GEOTECHNICAL DATA REPORT

P-991 MCSFR Bachelor Enlisted Quarters
Naval Weapons Station
Yorktown, Virginia

A/E Contract N62470-12-D-2003, WE44
GER Project No. 110-6619

prepared for
NAVFAC Mid-Atlantic
Norfolk, Virginia

January 12, 2015

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January 12, 2015

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Attention: **Ms. Jenny Britt**
Project Manager

Subject: **Geotechnical Data Report**
P-991 MCSFR Bachelor Enlisted Quarters
Naval Weapons Station Yorktown
Yorktown, Virginia
A/E Contract No. N62470-12-D-2003, WE44
GER Project No. 110-6619

GeoEnvironmental Resources, Inc. is pleased to present this geotechnical data report conducted for the above referenced project for NAVFAC Mid-Atlantic under A/E Contract No. N62470-12-D-2003, Task Order WE44.

We appreciate the opportunity to serve as your geotechnical consultant on this project and trust that you will contact us at your convenience with any questions concerning this report or the project in general.

Sincerely,
GeoEnvironmental Resources, Inc.

C. J. Lindemann, Jr., E.I.T.
Project Engineer

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SUMMARY

The subsurface conditions at the project site were explored by 1 piezocone penetration test (CPTu) sounding to a depth of 75 feet below existing grade, 2 dilatometer test (DMT) soundings conducted to a depth of 50 feet below existing grades and 3 direct push soil borings to a depth of 12 feet below existing grades. One constant head borehole permeameter test was conducted at a depth of about 5 feet below existing grade. Laboratory moisture content, grain size, plasticity and chemical analyses were conducted on selected soil samples recovered from the direct push borings.

The subsurface conditions encountered in the soil borings and in-situ test soundings were interpreted as 1 manmade and 5 suspected natural Coastal Plain stratigraphic layers. The generalized soil profile consists of uncontrolled fill at the DMT locations to depths of about 2 to 3 feet (Stratum A), soft to stiff clay to depths of about 9 to 12 feet (Stratum 2), loose to firm sand to depths of about 20 to 22 feet (Stratum 3), soft to firm clay and clayey silt to depths of about 32 to 33 feet (Stratum 4), firm to dense sand and silty sand with shell to depths of about 37 feet (Stratum 5), and interlayered soft to stiff clay and loose to dense sand with shell (Stratum 6) to the maximum depths explored. Stratum 1, encountered during prior investigations at the proposed MCSFR compound, was not encountered during this exploration.

The static groundwater table was encountered in the in-situ test soundings at depths of approximately 21 feet below the ground surface during the exploration. Seasonal high water table conditions are expected to be within 10 feet of the ground surface. Seams of perched water within the upper soils should be expected locally.

Surface materials encountered at the testing locations consisted of sedimentation, soil fill, topsoil-like material and crushed stone.

Soil infiltration rate measured in the Stratum 2 clay averaged less than 0.2 inch per hour.

Chemical analyses of a composite soil sample collected from the upper 3 feet at the site did not indicate the presence of TCLP metals, BTEX or Total Petroleum Hydrocarbons.

Construction activity was occurring on and around the project site at the time of the exploration. A building formerly existed at the project site based on previous studies conducted at the proposed MCSFR compound.

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Purpose of Study

The purpose of this study was to collect geotechnical data from the proposed P-991 Bachelor Enlisted Quarters site and to prepare this report of the findings in support of a design-build RFP solicitation.

Figure 1. *Site Location*

Project Information

The proposed project will design and construct a 3-story Bachelor Enlisted Quarters (BEQ) at the Marine Corps Security Force Regiment (MCSFR) compound at the Naval Weapons Station in Yorktown, Virginia. The site location is shown in Figure 1 and on Drawing 1 in Appendix A. We understand the building will likely be constructed using load bearing CMU walls, brick veneer and standing seam metal roof. The lower level of the building may be located below grade. The building site is located adjacent to the new parade ground which is currently under construction under a separate contract. Structural and site grading information associated with the proposed project are unknown at this time.

Site Description

The project site is located in the southeast area of Naval Weapons Station Yorktown and bordered by Longfellow Road on the east and an asphalt surfaced parking lot to the north. Directly south of and adjacent to the site is a parade ground deck for the P-984 project which was under construction at the time of the exploration. Stockpiles of soil and organic materials as part of the ongoing construction were deposited on much of the P-991 site as shown on the site photographs in Appendix B of this report. Previous studies conducted at the site indicated that a former building occupied much of the proposed P-991 building footprint. Approximate ground elevations at the site are believed to range between 55 and 60 feet above mean sea level; however, the site elevations may have been impacted by the construction activity. Overhead power lines and several underground utilities including water, electric, communications and sanitary sewer are present at the site.

Site Geology

The project site lies within Virginia's Atlantic Coastal Plain physiographic province. The Coastal Plain is characterized by an eastward thickening wedge of marine, estuarine and fluvial sediments that were deposited in a series of marine transgressive-regressive cycles, or high and low stands of sea level, during the Holocene to Miocene epochs of the late Cenozoic era.

According to the 1972 Virginia Division of Mineral Resources publication entitled "Geology of the Yorktown, Poquoson West, and Poquoson East Quadrangles, Virginia," the upper geologic units at the site are composed of Pleistocene age deposits of the Windsor Formation that include fluvial and estuarine silt, sand, clay and gravel. Older underlying units include consolidated Tertiary deposits of the Yorktown and Eastover Formations, undivided, described as marine deposits consisting of fossiliferous sand and shelly sand deposits, sand and clay. Metamorphic and igneous basement bedrock is located at more than 1000 feet below sea level.

Exploration Program

The subsurface exploration program consisted of the following sampling and testing at the approximate locations shown in Figure 2 and on Drawing 2 in Appendix A:

- Performing 1 piezocone penetration test (CPTu) sounding, designated CPT-1S, to a depth of 75 feet below existing grade.
- Performing 2 dilatometer test (DMT) soundings, designated DMT-1S and DMT-2S, to a depth of 50 feet below existing grades.
- Performing 3 direct push soil borings adjacent to the sounding locations to a depth of 12 feet below the existing ground surface.
- Conducting a constant head field saturated conductivity test at location DMT-2S at a depth of about 5 feet below existing grade to estimated soil permeability.

Figure 2. *Testing Location Plan*

- Performing geotechnical laboratory testing that included natural moisture content, grain size, and Atterberg limits on selected representative samples recovered from the soil borings.
- Collecting 1 composite soil sample from 0.5 to 3 foot depth at location CPT-1S for laboratory analysis of TCLP Metals, TPH and BTEX.

Drawings showing site and testing location information and interpreted subsurface data are provided in Appendix A. Field exploration data are provided in Appendix B. Laboratory test results are provided in Appendix C. Exploration procedures and interpretation methods used in this study are provided in Appendix D.

The testing locations and depths were selected by NAVFAC Mid-Atlantic. Test locations were established in the field using the site plans provided to us and available reference landmarks. Horizontal position (WGS84 lat/lon) of the test locations was measured in the field using a handheld GPS receiver with an accuracy of 3 meters. The measured geographic positions of the test locations are shown on the exploration program summary in Appendix B. Ground surface elevations at the testing locations were not able to be estimated using the site plan provided to us as a result of the ongoing construction activity.

The piezocone penetration test (CPTu) sounding was conducted at location CPT-1S using an integrated electronic seismic piezocone with a 15 cm^2 tip and a 225 cm^2 friction sleeve. The cone is designed with an equal end area friction sleeve and a tip end area ratio of 0.80. The piezocone dimensions and the operating procedure were in accordance with ASTM D 5778. Pore pressure filter elements made of porous plastic were saturated under a vacuum using silicone oil as the saturating fluid. The pore pressure element was 6 mm thick and was located immediately behind the tip (the U_2 location).

The cone was advanced using a 20-ton track mounted CPT rig. Tip resistance (qc), sleeve friction (fs) and dynamic pore pressure (u) data were recorded every five centimeters as the cone was advanced into the ground. The reported tip resistance (qt) was corrected for porewater effects.

The dilatometer test (DMT) soundings were performed at locations DMT-1S and DMT-2S in general accordance with ASTM D6335. The DMT is an in-situ test device having a relatively thin blade (14 mm) and flat face (95 mm wide by 220 mm long). The blade is pushed into the soil using the CPT rig to the

desired testing depths. One side of the flat blade contains a 60-mm diameter circular membrane. The membrane is expanded to take pressure readings after the DMT has been pushed to the desired depths - one foot intervals for this study. The DMT generally cannot be pushed through very dense, hard, or gravely soils that might damage the membrane or buckle the blade.

Dual gages provide measurements of the pressure required to expand the DMT membrane. The first measurement (A reading) is the pressure required to lift the membrane 0.1 mm off its seat so it is flush with the plane of the blade. The second measurement (B reading) is the pressure required to expand the membrane by an additional 1.0 mm into the soil. These pressures are used to estimate the in-situ lateral stress and lateral soil stiffness. DMT results have been correlated with other soil properties and used as the basis for some engineering design methodologies.

Field saturated hydraulic conductivity testing was conducted at a depth of about 5 feet adjacent to location DMT-2S using a constant head well permeameter. The constant head method is based on Darcy's Law, Q=kiA. The test involves creating a ponded height of water in an open well or borehole to establish a bulb of field saturated soil around the base of the borehole. Once the saturated bulb becomes established, the flow of water out of the borehole and into the soil should approach a constant rate (steady state flow). To accomplish the tests, boreholes were augered to the requested testing depths. After the inserting the permeameter into the boreholes, measurements of flow and time were recorded until a relatively steady flow rate was observed or until it was obvious that a steady state flow would not be achieved. The field saturated hydraulic conductivity, K_{fsat}, was calculated according to the procedures of Reynolds et al. (1993) and the US Bureau of Reclamation (1990).

Exploration Results

The subsurface conditions encountered at the testing locations are shown on the soil boring, cone penetration test and dilatometer test records in Appendix B. The soil boring records represent our interpretation of the subsurface conditions based on visual examination of the field samples obtained and laboratory classification testing on selected samples. The CPT and DMT sounding records represent direct measurement and interpretation of the subsurface conditions based on published correlations to strength, stiffness, behavior and other index properties. The lines designating the interface between various strata on the testing records represent the approximate interface location. In addition, the transition between strata may be gradual. The material types and strata depths shown on the testing records are not necessarily representative of all conditions that will be encountered during construction. Water levels shown on the soil boring and in-situ sounding records only represent the water conditions that were encountered during the exploration.

Soil Stratigraphy

The interpreted subsurface profile from the testing locations is composed of six general stratigraphic layers. Figure 3 and Drawing 3 in Appendix A show an estimated subsurface profile based on the findings from the specific test locations. Variations between the estimated profile and actual subsurface conditions should be expected.

STRATUM A is composed of uncontrolled FILL that consisted of sandy clay mixed with crushed stone and organic material. It was encountered in the upper 2 to 3 feet at the DMT locations and may extend deeper in other locations based on prior studies at the site. Stratum A is believed to be a result of previous building demolition and prior or current construction and earth moving activities.

STRATUM 1 was encountered during prior investigations at the MCSFR complex but was not encountered at the test locations for this project.

STRATUM 2 is composed of soft to stiff, low and high plasticity, silty and sandy CLAY (CL, CH, CL-ML) with occasional traces of roots and gravel. It was encountered below Stratum A or surface materials and

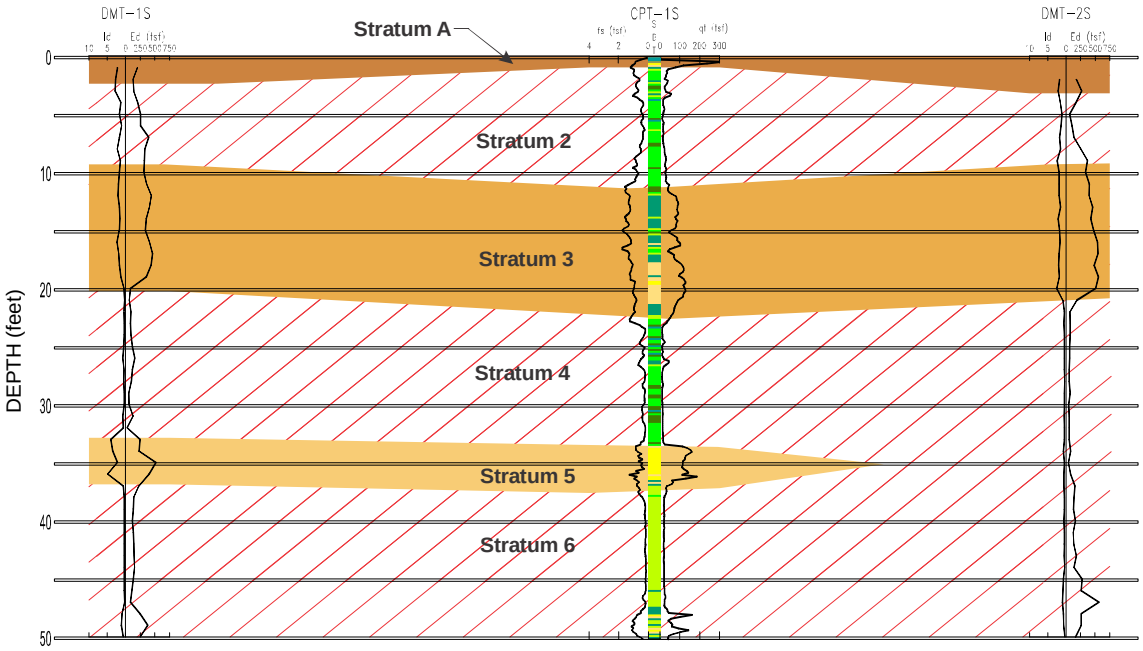


Figure 3. *Estimated Subsurface Profile*

extended to depths ranging from about 9 to 12 feet below the ground surface. DMT modulus (E_D) ranged from about 70 to 730 ksf and averaged about 420 ksf in Stratum 2. CPT tip resistance (qt) ranged from about 12 to 60 tsf and averaged about 26 tsf.

STRATUM 3 is composed of loose to firm clayey and silty SAND (SC, SM) with clay lenses. It was encountered below Stratum 2 and extended to depths of about 20 to 22 feet below the ground surface in the soundings. DMT modulus in Stratum 3 ranged from about 120 to 1060 ksf and averaged about 750 ksf. CPT tip resistance ranged from about 40 to 130 tsf and averaged about 90 tsf.

STRATUM 4 is composed of soft to firm CLAY and clayey SILT. It was encountered below Stratum 3 and extended to depths of about 32 to 35 feet below the ground surface in soundings CPT-1S and DMT-1S. It was not indicated at location DMT-2S. DMT modulus ranged from about 30 to 260 ksf and averaged about 100 ksf. CPT tip resistance ranged from about 10 to 44 tsf and averaged about 16 tsf.

STRATUM 5 was encountered at locations DMT-1S and CPT-1S from below Stratum 4 and extended to depths of about 37 feet below the ground surface. It is composed of firm to dense SAND and silty sand with shell. DMT modulus ranged from about 400 to 990 ksf and averaged about 600 ksf. CPT tip resistance ranged from about 60 to 190 tsf and averaged about 120 tsf.

STRATUM 6 was encountered below Stratum 5 in DMT-1S and CPT-1S and below Stratum 4 in DMT-2S and extended to the termination depths of the soundings conducted for this study. Stratum 6 is composed of interlayered soft to stiff CLAY and loose to dense SAND with shell. DMT modulus ranged from about 110 to 1070 ksf and averaged about 310 ksf. CPT tip resistance ranged from about 20 to 160 tsf and averaged about 50 tsf with the lower and higher resistances in the clay and sand layers, respectively.

Groundwater

The static groundwater table was encountered in the DMT and CPT soundings at depths of approximately 21 feet below existing grades. The observed groundwater levels represent the conditions encountered at the time frame of the exploration and do not necessarily indicate the water conditions that will be

encountered during construction. Fluctuation in the water levels may occur due to variations in precipitation, evaporation, tides, construction activity, surface runoff and other local factors.

We expect the reported groundwater table depths would lie between the normal seasonal low and high conditions based on the time of year in which the investigation was made and the amount of precipitation that has occurred prior to conducting this investigation. Seasonal high water table conditions are expected to be within 10 feet of the ground surface based on soil color, texture and redoxomorphic characteristics. Additionally, seams of perched water within the upper soils should be expected locally.

Surface Materials

The ground surface at testing location DMT-1S consisted of sedimentation from runoff and fill soils. At location CPT-1S, the surface was composed of approximately 6 inches of crushed stone mixed with orange low plasticity clay resulting from stockpiling of soils on the site and a construction entrance leading to it from the parking lot. Location DMT-2S was in a grassy portion of the site and consisted of approximately 6 inches of topsoil-like material. The thickness and composition of the surface materials can be expected to vary across the project limits.

Laboratory Testing

Appendix C of this report presents the results of the following geotechnical laboratory tests performed on selected disturbed soil samples recovered from the soil borings:

- 8 natural moisture content (ASTM D2216)
- 2 sieve analysis with #200 wash (ASTM D422, D1140)
- 6 Atterberg limits (ASTM D4318)

Chemical analyses of the composite soil sample collected from location CPT-1S included benzene, toluene, ethyl benzene and xylene (BTEX), total petroleum hydrocarbons (TPH) for both diesel and gasoline range organics (DRO & GRO), and toxicity characteristic leaching procedure (TCLP) for the 8 Resource Conservation Recovery Act (RCRA) metals. The test results did not detect the presence of any of these constituents above the laboratory reporting limits (RL). Complete analytical results are provided in Appendix C.

Soil Permeability

A field saturated hydraulic conductivity test to estimate in-situ soil permeability was conducted in the Stratum 2 clay at a depth of approximately 5 feet below the ground surface at location DMT-2S. The result of the test was an average soil permeability of less than 0.2 inch per hour Test results are provided in Appendix B.

Limitations

Regardless of the thoroughness of a geotechnical exploration, there is always a possibility that conditions between soundings or borings will be different from those encountered at the specific sounding or boring locations and that conditions will not be as anticipated by the designers or contractors. In addition, soil and groundwater conditions may become altered by construction activity and the passage of time. These possibilities should be considered. Unanticipated conditions should be reported to the design team along with timely recommendations to solve the problems encountered or created.

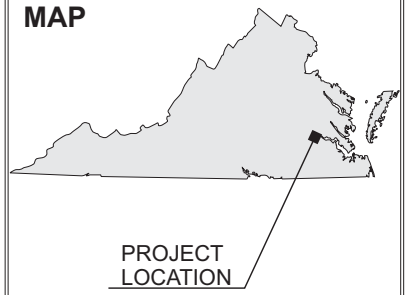
We have performed our services expressly for our client using that degree of care and skill ordinarily exercised under similar conditions by reputable members of our profession practicing in the same or similar locality. No other warranty, expressed or implied, is made. Third parties that rely on this report recognize that environmental and geologic conditions can vary from those encountered at the times and

locations where data are obtained, and that the limitation on available data may result in some level of uncertainty with respect to the interpretation of those conditions, despite due professional care.

APPENDIX A

DRAWINGS

VICINITY MAP



SOURCE:

Yorktown, VA
USGS 7.5 Minute Topographic Quadrangle, 2013

SCALE:

not to scale

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SITE LOCATION PLAN

P-991 MCSFR Bachelor Enlisted Quarters
NWS Yorktown, Virginia

PROJECT NUMBER	DRAWING NUMBER
110-6619	1

SCALE:

Not to scale

LEGEND:

- Approximate DMT Sounding Location
- Approximate CPT Sounding Location
- Approximate Field Infiltration Test Location

NOTES:
Field testing locations were not surveyed and may be several feet from the locations indicated. Testing locations shall be considered approximate.

Site plan underlay courtesy of Google Earth.

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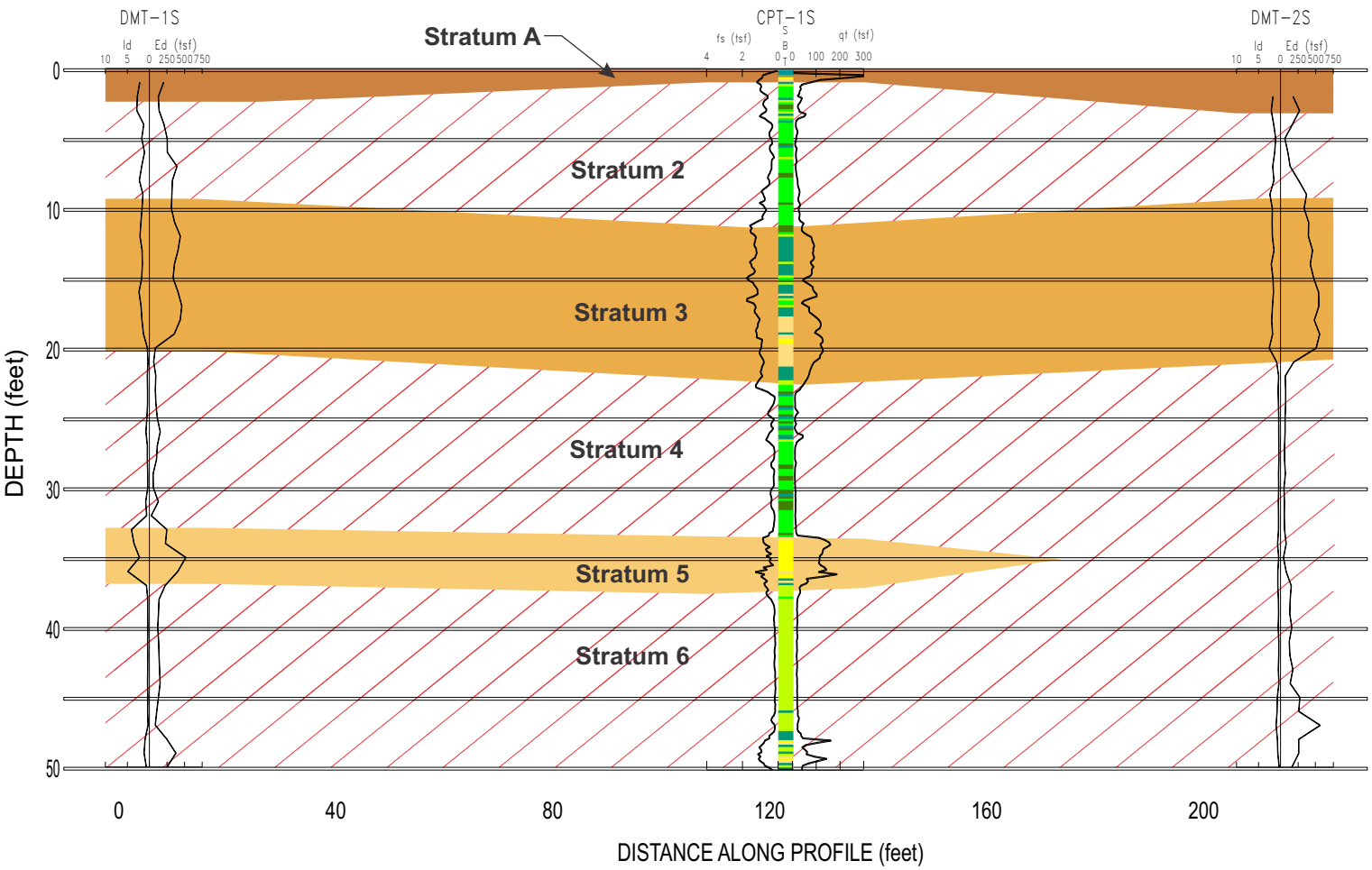
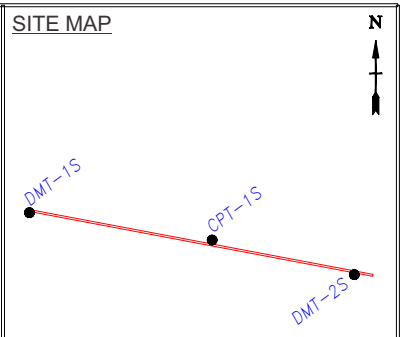
TESTING LOCATION PLAN

P-991 MCSFR Bachelor Enlisted Quarters
NWS Yorktown, Virginia

PROJECT NUMBER	DRAWING NUMBER
110-6619	2



SITE MAP



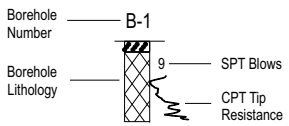
NOTES

The subsurface conditions presented are interpreted based on the data collected at specific test locations only. Actual subsurface conditions will likely vary from those indicated.

Not all testing locations and depths are shown for improved viewing.

Elevations and strata depths shown shall be considered approximate.

Explanation



Water level reading during drilling

Water level reading after drilling

? Denotes additional uncertainty

INTERPRETED STRATIGRAPHY

Stratum A: FILL as sandy clay mixed with crushed stone and organic material
Stratum 1: Not encountered during this investigation
Stratum 2: Soft to stiff, low and high plasticity, sandy and silty CLAY (CL, CH, CL-ML)
Stratum 3: Loose to firm clayey and silty SAND (SC, SM) with clay lenses
Stratum 4: Soft to firm CLAY and clayey SILT
Stratum 5: Firm to dense SAND and silty sand with SHELL
Stratum 6: Interlayered soft to stiff CLAY and loose to dense SAND with shell

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SUBSURFACE PROFILE

P-991 MCSFR Bachelor Enlisted Quarters
NWS Yorktown, Virginia

PROJECT NUMBER	DRAWING NUMBER
110-6619	3

APPENDIX B

FIELD TEST DATA

SUBSURFACE EXPLORATION PROGRAM SUMMARY

P-991 Bachelor Enlisted Quarters (MCSFR)
Naval Weapons Station, Yorktown, Virginia
GER Project No. 110-6619

TEST LOCATION DATA

Test Location	Geographic Coordinates		Test Date	Test Depth (ft)	Surface Elevation (ft)	Notes
	Latitude	Longitude				
CPT-1S	37.21716	-76.58387	12/15/2014	75		Env. Sample, Soil Boring
DMT-1S	37.21721	-76.58428	12/15/2014	50		Soil Boring
DMT-2S	37.21708	-76.58357	12/15/2014	50		Infiltration Test, Soil Boring

NOTES:
1. Coordinates are WGS84 and shall be considered accurate to no more than 10 feet.
2. Borings were field located using a handheld GPS device and were not physically surveyed.
3. Test location ground elevations are unknown due to site disturbance from nearby construction activities.

TEST BORING RECORDS

The enclosed test boring records represent our interpretation of the subsurface conditions encountered at the specific boring locations at the time explorations were made based on visual examination of the field samples obtained and selected laboratory classification testing if performed. The lines designating the interface between various strata on the boring records represent the approximate interface location. In addition, the transition between strata may be more gradual than indicated. Water levels shown represent the conditions only at the time of the field exploration. It is possible that soil and groundwater conditions between the individual boring locations will be different from those indicated. Boring surface and strata elevations, if shown, shall be considered approximate and are referenced to project datum shown on the plans or described in the geotechnical report unless noted otherwise.

BORING LOG LEGEND

KEY TO DRILLING SYMBOLS

Split Spoon Sample (ASTM D 1586)		Water Table at Time of Drilling		**H.S.A.**	Hollow Stem Auger Drilling
Undisturbed Sample (ASTM D 1587)		Water Table after 24 hrs.		**M.R.**	Mud Rotary Wash Drilling
Rock Coring (ASTM D 2113)		Boring Cave In		**PP**	Pocket Penetrometer (tsf)
		Loss of Drilling Fluid		**REC**	Core Recovery (%)
		Auger Refusal		**RQD**	Rock Quality Designator (%)
Roller Cone Advanced		Roller Cone Refusal		**SCR**	Solid Core Recovery (%)
Seepage into Borehole	———	Approximate Strata Change Depth Different Soil Types	--------		Approximate Strata Change Depth Similar Soil Types

CORRELATION OF RELATIVE DENSITY AND CONSISTENCY WITH STANDARD PENETRATION TEST RESISTANCE (ASTM D 1586)[§]

SPT RESISTANCE (N) IN BLOWS PER FOOT

SPT N	RELATIVE DENSITY[†] SAND & GRAVEL	SPT N	CONSISTENCY[†] SILT & CLAY
0 - 4	Very Loose	0 - 2	Very Soft
5 - 10	Loose	3 - 4	Soft
11 - 30	Firm	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
51 +	Very Dense	16 - 30	Very Stiff
		31 - 50	Hard
		51 +	Very Hard

ROCK QUALITY[‡]

FRACTURES, JOINT SPACING AND BEDDING

RQD (%)	DIAGNOSTIC DESCRIPTION	ROCK PARAMETER FIELD/LAB RATIO	SPACING	JOINTS	BEDDING
0 - 25	Very Poor	0.15	Less than 2"	Very Close	Very Thin
25 - 50	Poor	0.20	2" to 1'	Close	Thin
50 - 75	Fair	0.25	1' to 3'	Moderately Close	Medium
75 - 90	Good	0.30 to 0.70	3' to 10'	Wide	Thick
90 - 100	Excellent	0.70 to 1.00	More than 10'	Very Wide	Very Thick

HARDNESS

Very Hard - Breaking specimens requires several hard hammer blows

Hard - Hard hammer blow required to detach specimens

Moderately Hard - Light hammer blow required to detach specimens

Medium - May be scratched 1/16" deep by a knife or nail, breaks into several pieces by light hammer blow

Soft - Can be gouged readily by knife or nail, corners and edges broken by finger pressure

Very Soft - May be carved with a knife and readily broken by finger pressure

WEATHERING

Fresh - Fresh rock, bright crystals, no staining

Slight - Minimum stainaing and discoloration, open joints contain clay

Moderate - Significant portions of rock shows staining and discoloration, strong rock fragments

Severe - All rock shows staining, rock fabric evident but reduced strength

Very Severe - All rock shows staining, rock mass effectively reduced to soil with strong rock fragments remaining

Complete - Rock reduced to soil with rock fabric not discernable

[§] *Resistance of a standard 2-inch O.D., 1.375-inch I.D. split spoon sampler driven by a 140 pound hammer free-falling 30 inches.*

[†] *after Terzaghi and Peck, 1968*

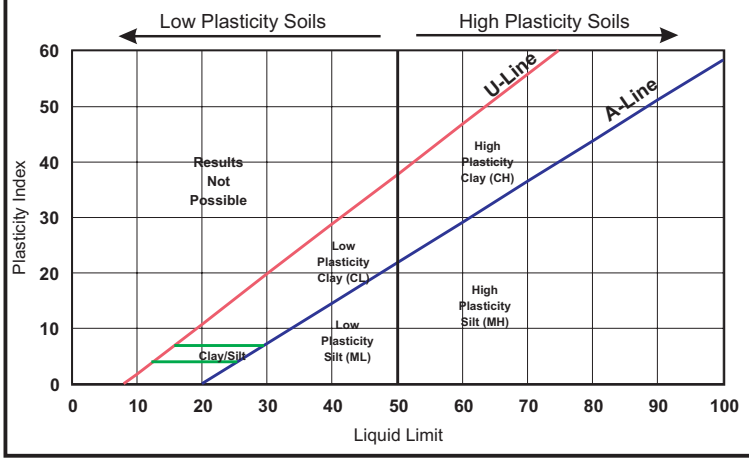
[‡] *after D. U. Deere, 1963, 1967*

GER

SOIL CLASSIFICATION CHART (ASTM D 2487)

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LOW PLASTICITY LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, CLAYEY SILTS, SILT-VERY FINE SAND MIXTURES, ROCK FLOUR
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY, SANDY, SILTY, & LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC CLAYS OF LOW PLASTICITY
		HIGH PLASTICITY LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS AND MICACEOUS, DIATOMACEOUS AND ELASTIC SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
OTHER SOILS	HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, MUCK, SWAMP SOILS WITH VERY HIGH ORGANIC CONTENTS
	UNCONTROLLED FILLS				DISTURBED SOILS WITH POSSIBLE DEBRIS AND RUBBLE, OLD CONSTRUCTION WASTES, NON-ENGINEERED BACKFILLS
	DECOMPOSED OR PARTIALLY WEATHERED ROCK				TRANSITIONAL MATERIAL BETWEEN SOIL AND ROCK WHICH MAY RETAIN THE RELICT STRUCTURE OF THE PARENT ROCK

Atterberg Limits



PARTICLE SIZE IDENTIFICATION

BOULDERS:		Greater than 300 mm (12 in.)
COBBLES:		75 mm to 300 mm (3 - 12 in.)
GRAVEL:	Coarse -	19.0 mm to 75 mm (0.75 - 3 in.)
	Fine -	4.75 mm to 19.0 mm (#4 - 0.75 in.)
SANDS:	Coarse -	2.00 mm to 4.75 mm
	Medium -	0.425 mm to 2.00 mm
	Fine -	0.075 mm to 0.425 mm
SILTS & CLAYS:		Less than 0.075 mm

PLASTICITY INDEX (PI) & SHRINK-SWELL POTENTIAL

0 - 4	None
4 - 15	Slight or Low
15 - 30	Medium to High
31+	High to Very High

ADDITIONAL RELATIVE DESCRIPTIVE VALUES

Trace < 10%	Some < 35% but > 20%
Little < 20% but > 10%	And > 35%

GER

SOIL BORING RECORD

GeoEnvironmental Resources, Inc. Environmental, Groundwater, Hazardous Materials, Geotechnical & Industrial Engineering Consultants		Boring No: **CPT-1S**
Project: **P-991 MCSFR BEQ**	GER Project Number: **110-6619**	Sheet No: **1** of **1**
Location: **NWS Yorktown, VA**	Driller: **ConeTec**	Date: **12/15/2014**
Depth (ft.): **12.0**	Elevation (ft.):	Client: **NAVFAC Mid-Atlantic**	Equipment: **Direct Push**

Elevation ft.	Elevation m	Depth ft.	Depth m	Lith-ology	Material Description	Ground Water	Comments
					6" AGGREGATE		Sample taken adjacent to CPT-1S
					Low Plasticity CLAY (CL) Mottled red, orange and grey, with trace organics		
			1				P.P. = 0.75 tsf
					Sandy, Silty CLAY (CL-ML) Brown, tan and orange, trace fine gravel		
		5					
					Low Plasticity CLAY (CL) Tan to tan and grey, trace organics		
			2				P.P. = 1.0 tsf
							P.P. = 1.25 tsf
		10	3				4 inch clayey sand layer with crushed stone at 10.5 feet
					Low Plasticity CLAY (CL) Grey to orange and red		P.P. = 1.25 tsf
					Boring terminated at 12 feet.		
			4				

GEOPROBE 6619 PROBE LOG.GPJ CPT.GDT 1/12/15

SOIL BORING RECORD

GeoEnvironmental Resources, Inc.	Environmental, Groundwater, Hazardous Materials, Geotechnical & Industrial Engineering Consultants	Boring No: **DMT-1S**
Project: **P-991 MCSFR BEQ**	GER Project Number: **110-6619**	Sheet No: **1** of **1**
Location: **NWS Yorktown, VA**	Driller: **ConeTec**	Date: **12/15/2014**
Depth (ft.): **12.0**	Elevation (ft.):	Client: **NAVFAC Mid-Atlantic**	Equipment: **Direct Push**

Elevation ft.	Elevation m	Depth ft.	Depth m	Lith-ology	Material Description	Ground Water	Comments
					FILL Sampled as red, sandy low plasticity clay with trace gravel, crushed stone and organics		Sample taken adjacent to DMT-1S P.P. = 0.75 tsf
			1		**High Plasticity CLAY (CH)** Red and orange to tan, with trace organics		P.P. = 2.25 tsf
		5					P.P. = 1.5 tsf
			2				P.P. = 1.75 tsf
							P.P. = 0.75 tsf
		10	3				P.P. = 1.25 tsf
					Silty SAND (SM) Orange, fine		
					Boring terminated at 12 feet.		
			4				

SOIL BORING RECORD

GeoEnvironmental Resources, Inc. Environmental, Groundwater, Hazardous Materials, Geotechnical & Industrial Engineering Consultants		Boring No: **DMT-2S**
Project: **P-991 MCSFR BEQ**	GER Project Number: **110-6619**	Sheet No: **1** of **1**
Location: **NWS Yorktown, VA**	Driller: **ConeTec**	Date: **12/15/2014**
Depth (ft.): **12.0**	Elevation (ft.):	Client: **NAVFAC Mid-Atlantic**	Equipment: **Direct Push**

Elevation ft.	Elevation m	Depth ft.	Depth m	Lith-ology	Material Description	Ground Water	Comments
					6" topsoil-like material		Sample taken adjacent to DMT-2S
					FILL Sampled as brown and orange low plasticity clay with trace organics and crushed stone		
					Low Plasticity CLAY (CL) Mottled orange and grey to tan and brown, with trace organics		P.P. = 1.5 tsf
			1				
		5					P.P. = 0.5 tsf
			2				
							P.P. = 1.25 tsf
							P.P. = 0.75 tsf
		10	3				
					Low Plasticity CLAY (CL) Orange, with little sand		3 inch layer of topsoil-like material at 9.67 feet P.P. = 1.5 tsf
					Clayey SAND (SC) Tan, fine to medium		
					Boring terminated at 12 feet.		
			4				

CPTu SOUNDINGS

References: ASTM D 5778, "**Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils**," Annual Book of ASTM Standards, Vol. 04.08, American Society for Testing and Materials, January 1996.

Lunne, T., Robertson, P.K., and Powell, J.J.M., "**Cone Penetration Testing in Geotechnical Practice**," Spoon Press, 1997.

Riaund, J. L. and Miran, J., "**The Cone Penetrometer Test**," Publication No. FHWA-SA-91-043, Final Report, U.S. Department of Transportation, Federal Highway Administration, February 1992.

Contractor: ConeTec, Inc.

Procedures: The CPT is a profiling tool described in ASTM D 5778 and various other publications. No physical soil sampling is conducted during the test. A compression model electronic piezocone penetrometer with a 15 cm^2 tip and a 225 cm^2 friction sleeve was used. The cone is designed with an equal end area friction sleeve and a tip end area ratio of 0.8. Prior to testing, the cone internal force transducers were calibrated in a laboratory. At the beginning of each sounding, the cone was outfitted with a vacuum-saturated, 6 mm thick porous plastic pore pressure element that is located immediately behind the tip (the u_2 location). The cone was advanced using a 15-ton hydraulic ramset mounted in a 25-ton truck or on a 20-ton tracked vehicle. As the cone was advanced into the ground, tip resistance (qc), sleeve friction (fs) and dynamic pore water pressure (u) were recorded every 2.5 centimeters (approximately every one inch).

Limitations: The enclosed testing records represent an interpretation of the subsurface conditions encountered at the specific testing locations at the time explorations were made. It is possible that subsurface conditions between testing locations will be different from those indicated. Strata contacts and surface elevations, if shown, shall be considered approximate and are referenced to project datum shown on the plans or described in the geotechnical report unless noted otherwise.

CPT SOIL BEHAVIOR TYPE (SBT)

KEY TO SBT COLORS SHOWN ON CPT LOGS

CPT RESISTANCE PROFILE LEGEND – NORMALIZED

- Sensitive Fine Grained (Silts & Clays)
- Organic Soils to Peat
- Clay – Clay to Silty Clay
- Silt Mixtures – Clayey Silt to Silty Clay
- Sand Mixtures–Silty Sand to Sandy Silt
- Sand – Clean Sand to Silty Sand
- Gravelly Sand to Sand
- Very Stiff Clay to Clayey Sand
- Very Stiff Fine Grained Soils
- Very Stiff Clay to Clayey Sand

CPT RESISTANCE PROFILE LEGEND – NON–NORMALIZED

- Sensitive Fine Grained (Silts & Clays)
- Organic Soils to Peat
- Clay
- Clay to Silty Clay
- Clayey Silt to Silty Clay
- Sandy Silt to Clayey Silt
- Silty Sand to Sandy Silt
- Sand to Silty Sand
- Sand
- Gravelly Sand to Sand
- Very Stiff Fine Grained (Silt & Clay)
- Very Dense Sand to Clayey Sand

• **Notes**

Soil behavior type is the classification of the soil based on its behavior and not necessarily the actual soil type.

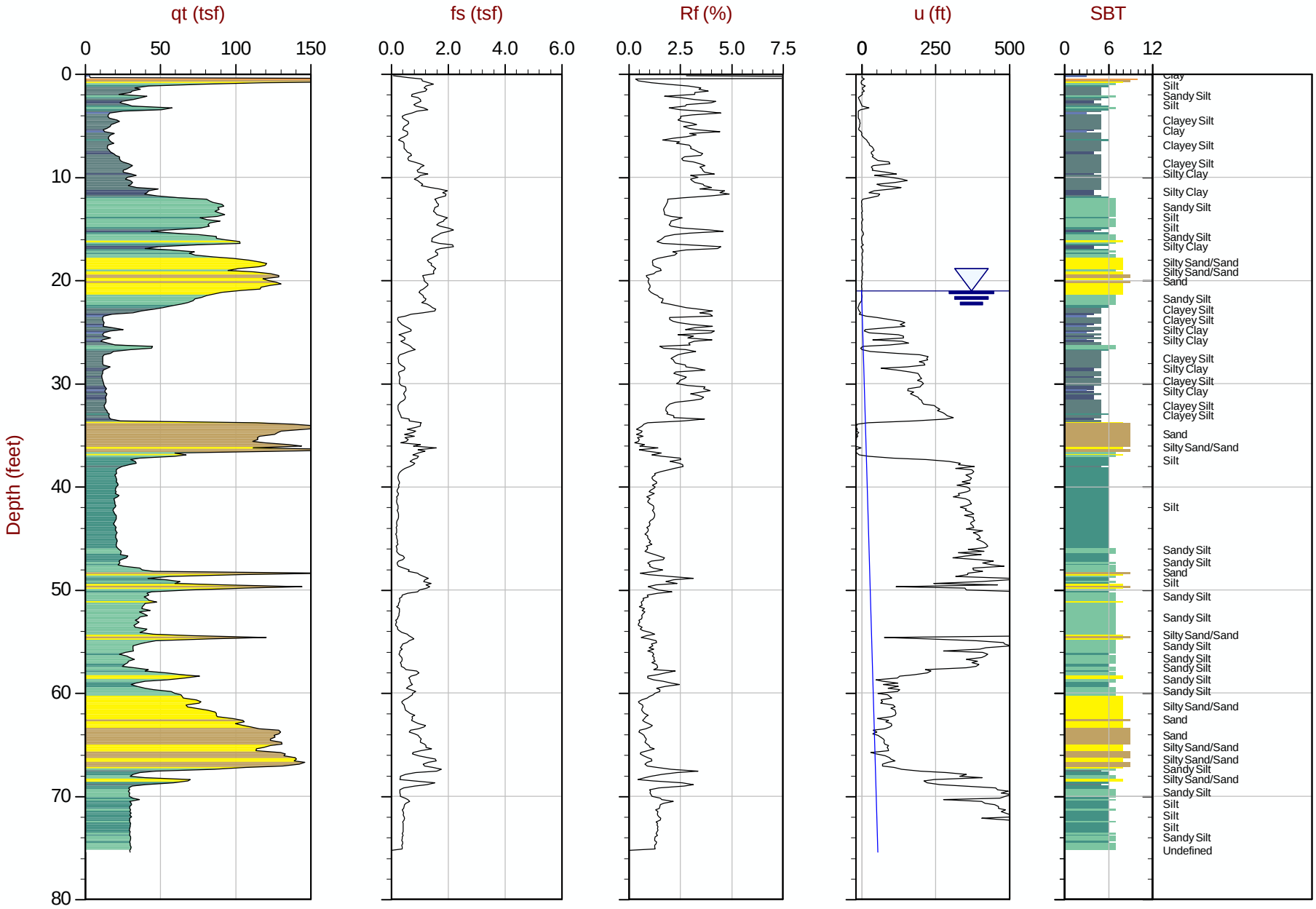
GER

CONETEC

GeoEnvironmental Resources

Job No: 14-54115
Date: 12:15:14 14:04
Site: P-991 BEQ NWSY

Sounding: CPT-1S
Cone: 349:T1500F15U500



Max Depth: 23.000 m / 75.46 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 14-54115_CP01S.COR
Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell, 1997
Coords: N: 37.21703 E: -76.58387
Page No: 1 of 1

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

DMT SOUNDING DATA

References: Schmertmann, J. H., "**Suggested ASTM Method for Performing the Flat Dilatometer Test**," *Geotechnical Testing Journal*, GTJODJ, Vol. 9, No. 2, June 1986, pp. 93-101.

Marchetti, S., et al, "**The Flat Dilatometer Test (DMT) in Soil Investigations**," *Report of the ISSMGE Technical Committee 16 on Ground Property Characterization from In-situ Testing*, IN-SITU 2001, May 2001.

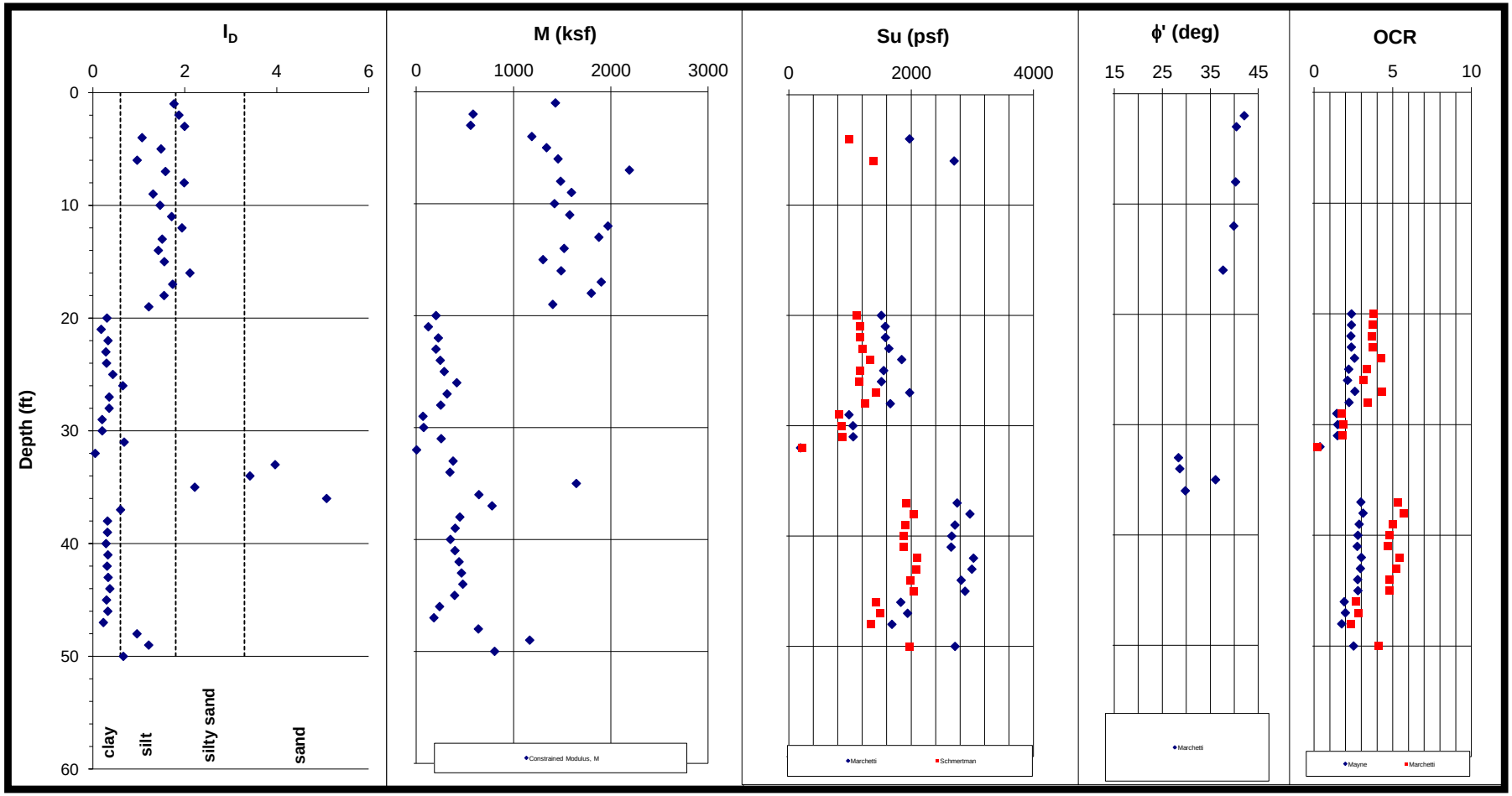
Riaund, J. L. And Miran, J., "**The Flat Dilatometer Test**," *Publication No. FHWA-SA-91-044*, Final Report, U.S. Department of Transportation, Federal Highway Administration, February 1992.

Contractor: ConeTec, Inc.

The enclosed testing records represent an interpretation of the subsurface conditions encountered at the specific testing locations at the time explorations were made. It is possible that subsurface conditions between testing locations will be different from those indicated. Surface and strata elevations, if shown, shall be considered approximate and are referenced to project datum shown on the plans or described in the geotechnical report unless noted otherwise.

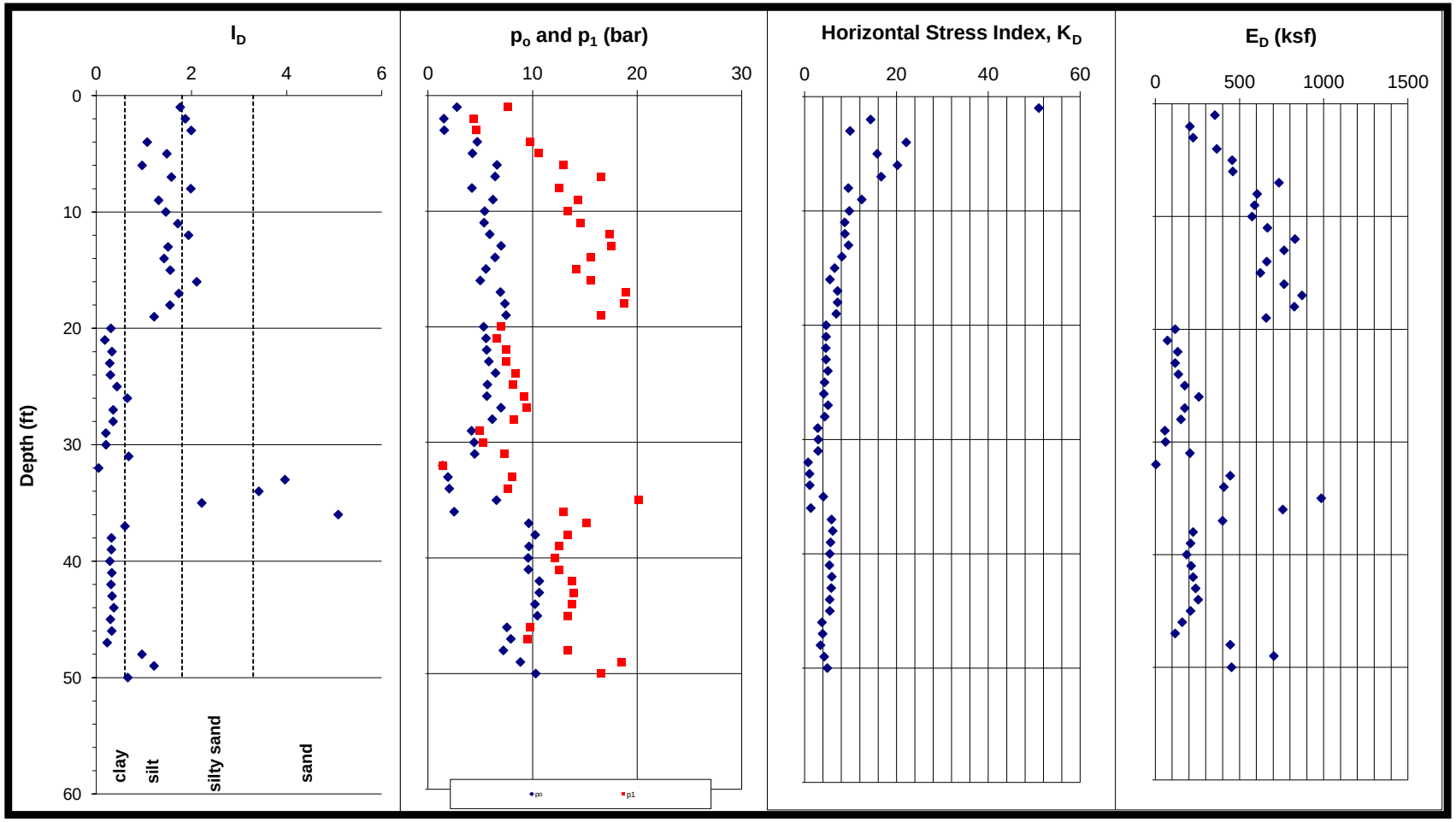
DILATOMETER TEST RESULTS

Job No.:	14-54115	Datum:	WGS 84 Lat/Long
Client:	GER	Latitude:	37.21721
Project:	P-991 BEQ NWSY	Longitude:	-76.58389
Sounding ID:	DMT-1S		
Date:	15-Dec-14		



DILATOMETER TEST RESULTS

Job No.:	14-54115	Datum:	WGS 84 Lat/Long
Client:	GER	Latitude:	37.21721
Project:	P-991 BEQ NWSY	Longitude:	-76.58389
Sounding ID:	DMT-1S		
Date:	15-Dec-14		



Job No.:	14-54115	Datum:	WGS 84 Lat/Long
Client:	GER	Latitude:	37.21721
Project:	P-991 BEQ NWSY	Longitude:	-76.58389
Sounding ID:	DMT-1S		
Date:	15-Dec-14		
Ground Water Depth (ft):	21.0		
Zm (bar):	0.0		

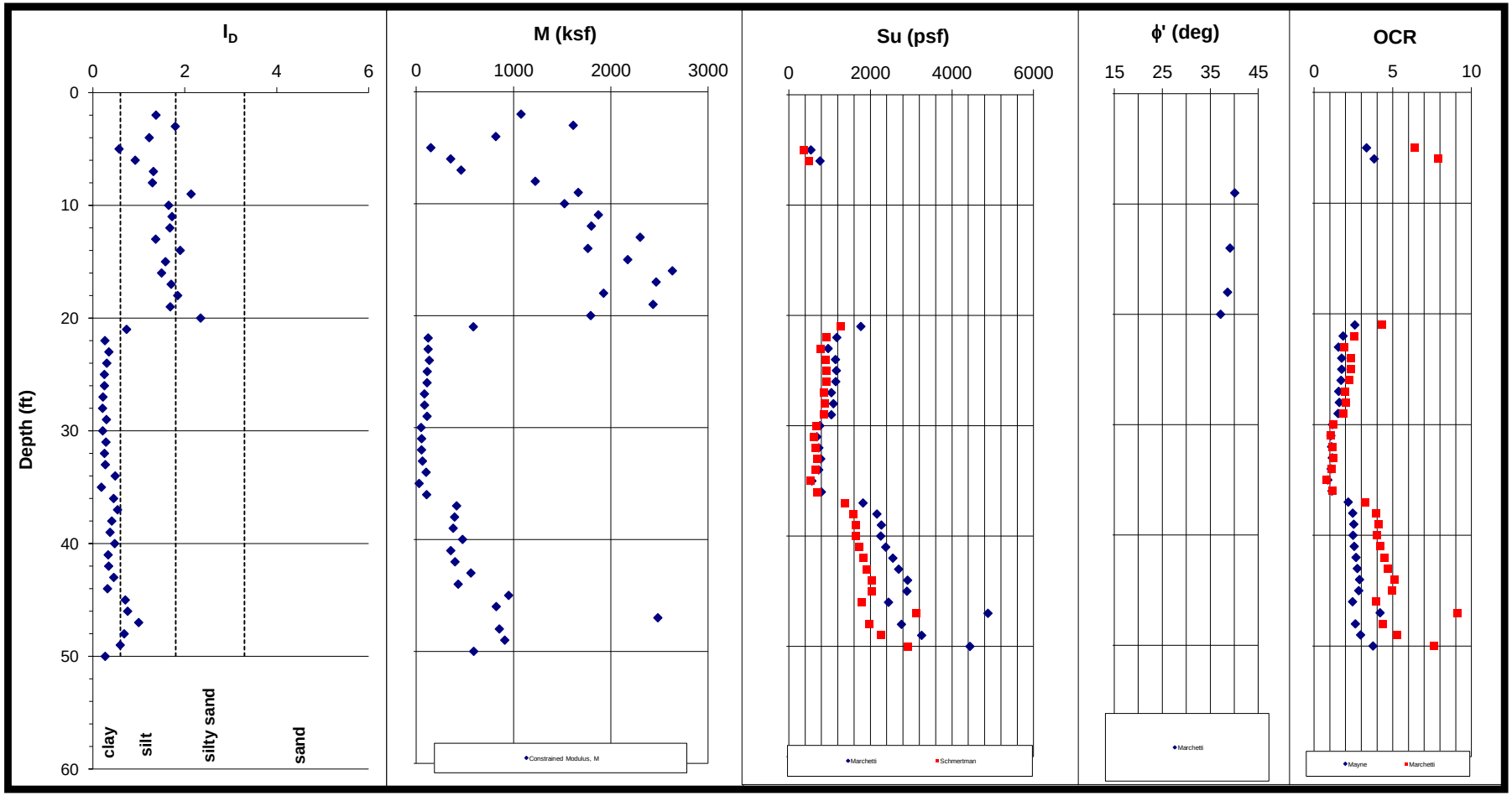
DILATOMETER TEST RESULTS

Depth[1] (ft)	A (bar)	B (bar)	C (bar)	Average ΔA (bar)	Average ΔB (bar)	p_o (bar)	p_1 (bar)	p_2 (bar)	u_o (psf)	γ_T[2] (pcf)	σ_{vo} (psf)	σ_{vo}' (psf)	I_D	K_D	E_D (bar)	K_o	OCR[3]	OCR[4]	φ'[4] (deg)	R_M	E_D (ksf)	s_u[4] (psf)	s_u[5] (psf)	M (ksf)
1.0	2.80	8.10		0.20	0.45	2.8	7.7		0	113	113	113	1.76	51.0	169					4.0	354			1430
2.0	1.45	4.80		0.20	0.45	1.5	4.4		0	107	220	220	1.87	14.4	98				42.1	2.8	205			584
3.0	1.50	5.10		0.20	0.45	1.6	4.7		0	108	328	328	2.00	9.9	107				40.4	2.5	224			559
4.0	4.75	10.20		0.20	0.45	4.7	9.8		0	117	445	445	1.07	22.1	175	2.9	11.3	42.5		3.3	365	1973	984	1188
5.0	4.35	11.00	0.4	0.20	0.45	4.3	10.6	0.6	0	117	562	562	1.48	15.8	219					2.9	457			1339
6.0	6.70	13.40		0.20	0.45	6.6	13.0		0	120	682	682	0.96	20.2	220	2.8	10.3	36.9		3.2	460	2702	1378	1458
7.0	6.70	17.00		0.20	0.45	6.4	16.6		0	123	804	804	1.58	16.7	352					3.0	734			2191
8.0	4.40	13.00		0.20	0.45	4.2	12.6		0	119	923	923	1.99	9.5	290				40.3	2.5	605			1484
9.0	6.40	14.80		0.20	0.45	6.2	14.4		0	121	1044	1044	1.31	12.4	282					2.7	590			1596
10.0	5.60	13.80		0.20	0.45	5.4	13.4		0	120	1165	1165	1.46	9.7	275					2.5	575			1421
11.0	5.60	15.00		0.20	0.45	5.4	14.6		0	121	1285	1285	1.71	8.7	319					2.4	666			1577
12.0	6.25	17.80		0.20	0.45	5.9	17.4		0	123	1408	1408	1.94	8.8	397				39.9	2.4	829			1970
13.0	7.30	18.00		0.20	0.45	7.0	17.6		0	123	1532	1532	1.51	9.5	366					2.5	765			1877
14.0	6.65	16.00		0.20	0.45	6.4	15.6		0	122	1654	1654	1.42	8.1	317					2.3	662			1520
15.0	5.75	14.60		0.20	0.45	5.5	14.2		0	121	1774	1774	1.55	6.5	299					2.1	624			1303
16.0	5.30	16.00		0.20	0.45	5.0	15.6		0	121	1896	1896	2.11	5.5	366				37.7	1.9	765			1489
17.0	7.30	19.40		0.20	0.45	6.9	19.0		0	124	2020	2020	1.74	7.2	417					2.2	871			1902
18.0	7.70	19.20		0.20	0.45	7.4	18.8		0	124	2144	2144	1.55	7.2	395					2.2	826			1799
19.0	7.70	17.00		0.20	0.45	7.5	16.6		0	123	2267	2267	1.22	6.9	315					2.1	658			1403
20.0	5.20	7.40	2.5	0.20	0.45	5.3	7.0	2.7	0	111	2378	2378	0.31	4.7	56	1.1	2.4	3.8		1.7	118	1512	1112	203
21.0	5.40	7.00		0.20	0.45	5.6	6.6		0	108	2486	2486	0.18	4.7	35	1.1	2.4	3.7		1.7	72	1576	1160	124
22.0	5.50	7.90		0.20	0.45	5.6	7.5		62	112	2598	2536	0.33	4.6	64	1.1	2.3	3.7		1.7	133	1579	1166	227
23.0	5.70	7.90		0.20	0.45	5.8	7.5		125	111	2709	2584	0.28	4.7	56	1.1	2.4	3.7		1.7	118	1635	1204	202
24.0	6.35	8.80		0.20	0.45	6.5	8.4		187	113	2822	2635	0.30	5.0	66	1.2	2.6	4.2		1.8	137	1845	1330	247
25.0	5.60	8.55	2.7	0.20	0.45	5.7	8.1	2.9	250	113	2935	2686	0.43	4.3	84	1.0	2.2	3.3		1.6	175	1551	1162	287
26.0	5.60	9.65		0.20	0.45	5.6	9.2		312	115	3051	2739	0.65	4.2	124	1.0	2.1	3.2		1.6	259	1514	1145	416
27.0	6.90	9.85		0.20	0.45	7.0	9.4		374	114	3165	2791	0.35	5.1	84	1.2	2.6	4.3		1.8	175	1975	1421	317
28.0	6.05	8.70		0.20	0.45	6.2	8.3		437	113	3278	2841	0.35	4.4	73	1.1	2.2	3.4		1.7	152	1659	1241	251
29.0	4.00	5.40		0.20	0.45	4.2	5.0		499	105	3383	2884	0.20	2.8	27	0.8	1.4	1.7		1.2	57	984	819	69
30.0	4.25	5.70		0.20	0.45	4.4	5.3		562	106	3489	2928	0.20	3.0	29	0.8	1.5	1.8		1.3	61	1049	865	76
31.0	4.40	7.75	1.0	0.20	0.45	4.5	7.3	1.2	624	113	3602	2978	0.68	2.9	98	0.8	1.5	1.8		1.2	205	1052	870	256
32.0	1.20	1.90		0.20	0.45	1.4	1.5		686	86	3688	3002	0.05	0.7	2	0.1	0.4	0.2		0.9	4	192	223	3
33.0	2.00	8.50		0.20	0.45	1.9	8.1		749	111	3799	3051	3.97	1.1	213				28.4	0.9	445			378
34.0	2.10	8.10		0.20	0.45	2.0	7.7		811	111	3911	3099	3.42	1.1	195				28.6	0.9	407			346
35.0	7.00	20.60		0.20	0.45	6.6	20.2		874	124	4035	3161	2.22	4.1	472				36.1	1.7	985			1645
36.0	2.80	13.40		0.20	0.45	2.5	13.0		936	116	4151	3215	5.09	1.3	363				29.8	0.9	757			644
37.0	9.70	15.60		0.20	0.45	9.6	15.2		998	121	4272	3273	0.60	5.8	191	1.3	3.0	5.3		1.9	400	2751	1913	779
38.0	10.20	13.80		0.20	0.45	10.3	13.4		1061	118	4390	3329	0.32	6.1	107	1.3	3.1	5.7		2.0	224	2960	2035	448
39.0	9.60	13.00		0.20	0.45	9.7	12.6		1123	117	4507	3384	0.32	5.6	100	1.3	2.9	5.0		1.9	209	2716	1906	400
40.0	9.50	12.60	6.0	0.20	0.45	9.6	12.2	6.2	1186	116	4623	3438	0.29	5.5	89	1.2	2.8	4.8		1.9	186	2662	1882	351
41.0	9.55	13.00		0.20	0.45	9.6	12.6		1248	117	4741	3493	0.33	5.4	102	1.2	2.7	4.7		1.9	213	2653	1882	398
42.0	10.60	14.20		0.20	0.45	10.7	13.8		1310	118	4859	3548	0.31	5.9	107	1.3	3.0	5.4		2.0	224	3018	2094	440
43.0	10.60	14.40		0.20	0.45	10.6	14.0		1373	119	4977	3605	0.33	5.8	115	1.3	2.9	5.2		1.9	240	2992	2085	465
44.0	10.20	14.20		0.20	0.45	10.2	13.8		1435	119	5096	3661	0.37	5.4	122	1.2	2.8	4.8		1.9	255	2817	1994	479
45.0	10.40	13.80	5.7	0.20	0.45	10.5	13.4	5.9	1498	118	5214	3716	0.30	5.5	100	1.2	2.8	4.8		1.9	209	2880	2035	394
46.0	7.45	10.20		0.20	0.45	7.5	9.8		1560	114	5328	3768	0.32	3.8	77	0.9	1.9	2.7		1.5	160	1830	1420	240
47.0	7.80	10.00		0.20	0.45	7.9	9.6		1622	113	5440	3818	0.23	3.9	56	1.0	2.0	2.8		1.5	118	1941	1492	181
48.0	7.30	13.80		0.20	0.45	7.2	13.4		1685	120	5560	3875	0.96	3.5	213	0.9	1.8	2.3		1.4	445	1685	1337	638
49.0	9.10	19.00		0.20	0.45	8.8	18.6		1747	124	5683	3936	1.21	4.2	337					1.7	704			1166
50.0	10.40	17.00	2.8	0.20	0.45	10.3	16.6	3.0	1810	122	5805	3996	0.66	4.9	217	1.1	2.5	4.1		1.8	453	2717	1971	805

1. Depth is referenced below the exisiting ground surface at the time of testing.
2. Mayne et al., 2002
3. Mayne, 1995
4. Marchetti et al., 2001
5. Schmertman, 1991

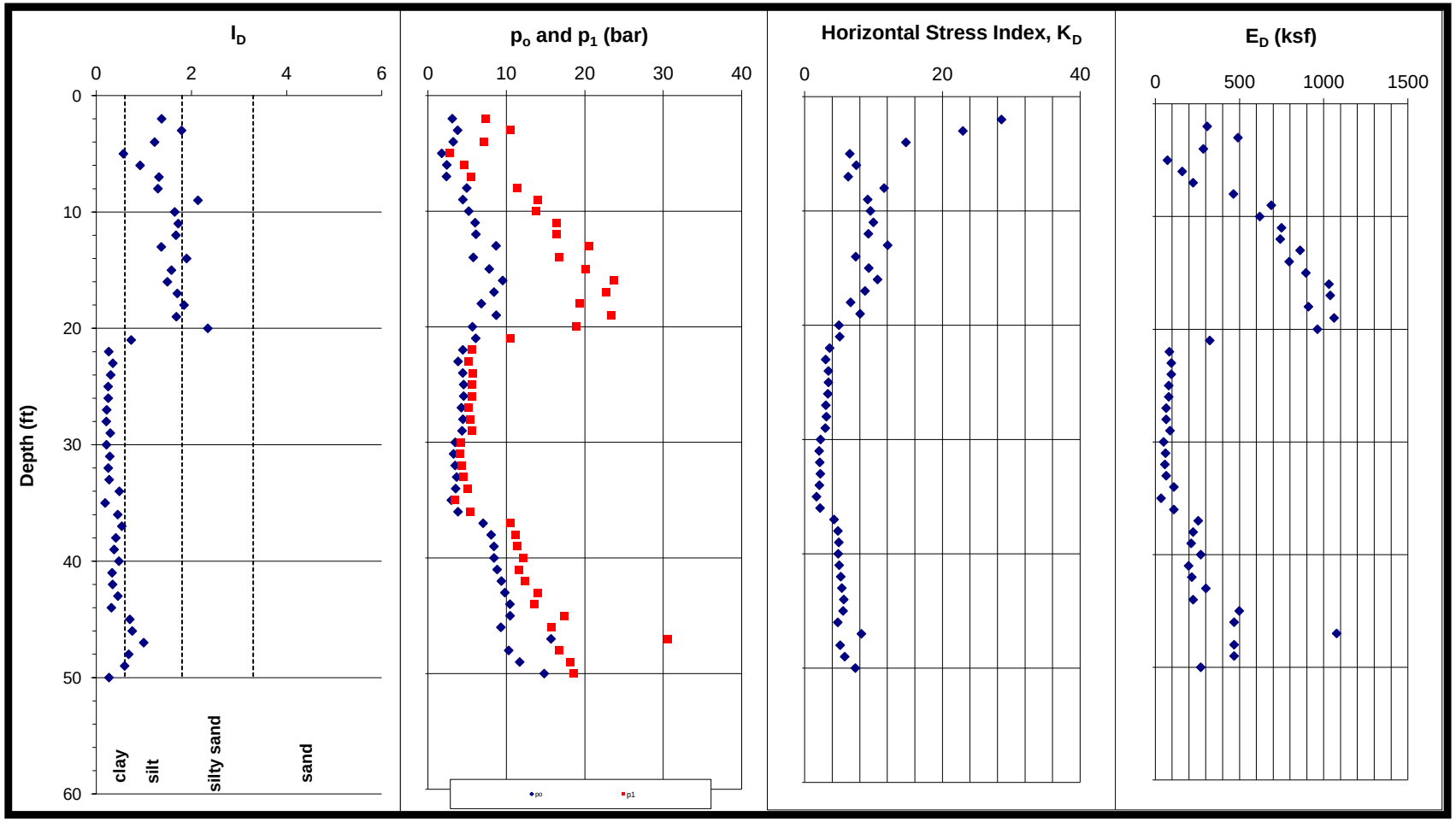
DILATOMETER TEST RESULTS

Job No.:	14-54115	Datum:	WGS 84 Lat/Long
Client:	GeoEnvironmental Resources	Latitude:	37.21708
Project:	P-991 BEQ NWSY	Longitude:	-76.58357
Sounding ID:	DMT-2S		
Date:	15-Dec-14		



DILATOMETER TEST RESULTS

Job No.:	14-54115	Datum:	WGS 84 Lat/Long
Client:	GeoEnvironmental Resources	Latitude:	37.21708
Project:	P-991 BEQ NWSY	Longitude:	-76.58357
Sounding ID:	DMT-2S		
Date:	15-Dec-14		



Job No.:	14-54115	Datum:	WGS 84 Lat/Long
Client:	GeoEnvironmental Resources	Latitude:	37.21708
Project:	P-991 BEQ NWSY	Longitude:	-76.58357
Sounding ID:	DMT-2S		
Date:	15-Dec-14		
Ground Water Depth (ft):	21.0		
Zm (bar):	0.0		

DILATOMETER TEST RESULTS

Depth[1] (ft)	A (bar)	B (bar)	C (bar)	Average ΔA (bar)	Average ΔB (bar)	p_o (bar)	p_1 (bar)	p_2 (bar)	u_o (psf)	γ_T[2] (pcf)	σ_{vo} (psf)	σ_{vo}' (psf)	I_D	K_D	E_D (bar)	K_o	OCR[3]	OCR[4]	φ'[4] (deg)	R_M	E_D (ksf)	s_u[4] (psf)	s_u[5] (psf)	M (ksf)
2.0	3.10	7.80		0.20	0.45	3.1	7.4		0	113	226	226	1.37	28.6	148					3.5	308			1077
3.0	3.90	11.00		0.20	0.45	3.8	10.6		0	117	343	343	1.79	23.0	235					3.3	491			1614
4.0	3.20	7.60		0.20	0.45	3.2	7.2		0	113	456	456	1.23	14.7	137					2.9	285			817
5.0	1.60	3.20	0.10	0.20	0.45	1.8	2.8	0.3	0	102	559	559	0.57	6.6	35	1.4	3.3	6.4		2.1	72	542	366	149
6.0	2.30	5.05		0.20	0.45	2.4	4.6		0	108	667	667	0.92	7.5	77	1.5	3.8	7.9		2.2	160	766	500	353
7.0	2.30	5.90		0.20	0.45	2.4	5.5		0	110	777	777	1.32	6.3	107					2.1	224			461
8.0	5.05	11.80		0.20	0.45	4.9	11.4		0	118	895	895	1.30	11.5	222					2.6	464			1223
9.0	4.70	14.40		0.20	0.45	4.4	14.0		0	120	1015	1015	2.14	9.2	330				40.1	2.4	689			1665
10.0	5.40	14.20		0.20	0.45	5.2	13.8		0	120	1135	1135	1.65	9.6	297					2.5	620			1523
11.0	6.30	16.80		0.20	0.45	6.0	16.4		0	122	1258	1258	1.72	10.0	359					2.5	750			1872
12.0	6.40	16.80		0.20	0.45	6.1	16.4		0	122	1380	1380	1.67	9.3	355					2.4	742			1800
13.0	9.05	21.00		0.20	0.45	8.7	20.6		0	125	1506	1506	1.37	12.0	412					2.7	860			2301
14.0	6.10	17.20		0.20	0.45	5.8	16.8		0	122	1628	1628	1.90	7.4	381				39.1	2.2	795			1764
15.0	8.20	20.60		0.20	0.45	7.8	20.2		0	125	1753	1753	1.58	9.3	428					2.4	894			2174
16.0	10.00	24.20		0.20	0.45	9.5	23.8		0	127	1880	1880	1.49	10.6	494					2.6	1031			2633
17.0	8.90	23.20		0.20	0.45	8.4	22.8		0	126	2007	2007	1.70	8.8	497					2.4	1039			2466
18.0	7.20	19.80		0.20	0.45	6.8	19.4		0	124	2131	2131	1.84	6.7	435				38.6	2.1	909			1925
19.0	9.20	23.80		0.20	0.45	8.7	23.4		0	127	2258	2258	1.68	8.1	508					2.3	1062			2434
20.0	6.10	19.40		0.20	0.45	5.7	19.0		0	124	2381	2381	2.34	5.0	461				37.1	1.9	963			1793
21.0	6.10	11.00		0.20	0.45	6.1	10.6		0	117	2499	2499	0.73	5.1	155	1.2	2.6	4.3		1.8	323	1766	1271	586
22.0	4.30	6.05		0.20	0.45	4.4	5.6		62	108	2607	2544	0.26	3.6	40	0.9	1.8	2.5		1.5	84	1177	922	122
23.0	3.70	5.60		0.20	0.45	3.8	5.2		125	108	2714	2590	0.35	3.0	46	0.8	1.6	1.9		1.3	95	964	789	122
24.0	4.30	6.20		0.20	0.45	4.4	5.8		187	109	2823	2636	0.30	3.4	46	0.9	1.8	2.3		1.4	95	1144	908	134
25.0	4.40	6.10	3.1	0.20	0.45	4.5	5.7	3.3	250	108	2931	2681	0.25	3.4	38	0.9	1.8	2.3		1.4	80	1166	925	113
26.0	4.40	6.10		0.20	0.45	4.5	5.7		312	108	3038	2726	0.25	3.4	38	0.9	1.7	2.3		1.4	80	1151	919	111
27.0	4.10	5.60		0.20	0.45	4.3	5.2		374	106	3145	2770	0.22	3.1	31	0.8	1.6	2.0		1.3	65	1043	852	84
28.0	4.30	5.80		0.20	0.45	4.5	5.4		437	106	3251	2814	0.21	3.2	31	0.8	1.6	2.0		1.3	65	1094	887	85
29.0	4.20	6.00		0.20	0.45	4.3	5.6		499	108	3359	2860	0.29	3.0	42	0.8	1.5	1.9		1.3	88	1043	857	111
30.0	3.30	4.60	2.1	0.20	0.45	3.5	4.2	2.3	562	103	3462	2901	0.21	2.3	24	0.6	1.2	1.2		1.0	49	761	668	49
31.0	3.10	4.55		0.20	0.45	3.3	4.1		624	104	3566	2942	0.28	2.1	29	0.6	1.1	1.1		0.9	61	689	618	55
32.0	3.30	4.70		0.20	0.45	3.5	4.3		686	104	3670	2984	0.25	2.2	27	0.6	1.1	1.2		0.9	57	737	655	54
33.0	3.50	5.00		0.20	0.45	3.7	4.6		749	105	3775	3027	0.27	2.3	31	0.6	1.2	1.2		1.0	65	783	689	64
34.0	3.40	5.50		0.20	0.45	3.5	5.1		811	108	3883	3072	0.49	2.1	53	0.6	1.1	1.1		0.9	110	733	656	101
35.0	2.80	3.90	1.7	0.20	0.45	3.0	3.5	1.9	874	100	3984	3110	0.18	1.7	16	0.5	0.9	0.8		0.9	34	566	535	29
36.0	3.70	5.80		0.20	0.45	3.8	5.4		936	108	4092	3156	0.45	2.2	53	0.6	1.1	1.2		1.0	110	798	706	106
37.0	7.00	11.00		0.20	0.45	7.0	10.6		998	116	4208	3210	0.54	4.3	122	1.0	2.2	3.3		1.6	255	1820	1369	415
38.0	8.00	11.60		0.20	0.45	8.1	11.2		1061	116	4324	3264	0.41	4.8	107	1.1	2.5	4.0		1.8	224	2161	1576	394
39.0	8.35	11.80		0.20	0.45	8.4	11.4		1123	116	4441	3318	0.37	5.0	102	1.2	2.5	4.1		1.8	213	2269	1644	379
40.0	8.40	12.60	4.2	0.20	0.45	8.4	12.2	4.4	1186	118	4559	3373	0.47	4.9	129	1.1	2.5	4.0		1.8	270	2253	1641	476
41.0	8.75	12.00		0.20	0.45	8.8	11.6		1248	116	4675	3427	0.33	5.0	95	1.2	2.6	4.2		1.8	198	2377	1717	355
42.0	9.30	12.80		0.20	0.45	9.4	12.4		1310	117	4792	3482	0.34	5.2	104	1.2	2.7	4.5		1.8	217	2551	1823	398
43.0	9.80	14.40		0.20	0.45	9.8	14.0		1373	119	4911	3539	0.45	5.4	144	1.2	2.7	4.7		1.9	301	2693	1910	561
44.0	10.40	14.00		0.20	0.45	10.5	13.6		1435	118	5029	3594	0.32	5.7	107	1.3	2.9	5.1		1.9	224	2912	2040	431
45.0	10.60	17.80	2.8	0.20	0.45	10.5	17.4	3.0	1498	123	5152	3655	0.70	5.6	239	1.3	2.8	4.9		1.9	498	2896	2037	950
46.0	9.40	16.20		0.20	0.45	9.3	15.8		1560	122	5274	3714	0.76	4.8	224	1.1	2.4	3.9		1.8	468	2444	1785	822
47.0	16.20	31.00		0.20	0.45	15.7	30.6		1622	130	5404	3782	1.00	8.2	516	1.6	4.2	9.1		2.3	1077	4882	3115	2483
48.0	10.40	17.20		0.20	0.45	10.3	16.8		1685	122	5527	3842	0.68	5.2	224	1.2	2.6	4.4		1.8	468	2762	1981	854
49.0	11.80	18.60		0.20	0.45	11.7	18.2		1747	123	5650	3902	0.59	5.8	224	1.3	3.0	5.3		1.9	468	3256	2267	910
50.0	14.80	19.00	6.0	0.20	0.45	14.8	18.6	6.2	1810	121	5771	3961	0.27	7.4	129	1.5	3.7	7.6		2.2	270	4441	2915	590

1. Depth is referenced below the exisiting ground surface at the time of testing.
2. Mayne et al., 2002
3. Mayne, 1995
4. Marchetti et al., 2001
5. Schmertman, 1991

SITE PHOTOGRAPHS

The enclosed site photographs represent the site conditions on the dates shown or discussed within the report. Site conditions after the photographs were taken may or may not be similar.

SITE PHOTOGRAPHS

Project: **P-991 MCSFR Bachelor Enlisted Quarters**
Location: **Naval Weapons Station, Yorktown, VA**
GER Project #: **110-6619**
Client: **NAVFAC Mid-Atlantic**
Contract #: **N62470-12-D-2003, CTO WE44**

Environmental
Groundwater
Hazardous Materials
Geotechnical
Industrial Hygiene

GER Consulting Engineers
GeoEnvironmental Resources, Inc.

2014-12-08: Site conditions near testing location DMT-2S facing south.

2014-12-08: Site conditions near testing location CPT-1S facing south.

SITE PHOTOGRAPHS

Project: **P-991 MCSFR Bachelor Enlisted Quarters**
Location: **Naval Weapons Station, Yorktown, VA**
GER Project #: **110-6619**
Client: **NAVFAC Mid-Atlantic**
Contract #: **N62470-12-D-2003, CTO WE44**

Environmental
Groundwater
Hazardous Materials
Geotechnical
Industrial Hygiene

GER Consulting Engineers
GeoEnvironmental Resources, Inc.

2014-12-08: Site conditions near testing location DMT-1S facing southwest.

FIELD PERMEABILITY TESTS

GER

MEASUREMENT OF FIELD SATURATED HYDRAULIC CONDUCTIVITY

Project: **P-991 MCSFR BEQ**
Location: **Naval Weapons Station Yorktown, VA**
GER Project #: **110-6619**
Client: **NAVFAC Mid-Atlantic**
Contract #: **N62470-12-D-2003-WE44**

GER Consulting Engineers
Environmental
Groundwater
Hazardous Materials
Geotechnical
Industrial Hygiene
GeoEnvironmental Resources, Inc.

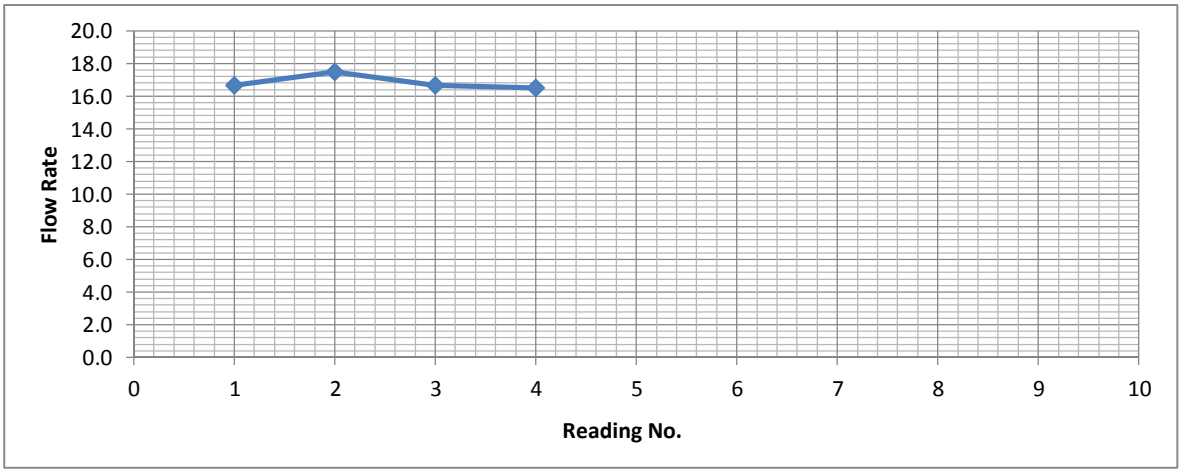
Boring/Test No: DMT-2S @ 5'

Setup Data

Test Date:	4-Jan-15		Investigator:	CJL	
Test Depth:	152.4	H (cm)	Depth to Water Table:	640.1	S (cm)
Borehole Diameter:	8.3	2r (cm)	Depth to Impermeable:	N/A	(cm)
Reservoir Height:	15.2	D (cm)	Reservoir Area:	81.1	A (cm^2)
Constant Head:	20.0	h (cm)	Water Temperature:	14	(^oC)
Soil Description:	Low plasticity CLAY (CL)		Soil Alpha:	0.04	

Field Readings

Reading No.	Time Actual (HH:mm:ss)	Reservoir Level (cm)	Reservoir Level (mL)	Time Interval (min)	Water Consumption (cm)	Water Consumption (mL)	Flow Rate (cm/min)	Flow Rate (mL/min)
0	0:00:00	15	2434					
1	0:04:52	14	2515	4.87	1	81	0.21	16.66
2	0:09:30	13	2596	4.63	1	81	0.22	17.50
3	0:14:22	12	2677	4.87	1	81	0.21	16.66
4	0:19:17	11	2758	4.92	1	81	0.20	16.49



Calculations

L = 507.7
L/h = 25.38
h/r = 4.85
C = 1.70
V_k/V_a = 1.20

Field Saturated Hydraulic Conductivity, K_{fsat}

by US Bureau of Reclamation, 1990	K_{fsat} =	0.010	cm/min
	K_{fsat} =	0.23	in/hr
by Reynolds et al., 1993	K_{fsat} =	0.006	cm/min
	K_{fsat} =	0.13	in/hr
AVG =		**0.008**	cm/min
		0.18	in/hr

APPENDIX C

LABORATORY TEST DATA

LABORATORY TESTING

The enclosed laboratory results represent the subsurface soil properties encountered at the specific boring locations based on the laboratory testing performed. It is possible that soil properties and conditions between the individual boring locations and depths will be different from those indicated.

LABORATORY DATA SUMMARY

Project: **P-991 BEQ, NWS Yorktown, VA**
GER Project Number: **110-6619**

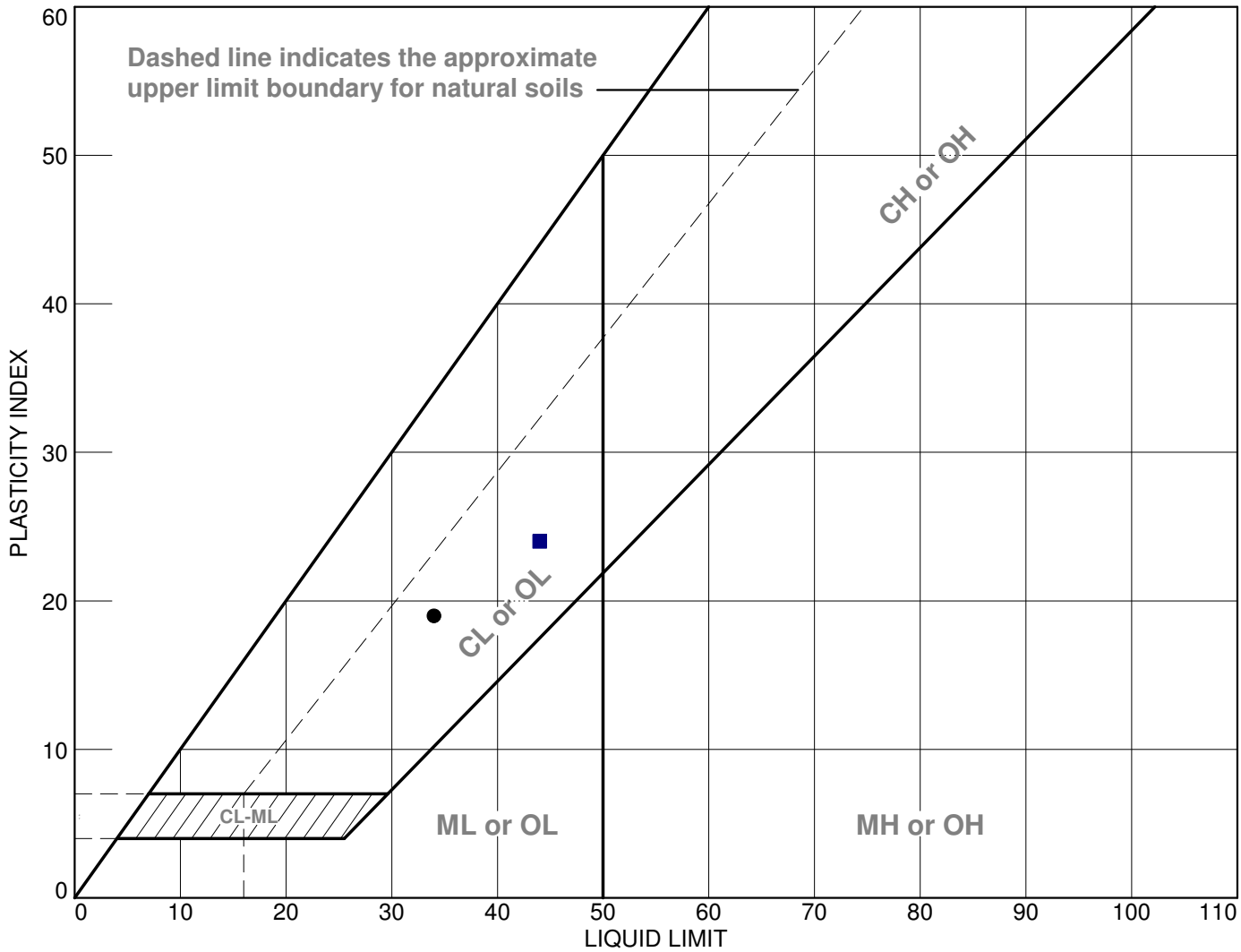
Number: **6047-110**
Date: **12/19/14**

SAMPLE NUMBER	DEPTH (FEET)	SAMPLE TYPE	CLASS.	MOISTURE CONTENT (%)	% FINES	LL	PL	PI	OTHER TESTS
CPT-1S	4 to 6	CPT	CL-ML	15.2	52.7	-	-	-	SIEVE
CPT-1S	8 to 10.5	CPT	CL	17.5	-	34	15	19	-
CPT-1S	11 to 12	CPT	CL	21.0	-	44	20	24	-
DMT-1S	4 to 6	DMT	CH	28.7	-	56	26	30	-
DMT-1S	6 to 8	DMT	CH	20.8	-	56	25	31	-
DMT-1S	8 to 12	DMT	SM	7.3	15.7	-	-	-	SIEVE
DMT-2S	2 to 4	DMT	CL	17.9	-	37	16	21	-
DMT-2S	6.5 to 8	DMT	CL	14.7	-	21	13	8	-

Tests performed in accordance with applicable ASTM Standards**.**

etc.

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	P991	CPT-1S	8 to 10.5 feet	17.5	15	34	19	CL
■	P991	CPT-1S	11 to 12 feet	21.0	20	44	24	CL

ENGINEERING AND TESTING CONSULTANTS, INC.

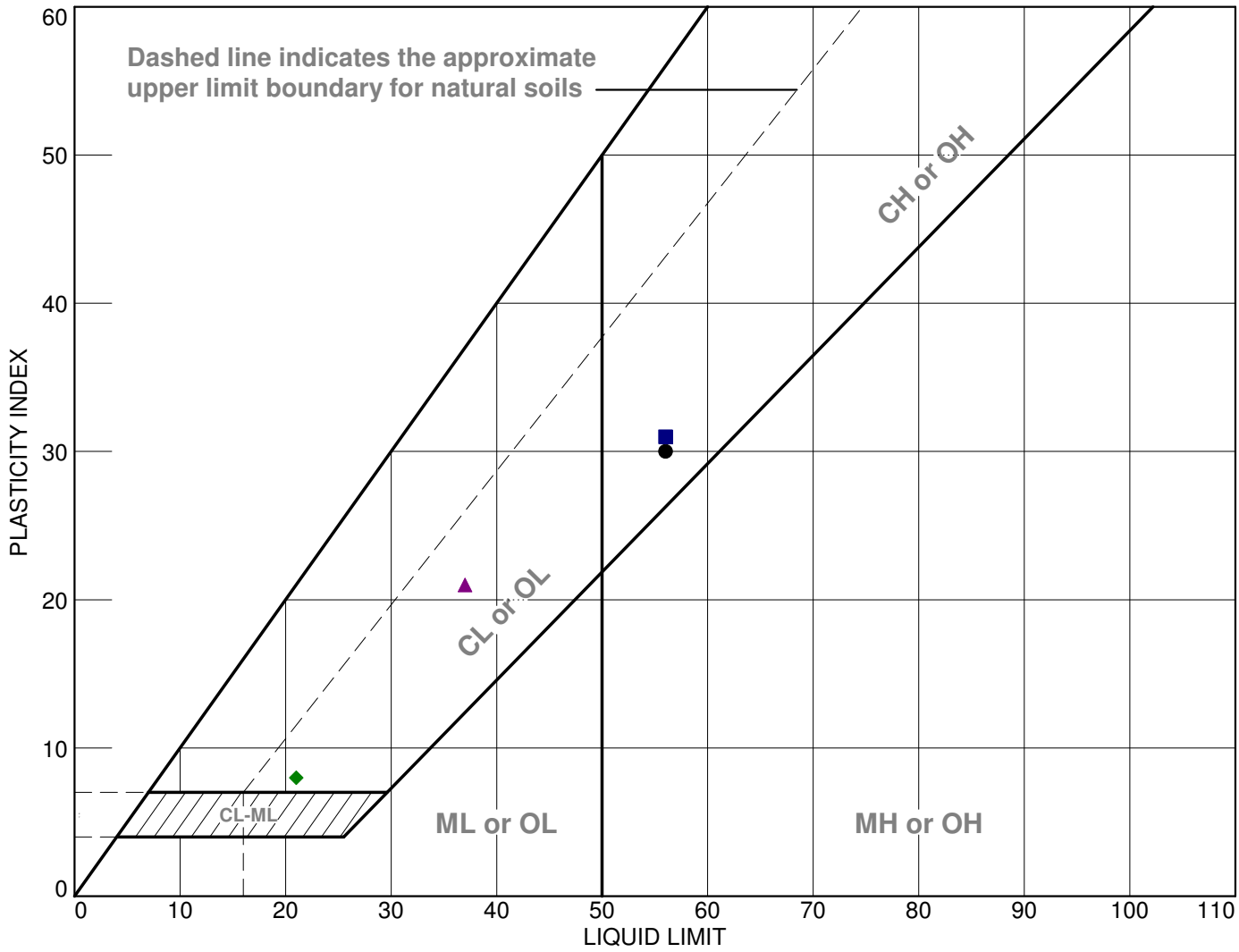
Virginia Beach, VA

Client: GeoEnvironmental Resources, Inc.
Project: P-991 BEQ, NWS Yorktown, VA

Project No.: 110-6619/6047-110 **Figure** 1

Tested By: Karen Perry **Checked By:** Deborah Cacace

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	P991	DMT-1S	4 to 6 feet	28.7	26	56	30	CH
■	P991	DMT-1S	6 to 8 feet	20.8	25	56	31	CH
▲	P991	DMT-2S	2 to 4 feet	17.9	16	37	21	CL
◆	P991	DMT-2S	6.5 to 8 feet	14.7	13	21	8	CL

ENGINEERING AND TESTING CONSULTANTS, INC.

Virginia Beach, VA

Client: GeoEnvironmental Resources, Inc.
Project: P-991 BEQ, NWS Yorktown, VA

Project No.: 110-6619/6047-110 **Figure** 2

Tested By: Karen Perry **Checked By:** Deborah Cacace

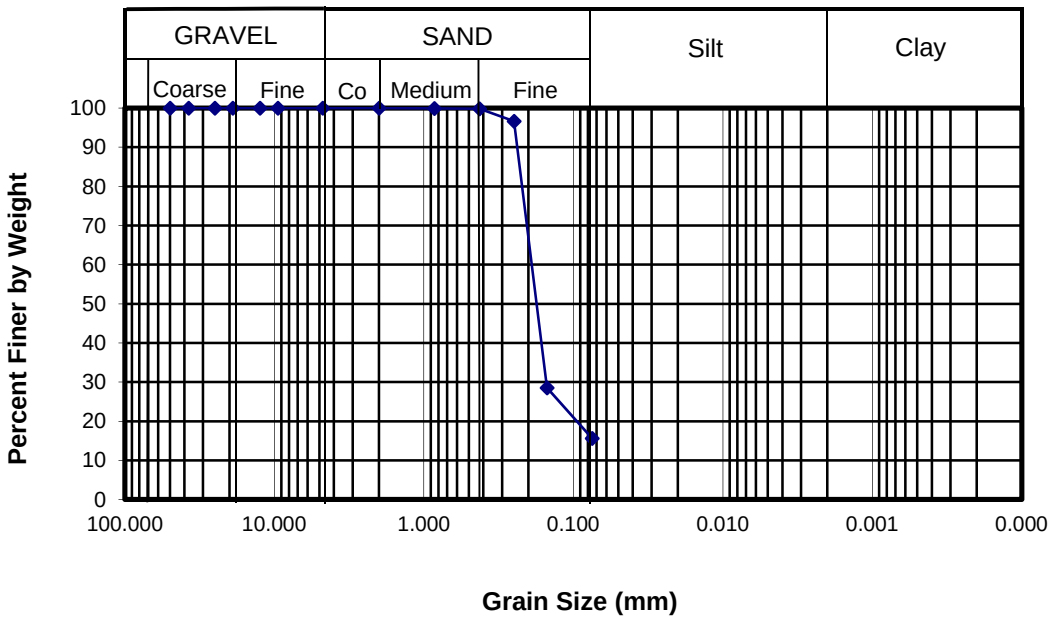
Engineering and Testing Consultants, Inc.

SIEVE ANALYSIS

Project Name: **P-991 BEQ, NWS Yorktown, VA**
GER Project Number: **110-6619**
Project Number: 6047-110
Sample Number: DMT-1S
Sample Depth: 11 to 12 feet
Sample Description: Silty SAND (SM), Tan-Orange, Fine
Test Method: ASTM D 422

Sieve Analysis Data

SIEVE NO.	PERCENT PASSING
2 Inch	100.0
1 1/2 Inch	100.0
1 Inch	100.0
3/4 Inch	100.0
1/2 Inch	100.0
3/8 Inch	100.0
4	100.0
10	100.0
20	99.9
40	99.8
60	96.7
100	28.5
200	15.7



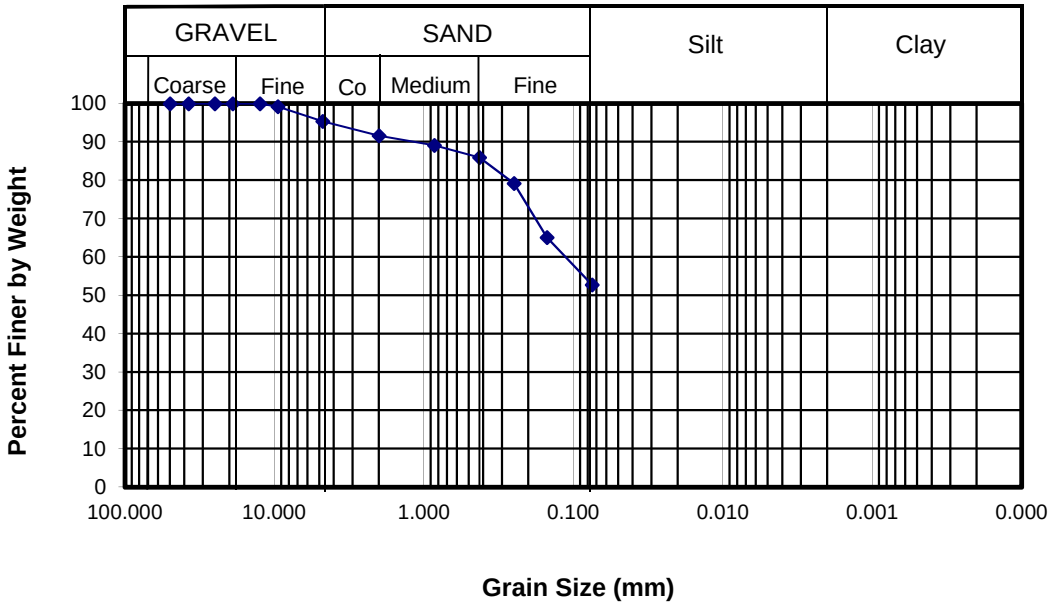
Engineering and Testing Consultants, Inc.

SIEVE ANALYSIS

Project Name: **P-991 BEQ, NWS Yorktown, VA**
GER Project Number: **110-6619**
Project Number: 6047-110
Sample Number: CPT-1S
Sample Depth: 4 to 6 feet
Sample Description: Sandy, Silty CLAY (CL-ML), Tan and Orange, Fine to Medium, Trace Fine Gravel
Test Method: ASTM D 422

Sieve Analysis Data

SIEVE NO.	PERCENT PASSING
2 Inch	100.0
1 1/2 Inch	100.0
1 Inch	100.0
3/4 Inch	100.0
1/2 Inch	100.0
3/8 Inch	99.2
4	95.4
10	91.6
20	89.1
40	85.9
60	79.2
100	65.1
200	52.7



TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

ANALYTICAL REPORT

TestAmerica Laboratories, Inc.
TestAmerica Pensacola
3355 McLemore Drive
Pensacola, FL 32514
Tel: (850)474-1001

TestAmerica Job ID: 400-99903-1
Client Project/Site: NWS Yorktown BEQ

For:
GeoEnvironmental Resources Inc GER
2712 Southern Blvd
Suite 101
Virginia Beach, Virginia 23452

Attn: Mr. Charles F.P. Crawley

Mark Swafford

Authorized for release by:
1/2/2015 4:15:34 PM

Mark Swafford, Project Manager I
(850)474-1001
mark.swafford@testamericainc.com

LINKS

Review your project results through TotalAccess

Have a Question? Ask The Expert

Visit us at: www.testamericainc.com

The test results in this report meet all 2003 NELAC and 2009 TNI requirements for accredited parameters, exceptions are noted in this report. This report may not be reproduced except in full, and with written approval from the laboratory. For questions please contact the Project Manager at the e-mail address or telephone number listed on this page.

This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.

Results relate only to the items tested and the sample(s) as received by the laboratory.

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Definitions/Glossary

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Qualifiers

Metals

Qualifier	Qualifier Description
^	ICV,CCV,ICB,CCB, ISA, ISB, CRI, CRA, DLCK or MRL standard: Instrument related QC exceeds the control limits.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CNF	Contains no Free Liquid
DER	Duplicate error ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision level concentration
MDA	Minimum detectable activity
EDL	Estimated Detection Limit
MDC	Minimum detectable concentration
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
NC	Not Calculated
ND	Not detected at the reporting limit (or MDL or EDL if shown)
PQL	Practical Quantitation Limit
QC	Quality Control
RER	Relative error ratio
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)

Case Narrative

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Job ID: 400-99903-1

Laboratory: TestAmerica Pensacola

Narrative

Job Narrative
400-99903-1

Comments
No additional comments.

Receipt
The sample was received on 12/18/2014 9:28 AM; the sample arrived in good condition, properly preserved and, where required, on ice.
The temperature of the cooler at receipt was 0.6º C.

Samples DMT-1S and DMT-2S were listed on the COC, but were not included in the shipment.

GC/MS VOA
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

GC VOA
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

GC Semi VOA
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Metals
Method 6010C: The low level check standard (CCVL) recovery associated with batch 400-241034 is outside the acceptance criteria for Lead (high bias). The bracketed sample result is below the reporting limit for this analyte, and has been qualified and reported.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

Organic Prep
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Detection Summary

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Client Sample ID: CPT-1S **Lab Sample ID: 400-99903-1**

No Detections.

This Detection Summary does not include radiochemical test results.

Sample Summary

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
400-99903-1	CPT-1S	Solid	12/15/14 10:25	12/18/14 09:28

Client Sample Results

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Client Sample ID: CPT-1S

Date Collected: 12/15/14 10:25
Date Received: 12/18/14 09:28

Lab Sample ID: 400-99903-1

Matrix: Solid
Percent Solids: 84.1

Method: 8260B - Volatile Organic Compounds (GC/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Benzene	<0.0059		0.0059		mg/Kg	☼	12/21/14 13:45	12/21/14 17:54	1
Toluene	<0.0059		0.0059		mg/Kg	☼	12/21/14 13:45	12/21/14 17:54	1
Ethylbenzene	<0.0059		0.0059		mg/Kg	☼	12/21/14 13:45	12/21/14 17:54	1
Xylenes, Total	<0.0059		0.0059		mg/Kg	☼	12/21/14 13:45	12/21/14 17:54	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*91*		*72 - 122*	*12/21/14 13:45*	*12/21/14 17:54*	*1*
Dibromofluoromethane	*85*		*79 - 123*	*12/21/14 13:45*	*12/21/14 17:54*	*1*
Toluene-d8 (Surr)	*105*		*80 - 120*	*12/21/14 13:45*	*12/21/14 17:54*	*1*

Method: 8015C - GRO by 8015C

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Gasoline Range Organics (GRO) -C6-C10	<5.7		5.7		mg/Kg	☼	12/18/14 16:35	12/19/14 00:49	50

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
a,a,a-Trifluorotoluene (fid)	*102*		*65 - 125*	*12/18/14 16:35*	*12/19/14 00:49*	*50*

Method: 8015C - Nonhalogenated Organics using GC/FID -Modified (Diesel Range Organics)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Diesel Range Organics [C10-C28]	<12		12		mg/Kg	☼	12/19/14 08:58	12/19/14 21:27	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
o-Terphenyl (Surr)	*73*		*27 - 151*	*12/19/14 08:58*	*12/19/14 21:27*	*1*

Method: 6010C - RCRA Metals - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<0.025		0.025		mg/L		12/21/14 23:46	12/22/14 19:36	1
Barium	<5.0		5.0		mg/L		12/21/14 23:46	12/22/14 19:36	1
Cadmium	<0.025		0.025		mg/L		12/21/14 23:46	12/22/14 19:36	1
Chromium	<0.050		0.050		mg/L		12/21/14 23:46	12/22/14 19:36	1
Lead	<0.025	^	0.025		mg/L		12/21/14 23:46	12/22/14 19:36	1
Selenium	<0.050		0.050		mg/L		12/21/14 23:46	12/22/14 19:36	1
Silver	<0.025		0.025		mg/L		12/21/14 23:46	12/22/14 19:36	1

Method: 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	<0.0016		0.0016		mg/L		12/22/14 15:52	12/23/14 15:04	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	**16**		0.10		%			12/29/14 15:17	1

QC Sample Results

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Method: 8260B - Volatile Organic Compounds (GC/MS)

Lab Sample ID: MB 400-240856/1-A — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240844 — **Prep Batch: 240856**

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Benzene	<0.0050		0.0050		mg/Kg		12/21/14 13:45	12/21/14 15:14	1
Toluene	<0.0050		0.0050		mg/Kg		12/21/14 13:45	12/21/14 15:14	1
Ethylbenzene	<0.0050		0.0050		mg/Kg		12/21/14 13:45	12/21/14 15:14	1
Xylenes, Total	<0.0050		0.0050		mg/Kg		12/21/14 13:45	12/21/14 15:14	1

Surrogate	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*89*		*72 - 122*	*12/21/14 13:45*	*12/21/14 15:14*	*1*
Dibromofluoromethane	*85*		*79 - 123*	*12/21/14 13:45*	*12/21/14 15:14*	*1*
Toluene-d8 (Surr)	*103*		*80 - 120*	*12/21/14 13:45*	*12/21/14 15:14*	*1*

Lab Sample ID: LCS 400-240856/2-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240844 — **Prep Batch: 240856**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Benzene	0.0500	0.0546		mg/Kg		109	74 - 119
Toluene	0.0500	0.0568		mg/Kg		114	76 - 120
Ethylbenzene	0.0500	0.0547		mg/Kg		109	78 - 120
Xylenes, Total	0.100	0.109		mg/Kg		109	70 - 120

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
4-Bromofluorobenzene	*92*		*72 - 122*
Dibromofluoromethane	*88*		*79 - 123*
Toluene-d8 (Surr)	*103*		*80 - 120*

Lab Sample ID: 400-99945-B-1-B MS — **Client Sample ID: Matrix Spike**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240844 — **Prep Batch: 240856**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Benzene	<0.0072		0.0681	0.0708		mg/Kg	☼	104	56 - 130
Toluene	<0.0072		0.0681	0.0743		mg/Kg	☼	105	55 - 130
Ethylbenzene	<0.0072		0.0681	0.0679		mg/Kg	☼	100	50 - 130
Xylenes, Total	<0.0072		0.136	0.129		mg/Kg	☼	95	51 - 130

Surrogate	*MS %Recovery*	*MS Qualifier*	*Limits*
4-Bromofluorobenzene	*92*		*72 - 122*
Dibromofluoromethane	*86*		*79 - 123*
Toluene-d8 (Surr)	*105*		*80 - 120*

Lab Sample ID: 400-99945-B-1-C MSD — **Client Sample ID: Matrix Spike Duplicate**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240844 — **Prep Batch: 240856**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Benzene	<0.0072		0.0661	0.0579		mg/Kg	☼	88	56 - 130	20	30
Toluene	<0.0072		0.0661	0.0609		mg/Kg	☼	88	55 - 130	20	30

Method: 8260B - Volatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: 400-99945-B-1-C MSD — **Client Sample ID: Matrix Spike Duplicate**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240844 — **Prep Batch: 240856**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Ethylbenzene	<0.0072		0.0661	0.0538		mg/Kg	☼	81	50 - 130	23	30
Xylenes, Total	<0.0072		0.132	0.103		mg/Kg	☼	78	51 - 130	22	30

Surrogate	*MSD %Recovery*	*MSD Qualifier*	*Limits*
4-Bromofluorobenzene	*99*		*72 - 122*
Dibromofluoromethane	*89*		*79 - 123*
Toluene-d8 (Surr)	*110*		*80 - 120*

Method: 8015C - GRO by 8015C

Lab Sample ID: MB 400-240464/1-A — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240543 — **Prep Batch: 240464**

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Gasoline Range Organics (GRO) -C6-C10	<5.0		5.0		mg/Kg		12/17/14 17:45	12/18/14 12:27	50

Surrogate	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
a,a,a-Trifluorotoluene (fid)	*101*		*65 - 125*	*12/17/14 17:45*	*12/18/14 12:27*	*50*

Lab Sample ID: LCS 400-240464/2-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240543 — **Prep Batch: 240464**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Gasoline Range Organics (GRO) -C6-C10	50.0	59.8		mg/Kg		120	62 - 141

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
a,a,a-Trifluorotoluene (fid)	*99*		*65 - 125*

Lab Sample ID: 400-99653-A-2-B MS — **Client Sample ID: Matrix Spike**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240543 — **Prep Batch: 240464**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Gasoline Range Organics (GRO) -C6-C10	<5.6		56.0	52.8		mg/Kg	☼	94	10 - 150

Surrogate	*MS %Recovery*	*MS Qualifier*	*Limits*
a,a,a-Trifluorotoluene (fid)	*99*		*65 - 125*

Method: 8015C - GRO by 8015C (Continued)

Lab Sample ID: 400-99653-A-2-C MSD — **Client Sample ID: Matrix Spike Duplicate**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240543 — **Prep Batch: 240464**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Gasoline Range Organics (GRO) -C6-C10	<5.6		56.0	57.4		mg/Kg	☼	102	10 - 150	8	32

Surrogate	*MSD %Recovery*	*MSD Qualifier*	*Limits*
a,a,a-Trifluorotoluene (fid)	*99*		*65 - 125*

Method: 8015C - Nonhalogenated Organics using GC/FID -Modified (Diesel Range Organics)

Lab Sample ID: MB 400-240668/8-A — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240784 — **Prep Batch: 240668**

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Diesel Range Organics [C10-C28]	<10		10		mg/Kg		12/19/14 08:58	12/19/14 21:08	1

Surrogate	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
o-Terphenyl (Surr)	*87*		*27 - 151*	*12/19/14 08:58*	*12/19/14 21:08*	*1*

Lab Sample ID: LCS 400-240668/4-C — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240784 — **Prep Batch: 240668**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Diesel Range Organics [C10-C28]	335	317		mg/Kg		95	63 - 153

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
o-Terphenyl (Surr)	*109*		*27 - 151*

Lab Sample ID: 400-99903-1 MS — **Client Sample ID: CPT-1S**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240784 — **Prep Batch: 240668**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Diesel Range Organics [C10-C28]	<12		390	301		mg/Kg	☼	77	62 - 204

Surrogate	*MS %Recovery*	*MS Qualifier*	*Limits*
o-Terphenyl (Surr)	*92*		*27 - 151*

Lab Sample ID: 400-99903-1 MSD — **Client Sample ID: CPT-1S**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240784 — **Prep Batch: 240668**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Diesel Range Organics [C10-C28]	<12		394	295		mg/Kg	☼	75	62 - 204	2	30

Method: 8015C - Nonhalogenated Organics using GC/FID -Modified (Diesel Range Organics) (Continued)

Lab Sample ID: 400-99903-1 MSD — **Client Sample ID: CPT-1S**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 240784 — **Prep Batch: 240668**

Surrogate	*MSD %Recovery*	*MSD Qualifier*	*Limits*
o-Terphenyl (Surr)	*82*		*27 - 151*

Method: 6010C - RCRA Metals

Lab Sample ID: LCS 400-240869/15-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 241034 — **Prep Batch: 240869**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	5.00	5.22		mg/L		104	80 - 120
Barium	29.9	32.0		mg/L		107	80 - 120
Cadmium	2.50	2.51		mg/L		100	80 - 120
Chromium	5.00	5.06		mg/L		101	80 - 120
Lead	5.00	4.97		mg/L		99	80 - 120
Selenium	5.00	4.99		mg/L		100	80 - 120
Silver	2.50	2.65		mg/L		106	80 - 120

Lab Sample ID: LB 400-240756/1-B — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: TCLP**
Analysis Batch: 241034 — **Prep Batch: 240869**

Analyte	LB Result	LB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<0.025		0.025		mg/L		12/21/14 23:46	12/22/14 20:14	1
Barium	<5.0		5.0		mg/L		12/21/14 23:46	12/22/14 20:14	1
Cadmium	<0.025		0.025		mg/L		12/21/14 23:46	12/22/14 20:14	1
Chromium	<0.050		0.050		mg/L		12/21/14 23:46	12/22/14 20:14	1
Lead	<0.025		0.025		mg/L		12/21/14 23:46	12/22/14 20:14	1
Selenium	<0.050		0.050		mg/L		12/21/14 23:46	12/22/14 20:14	1
Silver	<0.025		0.025		mg/L		12/21/14 23:46	12/22/14 20:14	1

Lab Sample ID: 400-99903-1 MS — **Client Sample ID: CPT-1S**
Matrix: Solid — **Prep Type: TCLP**
Analysis Batch: 241034 — **Prep Batch: 240869**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	<0.025		5.00	5.19		mg/L		104	75 - 125
Barium	<5.0		29.9	31.3		mg/L		104	75 - 125
Cadmium	<0.025		2.50	2.49		mg/L		100	75 - 125
Chromium	<0.050		5.00	5.10		mg/L		102	75 - 125
Lead	<0.025	^	5.00	5.03		mg/L		100	75 - 125
Selenium	<0.050		5.00	4.97		mg/L		99	75 - 125
Silver	<0.025		2.50	2.66		mg/L		107	75 - 125

Method: 6010C - RCRA Metals (Continued)

Lab Sample ID: 400-99903-1 MSD — **Client Sample ID: CPT-1S**
Matrix: Solid — **Prep Type: TCLP**
Analysis Batch: 241034 — **Prep Batch: 240869**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	<0.025		5.00	5.15		mg/L		103	75 - 125	1	20
Barium	<5.0		29.9	31.7		mg/L		105	75 - 125	1	20
Cadmium	<0.025		2.50	2.48		mg/L		99	75 - 125	0	20
Chromium	<0.050		5.00	4.99		mg/L		100	75 - 125	2	20
Lead	<0.025	^	5.00	4.97		mg/L		99	75 - 125	1	20
Selenium	<0.050		5.00	4.95		mg/L		99	75 - 125	0	20
Silver	<0.025		2.50	2.66		mg/L		107	75 - 125	0	20

Method: 7470A - Mercury (CVAA)

Lab Sample ID: LCS 400-240989/14-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 241165 — **Prep Batch: 240989**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Mercury	0.00800	0.00952		mg/L		119	80 - 120

Lab Sample ID: LB 400-240756/1-D — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: TCLP**
Analysis Batch: 241165 — **Prep Batch: 240989**

Analyte	LB Result	LB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	<0.0016		0.0016		mg/L		12/22/14 15:52	12/23/14 15:01	1

Lab Sample ID: 400-99903-1 MS — **Client Sample ID: CPT-1S**
Matrix: Solid — **Prep Type: TCLP**
Analysis Batch: 241165 — **Prep Batch: 240989**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Mercury	<0.0016		0.0160	0.0175		mg/L		104	80 - 120

Lab Sample ID: 400-99903-1 MSD — **Client Sample ID: CPT-1S**
Matrix: Solid — **Prep Type: TCLP**
Analysis Batch: 241165 — **Prep Batch: 240989**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Mercury	<0.0016		0.0160	0.0167		mg/L		100	80 - 120	4	20

QC Association Summary

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

GC/MS VOA

Analysis Batch: 240844

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	Total/NA	Solid	8260B	240856
400-99945-B-1-B MS	Matrix Spike	Total/NA	Solid	8260B	240856
400-99945-B-1-C MSD	Matrix Spike Duplicate	Total/NA	Solid	8260B	240856
LCS 400-240856/2-A	Lab Control Sample	Total/NA	Solid	8260B	240856
MB 400-240856/1-A	Method Blank	Total/NA	Solid	8260B	240856

Prep Batch: 240856

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	Total/NA	Solid	5035	
400-99945-B-1-B MS	Matrix Spike	Total/NA	Solid	5035	
400-99945-B-1-C MSD	Matrix Spike Duplicate	Total/NA	Solid	5035	
LCS 400-240856/2-A	Lab Control Sample	Total/NA	Solid	5035	
MB 400-240856/1-A	Method Blank	Total/NA	Solid	5035	

GC VOA

Prep Batch: 240464

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99653-A-2-B MS	Matrix Spike	Total/NA	Solid	5035	
400-99653-A-2-C MSD	Matrix Spike Duplicate	Total/NA	Solid	5035	
400-99903-1	CPT-1S	Total/NA	Solid	5035	
LCS 400-240464/2-A	Lab Control Sample	Total/NA	Solid	5035	
MB 400-240464/1-A	Method Blank	Total/NA	Solid	5035	

Analysis Batch: 240543

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99653-A-2-B MS	Matrix Spike	Total/NA	Solid	8015C	240464
400-99653-A-2-C MSD	Matrix Spike Duplicate	Total/NA	Solid	8015C	240464
400-99903-1	CPT-1S	Total/NA	Solid	8015C	240464
LCS 400-240464/2-A	Lab Control Sample	Total/NA	Solid	8015C	240464
MB 400-240464/1-A	Method Blank	Total/NA	Solid	8015C	240464

GC Semi VOA

Prep Batch: 240668

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	Total/NA	Solid	3546	
400-99903-1 MS	CPT-1S	Total/NA	Solid	3546	
400-99903-1 MSD	CPT-1S	Total/NA	Solid	3546	
LCS 400-240668/4-C	Lab Control Sample	Total/NA	Solid	3546	
MB 400-240668/8-A	Method Blank	Total/NA	Solid	3546	

Analysis Batch: 240784

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	Total/NA	Solid	8015C	240668
400-99903-1 MS	CPT-1S	Total/NA	Solid	8015C	240668
400-99903-1 MSD	CPT-1S	Total/NA	Solid	8015C	240668
LCS 400-240668/4-C	Lab Control Sample	Total/NA	Solid	8015C	240668
MB 400-240668/8-A	Method Blank	Total/NA	Solid	8015C	240668

QC Association Summary

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Metals

Leach Batch: 240756

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	TCLP	Solid	1311	
400-99903-1 MS	CPT-1S	TCLP	Solid	1311	
400-99903-1 MSD	CPT-1S	TCLP	Solid	1311	
LB 400-240756/1-B	Method Blank	TCLP	Solid	1311	
LB 400-240756/1-D	Method Blank	TCLP	Solid	1311	

Prep Batch: 240869

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	TCLP	Solid	3010A	240756
400-99903-1 MS	CPT-1S	TCLP	Solid	3010A	240756
400-99903-1 MSD	CPT-1S	TCLP	Solid	3010A	240756
LB 400-240756/1-B	Method Blank	TCLP	Solid	3010A	240756
LCS 400-240869/15-A	Lab Control Sample	Total/NA	Solid	3010A	

Prep Batch: 240989

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	TCLP	Solid	7470A	240756
400-99903-1 MS	CPT-1S	TCLP	Solid	7470A	240756
400-99903-1 MSD	CPT-1S	TCLP	Solid	7470A	240756
LB 400-240756/1-D	Method Blank	TCLP	Solid	7470A	240756
LCS 400-240989/14-A	Lab Control Sample	Total/NA	Solid	7470A	

Analysis Batch: 241034

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	TCLP	Solid	6010C	240869
400-99903-1 MS	CPT-1S	TCLP	Solid	6010C	240869
400-99903-1 MSD	CPT-1S	TCLP	Solid	6010C	240869
LB 400-240756/1-B	Method Blank	TCLP	Solid	6010C	240869
LCS 400-240869/15-A	Lab Control Sample	Total/NA	Solid	6010C	240869

Analysis Batch: 241165

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	TCLP	Solid	7470A	240989
400-99903-1 MS	CPT-1S	TCLP	Solid	7470A	240989
400-99903-1 MSD	CPT-1S	TCLP	Solid	7470A	240989
LB 400-240756/1-D	Method Blank	TCLP	Solid	7470A	240989
LCS 400-240989/14-A	Lab Control Sample	Total/NA	Solid	7470A	240989

General Chemistry

Analysis Batch: 241501

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
400-99903-1	CPT-1S	Total/NA	Solid	Moisture	

Lab Chronicle

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Client Sample ID: CPT-1S

Date Collected: 12/15/14 10:25
Date Received: 12/18/14 09:28

Lab Sample ID: 400-99903-1

Matrix: Solid
Percent Solids: 84.1

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	5035			240856	12/21/14 13:45	CAR	TAL PEN
Total/NA	Analysis	8260B		1	240844	12/21/14 17:54	CAR	TAL PEN
Total/NA	Prep	5035			240464	12/18/14 16:35	GRK	TAL PEN
Total/NA	Analysis	8015C		50	240543	12/19/14 00:49	GRK	TAL PEN
Total/NA	Prep	3546			240668	12/19/14 08:58	RDT	TAL PEN
Total/NA	Analysis	8015C		1	240784	12/19/14 21:27	RM	TAL PEN
TCLP	Leach	1311			240756	12/19/14 15:02	DAS	TAL PEN
TCLP	Prep	3010A			240869	12/21/14 23:46	DN1	TAL PEN
TCLP	Analysis	6010C		1	241034	12/22/14 19:36	GESP	TAL PEN
TCLP	Leach	1311			240756	12/19/14 15:02	DAS	TAL PEN
TCLP	Prep	7470A			240989	12/22/14 15:52	JAP	TAL PEN
TCLP	Analysis	7470A		1	241165	12/23/14 15:04	JAP	TAL PEN
Total/NA	Analysis	Moisture		1	241501	12/29/14 15:17	LEC	TAL PEN

Laboratory References:

TAL PEN = TestAmerica Pensacola, 3355 McLemore Drive, Pensacola, FL 32514, TEL (850)474-1001

Certification Summary

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Laboratory: TestAmerica Pensacola

All certifications held by this laboratory are listed. Not all certifications are applicable to this report.

Authority	Program	EPA Region	Certification ID	Expiration Date
Alabama	State Program	4	40150	06-30-15
Arizona	State Program	9	AZ0710	01-11-16
Arkansas DEQ	State Program	6	88-0689	09-01-15
Florida	NELAP	4	E81010	06-30-15
Georgia	State Program	4	N/A	06-30-15
Illinois	NELAP	5	200041	10-09-15
Iowa	State Program	7	367	07-31-16
Kansas	NELAP	7	E-10253	01-31-15
Kentucky (UST)	State Program	4	53	06-30-15
Kentucky (WW)	State Program	4	98030	12-31-15
Louisiana	NELAP	6	30976	06-30-15
Maryland	State Program	3	233	09-30-15
Massachusetts	State Program	1	M-FL094	06-30-15
Michigan	State Program	5	9912	06-30-15
New Jersey	NELAP	2	FL006	06-30-15
North Carolina (WW/SW)	State Program	4	314	12-31-15
Oklahoma	State Program	6	9810	08-31-15
Pennsylvania	NELAP	3	68-00467	01-31-15
Rhode Island	State Program	1	LAO00307	12-30-14
South Carolina	State Program	4	96026	06-30-15
Tennessee	State Program	4	TN02907	06-30-15
Texas	NELAP	6	T104704286-12-5	09-30-15
USDA	Federal		P330-13-00193	07-01-16
Virginia	NELAP	3	460166	06-14-15
West Virginia DEP	State Program	3	136	06-30-15

Method Summary

Client: GeoEnvironmental Resources Inc GER
Project/Site: NWS Yorktown BEQ

TestAmerica Job ID: 400-99903-1

Method	Method Description	Protocol	Laboratory
8260B	Volatile Organic Compounds (GC/MS)	SW846	TAL PEN
8015C	GRO by 8015C	SW846	TAL PEN
8015C	Nonhalogenated Organics using GC/FID -Modified (Diesel Range Organics)	SW846	TAL PEN
6010C	RCRA Metals	SW846	TAL PEN
7470A	Mercury (CVAA)	SW846	TAL PEN
Moisture	Percent Moisture	EPA	TAL PEN

Protocol References:

EPA = US Environmental Protection Agency

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

TAL PEN = TestAmerica Pensacola, 3355 McLemore Drive, Pensacola, FL 32514, TEL (850)474-1001

TestAmerica Virginia Beach
5135 Cleveland St.

Virginia Beach, VA 23462
Phone: 757.671.1291 Fax:

Chain of Custody Record

077869

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
TestAmerica Laboratories, Inc.
TAL-8210 (0713)

400-99903

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

Client Contact	Project Manager: Charles Crawley	Site Contact: Same	Date: 12/17/14	COC No:
Company Name: Geo Environmental Resources	Tel/Fax: 757 463 3200	Lab Contact: Same	Carrier:	1 of 1 COCs
Address: 2712 Southern Blvd, Suite 101	Analysis Turnaround Time			Sampler:
City/State/Zip: Virginia Beach, VA 23452	☐ CALENDAR DAYS ☐ WORKING DAYS			For Lab Use Only:
Phone: 757 463 3200	TAT if different from Below Normal			Walk-in Client:
Fax:	☐ 2 weeks			Lab Sampling:
Project Name: NWS Yorktown BEQ	☐ 1 week			
Site:	☐ 2 days			Job / SDG No.:
PO# 110-6619	☐ 1 day			

400-99903 COC

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y/N)	Perform MS / MSD (Y/N)	TCLP Metals	TPH - DRO/GRO	BTEX	Sample Specific Notes:
DMT-1S	12/15	10:25	C	Solid		N	N	X	X	X	
DMT-2S	12/15	10:25	C	Solid		N	N	X	X	X	
CPT-1S	12/15	10:25	C	Solid		N	N	X	X	X	

Preservation Used: 1= Ice, 2= HCl, 3= H2SO4, 4=HNO3, 5=NaOH, 6= Other

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample.

☒ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☒ Disposal by Lab ☐ Archive for_____ Months

Special Instructions/QC Requirements & Comments:

Custody Seals Intact: ☐ Yes ☒ No | Custody Seal No.: | Cooler Temp. (°C): Obs'd:_____ Corr'd:_____ Therm ID No.:_____

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
[signature]	GER	12/17/14	[signature]	TA	12/17/14 1353
Relinquished by: [signature]	Company: TA	Date/Time: 12/17/14	Received by: [signature]	Company:	Date/Time:
Relinquished by:	Company:	Date/Time: 1501	Received in Laboratory by: [signature]	Company: TA Pen	Date/Time: 12-18-14 9:28

0.6°C IR2

Login Sample Receipt Checklist

Client: GeoEnvironmental Resources Inc GER

Job Number: 400-99903-1

Login Number: 99903

List Source: TestAmerica Pensacola

List Number: 1

Creator: Crawford, Lauren E

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	N/A	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	N/A	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	0.6°C IR-2
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	False	Did not receive samples DMT-1S and DMT-2S
Samples are received within Holding Time.	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

APPENDIX D

PROCEDURES AND INTERPRETATION METHODS

GEOTECHNICAL EXPLORATION PROCEDURES

Boring, Sampling & Standard Penetration Testing

Standard penetration testing and split barrel sampling are conducted at regular intervals in a borehole in accordance with ASTM D 1586. Standard practice on most GER projects is to perform this testing and sampling continuously within the upper 10 feet of the subsurface, and then at maximum 5-foot center-to-center intervals thereafter. At the desired test depth, the drilling tools are removed and a split barrel sampler is connected to the drilling rods and lowered back into the borehole. The sampler is first seated six inches into the bottom of the hole to penetrate any loose cuttings from the drilling operations. It is then driven an additional 12 inches by the impact of a 140 pound hammer free-falling 30 inches. The number of hammer blows required to drive the sampler for each 6-inch interval is recorded. The combined number of blows required to drive the sampler the final 12 inches is designated *standard penetration resistance* or *N-value*. Representative portions of soil from each split barrel sample are placed in air tight glass jars or plastic bags and transported to a laboratory.

Undisturbed Sampling

Split barrel samples are used for visual examination and simple laboratory classification tests; however, they are disturbed and not sufficiently intact for quantitative laboratory testing such as strength or consolidation. When such laboratory testing is desired, relatively undisturbed samples are obtained by slowly pushing a 3-inch diameter, thin-walled (16 gauge) galvanized steel tube into the soil at desired sampling depths. This is followed by carefully removing the soil-filled tube from the borehole and sealing the ends to prevent moisture loss. The procedure is described in ASTM D 1587. Undisturbed tube samples are most frequently used for sampling cohesive soils (clay and silt), but may be used to sample fine grained cohesionless soils with the aid of a piston sampling head.

Excavation

When explorations do not require machine-drilled borings, excavations, test pits, hand auger borings and other means described in ASTM D 4700 may be used to observe shallow subsurface conditions and to collect soil samples. The maximum depth of these methods is generally limited by the depth of groundwater. These methods are useful in obtaining bulk samples for laboratory classification, compaction and other remolded tests.

Rock Coring

Core drilling methods described in ASTM D 2113 are used to advance boreholes into rock or extremely dense soils which are not penetrable by conventional boring methods and typically exhibit more than 100 blows per foot by ASTM D 1586. Core drilling methods employed by GER use double tube swivel-type designed equipment with a drilling fluid, in which an outer tube rotates and performs the cutting while the inner tube remains stationary and collects a continuous sample of rock.

In-Situ Methods

In-situ tests are sometimes used on projects to obtain additional subsurface data. These methods provide direct and empirical measurement of various soil properties without collection of actual samples. Because samples are not collected, it is not common practice in the U. S. to

utilize in-situ tests alone to accomplish geotechnical investigations. On projects where in-situ testing is used, it is customary to perform them in conjunction with borings.

Soil Classification

Soil classification tests provide a general guide to the engineering properties of various soil types. Samples obtained during drilling operations are examined and visually classified by an engineer or geologist according to consistency, color and texture. These classification descriptions are included on the boring records. The classification system is primarily qualitative and for detailed soil classification, two laboratory tests are necessary; grain size tests and plasticity tests. Using these test results, the soil can be classified according to the AASHTO or Unified Classification System (ASTM D 2487). Each of these classification systems and the in-place physical soil properties provides an index for estimating the soil's behavior. The soil classification and physical properties obtained are presented on the following sheets.

Grain Size Tests

Grain size tests are performed to determine the soil classification and the grain size distribution. The soil samples are prepared for testing according to ASTM D 421 (dry preparation) or ASTM D 2217 (wet preparation). The grain size distribution of soils coarser than the #200 U.S. Standard Sieve (0.074 mm opening) is determined by passing the samples through a standard set of nested sieves. Materials passing the No. 200 sieve are suspended in water and the grain size distribution calculated from the measured settlement rate. These tests are conducted in accordance with ASTM D 422.

Plasticity Tests

Plasticity tests are performed to determine the soil classification and plasticity characteristics. The soil plasticity characteristics are defined by the Plastic Index (PI) and the Liquid Limit (LL). The PI is related to the volume changes which occur in confined soils beneath foundations. The PI and LL are determined in accordance with ASTM D 4318.

Physical Properties

The in-place physical properties are described by the specific gravity, wet unit weight, moisture content, dry unit weight, void ratio and percent saturation of the soil. The specific gravity and moisture content are determined by ASTM D 854 and D 2216, respectively. The wet unit weight is found by obtaining a known volume of soil and dividing the wet sample weight by the known volume. The dry unit weight, void ratio and percent saturation are calculated values.

California Bearing Ratio

The California Bearing Ratio (CBR) test is a comparative measure of the shearing resistance of a soil. It is used with empirical curves to design asphalt pavement structures. The test is performed in accordance with ASTM D 1883 or Virginia Test Method Designation VTM-8. A representative bulk sample is compacted in a six-inch diameter CBR mold in five (5) equal layers, using 45 evenly spaced blows per layer with a 5.5 lb. hammer falling 12 inches. CBR tests may be run on the compacted samples in either soaked or unsoaked conditions, with samples penetrated at the rate of .05 inches per minute to a depth of 0.5 inches. The CBR value is the percentage of the load it takes to penetrate the soil to a specified depth compared to the load it takes to penetrate a standard crushed stone to the same depth.

Consolidation Tests

Consolidation tests determine the change in height of a soil sample with increasing load. The results of these tests are used to estimate the settlement and time rate of settlement of structures constructed on similar soils. The test is run in accordance with ASTM D 2435 on a single element of an extruded undisturbed sample. The test sample is trimmed into a disk approximately 2½ inches in diameter and one inch thick. The disk is confined in a stainless steel ring and sandwiched between porous plates and subjected to incrementally increasing vertical loads, with the resulting deformations measured with micrometer dial gauges. Void ratios and percent strain deformation are then calculated from these readings. The test results are presented in the form of a stress-strain or vertical pressure versus void ratio curve.

Triaxial Shear Tests

Triaxial shear tests are used to determine the strength characteristics and elastic properties of a soil sample. Triaxial shear tests are conducted either on relatively undisturbed samples of virgin material or on remolded-compacted samples of representative site materials. The samples are then trimmed into cylinders and encased in rubber membranes. Each is then placed into a compression chamber and confined by hydrostatic cell pressure. An axial load is applied until the sample fails in shear. Test results are presented in the form of stress-strain curves and stress paths to failure.

Various types of triaxial tests may be performed. The most suitable type of triaxial test is determined by the loading conditions imposed on the soil in the field and by drainage characteristics of the site. Types of triaxial tests normally performed include:

- Consolidated-Isotropic-Undrained (CIU test)
- Consolidated-Anisotropic-Undrained (CK_oU test)
- Consolidated-Isotropic-Drained (CID test)
- Consolidated-Anisotropic-Drained (CK_oD test)
- Unconsolidated-Undrained (UU test)

GeoEnvironmental Resources, Inc.

Dilatometer (DMT) Data Reduction Correlations

Corrected First Reading	$p_0 = 1.05(A - Z_M + \Delta A) - 0.05(B - Z_M - \Delta B)$	
Corrected Second Reading	$p_1 = B - Z_M - \Delta B$	
Corrected Third Reading	$p_2 = C - Z_M + \Delta A$	
Material Index	$I_D = \frac{p_1 - p_o}{p_o - u_o}$	Marchetti, 1997
Horizontal Stress Index	$K_D = \frac{p_o - u_o}{\sigma'_{vo}}$	
Dilatometer Modulus	$E_D = 34.7(p_1 - p_o)$	
Coeff. Earth Pressure In Situ	$K_o = \left(\frac{K_D}{1.5}\right)^{0.47} - 0.6$	
Overconsolidation Ratio	$OCR = (0.5K_D)^{1.56}$	
Undrained Shear Strength	$c_u = 0.22\sigma'_{vo}(0.5K_D)^{1.25}$	
Friction Angle	$\phi = 28 + 14.6\log K_D - 2.1\log^2 K_D$	
Vertical Drained Constrained Modulus	$M_{DMT} = R_M E_D$ If $I_D \le 0.6$ $R_M = 0.14 + 2.36\log K_D$ If $I_D \ge 3$ $R_M = 0.5 + 2\log K_D$ If $0.6 < I_D < 3$ $R_M = R_{M,o} + (2.5 - R_{M,o})\log K_D$ where $R_{M,o} = 0.14 + 0.15(I_D - 0.6)$ If $K_D > 10$ $R_M = 0.32 + 2.18\log K_D$ If $R_M < 0.85$ set $R_M = 0.85$	
Friction Angle	$\phi' = 37.3\left[\frac{K_D - 0.8}{K_o + 0.8}\right]^{0.082}$	Campanella & Robertson, 1991
Preconsol. Stress	$\sigma_p' = 0.509\ (p_o - u_o)$	Mayne, 1995
Total Unit Weight	$\gamma_T = 1.12\gamma_w \left(\frac{E_D}{p_a}\right)^{0.1} I_D^{-0.05}$	Mayne, et. al., 2002
Undrained Shear Strength	$s_u = \frac{p_o - u_o}{10}$	Schmertmann, 1981

Definitions

ΔA Reading: Quantification of resistance imparted by membrane to travel from the membrane's natural position to the A-position.

ΔB Reading: Quantification of resistance imparted by membrane to travel from the membrane's natural position to the B-position

A Position: Membrane just above feeler on sensing disk. Approximately flush with blade.

B Position: Membrane extended 1.1 mm into surrounding soil.

A Reading: Inflation pressure (reported in bar) required to expand membrane to A-position

B Reading: Inflation pressure (reported in bar) required to expand membrane to B-position.

C Reading: Deflation pressure (reported in bar) recorded when membrane is slowly deflated and returns to A- position.

Z_M: Zero gage reading. Reading of pressure gage when system is vented to atmosphere.

References

Marchetti S. (1997). "The Flat Dilatometer: Design Applications". Third Geotechnical Engineering Conference, Cairo University. Keynote lecture, 26 pp, Jan. 1997.

Campanella, R.G., and Robertson, P.K. (1991). Use and interpretation of a research dilatometer. Canadian Geotechnical Journal, **28**: 113-126.

Mayne, P.W. (1995) CPT determinations of overconsolidation ratio and lateral stresses in clean quartz sands, *Proceedings*, International Symposium on Cone Penetration Testing (CPT '95), Vol. 2, Swedish Geotechnical Society Report No. 3:95, Linkoping, pp. 215-220.

Mayne, P.W., Christopher, B., Berg, R., and DeJong, J. (2002). *Subsurface Investigations - Geotechnical Site Characterization*. Publication No. FHWA-NHI-01-031, National Highway Institute, Federal Highway Administration, Washington, D.C., 301 pages.
Schmertmann, J.H. (1981). Discussion to Marchetti (1980). Journal of the Geotechnical Engineering Division, ASCE, Vol. 107, No. GT6: 831-832. June, 1981.

Cone Penetration Test Interpretation Methods

CONETEC

ConeTec Interpretations as of April 8, 2014

ConeTec's interpretation routine provides a tabular output of geotechnical parameters based on current published CPT correlations and is subject to change to reflect the current state of practice. The interpreted values are not considered valid for all soil types. The interpretations are presented only as a guide for geotechnical use and should be carefully scrutinized for consideration in any geotechnical design. Reference to current literature is strongly recommended. ConeTec does not warranty the correctness or the applicability of any of the geotechnical parameters interpreted by the program and does not assume liability for any use of the results in any design or review. Representative hand calculations should be made for any parameter that is critical for design purposes. The end user of the interpreted output should also be fully aware of the techniques and the limitations of any method used in this program. The purpose of this document is to inform the user as to which methods were used and what the appropriate papers and/or publications are for further reference.

The CPT interpretations are based on values of tip, sleeve friction and pore pressure averaged over a user specified interval (e.g. 0.20m). Note that q_t is the tip resistance corrected for pore pressure effects and q_c is the recorded tip resistance. Since all ConeTec cones have equal end area friction sleeves, pore pressure corrections to sleeve friction, fs, are not required.

The tip correction is: $q_t = q_c + (1-a) \bullet u_2$

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)
a is the Net Area Ratio for the cone (typically 0.80 for ConeTec cones)

The total stress calculations are based on soil unit weights that have been assigned to the Soil Behavior Type zones, from a user defined unit weight profile or by using a single value throughout the profile.

Effective vertical overburden stresses are calculated based on a hydrostatic distribution of equilibrium pore pressures below the water table or from a user defined equilibrium pore pressure profile (this can be obtained from CPT dissipation tests). For over water projects the effects of the column of water have been taken into account as has the appropriate unit weight of water. How this is done depends on where the instruments were zeroed (i.e. on deck or at mud line).

Details regarding the interpretation methods for all of the interpreted parameters are provided in Table 1. The appropriate references cited in Table 1 are listed in Table 2. Where methods are based on charts or techniques that are too complex to describe in this summary the user should refer to the cited material.

The Soil Behavior Type classification charts (normalized and non-normalized) shown in Figures 1 and 2 are based on the charts developed by Dr. Robertson and Dr. Campanella at the University of British Columbia. These charts appear in many publications, most notably: Robertson, Campanella, Gillespie and Greig (1986); Robertson (1990) and Lunne, Robertson and Powell (1997). The Bq classification charts shown in Figures 3a and 3b are based on those described in Robertson (1990) and Lunne, Robertson and Powell (1997). The Jefferies and Davies SBT chart shown in Figure 3c is based on that discussed in Jefferies and Davies, 1993.

Where the results of a calculation/interpretation are declared 'invalid' the value will be represented by the text strings "-9999" or "-9999.0". In some cases the value 0 will be used. Invalid results will occur because of (and not limited to) one or a combination of:

1. Invalid or undefined CPT data (e.g. drilled out section or data gap).

2. Where the interpretation method is inappropriate, for example, drained parameters in an undrained material (and vice versa).

3. Where interpretation input values are beyond the range of the referenced charts or specified limitations of the interpretation method.

4. Where pre-requisite or intermediate interpretation calculations are invalid.

The parameters selected for output from the program are often specific to a particular project. As such, not all of the interpreted parameters listed in Table 1 may be included in the output files delivered with this report.

The output files are provided in Microsoft Excel XLS format. The ConeTec software has several options for output depending on the number or types of interpreted parameters desired. Each output file will be named using the original COR file basename followed by a three or four letter indicator of the interpretation set selected (e.g. BSC, TBL, NLI or IFI) and possibly followed by an operator selected suffix identifying the characteristics of the particular interpretation run.

Table 1
CPT Interpretation Methods

Interpreted Parameter	Description	Equation	Ref
Depth	Mid Layer Depth *(where interpretations are done at each point then Mid Layer Depth = Recorded Depth)*	*Depth (Layer Top) + Depth (Layer Bottom) / 2.0*	
Elevation	Elevation of Mid Layer based on sounding collar elevation supplied by client	Elevation = Collar Elevation - Depth	
Avgqc	Averaged recorded tip value (q_c)	$Avgqc = \frac{1}{n}\sum_{i=1}^{n} q_c$ *n=1 when interpretations are done at each point*	
Avgqt	Averaged corrected tip (q_t) where: $q_t = q_c + (1-a) \bullet u$	$Avgqt = \frac{1}{n}\sum_{i=1}^{n} q_t$ *n=1 when interpretations are done at each point*	
Avgfs	Averaged sleeve friction (f_s)	$Avgfs = \frac{1}{n}\sum_{i=1}^{n} fs$ *n=1 when interpretations are done at each point*	
AvgRf	Averaged friction ratio (Rf) where friction ratio is defined as: $Rf = 100\% \bullet \frac{fs}{qt}$	$AvgRf = 100\% \cdot \frac{Avgfs}{Avgqt}$ *n=1 when interpretations are done at each point*	

Interpreted Parameter	Description	Equation	Ref
Avgu	Averaged dynamic pore pressure *(u)*	$Avgu = \frac{1}{n}\sum_{i=1}^{n} u_i$ *n=1 when interpretations are done at each point*	
AvgRes	Averaged Resistivity (this data is not always available since it is a specialized test requiring an additional module)	$Avgu = \frac{1}{n}\sum_{i=1}^{n} RESISTIVITY_i$ *n=1 when interpretations are done at each point*	
AvgUVIF	Averaged UVIF ultra-violet induced fluorescence (this data is not always available since it is a specialized test requiring an additional module)	$Avgu = \frac{1}{n}\sum_{i=1}^{n} UVIF_i$ *n=1 when interpretations are done at each point*	
AvgTemp	Averaged Temperature (this data is not always available since it is a specialized test)	$Avgu = \frac{1}{n}\sum_{i=1}^{n} TEMPERATURE_i$ *n=1 when interpretations are done at each point*	
AvgGamma	Averaged Gamma Counts (this data is not always available since it is a specialized test requiring an additional module)	$Avgu = \frac{1}{n}\sum_{i=1}^{n} GAMMA_i$ *n=1 when interpretations are done at each point*	
SBT	Soil Behavior Type as defined by Robertson and Campanella	See Figure 1	2, 5
U.Wt.	Unit Weight of soil determined from one of the following user selectable options: 1) uniform value 2) value assigned to each SBT zone 3) user supplied unit weight profile	See references	5
T. Stress σ_v	Total vertical overburden stress at Mid Layer Depth. *A layer is defined as the averaging interval specified by the user. For data interpreted at each point the Mid Layer Depth is the same as the recorded depth.*	$TStress = \sum_{i=1}^{n} \gamma_i h_i$ *where* γ_i is layer unit weight h_i is layer thickness	
E. Stress σ_v'	Effective vertical overburden stress at Mid Layer Depth	$Estress = Tstress - u_{eq}$	
Ueq	Equilibrium pore pressure determined from one of the following user selectable options: 1) hydrostatic from water table depth 2) user supplied profile	For hydrostatic option: $u_{eq} = \gamma_w \cdot (D - D_{wt})$ where u_{eq} is equilibrium pore pressure γ_w is unit weight of water D is the current depth D_{wt} is the depth to the water table	
Cn	SPT N_{60} overburden correction factor	$Cn=(\sigma_v')^{-0.5}$ where σ_v' *is in tsf* $0.5 < C_n < 2.0$	
N_{60}	SPT N value at 60% energy calculated from qt/N ratios assigned to each SBT zone. This method has abrupt N value changes at zone boundaries.	*See Figure 1*	4, 5
$(N_1)_{60}$	SPT N_{60} value corrected for overburden pressure	$(N_1)_{60} = Cn \bullet N_{60}$	4
$N_{60}I_c$	SPT N_{60} values based on the Ic parameter	$(qt/pa)/ N_{60} = 8.5 (1 – Ic/4.6)$	5
$(N_1)_{60}Ic$	SPT N_{60} value corrected for overburden pressure (using N_{60} I_c). User has 2 options.	1) $(N_1)_{60}Ic= Cn \bullet (N_{60} Ic)$ 2) $q_{c1n}/ (N_1)_{60}Ic = 8.5 (1 – Ic/4.6)$	4 5

Interpreted Parameter	Description	Equation	Ref
$(N_1)_{60cs}Ic$	Clean sand equivalent SPT $(N_1)_{60}Ic$. User has 3 options.	1) $(N_1)_{60cs}Ic = \alpha + \beta((N_1)_{60}Ic)$ 2) $(N_1)_{60cs}Ic = K_{SPT} * ((N_1)_{60}Ic)$ 3) $q_{c1ncs})/ (N_1)_{60cs}Ic = 8.5\ (1 - Ic/4.6)$ FC ≤ 5%: $\alpha = 0$, $\beta=1.0$ FC ≥ 35% $\alpha = 5.0$, $\beta=1.2$ 5% < FC < 35% $\alpha = \exp[1.76 - (190/FC^2)]$ $\beta = [0.99 + (FC^{1.5}/1000)]$	10 10 5
Su	Undrained shear strength based on q_t Su factor N_{kt} is user selectable	$Su = \frac{qt - \sigma_v}{N_{kt}}$	1, 5
Su	Undrained shear strength based on pore pressure Su factor $N_{\Delta u}$ is user selectable	$Su = \frac{u_2 - u_{eq}}{N_{\Delta u}}$	1, 5
k	Coefficient of permeability (assigned to each SBT zone)		5
Bq	Pore pressure parameter	$Bq = \frac{\Delta u}{qt - \sigma_v}$ *where:* $\Delta u = u - u_{eq}$ *and* u *= dynamic pore pressure* u_{eq} *= equilibrium pore pressure*	1, 5
Q_t	Normalized q_t for Soil Behavior Type classification as defined by Robertson, 1990	$Qt = \frac{qt - \sigma_v}{\sigma'_v}$	2, 5
F_r	Normalized Friction Ratio for Soil Behavior Type classification as defined by Robertson, 1990	$Fr = 100\% \cdot \frac{fs}{qt - \sigma_v}$	2, 5
Net qt	Net tip resistance	$qt - \sigma_v$	
qe	Effective tip resistance	$qt - u_2$	
qeNorm	Normalized effective tip resistance	$\frac{qt - u_2}{\sigma'_v}$	
SBTn	Normalized Soil Behavior Type as defined by Robertson and Campanella	See Figure 2	2, 5
SBT-BQ	Non-normalized Soil Behavior type based on the Bq parameter	See Figure 3	2, 5
SBT-BQn	Normalized Soil Behavior based on the Bq parameter	See Figure 3	2, 5
SBT-JandD	Soil Behaviour Type as defined by Jeffries and Davies	See Figure 3	7

Interpreted Parameter	Description	Equation	Ref
I_c	Soil index for estimating grain characteristics	*$Ic = [(3.47 - \log_{10}Q)^2 + (\log_{10} Fr + 1.22)^2]^{0.5}$* *Where:* $Q = \left(\frac{qt - \sigma_v}{P_a}\right)\left(\frac{P_a}{\sigma_v'}\right)^n$ *And* *Fr is in percent* *P_a = atmospheric pressure* *n varies from 0.5 to 1.0 and is selected in an iterative manner based on the resulting I_c*	3, 8
FC	Apparent fines content (%)	*$FC=1.75(Ic^{3.25}) - 3.7$* *FC=100 for Ic > 3.5* *FC=0 for Ic < 1.26* *FC = 5% if 1.64 < Ic < 2.6 AND F_r<0.5*	3
Ic Zone	This parameter is the Soil Behavior Type zone based on the Ic parameter (valid for zones 2 through 7 on SBTn chart)	Ic < 1.31 Zone = 7 1.31 < Ic < 2.05 Zone = 6 2.05 < Ic < 2.60 Zone = 5 2.60 < Ic < 2.95 Zone = 4 2.95 < Ic < 3.60 Zone = 3 Ic > 3.60 Zone = 2	3
PHI ϕ	Friction Angle determined from one of the following user selectable options: a) Campanella and Robertson b) Durgunoglu and Mitchel c) Janbu d) Kulhawy and Mayne	See reference	5 5 5 11
Dr	Relative Density determined from one of the following user selectable options: a) Ticino Sand b) Hokksund Sand c) Schmertmann 1976 d) Jamiolkowski 1985 - All Sands e) Jamiolkowski et al 2003 (various compressibilities, Ko)	See reference Jamiolkowski et al 2003 reference	5 14
OCR	Over Consolidation Ratio	a) Based on Schmertmann's method involving a plot of S_u/σ_v' /($S_u/\sigma_v')_{NC}$ and OCR where the Su/p' ratio for NC clay is user selectable	9
State Parameter	The state parameter is used to describe whether a soil is contractive (SP is positive) or dilative (SP is negative) at large strains based on the work by Been and Jefferies	See reference	8, 6, 5
Es/qt	Intermediate parameter for calculating Young's Modulus, E, in sands. It is the Y axis of the reference chart.	Based on Figure 5.59 in the reference	5

Interpreted Parameter	Description	Equation	Ref
Young's Modulus E	Young's Modulus based on the work done in Italy. There are three types of sands considered in this technique. The user selects the appropriate type for the site from: a) OC Sands b) Aged NC Sands c) Recent NC Sands Each sand type has a family of curves that depend on mean normal stress. The program calculates mean normal stress and linearly interpolates between the two extremes provided in the Es/qt chart.	Mean normal stress is evaluated from: $\sigma'_m = \frac{1}{3}\left(\sigma'_v + \sigma'_h + \sigma'_h\right)^3$ where σ_v'= vertical effective stress σ_h'= horizontal effective stress and $\sigma_h = K_o \bullet \sigma_v'$ with Ko assumed to be 0.5	5
q_{c1}	q_t normalized for overburden stress used for seismic analysis	$q_{c1} = q_t \bullet (Pa/\sigma_v')^{0.5}$ where: Pa = atm. Pressure q_t is in MPa	3
q_{c1n}	q_{c1} in dimensionless form used for seismic analysis	$q_{c1n} = (q_{c1} / Pa)(Pa/\sigma_v')^n$ where: Pa = atm. Pressure and n ranges from 0.5 to 1.0 based on Ic.	3
K_{SPT}	Equivalent clean sand factor for $(N_1)60$	$K_{SPT} = 1 + ((0.75/30) \bullet (FC - 5))$	10
K_{CPT}	Equivalent clean sand correction for q_{c1N}	$K_{cpt} = 1.0$ for $I_c \leq 1.64$ $K_{cpt} = f(I_c)$ for $I_c > 1.64$ (see reference)	10
q_{c1ncs}	Clean sand equivalent q_{c1n}	$q_{c1ncs} = q_{c1n} \bullet K_{cpt}$	3
CRR	Cyclic Resistance Ratio (for Magnitude 7.5)	$q_{c1ncs} < 50$: $CRR_{7.5} = 0.833\ [q_{c1ncs}/1000] + 0.05$ $50 \leq q_{c1ncs} < 160$: $CRR_{7.5} = 93\ [q_{c1ncs}/1000]^3 + 0.08$	10
CSR	Cyclic Stress Ratio	$CSR = (\tau_{av}/\sigma_v') = 0.65\ (a_{max} / g)\ (\sigma_v/ \sigma_v')\ r_d$ $r_d = 1.0 - 0.00765\ z$ $z \leq 9.15$m $r_d = 1.174 - 0.0267\ z$ $9.15 < z \leq 23$m $r_d = 0.744 - 0.008\ z$ $23 < z \leq 30$m $r_d = 0.50$ $z > 30$m	10
MSF	Magnitude Scaling Factor	See Reference	10
FofS	Factor of Safety against Liquefaction	$FS = (CRR_{7.5} / CSR)\ MSF$	10
Liquefaction Status	Statement indicating possible liquefaction	Takes into account FofS and limitations based on I_c and q_{c1ncs}.	10

Interpreted Parameter	Description	Equation	Ref
Cont/Dilat Tip	Contractive / Dilative qc1 Boundary based on $(N_1)_{60}$	$(\sigma_v')_{boundary} = 9.58 \times 10^{-4} [(N_1)_{60}]^{4.79}$ qc1 is calculated from specified qt(MPa)/N ratio	13
Cq	Normalizing Factor	$Cq = 1.8 / (0.8 + ((\sigma_v'/Pa))$	12
qc1 (Cq)	Normalized tip resistance based on Cq	$q_{c1} = C_q * q_t$ (some papers use q_c)	12
Su(Liq)/s'v	Liquefied Shear Strength Ratio	$\frac{Su(Liq)}{\sigma_v'} = 0.03 + 0.0143(q_{c1})$ Note: σ_v' and s'v are synonymous	13

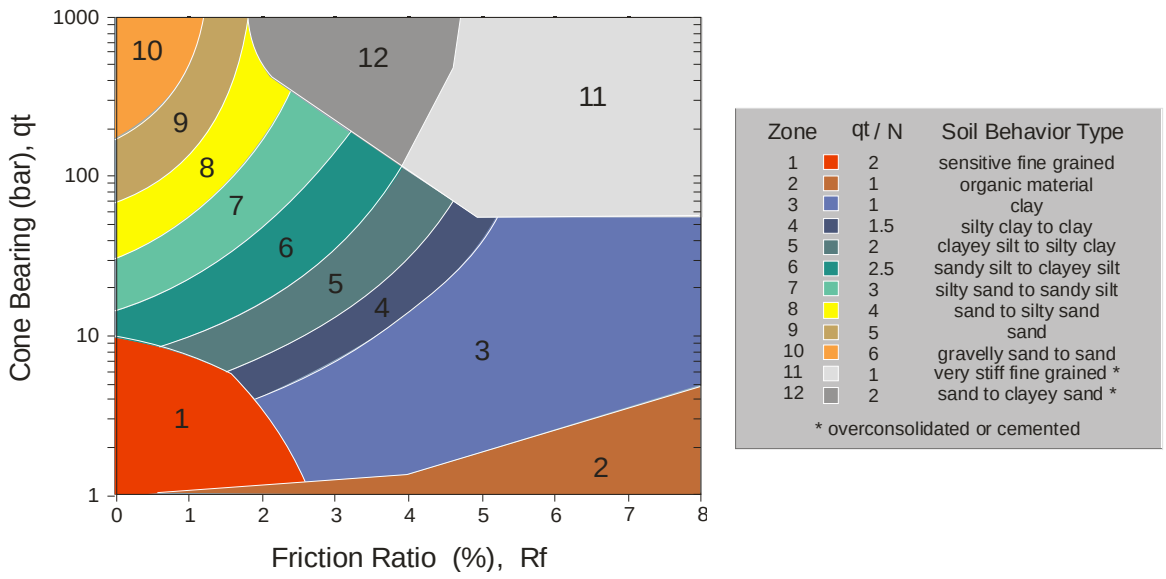

Figure 1 Non-Normalized Behavior Type Classification Chart

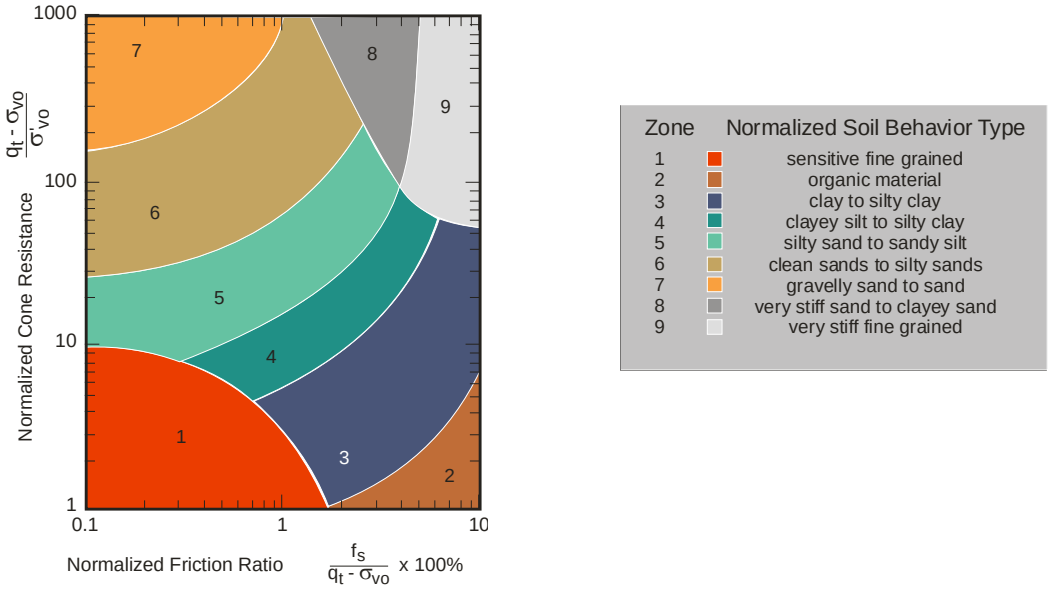

Figure 2 Normalized Behavior Type Classification Chart

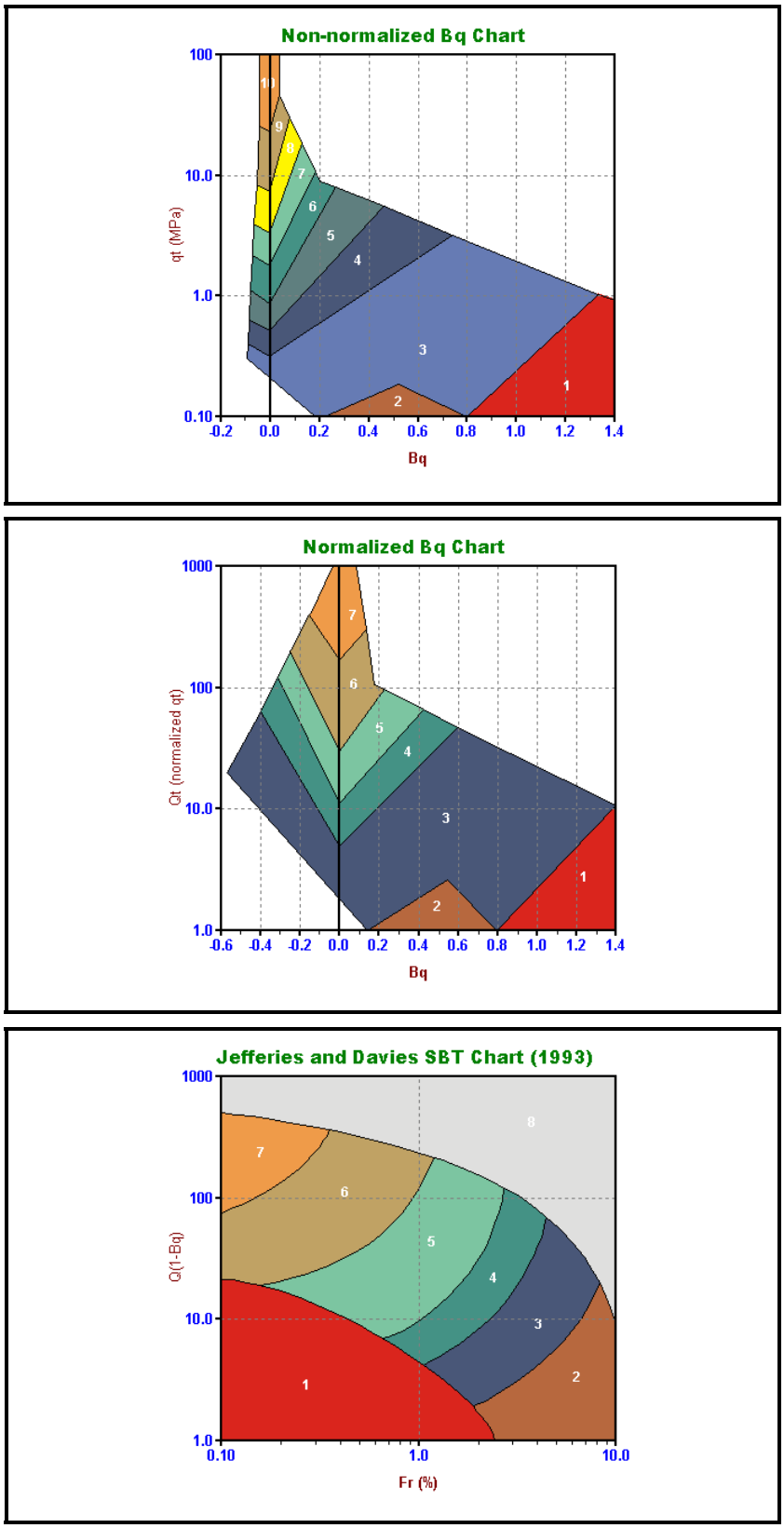

Figure 3 – Alternate Soil Behaviour Type Charts

Table 2 References

No.	References
1	Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, "Use of Piezometer Cone Data", Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.
2	Robertson, P.K., 1990, "Soil Classification Using the Cone Penetration Test", Canadian Geotechnical Journal, Volume 27.
3	Robertson, P.K. and Fear, C.E., 1998, "Evaluating cyclic liquefaction potential using the cone penetration test", Canadian Geotechnical Journal, 35: 442-459.
4	Robertson, P.K. and Wride, C.E., 1998, "Cyclic Liquefaction and its Evaluation Based on SPT and CPT", NCEER Workshop Paper, January 22, 1997
5	Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, " Cone Penetration Testing in Geotechnical Practice," Blackie Academic and Professional.
6	Plewes, H.D., Davies, M.P. and Jefferies, M.G., 1992, "CPT Based Screening Procedure for Evaluating Liquefaction Susceptibility", 45th Canadian Geotechnical Conference, Toronto, Ontario, October 1992.
7	Jefferies, M.G. and Davies, M.P., 1993. "Use of CPTu to Estimate equivalent N_{60}", Geotechnical Testing Journal, 16(4): 458-467.
8	Been, K. and Jefferies, M.P., 1985, "A state parameter for sands", Geotechnique, 35(2), 99-112.
9	Schmertmann, 1977, "Guidelines for Cone Penetration Test Performance and Design", Federal Highway Administration Report FHWA-TS-78-209, U.S. Department of Transportation
10	Proceedings of theNCEER Workshop on Evaluation of Liquefaction Resistance of Soils, Salt LakeCity, 1996. Chaired by Leslie Youd. 11
11	Kulhawy, F.H. and Mayne, P.W. ,1990, "Manual on Estimating Soil Properties for Foundation Design, *Report No. EL-6800"*, Electric Power Research Institute, Palo Alto, CA, August 1990, 306 p.
12	Olson, S.M. and Stark, T.D., 2002, "Liquefied strength ratio from liquefied flow filaure case histories", Canadian Geotechnical Journal, 39: 951-966.
13	Oslon, Scott M. and Stark, Timothy D., 2003, "Yield Strength Ratio and Liquefaction Analysis of Slopes and Embankments", Journal of Geotechnical and Geoenvironmental Engineering, ASCE, August 2003.
14	Jamiolkowski, M.B., Lo Presti, D.C.F., & Manassero, M. 2003. Evaluation of Relative Denisty and Shear Strength of Sands from CPT and DMT. Soil Behaviour and Soft Ground Construction, ASCE, GSP N0. 119, 201-238