November 5, 2018

FOUNDATION INVESTIGATION AND DESIGN REPORT

HIGH FILL EMBANKMENT
HIGHWAY 400/89 INTERCHANGE RECONSTRUCTION
TOWN OF INNISFIL, SIMCOE COUNTY
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 2438-13-00

Submitted to:
Morrison Hershfield Limited
Suite 300, 125 Commerce Valley Drive West
Markham, Ontario
L3T 7W4

REPORT

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1.0 INTRODUCTION

Golder Associated Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed reconstruction of Highway 400/89 interchange and bridge replacement. The proposed works will include high fill embankment areas along the following new road/ramp alignments:

- Realigned Highway 89 Approach Embankments east and west of Highway 400;
- Highway 89 East – Highway 400 South (Ramp E-S); and,
- Highway 89 West – Highway 400 South (Ramp W-S);
- Highway 400 North – Highway 89 East/West (Ramp N-E/W).
- Highway 89 East – Highway 400 North (Ramp E-N);
- Highway 89 East/West – Highway 400 North (Ramp E/W-N);
- Highway 400 South – Highway 89 East/West (Ramp S-E/W); and,
- Reive Boulevard north of Highway 89.

The purpose of this investigation is to establish the subsurface soil and groundwater conditions in the high fill embankment areas by borehole drilling, in situ testing and laboratory testing on selected soil samples. The investigation areas are shown in plan on Drawing 1.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated November 2, 2016, which forms part of the Consultant's Assignment Number (Number 2015-E-0038) for this project and associated adjustments made to the roadway profiles as part of the detail design. The work has been carried out with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated April 25, 2017.

2.0 SITE DESCRIPTION

The Highway 400/89 interchange is located about 20 km south of the City of Barrie in the Town of Innisfil, Ontario, as shown on the Key Plan on Drawing 1. Highway 400 consists of three lanes of traffic in each northbound and southbound directions. Highway 89 is oriented in an east-west direction and consists of one lane of traffic in each direction, with turning lanes connecting to the Highway 400 on-ramps.

The northwest quadrant of the interchange consists of agricultural lands, and a closed highway service centre. All infrastructure, excluding lamp standards, has been removed from the footprint of the closed service centre. The northeast quadrant of the interchange consists of an open field containing a small area vegetated with trees and an industrial facility and yard. The southeast quadrant is occupied by a commuter parking lot and an outlet mall. The southwest quadrant is occupied by an area densely populated with trees and agricultural lands. Overhead power lines extend along the south side of Highway 89.

The ground surface of Highway 400 varies from about Elevation 229 m to Elevation 229.5 m, and the existing Highway 89 grade at the existing underpass is at about Elevation 235.4 m.

The existing Highway 89 embankment has side slopes inclined at approximately two horizontal to one vertical (2H:1V). Based on observations of the embankment at the time of the borehole investigation, the side slopes appear to be performing adequately with no visual evidence of surficial sloughing or slope instability.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigation

A preliminary foundation investigation for the Highway 89 underpass was carried out by Golder in 2002 during which time a total of two boreholes, designated as Boreholes B1-1 and B1-2, were advanced near the east and west abutments of the underpass. The boreholes were advanced to depths of 28 m and 37 m below ground surface and geotechnical laboratory testing was carried out on selected soil samples. The results of this investigation are contained in a report titled, “Preliminary Foundation Investigation and Design Report, Highway 89 Underpass Structure Site 30-256, Highway 400 Widening from 1 km South of Highway 89 to Highway 11, G.W.P. 30-95-00”, dated January 2002 (GEOCRES No. 31D-465).

The locations of the boreholes advanced during the 2002 investigation are shown on Drawing 1, and the borehole records, including a summary of the laboratory testing results from this investigation, are presented in Appendix A. The northing and easting coordinates relative to the MTM NAD 83 (Zone 10) coordinate system, the ground surface elevations referenced to Geodetic datum and drilled depths are presented below and on the borehole records in Appendix A.

Borehole No.	Location (MTM NAD 83 Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
B1-1	4,895,635.8 (44.200617)	292,452.1 (-79.654489)	228.9	28.0
B1-2	4,895,623.5 (44.200506)	292,394.6 (-79.655208)	228.4	37.0

3.2 Current Investigation

Field work for the foundation investigation was carried out between July 11 and August 15, 2017 and between January 23 and February 15, 2018 during which time 33 boreholes were drilled specifically along the high fill embankments (i.e. HF and PMT series), supplemented with 8 boreholes drilled for the realigned underpass (i.e. 89UP series). The borehole locations are shown on Drawing 1. Detailed below are the applicable soil strata drawing, station limits of the high fills and the applicable boreholes for each ramp within the interchange.

Location	Soil Strata Drawing	Station Limits	Boreholes
Highway 89 (east and west of the underpass)	2	9+820 to 10+290	HF-01 to HF-04, HF-16 to HF-18 and 89UP-01, 89UP-03, 89UP-05 and 89UP-07 and 89UP-08
Ramp E-S	3	9+912 to 10+170	HF-01, HF-10 to HF-12, HF-21, 89UP-01 and 89UP-03

Location	Soil Strata Drawing	Station Limits	Boreholes
Reive Boulevard	4	10+010 to 10+110	HF-14 and HF-15
Ramp S-E/W Ramp E/W-N	4	10+220 to 10+380 10+040 to 10+110	HF-28 to HF-31 and PMT/VSP-02
Ramp W-N	4	10+050 to 10+110	HF-26, HF-27 and PMT-02
Ramp W-S	5	10+000 to 10+160	HF-05 to HF-09, HF-24, HF-25 and PMT/VSP-01
Ramp N-E/W	5	10+320 to 10+560	HF-12, HF-13 and HF-19 to HF-23

Boreholes were advanced to depths ranging between 5.2 m and 52.4 m below existing ground surface using a D-50 track mounted drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes were advanced through the overburden by 203 mm outer diameter (O.D.) continuous flight hollow stem augers and wash boring methods using 'NW' casing and a tricone. Soil samples were obtained at 0.75 m, 1.5 m and 3 m intervals of depth, using 50 mm O.D. split spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586)[1]. In-situ field vane testing, using MTO standard "N"-sized vanes, was carried out in the cohesive soils where encountered, to measure the undrained shear strength of the clayey silt to silty clay deposits (ASTM D2573 Standard for Test Method for Field Vane Shear Test). Thin-walled Shelby tube samples were also taken within the cohesive deposit at selected intervals (ASTM D1587 Standard Penetration for Think-Walled Sampling).

In addition, two boreholes were advanced in the southwest and southeast quadrant of the Highway 400 and Highway 89 interchange to carry out in-situ pressuremeter testing (PMT). The boreholes were advanced by Walker Drilling Ltd. using wash boring methods, and the PMT was carried out by In-Depth Geotechnical Inc. of Hamilton, Ontario. A detailed report summarizing the test procedures is provided in Appendix B. Upon completion of PMT, a 50 mm diameter PVC casing was installed in each borehole and the annulus between the casing and the open borehole was backfilled with a cement/bentonite mix using tremie methods. Once the grout cured, Vertical Seismic Profiling (VSP) was carried out by placing receivers (i.e., geophones) inside the casing at a specific interval of depth, generating seismic energy at the ground surface near the casing, and recoding data at the geophones. The VSP was carried out by a geophysicists from Golder. A detailed report summarizing the test procedures and results is provided in Appendix C.

Groundwater conditions were observed in the open boreholes during the drilling operations. A standpipe piezometer was installed in each of Boreholes 89UP-03, 89UP-07, HF-12, HF-15, HF-22, HF-23 and HF-26 to permit monitoring of the groundwater level. The standpipe piezometers consists of a 50 mm diameter PVC pipe with a slotted screen sealed at a depth within the boreholes. Details of standpipe piezometer installations and water level readings are presented on the borehole records in Appendix B. All open boreholes were backfilled with bentonite upon completion, in accordance with Ontario Regulation 903, Wells (as amended).

Field work was observed by a member of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground utility services, observed the drilling, sampling and in situ testing operations, and logged the boreholes. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further

[1] ASTM D1586-08a – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the soil.

visual examination and laboratory testing. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples, to MTO LS and/or ASTM Standards, as applicable. In addition, four, one-dimensional consolidation (oedometer) tests were carried out on samples of the silty clay to clayey silt deposit. The results of the geotechnical laboratory testing for the current investigation are included in Appendix E.

Borehole locations and ground surface elevations were obtained using a GPS (Trimble XH 3.5G), having an accuracy of 0.1 m in the vertical and 0.1 m in the horizontal directions. The locations, given in the borehole records and shown on Drawing 1 are positioned relative to North American Datum 1983 (NAD83CSRS), Modified Transverse Mercator (MTM) northing and easting coordinates, Zone 10, and the ground surface elevations referenced the Geodetic datum. The borehole locations in MTM NAD83 and geographic coordinates, ground surface elevations and drilled depths are summarized in Table 1, following the text of this report.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The project area is located within the Peterborough Drumlin Field physiographic region, as delineated in *The Physiography of Southern Ontario (Chapman and Putman, 1894)*[2]. The surficial soils in the Peterborough Drumlin Field consist primarily of gravelly sand till or sand and gravel deposits. Drumlins (glacially-shaped hills) are more frequent in the southern portion of the section of the Peterborough Drumlin Field traversed by Highway 400. Deposits of silt, clay or peat may be found in the low-lying areas between drumlins. The Lindsay and Verulam Formations which underlies the Peterborough Drumlin Field consists mainly of fossiliferous limestone.

4.2 Subsurface Conditions

Detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during the investigation and the results of the laboratory tests carried out on selected soil samples are presented on the borehole records provided in Appendix D. The results of the in situ field tests (i.e. SPT “N”-values and field vane) as presented on the Record of Borehole sheets and in sub-sections of Section 4.2 are uncorrected. The geotechnical laboratory testing plots are contained in Appendix E.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the stratigraphic profiles on Drawings 2 to 5 are inferred from non-contiguous sampling, observations of drilling progress and the results of Standard Penetration Tests and in situ field vane tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations; however, the factual data presented in the borehole records governs any interpretation of the site conditions. It should be noted that the interpreted stratigraphy shown on Drawings 2 to 5 is a simplification of the subsurface conditions.

In general, the subsurface conditions consist of a layer of topsoil or pavement structure underlain by granular fill, in turn underlain by an upper granular deposit of silt to silt and sand to silty sand. The upper granular deposit is underlain by an upper cohesive deposit composed of varved clayey silt to clay, underlain in places by a lower non-cohesive deposit and/or layers of silt to sandy silt to silty sand. The lower granular deposit is underlain by a lower

[2] Chapman, L.J. and Putman, D.F., 1984, The Physiography of Southern Ontario, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.)

cohesive deposit comprised of clayey silt and a deposit of glacial till that varies in composition from silt and sand to sandy clayey silt. A more detailed description of the subsurface conditions encountered in the boreholes during the previous and current field investigations is provided in the following sections.

4.2.1 Topsoil

A 102 mm to 685 mm thick layer of topsoil was encountered from ground surface in Boreholes HF-01 to HF-09, HF-12 to HF-18, HF-21 to HF-23, HF-26 to HF-31, PMT-01, PMT-02, 89UP-01, 89UP-03, 89UP-07, 89UP-08 and HF-02. In boreholes where the thickness of topsoil is greater than the length of the split spoon sampler, the SPT "N"-values range from 1 blow to 8 blows per 0.3 m of penetration, indicating a very loose to loose level of compactness.

4.2.2 Pavement Structure

Boreholes 89UP-02 and 89UP-06 advanced through the existing pavement structure on the westbound lane of Highway 89, Boreholes 89UP-04 and 89UP-05 advanced on the northbound lanes of Highway 400 and Boreholes HF-10, HF-11, HF-19, HF-20, HF-24 and HF-25 advanced from existing ramps penetrated the pavement structure which is comprised of asphaltic concrete ranging in thickness from approximately 102 mm to 250 mm. The asphaltic concrete is underlain by a layer of sand and gravel (granular road base material) ranging in thickness from approximately 250 mm to 2,100 mm. Within the gravelly sand fill in Borehole HF-24, asphaltic concrete was encountered between depths of 1.2 m and 1.4 m below ground surface.

4.2.3 Fill

Granular fill was encountered underlying the pavement structure and topsoil at all borehole locations advanced for the high fill embankments with the exception of Boreholes HF-02 HF-05, HF-12, HF-13 and HF-15. The fill is variable in composition and generally consists of layers of silt and sand silty sand and sand and gravel. Organic odour was noted in Borehole 89UP-05 throughout the fill layer and clayey silt pockets were encountered below a depth of 7.2 m in Borehole 89UP-06. The surface of the fill was encountered at Elevations 234.6 m and 234.8 m in Boreholes 89UP-02 and 89UP-06, respectively, both of which were advanced on Highway 89, and between Elevations 229.7 m and 225.7 m at the other borehole locations. In Boreholes 89UP-02 and 89UP-06, the fill extends to depths of 10.2 m and 9.1 m respectively, below ground surface (Elevations 225.3 m and 226.2 m), while the fill extends to depths between about 0.7 m and 3.7 m below ground surface (between Elevations 226.7 m and 224.4 m) at the other borehole locations.

The SPT "N"-values measured within the granular fill range from 3 blows to 56 blows per 0.3 m of penetration, indicating very loose to very dense levels of compactness.

The results of grain size distribution tests completed on sixteen samples of the granular fill are presented on Figures E-1, E-2A, E-2B and E-3 in Appendix E.

The water content measured on samples of various layers of the fill deposit range from 10 per cent to 23 per cent, and field observations indicate moist to wet conditions.

4.2.4 Silt to Silty Sand (Upper Granular Deposit)

Underlying the topsoil and/or fill in all boreholes and from ground surface in Borehole PMT-02, a non-cohesive deposit consisting of silt to sandy silt to silt and sand to silty sand was encountered, between about Elevations 228.4 m and 224.4 m. The thickness of the deposit ranges from about greater than 1.5 m where it was not fully penetrated to 21.3 m and the deposit extends to depths between about 20.8 m and 29.3 m (between Elevations 209.1 m and 205.3 m) below ground surface. Boreholes HF-01 to HF-06 and HF-08 to HF-31 terminated within this deposit at depths of between 5.2 m and 9.8 m (between Elevations 224.4 m and 217.7 m) below ground surface. In addition, Boreholes 89UP-01 and 89UP-08 terminated within this deposit at a depth of 8.2 m (Elevation 219.6 m) and 11.3 m (Elevation 216.3 m) respectively, below ground surface.

The SPT "N"-values recorded within the non-cohesive deposit range from 5 blows to 80 blows per 0.3 m of penetration, indicating a loose to very dense compactness condition. The SPT "N"-values recorded in the upper granular deposit between about Elevations 228 m and 214 m generally range from about 5 blows to 43 blows, and below about Elevation 214 m the SPT "N"-values range from about 14 blows to 80 blows.

The results of grain size distribution testing completed on eighty-eight samples is shown on Figures E-4A to E-4G, E-5, E-6A, E-6B and E-7A to E-7D in Appendix E. The deposit generally contains trace to some gravel and trace clay and the silt portion contains trace to some sand. At some locations, the deposit contains clayey silt to silty clay interlayers which are between about 0.1 m to 2.3 m thick as described further in Section 4.2.5.

Atterberg limits testing carried out on thirteen samples of the non-cohesive deposit measured liquid limits ranging from about 14 per cent to about 17 per cent, plastic limits ranging from about 12 per cent to about 15 per cent, and plasticity indices ranging from about 1 per cent to about 3 per cent, indicating that the portion of the silt to sandy silt layers of the deposit has slight plasticity as presented on the plasticity chart on Figures E-8A and E-8B in Appendix E.

The natural water content measured on samples of the silt to silty sand deposit ranges from about 10 per cent to 24 per cent.

4.2.5 Clayey Silt to Silty Clay (Interlayers)

Boreholes 89UP-03, 89UP-07 and 89UP-08 penetrated approximately 0.3 m to 2.3 m thick layers of clayey silt to silty clay within the upper granular deposit. The surface of the clayey silt to silty clay layers were encountered between about Elevations 226.0 m and 209.6 m. The grey clayey silt to silty clay contains trace to some sand and in Borehole 89UP-07 the lower 2.3 m thick interlayer at Elevation 218.5 m is varved.

The SPT "N"-values measured within the cohesive layer in Boreholes 89UP-07 are 8 blows and 23 blows (measured at the interface of the silty clay layer and the underlying silt deposit) per 0.3 m of penetration, suggesting a stiff to very stiff consistency. A SPT "N"-value measured at the interface of the silty clay layer and underlying silt and sand deposit in Borehole 89UP-03 is 44 blows per 0.3 m of penetration, suggesting a hard consistency. A SPT "N"-value measured at the interface of the silty clay layer and overlying silt and sand deposit in Borehole 89UP-08 is 15 blows per 0.3 m of penetration, suggesting a stiff consistency.

The natural water content measured on four samples of the clayey silt to silty clay deposit ranges from about 21 per cent to 25 per cent.

4.2.6 Clayey Silt with Sand to Clay (Upper Cohesive Deposit)

A varved cohesive deposit comprised of clayey silt with sand to clayey silt to silty clay to clay was encountered underlying the upper granular deposit in Boreholes B1-1, B1-2, 89UP-02 to 89UP-07, HF-02 and HF-07. The cohesive deposit is varved, comprised of silty clay with thin clayey silt and silt laminae, but includes homogenous zones of silty clay in places. The surface of the cohesive deposit was encountered at depths between about 20.8

m and 29.3 m (between Elevations 209.1 m and 205.3 m) below ground surface. The thickness of the varved cohesive deposit varies from about 9.6 m to 12.4 m and the deposit extended to between about Elevations 195.8 m and 194.0 m. Borehole B1-1 was terminated within this deposit at a depth of 28.0 m (Elevation 200.9 m) below ground surface.

The SPT "N"-values recorded within this deposit ranges from 0 blows (weight of hammer) to 40 blows per 0.3 m of penetration. In situ vane tests carried out within this deposit measured undrained shear strength ranging from about 11 kPa to greater than 96 kPa, but typically greater than 40 kPa. The sensitivity ranges from about 1 to 4, with the exception of Borehole 89UP-06 in which a sensitivity of about 7 was measured at Elevation 200.8 m. The in situ field vane tests results together with the SPT "N"-values indicate that the clayey silt to silty clay deposit predominately has a firm to very stiff consistency, with the exception of the upper zone of the silty clay deposit encountered in Borehole B1-1 which has a hard consistency based on an SPT "N"-value of 40 blows per 0.3 m of penetration recorded at about Elevation 207.0 m.

The results of grain size distribution tests completed on four samples of the cohesive deposit are shown on Figure E-9 in Appendix E. The clayey silt portion of the deposit generally contains trace to some gravel and trace sand to a sandy composition. As noted above, the cohesive deposit is generally varved with clayey silt and silt laminae, as shown on the photographs on Figure E-10.

Atterberg limits tests were carried out on twenty-two samples of the varved cohesive deposit and measured liquid limits ranging from about 15 per cent to about 53 per cent, plastic limits ranging from about 13 per cent to about 21 and plasticity indices ranging from about 5 per cent to about 33 per cent. The results of the Atterberg limits tests are shown on the plasticity charts on Figures E-11A to E-11D in Appendix E, indicate that the cohesive deposit can be classified as clayey silt of low plasticity to silty clay of intermediate plasticity to clay of high plasticity. The liquidity index of the upper varved cohesive deposit ranges from about 0.6 to 1.3.

Laboratory consolidation tests were carried out on four samples of the cohesive deposit obtained from Shelby tubes in Boreholes 89UP-03, 89UP-06, 89UP-07 and HF-07. A pre-consolidation stress ranging between about 335 kPa and 555 kPa was estimated from the void ratio versus logarithmic pressure plots and from the total work versus pressure plots. A bulk unit weight ranging between about 17.4 kN/m^3 and 18.8 kN/m^3 and a specific gravity between about 2.71 and 2.75 was measured on the consolidation test samples. The overconsolidation ratio (OCR) ranges from 1.0 to 2.2 and it is noted that an OCR value of 1.0 was estimated on a specimen recovered from Borehole 89UP-06 (Sample 24) which was advanced through the existing Highway 89 embankment where the vertical effective stress is higher in comparison to the other samples tested. Details of the test results are shown on Figures E-12A to E-12D, E-13A to E-13D, E-14A to E-14D and E-15A to E-15D in Appendix E, and the test results are summarized below.

Borehole and Sample No.	Sample Depth / Elevation	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	C_c	C_r	e_o	c_v [1] (cm^2/s)
89UP-03 Sample 20	24.7 m / 202.7 m	235	335	100	1.4	0.53	0.024	0.96	9.3×10^{-3} 1.7×10^{-3}
89UP-06 Sample 24	36.9 m / 198.5 m	410	410	~0	1.0	0.70	0.058	1.19	2.6×10^{-3} 1.5×10^{-4}
89UP-07 Sample 21	26.2 m / 201.0 m	250	555	305	2.2	0.52	0.022	0.91	6.0×10^{-3} 1.9×10^{-3}

HF-07 Sample 22	27.7 m / 199.6 m	265	370	105	1.4	0.50	0.030	0.95	2.7×10^{-3} 1.2×10^{-3}

Note:

1. Two coefficients of consolidation (c_v) have been presented for each sample. The first value (top line) is based on a stress range below the effective overburden stress (i.e., within the overconsolidated stress range). The second value (bottom line) is based on a stress range between the effective overburden stress and the final stress due to high fill embankments greater than 7.5 m in height (i.e., normally consolidated stress range).

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
σ_p' is the preconsolidation stress in kPa
OCR is the overconsolidation ratio
e_o is the initial void ratio
C_c is the compression index
C_r is the recompression index
c_v is the coefficient of consolidation in cm^2/s

The natural water content measured on thirty-six samples of this deposit ranges from about 20 per cent to 44 per cent.

4.2.7 Silt to Silty Sand (Lower Granular Deposit)

Underlying the upper cohesive deposit in Boreholes B1-2, 89UP-02 to 89UP-07, HF-02 and HF-07, a granular deposit consisting of silt to silt and sand to silty sand was encountered between Elevations 195.8 m and 194.0 m. The thickness of the deposit ranges from about 2.3 m to 6.5 m and the deposit extended to between about Elevations 193.5 m and 189.0 m. Boreholes HF-02 and B1-2 terminated within this deposit a depth of 35.7 m and 37.0 m (at Elevations 191.8 m and 191.4 m), respectively below ground surface.

The SPT “N”-values recorded in the lower granular deposit range from 27 blows to 106 blows per 0.3 m of penetration, with some values up to 100 blows for 0.08 m penetration, indicating a compact to very dense compactness condition.

The results of grain size distribution tests completed on six samples of this deposit are shown on Figure E-16 in Appendix E. The silt layers contain trace to some clay, trace to some sand, and the silt and sand layers contain trace clay. The deposit occasionally contains clayey silt inclusions and trace gravel.

The natural water content measured on fifteen samples of this deposit ranges from about 12 per cent to 24 per cent.

4.2.8 Sandy Clayey Silt to Clayey Silt (Lower Cohesive Deposit)

A lower cohesive deposit was encountered underlying the lower granular deposit in Boreholes 89UP-02 to 89UP-07 and HF-07. The surface of the deposit was encountered between about Elevations 193.5 m to 189.0 m, the thickness of the deposit ranges from between about 3.1 m to greater than 7.9 m and the deposit extends to between about Elevations 186.3 m and 182.9 m. Boreholes 89UP-02, 89UP-06 and HF-07 were terminated within this deposit at depths of 50.8 m (Elevation 184.6 m), 52.4 m (Elevation 183.0 m) and 35.7 m (Elevation 191.6 m), respectively.

The SPT “N”-values recorded within this deposit generally range from 15 blows to 77 blows per 0.3 m of penetration, with one value of 100 blows per 0.15 m of penetration. A SPT “N”-value measured in the upper portion of the clayey silt deposit in Borehole 89UP-06 at about Elevation 189.4 m is 0 blows per 0.3 m of penetration (weight of hammer) but two in situ vane tests carried out within this deposit between about Elevations 189.0 m and 188.0 m measured undrained shear strengths greater than 96 kPa. The two field vane tests results together with the SPT "N"-values suggest that the sandy clayey silt to clayey silt deposit has a very stiff to hard consistency.

The results of grain size distribution tests completed on five samples of this deposit are shown on Figure E-17 in Appendix E. The clayey silt deposit contains trace sand to sandy and trace gravel.

Atterberg limits tests were carried out on eight samples of this deposit and measured liquid limits ranging from about 18 per cent to 24 per cent, plastic limits ranging from about 11 per cent to 16 per cent and a plasticity indices ranging from about 4 per cent to 8 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure E-18 in Appendix E and indicate that the cohesive deposit can be classified as silt of slight plasticity to clayey silt of low plasticity.

The natural water content measured on ten samples of the deposit ranges from about 12 per cent to 22 per cent.

4.2.9 Silt and Sand to Silty Sand Till / Clayey Silt with Sand to Clayey Silt Till

A glacial till deposit was encountered underlying the lower cohesive deposit in Boreholes 89UP-03, 89UP-04, 89UP-05 and 89UP-07. The till deposit varies in composition from silt and sand to silty sand (i.e. granular till) to clayey silt with sand to clayey silt (i.e. cohesive till). Inferred cobbles and boulders were encountered between about Elevations 182.9 m and 182.3 m in Borehole 89UP-05. The surface of the till was encountered between Elevations 186.2 m and 182.9 m, and the boreholes were terminated within the till deposit at depths between about 49.2 m and 50.6 m (between Elevations 178.8 m and 176.6 m) below ground surface.

The SPT "N"-values measured within the granular till deposit range from 101 blows per 0.3 m of penetration to 100 blows per 0.08 m of penetration, indicating a very dense compactness condition. The SPT "N"-values measured within the cohesive till deposit range from 35 blows per 0.3 m of penetration to 100 blows per 0.05 m of penetration, suggesting a hard consistency.

Grain size distribution testing carried out on two samples of the granular till deposit are shown on Figure E-19 in Appendix E. The granular till consists of grey silt and sand to silty sand trace to some gravel, and trace clay. Grain size distribution of the three samples of the cohesive till deposit are shown on Figure E-20 in Appendix E. The cohesive till consists of grey clayey silt with sand to clayey silt, trace to some gravel.

Atterberg limit tests were carried out on three samples of the cohesive till deposit and measured liquid limits ranging from about 15 per cent to 23 per cent, plastic limits ranging from about 10 per cent to 11 per cent, and a plasticity indices ranging from about 4 per cent to 12 per cent. The results of the Atterberg limits tests shown on the plasticity chart on Figure E-21 indicate that cohesive till deposit can be classified as a clayey silt of low plasticity.

The natural water content measured in eight samples of the till deposit(s) ranges from about 7 per cent to 19 per cent.

4.2.10 Groundwater Conditions

The overburden samples obtained from the boreholes advanced during the previous and current investigations were generally moist to wet. The groundwater levels in the open boreholes or inside the drill casing were measured upon completion of drilling operations; however, the water levels in the drill casing does not necessarily reflect groundwater conditions on completion of drilling as water with drilling mud was used to advance Boreholes 89UP-02 to 89UP-07, HF-02, HF-04, HF-14 to HF-18, HF-20 to HF-22, HF-26, HF-27, HF-29 and HF-31.

Standpipe piezometers were installed in Boreholes 89UP-03, 89UP-07, HF-12, HF-15, HF-22, HF-23 and HF-26 to permit monitoring of groundwater level at this site. The piezometers in Boreholes 89UP-03, HF-12, HF-15, HF-22, HF-23, HF-26 and B1-2 are screened within the upper granular deposit and the piezometer in Borehole 89UP-07 is screened in the lower granular deposit. The measured water level in the piezometer installed in Borehole 89UP-07 is above the top of the lower granular deposit and therefore the groundwater in this deposit is artesian (but not flowing). Details of the piezometer installations and measured groundwater levels are shown on the borehole records in Appendix D. The groundwater levels recorded in open boreholes and in the piezometers (i.e. excluding water levels inside the casing in boreholes advanced using drill water/mud rotary methods) are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date (dd/mm/yyyy)	Comments
89UP-01	227.8	2.2	225.6	15/08/2017	Open borehole
89UP-03	227.4	3.3	224.1	21/07/2017	Open Borehole
		1.0	226.4	03/08/2017	Standpipe piezometer
		1.0	226.4	10/08/2017	
		1.2	226.2	15/08/2017	
		1.3	226.1	19/09/2017	
		0.7	226.7	05/03/2018	
		0.5	226.9	16/05/2018	
89UP-07	227.2	7.9	219.3	02/08/2017	Open borehole
		0.7	226.5	10/08/2017	Standpipe piezometer
		0.7	226.5	15/08/2017	
		0.9	226.3	19/09/2017	
		1.0	226.2	05/03/2018	
89UP-08	227.6	1.1	226.5	09/08/2017	Open borehole
HF-01	227.8	4.0	223.8	11/07/2017	Open borehole
HF-02	227.5	2.7	224.8	09/08/2017	Open borehole
HF-03	227.5	1.5	226.0	09/08/2017	Open borehole
HF-04	227.8	1.2	226.6	02/02/2018	Open borehole
HF-05	227.0	1.4	225.6	17/07/2017	Open borehole
HF-06	227.2	1.2	226.0	14/07/2017	Open borehole
HF-08	227.2	0.8	226.4	14/07/2017	Open borehole
HF-09	227.2	1.1	226.1	13/07/2017	Open borehole
HF-10	227.6	1.3	226.3	11/07/2017	Open borehole
HF-11	227.8	2.6	225.2	11/07/2017	Open borehole
HF-12	226.7	0.8	225.9	13/07/2017	Open borehole
		2.0	224.7	03/08/2017	Standpipe piezometer
		2.0	224.7	10/08/2017	
		2.1	224.6	15/08/2017	
		2.4	224.3	19/09/2017	

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date (dd/mm/yyyy)	Comments
		1.4	225.3	19/09/2017	
		0.3	226.4	05/03/2018	
HF-13	226.8	1.2	225.6	13/07/2017	Open borehole
HF-19	229.6	3.4	226.2	02/02/2018	Open borehole
HF-22	226.8	0.6	226.2	05/03/2018	Standpipe piezometer
HF-23	226.9	0.7	226.2	05/03/2018	Standpipe piezometer
HF-24	229.1	3.2	225.9	15/02/2018	Open borehole
HF-25	229.8	3.1	226.7	15/02/2018	Open borehole
HF-26	228.5	1.4	227.1	05/03/2018	Standpipe piezometer
HF-28	229.4	2.2	227.2	08/02/2018	Open borehole
HF-30	228.1	3.3	224.8	31/01/2018	Open borehole
B1-1	228.9	2.7	226.2	18/12/2000	Open borehole
B1-2	228.4	2.3	226.1	18/12/2000	Open borehole
		1.8	226.6	19/01/2001	Standpipe piezometer
		1.3	227.1	15/03/2001	

It should be noted that the groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Sandra McGaghran, M.Eng., P.Eng., a senior geotechnical engineer and Associate with Golder. Mr. Jorge Costa, P.Eng, a MTO Foundations Designated Contact and Senior Consultant with Golder conducted a technical review of the report and Ms. Lisa Coyne, P.Eng., Golder's MTO Foundations Designated Contact for this project and Principal with Golder, conducted an independent quality control review of the report.

GOLDER ASSOCIATES LTD.

Sandra McGaghran, M.Eng., P.Eng.
Senior Geotechnical Engineer, Associate

Lisa Coyne, P.Eng.
Principal, MTO Foundations Designated Contact

Jorge M.A. Costa, P.Eng
MTO Foundations Designated Contact, Senior Consultant

SMM/JMAC/LCC/rb

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PART B

FOUNDATION DESIGN REPORT
HIGH FILL EMBANKMENTS
HIGHWAY 400/89 INTERCHANGE RECONSTRUCTION
TOWN OF INNISFIL, SIMCOE COUNTY
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 2438-13-00

6.0 DISCUSSION AND RECOMMENDATIONS

This section of the report provides foundation design recommendations for high fill embankments associated with the reconstruction of the Highway 400/89 interchange, including the placement of high fills over an existing natural gas pipeline within the project limits. These recommendations are based on interpretation of factual data obtained from boreholes advanced during the field investigation, together with pressuremeter testing (PMT) and vertical seismic profile (VSP) testing. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the requirements for stability and settlement of the high fill embankments and underlying soils. The Foundation Investigation Report, discussion and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and its designers and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. Contractors must make their own interpretation based on the factual data presented in the Foundation Investigation Report (Part A of this report). Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

It is understood that the Highway 400/89 interchange improvements will involve the following works:

- Realignment of Highway 89 (i.e., the alignment will shift to the north of the existing Highway 89);
- Localized widening of Highway 400; and
- Reconstruction/realignment of Highway 400 on-ramps/off-ramps and Reive Boulevard (located in the northeast quadrant of the interchange).

The new/reconstructed Highway 89, Reive Boulevard and Highway 400 ramps will involve the construction of high fill embankments greater than 4.5 m in height. The following table summarizes the locations and extent of the areas investigated within the project limits that require foundation design for the new high fill embankments.

Foundation Investigation Area Designation	Foundation Investigation Area Limits	Proposed Maximum Embankment Height [1]
Highway 89 (West of Highway 89 Underpass)	STA 9+820 to STA 9+941	7.0 m
Highway 89 (East of Highway 89 Underpass)	STA 10+059 to STA 10+290	9.0 m
N-E/W Ramp	STA 10+320 to STA 10+560	7.5 m
E-S Ramp	STA 9+912 to STA 10+170	10.0 m
Reive Boulevard	STA 10+010 to STA 10+110	5.5 m
S-E/W Ramp	STA 10+220 to STA 10+380	6.0 m
E/W-N Ramp	STA 10+040 to STA 10+110	7.5 m

Foundation Investigation Area Designation	Foundation Investigation Area Limits	Proposed Maximum Embankment Height [1]
W-N Ramp	STA 10+050 to STA 10+110	8.0 m
W-S Ramp	STA 10+000 to STA 10+160	6.0 m

Note:
1. The proposed maximum embankment height is based on centreline profiles of Highway 89 Reive Boulevard, and Highway 400 on-ramp/off-ramp alignments and existing ground surface profiles provided by MH on October 25, 2017. Embankment heights are approximate and are relative to original ground surface.

It is further understood that the high fill embankments associated with the new W-S Ramp as well as the new/reconstructed ramps in the southeast quadrant (S-E/W, E/W-N and W-N Ramps) of the Highway 400/89 interchange will be constructed over an existing Enbridge Nominal Pipe Size (NPS) 6-inch steel extra high pressure (XHP) natural gas pipeline.

In addition, an existing Bell conduit will be relocated to the north and will coincide approximately with the north toe of the realigned Highway 89 embankment. Based on Drawing Nos 401 to 409a and 701, prepared by Telecon (dated July 30, 2018) and provided by MH on August 10, 2018, the Bell conduit will extend from the junction of where the existing Highway 89 is realigned to the north, both east and west of the Highway 400 underpass. Based on the profile along the proposed Bell conduit provided by MH on August 24, 2018, which were taken through the proposed Highway 89 embankment east of the underpass, the proposed Bell conduit will be located about 3.5 m below the proposed ground surface.

This report presents the results of embankment stability and settlement analyses and provides recommendations for stable embankment geometry and placement of new embankment fill materials, and implementation of mitigation alternatives that may be required to reduce post-construction settlements in selected utility crossing areas. The report also addresses potential geotechnical and construction concerns associated with embankment construction over the existing natural gas pipeline.

6.2 Analysis Methods

Based on the vertical profiles of the proposed Highway 89, Reive Boulevard, and Highway 400 ramp alignments provided to Golder by MH on October 25, 2017, the new high fill sections will require fill embankments ranging in height from about 4.5 m to about 10 m.

Section 6.2.1 of this report sets out the consequence and site understanding factors that have been used in the assessment and design for this project. Section 6.2.2 of this report summarizes the method used to analyze the stability for critical sections along each high fill area; while Section 6.2.3 provides an overview of methods used to estimate the magnitude of settlement of the foundation soils below the high fill embankments and below the existing natural gas pipeline where the new embankments will be constructed. Section 6.3 outlines the settlement performance requirements for the high fill areas based on MTO's embankment settlement criteria. Section 6.4 provides a summary and discussion on the results from the global stability analyses, and Sections 6.5 and 6.6 provide a summary of the results of settlement analyses for all high fill embankment areas, and for the gas main crossing areas, respectively. The foundation engineering parameters for input values for the stability and settlement analyses and the results of the analyses and recommendations for mitigating instability and time-dependent settlements for each individual high fill area, where applicable, are presented in Sections 6.4 to

6.6, Table 2, and on Figure 1. General aspects of subgrade preparation and embankment construction are presented in Section 6.9.

At all areas, the analyses assume that topsoil and any topsoil/organic soils/deposits containing deleterious materials will be removed prior to construction of the new embankments (as discussed in Section 6.9.1). The piezometric groundwater conditions required in the analyses are based on the groundwater levels noted in the open boreholes upon completion of drilling as well as measured in standpipe piezometers, where installed.

6.2.1 Consequence and Site Understanding

In accordance with Section 6.5 of the 2014 *Canadian Highway Bridge Design Code* (*CHBDC*, 2014) and its *Commentary*, the proposed embankments are expected to carry medium to high traffic volumes and their performance may have potential impacts on other transportation corridors; hence, the proposed high fill embankment works have been assessed as having a "typical consequence level" associated with exceeding limits states design. In addition, given the typical project-specific foundation investigation carried out for each high fill area (as presented in Part A of the report), in comparison to the degree of site understanding in Section 6.5 of *CHBDC* (2014), the level of confidence for design is considered to be a "typical degree of site and prediction model understanding." However, given the additional in situ testing (i.e., PMT and VSP) carried out at two crossing locations of the proposed high fill embankments (i.e., S-E/W, E/W-N, W-N Ramps and W-S Ramp) and the existing natural gas pipeline, a "high degree of site and prediction model understanding" was assumed in the settlement analyses at these two locations. Accordingly, the appropriate corresponding ultimate limit state (ULS) and serviceability limit state (SLS) consequence factor, Ψ, and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs}, from Tables 6.1 and 6.2 of the *CHBDC* have been used for design.

The *CHBDC* (2014) requires a minimum Factor of Safety of 1.54 (long-term/permanent condition and typical degree of understanding) to be satisfied for global slope stability of embankments. However, as this would place more stringent requirements on material types and testing during construction, MTO Foundations Section has stated via email correspondence on October 26 and 29, 2018 that the high fill embankments at this site can be designed using a minimum Factor of Safety of 1.3 against the instability of the embankment slopes in long-term/permanent conditions.

6.2.2 Global Stability

The following sections outline the method used to evaluate static global stability of the proposed high fill embankments. The geotechnical soil parameters used in the analyses are also presented. The results of the stability analyses are presented in Section 6.4 where they are discussed together with the results of the settlement analyses.

6.2.2.1 Method of Analysis

Given the presence of an extensive (i.e., about 20 m thick) non-cohesive deposit encountered at the ground surface within the project limits, stability analyses were carried out at one critical section corresponding to the greatest new embankment height. The critical section was analyzed using limit equilibrium methods.

Two-dimensional limit equilibrium slope stability analyses were performed using the commercially available program Slide (Version 6.0), developed by Rocscience Inc., employing the Morgenstern-Price method of analysis. Morgenstern-Price is a general method of slices which is based on equilibrium of forces and moments acting on each slice of soil mass above the potential failure surface. For all analyses, the Factors of Safety of numerous potential failure surfaces were computed in order to establish the minimum Factor of Safety. The Factor of Safety is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. For the purpose of the stability analysis, the Factor of Safety is equal to the inverse of the product of the consequence factor, Ψ, and the geotechnical resistance factor, ϕ_{gu}. (i.e., $FoS = 1/(\Psi \cdot \phi_{gu})$). Accordingly, a minimum Factor of Safety of 1.3 has been used for the design of the embankment slopes for the short-term/temporary conditions, as per Table 6.2 of CHBDC (2014). As discussed in Section 6.2.1, MTO Foundations Section has advised that a minimum Factor of Safety of 1.3 may also be used for the long-term/permanent conditions for this site.

6.2.2.2 Parameter Selection

The simplified stratigraphy together with the foundation engineering parameters employed for the different soil types encountered at the site are summarized in Table 2. The following is a summary of the embankment slope inclination, unit weight and effective friction angle for the new earth fill and granular fill, modelled in the slope stability analyses.

Fill Type	Recommended Slope Inclination	Bulk Unit Weight, γ	Effective Friction Angle, ϕ'	Cohesion, c'
Earth Fill	2H:1V	20 kN/m^3	32°	0 kPa
Granular (pavement structure)	3H:1V[1]	21 kN/m^3	45°	0 kPa

Note:

1. The shoulder rounding/upper portion of the side slope through the depth of the pavement structure is inclined at 3H:1V as per the Pavement Design Report.

For the non-cohesive soils present at this site, the effective stress parameters employed in the analysis were estimated from empirical correlations based on the results of in situ Standard Penetration Tests (SPT). A plot of SPT "N"-values (corrected to N_{60} based on automatic hammer energy) measured within each deposit at the site is shown on Figure 1. The correlations proposed by Peck et al (1974) and U.S. Navy (1986) were also employed and the results were adjusted by engineering judgment based on precedent experience in similar soil conditions. As discussed in Section 4.2.4, and as shown on Figure 1 and in Table 2, the upper granular deposit has been sub-divided into two layers; from the top of the deposit to about Elevation 214 m the corrected SPT "N"-values range from about 6 blows to 72 blows per 0.3 m of penetration (on average the SPT "N"-value is 25 blows) and below Elevation 214 m the corrected SPT "N"-values range from about 20 blows to 75 blows per 0.3 m of penetration (on average the SPT "N"-value is 45 blows).

For cohesive deposits, total stress parameters were employed in the analyses assuming short-term, undrained conditions (i.e., temporary conditions). The total stress parameters (i.e., average mobilized undrained shear strength – s_u) for the cohesive soils were assessed based on the results of in situ field vane shear tests, inferred from the laboratory consolidation test results, and estimated from correlations with the SPT results and other laboratory test data (i.e., natural water content, liquid limit, etc.), where appropriate. For the consolidation tests, the following correlation proposed by Mesri (1975) was employed to estimate the undrained shear strength:

$$s_u = 0.22\sigma'_p$$

where: s_u = average mobilized undrained shear strength (kPa)
σ'_p = preconsolidation stress (kPa)

Where appropriate, Bjerrum's correction factor was employed to estimate the average mobilized undrained shear strength from the results of the in situ field vane tests as follows:

$$s_{u(mob)} = \mu s_{u(FV)}$$ (after Bjerrum, 1973)

where: $s_{u(mob)}$ = average mobilized undrained shear strength (kPa)
$s_{u(FV)}$ = undrained shear strength from field vane test (kPa)
μ = Bjerrum's correction factor based on Plasticity Index

A plot of the undrained shear strength versus elevation (along with other strength parameters for the upper cohesive deposit) is shown on Figure 2.

Effective stress parameters were also employed to evaluate the stability of the embankments based on long-term, drained conditions (i.e., permanent conditions). The effective stress parameters (i.e., effective friction angle (ϕ') and effective cohesion (c')) for the cohesive deposits were estimated from empirical correlations based on the plasticity index. The correlations proposed by Mitchell (1993), Kulhawy and Mayne (1990), and Ladd et al. (1977) were employed and the results were adjusted by engineering judgment based on precedent experience in similar soil conditions.

For the purpose of the stability analysis, the groundwater level was assumed to be at Elevation 226.7 m, which is based on the highest piezometric groundwater level measured in Borehole 89UP-03.

6.2.3 Settlement

The following sections outline the method used to carry out the settlement analyses at each high fill area. The results of the analyses are presented in Section 6.4 where they are discussed together with the results of the slope stability analyses and recommendations regarding possible design and construction alternatives to mitigate post-construction settlement.

6.2.3.1 Method of Analysis

To estimate the magnitude of expected settlement, analyses were carried out at the critical sections of the proposed high fill areas. The critical sections correspond to the greatest embankment height. The settlement analyses assume that topsoil and any surficial deposits containing organics or any other deleterious materials have been removed and replaced with SSM, earth fill or granular fill. The settlement analyses were carried out using the commercially available program Settle^{3D} (Version 4.0), developed by Rocscience Inc. The stress distribution calculations used in the settlement analyses were based on Westergaard's (1938) solution.

The sources of settlement are considered to include:

- Immediate settlement of the granular soils (short-term);
- Primary time-dependent consolidation of the cohesive deposits (using Terzaghi's one-dimensional consolidation theory – long-term); and,
- Secondary time-dependent (creep) consolidation of the cohesive deposits (long-term).

The thickness of the compressible foundation soils is relatively consistent at the site; however, the height of the embankments will vary along the proposed highway/ramp alignments within each high fill area, and as such the settlements along the length of a given alignment will similarly vary. However, given that the analyses were carried out at the critical section of each high fill area, the settlements estimated will generally represent the maximum estimated value along a given section of the alignment.

6.2.3.2 Parameter Selection

The simplified stratigraphy together with the deformation and time-rate consolidation parameters, where applicable, employed for the different soil types encountered at the site are summarized in Table 2. Figure 2 presents the parameters associated with the extensive cohesive deposit encountered at the site and based on the graphical presentation of this data the upper varved cohesive deposit was subdivided into multiple layers based on the preconsolidation stress (function of OCR), void ratio, and compression index/recompression index.

The immediate compression of the non-cohesive deposits (i.e., silt to sandy silt to silt and sand to silty sand) were modelled by estimating an elastic modulus of deformation based on the SPT "N"-values and using correlations proposed by Bowles (1984) and Kulhawy and Mayne (1990). These estimated values were also compared with the typical range of expected values for similar soil types, as outlined in Section C6.9.3.6 of the *Commentary to the CHBDC* (2014) and adjusted, if necessary. However, the results of in situ Pressuremeter (PMT) and Seismic Vertical Profile (VSP) testing carried out within the project limits were used in order to refine the soil deformation parameters (i.e., modulus of elasticity or Young's modulus, E') of the upper granular deposit, which has a significant impact on the estimated magnitude of settlement below the high fill embankments.

The consolidation settlement of the cohesive deposits was assessed using the results of the laboratory consolidation test, where appropriate, and in situ field vane tests to estimate the stress history and deformation parameters for the cohesive deposits. In addition, the results of the laboratory index tests were employed to further assess deformation parameters (i.e., compression and recompression indices) using empirical correlations proposed in literature by Azzouz et al. (1976), Koppula (1986), Kulhawy and Mayne (1990), Nishida (1956) and Terzaghi and Peck (1967). The correlation by Koppula (1986) relating the natural water content and liquid limit to the compression index was found to be the most consistent with the results of laboratory consolidation tests for the clayey soils at this site.

The following correlation relating in situ undrained shear strength to preconsolidation stress (Mesri, 1975) was employed:

$$\sigma'_p = \frac{s_{u(mob)}}{0.22}$$

where:

σ'_p = preconsolidation stress (kPa); and,
$s_{u(mob)}$ = $\mu s_{u(FV)}$ (after Bjerrum, 1973), where $s_{u(mob)}$ = average mobilized undrained shear strength (kPa)
$s_{u(FV)}$ = undrained shear strength from field vane test (kPa)
μ = Bjerrum's correction factor based on Plasticity Index

The coefficient of consolidation, c_v (cm^2/s), required in the time-rate settlement analysis, was established using the results of the laboratory consolidation tests and/or estimated from the U.S. Navy (1986) correlation with liquid limit assuming normally consolidated or over consolidated soils, as applicable.

In addition to primary consolidation within the cohesive deposits (i.e., clayey silt to silty clay to clay), secondary compression may also occur. Secondary compression is referred to as creep settlement and occurs over a long period of time, after full dissipation of excess pore pressure under a constant stress. The following relationship has been employed for estimating the magnitude of creep settlement over the life of the embankment following the completion of primary settlement at each location:

$$S_c = HC_{\alpha\varepsilon}log(\frac{t}{t_{EoP}})$$

where:

S_c	=	secondary consolidation (creep) settlement (mm)
$C_{\alpha\epsilon}$	=	modified secondary compression index as estimated from laboratory consolidation tests and correlation by Mesri (1973)
H	=	initial thickness of compressible clay deposit (mm)
t	=	post-construction period of interest (20 years)
t_{EoP}	=	time to reach end of primary consolidation (years)

For the purpose of the stability analysis, the groundwater level was assumed to be at Elevation 226.7 m, which is based on the highest piezometric groundwater level measured in Borehole 89UP-03.

6.3 Settlement Performance Requirements

The settlement performance criterion for design of embankments within the high fill areas is outlined in MTO's Guideline titled, "Embankment Settlement Criteria for Design", dated July 2010. In general, new embankments not approaching a structural element and constructed on "non-compressible soils" (i.e., granular soils) are to be designed as follows:

- Total settlements and differential settlement rates are to be less than 50 mm and 200:1, respectively, over a 15-year and 20-year period following completion of construction for secondary highways and a King's highways, respectively.

Accordingly, Highway 89 is classified as a secondary highway and the Highway 400 ramps are classified as being components of a King's highway. Furthermore, the "non-compressible soil" category has been selected in establishing the post-construction settlement criterion since the new embankments will be founded directly on the extensive upper granular deposit.

However, where new embankments approach structural elements (such as bridge abutments), a more stringent settlement criterion associated with such a transition point will apply in accordance with Section 1.2 of MTO's Guideline. In this case, the east and west bridge approach embankments adjacent to the proposed Highway 89 underpass structure (i.e., 20 m away from the east and west bridge abutments) must satisfy a post-construction settlement criterion of 25 mm over a 15-year period following completion of construction. The bridge approach embankments are addressed in Golder's draft Foundation Investigation and Design Report titled, "Highway 400/89 Underpass Replacement, Site No. 30-256, Reconstruction of Highway 400/89 Interchange, Town of Innisfil, Simcoe County, Ministry of Transportation, Ontario G.W.P. 2438-13-00", dated May 2018.

The performance criteria outlined above form part of the overall design performance for each high fill area.

6.4 Global Stability – Results and Recommendations

The results of the global stability analyses for the high fill embankments along Highway 89, the six Highway 400 ramps, and Reive Boulevard are provided in this section.

Given the presence of an extensive (i.e., about 20 m thick) and competent non-cohesive deposit encountered at the ground surface within the project limits, stability analyses were carried out at two critical sections at the proposed E-S Ramp where it connects to the west abutment, corresponding to a new 10 m high embankment with a 2 m wide mid-height bench, and a new 8 m high embankment without a bench.

The *CHBDC* (2014) requires a Factor of Safety of 1.33 in the short-term/temporary condition and 1.54 in the long-term/permanent condition; however, as discussed in Section 6.2.1, MTO has stated that the high fill embankments at this site can be designed using a minimum Factor of Safety of 1.3 against the instability of the embankment slopes in the long-term/permanent condition. The stability analysis indicates that the 8 m high embankment and the 10 m high embankment with a mid-height bench will have a minimum Factor of Safety of 1.3 during the temporary/short-term and permanent/long-term conditions, for deep-seated, global failure surfaces of the side slopes that would impact the operation of the ramp/highway (see Figures 3 and 4). The Factors of Safety in the short-term and long-term conditions are both 1.3 as the near-surface soil deposits below the embankments are non-cohesive and the same drained soil parameters were used in both the short-term and long-term slope stability scenarios.

6.5 Settlement – General Results and Recommendations

The results of the settlement analyses for Highway 89, six Highway 400 ramps, and Reive Boulevard are provided in this section. Section 6.6 provides specific settlement results for the gas main crossing area, and settlement mitigation alternatives for this area.

Settlement analyses were carried out at a critical section within each high fill area, corresponding to the proposed maximum height of fill. A summary of the estimated magnitudes of settlement for each of the high fill embankment areas is presented below.

Foundation Investigation Area Designation	Foundation Investigation Area Limits	Proposed Maximum Embankment Height [1]	Factored Settlement (δ) over 15-Year or 20-Year Period at the Critical Section [2]
Highway 89 (East of Highway 89 Underpass)	STA 10+059 to STA 10+290	9.0 m	$\delta_{Immediate}$ = 100 mm $\delta_{Primary}$ = 35 mm $\delta_{Secondary}$ = 5 mm δ_{Total} = 140 mm
Highway 89 (West of Highway 89 Underpass)	STA 9+820 to STA 9+941	7.0 m	$\delta_{Immediate}$ = 75 mm $\delta_{Primary}$ = 20 mm $\delta_{Secondary}$ = ~0 mm δ_{Total} = 95 mm
W-S Ramp	STA 10+000 to STA 10+160	6.0 m	$\delta_{Immediate}$ = 55 mm $\delta_{Primary}$ = 15 mm $\delta_{Secondary}$ = ~0 mm δ_{Total} = 70 mm

Foundation Investigation Area Designation	Foundation Investigation Area Limits	Proposed Maximum Embankment Height [1]	Factored Settlement (δ) over 15-Year or 20-Year Period at the Critical Section [2]
N-E/W Ramp	STA 10+320 to STA 10+560	7.5 m	$\delta_{Immediate}$ = 75 mm $\delta_{Primary}$ = 20 mm $\delta_{Secondary}$ = ~0 mm δ_{Total} = 95 mm
E-S Ramp	STA 9+912 to STA 10+170	10.0 m	$\delta_{Immediate}$ = 100 mm $\delta_{Primary}$ = 30 mm $\delta_{Secondary}$ = 5 mm δ_{Total} = 135 mm
E/W-N Ramp	STA 10+040 to STA 10+110	7.5	$\delta_{Immediate}$ = 75 mm $\delta_{Primary}$ = 20 mm $\delta_{Secondary}$ = ~0 mm δ_{Total} = 95 mm
W-N Ramp	STA 10+050 to STA 10+110	8.0 m	$\delta_{Immediate}$ = 80 mm $\delta_{Primary}$ = 20 mm $\delta_{Secondary}$ = ~0 mm δ_{Total} = 100 mm
E/W-N Ramp	STA 10+040 to STA 10+110	7.5 m	$\delta_{Immediate}$ = 75 mm $\delta_{Primary}$ = 20 mm $\delta_{Secondary}$ = ~0 mm δ_{Total} = 95 mm
S-E/W Ramp	STA 10+220 to STA 10+380	6.0 m	$\delta_{Immediate}$ = 60 mm $\delta_{Primary}$ = 15 mm $\delta_{Secondary}$ = ~0 mm δ_{Total} = 75 mm
Reive Boulevard	STA 10+010 to STA 10+110	5.5 m	$\delta_{Immediate}$ = 60 mm $\delta_{Primary}$ = 15 mm $\delta_{Secondary}$ = ~0 mm δ_{Total} = 75 mm

Notes:

1. The proposed maximum embankment heights are based on centreline profiles of the highway, road and ramp alignments and existing ground surface profiles provided by MH on October 25, 2017. Embankment heights are approximate and are relative to original ground surface.
2. The total settlement (δ_{total}) is defined as the sum of the immediate settlement ($\delta_{immediate}$) due to elastic compression of the non-cohesive deposits as well as primary ($\delta_{primary}$) and secondary ($\delta_{secondary}$) settlements due to time-dependent consolidation of the cohesive deposits.

The settlement analyses indicate that the total factored settlement of the foundation soils along each high fill area is estimated to range between approximately 70 mm and 140 mm. The settlement is estimated to be comprised of between about 55 mm and 100 mm of immediate factored settlement due to compression of the non-cohesive deposits and between about 15 mm and 35 mm of factored primary consolidation settlement of the upper cohesive deposit. The magnitude of total factored secondary consolidation (creep) settlement for the upper cohesive deposit is estimated to be about 5 mm over a 15-year to 20-year period at the critical sections of the Highway 89 (east of proposed Highway 89 underpass) and the E-S Ramp alignments. At the other high fill areas, the secondary consolidation settlement is expected to be negligible.

Given that the majority of the total settlement is estimated to be comprised of immediate settlement which is expected to occur during or shortly after construction, and considering that the total consolidation settlement is estimated to range between about 15 mm and 40 mm within the first 15 years or 20 years following completion of construction (satisfying the post-construction settlement criterion of 50 mm over a 15-year or 20-year period), settlement mitigation measures are not required as long as paving occurs after the immediate settlement has occurred. The Contractor should be notified about the magnitude of the estimated immediate settlement so that the embankment is constructed such that the resultant embankment/finished grade after the immediate settlement has occurred meets the geometric requirements. Therefore, a short delay prior to final paving may be required, particularly for the higher embankments sections.

6.6 Settlement Due to Embankment Construction over Existing Gas Pipeline

As noted in Section 6.1, an existing Enbridge natural gas pipeline runs generally parallel to Highway 89 (and south of Highway 89) as shown on Drawing 1. As a result of the proposed Highway 400/89 interchange improvements, new fill associated with the proposed Highway 400 ramp embankments, located in the southwest and southeast quadrants of the interchange, will be placed directly over the existing pipeline. Details pertaining to the fill placement are provided below. It is noted that the existing pipeline details have been interpreted based on Enbridge's As-Laid Drawing Nos. 5N543-1 and 5N542-6, dated July 6, 2005. The drawings were provided to Golder and Morrison Hershfield Limited (MH) by MTO on September 26, 2017.

Proposed Ramp	Approximate Chainage	Approximate Embankment Height	Existing Ground Surface Elev.	Proposed Grade Elev.	Approximate Pipeline Invert Elevation	Approximate Soil Cover [3]
W-S Ramp	STA 10+200	4.0 m	227.3 m [1]	231.3 m	224.4 m	2.8 m
W-N Ramp	STA 10+125	3.6 m	229.1 m [2]	232.7 m	224.4 m	4.6 m
E/W-N Ramp	STA 10+120	4.0 m	229.0 m [2]	233.0 m	224.4 m	4.5 m
S-E/W Ramp	STA 10+315	5.0 m	229.1 m [2]	234.1 m	224.4 m	4.6 m

Notes:

1. The area in the vicinity of the W-S Ramp is comprised of a wooded area.
2. The area in the vicinity of the W-N, E/W-N and S-E/W Ramps is comprised of a fill embankment associated with the existing E/W-N and S-E/W Ramps.
3. Soil cover is defined as zone between the obvert of the pipeline and top of the existing ground surface.

6.6.1 Settlement Analyses

The method of settlement analyses and parameter selection was carried out in accordance with Sections 6.2.3.1 and 6.2.3.2, respectively. However, in order to conduct a more extensive assessment of the deformation parameter (i.e., modulus of elasticity or Young's modulus, E') of the upper granular deposit, which has a significant impact on the estimated magnitude of settlement below the existing pipeline, in situ Pressuremeter (PMT) and Seismic Vertical Profile (VSP) testing was carried out in areas where placement of new fill over the existing pipeline is proposed. The PMT and VSP tests were carried out in two areas as follows:

Test Borehole [1]	Approximate Location	Relevant Boreholes [2]
PMT-01	Near the future W-S Ramp (west side of Highway 400)	HF-06, HF-07 and HF-08
PMT-02	Near the future W-N, E/W-N and S-E/W Ramps (east side of Highway 400)	HF-26, HF-29 and HF-30

Notes:

1. The test boreholes where PMT and VSP testing was carried out are also shown on Drawing 1.
2. Relevant boreholes (i.e., boreholes advanced in close proximity to Boreholes PMT-01 and PMT-02) were utilized to compare SPT "N"-values with PMT and VSP test results.

Detailed reports summarizing the PMT and VSP test procedures and results are presented in Appendices B and C, respectively. Furthermore, plots of the modulus of elasticity (estimated from SPT, PMT and VSP tests) versus elevation are presented on Figures 5 and 6 which summarize results obtained at Boreholes PMT-01 and PMT-02, respectively. The figures also depict the selected lowerbound and upperbound design lines of the soil modulus used in the settlement analyses.

Based on the selected deformation parameters associated with the upper granular and varved cohesive deposits, the estimated magnitudes of settlement below the invert of the existing pipeline at the centreline of the embankments are summarized below. Complete unfactored settlement profiles below the embankments are shown on Figures 7 and 8. It is noted that the settlements associated with the soil deposits encountered below the upper cohesive deposit are expected to be negligible given the depth (i.e., encountered about 30 m below existing ground surface) and strength (i.e., generally dense/very dense and very stiff/hard) of these deposits.

Proposed Ramp(s)	*LOWB or UPB* [1]	*Unfactored Settlement*				*Factored Settlement*			
		$\delta_{Immediate}$	$\delta_{Primary}$	$\delta_{Secondary}$	δ_{Total} [2]	$\delta_{Immediate}$	$\delta_{Primary}$	$\delta_{Secondary}$	δ_{Total} [2]
	Centreline of Embankment(s)								
Gas Main Crossing at W-S Ramp	LOWB	*~20 mm*	*~5 mm*	*~0 mm*	*~25 mm*	*~22 mm*	*~5 mm*	*~0 mm*	*~27 mm*
	UPB	*~15 mm*	*~5 mm*	*~0 mm*	*~20 mm*	*~17 mm*	*~5 mm*	*~0 mm*	*~22 mm*
Gas Main Crossing at W-N, E/W-N and S-E/W Ramps [3]	LOWB	*~25 mm*	*12 mm*	*~0 mm*	*~37 mm*	*~28 mm*	*~13 mm*	*~0 mm*	*~41 mm*
	UPB	*~20 mm*	*12 mm*	*~0 mm*	*~32 mm*	*~22 mm*	*~13 mm*	*~0 mm*	*~35 mm*

Notes:

1. "LOWB" refers to settlement analyses based on the lowerbound estimate of the elastic soil modulus of the upper granular deposit (i.e., resulting in a higher magnitude of estimated settlement), and "UPB" refers to settlement analyses based on the upperbound estimate of the elastic soil modulus of the upper granular deposit (i.e., resulting in a lower magnitude of estimated settlement).
2. The total settlement (δ_{total}) is defined as the sum of the immediate settlement ($\delta_{immediate}$) due to elastic compression of the non-cohesive deposits as well as primary ($\delta_{primary}$) and secondary ($\delta_{secondary}$) settlements due to time-dependent consolidation of the cohesive deposits.
3. Given that the W-N, E/W-N and S-E/W Ramps will be between about 4 m and 5 m high and constructed next to each other at the location of existing pipeline crossing (and thereby creating an extensive zone of influence from the combined loading), the estimated settlement at the centreline of each embankment is expected to be very similar.

6.6.2 Settlement Mitigation Measures

Based on email correspondence between MH, MTO and a representative from Enbridge Gas Distribution, it is understood that the existing pipeline can tolerate 15 mm of total settlement. It is assumed that this magnitude of settlement is unfactored and that the factored allowable settlement is about 17 mm (i.e., 15 mm divided by ϕ_{gs} = 0.9). Consequently, in order to construct the proposed embankments over the existing pipeline and satisfy the aforementioned settlement criterion, the alternatives presented below can be considered. However, these options will require a detailed technical evaluation and a risk and cost assessment in conjunction with MH and MTO, as well as approval from the utility owner before the preferred alternative is selected and incorporated into the design.

The potential settlement mitigation measures are as follows:

- Ground improvement (e.g., compaction grouting or jet grouting) to increase the elastic modulus of the soil below the invert of the pipeline.
  - In addition to detailed grouting design and analyses, an experienced contractor is required to ensure that the base of the pipeline is not disturbed during the grouting operation.
- Construction of an arch/box culvert at the location of the pipeline to minimize the magnitude of load being transferred directly below the pipeline and reduce the overall embankment loading.
  - Although this option will likely reduce the load imposed on the pipeline, the loading stress from the wide embankments will still result in settlement of the foundation soils below the pipeline.
- Construction of a structural slab supported on deep/intermediate foundation units which can transfer the embankment load to a competent stratum well below the pipeline.
  - Consideration could be given to installing foundation units such as CFA's instead of driving steel piles which would generate vibrations that may be detrimental to the integrity of the pipeline or can result in additional settlement of the pipeline.
- Construction of a pile-supported granular load transfer platform which can transfer the embankment loading well below the pipeline.
  - Similar to the pile-supported structural slab, consideration must be given to a pile system that will not disturb the pipeline during installation.
- Installation of deep foundation units below the pipeline to ensure that the loads induced by the embankments are transferred to a competent stratum below the pipeline.
  - This alternative would likely be extremely challenging to execute without disturbing the existing pipeline.
- Encasement of the existing pipeline with a large pipe/casing that may be cambered to accommodate the estimated settlement along the width of the embankment.
  - Installation may be challenging and caution is required not to disturb the pipeline. An extensive dewatering system would be required to either expose the pipeline or to excavate entry/exit pits next to the proposed crossings, depending on the selected installation method.
- Construction of a compressible layer within the backfill above the existing pipeline to reduce the embankment loading imposed on the pipeline (i.e., induced trench method).
  - Stress induced by the embankments will arch around the compressible layer (i.e., stress concentrations will be higher within the stiffer portions of the foundations soils next to the compressible layer) and result in settlement of foundation soils below the invert of the pipeline.

- Use of lightweight fill to construct the proposed embankments and reduce the overall embankment loading (more details provided below).

In addition to the potential settlement mitigation alternatives outlined above, consideration should be given to the following options:

- First and foremost, consideration should be given to carrying out detailed soil-pipe interaction/pipe integrity analyses in areas where the embankments will be constructed over the existing pipeline. If the settlement profile along the embankment (and beyond the toes of the embankment) is gradual and given that the existing pipeline consist of steel, the pipeline may be able to tolerate the estimated magnitudes of settlement without employing any settlement mitigation measures.
- Relocation of the existing pipeline. The pipeline could be realigned to be installed in areas where the new embankment loads are low enough so that the pipeline will experience settlements that are below the settlement criterion.

As noted above, one of the settlement mitigation measures that has been employed effectively on numerous MTO projects is the placement of lightweight fill instead of conventional earth or granular fill. The use of lightweight fill reduces the load applied to the foundation soils due to the low density of the fill materials. This in turn reduces the magnitude of settlement. A list of lightweight fill materials, and their corresponding bulk unit weights, utilized in settlement analyses is as follows:

- **Ultra-Lightweight Slag (Litex 4443)** – bulk unit weight of 11 kN/m^3
- **Cellular Concrete** – bulk unit weight of 5 to 8 kN/m^3
- **Expanded Polystyrene (EPS)** – bulk unit weight of 0.5 kN/m^3

Lightweight slag (Litex 4449) was not utilized in settlement analyses because this material is not light enough (i.e., it has a bulk unit weight of approximately 15 kN/m^3) to satisfy the settlement criterion of 15 mm at both locations where the new ramp embankments will be constructed over the existing pipeline. The estimated magnitudes of settlement below the invert of the existing pipeline at the centreline of the embankments are summarized below for these lightweight fill options. In order to achieve the settlement criterion, the settlement analyses assumes that the lightweight fill core will be approximately 25 m long (i.e., with the existing pipeline positioned in the middle of the core) on the W-S Ramp in the southwest quadrant, and approximately 30 m long on the W-N, E/W-N and S-E/W Ramps in the southeast quadrant, and that the lightweight fill will encompass the entire width of the embankments (i.e., from toe-to-toe of the embankments).

Proposed Ramp(s)	***LOWB or UPB*** [1]	***Unfactored Settlement***				***Factored Settlement***			
		$\delta_{Immediate}$	$\delta_{Primary}$	$\delta_{Secondary}$	δ_{Total} [2]	$\delta_{Immediate}$	$\delta_{Primary}$	$\delta_{Secondary}$	δ_{Total} [2]
	Ultra-Lightweight Slag (3.5 m thick at the W-S Ramp)								
W-S Ramp	LOWB	*11 mm*	*5 mm*	*~0 mm*	*16 mm*	*~12 mm*	*~5 mm*	*~0 mm*	*~17 mm*
	UPB	*9 mm*	*5 mm*	*~0 mm*	*14 mm*	*~10 mm*	*~5 mm*	*~0 mm*	*~15 mm*
W-N, E/W-N and S-E/W Ramps [3]	LOWB	*The use of ultra-lightweight slag to construct the three ramp embankments will not satisfy the unfactored settlement criterion of 15 mm*							
	UPB								

	Cellular Concrete (3 m thick core at the W-S Ramp ; 4.5 m thick core at the S-E/W Ramp [4])								
W-S Ramp	LOWB	*10 mm*	*4 mm*	*~0 mm*	*14 mm*	*~11 mm*	*~4 mm*	*~0 mm*	*~15 mm*
	UPB	*8 mm*	*4 mm*	*~0 mm*	*12 mm*	*~9 mm*	*~4 mm*	*~0 mm*	*~13 mm*
W-N, E/W-N and S-E/W Ramps [1]	LOWB	*10 mm*	*6 mm*	*~0 mm*	*16 mm*	*~11 mm*	*~7 mm*	*~0 mm*	*~18 mm*
	UPB	*7 mm*	*6 mm*	*~0 mm*	*13 mm*	*~8 mm*	*~7 mm*	*~0 mm*	*~15 mm*
	EPS (2 m thick core at the W-S Ramp ; 3.5 m thick core at the S-E/W Ramp [5])								
W-S Ramp	LOWB	*10 mm*	*4 mm*	*~0 mm*	*14 mm*	*~11 mm*	*~4 mm*	*~0 mm*	*~15 mm*
	UPB	*8 mm*	*4 mm*	*~0 mm*	*12 mm*	*~9 mm*	*~4 mm*	*~0 mm*	*~13 mm*
W-N, E/W-N and S-E/W Ramps [1]	LOWB	*8 mm*	*6 mm*	*~0 mm*	*14 mm*	*~9 mm*	*~7 mm*	*~0 mm*	*~16 mm*
	UPB	*7 mm*	*6 mm*	*~0 mm*	*13 mm*	*~8 mm*	*~7 mm*	*~0 mm*	*~15 mm*

Notes:

1. "LOWB" refers to settlement analyses based on the lowerbound estimate of the elastic soil modulus of the upper granular deposit (i.e., resulting in a higher magnitude of estimated settlement), and "UPB" refers to settlement analyses based on the upperbound estimate of the elastic soil modulus of the upper granular deposit (i.e., resulting in a lower magnitude of estimated settlement).
2. The total settlement (δ_{total}) is defined as the sum of the immediate settlement ($\delta_{immediate}$) due to elastic compression of the non-cohesive deposits as well as primary ($\delta_{primary}$) and secondary ($\delta_{secondary}$) settlements due to time-dependent consolidation of the cohesive deposits.
3. Given that the W-N, E/W-N and S-E/W Ramps will be between about 4 m and 5 m high and constructed next to each other at the location of existing pipeline crossing (and thereby creating an extensive zone of influence from the combined loading), the estimated settlement at the centreline of each embankment is expected to be very similar.
4. An approximately 3.1 m and 3.5 m thick cellular concrete core is also required to construct the W-N and E/W-N Ramps.
5. An approximately 2.1 m and 2.5 m thick cellular concrete core is also required to construct the W-N and E/W-N Ramps.

6.7 Settlement Due to Embankment Construction over Relocated Bell Conduit

As noted in Section 6.1, the existing Bell conduit will be relocated north of the realigned Highway 89 and will coincide approximately with the north toe of the underpass embankment and based on staging it is understood the conduit will be installed prior to the construction of the new and realigned ramps and therefore the conduit will experience settlement. The conduit will be located about 3.5 m below the proposed ground surface.

6.7.1 Settlement Analyses

The method of settlement analyses and parameter selection was carried out in accordance with Sections 6.2.3.1 and 6.2.3.2, respectively.

Based on the selected deformation soil parameters associated with the upper granular deposits and the varved cohesive deposit, the estimated magnitudes of settlement below the invert of the proposed Bell conduit are summarized below.

Location	***Unfactored Settlement***				***Factored Settlement***			
	$\delta_{Immediate}$	$\delta_{Primary}$	$\delta_{Secondary}$	δ_{Total} [1]	$\delta_{Immediate}$	$\delta_{Primary}$	$\delta_{Secondary}$	δ_{Total} [1]
N-E/W Ramp	*~65 mm*	*~15 mm*	*~0 mm*	*~80 mm*	*~81 mm*	*~19 mm*	*~0 mm*	*~100 mm*
E-S Ramp	*~65 mm*	*~20 mm*	*~0 mm*	*~85 mm*	*~81 mm*	*~25 mm*	*~0 mm*	*~106 mm*
Toe of Highway 89 North Embankment	*~25 mm*	*~10 mm*	*~0 mm*	*~35 mm*	*~31 mm*	*~13 mm*	*~0 mm*	*~44 mm*
Reive Boulevard Ramp	*~45 mm*	*~10 mm*	*~0 mm*	*~55 mm*	*~56 mm*	*~12 mm*	*~0 mm*	*~68 mm*

Location	*Unfactored Settlement*				*Factored Settlement*			
	$\delta_{Immediate}$	$\delta_{Primary}$	$\delta_{Secondary}$	δ_{Total} [1]	$\delta_{Immediate}$	$\delta_{Primary}$	$\delta_{Secondary}$	δ_{Total} [1]

Notes:

1. The total settlement (δ_{total}) is defined as the sum of the immediate settlement ($\delta_{immediate}$) due to elastic compression of the non-cohesive deposits as well as primary ($\delta_{primary}$) and secondary ($\delta_{secondary}$) settlements due to time-dependent consolidation of the cohesive deposits.

If the Bell conduit cannot tolerate this magnitude of settlement, mitigation measures will be required and can be provided.

6.8 Liquefaction Potential Below Embankments

Liquefaction is a phenomenon whereby seismically-induced shaking generates shear stresses within the soil under undrained conditions. These stresses tend to densify the soil (i.e. leading to potentially large surface deformations) and under undrained conditions generate excess pore water pressures. The excess pore water pressures can lead to sudden temporary losses in strength. Where existing static shear stresses are present, the loss of strength can lead to significant lateral movements (i.e., analogous to a slope failure) often referred to as “lateral spreading”, or under certain conditions even catastrophic failure of the slope often referred to as “flow slides”.

The liquefaction susceptibility of granular soils was evaluated by comparing the penetration resistance required to trigger liquefaction with the available penetration resistance. Liquefaction is predicted to occur when the available penetration resistance is less than the resistance required.

The methodology used to assess liquefaction potential at the site is consistent with that presented in the *Commentary to the CHBDC, 2014*. It involves comparing the cyclic shear stresses applied to the soil by the design earthquake, represented as the cyclic stress ratio (CSR), to the cyclic shear strength, represented as the cyclic resistance ratio (CRR) provided by the soil.

The liquefaction analysis was carried out using in-situ testing data collected at the borehole locations. The design groundwater level was determined based on the highest measured groundwater level in the standpipe piezometer installed in Borehole 89UP-03 at about Elevation 226.7 m (measured on August 3 and 10, 2017). The CRR with depth was calculated at each borehole location using the parameter, $(N_1)_{60cs}$, that is based on the SPT “N”-value obtained in the field and corrected for overburden stress, rod length during sampling, hammer energy efficiencies, and fines content.

The results of the liquefaction assessment indicate that the silts and sands at the site are not considered liquefiable during the 2,475-year design earthquake.

6.9 Construction Considerations

The following sections discuss general aspects of subgrade preparation and embankment construction for the high fill areas.

6.9.1 Removal of Organic Materials

Based on the information from the boreholes advanced during the field investigation, the thickness of organic deposits (mainly topsoil) generally ranges between about 0.2 m and 0.7 m. After clearing and grubbing of the high fill areas, particularly the proposed W-S Ramp, which will traverse a wooded area at the southwest quadrant of the Highway 400/89 interchange, and prior to the placement of any fill for new construction, all surficial and near surface layers of topsoil, organic soils, and any deposits containing deleterious materials within the high fill areas should be stripped from the plan limits of the proposed works regardless of height in accordance with OPSS.PROV 206 (Grading).

6.9.2 Groundwater and Surface Water Control

Excavations within the plan limits of the proposed works will be required to remove topsoil and/or any organic soils/deposits containing deleterious materials prior to embankment fill placement, which will generally be maintained above the groundwater table. However, if construction operations are carried out during the wet season or periods of heavy or sustained precipitation, some groundwater flow into deeper sub-excavations (if required) may occur due to the presence of relatively permeable granular deposits encountered within the project limits. Unwatering is not required for the excavation and backfilling along the high fill areas; however, surface water should be directed away from the excavations at all times.

6.9.3 Embankment Construction

Placement of Select Subgrade Material (SSM), earth fill meeting the requirements of OPSS.PROV 212 (*Borrow*), or granular fill (satisfying OPSS.PROV 1010 Granular ‘B’ Type I or Type II requirements) above the water table for construction of new embankments (including backfilling operations) should be carried out in accordance with the requirements as outlined in OPSS.PROV 206 (Grading). The SSM, earth fill or granular fill should be compacted in accordance with OPSS.PROV 501 (Compacting). Inspection and field testing should be carried out by qualified personnel during construction to confirm that appropriate materials are being utilized and that adequate levels of compaction are being achieved. Side slopes for the SSM, earth fill or granular fill (or EPS fill, cellular concrete, ultra-lightweight slag, if utilized) roadway embankment should be no steeper than 2 horizontal to 1 vertical (2H:1V). The embankment side slopes should also include a minimum 2 m wide bench at mid-height for all fill heights greater than 8 m as suggested in OPSD 202.010 (Slope Flattening). In addition, benching of the existing ramp(s) and Highway 89 side slopes should be carried out to “key in” the new fill materials for the realigned ramps/highways in accordance with OPSD 208.010 (Benching of Earth Slopes).

In order to reduce erosion of the embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the embankments. The erosion protection must be in accordance with OPSS.PROV 804 (Seed and Cover).

If required, the EPS fill should be installed in accordance with the Non-Standard Special Provision (NSSP) for Rigid Expanded Polystyrene Embankment Fill. It is recommended that a levelling pad comprised of at least 300 mm of OPSS.PROV 1010 (Aggregates) Granular ‘A’ material be placed prior to the installation of the EPS. The levelling pad should be compacted to at least 95 per cent of the Standard Proctor maximum dry density. The EPS should be covered with a 10 mil thick polyethylene sheet and overlain with a minimum 125 mm thick 30 MPa reinforced concrete top slab constructed on top of the EPS, followed by a protective cover/pavement structure over the slab. The EPS on the side slopes of the embankment should be covered with a 1 m thick layer of conventional soil/granular material at an inclination no steeper than 2H:1V. Along the longitudinal length of the ramp it is recommended that lightweight fill material will be placed at an inclination of 5H:1V so that there is a transition between the lightweight fill material and the of the earth fill and so that the resulting settlement is gradual. The embankment side slopes should be constructed at an inclination no steeper than 2H:1V.

If cellular concrete or ultra-lightweight slag is selected, the embankment should be installed in accordance with the NSSPs for Cellular Concrete or Ultra-Lightweight Material, respectively.

6.9.4 Instrumentation and Monitoring

It is recommended that settlement monitoring be carried out for the embankment construction in the vicinity of the gas main along the W-S Ramp and along the W-N and S-E/W Ramp, to monitor the magnitude and rate of settlement/deformation during the construction of the EPS embankment and for a period of two months following completion of the EPS embankment, to confirm that the settlement is less than Enbridge's reported permitted settlement of 15 mm.

A monitoring program has been developed, consisting of the following:

- Settlement plates installed on the ground surface prior to construction of the embankment; and
- Settlement rods, installed within a borehole drilled adjacent to the pipeline, with the base of the rod at the same elevation as the invert of the existing pipeline.

Instrumentation and monitoring plans (See Drawing 6) and an NSSP for settlement monitoring are included in Appendix F, for inclusion in the Contract Documents.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Tomasz Zalucki, P.Eng., a geotechnical engineer, and reviewed by Ms. Sandra McGaghran, M.Eng., P.Eng., a senior geotechnical engineer and Associate with Golder. Ms. Lisa Coyne, P.Eng., a Principal and MTO Foundations Designated Contact for Golder, conducted an independent technical and quality control review of this report.

GOLDER ASSOCIATES LTD.

Tomasz Zalucki, P.Eng.
Geotechnical Engineer

Sandra McGaghran, M.Eng., P.Eng.
Senior Geotechnical Engineer, Associate

Lisa Coyne, P.Eng.
Principal, MTO Foundations Designated Contact

TZ/SMM/LCC/tz/rb

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ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

ASTM D1587 Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes

ASTM D2573 Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils

Commercial Software:

Slide (Version 6.0) by Rocscience Inc.

Settle^{3D} (Version 4.0) by Rocscience Inc.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213 Construction Projects (as amended)

Ontario Provincial Standard Specifications (OPSS):

OPSS.PROV 206 Construction Specification for Grading

OPSS.PROV 501 Construction Specification for Compacting

OPSS 802 Construction Specification for Topsoil

OPSS 803 Construction Specification for Sodding

OPSS.PROV 804 Construction Specification for Seed and Cover

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material

Ontario Provincial Standard Drawings (OPSD):

OPSD 202.010 Slope Flattening

OPSD 208.010 Benching of Earth Slopes

Ontario Regulations:

R.R.O 1990, Regulation 903 Wells, under Ontario Water Resources Act, R.S.O. 1990, c. O.40

TABLE 1 – SUMMARY OF BOREHOLE LOCATIONS FROM 2017/2018 INVESTIGATION HIGH FILL EMBANKMENTS, HIGHWAY 400/89 INTERCHANGE

Borehole No.	Location (MTM NAD 83 – Zone 10)		Ground Surface Elevation (m), (Geodetic Datum)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
HF-01	4,895,603.0 (44.200320)	292,316.5 (-79.656185)	227.8	5.2
HF-02	4,895,665.0 (44.200881)	292,504.8 (-79.653830)	227.5	35.7
HF-03	4,895,693.1 (44.201135)	292,575.5 (-79.652946)	227.5	8.2
HF-04	4,895,694.3 (44.201156)	292,648.2 (-79.652040)	227.8	6.7
HF-05	4,895,517.7 (44.199551)	292,255.6 (-79.656945)	227.0	5.2
HF-06	4,895,503.9 (44.199427)	292,288.0 (-79.656539)	227.2	8.2
HF-07	4,895,478.1 (44.199196)	292,331.7 (-79.655992)	227.3	35.7
HF-08	4,895,469.0 (44.199114)	292,368.5 (-79.655531)	227.2	8.2
HF-09	4,895,449.3 (44.198938)	292,404.0 (-79.655086)	227.2	5.2
HF-10	4,895,613.9 (44.200417)	292,273.6 (-79.656721)	227.6	8.2
HF-11	4,895,635.6 (44.200612)	292,234.1 (-79.657216)	227.8	6.7
HF-12	4,895,670.6 (44.200927)	292,213.9 (-79.657470)	226.7	5.2
HF-13	4,895,650.6 (44.200747)	292,203.3 (-79.657603)	226.8	5.2
HF-14	4,895,742.6 (44.201590)	292,608.7 (-79.652536)	228.0	6.7
HF-15	4,895,764.4 (44.201785)	292,551.3 (-79.653255)	227.1	6.7
HF-16	4,895,581.4 (44.200133)	292,260.0 (-79.656895)	227.8	8.2
HF-17	4,895,595.0 (44.200256)	292,291.5 (-79.656500)	227.5	9.8
HF-18	4,895,703.0 (44.201235)	292,682.9 (-79.651607)	228.1	5.2
HF-19	4,895,582.4 (44.200142)	292,226.7 (-79.657311)	229.6	5.2
HF-20	4,895,608.5 (44.200377)	292,219.5 (-79.657402)	228.4	8.2
HF-21	4,895,723.3 (44.201410)	292,214.5 (-79.657468)	226.6	8.2
HF-22	4,895,770.4 (44.201834)	292,226.3 (-79.657321)	226.8	5.2

TABLE 1 – SUMMARY OF BOREHOLE LOCATIONS FROM 2017/2018 INVESTIGATION HIGH FILL EMBANKMENTS, HIGHWAY 400/89 INTERCHANGE

Borehole No.	Location (MTM NAD 83 – Zone 10)		Ground Surface Elevation (m), (Geodetic Datum)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Northing (m) (Latitude, °)		
HF-23	4,895,815.5 (44.202240)	292,244.4 (-79.657096)	226.9	5.2
HF-24	4,895,520.6 (44.199585)	292,191.0 (-79.657756)	229.1	6.7
HF-25	4,895,510.1 (44.199491)	292,238.8 (-79.657158)	229.8	9.8
HF-26	4,895,578.2 (44.200110)	292,615.8 (-79.652443)	228.5	5.2
HF-27	4,895,621.1 (44.200496)	292,594.5 (-79.652711)	227.6	8.2
HF-28	4,895,492.9 (44.199342)	292,593.3 (-79.652723)	229.4	5.2
HF-29	4,895,521.9 (44.199603)	292,610.6 (-79.652507)	228.2	6.7
HF-30	4,895,594.9 (44.200261)	292,627.7 (-79.652294)	228.1	5.2
HF-31	4,895,626.4 (44.200545)	292,631.5 (-79.652247)	228.0	8.2
PMT/VSP-01	4,895,473.7 (44.199165)	292,331.2 (-79.656001)	227.2	34.6
PMT/VSP-02	4,895,579.3 (44.200120)	292,616.8 (-79.652431)	228.4	22.2
89UP-01	4,895,618.4 (44.200459)	292,361.9 (-79.655616)	227.8	8.2
89UP-02	4,895,597.2 (44.200269)	292,389.9 (-79.655266)	235.4	50.8
89UP-03	4,895,628.3 (44.200549)	292,375.2 (-79.655451)	227.4	49.2
89UP-04	4,895,619.3 (44.200469)	292,430.3 (-79.654761)	229.3	50.5
89UP-05	4,895,649.6 (44.200750)	292,418.6 (-79.654912)	229.2	50.4
89UP-06	4,895,621.9 (44.200493)	292,469.4 (-79.654271)	235.4	52.4
89UP-07	4,895,660.9 (44.200843)	292,451.0 (-79.654503)	227.2	50.6
89UP-08	4,895,655.5 (44.200795)	292,478.1 (-79.654165)	227.6	11.3

TABLE 2 – SUMMARY OF FOUNDATION ENGINEERING PARAMETERS FOR HIGH FILL AREAS

Foundation Investigation Area	Stratigraphic Unit	Top Elevation (m)	Thickness (m)	γ (kN/m^3)	ϕ' (°)	c' (kPa)	s_u (kPa)	σ_p' (kPa)	OCR	e_o	C_c	C_r	m_v (kPa^{-1})	E' (MPa)	c_v (cm^2/s)
High Fill Areas: Highway 89 N-E/W Ramp E-S/W Ramp W-N Ramp E/W-N Ramp S-E/W Ramp W-S Ramp Reive Boulevard	Silt and Sand to Silty Sand to Sand to Gravelly Sand (Fill) / Clayey Silt (Fill) in Borehole HF-03 (0.5 m thick)	228.9 – 226.7 ~ 235.2 (Hwy 89)	0.5 – 2.3 8.9 – 10.0 (Hwy 89)	19	32	0	--	--	--	--	--	--	--	10 – 30	--
	Compact Silt to Sandy Silt to Silt and Sand to Silty Sand (Upper Granular Deposit)	227.7 – 224.6	13.7 – 10.6	19	32	0	--	--	--	--	--	--	--	10 – 45	--
	Dense to Very Dense Silt to Sandy Silt to Silt and Sand to Silty Sand (Upper Granular Deposit)	~214	~5.0	19	36	0	--	--	--	--	--	--	--	55	
	Varved Clayey Silt to Silty Clay with Silt and Clay Laminae (Upper Cohesive Deposit)	209.1 – 205.3	9.6 – 12.4	18.5	31	0	75 – 90	340 – 410	1.0 – 2.2	0.75 – 1.15	0.40 – 0.67	0.02 – 0.046	--	--	$8.4 \times 10^{-3} – 2.1 \times 10^{-2}$ (Overconsolidated Range) $2.0 \times 10^{-3} – 5.0 \times 10^{-3}$ (Normally Consolidated Range)
	Silt to Sandy Silt to Silt and Sand to Silty Sand (Lower Cohesive Deposit)	195.7 – 194.0	3.0 – 6.5	19	36	0	--	--	--	--	--	--	--	75	--
	Sandy Clayey Silt to Clayey Silt (Lower Cohesive Deposit)	190.9 – 189.0	~6.1 (up to 7.9, but not fully penetrated)	18.5	34	0	100 – 150	450 – 680	1.4 – 2.1	--	--	--	1.3×10^{-5}	--	--
	Clayey Silt with Sand to Clayey Silt (Till) / Silt and Sand (Till)	184.2 – 182.9	4.7 – 7.6, but not fully penetrated	21	38	0	--	--	--	--	--	--	--	175	--

Note:

1. Complete plots of the parameters (i.e., undrained shear strength (s_u), preconsolidation stress (σ_p'), void ratio (e_o), compression index (C_c) and recompression index (C_r)) versus elevation for the upper cohesive deposit are presented on Figure 2.

TABLE 3 – COMPARISON OF LIGHTWEIGHT FILL SETTLEMENT MITIGATION OPTIONS FOR HIGH FILL EMBANKMENT OVER THE EXISTING GAS MAIN

Option	Advantages	Disadvantages	Constructability/ Construction Risk	Costs
Lightweight or ultra-lightweight slag *	• MTO has good experience and performance with slag fill in high fill embankments • Meets the settlement criteria of 15 mm	• Requires the thickest amount of lightweight fill of the three options	• Careful compaction of slag fill required to avoid particle breakage and overcompaction	• Lowest cost of the three options
Expanded Polystyrene (EPS)	• Requires the least amount of lightweight fill of the three options • MTO has good experience and performance with slag fill in high fill embankments • Meets the settlement criteria of 15 mm	• Highest cost of the three options • Potential to affect schedule • Must be installed above the groundwater	• Although the EPS is to be wrapped in 10 mil polyethylene there remains low potential risk that if a fuel spill occurred that it could damage the EPS.	• Highest cost of the three alternatives **PREFERRED OPTION FROM FOUNDATIONS PERSPECTIVE**
Cellular Concrete	• MTO has good experience and performance with slag fill in high fill embankments • Meets the settlement criteria of 15 mm	• Requires the less amount of lightweight fill compared to the slag option • Requires mobilization of the grout plant for mixing of the cellular concrete	• Specialized contractor required, with special measures needed during placement of cellular concrete, including limiting lift thicknesses and allowing time to cure; however, these are not unusually onerous	• Costs associated with mobilizing the mixing/foaming plant for the cellular concrete to the site

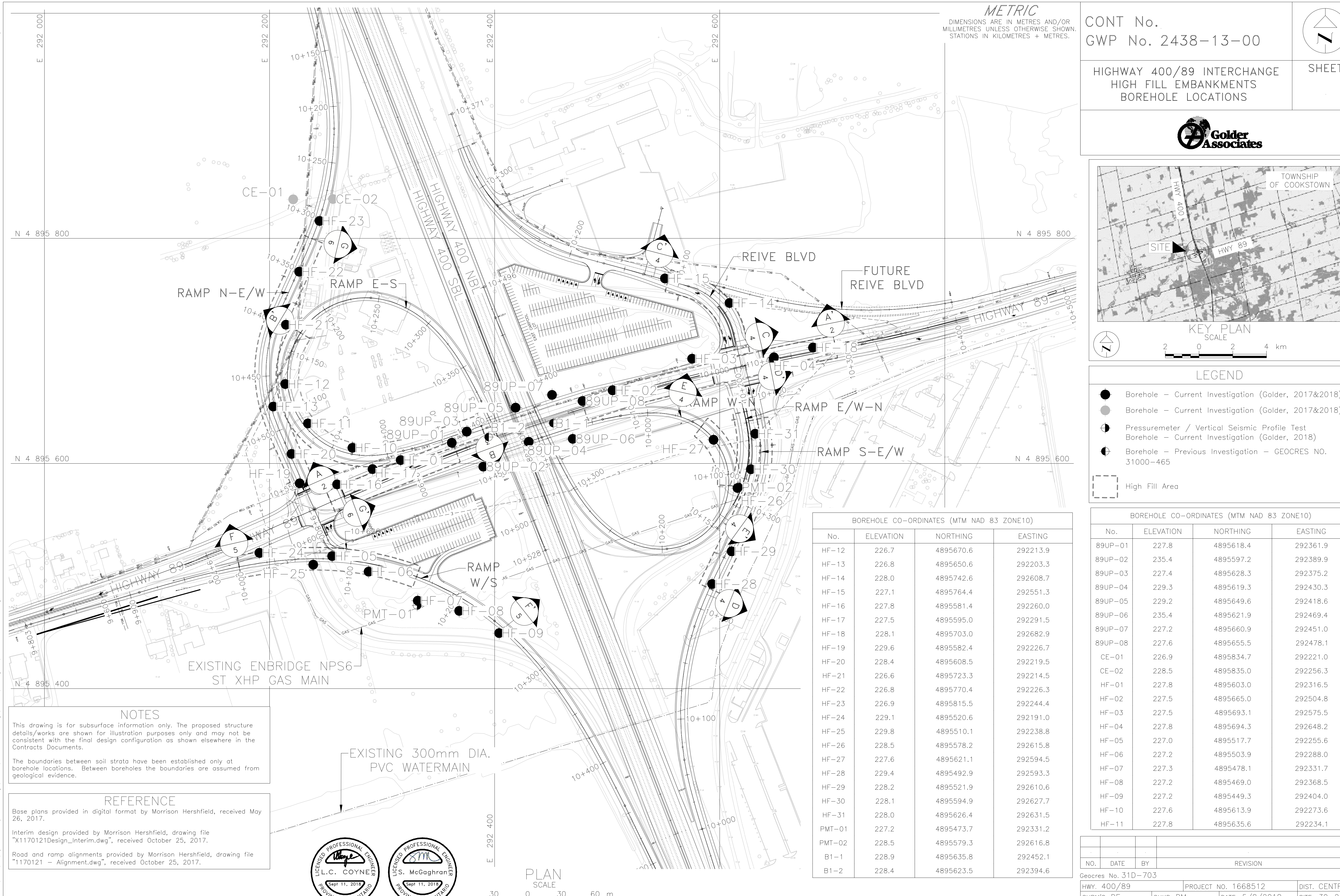
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2438–13–00

SHEET

HIGHWAY 400/89 INTERCHANGE HIGH FILL EMBANKMENTS BOREHOLE LOCATIONS

Golder Associates



LEGEND

- Borehole – Current Investigation (Golder, 2017&2018)
- Borehole – Current Investigation (Golder, 2017&2018)
- Pressuremeter / Vertical Seismic Profile Test Borehole – Current Investigation (Golder, 2018)
- Borehole – Previous Investigation – GEOCRES NO. 31000–465
- High Fill Area

NOTES

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The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by Morrison Hershfield, received May 26, 2017.

Interim design provided by Morrison Hershfield, drawing file "X1170121Design_Interim.dwg", received October 25, 2017.

Road and ramp alignments provided by Morrison Hershfield, drawing file "1170121 – Alignment.dwg", received October 25, 2017.

LICENSED PROFESSIONAL ENGINEER L.C. COYNE Sept 11, 2018 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S. McGaghran Sept 11, 2018 PROVINCE OF ONTARIO

BOREHOLE CO–ORDINATES (MTM NAD 83 ZONE10)

No.	ELEVATION	NORTHING	EASTING
HF–12	226.7	4895670.6	292213.9
HF–13	226.8	4895650.6	292203.3
HF–14	228.0	4895742.6	292608.7
HF–15	227.1	4895764.4	292551.3
HF–16	227.8	4895581.4	292260.0
HF–17	227.5	4895595.0	292291.5
HF–18	228.1	4895703.0	292682.9
HF–19	229.6	4895582.4	292226.7
HF–20	228.4	4895608.5	292219.5
HF–21	226.6	4895723.3	292214.5
HF–22	226.8	4895770.4	292226.3
HF–23	226.9	4895815.5	292244.4
HF–24	229.1	4895520.6	292191.0
HF–25	229.8	4895510.1	292238.8
HF–26	228.5	4895578.2	292615.8
HF–27	227.6	4895621.1	292594.5
HF–28	229.4	4895492.9	292593.3
HF–29	228.2	4895521.9	292610.6
HF–30	228.1	4895594.9	292627.7
HF–31	228.0	4895626.4	292631.5
PMT–01	227.2	4895473.7	292331.2
PMT–02	228.5	4895579.3	292616.8
B1–1	228.9	4895635.8	292452.1
B1–2	228.4	4895623.5	292394.6

BOREHOLE CO–ORDINATES (MTM NAD 83 ZONE10)

No.	ELEVATION	NORTHING	EASTING
89UP–01	227.8	4895618.4	292361.9
89UP–02	235.4	4895597.2	292389.9
89UP–03	227.4	4895628.3	292375.2
89UP–04	229.3	4895619.3	292430.3
89UP–05	229.2	4895649.6	292418.6
89UP–06	235.4	4895621.9	292469.4
89UP–07	227.2	4895660.9	292451.0
89UP–08	227.6	4895655.5	292478.1
CE–01	226.9	4895834.7	292221.0
CE–02	228.5	4895835.0	292256.3
HF–01	227.8	4895603.0	292316.5
HF–02	227.5	4895665.0	292504.8
HF–03	227.5	4895693.1	292575.5
HF–04	227.8	4895694.3	292648.2
HF–05	227.0	4895517.7	292255.6
HF–06	227.2	4895503.9	292288.0
HF–07	227.3	4895478.1	292331.7
HF–08	227.2	4895469.0	292368.5
HF–09	227.2	4895449.3	292404.0
HF–10	227.6	4895613.9	292273.6
HF–11	227.8	4895635.6	292234.1

NO.	DATE	BY	REVISION

Geocres No. 31D–703

HWY. 400/89		PROJECT NO. 1668512	DIST. CENTRAL
SUBM'D. DF	CHKD. DM	DATE: 5/8/2018	SITE: 30–256
DRAWN: SMD	CHKD. SMM	APPD. JMAC/LCC	DWG. 1

PLOT DATE: September 12, 2018
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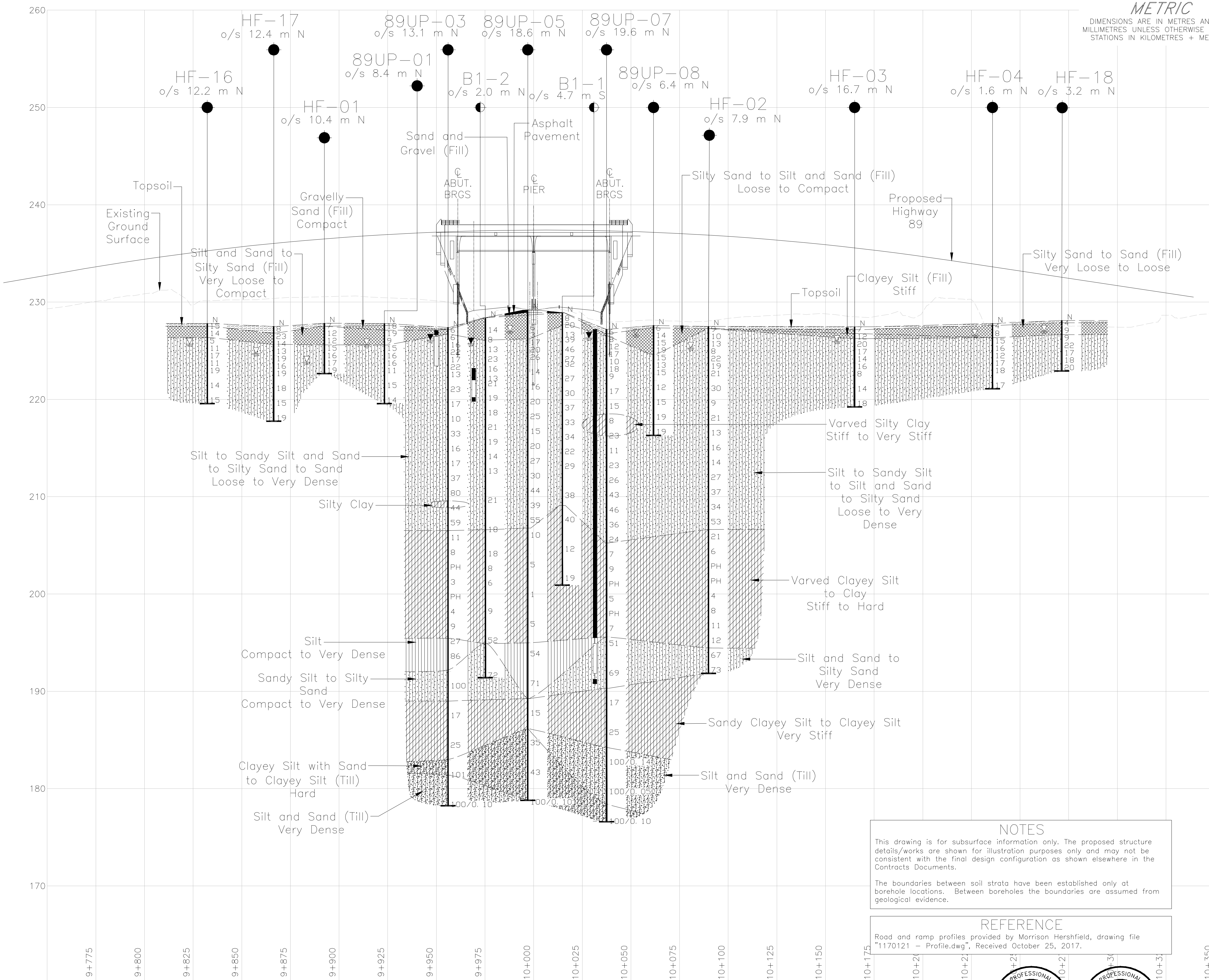

NOTES

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REFERENCE

Road and ramp profiles provided by Morrison Hershfield, drawing file "1170121 – Profile.dwg", Received October 25, 2017.

SCALE 1:500 m (A-A') HIGHWAY 89 PROFILE

SCALE 20 0 20 40 m

L.C. COYNE — LICENSED PROFESSIONAL ENGINEER — Sept 11, 2018 — PROVINCE OF ONTARIO

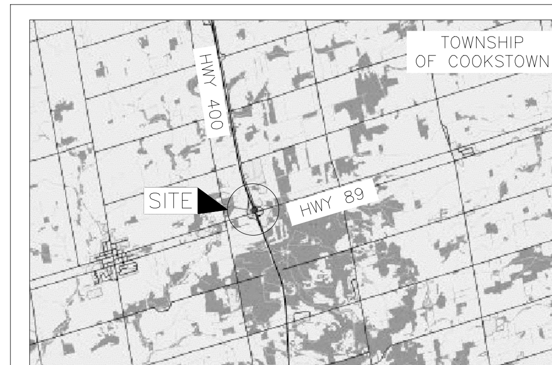
S. McGaghran — LICENSED PROFESSIONAL ENGINEER — Sept 11, 2018 — PROVINCE OF ONTARIO

CONT No.
GWP No. 2438-13-00

HIGHWAY 89
HIGH FILL EMBANKMENTS
SOIL STRATA

SHEET

Golder Associates



KEY PLAN

SCALE 2 0 2 4 km

LEGEND

- Borehole – Current Investigation (Golder, 2017 & 2018)
- Borehole – Previous Investigation (GEOCRES NO. 31000-465)
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on March 5, 2018 and March 15, 2001 in Borehole B1-2
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE10)			
No.	ELEVATION	NORTHING	EASTING
89UP-01	227.8	4895618.4	292361.9
89UP-03	227.4	4895628.3	292375.2
89UP-05	229.2	4895649.6	292418.6
89UP-07	227.2	4895660.9	292451.0
89UP-08	227.6	4895655.5	292478.1
HF-01	227.8	4895603.0	292316.5
HF-02	227.5	4895665.0	292504.8
HF-03	227.5	4895693.1	292575.5
HF-04	227.8	4895694.3	292648.2
HF-16	227.8	4895581.4	292260.0
HF-17	227.5	4895595.0	292291.5
HF-18	228.1	4895703.0	292682.9
B1-1	228.9	4895635.8	292452.1
B1-2	228.4	4895623.5	292394.6

NO.	DATE	BY	REVISION

Geocres No. 31D-703

HWY. 400/89	PROJECT NO. 1668512		DIST. CENTRAL
SUBM'D. DF	CHKD. DM	DATE: 5/8/2018	SITE:
DRAWN: SMD	CHKD. SMM	APPD. JMAC/LCC	DWG. 2

PLOT DATE: September 12, 2018
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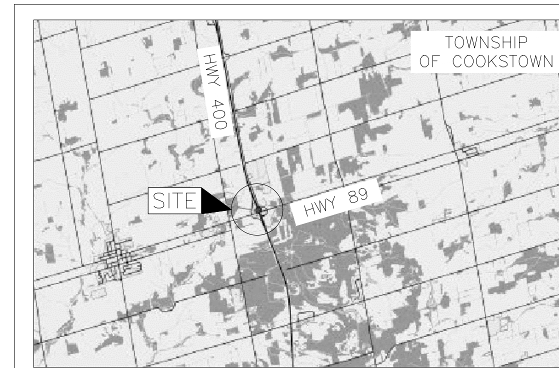
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2438-13-00

HIGHWAY 400 / 89 INTERCHANGE E-S RAMP HIGH FILL EMBANKMENTS SOIL STRATA

SHEET

Golder Associates



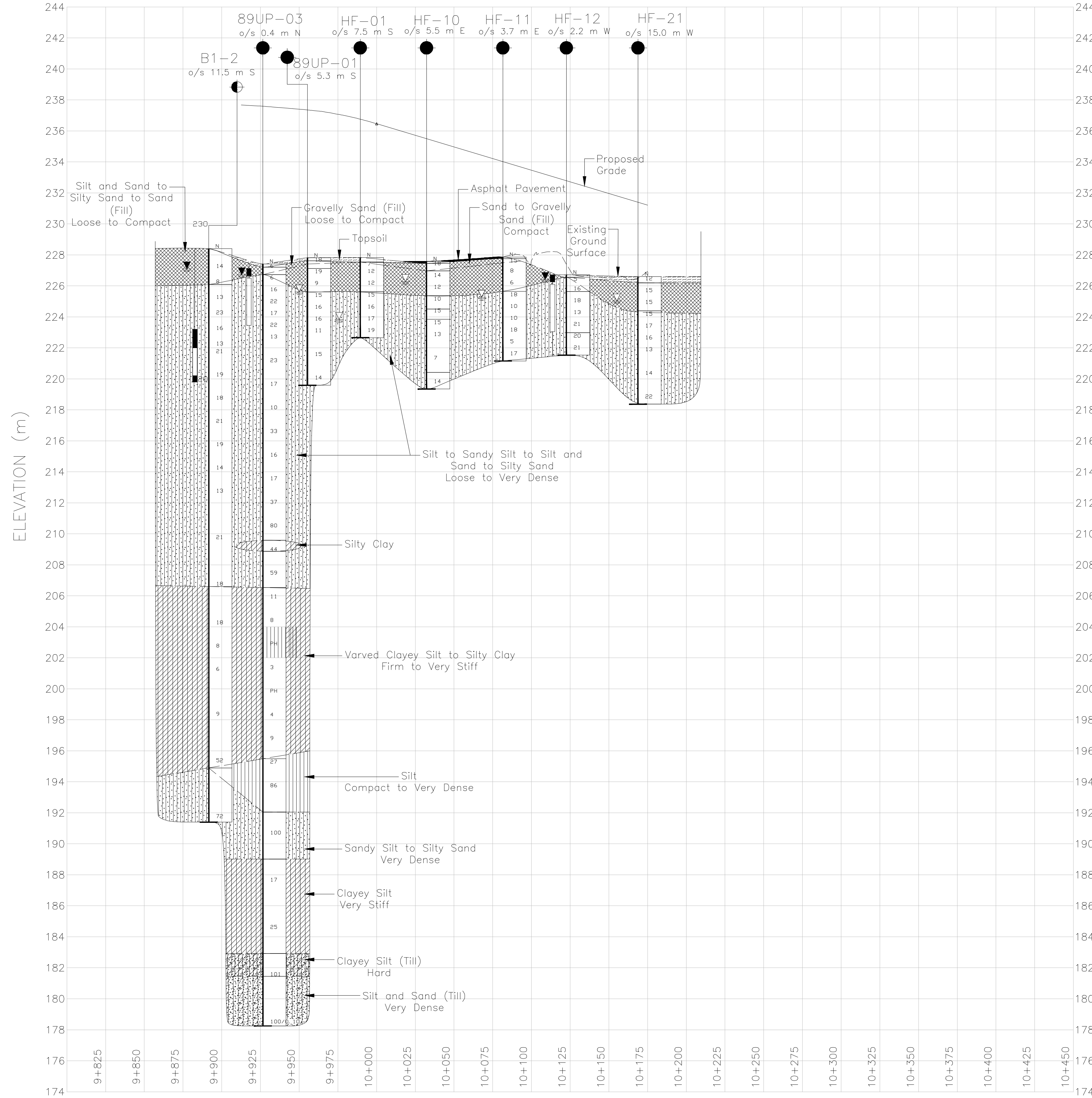
KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation (Golder, 2017&2018)
- Borehole – Previous Investigation – GEOCRES NO. 3100-465
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on March 5, 2018 and March 15, 2001 in Borehole B1-2
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
89UP-01	227.8	4895618.4	292361.9
89UP-03	227.4	4895628.3	292375.2
B1-2	228.4	4895623.5	292394.6
HF-01	227.8	4895603.0	292316.5
HF-10	227.6	4895613.9	292273.6
HF-11	227.8	4895635.6	292234.1
HF-12	226.7	4895670.6	292213.9
HF-21	226.6	4895723.3	292214.5



B-B' E-S RAMP PROFILE

HORIZONTAL SCALE
30 0 30 60 m

VERTICAL SCALE
3 0 3 6 m

REFERENCE

Road and ramp profiles provided by Morrison Hershfield, drawing file "1170121 – Profile.dwg", Received October 25, 2017.

NOTES

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LICENSED PROFESSIONAL ENGINEER L.C. COYNE Sept 11, 2018 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S. McGaghran Sept 11, 2018 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31D-703			
HWY. 400/89	PROJECT NO. 1668512		DIST. CENTRAL
SUBM'D. DF	CHKD. DM	DATE: 5/3/2018	SITE:
DRAWN: SMD	CHKD. SMM	APPD. JMAC/LCC	DWG. 3

MINISTRY OF TRANSPORTATION, ONTARIO

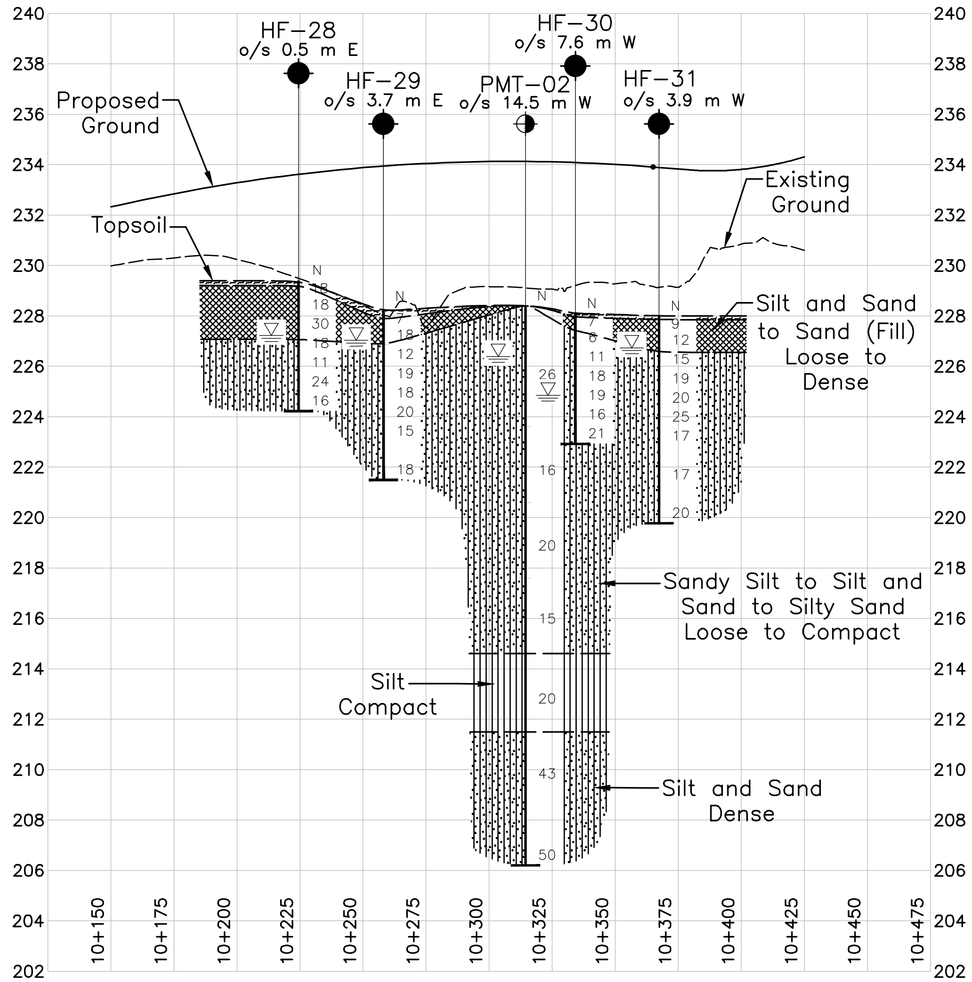
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2438-13-00

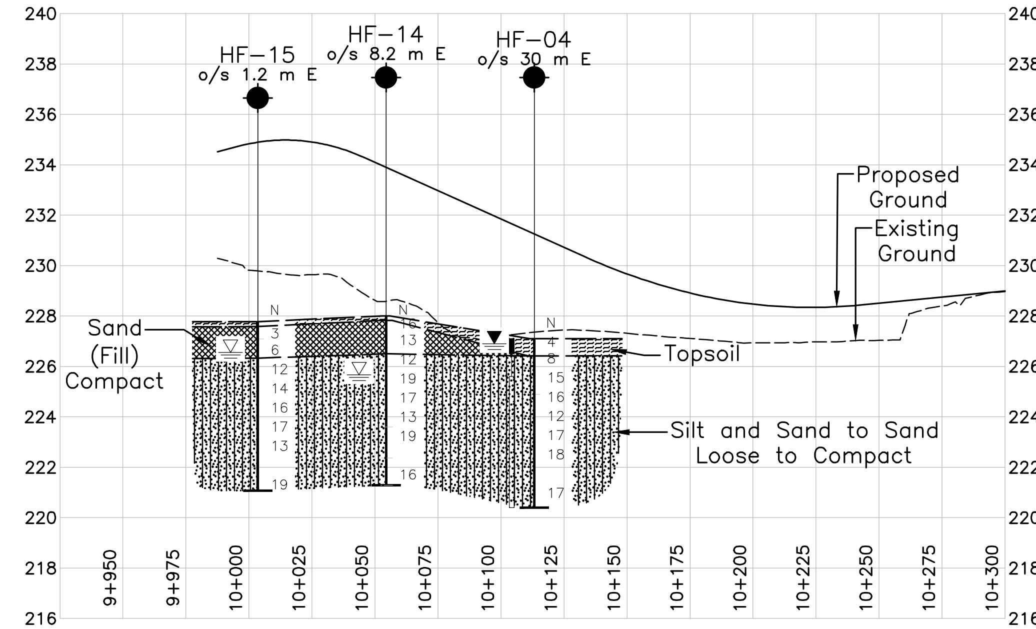
HIGHWAY 400/89 INTERCHANGE
RAMPS E/W-N, S-E/W, W-N AND REIVE BOULEVARD
HIGH FILL EMBANKMENTS
SOIL STRATA

SHEET

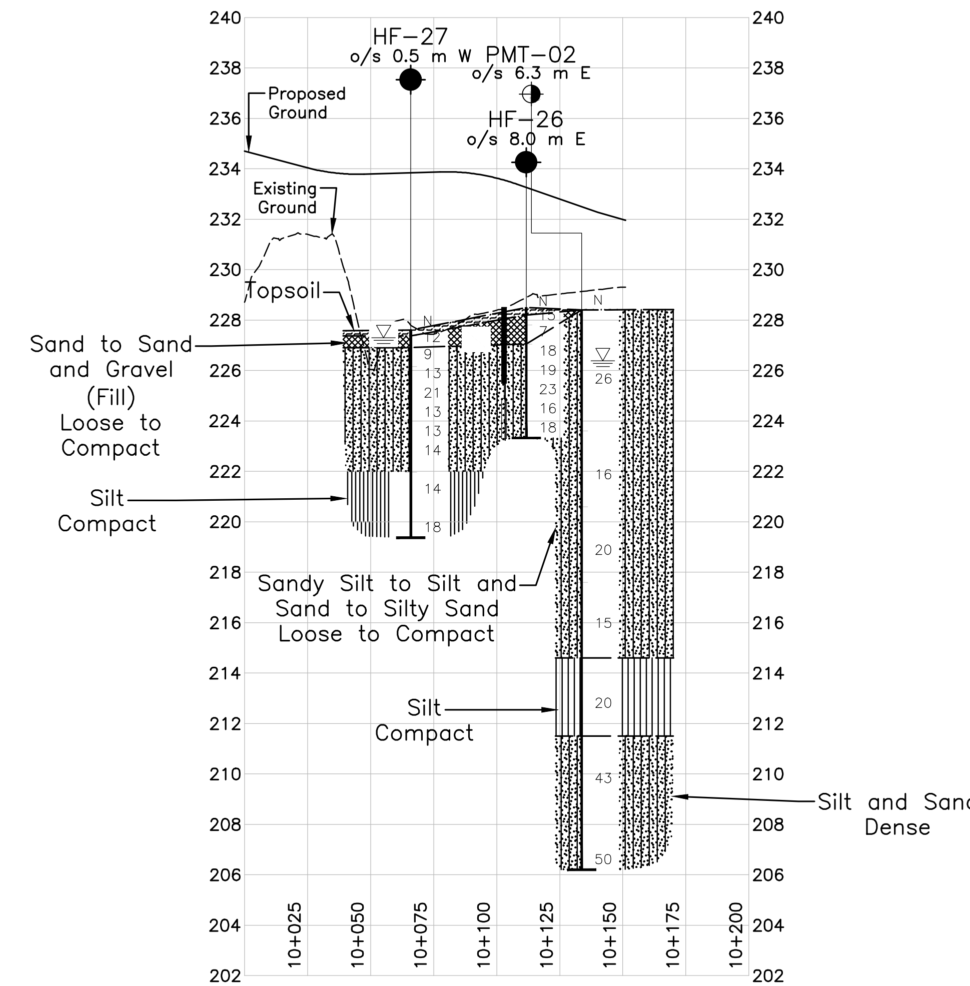
Golder Associates



D-D' RAMP E/W-N AND RAMP S-E/W PROFILE



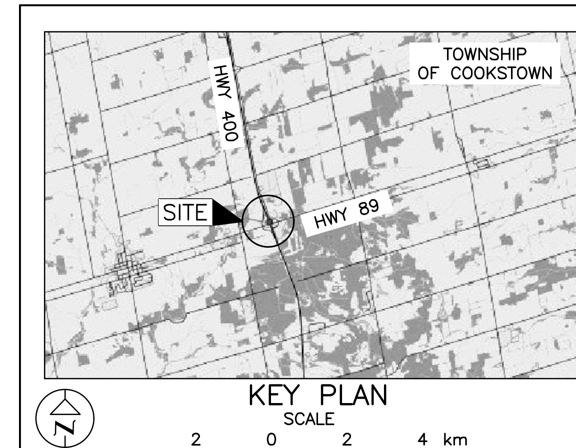
C-C' REIVE BOULEVARD PROFILE



E-E' W-N RAMP PROFILE

HORIZONTAL SCALE
30 0 30 60 m

VERTICAL SCALE
3 0 3 6 m



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation (Golder, 2017&2018)
- Pressuremeter / Vertical Seismic Profile Test Borehole – Current Investigation (Golder, 2018)
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on March 5, 2018
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE10)

No.	ELEVATION	NORTHING	EASTING
HF-04	227.8	4895694.3	292648.2
HF-14	228.0	4895742.6	292608.7
HF-15	227.1	4895764.4	292551.3
HF-26	228.5	4895578.2	292615.8
HF-27	227.6	4895621.1	292594.5
HF-28	229.4	4895492.9	292593.3
HF-29	228.2	4895521.9	292610.6
HF-30	228.1	4895594.9	292627.7
HF-31	228.0	4895626.4	292631.5
PMT-02	228.5	4895579.3	292616.8

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Road and ramp profiles provided by Morrison Hershfield, drawing file "1170121 – Profile.dwg", Received October 25, 2017.

NO.	DATE	BY	REVISION
.	.	.	

Geocres No. 31D-703

HWY. 400/89	PROJECT NO. 1668512		DIST. CENTRAL
SUBM'D. DF	CHKD. DM	DATE: 5/4/2018	SITE: .
DRAWN: SMD/TB	CHKD. SMM	APPD. LCC/JMAC	DWG. 4

PLOT DATE: September 12, 2018
FILENAME: S:\Clients\MTO\Hwy_400_and_Hwy_89_Interchange\99_PROJ\1668512_Detailed_Design\40_PROD\0007_High_Fill\1668512-0007-BG-0005.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

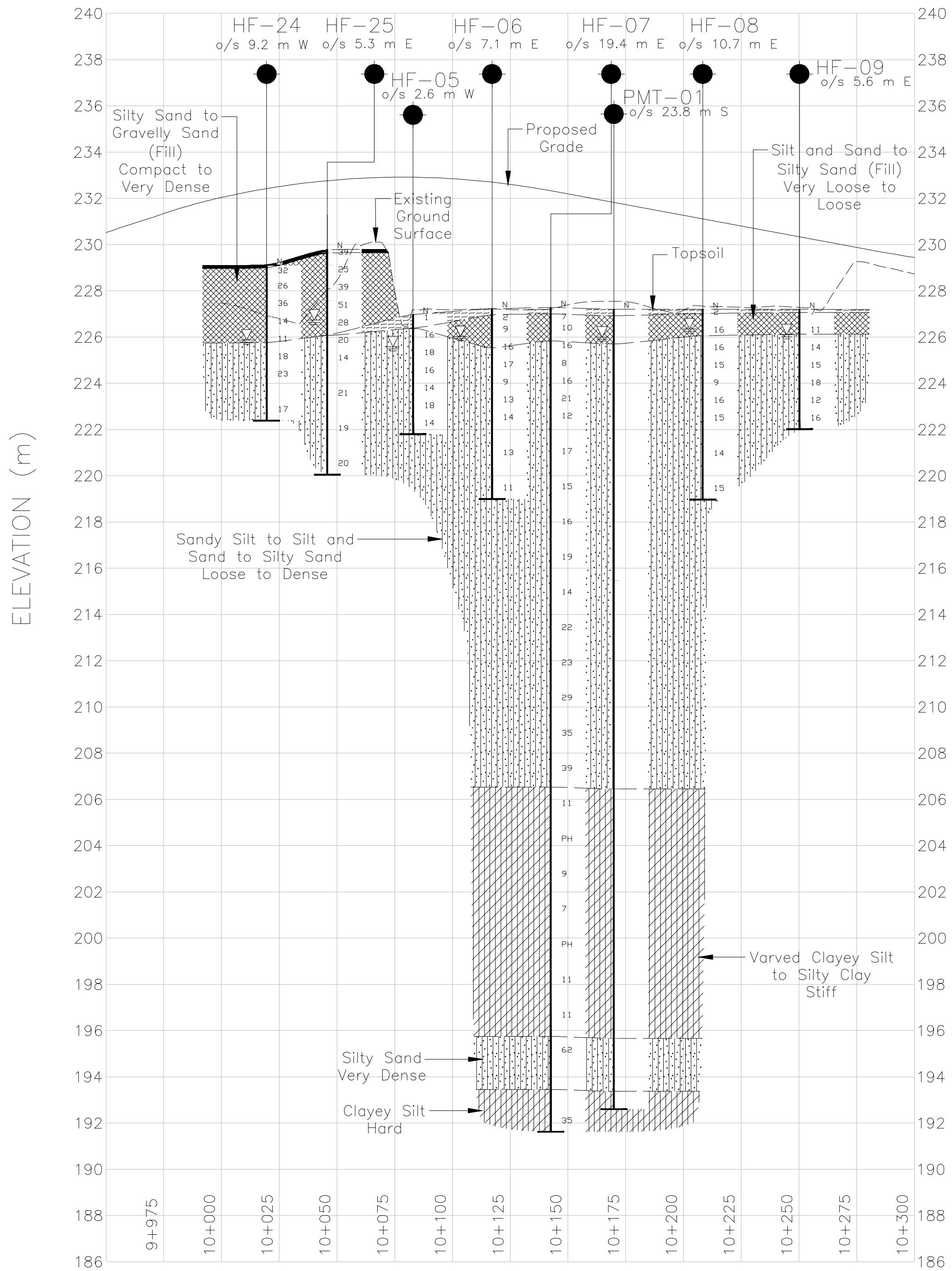
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2438-13-00

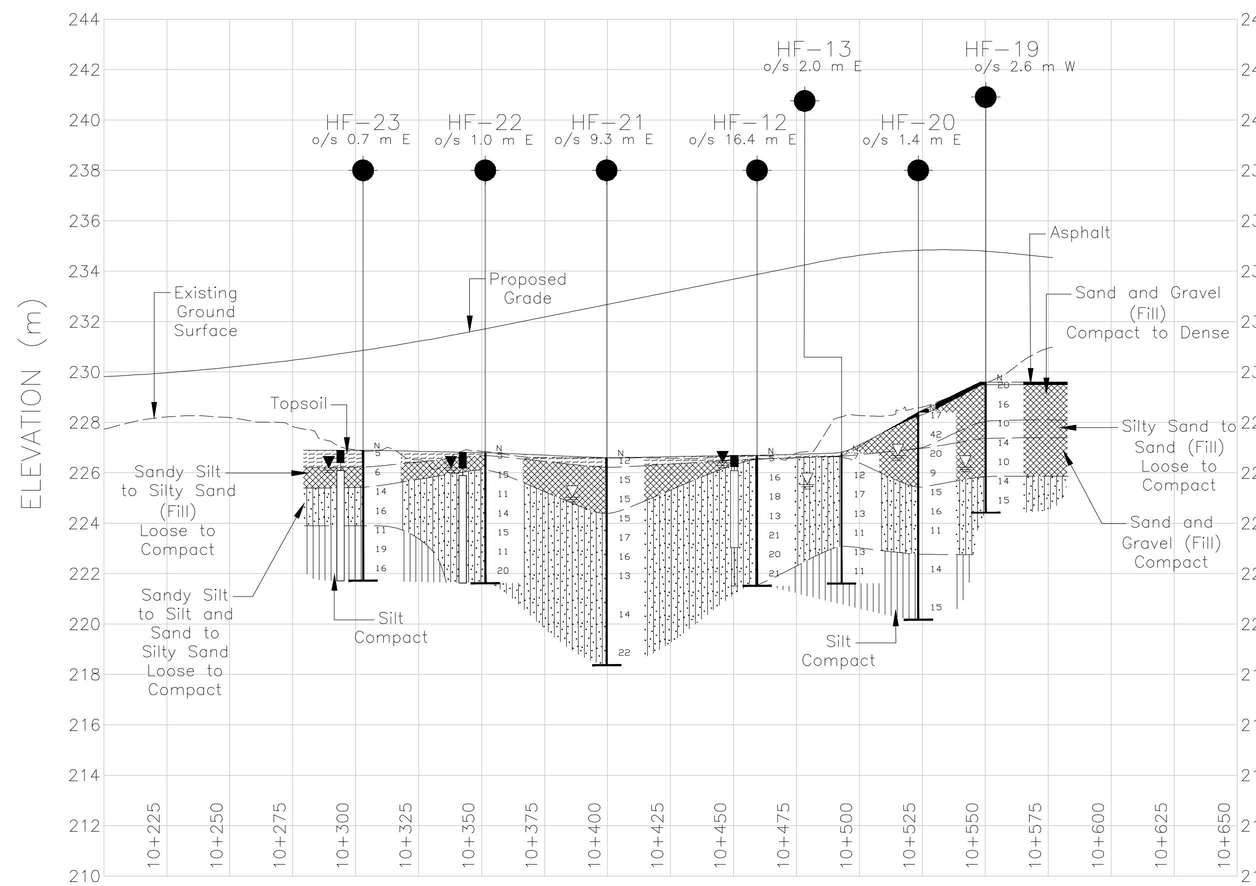
HIGHWAY 400 / 89 INTERCHANGE
W-S RAMP AND N-E/W RAMP
HIGH FILL EMBANKMENTS
SOIL STRATA

SHEET

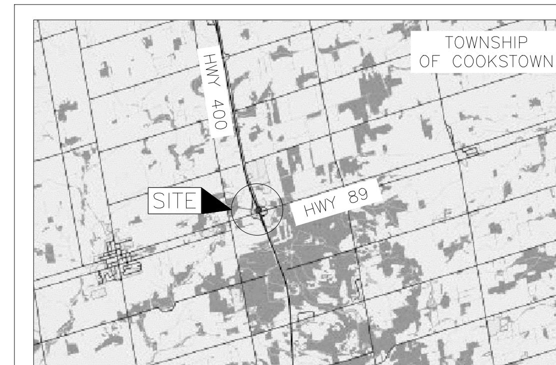
Golder Associates



F-F' W-S RAMP PROFILE



G-G' N-E/W RAMP PROFILE



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation (Golder, 2017 & 2018)
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on March 5, 2018
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE10)

No.	ELEVATION	NORTHING	EASTING
HF-05	227.0	4895517.7	292255.6
HF-06	227.2	4895503.9	292288.0
HF-07	227.3	4895478.1	292331.7
HF-08	227.2	4895469.0	292368.5
HF-09	227.2	4895449.3	292404.0
HF-12	226.7	4895670.6	292213.9
HF-13	226.8	4895650.6	292203.3
HF-19	229.6	4895582.4	292226.7
HF-20	228.4	4895608.5	292219.5
HF-21	226.6	4895723.3	292214.5
HF-22	226.8	4895770.4	292226.3
HF-23	226.9	4895815.5	292244.4
HF-24	229.1	4895520.6	292191.0
HF-25	229.8	4895510.1	292238.8

LICENSED PROFESSIONAL ENGINEER L.C. COYNE Sept 11, 2018 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S. McGaghran Sept 11, 2018 PROVINCE OF ONTARIO

HORIZONTAL SCALE 30 0 30 60 m

VERTICAL SCALE 3 0 3 6 m

REFERENCE

Road and ramp profiles provided by Morrison Hershfield, drawing file "1170121 – Profile.dwg", Received October 25, 2017.

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

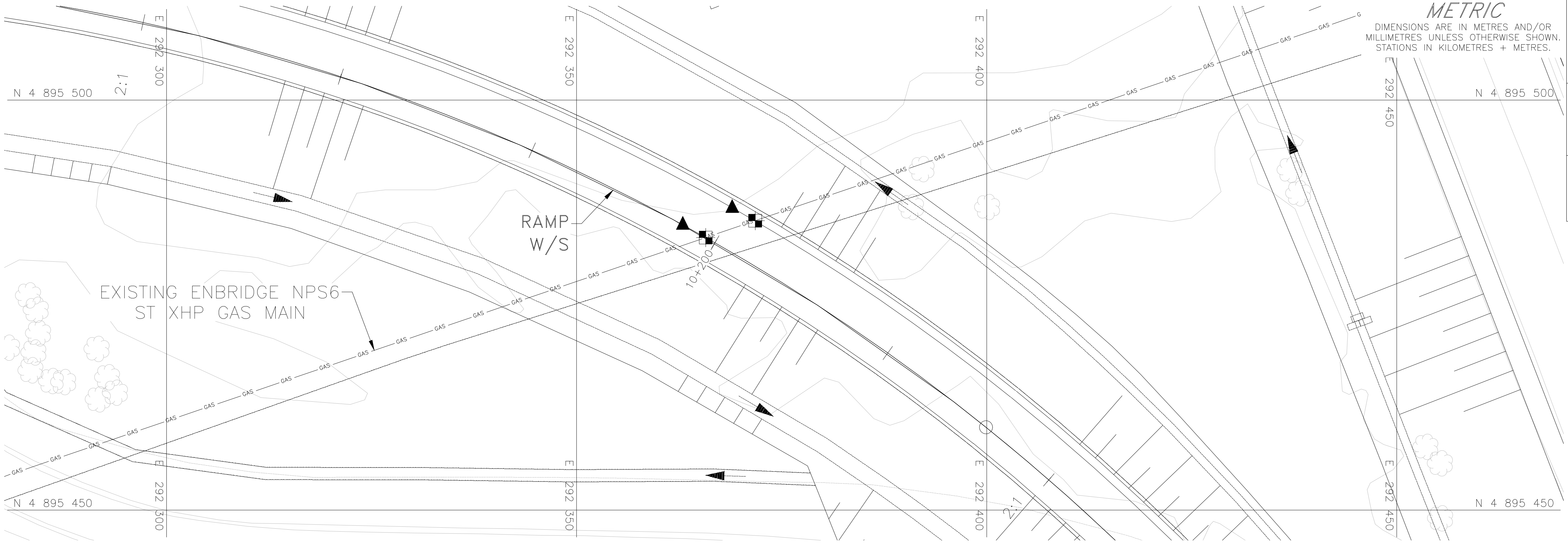
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

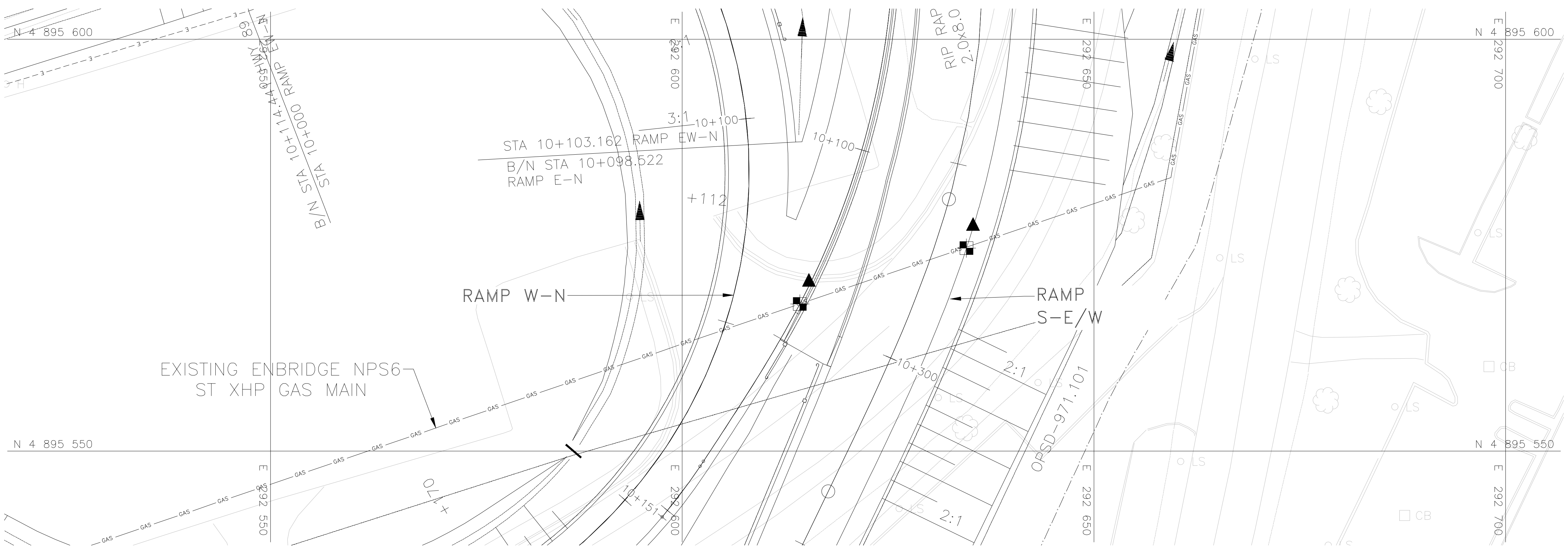
Geocres No. 31D-703

HWY. 400/89	PROJECT NO. 1668512		DIST. CENTRAL
SUBM'D. DF	CHKD. DM	DATE: 5/8/2018	SITE:
DRAWN: SMD	CHKD. SMM	APPD. JMAC/LCC	DWG. 5

PLOT DATE: September 12, 2018



W–S RAMP
SCALE
6 0 6 12 m



RAMP S–E/W
SCALE
6 0 6 12 m

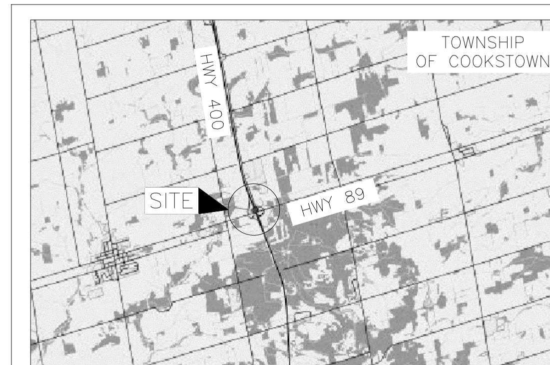
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2438–13–00

HWY 400 AND HWY 89 INTERCHANGE
HIGH FILL EMBANKMENTS
MONITORING INSTRUMENTATION PLAN

SHEET

Golder Associates



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Settlement Plate (SP)
- Settlement Rod (SR)

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

REFERENCE

Base plans provided in digital format by Morrison Hershfield, received May 26, 2017.

Design plan provided by Morrison Hershfield, drawing file "X1170121Design.dwg", received September 21, 2018.

Road and ramp alignments provided by Morrison Hershfield, drawing file "1170121 – Alignment.dwg", received October 25, 2017.

LICENSED PROFESSIONAL ENGINEER L.C. COYNE Oct. 12, 2018 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S. McGaghran Oct. 12, 2018 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31D–703

HWY. 400/89	PROJECT NO. 1668512	DIST. CENTRAL
SUBM'D. DM	CHKD. SMM	DATE: 10/12/2018	SITE:
DRAWN: SMD/DD	CHKD. SMM	APPD. LCC	DWG. 6

PLOT DATE: October 12, 2018
FILENAME: S:\Clients\MTO\Hwy_400_and_Hwy_89_Interchange\99_PROJ\1668512_Detailed_Design\40_PROD\0007_High_Fill\1668512-0007-BG-0007.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

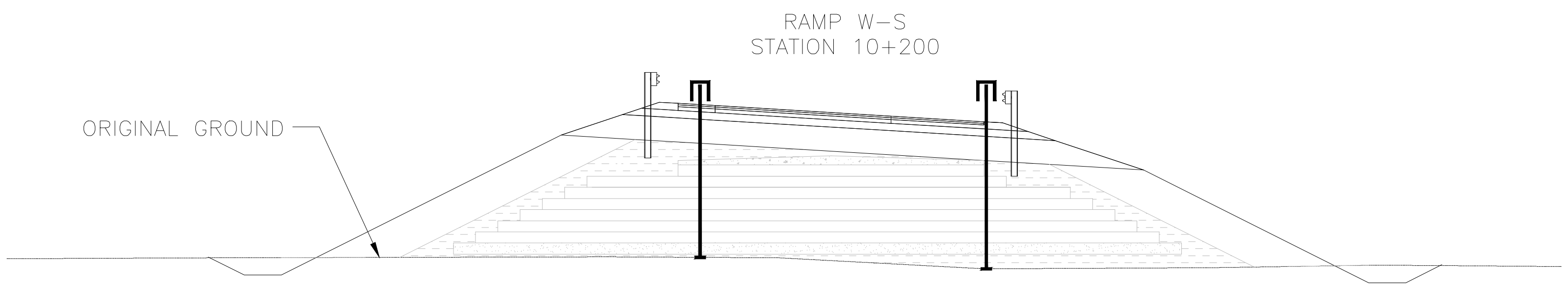
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2438-13-00

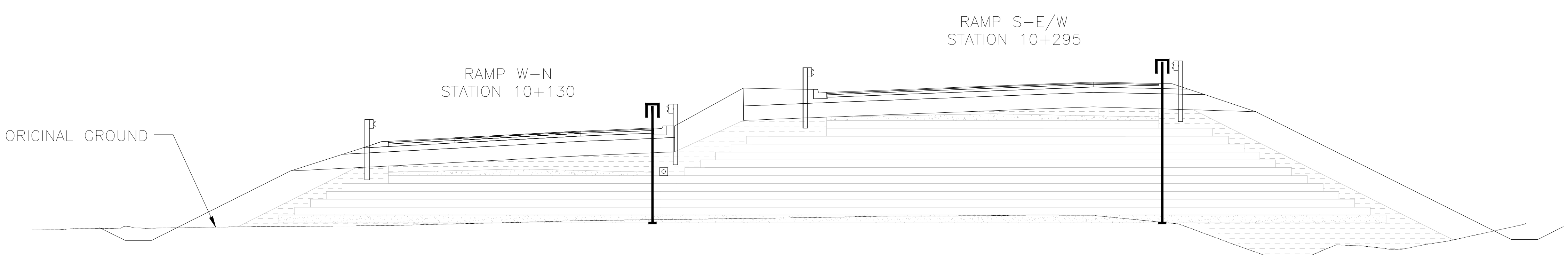
HWY 400 AND HWY 89 INTERCHANGE
HIGH FILL EMBANKMENTS
EMBANKMENT MONITORING SECTION

SHEET

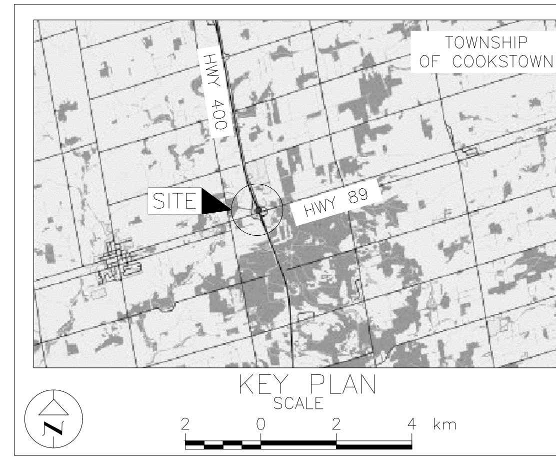
Golder Associates



MONITORING SECTION
NOT TO SCALE



MONITORING SECTION
NOT TO SCALE



KEY PLAN
SCALE

LEGEND

Settlement Plate (Schematic Section)

NOTES

1. See specification for location and depth.
2. Subsurface details shown for illustration purposes only.

REFERENCE

Monitoring sections provided in digital format by MH file no. x_1170121_TS-working.dwg, received September 12, 2018.

LICENSED PROFESSIONAL ENGINEER
L.C. COYNE
Oct. 12, 2018
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S. McGaghran
Oct. 12, 2018
PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31D-703

HWY. 400/89	PROJECT NO. 1668512		DIST. CENTRAL
SUBM'D.	CHKD. SMM	DATE: 10/12/2018	SITE:
DRAWN: SMD/DD	CHKD. SMM	APPD. LCC	DWG. 7

PLOT DATE: October 12, 2018
FILENAME: S:\Clients\MTO\Hwy_400_and_Hwy_89_Interchange\99_PROJ\1668512_Detailed_Design\40_PROD\0007_High_Fill\1668512-0007-BG-0009.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

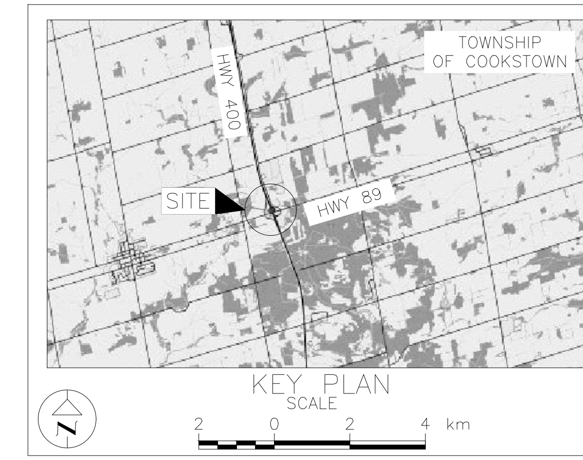
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2438–13–00

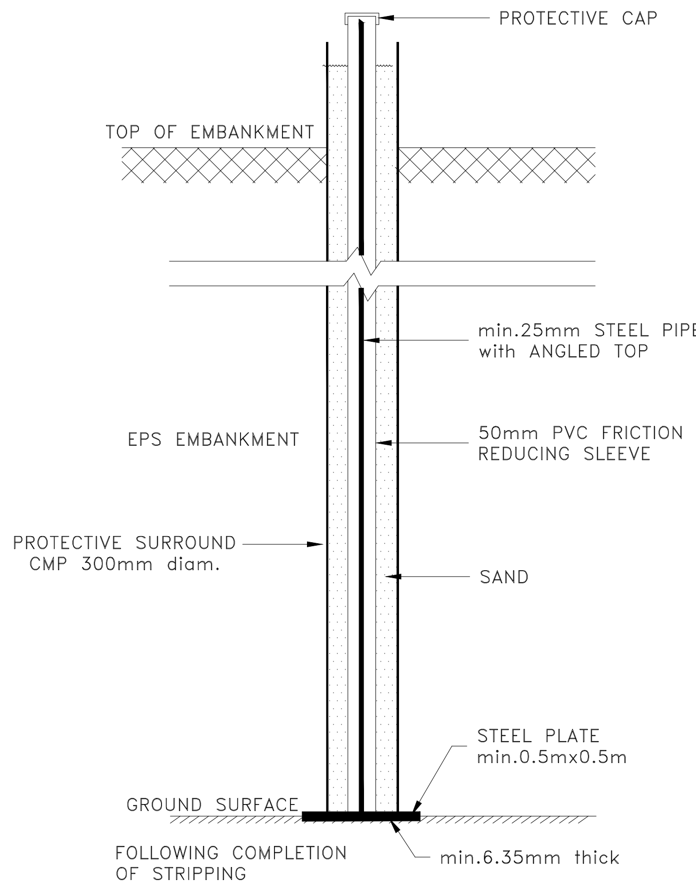
HWY 400 AND HWY 89 INTERCHANGE
HIGH FILL EMBANKMENTS
TYPICAL INSTRUMENT INSTALLATION DETAILS

SHEET

Golder Associates

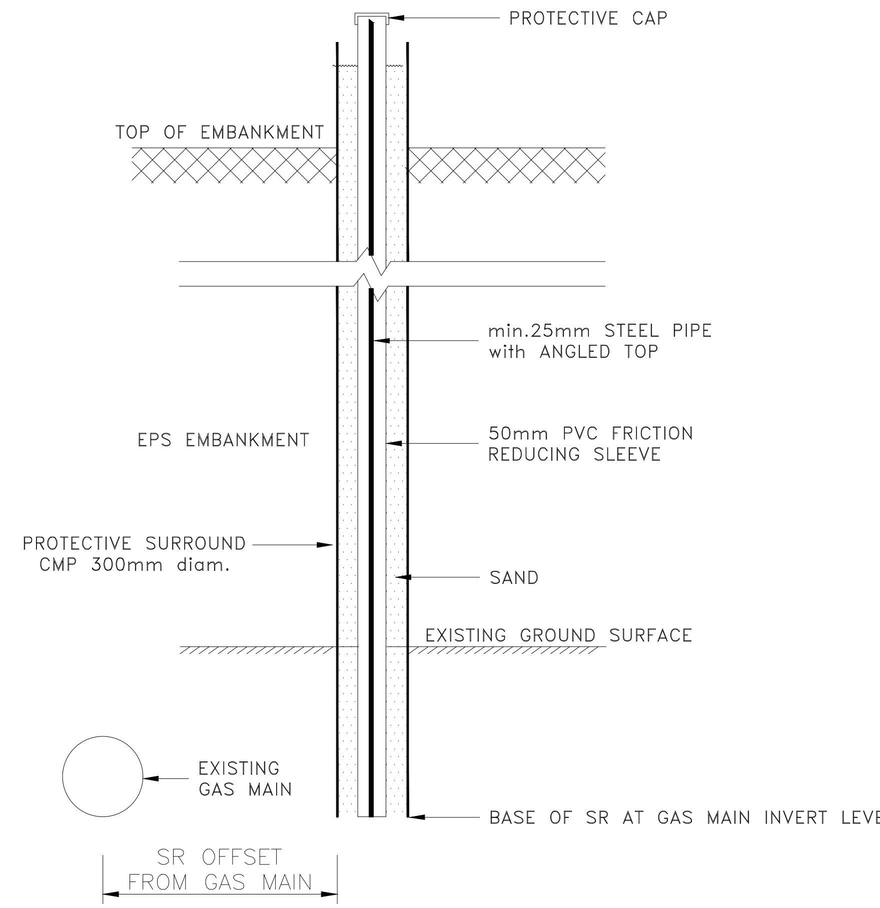


KEY PLAN
SCALE
2 0 2 4 km



SETTLEMENT PLATE (SP)
RAMP W–S,
RAMP S–E/W and W–N

NOT TO SCALE



SETTLEMENT ROD (SR)
RAMP W–S,
RAMP S–E/W and W–N

NOT TO SCALE

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

LICENSED PROFESSIONAL ENGINEER L.C. COYNE Oct. 12, 2018 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S. McGaghran Oct. 12, 2018 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

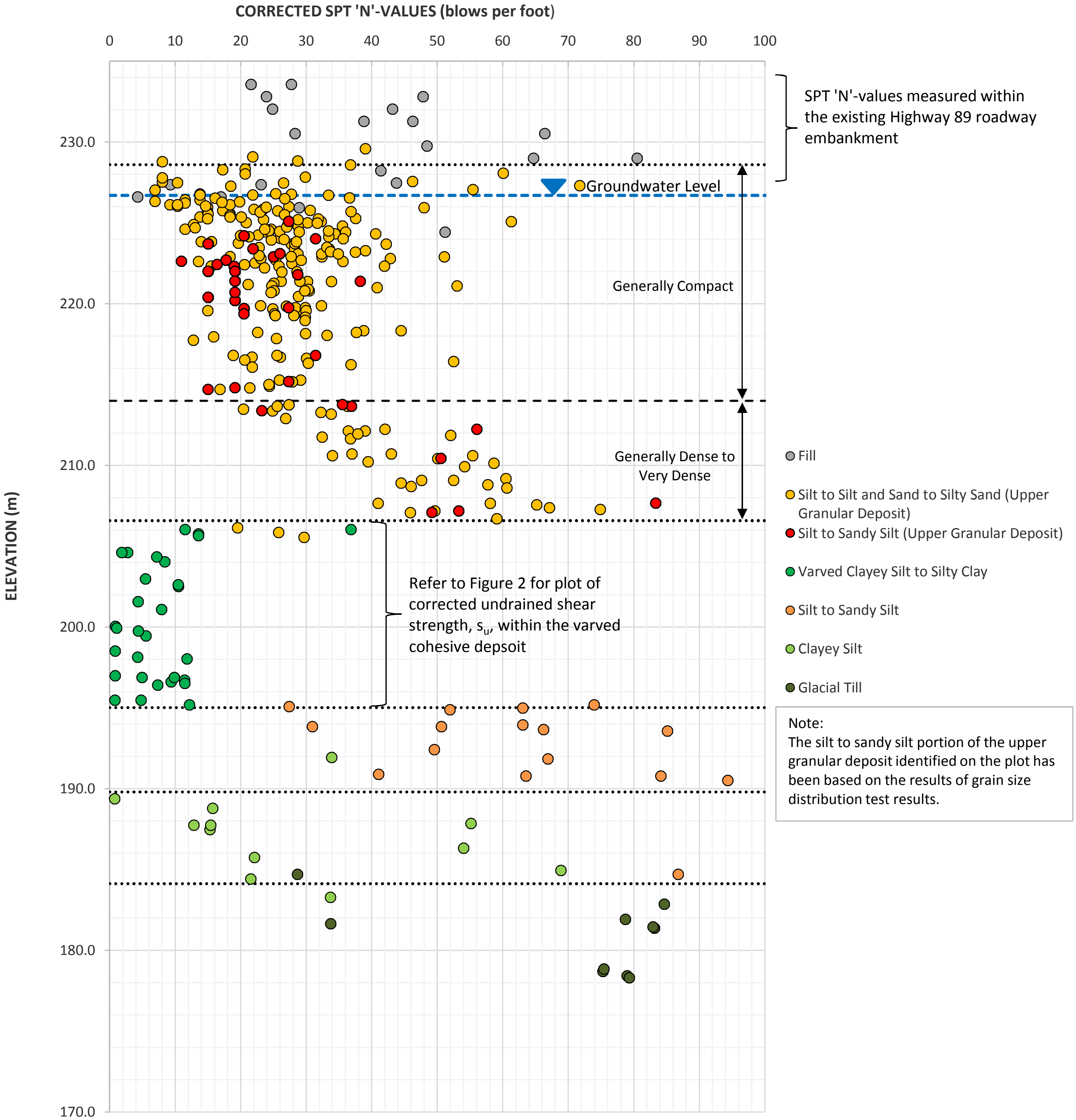
Geocres No. 31D–703

HWY. 400/89	PROJECT NO. 1668512		DIST. CENTRAL
SUBM'D. DM	CHKD. SMM	DATE: 10/12/2018	SITE:
DRAWN: SMD/DD	CHKD. SMM	APPD. LCC	DWG. 8

PLOT DATE: October 12, 2018

CORRECTED SPT 'N'-VALUES VERSUS ELEVATION
Highway 400/89 Interchange, High Fill Embankments

FIGURE 1



Date: October 2018
Project No: 1668512

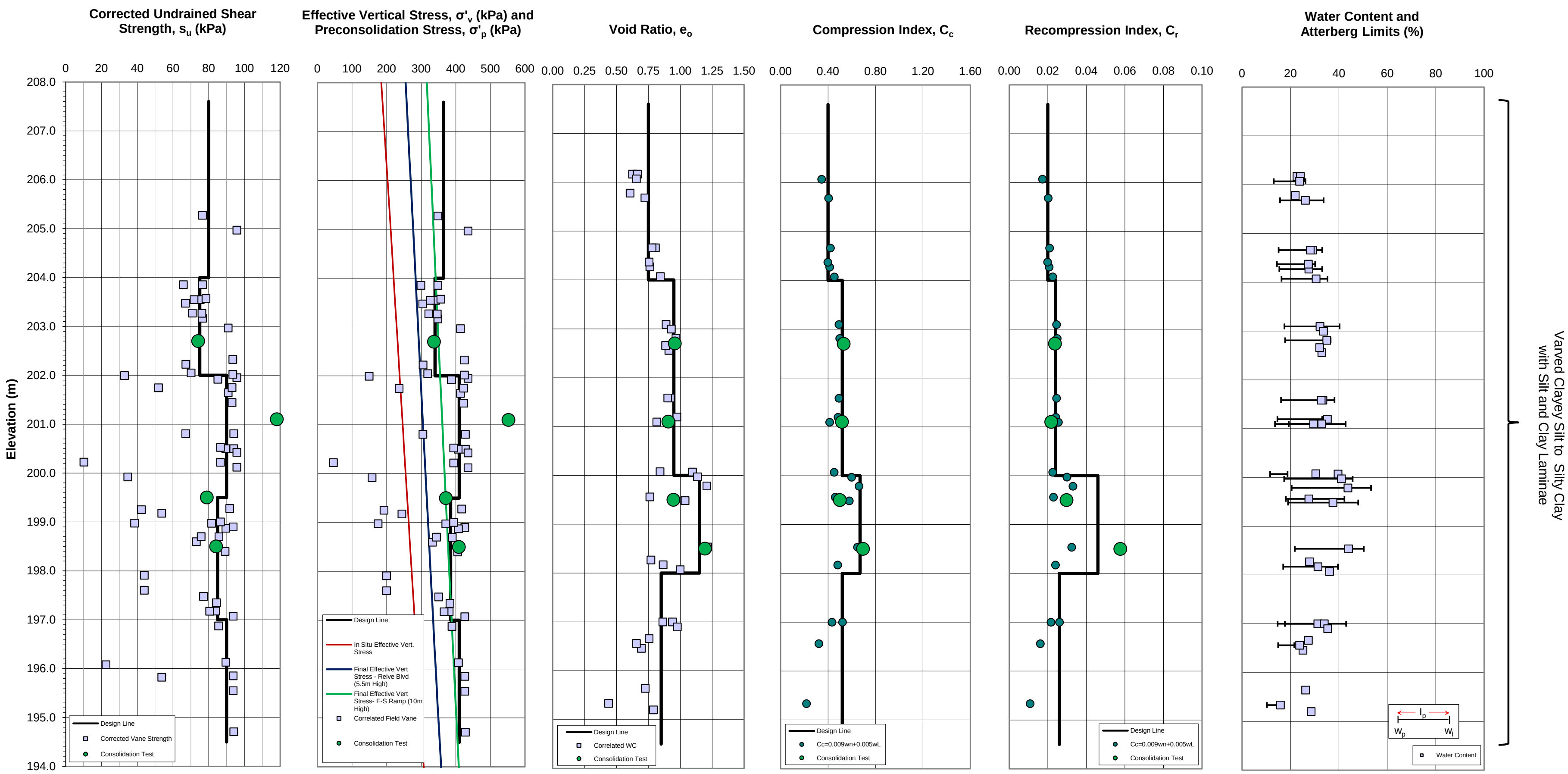
Prepared By: TZ
Checked By: LCC/JMAC

Golder Associates

Golder Associates Ltd.

SUMMARY PLOT OF ENGINEERING PARAMETERS FOR VARVED COHESIVE DEPOSITS
Highway 400/89 Interchange - High Fill Embankments

FIGURE 2



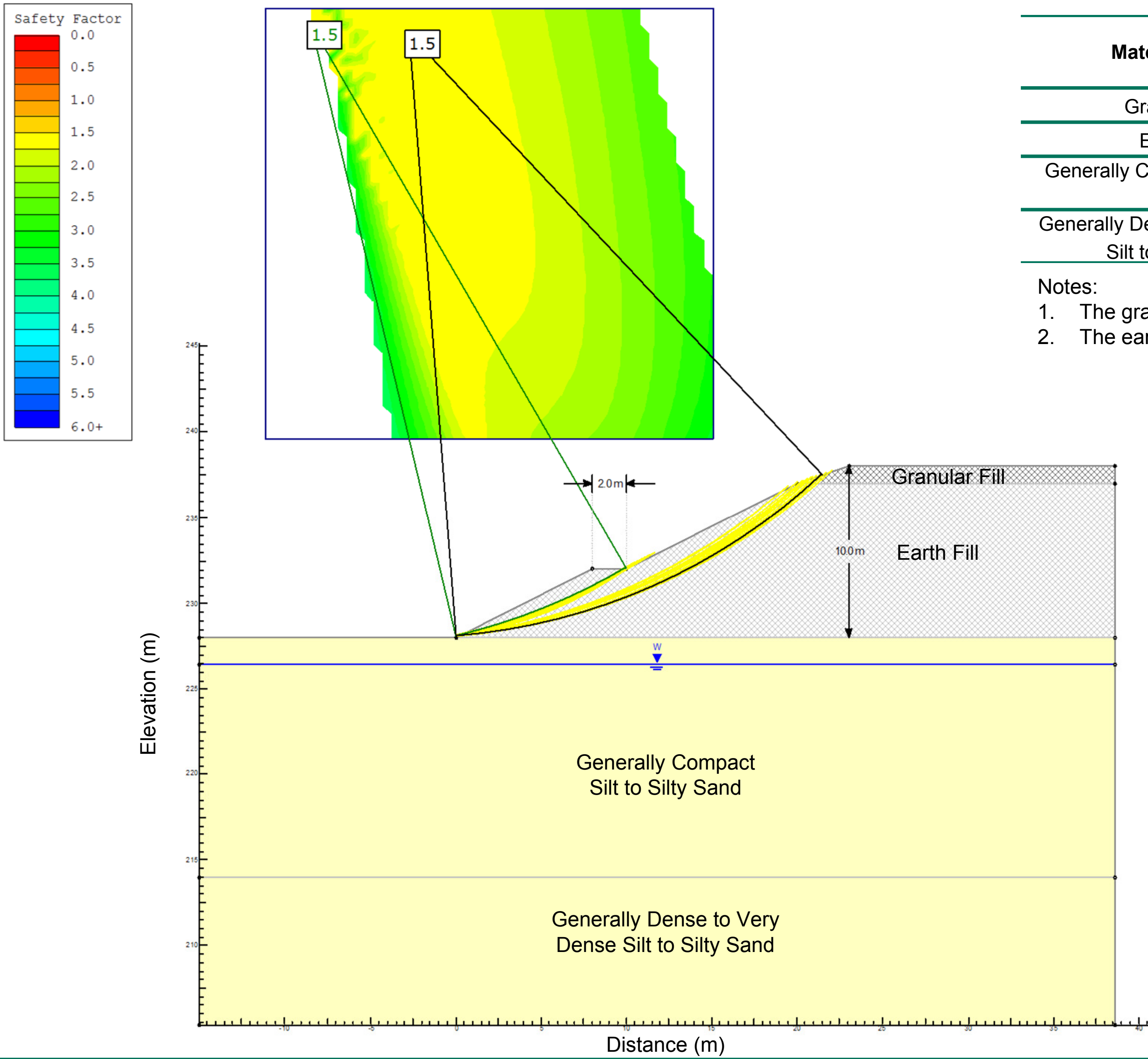
Date: September 2018
Project No: 1668512

Prepared By: TZ
Checked By: LCC/JMAC

Golder Associates Ltd.

Highway 400/89 Interchange Replacement – High Fill Areas
Global Slope Stability – Highway 89 and E-S Ramp
10 m High Embankment with 2m Wide Bench (Permanent Condition)

Figure 3



Material Name	ɣ (kN/m³)	s_u (kPa)	ϕ' (degrees)
Granular Fill	21	--	40
Earth Fill	20	--	32
Generally Compact Silt to Silty Sand	19	--	32
Generally Dense to Very Dense Silt to Silty Sand	19	--	36

Notes:
1. The granular fill slopes are constructed at 3H:1V.
2. The earth fill slopes are constructed at 2H:1V.

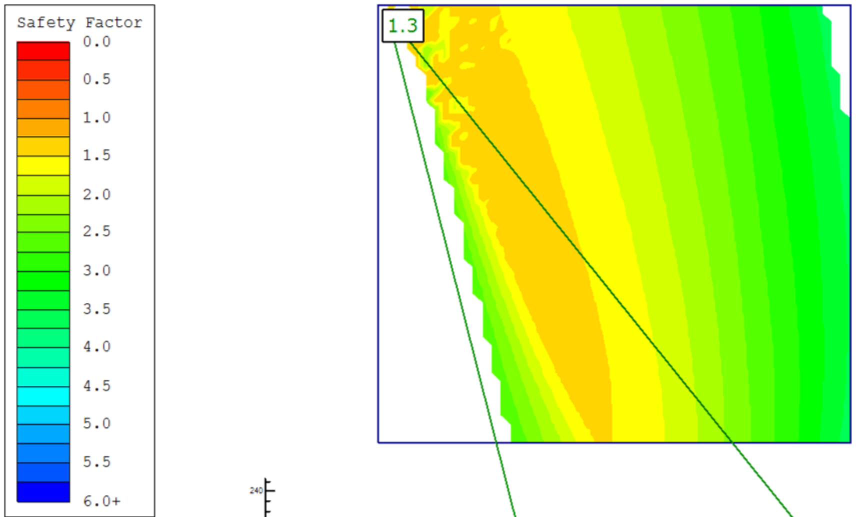
Date: November 2, 2018
Project No: 1668512

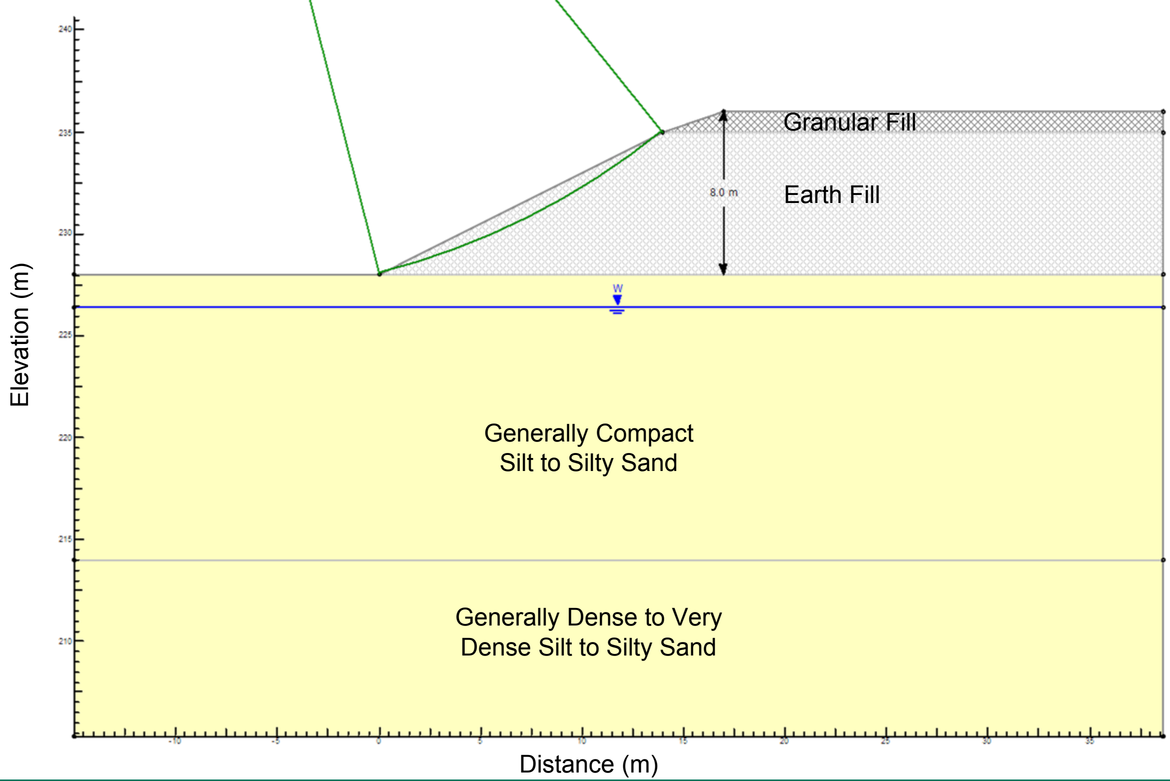
Analysis By: DM/TZ **Reviewed By:** SMM

Golder Associates

Highway 400/89 Interchange Replacement – High Fill Areas
Global Slope Stability – Highway 89 and E-S Ramp
8 m High Embankment (Permanent Condition)

Figure 4





Material Name	γ (kN/m³)	s_u (kPa)	ϕ' (degrees)
New Granular Fill	21	--	40
New Earth Fill	20	--	32
Generally Compact Silt to Silty Sand	19	--	32
Generally Dense to Very Dense Silt to Silty Sand	19	--	36

Notes:
1. The granular fill slopes are constructed at 3H:1V.
2. The earth fill slopes are constructed at 2H:1V.

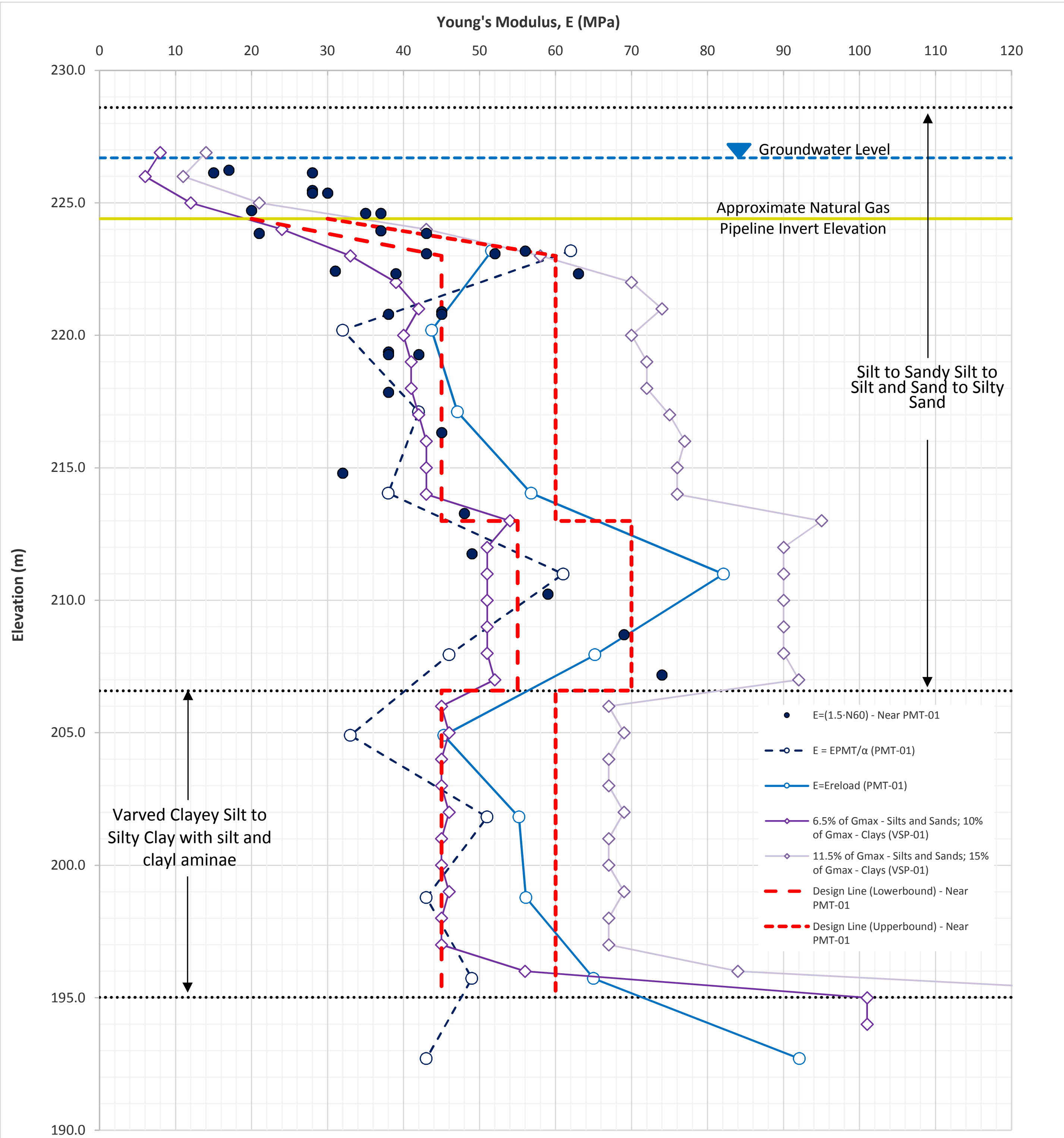
Date: November 2, 2018
Project No: 1668512

Analysis By: DM/TZ **Reviewed By:** SMM

Golder Associates

PRESSUREMETER (PMT) AND VERTICAL SEISMIC PROFILE (VSP) RESULTS: W-S RAMP
Highway 400/89 Interchange, High Fill Embankments

FIGURE 5



Date: October 2018
Project No: 1668512

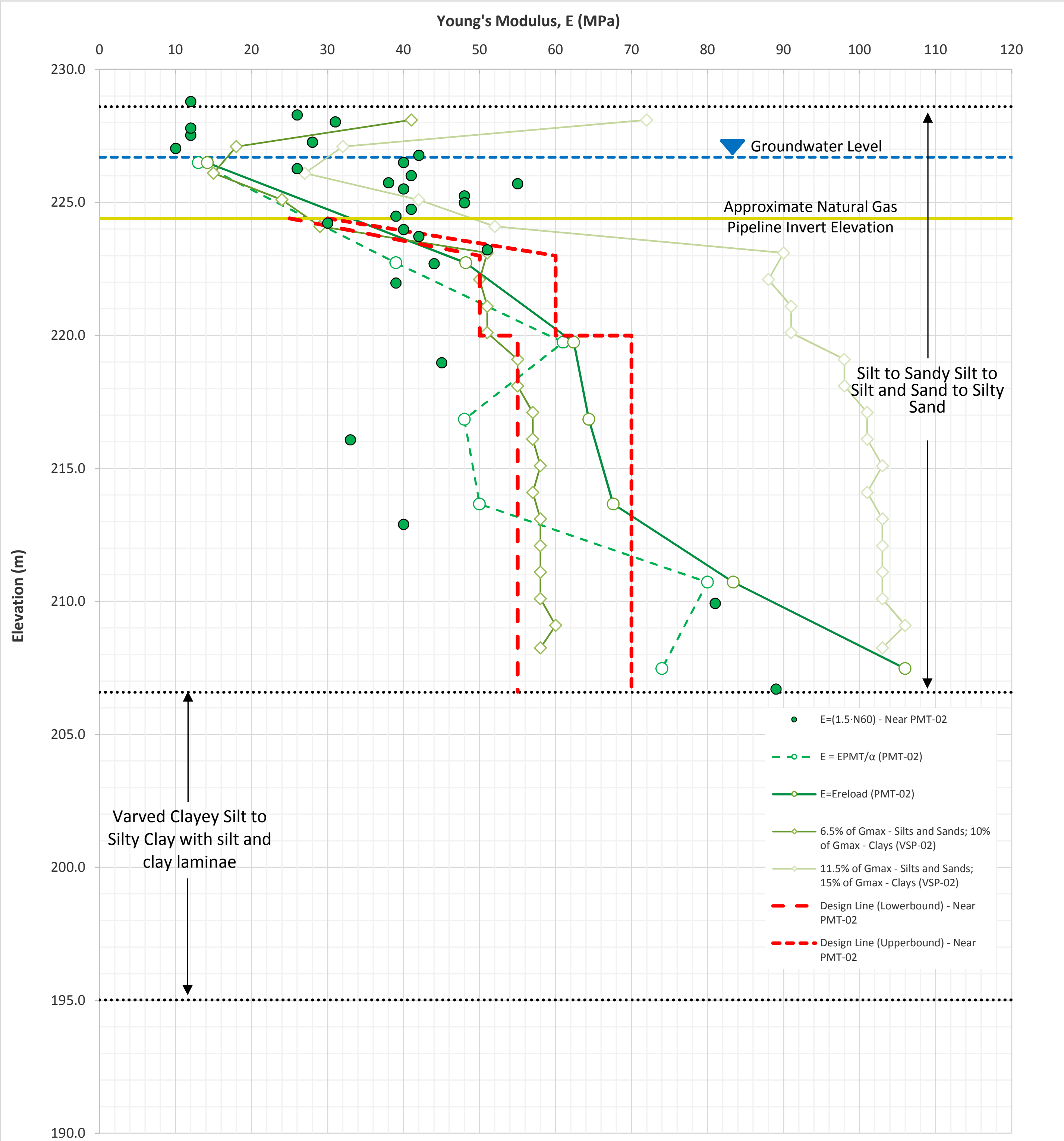
Prepared By: TZ
Checked By: LCC/JMAC

Golder Associates

Golder Associates Ltd.

PRESSUREMETER (PMT) AND VERTICAL SEISMIC PROFILE (VSP) RESULTS: W-N RAMP, E/W-N RAMP AND S-E/W RAMP
Highway 400/89 Interchange, High Fill Embankments

FIGURE 6



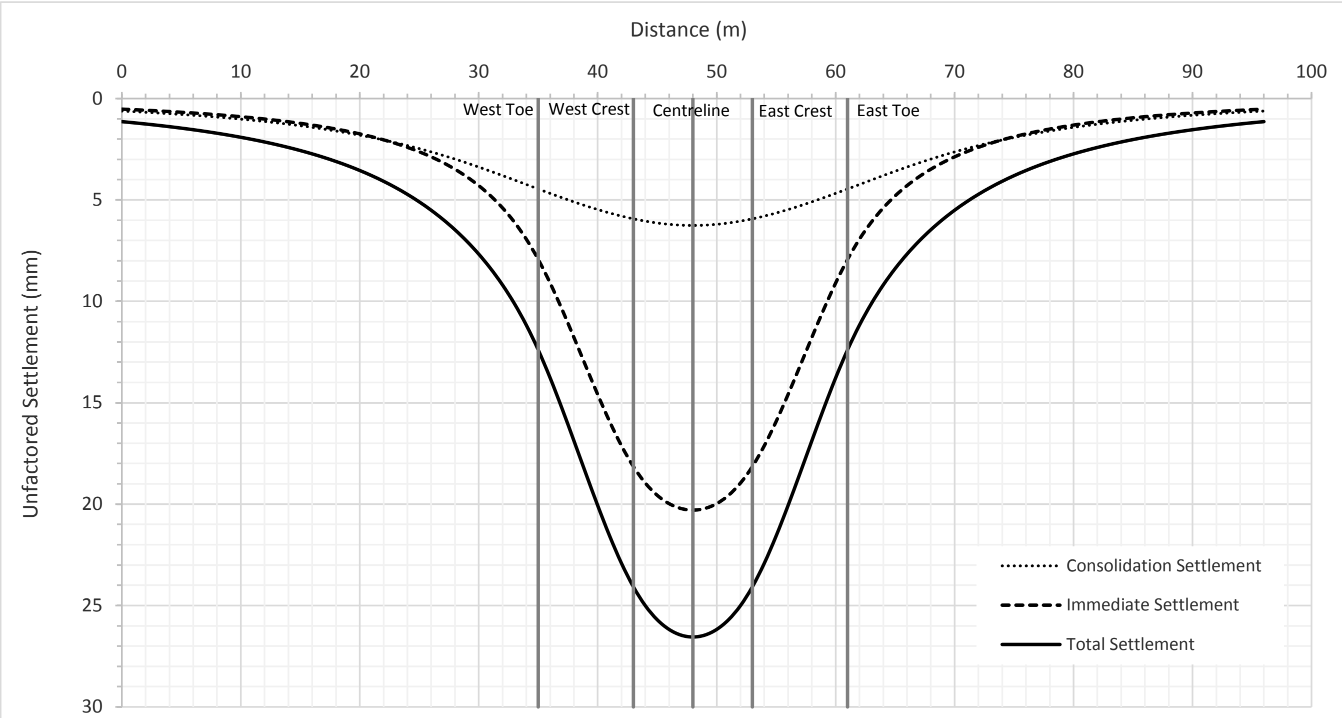
Date: October 2018
Project No: 1668512
Prepared By: TZ
Checked By: LCC/JMAC

Golder Associates Ltd.

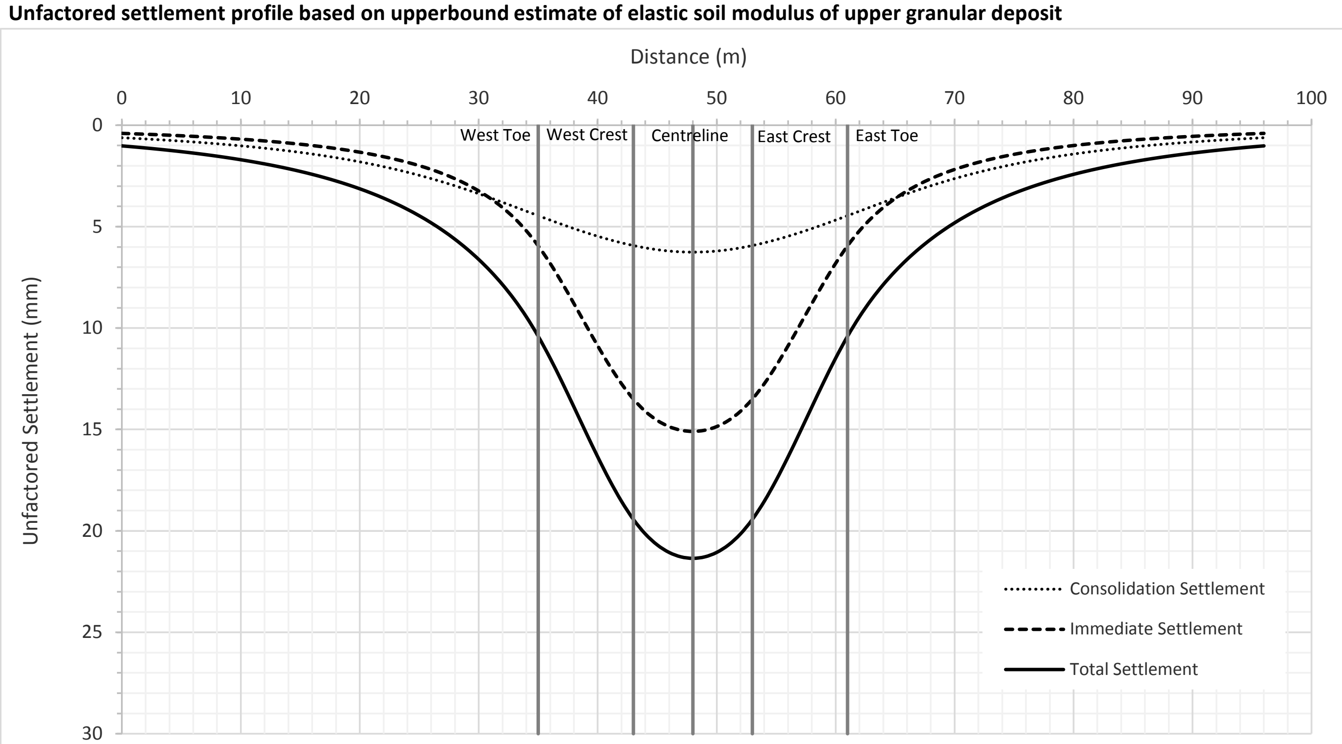
UNFACTORED SETTLEMENT PROFILE
GAS MAIN CROSSING AT W-S RAMP
Highway 400/89 Interchange, High Fill Embankments

FIGURE 7

Unfactored settlement profile based on lowerbound estimate of elastic soil modulus of upper granular deposit



Unfactored settlement profile based on upperbound estimate of elastic soil modulus of upper granular deposit



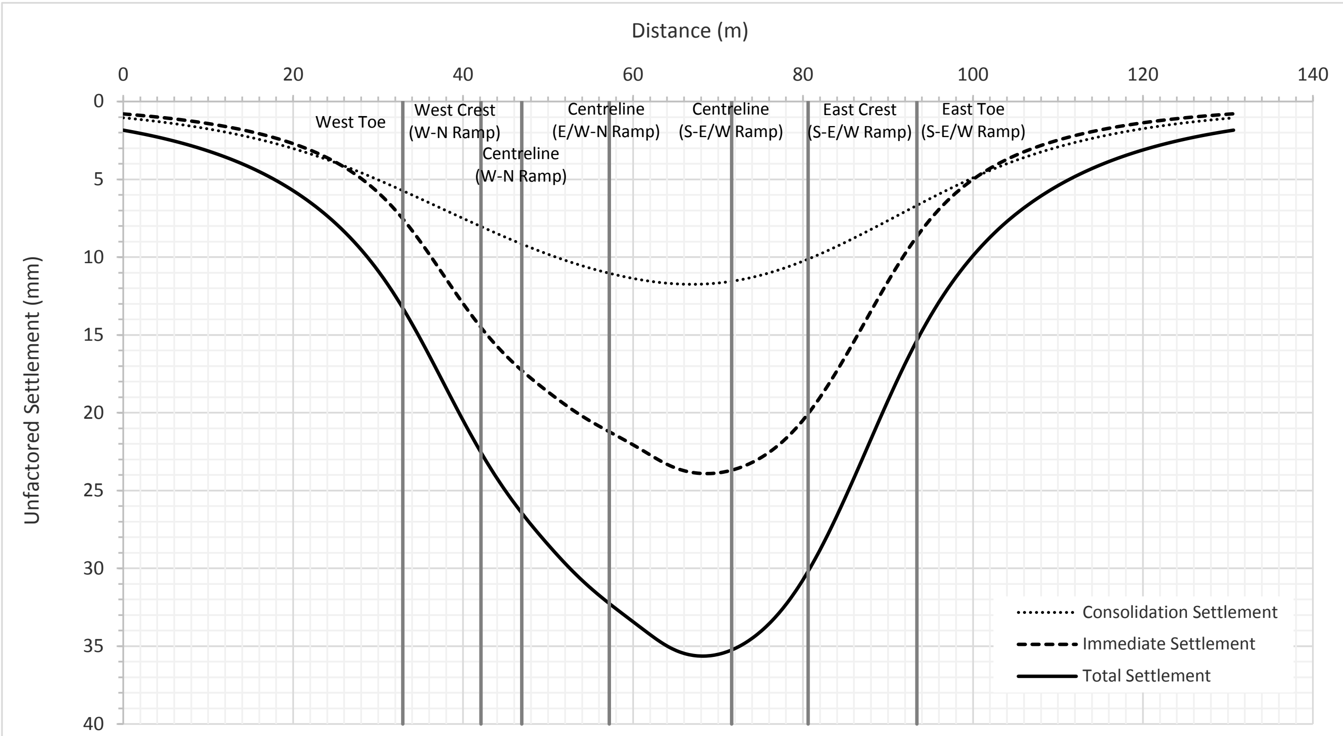
Date: October 2018
Project No: 1668512

Prepared By: TZ
Checked By: LCC

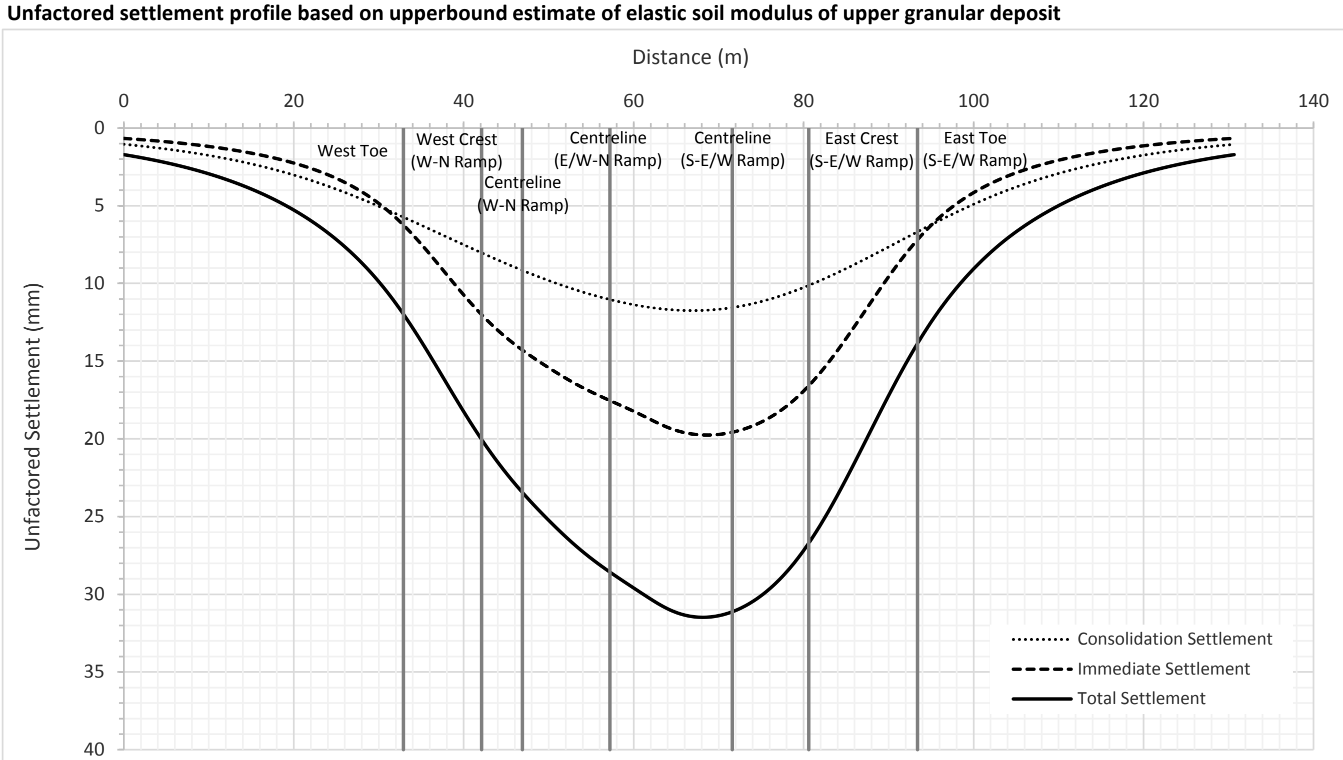
Golder Associates Ltd.

UNFACTORED SETTLEMENT PROFILE GAS MAIN CROSSING AT W-N RAMP, E/W-N RAMP AND S-E/W RAMP Highway 400/89 Interchange, High Fill Embankments	FIGURE 8

Unfactored settlement profile based on lowerbound estimate of elastic soil modulus of upper granular deposit



Unfactored settlement profile based on upperbound estimate of elastic soil modulus of upper granular deposit



Date: October 2018 **Prepared By:** TZ
Project No: 1668512 **Checked By:** LCC

Golder Associates

Golder Associates Ltd.

APPENDIX A

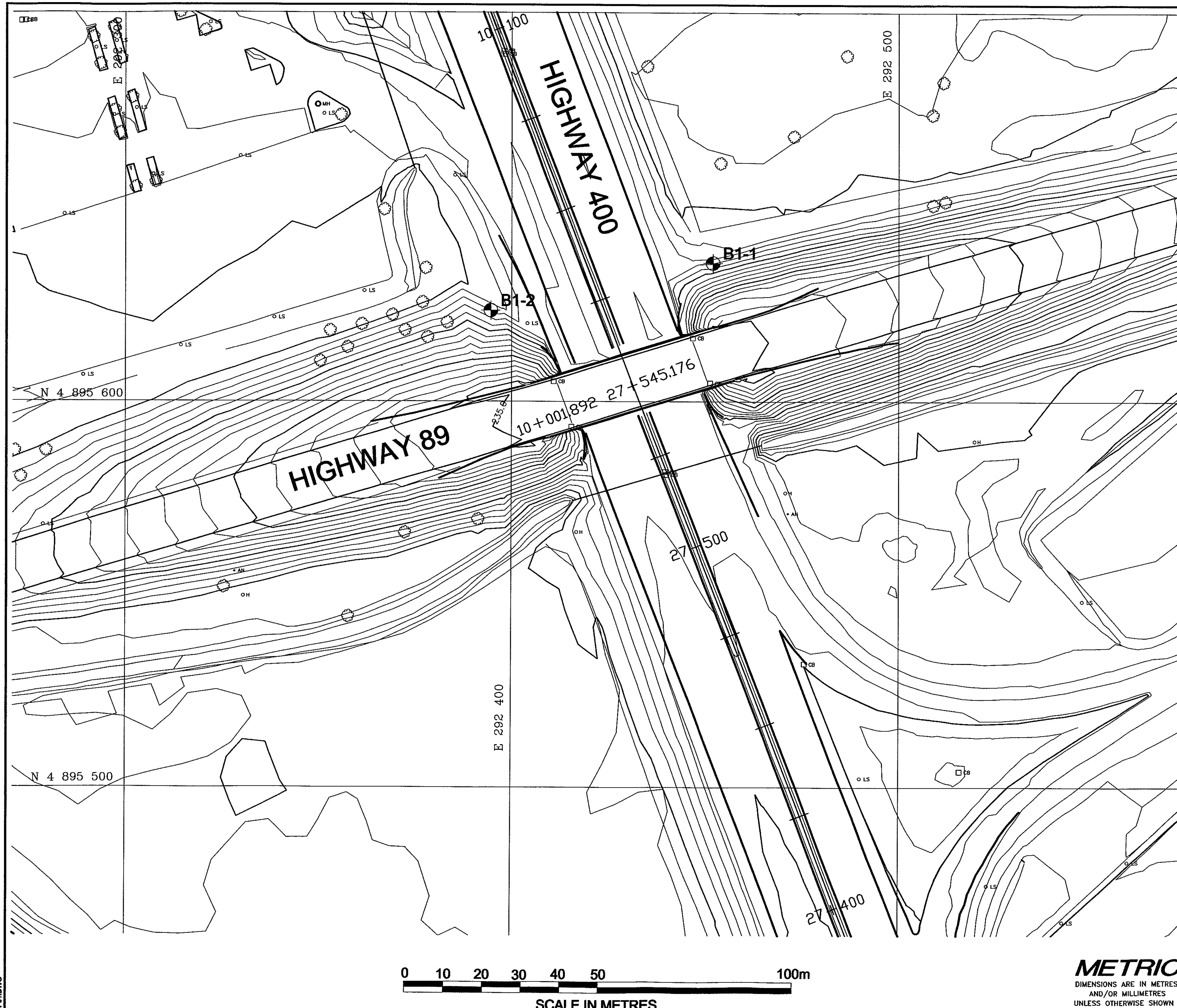
2002 Investigation – MTO GEOCRES No. 31D00-465

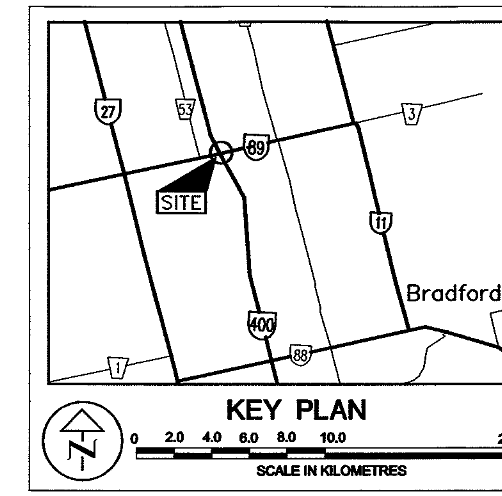
DIST	HWY 400
CONT. No.	
GWP No.	30-95-00

HIGHWAY 89 UNDERPASS
HWY 400
BOREHOLE LOCATION PLAN

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA





LEGEND

- Borehole, previous investigation
- Borehole, present investigation

No.	ELEVATION	LOCATION NORTHING	LOCATION EASTING
B1-1	228.9	4,895,635.8	292,452.1
B1-2	228.4	4,895,623.5	292,394.6

REFERENCE
This drawing was created from digital file "33811.dwg" provided by URS Cole Sherman

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

NO.	DATE	BY	REVISION

Geocres No.

HWY. No. 400		PROJECT NO.: 001-1143F	
SUBM'D. LCC	CHKD: ASP	DATE: JANUARY 2001	SITE 30-256
DRAWN: MHW	CHKD. LCC	APPD. ASP	DWG. 1

P1143F01.DWG

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No B1-1

METRIC

PROJECT 001-1143F			
W.P. 30-95-00	LOCATION N 4895635.8; E 292452.1		ORIGINATED BY PKS
DIST SW	HWY 400	BOREHOLE TYPE 108mm DIAMETER SOLID STEM AUGERS	COMPILED BY LCC
DATUM Geodetic	DATE Dec.14-18/2000		CHECKED BY ASP

Column headings: SOIL PROFILE (ELEV / DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

ELEV / DEPTH	DESCRIPTION
228.9	GROUND SURFACE
0.0	Silty Sand, trace to some gravel with pockets of clay (Fill) Loose to compact Moist Brown
227.7 1.2	Silty Sand to Sandy Silt, trace gravel, trace clay, containing silty clay layers Compact to dense Wet Brown to grey Becoming grey below 3.8m depth Increasing frequency of silty clay layers, 25mm to 100mm in thickness, below 10.7m depth.

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	8				
2	SS	20				
3	SS	13				
4	SS	39	0	55	43	2
5	SS	46				
6	SS	27				
7	SS	32	0	24	74	2
8	SS	27				
9	SS	30				
10	SS	37				
11	SS	33				
12	SS	34				
13	SS	22				

Elevation scale: 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215, 214

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No B1-1

METRIC

PROJECT 001-1143F
W.P. 30-95-00
LOCATION N 4895635.8; E 292452.1
ORIGINATED BY PKS
DIST SW HWY 400
BOREHOLE TYPE 108mm DIAMETER SOLID STEM AUGERS
COMPILED BY LCC
DATUM Geodetic
DATE Dec.14-18/2000
CHECKED BY ASP

— CONTINUED FROM PREVIOUS PAGE —

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NOTES (WATER CONTENT)
	Silty Sand to Sandy Silt, trace gravel, trace clay, containing silty clay layers Compact to dense Wet Brown to grey	14	SS	29	213	w ≈ 20%
		15	SS	38	210	
209.1 / 19.8	Silty Clay, trace sand Stiff to hard Wet Grey				209	
		16	SS	40	207	w_p ≈ 17, w ≈ 21, w_L ≈ 30
		17	SS	12	204	
200.9 / 28.0		18	SS	19	201	

Elevation scale: 213, 212, 211, 210, 209, 208, 207, 206, 205, 204, 203, 202, 201

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT w_p, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L
WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

END OF BOREHOLE

Notes:
1.Hole terminated due to tightening of soil around augers and resulting difficulties in advancing/withdrawing augers.
2.Water level in open borehole on December 15 and 18, 2000 at 2.7m depth (Elev.226.2m)

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No B1-2

METRIC

PROJECT	001-1143F		
W.P.	30-95-00	LOCATION	N 4895623.5; E 292394.6
DIST	SW	HWY	400
BOREHOLE TYPE	108mm ID HOLLOW STEM AUGERS AND CASING		
DATUM	Geodetic	DATE	Dec.14-18/2000
ORIGINATED BY	GPD	COMPILED BY	LCC
CHECKED BY	ASP		

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
228.4	GROUND SURFACE
0.0	Silty Sand, trace gravel, trace organics (Fill) Loose to compact Moist Brown
226.1 / 2.3	Silty Sand to Sandy Silt, trace clay Compact Wet Brown

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	14	
2	SS	8	
3	SS	13	
4	SS	23	0 71 29 0
5	SS	16	
6	SS	13	0 34 65 1
7	SS	21	
8	SS	19	
9	SS	18	
10	SS	21	
11	SS	19	
12	SS	14	

Chart column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (228 to 214); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X REMOULDED (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) (10 20 30); UNIT WEIGHT γ kN/m^3

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

O $^{3\%}$ STRAIN AT FAILURE

ON_MOT 0011143F.GPJ ON_MOT.GDT 14/1/02

Ministry of Transportation Ontario

RECORD OF BOREHOLE No B1-2

METRIC

PROJECT 001-1143F

W.P. 30-95-00 LOCATION N 4895623.5; E 292394.6 ORIGINATED BY GPD

DIST SW HWY 400 BOREHOLE TYPE 108mm ID HOLLOW STEM AUGERS AND CASING COMPILED BY LCC

DATUM Geodetic DATE Dec.14-18/2000 CHECKED BY ASP

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH / DCPT	WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty Sand to Sandy Silt, trace clay Compact Wet Brown	13	SS	13	213				
					212				
					211				
		14	SS	21	210		w ≈ 21		
					209				
					208				
		15	SS	18	207				
206.6 21.8	Silty Clay, trace sand Firm to very stiff Moist Grey				206				
					205				
		16	SS	18	204		w_P ≈ 19, w ≈ 29, w_L = 43		
					203				
		17	SS	8	202				
					201	× ≈ 20, + ≈ 78			
		18	SS	6	200	× ≈ 20, + ≈ 90			
					199				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No B1-2

METRIC

PROJECT 001-1143F
W.P. 30-95-00
DIST SW HWY 400
DATUM Geodetic
LOCATION N 4895623.5; E 292394.6
BOREHOLE TYPE 108mm ID HOLLOW STEM AUGERS AND CASING
DATE Dec.14-18/2000
ORIGINATED BY GPD
COMPILED BY LCC
CHECKED BY ASP

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X REMOULDED — 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

— CONTINUED FROM PREVIOUS PAGE —

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	Silty Clay, trace sand Firm to very stiff Moist Grey	19	SS	9	198, 197, 196, 195
194.9 33.5	Silty Sand containing silty clay layers Very dense Wet Grey	20	SS	52	194, 193, 192
		21	SS	72	
191.4 37.0	END OF BOREHOLE				

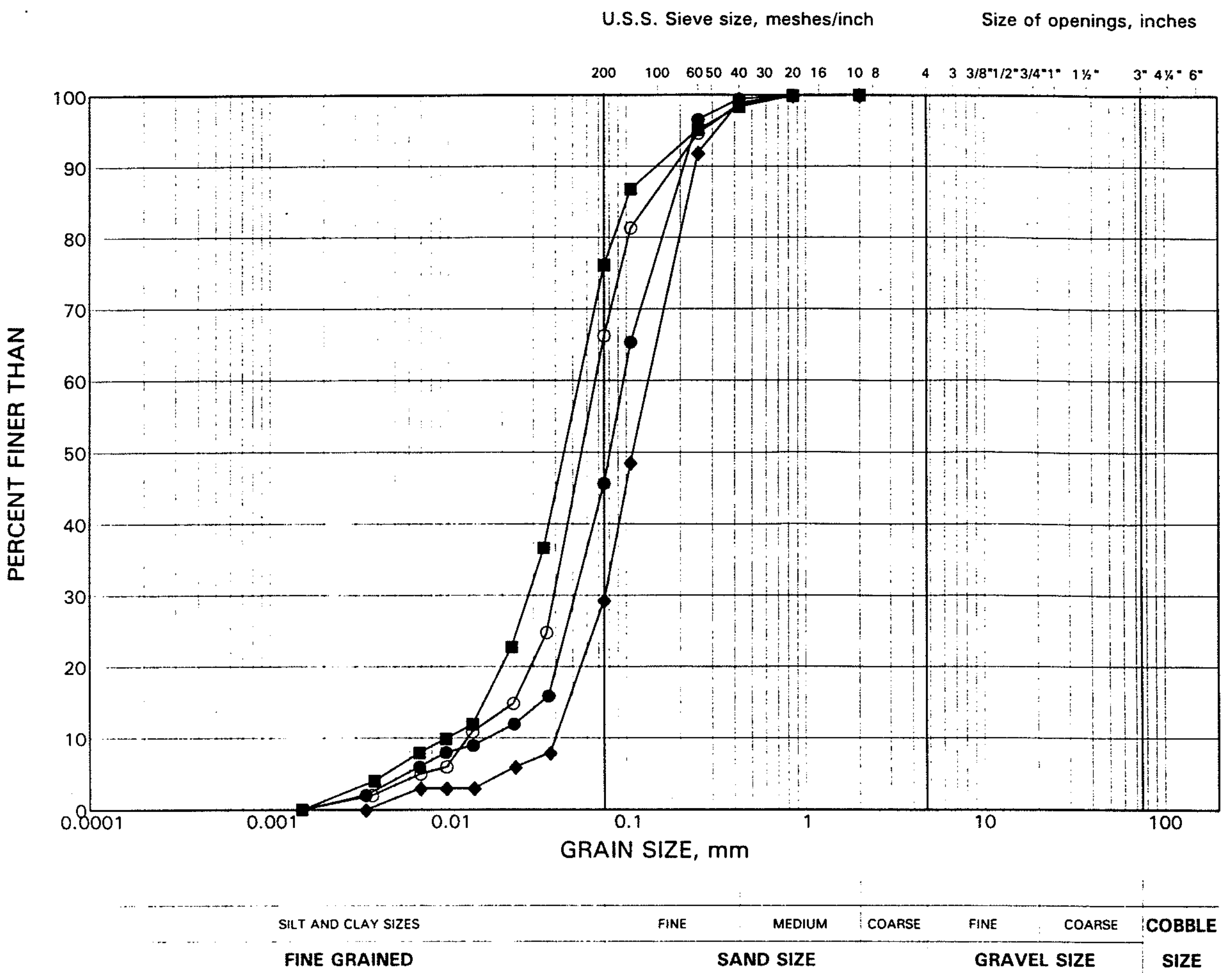
Notes:
1. Water level in open borehole at 2.3m depth (Elev.226.1m) on completion of drilling operations.
2. Water level in piezometer at 1.8m depth (Elev.226.6m) on January 19, 2001, and at 1.3m depth (Elev.227.1m) on March 15, 2001.

$+^3, \times^3$: Numbers refer to Sensitivity
$O^{3\%}$ STRAIN AT FAILURE

ON_MOT 0011143F.GPJ ON_MOT.GDT 14/1/02

GRAIN SIZE DISTRIBUTION TEST RESULTS
Silty Sand to Sandy Silt Deposit

FIGURE 1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	B1-1	4	226.3
■	B1-1	7	224.0
◆	B1-2	4	225.0
○	B1-2	6	223.5

Golder Associates

APPENDIX B

Pressuremeter Test Results

In-Depth
Geotechnical Inc.

In-Situ Pressuremeter Testing **Project No. IDG 180411**

HWY 400 and HWY 89, Innisfil, Ontario

Boring Nos. 01-PMT and 02-PMT

February 3, 2018

Prepared for:

Mr. David Marmor, E.I.T.

Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
L5N 7K2

In-Depth Geotechnical Inc.

20 Ravenscliffe Avenue
Hamilton, Ontario
L8P 3M4
Phone: (905) 541 9937
Fax: (877) 624 0140

Table of Contents

1. Introduction

In-Depth Geotechnical Inc. was retained by Golder Associates Ltd. (Golder) to conduct Pressuremeter testing in relation to their Geotechnical Investigation at the HWY 400 and HWY 89 site, in Innisfil, Ontario.

This report presents the results of pressuremeter testing (PMT) carried out at two borehole locations with the purpose of evaluating specific parameters related to a) shear strength; and b) deformation properties of the encountered soils.

This report includes data obtained by use of a pre-bored pressuremeter system. Inferred characteristics of the data are also presented including initial contact pressure, limit pressure, secant deformation modulus values during loading, unloading and reloading cycles, and yield pressure if and when justified by the data. Multiple methods are available for interpretation of this data to estimate engineering properties of soils but such methods are not discussed or included in this report except for the characteristics of the data plots as described above.

2. Field Testing Procedures

Pressuremeter testing was performed at two borehole locations, as indicated on site by Golder representatives, namely, Boring Nos. 01-PMT and 02-PMT.

Drilling procedures were undertaken by Walker Drilling Contractor. The boreholes were advanced using mud rotary drilling technique with a rubber track-mounted Diedrich D50 drill rig.

Field work was completed between January 24 and 25, 2018 for BH 01-PMT and between January 29 and 30, 2018 for BH 02-PMT. Details of maximum depth of testing and number of PMT tests completed per borehole are:

	Maximum Depth *[m]*	Number PMT tests	Ground Elevation *[m]*
Borehole No. BH 01-PMT	34.60	11	100.00 assumed
Borehole No. BH 02-PMT	21.50	7	100.00 assumed

The test sections of the boring were drilled with a tricone bit, with a nominal diameter of 3 $^{1}/_{16}$ inch. The bit was advanced using continuous circulation of drilling mud to flush soil cuttings, producing a controlled diameter hole for the pressuremeter probe. A positive water head was kept inside the surface casing throughout drilling and in-situ testing procedures. In general, the drilling fluid remained at the top of casing.

Pre-boring pressuremeter testing was completed using a TEXAM unit. The testing procedure was in general accordance with Procedure B, volume-controlled loading, as outlined in the ASTM D 4719-00 Standard Test Method for Pre-bored Pressuremeter Testing of Soils. The testing equipment was calibrated for pressure and volume losses as indicated in the above mentioned standard. The Record of Calibration for the PMT probe utilized in this job is attached on Appendix Three. The control unit was de-aired prior to every test. Also, checks were completed to ensure that the probe, tubing, and control unit assembly were fully saturated, and that the probe membrane was leakage-free at high pressures. Two readings were taken for each volume step, namely for time delays of 15 and 30 seconds. One unload-reload cycle was performed on each PMT test.

3. Pressuremeter Test Results

Details for each pressuremeter test results are presented in Appendix One. Summaries of pressuremeter test results for each boring are illustrated in Table Nos. 1 and 2 below.

A general guideline to interpret and infer soil properties based on available PMT test data is attached to Appendix Two. This guideline suggests accepted current procedures to estimate or infer shear strength, deformation properties, and other related soil parameters.

Undrained shear strength values for cohesive soils can be inferred using the method suggested in Appendix B. Likewise, for cohesionless soils, approximated values of the friction angles can be correlated to the estimated values of the net limit pressure whenever available. See Figure 6-86 in page Appendix Two - 5.

Based on pressuremeter test data, we have included subsoil profiles for the tested borings, plotting the distributions of the interpreted PMT parameters with depth. These profiles are included in Drawings listed in the following pages, and, as mentioned above, summarized in Table Nos. 1 and 2.

Inferred values of the Young's Modulus are included in Table No. 1. These values were inferred with the Menard's α Rheological Parameter, in accordance with the procedure suggested by Baud and Gambin using the Pressiorama Chart. This Pressiorama Chart is included in Appendix Two.

Table No. 1

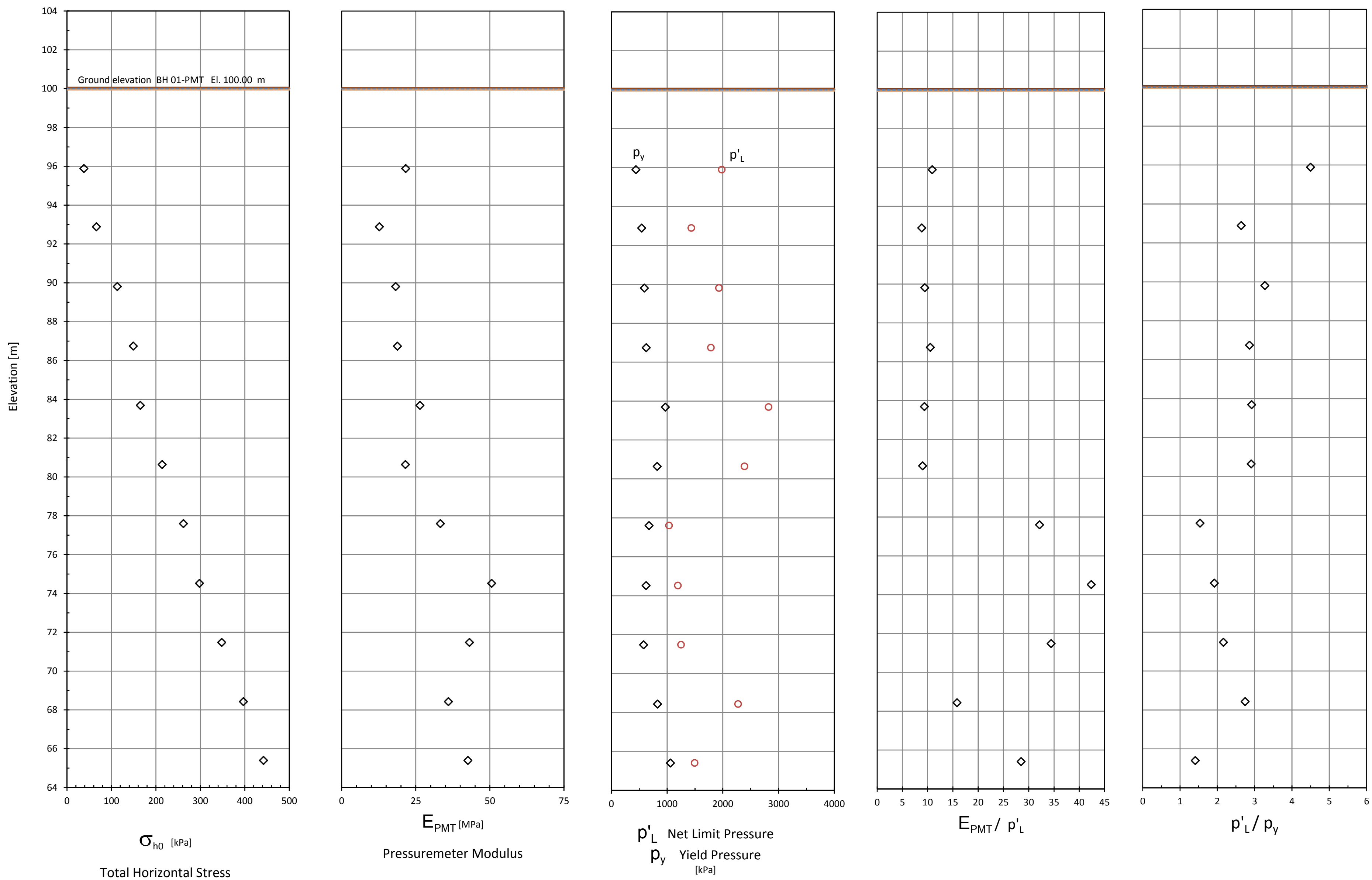
Summary of Pressuremeter Test Results									Boring No.:		BH 01-PMT	
Test No.	Depth [m]	Elevation [m]	p_0 [kPa]	E_{PMT} [MPa]	$E_{Unload\ 1}$ [MPa]	$E_{Reload\ 1}$ [MPa]	p_y [kPa]	p^*_L [kPa]	E_{PMT} / p^*_L	p^*_L / p_y	α Menard's Parameter	E_{Young} [MPa]
1	4.11	95.89	38	21.6	84.5	51.6	441	1983	10.9	4.5	0.35	62
2	7.11	92.89	66	12.7	68.0	43.7	544	1436	8.8	2.6	0.39	32
3	10.19	89.81	113	18.2	81.6	47.1	590	1932	9.4	3.3	0.43	42
4	13.26	86.74	149	18.8	87.2	56.8	625	1788	10.5	2.9	0.50	38
5	16.31	83.69	165	26.4	141.1	82.1	967	2821	9.4	2.9	0.43	61
6	19.36	80.64	214	21.5	109.5	65.2	822	2389	9.0	2.9	0.47	46
7	22.40	77.60	262	33.3	81.2	45.3	675	1036	32.1	1.5	1.00	33
8	25.48	74.52	298	50.6	94.5	55.2	622	1194	42.4	1.9	1.00	51
9	28.52	71.48	348	43.1	75.7	56.1	579	1252	34.4	2.2	1.00	43
10	31.57	68.43	397	36.0	105.4	65.0	829	2276	15.8	2.7	0.73	49
11	34.60	65.40	442	42.6	153.2	92.1	1060	1495	28.5	1.4	1.00	43

1. E_{PMT} is the Pressuremeter modulus, indicated also as E_0 in the Pressuremeter Test Reports
2. Surface elevation at El. 100.00 [m]
3. Groundwater elevation at El. n/a [m]

Table No. 2

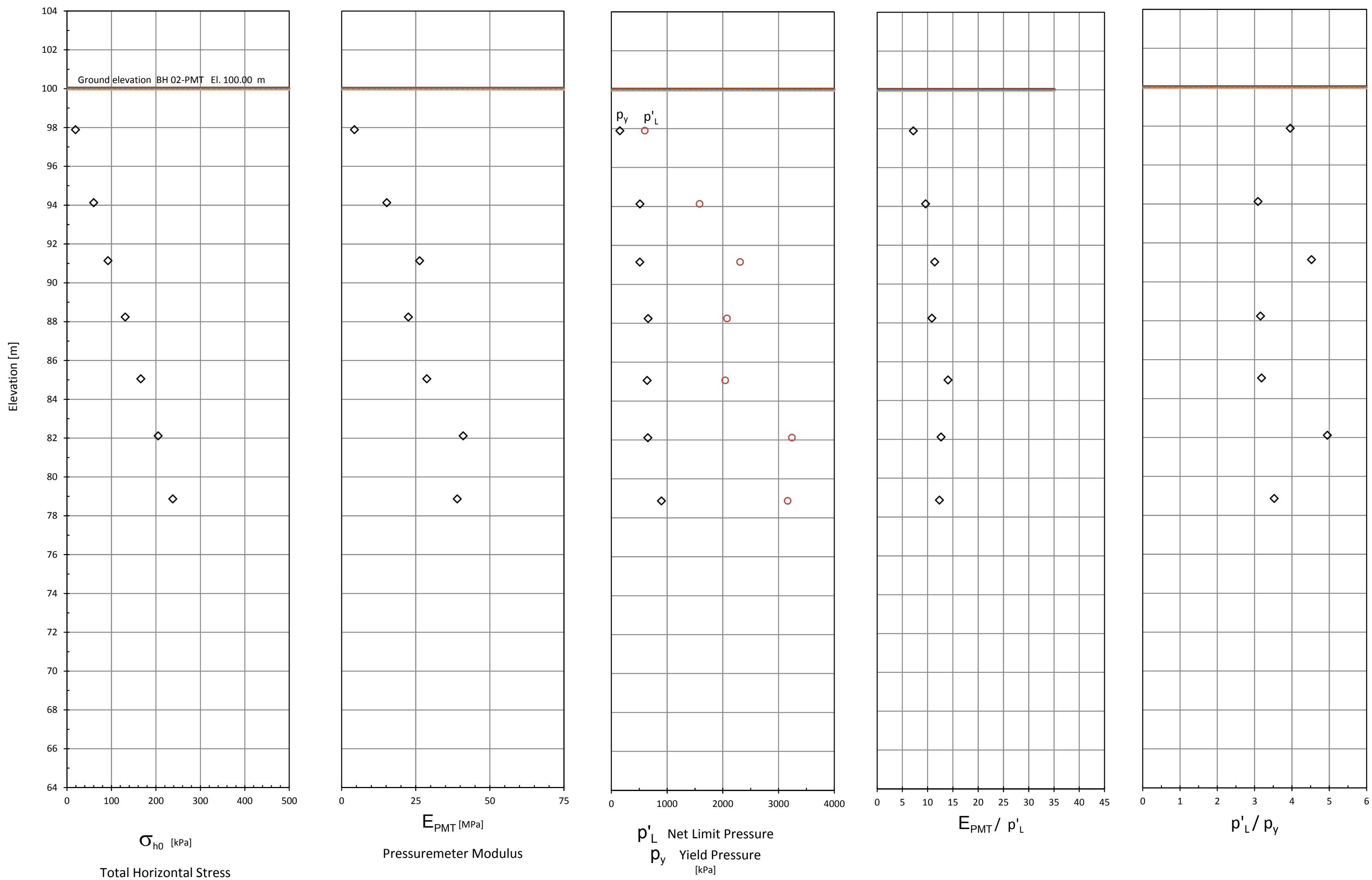
Summary of Pressuremeter Test Results								Boring No.:		BH 02-PMT	
Test No.	Depth [m]	Elevation [m]	p_0 [kPa]	E_{PMT} [MPa]	$E_{Unload\ 1}$ [MPa]	$E_{Reload\ 1}$ [MPa]	p_y [kPa]	p^*_L [kPa]	E_{PMT} / p^*_L	p^*_L / p_y	α Menard's Parameter	E_{Young} [MPa]
1	2.11	97.89	19	4.3	19.9	14.2	152	601	7.2	4.0	0.32	13
2	5.87	94.13	60	15.2	69.8	48.2	513	1585	9.6	3.1	0.39	39
3	8.86	91.14	92	26.3	87.9	62.4	511	2311	11.4	4.5	0.43	61
4	11.76	88.24	131	22.5	97.9	64.4	658	2077	10.8	3.2	0.47	48
5	14.94	85.06	166	28.7	104.8	67.6	642	2045	14.0	3.2	0.57	50
6	17.88	82.12	205	41.0	122.9	83.4	655	3241	12.7	4.9	0.51	80
7	21.13	78.87	238	39.0	149.5	106.0	898	3165	12.3	3.5	0.53	74

1. E_{PMT} is the Pressuremeter modulus, indicated also as E_0 in the Pressuremeter Test Reports
2. Surface elevation at El. 100.00 [m]
3. Groundwater elevation at El. n/a [m]



HWY 400 and HWY 89, Innisfil, Ontario	**Boring No.: BH 01-PMT**
Pressuremeter Test Results	
Date: February 3, 2018	Project No.: IDG 180411

In-Depth Geotechnical Inc.



HWY 400 and HWY 89, Innisfil, Ontario	**Boring No.: BH 02-PMT**	In-Depth Geotechnical Inc.
Pressuremeter Test Results		
Date: February 3, 2018	Project No.: IDG 180411	

4. Closure

The subsoils data presented in this report is based on in-situ PMT testing and interpretation procedures. It should be noted that soil conditions may vary within the site and interpreted data may not be entirely representative of conditions at locations away from the tested borings. Therefore care should be exercised when extrapolating or inferring subsoil conditions away from the borehole location.

We trust that the present report fulfill your requirements. Should you have any question, please feel free to contact the undersigned.

Sincerely,

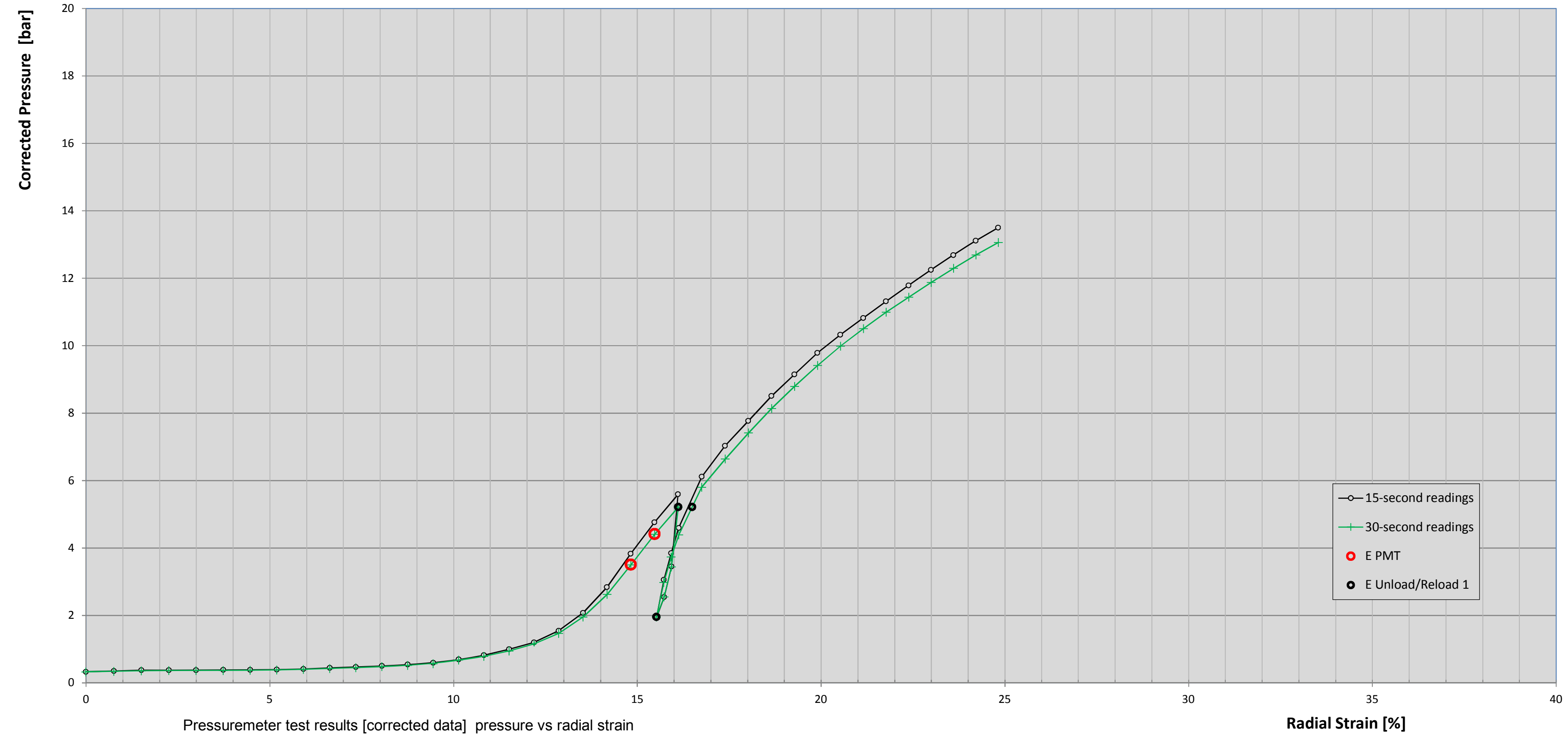
In-Depth Geotechnical Inc.

Gabriel Sedran, P.Eng., Ph.D.
President

Appendix One

Pressuremeter Results - Data

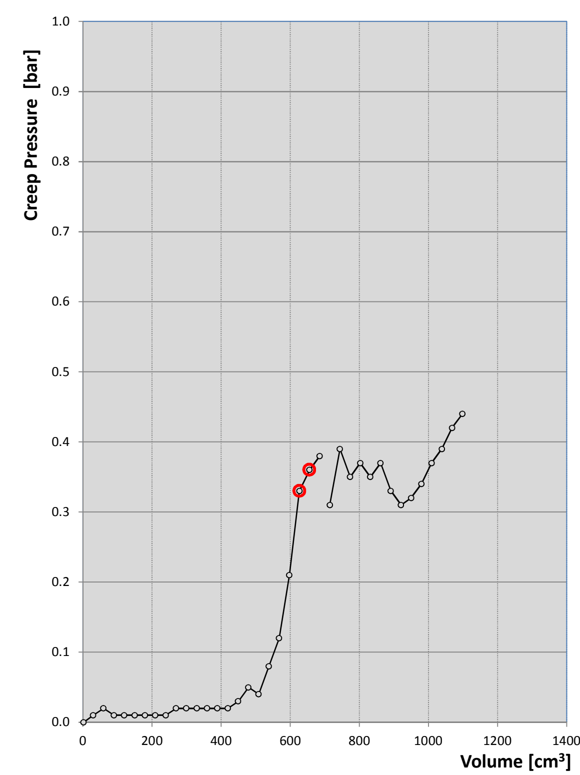
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	Δr/r₀ [%]	Pressure [bar]	Volume [cm³]	Δr/r₀ [%]	Volume [cm³]	Δp 30-15 [bar]	Pressure [bar]	1 / V
2	0.10	0.10	0.33	2	0.00	0.33	2	0.00	2	0.00	0.33	0.52352
30	0.15	0.14	0.36	29.9	0.76	0.35	29.9	0.76	29.9	0.01	0.35	0.03347
60	0.20	0.18	0.38	59.8	1.51	0.36	59.8	1.51	59.8	0.02	0.36	0.01671
90	0.23	0.22	0.38	89.8	2.26	0.37	89.8	2.26	89.8	0.01	0.37	0.01114
120	0.25	0.24	0.38	119.8	3.00	0.37	119.8	3.00	119.8	0.01	0.37	0.00835
150	0.28	0.27	0.38	149.7	3.74	0.37	149.8	3.74	149.8	0.01	0.37	0.00668
180	0.31	0.30	0.39	179.7	4.47	0.38	179.7	4.47	179.7	0.01	0.38	0.00556
210	0.34	0.33	0.40	209.7	5.19	0.39	209.7	5.19	209.7	0.01	0.39	0.00477
240	0.37	0.36	0.41	239.7	5.92	0.40	239.7	5.92	239.7	0.01	0.40	0.00417
270	0.42	0.40	0.45	269.6	6.63	0.43	269.6	6.63	269.6	0.02	0.43	0.00371
300	0.46	0.44	0.47	299.6	7.34	0.45	299.6	7.34	299.6	0.02	0.45	0.00334
330	0.50	0.48	0.50	329.6	8.05	0.48	329.6	8.05	329.6	0.02	0.48	0.00303
360	0.55	0.53	0.54	359.5	8.75	0.52	359.5	8.75	359.5	0.02	0.52	0.00278
390	0.61	0.59	0.60	389.5	9.45	0.58	389.5	9.45	389.5	0.02	0.58	0.00257
420	0.72	0.70	0.70	419.4	10.14	0.68	419.4	10.14	419.4	0.02	0.68	0.00238
450	0.85	0.82	0.82	449.2	10.83	0.79	449.3	10.83	449.3	0.03	0.79	0.00223
480	1.03	0.98	1.00	479.1	11.51	0.95	479.1	11.51	479.1	0.05	0.95	0.00209
510	1.24	1.20	1.20	508.9	12.19	1.16	508.9	12.19	508.9	0.04	1.16	0.00196
540	1.59	1.51	1.55	538.6	12.86	1.47	538.6	12.86	538.6	0.08	1.47	0.00186
570	2.12	2.00	2.08	568.1	13.52	1.96	568.2	13.52	568.2	0.12	1.96	0.00176
600	2.89	2.68	2.84	597.4	14.18	2.63	597.6	14.18	597.6	0.21	2.63	0.00167
630	3.88	3.55	3.83	626.5	14.82	3.50	626.8	14.83	626.8	0.33	3.50	0.00160
660	4.82	4.46	4.77	655.7	15.46	4.41	656.0	15.47	656.0	0.36	4.41	0.00152
690	5.65	5.27	5.59	684.9	16.11	5.21	685.3	16.11	685.3	0.38	5.21	0.00146
680	3.51	3.50	3.45	676.8	15.93	3.44	676.9	15.93			3.44	0.00148
670	2.60	2.61	2.55	667.7	15.73	2.56	667.7	15.73			2.56	0.00150
660	1.99	2.01	1.94	658.2	15.52	1.96	658.2	15.52			1.96	0.00152
670	3.11	3.04	3.06	667.2	15.72	2.99	667.3	15.72			2.99	0.00150
680	3.90	3.79	3.84	676.5	15.92	3.73	676.6	15.92			3.73	0.00148
690	4.65	4.45	4.59	685.8	16.13	4.39	686.0	16.13			4.39	0.00146
720	6.18	5.87	6.12	714.4	16.75	5.81	714.7	16.76	714.7	0.31	5.81	0.00140
750	7.10	6.71	7.03	743.6	17.38	6.64	744.0	17.39	744.0	0.39	6.64	0.00134
780	7.84	7.49	7.77	773.0	18.02	7.42	773.3	18.02	773.3	0.35	7.42	0.00129
810	8.59	8.22	8.51	802.3	18.65	8.14	802.6	18.65	802.6	0.37	8.14	0.00125
840	9.23	8.88	9.15	831.7	19.28	8.80	832.0	19.28	832.0	0.35	8.80	0.00120
870	9.87	9.50	9.79	861.1	19.90	9.42	861.5	19.91	861.5	0.37	9.42	0.00116
900	10.41	10.08	10.32	890.6	20.53	9.99	890.9	20.53	890.9	0.33	9.99	0.00112
930	10.91	10.60	10.82	920.2	21.15	10.51	920.5	21.15	920.5	0.31	10.51	0.00109
960	11.41	11.09	11.32	949.7	21.76	11.00	950.0	21.77	950.0	0.32	11.00	0.00105
990	11.88	11.54	11.78	979.3	22.38	11.44	979.6	22.39	979.6	0.34	11.44	0.00102
1020	12.35	11.98	12.25	1008.9	22.99	11.88	1009.2	23.00	1009.2	0.37	11.88	0.00099
1050	12.79	12.40	12.69	1038.5	23.60	12.30	1038.9	23.61	1038.9	0.39	12.30	0.00096
1080	13.22	12.80	13.11	1068.1	24.21	12.69	1068.5	24.22	1068.5	0.42	12.69	0.00094
1110	13.61	13.17	13.50	1097.8	24.82	13.06	1098.2	24.82	1098.2	0.44	13.06	0.00091



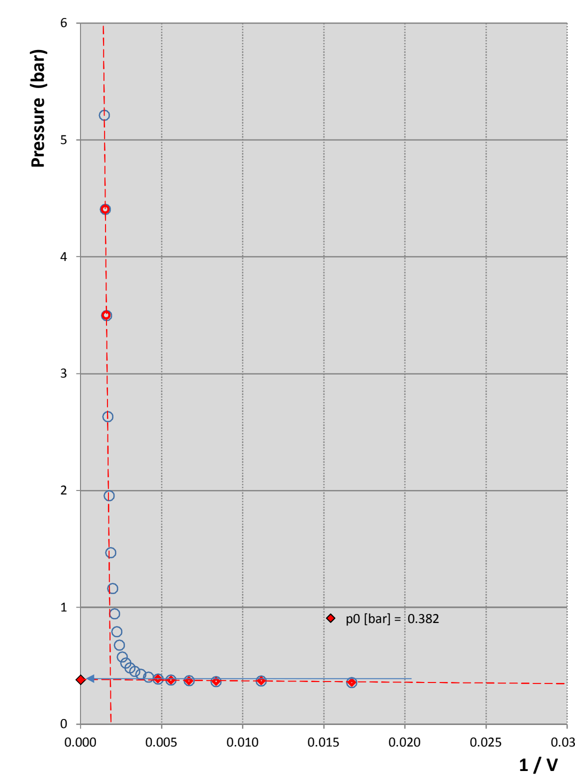
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

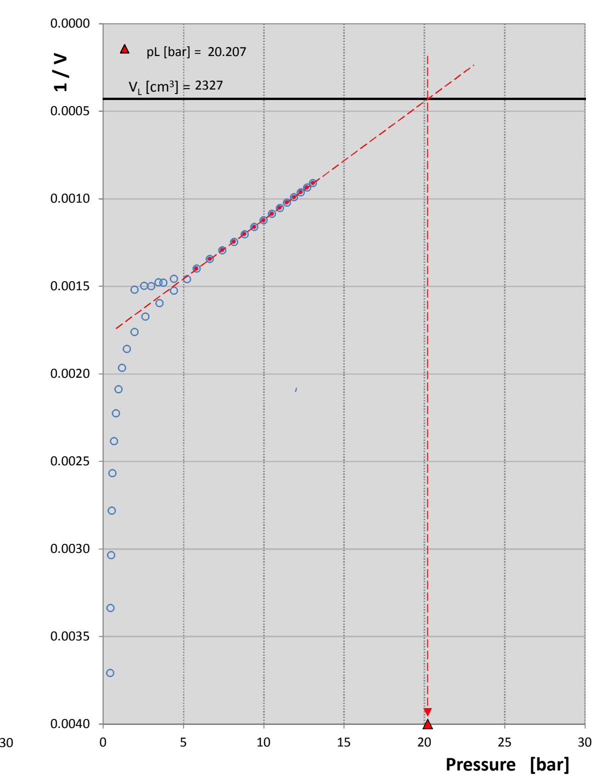
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	0.38	[bar]	179.7	4.5	
p_L	20.21	[bar]			
p^*_L	19.83	[bar]			
p_Y	4.41	[bar]	656	15.5	
E_{PMT}	216	[bar]	627	14.8	[14.8 - 15.6 %]
E_{PMT} / p^*_L	10.9				
$E_{Unload\ 1}$	845	[bar]	658	15.5	
$E_{Reload\ 1}$	516	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15-30\ sec]}$



Determination of total contact pressure p_0

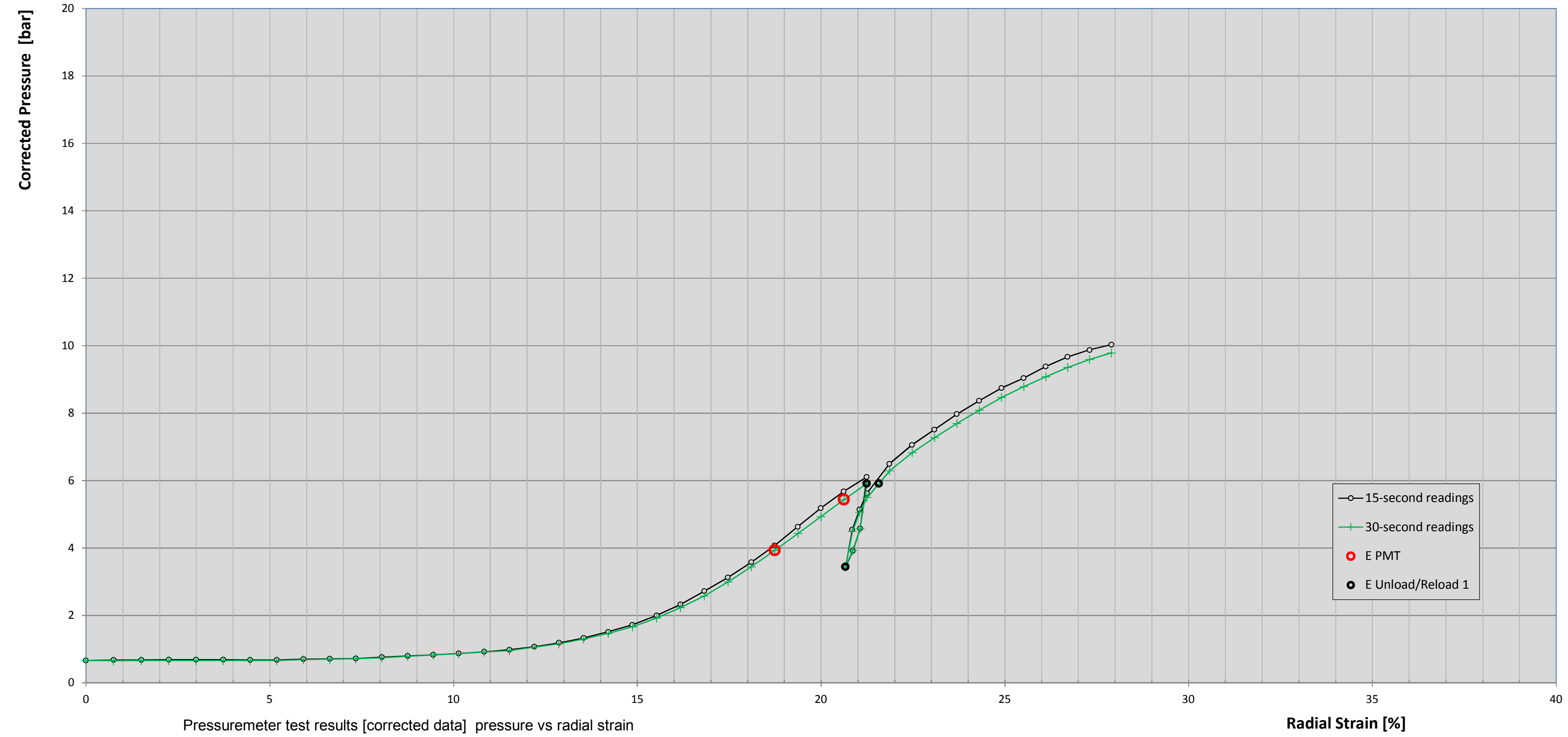


Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall

Test Date: January 23, 2018	**Project:** **HWY 400 and HWY 89**	**PMT TEST No.: 1**	In-Depth Geotechnical Inc.
Test Depth [m]: 4.11 (center of the probe)	Client: Golder Associates	**Borehole No.: BH 01-PMT**	
Drilling Company: Walker Drilling	In-Depth Geotechnical Project No.: IDG 180411		

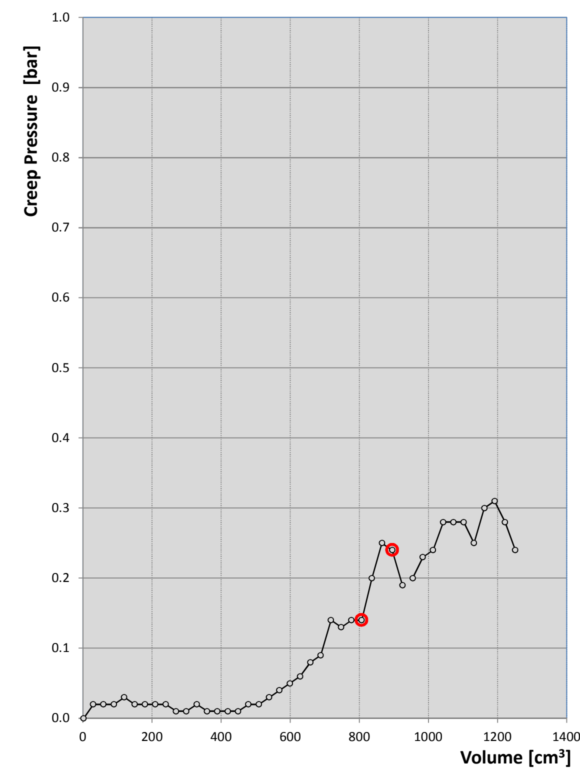
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume	Pressure [bar]		Pressure	Volume	$\Delta r/r_0$	Pressure	Volume	$\Delta r/r_0$	Volume	Δp_{30-15}	Pressure	1 / V
[cm³]	15 sec	30 sec	[bar]	[cm³]	[%]	[bar]	[cm³]	[%]	[cm³]	[bar]	[bar]	
2	0.14	0.14	0.66	2	0.00	0.66	2	0.00	2	0.00	0.66	0.53355
30	0.18	0.16	0.68	29.8	0.76	0.66	29.9	0.76	29.9	0.02	0.66	0.03349
60	0.21	0.19	0.68	59.8	1.51	0.66	59.8	1.51	59.8	0.02	0.66	0.01671
90	0.24	0.22	0.69	89.8	2.26	0.67	89.8	2.26	89.8	0.02	0.67	0.01114
120	0.27	0.24	0.69	119.8	3.00	0.66	119.8	3.00	119.8	0.03	0.66	0.00835
150	0.29	0.27	0.69	149.7	3.74	0.67	149.8	3.74	149.8	0.02	0.67	0.00668
180	0.31	0.29	0.68	179.7	4.47	0.66	179.7	4.47	179.7	0.02	0.66	0.00556
210	0.33	0.31	0.68	209.7	5.19	0.66	209.7	5.19	209.7	0.02	0.66	0.00477
240	0.37	0.35	0.71	239.7	5.92	0.69	239.7	5.92	239.7	0.02	0.69	0.00417
270	0.39	0.38	0.71	269.6	6.63	0.70	269.7	6.63	269.7	0.01	0.70	0.00371
300	0.42	0.41	0.73	299.6	7.34	0.72	299.6	7.34	299.6	0.01	0.72	0.00334
330	0.47	0.45	0.77	329.6	8.05	0.75	329.6	8.05	329.6	0.02	0.75	0.00303
360	0.51	0.50	0.80	359.5	8.75	0.79	359.6	8.75	359.6	0.01	0.79	0.00278
390	0.55	0.54	0.83	389.5	9.45	0.82	389.5	9.45	389.5	0.01	0.82	0.00257
420	0.60	0.59	0.87	419.5	10.14	0.86	419.5	10.14	419.5	0.01	0.86	0.00238
450	0.66	0.65	0.93	449.4	10.83	0.92	449.4	10.83	449.4	0.01	0.92	0.00223
480	0.72	0.70	0.98	479.4	11.52	0.96	479.4	11.52	479.4	0.02	0.96	0.00209
510	0.82	0.80	1.08	509.3	12.20	1.06	509.3	12.20	509.3	0.02	1.06	0.00196
540	0.94	0.91	1.19	539.2	12.87	1.16	539.2	12.87	539.2	0.03	1.16	0.00185
570	1.09	1.05	1.34	569.0	13.54	1.30	569.1	13.54	569.1	0.04	1.30	0.00176
600	1.27	1.22	1.52	598.9	14.21	1.47	598.9	14.21	598.9	0.05	1.47	0.00167
630	1.48	1.42	1.72	628.7	14.87	1.66	628.7	14.87	628.7	0.06	1.66	0.00159
660	1.76	1.68	2.00	658.4	15.53	1.92	658.5	15.53	658.5	0.08	1.92	0.00152
690	2.09	2.00	2.33	688.1	16.18	2.24	688.2	16.18	688.2	0.09	2.24	0.00145
720	2.49	2.35	2.72	717.8	16.82	2.58	717.9	16.83	717.9	0.14	2.58	0.00139
750	2.90	2.77	3.13	747.4	17.47	3.00	747.5	17.47	747.5	0.13	3.00	0.00134
780	3.36	3.22	3.58	777.0	18.10	3.44	777.1	18.11	777.1	0.14	3.44	0.00129
810	3.86	3.72	4.08	806.5	18.74	3.94	806.7	18.74	806.7	0.14	3.94	0.00124
840	4.42	4.22	4.63	836.0	19.37	4.43	836.2	19.37	836.2	0.20	4.43	0.00120
870	4.97	4.72	5.18	865.5	19.99	4.93	865.8	20.00	865.8	0.25	4.93	0.00116
900	5.47	5.23	5.68	895.1	20.62	5.44	895.3	20.62	895.3	0.24	5.44	0.00112
930	5.90	5.71	6.10	924.7	21.24	5.91	924.9	21.24	924.9	0.19	5.91	0.00108
920	4.37	4.37	4.57	916.1	21.06	4.57	916.1	21.06			4.57	0.00109
910	3.71	3.73	3.92	906.7	20.86	3.94	906.6	20.86			3.94	0.00110
900	3.22	3.24	3.43	897.1	20.66	3.45	897.1	20.66			3.45	0.00111
910	4.34	4.29	4.55	906.1	20.85	4.50	906.1	20.85			4.50	0.00110
920	4.94	4.86	5.14	915.6	21.05	5.06	915.6	21.05			5.06	0.00109
930	5.42	5.30	5.62	925.1	21.25	5.50	925.2	21.25			5.50	0.00108
960	6.29	6.09	6.49	954.3	21.86	6.29	954.5	21.86	954.5	0.20	6.29	0.00105
990	6.86	6.63	7.06	983.8	22.47	6.83	984.0	22.48	984.0	0.23	6.83	0.00102
1020	7.32	7.08	7.51	1013.4	23.09	7.27	1013.6	23.09	1013.6	0.24	7.27	0.00099
1050	7.78	7.50	7.97	1043.0	23.70	7.69	1043.3	23.70	1043.3	0.28	7.69	0.00096
1080	8.18	7.90	8.37	1072.7	24.30	8.09	1072.9	24.31	1072.9	0.28	8.09	0.00093
1110	8.56	8.28	8.74	1102.3	24.91	8.46	1102.6	24.91	1102.6	0.28	8.46	0.00091
1140	8.86	8.61	9.04	1132.0	25.51	8.79	1132.3	25.52	1132.3	0.25	8.79	0.00088
1170	9.21	8.91	9.38	1161.7	26.11	9.08	1162.0	26.12	1162.0	0.30	9.08	0.00086
1200	9.50	9.19	9.67	1191.5	26.71	9.36	1191.7	26.71	1191.7	0.31	9.36	0.00084
1230	9.71	9.43	9.87	1221.3	27.31	9.59	1221.5	27.31	1221.5	0.28	9.59	0.00082
1260	9.87	9.63	10.03	1251.1	27.90	9.79	1251.3	27.90	1251.3	0.24	9.79	0.00080



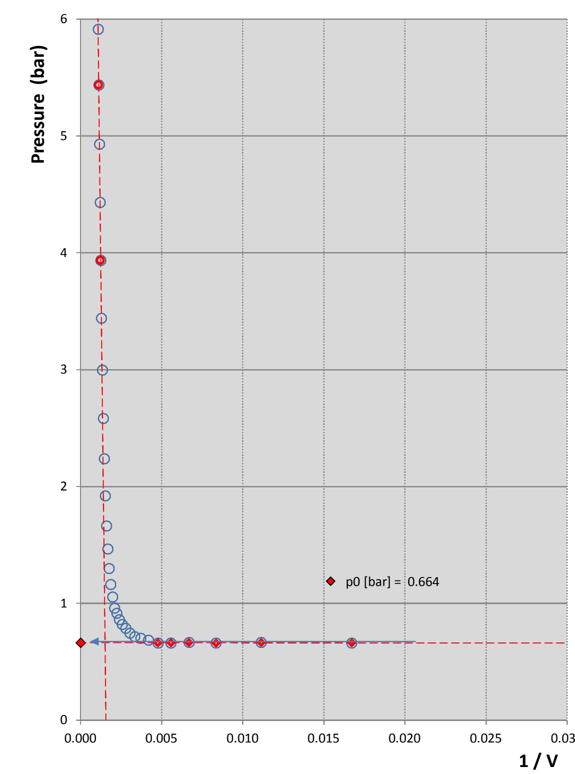
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

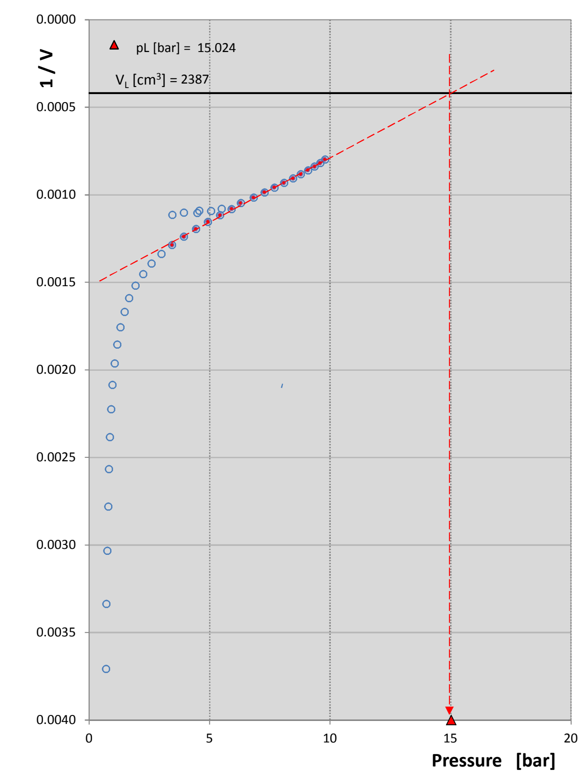
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	0.66	[bar]	209.7	5.2	
p_L	15.02	[bar]			
p^*_L	14.36	[bar]			
p_Y	5.44	[bar]	895	20.6	
E_{PMT}	127	[bar]	807	18.7	[18.7 - 20.6 %]
E_{PMT} / p^*_L	8.8				
$E_{Unload\ 1}$	680	[bar]	897	20.7	
$E_{Reload\ 1}$	437	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15-30\ sec]}$



Determination of total contact pressure p_0

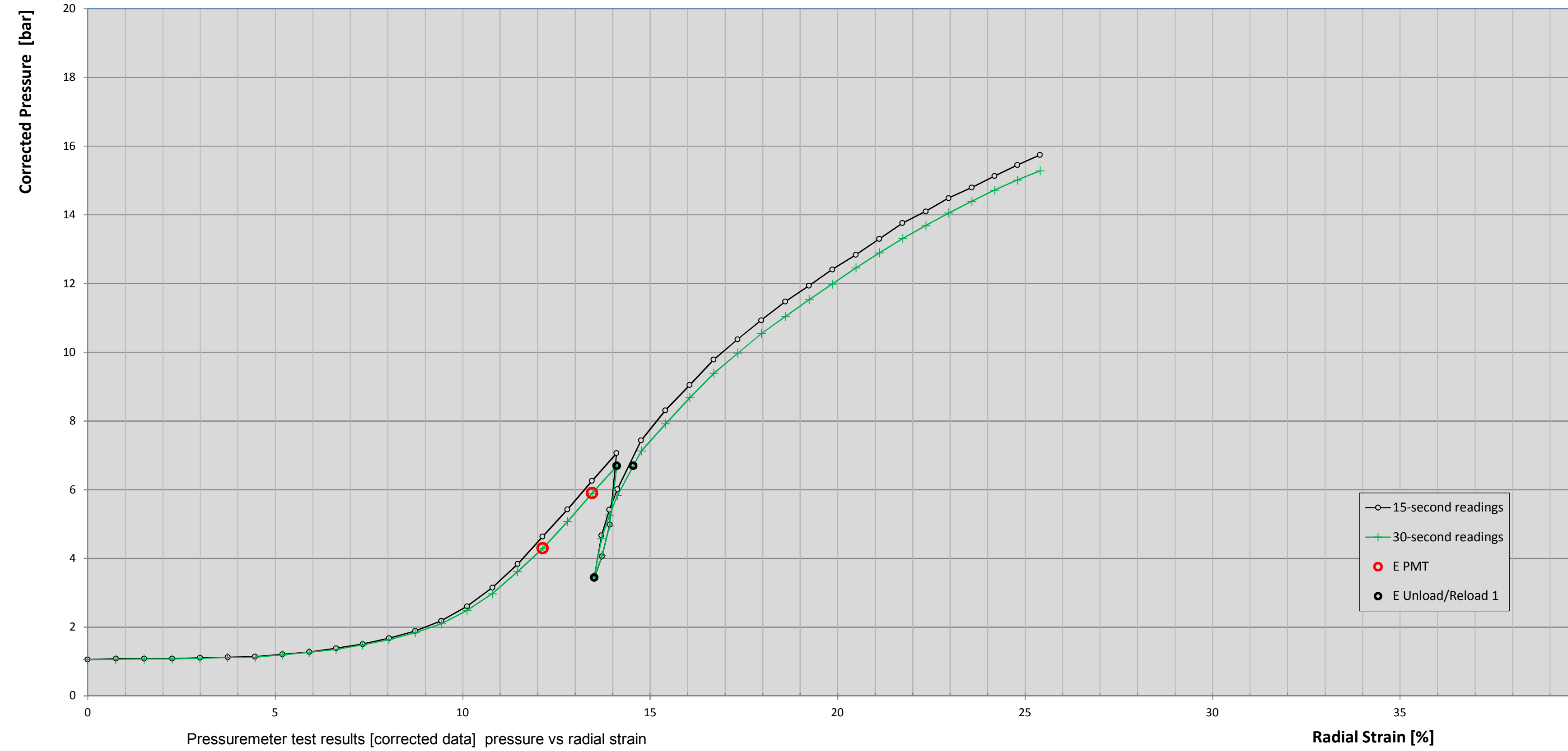


Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall

Test Date: January 23, 2018	**Project:** **HWY 400 and HWY 89**	**PMT TEST No.: 2**
Test Depth [m]: 7.11 (center of the probe)	Client: Golder Associates	**Borehole No.: BH 01-PMT**
Drilling Company: Walker Drilling	In-Depth Geotechnical Project No.: IDG 180411	In-Depth Geotechnical Inc.

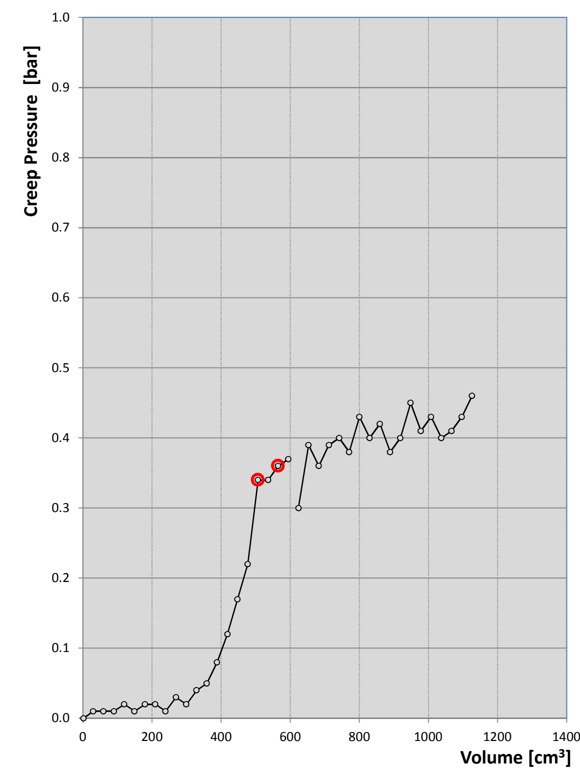
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm^3]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm^3]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm^3]	$\Delta r/r_0$ [%]	Volume [cm^3]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	0.23	0.23	1.06	2	0.00	1.06	2	0.00	2	0.00	1.06	0.55761
30	0.28	0.27	1.08	29.7	0.75	1.07	29.8	0.75	29.8	0.01	1.07	0.03361
60	0.31	0.30	1.08	59.7	1.51	1.07	59.7	1.51	59.7	0.01	1.07	0.01674
90	0.34	0.33	1.09	89.7	2.25	1.08	89.7	2.25	89.7	0.01	1.08	0.01115
120	0.39	0.37	1.11	119.6	3.00	1.09	119.7	3.00	119.7	0.02	1.09	0.00836
150	0.43	0.42	1.13	149.6	3.73	1.12	149.6	3.73	149.6	0.01	1.12	0.00668
180	0.47	0.45	1.14	179.6	4.46	1.12	179.6	4.46	179.6	0.02	1.12	0.00557
210	0.56	0.54	1.21	209.5	5.19	1.19	209.5	5.19	209.5	0.02	1.19	0.00477
240	0.64	0.63	1.28	239.4	5.91	1.27	239.4	5.91	239.4	0.01	1.27	0.00418
270	0.76	0.73	1.38	269.3	6.62	1.35	269.3	6.62	269.3	0.03	1.35	0.00371
300	0.90	0.88	1.51	299.2	7.33	1.49	299.2	7.33	299.2	0.02	1.49	0.00334
330	1.08	1.04	1.68	329.0	8.04	1.64	329.1	8.04	329.1	0.04	1.64	0.00304
360	1.30	1.25	1.89	358.8	8.74	1.84	358.9	8.74	358.9	0.05	1.84	0.00279
390	1.60	1.52	2.18	388.6	9.43	2.10	388.6	9.43	388.6	0.08	2.10	0.00257
420	2.03	1.91	2.60	418.2	10.11	2.48	418.3	10.12	418.3	0.12	2.48	0.00239
450	2.58	2.41	3.15	447.7	10.79	2.98	447.8	10.80	447.8	0.17	2.98	0.00223
480	3.28	3.06	3.84	477.1	11.46	3.62	477.3	11.47	477.3	0.22	3.62	0.00210
510	4.08	3.74	4.64	506.3	12.13	4.30	506.6	12.14	506.6	0.34	4.30	0.00197
540	4.87	4.53	5.42	535.6	12.79	5.08	535.9	12.80	535.9	0.34	5.08	0.00187
570	5.71	5.35	6.26	564.9	13.45	5.90	565.2	13.46	565.2	0.36	5.90	0.00177
600	6.52	6.15	7.07	594.1	14.10	6.70	594.5	14.11	594.5	0.37	6.70	0.00168
590	4.43	4.40	4.98	586.0	13.92	4.95	586.0	13.92			4.95	0.00171
580	3.52	3.53	4.07	576.8	13.72	4.08	576.8	13.72			4.08	0.00173
570	2.87	2.89	3.42	567.4	13.51	3.44	567.4	13.51			3.44	0.00176
580	4.12	4.03	4.67	576.3	13.70	4.58	576.4	13.71			4.58	0.00173
590	4.87	4.72	5.42	585.6	13.91	5.27	585.8	13.92			5.27	0.00171
600	5.47	5.28	6.02	595.1	14.12	5.83	595.3	14.13			5.83	0.00168
630	6.89	6.59	7.43	623.8	14.76	7.13	624.1	14.77	624.1	0.30	7.13	0.00160
660	7.77	7.38	8.31	653.0	15.41	7.92	653.4	15.41	653.4	0.39	7.92	0.00153
690	8.51	8.15	9.05	682.4	16.05	8.69	682.7	16.06	682.7	0.36	8.69	0.00146
720	9.25	8.86	9.78	711.7	16.69	9.39	712.0	16.70	712.0	0.39	9.39	0.00140
750	9.85	9.45	10.38	741.2	17.33	9.98	741.5	17.34	741.5	0.40	9.98	0.00135
780	10.41	10.03	10.93	770.6	17.97	10.55	771.0	17.98	771.0	0.38	10.55	0.00130
810	10.96	10.53	11.48	800.2	18.60	11.05	800.5	18.61	800.5	0.43	11.05	0.00125
840	11.42	11.02	11.93	829.7	19.23	11.53	830.1	19.24	830.1	0.40	11.53	0.00120
870	11.90	11.48	12.41	859.3	19.86	11.99	859.7	19.87	859.7	0.42	11.99	0.00116
900	12.33	11.95	12.84	888.9	20.49	12.46	889.3	20.50	889.3	0.38	12.46	0.00112
930	12.79	12.39	13.29	918.5	21.11	12.89	918.9	21.12	918.9	0.40	12.89	0.00109
960	13.26	12.81	13.76	948.1	21.73	13.31	948.5	21.74	948.5	0.45	13.31	0.00105
990	13.60	13.19	14.10	977.8	22.35	13.69	978.2	22.36	978.2	0.41	13.69	0.00102
1020	13.99	13.56	14.49	1007.4	22.96	14.06	1007.8	22.97	1007.8	0.43	14.06	0.00099
1050	14.30	13.90	14.79	1037.2	23.58	14.39	1037.5	23.58	1037.5	0.40	14.39	0.00096
1080	14.64	14.23	15.13	1066.8	24.18	14.72	1067.2	24.19	1067.2	0.41	14.72	0.00094
1110	14.96	14.53	15.45	1096.6	24.79	15.02	1096.9	24.80	1096.9	0.43	15.02	0.00091
1140	15.26	14.80	15.74	1126.3	25.39	15.28	1126.7	25.40	1126.7	0.46	15.28	0.00089



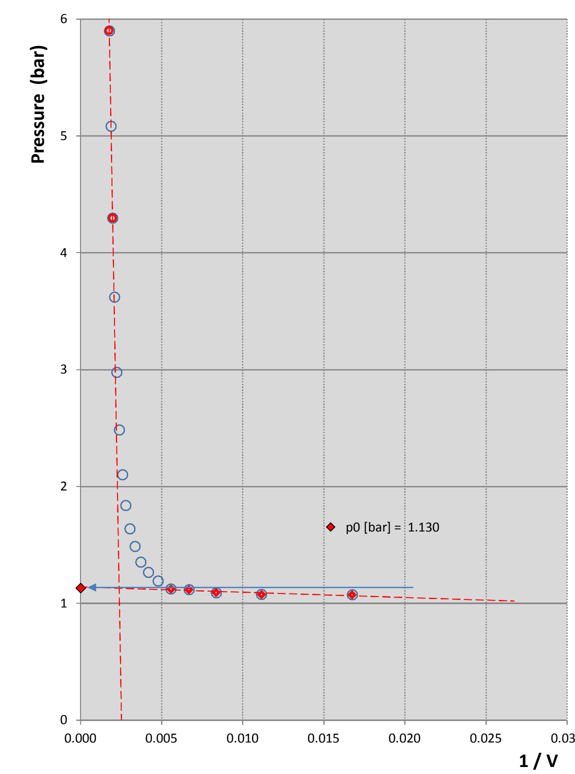
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

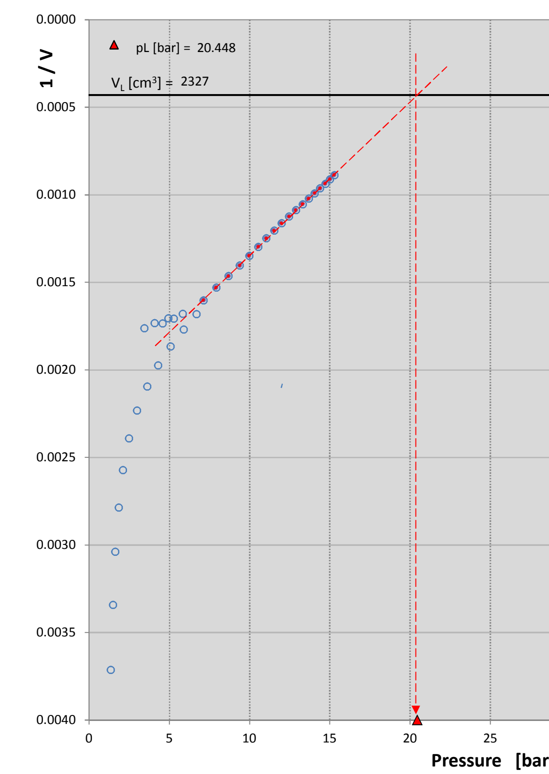
[30-second readings]			volume [cm^3]	radial strain [%]	strain range [%]
p_0	1.13	[bar]	179.6	4.5	
p_L	20.45	[bar]			
p^*_L	19.32	[bar]			
p_Y	5.90	[bar]	565	13.5	
E_{PMT}	182	[bar]	507	12.1	[12.1 - 13.5 %]
E_{PMT} / p^*_L	9.4				
$E_{Unload\ 1}$	816	[bar]	567	13.5	
$E_{Reload\ 1}$	471	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15-30\ sec]}$



Determination of total contact pressure p_0

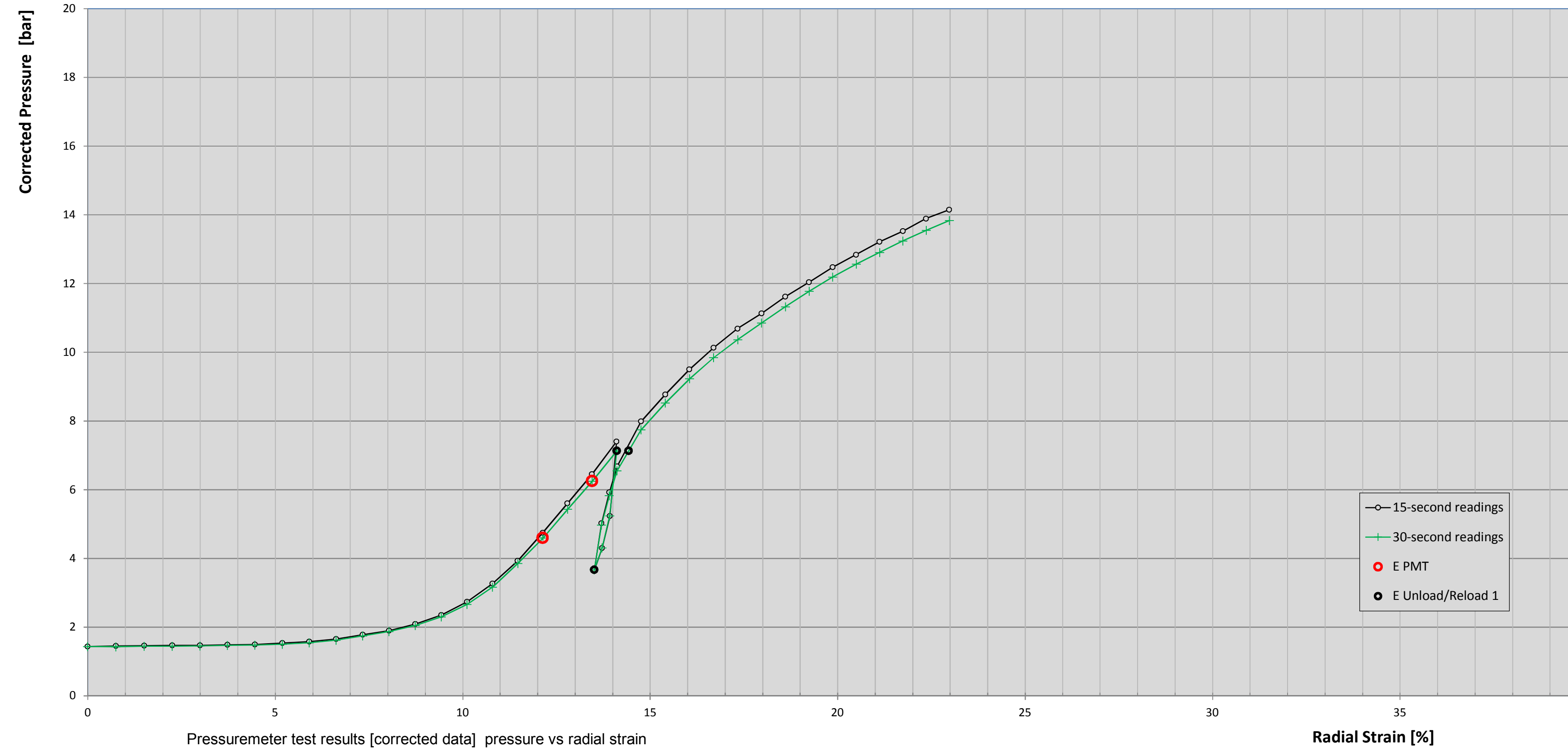


Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model Volume-controlled test as per ASTM D4719 Method B Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Probe Designation : NX Probe (76 mm OD) Probe No.: E 309 Calibration Record No.: 1 Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit Time elapsed from hole drilling to testing ~ 5 minutes Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Test Date: January 23, 2018 Test Depth [m]: 10.19 (center of the probe) Drilling Company: Walker Drilling

Project: **HWY 400 and HWY 89**	**PMT TEST No.: 3**	In-Depth Geotechnical Inc.
Client: Golder Associates	**Borehole No.: BH 01-PMT**	
In-Depth Geotechnical Project No.: IDG 180411		

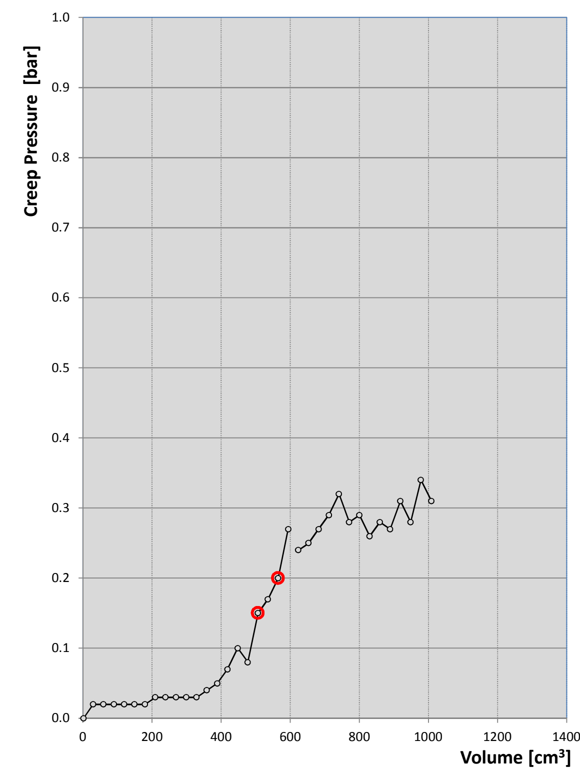
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Volume [cm³]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	0.31	0.31	1.44	2	0.00	1.44	2	0.00	2	0.00	1.44	0.58089
30	0.35	0.33	1.45	29.7	0.75	1.43	29.7	0.75	29.7	0.02	1.43	0.03367
60	0.39	0.37	1.47	59.6	1.50	1.45	59.7	1.50	59.7	0.02	1.45	0.01676
90	0.42	0.40	1.47	89.6	2.25	1.45	89.6	2.25	89.6	0.02	1.45	0.01116
120	0.45	0.43	1.47	119.6	2.99	1.45	119.6	2.99	119.6	0.02	1.45	0.00836
150	0.49	0.47	1.49	149.6	3.73	1.47	149.6	3.73	149.6	0.02	1.47	0.00669
180	0.52	0.50	1.50	179.5	4.46	1.48	179.6	4.46	179.6	0.02	1.48	0.00557
210	0.58	0.55	1.53	209.5	5.19	1.50	209.5	5.19	209.5	0.03	1.50	0.00477
240	0.64	0.61	1.58	239.4	5.91	1.55	239.5	5.91	239.5	0.03	1.55	0.00418
270	0.73	0.70	1.65	269.3	6.62	1.62	269.4	6.63	269.4	0.03	1.62	0.00371
300	0.87	0.84	1.78	299.2	7.33	1.75	299.2	7.33	299.2	0.03	1.75	0.00334
330	1.00	0.97	1.90	329.1	8.04	1.87	329.1	8.04	329.1	0.03	1.87	0.00304
360	1.20	1.16	2.09	358.9	8.74	2.05	359.0	8.74	359.0	0.04	2.05	0.00279
390	1.47	1.42	2.35	388.7	9.43	2.30	388.7	9.43	388.7	0.05	2.30	0.00257
420	1.86	1.79	2.74	418.3	10.12	2.67	418.4	10.12	418.4	0.07	2.67	0.00239
450	2.40	2.30	3.27	447.8	10.80	3.17	447.9	10.80	447.9	0.10	3.17	0.00223
480	3.07	2.99	3.93	477.2	11.47	3.85	477.3	11.47	477.3	0.08	3.85	0.00210
510	3.89	3.74	4.75	506.5	12.13	4.60	506.6	12.14	506.6	0.15	4.60	0.00197
540	4.75	4.58	5.61	535.7	12.79	5.44	535.9	12.80	535.9	0.17	5.44	0.00187
570	5.60	5.40	6.45	565.0	13.45	6.25	565.1	13.46	565.1	0.20	6.25	0.00177
600	6.55	6.28	7.40	594.1	14.10	7.13	594.4	14.11	594.4	0.27	7.13	0.00168
590	4.38	4.39	5.23	586.1	13.92	5.24	586.1	13.92			5.24	0.00171
580	3.45	3.46	4.30	576.9	13.72	4.31	576.9	13.72			4.31	0.00173
570	2.80	2.82	3.65	567.5	13.51	3.67	567.5	13.51			3.67	0.00176
580	4.17	4.12	5.02	576.3	13.70	4.97	576.3	13.70			4.97	0.00174
590	5.07	4.98	5.92	585.4	13.91	5.83	585.5	13.91			5.83	0.00171
600	5.83	5.70	6.68	594.8	14.12	6.55	594.9	14.12			6.55	0.00168
630	7.14	6.90	7.99	623.6	14.76	7.75	623.8	14.76	623.8	0.24	7.75	0.00160
660	7.93	7.68	8.77	652.9	15.40	8.52	653.1	15.41	653.1	0.25	8.52	0.00153
690	8.66	8.39	9.50	682.2	16.05	9.23	682.5	16.05	682.5	0.27	9.23	0.00147
720	9.30	9.01	10.14	711.6	16.69	9.85	711.9	16.70	711.9	0.29	9.85	0.00140
750	9.86	9.54	10.69	741.1	17.33	10.37	741.4	17.34	741.4	0.32	10.37	0.00135
780	10.31	10.03	11.13	770.7	17.97	10.85	771.0	17.98	771.0	0.28	10.85	0.00130
810	10.80	10.51	11.62	800.3	18.61	11.33	800.6	18.61	800.6	0.29	11.33	0.00125
840	11.22	10.96	12.04	829.9	19.24	11.78	830.2	19.24	830.2	0.26	11.78	0.00120
870	11.66	11.38	12.47	859.5	19.87	12.19	859.8	19.87	859.8	0.28	12.19	0.00116
900	12.03	11.76	12.84	889.2	20.49	12.57	889.4	20.50	889.4	0.27	12.57	0.00112
930	12.41	12.10	13.22	918.9	21.12	12.91	919.1	21.12	919.1	0.31	12.91	0.00109
960	12.72	12.44	13.52	948.6	21.74	13.24	948.8	21.75	948.8	0.28	13.24	0.00105
990	13.09	12.75	13.89	978.2	22.36	13.55	978.5	22.36	978.5	0.34	13.55	0.00102
1020	13.35	13.04	14.15	1008.0	22.97	13.84	1008.3	22.98	1008.3	0.31	13.84	0.00099



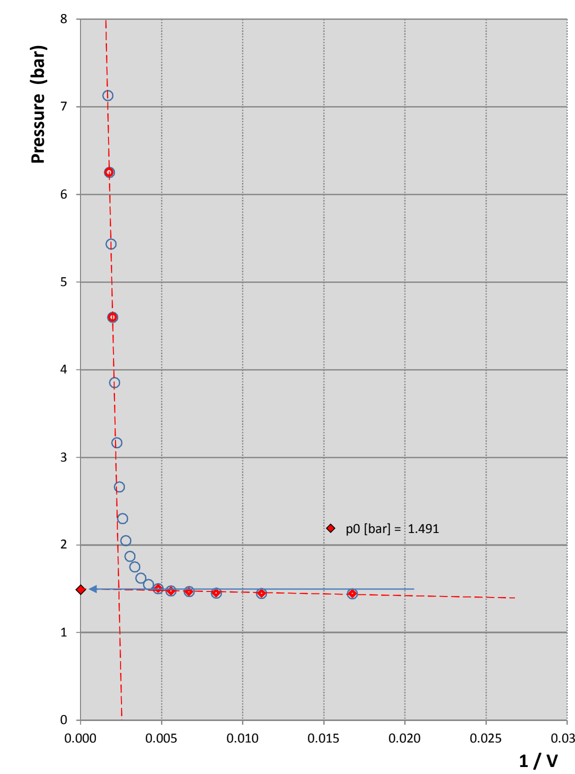
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

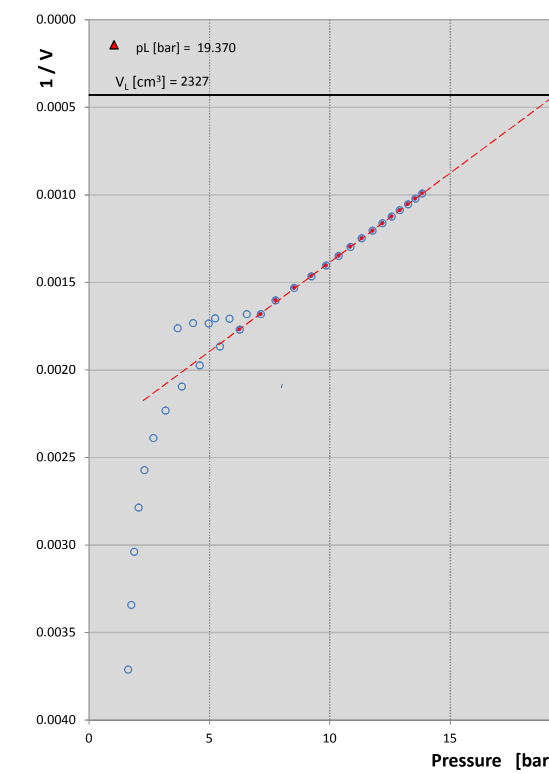
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	1.49	[bar]	179.6	4.5	
p_L	19.37	[bar]			
p^*_L	17.88	[bar]			
p_Y	6.25	[bar]	565	13.5	
E_{PMT}	188	[bar]	507	12.1	[12.1 - 13.5 %]
E_{PMT} / p^*_L	10.5				
$E_{Unload\ 1}$	872	[bar]	567	13.5	
$E_{Reload\ 1}$	568	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15\text{-}30\ sec]}$



Determination of total contact pressure p_0



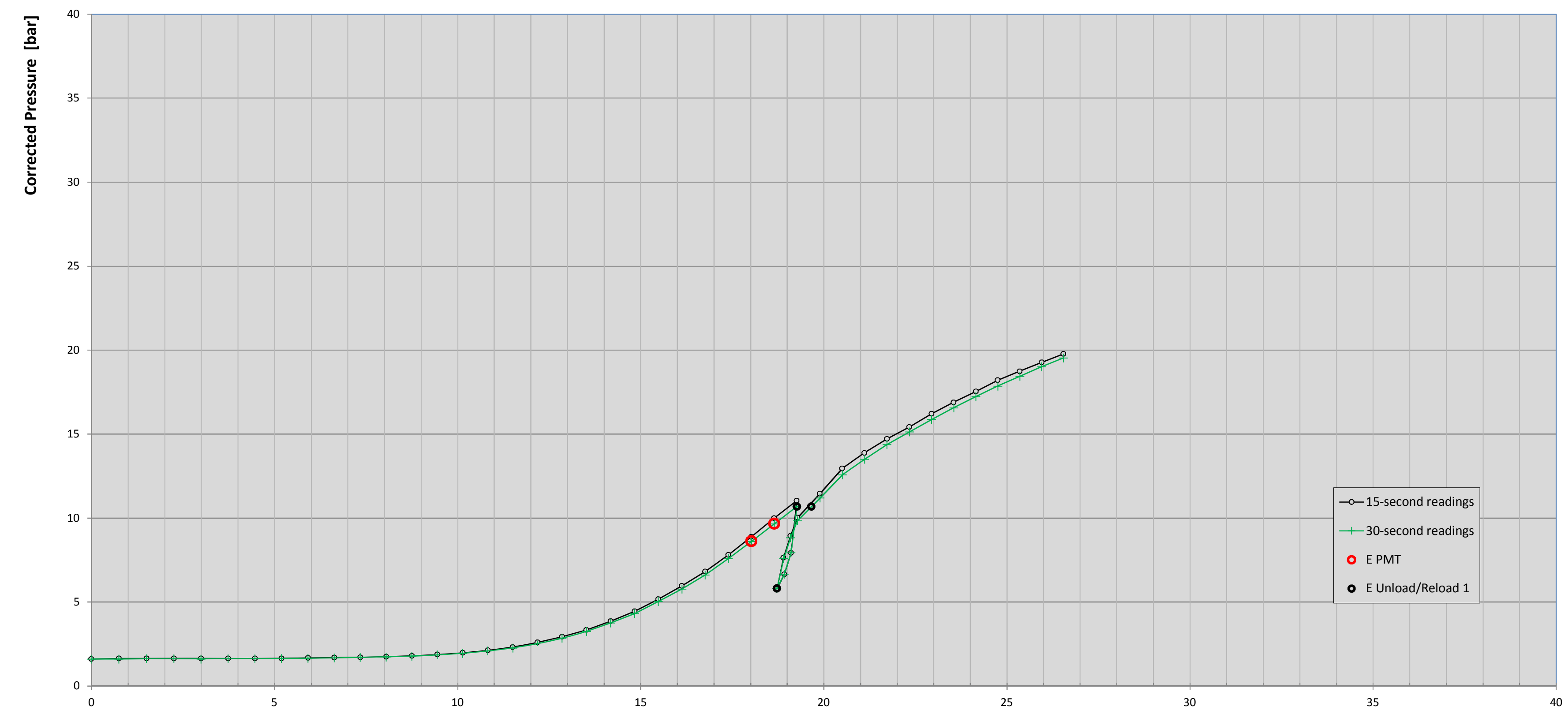
Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model Volume-controlled test as per ASTM D4719 Method B Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Probe Designation : NX Probe (76 mm OD) Probe No.: E 309 Calibration Record No.: 1 Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit Time elapsed from hole drilling to testing ~ 5 minutes Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Test Date: January 23, 2018 Test Depth [m]: 13.26 (center of the probe) Drilling Company: Walker Drilling	Project: HWY 400 and HWY 89 Client: Golder Associates In-Depth Geotechnical Project No.: IDG 180411

PMT TEST No.: 4

Borehole No.: BH 01-PMT

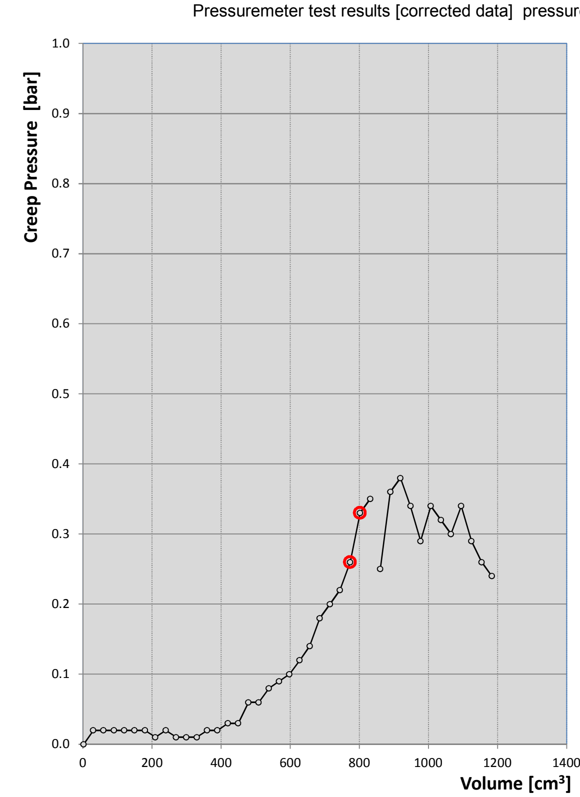
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure	Volume	$\Delta r/r_0$	Pressure	Volume	$\Delta r/r_0$	Volume	Δp_{30-15}	Pressure	1 / V
[cm³]			[bar]	[cm³]	[%]	[bar]	[cm³]	[%]	[cm³]	[bar]	[bar]	
2	0.19	0.19	1.62	2	0.00	1.62	2	0.00	2	0.00	1.62	0.54666
30	0.24	0.22	1.64	29.8	0.75	1.62	29.8	0.75	29.8	0.02	1.62	0.03355
60	0.27	0.25	1.64	59.8	1.51	1.62	59.8	1.51	59.8	0.02	1.62	0.01673
90	0.30	0.28	1.65	89.7	2.25	1.63	89.7	2.26	89.7	0.02	1.63	0.01114
120	0.32	0.30	1.64	119.7	3.00	1.62	119.7	3.00	119.7	0.02	1.62	0.00835
150	0.35	0.33	1.65	149.7	3.73	1.63	149.7	3.73	149.7	0.02	1.63	0.00668
180	0.38	0.36	1.65	179.7	4.47	1.63	179.7	4.47	179.7	0.02	1.63	0.00557
210	0.40	0.39	1.65	209.6	5.19	1.64	209.6	5.19	209.6	0.01	1.64	0.00477
240	0.44	0.42	1.68	239.6	5.91	1.66	239.6	5.91	239.6	0.02	1.66	0.00417
270	0.47	0.46	1.69	269.6	6.63	1.68	269.6	6.63	269.6	0.01	1.68	0.00371
300	0.51	0.50	1.72	299.5	7.34	1.71	299.6	7.34	299.6	0.01	1.71	0.00334
330	0.55	0.54	1.75	329.5	8.05	1.74	329.5	8.05	329.5	0.01	1.74	0.00303
360	0.61	0.59	1.80	359.5	8.75	1.78	359.5	8.75	359.5	0.02	1.78	0.00278
390	0.70	0.68	1.88	389.4	9.45	1.86	389.4	9.45	389.4	0.02	1.86	0.00257
420	0.81	0.78	1.98	419.3	10.14	1.95	419.3	10.14	419.3	0.03	1.95	0.00238
450	0.96	0.93	2.13	449.1	10.83	2.10	449.2	10.83	449.2	0.03	2.10	0.00223
480	1.16	1.10	2.32	479.0	11.51	2.26	479.0	11.51	479.0	0.06	2.26	0.00209
510	1.44	1.38	2.60	508.7	12.18	2.54	508.8	12.19	508.8	0.06	2.54	0.00197
540	1.78	1.70	2.93	538.4	12.85	2.85	538.5	12.86	538.5	0.08	2.85	0.00186
570	2.20	2.11	3.35	568.0	13.52	3.26	568.1	13.52	568.1	0.09	3.26	0.00176
600	2.71	2.61	3.86	597.6	14.18	3.76	597.7	14.18	597.7	0.10	3.76	0.00167
630	3.30	3.18	4.44	627.0	14.83	4.32	627.1	14.84	627.1	0.12	4.32	0.00159
660	4.04	3.90	5.18	656.4	15.48	5.04	656.5	15.48	656.5	0.14	5.04	0.00152
690	4.82	4.64	5.96	685.7	16.12	5.78	685.8	16.13	685.8	0.18	5.78	0.00146
720	5.68	5.48	6.81	714.9	16.76	6.61	715.1	16.76	715.1	0.20	6.61	0.00140
750	6.68	6.46	7.81	744.0	17.39	7.59	744.2	17.40	744.2	0.22	7.59	0.00134
780	7.76	7.50	8.88	773.0	18.02	8.62	773.3	18.02	773.3	0.26	8.62	0.00129
810	8.88	8.55	10.00	802.0	18.64	9.67	802.3	18.65	802.3	0.33	9.67	0.00125
840	9.93	9.58	11.04	831.1	19.26	10.69	831.4	19.27	831.4	0.35	10.69	0.00120
830	6.81	6.83	7.92	823.9	19.11	7.94	823.9	19.11			7.94	0.00121
820	5.53	5.56	6.65	815.0	18.92	6.68	815.0	18.92			6.68	0.00123
810	4.67	4.70	5.79	805.8	18.72	5.82	805.8	18.72			5.82	0.00124
820	6.53	6.48	7.65	814.1	18.90	7.60	814.2	18.90			7.60	0.00123
830	7.83	7.72	8.94	823.0	19.09	8.83	823.1	19.09			8.83	0.00121
840	8.91	8.74	10.02	832.0	19.28	9.85	832.1	19.29			9.85	0.00120
870	10.35	10.10	11.46	860.7	19.89	11.21	860.9	19.90	860.9	0.25	11.21	0.00116
900	11.84	11.48	12.95	889.4	20.50	12.59	889.7	20.50	889.7	0.36	12.59	0.00112
930	12.78	12.40	13.88	918.5	21.11	13.50	918.9	21.12	918.9	0.38	13.50	0.00109
960	13.62	13.28	14.72	947.8	21.72	14.38	948.1	21.73	948.1	0.34	14.38	0.00105
990	14.33	14.04	15.43	977.1	22.33	15.14	977.4	22.34	977.4	0.29	15.14	0.00102
1020	15.12	14.78	16.22	1006.4	22.94	15.88	1006.7	22.95	1006.7	0.34	15.88	0.00099
1050	15.80	15.48	16.89	1035.8	23.55	16.57	1036.1	23.55	1036.1	0.32	16.57	0.00097
1080	16.45	16.15	17.54	1065.2	24.15	17.24	1065.5	24.16	1065.5	0.30	17.24	0.00094
1110	17.12	16.78	18.21	1094.6	24.75	17.87	1094.9	24.76	1094.9	0.34	17.87	0.00091
1140	17.66	17.37	18.74	1124.1	25.35	18.45	1124.4	25.36	1124.4	0.29	18.45	0.00089
1170	18.20	17.94	19.27	1153.6	25.95	19.01	1153.9	25.95	1153.9	0.26	19.01	0.00087
1200	18.71	18.47	19.78	1183.2	26.54	19.54	1183.4	26.55	1183.4	0.24	19.54	0.00085



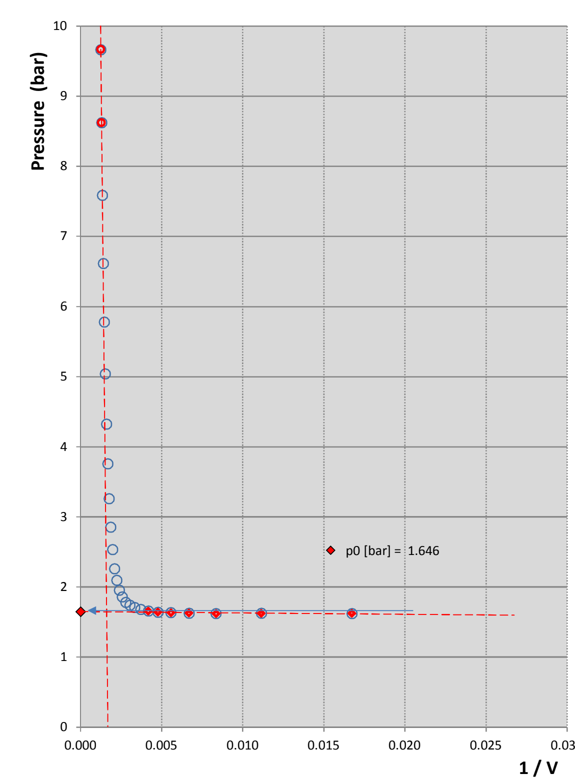
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

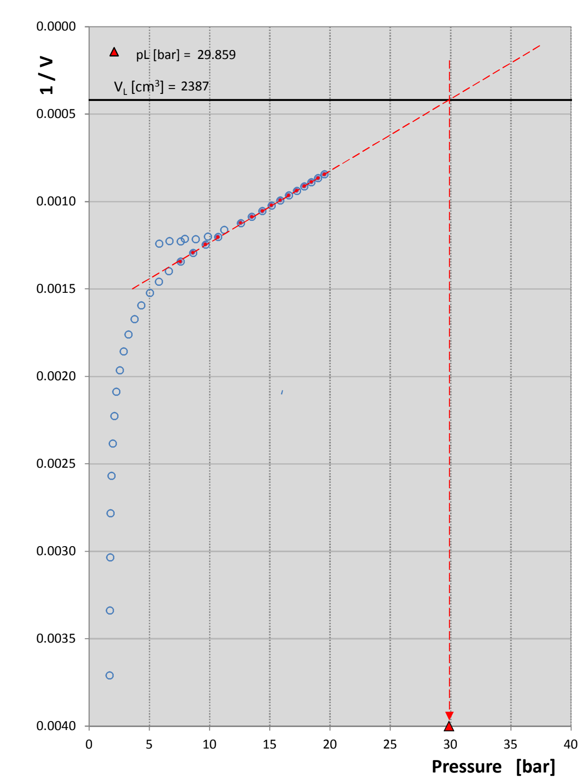
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	1.65	[bar]	209.6	5.2	
p_L	29.86	[bar]			
p^*_L	28.21	[bar]			
p_Y	9.67	[bar]	802	18.6	
E_{PMT}	264	[bar]	773	18.0	[18.0 - 18.7 %]
E_{PMT} / p^*_L	9.3				
$E_{Unload\ 1}$	1411	[bar]	806	18.7	
$E_{Reload\ 1}$	821	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15\text{-}30\ sec]}$



Determination of total contact pressure p_0

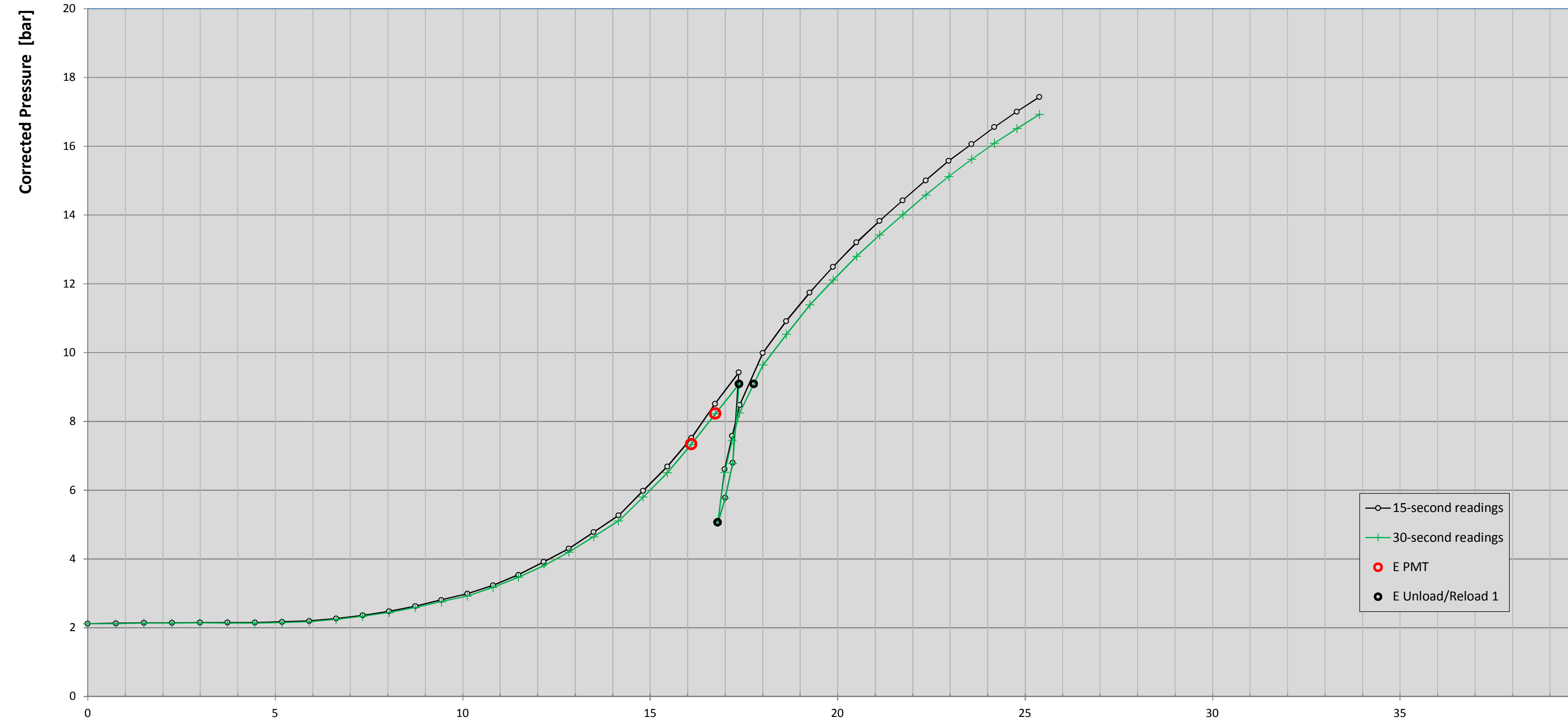


Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit	Test Date: January 24, 2018
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes	Test Depth [m]: 16.31 (center of the probe)
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Drilling Company: Walker Drilling

Project:	**HWY 400 and HWY 89**	**PMT TEST No.:**	**5**
Client:	Golder Associates	**Borehole No.:**	**BH 01-PMT**
In-Depth Geotechnical Project No.:	IDG 180411		

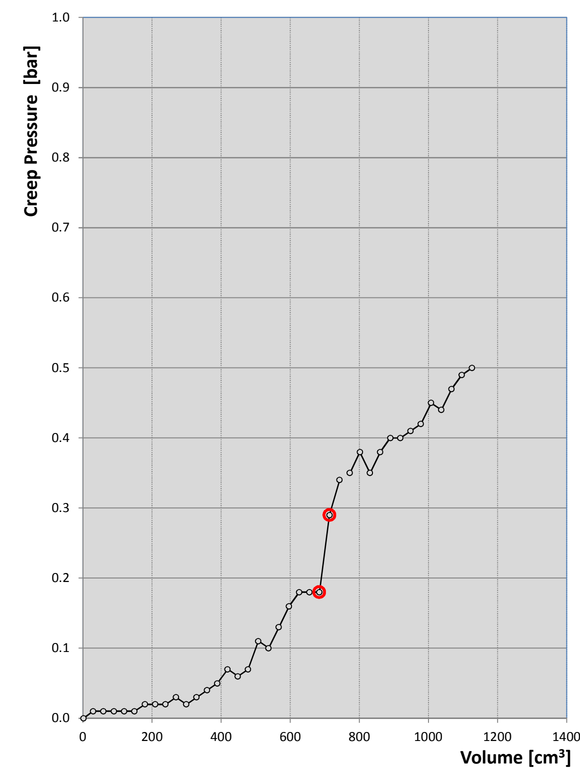
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Volume [cm³]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	0.39	0.39	2.11	2	0.00	2.11	2	0.00	2	0.00	2.11	0.60620
30	0.43	0.42	2.13	29.6	0.75	2.12	29.6	0.75	29.6	0.01	2.12	0.03376
60	0.47	0.46	2.14	59.6	1.50	2.13	59.6	1.50	59.6	0.01	2.13	0.01678
90	0.50	0.49	2.15	89.6	2.25	2.14	89.6	2.25	89.6	0.01	2.14	0.01117
120	0.53	0.52	2.15	119.5	2.99	2.14	119.5	2.99	119.5	0.01	2.14	0.00837
150	0.55	0.54	2.15	149.5	3.73	2.14	149.5	3.73	149.5	0.01	2.14	0.00669
180	0.58	0.56	2.15	179.5	4.46	2.13	179.5	4.46	179.5	0.02	2.13	0.00557
210	0.62	0.60	2.17	209.4	5.19	2.15	209.5	5.19	209.5	0.02	2.15	0.00477
240	0.66	0.64	2.20	239.4	5.91	2.18	239.4	5.91	239.4	0.02	2.18	0.00418
270	0.75	0.72	2.27	269.3	6.62	2.24	269.4	6.62	269.4	0.03	2.24	0.00371
300	0.85	0.83	2.36	299.2	7.33	2.34	299.3	7.34	299.3	0.02	2.34	0.00334
330	0.98	0.95	2.48	329.1	8.04	2.45	329.1	8.04	329.1	0.03	2.45	0.00304
360	1.14	1.10	2.63	359.0	8.74	2.59	359.0	8.74	359.0	0.04	2.59	0.00279
390	1.33	1.28	2.81	388.8	9.43	2.76	388.9	9.44	388.9	0.05	2.76	0.00257
420	1.52	1.45	2.99	418.6	10.13	2.92	418.7	10.13	418.7	0.07	2.92	0.00239
450	1.77	1.71	3.24	448.4	10.81	3.18	448.5	10.81	448.5	0.06	3.18	0.00223
480	2.08	2.01	3.54	478.1	11.49	3.47	478.2	11.49	478.2	0.07	3.47	0.00209
510	2.46	2.35	3.92	507.8	12.16	3.81	507.9	12.17	507.9	0.11	3.81	0.00197
540	2.85	2.75	4.30	537.4	12.83	4.20	537.5	12.84	537.5	0.10	4.20	0.00186
570	3.33	3.20	4.78	567.0	13.50	4.65	567.1	13.50	567.1	0.13	4.65	0.00176
600	3.82	3.66	5.27	596.6	14.16	5.11	596.7	14.16	596.7	0.16	5.11	0.00168
630	4.54	4.36	5.98	625.9	14.81	5.80	626.1	14.81	626.1	0.18	5.80	0.00160
660	5.25	5.07	6.69	655.3	15.46	6.51	655.4	15.46	655.4	0.18	6.51	0.00153
690	6.08	5.90	7.52	684.5	16.10	7.34	684.7	16.10	684.7	0.18	7.34	0.00146
720	7.08	6.79	8.51	713.6	16.73	8.22	713.9	16.74	713.9	0.29	8.22	0.00140
750	8.00	7.66	9.43	742.8	17.37	9.09	743.1	17.37	743.1	0.34	9.09	0.00135
740	5.37	5.35	6.80	735.2	17.20	6.78	735.2	17.20			6.78	0.00136
730	4.35	4.34	5.78	726.1	17.00	5.77	726.1	17.00			5.77	0.00138
720	3.60	3.63	5.03	716.8	16.80	5.06	716.7	16.80			5.06	0.00140
730	5.18	5.09	6.61	725.3	16.99	6.52	725.4	16.99			6.52	0.00138
740	6.15	6.02	7.58	734.5	17.19	7.45	734.6	17.19			7.45	0.00136
750	7.05	6.82	8.48	743.7	17.39	8.25	743.9	17.39			8.25	0.00134
780	8.57	8.22	9.99	772.3	18.00	9.64	772.6	18.01	772.6	0.35	9.64	0.00129
810	9.50	9.12	10.92	801.5	18.63	10.54	801.8	18.64	801.8	0.38	10.54	0.00125
840	10.33	9.98	11.74	830.7	19.26	11.39	831.0	19.26	831.0	0.35	11.39	0.00120
870	11.08	10.70	12.49	860.0	19.88	12.11	860.4	19.89	860.4	0.38	12.11	0.00116
900	11.80	11.40	13.21	889.4	20.50	12.81	889.8	20.51	889.8	0.40	12.81	0.00112
930	12.42	12.02	13.82	918.8	21.12	13.42	919.2	21.13	919.2	0.40	13.42	0.00109
960	13.02	12.61	14.42	948.3	21.73	14.01	948.7	21.74	948.7	0.41	14.01	0.00105
990	13.61	13.19	15.01	977.8	22.35	14.59	978.2	22.36	978.2	0.42	14.59	0.00102
1020	14.18	13.73	15.57	1007.3	22.96	15.12	1007.7	22.97	1007.7	0.45	15.12	0.00099
1050	14.67	14.23	16.06	1036.8	23.57	15.62	1037.2	23.58	1037.2	0.44	15.62	0.00096
1080	15.17	14.70	16.56	1066.4	24.17	16.09	1066.8	24.18	1066.8	0.47	16.09	0.00094
1110	15.62	15.13	17.00	1096.0	24.78	16.51	1096.4	24.79	1096.4	0.49	16.51	0.00091
1140	16.05	15.55	17.43	1125.6	25.38	16.93	1126.0	25.39	1126.0	0.50	16.93	0.00089



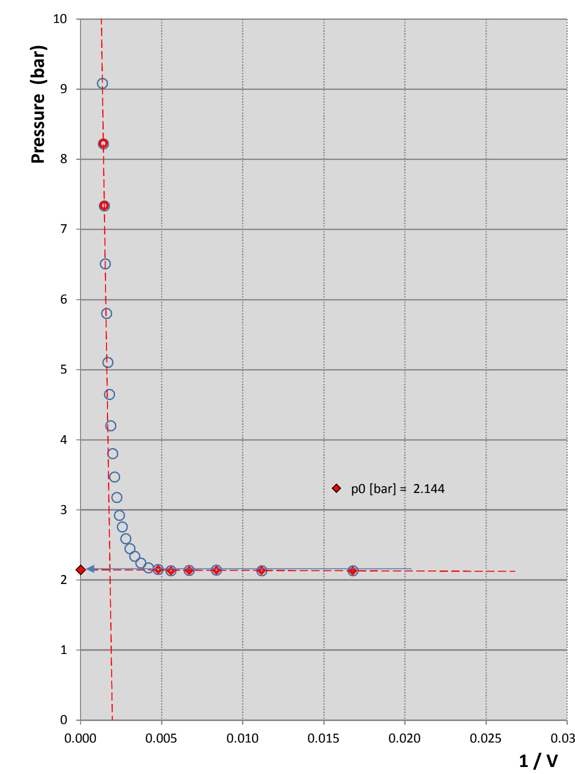
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

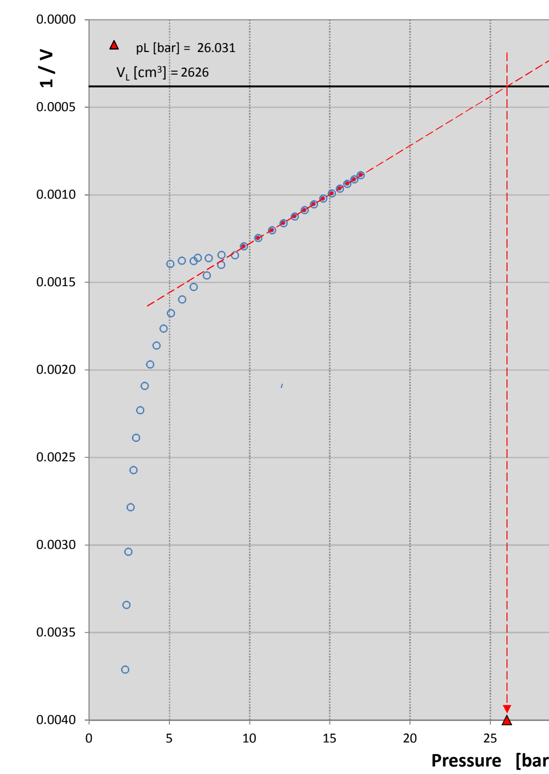
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	2.14	[bar]	329.1	8.0	
p_L	26.03	[bar]			
p^*_L	23.89	[bar]			
p_Y	8.22	[bar]	714	16.7	
E_{PMT}	215	[bar]	685	16.1	[16.1 - 16.7 %]
E_{PMT} / p^*_L	9.0				
$E_{Unload\ 1}$	1095	[bar]	717	16.8	
$E_{Reload\ 1}$	652	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15-30\ sec]}$



Determination of total contact pressure p_0



Determination of Limit Pressure p_L

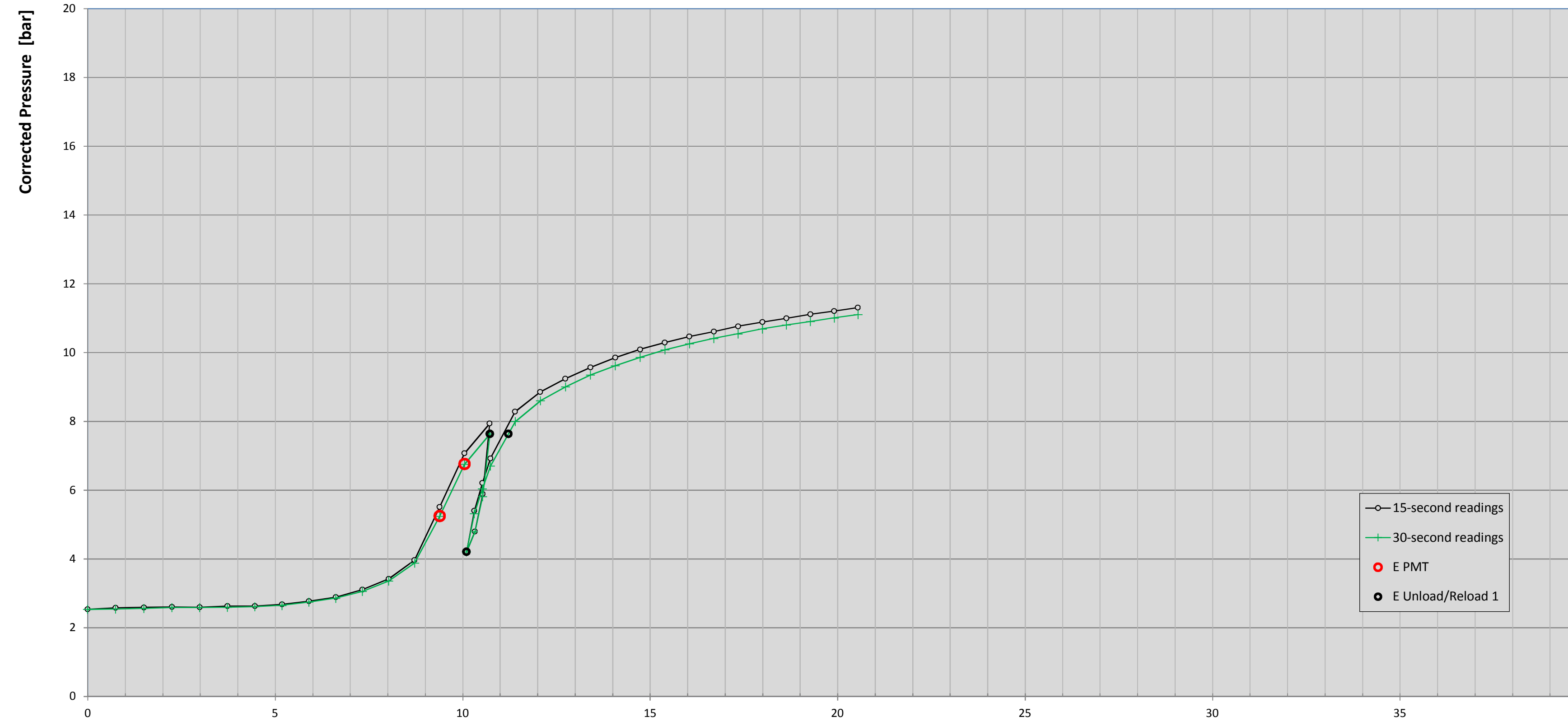
Pressuremeter Equipment: TEXAM Model Volume-controlled test as per ASTM D4719 Method B Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Probe Designation : NX Probe (76 mm OD) Probe No.: E 309 Calibration Record No.: 1 Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit Time elapsed from hole drilling to testing ~ 5 minutes Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Test Date: January 24, 2018 Test Depth [m]: 19.36 (center of the probe) Drilling Company: Walker Drilling
Project: **HWY 400 and HWY 89**	Client: Golder Associates	In-Depth Geotechnical Project No.: IDG 180411	
PMT TEST No.: 6	**Borehole No.: BH 01-PMT**		

In-Depth Geotechnical Inc.

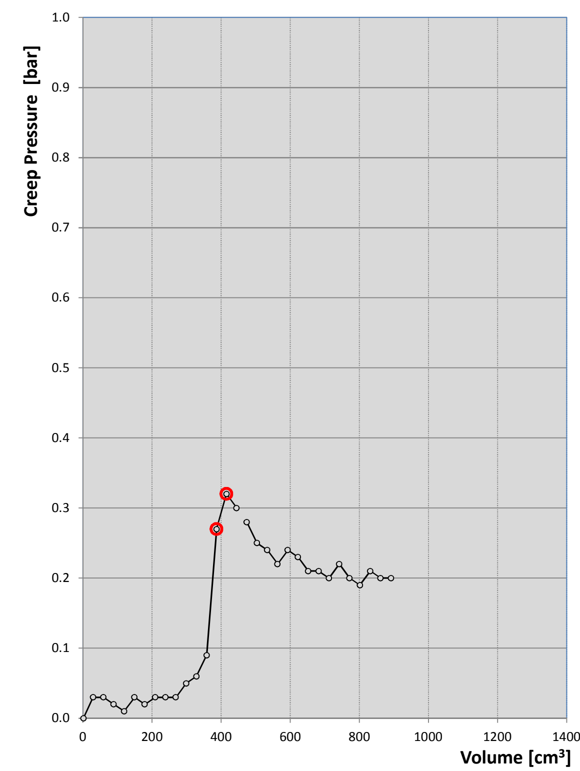
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	Δr/r₀ [%]	Pressure [bar]	Volume [cm³]	Δr/r₀ [%]	Volume [cm³]	Δp 30-15 [bar]	Pressure [bar]	1 / V
2	0.51	0.51	2.53	2	0.00	2.53	2	0.00	2	0.00	2.53	0.64858
30	0.58	0.55	2.58	29.5	0.75	2.55	29.5	0.75	29.5	0.03	2.55	0.03389
60	0.62	0.59	2.59	59.4	1.50	2.56	59.5	1.50	59.5	0.03	2.56	0.01682
90	0.66	0.64	2.60	89.4	2.25	2.58	89.4	2.25	89.4	0.02	2.58	0.01118
120	0.68	0.67	2.60	119.4	2.99	2.59	119.4	2.99	119.4	0.01	2.59	0.00838
150	0.73	0.70	2.63	149.3	3.73	2.60	149.4	3.73	149.4	0.03	2.60	0.00669
180	0.76	0.74	2.63	179.3	4.46	2.61	179.3	4.46	179.3	0.02	2.61	0.00558
210	0.83	0.80	2.68	209.3	5.18	2.65	209.3	5.18	209.3	0.03	2.65	0.00478
240	0.94	0.91	2.78	239.2	5.90	2.75	239.2	5.90	239.2	0.03	2.75	0.00418
270	1.07	1.04	2.89	269.0	6.62	2.86	269.1	6.62	269.1	0.03	2.86	0.00372
300	1.30	1.25	3.11	298.8	7.33	3.06	298.9	7.33	298.9	0.05	3.06	0.00335
330	1.62	1.56	3.42	328.5	8.03	3.36	328.6	8.03	328.6	0.06	3.36	0.00304
360	2.18	2.09	3.97	358.0	8.72	3.88	358.1	8.72	358.1	0.09	3.88	0.00279
390	3.73	3.46	5.51	386.6	9.38	5.24	386.9	9.39	386.9	0.27	5.24	0.00258
420	5.30	4.98	7.07	415.2	10.05	6.75	415.5	10.05	415.5	0.32	6.75	0.00241
450	6.17	5.87	7.94	444.5	10.72	7.64	444.7	10.73	444.7	0.30	7.64	0.00225
440	4.12	4.05	5.89	436.3	10.53	5.82	436.4	10.53			5.82	0.00229
430	3.03	3.02	4.80	427.3	10.32	4.79	427.3	10.32			4.79	0.00234
420	2.43	2.44	4.20	417.8	10.11	4.21	417.8	10.11			4.21	0.00239
430	3.63	3.55	5.40	426.7	10.31	5.32	426.8	10.31			5.32	0.00234
440	4.44	4.27	6.21	436.0	10.53	6.04	436.2	10.53			6.04	0.00229
450	5.16	4.94	6.93	445.4	10.74	6.71	445.6	10.74			6.71	0.00224
480	6.52	6.24	8.28	474.1	11.40	8.00	474.4	11.40	474.4	0.28	8.00	0.00211
510	7.10	6.85	8.85	503.6	12.07	8.60	503.8	12.07	503.8	0.25	8.60	0.00198
540	7.49	7.25	9.24	533.3	12.74	9.00	533.5	12.74	533.5	0.24	9.00	0.00187
570	7.82	7.60	9.57	563.0	13.41	9.35	563.2	13.41	563.2	0.22	9.35	0.00178
600	8.11	7.87	9.86	592.7	14.07	9.62	592.9	14.08	592.9	0.24	9.62	0.00169
630	8.35	8.12	10.09	622.5	14.73	9.86	622.7	14.74	622.7	0.23	9.86	0.00161
660	8.55	8.34	10.29	652.3	15.39	10.08	652.5	15.40	652.5	0.21	10.08	0.00153
690	8.73	8.52	10.47	682.2	16.05	10.26	682.3	16.05	682.3	0.21	10.26	0.00147
720	8.88	8.68	10.61	712.0	16.70	10.41	712.2	16.70	712.2	0.20	10.41	0.00140
750	9.04	8.82	10.77	741.9	17.35	10.55	742.1	17.35	742.1	0.22	10.55	0.00135
780	9.17	8.97	10.89	771.8	17.99	10.69	771.9	18.00	771.9	0.20	10.69	0.00130
810	9.28	9.09	10.99	801.7	18.63	10.80	801.8	18.64	801.8	0.19	10.80	0.00125
840	9.40	9.19	11.11	831.6	19.27	10.90	831.7	19.28	831.7	0.21	10.90	0.00120
870	9.50	9.30	11.21	861.5	19.91	11.01	861.6	19.91	861.6	0.20	11.01	0.00116
900	9.60	9.40	11.31	891.4	20.54	11.11	891.6	20.54	891.6	0.20	11.11	0.00112

Interpreted PMT Test Results

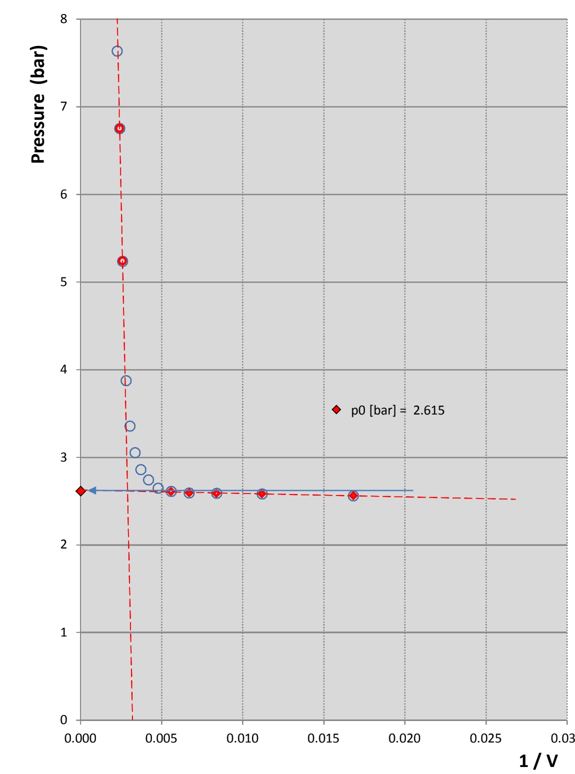
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	2.62	[bar]	179.3	4.5	
p_L	12.98	[bar]			
p^*_L	10.36	[bar]			
p_Y	6.75	[bar]	416	10.1	
E_{PMT}	333	[bar]	387	9.4	[9.4 - 10.1 %]
E_{PMT} / p^*_L	32.1				
$E_{Unload\ 1}$	812	[bar]	418	10.1	
$E_{Reload\ 1}$	453	[bar]			



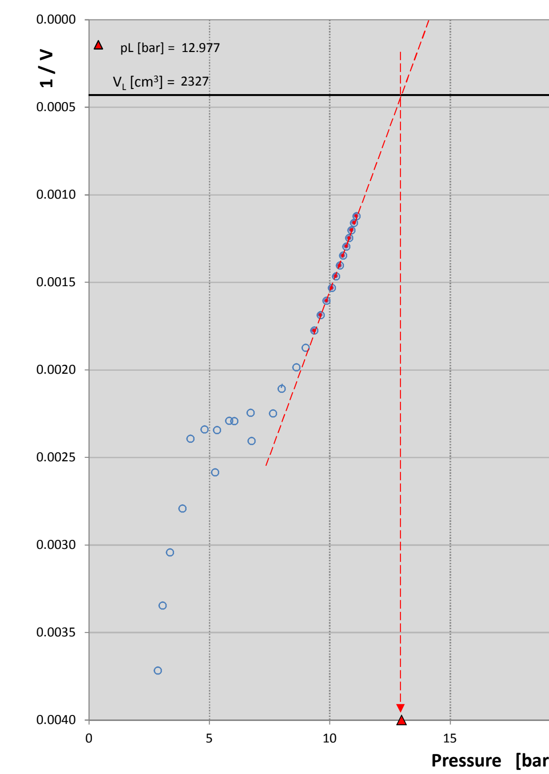
Pressuremeter test results [corrected data] pressure vs radial strain



Pressure difference from 15 to 30 sec. readings Δp [15-30 sec]



Determination of total contact pressure p_0



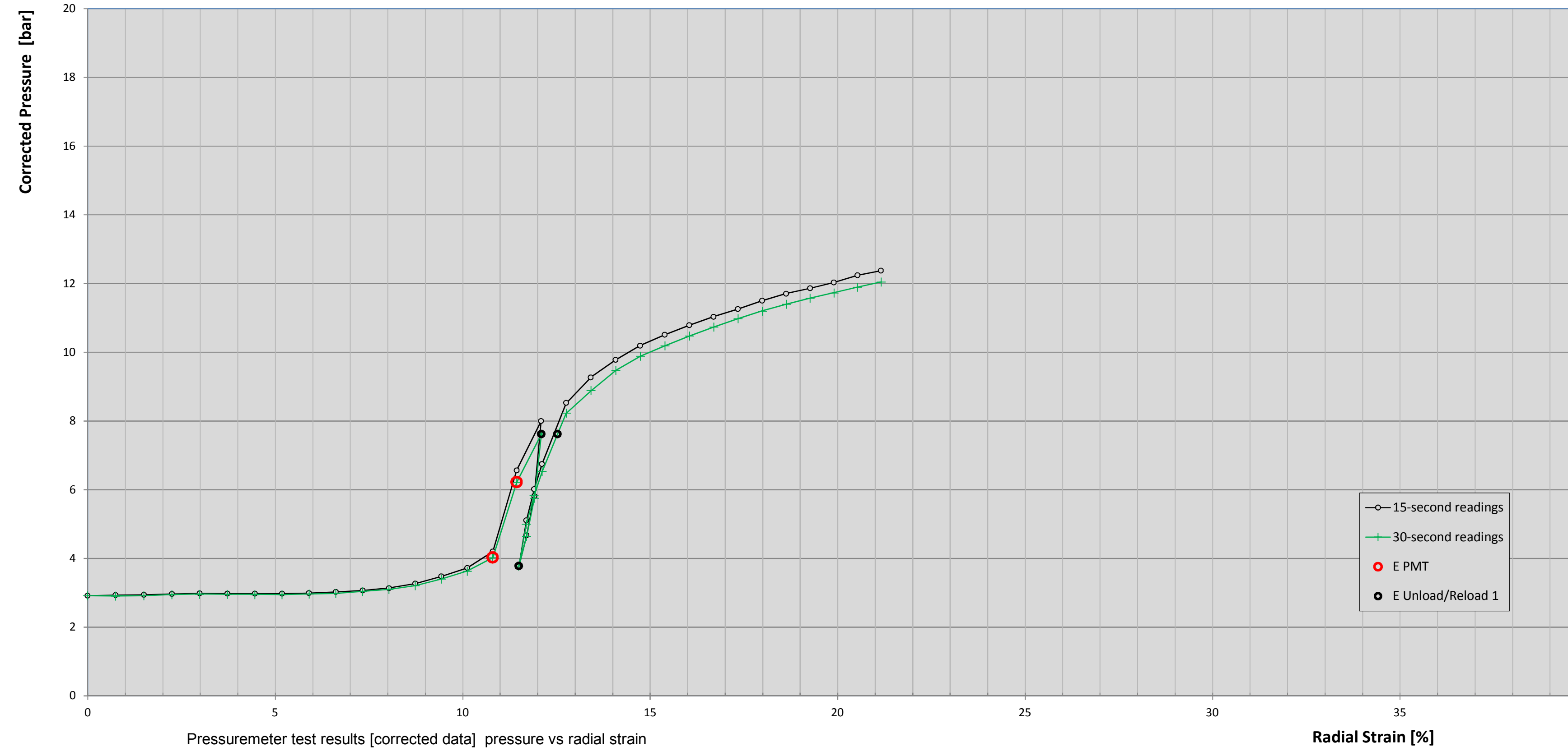
Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit	Test Date: January 24, 2018	Project: HWY 400 and HWY 89
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes	Test Depth [m]: 22.40 (center of the probe)	Client: Golder Associates
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Drilling Company: Walker Drilling	In-Depth Geotechnical Project No.: IDG 180411

PMT TEST No.: 7

Borehole No.: BH 01-PMT

Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	Δr/r₀ [%]	Pressure [bar]	Volume [cm³]	Δr/r₀ [%]	Volume [cm³]	Δp 30-15 [bar]	Pressure [bar]	1 / V
2	0.59	0.59	2.92	1	0.00	2.92	1	0.00	1	0.00	2.92	0.68030
30	0.63	0.61	2.93	29.4	0.75	2.91	29.5	0.75	29.5	0.02	2.91	0.03395
60	0.67	0.64	2.94	59.4	1.50	2.91	59.4	1.50	59.4	0.03	2.91	0.01683
90	0.72	0.70	2.97	89.4	2.25	2.95	89.4	2.25	89.4	0.02	2.95	0.01119
120	0.76	0.74	2.98	119.3	2.99	2.96	119.3	2.99	119.3	0.02	2.96	0.00838
150	0.78	0.76	2.98	149.3	3.72	2.96	149.3	3.72	149.3	0.02	2.96	0.00670
180	0.80	0.78	2.97	179.3	4.46	2.95	179.3	4.46	179.3	0.02	2.95	0.00558
210	0.82	0.80	2.97	209.3	5.18	2.95	209.3	5.18	209.3	0.02	2.95	0.00478
240	0.85	0.83	2.99	239.2	5.90	2.97	239.3	5.91	239.3	0.02	2.97	0.00418
270	0.90	0.86	3.02	269.2	6.62	2.98	269.2	6.62	269.2	0.04	2.98	0.00371
300	0.96	0.93	3.07	299.1	7.33	3.04	299.2	7.33	299.2	0.03	3.04	0.00334
330	1.04	1.00	3.14	329.1	8.04	3.10	329.1	8.04	329.1	0.04	3.10	0.00304
360	1.18	1.12	3.27	358.9	8.74	3.21	359.0	8.74	359.0	0.06	3.21	0.00279
390	1.40	1.32	3.48	388.7	9.43	3.40	388.8	9.43	388.8	0.08	3.40	0.00257
420	1.65	1.56	3.72	418.5	10.12	3.63	418.6	10.12	418.6	0.09	3.63	0.00239
450	2.13	1.96	4.20	448.1	10.80	4.03	448.2	10.81	448.2	0.17	4.03	0.00223
480	4.50	4.16	6.56	476.0	11.44	6.22	476.3	11.45	476.3	0.34	6.22	0.00210
510	5.94	5.56	8.00	504.7	12.09	7.62	505.0	12.10	505.0	0.38	7.62	0.00198
500	3.76	3.70	5.82	496.6	11.91	5.76	496.7	11.91			5.76	0.00201
490	2.61	2.59	4.67	487.7	11.71	4.65	487.7	11.71			4.65	0.00205
480	1.70	1.72	3.76	478.5	11.50	3.78	478.5	11.50			3.78	0.00209
490	3.05	2.94	5.11	487.3	11.70	5.00	487.4	11.70			5.00	0.00205
500	3.96	3.78	6.02	496.4	11.91	5.84	496.6	11.91			5.84	0.00201
510	4.69	4.48	6.75	505.8	12.12	6.54	506.0	12.12			6.54	0.00198
540	6.47	6.18	8.52	534.2	12.76	8.23	534.4	12.77	534.4	0.29	8.23	0.00187
570	7.22	6.84	9.27	563.5	13.42	8.89	563.9	13.43	563.9	0.38	8.89	0.00177
600	7.73	7.43	9.78	593.1	14.08	9.48	593.3	14.08	593.3	0.30	9.48	0.00169
630	8.15	7.84	10.19	622.7	14.74	9.88	623.0	14.74	623.0	0.31	9.88	0.00161
660	8.47	8.15	10.51	652.4	15.39	10.19	652.7	15.40	652.7	0.32	10.19	0.00153
690	8.75	8.44	10.79	682.1	16.05	10.48	682.4	16.05	682.4	0.31	10.48	0.00147
720	9.00	8.70	11.03	711.9	16.70	10.73	712.2	16.70	712.2	0.30	10.73	0.00140
750	9.23	8.95	11.26	741.7	17.34	10.98	742.0	17.35	742.0	0.28	10.98	0.00135
780	9.48	9.18	11.50	771.5	17.99	11.20	771.8	17.99	771.8	0.30	11.20	0.00130
810	9.69	9.38	11.71	801.3	18.63	11.40	801.6	18.63	801.6	0.31	11.40	0.00125
840	9.85	9.56	11.86	831.2	19.26	11.57	831.4	19.27	831.4	0.29	11.57	0.00120
870	10.02	9.72	12.03	861.0	19.90	11.73	861.3	19.90	861.3	0.30	11.73	0.00116
900	10.23	9.89	12.24	890.8	20.53	11.90	891.1	20.54	891.1	0.34	11.90	0.00112
930	10.37	10.04	12.37	920.7	21.16	12.04	921.0	21.16	921.0	0.33	12.04	0.00109

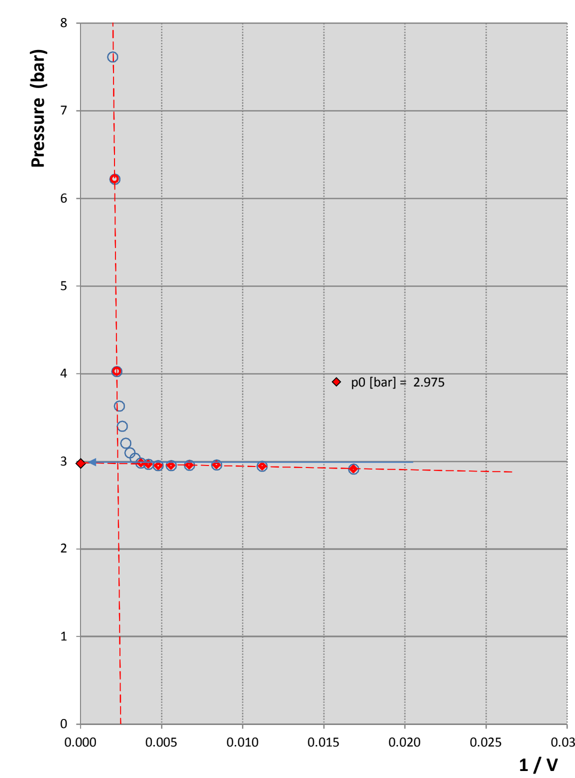


Pressuremeter test results [corrected data] pressure vs radial strain

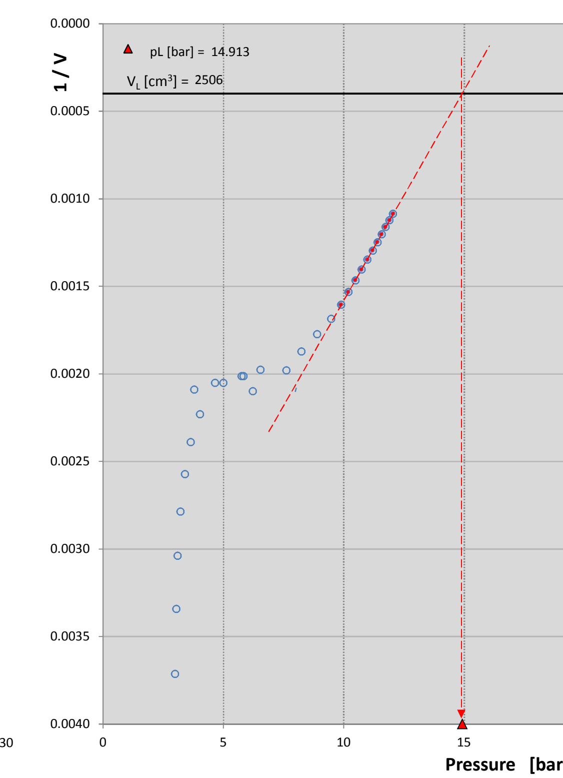
Interpreted PMT Test Results

[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	2.98	[bar]	269.2	6.6	
p_L	14.91	[bar]			
p^*_L	11.94	[bar]			
p_Y	6.22	[bar]	476	11.4	
E_{PMT}	506	[bar]	448	10.8	[10.8 - 11.5 %]
E_{PMT} / p^*_L	42.4				
$E_{Unload\ 1}$	945	[bar]	478	11.5	
$E_{Reload\ 1}$	552	[bar]			

Pressure difference from 15 to 30 sec. readings $\Delta p_{[15\text{-}30\ sec]}$



Determination of total contact pressure p_0



Determination of Limit Pressure p_L

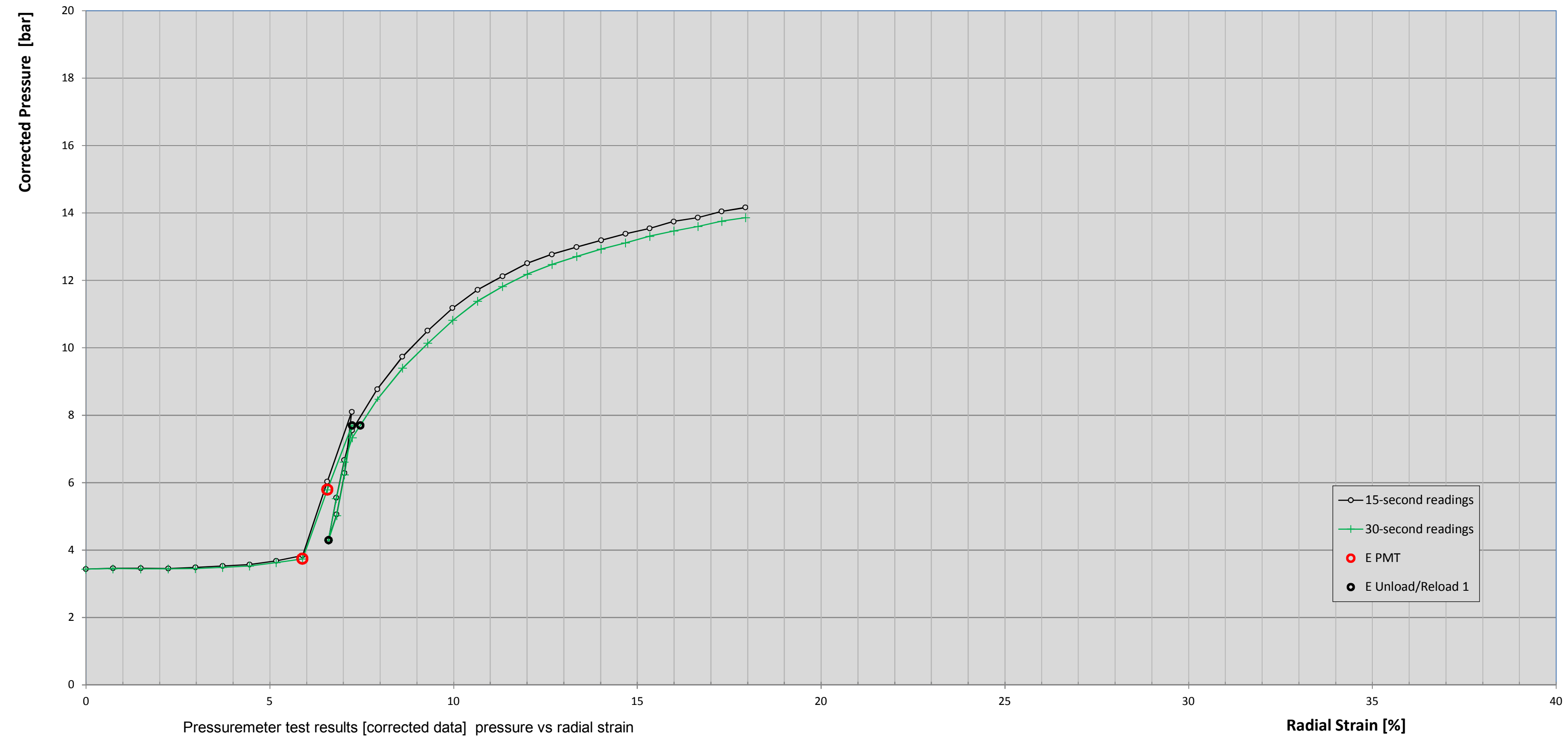
Pressuremeter Equipment: TEXAM Model Volume-controlled test as per ASTM D4719 Method B Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Probe Designation : NX Probe (76 mm OD) Probe No.: E 309 Calibration Record No.: 1 Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit Time elapsed from hole drilling to testing ~ 5 minutes Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Test Date: January 24, 2018 Test Depth [m]: 25.48 (center of the probe) Drilling Company: Walker Drilling	**Project:** **HWY 400 and HWY 89** Client: Golder Associates In-Depth Geotechnical Project No.: IDG 180411

PMT TEST No.: 8

Borehole No.: BH 01-PMT

In-Depth Geotechnical Inc.

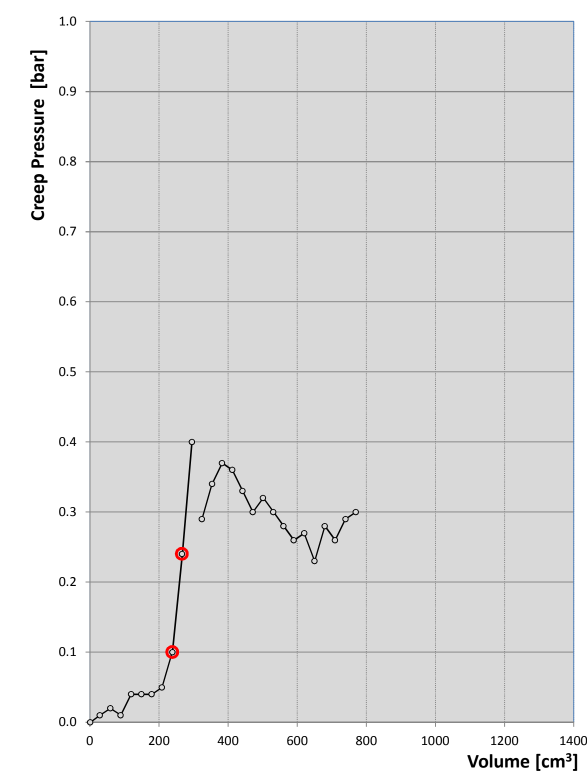
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	Δr/r0 [%]	Pressure [bar]	Volume [cm³]	Δr/r0 [%]	Volume [cm³]	Δp 30-15 [bar]	Pressure [bar]	1 / V
2	0.81	0.81	3.43	1	0.00	3.43	1	0.00	1	0.00	3.43	0.78598
30	0.86	0.85	3.46	29.2	0.74	3.45	29.2	0.74	29.2	0.01	3.45	0.03420
60	0.89	0.87	3.46	59.2	1.49	3.44	59.2	1.49	59.2	0.02	3.44	0.01689
90	0.91	0.90	3.45	89.2	2.24	3.44	89.2	2.24	89.2	0.01	3.44	0.01121
120	0.97	0.93	3.49	119.1	2.98	3.45	119.2	2.98	119.2	0.04	3.45	0.00839
150	1.03	0.99	3.53	149.1	3.72	3.49	149.1	3.72	149.1	0.04	3.49	0.00671
180	1.10	1.06	3.57	179.0	4.45	3.53	179.0	4.45	179.0	0.04	3.53	0.00559
210	1.23	1.18	3.68	208.9	5.17	3.63	208.9	5.18	208.9	0.05	3.63	0.00479
240	1.40	1.30	3.84	238.7	5.89	3.74	238.8	5.90	238.8	0.10	3.74	0.00419
270	3.61	3.37	6.03	266.8	6.56	5.79	267.0	6.57	267.0	0.24	5.79	0.00375
300	5.69	5.29	8.10	294.9	7.23	7.70	295.2	7.24	295.2	0.40	7.70	0.00339
290	3.87	3.82	6.28	286.5	7.03	6.23	286.6	7.03			6.23	0.00349
280	2.64	2.61	5.06	277.6	6.82	5.03	277.7	6.82			5.03	0.00360
270	1.88	1.87	4.30	268.3	6.60	4.29	268.3	6.60			4.29	0.00373
280	3.14	3.11	5.56	277.2	6.81	5.53	277.2	6.81			5.53	0.00361
290	4.26	4.20	6.67	286.2	7.02	6.61	286.2	7.03			6.61	0.00349
300	5.15	4.93	7.56	295.4	7.24	7.34	295.6	7.25			7.34	0.00338
330	6.37	6.08	8.77	324.3	7.93	8.48	324.5	7.93	324.5	0.29	8.48	0.00308
360	7.35	7.01	9.74	353.4	8.61	9.40	353.7	8.62	353.7	0.34	9.40	0.00283
390	8.13	7.76	10.51	382.7	9.29	10.14	383.0	9.30	383.0	0.37	10.14	0.00261
420	8.81	8.45	11.18	412.1	9.97	10.82	412.4	9.98	412.4	0.36	10.82	0.00242
450	9.35	9.02	11.72	441.6	10.65	11.39	441.9	10.66	441.9	0.33	11.39	0.00226
480	9.76	9.46	12.12	471.2	11.33	11.82	471.5	11.34	471.5	0.30	11.82	0.00212
510	10.15	9.83	12.50	500.9	12.01	12.18	501.2	12.01	501.2	0.32	12.18	0.00200
540	10.42	10.12	12.77	530.6	12.68	12.47	530.9	12.69	530.9	0.30	12.47	0.00188
570	10.64	10.36	12.99	560.4	13.35	12.71	560.7	13.36	560.7	0.28	12.71	0.00178
600	10.84	10.58	13.19	590.3	14.02	12.93	590.5	14.02	590.5	0.26	12.93	0.00169
630	11.04	10.77	13.38	620.1	14.68	13.11	620.3	14.68	620.3	0.27	13.11	0.00161
660	11.20	10.97	13.54	649.9	15.34	13.31	650.1	15.34	650.1	0.23	13.31	0.00154
690	11.41	11.13	13.75	679.7	15.99	13.47	680.0	16.00	680.0	0.28	13.47	0.00147
720	11.53	11.27	13.86	709.6	16.65	13.60	709.9	16.65	709.9	0.26	13.60	0.00141
750	11.72	11.43	14.05	739.5	17.29	13.76	739.7	17.30	739.7	0.29	13.76	0.00135
780	11.84	11.54	14.16	769.4	17.94	13.86	769.6	17.95	769.6	0.30	13.86	0.00130



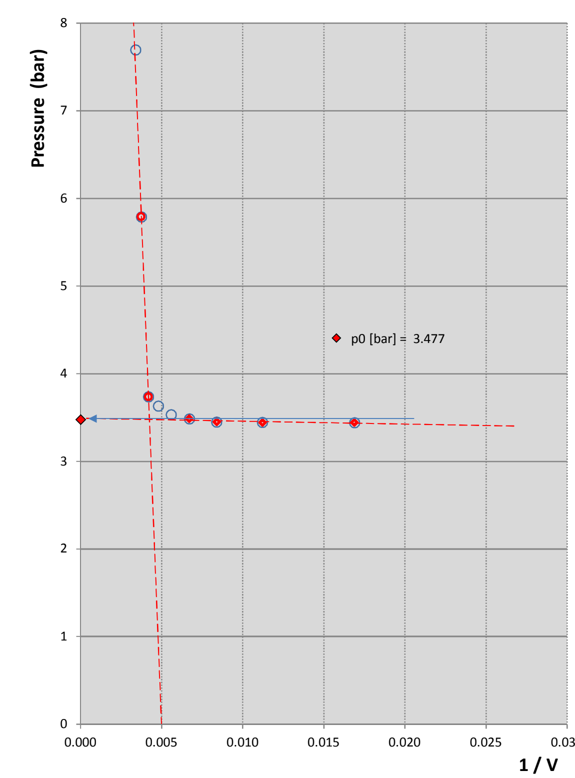
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

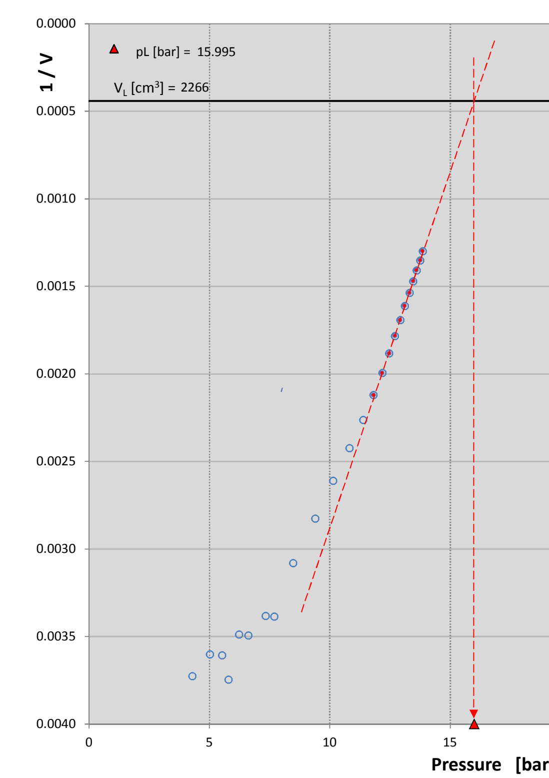
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	3.48	[bar]	149.1	3.7	
p_L	15.99	[bar]			
p^*_L	12.52	[bar]			
p_Y	5.79	[bar]	267	6.6	
E_{PMT}	431	[bar]	239	5.9	[5.9 - 6.6 %]
E_{PMT} / p^*_L	34.5				
$E_{Unload\ 1}$	757	[bar]	268	6.6	
$E_{Reload\ 1}$	561	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15\text{-}30\ sec]}$



Determination of total contact pressure p_0



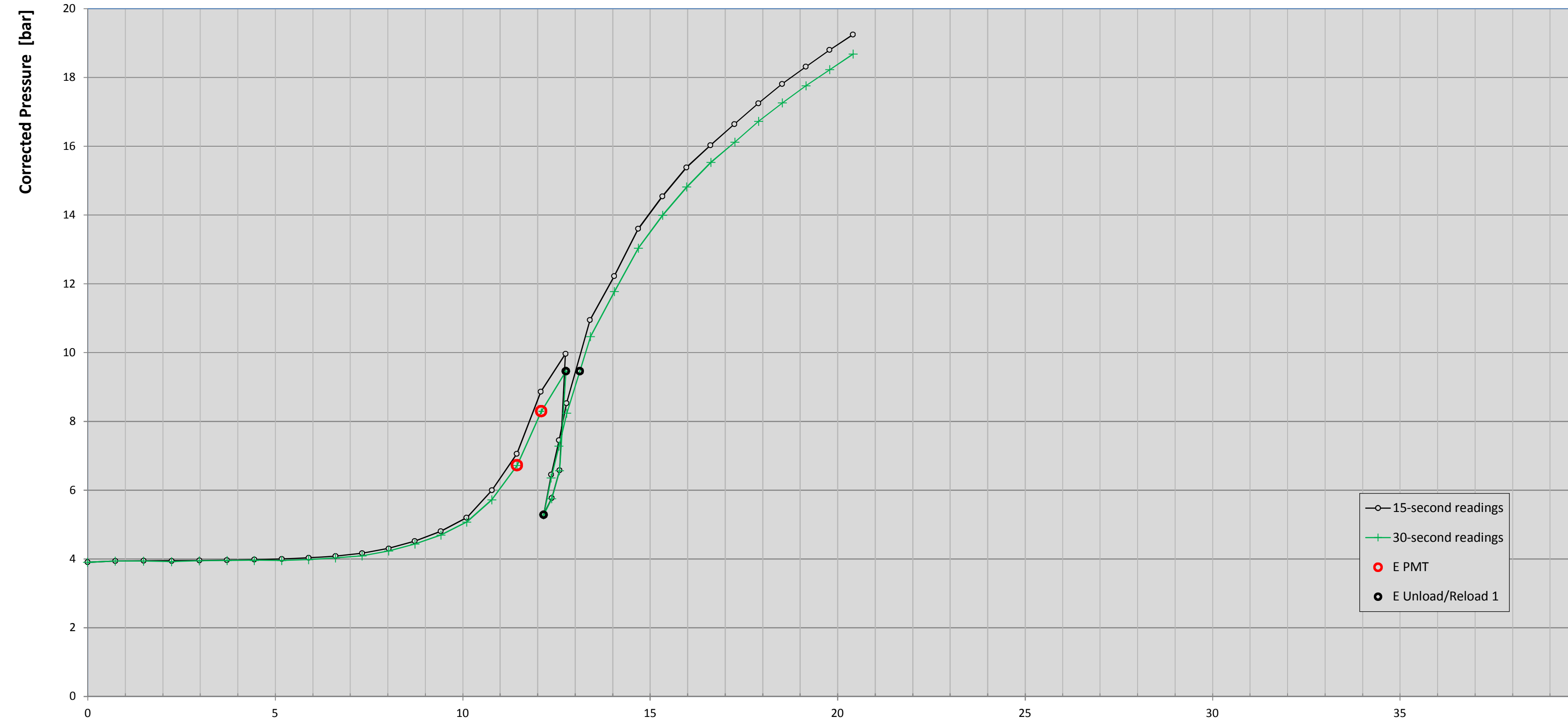
Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit	Test Date: January 24, 2018
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes	Test Depth [m]: 28.52 (center of the probe)
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Drilling Company: Walker Drilling

Project:	**HWY 400 and HWY 89**	**PMT TEST No.:**	**9**
Client:	Golder Associates	**Borehole No.:**	**BH 01-PMT**
In-Depth Geotechnical Project No.:	IDG 180411		

In-Depth Geotechnical Inc.

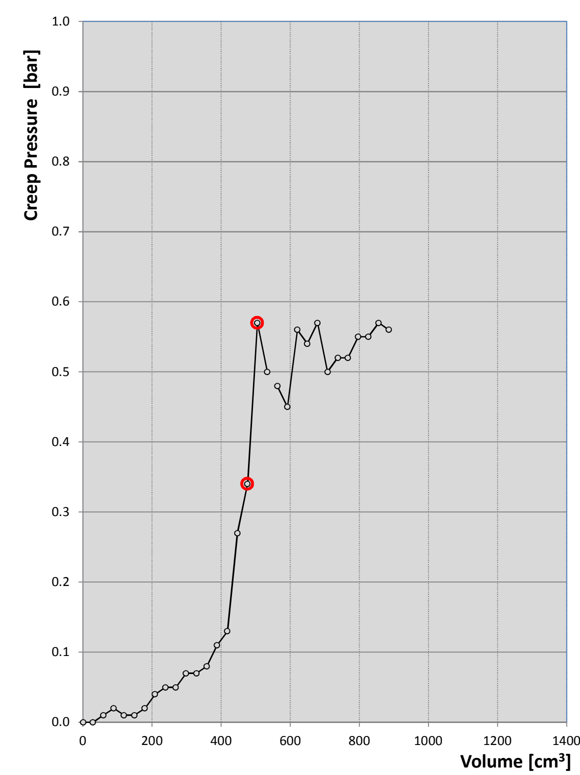
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Volume [cm³]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	0.98	0.98	3.90	1	0.00	3.90	1	0.00	1	0.00	3.90	0.89320
30	1.04	1.04	3.94	29.1	0.74	3.94	29.1	0.74	29.1	0.00	3.94	0.03440
60	1.08	1.07	3.95	59.0	1.49	3.94	59.0	1.49	59.0	0.01	3.94	0.01694
90	1.10	1.08	3.94	89.0	2.24	3.92	89.0	2.24	89.0	0.02	3.92	0.01123
120	1.14	1.13	3.96	119.0	2.98	3.95	119.0	2.98	119.0	0.01	3.95	0.00840
150	1.17	1.16	3.96	148.9	3.72	3.95	149.0	3.72	149.0	0.01	3.95	0.00671
180	1.21	1.19	3.98	178.9	4.45	3.96	178.9	4.45	178.9	0.02	3.96	0.00559
210	1.25	1.21	4.00	208.9	5.17	3.96	208.9	5.17	208.9	0.04	3.96	0.00479
240	1.30	1.25	4.03	238.8	5.90	3.98	238.9	5.90	238.9	0.05	3.98	0.00419
270	1.36	1.31	4.08	268.8	6.61	4.03	268.8	6.61	268.8	0.05	4.03	0.00372
300	1.46	1.39	4.16	298.7	7.32	4.09	298.8	7.32	298.8	0.07	4.09	0.00335
330	1.61	1.54	4.31	328.6	8.03	4.24	328.6	8.03	328.6	0.07	4.24	0.00304
360	1.83	1.75	4.52	358.4	8.73	4.44	358.4	8.73	358.4	0.08	4.44	0.00279
390	2.13	2.02	4.81	388.1	9.42	4.70	388.2	9.42	388.2	0.11	4.70	0.00258
420	2.53	2.40	5.20	417.7	10.10	5.07	417.8	10.11	417.8	0.13	5.07	0.00239
450	3.33	3.06	5.99	447.0	10.78	5.72	447.3	10.78	447.3	0.27	5.72	0.00224
480	4.40	4.06	7.06	476.0	11.44	6.72	476.4	11.45	476.4	0.34	6.72	0.00210
510	6.21	5.64	8.86	504.4	12.09	8.29	504.9	12.10	504.9	0.57	8.29	0.00198
540	7.31	6.81	9.96	533.4	12.74	9.46	533.9	12.75	533.9	0.50	9.46	0.00187
530	3.93	3.92	6.58	526.5	12.59	6.57	526.5	12.59			6.57	0.00190
520	3.12	3.10	5.77	517.2	12.38	5.75	517.2	12.38			5.75	0.00193
510	2.65	2.63	5.30	507.6	12.16	5.28	507.6	12.16			5.28	0.00197
520	3.80	3.71	6.45	516.6	12.36	6.36	516.7	12.36			6.36	0.00194
530	4.80	4.63	7.45	525.7	12.57	7.28	525.8	12.57			7.28	0.00190
540	5.88	5.59	8.53	534.7	12.77	8.24	535.0	12.78			8.24	0.00187
570	8.30	7.82	10.95	562.5	13.40	10.47	563.0	13.41	563.0	0.48	10.47	0.00178
600	9.58	9.13	12.22	591.4	14.04	11.77	591.8	14.05	591.8	0.45	11.77	0.00169
630	10.96	10.40	13.60	620.2	14.68	13.04	620.7	14.69	620.7	0.56	13.04	0.00161
660	11.90	11.36	14.54	649.3	15.32	14.00	649.8	15.34	649.8	0.54	14.00	0.00154
690	12.75	12.18	15.39	678.5	15.97	14.82	679.1	15.98	679.1	0.57	14.82	0.00147
720	13.40	12.90	16.03	708.0	16.61	15.53	708.4	16.62	708.4	0.50	15.53	0.00141
750	14.02	13.50	16.64	737.4	17.25	16.12	737.9	17.26	737.9	0.52	16.12	0.00136
780	14.63	14.11	17.25	766.9	17.89	16.73	767.3	17.90	767.3	0.52	16.73	0.00130
810	15.20	14.65	17.81	796.3	18.52	17.26	796.8	18.53	796.8	0.55	17.26	0.00125
840	15.70	15.15	18.31	825.9	19.15	17.76	826.4	19.16	826.4	0.55	17.76	0.00121
870	16.19	15.62	18.80	855.5	19.78	18.23	856.0	19.79	856.0	0.57	18.23	0.00117
900	16.64	16.08	19.24	885.1	20.41	18.68	885.6	20.42	885.6	0.56	18.68	0.00113



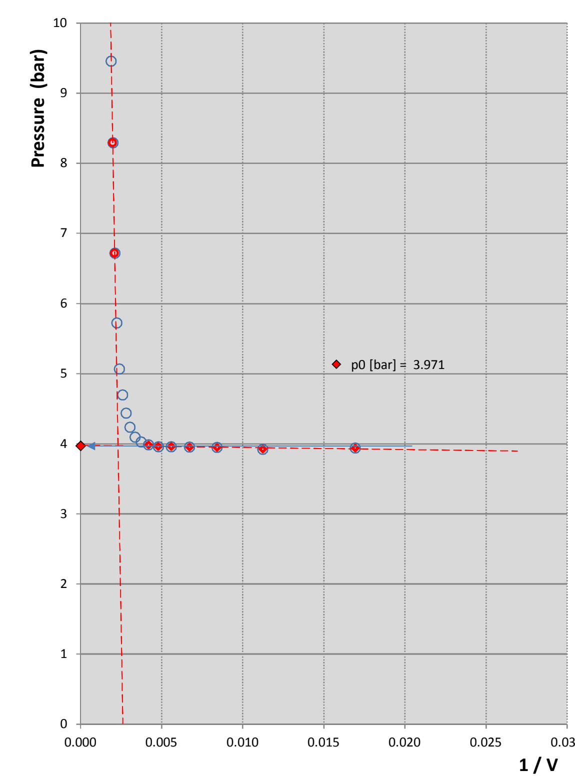
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

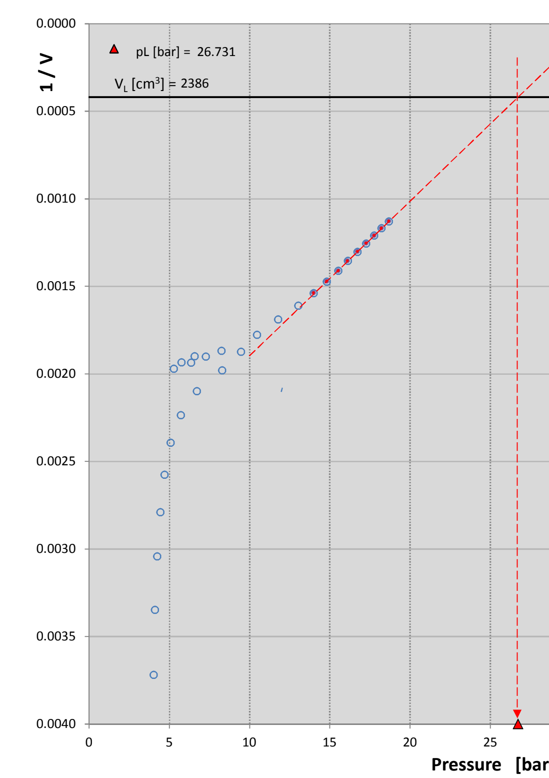
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	3.97	[bar]	208.9	5.2	
p_L	26.73	[bar]			
p^*_L	22.76	[bar]			
p_Y	8.29	[bar]	505	12.1	
E_{PMT}	360	[bar]	476	11.4	[11.5 - 12.1 %]
E_{PMT} / p^*_L	15.8				
$E_{Unload\ 1}$	1054	[bar]	508	12.2	
$E_{Reload\ 1}$	650	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15\text{-}30\ sec]}$



Determination of total contact pressure p_0

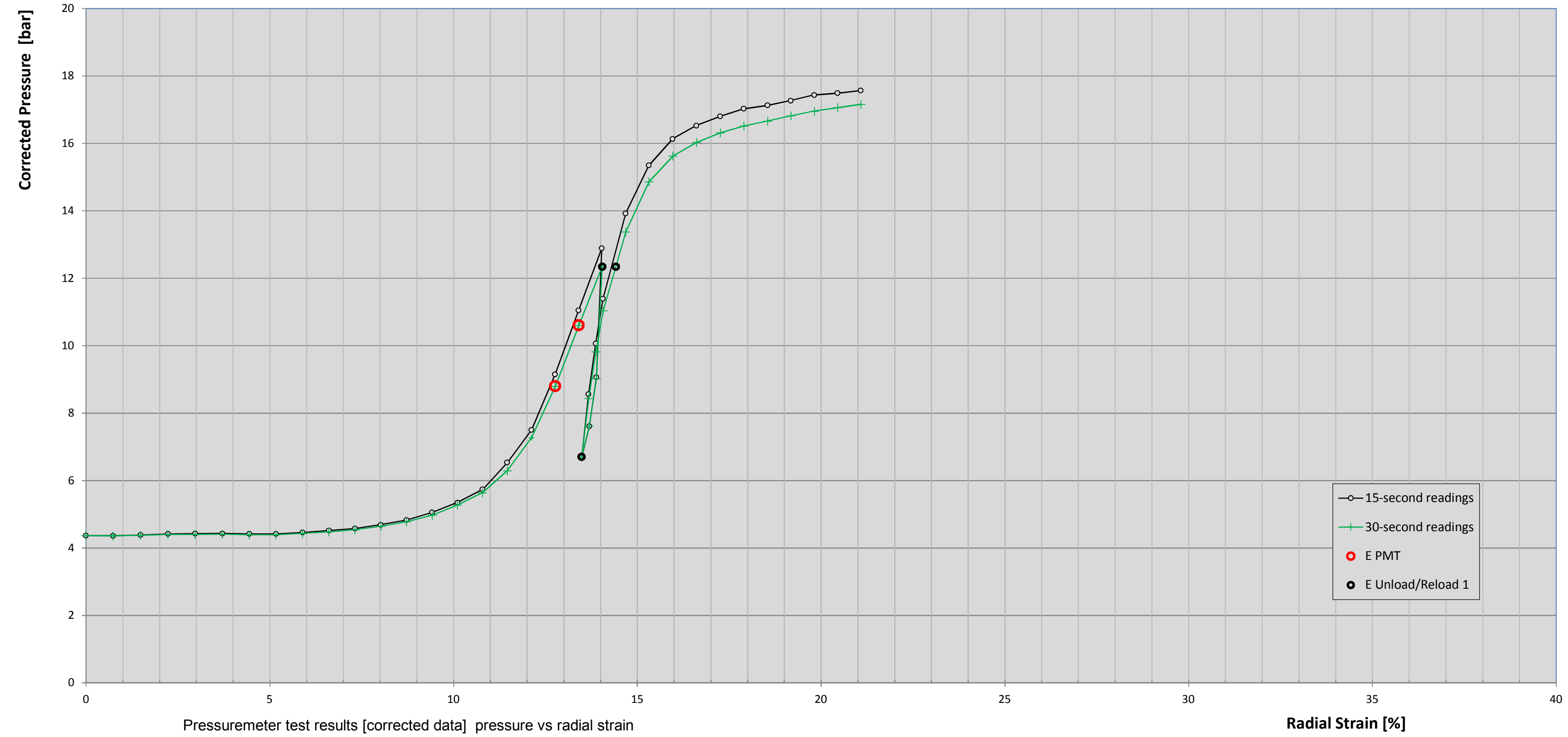


Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit	Test Date: January 24, 2018
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes	Test Depth [m]: 31.57 (center of the probe)
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Drilling Company: Walker Drilling

Project:	**HWY 400 and HWY 89**	**PMT TEST No.:**	**10**
Client:	Golder Associates	**Borehole No.:**	**BH 01-PMT**
In-Depth Geotechnical Project No.:	IDG 180411		

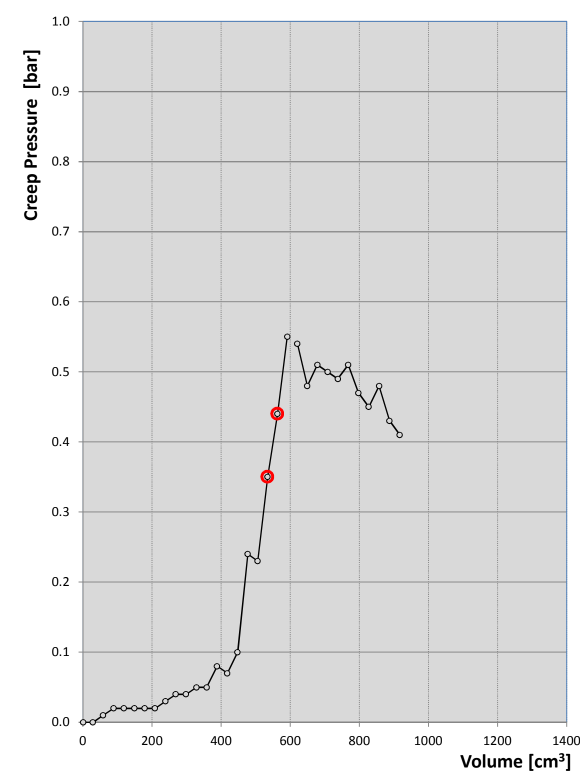
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Volume [cm³]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	1.15	1.15	4.37	1	0.00	4.37	1	0.00	1	0.00	4.37	1.03429
30	1.17	1.17	4.36	28.9	0.73	4.36	28.9	0.73	28.9	0.00	4.36	0.03454
60	1.22	1.21	4.39	58.9	1.49	4.38	58.9	1.49	58.9	0.01	4.38	0.01697
90	1.28	1.26	4.42	88.9	2.23	4.40	88.9	2.23	88.9	0.02	4.40	0.01125
120	1.31	1.29	4.42	118.8	2.98	4.40	118.8	2.98	118.8	0.02	4.40	0.00841
150	1.34	1.32	4.43	148.8	3.71	4.41	148.8	3.71	148.8	0.02	4.41	0.00672
180	1.35	1.33	4.42	178.8	4.44	4.40	178.8	4.44	178.8	0.02	4.40	0.00559
210	1.37	1.35	4.42	208.8	5.17	4.40	208.8	5.17	208.8	0.02	4.40	0.00479
240	1.43	1.40	4.46	238.7	5.89	4.43	238.7	5.89	238.7	0.03	4.43	0.00419
270	1.50	1.46	4.52	268.7	6.61	4.48	268.7	6.61	268.7	0.04	4.48	0.00372
300	1.58	1.54	4.58	298.6	7.32	4.54	298.6	7.32	298.6	0.04	4.54	0.00335
330	1.70	1.65	4.69	328.5	8.02	4.64	328.5	8.03	328.5	0.05	4.64	0.00304
360	1.85	1.80	4.83	358.3	8.72	4.78	358.4	8.73	358.4	0.05	4.78	0.00279
390	2.08	2.00	5.05	388.1	9.42	4.97	388.2	9.42	388.2	0.08	4.97	0.00258
420	2.38	2.31	5.35	417.9	10.11	5.28	417.9	10.11	417.9	0.07	5.28	0.00239
450	2.78	2.68	5.74	447.5	10.79	5.64	447.6	10.79	447.6	0.10	5.64	0.00223
480	3.58	3.34	6.53	476.8	11.46	6.29	477.0	11.46	477.0	0.24	6.29	0.00210
510	4.55	4.32	7.50	505.9	12.12	7.27	506.1	12.13	506.1	0.23	7.27	0.00198
540	6.20	5.85	9.15	534.4	12.77	8.80	534.7	12.77	534.7	0.35	8.80	0.00187
570	8.10	7.66	11.04	562.7	13.40	10.60	563.1	13.41	563.1	0.44	10.60	0.00178
600	9.95	9.40	12.89	591.1	14.03	12.34	591.6	14.05	591.6	0.55	12.34	0.00169
590	6.12	6.08	9.06	584.5	13.89	9.02	584.5	13.89			9.02	0.00171
580	4.67	4.68	7.61	575.8	13.69	7.62	575.8	13.69			7.62	0.00174
570	3.74	3.76	6.68	566.6	13.49	6.70	566.6	13.49			6.70	0.00176
580	5.62	5.49	8.56	575.0	13.67	8.43	575.1	13.68			8.43	0.00174
590	7.12	6.88	10.06	583.6	13.87	9.82	583.8	13.87			9.82	0.00171
600	8.45	8.10	11.39	592.4	14.06	11.04	592.7	14.07			11.04	0.00169
630	10.98	10.44	13.92	620.1	14.68	13.38	620.6	14.69	620.6	0.54	13.38	0.00161
660	12.41	11.93	15.34	648.9	15.31	14.86	649.3	15.32	649.3	0.48	14.86	0.00154
690	13.20	12.69	16.13	678.1	15.96	15.62	678.6	15.97	678.6	0.51	15.62	0.00147
720	13.60	13.10	16.53	707.8	16.61	16.03	708.2	16.62	708.2	0.50	16.03	0.00141
750	13.88	13.39	16.80	737.5	17.25	16.31	738.0	17.26	738.0	0.49	16.31	0.00136
780	14.11	13.60	17.02	767.3	17.90	16.51	767.8	17.91	767.8	0.51	16.51	0.00130
810	14.22	13.75	17.13	797.2	18.54	16.66	797.6	18.55	797.6	0.47	16.66	0.00125
840	14.36	13.91	17.27	827.1	19.18	16.82	827.5	19.19	827.5	0.45	16.82	0.00121
870	14.53	14.05	17.43	856.9	19.81	16.95	857.4	19.82	857.4	0.48	16.95	0.00117
900	14.59	14.16	17.49	886.9	20.45	17.06	887.3	20.45	887.3	0.43	17.06	0.00113
930	14.67	14.26	17.57	916.8	21.08	17.16	917.2	21.08	917.2	0.41	17.16	0.00109



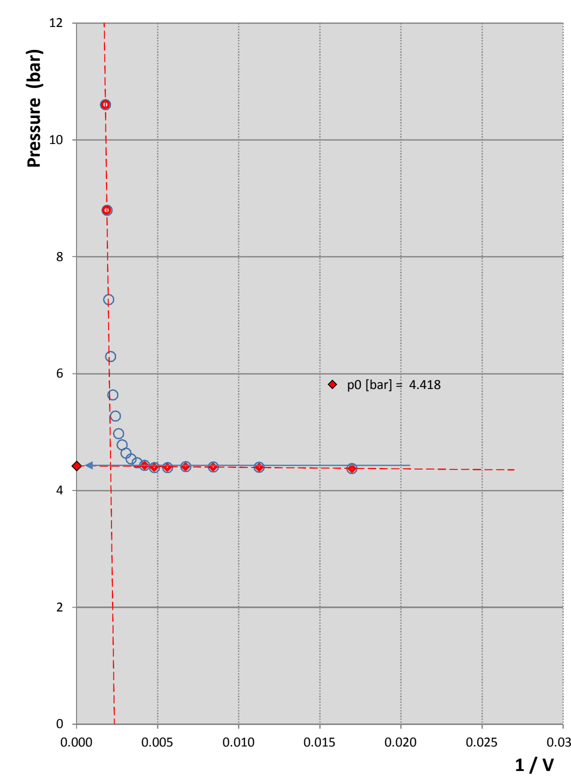
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

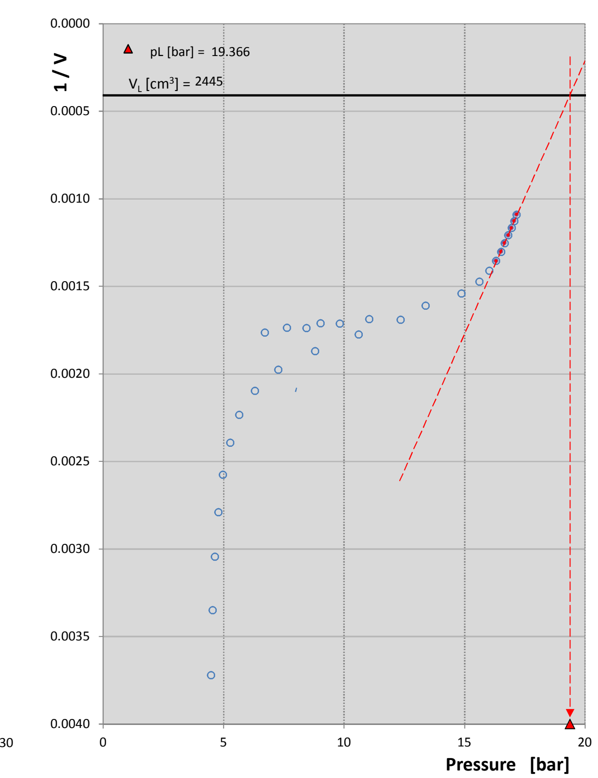
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	4.42	[bar]	238.7	5.9	
p_L	19.37	[bar]			
p^*_L	14.95	[bar]			
p_Y	10.60	[bar]	563	13.4	
E_{PMT}	426	[bar]	535	12.8	[12.8 - 13.4 %]
E_{PMT} / p^*_L	28.5				
$E_{Unload\ 1}$	1532	[bar]	567	13.5	
$E_{Reload\ 1}$	921	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15-30\ sec]}$



Determination of total contact pressure p_0



Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309
	Calibration Record No.: 1
Volume increments: 40 cm³	Tubing Length: 150 [ft]
Maximum Volume: 1400 cm³	Probe Lenght: 0.46 [m]
Maximum Pressure: 100 bar	Probe Initial Volume: 1968 cm³

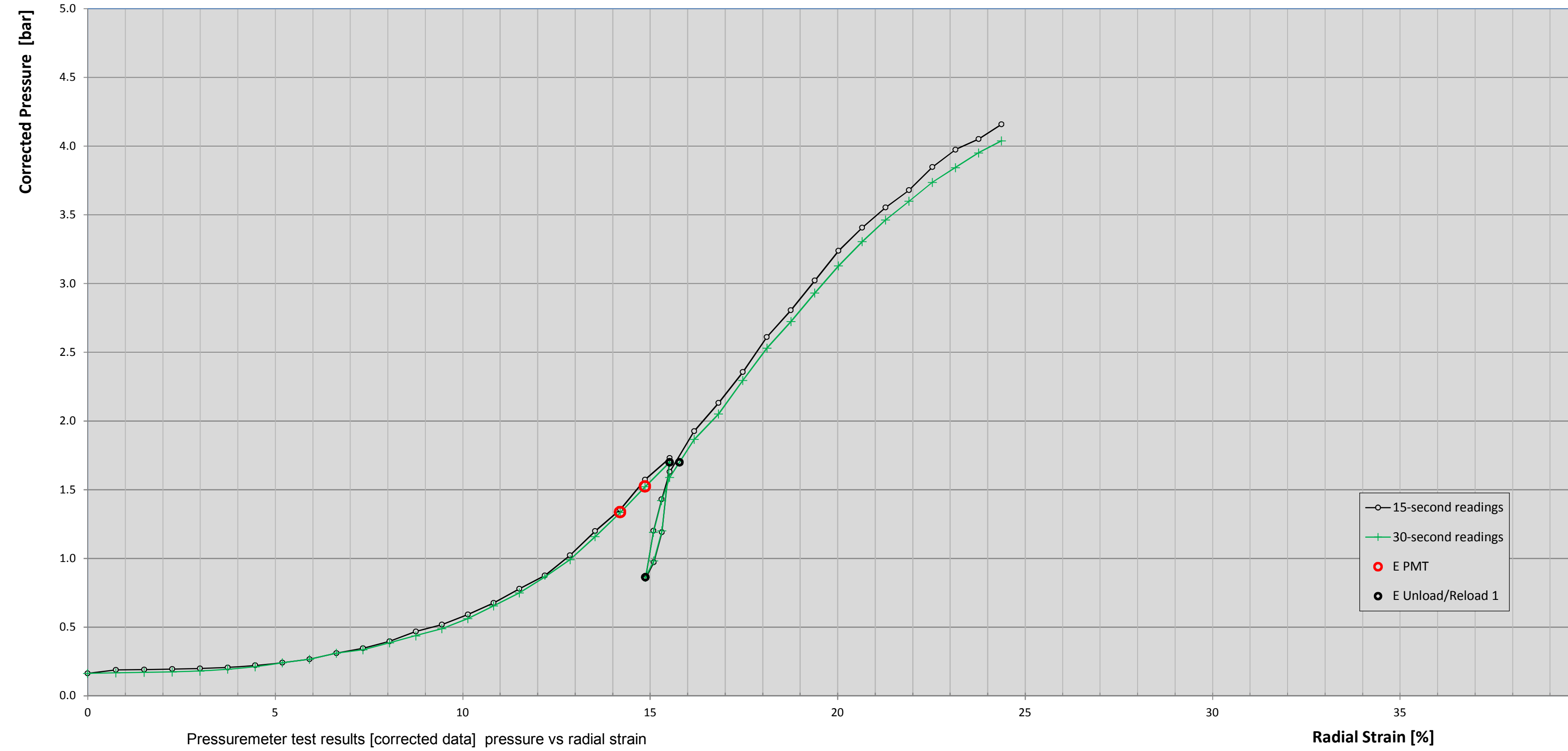
Drilling Method: Mud Rotary Drilling
Drilling Bit: Tricone Bit
Time elapsed from hole drilling to testing ~ 5 minutes
Engineer: Gabriel Sedran, P.Eng., Ph.D.
Operator: Scott Hall

Test Date: January 24, 2018
Test Depth [m]: 34.60 (center of the probe)
Drilling Company: Walker Drilling

Project: **HWY 400 and HWY 89**
Client: Golder Associates
In-Depth Geotechnical Project No.: IDG 180411

PMT TEST No.: 11
Borehole No.: BH 01-PMT

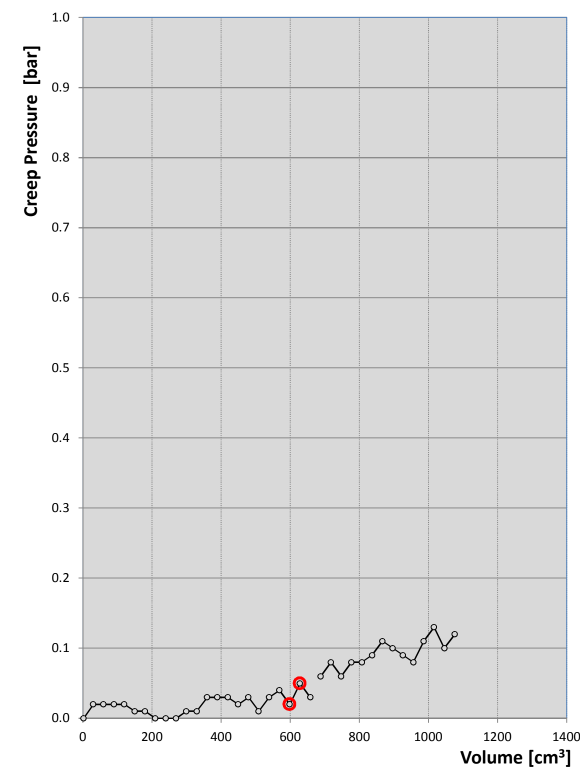
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Volume [cm³]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	0.13	0.13	0.16	2	0.00	0.16	2	0.00	2	0.00	0.16	0.53101
30	0.18	0.16	0.19	29.8	0.76	0.17	29.9	0.76	29.9	0.02	0.17	0.03349
60	0.21	0.19	0.19	59.8	1.51	0.17	59.8	1.51	59.8	0.02	0.17	0.01671
90	0.24	0.22	0.19	89.8	2.26	0.17	89.8	2.26	89.8	0.02	0.17	0.01114
120	0.27	0.25	0.20	119.8	3.00	0.18	119.8	3.00	119.8	0.02	0.18	0.00835
150	0.30	0.29	0.21	149.7	3.73	0.20	149.7	3.74	149.7	0.01	0.20	0.00668
180	0.34	0.33	0.22	179.7	4.47	0.21	179.7	4.47	179.7	0.01	0.21	0.00556
210	0.38	0.38	0.24	209.7	5.19	0.24	209.7	5.19	209.7	0.00	0.24	0.00477
240	0.42	0.42	0.27	239.6	5.91	0.27	239.6	5.91	239.6	0.00	0.27	0.00417
270	0.48	0.48	0.31	269.6	6.63	0.31	269.6	6.63	269.6	0.00	0.31	0.00371
300	0.53	0.52	0.35	299.5	7.34	0.34	299.5	7.34	299.5	0.01	0.34	0.00334
330	0.59	0.58	0.40	329.5	8.05	0.39	329.5	8.05	329.5	0.01	0.39	0.00304
360	0.67	0.64	0.47	359.4	8.75	0.44	359.4	8.75	359.4	0.03	0.44	0.00278
390	0.73	0.70	0.52	389.3	9.45	0.49	389.4	9.45	389.4	0.03	0.49	0.00257
420	0.81	0.78	0.59	419.3	10.14	0.56	419.3	10.14	419.3	0.03	0.56	0.00238
450	0.90	0.88	0.68	449.2	10.83	0.66	449.2	10.83	449.2	0.02	0.66	0.00223
480	1.01	0.98	0.78	479.1	11.51	0.75	479.1	11.51	479.1	0.03	0.75	0.00209
510	1.11	1.10	0.87	509.0	12.19	0.86	509.0	12.19	509.0	0.01	0.86	0.00196
540	1.26	1.23	1.02	538.9	12.87	0.99	538.9	12.87	538.9	0.03	0.99	0.00186
570	1.44	1.40	1.20	568.7	13.54	1.16	568.7	13.54	568.7	0.04	1.16	0.00176
600	1.60	1.58	1.36	598.6	14.20	1.34	598.6	14.20	598.6	0.02	1.34	0.00167
630	1.82	1.77	1.57	628.4	14.86	1.52	628.4	14.86	628.4	0.05	1.52	0.00159
660	1.98	1.95	1.73	658.2	15.52	1.70	658.2	15.52	658.2	0.03	1.70	0.00152
650	1.44	1.45	1.19	648.7	15.31	1.20	648.7	15.31			1.20	0.00154
640	1.22	1.23	0.97	638.9	15.10	0.98	638.9	15.10			0.98	0.00157
630	1.10	1.11	0.85	629.0	14.88	0.86	629.0	14.88			0.86	0.00159
640	1.45	1.44	1.20	638.7	15.09	1.19	638.7	15.09			1.19	0.00157
650	1.68	1.67	1.43	648.5	15.31	1.42	648.5	15.31			1.42	0.00154
660	1.88	1.84	1.63	658.3	15.52	1.59	658.3	15.52			1.59	0.00152
690	2.18	2.12	1.93	688.0	16.18	1.87	688.1	16.18	688.1	0.06	1.87	0.00145
720	2.39	2.31	2.13	717.9	16.83	2.05	717.9	16.83	717.9	0.08	2.05	0.00139
750	2.62	2.56	2.36	747.6	17.47	2.30	747.7	17.47	747.7	0.06	2.30	0.00134
780	2.88	2.80	2.61	777.4	18.11	2.53	777.5	18.12	777.5	0.08	2.53	0.00129
810	3.08	3.00	2.80	807.2	18.75	2.72	807.3	18.76	807.3	0.08	2.72	0.00124
840	3.30	3.21	3.02	837.0	19.39	2.93	837.1	19.39	837.1	0.09	2.93	0.00119
870	3.52	3.41	3.24	866.8	20.02	3.13	866.9	20.02	866.9	0.11	3.13	0.00115
900	3.69	3.59	3.41	896.7	20.65	3.31	896.8	20.65	896.8	0.10	3.31	0.00112
930	3.84	3.75	3.55	926.6	21.28	3.46	926.6	21.28	926.6	0.09	3.46	0.00108
960	3.97	3.89	3.68	956.4	21.90	3.60	956.5	21.91	956.5	0.08	3.60	0.00105
990	4.14	4.03	3.85	986.3	22.52	3.74	986.4	22.53	986.4	0.11	3.74	0.00101
1020	4.27	4.14	3.97	1016.2	23.14	3.84	1016.3	23.15	1016.3	0.13	3.84	0.00098
1050	4.35	4.25	4.05	1046.1	23.76	3.95	1046.2	23.76	1046.2	0.10	3.95	0.00096
1080	4.46	4.34	4.16	1076.0	24.37	4.04	1076.1	24.37	1076.1	0.12	4.04	0.00093



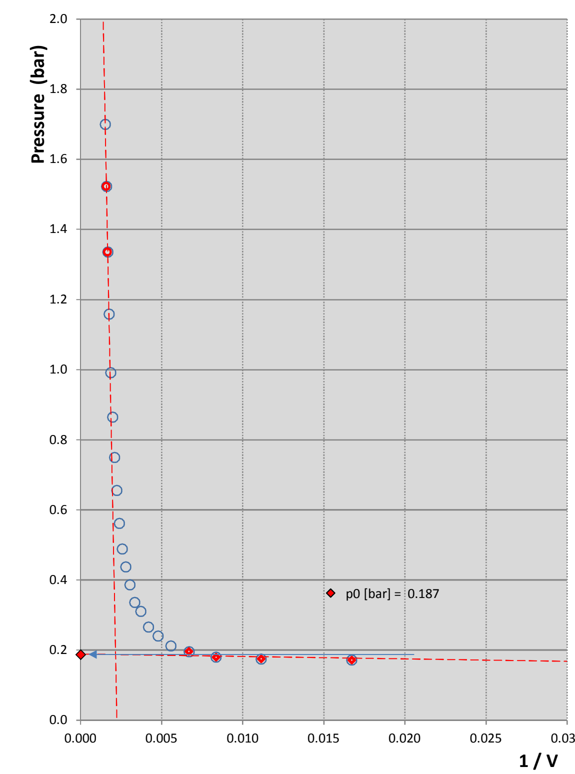
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

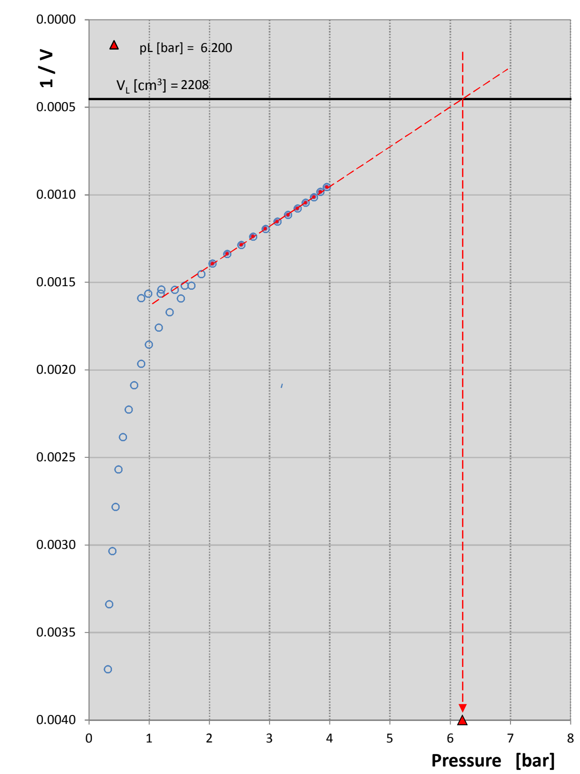
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	0.19	[bar]	119.8	3.0	
p_L	6.20	[bar]			
p^*_L	6.01	[bar]			
p_Y	1.52	[bar]	628	14.9	
E_{PMT}	43	[bar]	599	14.2	[14.2 - 14.8 %]
E_{PMT} / p^*_L	7.2				
$E_{Unload\ 1}$	199	[bar]	629	14.9	
$E_{Reload\ 1}$	142	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15\text{-}30\ sec]}$



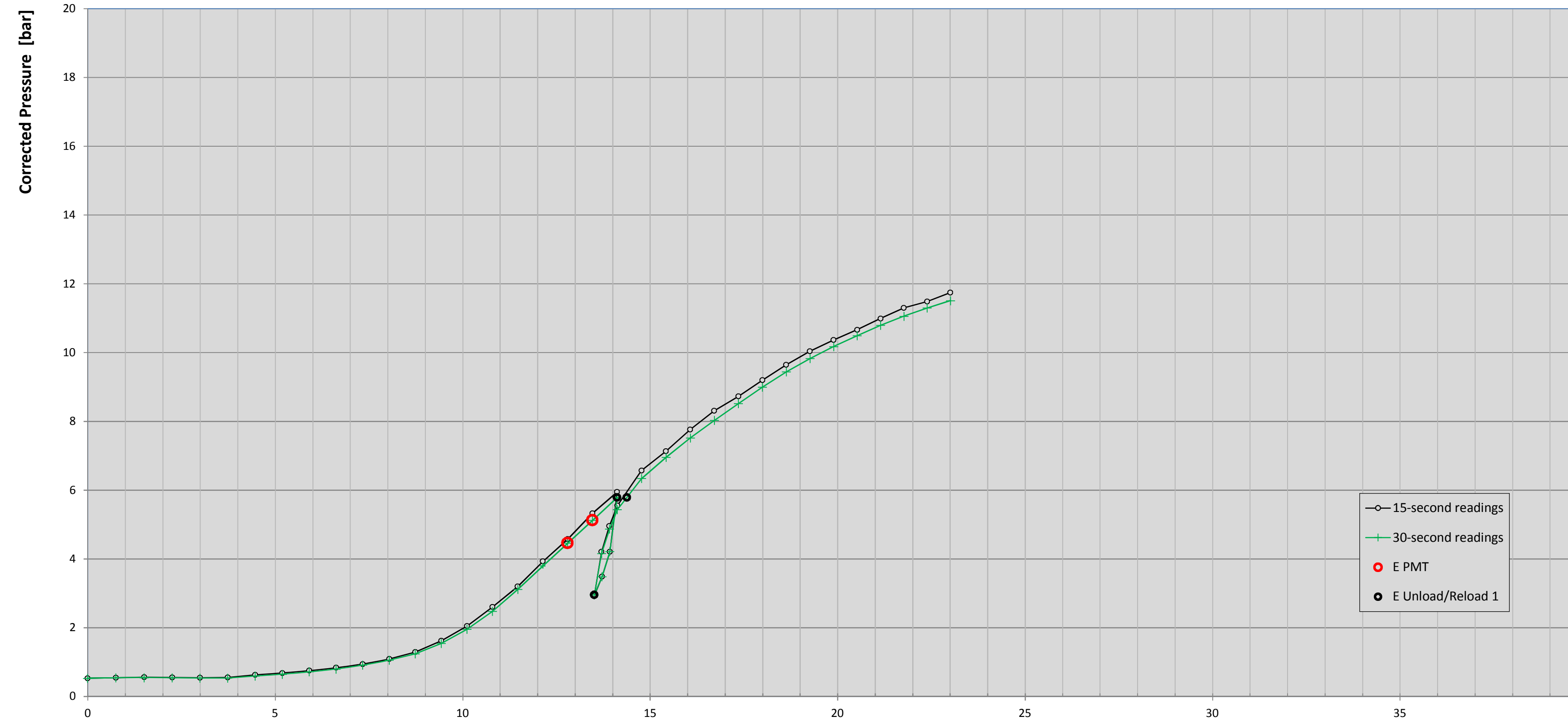
Determination of total contact pressure p_0



Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit	Test Date: January 29, 2018	**Project:** **HWY 400 and HWY 89**	**PMT TEST No.: 1**	In-Depth Geotechnical Inc.
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes	Test Depth [m]: 2.11 (center of the probe)	Client: Golder Associates	**Borehole No.: BH 02-PMT**	
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Drilling Company: Walker Drilling	In-Depth Geotechnical Project No.: IDG 180411		

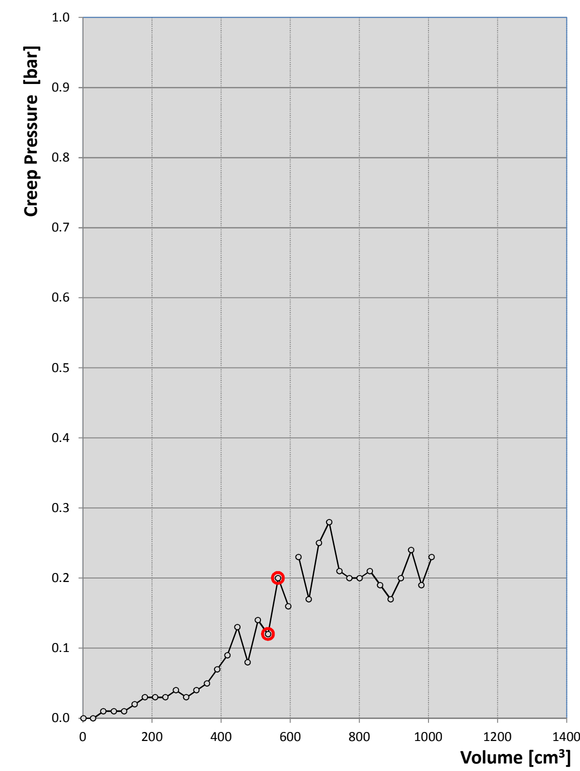
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Volume [cm³]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	0.13	0.13	0.53	2	0.00	0.53	2	0.00	2	0.00	0.53	0.53101
30	0.17	0.17	0.55	29.8	0.76	0.55	29.8	0.76	29.8	0.00	0.55	0.03350
60	0.21	0.20	0.56	59.8	1.51	0.55	59.8	1.51	59.8	0.01	0.55	0.01672
90	0.23	0.22	0.55	89.8	2.26	0.54	89.8	2.26	89.8	0.01	0.54	0.01114
120	0.25	0.24	0.55	119.8	3.00	0.54	119.8	3.00	119.8	0.01	0.54	0.00835
150	0.28	0.26	0.55	149.7	3.74	0.53	149.8	3.74	149.8	0.02	0.53	0.00668
180	0.38	0.35	0.63	179.7	4.47	0.60	179.7	4.47	179.7	0.03	0.60	0.00557
210	0.45	0.42	0.68	209.6	5.19	0.65	209.6	5.19	209.6	0.03	0.65	0.00477
240	0.54	0.51	0.75	239.5	5.91	0.72	239.5	5.91	239.5	0.03	0.72	0.00417
270	0.64	0.60	0.84	269.4	6.63	0.80	269.5	6.63	269.5	0.04	0.80	0.00371
300	0.76	0.73	0.94	299.3	7.34	0.91	299.3	7.34	299.3	0.03	0.91	0.00334
330	0.92	0.88	1.10	329.2	8.04	1.06	329.2	8.04	329.2	0.04	1.06	0.00304
360	1.13	1.08	1.30	359.0	8.74	1.25	359.0	8.74	359.0	0.05	1.25	0.00279
390	1.46	1.39	1.62	388.7	9.43	1.55	388.8	9.43	388.8	0.07	1.55	0.00257
420	1.90	1.81	2.05	418.3	10.12	1.96	418.4	10.12	418.4	0.09	1.96	0.00239
450	2.46	2.33	2.60	447.8	10.80	2.47	447.9	10.80	447.9	0.13	2.47	0.00223
480	3.06	2.98	3.20	477.3	11.47	3.12	477.3	11.47	477.3	0.08	3.12	0.00210
510	3.80	3.66	3.93	506.6	12.14	3.79	506.7	12.14	506.7	0.14	3.79	0.00197
540	4.45	4.33	4.58	536.0	12.80	4.46	536.1	12.80	536.1	0.12	4.46	0.00187
570	5.20	5.00	5.33	565.3	13.46	5.13	565.5	13.46	565.5	0.20	5.13	0.00177
600	5.82	5.66	5.94	594.8	14.12	5.78	594.9	14.12	594.9	0.16	5.78	0.00168
590	4.08	4.09	4.21	586.3	13.93	4.22	586.3	13.93			4.22	0.00171
580	3.36	3.36	3.49	577.0	13.72	3.49	577.0	13.72			3.49	0.00173
570	2.80	2.83	2.93	567.5	13.51	2.96	567.5	13.51			2.96	0.00176
580	4.08	4.03	4.21	576.3	13.71	4.16	576.4	13.71			4.16	0.00173
590	4.83	4.75	4.96	585.7	13.91	4.88	585.7	13.92			4.88	0.00171
600	5.43	5.31	5.55	595.1	14.12	5.43	595.2	14.13			5.43	0.00168
630	6.45	6.22	6.57	624.2	14.77	6.34	624.4	14.77	624.4	0.23	6.34	0.00160
660	7.01	6.84	7.13	653.7	15.42	6.96	653.9	15.42	653.9	0.17	6.96	0.00153
690	7.65	7.40	7.77	683.1	16.07	7.52	683.4	16.07	683.4	0.25	7.52	0.00146
720	8.20	7.92	8.31	712.6	16.71	8.03	712.9	16.72	712.9	0.28	8.03	0.00140
750	8.62	8.41	8.72	742.3	17.35	8.51	742.4	17.36	742.4	0.21	8.51	0.00135
780	9.10	8.90	9.20	771.8	17.99	9.00	772.0	18.00	772.0	0.20	9.00	0.00130
810	9.55	9.35	9.64	801.4	18.63	9.44	801.6	18.63	801.6	0.20	9.44	0.00125
840	9.95	9.74	10.04	831.1	19.26	9.83	831.2	19.27	831.2	0.21	9.83	0.00120
870	10.28	10.09	10.37	860.8	19.89	10.18	860.9	19.90	860.9	0.19	10.18	0.00116
900	10.58	10.41	10.66	890.5	20.52	10.49	890.6	20.53	890.6	0.17	10.49	0.00112
930	10.91	10.71	10.99	920.2	21.15	10.79	920.4	21.15	920.4	0.20	10.79	0.00109
960	11.22	10.98	11.30	949.9	21.77	11.06	950.1	21.77	950.1	0.24	11.06	0.00105
990	11.41	11.22	11.49	979.7	22.39	11.30	979.9	22.39	979.9	0.19	11.30	0.00102
1020	11.67	11.44	11.74	1009.5	23.01	11.51	1009.7	23.01	1009.7	0.23	11.51	0.00099



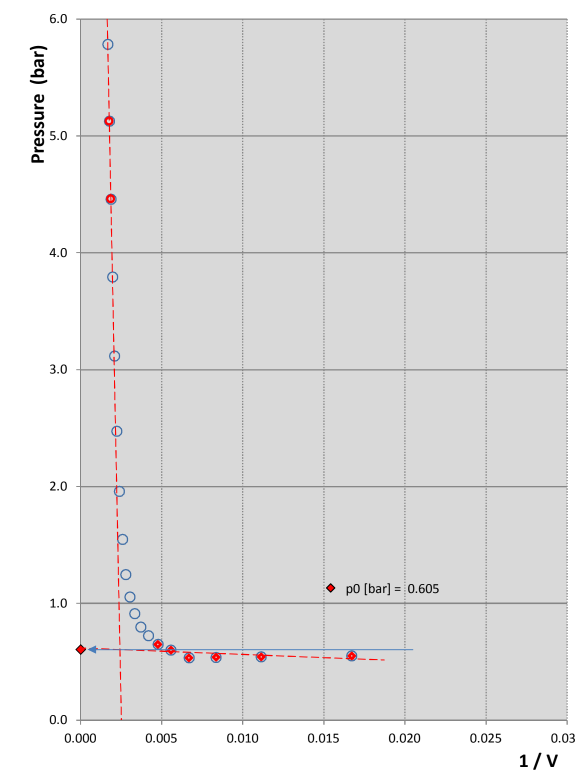
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

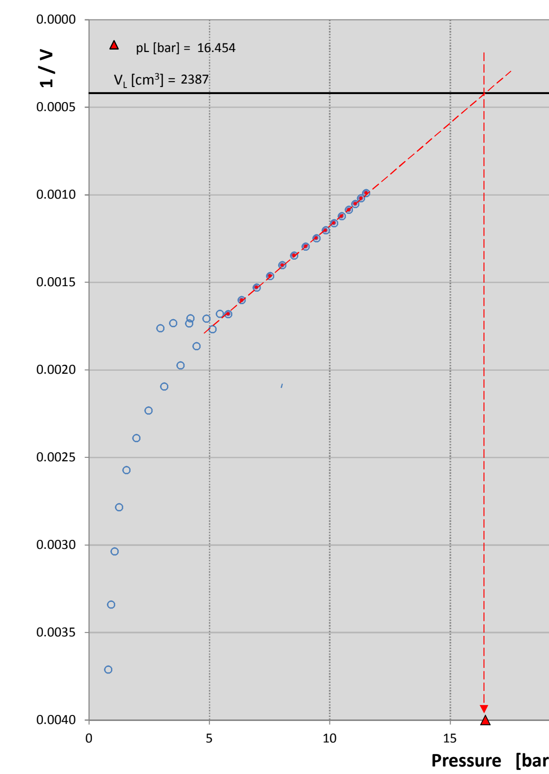
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	0.60	[bar]	209.6	5.2	
p_L	16.45	[bar]			
p^*_L	15.85	[bar]			
p_Y	5.13	[bar]	566	13.5	
E_{PMT}	152	[bar]	536	12.8	[12.8- 13.5 %]
E_{PMT} / p^*_L	9.6				
$E_{Unload\ 1}$	698	[bar]	567	13.5	
$E_{Reload\ 1}$	492	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15-30\ sec]}$



Determination of total contact pressure p_0



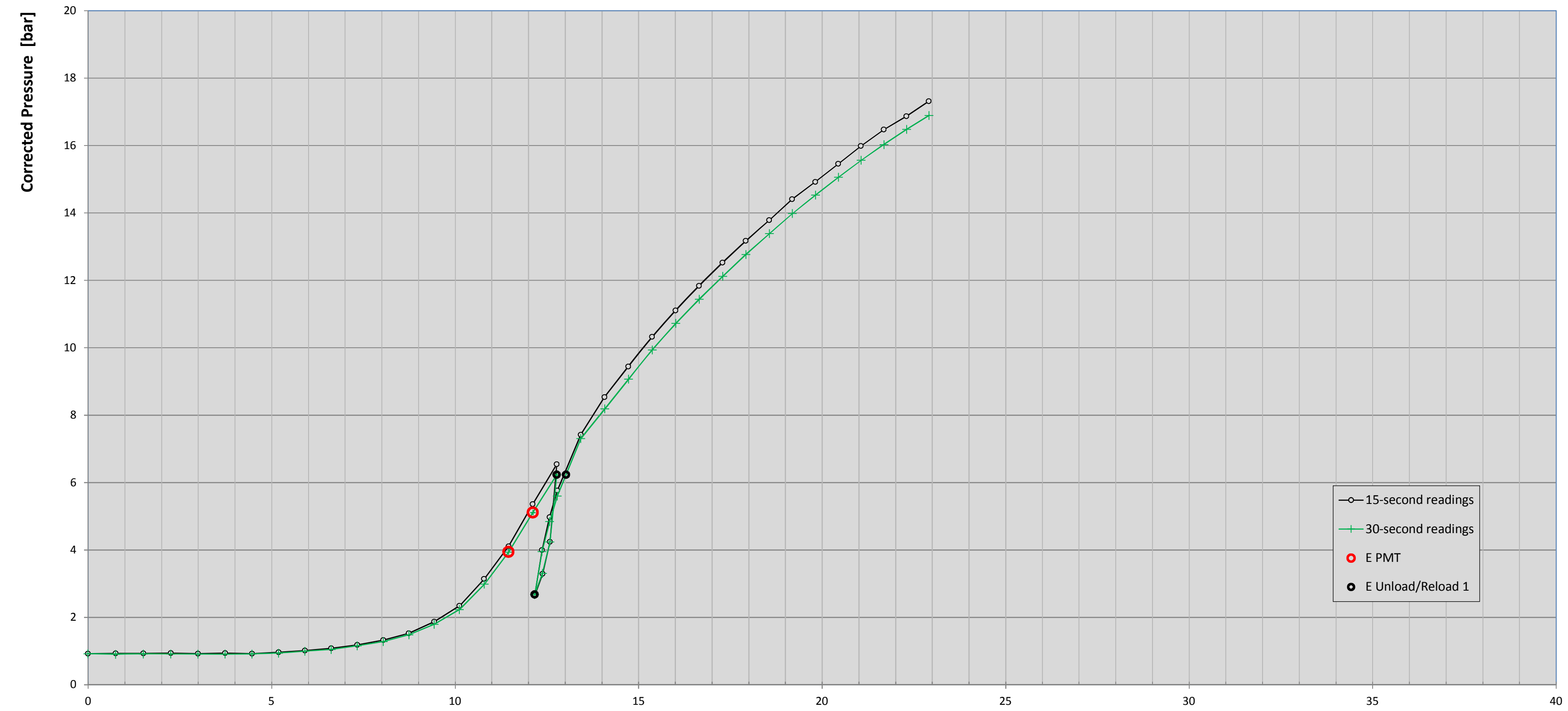
Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall

Test Date:	January 29, 2018
Test Depth [m]:	5.87 (center of the probe)
Drilling Company:	Walker Drilling
Project:	**HWY 400 and HWY 89**
Client:	Golder Associates
In-Depth Geotechnical Project No.:	IDG 180411
PMT TEST No.:	**2**
Borehole No.:	**BH 02-PMT**

In-Depth Geotechnical Inc.

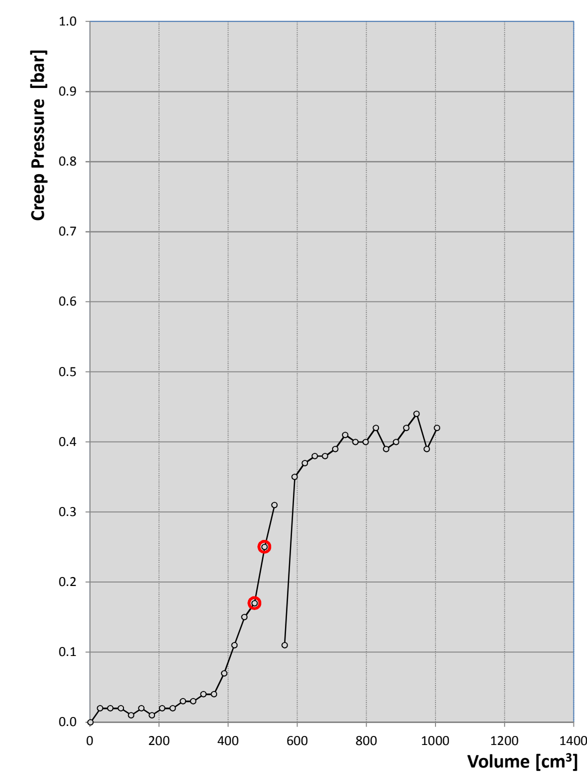
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Volume [cm³]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	0.23	0.23	0.93	2	0.00	0.93	2	0.00	2	0.00	0.93	0.55761
30	0.26	0.24	0.93	29.8	0.75	0.91	29.8	0.75	29.8	0.02	0.91	0.03357
60	0.29	0.27	0.93	59.7	1.51	0.91	59.8	1.51	59.8	0.02	0.91	0.01673
90	0.32	0.30	0.94	89.7	2.25	0.92	89.7	2.25	89.7	0.02	0.92	0.01114
120	0.33	0.32	0.92	119.7	3.00	0.91	119.7	3.00	119.7	0.01	0.91	0.00835
150	0.37	0.35	0.94	149.7	3.73	0.92	149.7	3.73	149.7	0.02	0.92	0.00668
180	0.38	0.37	0.92	179.7	4.47	0.91	179.7	4.47	179.7	0.01	0.91	0.00557
210	0.44	0.42	0.96	209.6	5.19	0.94	209.6	5.19	209.6	0.02	0.94	0.00477
240	0.51	0.49	1.02	239.5	5.91	1.00	239.6	5.91	239.6	0.02	1.00	0.00417
270	0.59	0.56	1.08	269.5	6.63	1.05	269.5	6.63	269.5	0.03	1.05	0.00371
300	0.71	0.68	1.19	299.4	7.34	1.16	299.4	7.34	299.4	0.03	1.16	0.00334
330	0.86	0.82	1.33	329.2	8.04	1.29	329.3	8.04	329.3	0.04	1.29	0.00304
360	1.07	1.03	1.53	359.0	8.74	1.49	359.1	8.74	359.1	0.04	1.49	0.00278
390	1.42	1.35	1.87	388.7	9.43	1.80	388.8	9.43	388.8	0.07	1.80	0.00257
420	1.90	1.79	2.34	418.3	10.12	2.23	418.4	10.12	418.4	0.11	2.23	0.00239
450	2.70	2.55	3.14	447.6	10.79	2.99	447.7	10.79	447.7	0.15	2.99	0.00223
480	3.68	3.51	4.11	476.7	11.46	3.94	476.8	11.46	476.8	0.17	3.94	0.00210
510	4.93	4.68	5.36	505.6	12.11	5.11	505.8	12.12	505.8	0.25	5.11	0.00198
540	6.12	5.81	6.54	534.5	12.77	6.23	534.8	12.77	534.8	0.31	6.23	0.00187
530	3.82	3.82	4.25	526.6	12.59	4.25	526.6	12.59			4.25	0.00190
520	2.87	2.88	3.30	517.4	12.38	3.31	517.4	12.38			3.31	0.00193
510	2.22	2.25	2.65	508.0	12.17	2.68	508.0	12.17			2.68	0.00197
520	3.57	3.53	4.00	516.8	12.37	3.96	516.8	12.37			3.96	0.00193
530	4.55	4.42	4.98	525.9	12.57	4.85	526.0	12.58			4.85	0.00190
540	5.34	5.18	5.76	535.2	12.78	5.60	535.3	12.79			5.60	0.00187
570	7.00	6.89	7.42	563.7	13.42	7.31	563.8	13.43	563.8	0.11	7.31	0.00177
600	8.12	7.77	8.54	592.7	14.07	8.19	593.0	14.08	593.0	0.35	8.19	0.00169
630	9.03	8.66	9.45	621.9	14.72	9.08	622.2	14.73	622.2	0.37	9.08	0.00161
660	9.91	9.53	10.32	651.1	15.36	9.94	651.4	15.37	651.4	0.38	9.94	0.00154
690	10.70	10.32	11.11	680.4	16.01	10.73	680.7	16.02	680.7	0.38	10.73	0.00147
720	11.43	11.04	11.83	709.7	16.65	11.44	710.1	16.66	710.1	0.39	11.44	0.00141
750	12.13	11.72	12.53	739.1	17.29	12.12	739.5	17.29	739.5	0.41	12.12	0.00135
780	12.78	12.38	13.17	768.5	17.92	12.77	768.9	17.93	768.9	0.40	12.77	0.00130
810	13.40	13.00	13.79	798.0	18.55	13.39	798.3	18.56	798.3	0.40	13.39	0.00125
840	14.02	13.60	14.40	827.4	19.18	13.98	827.8	19.19	827.8	0.42	13.98	0.00121
870	14.54	14.15	14.92	856.9	19.81	14.53	857.3	19.82	857.3	0.39	14.53	0.00117
900	15.08	14.68	15.46	886.5	20.44	15.06	886.8	20.44	886.8	0.40	15.06	0.00113
930	15.61	15.19	15.99	916.0	21.06	15.57	916.4	21.07	916.4	0.42	15.57	0.00109
960	16.10	15.66	16.47	945.5	21.68	16.03	945.9	21.69	945.9	0.44	16.03	0.00106
990	16.50	16.11	16.87	975.2	22.29	16.48	975.5	22.30	975.5	0.39	16.48	0.00103
1020	16.95	16.53	17.32	1004.8	22.91	16.90	1005.1	22.92	1005.1	0.42	16.90	0.00099



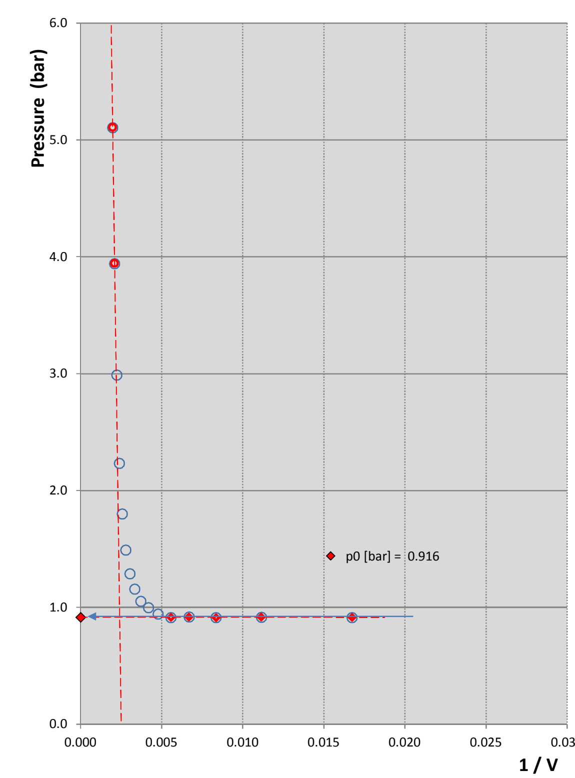
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

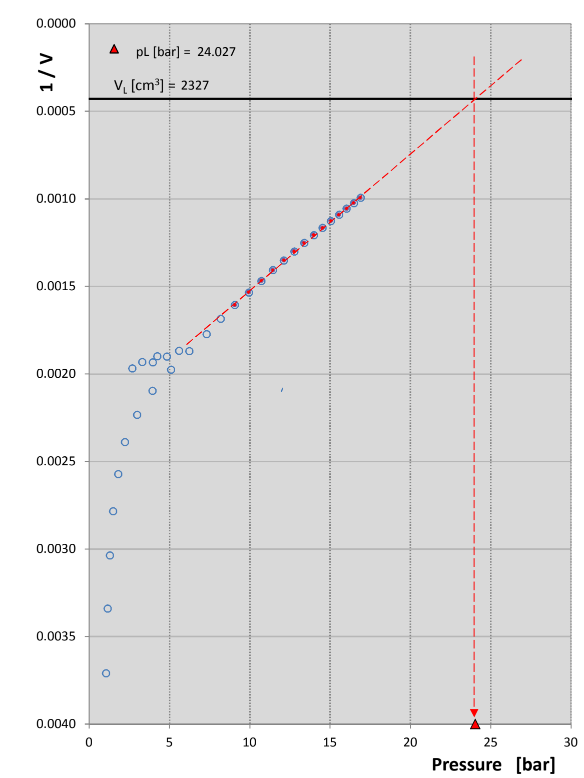
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	0.92	[bar]	179.7	4.5	
p_L	24.03	[bar]			
p^*_L	23.11	[bar]			
p_Y	5.11	[bar]	506	12.1	
E_{PMT}	263	[bar]	477	11.5	[11.5- 12.1 %]
E_{PMT} / p^*_L	11.4				
$E_{Unload\ 1}$	879	[bar]	508	12.2	
$E_{Reload\ 1}$	624	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15-30\ sec]}$



Determination of total contact pressure p_0

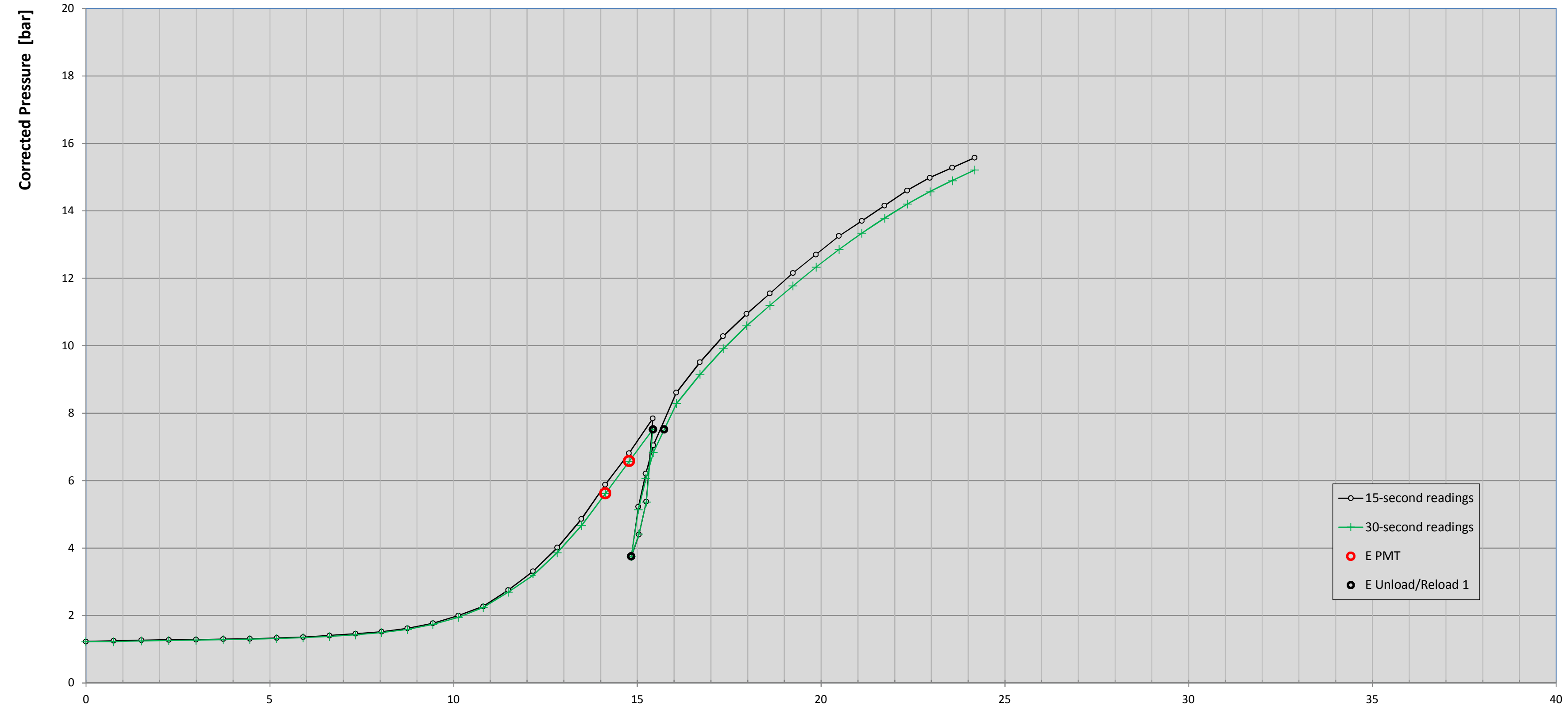


Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model Volume-controlled test as per ASTM D4719 Method B Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Probe Designation : NX Probe (76 mm OD) Probe No.: E 309 Calibration Record No.: 1 Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit Time elapsed from hole drilling to testing ~ 5 minutes Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Test Date: January 29, 2018 Test Depth [m]: 8.86 (center of the probe) Drilling Company: Walker Drilling

Project: **HWY 400 and HWY 89**	**PMT TEST No.: 3**	In-Depth Geotechnical Inc.
Client: Golder Associates	**Borehole No.: BH 02-PMT**	
In-Depth Geotechnical Project No.: IDG 180411		

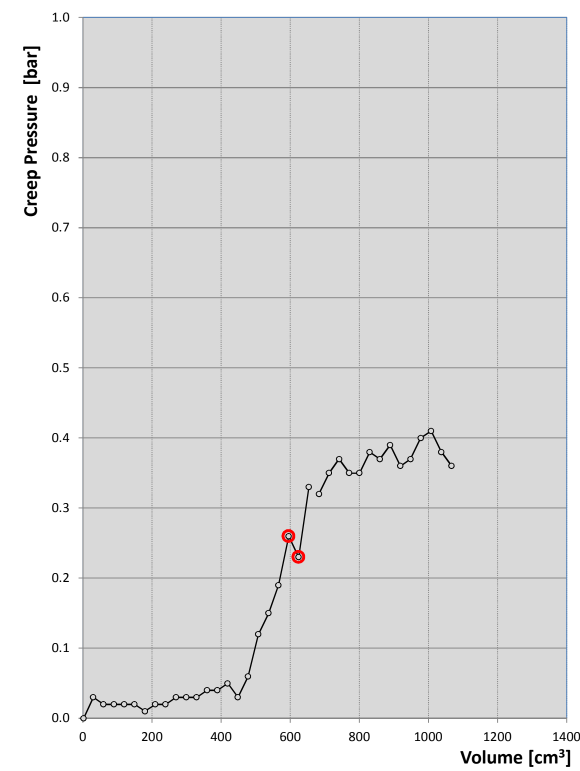
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Volume [cm³]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	0.25	0.25	1.23	2	0.00	1.23	2	0.00	2	0.00	1.23	0.56325
30	0.30	0.27	1.26	29.7	0.75	1.23	29.8	0.75	29.8	0.03	1.23	0.03361
60	0.34	0.32	1.27	59.7	1.51	1.25	59.7	1.51	59.7	0.02	1.25	0.01675
90	0.38	0.36	1.28	89.7	2.25	1.26	89.7	2.25	89.7	0.02	1.26	0.01115
120	0.41	0.39	1.29	119.6	3.00	1.27	119.6	3.00	119.6	0.02	1.27	0.00836
150	0.45	0.43	1.30	149.6	3.73	1.28	149.6	3.73	149.6	0.02	1.28	0.00668
180	0.48	0.47	1.31	179.6	4.46	1.30	179.6	4.46	179.6	0.01	1.30	0.00557
210	0.53	0.51	1.34	209.5	5.19	1.32	209.5	5.19	209.5	0.02	1.32	0.00477
240	0.57	0.55	1.36	239.5	5.91	1.34	239.5	5.91	239.5	0.02	1.34	0.00418
270	0.63	0.60	1.41	269.4	6.63	1.38	269.5	6.63	269.5	0.03	1.38	0.00371
300	0.70	0.67	1.46	299.4	7.34	1.43	299.4	7.34	299.4	0.03	1.43	0.00334
330	0.77	0.74	1.52	329.3	8.04	1.49	329.3	8.04	329.3	0.03	1.49	0.00304
360	0.88	0.84	1.62	359.2	8.75	1.58	359.2	8.75	359.2	0.04	1.58	0.00278
390	1.04	1.00	1.78	389.1	9.44	1.74	389.1	9.44	389.1	0.04	1.74	0.00257
420	1.27	1.22	2.00	418.9	10.13	1.95	418.9	10.13	418.9	0.05	1.95	0.00239
450	1.55	1.52	2.27	448.6	10.81	2.24	448.6	10.82	448.6	0.03	2.24	0.00223
480	2.04	1.98	2.76	478.2	11.49	2.70	478.2	11.49	478.2	0.06	2.70	0.00209
510	2.60	2.48	3.31	507.7	12.16	3.19	507.8	12.16	507.8	0.12	3.19	0.00197
540	3.31	3.16	4.02	537.0	12.82	3.87	537.2	12.83	537.2	0.15	3.87	0.00186
570	4.16	3.97	4.87	566.3	13.48	4.68	566.4	13.48	566.4	0.19	4.68	0.00177
600	5.18	4.92	5.88	595.3	14.13	5.62	595.6	14.13	595.6	0.26	5.62	0.00168
630	6.11	5.88	6.81	624.5	14.78	6.58	624.7	14.78	624.7	0.23	6.58	0.00160
660	7.15	6.82	7.85	653.6	15.42	7.52	653.9	15.43	653.9	0.33	7.52	0.00153
650	4.68	4.67	5.38	645.8	15.25	5.37	645.8	15.25			5.37	0.00155
640	3.70	3.72	4.40	636.7	15.05	4.42	636.7	15.05			4.42	0.00157
630	3.04	3.06	3.74	627.3	14.84	3.76	627.3	14.84			3.76	0.00159
640	4.53	4.44	5.23	635.9	15.03	5.14	636.0	15.03			5.14	0.00157
650	5.51	5.37	6.21	645.0	15.23	6.07	645.2	15.23			6.07	0.00155
660	6.35	6.14	7.05	654.3	15.43	6.84	654.5	15.44			6.84	0.00153
690	7.92	7.60	8.61	682.9	16.06	8.29	683.2	16.07	683.2	0.32	8.29	0.00146
720	8.82	8.47	9.51	712.1	16.70	9.16	712.4	16.71	712.4	0.35	9.16	0.00140
750	9.60	9.23	10.28	741.4	17.34	9.91	741.7	17.34	741.7	0.37	9.91	0.00135
780	10.27	9.92	10.95	770.8	17.97	10.60	771.1	17.98	771.1	0.35	10.60	0.00130
810	10.88	10.53	11.55	800.2	18.60	11.20	800.5	18.61	800.5	0.35	11.20	0.00125
840	11.49	11.11	12.16	829.7	19.23	11.78	830.0	19.24	830.0	0.38	11.78	0.00120
870	12.04	11.67	12.71	859.2	19.86	12.34	859.5	19.87	859.5	0.37	12.34	0.00116
900	12.59	12.20	13.25	888.7	20.48	12.86	889.0	20.49	889.0	0.39	12.86	0.00112
930	13.04	12.68	13.70	918.3	21.11	13.34	918.6	21.11	918.6	0.36	13.34	0.00109
960	13.50	13.13	14.16	947.9	21.73	13.79	948.2	21.73	948.2	0.37	13.79	0.00105
990	13.95	13.55	14.60	977.5	22.34	14.20	977.8	22.35	977.8	0.40	14.20	0.00102
1020	14.33	13.92	14.98	1007.1	22.96	14.57	1007.5	22.96	1007.5	0.41	14.57	0.00099
1050	14.63	14.25	15.28	1036.9	23.57	14.90	1037.2	23.58	1037.2	0.38	14.90	0.00096
1080	14.93	14.57	15.57	1066.6	24.18	15.21	1066.9	24.19	1066.9	0.36	15.21	0.00094



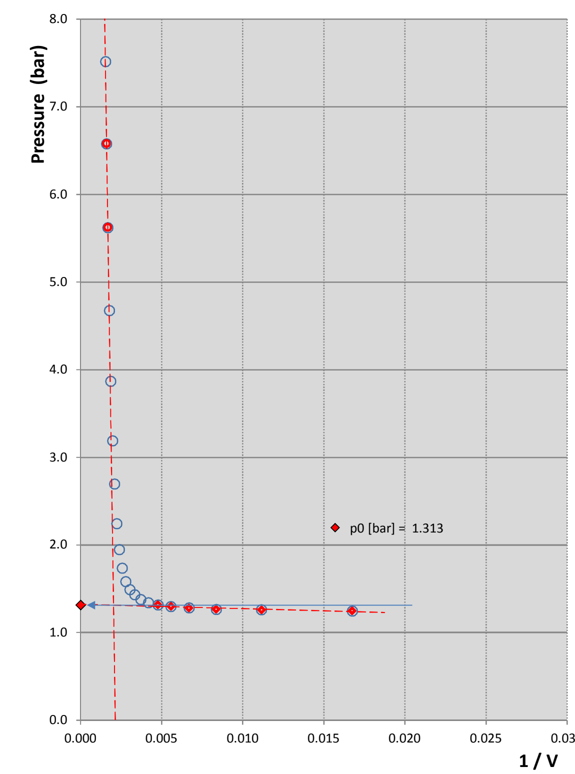
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

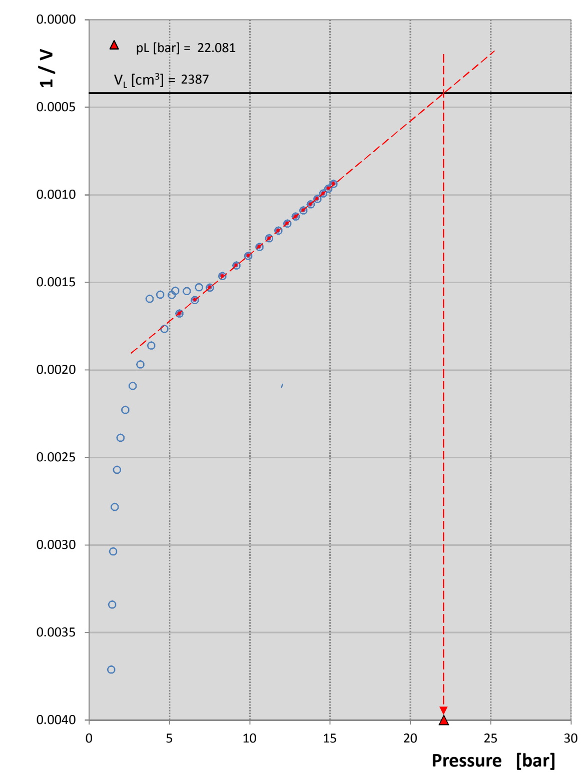
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	1.31	[bar]	209.5	5.2	
p_L	22.08	[bar]			
p^*_L	20.77	[bar]			
p_Y	6.58	[bar]	625	14.8	
E_{PMT}	225	[bar]	596	14.1	[14.1- 14.8 %]
E_{PMT} / p^*_L	10.8				
$E_{Unload\ 1}$	979	[bar]	627	14.8	
$E_{Reload\ 1}$	644	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15\text{-}30\ sec]}$



Determination of total contact pressure p_0

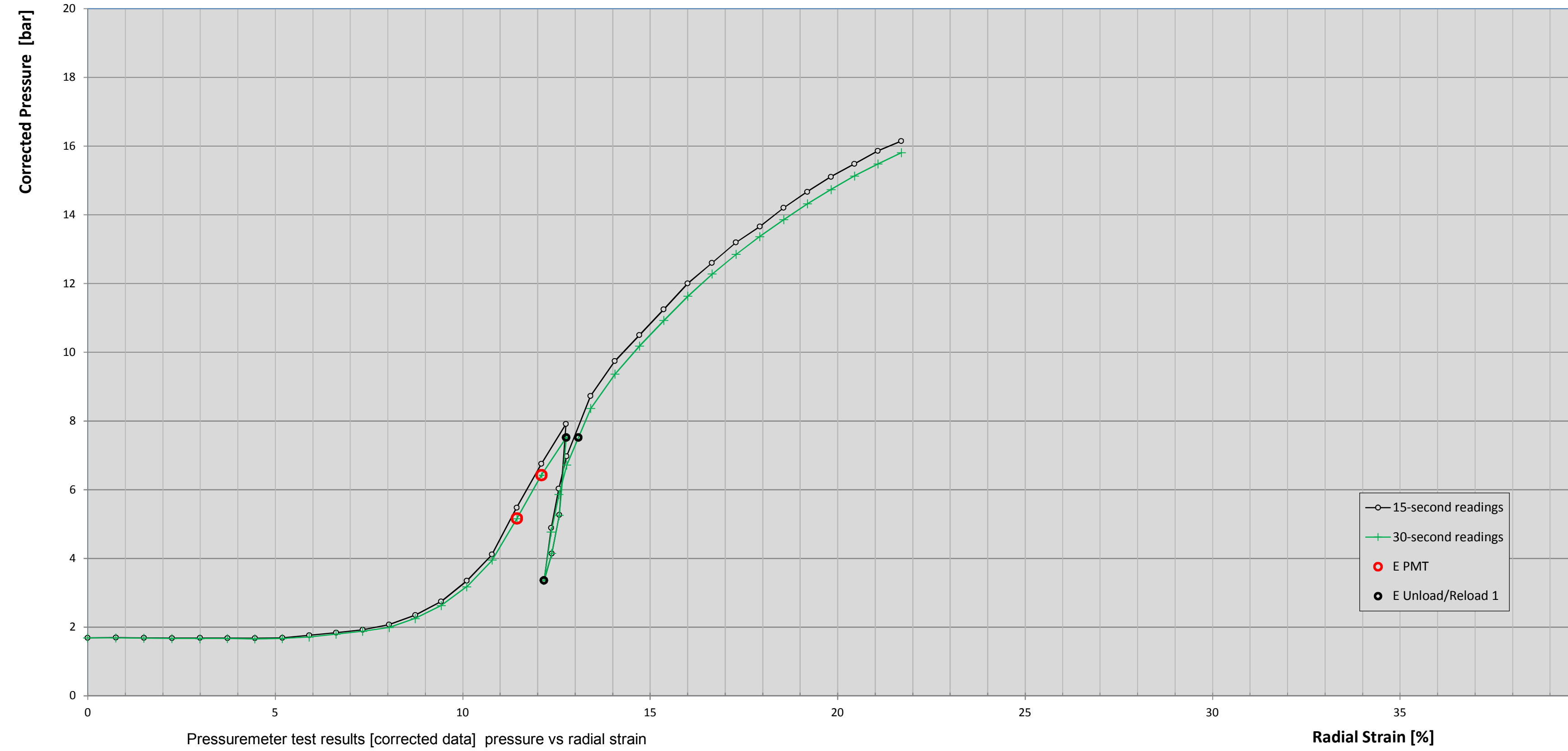


Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit	Test Date: January 29, 2018
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes	Test Depth [m]: 11.76 (center of the probe)
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Drilling Company: Walker Drilling

Project:	**HWY 400 and HWY 89**	**PMT TEST No.:**	**4**
Client:	Golder Associates	**Borehole No.:**	**BH 02-PMT**
In-Depth Geotechnical Project No.:	IDG 180411		

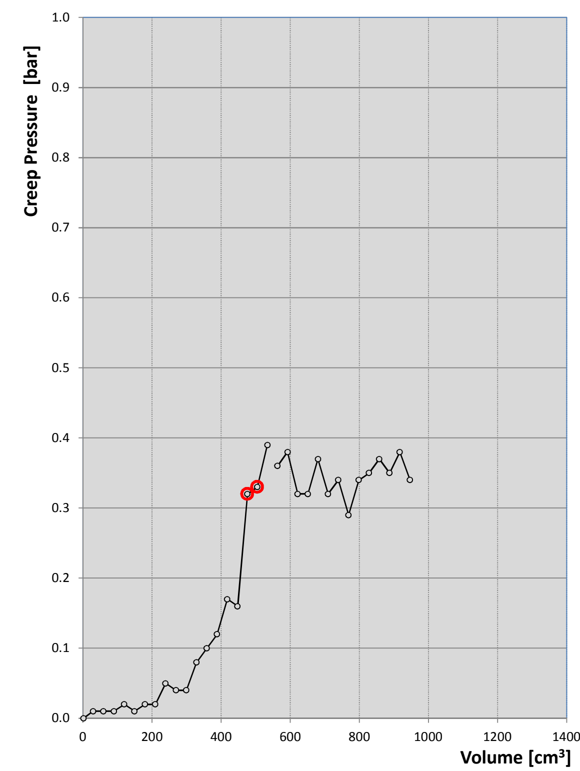
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Pressure [bar]	Volume [cm³]	$\Delta r/r_0$ [%]	Volume [cm³]	Δp_{30-15} [bar]	Pressure [bar]	1 / V
2	0.40	0.40	1.69	2	0.00	1.69	2	0.00	2	0.00	1.69	0.60952
30	0.43	0.42	1.70	29.6	0.75	1.69	29.6	0.75	29.6	0.01	1.69	0.03376
60	0.45	0.44	1.69	59.6	1.50	1.68	59.6	1.50	59.6	0.01	1.68	0.01678
90	0.47	0.46	1.68	89.6	2.25	1.67	89.6	2.25	89.6	0.01	1.67	0.01116
120	0.50	0.48	1.69	119.6	2.99	1.67	119.6	2.99	119.6	0.02	1.67	0.00836
150	0.52	0.51	1.68	149.5	3.73	1.67	149.5	3.73	149.5	0.01	1.67	0.00669
180	0.54	0.52	1.68	179.5	4.46	1.66	179.5	4.46	179.5	0.02	1.66	0.00557
210	0.57	0.55	1.69	209.5	5.19	1.67	209.5	5.19	209.5	0.02	1.67	0.00477
240	0.66	0.61	1.76	239.4	5.91	1.71	239.5	5.91	239.5	0.05	1.71	0.00418
270	0.75	0.71	1.84	269.3	6.62	1.80	269.4	6.63	269.4	0.04	1.80	0.00371
300	0.85	0.81	1.92	299.2	7.33	1.88	299.3	7.34	299.3	0.04	1.88	0.00334
330	1.01	0.93	2.07	329.1	8.04	1.99	329.2	8.04	329.2	0.08	1.99	0.00304
360	1.30	1.20	2.36	358.8	8.74	2.26	358.9	8.74	358.9	0.10	2.26	0.00279
390	1.70	1.58	2.75	388.5	9.43	2.63	388.6	9.43	388.6	0.12	2.63	0.00257
420	2.31	2.14	3.35	417.9	10.11	3.18	418.1	10.11	418.1	0.17	3.18	0.00239
450	3.08	2.92	4.11	447.2	10.78	3.95	447.4	10.79	447.4	0.16	3.95	0.00224
480	4.45	4.13	5.48	476.0	11.44	5.16	476.3	11.45	476.3	0.32	5.16	0.00210
510	5.73	5.40	6.75	504.9	12.10	6.42	505.1	12.10	505.1	0.33	6.42	0.00198
540	6.89	6.50	7.91	533.8	12.75	7.52	534.2	12.76	534.2	0.39	7.52	0.00187
530	4.25	4.24	5.27	526.2	12.58	5.26	526.2	12.58			5.26	0.00190
520	3.12	3.13	4.14	517.2	12.38	4.15	517.2	12.38			4.15	0.00193
510	2.32	2.34	3.34	507.9	12.17	3.36	507.9	12.17			3.36	0.00197
520	3.87	3.75	4.89	516.5	12.36	4.77	516.6	12.36			4.77	0.00194
530	5.01	4.84	6.03	525.5	12.56	5.86	525.7	12.57			5.86	0.00190
540	5.95	5.70	6.97	534.7	12.77	6.72	534.9	12.78			6.72	0.00187
570	7.71	7.35	8.73	563.1	13.41	8.37	563.4	13.42	563.4	0.36	8.37	0.00177
600	8.73	8.35	9.74	592.2	14.06	9.36	592.5	14.07	592.5	0.38	9.36	0.00169
630	9.49	9.17	10.50	621.5	14.71	10.18	621.8	14.72	621.8	0.32	10.18	0.00161
660	10.24	9.92	11.25	650.8	15.36	10.93	651.1	15.36	651.1	0.32	10.93	0.00154
690	11.00	10.63	12.00	680.1	16.00	11.63	680.5	16.01	680.5	0.37	11.63	0.00147
720	11.60	11.28	12.60	709.6	16.65	12.28	709.9	16.65	709.9	0.32	12.28	0.00141
750	12.20	11.86	13.19	739.0	17.29	12.85	739.3	17.29	739.3	0.34	12.85	0.00135
780	12.67	12.38	13.66	768.6	17.92	13.37	768.9	17.93	768.9	0.29	13.37	0.00130
810	13.22	12.88	14.20	798.1	18.56	13.86	798.4	18.57	798.4	0.34	13.86	0.00125
840	13.69	13.34	14.67	827.7	19.19	14.32	828.0	19.20	828.0	0.35	14.32	0.00121
870	14.13	13.76	15.11	857.3	19.82	14.74	857.6	19.83	857.6	0.37	14.74	0.00117
900	14.51	14.16	15.48	887.0	20.45	15.13	887.3	20.45	887.3	0.35	15.13	0.00113
930	14.89	14.51	15.86	916.6	21.07	15.48	917.0	21.08	917.0	0.38	15.48	0.00109
960	15.18	14.84	16.15	946.4	21.69	15.81	946.7	21.70	946.7	0.34	15.81	0.00106



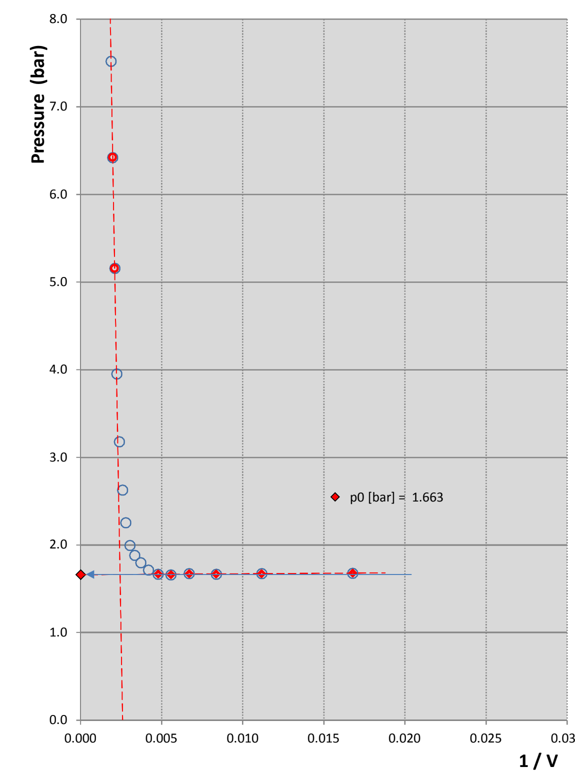
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

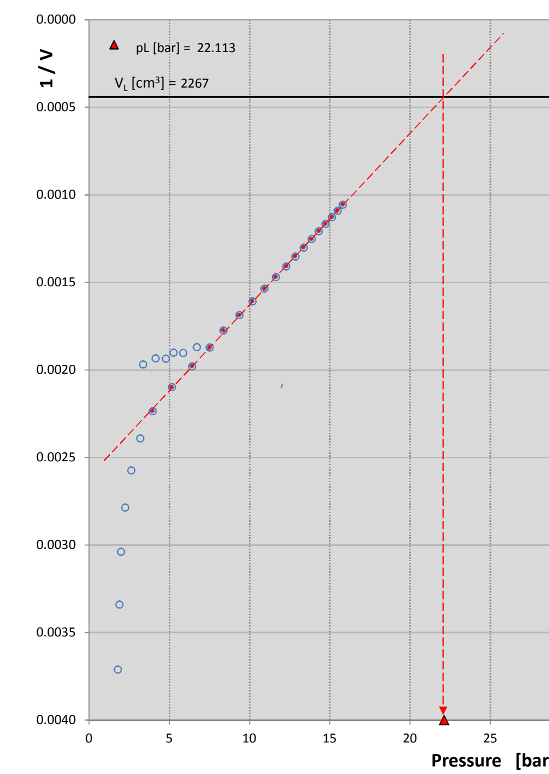
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	1.66	[bar]	149.5	3.7	
p_L	22.11	[bar]			
p^*_L	20.45	[bar]			
p_Y	6.42	[bar]	505	12.1	
E_{PMT}	287	[bar]	476	11.4	[11.5- 12.1 %]
E_{PMT} / p^*_L	14.0				
$E_{Unload\ 1}$	1048	[bar]	508	12.2	
$E_{Reload\ 1}$	676	[bar]			



Pressure difference from 15 to 30 sec. readings $\Delta p_{[15\text{-}30\ sec]}$



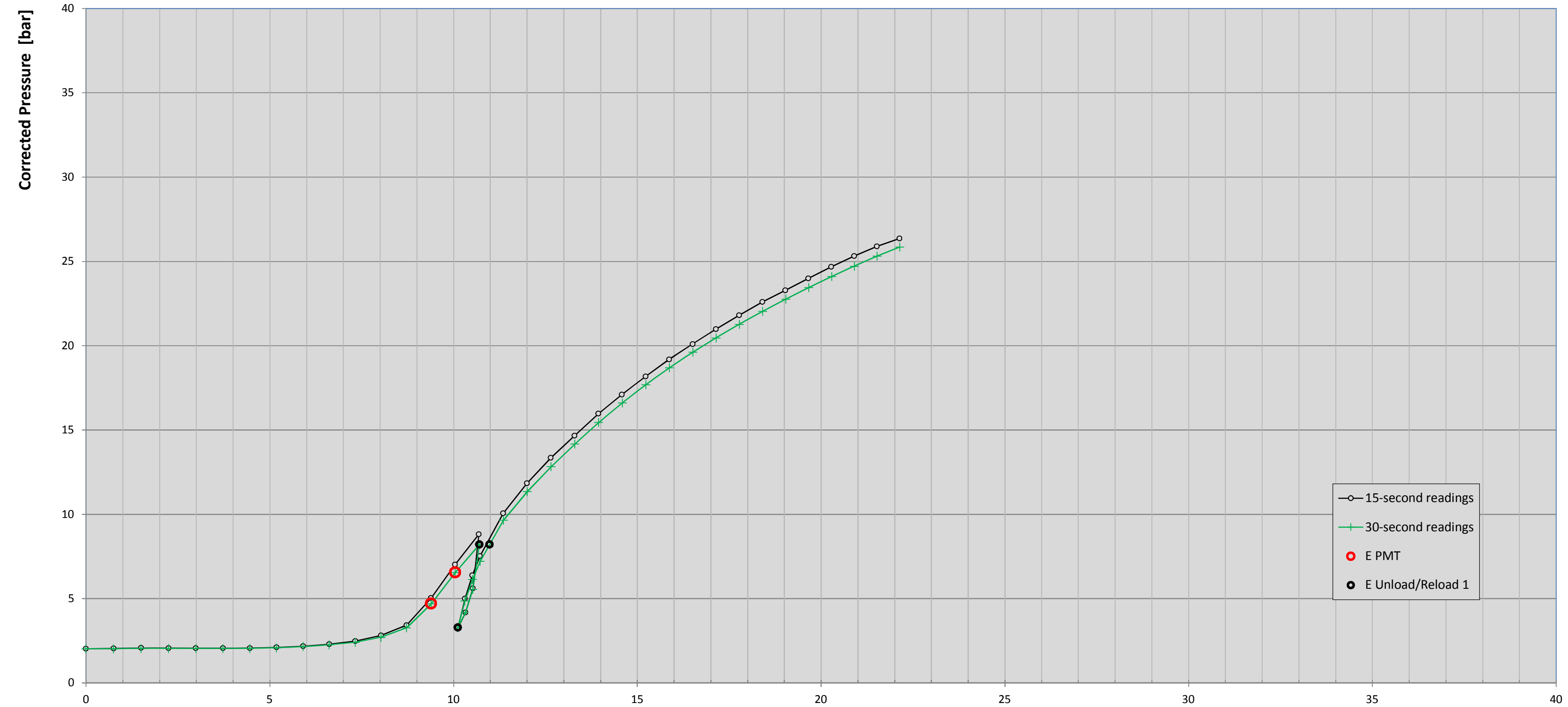
Determination of total contact pressure p_0



Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model Volume-controlled test as per ASTM D4719 Method B Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Probe Designation : NX Probe (76 mm OD) Probe No.: E 309 Calibration Record No.: 1 Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit Time elapsed from hole drilling to testing ~ 5 minutes Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Test Date: January 29, 2018 Test Depth [m]: 14.94 (center of the probe) Drilling Company: Walker Drilling
Project: HWY 400 and HWY 89 Client: Golder Associates In-Depth Geotechnical Project No.: IDG 180411	**PMT TEST No.: 5** **Borehole No.: BH 02-PMT**	In-Depth Geotechnical Inc.	

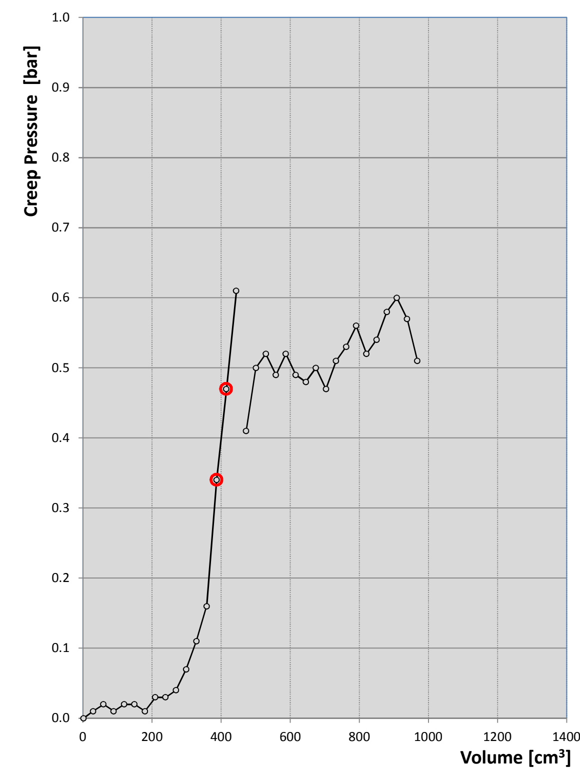
Field Test Data (uncorrected)			Corrected Test data						Creep		Auxiliary Data	
			15-second readings			30-second readings					30 sec	
Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec	Pressure [bar]	Volume [cm³]	Δr/r₀ [%]	Pressure [bar]	Volume [cm³]	Δr/r₀ [%]	Volume [cm³]	Δp 30-15 [bar]	Pressure [bar]	1 / V
2	0.45	0.45	2.03	2	0.00	2.03	2	0.00	2	0.00	2.03	0.62668
30	0.49	0.48	2.05	29.6	0.75	2.04	29.6	0.75	29.6	0.01	2.04	0.03382
60	0.55	0.53	2.08	59.5	1.50	2.06	59.5	1.50	59.5	0.02	2.06	0.01680
90	0.56	0.55	2.06	89.5	2.25	2.05	89.5	2.25	89.5	0.01	2.05	0.01117
120	0.59	0.57	2.07	119.5	2.99	2.05	119.5	2.99	119.5	0.02	2.05	0.00837
150	0.62	0.60	2.07	149.4	3.73	2.05	149.5	3.73	149.5	0.02	2.05	0.00669
180	0.64	0.63	2.07	179.4	4.46	2.06	179.4	4.46	179.4	0.01	2.06	0.00557
210	0.71	0.68	2.12	209.4	5.19	2.09	209.4	5.19	209.4	0.03	2.09	0.00478
240	0.80	0.77	2.19	239.3	5.91	2.16	239.3	5.91	239.3	0.03	2.16	0.00418
270	0.93	0.89	2.31	269.2	6.62	2.27	269.2	6.62	269.2	0.04	2.27	0.00371
300	1.13	1.06	2.49	299.0	7.33	2.42	299.0	7.33	299.0	0.07	2.42	0.00334
330	1.47	1.36	2.82	328.7	8.03	2.71	328.8	8.03	328.8	0.11	2.71	0.00304
360	2.09	1.93	3.43	358.1	8.72	3.27	358.3	8.72	358.3	0.16	3.27	0.00279
390	3.71	3.37	5.05	386.7	9.38	4.71	387.0	9.39	387.0	0.34	4.71	0.00258
420	5.69	5.22	7.02	414.9	10.04	6.55	415.3	10.05	415.3	0.47	6.55	0.00241
450	7.50	6.89	8.82	443.3	10.69	8.21	443.8	10.70	443.8	0.61	8.21	0.00225
440	4.29	4.24	5.61	436.1	10.53	5.56	436.2	10.53			5.56	0.00229
430	2.86	2.85	4.19	427.4	10.33	4.18	427.4	10.33			4.18	0.00234
420	1.93	1.96	3.26	418.3	10.12	3.29	418.2	10.12			3.29	0.00239
430	3.68	3.55	5.01	426.7	10.31	4.88	426.8	10.31			4.88	0.00234
440	5.06	4.83	6.38	435.5	10.51	6.15	435.7	10.52			6.15	0.00230
450	6.20	5.90	7.52	444.4	10.72	7.22	444.7	10.72			7.22	0.00225
480	8.75	8.34	10.07	472.1	11.35	9.66	472.5	11.36	472.5	0.41	9.66	0.00212
510	10.54	10.04	11.85	500.5	12.00	11.35	501.0	12.01	501.0	0.50	11.35	0.00200
540	12.05	11.53	13.36	529.2	12.65	12.84	529.6	12.66	529.6	0.52	12.84	0.00189
570	13.37	12.88	14.68	558.0	13.29	14.19	558.4	13.30	558.4	0.49	14.19	0.00179
600	14.68	14.16	15.98	586.8	13.94	15.46	587.3	13.95	587.3	0.52	15.46	0.00170
630	15.80	15.31	17.10	615.8	14.58	16.61	616.2	14.59	616.2	0.49	16.61	0.00162
660	16.88	16.40	18.18	644.8	15.23	17.70	645.3	15.24	645.3	0.48	17.70	0.00155
690	17.90	17.40	19.19	673.9	15.87	18.69	674.4	15.88	674.4	0.50	18.69	0.00148
720	18.81	18.34	20.10	703.1	16.50	19.63	703.5	16.51	703.5	0.47	19.63	0.00142
750	19.70	19.19	20.98	732.3	17.14	20.47	732.8	17.15	732.8	0.51	20.47	0.00136
780	20.53	20.00	21.81	761.6	17.77	21.28	762.0	17.78	762.0	0.53	21.28	0.00131
810	21.33	20.77	22.60	790.8	18.40	22.04	791.3	18.41	791.3	0.56	22.04	0.00126
840	22.02	21.50	23.29	820.2	19.03	22.77	820.7	19.04	820.7	0.52	22.77	0.00122
870	22.73	22.19	24.00	849.6	19.66	23.46	850.1	19.67	850.1	0.54	23.46	0.00118
900	23.42	22.84	24.68	879.0	20.28	24.10	879.5	20.29	879.5	0.58	24.10	0.00114
930	24.06	23.46	25.32	908.4	20.90	24.72	908.9	20.91	908.9	0.60	24.72	0.00110
960	24.63	24.06	25.89	937.9	21.52	25.32	938.4	21.53	938.4	0.57	25.32	0.00107
990	25.11	24.60	26.36	967.4	22.13	25.85	967.9	22.14	967.9	0.51	25.85	0.00103



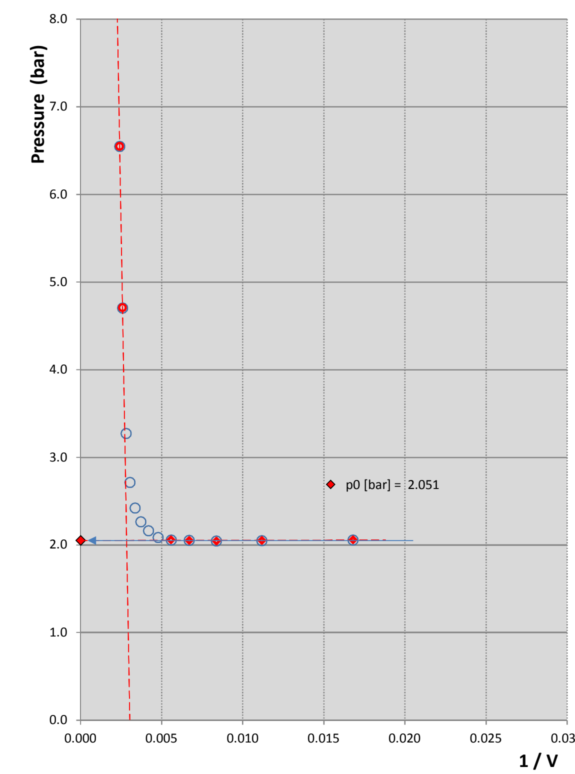
Pressuremeter test results [corrected data] pressure vs radial strain

Interpreted PMT Test Results

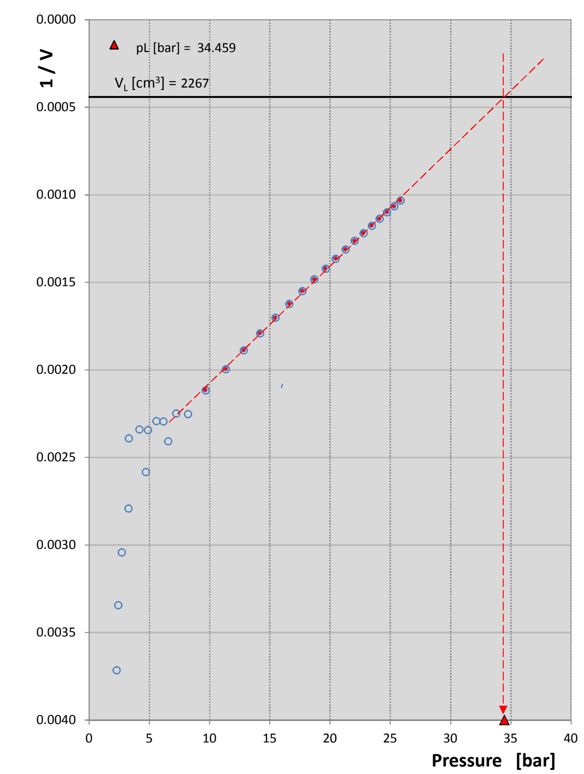
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	2.05	[bar]	149.5	3.7	
p_L	34.46	[bar]			
p^*_L	32.41	[bar]			
p_Y	6.55	[bar]	415	10.0	
E_{PMT}	410	[bar]	387	9.4	[9.4 - 10.1 %]
E_{PMT} / p^*_L	12.6				
$E_{Unload\ 1}$	1229	[bar]	418	10.1	
$E_{Reload\ 1}$	834	[bar]			



Pressure difference from 15 to 30 sec. readings Δp [15-30 sec]



Determination of total contact pressure p_0



Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling	Test Date: January 29, 2018	Project: HWY 400 and HWY 89
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309	Drilling Bit: Tricone Bit	Test Depth [m]: 17.88 (center of the probe)	Client: Golder Associates
Volume increments: 40 cm³	Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes	Drilling Company: Walker Drilling	In-Depth Geotechnical Project No.: IDG 180411
Maximum Volume: 1400 cm³	Tubing Length: 150 [ft]	Engineer: Gabriel Sedran, P.Eng., Ph.D.		
Maximum Pressure: 100 bar	Probe Lenght: 0.46 [m]	Operator: Scott Hall		
	Probe Initial Volume: 1968 cm³			

PMT TEST No.: 6

Borehole No.: BH 02-PMT

Field Test Data (uncorrected)

Volume [cm³]	Pressure [bar] 15 sec	Pressure [bar] 30 sec
2	0.48	0.48
30	0.51	0.50
60	0.55	0.53
90	0.57	0.55
120	0.60	0.58
150	0.62	0.60
180	0.64	0.62
210	0.66	0.65
240	0.68	0.66
270	0.71	0.70
300	0.75	0.73
330	0.79	0.76
360	0.83	0.80
390	0.89	0.85
420	1.02	0.98
450	1.18	1.15
480	1.46	1.43
510	1.86	1.76
540	2.42	2.32
570	3.14	3.04
600	4.47	4.25
630	6.10	5.75
660	7.66	7.36
690	9.15	8.82
680	5.81	5.81
670	4.36	4.36
660	3.41	3.45
670	5.55	5.47
680	6.96	6.85
690	8.33	8.15
720	10.36	10.08
750	11.53	11.24
780	12.87	12.58
810	13.90	13.69
840	14.84	14.53
870	15.82	15.52
900	16.70	16.40
930	17.52	17.24
960	18.23	17.97
990	18.98	18.67
1020	19.60	19.32
1050	20.17	19.93
1080	20.71	20.50

Corrected Test data

15-second readings Pressure [bar]	Volume [cm³]	Δr/r₀ [%]	30-second readings Pressure [bar]	Volume [cm³]	Δr/r₀ [%]
2.38	2	0.00	2.38	2	0.00
2.38	29.5	0.75	2.37	29.6	0.75
2.40	59.5	1.50	2.38	59.5	1.50
2.39	89.5	2.25	2.37	89.5	2.25
2.40	119.5	2.99	2.38	119.5	2.99
2.39	149.4	3.73	2.37	149.5	3.73
2.39	179.4	4.46	2.37	179.4	4.46
2.39	209.4	5.19	2.38	209.4	5.19
2.39	239.4	5.91	2.37	239.4	5.91
2.41	269.4	6.63	2.40	269.4	6.63
2.43	299.3	7.34	2.41	299.3	7.34
2.46	329.3	8.04	2.43	329.3	8.04
2.49	359.3	8.75	2.46	359.3	8.75
2.54	389.2	9.44	2.50	389.2	9.44
2.67	419.1	10.14	2.63	419.1	10.14
2.82	448.9	10.82	2.79	449.0	10.82
3.10	478.7	11.50	3.07	478.7	11.50
3.49	508.3	12.18	3.39	508.4	12.18
4.05	537.8	12.84	3.95	537.9	12.84
4.76	567.2	13.50	4.66	567.3	13.50
6.09	596.0	14.14	5.87	596.2	14.15
7.72	624.5	14.78	7.37	624.8	14.78
9.28	653.1	15.41	8.98	653.4	15.41
10.76	681.8	16.04	10.43	682.1	16.04
7.42	674.8	15.88	7.42	674.8	15.88
5.97	666.1	15.69	5.97	666.1	15.69
5.03	656.9	15.49	5.07	656.9	15.49
7.16	665.0	15.67	7.08	665.1	15.67
8.57	673.7	15.86	8.46	673.8	15.86
9.94	682.5	16.05	9.76	682.7	16.06
11.97	710.7	16.67	11.69	710.9	16.68
13.13	739.6	17.30	12.84	739.9	17.30
14.47	768.4	17.92	14.18	768.7	17.93
15.49	797.5	18.55	15.28	797.7	18.55
16.43	826.7	19.17	16.12	826.9	19.17
17.40	855.8	19.79	17.10	856.1	19.79
18.28	885.0	20.41	17.98	885.3	20.41
19.10	914.3	21.02	18.82	914.5	21.03
19.81	943.6	21.64	19.55	943.9	21.64
20.55	972.9	22.25	20.24	973.2	22.25
21.17	1002.4	22.86	20.89	1002.6	22.86
21.74	1031.9	23.47	21.50	1032.1	23.47
22.27	1061.4	24.07	22.06	1061.6	24.08

Creep

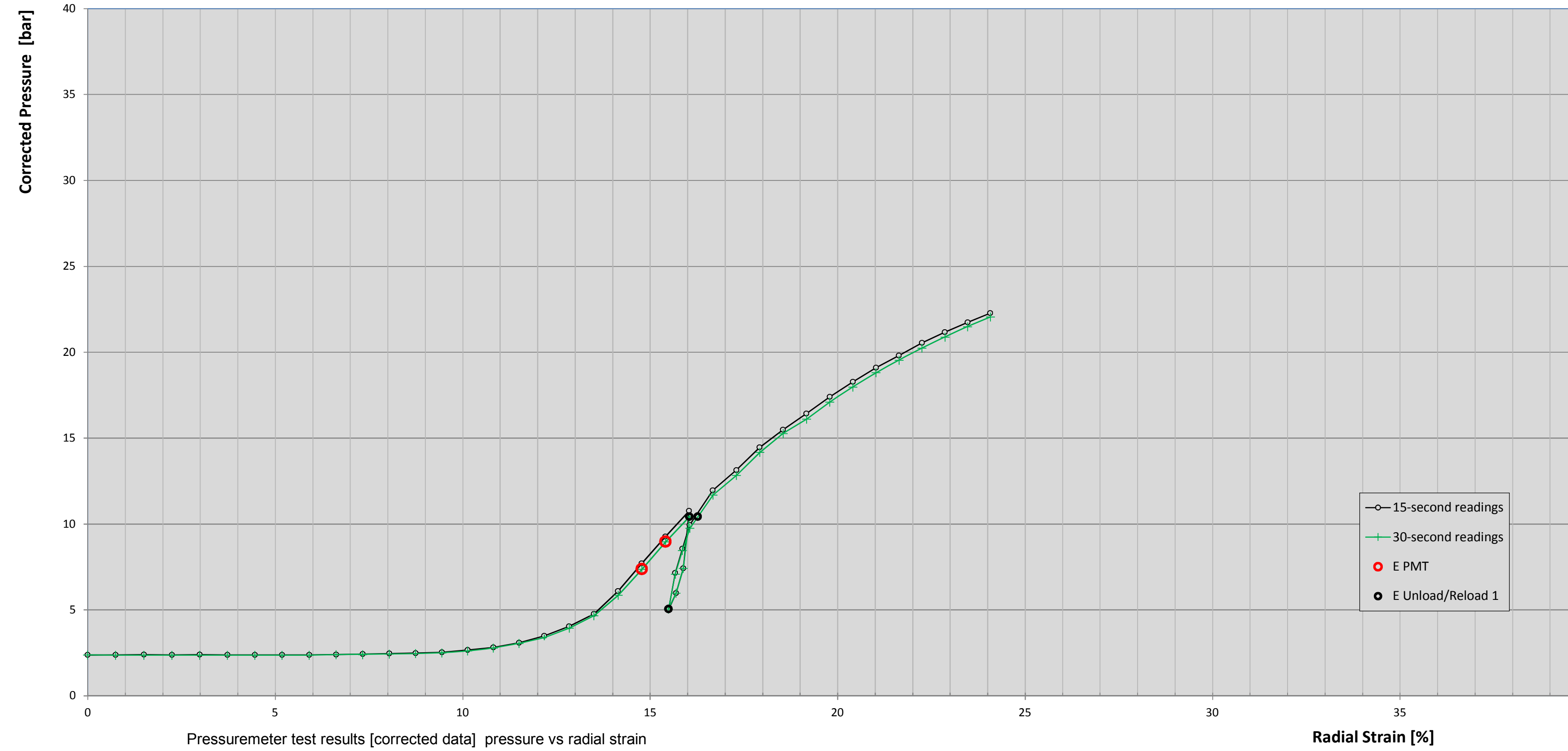
Volume [cm³]	Δp 30-15 [bar]
2	0.00
29.6	0.01
59.5	0.02
89.5	0.02
119.5	0.02
149.5	0.02
179.4	0.02
209.4	0.01
239.4	0.02
269.4	0.01
299.3	0.02
329.3	0.03
359.3	0.03
389.2	0.04
419.1	0.04
449.0	0.03
478.7	0.03
508.4	0.10
537.9	0.10
567.3	0.10
596.2	0.22
624.8	0.35
653.4	0.30
682.1	0.33
710.9	0.28
739.9	0.29
768.7	0.29
797.7	0.21
826.9	0.31
856.1	0.30
885.3	0.30
914.5	0.28
943.9	0.26
973.2	0.31
1002.6	0.28
1032.1	0.24
1061.6	0.21

Auxiliary Data

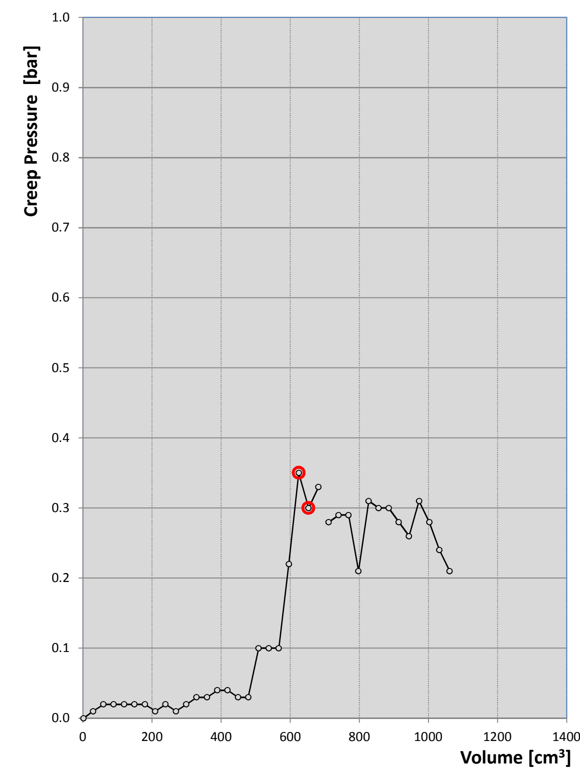
30 sec Pressure [bar]	1 / V
2.38	0.63744
2.37	0.03384
2.38	0.01680
2.37	0.01117
2.38	0.00837
2.37	0.00669
2.37	0.00557
2.38	0.00478
2.37	0.00418
2.40	0.00371
2.41	0.00334
2.43	0.00304
2.46	0.00278
2.50	0.00257
2.63	0.00239
2.79	0.00223
3.07	0.00209
3.39	0.00197
3.95	0.00186
4.66	0.00176
5.87	0.00168
7.37	0.00160
8.98	0.00153
10.43	0.00147
7.42	0.00148
5.97	0.00150
5.07	0.00152
7.08	0.00150
8.46	0.00148
9.76	0.00146
11.69	0.00141
12.84	0.00135
14.18	0.00130
15.28	0.00125
16.12	0.00121
17.10	0.00117
17.98	0.00113
18.82	0.00109
19.55	0.00106
20.24	0.00103
20.89	0.00100
21.50	0.00097
22.06	0.00094

Interpreted PMT Test Results

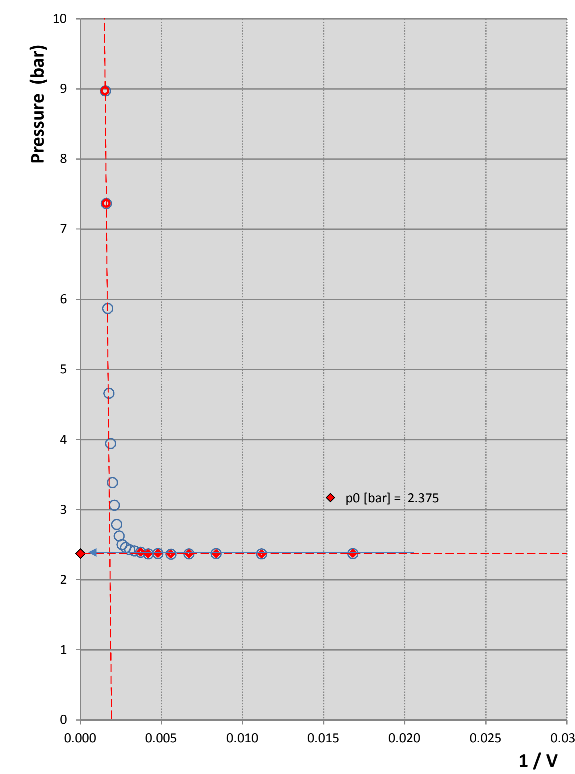
[30-second readings]			volume [cm³]	radial strain [%]	strain range [%]
p_0	2.38	[bar]	239.4	5.9	
p_L	34.02	[bar]			
p^*_L	31.65	[bar]			
p_Y	8.98	[bar]	653	15.4	
E_{PMT}	390	[bar]	625	14.8	[14.8 - 15.4 %]
E_{PMT} / p^*_L	12.3				
$E_{Unload\ 1}$	1495	[bar]	657	15.5	
$E_{Reload\ 1}$	1060	[bar]			



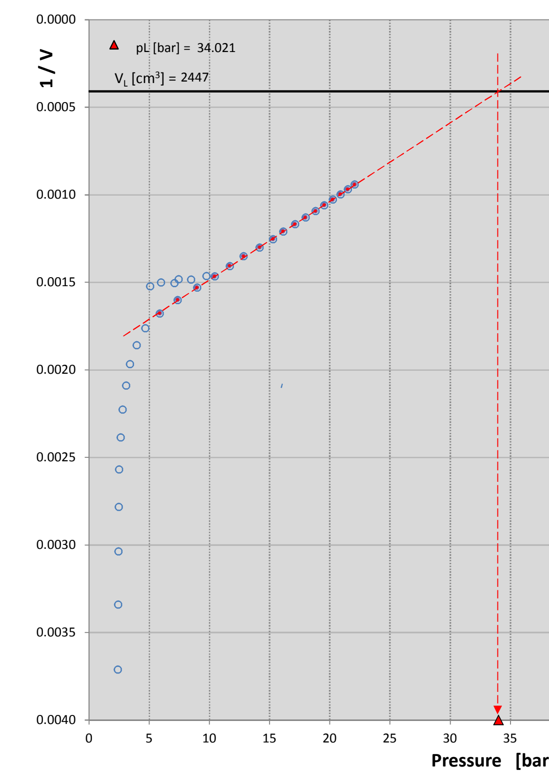
Pressuremeter test results [corrected data] pressure vs radial strain



Pressure difference from 15 to 30 sec. readings Δp [15-30 sec]



Determination of total contact pressure p_0



Determination of Limit Pressure p_L

Pressuremeter Equipment: TEXAM Model	Probe Designation : NX Probe (76 mm OD)	Drilling Method: Mud Rotary Drilling Drilling Bit: Tricone Bit	Test Date: January 30, 2018	Project: HWY 400 and HWY 89	PMT TEST No.: 7
Volume-controlled test as per ASTM D4719 Method B	Probe No.: E 309 Calibration Record No.: 1	Time elapsed from hole drilling to testing ~ 5 minutes	Test Depth [m]: 21.13 (center of the probe)	Client: Golder Associates	
Volume increments: 40 cm³ Maximum Volume: 1400 cm³ Maximum Pressure: 100 bar	Tubing Length: 150 [ft] Probe Lenght: 0.46 [m] Probe Initial Volume: 1968 cm³	Engineer: Gabriel Sedran, P.Eng., Ph.D. Operator: Scott Hall	Drilling Company: Walker Drilling	In-Depth Geotechnical Project No.: IDG 180411	Borehole No.: BH 02-PMT

Appendix Two

Pressuremeter Data Interpretation

Interpretation of Pressuremeter Test Results

Prebored pressuremeter test results are expressed in terms of applied pressure versus radial strain. Both pressure and strain measurements must be corrected for pressure and volume loses using the corresponding probe and system calibration curves.

The typical pressure versus radial strain curve features up to four distinctive portions which characterize the stress-strain behaviour of the soil, namely:

a) The linear pseudo-elastic stress-strain portion of the deformation curve;
b) The departure from linear elastic conditions starting at the yield pressure p_y;
c) The unload-reload portion of the test (usually two cycles are performed); and
d) The development of soil failure, which is represented by the net limit pressure p^*_L.

Based on these test features the following soil parameters are determined or estimated:

1. **Total Horizontal Stress σ_{ho} or p_o**:

When using the prebored TEXAM unit, the initial contact pressure is taken as the pressure at the intersection of the two lines representing the pseudo elastic and the initial expansion portions of the pressure vs. 1/V plot, as shown in the PMT data sheets, in Appendix One. In the context of this report, σ_{ho} is also equivalent to the total contact pressure p_0.

2. **Pressuremeter modulus E_{PMT}**:

The pressuremeter modulus is represented by the slope of the pressure versus radial strain curve along its linear portion, and may be calculated as follows:

$$E_{PMT} = (1+\upsilon)(p_2 - p_1)\frac{\left(1+\left(\frac{\Delta R}{R_o}\right)_2\right)^2 + \left(1+\left(\frac{\Delta R}{R_o}\right)_1\right)^2}{\left(1+\left(\frac{\Delta R}{R_o}\right)_2\right)^2 - \left(1+\left(\frac{\Delta R}{R_o}\right)_1\right)^2}$$

where the sub-indices 1 and 2 indicate the beginning and the end of the linear portion of the curve, respectively. These two points are shown in pressuremeter curves with two red oversized circles. For the self-boring probe, the linear portion of the stress-strain response occurs between the very first data point (zero volume increase) and the subsequent two or three data points.

In this determination a value of the Poisson's ratio, typically $\nu = 0.33$ for most soils, must be assumed. For saturated clays a value of $\nu = 0.45$ is suggested.

The Pressuremeter modulus E_{PMT} corresponds to large strains, namely for radial strains in the 2 to 5 % range, and it is therefore considered to be a relatively low value of the elastic modulus.

In practice, the Young's modulus E can be inferred from Pressuremeter testing using the Menard α factor:

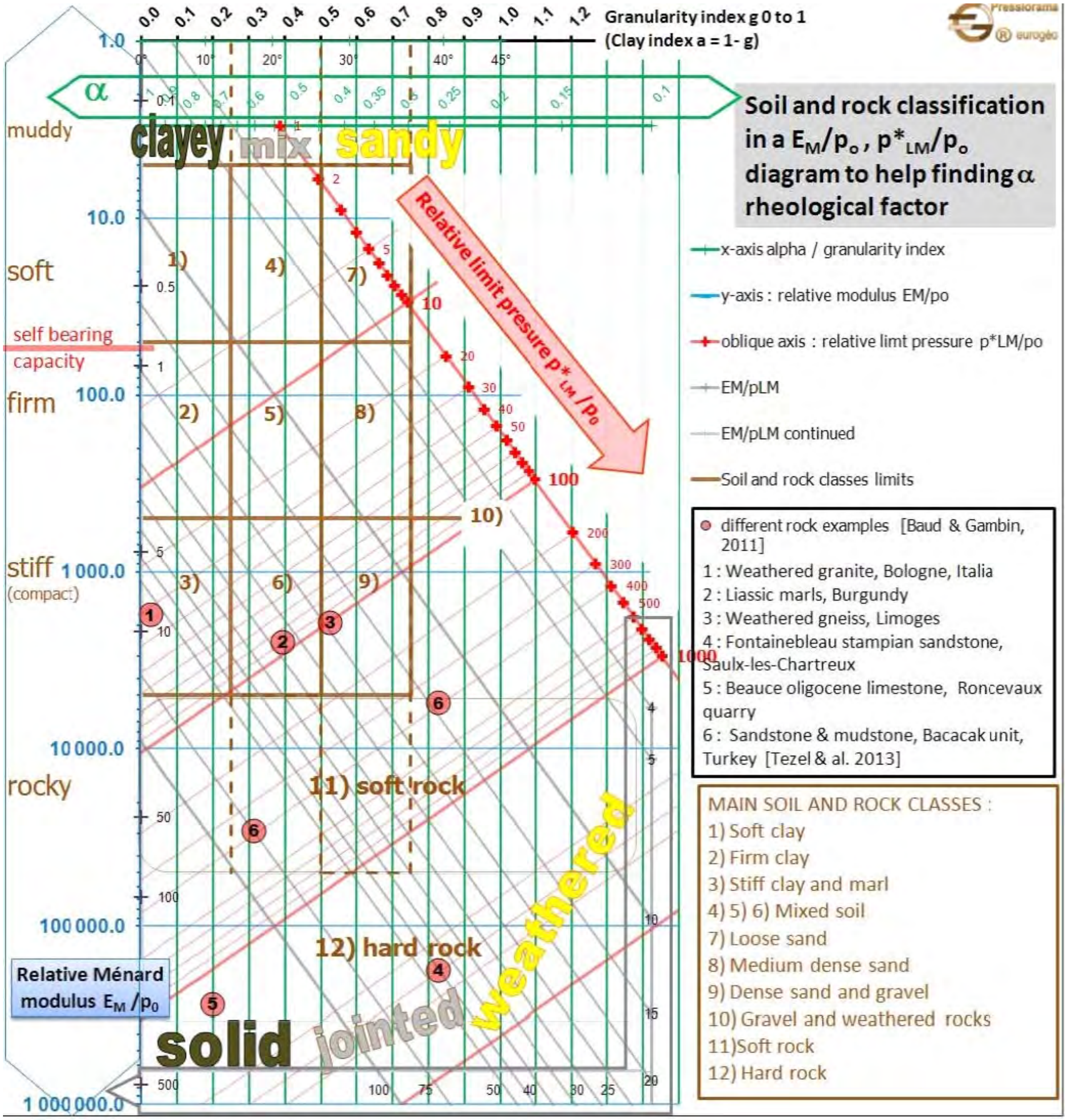
$E = E_{PMT} / \alpha$

Typical values of the Menard α factor are suggested in the following Table:

Soil type	Peat		Clay		Silt		Sand		Sand and gravel	
	E/p_L^*	α	E/p_L^*	α	E/p_L^*	α	E/p_L^*	α	E/p_L^*	α
Over consolidated		1	> 16	1	> 14	2/3	> 12	1/2	> 10	1/3
Normally consolidated	For all values	1	9-16	2/3	8-14	1/2	7-12	1/3	6-10	1/4
Weathered and/or remoulded		1	7-9	1/2		1/2		1/3		1/4
Rock	Extremely fractured				Other				Slightly fractured or extremely weathered	
	α = 1/3				α = 1/2				α = 2/3	

(from 'The Pressuremeter', J.L. Briaud. Balkema, 1992)

Alternatively, better-defined values of the Menard α parameter can be obtained from the Pressiorama chart introduced by Baud et.al., as illustrated below.



Baud J.P., and Gambin M. 2013. *"Détermination du coefficient rhéologique α de Ménard dans le diagramme Pressiorama".* Proceedings of the 18th International Conference on Soil Mechanics and Geotechnical Engineering. Paris, 2013, Parallel Session ISP 6, International Symposium on the Pressuremeter.

3. **Yield Pressure p_y**:

The yield pressure indicates the end of the linear pseudo-elastic deformations and the onset of plasticity. This yield pressure is useful in indicating beyond which pressure significant creep deformations may occur.

4. **Unload-Reload Modulus E_R**:

The reload modulus is represented by the slope of the unload-reload loop, and may be used to determine elastic soil deformations upon unloading conditions such as those typically encountered during excavations.

5. **Net Limit Pressure p^*_L**:

The net limit pressure is a measure of the strength of the soil (either under undrained conditions for cohesive soils, or drained conditions for non-cohesive soils). This parameter is defined as the pressure reached when the soil cavity has been extended to twice its original soil cavity volume V_c (minus the initial total contact pressure p_o).

The limit pressure is not always attained during testing. In such cases, the value of p_L is inferred by plotting pressure versus 1/V for the plastic phase of the deformations. This method of inferring p_L, known as the "upside down curve" method, is described in "*The Pressuremeter and Foundation Engineering*" textbook, by F. Baguelin, J.F.Jezequel, and D.H. Shields, published in 1978 by Trans Tech Publications, Section: Methods of extrapolating pressuremeter curves to p_L. See also ASTM D4719-00, Section 10.6.

It should be noted that radial strains are calculated from the volume of fluid (typically tap water) injected into the probe. In this regard, the radial strains shown in the results are related to the probe expansion, not the cavity's expansion. The cavity initial volume, V_c, is calculate by adding the probe initial volume, V_0, plus the volume of water injected into the probe at the initial contact pressure p_0. For the self-boring PMT probe,

6. Some Additional Parameters

In addition, two useful ratios, (E_{PMT} / p^*_L) and (p^*_L / p_y), may be used as a general guideline for soil identification, as follows:

for sands $7 < E_{PMT} / p^*_L < 12$

for clays $12 < E_{PMT} / p^*_L$

Also, as presented in the Canadian Foundation Engineering Manual (4th Edition, 2006)

TABLE 4.7 *Typical Menard Pressuremeter Values*

Type Of Soil	Limit Pressure (kPa)	E_M / p_l
Soft clay	50 – 300	10
Firm clay	300 – 800	10
Stiff clay	600 - 2500	15
Loose silty sand	100 – 500	5
Silt	200 - 1500	8
Sand and gravel	1200 – 5000	7
Till	1000 – 5000	8
Old fill	400 – 1000	12
Recent fill	50 - 300	12

For most soil types the ratio between the limit and the yield pressures may be expressed as:

$$1.3 < (p^*_L / p_y) < 2.0$$

Also as a general guideline, clayey and sandy soils may have the following parameters:

Table 10. Approximate common values for the pressuremeter parameters.

CLAY					
Soil type	Soft	Medium	Stiff	Very stiff	Hard
p_L^* (kPa)	0 - 200	200 - 400	400 - 800	800 - 1600	>1600
E_o (kPa)	0 - 2500	2500 - 5000	5000 - 12000	12000 - 25000	>25000

SAND				
Soil type	Loose	Compact	Dense	Very dense
p_L^* (kPa)	0 - 500	500 - 1500	1500 - 2500	> 2500
E_o (kPa)	0 - 3500	3500 - 12000	12000 - 22500	> 22500

Note: 100 kPa = 1.04 tsf

(from 'The Pressuremeter', J.L. Briaud. Balkema, 1992)

Inferred Shear Strength Parameters

The undrained shear strength of cohesive soils may be estimated as:

$$\frac{S_u}{p_a} = 0.21\left(\frac{p_L^*}{p_a}\right)^{0.75}$$

where p_a represents a reference pressure (i.e., atmospheric pressure = 100 kPa), after J.L. Briaud ('The Pressuremeter', Balkema, 1992).

The drained friction angle of cohesionless soils (c' = 0) may be estimated using the empirical correlations illustrated in the graph shown below. This approach is outlined by Baguelin et.al. in *"The Pressuremeter and Foundation Engineering"* (F. Baguelin; J.F. Jézéquel; and D.H. Shields. TransTech Publications. 1978), and it requires some knowledge on the state or conditions of the cohesionless material. This approach only provides a likely range of friction angles from interpreted limit pressure values.

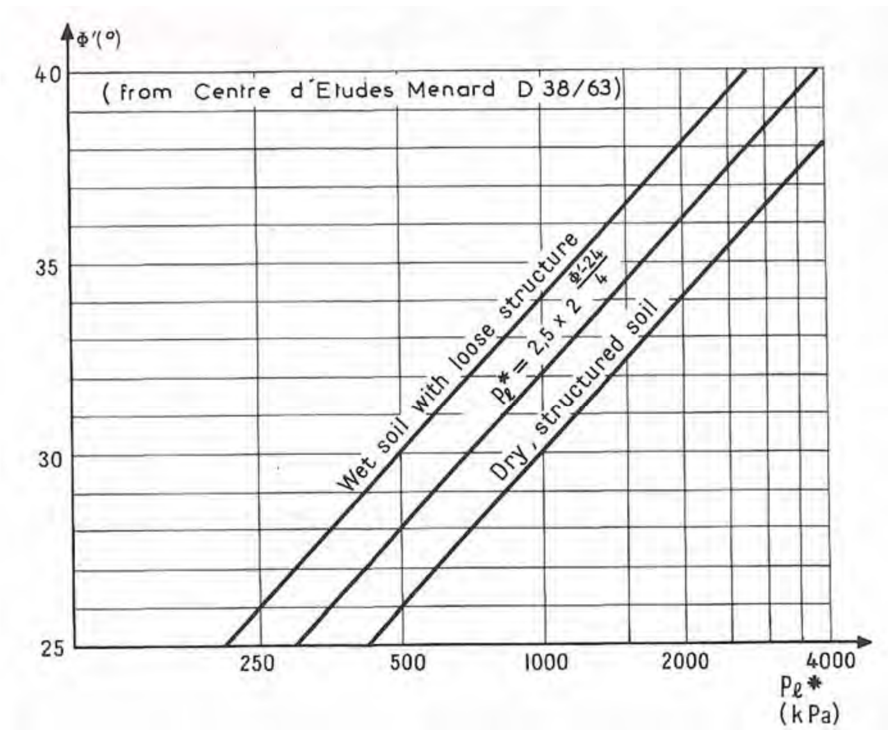


Fig. 6-86: MÉNARD's graph to determine Φ' from p_1^*.

Conservative estimates (lower-bound estimates) of strength parameters can also be inferred from the following table:

Table 8. Guidelines for estimating the limit pressure of the soil.

Soils		Pressuremeter p_L (kPa)	SPT blow count N (blows/30 cm)	Undrained shear strength S_u (kPa)
Sand	loose	0 - 500	0 - 10	
	medium	500 - 1500	10 - 30	
	dense	1500 - 2500	30 - 50	
	very dense	> 2500	> 50	
Clay	soft	0 - 200		0 - 25
	firm	200 - 400		25 - 50
	stiff	400 - 800		50 - 100
	very stiff	800 - 1600		100 - 200
	hard	> 1600		> 200
Note: 100 kPa = 1.044 tsf; 1 cm = 0.033 ft				

(From 'The Pressuremeter', J.L. Briaud. Balkema, 1992)

Appendix Three

Calibration Data

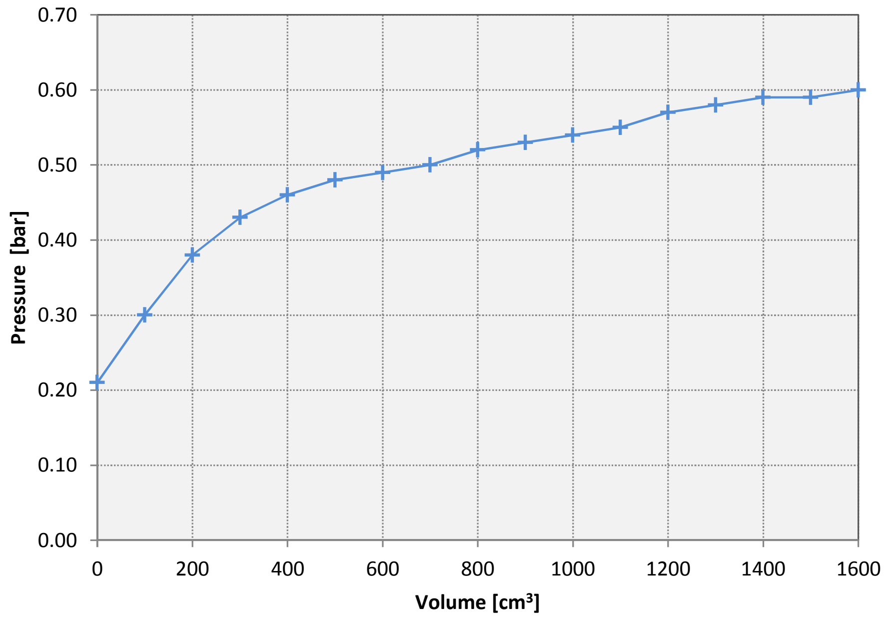
Calibration Date:	December 13, 2017
Probe Designation:	E 309
Calibration Record No.:	1
Length of Tubing:	150 feet
Calibrated by:	T.H.

In-Depth Geotechnical Inc.

Membrane stiffness calibration

Pressure [bar]	Volume cm³
0.21	0
0.30	100
0.38	200
0.43	300
0.46	400
0.48	500
0.49	600
0.50	700
0.52	800
0.53	900
0.54	1000
0.55	1100
0.57	1200
0.58	1300
0.59	1400
0.59	1500
0.60	1600

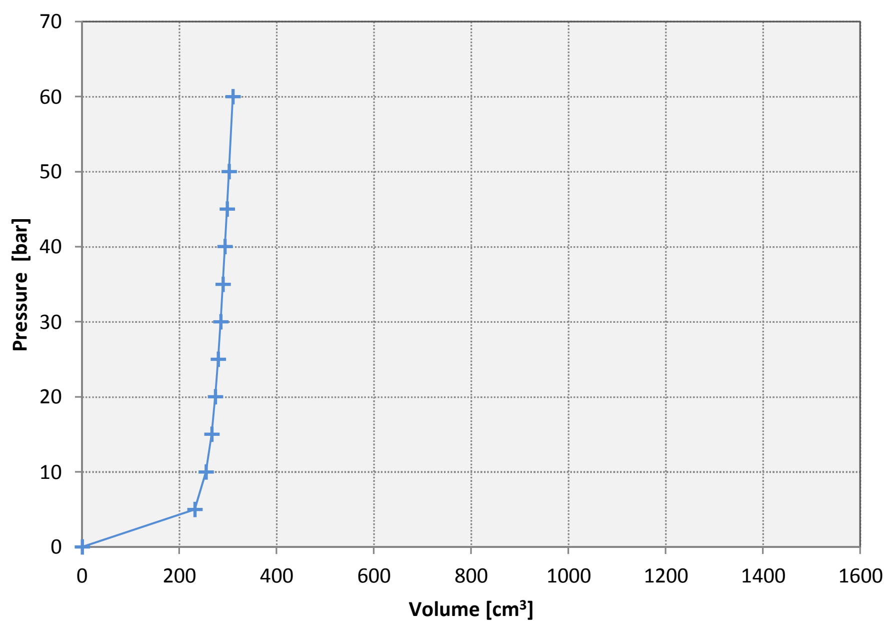
Membrane Stiffness (Air Calibration)



Volume calibration

Pressure [bar]	Volume cm³
0	0.0
5	231.9
10	254.8
15	266.6
20	273.6
25	279.5
30	284.6
35	289.3
40	293.7
45	297.9
50	302.0
60	309.9
Reload Cal. Data	
25	280.8
50	302.4

System Stiffness (Compliance Calibration)



APPENDIX C

Vertical Seismic Profile Test Results

TECHNICAL MEMORANDUM

DATE February 16, 2018 **PROJECT No.** 1668512/1000/1005

TO David Marmor
Golder Associates

FROM Stephane Sol, Christopher Phillips **EMAIL** ssol@golder.com, cphillips@golder.com

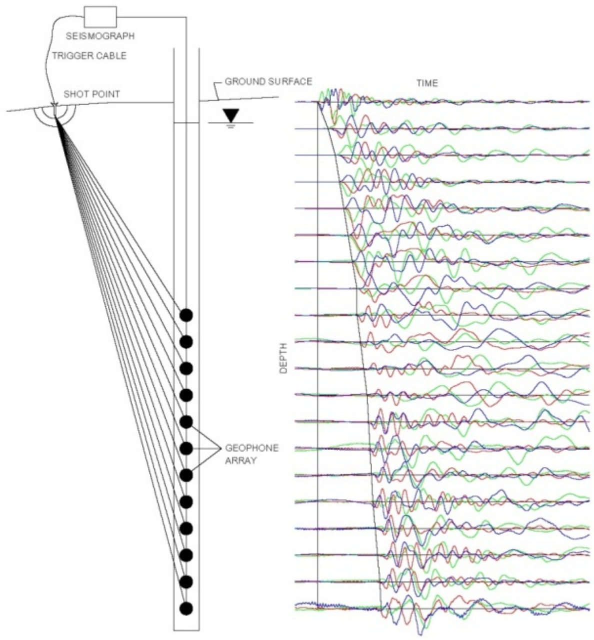
VERTICAL SEISMIC PROFILING TEST RESULTS
HWY400 AND HWY89, INNISFIL, ONTARIO

This memorandum presents the results of two Vertical Seismic Profiling (VSP) testing carried out at a site located at the intersection of HWY400 and HWY89 south of Innisfil. VSP testing was carried out on February 12 2018. Borehole PMT-01, located in the SW quadrant of the intersection, was drilled to an approximate depth of 35.7 m below the existing ground surface and then cased with a 2 inch PVC pipe grouted in place. The borehole consisted of approximately 1.5 m of silty sand fill, 10.2 m of silt and sand, 9.1 m of silt, 10.7 m of clayey silt, 2.3 m of silty sand and clayey silt to bottom of the borehole. Borehole PMT-02, located in the SE quadrant of the intersection, was drilled to an approximate depth of 22 m below the existing ground surface and then cased with a 2 inch PVC pipe grouted in place. The borehole consisted of variations of silty sand, sand, and sandy silt.

Methodology

For the VSP method, seismic energy is generated at the ground surface by an active seismic source and recorded by a geophone located in a nearby borehole at a known depth. The active seismic source can be either compression or shear wave. The time required for the energy to travel from the source to the receiver (geophone) provides a measurement of the average compression or shear-wave seismic velocity of the medium between the source and the receiver. Data obtained from different geophone depths are used to calculate a detailed vertical seismic velocity profile of the subsurface in the immediate vicinity of the test borehole.

The high resolution results of a VSP survey are often used for earthquake engineering site classification, as per the 2015 National Building Code of Canada.



Example 1: Layout and resulting time traces from a VSP survey.

Fieldwork

The fieldwork was carried out on February 12, 2018, by personnel from the Golder Mississauga offices.

At PMT-01, the compression and shear-wave seismic sources were used and they were located 2 m, and 1.95 m from the borehole. The seismic source for the compression wave test consisted of a 9.9 kilogram sledge hammer vertically impacted on a metal plate. The seismic source for the shear-wave test consisted of a 1 metre long aluminium plate, hammer into the ground and horizontally struck with a 9.9 kilogram sledge hammer on alternate ends of the beam to induce polarized shear waves. Test measurements started at ground surface and were recorded in the borehole with a 3-component receiver spaced mostly at 1-metre intervals below the ground surface to a maximum depth of the casing (33.8 m).

At PMT-02, the compression and shear-wave seismic sources were used and they were located 2 m, and 2.27 m from the borehole. The seismic source for the shear-wave test consisted of a 2.4 metre long, 150 millimetre by 150 millimetre wooden beam, weighted by a vehicle and horizontally struck with a 9.9 kilogram sledge hammer on alternate ends of the beam to induce polarized shear waves. The shear source was coupled to the ground surface by parking a vehicle on top of it. Test measurements started at ground surface and were recorded in the borehole with a 3-component receiver spaced mostly at 1-metre intervals below the ground surface to a maximum depth of the casing (20.7 m).

The seismic records collected for each source location were stacked a minimum of five times to minimize the effects of ambient background seismic noise on the collected data. The data was sampled at 0.020833 millisecond intervals and a total time window of 0.341 seconds was collected for each seismic shot.

Data Processing

Processing of the VSP test results consisted of the following main steps:

1) Combination of seismic records to present seismic traces for all depth intervals on a single plot for each seismic source and for each component;

2) Low Pass Filtering of data to remove spurious high frequency noise;

3) First break picking of the compression and shear-wave arrivals; and,

4) Calculation of the average compression and shear-wave velocity to each tested depth interval.

Processing of the VSP data was completed using the SeisImager/SW software package (Geometrics Inc.). The seismic records at PMT-01 are presented on the following two plots and show the first break picks of the compression wave (Figure 1) and shear wave arrivals (Figure 2) overlaid on the seismic waveform traces recorded at the different geophone depths. The arrivals were picked on the vertical component for the compression source and on the two horizontal components for the shear source.

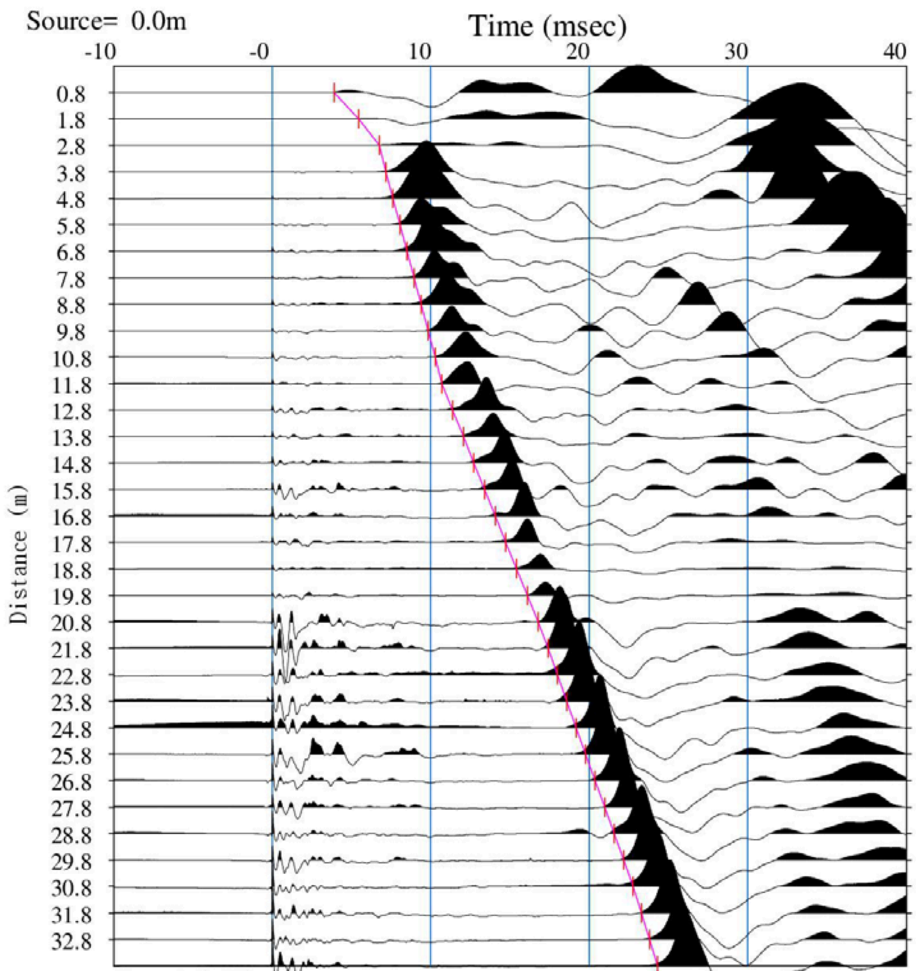


Figure 1: First break picking of compression wave arrivals (red) along the seismic traces recorded at each receiver depth of Borehole PMT-01.

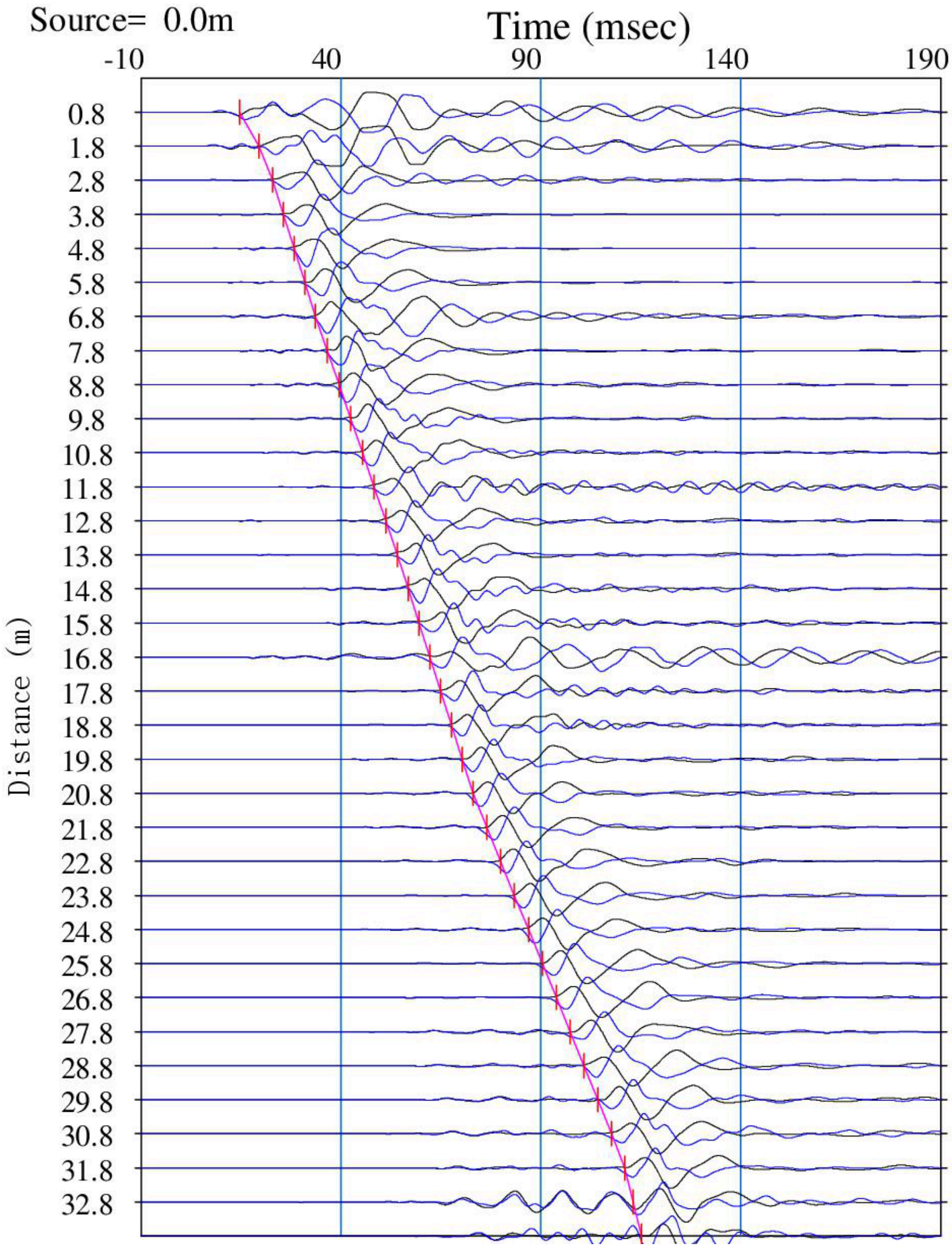


Figure 2: First break picking of shear wave arrivals (red) along the seismic traces recorded at each receiver depth of Borehole PMT-01.

The seismic records at PMT-02 are presented on the following two plots and show the first break picks of the compression wave (Figure 3) and shear wave arrivals (Figure 4) overlaid on the seismic waveform traces recorded at the different geophone depths. The arrivals were picked on the vertical component for the compression source and on the two horizontal components for the shear source.

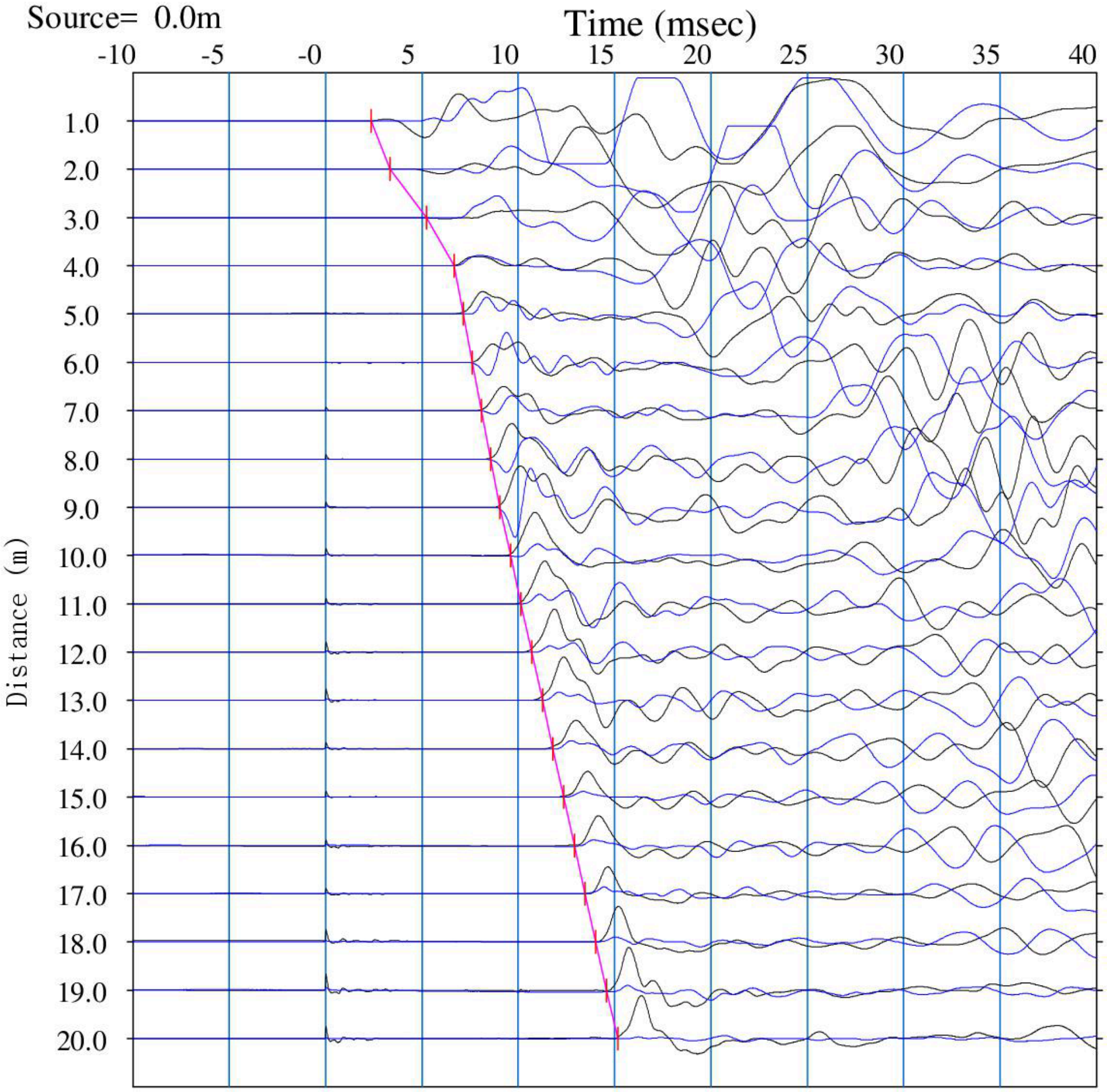


Figure 3: First break picking of compression wave arrivals (red) along the seismic traces recorded at each receiver depth of Borehole PMT-02.

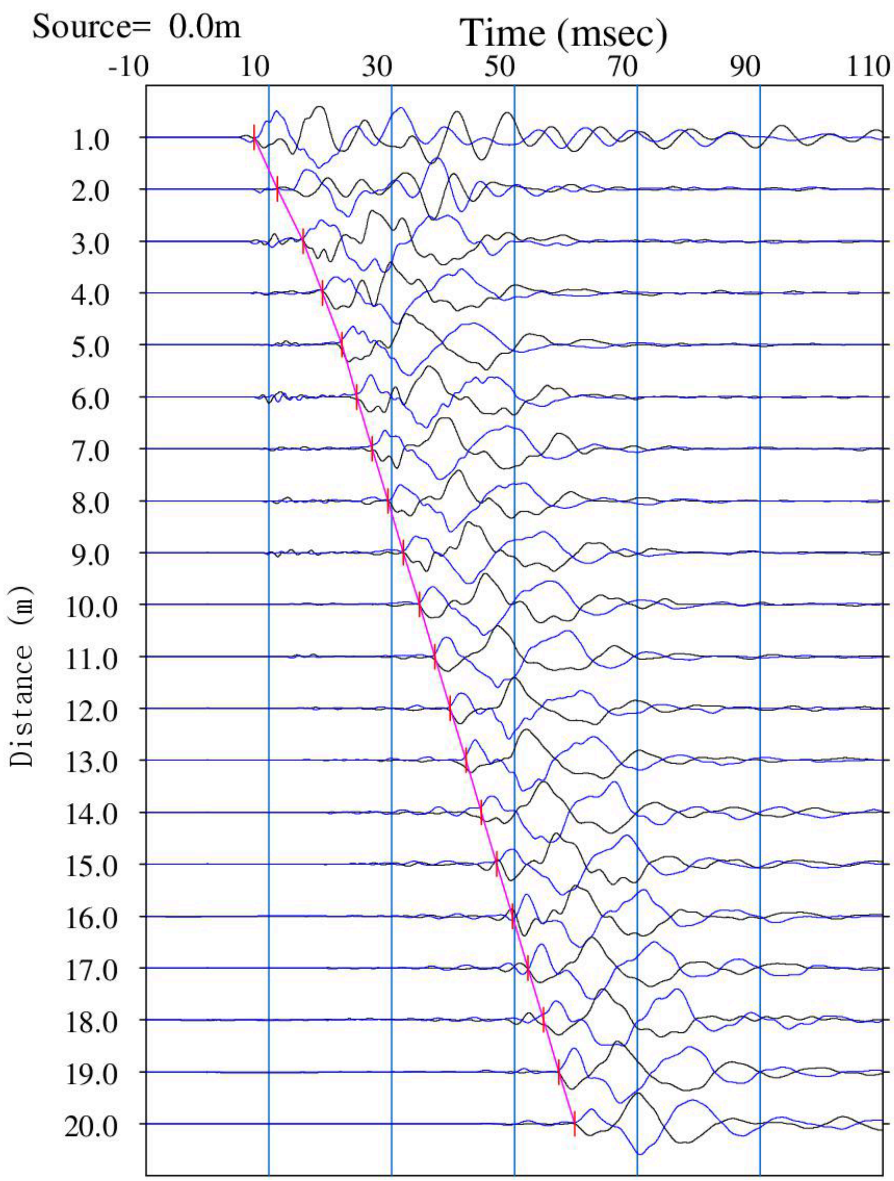


Figure 4: First break picking of shear wave arrivals (red) along the seismic traces recorded at each receiver depth of Borehole PMT-02.

Results

The VSP results at PMT-01 and PMT-02 are summarized in Tables 1, and Table 2, respectively. The shear wave and compression wave layer velocities were calculated by best fitting a theoretical travel time model to the field data. The depths presented on the table are relative to ground surface.

The estimated dynamic engineering moduli, based on the calculated wave velocities, are also presented in Tables 1 and 2. The engineering moduli were calculated using an estimated bulk density, based on the borehole log. At borehole PMT-01, an estimated bulk density of 2000 kg/m^3 was used for the sand and silt layers and an estimated bulk density of 1,850 kg/m^3 was used for the clay layers. At borehole PMT-02, an estimated bulk density of 2000 kg/m^3 was used for the sand and silt layer.

At borehole PMT-01, the average shear wave velocity from ground surface to a depth of 30 metres was measured to be 286 metres per second. At borehole PMT-02, the average shear wave velocity from ground surface to a depth of 30 metres was measured to be 352 metres per second. The average velocity at PMT-02 was calculated assuming that the velocity from 20.7 metres to a depth of 30 metres was constant with an average shear-wave velocity value of 390m/s which is equal to the velocity at the bottom of the borehole.

Limitations

This technical memorandum, which specifically includes all tables, figures and attachments, is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this memo.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this memo, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this memo, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this memo.

The findings and conclusions of this memo are valid only as of the date of this memo. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this memo, and to provide amendments as required.

Closure

We trust that these results meet your current needs. If you have any questions or require clarification, please contact the undersigned at your convenience.

GOLDER ASSOCIATES LTD.

Stephane Sol, Ph.D., P.Geo
Senior Geophysicist

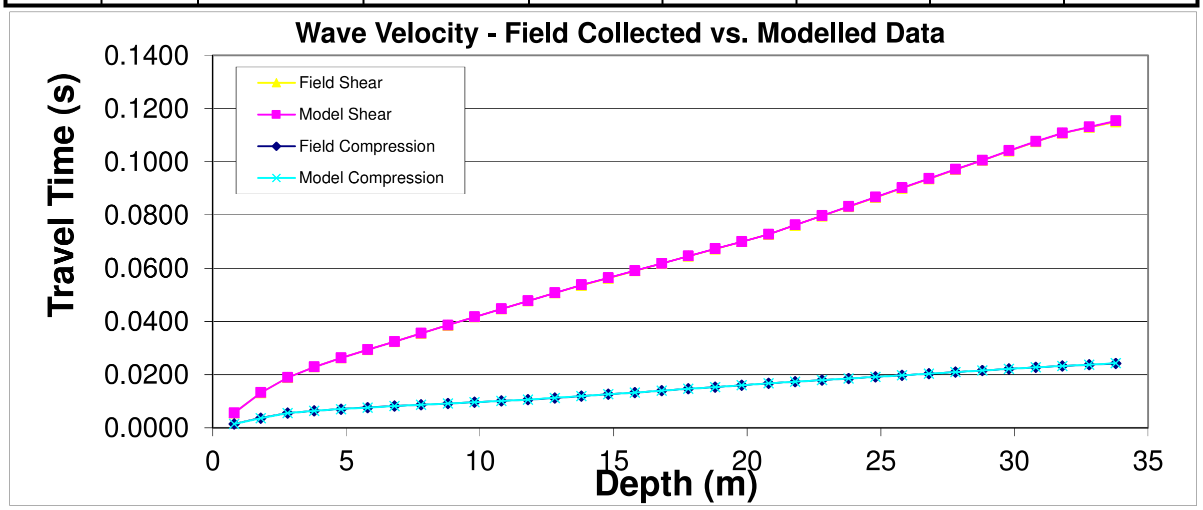
Christopher Phillips, M.Sc., P.Geo
Principal, Senior Geophysicist

SS/CRP/
https://golderassociates.sharepoint.com/sites/12201g/5 - technical work/field work/geophysics/report/1668512_1000_1005 tech memovsp_innisfil.docx

Attachment: Table 1 – Compression and Shear Wave Velocity Profiles at Borehole PMT-01
Table 2 – Compression and Shear Wave Velocity Profiles at Borehole PMT-02

TABLE 1
SHEAR WAVE VELOCITY PROFILE AT BOREHOLE PMT-01

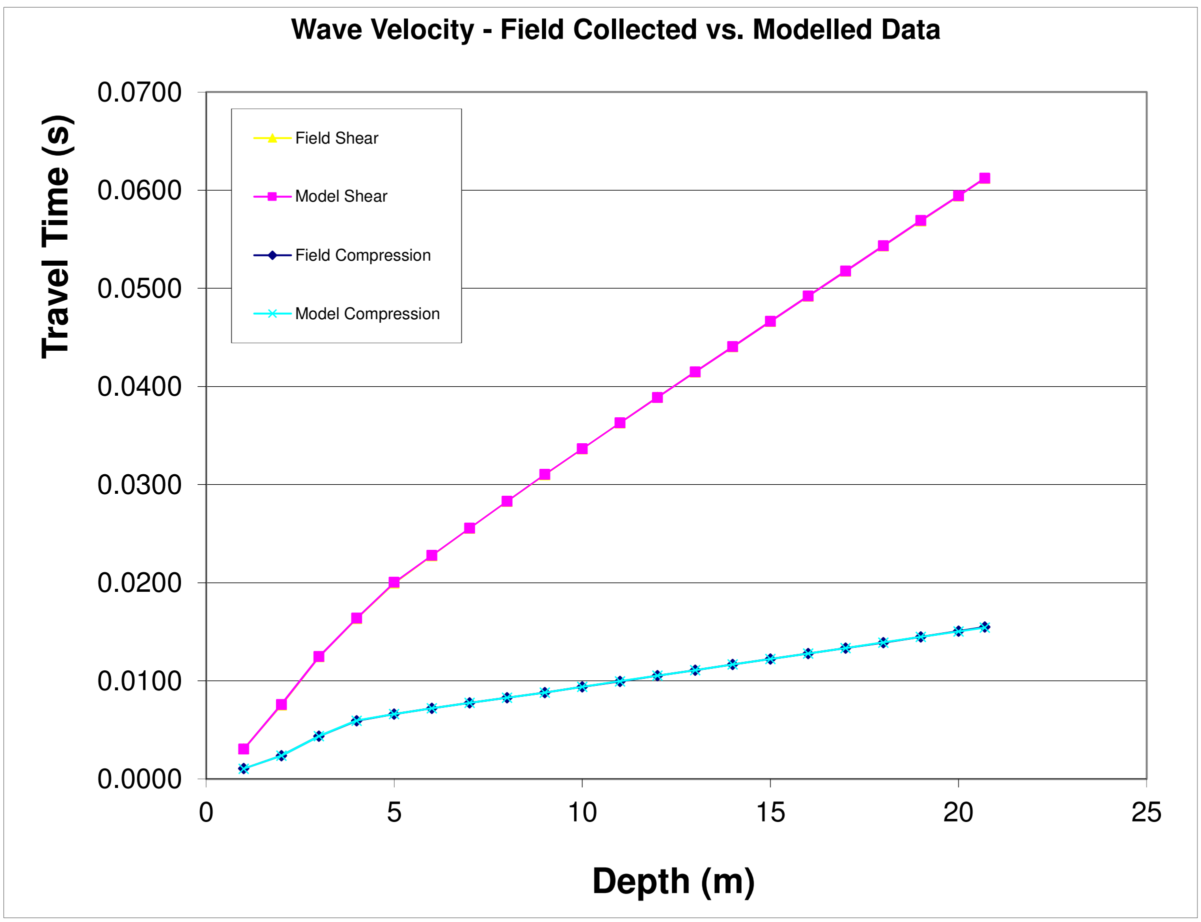
Layer Depth (m)		Velocities (m/s)		Estimated Bulk Density (kg/m^3)	Dynamic Engineering Properties			
Top	Bottom	Compressional Wave	Shear Wave		Poissons Ratio	Shear Modulus (MPa)	Deformation Modulus (MPa)	Bulk Modulus (MPa)
0.0	0.8	550	144	2000	0.46	41	121	550
0.8	1.8	460	130	2000	0.46	34	98	378
1.8	2.8	545	179	2000	0.44	64	184	509
2.8	3.8	1140	252	2000	0.47	127	374	2430
3.8	4.8	1480	293	2000	0.48	172	508	4152
4.8	5.8	1700	320	2000	0.48	205	607	5507
5.8	6.8	1840	330	2000	0.48	218	646	6481
6.8	7.8	1960	320	2000	0.49	205	609	7410
7.8	8.8	2090	325	2000	0.49	211	629	8455
8.8	9.8	2100	325	2000	0.49	211	629	8538
9.8	10.8	2100	330	2000	0.49	218	648	8530
10.8	11.8	2240	335	2000	0.49	224	668	9736
11.8	12.8	1450	335	2000	0.47	224	661	3906
12.8	13.8	1470	335	2000	0.47	224	661	4023
13.8	14.8	1470	375	2000	0.47	281	824	3947
14.8	15.8	1470	365	2000	0.47	266	782	3967
15.8	16.8	1490	365	2000	0.47	266	782	4085
16.8	17.8	1470	365	2000	0.47	266	782	3967
17.8	18.8	1470	365	2000	0.47	266	782	3967
18.8	19.8	1470	365	2000	0.47	266	782	3967
19.8	20.8	1430	370	2000	0.46	274	802	3725
20.8	21.8	1630	285	1850	0.48	150	446	4715
21.8	22.8	1660	290	1850	0.48	156	462	4890
22.8	23.8	1660	285	1850	0.48	150	446	4898
23.8	24.8	1660	285	1850	0.48	150	446	4898
24.8	25.8	1670	290	1850	0.48	156	462	4952
25.8	26.8	1670	285	1850	0.49	150	446	4959
26.8	27.8	1660	285	1850	0.48	150	446	4898
27.8	28.8	1670	290	1850	0.48	156	462	4952
28.8	29.8	1670	285	1850	0.49	150	446	4959
29.8	30.8	1670	285	1850	0.49	150	446	4959
30.8	31.8	1850	320	1850	0.48	189	562	6079
31.8	32.8	1950	430	1850	0.47	342	1009	6579
32.8	33.8	1950	430	1850	0.47	342	1009	6579



Notes
1. Depth Presented relative to ground surface.
2. This Table to be analyzed in conjunction with the accompanying report.

TABLE 2
SHEAR WAVE VELOCITY PROFILE AT BOREHOLE PMT-02

Layer Depth (m)		Velocities (m/s)		Estimated Bulk Density (kg/m^3)	Dynamic Engineering Properties			
Top	Bottom	Compressional Wave	Shear Wave		Poissons Ratio	Shear Modulus (MPa)	Deformation Modulus (MPa)	Bulk Modulus (MPa)
0.0	1.0	950	330	2000	0.43	218	624	1515
1.0	2.0	765	220	2000	0.45	97	282	1041
2.0	3.0	500	205	2000	0.40	84	235	388
3.0	4.0	630	255	2000	0.40	130	365	620
4.0	5.0	1500	275	2000	0.48	151	448	4298
5.0	6.0	1700	365	2000	0.48	266	786	5425
6.0	7.0	1800	360	2000	0.48	259	767	6134
7.0	8.0	1880	365	2000	0.48	266	789	6714
8.0	9.0	1970	365	2000	0.48	266	790	7407
9.0	10.0	1720	380	2000	0.47	289	852	5532
10.0	11.0	1730	380	2000	0.47	289	852	5601
11.0	12.0	1750	385	2000	0.47	296	874	5730
12.0	13.0	1760	385	2000	0.47	296	874	5800
13.0	14.0	1780	390	2000	0.47	304	897	5931
14.0	15.0	1780	385	2000	0.48	296	875	5942
15.0	16.0	1780	390	2000	0.47	304	897	5931
16.0	17.0	1780	390	2000	0.47	304	897	5931
17.0	18.0	1780	390	2000	0.47	304	897	5931
18.0	19.0	1780	390	2000	0.47	304	897	5931
19.0	20.0	1780	395	2000	0.47	312	920	5921
20.0	20.7	1780	390	2000	0.47	304	897	5931



Notes
1. Depth Presented relative to ground surface.
2. This Table to be analyzed in conjunction with the accompanying report.

APPENDIX D

Borehole Records - Current Investigation

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1. $\tau = c' + \sigma' \tan \phi'$
2. shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to “A” size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

Foundation Design

RECORD OF BOREHOLE No 89UP-01

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4895618.4; E 292361.9 MTM NAD 83 ZONE 10 (LAT. 44.200459; LONG. -79.655616)

BOREHOLE TYPE D50 Track Mount, 203mm O.D. Continuous Flight Hollow Stem Augers

DATE August 15, 2017

ORIGINATED BY DF

COMPILED BY DH

CHECKED BY SMM/TZ

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
227.8	GROUND SURFACE
0.0	TOPSOIL (200 mm)
0.2	Gravelly sand, trace silt, trace organics (FILL) Compact Brown Moist
227.1 / 0.7	Silty sand, trace gravel (FILL) Loose to compact Brown mottled with oxidation staining Moist
225.6 / 2.2	SILT and SAND, trace to some clay Compact Grey Wet
219.6 / 8.2	END OF BOREHOLE

NOTE:

1. Water level measured in open borehole at a depth of about 2.2 m below ground surface (Elev. 225.6 m) upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	18				
2	SS	19				
3	SS	9				
4	SS	15				
5	SS	16	0	57	41	2
6	SS	16				
7	SS	11				
8	SS	15				
9	SS	14	0	30	64	6

GROUND WATER CONDITIONS: water level symbol at approx. Elev. 225.6

ELEVATION SCALE: 227, 226, 225, 224, 223, 222, 221, 220

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20, 40, 60, 80, 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L

WATER CONTENT (%): 10, 20, 30

UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\HWY_400_AND_HWY_89_INTERCHANGE\02_DATA\GINT\HWY_400_AND_HWY_89_INTERCHANGE.GPJ GAL-GTA.GDT 09/12/18

Golder Associates

RECORD OF BOREHOLE No 89UP-02

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895597.2; E 292389.9 MTM NAD 83 ZONE 10 (LAT. 44.200269; LONG. -79.655266)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DM

DATUM Geodetic

DATE June 11 to 15, 2017

CHECKED BY SMM/TZ

Column headings: SOIL PROFILE (ELEV / DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR, SA, SI, CL)

ELEV / DEPTH (m)	DESCRIPTION
235.4	GROUND SURFACE
0.0	ASPHALT (165 mm)
0.2	Sand and gravel (FILL) (600 mm)
234.6 / 0.8	Silt and sand, trace to some clay (FILL) Compact to dense Brown Moist
225.2 / 10.2	Sandy SILT to SILT and SAND, trace clay Dense Brown to grey Moist to wet - Grey below a depth of about 11.2 m
221.4 / 14.0	SILT, some clay, trace to some sand Compact Grey Moist

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	18				
2	SS	17	0	56	40	4
3	SS	19				
4	SS	26				
5	SS	20				
6	SS	45	0	51	45	4
7	SS	33	0	63	30	7
8	SS	23	0	58	35	7
9A / 9B	SS	40				
10A / 10B	SS	41	0	59	39	2
11A / 11B	SS	28	0	8	78	14

Remark at sample 11B: H

Elevation scale: 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-02 SHEET 2 OF 4 METRIC

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895597.2; E 292389.9 MTM NAD 83 ZONE 10 (LAT. 44.200269; LONG. -79.655266)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DM
DATUM Geodetic
DATE June 11 to 15, 2017
CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
220.0 15.4	SILT and SAND, trace clay. Compact to dense. Grey. Moist	12A / 12B	SS	23	0	42	56	2
		13A / 13B	SS	34				
217.6 17.8	SILT, trace to some sand, trace clay. Compact to very dense. Grey. Moist to wet	14	SS	17				
		15	SS	27				
		16	SS	26				
		17	SS	41	0	8	88	4
		18	SS	43				
		19	SS	62				
		20	SS	61	0	19	77	4
206.9 28.5	Varved SILTY CLAY, with silt and clay laminae. Firm to Stiff. Grey. Moist	21	SS	21				

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%); GROUND WATER CONDITIONS; ELEVATION SCALE (220 to 206); STRAT PLOT.

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 89UP-02 SHEET 3 OF 4 METRIC

PROJECT 1668512

G.W.P. 2438-13-00 LOCATION N 4895597.2; E 292389.9 MTM NAD 83 ZONE 10 (LAT. 44.200269; LONG. -79.655266) ORIGINATED BY DF

DIST Central HWY 400 BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud COMPILED BY DM

DATUM Geodetic DATE June 11 to 15, 2017 CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Varved SILTY CLAY, with silt and clay laminae Firm to Stiff Grey Moist	22	SS	3	205	
					204	
		23	TO	PH	203	
		24	SS	WH	202	
					201	
		25	SS	WH	200	
					199	
197.4 38.0	CLAYEY SILT, trace sand Soft to firm Grey Wet	26	SS	WH	197	
		27	SS	WH	196 / 195	
194.5 40.9	SILT, trace to some sand, trace clay Very dense Grey Moist	28	SS	81	194	
					193 / 192	
		29	SS	55	191	0 9 89 2

Field vane shear strength plot annotations (sensitivity): 3, 3 (approx. elev. 204); 3 (elev. 202); >96, >96 (approx. elev. 201); 2, 1 (approx. elev. 199); 2, 1 (approx. elev. 198); 1 (approx. elev. 196).

Continued Next Page

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-02 SHEET 4 OF 4 METRIC

PROJECT 1668512
G.W.P. 2438-13-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4895597.2; E 292389.9 MTM NAD 83 ZONE 10 (LAT. 44.200269; LONG. -79.655266)
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
DATE June 11 to 15, 2017

ORIGINATED BY DF
COMPILED BY DM
CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL
	SILT, trace to some sand, trace clay Very dense Grey Moist				190					
189.4 / 46.0	CLAYEY SILT, trace sand Hard Grey Moist				189					
		30	SS	77	188	wP–w–wL plotted (~17–22%)	0	2	75	23
					187					
					186					
		31	SS	100/0.15	185					
184.6 / 50.8	END OF BOREHOLE									

NOTE:

1. Water level measurements in the casing at the beginning of each work shift:

Date	Depth (m)	Elev. (m)
12/06/17	11.3	224.1
13/06/17	9.3	226.1
14/06/17	5.0	230.4
15/06/17	2.0	233.4

The water level measurements are not considered to be representative of the groundwater level due to introduction of water/drilling mud during wash boring operations.

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 89UP-03

METRIC

PROJECT	1668512		
G.W.P.	2438-13-00	LOCATION	N 4895628.3; E 292375.2 MTM NAD 83 ZONE 10 (LAT. 44.200549; LONG. -79.655451)
DIST	Central	HWY	400
BOREHOLE TYPE	D50 Track Mount, NW Casing and Wash Boring with Drilling Mud		
DATUM	Geodetic	DATE	July 17 to 21, 2017
ORIGINATED BY	DF	COMPILED BY	DH
CHECKED BY	SMM/TZ		

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
227.4	GROUND SURFACE
0.0	TOPSOIL
0.2	Gravelly sand, some silt (FILL) Loose Brown Moist
226.7 / 0.7	SILT, trace to some sand to SILT and SAND, trace to some clay Loose to very dense Grey Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	6	
2	SS	6	
3	SS	16	
4	SS	22	
5	SS	17	0 44 48 8
6	SS	22	
7	SS	13	
8A / 8B	SS	23	
9	SS	17	
10	SS	10	
11A / 11B	SS	33	
12	SS	16	
13	SS	17	0 13 75 12

ELEVATION SCALE: 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215, 214, 213

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m^3

GROUND WATER CONDITIONS; STRAT PLOT

Continued Next Page

+^{3}, ×^{3}: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 89UP-03 SHEET 2 OF 4 METRIC

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895628.3; E 292375.2 MTM NAD 83 ZONE 10 (LAT. 44.200549; LONG. -79.655451)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DH
DATUM Geodetic
DATE July 17 to 21, 2017
CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	Elevation	Shear strength (kPa) / Sensitivity	Water content	Unit weight (kN/m³)
	SILT, trace to some sand to SILT and SAND, trace to some clay Loose to very dense Grey Wet	14	SS	37	212		○ ~20	
		15	SS	80	210			
209.6 17.8	SILTY CLAY, trace sand Grey Moist							
208.9 18.5	SILT and SAND Dense to very dense Grey Wet	16A 16B	SS	44	209		○	
		17	SS	59	207		○	
206.5 20.9	Varved CLAYEY SILT to SILTY CLAY with silt and clay laminae Stiff to very stiff Grey Moist - Sand inclusions from 20.9 m to 22.4 m	18	SS	11	206		○	
		19	SS	8	204		wP–w–wL	
					203	+ 4; + 3		
		20	TO	PH				18.5 (C)
					202	>96 +; +		
		21	SS	3	201		wP–wL, ○	
					200	>96 +; >96 +		
		22	TO	PH				
					199	>96 +; + 3		
		23	SS	4	198		wP–w–wL	

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+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

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Golder Associates

RECORD OF BOREHOLE No 89UP-03

SHEET 3 OF 4 — **METRIC**

PROJECT: 1668512			
G.W.P.: 2438-13-00	LOCATION: N 4895628.3; E 292375.2 MTM NAD 83 ZONE 10 (LAT. 44.200549; LONG. -79.655451)	ORIGINATED BY: DF
DIST: Central	HWY: 400	BOREHOLE TYPE: D50 Track Mount, NW Casing and Wash Boring with Drilling Mud	COMPILED BY: DH
DATUM: Geodetic		DATE: July 17 to 21, 2017	CHECKED BY: SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

Soil Profile

ELEV / DEPTH (m)	DESCRIPTION
	Varved CLAYEY SILT to SILTY CLAY with silt and clay laminae Stiff to very stiff Grey Moist
195.5 / 31.9	SILT, some sand, trace clay Compact to very dense Grey Wet - Clayey silt inclusions encountered between depths of about 32.0 m and 32.6 m
192.0 / 35.4	Sandy SILT, trace clay Very dense Grey Wet
189.0 / 38.4	CLAYEY SILT, some sand Very stiff Grey Moist
182.9 / 44.5	CLAYEY SILT (TILL) Grey Moist

Samples

NUMBER	TYPE	"N" VALUES	WATER CONTENT (%) (approx.)	GRAIN SIZE DISTRIBUTION (%) GR / SA / SI / CL
24	SS	9	~28	
25	SS	27	~20	
26	SS	86	~18	0 / 15 / 84 / 1
27A	SS	100	~20	
27B			~19	
28	SS	17		
29	SS	25	~16 (WP ~12, WL ~20)	0 / 16 / 63 / 21

Field vane shear strength: >96 kPa (at about elev. 196.9, 195.9 and 195.6 m)

Elevation scale: 197 to 183 m

Shear strength legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity O $^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-03 SHEET 4 OF 4 METRIC

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895628.3; E 292375.2 MTM NAD 83 ZONE 10 (LAT. 44.200549; LONG. -79.655451)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DH
DATUM Geodetic
DATE July 17 to 21, 2017
CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAYEY SILT (TILL) Grey Moist					182	
181.4 / 46.0	SILT and SAND, trace gravel, trace clay (TILL) Very dense Grey Wet	30A / 30B	SS	101		181	
						180	
						179	
178.2 / 49.2		31	SS	100/0.10			3 54 42 1

END OF BOREHOLE

NOTES:

1. Water level measurements in the casing at the begining of each work shift:

Date	Depth (m)	Elev. (m)
18/07/17	0.7	226.7
19/07/17	1.6	225.8
20/07/17	0.0	227.4
21/07/17	3.3	224.1

2. A borehole was advanced to a depth of about 4.0 m immediatly next to borehole 89UP-03 in order to install a standpipe piezometer.

3. Water level measurements in standpipe piezometer:

Date	Depth (m)	Elev. (m)
03/08/17	1.0	226.4
10/08/17	1.0	226.4
15/08/17	1.2	226.2
19/09/17	1.3	226.1
05/03/18	0.7	226.7
16/05/18	0.5	226.9

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-04 SHEET 1 OF 4 METRIC

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895619.3; E 292430.3 MTM NAD 83 ZONE 10 (LAT. 44.200469; LONG. -79.654761)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DH
DATUM Geodetic
DATE July 4, 5, 24 and 25, 2017
CHECKED BY SMM/TZ

SOIL PROFILE

ELEV / DEPTH (m)	DESCRIPTION
229.3	GROUND SURFACE
0.0	ASPHALT (250 mm)
228.8	Sand and gravel (FILL) (280 mm)
0.5	Silt and sand, trace clay, trace organics (FILL) Compact Brown to grey Moist
226.3 / 3.0	SILT and SAND, trace clay Compact to dense Grey Moist to wet
217.6 / 11.7	SILT, trace to some sand, trace to some clay Compact Grey Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	Water content (%)	Remarks: GR	SA	SI	CL
1	SS	15	○	0	67	31	2
2	SS	12	○				
3	SS	16					
4	SS	38	○				
5	SS	22					
6	SS	26	○	0	53	42	5
7	SS	19					
8	SS	19	○				
9	SS	15	○				
10	SS	18					
11	SS	20	H ○	0	8	84	8

GROUND WATER CONDITIONS: water level symbol at approx. elevation 221.2

ELEVATION SCALE: 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Foundation Design

Golder Associates

RECORD OF BOREHOLE No 89UP-04

METRIC

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895619.3; E 292430.3 MTM NAD 83 ZONE 10 (LAT. 44.200469; LONG. -79.654761)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DH
DATUM Geodetic
DATE July 4, 5, 24 and 25, 2017
CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH / WATER CONTENT	REMARKS
	SILT, trace to some sand, trace to some clay Compact Grey Wet	12	SS	19	214		
213.0 16.3	Silty SAND Compact to dense Grey Wet	13	SS	28	213, 212	w ≈ 20%	
	- Silty clay layer encountered between depths of about 18.3 m and 18.4 m	14	SS	27	211, 210		
		15	SS	43	209, 208	w ≈ 20%	
207.7 21.6	Varved SILTY CLAY, with silt and clay laminae Very stiff to hard Grey Moist	16	SS	32	207, 206	w ≈ 22%	
		17	SS	6	205, 204, 203	w_P ≈ 18%, w ≈ 32%, w_L = 40	
					202	Field vane >96, >96	
		18	SS	7	201, 200	w ≈ 40%	

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

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Golder Associates

RECORD OF BOREHOLE No 89UP-04

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895619.3; E 292430.3 MTM NAD 83 ZONE 10 (LAT. 44.200469; LONG. -79.654761)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DH

DATUM Geodetic

DATE July 4, 5, 24 and 25, 2017

CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Varved SILTY CLAY, with silt and clay laminae Very stiff to hard Grey Moist	19	SS	10	197	w_P – w – w_L (43)	
195.5 33.8	SILT, trace sand, trace clay Dense to very dense Grey Wet	20	SS	33	194	w plotted	
		21	SS	94	191	w plotted	0 5 93 2
190.0 39.3	Sandy CLAYEY SILT, some sand Very stiff Grey Moist	22	SS	18	188	w_P – w – w_L	1 20 59 20
186.3 43.0	SILT, trace to some clay, trace sand Very dense Grey Moist	23	SS	106	185	w_P – w – w_L	

Elevation scale: 199, 198, 197, 196, 195, 194, 193, 192, 191, 190, 189, 188, 187, 186, 185

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100; >96

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   ○ $^{3\%}$ STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No 89UP-04

SHEET 4 OF 4

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895619.3; E 292430.3 MTM NAD 83 ZONE 10 (LAT. 44.200469; LONG. -79.654761)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DH

DATUM Geodetic

DATE July 4, 5, 24 and 25, 2017

CHECKED BY SMM/TZ

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---					
	SILT, trace to some clay, trace sand Very dense Grey Moist					
183.3 46.0	Silty SAND, trace to some gravel, trace clay (TILL) Very dense Grey Moist	24	SS	100/0.08	o	
180.3 49.0	CLAYEY SILT with SAND, trace gravel (TILL) Hard Grey Moist	25	SS	100/0.09	o (with plastic–liquid limit range)	5 30 46 19
178.8 50.5	END OF BOREHOLE					

Elevation scale: 184, 183, 182, 181, 180, 179

NOTE:

1. Water level measurements in the casing at the beginning of each work shift:

Date	Depth (m)	Elev. (m)
05/07/17	0.8	228.5
24/07/17	3.8	225.5
25/07/17	8.2	221.1

The water level measurements are not considered to be representative of the groundwater level due to introduction of water/drilling mud during wash boring operations.

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-05

SHEET 1 OF 4 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895649.6; E 292418.6 MTM NAD 83 ZONE 10 (LAT. 44.200750; LONG. -79.654912)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DM
DATUM Geodetic
DATE June 26 to 29 and July 3, 2017
CHECKED BY SMM/TZ

SOIL PROFILE

ELEV / DEPTH (m)	DESCRIPTION
229.2	GROUND SURFACE
0.0	ASPHALT (250 mm)
	Sand and gravel (FILL) (250 mm)
0.5	Silt and sand, trace to some clay with organic odour (FILL) Very loose to loose Brown mottled with grey Moist to wet
226.2 / 3.0	Silty SAND Compact Grey Wet
223.6 / 5.6	SILT to Sandy SILT, trace clay with clayey silt pockets Compact to very dense Grey Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	Approx. Elev.	Water Content (%)	GR	SA	SI	CL
1	SS	6	227.5					
2	SS	3	226.6	~21	0	45	46	9
3	SS	17	225.8					
4	SS	20	225.1	~17				
5	SS	26	224.3					
6	SS	14	222.8					
7	SS	16	221.3					
8	SS	20	219.8	~18	0	26	73	1
9	SS	25	218.2					
10	SS	15	216.7	~20				
11	SS	20	215.1	~20 (plastic limit ~15)	0	11	77	12

Groundwater level symbol (∇) at approx. elevation 220.3.

Elevation scale: 229 to 215.

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-05

SHEET 2 OF 4 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895649.6; E 292418.6 MTM NAD 83 ZONE 10 (LAT. 44.200750; LONG. -79.654912)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DM
DATUM Geodetic
DATE June 26 to 29 and July 3, 2017
CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DYNAMIC CONE / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT kN/m³	GR	SA	SI	CL
	SILT to Sandy SILT, trace clay with clayey silt pockets Compact to very dense Grey Wet	12	SS	27	214		o (~19)		0	10	87	3
		13	SS	30	212							
		14	SS	44	211							
		15	SS	39	209		o (~19)					
		16	SS	55	208		o (~20)					
206.8 22.4	Varved CLAYEY SILT, with silt and clay laminae Stiff to very stiff Grey Wet	17	SS	10	206		wP–w–wL		0	0	62	38
					205	+ >96 (field vane)						
204.1 25.1	Varved SILTY CLAY, with silt and clay laminae Stiff to very stiff Grey Wet	18	SS	5	203		o (~34)					
		19	SS	1	200		wP–w (41.1, 46)					

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-05

SHEET 3 OF 4 — METRIC

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895649.6; E 292418.6 MTM NAD 83 ZONE 10 (LAT. 44.200750; LONG. -79.654912)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DM
DATUM Geodetic
DATE June 26 to 29 and July 3, 2017
CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DYNAMIC CONE / SHEAR STRENGTH	WATER CONTENT	GR	SA	SI	CL
	Varved SILTY CLAY, with silt and clay laminae; Stiff to very stiff; Grey; Wet				199	Field vane >96 (approx. 198.9)					
		20	SS	5	197		~36				
					196	Field vane >96 (approx. 196.1)					
195.0 / 34.2	SILT, trace to some sand, trace clay; Very dense; Grey; Wet	21	SS	54	194		~18	0	9	89	2
		22	SS	71	191		~17				
189.3 / 39.9	CLAYEY SILT, trace to some sand; Very stiff; Grey; Wet	23	SS	15	188		~12				
186.2 / 43.0	Sandy CLAYEY SILT, some gravel (TILL); Hard; Grey; Wet	24	SS	35	185		~12 (with Wp/WL range)	14	24	48	14

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

Legend: SHEAR STRENGTH kPa — ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED

Golder Associates

RECORD OF BOREHOLE No 89UP-05 SHEET 4 OF 4 METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895649.6; E 292418.6 MTM NAD 83 ZONE 10 (LAT. 44.200750; LONG. -79.654912)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DM

DATUM Geodetic

DATE June 26 to 29 and July 3, 2017

CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
	Sandy CLAYEY SILT, some gravel (TILL) Hard Grey Wet - Inferred cobbles/boulders encountered between depths of about 46.3 m and 46.9 m				184 183 182	
		25	SS	43		~10
					181 180 179	
178.8 50.4	END OF BOREHOLE	26	SS	100/0.10		

NOTE:

1. Water level measurements in the casing at the beginning of each work shift:

Date	Depth (m)	Elev. (m)
27/06/17	1.1	228.1
28/06/17	4.3	224.9
29/06/17	1.1	228.1
03/07/17	9.0	220.2

The water level measurements are not considered to be representative of the groundwater level due to introduction of water/drilling mud during wash boring operations.

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

Foundation Design

Golder Associates

RECORD OF BOREHOLE No 89UP-06

SHEET 1 OF 4

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895621.9; E 292469.4 MTM NAD 83 ZONE 10 (LAT. 44.200493; LONG. -79.654271)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DM

DATUM Geodetic

DATE June 18 to 21, 2017

CHECKED BY SMM/TZ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) w	GR	SA	SI	CL
235.4	GROUND SURFACE										
0.0	ASPHALT (200 mm)										
0.2	Sand and gravel (FILL) (430 mm)					235					
234.8 0.6	Silt and sand, trace to some clay (FILL) Compact to very dense Brown Moist					234					
		1	SS	14							
		2	SS	34		233					
		3	SS	33		232	~16	0	52	45	3
		4	SS	31		231					
	- Oxidation staining encountered below a depth of about 4.9 m	5	SS	47			~10				
		6	SS	36		230					
		7	SS	56		229					
	- Clayey silt pockets encountered below a depth of about 7.2 m	8	SS	30		228	~14	0	47	43	10
		9	SS	20	∇						
		10	SS	26		227					
226.3 9.1	SILT and SAND, trace clay Compact to dense Grey Wet	11	SS	38		226					
						225					
		12	SS	28			~19	0	57	41	2
						224					
	- Grey below a depth of about 12.2 m	13	SS	26		223	~16				
						222					
		14	SS	25		221	~17				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-06

METRIC

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895621.9; E 292469.4 MTM NAD 83 ZONE 10 (LAT. 44.200493; LONG. -79.654271)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DM
DATUM Geodetic
DATE June 18 to 21, 2017
CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
	SILT and SAND, trace clay Compact to dense Grey Wet	15	SS	23	o (~19)	0	40	58	2
		16	SS	39					
217.9 17.5	Sandy SILT, trace to some clay Compact to dense Grey Wet	17	SS	23	o (~20), H	0	29	59	12
		18	SS	24	o (~23)				
		19	SS	26	o (~19)	0	23	70	7
		20	SS	37					
		21	SS	43					
206.1 29.3									

Elevation scale: 220, 219, 218, 217, 216, 215, 214, 213, 212, 211, 210, 209, 208, 207, 206

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED — 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+³, ×³: Numbers refer to Sensitivity   O³% STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-06

SHEET 3 OF 4 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895621.9; E 292469.4 MTM NAD 83 ZONE 10 (LAT. 44.200493; LONG. -79.654271)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud
COMPILED BY DM
DATUM Geodetic
DATE June 18 to 21, 2017
CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	Varved CLAYEY SILT to SILTY CLAY with silt and clay laminae Stiff Grey Wet				205					
		22	SS	2			0	0	54	46
					204					
					203					
					202					
		23	SS	5						
					201					
					200					
					199					
		24	TO	PH		17.4 (C)				
					198					
					197					
					196					
195.5 39.9	Sandy CLAYEY SILT, trace to some gravel Firm Grey Wet	25A 25B	SS	6			6	29	51	14
					195					
193.9 41.5	SILT, trace sand Very dense Grey Wet				194					
					193					
		26	SS	65						
					192					
190.9 44.5					191					

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 89UP-06

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895621.9; E 292469.4 MTM NAD 83 ZONE 10 (LAT. 44.200493; LONG. -79.654271)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DM

DATUM Geodetic

DATE June 18 to 21, 2017

CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DYNAMIC CONE PENETRATION / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAYEY SILT Very stiff to hard Grey Moist				190				
		27	SS	WH			Wp–w–WL plotted		
					189	Field vane >96, >96			
					188				
					187				
		28	SS	77			Wp–w–WL plotted		0 0 67 23
					186				
					185				
					184				
183.0		29	SS	50			w plotted		
52.4	END OF BOREHOLE				183				

NOTE:

1. Water level measurements in the casing at the beginning of each work shift:

Date	Depth (m)	Elev. (m)
19/06/17	2.9	232.5
20/06/17	1.6	233.8
21/06/17	8.1	227.3

The water level measurements are not considered to be representative of the groundwater level due to introduction of water/drilling mud during wash boring operations.

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 89UP-07

SHEET 1 OF 4 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895660.9; E 292451.0 MTM NAD 83 ZONE 10 (LAT. 44.200843; LONG. -79.654503)

ORIGINATED BY DM

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DH

DATUM Geodetic

DATE July 28 and 31 and August 1 and 2, 2017

CHECKED BY SMM/TZ

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) w	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.2	GROUND SURFACE						
0.0 / 226.7	TOPSOIL (460 mm) Loose	1	SS	6	227	~16	
0.7 / 226.0	Silty sand, trace organics (FILL) Loose Brown Moist	2A	SS	8			
1.5	Silty SAND Loose Grey to brown Wet	2B			226	~20	
	CLAYEY SILT, some sand Grey Wet	3	SS	12	225		
	SILT and SAND, trace clay Loose to compact Grey Wet	4	SS	17		~17	
		5	SS	10	224		
		6	SS	18	223	~18	0 32 66 2
		7	SS	9	222		
		8	SS	17	221	~17	
		9	SS	15	220 / 219		
218.5 / 8.7	Varved SILTY CLAY, trace sand, with silt and clay laminae Stiff to very stiff Grey Moist	10	SS	8	218	~25	
216.2 / 11.0	SILT, some sand, trace to some clay Compact to dense Grey Wet	11A / 11B	SS	23	217 / 216	~23 / ~20	
		12	SS	11	215	~20	0 16 77 7
		13	SS	23	214 / 213	~20	

Groundwater level symbol shown at approx. elev. 226.0 (sample 2A).

Continued Next Page

+3, ×3: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 89UP-07

METRIC

PROJECT 1668512
RECORD OF BOREHOLE No 89UP-07 SHEET 2 OF 4 METRIC
G.W.P. 2438-13-00 LOCATION N 4895660.9; E 292451.0 MTM NAD 83 ZONE 10 (LAT. 44.200843; LONG. -79.654503) ORIGINATED BY DM
DIST Central HWY 400 BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud COMPILED BY DH
DATUM Geodetic DATE July 28 and 31 and August 1 and 2, 2017 CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	SILT, some sand, trace to some clay Compact to dense Grey Wet	14	SS	26	212						
		15	SS	43	210	○					
		16	SS	46	209	○					
		17	SS	36	207	○		0	4	89	7
205.2		18A 18B	SS	24	206–205	○ ○					
22.0	Varved SILTY CLAY, with silt and clay laminae Soft to stiff Grey Moist	19	SS	7	204	├─○─┤					
		20	SS	9	203–202	○					
		21	TO	PH	201		18.8 (C)				
		22	SS	5	200–199	├─○─┤ 48					
		23	TO	PH	198						

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Foundation Design

Golder Associates

RECORD OF BOREHOLE No 89UP-07

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895660.9; E 292451.0 MTM NAD 83 ZONE 10 (LAT. 44.200843; LONG. -79.654503)

ORIGINATED BY DM

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DH

DATUM Geodetic

DATE July 28 and 31 and August 1 and 2, 2017

CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Varved SILTY CLAY, with silt and clay laminae; Soft to stiff; Grey; Moist	24	SS	7	o	
195.6 / 31.6	SILT and SAND, some gravel, trace clay; Very dense; Grey; Wet	25	SS	51	o	20 38 39 3
		26	SS	69		
190.3 / 36.9	Sandy CLAYEY SILT, trace gravel; Very stiff; Grey; Moist	27	SS	17	Wp–w–WL	4 22 56 18
		28	SS	25	o	
184.2 / 43.0	SILT and SAND, trace clay (TILL); Very dense; Grey; Wet	29	SS	100/0.14	o	0 40 58 2

Elevation scale: 197, 196, 195, 194, 193, 192, 191, 190, 189, 188, 187, 186, 185, 184, 183

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No 89UP-07

SHEET 4 OF 4 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895660.9; E 292451.0 MTM NAD 83 ZONE 10 (LAT. 44.200843; LONG. -79.654503)

ORIGINATED BY DM

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DH

DATUM Geodetic

DATE July 28 and 31 and August 1 and 2, 2017

CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) w_P / w / w_L	GR	SA	SI	CL
	SILT and SAND, trace clay (TILL) Very dense Grey Wet				182					
					181					
		30	SS	100/0.05	180					
					179					
178.4 48.8	CLAYEY SILT with SAND, trace gravel (TILL) Hard Grey Moist				178					
					177					
176.6		31	SS	100/0.10		plotted	1	31	44	24
50.6	END OF BOREHOLE									

NOTE:

1. Water level measurements in the casing at the begining of each work shift:

Date	Depth (m)	Elev. (m)
31/07/17	6.2	221.0
01/08/17	5.9	221.3
02/08/17	7.9	219.3

2. Water level measurements in standpipe piezometer:

Date	Depth (m)	Elev. (m)
10/08/17	0.7	226.5
15/08/17	0.7	226.5
19/08/17	0.9	226.3
05/03/18	1.0	226.2

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No 89UP-08

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895655.5; E 292478.1 MTM NAD 83 ZONE 10 (LAT. 44.200795; LONG. -79.654165)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track Mount, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DH

DATUM Geodetic

DATE August 9, 2017

CHECKED BY SMM/TZ

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.6	GROUND SURFACE					
0.0	TOPSOIL (250 mm)					
0.3	Silt and sand to silty sand to sand and silt, trace clay (FILL) Loose to compact Brown mottled with oxidation staining Moist	1	SS	6		
		2A / 2B	SS	14	▽	
		3	SS	15		0 64 33 3
		4	SS	19		
224.6 / 3.0	SILT and SAND Compact Brown Wet	5	SS	15		
		6	SS	13		
		7A / 7B	SS	15		
222.6 / 5.0	SILTY CLAY Stiff Grey Moist					
222.0 / 5.6	SILT and SAND, trace to some clay Compact Grey Wet	8	SS	12		
		9	SS	15		0 50 44 6
		10	SS	19		
		11	SS	19		0 32 64 4
216.3 / 11.3	END OF BOREHOLE					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

ELEVATION SCALE: 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217

NOTE:

1. Water level measured in open borehole at a depth of about 1.1 m (Elev. 226.5 m) below ground surface upon completion of drilling.

+ ³, × ³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

Foundation Design

Golder Associates

RECORD OF BOREHOLE No HF-01

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895603.0; E 292316.5 MTM NAD 83 ZONE 10 (LAT. 44.200320; LONG. -79.656185)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY DH

DATUM Geodetic

DATE July 11, 2017

CHECKED BY SMM

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.8	GROUND SURFACE						
227.5 / 0.0	TOPSOIL (300 mm)						
0.3	Silt and sand, trace clay, trace rootlets (FILL) Loose to compact Brown Moist	1	SS	7		~5	
		2	SS	12			
225.6		3	SS	12		~18	0 61 35 4
2.2	SILT and SAND, trace clay Compact Grey Moist to wet	4	SS	15			
		5	SS	16		~20	0 47 50 3
		6	SS	17	▽		
222.6		7	SS	19		~22	
5.2	END OF BOREHOLE						

NOTE:

1. Water level measured in open borehole at a depth of about 4.0 m below ground surface (Elev. 228.8 m) upon completion of drilling.

Elevation scale: 227, 226, 225, 224, 223

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

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RECORD OF BOREHOLE No HF-02

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895665.0; E 292504.8 MTM NAD 83 ZONE 10 (LAT. 44.200881; LONG. -79.653830)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DH

DATUM Geodetic

DATE August 4, 8 and 9, 2017

CHECKED BY SMM/TZ

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
227.5	GROUND SURFACE
0.0	TOPSOIL (230 mm)
0.2	Silty SAND, trace rootlets Loose Brown Moist
226.8 / 0.7	SILT and SAND, trace to some clay Compact Brown Moist
226.0 / 1.5	Silty SAND, trace clay Loose to compact Grey Wet
221.1 / 6.4	SILT, trace to some sand to SILT and SAND, trace clay Loose to very dense Grey Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	9				
2	SS	10	0	35	58	7
3	SS	13				
4	SS	8				
5	SS	22				
6	SS	19	0	70	28	2
7	SS	21				
8	SS	30				
9	SS	9	0	36	63	1
10	SS	21				
11	SS	13				
12	SS	16				
13	SS	14				

GROUND WATER CONDITIONS: water level symbol at approx. elevation 225.

ELEVATION SCALE: 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215, 214, 213

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-02

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895665.0; E 292504.8 MTM NAD 83 ZONE 10 (LAT. 44.200881; LONG. -79.653830)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DH

DATUM Geodetic

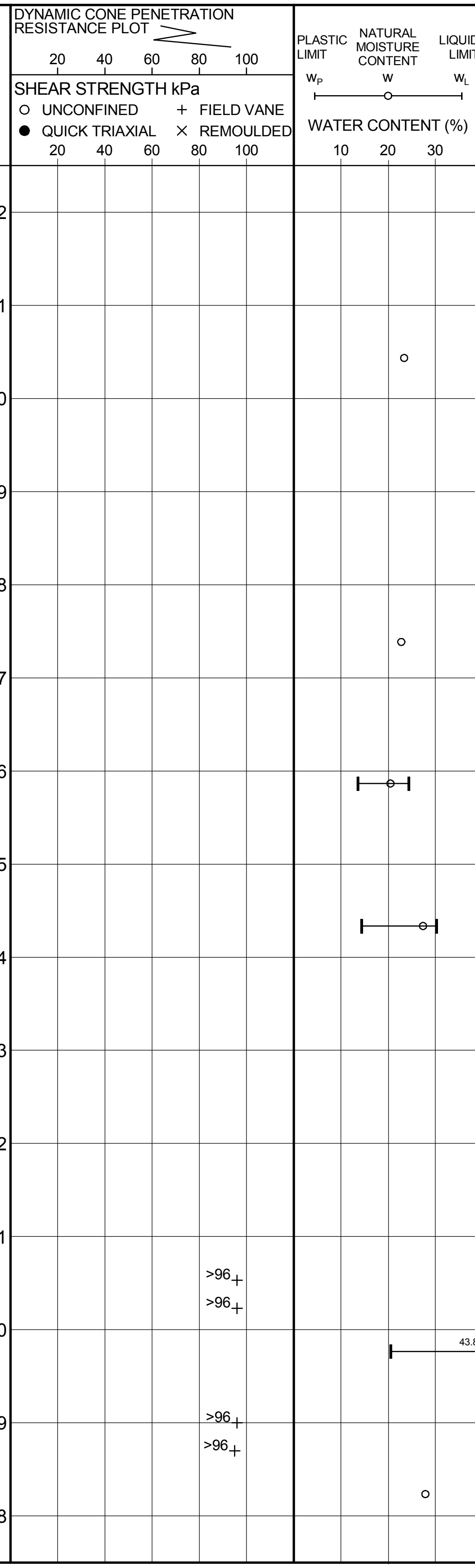
DATE August 4, 8 and 9, 2017

CHECKED BY SMM/TZ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT, trace to some sand to SILT and SAND, trace clay Loose to very dense Grey Wet	14	SS	27	
		15	SS	37	0 8 88 4
		16	SS	34	
		17	SS	53	
206.6 / 20.9	Varved CLAYEY SILT to CLAY, with silt and clay laminae Stiff to very stiff Grey Moist	18	SS	21	
		19	SS	6	
		20	TO	PH	
	- Sand inclusions encountered between depths of about 25.9 m (Elev. 201.6 m) and 26.4 m (Elev. 201.1 m)	21	TO	PH	
		22	SS	4	
		23	SS	8	

ELEVATION SCALE: 212, 211, 210, 209, 208, 207, 206, 205, 204, 203, 202, 201, 200, 199, 198



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+3, ×3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

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PROJECT 1668512

RECORD OF BOREHOLE No HF-02

METRIC

G.W.P. 2438-13-00 | LOCATION N 4895665.0; E 292504.8 MTM NAD 83 ZONE 10 (LAT. 44.200881; LONG. -79.653830) | ORIGINATED BY DF

DIST Central HWY 400 | BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud | COMPILED BY DH

DATUM Geodetic | DATE August 4, 8 and 9, 2017 | CHECKED BY SMM/TZ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---									
	Varved CLAYEY SILT to CLAY, with silt and clay laminae Stiff to very stiff Grey Moist				197					
		24	SS	11	196					
		25	SS	12	195	○				
194.4 33.1	Silty SAND, trace clay Very dense Grey Wet				194					
		26A 26B	SS	67	193	○ ○				
191.8 35.7		27	SS	73	192	○	0	75	23	2
	END OF BOREHOLE									

NOTE:

1. Water level measurements in the casing at the beginning of each work shift:

Date	Depth (m)	Elev. (m)
08/08/17	1.3	226.2
09/08/17	2.7	224.8

The water level measurements are not considered to be representative of the groundwater level due to introduction of water/drilling mud during wash boring operations.

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-03

SHEET 1 OF 1

METRIC

PROJECT 1668512			
G.W.P. 2438-13-00	LOCATION N 4895693.1; E 292575.5 MTM NAD 83 ZONE 10 (LAT. 44.201135; LONG. -79.652946)	ORIGINATED BY DF	
DIST Central	HWY 400	BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud	COMPILED BY DH
DATUM Geodetic	DATE August 9, 2017	CHECKED BY SMM	

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.5	GROUND SURFACE				
0.0	TOPSOIL (300 mm)				
227.2	Silty sand, trace rootlets (FILL) Loose Brown, mottled Moist	1	SS	7	
226.8 / 0.7	Clayey silt, trace sand (FILL) Stiff Brown, mottled Moist	2A / 2B	SS	12	
226.3 / 1.2	SILT, some sand, trace clay Compact Brown, varved Moist to wet	3A / 3B	SS	20	0 19 76 5
225.2 / 2.3	SILT and SAND, trace clay Compact Brown Wet	4A / 4B	SS	17	
		5	SS	14	0 49 49 2
223.8 / 3.7	Sandy SILT to Silty SAND, trace clay Loose to compact Brown to grey Wet	6	SS	16	
		7	SS	8	0 25 74 1
		8A / 8B	SS	14	
		9	SS	18	
219.3 / 8.2	END OF BOREHOLE				

Ground water conditions: water level symbol at Elev. 226.0 m.

Elevation scale: 227, 226, 225, 224, 223, 222, 221, 220

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

NOTE:

1. Water level measured in open borehole at a depth of 1.5 m below ground surface (Elev. 226.0 m) upon completion of drilling.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-04

SHEET 1 OF 1

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895694.3; E 292648.2 MTM NAD 83 ZONE 10 (LAT. 44.201156; LONG. -79.652040)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud

COMPILED BY EG

DATUM Geodetic

DATE February 2, 2018

CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) w	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
227.8	GROUND SURFACE											
0.0	TOPSOIL (200 mm)	1A	SS	4								
0.2	Sand, some to trace silt (FILL) Very loose Light brown Moist	1B										
227.1 / 0.7	Sandy silt, some clay (FILL) Loose Brown/grey, mottled Moist	2	SS	8	∇	227						
226.4 / 1.5	SILT and SAND, trace clay Compact Light brown, stratified Wet	3	SS	15		226			0	59	38	3
		4	SS	16		225						
		5	SS	12		224						
	- Silt inclusions at a depth of about 4.1 m	6	SS	17								
		7	SS	18		223			0	63	34	3
						222						
		8	SS	17								
221.1 / 6.7	END OF BOREHOLE											

Column headings: SOIL PROFILE; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10, 20, 30; REMARKS & GRAIN SIZE DISTRIBUTION (%); STRAT PLOT.

NOTES:

1. Water level measured in open borehole at a depth of about 1.2 m below ground surface (Elev. 226.6 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No HF-05

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895517.7; E 292255.6 MTM NAD 83 ZONE 10 (LAT. 44.199551; LONG. -79.656945)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY DH

DATUM Geodetic

DATE July 17, 2017

CHECKED BY SMM

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.0	GROUND SURFACE						
0.0	TOPSOIL (610 mm)	1	SS	1			
226.4 / 0.6	Silty SAND, trace clay Compact Brown to grey Wet	2	SS	16	▽	226	0 69 30 1
		3	SS	18		225	
	- Grey below a depth of about 2.3 m (Elev. 224.7 m)	4	SS	16		224	
		5	SS	14			
223.3 / 3.7	SILT, some sand, trace clay Compact Grey Wet	6	SS	18		223	0 12 84 4
222.5 / 4.5	Silty SAND Compact Grey Wet	7	SS	14		222	
221.8 / 5.2	END OF BOREHOLE						

Chart columns: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³

NOTE:

1. Water level measured in open borehole at a depth of about 1.4 m below ground surface (Elev. 225.6 m) upon completion of drilling.

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-06

SHEET 1 OF 1

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895503.9; E 292288.0 MTM NAD 83 ZONE 10 (LAT. 44.199427; LONG. -79.656539)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY DH

DATUM Geodetic

DATE July 14, 2017

CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
227.2	GROUND SURFACE					227						
0.0	TOPSOIL (250 mm)											
0.3	Silt and sand, trace to some clay (FILL) Very loose to loose Brown Moist to wet	1	SS	2								
		2	SS	9	∇	226	o		0	50	44	6
225.5 / 1.7	SILT and SAND, trace clay Loose to compact Grey Wet	3A / 3B	SS	16			o / o					
		4	SS	17		225						
		5	SS	9		224	o	NP	0	46	52	2
		6	SS	13		223	o					
222.7 / 4.5	SILT, some sand, trace clay Compact Grey Wet	7	SS	14		222	▮ o		0	12	84	4
		8	SS	13		221						
220.0 / 7.2	Silty SAND with clayey silt laminae Compact Grey Wet					220						
		9	SS	11			o					
219.0 / 8.2	END OF BOREHOLE					219						

NOTE:

1. Water level measured in open borehole at a depth of about 1.2 m below ground surface (Elev. 226.0 m) upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-07

METRIC

PROJECT	1668512		
G.W.P.	2438-13-00	LOCATION	N 4895478.1; E 292331.7 MTM NAD 83 ZONE 10 (LAT. 44.199196; LONG. -79.655992)
DIST	Central	HWY	400
BOREHOLE TYPE	D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud		
DATUM	Geodetic	DATE	August 11, 14 and 15, 2017
ORIGINATED BY	DF	COMPILED BY	DH
CHECKED BY	SMM		

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
227.3	GROUND SURFACE
227.0 / 0.0	TOPSOIL (280 mm)
0.3	Silty sand (FILL) Loose to compact Brown, mottled Moist
225.9 / 1.5	Sandy SILT to SILT and SAND, trace clay Loose to compact Grey Wet
215.6 / 11.7	SILT, trace sand to sandy, trace to some clay Compact to dense Grey Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	7				
2	SS	10				
3	SS	16	0	47	51	2
4	SS	8				
5	SS	16				
6	SS	21				
7	SS	12	0	21	75	4
8	SS	17				
9	SS	15	0	31	67	2
10A / 10B	SS	16				
11	SS	19				
12	SS	14	0	7	82	11
13	SS	22				

Ground water level symbol (▽) shown at approximately elevation 225.6.

ELEVATION SCALE: 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215, 214, 213

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20, 40, 60, 80, 100

SHEAR STRENGTH kPa: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED — 20, 40, 60, 80, 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10, 20, 30

UNIT WEIGHT γ kN/m³

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-07

METRIC

PROJECT 1668512			
G.W.P. 2438-13-00	LOCATION N 4895478.1; E 292331.7 MTM NAD 83 ZONE 10 (LAT. 44.199196; LONG. -79.655992)	ORIGINATED BY DF	
DIST Central HWY 400	BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud	COMPILED BY DH	
DATUM Geodetic	DATE August 11, 14 and 15, 2017	CHECKED BY SMM	

Column headings: SOIL PROFILE (ELEV DEPTH; DESCRIPTION; STRAT PLOT) | SAMPLES (NUMBER; TYPE; "N" VALUES) | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100) | PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (kPa)	UNIT WEIGHT	GR SA SI CL
	SILT, trace sand to sandy, trace to some clay Compact to dense Grey Wet				212			
		14	SS	23				
					211			
		15	SS	29	210			
					209			
		16	SS	35	208			
		17	SS	39	207			0 18 79 3
206.5 20.8	Varved CLAYEY SILT to SILTY CLAY, silt and clay laminae Stiff Grey Wet				206			
		18	SS	11	205			
		19	TO	PH	204			
					203			
		20	SS	9	202	>96 + >96 +		
		21	SS	7	201			
					200	>96 + >96 +		
		22	TO	PH	199	(42)	18.6 (C)	
						>96 + >96 +		
		23	SS	11	198			

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HF-07

SHEET 3 OF 3 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00 LOCATION N 4895478.1; E 292331.7 MTM NAD 83 ZONE 10 (LAT. 44.199196; LONG. -79.655992) ORIGINATED BY DF

DIST Central HWY 400 BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud COMPILED BY DH

DATUM Geodetic DATE August 11, 14 and 15, 2017 CHECKED BY SMM

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Varved CLAYEY SILT to SILTY CLAY, silt and clay laminae, Stiff, Grey, Wet	24	SS	11	0 5 72 23
195.8 / 31.5	Silty SAND, Dense, Grey, Wet	25	SS	62	
193.5 / 33.8	CLAYEY SILT, trace sand, trace gravel, Hard, Grey, Moist	26	SS	35	
191.6 / 35.7	END OF BOREHOLE				

Elevation scale: 197, 196, 195, 194, 193, 192

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

1. Water level measurements in the NW casing at the beginning of each work shift:

Date	Depth (m)	Elev. (m)
14/08/17	1.6	225.7
15/08/17	1.7	225.6

2. The water level measurements are not considered to be representative of the groundwater level due to introduction of water/ drilling mud during washboring operations.

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

Foundation Design

RECORD OF BOREHOLE No HF-08

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895469.0; E 292368.5 MTM NAD 83 ZONE 10 (LAT. 44.199114; LONG. -79.655531)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY DH
DATUM Geodetic
DATE July 14, 2017
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%) (approx.)	GR	SA	SI	CL
227.2	GROUND SURFACE									
0.0	TOPSOIL (180 mm)									
0.2	Silty sand (FILL) Very loose to compact Grey to brown Wet	1	SS	2						
		2A / 2B	SS	16	∇ (water level, Elev. ~226.4)	~18				
226.1 / 1.1	SILT and SAND, trace clay Loose to compact Brown to grey Wet	3	SS	16		~20	0	52	46	2
		4	SS	15		~20				
		5	SS	9		~19				
		6	SS	16						
		7	SS	15		~19	0	53	46	1
		8	SS	14						
		9	SS	15		~19				
219.0 / 8.2	END OF BOREHOLE									

NOTE:

1. Water level measured in open borehole at a depth of about 0.8 m below ground surface (Elev. 226.4 m) upon completion of drilling.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL. Elevation scale 227 to 219.

+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-09

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895449.3; E 292404.0 MTM NAD 83 ZONE 10 (LAT. 44.198938; LONG. -79.655086)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY DH
DATUM Geodetic
DATE July 13, 2017
CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.2	GROUND SURFACE						
0.0	TOPSOIL (130 mm)						
0.1	Silt and sand, with rootlets (FILL) Loose to compact Grey to brown, mottled Moist to wet	1	SS	7		227	
		2A / 2B	SS	11	▽		
226.1 / 1.1	SILT and SAND, trace clay Compact Brown to grey Wet					226	
		3	SS	14			0 41 55 4
		4	SS	15		225	
		5	SS	18		224	0 42 56 2
		6	SS	12		223	
		7	SS	16			
222.0 / 5.2	END OF BOREHOLE						

Dynamic cone penetration resistance plot (20, 40, 60, 80, 100); Shear strength kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100).

Plastic limit W_P, natural moisture content W, liquid limit W_L; Water content (%) 10, 20, 30. Unit weight γ kN/m³.

NOTE:

1. Water level measured in open borehole at a depth of about 1.1 m below ground surface (Elev. 226.1 m) upon completion of drilling.

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-10

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895613.9; E 292273.6 MTM NAD 83 ZONE 10 (LAT. 44.200417; LONG. -79.656721)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY DH
DATUM Geodetic
DATE July 11, 2017
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR SA SI CL
227.6	GROUND SURFACE						
0.0	ASPHALT (130 mm)						
0.1	Sand, some gravel, trace silt (FILL) Compact Brown Moist	1	SS	18			
227.0 / 0.6	Silty sand, trace clay (FILL) Compact Brown with oxidation staining Moist to wet	2	SS	14	∇	~16	0 78 21 1
		3	SS	12			
225.4 / 2.2	Silty SAND Compact Grey Wet	4	SS	10		~20	
224.5 / 3.1	SILT, some sand, trace clay Compact Grey Wet	5	SS	15		~21	0 18 79 3
223.9 / 3.7	Silty SAND, trace clay Loose to compact Grey Wet	6	SS	15			
		7	SS	13		~17	
		8A / 8B	SS	7		~21	
220.4 / 7.2	SILT, some clay with sand inclusions Compact Grey Moist	9	SS	14		~21	
219.4 / 8.2	END OF BOREHOLE						

NOTE:

1. Water level measured in open borehole at a depth of about 1.3 m below ground surface (Elev.226.3 m) upon completion of drilling.

Elevation scale: 227, 226, 225, 224, 223, 222, 221, 220

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-11

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895635.6; E 292234.1 MTM NAD 83 ZONE 10 (LAT. 44.200612; LONG. -79.657216)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY DH
DATUM Geodetic
DATE July 11, 2017
CHECKED BY SMM

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	Water content (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.8	GROUND SURFACE						
0.0	ASPHALT (115 mm)						
227.3 / 0.5	Gravelly sand, trace to some silt (FILL) Compact Brown Moist	1A / 1B	SS	15			
	Silty sand (FILL) Loose Brown to black to grey, mottled Moist	2	SS	8			
		3	SS	6		~14	
225.6 / 2.2	SILT and SAND, trace clay Loose to compact Grey Moist to wet	4	SS	18	▽	~19	0 34 65 1
		5	SS	10		~19	
		6	SS	10			
		7	SS	18		~20	0 31 67 2
		8	SS	5			
		9	SS	17		~19	
221.1 / 6.7	END OF BOREHOLE						

Elevation scale: 227, 226, 225, 224, 223, 222

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

NOTE:

1. Water level measured in open borehole at a depth of about 2.6 m below ground (Elev. 225.2 m) surface upon completion of drilling.

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-12

SHEET 1 OF 1

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895670.6; E 292213.9 MTM NAD 83 ZONE 10 (LAT. 44.200927; LONG. -79.657470)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY DH

DATUM Geodetic

DATE July 13, 2017

CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
226.7	GROUND SURFACE										
0.0	TOPSOIL (150 mm)										
0.2	Silty SAND, trace rootlets, Loose to compact, Brown, Moist to wet	1	SS	5							
					226						
225.6 / 1.1	SILT and SAND, trace clay, Compact, Brown to grey, Wet	2A / 2B	SS	16		o					
		3	SS	18	225	o		0	39	58	3
		4	SS	13	224						
		5	SS	21		o					
223.0 / 3.7	Sandy SILT, trace to some clay, Compact, Grey, Wet	6	SS	20	223						
		7	SS	21	222	o		0	21	73	6
221.5 / 5.2	END OF BOREHOLE										

Column headings also include: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10, 20, 30; REMARKS & GRAIN SIZE DISTRIBUTION (%).

NOTES:

1. Water level measured at a depth of about 0.8 m below ground surface (Elev. 225.9 m) upon completion of drilling.

2. Groundwater level measurements in piezometer:

Date	Depth (m)	Elev. (m)
03/08/17	2.0	224.7
10/08/17	2.0	224.7
15/08/17	2.1	224.6
19/09/17	2.4	224.3
19/09/17	1.4	225.3
05/03/18	0.3	226.4

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No HF-13

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4895650.6; E 292203.3 MTM NAD 83 ZONE 10 (LAT. 44.200747; LONG. -79.657603)
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
DATE July 13, 2017
ORIGINATED BY DF
COMPILED BY DH
CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
226.8	GROUND SURFACE						
0.0	TOPSOIL (130 mm)						
0.1	SILT and SAND, trace to some clay Loose to compact Brown to grey Moist to wet	1	SS	7			
		2	SS	12	▽	226	0 55 39 6
		3	SS	17		225	
		4	SS	13		224	
223.1		5	SS	11			
3.7	SILT, trace to some clay, trace to some sand Compact Grey Wet	6	SS	13		223	0 11 77 12
221.6		7	SS	11		222	
5.2	END OF BOREHOLE NOTE: 1. Water level measured in open borehole at a depth of about 1.2 m below ground surface (Elev. 225.6 m) upon completion of drilling.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-14

SHEET 1 OF 1 — METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895742.6; E 292608.7 MTM NAD 83 ZONE 10 (LAT. 44.201590; LONG. -79.652536)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE February 2, 2018

CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	UNIT WEIGHT (kN/m³)	GR	SA	SI	CL
228.0	GROUND SURFACE										
0.0	TOPSOIL (180 mm)	1A	SS	16							
0.2	Sand, trace gravel, trace silt (FILL), Compact, Brown, Moist	1B									
		2	SS	13		○					
226.5 / 1.5	SILT and SAND, trace to some clay, Compact, Light brown to brown/grey, mottled, Moist to wet	3	SS	12		○					
		4	SS	19	▽ (Elev. 225.7 m)						
		5	SS	17		○		0	68	30	2
		6	SS	13							
223.6 / 4.4	SILT, some sand, trace to some clay, Compact, Brown/grey, Moist to wet	7	SS	19		○	NP	0	18	76	6
222.4 / 5.6	SAND, trace silt, trace clay, Compact, Brown/grey, mottled, Wet	8	SS	16		○					
221.3 / 6.7	END OF BOREHOLE										

ELEVATION SCALE: 227, 226, 225, 224, 223, 222

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%): 10 20 30

NOTES:

1. Water level measured in open borehole at a depth of about 2.3 m below ground surface (Elev. 225.7 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

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Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-15

SHEET 1 OF 1

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895764.4; E 292551.3 MTM NAD 83 ZONE 10 (LAT. 44.201785; LONG. -79.653255)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE February 1, 2018

CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.1	GROUND SURFACE				
0.0	TOPSOIL (685 mm) Very loose	1	SS	3	
226.4 / 0.7	SAND, some silt, trace clay Loose to compact Brown to brown/grey, stratified Moist to wet	2	SS	6	
		3	SS	12	
224.9 / 2.2	SILT and SAND, trace to some clay Compact Grey Wet	4	SS	14	0 45 51 4
		5	SS	16	
		6	SS	17	NP; 0 32 63 5
		7	SS	13	
		8	SS	19	
220.4 / 6.7	END OF BOREHOLE				

Elevation scale: 227, 226, 225, 224, 223, 222, 221

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

NOTES:

1. Water level measured in open borehole at a depth of about 1.7 m below ground surface (Elev. 225.4 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

3. A borehole was advanced to a depth of 2.4 m immediately next to borehole HF-15 in order to install a standpipe piezometer.

4. Groundwater level measurements in piezometer:

Date	Depth (m)	Elev. (m)
05/03/18	0.2	226.9

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-16

SHEET 1 OF 1

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895581.4; E 292260.0 MTM NAD 83 ZONE 10 (LAT. 44.200133; LONG. -79.656895)

ORIGINATED BY PFP

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE February 8, 2018

CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
227.8	GROUND SURFACE											
227.5 / 0.0	TOPSOIL (280 mm)											
0.3	Sand, trace to some silt, trace gravel, trace organics (FILL) Compact Brown with black staining Moist	1	SS	15								
		2	SS	14		227	~20					
226.3 / 1.5	Sandy SILT, trace to some clay Loose to compact Brown to grey Moist to wet	3	SS	5	∇	226	~19					
		4	SS	11		225	~25					
		5	SS	17								
		6	SS	11		224	~20		0	24	69	7
		7	SS	19		223						
		8	SS	14		222 / 221	~21		0	26	69	5
219.6		9	SS	15		220						
8.2	END OF BOREHOLE											

Dynamic cone penetration resistance plot scale: 20, 40, 60, 80, 100. Shear strength kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100). Plastic limit W_P, natural moisture content W, liquid limit W_L; water content (%) 10, 20, 30.

NOTES:

1. Water level measured in open borehole at a depth of about 2.1 m below ground surface (Elev. 225.7 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

$+^3, \times^3$: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HF-17

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4895595.0; E 292291.5 MTM NAD 83 ZONE 10 (LAT. 44.200256; LONG. -79.656500)
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
DATE February 2, 2018

ORIGINATED BY DF
COMPILED BY EG
CHECKED BY SMM

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
227.5	GROUND SURFACE								
0.0	TOPSOIL (685 mm) Loose	1	SS	8					
226.8 / 0.7	Silty sand, trace gravel (FILL) Compact Brown mottled with oxidation stains Moist	2	SS	23					
225.7 / 1.8	SAND, some silt, trace to some clay Compact Brown to grey Moist to wet	3A / 3B	SS	14					
		4	SS	13	▽				
224.5 / 3.0	SILT, trace to some sand to SILT and SAND, trace to some clay Compact Grey Wet	5	SS	19					
		6	SS	16		0	11	79	10
		7	SS	19		0	36	60	4
	- Sand seam between depths of about 6.4 m and 6.7 m	8A / 8B	SS	18					
		9	SS	15		0	11	81	8
		10	SS	19					
217.7 / 9.8	END OF BOREHOLE								

Elevation scale: 227, 226, 225, 224, 223, 222, 221, 220, 219, 218

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

NOTES:

1. Water level measured in open borehole at a depth of about 2.8 m below ground surface (Elev. 224.7 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HF-18

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895703.0; E 292682.9 MTM NAD 83 ZONE 10 (LAT. 44.201235; LONG. -79.651607)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY EG
DATUM Geodetic
DATE February 2, 2018
CHECKED BY SMM

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) (approx.)	GR	SA	SI	CL
228.1	GROUND SURFACE					228					
0.0	TOPSOIL (230 mm)	1A	SS	4							
0.2	Silty sand (FILL) Very loose to loose Brown, mottled Moist	1B									
		2	SS	9	∇	227	~19	0	73	24	3
226.6 1.5	SILT and SAND to Silty SAND, trace clay Loose to compact Brown, stratified Wet	3	SS	9			~20				
		4	SS	22		226					
	- Silt inclusions between depths of about 2.3 m and 2.9 m	5	SS	17		225	~20	0	60	36	4
		6	SS	18		224					
222.9		7	SS	20		223	~22				
5.2	END OF BOREHOLE										

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10, 20, 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%).

NOTES:

1. Water level measured in open borehole at a depth of about 1.1 m below ground surface (Elev. 227.0 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-19

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895582.4; E 292226.7 MTM NAD 83 ZONE 10 (LAT. 44.200142; LONG. -79.657311)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE February 2, 2018

CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
229.6	GROUND SURFACE											
0.0	ASPHALT (102 mm)	1A	SS	20								
0.1	Sand and gravel, trace silt (FILL) Compact Brown Moist	1B				229						
		2	SS	16			o					
228.1 / 1.5	Silty sand, some gravel, some to trace clay (FILL) Compact Grey/brown Moist	3	SS	10		228	o					
227.4 / 2.2	Sand and gravel, trace to some silt, trace clay (FILL) Compact Black to brown Moist	4	SS	14		227	o		37	55	6	2
		5	SS	10	▽							
225.9 / 3.7	SILT and SAND, trace to some clay Compact Grey Wet	6	SS	14		226	o		0	51	41	8
		7	SS	15		225						
224.4 / 5.2	END OF BOREHOLE											

NOTES:

1. Water level measured in open borehole at a depth of about 3.4 m below ground surface (Elev. 226.2 m) upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-20

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895608.5; E 292219.5 MTM NAD 83 ZONE 10 (LAT. 44.200377; LONG. -79.657402)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE February 5, 2018

CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
228.4	GROUND SURFACE					
0.0	ASPHALT (152 mm)					
0.2	Sand and gravel, trace silt (FILL) Compact to dense Brown Moist	1	SS	17	228	
		2	SS	42		
227.0 / 1.5	Sand, trace silt (FILL) Compact Brown, mottled Moist	3	SS	20	227	
226.2 / 2.2	Sandy silt, some to trace clay (FILL) Loose Brown, mottled Moist	4	SS	9	226	
225.4 / 3.0	SILT and SAND, trace to some clay, trace gravel Compact Brown to grey Wet	5	SS	15	225	1 35 58 6
		6	SS	16	224	
		7	SS	11	223	
222.8 / 5.6	SILT, some sand, some clay Compact Grey, stratified Wet	8	SS	14	222	0 12 73 15
					221	
		9	SS	15		
220.2 / 8.2	END OF BOREHOLE					

Ground water conditions: ∇ at approx. Elev. 226.7 m.

Column headings also include: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

NOTES:

1. Water level measured in open borehole at a depth of about 1.7 m below ground surface (Elev. 226.7 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-21

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895723.3; E 292214.5 MTM NAD 83 ZONE 10 (LAT. 44.201410; LONG. -79.657468)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY EG
DATUM Geodetic
DATE February 6, 2018
CHECKED BY SMM

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
226.6	GROUND SURFACE					
0.0	TOPSOIL (405 mm)	1A	SS	12		
226.2 / 0.4	Sand, some silt, trace clay (FILL) Compact Brown, mottled Moist	1B				
		2	SS	15		
		3	SS	15	∇ (water level, Elev. 225.0)	
224.4 / 2.2	Sandy SILT to SILT and SAND, trace to some clay Compact Grey Wet	4	SS	15		0 49 44 7
		5	SS	17		
	- Sand seam between depths of about 3.8 m to 4.5 m	6	SS	16		
		7	SS	13		
		8	SS	14		0 21 71 8
		9	SS	22		
218.4 / 8.2	END OF BOREHOLE					

Elevation scale: 226, 225, 224, 223, 222, 221, 220, 219

Dynamic cone penetration resistance plot: 20, 40, 60, 80, 100
Shear strength kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100
Plastic limit W_P, Natural moisture content W, Liquid limit W_L; Water content (%): 10, 20, 30
Unit weight γ kN/m³

NOTES:

1. Water level measured in open borehole at a depth of about 1.6 m below ground surface (Elev. 225.0 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

+ ³, × ³: Numbers refer to Sensitivity   ○ ³% STRAIN AT FAILURE

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Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-22

SHEET 1 OF 1

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895770.4; E 292226.3 MTM NAD 83 ZONE 10 (LAT. 44.201834; LONG. -79.657321)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE February 6, 2018

CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
226.8	GROUND SURFACE									
0.0	TOPSOIL (102 mm)									
0.1	Silty sand, trace clay (FILL) Loose Brown, mottled Moist	1A / 1B	SS	5						
226.1 0.7	Sandy SILT, trace to some clay Compact Brown to grey, stratified Moist to wet	2	SS	15	226					
		3	SS	11	225	~20	0	29	64	7
		4	SS	14	224	~20				
		5	SS	15	223	~21				
		6	SS	11		~21 (wP ~12)	0	26	67	7
221.6		7	SS	20	222					
5.2	END OF BOREHOLE									

END OF BOREHOLE

NOTES:

1. Water level measured in open borehole at a depth of about 1.5 m below ground surface (Elev. 225.3 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

3. A borehole was advanced to a depth of 2.4 m immediately next to borehole HF-22 in order to install a standpipe piezometer.

4. Groundwater level measurements in piezometer:

Date	Depth (m)	Elev. (m)
05/03/18	0.6	226.2

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity   O³% STRAIN AT FAILURE

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Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-23

SHEET 1 OF 1

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895815.5; E 292244.4 MTM NAD 83 ZONE 10 (LAT. 44.202240; LONG. -79.657096)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE February 6, 2018

CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
226.9	GROUND SURFACE									
0.0	TOPSOIL (685 mm) Loose	1	SS	5						
226.2 0.7	Sandy silt, trace clay (FILL) Loose Brown, mottled Moist	2	SS	6	226					
225.4 1.5	SILT and SAND, some sand, trace to some clay Compact Brown to grey, stratified Wet	3	SS	14	225	o	0	33	61	6
		4	SS	16		o				
223.9 3.0	SILT, some sand, some clay Compact Brown to grey Wet	5	SS	11	224	H o	0	18	69	13
		6	SS	19	223	o				
		7	SS	16	222	o				
221.7 5.2	END OF BOREHOLE									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

1. Water level measured in open borehole at a depth of about 1.6 m below ground surface (Elev. 225.3 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

3. A borehole was advanced to a depth of 2.3 m immediately next to borehole HF-23 in order to install a standpipe piezometer.

2. Groundwater level measurements in piezometer:

Date	Depth (m)	Elev. (m)
05/03/18	0.7	226.2

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-24

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895520.6; E 292191.0 MTM NAD 83 ZONE 10 (LAT. 44.199585; LONG. -79.657756)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY EG
DATUM Geodetic
DATE February 15, 2018
CHECKED BY SMM

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
229.1	GROUND SURFACE
0.0	ASPHALT (127 mm)
0.1	Gravelly sand, trace silt (FILL) Compact to dense Brown Moist - Auger grinding at a depth of about 0.5 m - Asphalt structure from between depths of about 1.2 m and 1.4 m
226.9 2.2	Silty sand, trace to some clay, trace gravel, trace organics (FILL) Compact Dark grey, mottled Moist
225.7 3.4	Sandy SILT, trace to some clay Compact Brown to grey, mottled Wet
222.4 6.7	END OF BOREHOLE

NOTES:

1. Water level measured in open borehole at a depth of about 3.2 m below ground surface (Elev. 225.9 m) upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	32				
2	SS	26				
3	SS	36				
4	SS	14	1	63	29	7
5A / 5B	SS	11				
6	SS	18				
7	SS	23	0	22	71	7
8	SS	17				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (229, 228, 227, 226, 225, 224, 223); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

+³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-25

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895510.1; E 292238.8 MTM NAD 83 ZONE 10 (LAT. 44.199491; LONG. -79.657158)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D90 Truck-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY JIL

DATUM Geodetic

DATE February 15, 2018

CHECKED BY SMM

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
229.8	GROUND SURFACE										
0.0	ASPHALT (140 mm)										
0.1	Gravelly sand (FILL) Dense Brown Moist	1	SS	39							
229.1 0.7	Silty sand, trace gravel, contains clayey silt pockets (FILL) Compact to dense Brown to grey Moist	2	SS	25		~9					
		3A 3B	SS	39							
227.6 2.2	Sand, trace gravel (FILL) Compact to very dense Brown Moist	4	SS	51		~5					
		5	SS	28	∇ (Elev. 226.7 m)						
226.1 3.7	SILT and SAND, trace to some clay Compact Brown to grey Wet	6	SS	20		~22		0	48	50	2
		7	SS	14							
		8	SS	21		~16					
		9	SS	19							
		10	SS	20		~20	NP	0	32	62	6
220.0 9.8	END OF BOREHOLE										

Elevation scale: 229, 228, 227, 226, 225, 224, 223, 222, 221, 220

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

NOTES:

1. Water level measured in open borehole at a depth of about 3.1 m below ground surface (Elev. 226.7 m) upon completion of drilling.

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

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Golder Associates

RECORD OF BOREHOLE No HF-26

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00 LOCATION N 4895578.2; E 292615.8 MTM NAD 83 ZONE 10 (LAT. 44.200110; LONG. -79.652443) ORIGINATED BY DF

DIST Central HWY 400 BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers COMPILED BY EG

DATUM Geodetic DATE January 31, 2018 CHECKED BY SMM

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%) w	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
228.5	GROUND SURFACE					
0.0 / 228.2	TOPSOIL (305 mm)	1A / 1B	SS	15		
227.8 / 0.7	Sand and gravel, trace silt (FILL) Compact Brown Moist					
	Sand, trace silt (FILL) Loose Brown mottled with oxidation stains Moist	2	SS	7	~20	
227.0 / 1.5	SILT and SAND, trace to some clay Compact Light brown, laminated Wet - Silty sand layer with clay inclusions between depths of about 2.3 m and 2.9 m	3	SS	18		
		4	SS	19	~21	0 44 50 6
		5	SS	23		
		6	SS	16	~20	0 60 36 4
223.3		7	SS	18		
5.2	END OF BOREHOLE					

Elevation scale: 228, 227, 226, 225, 224

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100

Shear Strength kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

Water content scale: 10 20 30 (Plastic Limit W_P, Natural Moisture Content W, Liquid Limit W_L)

Unit Weight γ kN/m³

NOTES:

1. Water level measured in open borehole at a depth of about 3.1 m below ground surface (Elev. 225.4 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

3. Groundwater level measurements in piezometer:

Date	Depth (m)	Elev. (m)
05/03/18	1.4	227.1

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-27

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895621.1; E 292594.5 MTM NAD 83 ZONE 10 (LAT. 44.200496; LONG. -79.652711)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE January 31, 2018

CHECKED BY SMM

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.6	GROUND SURFACE						
0.0	TOPSOIL (230 mm)	1A	SS	12	∇ (water level)		
0.2	Sand and gravel, trace silt (FILL) Compact Brown/grey Moist	1B					
226.9 / 0.7	Sandy SILT, some to trace clay Loose Light brown Wet	2	SS	9		o	
226.1 / 1.5	SILT and SAND, trace to some clay Compact Light brown, stratified Wet	3	SS	13		o	0 57 37 6
		4	SS	21			
		5	SS	13		o	
		6	SS	13			
	- Silt inclusions between depths of about 4.6 m and 5.2 m	7	SS	14		o	
222.0 / 5.6	SILT, some sand, trace to some clay Compact Light brown Wet	8	SS	14		o	0 13 79 8
		9	SS	18			
219.4 / 8.2	END OF BOREHOLE						

Column headings also include: SOIL PROFILE; STRAT PLOT; SAMPLES; ELEVATION SCALE (227 to 220); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

NOTES:

1. Water level measured in open borehole at a depth of about 0.3 m below ground surface (Elev. 227.3 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

$+^3, \times^3$: Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

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Golder Associates

RECORD OF BOREHOLE No HF-28

SHEET 1 OF 1 **METRIC**

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895492.9; E 292593.3 MTM NAD 83 ZONE 10 (LAT. 44.199342; LONG. -79.652723)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE February 8, 2018

CHECKED BY SMM

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
229.4	GROUND SURFACE							
0.0	TOPSOIL (203 mm)	1	SS	18				
0.2	Silty sand, trace to some clay (FILL) Compact to dense Brown to grey, mottled Moist	2	SS	18	2	67	26	5
		3	SS	30				
227.1	- Asphalt structure between depths of about 1.9 m and 2.1 m							
2.3	SILT and SAND, trace to some clay Compact Light brown Moist to wet	4	SS	18				
		5	SS	11	0	44	47	9
		6	SS	24				
		7	SS	16				
224.2 / 5.2	END OF BOREHOLE							

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (229, 228, 227, 226, 225); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³.

NOTES:

1. Water level measured in open borehole at a depth of about 2.2 m below ground surface (Elev. 227.2 m) upon completion of drilling.

+³, ×³: Numbers refer to Sensitivity   ○³% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-29

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895521.9; E 292610.6 MTM NAD 83 ZONE 10 (LAT. 44.199603; LONG. -79.652507)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY EG
DATUM Geodetic
DATE February 8, 2018
CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
228.2	GROUND SURFACE							
0.0 227.9	TOPSOIL (305 mm)					228		
0.3	Silt and sand, trace clay (FILL) Loose to compact Brown/mottled Moist	1	SS	7				
		2	SS	18	▽	227	~17	0 61 36 3
226.9 1.3	SILT and SAND, trace clay, inclusions of silt, inclusions of clay Compact Brown to grey, mottled Wet	3	SS	12		226		
		4	SS	19		225	~22	
		5	SS	18				
		6	SS	20		224	~21	0 54 43 3
		7	SS	15		223		
		8	SS	18		222	~22	
221.5 6.7	END OF BOREHOLE							

NOTES:

1. Water level measured in open borehole at a depth of about 1.2 m below ground surface (Elev. 227.0 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No HF-30

SHEET 1 OF 1 METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895594.9; E 292627.7 MTM NAD 83 ZONE 10 (LAT. 44.200261; LONG. -79.652294)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE January 31, 2018

CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
228.1	GROUND SURFACE							
0.0	TOPSOIL (152 mm)	1A	SS	7		228		
0.2	Sand, trace silt (FILL) Loose Brown, mottled Moist	1B						
227.4 / 0.7	SILT and SAND, trace to some clay Loose to compact Light brown Wet	2	SS	6		227	~20.5	
		3	SS	11		226		
		4	SS	18			~20	
	- Silty sand layers between depths of about 3.1 m and 3.7 m	5	SS	19	▽	225	~20	0 43 52 5
		6	SS	16		224	~21	
		7	SS	21			~19	0 57 38 5
222.9 / 5.2	END OF BOREHOLE					223		

NOTES:

1. Water level measured in open borehole at a depth of about 3.3 m below ground surface (Elev. 224.8 m) upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No HF-31

SHEET 1 OF 1 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895626.4; E 292631.5 MTM NAD 83 ZONE 10 (LAT. 44.200545; LONG. -79.652247)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY EG
DATUM Geodetic
DATE February 1, 2018
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) w	GR	SA	SI	CL
228.0	GROUND SURFACE										
0.0	TOPSOIL (152 mm)	1A	SS	9							
0.2	Silt and sand, trace clay (FILL) Loose to compact Brown, mottled Moist to wet	1B									
		2	SS	12	▽	227	~17	0	47	49	4
226.5 / 1.5	SILT and SAND, trace clay Compact Brown/grey, mottled Wet	3	SS	15		226	~21				
		4	SS	19		225					
		5	SS	20			~20	0	66	30	4
		6	SS	25		224					
		7	SS	17		223	~22				
		8	SS	17		222 / 221	~21	0	47	50	3
219.8		9	SS	20		220					
8.2	END OF BOREHOLE										

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

1. Water level measured in open borehole at a depth of about 1.3 m below ground surface (Elev. 226.7 m) upon completion of drilling.

2. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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Golder Associates

Foundation Design

RECORD OF BOREHOLE No PMT-01

SHEET 1 OF 3

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4895473.7; E 292331.2 MTM NAD 83 ZONE 10 (LAT. 44.199165; LONG. -79.656001)

BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud

DATE January 23 to 25, 2018

ORIGINATED BY DF

COMPILED BY DM

CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.2	GROUND SURFACE										
226.9 / 0.0	TOPSOIL (280 mm)						227				
0.3	Silty sand (FILL) Brown, mottled Moist					▽	226				
225.7 / 1.5	Sandy SILT to SILT and SAND , trace clay Grey Wet						225, 224, 223, 222, 221, 220, 219, 218, 217, 216				
215.5 / 11.7	SILT, trace sand to sandy, trace to some clay Grey Wet						215, 214, 213				

Dynamic cone penetration resistance plot scale: 20 40 60 80 100

Shear strength legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED. Scale: 20 40 60 80 100

Plastic limit W_P, natural moisture content W, liquid limit W_L. Water content scale: 10 20 30

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No PMT-01

SHEET 2 OF 3

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895473.7; E 292331.2 MTM NAD 83 ZONE 10 (LAT. 44.199165; LONG. -79.656001)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud

COMPILED BY DM

DATUM Geodetic

DATE January 23 to 25, 2018

CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILT, trace sand to sandy, trace to some clay Grey Wet						212 211 210 209 208 207				
206.5 20.8	Varved CLAYEY SILT to SILTY CLAY, trace to some sand, with silt and clay laminae Grey Wet						206 205 204 203 202 201 200 199 198				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No PMT-01 SHEET 3 OF 3 METRIC

PROJECT 1668512

G.W.P. 2438-13-00 LOCATION N 4895473.7; E 292331.2 MTM NAD 83 ZONE 10 (LAT. 44.199165; LONG. -79.656001) ORIGINATED BY DF

DIST Central HWY 400 BOREHOLE TYPE D50 Track-Mounted, NW Casing and Wash Boring with Drilling Mud COMPILED BY DM

DATUM Geodetic DATE January 23 to 25, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Varved CLAYEY SILT to SILTY CLAY, trace to some sand, with silt and clay laminae Grey Wet						197				
							196				
195.7 31.5	Silty SAND Grey Wet						195				
							194				
193.4 33.8	CLAYEY SILT, trace sand, trace gravel Grey Moist						193				
192.6 34.6	END OF BOREHOLE										

NOTES:

1. In-situ pressuremeter testing carried out in open borehole at selected depth intervals.

2. A 50 mm diameter PVC Casing was installed upon completion of pressuremeter testing to carry out vertical seismic profiling.

3. Water level measurements in the NW casing at the beginning of each work shift.

4. The water level measurements are not considered to be representative of the groundwater level due to introduction of water/ drilling mud during washboring operations.

Date	Depth (m)	Elev. (m)
24/01/18	1.4	225.8
25/01/18	1.2	226.0

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No PMT-02

SHEET 1 OF 2

METRIC

PROJECT 1668512

G.W.P. 2438-13-00

LOCATION N 4895579.3; E 292616.8 MTM NAD 83 ZONE 10 (LAT. 44.200120; LONG. -79.652431)

ORIGINATED BY DF

DIST Central HWY 400

BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY EG

DATUM Geodetic

DATE January 29-30, 2018

CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
228.4	GROUND SURFACE				
0.0	Silty SAND Compact Grey/brown, laminated Wet	1	SS	26	
223.6 4.8	Sandy SILT, trace clay Compact Light brown/grey, mottled Wet	2	SS	16	
220.6 7.8	SILT and SAND, trace clay Compact Grey Wet	3	SS	20	0 62 34 4
217.6 10.8	Sandy SILT, trace to some clay Compact Grey Wet	4	SS	15	0 29 66 5
214.6 13.8	SILT, some sand, trace to some clay Compact Grey Wet				

Elevation scale: 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215, 214

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No PMT-02

SHEET 2 OF 2 **METRIC**

PROJECT 1668512
G.W.P. 2438-13-00
LOCATION N 4895579.3; E 292616.8 MTM NAD 83 ZONE 10 (LAT. 44.200120; LONG. -79.652431)
ORIGINATED BY DF
DIST Central HWY 400
BOREHOLE TYPE D50 Track-Mounted, 203mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY EG
DATUM Geodetic
DATE January 29-30, 2018
CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT W_P – NATURAL MOISTURE CONTENT W – LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILT, some sand, trace to some clay Compact Grey Wet						213				
			5	SS	20				○		0 14 74 12
							212				
211.5 16.9	SILT and SAND Dense Grey, laminated Wet						211				
							210				
			6	SS	43				○		
							209				
							208				
							207				
206.2			7	SS	50				○		
22.2	END OF BOREHOLE										

NOTES:

1. In-situ pressuremeter testing carried out in open borehole at selected depth intervals.

2. A 50 mm diameter PVC Casing was installed upon completion of pressuremeter testing to carry out vertical seismic profiling.

3. Water level measured in open borehole at a depth of about 2.0 m below ground surface (Elev. 226.4 m) upon completion of drilling.

4. The water level measurement is not considered to be representative of the groundwater level due to introduction of water/drilling mud.

GTA-MTO 001 S:\CLIENTS\MTO\HWY_400_AND_HWY_89_INTERCHANGE\02_DATA\GINT\HWY_400_AND_HWY_89_INTERCHANGE.GPJ GAL-GTA.GDT 11/05/18

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

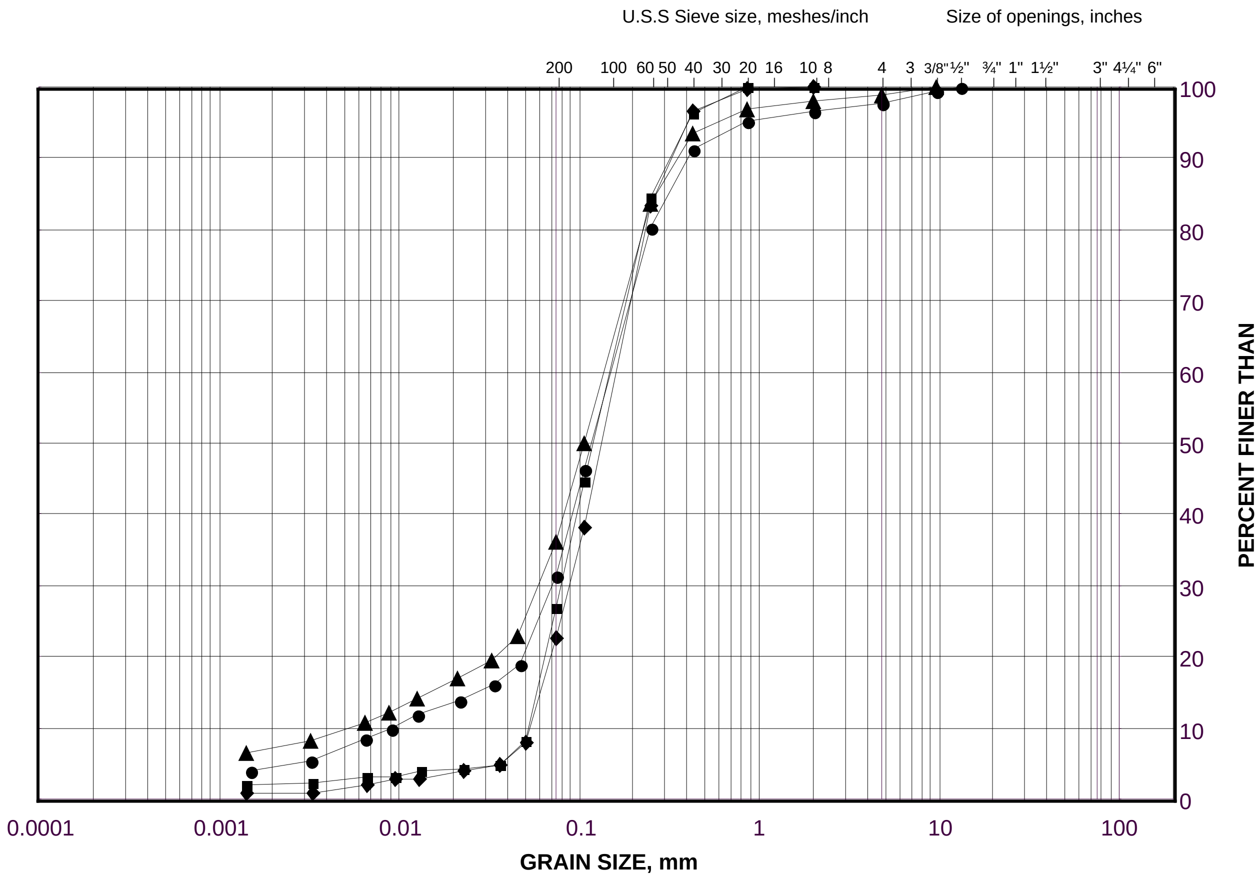
APPENDIX E

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Silty Sand (FILL)

FIGURE E-1



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-28	2	228.3
■	HF-18	2	227.1
◆	HF-10	2	226.5
▲	HF-24	4	226.5

Project Number: 1668512

Checked By: SMM

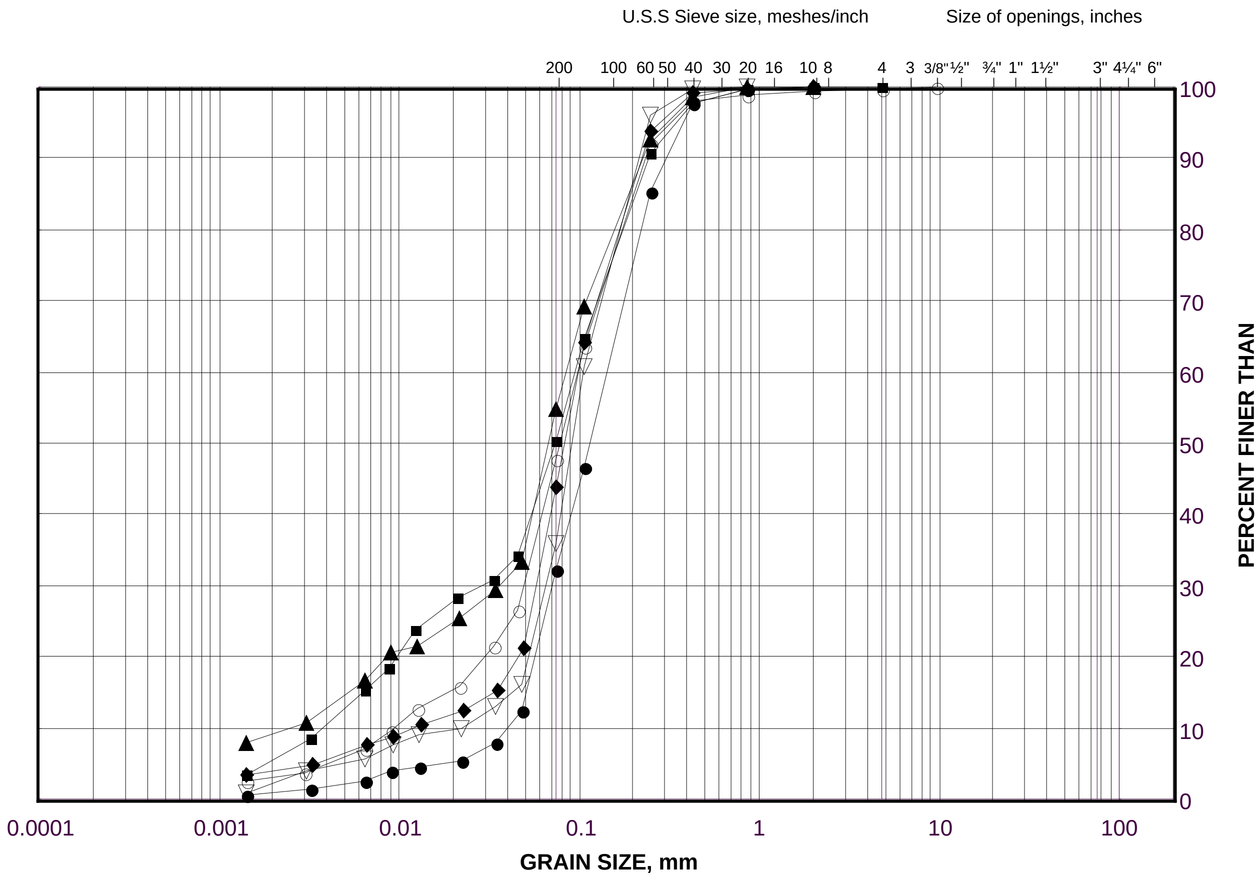
Golder Associates

Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt and Sand (FILL)

FIGURE E-2A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-04	1	227.5
■	HF-06	2	226.2
◆	89UP-02	2	232.8
▲	89UP-05	2	226.6
▽	89UP-08	3	225.8
❍	89UP-06	3	232.0

Project Number: 1668512

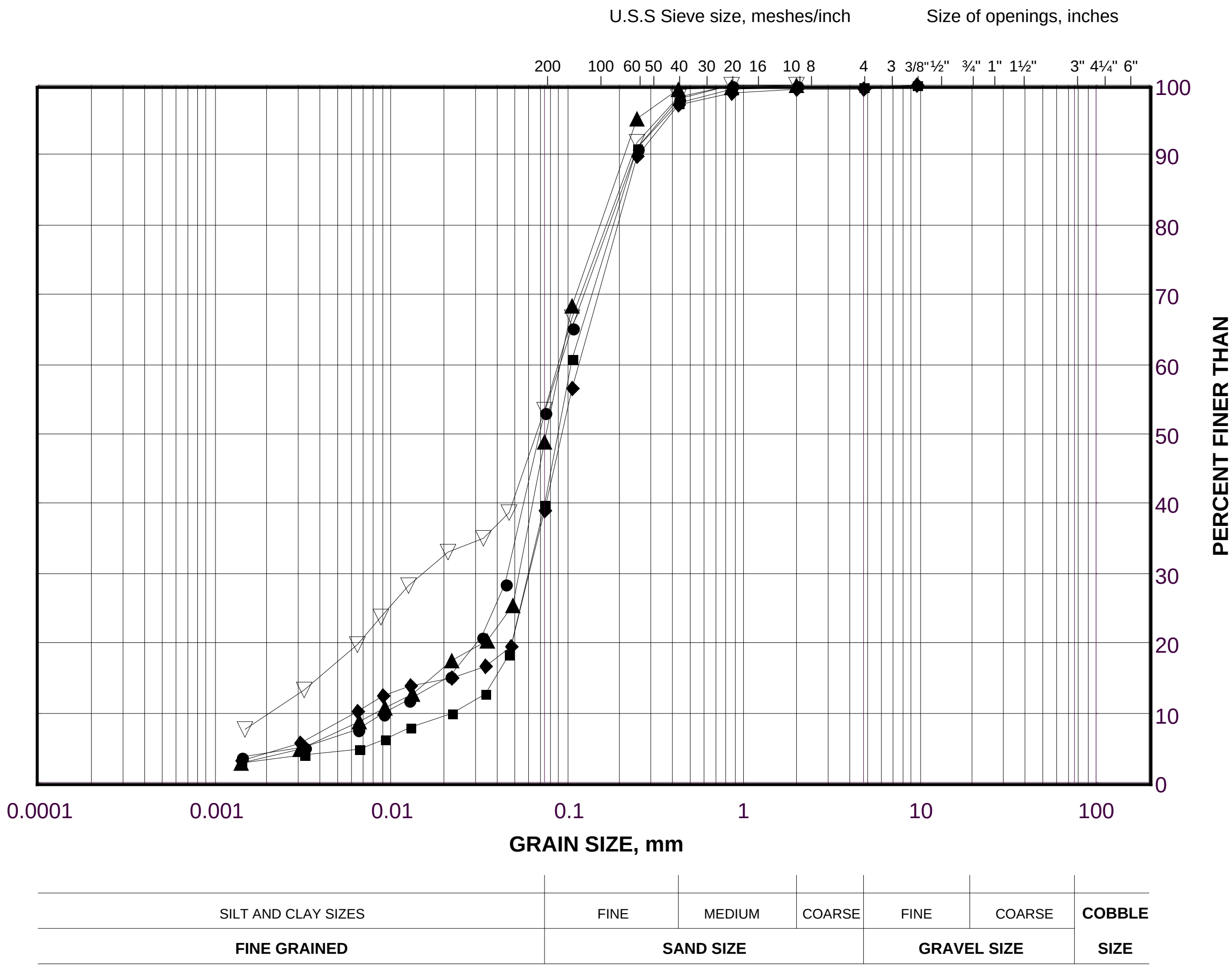
Checked By: SMM

Golder Associates

Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION
Silt and Sand (FILL)

FIGURE E-2B



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-31	2	226.9
■	HF-29	2	227.1
◆	HF-01	3	226.0
▲	89UP-02	6	229.0
▽	89UP-06	8	228.2

Project Number: 1668512

Checked By: SMM

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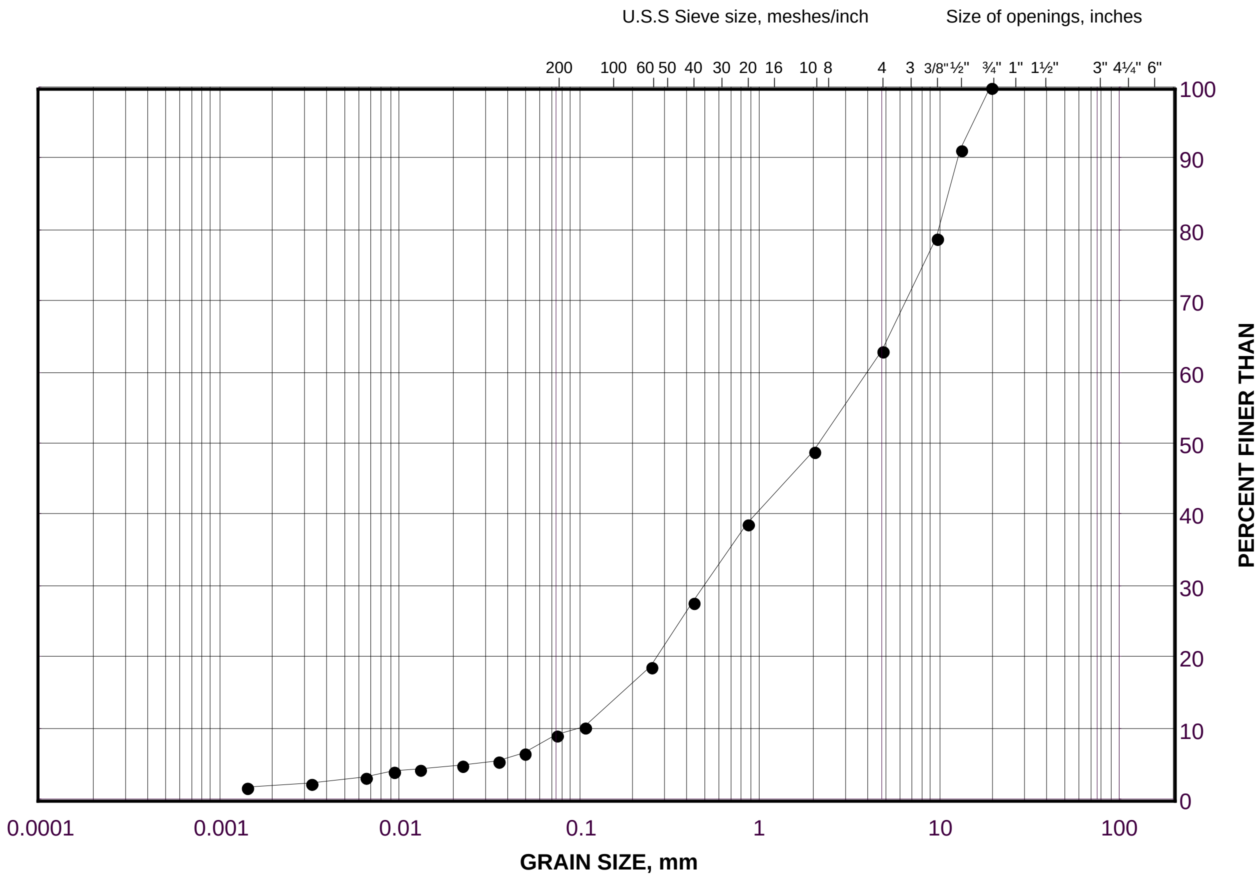
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Sand and Gravel (FILL)

FIGURE E-3



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-19	4	227.0

Project Number: 1668512

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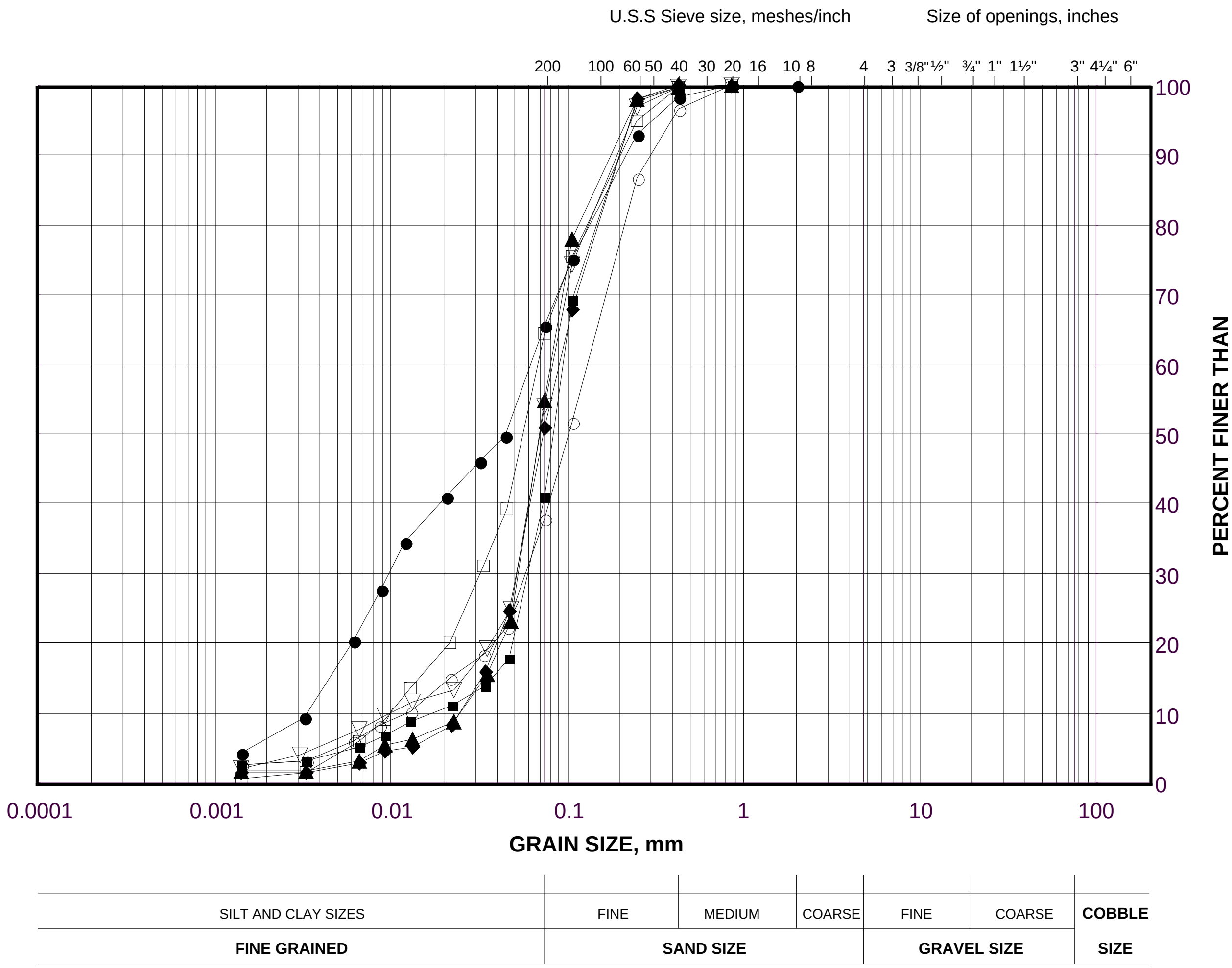
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt and Sand (Upper Granular Deposit)

FIGURE E-4A



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-02	2	226.4
■	HF-04	3	225.9
◆	HF-03	5	224.1
▲	HF-06	5	223.9
▽	HF-01	5	224.5
❍	HF-04	7	222.9
□	HF-02	9	219.6

Project Number: 1668512

Checked By: SMM

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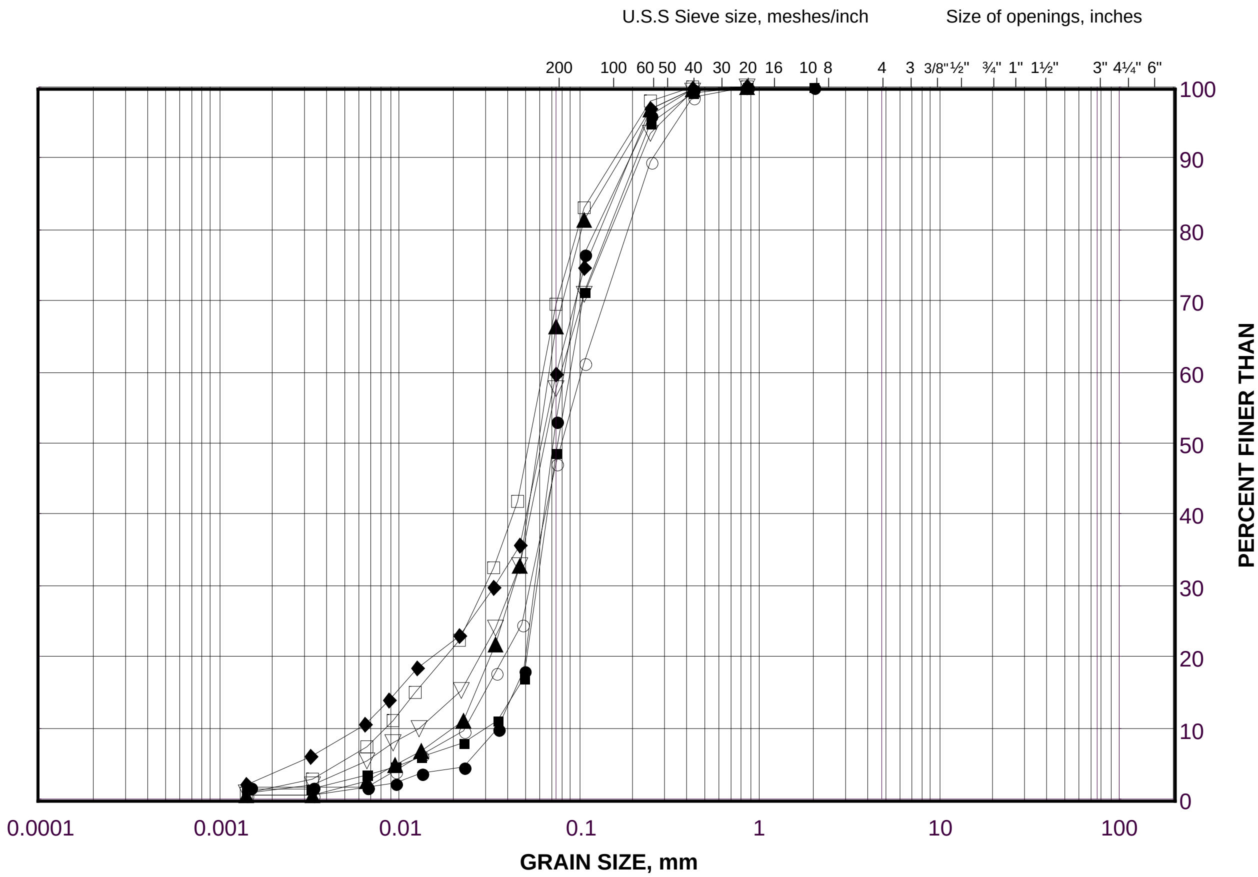
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt and Sand (Upper Granular Deposit)

FIGURE E-4B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-07	3	225.4
■	HF-08	3	225.4
◆	HF-09	3	225.4
▲	HF-11	4	225.2
▽	HF-09	5	223.9
❍	HF-08	7	222.3
☐	HF-07	9	219.4

Project Number: 1668512

Checked By: SMM

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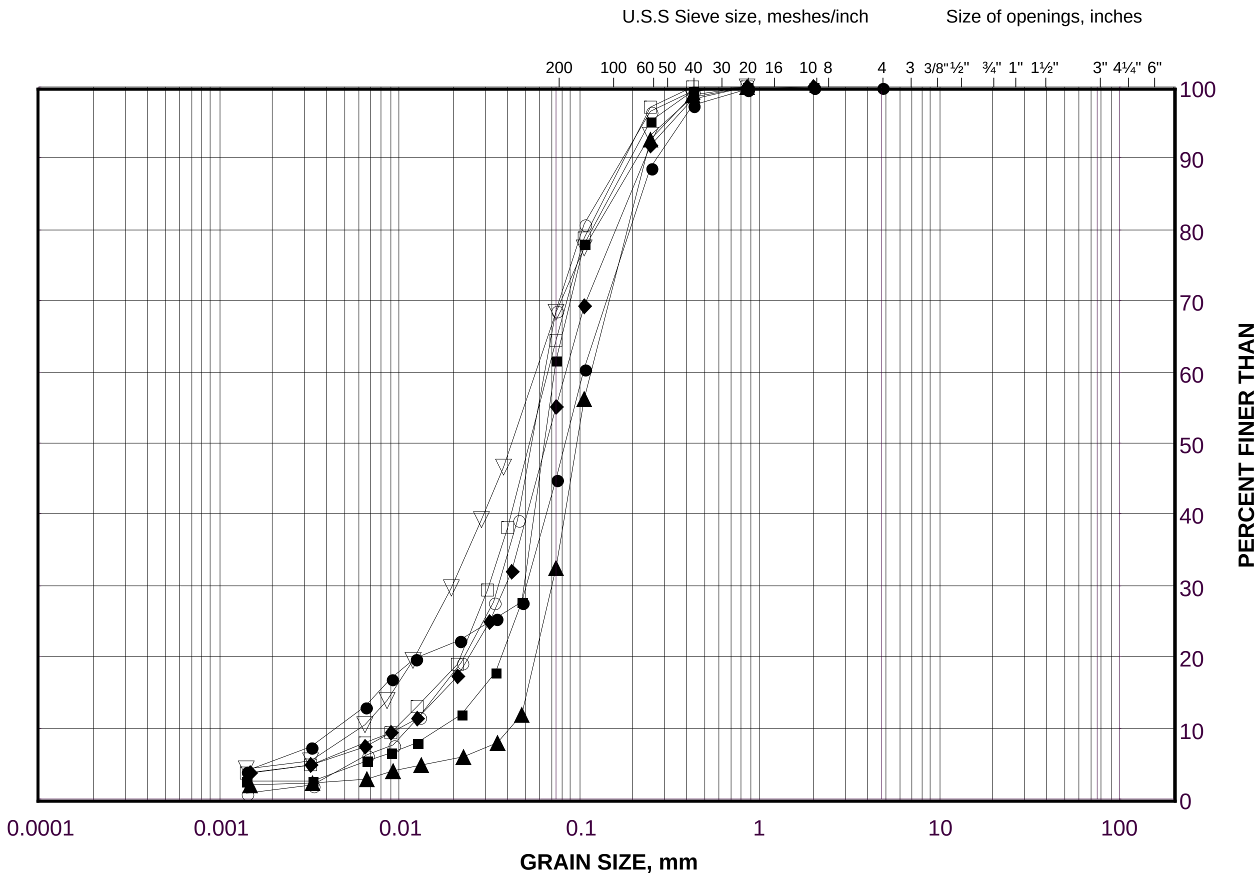
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt and Sand (Upper Granular Deposit)

FIGURE E-4C



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-13	2	225.7
■	HF-12	3	224.9
◆	HF-15	4	224.5
▲	HF-14	5	224.7
▽	HF-15	6	223.0
❍	HF-11	7	222.9
☐	HF-17	7	222.6

Project Number: 1668512

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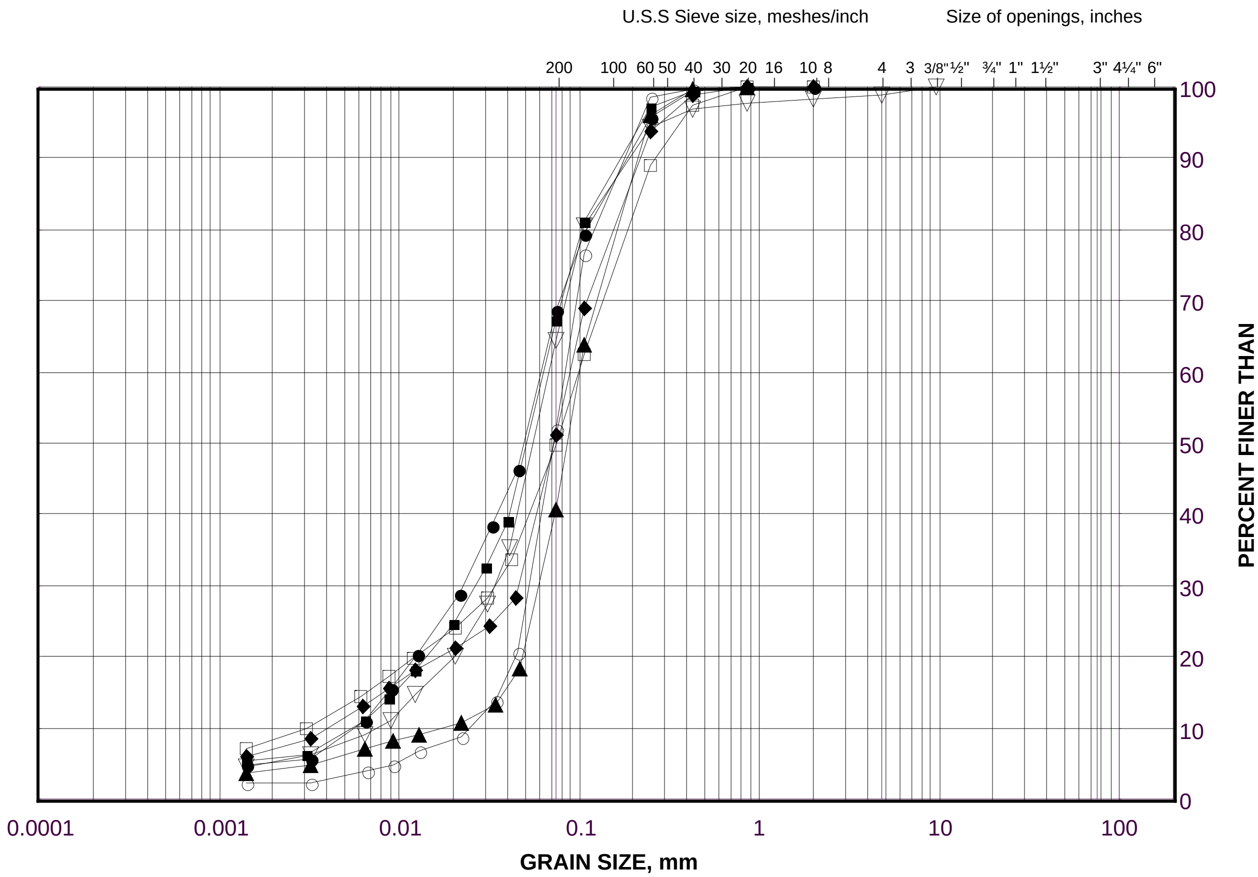
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt and Sand (Upper Granular Deposit)

FIGURE E-4D



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-25	10	220.4
■	HF-23	3	225.1
◆	HF-21	4	224.0
▲	HF-18	5	224.7
▽	HF-20	5	225.1
❍	HF-25	6	225.7
□	HF-19	6	225.5

Project Number: 1668512

Checked By: SMM

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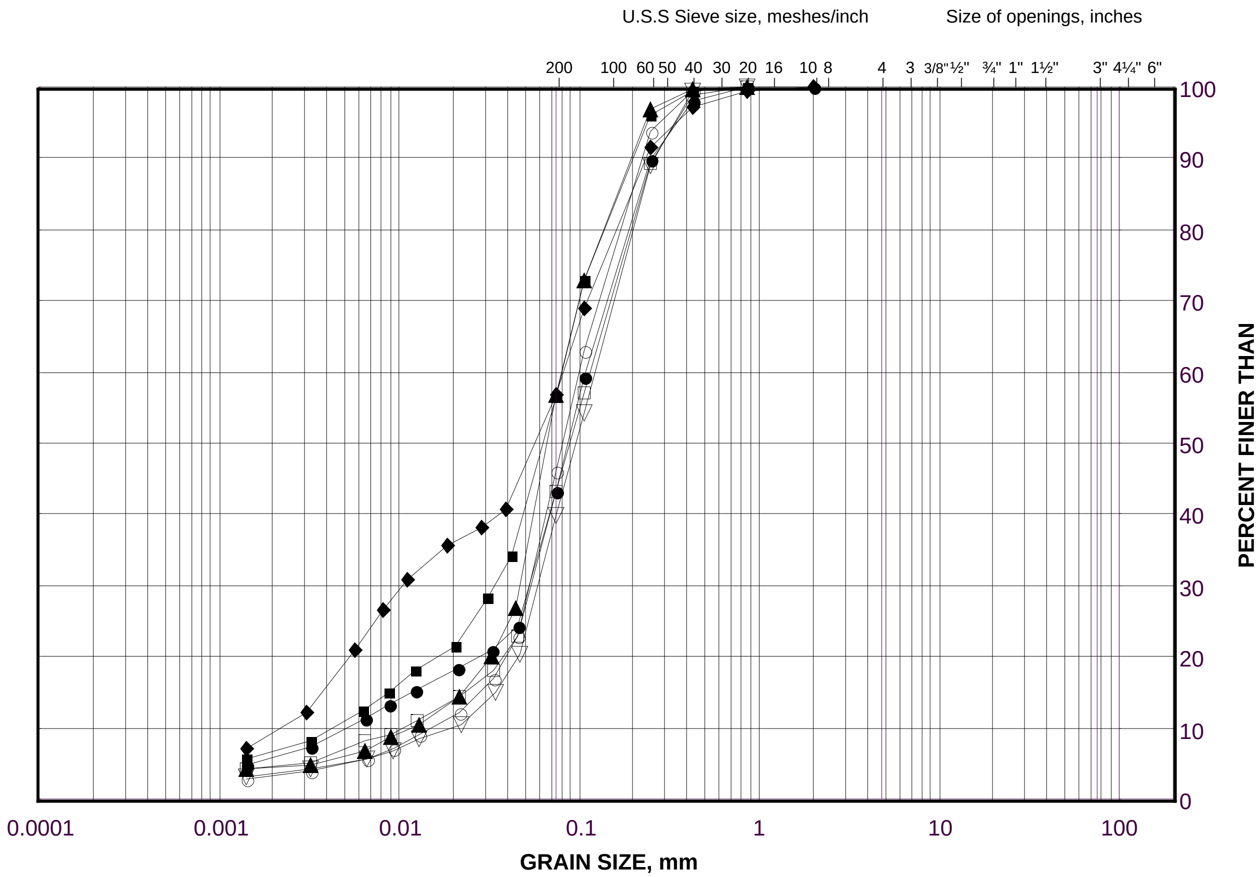
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION Silt and Sand (Upper Granular Deposit)	FIGURE E-4E



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-27	3	225.8
■	HF-26	4	225.9
◆	HF-28	5	226.1
▲	HF-30	5	224.7
▽	HF-26	6	224.4
❍	HF-29	6	224.1
☐	HF-30	7	223.2

Project Number: 1668512

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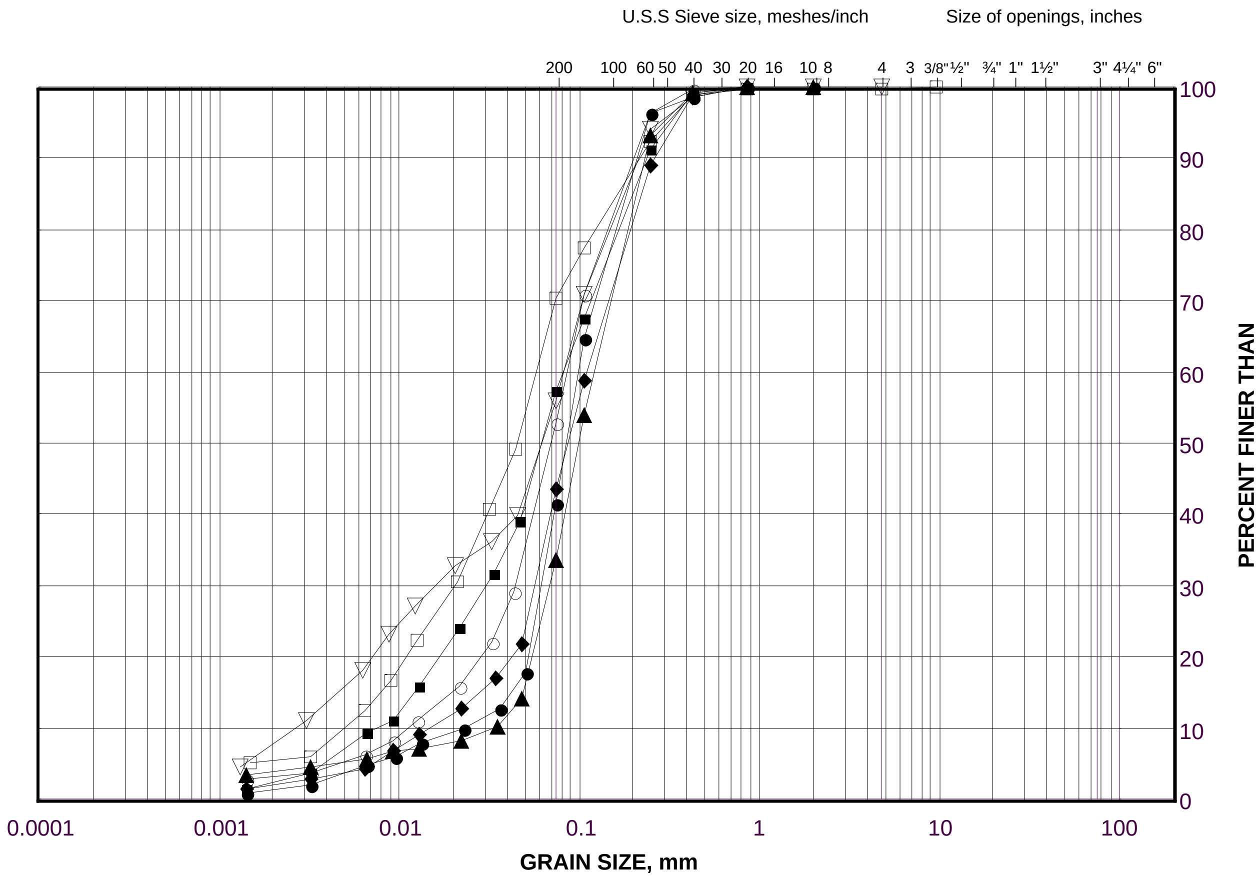
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION Silt and Sand (Upper Granular Deposit)	FIGURE E-4F



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-02	10B	222.9
■	89UP-02	12B	219.8
◆	89UP-01	5	224.4
▲	HF-31	5	224.7
▽	89UP-03	5	224.1
❍	HF-31	8	221.6
☐	89UP-01	9	219.9

Project Number: 1668512

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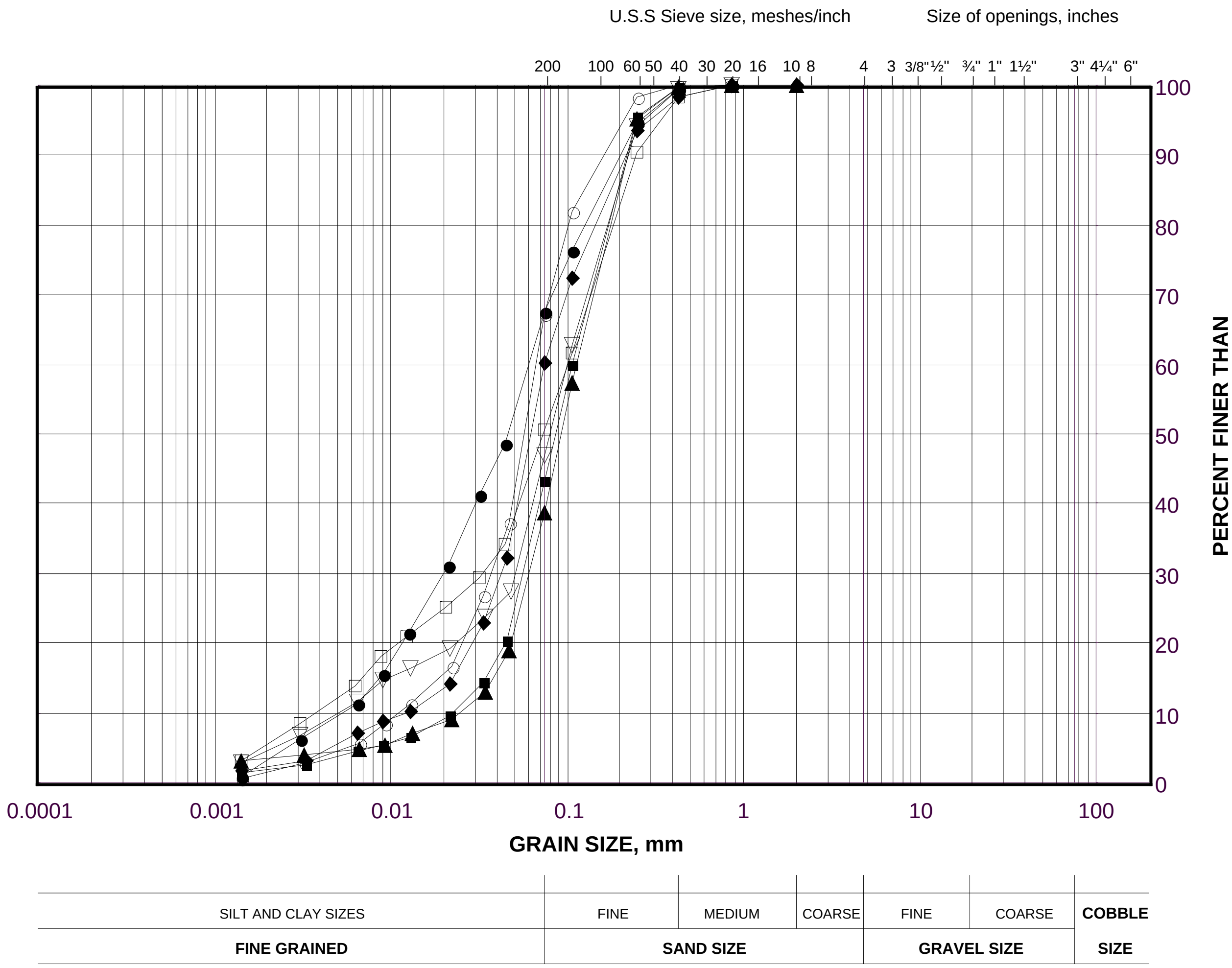
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt and Sand (Upper Granular Deposit)

FIGURE E-4G



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-08	11	216.6
■	89UP-06	12	224.4
◆	89UP-06	15	219.9
▲	PMT-02	3	218.8
▽	89UP-04	6	222.9
❍	89UP-07	6	223.1
□	89UP-08	9	219.7

Project Number: 1668512

Checked By: SMM

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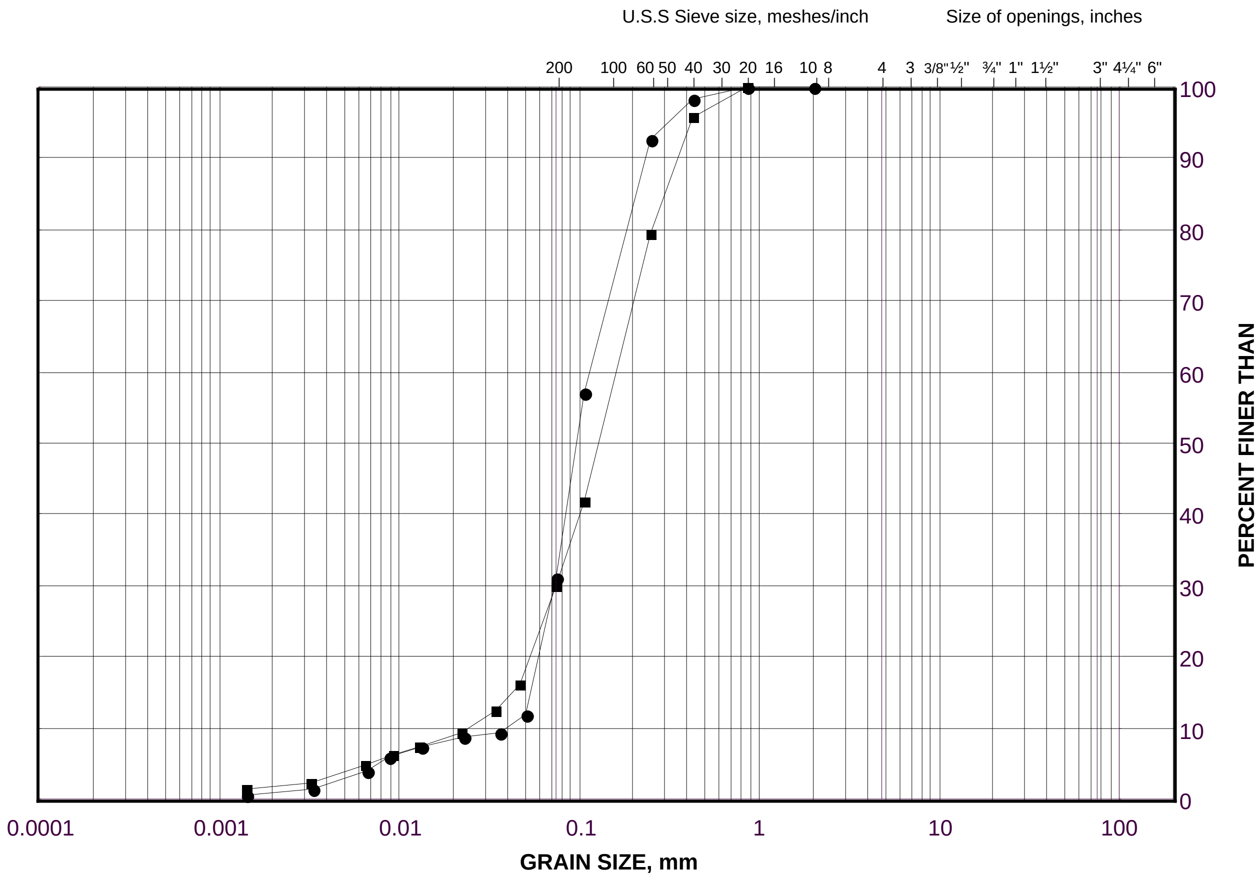
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION
Silty Sand (Upper Granular Deposit)

FIGURE E-5



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-05	2	225.9
■	HF-02	6	223.4

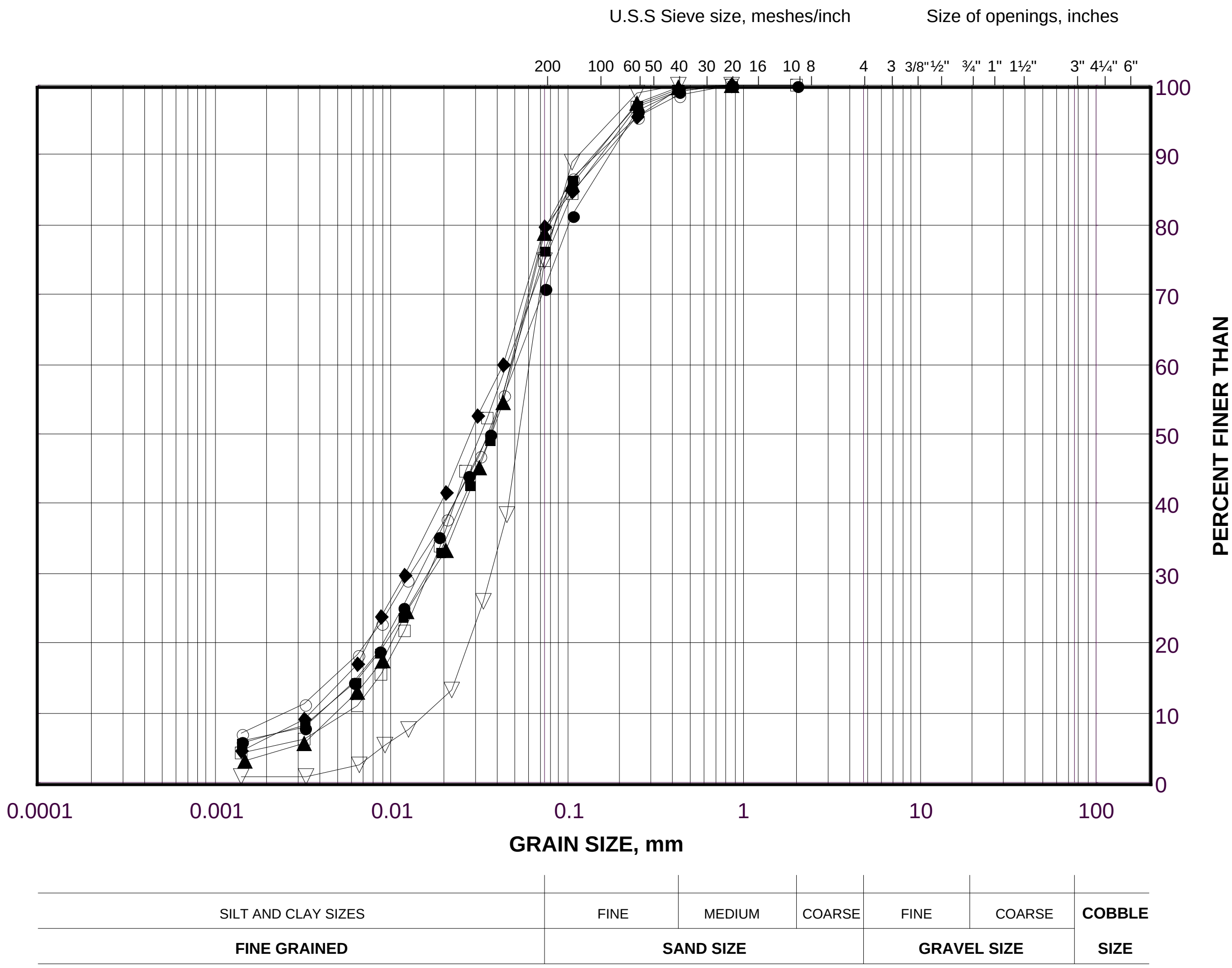
Project Number: 1668512

Checked By: SMM

Golder Associates

Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION Sandy Silt (Upper Granular Deposit)	FIGURE E-6A



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-22	3	225.0
■	HF-16	6	223.7
◆	HF-12	7	221.8
▲	HF-07	7	222.4
▽	HF-03	7	222.6
❍	HF-21	8	220.2
□	HF-16	8	221.4

Project Number: 1668512

Checked By: SMM

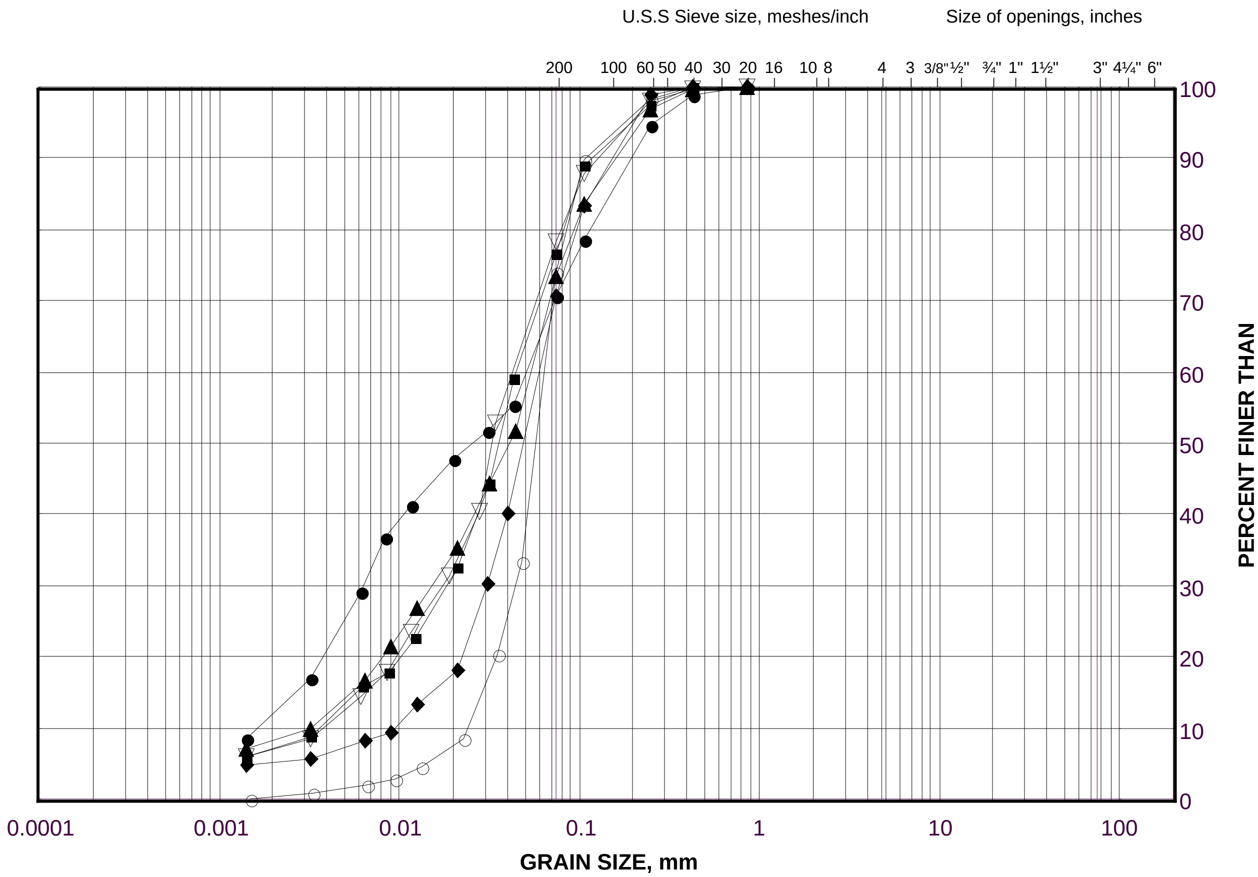
Golder Associates

Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Sandy Silt (Upper Granular Deposit)

FIGURE E-6B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-06	17	216.8
■	89UP-06	19	213.8
◆	PMT-02	4	215.9
▲	HF-22	6	222.7
▽	HF-24	7	224.2
❍	89UP-05	8	219.8

Project Number: 1668512

Checked By: SMM

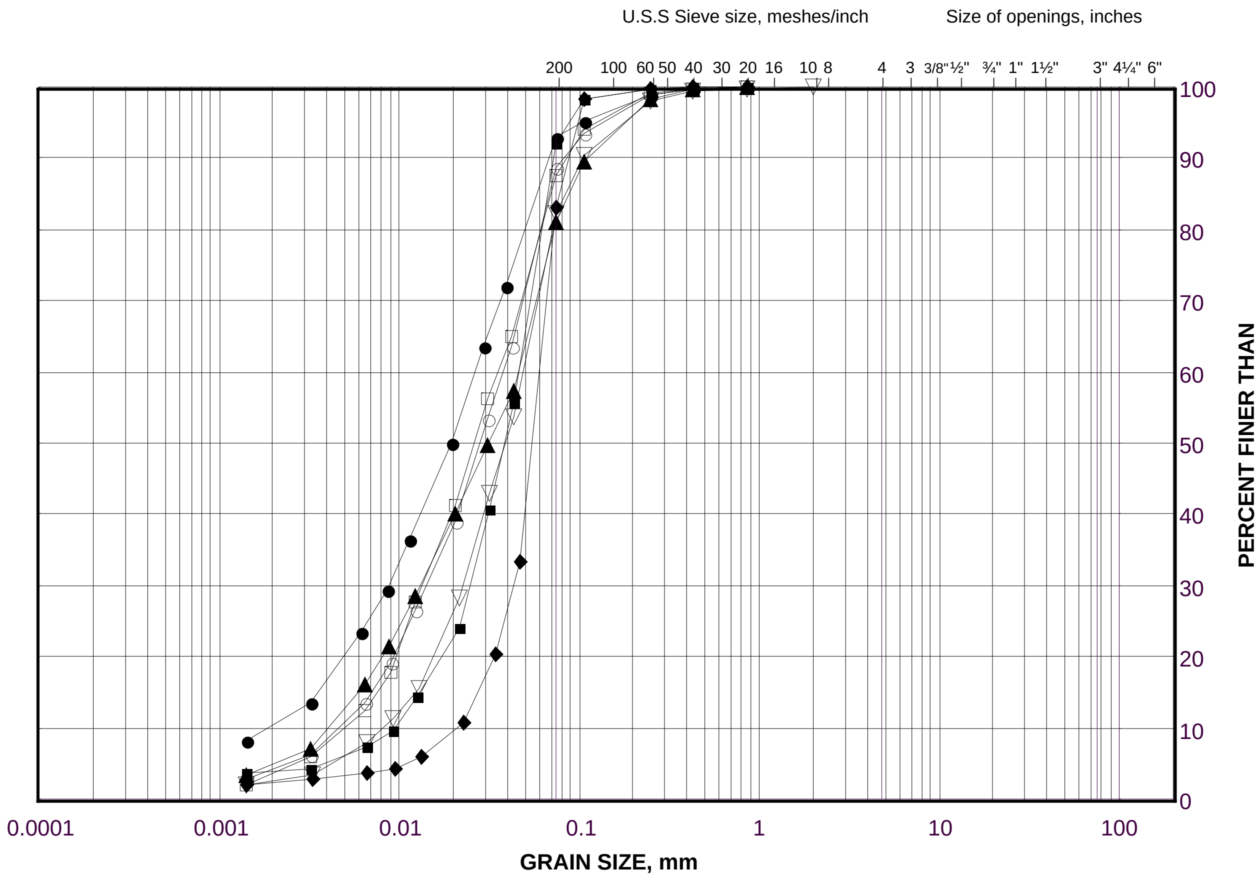
Golder Associates

Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt (Upper Granular Deposit)

FIGURE E-7A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-07	12	214.8
■	HF-02	15	210.4
◆	HF-07	17	207.2
▲	HF-03	3A	225.8
▽	HF-10	5	224.2
❍	HF-05	6	222.9
□	HF-06	7	222.3

Project Number: 1668512

Checked By: SMM

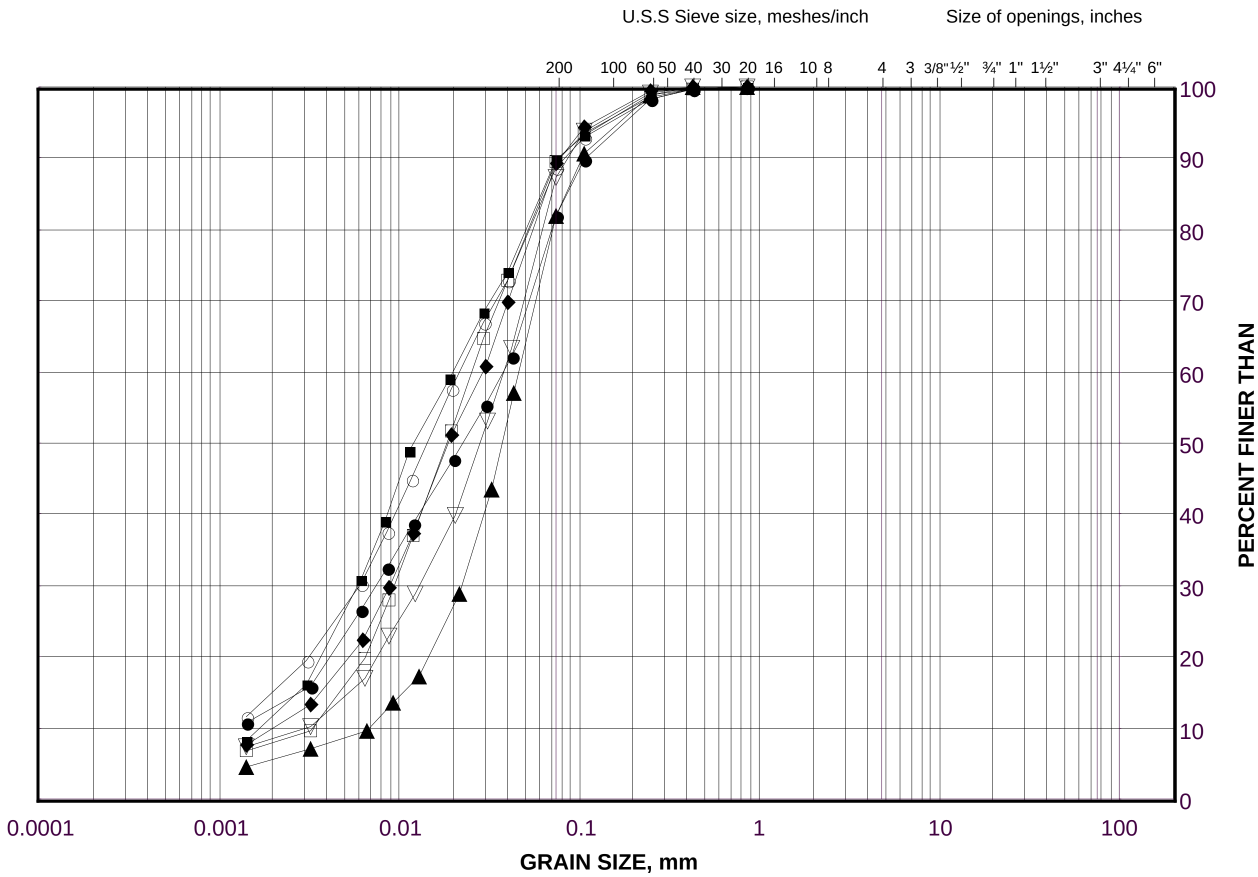
Golder Associates

Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt (Upper Granular Deposit)

FIGURE E-7B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-23	5	223.5
■	HF-13	6	222.7
◆	HF-17	6	223.4
▲	HF-14	7	223.1
▽	HF-27	8	221.2
❍	HF-20	8	222.0
☐	HF-17	9	219.6

Project Number: 1668512

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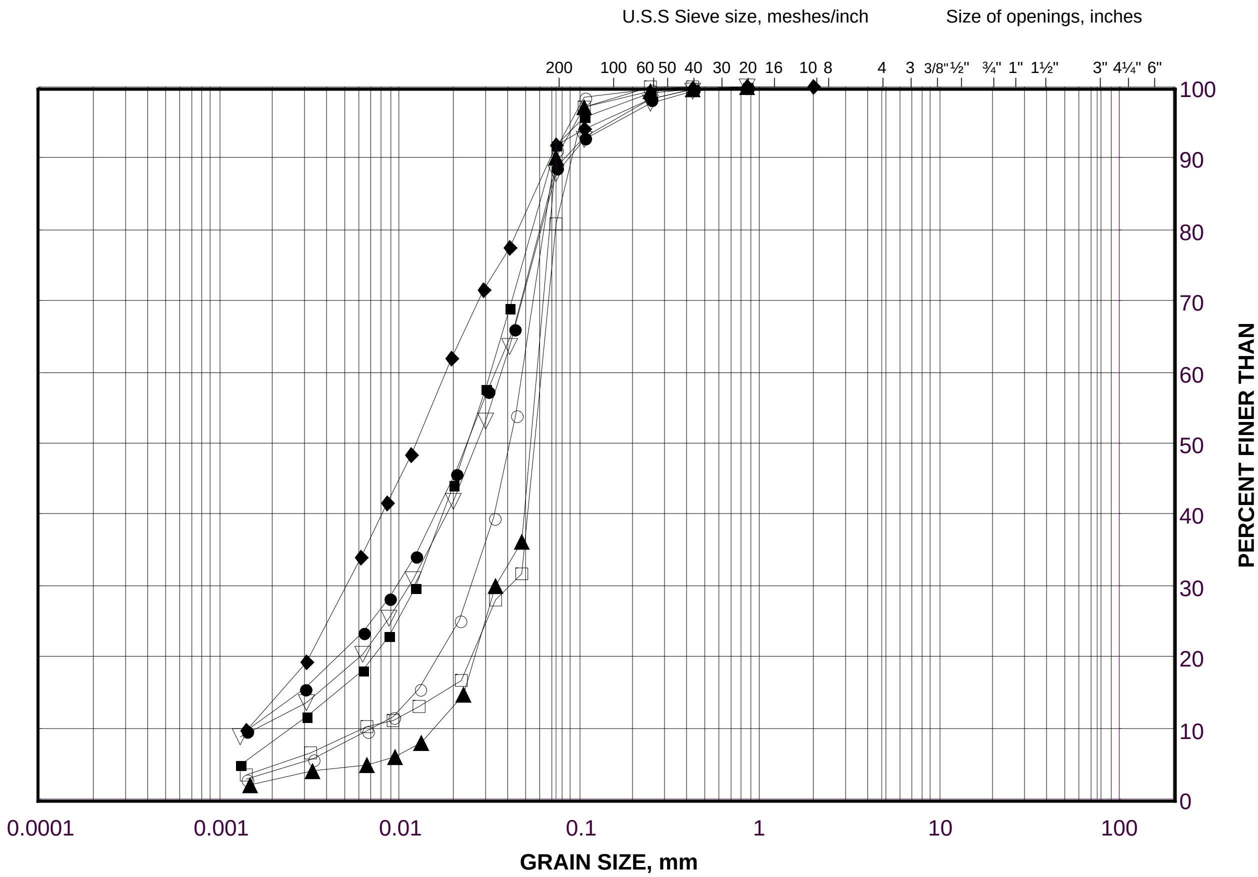
Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt (Upper Granular Deposit)

FIGURE E-7C



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-05	11	215.1
■	89UP-04	11	215.3
◆	89UP-02	11B	221.2
▲	89UP-05	12	213.7
▽	89UP-03	13	213.4
❍	89UP-02	17	212.2
☐	89UP-02	20	207.7

Project Number: 1668512

Checked By: SMM

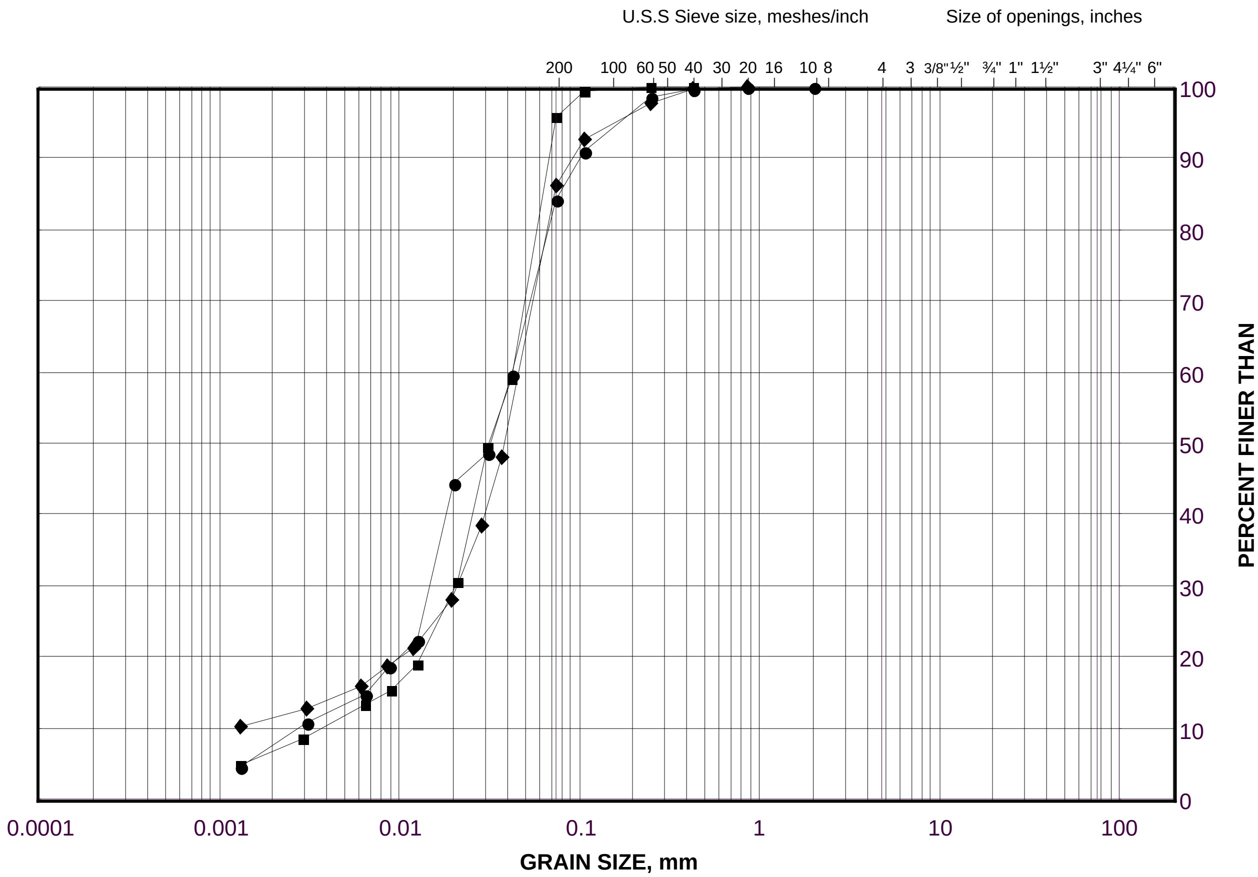
Golder Associates

Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Silt (Upper Granular Deposit)

FIGURE E-7D



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-07	12	214.7
■	89UP-07	17	207.1
◆	PMT-02	5	212.7

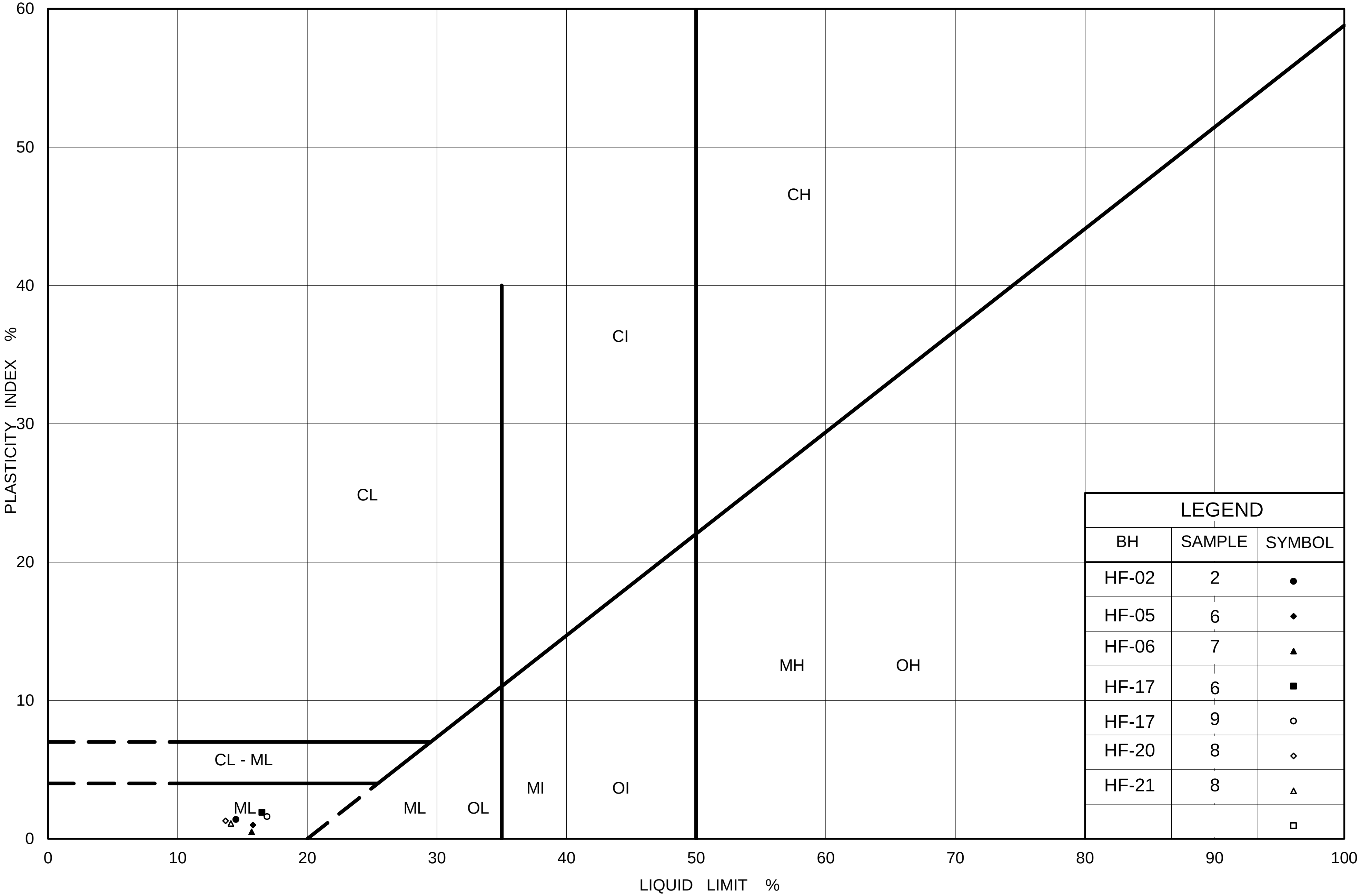
Project Number: 1668512

Checked By: SMM

Golder Associates

Date: 24-Apr-18

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
HF-02	2	●
HF-05	6	◆
HF-06	7	▲
HF-17	6	■
HF-17	9	○
HF-20	8	◇
HF-21	8	△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART

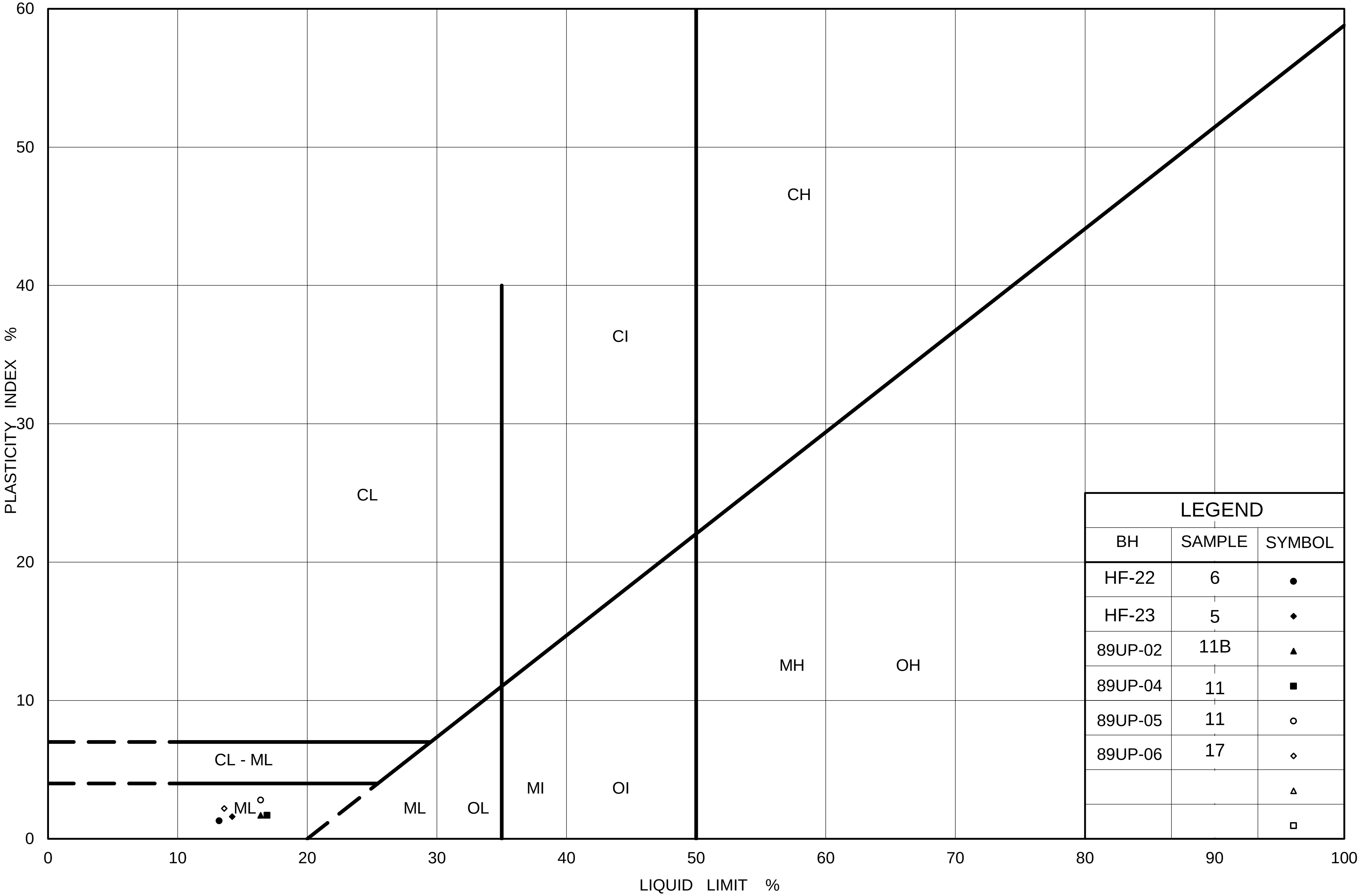
Silt to Sandy Silt to Silt and Sand (Upper Granular Deposit)

Figure No. E-8A

Project No. 1668512

Checked By: SMM

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART

Silt to Sandy Silt to Silt and Sand (Upper Granular Deposit)

Figure No. E-8B

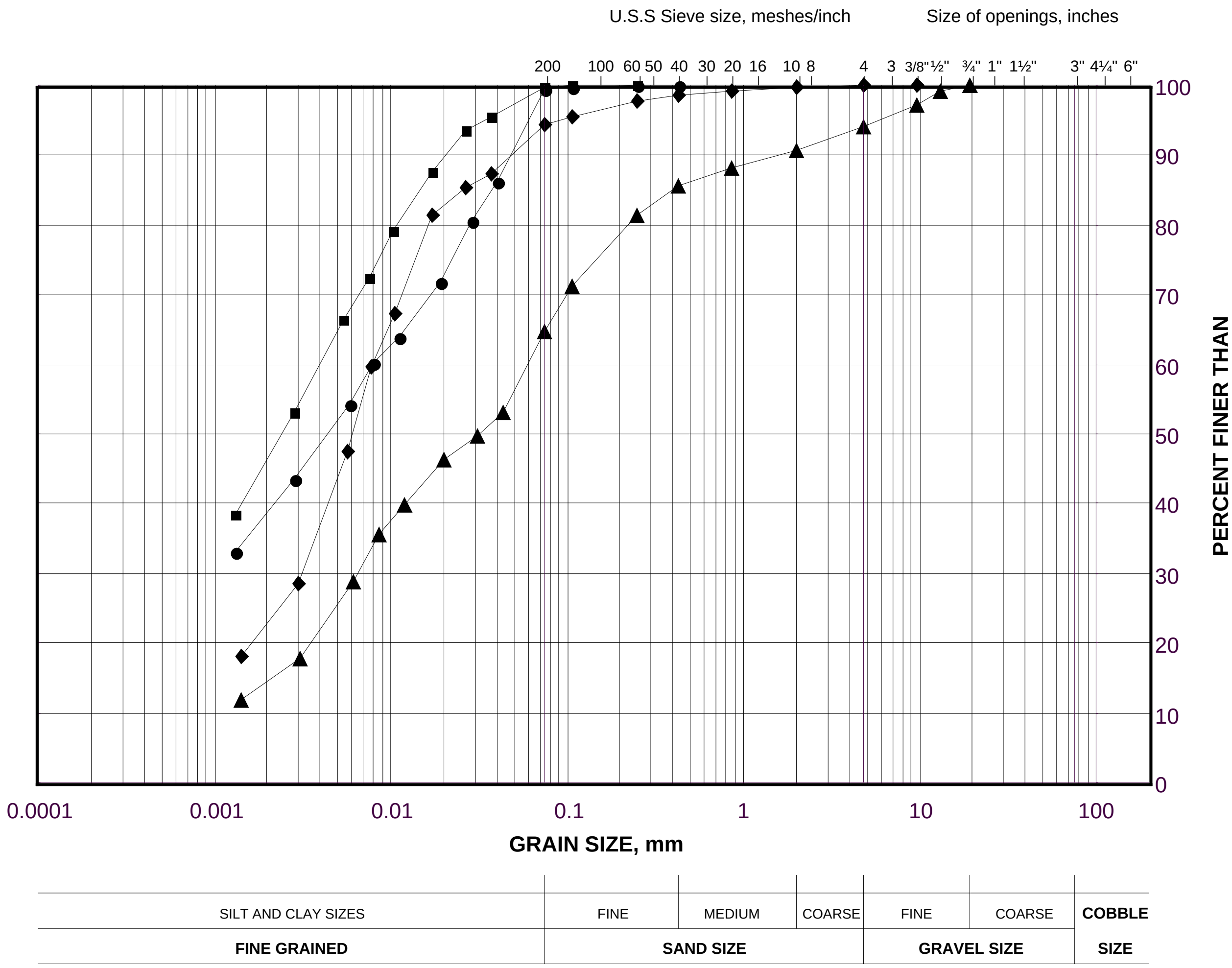
Project No. 1668512

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt to Clayey Silt (Upper Cohesive Deposit)

FIGURE E-9



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-05	17	206.0
■	89UP-06	22	204.6
◆	HF-07	24	196.5
▲	89UP-06	25B	195.3

Project Number: 1668512

Checked By: SMM

Golder Associates

Date: 24-Apr-18

Highway 400 / 89 High Fill Embankment
Upper Cohesive Deposit – Varved Soil Matrix

Figure E-10

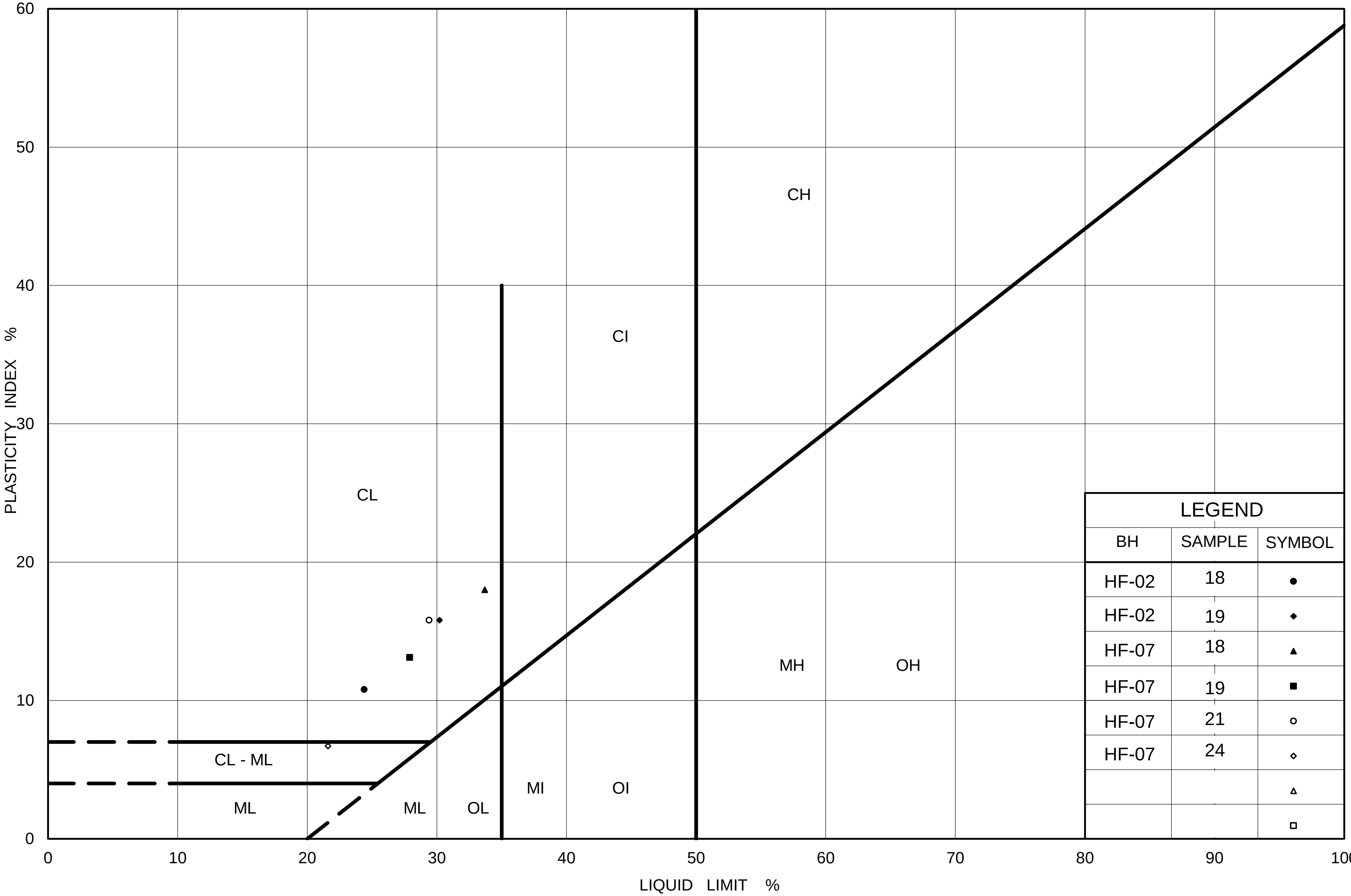
Photograph 1: Soil Sample from Borehole 89UP-03 Sample 20 (Location of Proposed West Abutment)

Photograph 2: Soil Sample from Borehole 89UP-07 Sample 21 (Location of Proposed East Abutment)

Photograph 3: Soil Sample from Borehole 89UP-06 Sample 24 (Location of Proposed East Abutment)

Notes:

1. The dark bands (i.e., laminae) represent the silty clay of intermediate plasticity to clay of high plasticity, while the lighter varves represent the clayey silt of low plasticity and/or silt.
2. The soil samples were extracted from Shelby tubes and dried to illustrate the distinctions between the various varves.



LEGEND

BH	SAMPLE	SYMBOL
HF-02	18	●
HF-02	19	◆
HF-07	18	▲
HF-07	19	■
HF-07	21	○
HF-07	24	◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART

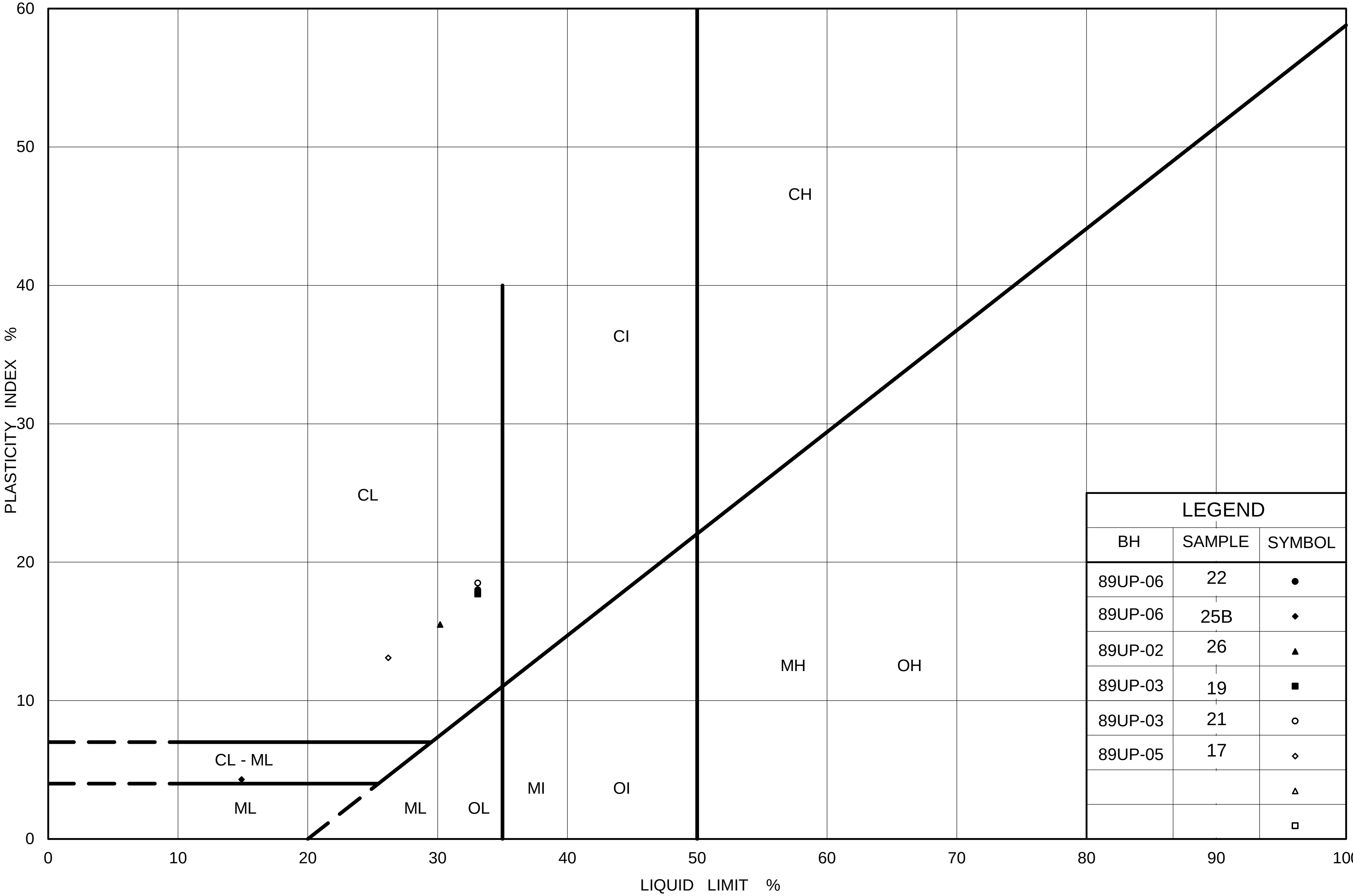
Sandy Clayey Silt to Clayey Silt (Upper Cohesive Deposit)

Figure No. E-11A

Project No. 1668512

Checked By: SMM

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
89UP-06	22	●
89UP-06	25B	◆
89UP-02	26	▲
89UP-03	19	■
89UP-03	21	○
89UP-05	17	◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART

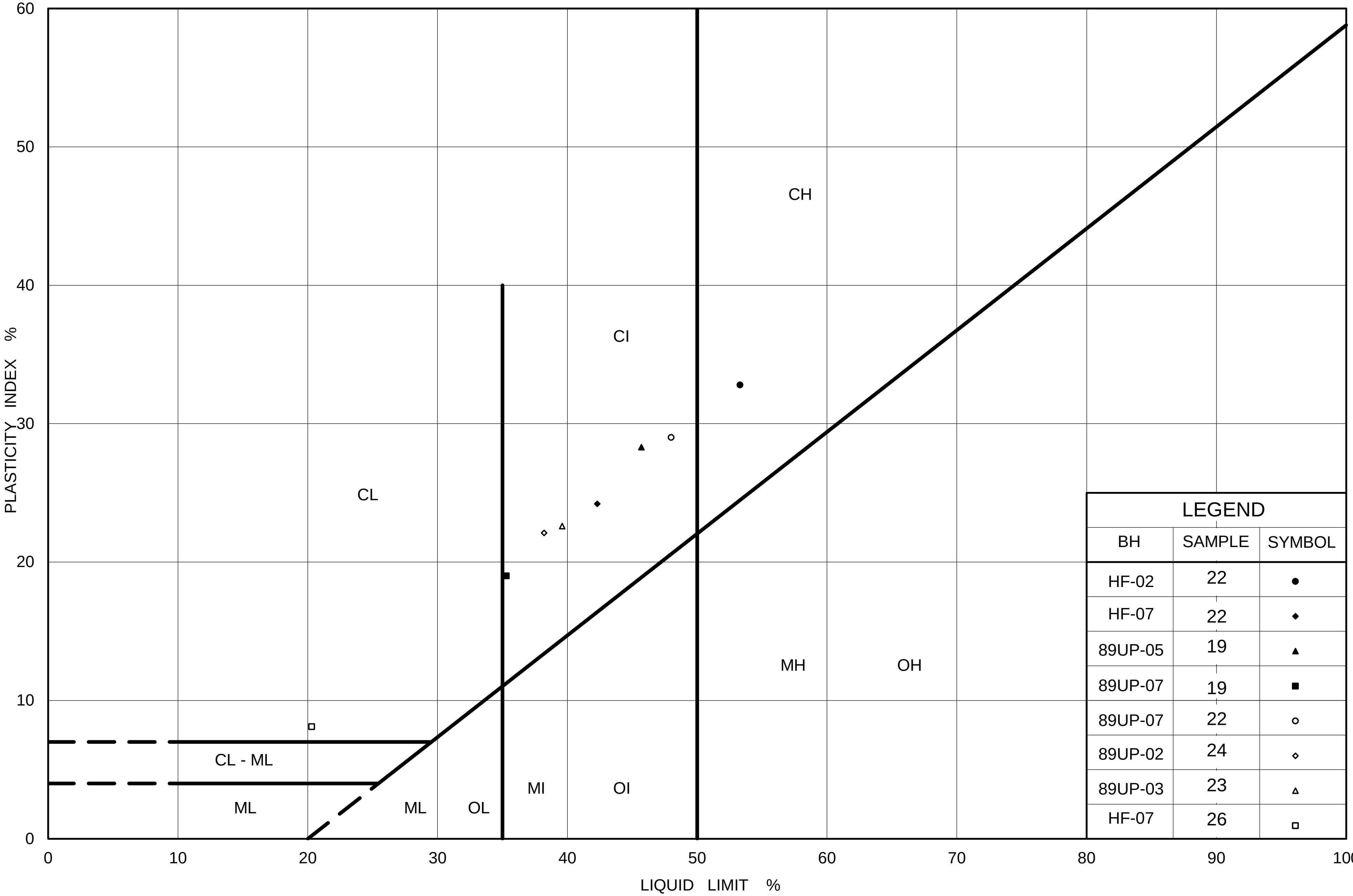
Sandy Clayey Silt to Clayey Silt (Upper Cohesive Deposit)

Figure No. E-11B

Project No. 1668512

Checked By: SMM

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
HF-02	22	●
HF-07	22	◆
89UP-05	19	▲
89UP-07	19	■
89UP-07	22	○
89UP-02	24	◇
89UP-03	23	△
HF-07	26	□

Ministry of Transportation

Ontario

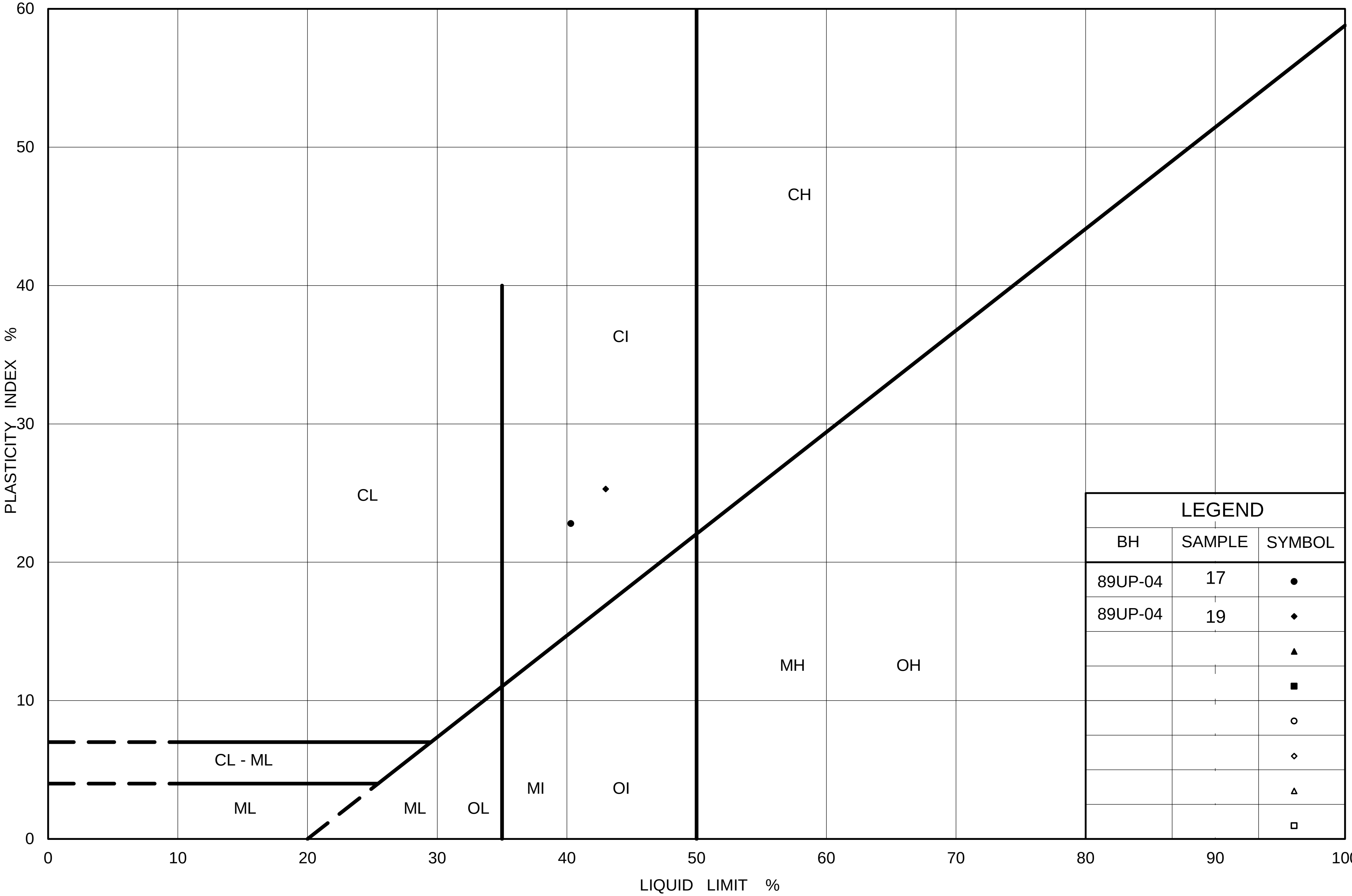
PLASTICITY CHART
Silty Clay to Clay (Upper Cohesive Deposit)

Figure No. E-11C

Project No. 1668512

Checked By: SMM

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay (Upper Cohesive Deposit)

Figure No. E-11D

Project No. 1668512

Checked By: SMM

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE E-12A

SAMPLE IDENTIFICATION

Project Number	1668512(1000)	Sample Number	TO 20
Borehole Number	89UP-03	Sample Depth, m	24.39-25.00

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	2		
Date Started	7/27/2017		
Date Completed	8/15/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.53	Unit Weight, kN/m^3	18.46
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	13.67
Area, cm^2	31.57	Specific Gravity, measured	2.73
Volume, cm^3	80.00	Solids Height, cm	1.294
Water Content, %	35.04	Volume of Solids, cm^3	40.85
Wet Mass, g	150.60	Volume of Voids, cm^3	39.15
Dry Mass, g	111.52	Degree of Saturation, %	99.8

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.534	0.958	2.534				
5.90	2.534	0.958	2.534				
10.75	2.534	0.958	2.534				
20.53	2.532	0.957	2.532	60	2.27E-02	7.67E-05	1.70E-07
40.00	2.525	0.952	2.525	145	9.32E-03	1.36E-04	1.24E-07
78.82	2.507	0.937	2.507	211	6.31E-03	1.89E-04	1.17E-07
156.26	2.485	0.920	2.485	140	9.35E-03	1.13E-04	1.04E-07
226.14	2.465	0.905	2.465	118	1.09E-02	1.12E-04	1.20E-07
78.82	2.482	0.918	2.482				
40.00	2.488	0.923	2.488				
78.82	2.479	0.916	2.479	109	1.20E-02	9.15E-05	1.07E-07
226.11	2.461	0.902	2.461	113	1.14E-02	4.85E-05	5.40E-08
312.48	2.441	0.886	2.441	231	5.47E-03	9.05E-05	4.85E-08
441.12	2.388	0.845	2.388	409	2.96E-03	1.62E-04	4.70E-08
620.45	2.292	0.772	2.292	2196	5.07E-04	2.11E-04	1.05E-08
1241.20	2.109	0.630	2.109	778	1.21E-03	1.17E-04	1.39E-08
2481.08	1.981	0.531	1.981	470	1.77E-03	4.06E-05	7.05E-09
441.14	2.026	0.566	2.026				
224.46	2.052	0.586	2.052				
78.82	2.096	0.620	2.096				
20.53	2.149	0.660	2.149				
5.90	2.184	0.688	2.184				

Note:
Consolidation loading and unloading schedule assigned by the client.
cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)
Specimen taken 48-56cm from top of the tube.
Specimen swelled under 10.75 kPa.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

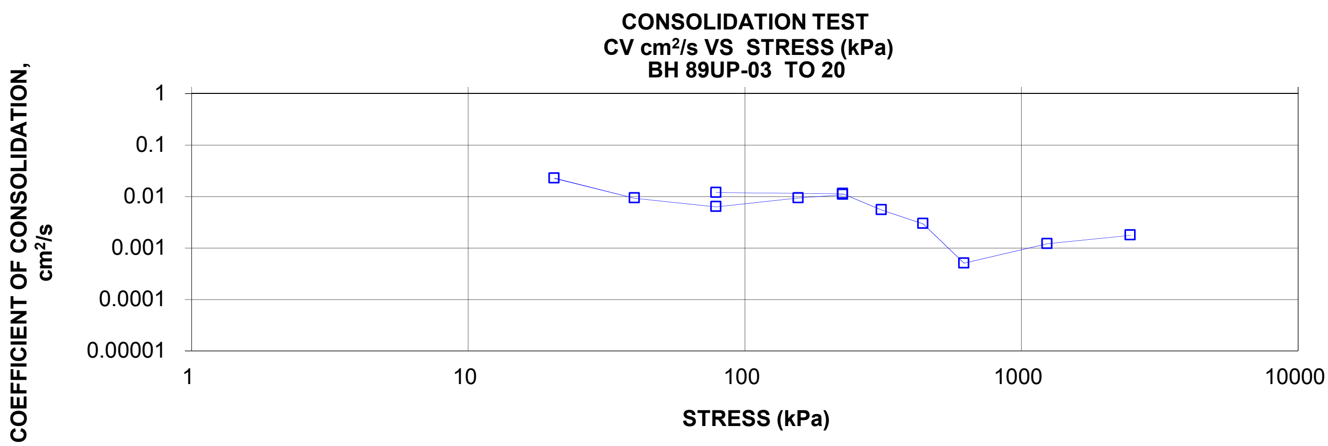
Sample Height, cm	2.18	Unit Weight, kN/m^3	20.11
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	15.86
Area, cm^2	31.57	Specific Gravity, measured	2.73
Volume, cm^3	68.94	Solids Height, cm	1.294
Water Content, %	26.78	Volume of Solids, cm ^{3}	40.85
Wet Mass, g	141.39	Volume of Voids, cm ^{3}	28.09
Dry Mass, g	111.52		

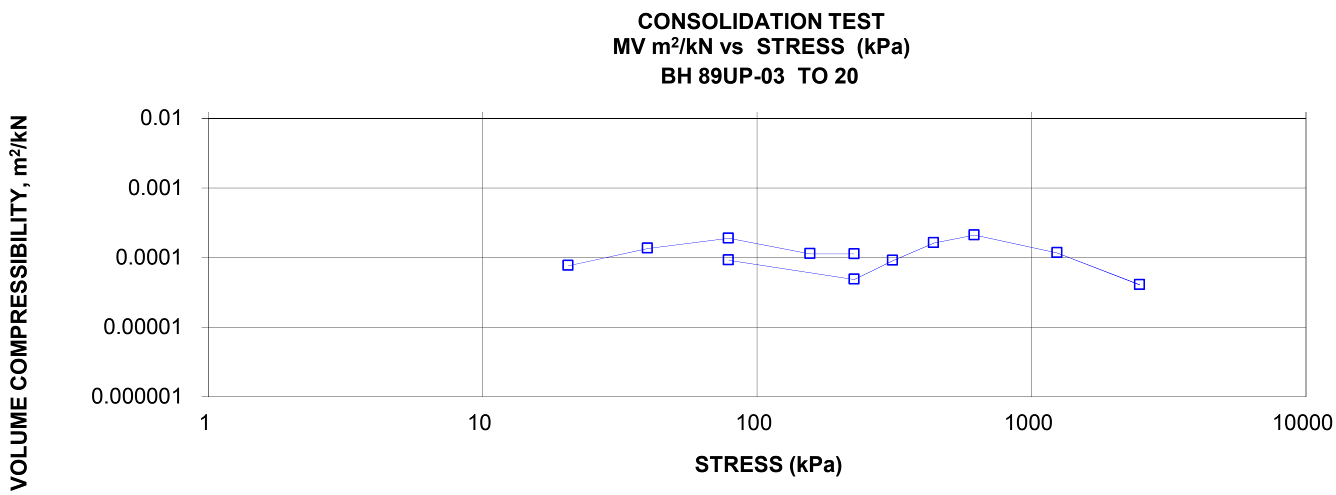
Prepared By: LH

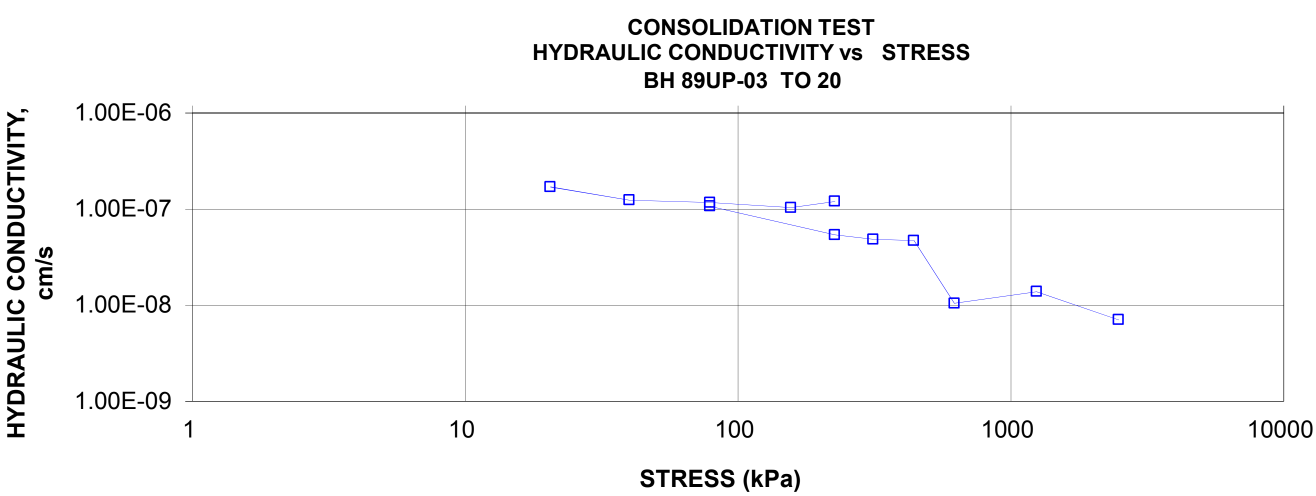
Golder Associates

Checked By: TZ

CONSOLIDATION TEST SUMMARY	FIGURE E-12B







Project No. 1668512(1000)

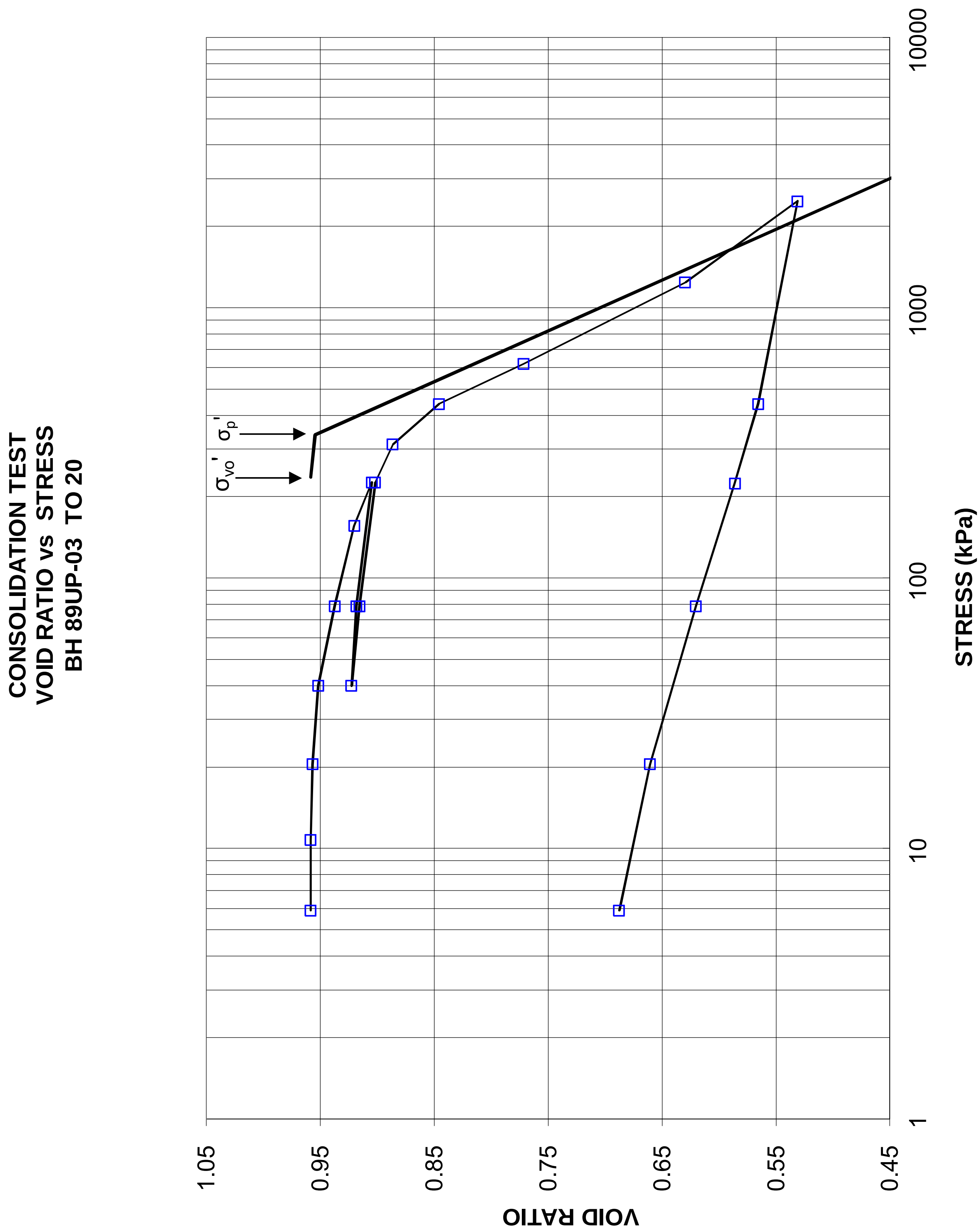
Prepared By: LH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE E-12C



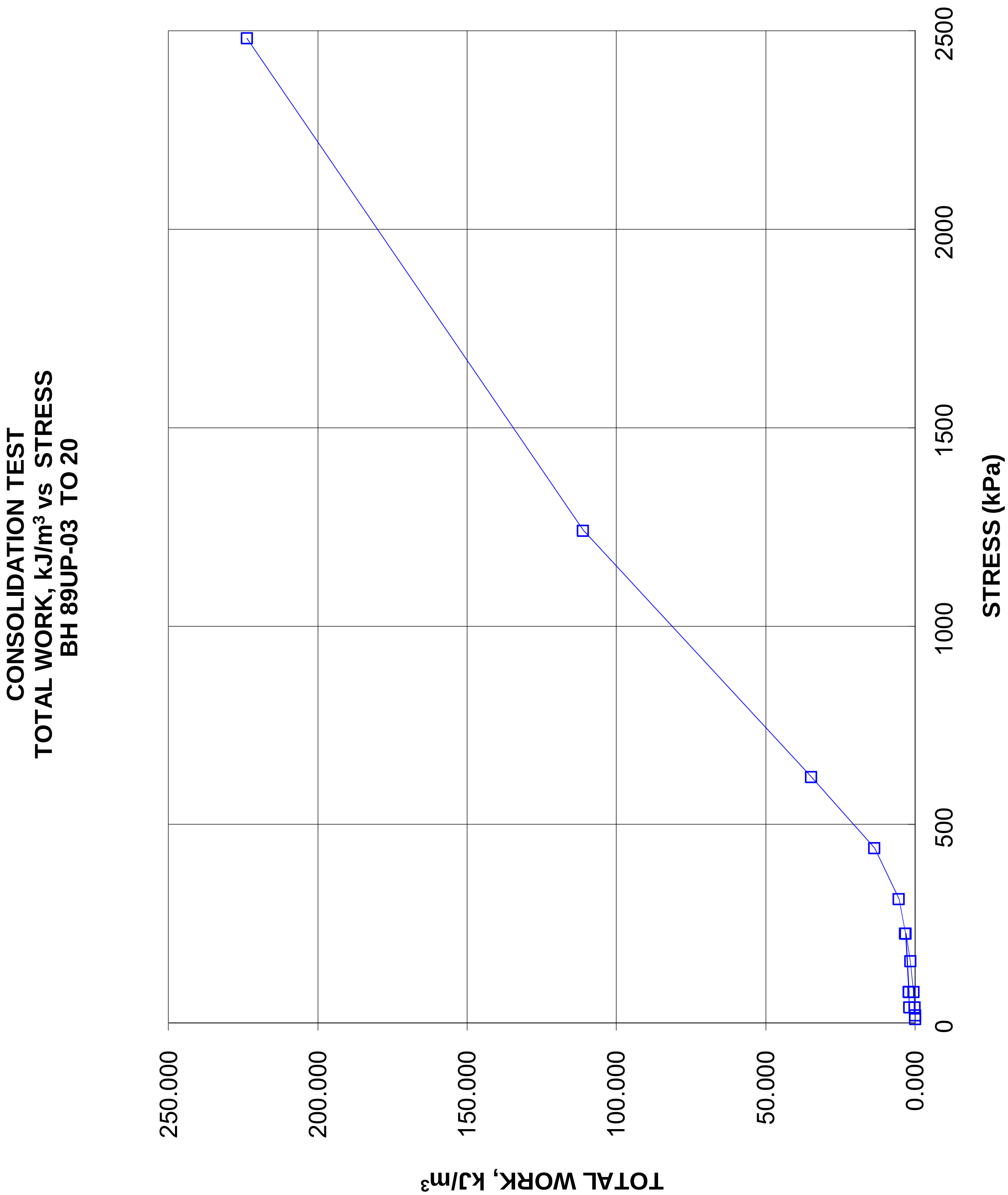
Project No. 1668512(1000)

Prepared By: LH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST TOTAL WORK VS STRESS	FIGURE E-12D



Project No. 1668512(1000)

Prepared By: LH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE E-13A

SAMPLE IDENTIFICATION

Project Number	1668512(1000)	Sample Number	24
Borehole Number	89UP-06	Sample Depth, m	36.93-36.88

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	8		
Date Started	8/23/2017		
Date Completed	9/13/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m^3	17.44
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	12.11
Area, cm^2	31.50	Specific Gravity, measured	2.71
Volume, cm^3	59.94	Solids Height, cm	0.867
Water Content, %	44.00	Volume of Solids, cm^3	27.32
Wet Mass, g	106.62	Volume of Voids, cm^3	32.62
Dry Mass, g	74.04	Degree of Saturation, %	99.9

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.903	1.194	1.903				
6.36	1.905	1.196	1.905				
11.22	1.907	1.199	1.907				
21.02	1.904	1.196	1.904	135	5.70E-03	1.37E-04	7.63E-08
40.53	1.892	1.182	1.892	392	1.94E-03	3.23E-04	6.14E-08
79.44	1.872	1.158	1.872	372	2.00E-03	2.82E-04	5.52E-08
157.05	1.851	1.134	1.851	296	2.45E-03	1.41E-04	3.40E-08
312.54	1.817	1.095	1.817	234	2.99E-03	1.12E-04	3.29E-08
410.46	1.793	1.068	1.793	265	2.57E-03	1.29E-04	3.26E-08
157.05	1.808	1.084	1.808				
40.53	1.840	1.121	1.840				
11.22	1.865	1.150	1.865				
40.48	1.857	1.141	1.857	360	2.03E-03	1.47E-04	2.93E-08
157.05	1.823	1.101	1.823	317	2.22E-03	1.55E-04	3.37E-08
410.34	1.781	1.054	1.781	267	2.52E-03	8.56E-05	2.11E-08
500.09	1.760	1.030	1.760	2579	2.55E-04	1.23E-04	3.07E-09
589.77	1.727	0.992	1.727	14789	4.28E-05	1.94E-04	8.12E-10
1197.85	1.564	0.803	1.564	1058	4.90E-04	1.41E-04	6.78E-09
2394.07	1.451	0.673	1.451	614	7.27E-04	4.97E-05	3.54E-09
589.78	1.490	0.717	1.490				
157.05	1.548	0.785	1.548				
40.53	1.615	0.862	1.615				
11.22	1.669	0.925	1.669				

Note:
Consolidation loading and unloading schedule assigned by the client.
cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)
Specimen swelled under 11.22 kPa.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

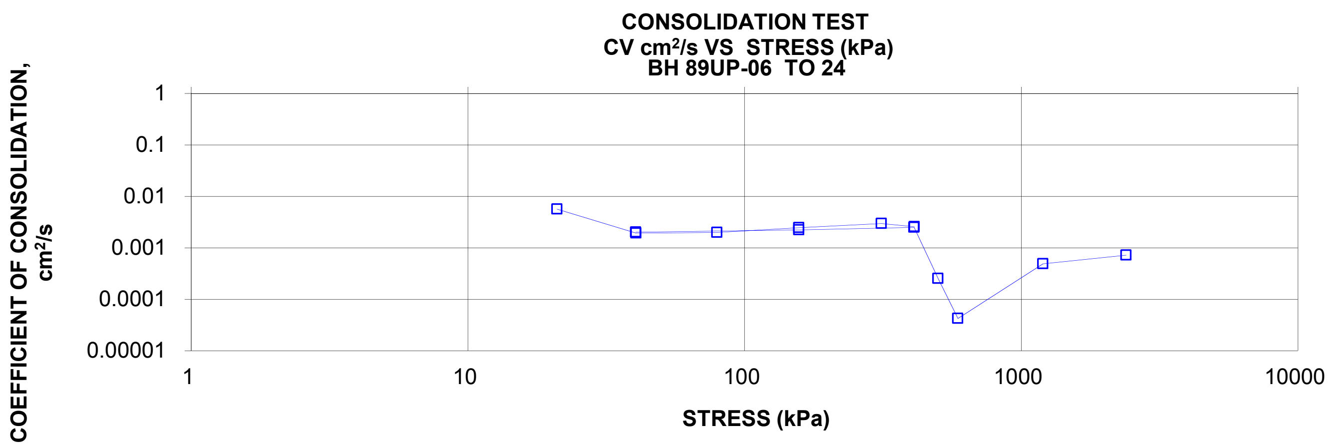
Sample Height, cm	1.67	Unit Weight, kN/m^3	18.76
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	13.81
Area, cm^2	31.50	Specific Gravity, measured	2.71
Volume, cm^3	52.58	Solids Height, cm	0.867
Water Content, %	35.87	Volume of Solids, cm^3	27.32
Wet Mass, g	100.60	Volume of Voids, cm^3	25.26
Dry Mass, g	74.04		

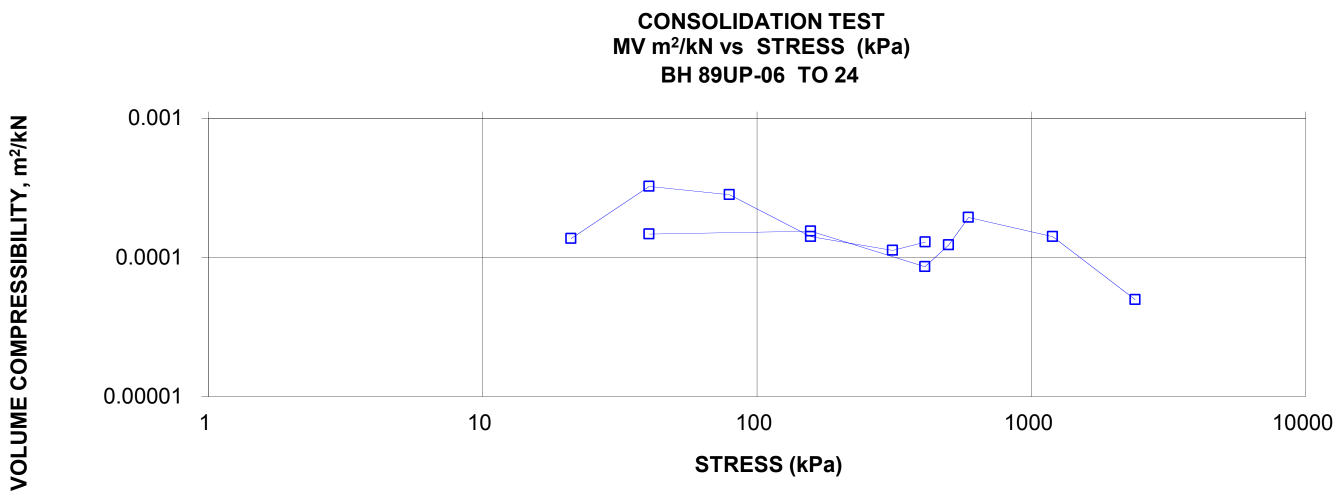
Prepared By: LH

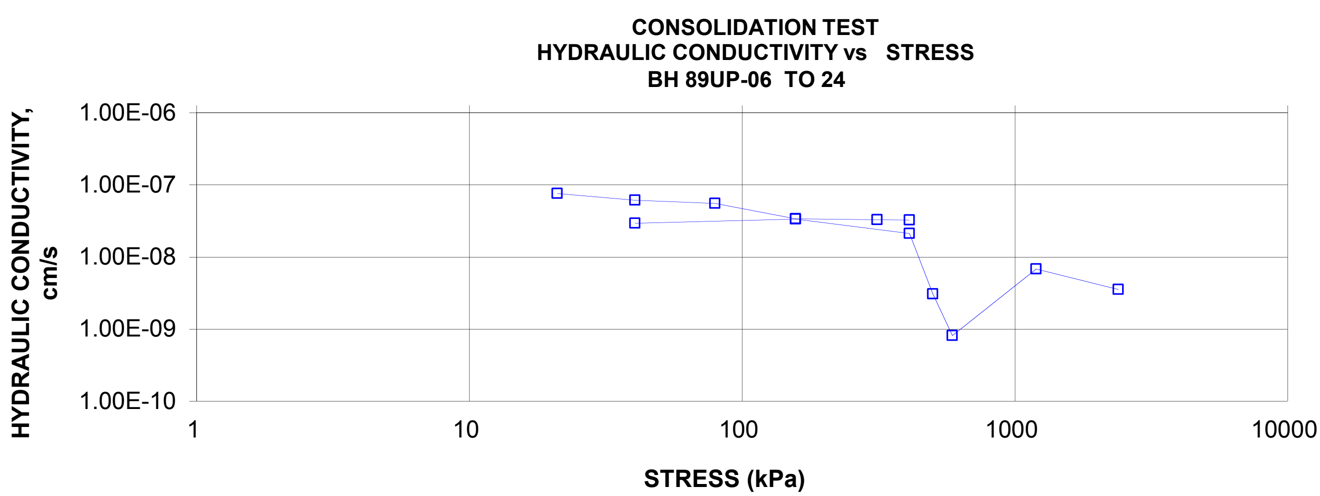
Golder Associates

Checked By: TZ

CONSOLIDATION TEST SUMMARY	FIGURE E-13B







Project No. 1668512(1000)

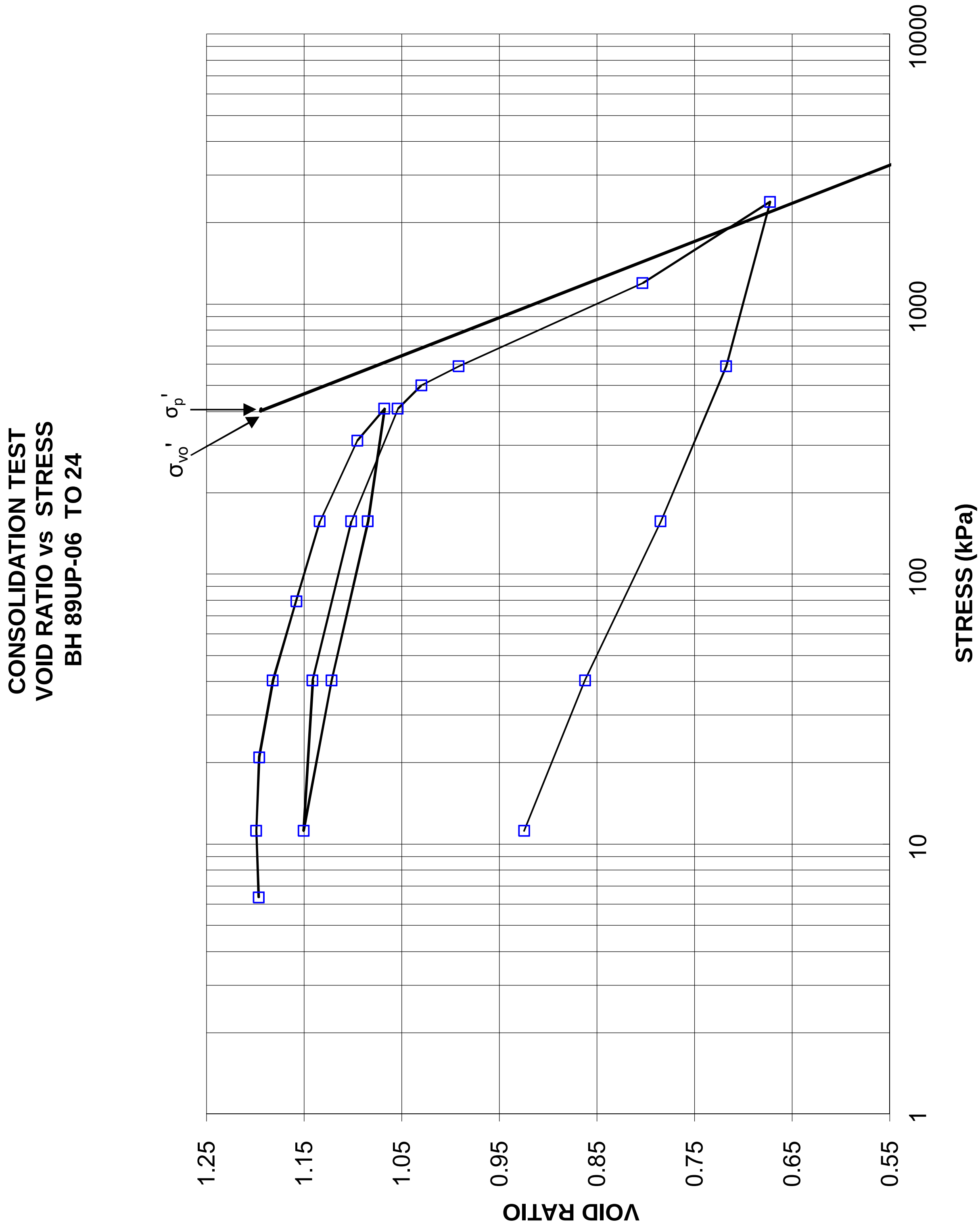
Prepared By: LH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE E-13C



Project No. 1668512(1000)

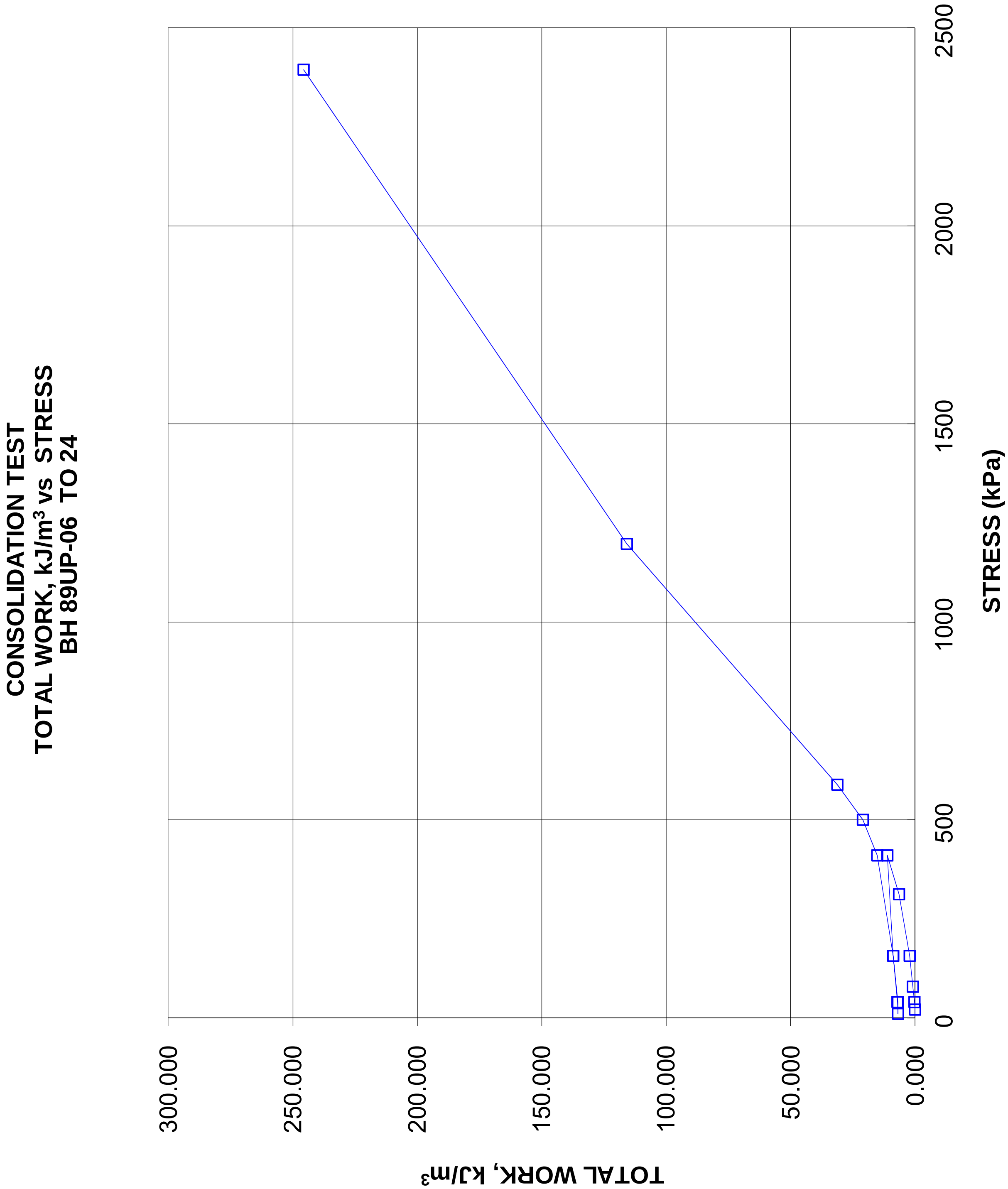
Prepared By: LH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE E-13D



Project No. 1668512(1000)

Prepared By: LH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE E-14A

SAMPLE IDENTIFICATION

Project Number	1668512(1000)	Sample Number	21
Borehole Number	89UP-07	Sample Depth, m	25.91-26.52

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	8/10/2017		
Date Completed			

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.52	Unit Weight, kN/m^3	18.81
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	14.14
Area, cm^2	31.53	Specific Gravity, measured	2.75
Volume, cm^3	79.52	Solids Height, cm	1.322
Water Content, %	33.08	Volume of Solids, cm^3	41.68
Wet Mass, g	152.54	Volume of Voids, cm^3	37.84
Dry Mass, g	114.62	Degree of Saturation, %	100.2

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.522	0.908	2.522				
6.13	2.522	0.908	2.522				
10.99	2.522	0.908	2.522				
20.78	2.518	0.905	2.518	94	1.43E-02	1.46E-04	2.04E-07
40.27	2.508	0.898	2.508	83	1.61E-02	2.03E-04	3.20E-07
79.18	2.494	0.886	2.494	85	1.55E-02	1.49E-04	2.26E-07
156.72	2.471	0.869	2.471	144	8.99E-03	1.19E-04	1.04E-07
251.41	2.447	0.851	2.447	240	5.29E-03	1.01E-04	5.23E-08
79.18	2.462	0.863	2.462				
20.78	2.478	0.874	2.478				
79.18	2.467	0.866	2.467	126	1.02E-02	7.40E-05	7.43E-08
201.81	2.450	0.853	2.450	135	9.43E-03	5.43E-05	5.02E-08
401.46	2.419	0.830	2.419	154	8.06E-03	6.10E-05	4.81E-08
696.30	2.368	0.791	2.368	390	3.05E-03	6.93E-05	2.07E-08
1391.19	2.188	0.655	2.188	821	1.24E-03	1.03E-04	1.24E-08
2780.90	2.061	0.559	2.061	694	1.30E-03	3.61E-05	4.60E-09
695.70	2.093	0.583	2.093				
201.83	2.137	0.616	2.137				
79.18	2.169	0.641	2.169				

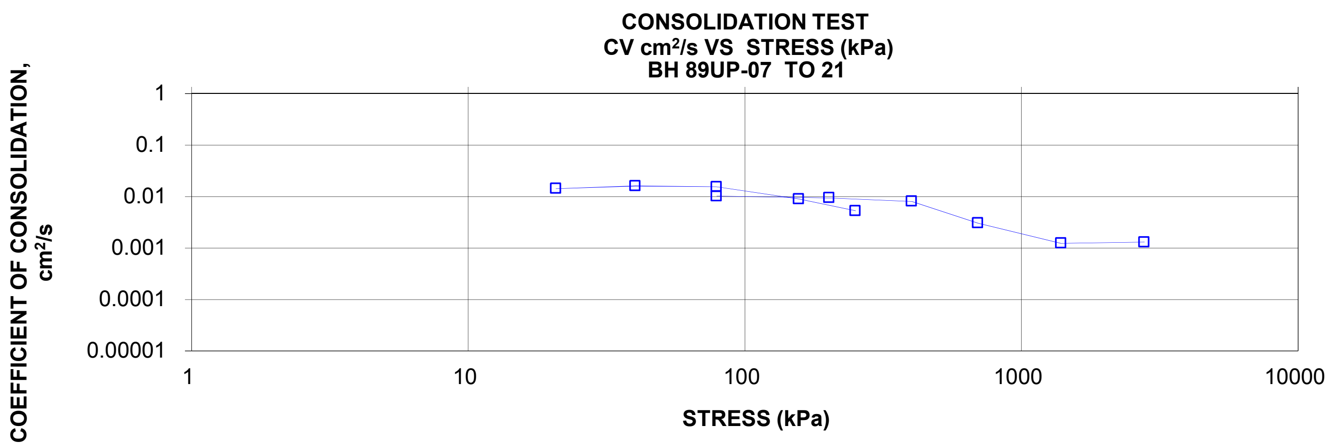
Note:
Consolidation loading and unloading schedule assigned by the client.
cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)
Specimen taken 18-22cm from bottom of the tube.
Specimen swelled under 10.99 kPa.

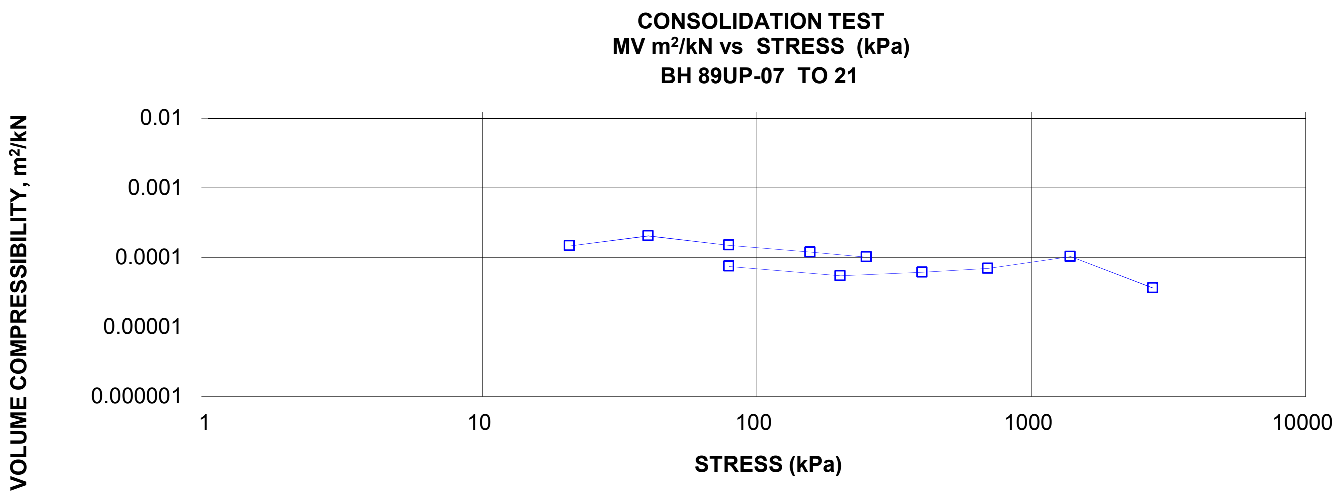
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

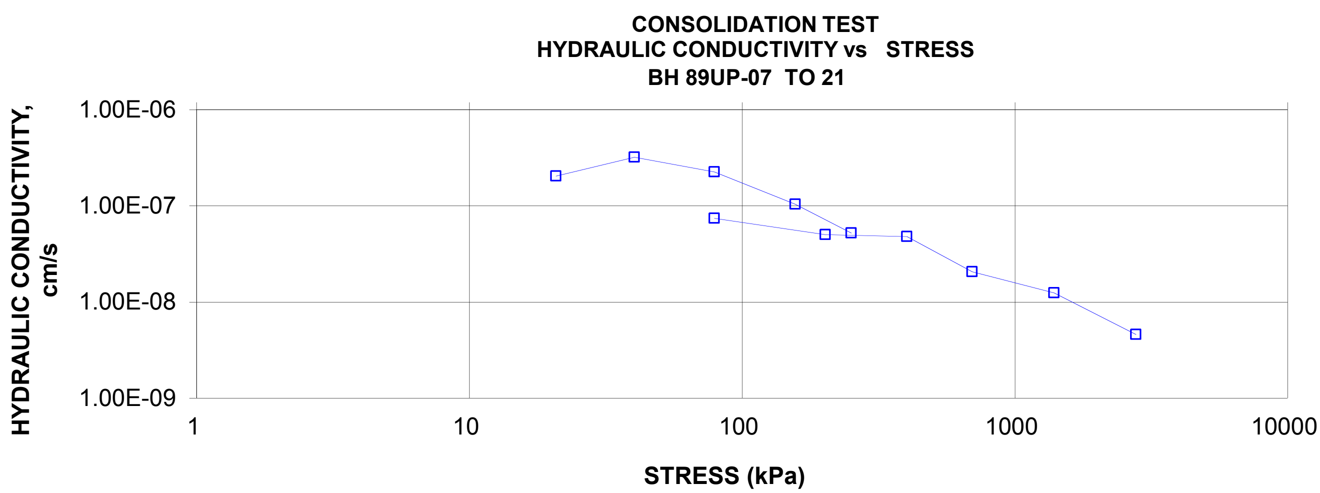
Sample Height, cm	2.17	Unit Weight, kN/m^3	20.98
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	16.44
Area, cm^2	31.53	Specific Gravity, measured	2.75
Volume, cm^3	68.39	Solids Height, cm	1.322
Water Content, %	27.65	Volume of Solids, cm^3	41.68
Wet Mass, g	146.31	Volume of Voids, cm^3	26.71
Dry Mass, g	114.62		

Prepared By: LH **Golder Associates** Checked By: TZ

CONSOLIDATION TEST SUMMARY	FIGURE E-14B







Project No. 1668512(1000)

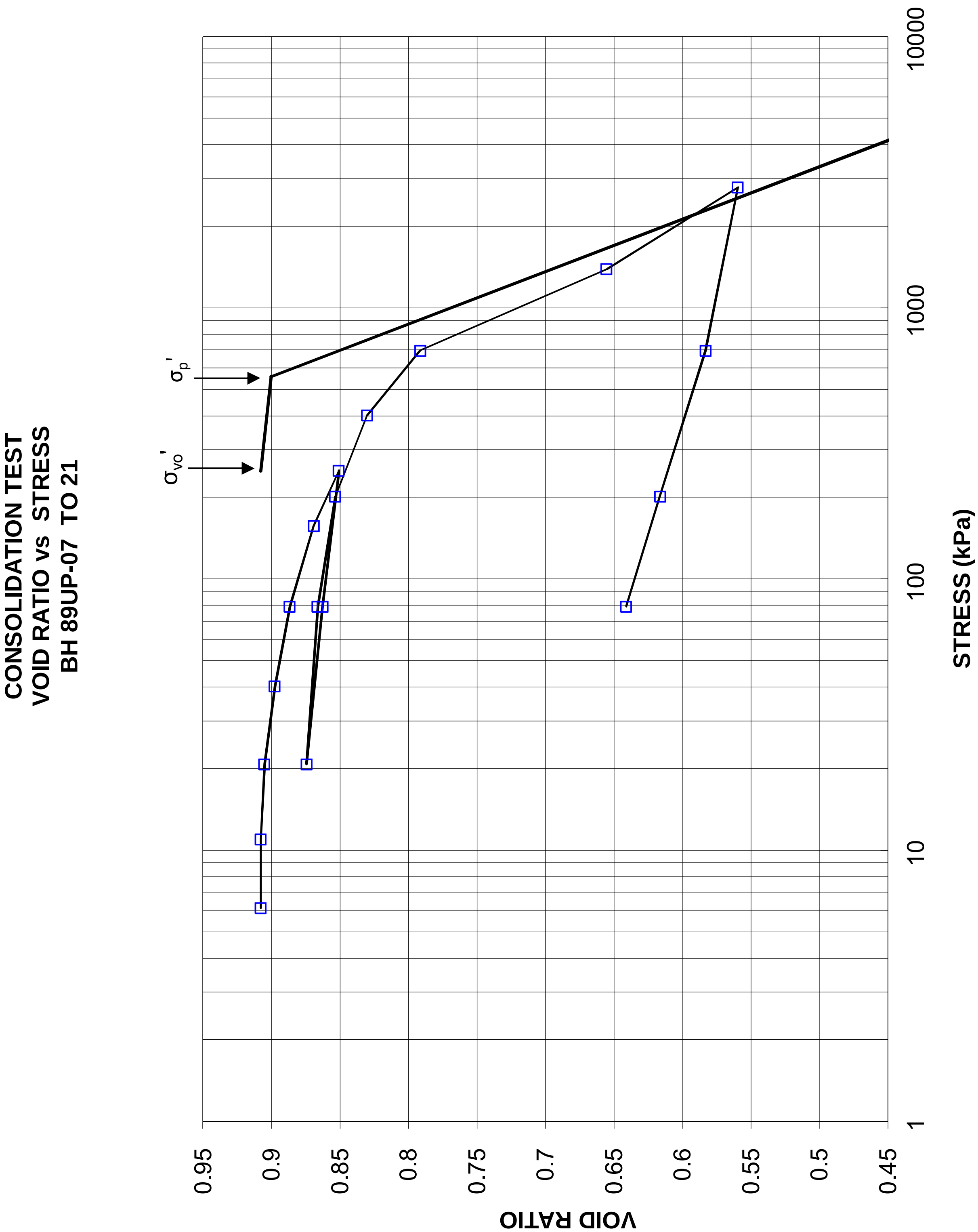
Prepared By: LH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE E-14C



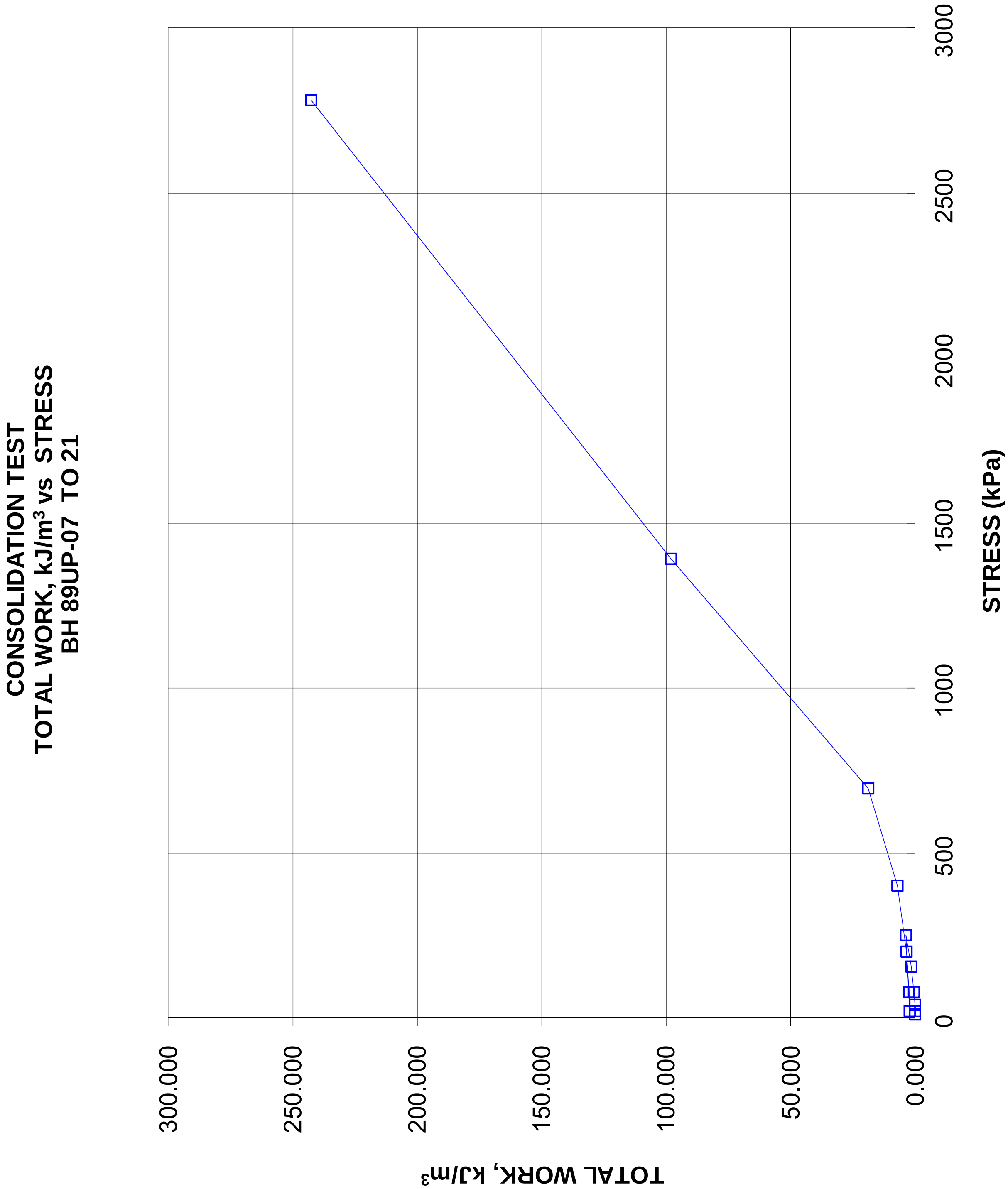
Project No. 1668512(1000)

Prepared By: LH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST TOTAL WORK VS STRESS	FIGURE E-14D



Project No. 1668512(1000)

Golder Associates

Prepared By: LH

Checked By: TZ

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE E-15A

SAMPLE IDENTIFICATION

Project Number	1668512(1000)	Sample Number	22
Borehole Number	HF-07	Sample Depth, m	27.68-27.86

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	7		
Date Started	8/24/2017		
Date Completed	9/15/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.89	Unit Weight, kN/m^3	18.57
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	13.80
Area, cm^2	31.50	Specific Gravity, measured	2.74
Volume, cm^3	59.53	Solids Height, cm	0.971
Water Content, %	34.54	Volume of Solids, cm^3	30.58
Wet Mass, g	112.73	Volume of Voids, cm^3	28.95
Dry Mass, g	83.79	Degree of Saturation, %	100.0

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.890	0.947	1.890				
5.89	1.889	0.946	1.889				
10.76	1.890	0.947	1.890				
20.56	1.887	0.944	1.887	148	5.10E-03	1.57E-04	7.83E-08
40.07	1.880	0.937	1.880	296	2.53E-03	1.84E-04	4.58E-08
78.97	1.865	0.921	1.865	358	2.06E-03	2.08E-04	4.20E-08
156.69	1.844	0.899	1.844	279	2.58E-03	1.46E-04	3.70E-08
250.94	1.819	0.873	1.819	420	1.67E-03	1.40E-04	2.30E-08
78.97	1.833	0.888	1.833				
20.68	1.850	0.905	1.850				
78.98	1.836	0.891	1.836	231	3.09E-03	1.25E-04	3.80E-08
156.69	1.827	0.881	1.827	208	3.40E-03	6.47E-05	2.16E-08
320.97	1.804	0.858	1.804	148	4.66E-03	7.25E-05	3.31E-08
450.98	1.783	0.837	1.783	427	1.58E-03	8.55E-05	1.32E-08
900.82	1.656	0.706	1.656	667	8.72E-04	1.49E-04	1.27E-08
1999.97	1.544	0.590	1.544	390	1.30E-03	5.42E-05	6.87E-09
450.88	1.573	0.621	1.573				
78.97	1.621	0.670	1.621				
10.76	1.690	0.740	1.690				

Note:
Consolidation loading and unloading schedule assigned by the client.
cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)
Specimen swelled under 10.99 kPa.

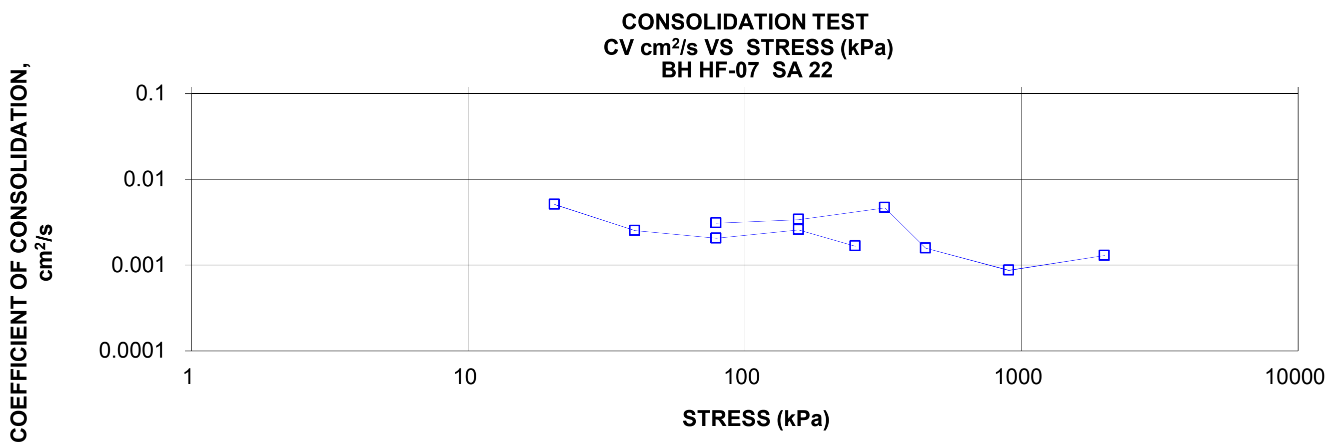
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

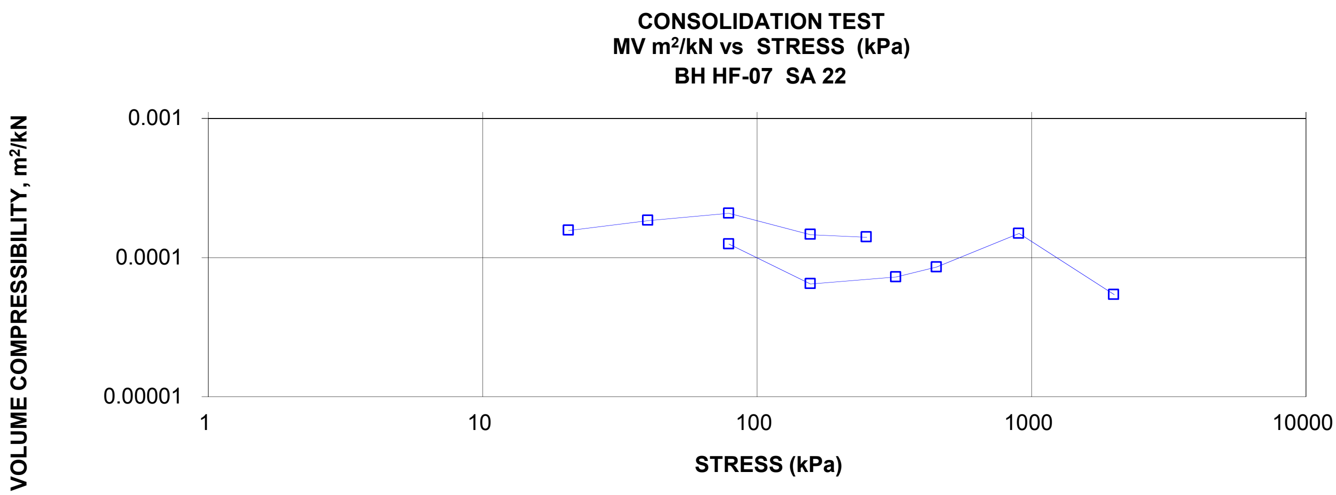
Sample Height, cm	1.69	Unit Weight, kN/m^3	19.70
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	15.44
Area, cm^2	31.50	Specific Gravity, measured	2.74
Volume, cm^3	53.22	Solids Height, cm	0.971
Water Content, %	27.62	Volume of Solids, cm^3	30.58
Wet Mass, g	106.93	Volume of Voids, cm^3	22.64
Dry Mass, g	83.79		

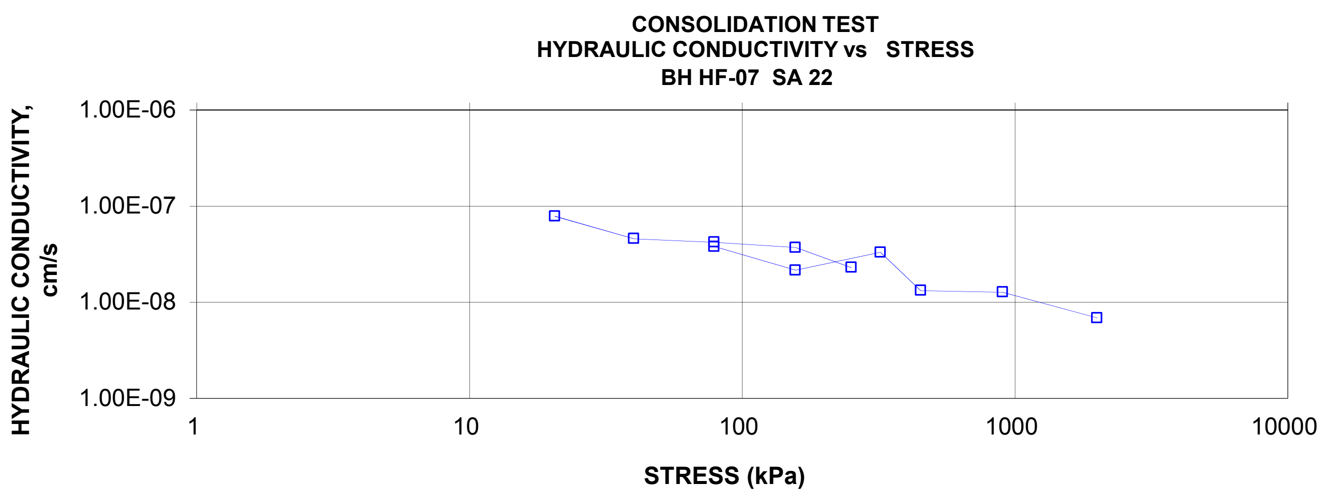
Prepared By: LH **Golder Associates** Checked By: TZ

CONSOLIDATION TEST SUMMARY

FIGURE E-15B







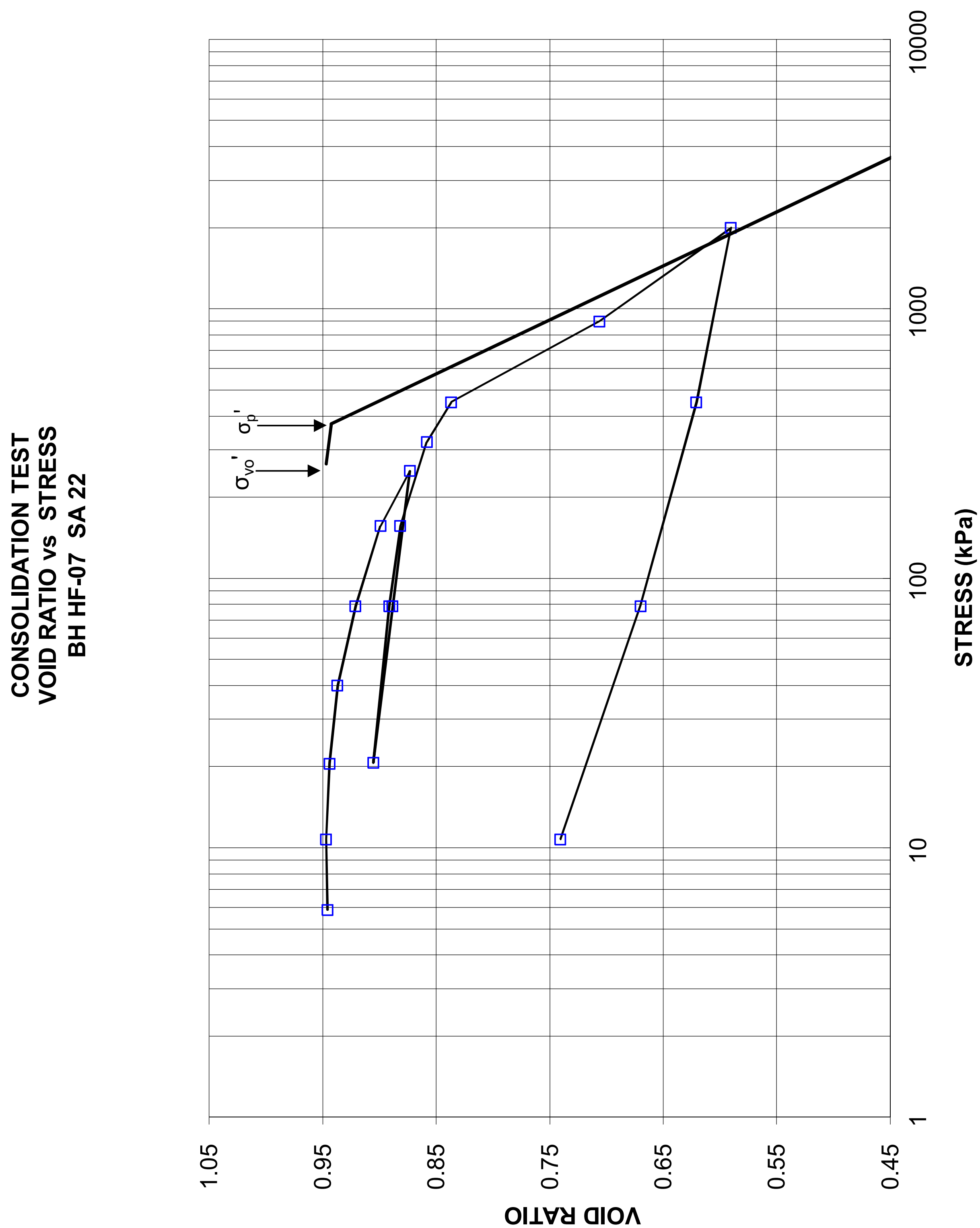
Project No. 1668512(1000)

Prepared By: AH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST VOID RATIO VS LOG STRESS	FIGURE E-15C



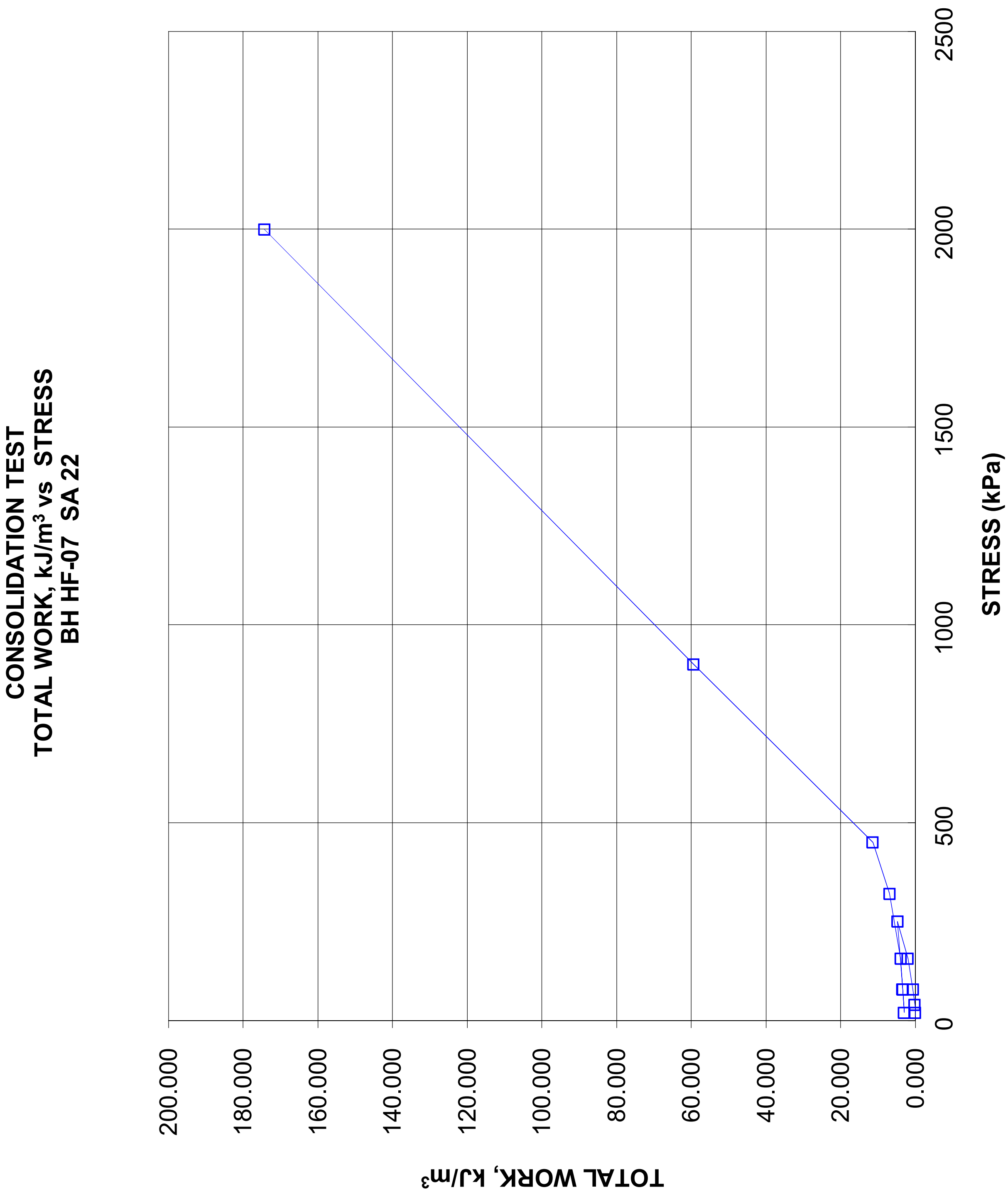
Project No. 1668512(1000)

Prepared By: AH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST TOTAL WORK VS STRESS	FIGURE E-15D



Project No. 1668512(1000)

Golder Associates

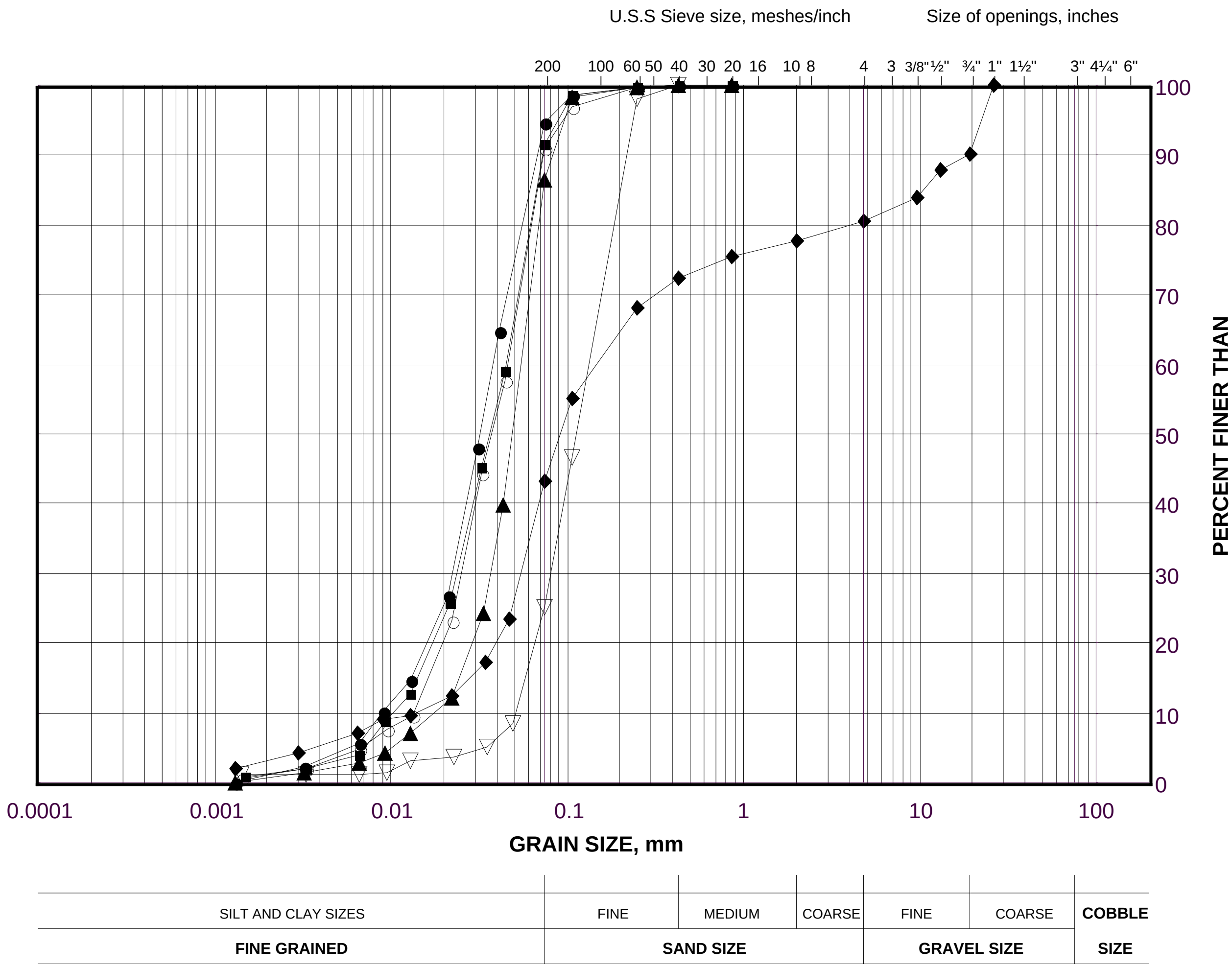
Prepared By: AH

Checked By: TZ

GRAIN SIZE DISTRIBUTION

Silt to Silt and Sand to Silty Sand (Lower Granular Deposit)

FIGURE E-16



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-04	21	190.9
■	89UP-05	21	193.8
◆	89UP-07	25	194.9
▲	89UP-03	26	193.6
▽	HF-02	27	192.1
❍	89UP-02	29	190.9

Project Number: 1668512

Checked By: SMM

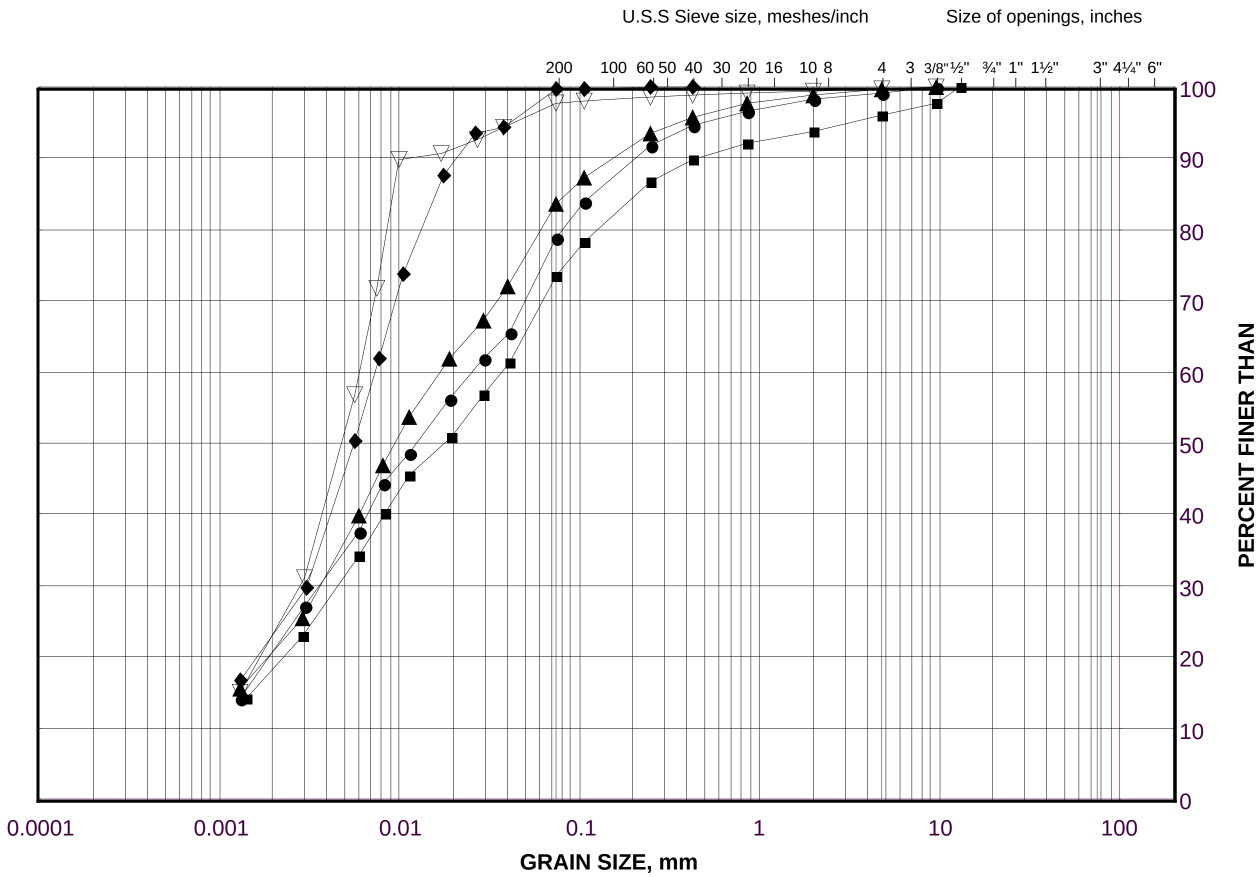
Golder Associates

Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt to Clayey Silt (Lower Cohesive Deposit)

FIGURE E-17



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-04	22	187.8
■	89UP-07	27	188.8
◆	89UP-06	28	186.3
▲	89UP-03	29	184.4
▽	89UP-02	30	187.9

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Checked By: SMM

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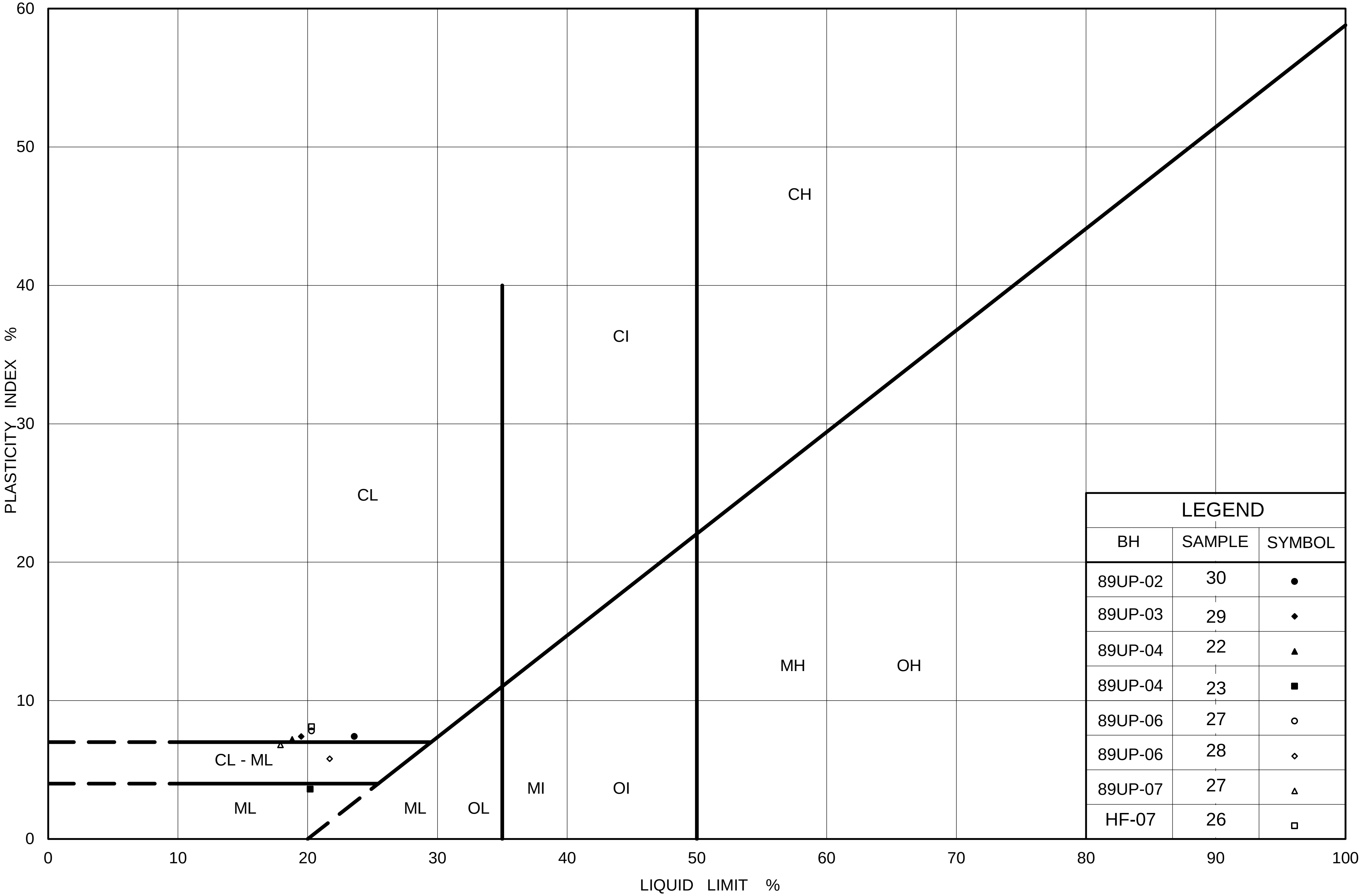
Date: 24-Apr-18

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART

Silt to Sandy Clayey Silt to Clayey Silt
(Lower Cohesive Deposit)

Figure No. E-18

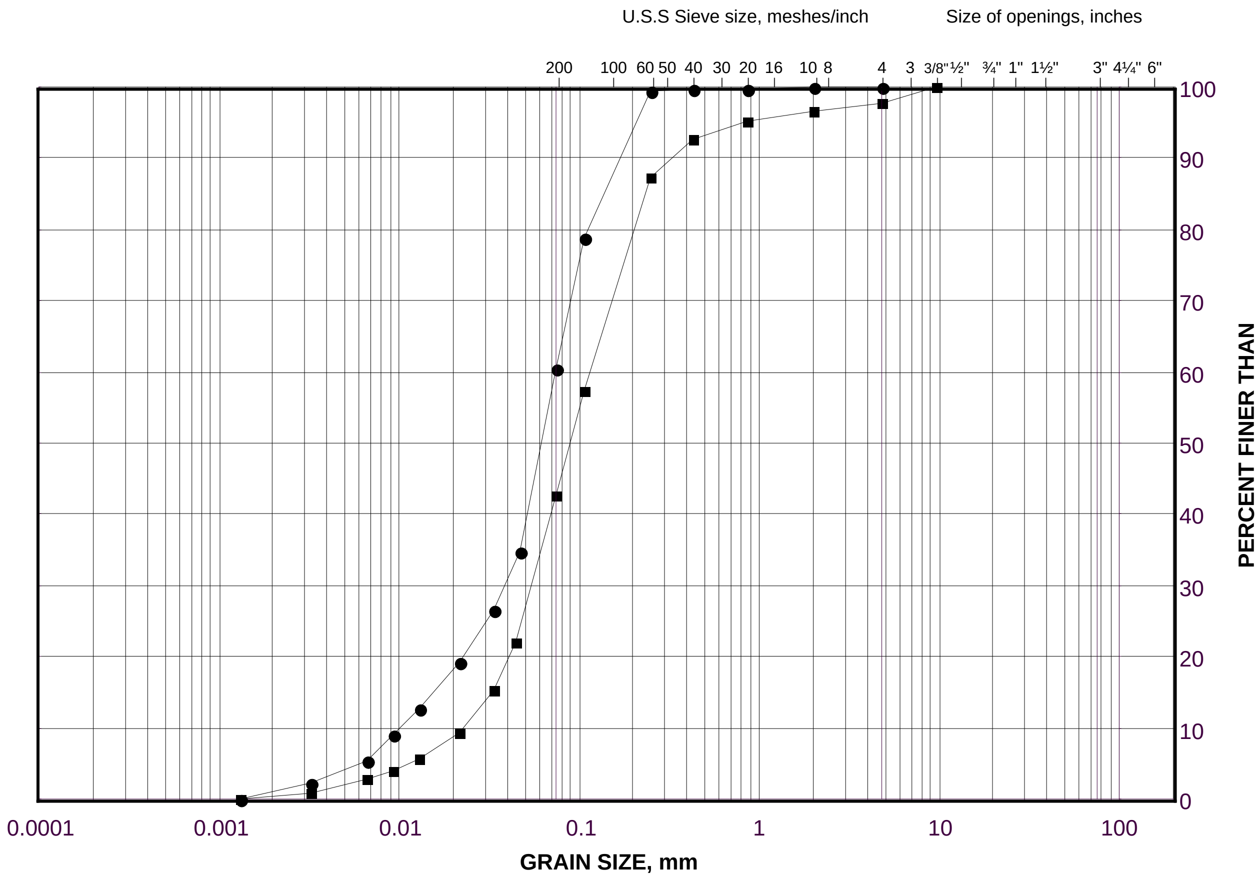
Project No. 1668512

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Silt and Sand (Till)

FIGURE E-19



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-07	29	182.9
■	89UP-03	31	178.3

Project Number: 1668512

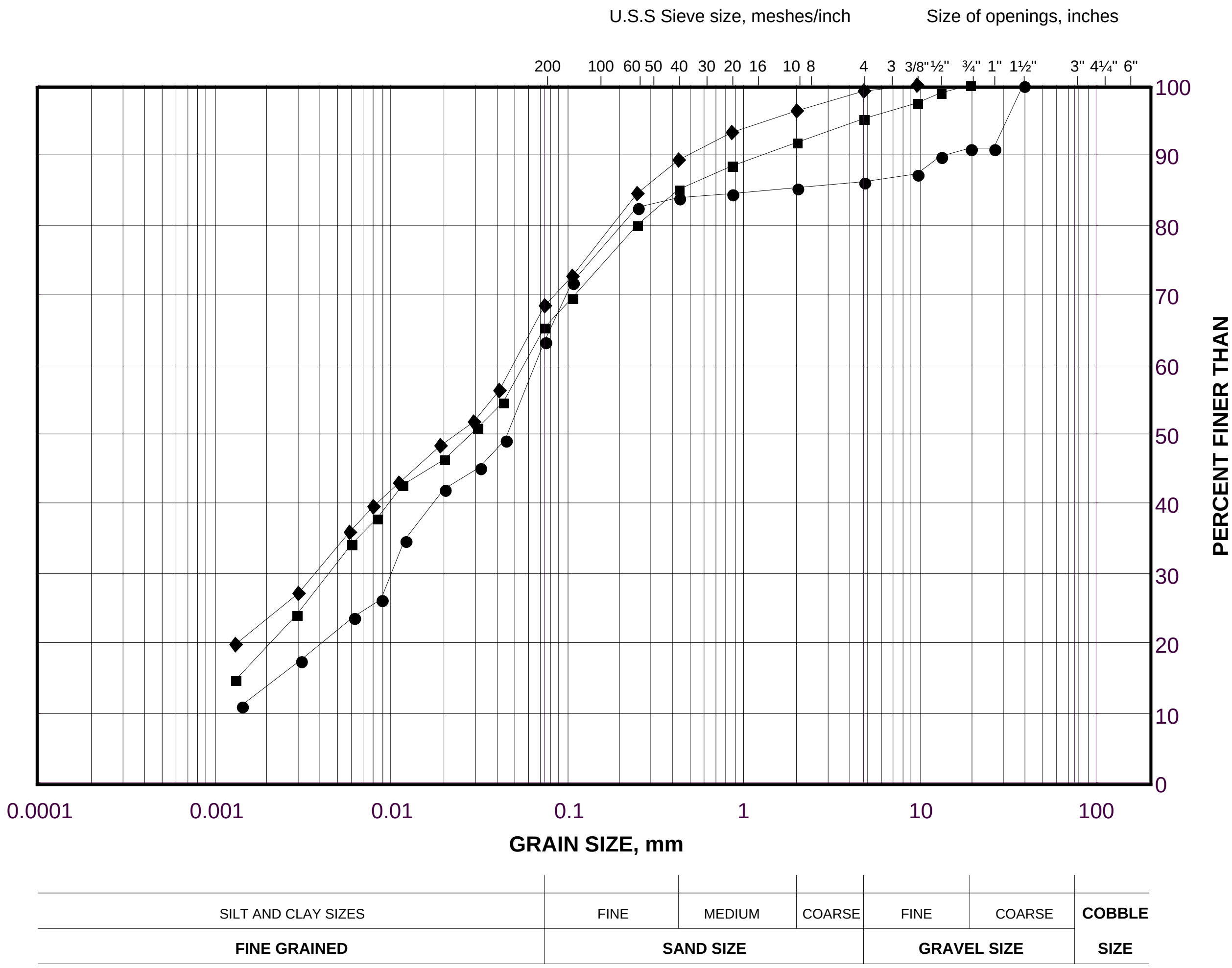
Checked By: SMM

Golder Associates

Date: 24-Apr-18

GRAIN SIZE DISTRIBUTION
Clayey Silt with Sand (Till)

FIGURE E-20



LEGEND

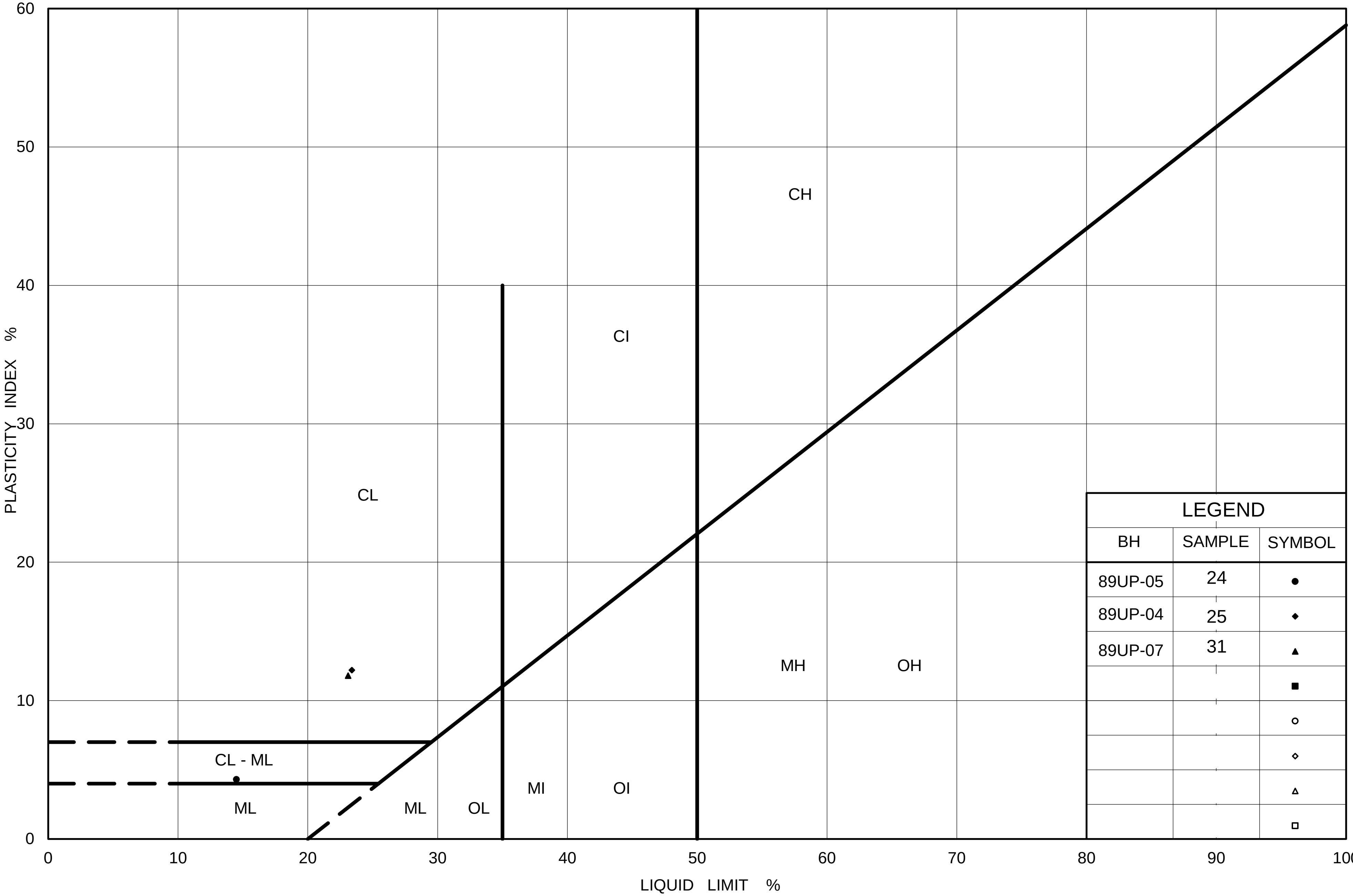
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	89UP-05	24	184.7
■	89UP-04	25	178.9
◆	89UP-07	31	176.8

Project Number: 1668512

Checked By: SMM

Golder Associates

Date: 24-Apr-18



BH	SAMPLE	SYMBOL
89UP-05	24	●
89UP-04	25	◆
89UP-07	31	▲
		■
		○
		◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt with Sand (Till)

Figure No. E-21

Project No. 1668512

Checked By: SMM

APPENDIX F

Non-Standard Special Provisions

<u>SUPPLY AND INSTALLATION OF EMBANKMENT MONITORING EQUIPMENT</u> – Item No.

Special Provision

1.0 SCOPE

The Contractor shall retain a Foundation Engineering consultant registered in MTO's Consultant Registry, Appraisal and Qualifications System (RAQS) for "Geotechnical Specialty – Medium Complexity", to undertake the supply and installation of geotechnical settlement monitoring instrumentation (settlement plates, settlement rods and temporary benchmarks) and for providing appropriate recommendations based on the measurement readings.

The Contractor shall retain a Foundation Engineering consultant registered in MTO's Consultant Registry, Appraisal and Qualifications System (RAQS) for "Geotechnical Specialty – High Complexity", to undertake the supply and installation of geotechnical monitoring instrumentation (vibrating wire piezometers and vibrating wire inline extensometers) and for providing appropriate recommendations based on the measurement readings.

The Contractor shall also implement an embankment monitoring program to take, record and distribute all appropriate and timely measurements and transmit recommendations from the Foundation Engineering consultants to the Contract Administrator.

1.1 General Scope

This general special provision and the other item-specific special provisions contain the requirements for the supply and installation of the following geotechnical monitoring instrumentation:

- Settlement Plates (SP);
- Deep Settlement Rods (DSR);
- Vibrating Wire Piezometers (VWP); and,
- Vibrating Wire Inline Extensometer (VWIX).

This general special provision also contains the requirements for the supply and installation of temporary survey Benchmarks related to the geotechnical monitoring instrumentation.

1.2 Purpose

The purpose of these instruments and equipment is to monitor the progress of the settlement at the abutments during the preload period and to monitor the progress of settlement in the foundation soils under and adjacent to the high fill embankments along the W-S Ramp and the combined embankment for the W-N Ramp and the S-E/W Ramp where it crosses the existing gas main. The purpose of the temporary survey Benchmarks is to provide non-settling references for the surveying of the monitoring instruments.

The duration of the preloading period prior to driving the steel H-piles at the abutments will be controlled by the instrumentation readings, as specified elsewhere in the Contract Documents. The completed, preloaded embankments at the abutments shall remain undisturbed until such time as the monitoring shall indicate that a sufficient degree of compression of the foundation soil has been achieved.

2.0 REFERENCES

2.1 General

When the Contract Documents indicate that provincial oriented specifications are to be used and there is a provincial oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a municipal oriented specification is specified in the Contract Documents.

This Special Provision refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 905 Steel Reinforcement for Concrete

Ontario Provincial Standards Specifications, Material

OPSS1010 Aggregates – Base, Subbase, Select Subgrade and Backfill Material

OPSS.PROV 1350 Concrete – Materials and Production

OPSS 1250 Clay Seal

OPSS 1301 Cementing Materials

OPSS 1801 Corrugated Steel Pile (CSP) Products

Ontario Water Resources Act RRO 1990:

Regulation 903 Wells

2.2 Subsurface Conditions

The subsurface conditions at the site are described in the Foundation Investigation Reports for this Contract.

Foundation Investigation Report – High Fill Embankment, Highway 400/89 Reconstruction, Town of Innisfil, Simcoe County, Ministry of Transportation, Ontario. G.W.P. 2438-13-00

Foundation Investigation Report – Highway 400/89 Underpass Replacement, Structure Site No. 30-256, Reconstruction of Highway 400/89 Interchange, Town of Innisfil, Simcoe County, G.W.P. 2483-13-00

Foundation Investigation Report – Trenchless Installation of Proposed Culvert C-21, Highway 400/89 Interchange Reconstruction, Town of Innisfil, Simcoe County, G.W.P. 2483-13-00

3.0 DEFINITIONS

Contractor means the Contractor and his Geotechnical Consultant.

Equal shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

Geotechnical Engineering Consultant means a consultant with MTO classification of "Geotechnical (Structures and Embankments) - High Complexity", to undertake the supply and installation of geotechnical instruments.

Monitoring Program means the monitoring readings conducted by others as part of the Contract Administration Assignment.

Settlement Plate means a plate installed at the defined level with a series of rods attached to a plate for the purposes of settlement monitoring.

Settlement Plate means a plate installed at the defined level with a series of rods attached to a plate for the purposes of settlement monitoring.

Temporary Survey Benchmark means a non-yielding, deep-seated survey reference point.

Vibrating Wire Inline Extensometer means a series of displacement transducers installed in a sampled borehole for the purposes of measuring settlement corresponding to depth

Vibrating Wire Piezometer means a sensor attached to a cable installed in a borehole for the purposes of measuring pore pressure response.

4.0 SUBMISSION AND DESIGN REQUIREMENTS

4.1 Submission Requirements

4.1.1 Notification

The Contract Administrator shall be notified a minimum of fifteen (15) working days in advance of commencing the installation of instruments.

4.1.2 Installation Methods

The Contractor shall submit details of the proposed installation methods including locations and types of the data acquisition system(s), monitoring enclosure(s), temporary survey benchmarks and installation schedule, to the Contract Administrator, a minimum of fifteen (15) working days before the start of instrument installation.

5.0 MATERIALS

5.1 Materials for Temporary Benchmarks (TBM)

The Contractor shall supply all materials and equipment required for the installation of the Benchmarks.

5.1.1 Rod

The Contractor shall supply a steel pipe, Schedule 40, with an outside diameter not less than 25.4 mm, supplied in lengths as required to complete the installation as described in Section 7.2.2.

The top end of each length of TBM rod shall be threaded to receive a cap or to allow for connection of successive lengths of rods. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

5.1.2 Sand

The Contractor shall supply clean, washed sand. The sand shall be Sakcrete washed general-purpose sand – or equal.

5.1.3 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU – OPSS 1301).

5.1.4 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type GU – OPSS 1301).

5.1.5 Friction-Reducing Sleeve

The Contractor shall supply a friction-reducing sleeve consisting of Schedule 40 – 50.8 mm (2") outer diameter PVC pipe cut perpendicular to the axis of the pipe.

5.2 Materials for Vibrating Wire Piezometer

The Contractor shall supply all materials and equipment required for the installation of the Vibrating Wire Piezometer.

5.2.1 Vibrating Wire Piezometer

The vibrating wire piezometer sensors shall be:

- Slope Indicator model 52611020 (-5 to 50 psi); or
- RST model VW2100-0.35; or
- Equal.

The VWPs shall be compatible with the Slope Indicator VW Minilogger, model 52613310, or equal. All VWPs shall be of the same make/supplier.

All VWPs shall be calibrated prior to installation and the calibration data for each piezometer shall be provided to the Contract Administrator.

5.2.2 Signal Cable

The signal cable shall be:

- Slope Indicator model 50613524 cable; or
- RST model EL380004 cable; or
- Equal.

The length of cable for each piezometer shall be carefully estimated from the construction drawings to ensure that there is sufficient length of signal cable for each piezometer to provide enough slack in the borehole and along the trenches until each cable is out of the embankment footprint area where they shall be protected from earthmoving equipment and extended to the monitoring station.

5.2.3 Bentonite

Bentonite to form borehole plugs as required shall be in accordance with OPSS 1205 in pellet form in sufficient quantity.

5.2.4 Filter Sand

Sand for filters around VWP sensors shall be clean washed sand, such as “Sakcrete” washed general-purpose sand; or similar.

5.2.5 Protective Surround

Protective casing as recommended by the manufacturer shall be provided over the length of the piezometers through the rock fill. Sand for additional protection around the casing shall be clean washed sand, such as “Sakcrete” washed general-purpose sand; or similar.

5.2.6 Grout

Grout shall be cement-bentonite mix consisting of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU - OPSS 1301).

5.2.7 Trench Burial and Conduit

The signal cable for each piezometer shall be buried in a shallow trench at the locations indicated in Table 1C and taken out of the embankment footprint area if possible and/or to an area that will not be impacted by construction operations. Conduits to protect the signal cables in the trenches and above ground surface shall consist of Schedule 40 – 75 mm - 3" - steel pipe or Schedule 80 - 75 mm - 3" - rigid PVC pipe. A minimum 300 mm protective surround consisting of OPSS.PROV 1010 Granular ‘A’ in accordance OPSS.PROV 1010 shall be placed around the conduit. If appropriate, several signal cables may be housed in a single conduit and laid in a common trench.

5.2.8 Data Acquisition System (Data Logger)

The signal cables from the vibrating wire piezometers shall be connected to the nearest data-logger. A minimum of one (1) data-loggers shall be installed at each abutment. The data acquisition systems shall be from the same supplier as the VWPs and shall consists of:

- Slope Indicator Model 56701000 (CR1000); or
- RST Model ELGL1200; or
- Equal.

The data-logger shall consist of the following:

- ENC 16/18 Water-proof Enclosure Model 56705020, Model ELF0638, or equal;
- SC32A Serial Interface (with RS232 transfer cable) Model 56704010, Model CS-SC32A, or equal;
- VW Interface Model 56701510 or 56701500, Model CS-AVW200, or equal;
- AM16/32 Multiplexer Model 56702110, Model ELGL2042, or equal;
- A suitable power supply which shall be able to last for 1 year);
- Cellular Modem
- LoggerNet Software Model 56708020, Model CS-Loggernet, or equal.

The data-loggers shall be programmed according to the following:

- Recording Software: VWP data shall be recorded four (4) times a day (i.e. one (1) reading every 6 hours); and,
- Test Software: once this program is transferred to the data-logger, the system shall be able to be tested to confirm readings can be gathered manually at the site and remotely by use of the cellular network.

The real-time data shall be retrieved remotely by cellular network. The Contractor shall be responsible for obtaining the cellular plan to allow for retrieval of the data by the cellular network for the duration of the construction.

5.2.9 Wooden Posts

Wooden posts for the support of the data acquisition system enclosures shall be:

- 100 mm x 100 mm (4"x4"), minimum 3 m (10') long pressured treated lumber.

5.3 Materials for Vibrating Wire Inline Extensometer (VWIX)

The Contractor shall supply all materials and equipment required for the installation of the Vibrating Wire Inline Extensometer.

5.3.1 Vibrating Wire Inline Extensometer Sensors

The vibrating wire inline extensometer sensors shall be:

- RST EXINLINE-1150; or
- Equal.

The VWIXs shall be compatible with the RST RSTAR L900 compatible data loggers, model CR300, or equal. The sensors shall be capable of measuring a total displacement of up to 150 mm, corresponding to 50 mm of displacement from each anchor. All VWIXs shall be of the same make/supplier.

All VWIXs shall be calibrated prior to installation and the calibration data for each instrument shall be provided to the Contract Administrator.

5.3.2 Anchors

A minimum of four (4) anchors shall be installed at each extensometer as follows:

- Three (3) Hydraulic Borros Anchors Model EXIL13000
- One (1) Groutable Anchors with Spring Legs Model EXIL12000

The locations of the extensometers and depths of the anchors are specified in Table 1D. Prior to the installation of the bottom anchor, soil samples shall be obtained as specified in Section 7.4.2 to confirm the bottom anchor is installed at least 3 m into the hard clayey silt till.

5.3.3 Signal Cable

The signal cable shall be:

- RST Model EL380004 cable; or
- Equal.

The length of cable for each extensometer shall be carefully estimated from the construction drawings to ensure that there is sufficient length of signal cable for each extensometer to provide enough slack in the borehole and along the trenches until each cable is out of the embankment footprint area where they shall be protected from earthmoving equipment and extended to the monitoring station.

5.3.4 Bentonite

Bentonite to form borehole plugs as required shall be in accordance with OPSS 1205 in pellet form in sufficient quantity.

5.3.5 Protective Surround

Protective casing as recommended by the manufacturer shall be provided over the length of the extensometer through the embankment fill. Sand for additional protection around the casing shall be clean washed sand, such as “Sakcrete” washed general-purpose sand; or similar.

5.3.6 Grout

Grout shall be cement-bentonite mix consisting of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU - OPSS 1301).

5.3.7 Trench Burial and Conduit

The signal cable for each VWIX shall be buried in a shallow trench at the locations indicated in Table 1D, and taken out of the embankment footprint area if possible and/or to an area that will not be impacted by construction operations. Conduits to protect the signal cables in the trenches and above ground surface shall consist of Schedule 40 – 75 mm - 3" - steel pipe or Schedule 80 – 75 mm - 3" - rigid PVC pipe. A minimum 300 mm protective surround consisting of OPSS.PROV 1010 Granular ‘A’ shall be placed around the conduit. If appropriate, several signal cables may be housed in a single conduit and laid in a common trench.

5.3.8 Data Acquisition System (Data Logger)

The signal cables from the VWIXs shall be connected to the nearest data logger. Two (2) dataloggers shall be installed; one at each abutment. The data acquisition systems shall be from the same supplier as the VWIXs and shall consists of:

- RST FlexDAQ (CR300); or
- Equal.

The data logger shall consist of the following:

- RST L900 RTU, or equal
  - RST Node Model DT2055
  - RST Data Logger Model CR300
  - Cellular Modem
- RST FlexDAQ weatherproof enclosure, or equal;
- A suitable power supply which shall be able to last for 1 year);
- LoggerNet Software Version 4.4.2, or equal.

The data-loggers shall be programmed according to the following:

- Recording Software: VWIX data shall be recorded six (6) times a day (i.e. one (1) reading every 4 hours); and,
- Test Software: once this program is transferred to the data-logger, the system shall be able to be tested to confirm readings can be gathered manually at the site and remotely by use of the cellular network.

The real-time data shall be retrieved remotely by cellular network. The contractor shall be responsible for obtaining the cellular plan to allow for retrieval of the data by the cellular network for the duration of the construction.

5.3.10 Wooden Posts

Wooden posts for the support of the data acquisition system enclosures shall be:

- 100 mm x 100 mm (4"x4"), minimum 3 m (10') long pressured treated lumber.

6.0 EQUIPMENT

6.1 Monitoring Equipment Operation and Weather Conditions

All monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their location within the ground or on the surface. The instruments shall be capable of operating within the manufacturer's stated accuracy throughout the temperature range. Monitoring will be conducted potentially year-round by the Contract Administrator.

6.2 Data Logger

The Contractor shall submit a detailed proposal on the setup of the data-logging system (i.e. numbers and locations of the data-logging unit(s)) to the Contract Administrator for review, prior to ordering the data-logger(s).

7.0 CONSTRUCTION

7.1 Monitoring Instrument Installations

7.1.1 Drawings

Reference shall be made to the following drawings that are contained elsewhere in the Contract Documents:

- Monitoring Instrumentation Plans;
- Typical Monitoring Sections; and
- Typical Instrument Installation Details.

7.1.2 Quantities and Locations of Instruments

The quantities and approximate location of instruments are presented in Table 1A and are shown on the Contract Drawings. The final locations shall be "field fit" by the Contractor to take account of any utilities that may be present, construction operations, and safe access conditions.

Table 1A – Instrument Quantities and Locations

Monitoring Section[1]	**Quantities**			
	SP	**DSR**	**VWP**	**VWIX**
West Abutment Approach Embankment	3	--	3	1
East Abutment Approach Embankment	3	--	3	1
Gas main - W-S Ramp (Station 10+202)	2	2	--	--
Gas main - W-N Ramp and the S-E/W Ramp (Station 10+290)	2	2	--	--
TOTAL:	**10**	**4**	**6**	**2**

7.1.3 Materials and Equipment

The Contractor shall supply all materials and equipment required for the installation of instrumentation unless otherwise noted.

7.1.4 Instrument Location

Prior to the installation of instruments, the Contractor shall accurately survey and stake the location of each instrument and obtain a ground elevation at each instrument location.

7.1.5 Underground Utilities

The Contractor shall be responsible for locating and protecting all underground utilities prior to drilling boreholes for installing instruments. Any damage to underground utilities caused by the Contractor's work shall be repaired by the Contractor at no cost to the Owner or Contract Administrator.

7.1.6 Marking and Labelling

The location of any above-ground monitoring fixture shall be made clearly visible to nearby traffic before, during and after embankment construction. Marking shall be of sufficient size to be visible from a reversing vehicle and after heavy snow falls, if and where applicable.

Instruments shall be clearly labelled in the field, with each instrument having a unique identifier as contained in the other item-specific special provisions. The labelling shall remain legible for the entire duration of monitoring.

7.1.7 Protection of Instruments

The Contractor shall adequately protect all instruments such that they are not damaged during construction. Any instrument damaged by the Contractor's work shall be immediately replaced by the Contractor at no cost to the Owner or Contract Administrator.

7.1.8 Survey Personnel

Surveying to establish the benchmarks and other elevations shall be carried out by a registered surveyor with appropriate equipment. The surveyor shall be retained by the Contractor.

7.1.9 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 mm or better.

7.1.10 Boreholes

The Contractor shall make a basic stratigraphic log of boreholes as they are being drilled for the installation of monitoring instruments. In situ or laboratory geotechnical testing is not required.

Boreholes shall be advanced using conventional drilling methods, where applicable, and shall be as straight and vertical as practicable.

7.1.11 Installation Program

The instruments shall be installed prior to the commencement of the embankment construction Table 1B gives a summary of the installation schedule requirements.

Table 1B – Instrument Installation Program

Instrument Type	Instrument Location	Start Installation	Finish Installation
SP	At ground surface after stripping, along alignment of gas main and beneath EPS embankment.	After stripping and prior to start of EPS embankment construction.	At completion of EPS embankment construction.
SP	Approach Embankment at the East and West Abutment.	After stripping and prior to start of approach embankment construction.	At completion of approach embankment construction.

Instrument Type	Instrument Location	Start Installation	Finish Installation
DSR	Offset from gas main and at the gas main invert depth.	Prior to start of EPS embankment construction.	At completion of EPS embankment construction.
VWP	Approach Embankment at the East and West Abutment.	Before start of embankment construction.	At completion of approach embankment construction.
VWIX	Approach Embankment at the East and West Abutment	Before start of embankment construction	At completion of approach embankment construction.

7.2 Benchmark Installation

7.2.1 Number and Locations

The minimum number and approximate locations of the Benchmarks are to be determined by the Contractor and his Foundation Engineering consultant in conjunction with the Contract Administrator, the Foundation Monitoring Consultant, and Surveyors. For bidding purposes assume that 6 benchmarks are required: 3 benchmarks anchored at 6 m depth and 3 benchmarks anchored at 15 m depth (through the existing embankments). The number and locations of Benchmarks shall be determined in the field to satisfy the following conditions:

- Direct sighting is possible from all instruments to at least one Benchmark.
- Each Benchmark is located in an area that will not experience a change in loading (due to grade raise or excavation) that could induce settlement or heave in the ground in which the Benchmark is installed (i.e. non-settling benchmark).
- Each Benchmark is located in such a way to minimize interference with and damage by construction activities.
- The rod anchor elevation shall be adjusted in the field to extend approximately 1 m into soils having Standard Penetration Test ‘N’ values of greater than 25 blows per 0.3 m of penetration. Reference shall be made to the Foundation Investigation Reports for information in order to determine the anchor elevation for each Benchmark location selected.

Intermediate tie-in points may be required as deemed necessary by the surveyor, and shall be tied into the temporary benchmarks during each reading.

7.2.2 Installation

The Contractor shall install Benchmarks in accordance with the following:

7.2.3 Borehole

The borehole shall be advanced to rod anchor elevations controlled by the Standard Penetration test “N” values given above, using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, friction-reducing sleeve and rod anchor. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

7.2.4 Rod

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

7.2.5 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting at the bottom of the borehole. The bottom portion of the rod shall be fixed against the surrounding native soil by grouting the bottom 0.5 m of the borehole to form a concrete/soil anchor.

Once grouting is completed and the rod anchor grout has set, the contractor shall pour clean sand in the lower 0.5 m length of the borehole above the concrete/soil anchor to create a base for the end of the friction reducing sleeve to rest on.

The elevation of the bottom of the rod anchor shall be determined by measuring the length of the rod to the ground surface elevation.

7.2.6 Friction-Reducing Sleeve

The friction-reducing sleeve shall be installed over the entire length of the rod above the rod anchor and sand, extending up to ground surface.

7.2.7 Installation Details

The elevation, easting and northing of the top of the Benchmark rod shall be surveyed.

7.3 Vibrating Wire Piezometer (VWP) Installation

7.3.1 Number and Locations

The locations of the VWP are shown in the Contract Documents and in Tables 1A to 1C. The VWP shall be installed in boreholes immediately prior to construction of the approach embankment at the abutments. The VWPs shall be installed to a tip elevation given in Table 1C. Installation of the VWPs shall be as per the manufacturer's recommendations in addition to what is stated or emphasised below.

The VWIX signal cables shall be extended to the data-logger enclosure areas through a metal or plastic conduit buried in trenches with protective surround, as specified in Section 5.2.5. The final location of the monitoring enclosure should be determined on-site prior to ordering instruments to ensure there is sufficient cable length(s). Due to the restricted working area, the location of the monitoring enclosure should be determined to avoid construction traffic.

Table 1C – Vibrating Wire Piezometer Locations and Elevations

Monitoring Location	Hwy 89 Station	Offset from Highway 89 Centreline	Approximate Elevation of Existing Ground Surface (m)	Tip Elevation (m)
Approach Embankment at	9+961	0.0 m (on centreline)	227.5	202.5
				199.5

Monitoring Location	Hwy 89 Station	Offset from Highway 89 Centreline	Approximate Elevation of Existing Ground Surface (m)	Tip Elevation (m)
East Abutment				186.0
Approach Embankment at West Abutment	10+039		227.2	201.5
				198.5
				188.0

7.3.2 Borehole Installation

The borehole at each VWP location shall be advanced to 300 mm below the lowest tip elevation using suitable drilling techniques. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris. A split spoon sample shall be taken at the proposed installation depth to confirm the soil stratum at the VWP tip elevation. The borehole shall be filled with water prior to installation of the VWP tip.

7.3.3 Protective Enclosures for Data Loggers

The data-logger shall be installed in a protective enclosure near each approach embankment to prevent vandalism and prolonged wear-out of the data-loggers against extreme weather. The protective enclosure shall be lockable and weather proofed. The Contractor shall submit a detailed proposal of the protective enclosure (i.e. materials and location(s) etc.) to the Contract Administrator for review, prior to construction/installation.

The Contractor shall ensure access to the protective enclosure at all times, including but not limited to snow clearing in the winter.

7.3.4 Completion of Installation

It is known that the process of installing VWPs can temporarily alter the pore water pressure acting on the piezometer tip. The installation of a VWP shall not be considered to be complete until the pore pressure acting on the piezometer has returned to and stabilized at the value prevailing in the surrounding, unaffected soil mass. The Contractor shall take daily reading of the pore pressures, for the period noted below until the value has stabilized as determined by the Contract Administrator. Stabilization shall be deemed to have occurred:

- When no change in the measured value has occurred over a period of five (5) consecutive days and the measured value is within 10 per cent of the anticipated hydrostatic value; and,
- When the daily rate of change is less than four (4) kPa per day for three (3) consecutive days and the measured value is within 5 per cent of the anticipated hydrostatic value.

The Contractor should be prepared to wait for a period of 10 days to 15 days after completion of installation of the instruments for the baseline readings to stabilize.

7.4 Vibrating Wire Inline Extensometers

7.4.1 General

The locations of the VWIX are as shown in Table 1D. Installation of the extensometers shall be as per the manufacturer's recommendations in addition to what is stated or emphasised below. The extensometers shall be installed in boreholes immediately prior to construction of the approach embankment at the abutments.

The VWIX signal cables shall be extended to the data-logger enclosure areas through a metal or plastic conduit buried in trenches with protective surround, as specified in Section 5.2.7. The final location of the monitoring enclosure should be determined on-site prior to ordering instruments to ensure there is sufficient cable length(s). Due to the restricted working area, the location of the monitoring enclosure should be determined to avoid construction traffic.

Table 1D – Vibrating Wire Inline Extensometer Locations and Elevations

Monitoring Location	Hwy 89 Station	Offset from Centreline	Approximate Elevation of Existing Ground Surface (m)	Anchor Type[1,2]	Anchor Elevation (m)
Approach Embankment at East Abutment			227.2	HBA	
				HBA	
				HBA	
				GASL	
Approach Embankment at West Abutment			227.2	HBA	
				HBA	
				HBA	
				GASL	

Note: 1 HBA – Hydraulic Borros Anchor
2 GASL – Groutable Anchors with Spring Legs

7.4.2 Borehole Installation

The borehole at each VWIX location shall be advanced to 300 mm below the lowest anchor elevation using suitable drilling techniques. Under the oversight of the Contract Administrator's Foundation Consultant, during borehole advancement, 3 inch diameter Shelby tube samples shall be collected as per ASTM D1587 at intervals of 1.5 m using a hydraulic piston sampler, or as otherwise directed by the Contract Administrator. At each extensometer, for 3.0 m above the lowest anchor elevation, split-spoon samples shall be taken at intervals of 1.5 m to confirm the appropriate soil stratum, as directed by the Contract Administrator's Foundation Consultant. Equipment to complete the sampling and field vane shear testing (e.g. Drill rig, 'N'-Vane adapter, 50 mm split-spoon, hydraulic piston sampler) shall be provided. Contract Administrator's Foundation Consultant will be on site to collect the retrieved Shelby tube samples and perform the field vane shear strength testing; however, the Contractor should allow for time associated with field vane shear testing (ASTM D2573) between the Shelby tube samples. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris prior to sampling, testing and installation of the VWIXs.

7.4.3 Protective Enclosures for Data Loggers

The data-logger shall be installed in a protective enclosure near each approach embankment to prevent vandalism and prolonged wear-out of the data-loggers against extreme weather. The protective enclosure shall be lockable and weather proofed. The Contractor shall submit a detailed proposal of the protective enclosure (i.e. materials and location(s) etc.) to the Contract Administrator for review, prior to construction/installation.

The Contractor shall ensure access to the protective enclosure at all times, including but not limited to snow clearing in the winter.

7.5 Monitoring Program

7.5.1 Notification

The Contractor shall notify the Contract Administrator no later than three (3) working days after the completion of installation of Benchmarks, Settlement Plates, Deep Settlement Rods, Vibrating Wire Piezometers and Vibrating Wire Inline Extensometers.

7.5.2 Reporting

The Contractor shall supply the information outlined in the following sections to the Contract Administrator within three (3) days of completion of installation of each instrument.

7.5.2.1 Temporary Survey Benchmarks

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- TBM Northing and Easting in MTM NAD 83 coordinates;
- Elevation of the rod anchor bottom, rod anchor length, and top of rod in Geodetic datum;
- Date of installation;
- Stratigraphic log of subsurface conditions at the TBMs, including notes on drilling method obstructions it encountered;
- Installation notes/sketches; and,
- Description of TBM (rod), sleeves and rod anchors.

7.5.2.2 Settlement Plates and Deep Settlement Rods

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- SP and DSR Northing and Easting in MTM NAD 83 coordinates;
- Elevation of base of plate and top of rod in Geodetic datum;
- Date of installation;
- Installation notes/sketches; and,
- Description of SP rods, sleeves and plates.

Adjustments in the length of any SP or DSR rod shall be coordinated with the Contract Administrator to allow surveying by others of the elevation of the top of the rod immediately before and immediately after adjustment. This surveying is necessary to accurately track the settlement data.

7.5.2.3 Vibrating Wire Piezometers

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- VWP Northings and Eastings in MTM NAD 83 coordinates;
- Elevations of VW sensors in Geodetic datum;
- Dates of installation;
- Stratigraphic log of subsurface conditions, including drilling method notes;
- Installation notes / sketches;
- Model, make and serial numbers of VW sensors, readout unit and signal cable; and,
- Calibration details of VW sensors.

7.5.2.4 Vibrating Wire Inline Extensometers

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- VWIX Northings and Eastings in MTM NAD 83 coordinates;
- Elevations of anchors and sensors in Geodetic datum;
- Dates of installation;
- Stratigraphic log of subsurface conditions, including drilling method notes;
- Installation notes / sketches;
- Model, make and serial numbers of VWIX sensors, readout unit and signal cable; and,
- Calibration details of VWIX sensors.

7.5.3 Monitoring

The Contractor shall meet with the Contract Administrator and staff responsible for the ongoing monitoring immediately after installation of the instruments and before the start of embankment construction. At this meeting, the Contractor shall hand over to the Contract Administrator all records pertaining to the installation of the instruments, and all equipment to be supplied by the Contractor, as identified in the item-specific special provisions.

Monitoring by the Contract Administrator's representative for the baseline readings shall commence within seven working days after the hand-over meeting. The monitoring shall continue on a schedule to be determined by the Contract Administrator throughout the construction of the embankments, and for up to approximately 6 weeks to 3 months following the completion of construction to the preload grade.

7.5.4 Decommissioning of Instruments

At the end of the monitoring period, the Contractor shall decommission all the temporary survey Benchmarks and tie-in points by removing the rod and friction-reducing sleeve to at least 1.5 m below grade by excavating and backfilling with compacted granular fill in accordance with the specifications for fill placement.

At the end of the monitoring period, the Contractor shall decommission all Settlement Plates, Deep Settlement Rods, Vibrating Wire Piezometers and Vibrating Wire Inline Extensometers, unless otherwise advised by the Contract Administrator. Decommissioning of instrumentation shall be carried out per the item-specific special provisions and according to the Ontario Water Resources Act, Regulation 903 (as amended).

8.0 QUALITY ASSURANCE – Not Used

9.0 MEASUREMENT FOR PAYMENT – Not Used

10.0 BASIS OF PAYMENT

10.1 Supply and Installation of Embankment Monitoring Equipment - Item

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment and Material to do the work, including the supply, installation and decommissioning of survey benchmarks, Vibrating Wire Piezometers and Vibrating Wire Inline Piezometers, as well as performing all required monitoring and reporting.

SETTLEMENT PLATES – Item No.

Special Provision

1.0 SCOPE

1.1 General Scope

This special provision contains the requirements for the supply and installation of Settlement Plates (SPs).

The purpose of the SPs is to monitor settlements at approximately the existing ground surface elevation above the alignment of the existing gas main prior to construction of the Expanded Polystyrene (EPS) embankment for the W-S Ramp and the combined embankment for the W-N Ramp and the S-E/W Ramp.

In addition, Settlement Plates are also required to be installed prior to the construction of the approach embankments which are to be preloaded prior to driving of the steel H-piles at the abutments. The completed, preloaded embankments at the abutments shall remain undisturbed until such time as the monitoring indicates that a sufficient degree of compression of the foundation soil has been achieved.

Settlement is measured by survey of the top of the rod with reference to stable, non-settling Benchmarks. The settlement readings are intended to confirm that the settlements at the gas main level are maintained at less than 15 mm.

2.0 REFERENCES – Not Used

3.0 DEFINITIONS – Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS – Not Used

5.0 MATERIALS

The Contractor shall supply all materials and equipment required for the installation of the SPs.

5.1 Plate

The Contractor shall supply a steel plate with a thickness of at least 6.35 mm. The plate shall be at least 0.5 m wide by 0.5 m long.

5.2 Rod

The SP rod shall be fixed to the centre of the plate and perpendicular to the plate. The coupling of the rods shall be such that all sections have the same axis and that no separation or contraction will occur at the couplings.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

5.3 Sand

The Contractor shall supply clean, washed sand. The sand shall be Sakcrete washed general-purpose sand – or equal.

5.4 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU – OPSS 1301).

5.6 Friction-Reducing Sleeve

The Contractor shall supply a friction-reducing sleeve consisting of Schedule 40 – 50.8 mm (2") outer diameter PVC pipe cut perpendicular to the axis of the pipe.

5.7 Extension of Rod

The SP rods shall be extended upwards as the embankment is constructed so that the top of the rod is always at least 0.3 m but not more than 2 m above the surrounding fill.

5.7 Protective Surround

The Contractor shall supply a protective surround for the portion of the rod and friction-reducing sleeve within the backfill/embankment.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP – OPSS 1801) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the friction-reducing sleeve shall be filled with medium to coarse sand.

6.0 EQUIPMENT – Not Used

7.0 CONSTRUCTION

7.1 Installation

7.1.1 General Procedure

As embankment construction proceeds, the rods shall be extended above the new top of embankment. Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the plate.

7.1.2 Location

The Contractor shall install SPs at the locations shown on the Contract Drawings and given in Table 1. The instrument locations should be field fit to avoid the Contractor's operations, but to be as close to the intended locations as practicable.

Table 1 – Settlement Plate Locations

Monitoring Section[1]	Point ID	Approx. Station/Offset	Approx. Elevation of Ground Surface[2] (m)
Gas main - W-S Ramp	SP1	10+197 RSH	227.0
Gas main - W-S Ramp	SP2	10+197 LSH	227.0
Gas main - W-N Ramp	SP3	10+130 LSH	228.5
Gas main - S-E/W Ramp	SP4	10+295 RSH	228.5
TOTAL:	**4**		

1. Station referenced to Ramp centreline.
2. Ground surface elevation estimated following completion of topsoil removal and prior to embankment construction.

The Contractor shall install SPs as shown on the Contract Drawings and the Typical Installation Detail, in addition to what is stated below.

7.1.3 Plate

The settlement plate shall be installed horizontally on the undisturbed native soil or existing embankment fill just below the existing ground surface.

7.1.4 Rod

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

7.1.5 Friction-Reducing Sleeve

The friction-reducing sleeve shall be installed over the entire length of the rod that is below ground and within the embankment fill except that the cap on top of the SP rod shall extend 25 mm above the top of the friction sleeve at all times.

7.1.6 Extension of Rod

The SP rods shall be extended upwards as the embankment widening is constructed so that the top of the rod is always at least 0.3 m, but not more than 2 m above the surrounding fill.

7.1.7 Protective Surround

The CSP, friction-reducing sleeve and sand surround shall be extended concurrent with the rods, where applicable. The SP rod shall be in the centre of the CSP and friction-reducing sleeve. The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the sleeve.

7.1.8 Miscellaneous Installation Details

The elevation, northing and easting of the top of the rod shall be surveyed by the Contractor.

The total distance from the rod anchor to the top of the rod shall be measured and recorded by the Contractor to an accuracy of ± 2 mm or better.

The Contractor is responsible for preventing damage to the settlement plate during the embankment construction. If the rod is damaged during fill placement, the rods, friction-reducing sleeve and protective surround shall be replaced before resuming the fill placement.

8.0 QUALITY ASSURANCE – Not Used

9.0 MEASUREMENT FOR PAYMENT

Measurement for payment will be made on the basis of the number of units of SPs installed, including extension through the embankment construction.

10.0 BASIS OF PAYMENT

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment and Material to do the work, including all appurtenances and extension through the embankment construction.

<u>SETTLEMENT RODS</u> – Item No.

Special Provision

1.0 SCOPE

1.1 General Scope

This special provision contains the requirements for the supply and installation of deep Settlement Rods (DSRs).

The purpose of the DSRs is to monitor settlements at approximately the invert elevation of the existing gas main prior to construction of the EPS embankment for the W-S Ramp and the combined embankment for the W-N Ramp and the S-E/W Ramp.

Settlement is measured by survey of the top of the rod with reference to stable, non-settling Benchmarks. The settlement readings are intended to confirm that the settlements at the gas main are maintained at less than 15 mm.

2.0 REFERENCES – Not Used

3.0 DEFINITIONS – Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS – Not Used

5.0 MATERIALS

The Contractor shall supply all materials and equipment required for the installation of the DSRs.

5.1 Rod

The Contractor shall supply a steel pipe, Schedule 40, with an outside diameter not less than 25.4 mm, supplied in lengths as required to complete the installation as described in Section 1.3.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

5.2 Sand

The Contractor shall supply clean, washed sand. The sand shall be Sakcrete washed general-purpose sand – or equal.

5.3 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU – OPSS 1301).

5.4 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type GU – OPSS 1301).

5.5 Friction-Reducing Sleeve

The Contractor shall supply a friction-reducing sleeve consisting of Schedule 40 – 50.8 mm (2") outer diameter PVC pipe cut perpendicular to the axis of the pipe.

5.6 Extension of Rod

The DSR rods shall be extended upwards as the embankment is constructed so that the top of the rod is always at least 0.3 m but not more than 2 m above the surrounding fill.

5.7 Protective Surround

The Contractor shall supply a protective surround for the portion of the rod and friction-reducing sleeve within the backfill/embankment.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP – OPSS 1801) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the friction-reducing sleeve shall be filled with medium to coarse sand.

6.0 EQUIPMENT – Not Used

7.0 CONSTRUCTION

7.1 Installation

7.1.1 General Procedure

As embankment construction proceeds, the rods shall be extended above the new top of embankment. Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the plate.

7.1.2 Location

The Contractor shall install DSRs at the locations shown on the Contract Drawings and given in Table 1. The instrument locations should be field fit to avoid the Contractor's operations, but to be as close to the intended locations as practicable.

Table 1 – Settlement Rod Locations

Monitoring Section[1]	Point ID	Approx. Station/Offset	Approx. Elevation of Ground Surface[2] (m)	Estimated Elevation of Rod Anchor[3] (m)
Gas main - W-S Ramp	DSR1	10+197 RSH	227.0	224.4
Gas main - W-S Ramp	DSR2	10+197 LSH	227.0	224.4
Gas main - W-N Ramp	DSR3	13+130 LSH	228.5	224.4

Monitoring Section[1]	Point ID	Approx. Station/Offset	Approx. Elevation of Ground Surface[2] (m)	Estimated Elevation of Rod Anchor[3] (m)
Gas main - S-E/W Ramp	DSR4	10+295 RSH	228.5	224.4
TOTAL:	**4**			

1. Station referenced to Ramp centreline.
2. Ground surface elevation estimated following completion of subexcavation and backfill operation, prior to embankment construction.
3. Based on invert elevation of gas main from As-Laid drawings, to be confirmed by hydrovaccing.

The Contractor shall install DSRs as shown on the Contract Drawings and the Typical Installation Detail, in addition to what is stated below.

7.1.3 Rod

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

7.1.4 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting at the bottom of the borehole. The bottom portion of the rod shall be fixed against the surrounding native soil by grouting the bottom 0.5 m of the borehole to form a concrete/soil anchor.

Once grouting is completed and the rod anchor grout has set, the contractor shall pour clean sand in the lower 0.5 m length of the borehole above the concrete/soil anchor to create a base for the end of the friction reducing sleeve to rest on.

The elevation of the bottom of the rod anchor shall be determined by measuring the length of the rod to the ground surface elevation.

7.1.5 Friction-Reducing Sleeve

The friction-reducing sleeve shall be installed over the entire length of the rod above the rod anchor and sand, extending up to ground surface.

7.1.6 Extension of Rod

The SP rods shall be extended upwards as the embankment widening is constructed so that the top of the rod is always at least 0.3 m, but not more than 2 m above the surrounding fill.

7.1.7 Protective Surround

The CSP, friction-reducing sleeve and sand surround shall be extended concurrent with the rods, where applicable. The SP rod shall be in the centre of the CSP and friction-reducing sleeve. The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the sleeve.

7.1.7 Miscellaneous Installation Details

The elevation, northing and easting of the top of the rod shall be surveyed by the Contractor.

The total distance from the rod anchor to the top of the rod shall be measured and recorded by the Contractor to an accuracy of ± 2 mm or better.

The Contractor is responsible for preventing damage to the settlement rod during the fill placement process and wall construction. If the rod is damaged during fill placement, the rods, friction-reducing sleeve and protective surround shall be replaced before resuming the fill placement.

8.0 QUALITY ASSURANCE – Not Used

9.0 MEASUREMENT FOR PAYMENT

Measurement for payment will be made on the basis of the number of units of DSRs installed, including extension through the embankment construction.

10.0 BASIS OF PAYMENT

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment and Material to do the work, including all appurtenances and extension through the embankment costruction.

<u>EXPANDED POLYSTYRENE EMBANKMENT</u> – Item No.

Special Provision

1.0 SCOPE

This special provision covers the requirements for the supply and construction of the rigid expanded polystyrene embankment fill and associated works as shown on the Contract Drawings.

2.0 REFERENCES

2.1 General

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This special provision refers to the following standards, specifications or publications.

Ontario Provincial Standard Specifications, Construction

OPSS.PROV 212	Earth Borrow
OPSS.PORV 501	Compacting
OPSS.PROV 517	Dewatering
OPSS.PROV 904	Concrete Structures

Ontario Provincial Standard Specifications, Materials

OPSS.PROV 1010	Aggregates – Base, Subbase, Select Subgrade, and Backfill Material

National Standards of Canada

CAN/ULC-S102-10	Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies
CAN/ULC-S701-97	Thermal Insulation, Polystyrene, Boards and Pipe Covering

ASTM International

ASTM C177	Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of Guarded-Hot-Plate Apparatus
ASTM C203	Standard Test Method for Breaking Load and Flexural Properties of Block-Type Thermal Insulation
ASTM C518	Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM D1621	Standard Test Method for Compressive Properties of Rigid Cellular Plastics
ASTM D2126	Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging

ASTM D2842	Standard Test Method for Water Absorption by Rigid Cellular Plastics
ASTM D2863	Standard Test Method for Measuring the Minimum Oxygen Content
ASTM D6817	Standard Specification for Rigid Cellular Polystyrene Geofoam

2.2 Subsurface Conditions

The subsurface conditions at the site are described in the Foundation Investigation Report for this Contract.

> High Fill Embankment, Highway 400/89 Reconstruction, Town of Innisfil, Simcoe County, Ministry of Transportation, Ontario. G.W.P. 2438-13-00

3.0 DEFINITIONS

For the purpose of this special provision, the following definitions apply:

Rigid Expanded Polystyrene means moulded rigid blocks produced by a process of pre-expansion, aging and forming of petroleum based raw material.

Rigid Extruded Expanded Polystyrene means rigid boards made by extrusion of expanded polystyrene beads.

Production Lot means the quantity of rigid polystyrene blocks produced in a continuous period of manufacturing the same grade and thickness of product within the same production day.

Contractor's Engineer means an Engineer with a minimum of five (5) years experience related to the design and/or construction of expanded polystyrene systems of similar scope to that in the Contract, or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the Contract. The Contractor's Engineer shall be retained by the Contractor to ensure conformance with the Contract documents and issue of certificate(s) of conformance.

4.0 SUBMISSION AND DESIGN REQUIREMENTS

4.1 Submission of Shop Drawings

At least three (3) weeks before the commencement of work, the Contractor shall submit to the Contract Administrator six (6) copies of the shop drawings and method statement signed and sealed by the Contractor's Engineer that provides full details of materials and construction procedure.

4.2 Details of Delivery, Storage, Handling, and Protection

The Contractor shall submit the method of delivery, storage, handling and protection from damage by weather, traffic, construction staging and other causes as per the rigid expanded polystyrene manufacturer's requirement.

4.3 Details of Construction Methodology

The Contractor shall submit full details of the following.

a) The method of foundation excavation and preparation.
b) Construction of 300 mm thick levelling pad.
c) The method of placement of expanded polystyrene blocks including temporary ballasting and protection of blocks during installation. The shop drawings shall indicate laying pattern and block dimensions on a layer-by-layer basis.
d) The method and limits of placement of polyethylene sheeting.
e) The method of placement of 125 mm thick, 30 MPa reinforced concrete top slab (or equivalent).
f) The method of placement of subbase material.
g) The method of placement of side slope cover.

The Contractor shall submit to the Contract Administrator, for review, the details of the sequence and method of installation at least three weeks prior to the installation of the rigid expanded polystyrene embankments. The submittals shall satisfy the specifications and at a minimum contain the above information and include a detailed description of proposed installation procedures.

Quality test certificates for each production lot supplied, showing compliance with all requirements of this special provision shall be obtained by the Contractor and submitted to the Contract Administrator prior to installation.

A Request to Proceed shall be submitted to the Contract Administrator upon completion of the foundation excavation and preparation and prior to commencement of the installation of the 300 mm thick levelling pad. The next operation after the completion of the foundation excavation and preparation shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

A Request to Proceed shall be submitted to the Contract Administrator upon completion of the 300 mm thick levelling pad and prior to placement of the expanded polystyrene blocks. The next operation after completion of the levelling pad shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

A Request to Proceed shall be submitted to the Contract Administrator upon completion of the placement of the expanded polystyrene blocks and prior to commencement of the placement of the polyethylene sheeting and reinforced concrete top slab. The next operation after the completion of the placement of the expanded polystyrene blocks shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

A Request to Proceed shall be submitted to the Contract Administrator upon completion of the placement of the polyethylene sheeting and reinforced concrete top slab and prior to commencement of the placement of the subbase material and side slope cover. The next operation after the completion of the placement of the polyethylene sheeting and reinforced concrete top slab shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

4.4 Details of Material to be Supplied

The Contractor shall submit:

- A general statement as to the type, composition, and method of production of the material.
- The manufacturer’s name, address, phone number, identification of a contact person and description of background experience in the manufacturing of the rigid expanded polystyrene.
- An identification of a laboratory accredited by the Standards Council of Canada to conduct the testing of the physical and mechanical properties of the rigid expanded polystyrene.

- The physical and mechanical properties of the rigid expanded polystyrene including:
  - Geometry
  - Nominal Density
  - Compressive Strength
  - Flexural Strength
  - Thermal Resistance
  - Dimensional Stability
  - Flammability
  - Water Absorption
- Aging and durability characteristics of the polystyrene including the chemical, biological and ultra-violet degradation resistance of the rigid polystyrene.
- A sample of the expanded polystyrene material to the Contract Administrator for review.

Each block of the same production lot shall be stamped with the same production code showing plant identification, type and date of production. The polystyrene shall be free from defects affecting serviceability.

5.0 MATERIALS

5.1 Granular Levelling Pad

The levelling pad shall consist of a Granular 'A' material with gradation and physical requirements as specified in OPSS.PROV 1010.

5.2 Rigid Expanded Polystyrene

5.2.1 Material Requirements

Requirements shall be as shown in Table 1 and as described below.

Table 1 – Material Properties

PROPERTY	UNIT	REQUIREMENTS	TEST PROCEDURE
Geometry - Linear Dimensions - Flatness - Squareness	mm (min)	1200 x 600 x 300 ± 1% 10 mm in 3 m ± 0.5%	--
Nominal Density	kg/m^3 (max)	50	--
Compressive Strength at 5% Deformation	kPa (min)	115	ASTM D1621 (Procedure A)
Flexural Strength	kPa (min)	240	ASTM C203
Dimensional Stability	% linear change (max)	1.5	ASTM D2126
Thermal Resistance	$m^2 \cdot {}^oC/W$ (min for 25 mm thickness)	0.7	ASTM C177 or C518
Flammability	Limiting Oxygen Index (min)	24	ASTM D2863
Water Absorption	% by Volume (max)	4	ASTM D2842

Geometry

The expanded polystyrene shall be supplied in the form of rectangular parallel blocks of minimum acceptable dimensions of 1200 mm x 600 mm x 300 mm. The maximum deviation from the specified linear dimensions shall be ± 1%.

The flatness of the block faces shall be within ± 10 mm of a line formed by a 3 m straight edge.

The maximum difference in corner-to-corner dimensions (squareness) shall be 0.5%.

The thickness shall be within –3 mm to +5 mm.

Compressive Strength

The minimum compressive strength, measured in accordance with ASTM D1621, Procedure A, shall be 115 kPa at a strain of not more than 5%. The maximum permissible permanent stress level should not exceed 30% of the compressive strength of the material at 5% deformation.

Flexural Strength

The minimum flexural strength of the polystyrene shall be 240 kPa. The flexural strength shall be determined in accordance to ASTM C203, Method 1, Procedure B.2.7.4 Dimensional Stability.

Dimensional Stability

Dimensional Stability shall be determined in accordance with ASTM D2126, Procedure G. A tolerance of 1.5% shall be satisfied.

Thermal Resistance

The thermal resistance shall be 0.7 $m^2.^oC/W$ for a 25 mm thickness using the following equation and using the average value from three specimens:

$$R_{25\,mm} = \frac{R}{thickness\ (mm)} \cdot 25mm$$

The thermal resistance shall be measured in accordance with ASTM C177 or C518.

Flammability

The expanded polystyrene shall be classified as to surface burning characteristics in accordance with CAN/ULC-S102-10 having a flame spread rating less than 500. The expanded polystyrene shall have a minimum limiting oxygen index measured in accordance with ASTM D2863.

Water Absorption

The water absorption as measured by ASTM D2842 shall be limited to 4% by volume.

Chemical Resistance

The expanded polystyrene shall be resistant to common inorganic acids and alkalis. A table identifying the chemical resistance as either resistant limited or not resistant shall be submitted.

Biological Resistance

The expanded polystyrene shall be resistant to biological degradation caused by organisms or enzymes.

Environmental

The expanded polystyrene shall be inert, non-nutritive and highly stable and shall not produce undesirable gases or leachate.

Polyethylene Sheeting

The protective sheeting shall be at a minimum 10 mil (0.25 mm) polyethylene sheeting or better if specified elsewhere in the Contract.

Concrete Top Slab

The concrete top slab shall consist of 30 MPa reinforced concrete as shown on the Contract Drawings.

5.2.2 Delivery, Storage, Handling and Protection of Material

The product shall be suitably marked to identify its type, number and the manufacturer's name or trademark.

The Contractor shall protect the expanded polystyrene from exposure to moisture and sunlight to avoid ultraviolet degradation as per manufacturer's recommendation.

Protection of materials and works from damage by weather, traffic, construction staging, fire or vandalism and other causes shall be the responsibility of the Contractor.

EPS shall not be exposed to open flame or other ignition source. The Contractor shall protect the EPS blocks from petroleum-based products such as gasoline and diesel fuel and organic solvents such as acetone, benzene and paint thinner.

6.0 EQUIPMENT

All cutting of polystyrene materials shall be by electric equipment or by hand.

Heavy equipment shall be limited in weight and size and restricted in operation to avoid damaging the expanded polystyrene as per the manufacturer's requirement.

7.0 CONSTRUCTION

7.1 Qualification

The Contractor shall have on site at the commencement of the work, a representative of the supplier of the rigid expanded polystyrene to advise on recommended construction procedure.

The Contractor shall maintain liaison with the supplier throughout the construction of the embankment for advice and guidance as required. Periodic site visits by the supplier should be coordinated as required.

7.2 Foundation Excavation

Foundation excavation shall be carried out to the design elevations shown on the Contract Drawings. Any softened, loosened or deleterious materials at the foundation footing elevation shall be subexcavated and replaced with Granular ‘A’ or Granular ‘B’ material.

7.3 Levelling Pad

Place, level and compact a layer of Granular ‘A’ material in accordance with OPSS.PROV 501 to within ±30 mm of the design elevation. The levelling pad shall not deviate by more than 10 mm at any place on a 3 m straight edge over the limits of the bottom course of blocks. The levelling pad shall not be placed on standing water, accumulated snow or ice or frozen ground. The levelling pad must be placed in-the-dry.

7.4 Installation of Blocks

- The individually marked blocks shall be placed on the prepared levelling pad. The top surface of the first layer of blocks is to be set plane and level. Local trimming of the blocks may be necessary.

- Subsequent successive layers shall be oriented with the long axis of blocks positioned at 90º to the previous layer in order to avoid continuous joints. Block joints shall be offset and staggered between layers.

- A continuous check shall be kept to ensure the evenness of the blocks is satisfactory in each layer. Blocks shall be laid with joints with maximum opening of 10 mm between blocks. Differences in heights between adjacent blocks in the same layer should not exceed 5 mm.

- Sloping end adjustments at the abutments shall be accomplished by levelling terraces in the subsoil in accordance with the block thickness.

- Temporary ballast shall be provided as necessary to prevent movement of expanded polystyrene both in storage and as placed due to windy conditions. Timber fasteners or equivalent shall be used as necessary.

- The expanded polystyrene embankment shall be protected from accidental ignition due to welding, smoking, grinding or cutting tools, etc. The Contractor shall take all necessary precautions to prevent ignition of the expanded polystyrene.

- The expanded polystyrene shall be protected from organic solvents and other aggressive, harmful chemicals during construction. The proposed method of protection during construction shall be submitted to the Contract Administrator for review.

- Exposed blocks shall be covered immediately to avoid possible burrowing by animals.

- Individually marked blocks shall be fabricated and placed to ensure the top surface matches the superelevation and crossfall shown on the drawings.

- The top surface and side surfaces of the expanded polystyrene shall be covered with 10 mil polyethylene sheeting extending onto adjacent work at the longitudinal ends of the embankment. All joints shall be lapped a minimum of 300 mm to provide a fully sealed enclosure.

7.5 Concrete Top Slab

The concrete top slab shall be poured after the polyethylene sheeting is fixed in place. Place 125 mm thick 30 MPa reinforced concrete in accordance with OPSS.PROV 904 to within ± 30 mm of the design elevation.

7.6 Side Slope Cover

The side slopes of the rigid expanded polystyrene embankment shall be covered with granular fill as detailed elsewhere in the Contract Drawings.

8.0 QUALITY ASSURANCE

8.1 General

The Contract Administrator may undertake an independent testing program of the expanded polystyrene. Sampling and testing will be carried out in conformance with the relevant test procedure. The physical and thermal property testing identified in Table 1 will be conducted. A recognized testing laboratory accredited by the Standards Council of Canada shall conduct the testing.

8.2 Sampling Frequency

Sufficient sample material shall be obtained from blocks randomly selected by the Contract Administrator from each production lot as soon as the material arrives on site. As a minimum, three (3) blocks shall be tested.

8.3 Acceptance or Rejection

Failure of any one of the sample blocks to comply with any requirements of this special provision shall be cause for rejection of the production lot from which it was taken. Culling of the rejected material by the Contractor shall be permitted and a proposal for retesting the remaining material shall be submitted to the Contract Administrator to demonstrate conformance with the specification. Retesting of material remaining from culling rejected material shall be at no cost to the Owner.

Replacement of the blocks shall be at the Contractor’s expense.

9.0 MEASUREMENT FOR PAYMENT

9.1 Actual Measurement

Measurement will be by volume in cubic metres measured in its original position and based on cross-sections.

10.0 BASIS OF PAYMENT

10.1 Expanded Polystyrene Embankment - Item

Payment at the Contract price for the above tender item shall be full compensation for all labour, materials and equipment to do the work, including but not limited to polyethylene sheeting, any dewatering/ unwatering of the excavation and/or temporary ballasting or other measures as may be necessary for the construction of all components of the rigid expanded polystyrene.

The concrete top slab and granular levelling pad shall be paid for under the appropriate tender items as detailed elsewhere in the Contract.

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For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario, L5N 7K2
Canada
T: +1 (905) 567 4444