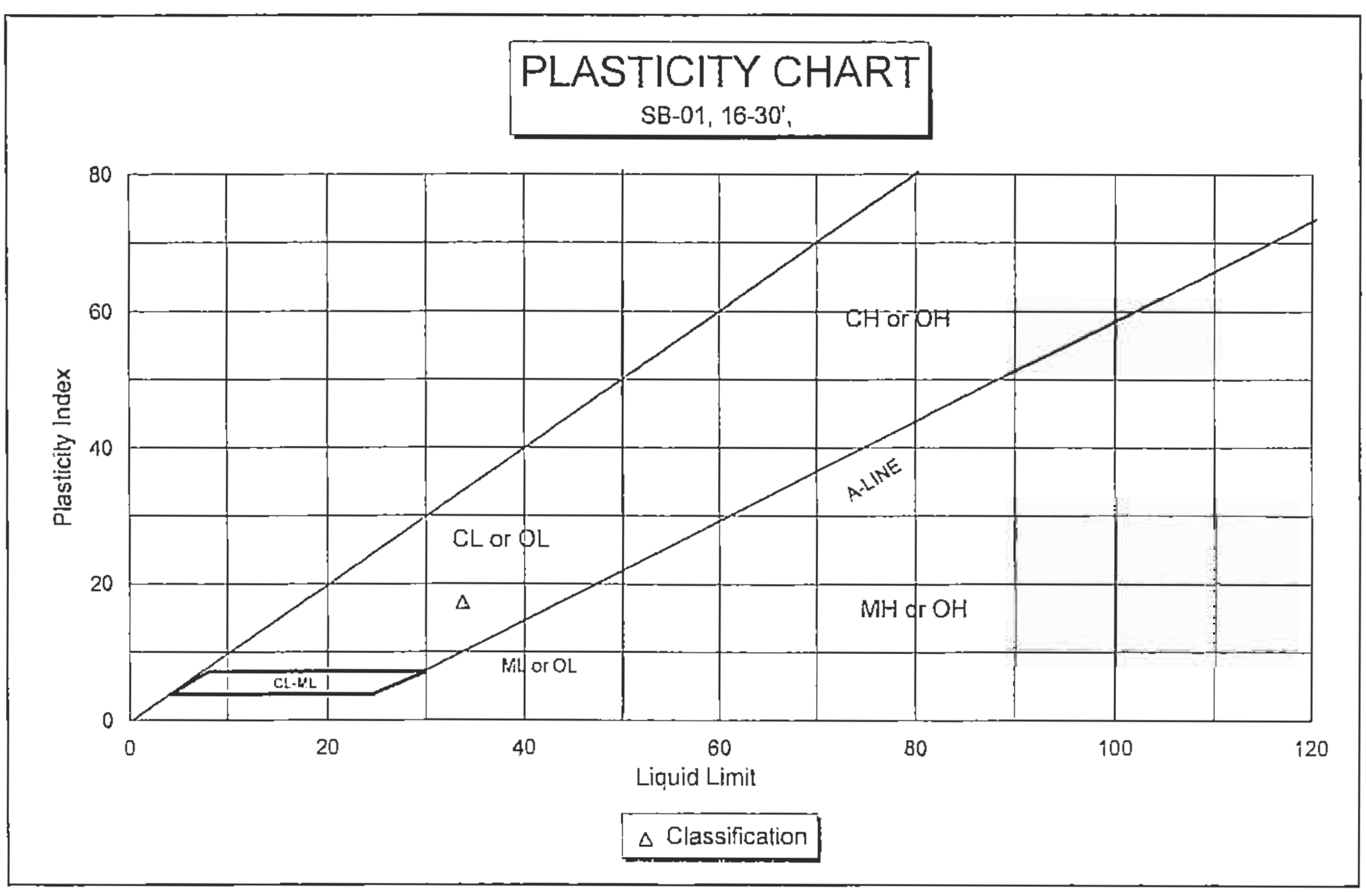
	1	2	3	4	5
Number of Blows	21	15	25	28	30
Wt Dish & Wet Soil	12.33	14.20	12.33	13.84	16.23
Wt Dish & Dry Soil	9.49	10.77	9.50	10.66	12.48
Wt of Moisture	2.84	3.43	2.83	3.18	3.75
Wt of Dish	1.14	1.14	1.14	1.14	1.15
Wt of Dry Soil	8.35	9.63	8.36	9.52	11.33
Moisture Content	34.01	35.62	33.85	33.40	33.10

Liquid Limit	33.7
Plastic Limit	16.4
Plasticity Index	17.3

Atterberg Classification CL

Data entry by: SR   Date: 09/27/2007
Checked by: BKL   Date: 9.28.07
FileName: RGG01630   ADVANCED TERRA TESTING, INC.


Atterberg Limits, Flow Curve
SB-01, 16-30',
36
35
34
33
32
Moisture Content
Number of Blows
25


PLASTICITY CHART
SB-01, 16-30',
80
60
40
20
0
Plasticity Index
0
20
40
60
80
100
120
Liquid Limit
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	Retec	JOB NO.	2570-21
BORING NO.	SB-01	DATE SAMPLED	
DEPTH	30-39'	DATE TESTED	09-24-07 MLM
SAMPLE NO.			
SOIL DESCR.	#10331-007-0200		
LOCATION	High/Hunter Mesa		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	8.19	7.82	8.30
Wt Dish & Dry Soil	7.29	6.96	7.40
Wt of Moisture	0.90	0.86	0.90
Wt of Dish	1.14	1.15	1.14
Wt of Dry Soil	6.15	5.81	6.26
Moisture Content	14.63	14.80	14.38

Liquid Limit Determination   Device Number 0860

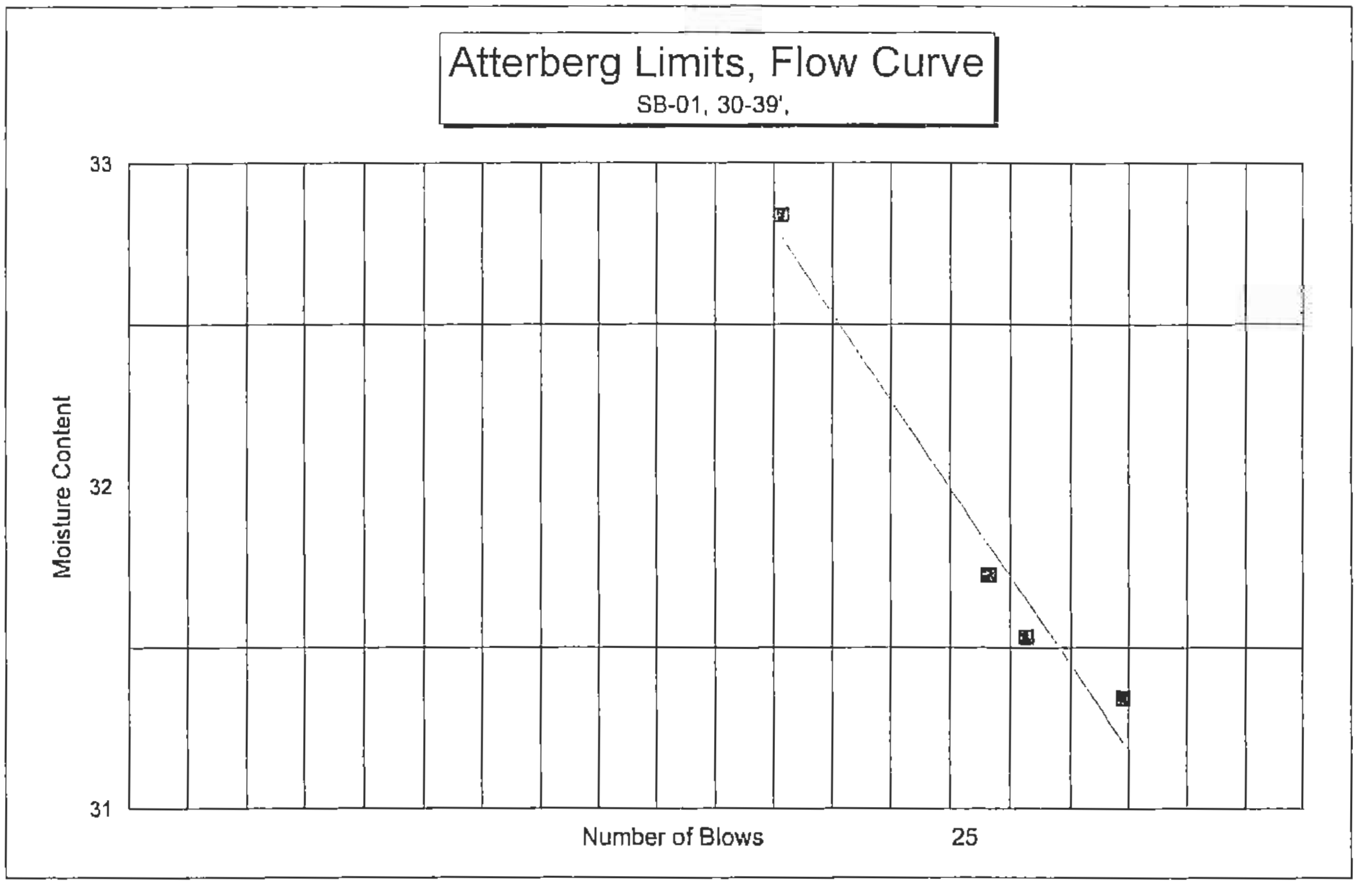
	1	2	3	4
Number of Blows	35	29	27	18
Wt Dish & Wet Soil	11.69	13.07	12.60	12.73
Wt Dish & Dry Soil	9.17	10.21	9.84	9.86
Wt of Moisture	2.52	2.86	2.76	2.87
Wt of Dish	1.13	1.14	1.14	1.12
Wt of Dry Soil	8.04	9.07	8.70	8.74
Moisture Content	31.34	31.53	31.72	32.84

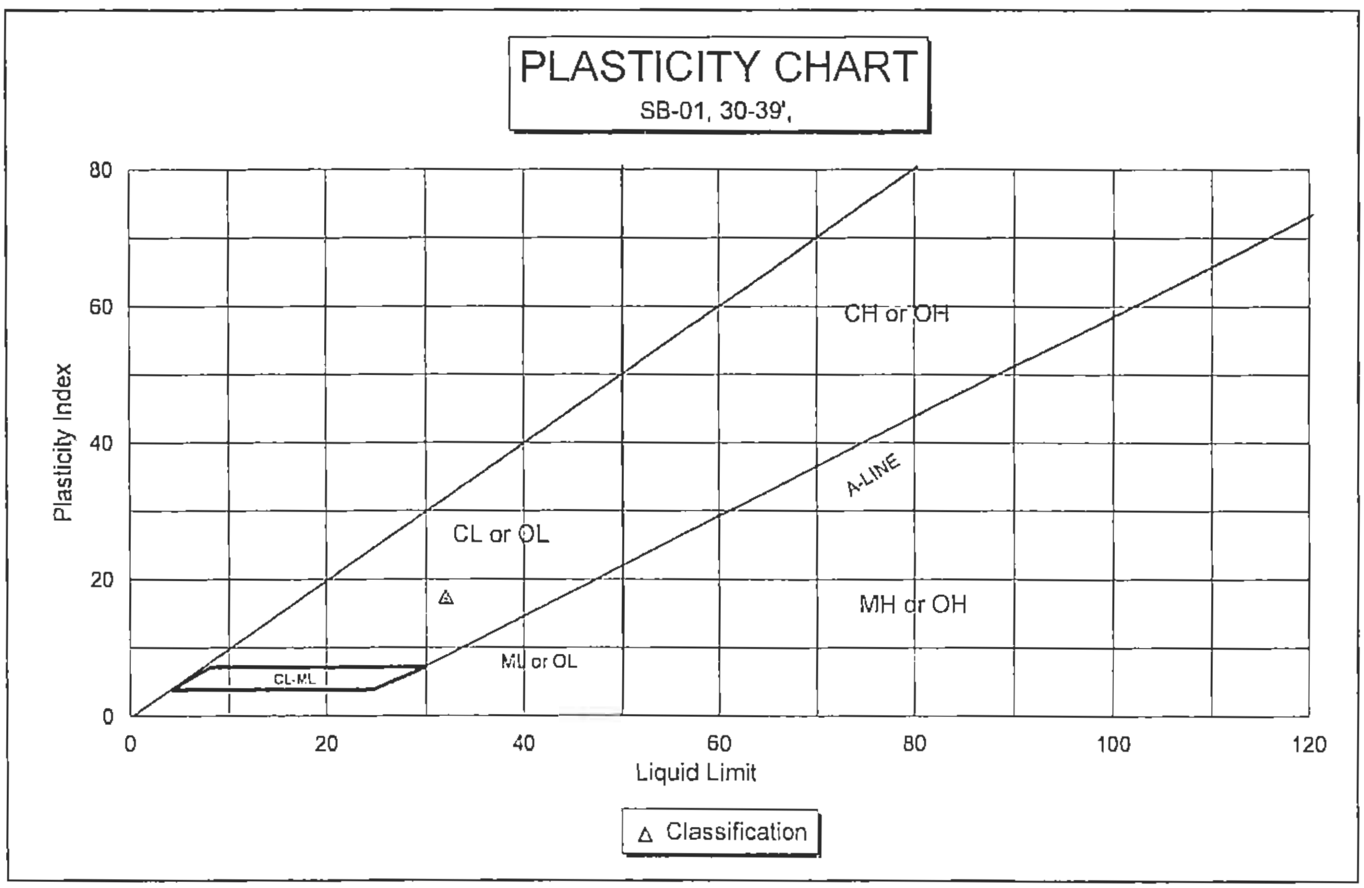
Liquid Limit	32.0
Plastic Limit	14.6
Plasticity Index	17.4

Atterberg Classification CL

Data entry by: SR Date: 09/27/2007
Checked by: BKL Date: 9.28.07
FileName: RGG0SB01

ADVANCED TERRA TESTING, INC.


Atterberg Limits, Flow Curve
SB-01, 30-39',
33
32
31
Moisture Content
Number of Blows
25


PLASTICITY CHART
SB-01, 30-39',
80
60
40
20
0
Plasticity Index
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
20
40
60
80
100
120
Liquid Limit
Classification

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	Retec	JOB NO.	2570-21
BORING NO.	SB-03	DATE SAMPLED	
DEPTH	6-18'	DATE TESTED	09-24-07 MLM
SAMPLE NO.			
SOIL DESCR.	#10331-007-0200		
LOCATION	High/Hunter Mesa		

Plastic Limit
Determination

	1	2	3
Wt Dish & Wet Soil	7.87	8.09	8.84
Wt Dish & Dry Soil	7.04	7.22	7.86
Wt of Moisture	0.83	0.87	0.98
Wt of Dish	1.14	1.14	1.14
Wt of Dry Soil	5.90	6.08	6.72
Moisture Content	14.07	14.31	14.58

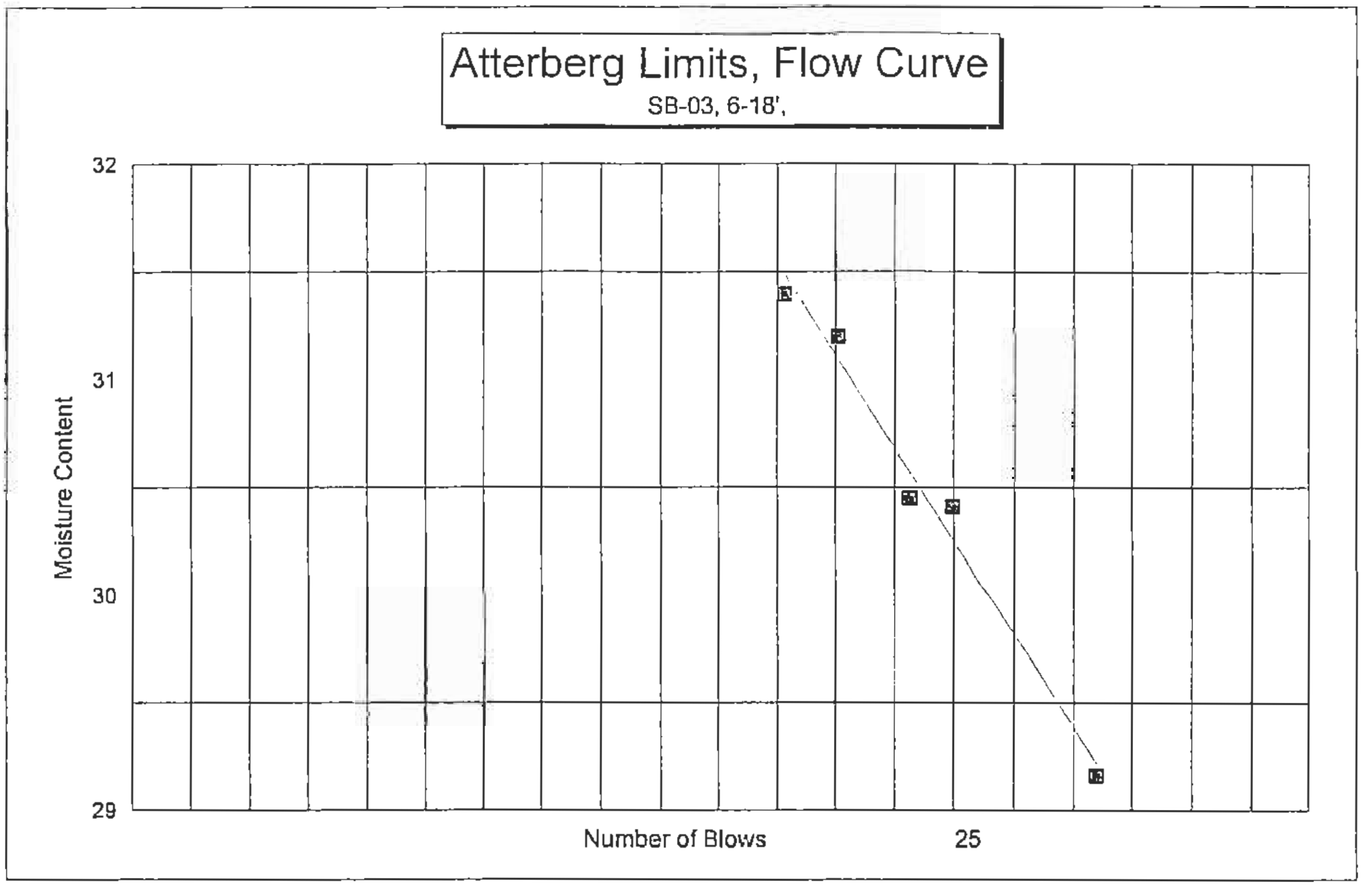
Liquid Limit Determination   Device Number   0860

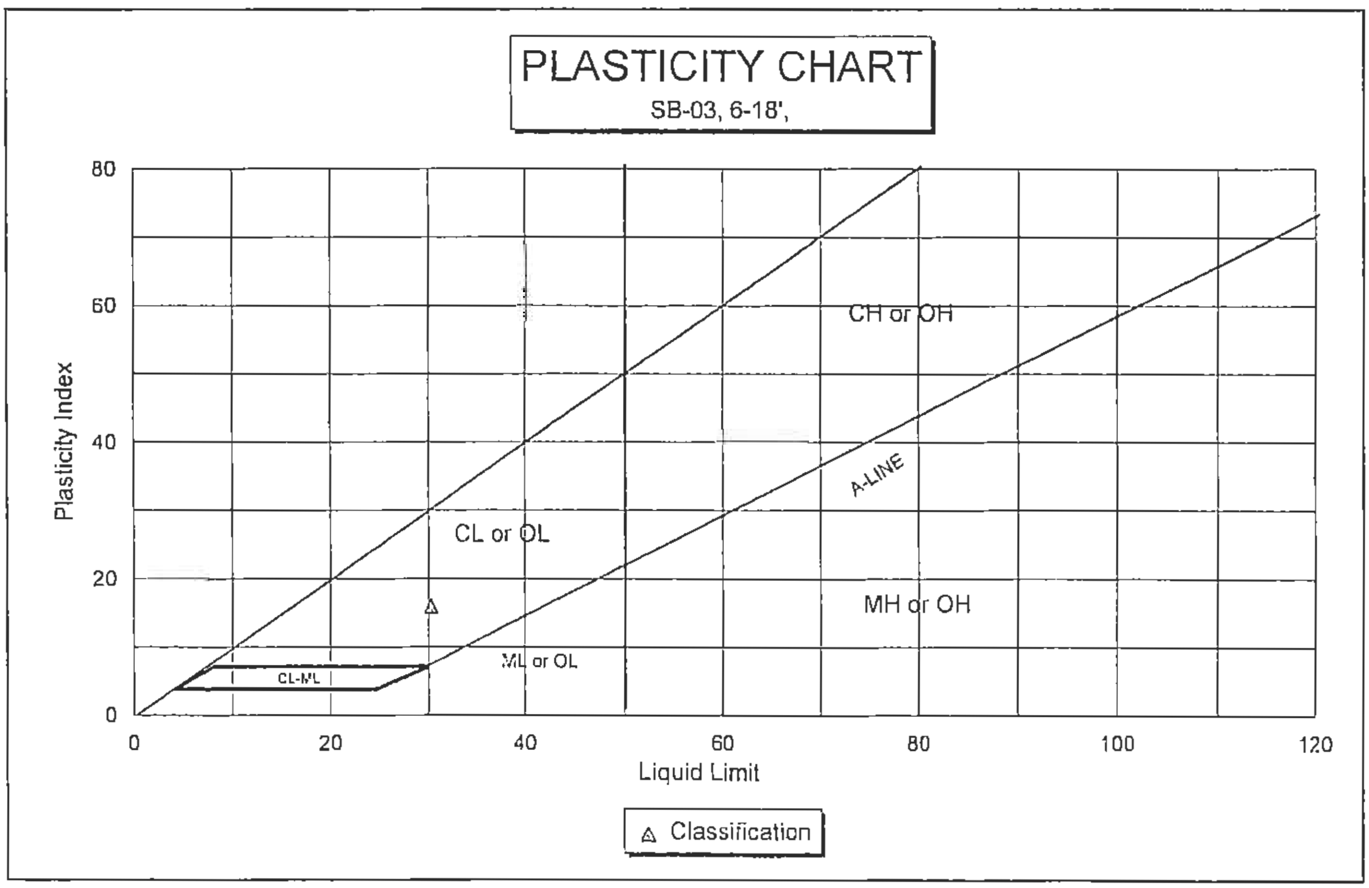
	1	2	3	4	5
Number of Blows	33	25	20	18	23
Wt Dish & Wet Soil	13.02	13.49	12.62	11.98	12.45
Wt Dish & Dry Soil	10.34	10.61	9.89	9.39	9.81
Wt of Moisture	2.68	2.88	2.73	2.59	2.64
Wt of Dish	1.15	1.14	1.14	1.14	1.14
Wt of Dry Soil	9.19	9.47	8.75	8.25	8.67
Moisture Content	29.16	30.41	31.20	31.39	30.45

Liquid Limit	30.3
Plastic Limit	14.3
Plasticity Index	15.9

Atterberg Classification   CL

Data entry by: SR   Date: 09/27/2007
Checked by: BKC   Date: 9-28-07
FileName: RGG0SB03   ADVANCED TERRA TESTING, INC.


Atterberg Limits, Flow Curve
SB-03, 6-18',
32
31
30
29
Moisture Content
Number of Blows
25


PLASTICITY CHART
SB-03, 6-18',
80
60
40
20
0
Plasticity Index
0
20
40
60
80
100
120
Liquid Limit
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
Classification

MOISTURE CONTENT
ASTM D 2216

Moisture Content Determinations
ASTM D 2216

CLIENT: Retec JOB NO.: 2570-21
LOCATION: High-Hunter Mesa, #10331-007-0200

BORING	SB-1	SB-01	SB-01	SB-02
SAMPLE DEPTH	0-12.5'	16-30'	30-39'	8-40'
SAMPLE NO.				
DATE SAMPLED				
DATE TESTED	09-13-07 RS	09-13-07 RS	09-13-07 RS	09-13-07 RS
SOIL DESCRIPTION				
MOISTURE DETERMINATIONS				
Wt. of Wet Soil & Dish (gms)	374.38	227.16	249.91	374.67
Wt. of Dry Soil & Dish (gms)	342.09	217.04	236.64	357.92
Net Loss of Moisture (gms)	32.29	10.12	13.27	16.75
Wt. of Dish (gms)	8.27	8.26	6.61	6.73
Wt. of Dry Soil (gms)	333.82	208.78	230.03	351.19
Moisture Content (%)	9.7	4.8	5.8	4.8

BORING	SB-03
SAMPLE DEPTH	6-18'
SAMPLE NO.	
DATE SAMPLED	
DATE TESTED	09-13-07 RS
SOIL DESCRIPTION	
MOISTURE DETERMINATIONS	
Wt. of Wet Soil & Dish (gms)	764.52
Wt. of Dry Soil & Dish (gms)	709.41
Net Loss of Moisture (gms)	55.11
Wt. of Dish (gms)	15.12
Wt. of Dry Soil (gms)	694.29
Moisture Content (%)	7.9

Data entered by: SR Date: 09/14/2007
Data checked by: BKL Date: 9.14.07
FileName: RGN0HIGH ADVANCED TERRA TESTING, INC