FOUNDATION INVESTIGATION REPORT
PROPOSED WIDENING OF SOUTHBOUND HIGHWAY 400 BRIDGE OVER THE SEVERN RIVER
W.P. 2360-06-00, SITE 42-86/1&2, GEOCRES31D-564

McCormick Rankin

TRANETOB20462AA
January 07, 2014

REPORT

Coffey
20 Meteor Drive Etobicoke Ontario M9W 1A4 Canada

CONTENTS

FOUNDATION INVESTIGATION REPORT
PROPOSED WIDENING OF SOUTHBOUND HIGHWAY 400 BRIDGE
OVER THE SEVERN RIVER, W.P. 2360-06-00, SITE 42-86/1&2

1 INTRODUCTION

Coffey was retained by McCormick Rankin (MRC) to carry out a foundation investigation for the proposed Highway 400 southbound Bridge widening for realigned northbound lanes over the Severn River in the Township of Tay, Ontario.

The existing northbound Severn River Bridge is an approximately 31 m long single span, rigid frame concrete structure, supported on shallow foundations bearing on mass concrete inset 0.3 m into bedrock. This circa 1957 structure will be demolished. The existing southbound bridge which was built in 1991 will be widened to accommodate the proposed realigned northbound lanes. The widening will take place towards the median of the existing highway.

At the present time, the bridge widening is expected to be similar to the existing southbound bridge, which is a single span, rigid frame concrete structure with a clear span length of 27.5 m and a total length of 46.5 m.

The purpose of this investigation was to obtain information about the subsurface conditions at the proposed bridge widening site by means of boreholes, and to determine the engineering characteristics of the overburden soils and of the underlying bedrock, by means of field and laboratory tests.

The findings of the investigation are presented in this report.

2 SITE DESCRIPTION AND GEOLOGY

The site is located on Highway 400 at the mouth of Severn River at Little Lake joining Georgian Bay, as shown on Drawing 1. The surrounding area is generally gently rolling and rock outcrops are visible in the vicinity.

According to the Physiography of Southern Ontario by L.J. Chapman and D.F. Putnam, 1984, the project site is located at the interface of Physiographic Regions ‘Algonquin Highland’ and ‘Carden Plain’.

The geology at the site is dominated by felsic igneous bedrock with shallow overburden. Bedrock at the site is known as granite and biotite gneiss of the Grenville Province.

According to Map 2418 of Ontario Geological Survey, the site is located immediately north of the confluence of Precambrian rocks with more recent Ordovician formations. The main body of geologic formations consist of late to middle Cambrian clastic metasediments which are comprised of conglomerate, greywacke, arkose, calcareous sandstone and siltstone, shale and derived metamorphic rocks, while in the vicinity of the site late Precambrian granitic to syenitic rocks are also found.

Previous site specific investigations show the presence of granite gneiss rocks.

Overburden, where present, consists of silty sands, either surficial loose deposits or as dense glacial till above the bedrock. Silty clay is also present in areas where bedrock is relatively deeper in occurrence. Organic mucks are also common in marshy areas.

3 INVESTIGATION PROCEDURES

The field work for this investigation was performed during the period of May 23 to June 14, 2013 and consisted of drilling and sampling eight boreholes. Boreholes 1, 2, 7 and 8, which were advanced from the top of the existing road embankment by augering, were terminated upon encountering refusal on the augers, on possible bedrock surface. The depth of these boreholes ranged from 5.8 to 10.7 m.

Boreholes 3 and 5 were also advanced from the top of the road embankment but in these boreholes rock coring was implemented upon encountering refusal at depths of 8.3 and 13.1 m, respectively. In these boreholes, the bedrock was proven by diamond drilling and obtaining NQ size rock cores to depth of 12.1 and 16.5 m, respectively, below the ground surface.

Boreholes 4, 4A and 6 were advanced on water from a barge, in the River. These boreholes were advanced in the overburden by washboring methods inside a steel casing. Upon encountering refusal to washboring at depths of between 3.7 m and 5.1 m below the water's surface in the River, the bedrock was proved in Boreholes 4 and 6 by rock coring and diamond drilling methods and obtaining BQ size rock cores to between 3.0 and 3.1 m below the bedrock surface or to depths of between 6.8 and 8.1 m below the water surface in the River. Overburden in Borehole 4 could not be sampled due to the presence of rock fill and therefore another borehole (BH 4A) was put down nearby Borehole 4, away from rock fill, in order to obtain samples of the overburden and to carry out standard penetration tests.

The drilling of boreholes put down from land was carried out by Davis Drilling of Milton, Ontario, while boreholes from the barge were effected by Walker Drilling of Utopia, Ontario.

The field work was carried out under the supervision and direction of an engineer from our office. The boreholes were advance using a track mounted or a barge mounted drilling rig, outfitted with tools and equipment for soil sampling and testing.

The boreholes were advanced using three different methods (i.e. continuous–flight, hollow-stem augers and washboring in the overburden and rock coring) depending on the subsurface conditions.

Samples in the overburden were taken at frequent intervals of depth by the Standard Penetration Test method (SPT), in general accordance with ASTM D1586. This test consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm O.D. split barrel (SS-split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of the compactness condition of cohesionless granular soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils).

Rock coring was implemented using NQ or BQ size cores.

Boreholes 1, 2, 3, 5, 7 and 8 were advanced by a track mounted CME 55 drill rig owned and operated by Davis Drilling Ltd. Of Milton, Ontario, while Boreholes 4, 4A and 6 were advanced from a barge using a D25 Diedrich type drill rig owned and operated by Walker Drilling Ltd. of Utopia, Ontario.

Groundwater conditions in the open boreholes were observed during drilling and upon completion. In addition, a piezometer was installed in each of Boreholes 2 and 8 to enable groundwater level monitoring in the boreholes over a prolonged period of time without interference from surface water. The remaining boreholes were grouted upon their completion using a cement/bentonite mixture as per MTO procedures. Boreholes 2 and 8, in which piezometers were installed, were not decommissioned, as piezometers may be useful during the construction. We recommend that a clause be included in the Contract Documents to decommission these two boreholes during the construction, as part of the Contract.

The borehole locations were established in the field by Coffey engineering staff, in relation to the existing features. The locations were then tied in and the geodetic elevations of the ground at the borehole locations were determined by the client's surveyors. The survey information was provided to us.

The soil and rock samples were transported to our geotechnical laboratory in Toronto for further examination and classification. A laboratory programme, consisting of natural moisture content, grain size analyses, and Atterberg Limit tests, was performed on selected representative soil samples and point load tests on selected rock cores. In addition selected rock cores were sent to Golder Associates Laboratory in Mississauga, Ontario to carry out unconfined compression tests.

4 SUBSURFACE CONDITIONS

The subsurface conditions were explored at eight boreholes plus a ninth borehole (BH 4A) adjacent to Borehole 4. The plan locations of the boreholes and profile are shown on Drawing No. 1, while stratigraphic sections at foundation locations are presented on Drawing Nos. 2 and 3.

Boreholes 1, 3, 5 and 7 were advanced from the top of the highway embankment, from the paved portion of the highway and contacted 120 to 190 mm of asphaltic concrete underlain by granular pavement fill, which is in turn underlain by embankment fill to depths of 7.3 to 13.1 m or to El. 176.6 to 172.1 m.

Borehole 2 was advanced from the unpaved portion of the highway embankment and contacted below a 0.1 m thick veneer of topsoil, embankment fill extending to a depth of 5.3 m below the ground surface or to El. 177.3 m.

In Boreholes 5 and 7, the embankment fill extends right down to the surface of the bedrock /inferred bedrock, while in Boreholes 1, 2 and 3, the embankment fill is underlain by a 0.5 m thick basal sand/silty sand layer, overlying the bedrock, at El. 176.8 to 175.9 m.

Borehole 8 was also advanced from the unpaved portion of the highway embankment and in this borehole, below 0.15 m topsoil, the embankment fill is underlain by 1.7 m of gravelly sand at a depth of 7.3 m or at El. 177.1 m, which is further underlain at a depth of 9.0 m below the ground surface or at El. 175.4 m, by a silty clay deposit. The silty clay deposit at this borehole location is 1.7 m thick and extends to 10.7 m (El. 173.7 m) where the surface of the bedrock was inferred from refusal to further augering.

Boreholes 4, 4A and 6 were advanced from a barge. Below 1.7 to 2.2 m water in the river/lake, the river/lake bottom was contacted at between El. 174.3 m and 173.8 m. The overburden encountered in Boreholes 4A and 8 consisted of basically sandy (granular) soils to the surface of the bedrock at El. 172.6 m and 170.9 m, respectively. In Borehole 4A, a 0.6 m thick silty clay layer was encountered, in between two layers of granular overburden soils. In Borehole 4, the overburden was mixed with rock fill.

In summary, below up to about 13 m of embankment fill and some native shallow overburden, the surface of the bedrock at the borehole locations were found/inferred at between El. 176.8 m (BH 2) and 170.9 m (BH 6).

At the locations of Boreholes 1, 2, and 3 on the east side of the River, the surface of the bedrock was contacted/inferred at El. 176.8 and 175.9 m (relatively level). However at the location of Borehole 4 it was contacted at El. 172.3 m (at an elevation of about 4 m lower). This is likely to be due to previous construction activities and possibly due to erosion by the River. On the west side of the River, the surface of the bedrock at Boreholes 5 and 8 were contacted/inferred at El. 172.1 and 173.7 m, respectively, while at Borehole 7, there appears to be a high point, as the surface of the bedrock at this location was inferred at El. 176.2 m. At Borehole 6, which was drilled in the River, the surface of the bedrock was contacted at El. 170.9 m (i.e. at a low elevation), probably due to river erosion or also possibly due to construction activities, similar to Borehole 4.

The bedrock was found to consist of greyish/pinkish granite gneiss of generally sound quality.

Details of the subsurface conditions encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A. The following paragraphs are only meant to amplify and complement these data.

4.1 Asphalt

Boreholes 1, 3, 5 and 7, which were advanced from the paved portion of the highway embankment, contacted 120 mm (BH 7) to 180-190 mm (BH 1, 3 and 5) of asphaltic concrete.

4.2 Topsoil

In Boreholes 2 and 8, which were drilled from the existing highway embankment, a 0.1 to 0.15 m thick topsoil layer was found at the ground surface level.

4.3 Pavement and Embankment Fill

Boreholes 1, 2, 3, 5, 7 and 8 were advanced from the existing highway embankment and contacted about 5.3 to 12.9 m thick pavement and/or embankment fill.

In Boreholes 5 and 7, the embankment fill was found to extend to the surface of the bedrock/inferred bedrock at depths/elevations of 13.1 m /172.1 m and 9.3 m/ 176.2 m, respectively.

In Boreholes 1, 2, 3 and 8, the embankment fill was found to be underlain by native overburden at depths of 5.3 to 7.8 m below the ground surface or at El. 177.3-176.4 m.

Granular pavement fill was contacted below the paved portion of the roadway, underlying the asphaltic concrete. The grain size distribution of four samples from the granular pavement fill is given in Appendix B in Figure B-1. These indicate the following grain size distribution:

Gravel:	22-40%
Sand:	46-63%
Silt & Clay:	12-16%

The embankment fill generally consists of a heterogeneous mixture of silty sand to sandy silt with traces to some clay and gravel size particles. From its grain size distribution and the general appearance of the samples from the fill, as retrieved by the split spoon sampler, it appears that the fill was derived from the indigenous glacial till deposits. The fill was found to be generally clean (i.e. devoid of deleterious soils/materials, such as organics). The presence of occasional clayey zones was also noted.

The grain size distribution of ten samples from the embankment fill is given in Figure B-2, in an envelope form, in Appendix B. The following grain size distribution is indicated:

Gravel:	2-10%

Sand:	49-66%
Silt:	18-27 %
Clay:	13-17%

Figure B-3 in Appendix B shows the grain size distribution of samples from the more siltier zones of the fill. The curves indicate the following grain size distribution:

Gravel:	2-9%
Sand:	34-41%
Silt:	33-46%
Clay:	17-18%

There are occasional gravelly zones which were encountered in the makeup of the embankment fill. Such a zone was contacted in Borehole 5 immediately beneath the pavement fill and was found to extend to a depth of 3.7 m or to El. 181.5 m. The grain size distribution curve of a sample is given in Figure B-4, indicating the following:

Gravel:	41%
Sand:	44%
Silt:	13%
Clay:	2%

The embankment fill is considered to be a typically granular (non-cohesive) soil. The presence of cobbles and boulders should always be anticipated in fill which are derived from glacial till (which the bulk of the embankment fill at this site appears to be), unless, of course, such coarser particle sizes were removed from the fill during its construction. As well, some of the coarser gravel, which is presented, may be misrepresented in the split-spoon-samples (i.e. the percentage of gravel may be higher than shown on the results presented). Standard Penetration Tests (SPT) performed in the embankment fill yielded N-values which generally ranged from 3 to 57 blows/0.3m. There are some higher recorded values, but there were attributed to the presence of oversize gravel particles in the fill. The recorded N-values indicate a very loose to very dense relative density. In most cases, the recorded average N-values lie in the range of 10 to 20 blows/0.3m, which indicate a generally compact material with some loose and occasional very loose and dense zones. From these results it appears that some systematic compaction was applied when the embankment was first constructed some twenty years ago, but the compactive effort was applied somewhat sporadically where some zones received little or no compaction.

4.4 Native Overburden

Natural (i.e. native) overburden was contacted in Boreholes 1, 2, 3, 4A, 6 and 8. The thickness of the native overburden at the borehole locations was found to range from 0.5 m at Boreholes 1, 2 and 3; 1.7 m at Boreholes 8 and 4A to 2.9 m at Borehole 6. The native overburden was found to typically consist of sandy (granular) soils but layers of a cohesive (silty clay) deposit were contacted in Boreholes 4A and 8, as described in the following paragraphs.

4.4.1 Silty Sand, Sand, Gravelly Sand and Sand & Gravel

Basically granular basal soils, consisting of silty sand to sand, were contacted in Boreholes 1, 2, 3, 4A and 6. At some borehole locations, these deposits were found to contain traces to some gravel.

These deposits were contacted in Boreholes 1, 2 and 3, immediately below the embankment fill at elevations ranging from 177.3 to 176.4 m and extended to the surface of the bedrock/inferred bedrock at a depth of 0.5 m below these elevations (i.e. 0.5 m thick deposit) at El. 176.8 to 175.9 m.

The grain size distribution of a sample from Borehole 3 is given in Figure B-5 in Appendix B, which indicates the following grain size range:

Gravel:	8%
Sand (mostly fine sand):	65%
Silt &Clay:	27%

These granular (non-cohesive) soils were found to be wet and water bearing and based on N-values of 38 to greater than 100 blows/0.3 m, their relative density is described as dense to very dense.

Boreholes 4A and 6 were advanced from a barge in the River. In Borehole 6, a 0.8 m thick sand layer was contacted immediately below the River bottom at El. 173.8 m. A Standard Penetration test performed in this deposit yielded an N-value of 7 blows/0.3 m, indicating a loose condition. In Borehole 4A, a 0.6 m thick sand layer was contacted at a depth of 1.1 m below the River bottom or at El. 173.2 m. This deposit extended to the surface of the bedrock and based on a recorded N-value of 22 blows/0.3 m, its relative density is described as compact.

In Borehole 8, a gravelly sand deposit was contacted below the embankment fill at depth/elevation of 7.3 m/177.1 m. The thickness of this deposit, which was identified as a possible fill, extended to depth/elevation of 9.0 m/175.4 m at the surface of underlying basal silty clay.

The grain size distribution of the sample recovered from this granular (non-cohesive) deposit is presented in Figure B-6 (Appendix B). The results are as follows;

Gravel:	26%
Sand:	65%
Silt &Clay:	9%

From a recorded N-value of 16 blows/0.3 m, the relative density of this layer can be described as compact.

Sand and gravel layers were contacted in Boreholes 4A and 6. In Borehole 4A, the deposit was contacted immediately below the River bottom at El. 174.3, and extended to the surface of underlying silty clay at El. 173.8 m (i.e. 0.5 m thick). From a recorded N-value of 6 blows/0.3 m this river bottom deposit is described as loose. In Borehole 6, another sand & gravel layer was contacted at a depth of 2.0 m below the River bottom. This deposit was found to be 0.9 m thick and extended to the surface of the bedrock at El. 170.9 m. From a recorded N-value of in excess of 100 blows/0.3 m, the relative density of this basal granular soil is considered very dense.

4.4.2 Silty Sand Till

Borehole 6 contacted at 0.6 m below the River bottom or at El. 173.0 m, a 1.2 m thick glacial till layer consisting of a heterogeneous mixture of silty sand with traces of gravel and clay size particles. The grain size distribution of a sample recovered from this granular (non-cohesive) deposit is given in Figure B-7 in Appendix B. The grain size distribution was found to be as follows;

Gravel:	12%
Sand:	62%

Silt &Clay: 26%

Standard Penetration tests performed in this deposit yielded N-values of 70 and in excess of 100 blows /0.3 m, which indicate a very dense relative density.

4.4.3 Silty Clay

A 0.6 m thick layer of silty clay was contacted in Borehole 4A at a depth of 0.5 m below the River bottom or at El. 173.8 m, sandwiched between two layers of granular soil. Silty clay was also encountered in Borehole 8, at a depth of 9.0 m (El. 175.4 m) and extended to the surface of the inferred bedrock at El. 173.7 m.

Atterberg Limits tests performed on two soil samples retrieved from this cohesive deposit yielded the following index values, as shown in the individual Record of Borehole Sheets and also on the Plasticity Chart in Figure B-8 (Appendix B):

Liquid Limit: 33-43%

Plastic Limit: 15-21%

Plastic Index: 18-22%

These results are characteristic of low to medium plasticity.

N values of 4 and 11 blows/0.3 m were recorded in Boreholes 4A and 8, respectively. Based on these results together with pocket penetrometer tests and visual & tactile examination of the recovered samples, the consistency of the silty clay encountered in Borehole 4A is described as very soft to soft, while in Borehole 8, its consistency is considered stiff.

This deposit is considered to be practically impervious. The deposit, as encountered in Borehole 4A, is considered weak and highly compressible.

4.5 Bedrock

In Boreholes 1, 2, 7 and 8, bedrock was inferred from refusal to augering while in Boreholes 3, 4, 5 and 6, upon encountering refusal on the augers, the presence of bedrock was proven by coring (i.e. diamond drilling) and obtaining rock cores to depths ranging from 3.0 to 3.8 m below the surface of the bedrock. In Boreholes 4 and 6 which were advanced by washboring methods from a barge, BQ size core samples were obtained, while in Boreholes 3 and 5, which were advanced from land, using a larger drilling rig, NQ size rock cores were obtained.

In boreholes where coring was effected, the bedrock was identified as granite gneiss, with a colour varying from light to medium (occasionally darkish) grey with a typically a pinkish tone and/or pink insets. Photographs of the rock cores are attached in Appendix D of this report.

The following table summarizes the bedrock elevations and condition in the boreholes.

Table 4.5.1

Borehole Number	Top of Bedrock Elevation (m)	Coring Size	Total Core Length (m)	T.C.R. (%)**	R.Q.D.(%)***
1	176.2*	N/A	N/A	N/A	N/A
2	176.8*	N/A	N/A	N/A	N/A
3	175.9	NQ	3.8	93-98	70-98
4	172.3	BQ	3.1	98-100	86-100
4A	172.6*	N/A	N/A	N/A	N/A

Borehole Number	Top of Bedrock Elevation (m)	Coring Size	Total Core Length (m)	T.C.R. (%)**	R.Q.D.(%)***
5	172.1	NQ	3.4	100	42-100
6	171.2-170.9	BQ	3.0	100	100
7	176.2*	N/A	N/A	N/A	N/A
8	173.7*	N/A	N/A	N/A	N/A

* inferred ** T.C.R. = total core recovery *** R.Q.D.= rock quality designation

N/A not applicable

From the above table, it can be seen that the surface of the bedrock was contacted or inferred between Elevations 176.8 m (BH 2) and 171.2/170.9 m (BH 6). It is noted that at the south abutment location at Boreholes 1, 2 and 3 locations, the surface of the bedrock is relatively higher and level (i.e. an elevation difference of only 0.9 m in the surface elevations of the bedrock at these three borehole locations) at between El. 176.8 and 175.9 m. But at the location of Borehole 4, the bedrock surface was contacted at El. 172.3 m (i.e. about 4 m lower). This is likely to be due to previous construction activities and possibly due to erosion by the River.

On the west side of the River (i.e. north abutment location), the surface of the bedrock at Boreholes 5 and 8 were contacted /inferred at El. 173.7 – 172.1 m, whereas at Borehole 7, it was inferred at El. 176.2 m (i.e. about 3 m higher). At Borehole 6, which was drilled in the River, the surface of the bedrock was contacted at El. 170.9 m (i.e. at a low elevation), probably, similar to Borehole 4, due to River erosion and/or previous construction activities.

In general, at most borehole locations the top 0.1 to 0.3 m of the bedrock was found to be highly fractured, but below this upper zone, the bedrock appeared to be rather sound.

The percentage of core recovery was 93-100 %, while the RQD values generally varied from 70 to 100 % (excluding the upper 0.3 m in Borehole 5 where the RQD value was only 42%). These values indicate a fair to excellent but generally good to excellent rock quality.

Based on these values and examination of the rock cores, the bedrock below about the top 0.3 m can be described as a sound and massive rock of good to excellent quality, at the cored locations.

To determine the compressive strength and hardness of the rock, a total of five samples were subjected to unconfined compressive testing. The unconfined compressive strength (UCS) of the tested samples ranged from 99.6 to 131.7 MPa with an average of 111.5 MPa. The results of these unconfined compressive tests are given in Appendix D.

Point Load Index tests were performed in our laboratory on 23 rock core samples. The test results are presented in Appendix B. $I_{s(50)}$ values ranging from 1.1 to 8.8 MPa and UCS values (using typical K=24) of 27.5 to 211.0 MPa were recorded.

Based on these results, the rock encountered at the site is classified as typically R4 to R5 (strong to very strong).

4.6 Groundwater Conditions

Groundwater conditions in the open boreholes were observed while drilling and upon completion of each borehole. However, Boreholes 4, 4A and 6 were put down from water's surface (from a barge) in the River, using washboring methods and as such no reliable water level observations could be made in these three boreholes.

In the remaining boreholes the groundwater table was inferred from the observations made in the boreholes to be at between El. 176 and 177 m.

In the piezometers installed in Boreholes 2 and 8, the groundwater table was measured twenty days after the installation at El. 177.1 m and 176.9 m, respectively.

It should be pointed out that the groundwater level at the site could be largely influenced by the regulated water level in the River depending on the requirements of the Trent-Severn waterway system. We took elevations of the water in the River once a day during the period of June 12-13 and 14, 2013, during which time it was measured to be between El. 175.9 and 176.0 m. It should however be pointed out that the water level may and probably did fluctuate during the course of each day. These values should therefore be considered approximate only.

The groundwater table would also be subject to seasonal fluctuations and variations due to major weather events.

For and on behalf of Coffey.

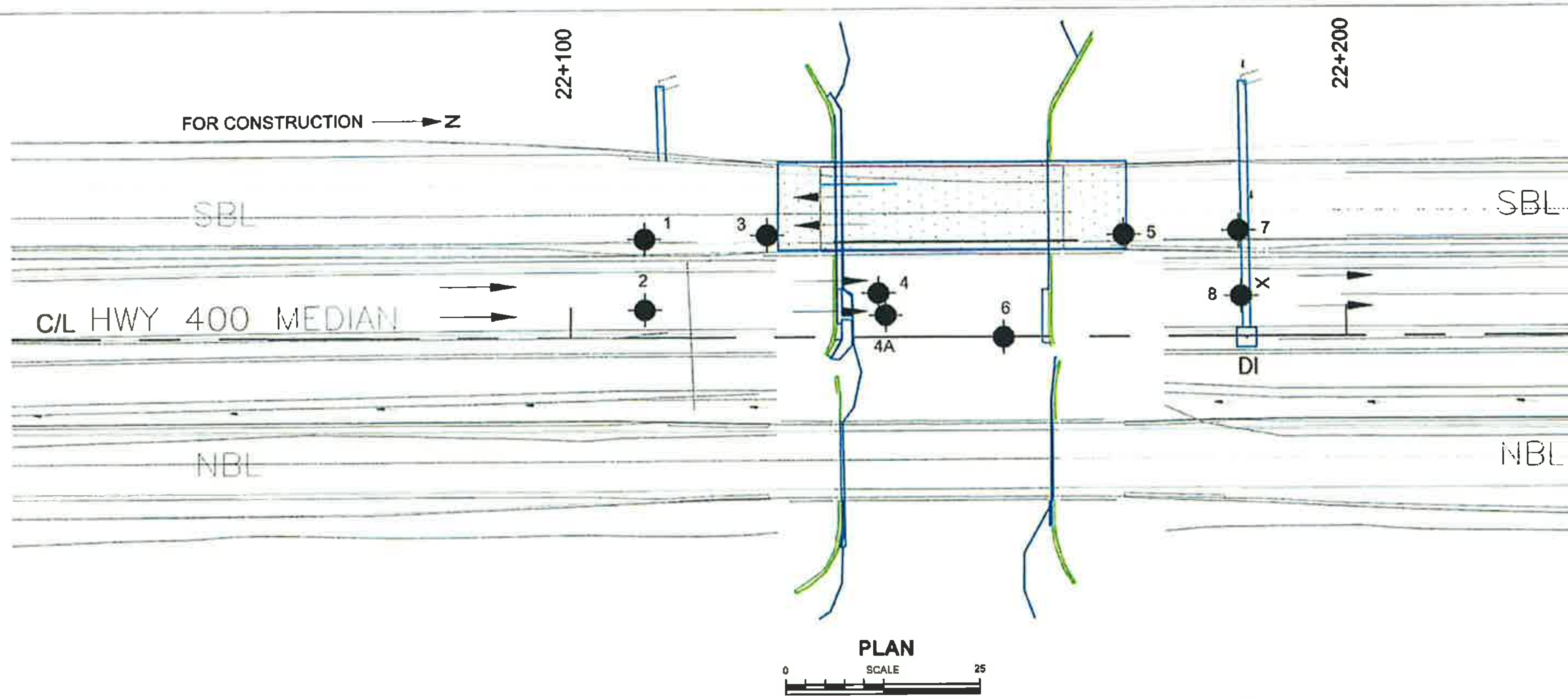
Gwangha Roh, P.Eng., Ph. D.
Senior Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
G. H. ROH
100148471
PROVINCE OF ONTARIO

Zuhtu Ozden, P.Eng.
Senior Principal

REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
PROVINCE OF ONTARIO

Drawings

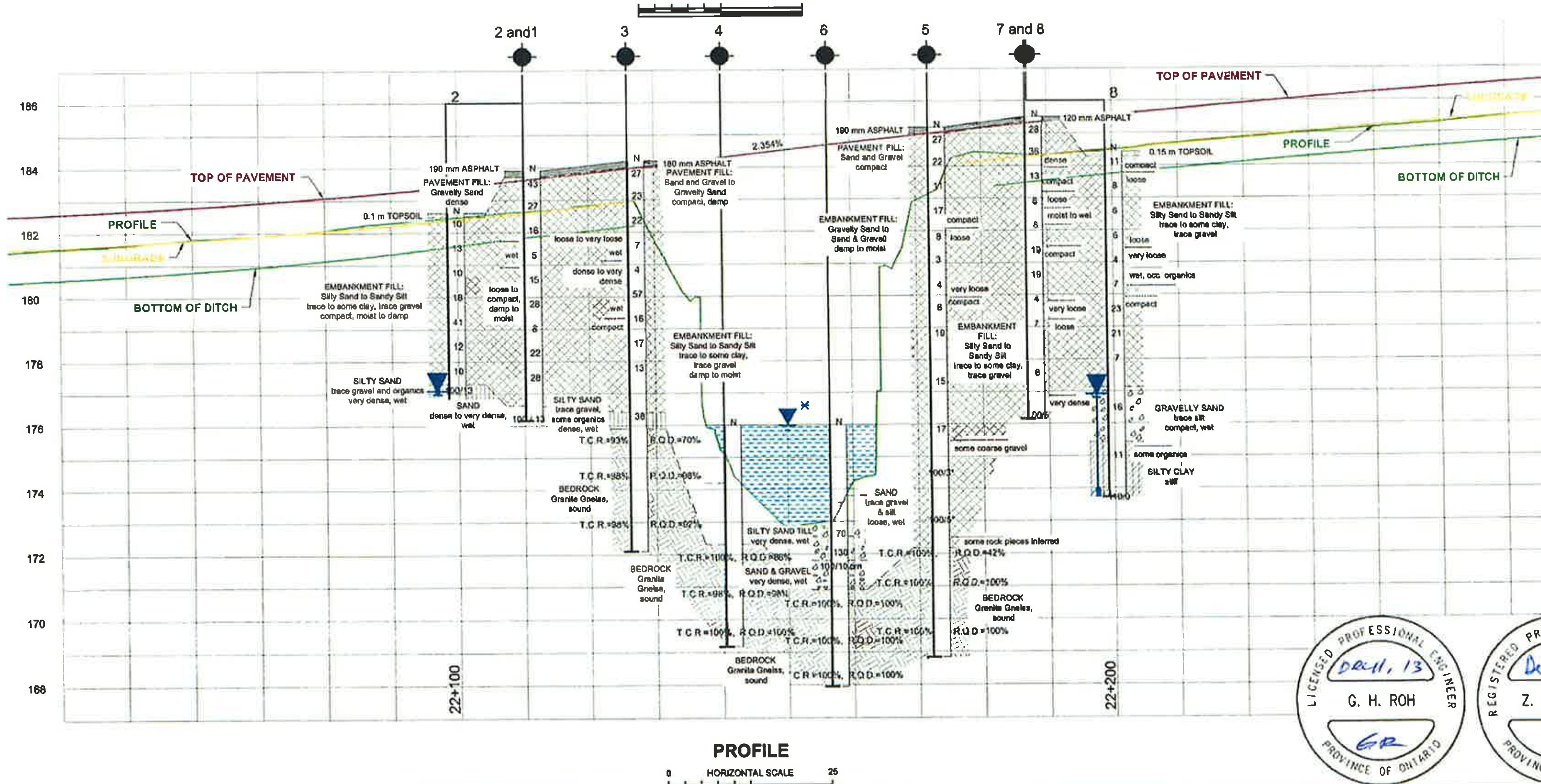


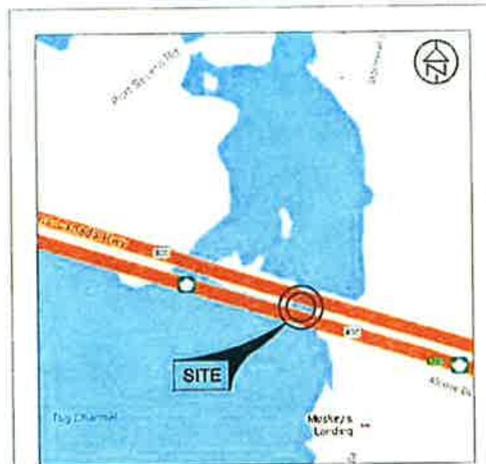
METRIC

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

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.





KEY PLAN
N.T.S.

CONT No. -
W.P.: 2360-06-00

CONTRACT A, HIGHWAY 400, PORT SEVERN RIVER BRIDGE BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

LEGEND

- Borehole
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No	ELEVATION	STATION	OFFSET
BH1	183 9	22+110	12 8m Lt C/L
BH2	182 8	22+110	3 6m Lt C/L
BH3	184 2	22+126	13 3m Lt C/L
BH4	176 0	22+140	5 7m Lt C/L
BH5	185 2	22+172	13 2m Lt C/L
BH6	176 0	22+156	@ C/L
BH7	185 5	22+187	13.7m Lt C/L
BH8	184.4	22+187	5 3m Lt C/L
BH4A	176 0	22+141	2 9m Lt C/L

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

NOTE: This drawing is for subsurface information only.. Surface details and features are for conceptual illustration.

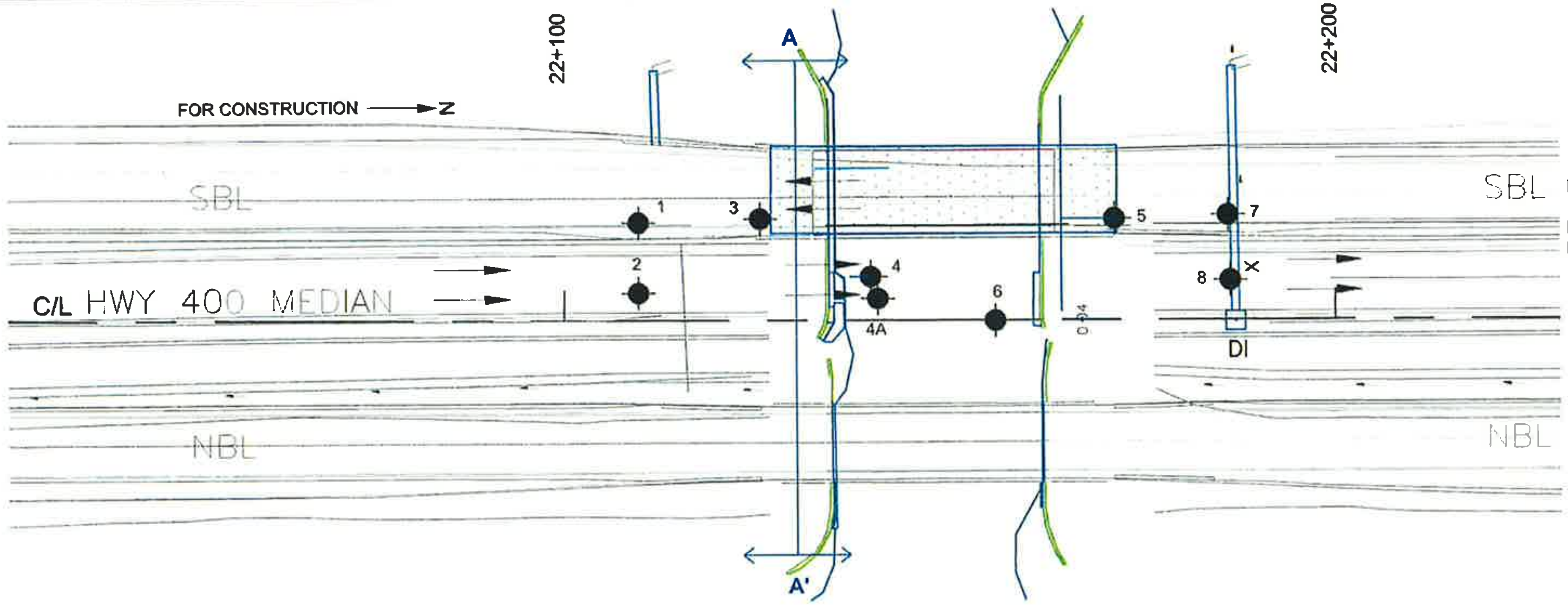
LICENSED PROFESSIONAL ENGINEER — G. H. ROH — Dec 11, 13 — PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER — Z. S. OZDEN — Dec. 11/13 — PROVINCE OF ONTARIO

REVISIONS	DATE	BY	DESCRIPTION

Geocres No -31D-564

TRANETOB20462AA			DIST
SUBM'D	CHECKED	DATE December , 2013	SITE 42-86/1&2
DRAWN SSH	CHECKED SS	APPROVED ZO	DWG 1



PLAN

SCALE 0 25

METRIC

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

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.

CONT No. -

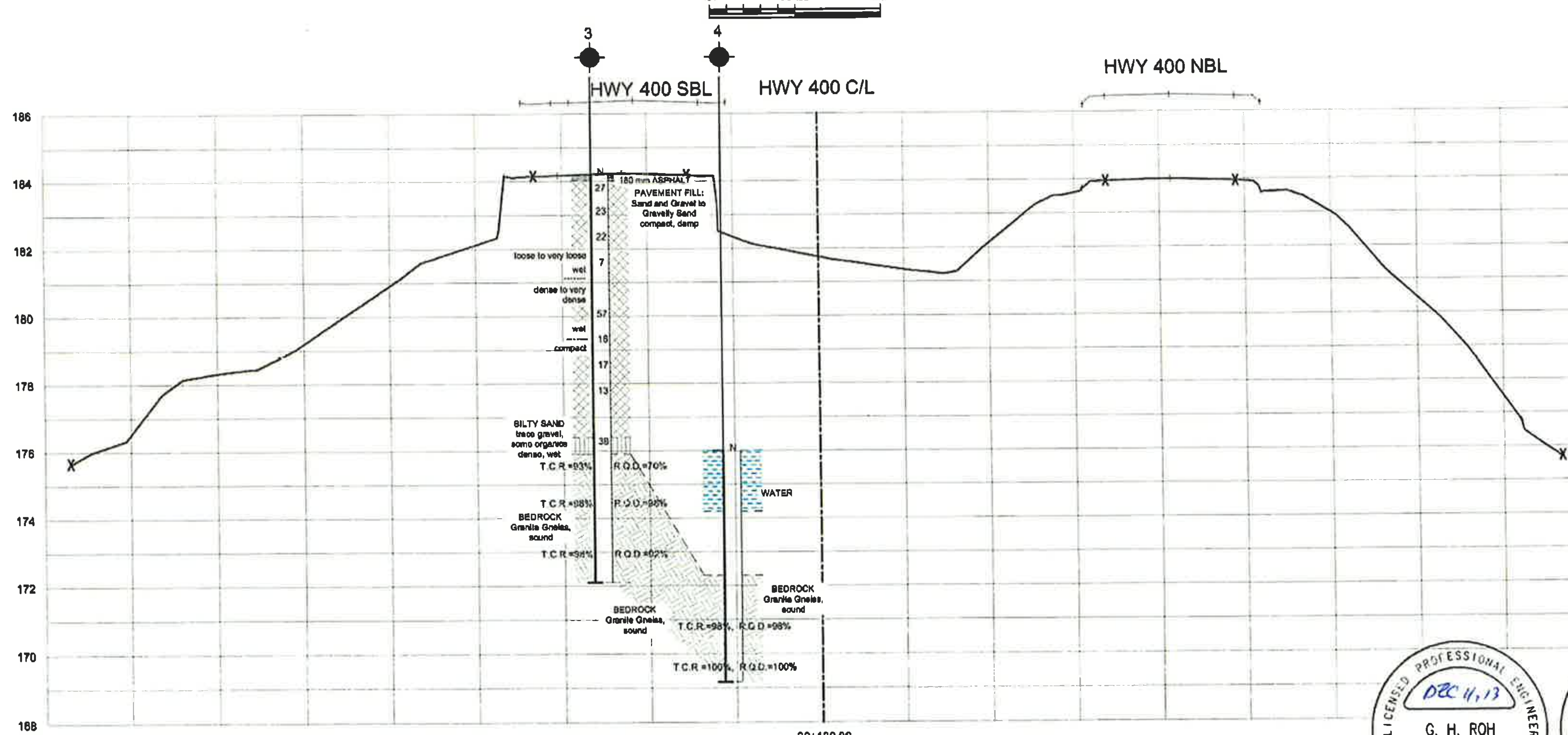
W.P.: 2360-06-00

SHEET

CONTRACT A, HIGHWAY 400, PORT SEVERN RIVER BRIDGE BOREHOLE LOCATION PLAN AND SOIL STRATA-Section A-A'

coffey geotechnics SPECIALISTS MANAGING THE EARTH

KEY PLAN
N.T.S.



SECTION A-A'

HORIZONTAL SCALE 0 10

LEGEND

- Borehole
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- A A' Section

No	ELEVATION	STATION	OFFSET
BH3	184 2	22+125	13 3m Lt C/L
BH4	176 0	22+140	5 7m Lt C/L

-NOTE-

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

NOTE: This drawing is for subsurface information only.. Surface details and features are for conceptual illustration.

LICENSED PROFESSIONAL ENGINEER G. H. ROH DEC 11/13 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER Z. S. OZDEN Dec 11/13 PROVINCE OF ONTARIO

REVISIONS	DATE	BY	DESCRIPTION

Geocres No -31D-564

TRANETOB20462AA			DIST
SUBM'D	CHECKED	DATE December, 2013	SITE 42-86/182
DRAWN SSH	CHECKED GR	APPROVED ZO	DWG 2

METRIC

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

CONT No. -
W.P.: 2360-06-00

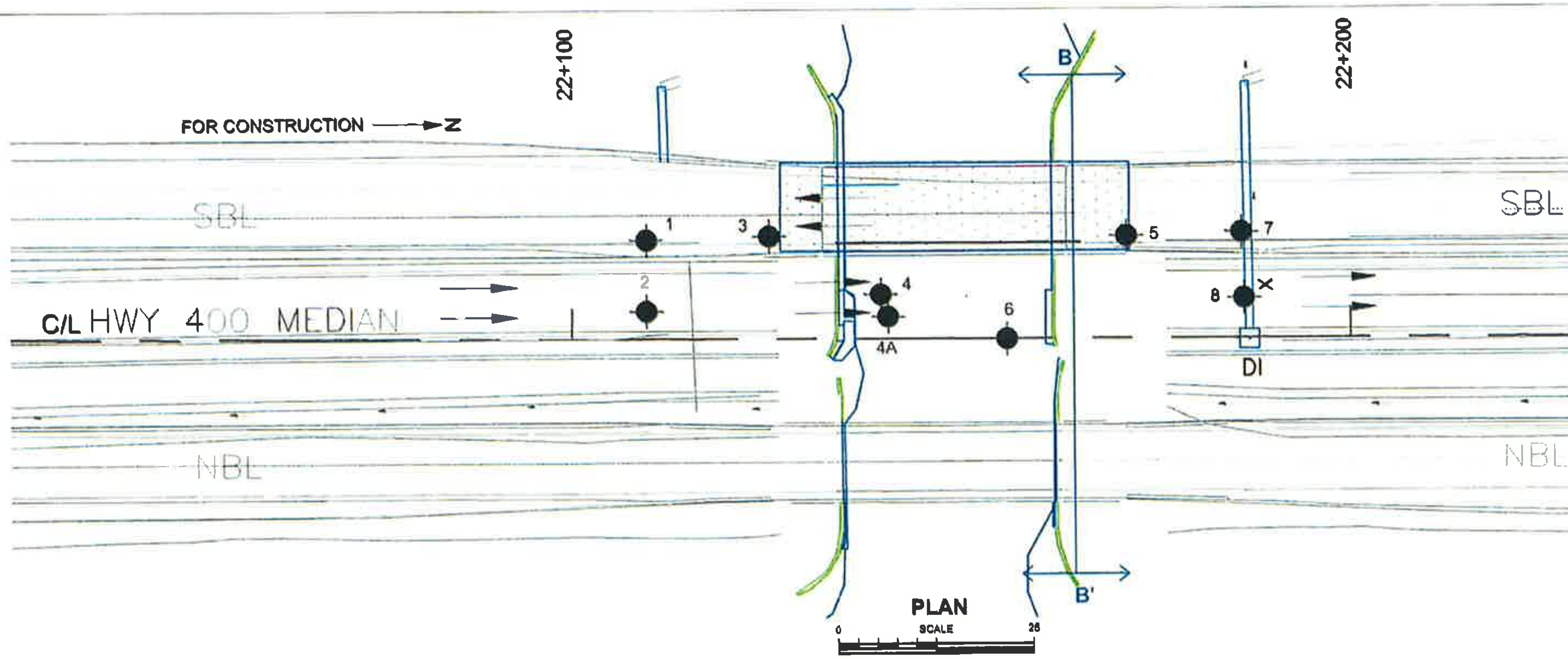
CONTRACT A, HIGHWAY 400,
PORT SEVERN RIVER BRIDGE
BOREHOLE LOCATION PLAN
AND SOIL STRATA - SECTION B-B'

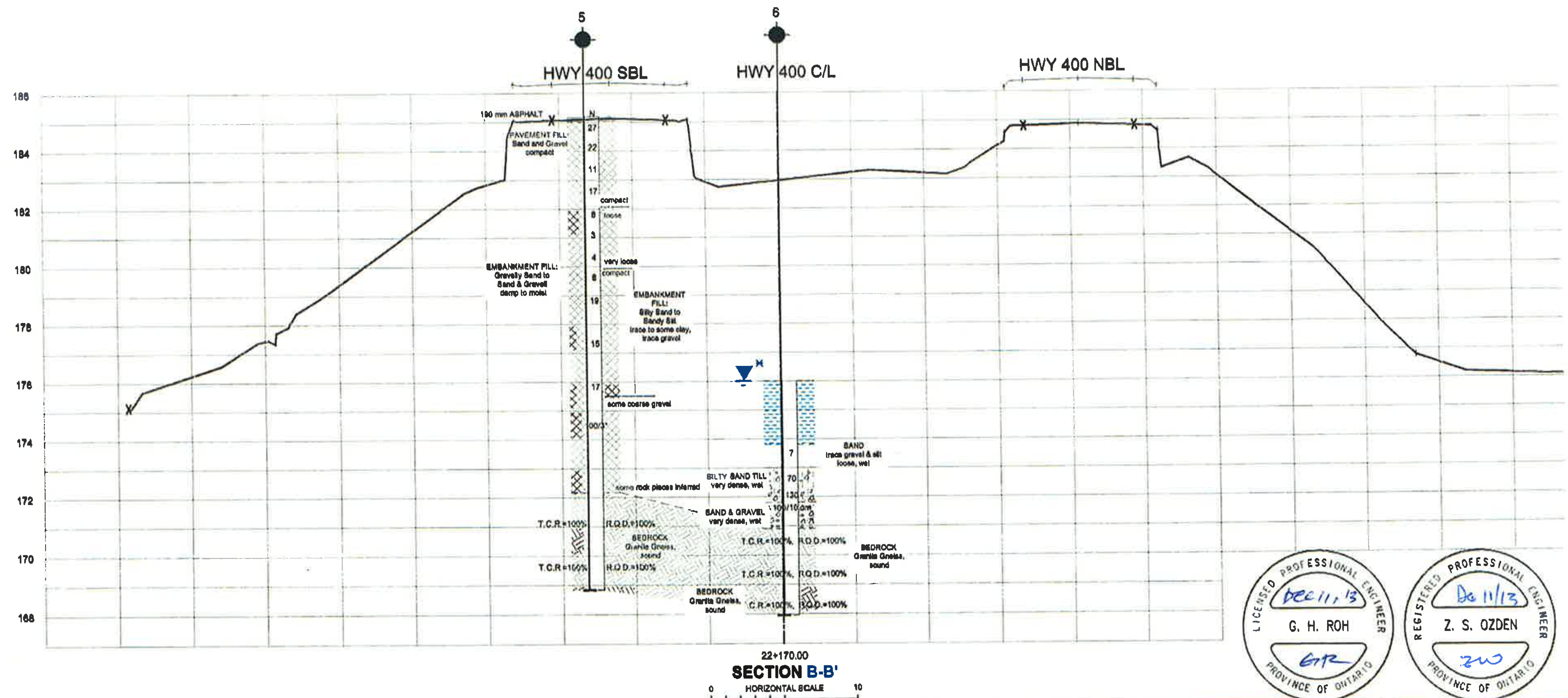
SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.





LEGEND

(symbol)	Borehole
N	Blows/0.3m (Std Pen Test, 475 J/blow)
(symbol)	Water Level at Time of Investigation (W L NOT STABILIZED)
B–B'	Section

No	ELEVATION	STATION	OFFSET
BH5	185 2	22+172	13 2m Lt C/L
BH6	176 0	22+166	@ C/L

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

NOTE: This drawing is for subsurface information only.. Surface details and features are for conceptual illustration.

LICENSED PROFESSIONAL ENGINEER
Dec 11, 13
G. H. ROH
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
Dec 11/13
Z. S. OZDEN
PROVINCE OF ONTARIO

REVISIONS	DATE	BY	DESCRIPTION

Geocres No -31D-564

TRANETOB20462AA			DIST
SUBM'D	CHECKED	DATE December , 2013	SITE 42-66/182
DRAWN SSH	CHECKED GR	APPROVED ZO	DWG 3

Appendix A

Record of Borehole Sheets

RECORD OF BOREHOLE No 1

METRIC

GWP: WP 2360-09-00	LOCATION: 22+110, 12.8 m Lt C/L (N 4962143.863, E 287411.348)		ORIGINATED BY: LG
DIST: 5 HWY: 400	BOREHOLE TYPE: Hollow Stem Auger		COMPILED BY: SSH
DATUM: Geodetic	DATE: 30/05/2013	30/05/2013	CHECKED BY: ZO

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.9	GROUND SURFACE						
183.7 / 0.2	190 mm **ASPHALT**						
183.2 / 0.7	**PAVEMENT FILL:** Gravelly Sand, brown, dense	1	SS	43		○	32 56 (12)
	EMBANKMENT FILL: Silty Sand to Sandy Silt, trace to some clay, trace gravel, greyish brown, loose to compact, damp to moist	2	SS	27	183	○	3 58 22 17
		3	SS	16	182	○	
	wet	4	SS	5	181	○	
		5	SS	15		○	
		6	SS	28	180	○	2 34 46 18
		7	SS	8	179	○	
		8	SS	22	178	○	
		9	SS	28	177	○	
176.6 / 7.3	**SAND** grey, dense to very dense, wet						
176.2 / 7.8		10	SS	100 / 13 cm		○	spoon wet and bouncing

End of Borehole
Auger refusal @ 7.8 m
Probable Bedrock
Borehole open & dry on completion (not stabilized)

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE (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; GROUND WATER CONDITIONS; STRAT PLOT.

+ 3, × 3: Numbers refer to Sensitivity

15 ⊕ 5 (20 / 10) (%) STRAIN AT FAILURE

TRANETOB20462AA: Hwy 400, Port Severn

RECORD OF BOREHOLE No 2

METRIC

GWP: WP 2360-09-00	LOCATION: 22+110, 3.6 m Lt C/L (N 4962152.644, E 287414.103)		ORIGINATED BY: LG
DIST: 5	HWY: 400	BOREHOLE TYPE: Hollow Stem Auger	COMPILED BY: SSH
DATUM: Geodetic	DATE: 30/05/2013 30/05/2013		CHECKED BY: ZO

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.6	GROUND SURFACE						
182.5 / 0.1	0.1 m **TOPSOIL**						
	EMBANKMENT FILL: Silty Sand to Sandy Silt trace to some clay, trace gravel greyish brown, compact, moist to damp	1	SS	10	182		
		2	SS	13	181		
		3	SS	10			
		4	SS	18	180		2 56 26 16
		5	SS	41	179		
		6	SS	12	178		
		7	SS	10			2 66 19 13
177.3 / 5.3	**SILTY SAND** trace gravel and organics grey, very dense, wet	8	SS	100/13	177		spoon wet and bouncing
176.8 / 5.8							

End of Borehole
Auger refusal @ 5.8 m
Probable Bedrock
Borehole open & dry on completion (not stabilized)
Piezometer installed to 5.6 m
Water level in piezometer at 5.5 m (El. 177.1 m) on June 17, 2013

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE — 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   20 / 15 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

METRIC

GWP: WP 2360-09-00
LOCATION: 22+125, 13.3 m Lt C/L (N 4962148.179, E 287396.107)
ORIGINATED BY: LG

DIST: 5 HWY: 400
BOREHOLE TYPE: Hollow Stem Auger + NQ Coring
COMPILED BY: SSH

DATUM: Geodetic
DATE: 23/05/2013 23/05/2013
CHECKED BY: ZO

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.2	GROUND SURFACE				
184.0 / 0.2	180 mm **ASPHALT**				
	PAVEMENT FILL: Sand and Gravel to Gravelly Sand, brown, compact, damp	1	SS	27	
		2	SS	23	36 48 (16)
		3	SS	22	40 46 (14)
181.9 / 2.3	**EMBANKMENT FILL:** Silty Sand to Sandy Silt, trace to some clay, trace gravel, damp to moist; loose to very loose, wet, brown	4	SS	7	
		5	SS	4	10 55 19 16
	-------- greyish brown, dense to very dense, wet	6	SS	57	
	-------- compact	7	SS	16	3 40 39 18
		8	SS	17	
	-------- grey	9	SS	13	
176.4 / 7.8	**SILTY SAND** trace gravel, some organics, grey / black, dense, wet	10	SS	38	8 65 (27)
175.9 / 8.3	**BEDROCK** Granite Gneiss, greyish / pink, sound; ---------fractured	11	RC	T.C.R.=93% R.Q.D.=70%	Auger refusal and Start of NQ coring at 8.3 m
		12	RC	T.C.R.=98% R.Q.D.=98%	
		13	RC	T.C.R.=98% R.Q.D.=92%	
172.1 / 12.1	End of Borehole. Borehole open and dry upon completion (prior to coring), not stabilized				

Elevation scale: 184, 183, 182, 181, 180, 179, 178, 177, 176, 175, 174, 173

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE; 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
20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

TRANETOB20462AA: Hwy 400, Port Severn

RECORD OF BOREHOLE No 4

METRIC

GWP WP 2360-09-00 LOCATION 22+140, 5.7 m Lt C/L (N 4962159.701, E 287384.714) ORIGINATED BY LG

DIST 5 HWY 400 BOREHOLE TYPE Washboring and BQ Rock Coring from barge COMPILED BY SSH

DATUM Geodetic DATE 13/06/2013 14/06/2013 CHECKED BY ZO

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS
176.0	WATER SURFACE						176	
0.0	**WATER**						175	
174.2 / 1.8	**River Bottom**; wash bored through overburden without sampling due to the presence of rockfill (see Record of Borehole 4A for details of overburden)						174, 173	
172.3 / 3.7	**BEDROCK** Granite Gneiss sound; fractured (at top); mainly pink / greyish / pink		1	RC	T.C.R.=100% R.Q.D=86%		172	
			2	RC	T.C.R.=98% R.Q.D=98%		171	
			3	RC	T.C.R.=100% R.Q.D=100%		170	
169.2 / 6.8	End of Borehole							

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE (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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Foundation Design

TRANETOB20462AA: Hwy 400, Port Severn

RECORD OF BOREHOLE No 4A

1 OF 1 **METRIC**

GWP WP 2360-09-00 LOCATION 22+141, 2.9 m Lt C/L (N 4962162.711, E 287384.702) ORIGINATED BY LG

DIST 5 HWY 400 BOREHOLE TYPE Washboring from barge COMPILED BY SSH

DATUM Geodetic DATE 14/06/2013 14/06/2013 CHECKED BY ZO

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
176.0	WATER SURFACE				176	
0.0	**WATER**				175	
174.3 / 1.7	**SAND AND GRAVEL** grey, loose, wet	1	SS	6	174	w ≈ 9
173.8 / 2.2	**SILTY CLAY** reddish grey, soft	2	SS	4		wP ≈ 15, wL ≈ 32, w ≈ 35
173.2 / 2.8	**SAND** some silt and gravel grey, compact, wet	3	SS	22	173	w ≈ 14
172.6 / 3.4	End of Borehole See Record of Borehole 4 for continuation of stratigraphy Auger refusal @ 3.4 m Probable Bedrock					

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 ● POCKET PENETR. × LAB VANE (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, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

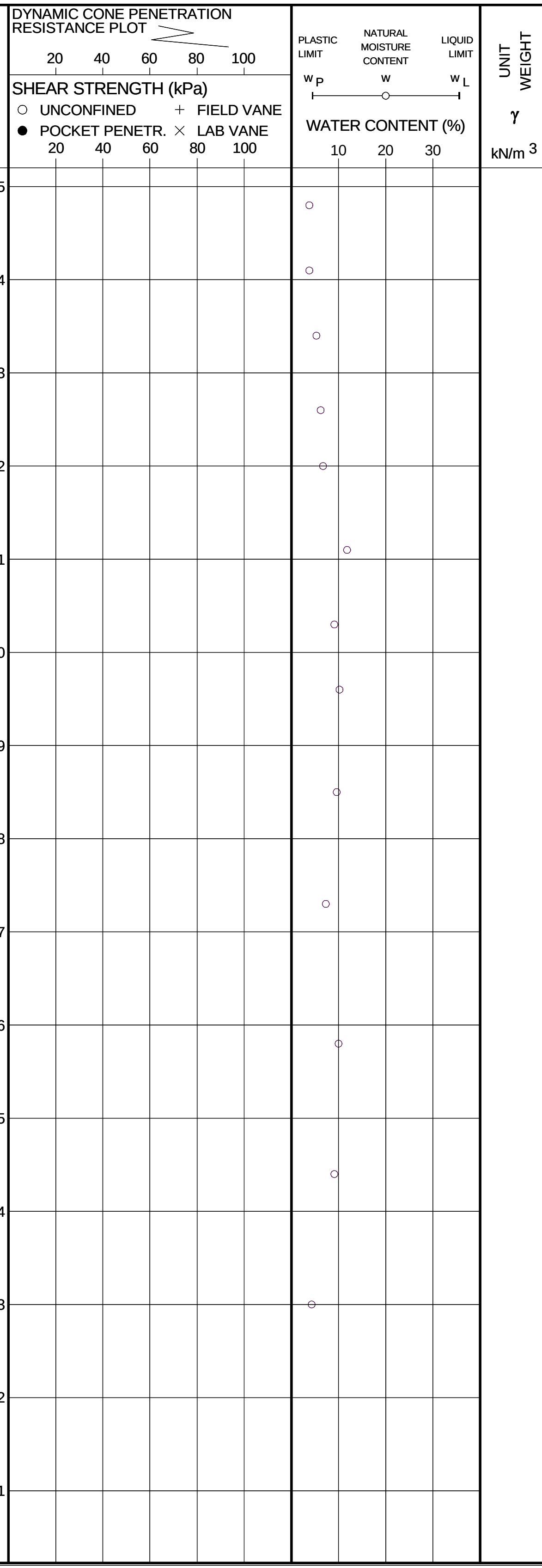
RECORD OF BOREHOLE No 5

METRIC

GWP	WP 2360-09-00	LOCATION	22+172, 13.2 m Lt C/L (N 4962162.063, E 287352.273)
DIST	5 HWY 400	BOREHOLE TYPE	Hollow Stem Augering and NQ Coring
DATUM	Geodetic	DATE	23/05/2013 23/05/2013

ORIGINATED BY LG
COMPILED BY SSH
CHECKED BY ZO

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.2	GROUND SURFACE					
185.0 / 0.2	190 mm **ASPHALT**				185	
	PAVEMENT FILL: Sand and Gravel brown, compact	1	SS	27		
184.1 / 1.1		2	SS	22	184	
	EMBANKMENT FILL: Gravelly Sand to Sand and Gravel brown, damp to moist	3	SS	11		41 44 13 2
		4	SS	17	183	
	compact / loose	5	SS	8	182	
181.5 / 3.7		6	SS	3	181	9 41 33 17
	very loose / compact	7	SS	4	180	
		8	SS	8		
	compact; **EMBANKMENT FILL:** Silty Sand to Sandy Silt trace to some clay, trace gravel brown to 6 m, greyish brown to 10 m, grey below moist to wet to 6 m,moist 6 m to 10 m, wet below 10 m	9	SS	19	179	
		10	SS	15	178 / 177	6 58 20 16
		11	SS	17	176	
	some coarse gravel				175	* Nvalue influnced by coarse gravel
		12	SS	100/3*	174	
		13	SS	100/5*	173	
172.1 / 13.1	some rock pieces inferred					
	fractured	14	RC	T.C.R.=100% R.Q.D.=42%	172	Auger refusal and Start of NQ coring at 13.1 m
	BEDROCK Granite Gneiss greyish / pink, sound	15	RC	T.C.R.=100% R.Q.D.=100%	171	



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

TRANETOB20462AA: Hwy 400, Port Severn

RECORD OF BOREHOLE No 5

METRIC

GWP	WP 2360-09-00	LOCATION	22+172, 13.2 m Lt C/L (N 4962162.063, E 287352.273)	ORIGINATED BY	LG
DIST	5 HWY 400	BOREHOLE TYPE	Hollow Stem Augering and NQ Coring	COMPILED BY	SSH
DATUM	Geodetic	DATE	23/05/2013 23/05/2013	CHECKED BY	ZO

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 ● POCKET PENETR. × LAB VANE (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
170.2											
	BEDROCK Granite Gneiss greyish / pink, sound		16	RC	T.C.R.=100% R.Q.D=100%		170				
							169				
168.7											
16.5	End of Borehole Borehole open and dry upon completion (prior to coring), not stabilized										

+ ³, × ³ : Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

TRANETOB20462AA: Hwy 400, Port Severn

RECORD OF BOREHOLE No 6

METRIC

GWP WP 2360-09-00 | LOCATION 22+156, @ C/L (N 4962170.075, E 287371.025) | ORIGINATED BY LG

DIST 5 HWY 400 | BOREHOLE TYPE HQ Casing + Washboring; BQ Coring from barge | COMPILED BY SSH

DATUM Geodetic | DATE 14/06/2013 14/06/2013 | CHECKED BY ZO

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
176.0	WATER SURFACE					176		
0.0	**WATER**					175, 174		
173.8 2.2	**River Bottom**				▼			
	SAND trace gravel and silt grey, loose, wet	1	SS	7			○ (~15)	
173.0 3.0	**SILTY SAND TILL** grey, very dense, wet	2	SS	70		173	○ (~12)	12 62 (26)
		3	SS	130		172	○ (~10)	
171.8 4.2	**SAND AND GRAVEL** grey, very dense, wet broken rock pieces contacted below 4.8 m (possible shattered bedrock)	4	SS	100/10 cm			○ (~12)	
170.9 5.1	**BEDROCK** Granite Gneiss greyish / pink, sound	5	RC	T.C.R.=100% R.Q.D.=100%		171, 170		
		6	RC	T.C.R.=100% R.Q.D.=100%		169		
168.0 8.1		7	RC	T.C.R.=100% R.Q.D.=100%		168		
	End of Borehole							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE — 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

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7

METRIC

GWP: WP 2360-09-00 | LOCATION: 22+187, 13.7 m Lt C/L (N 4962166.060, E 287338.083) | ORIGINATED BY: LG
DIST: 5 | HWY: 400 | BOREHOLE TYPE: Hollow Stem Auger | COMPILED BY: SSH
DATUM: Geodetic | DATE: 29/05/2013 29/05/2013 | CHECKED BY: ZO

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) (approx.)	REMARKS GR SA SI CL
185.5	GROUND SURFACE							
185.4 / 0.1	120 mm **ASPHALT**							
185.2 / 0.3	**PAVEMENT FILL:** Sand and Gravel, brown, compact	1	SS	28		185	~3	22 63 (15)
184.9 / 0.6	**PAVEMENT FILL:** Gravelly Sand, brown, compact	2	SS	36			~5	7 58 20 15
	EMBANKMENT FILL: Silty Sand to Sandy Silt, trace to some clay, trace gravel, greyish brown, damp to moist; dense					184		
	compact	3	SS	13			~7	
	loose	4	SS	8		183	~8	
	moist to wet	5	SS	6		182	~9	3 61 21 15
	compact	6	SS	19			~9	
		7	SS	19		181	~10	
	very loose	8	SS	4		180	~9	
	loose	9	SS	7		179	~11	
	moist to wet	10	SS	6		178	~11	5 60 18 17
	very dense	11	SS	100/5	▽	177	~10	
176.2 / 9.3	End of Borehole. Auger refusal @ 9.4 m. Probable Bedrock. Borehole dry and open to 8.8 m upon completion (non stabilized)							

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE (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 (%).

+ 3, × 3: Numbers refer to Sensitivity
15 ⊕ 5 (20 / 10): (%) STRAIN AT FAILURE

TRANETOB20462AA: Hwy 400, Port Severn

RECORD OF BOREHOLE No 8

METRIC

GWP: WP 2360-09-00	LOCATION: 22+187, 5.3 m Lt C/L (N 4962174.284, E 287340.342)		ORIGINATED BY: LG
DIST: 5	HWY: 400	BOREHOLE TYPE: Hollow Stem Auger	COMPILED BY: SSH
DATUM: Geodetic	DATE: 28/05/2013 28/05/2013		CHECKED BY: ZO

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.4	GROUND SURFACE					
184.3 / 0.2	0.15 m **TOPSOIL**					
	EMBANKMENT FILL: Silty Sand to Sandy Silt, trace to some clay, trace gravel, greyish brown, moist to damp; compact	1	SS	11	184	
	loose	2	SS	8	183	3 61 21 15
		3	SS	6		
	loose	4	SS	6	182	
	very loose; wet, occ. organics	5	SS	4	181	
	loose	6	SS	7	180	
	compact	7	SS	23		
		8	SS	21	179	7 49 27 17
	loose; moist to wet	9	SS	7	178	
177.1 / 7.3	**GRAVELLY SAND** trace silt, brown, compact, wet (possible fill)	10	SS	16	177, 176	sampler wet; 26 65 (9)
175.4 / 9.0	**SILTY CLAY** brown, stiff; some organics	11	SS	11	175, 174	
173.7 / 10.7	End of Borehole	12	SS	110/0		spoon bouncing

Water content (%), plotted: Sample 11 — 43 (with plastic limit marked).

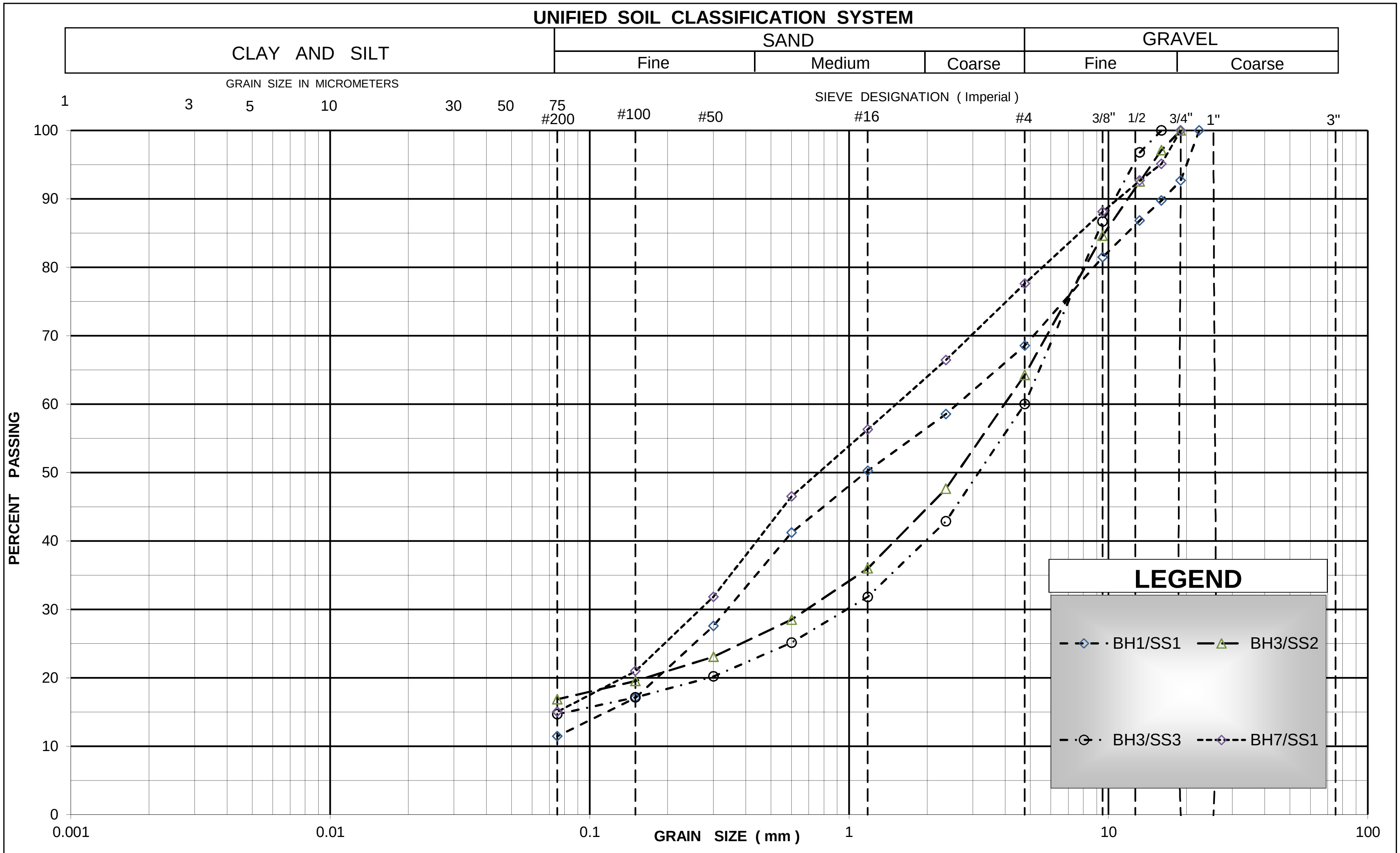
End of Borehole
Auger refusal @ 10.7 m
Probable Bedrock
*Wet cave at 8.5 m upon completion
Piezometer installed to 10.5 m
Water level in piezometer 7.5 m (el 176.9 m) on June 17, 2013

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE (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   20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Appendix B

Test Results

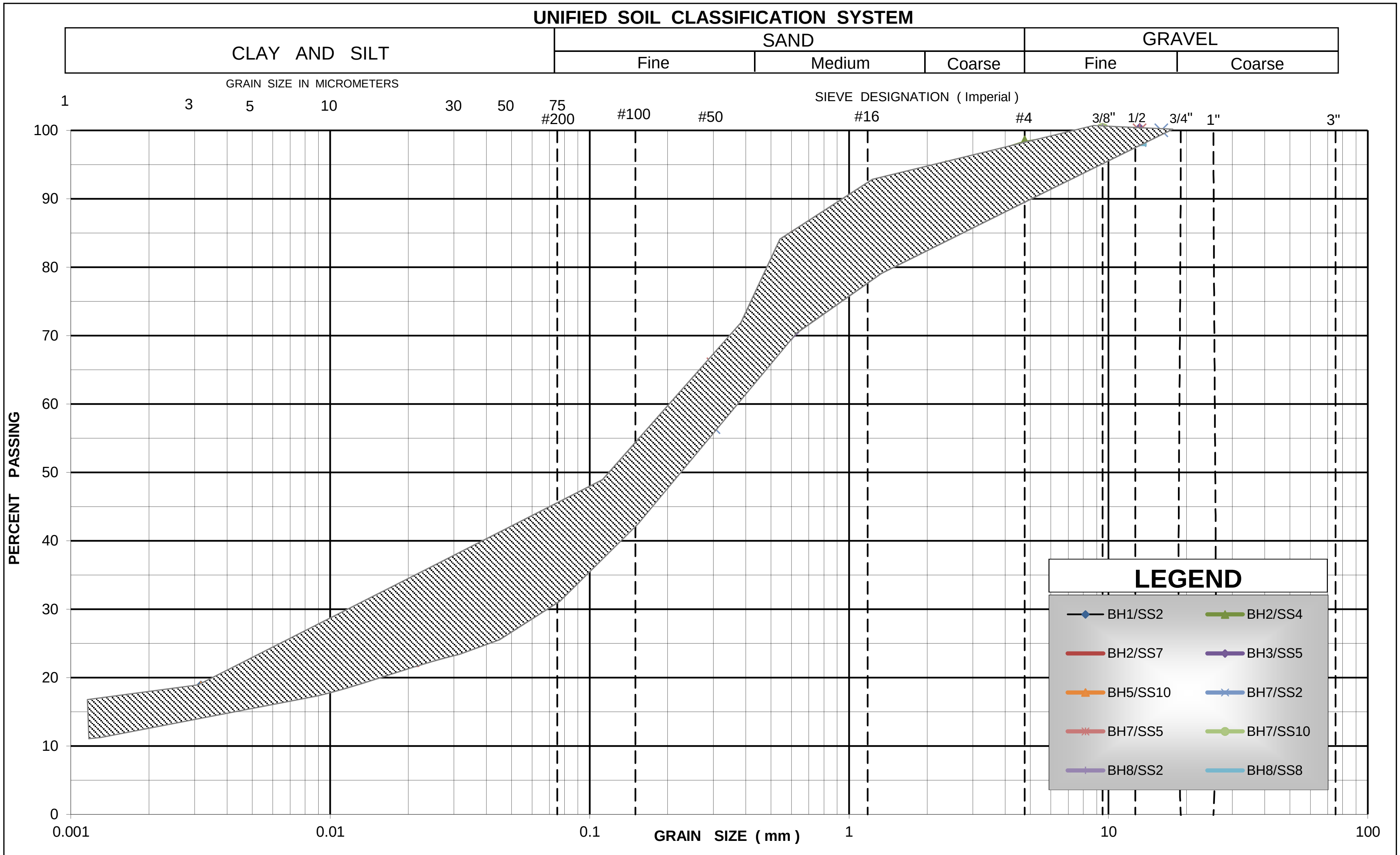


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

PAVEMENT FILL: Gravelly Sand, trace to some silt

Figure: B-1	
PROJECT # : TRANETOB20462AA	
DATE :	JULY, 2013



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

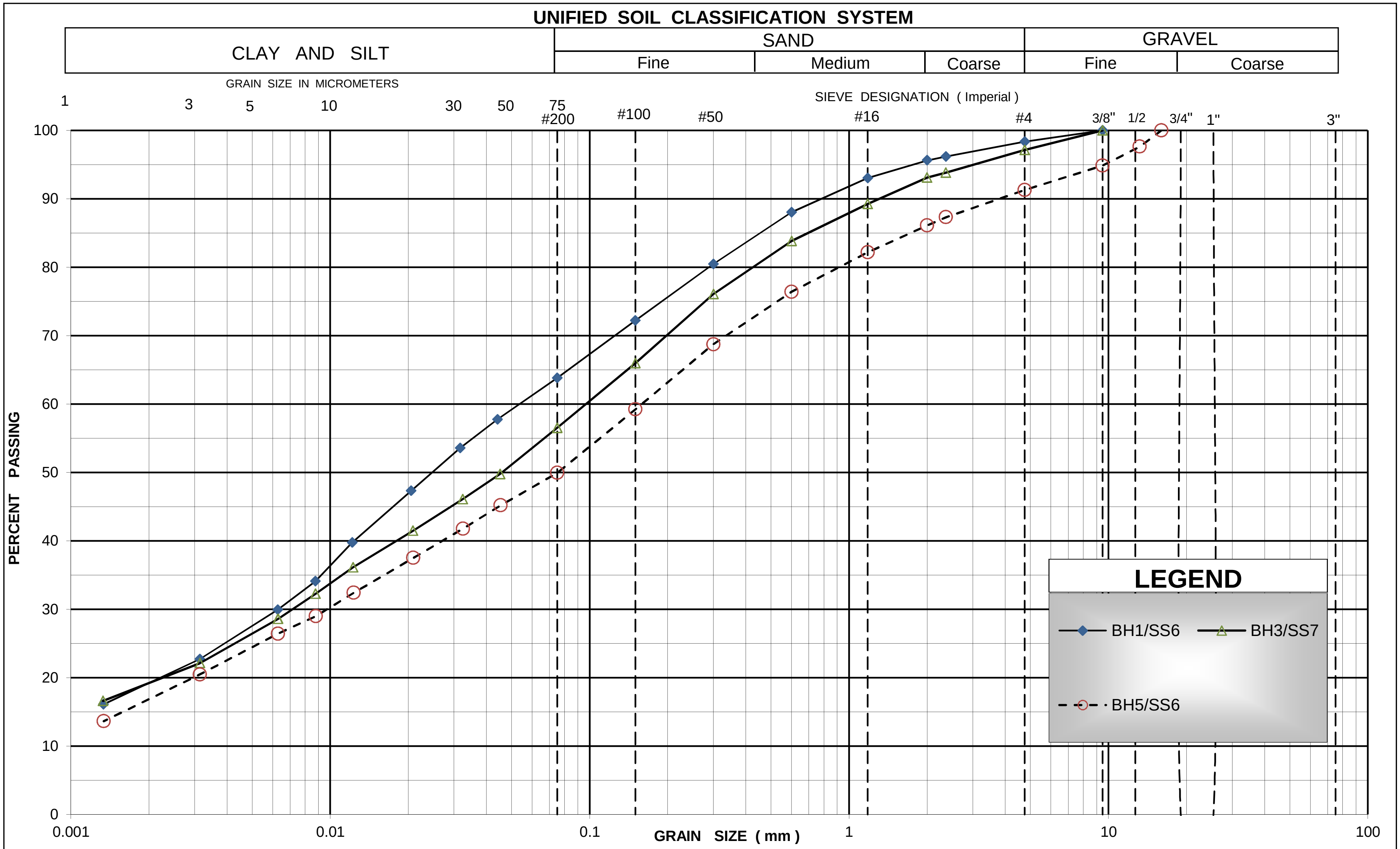
GRAIN SIZE DISTRIBUTION

EMBANKMENT FILL: Silty Sand, trace to some clay, trace gravel

Figure: B-2

PROJECT # : TRANETOB20462AA

DATE : JULY, 2013



coffey geotechnics SPECIALISTS MANAGING THE EARTH

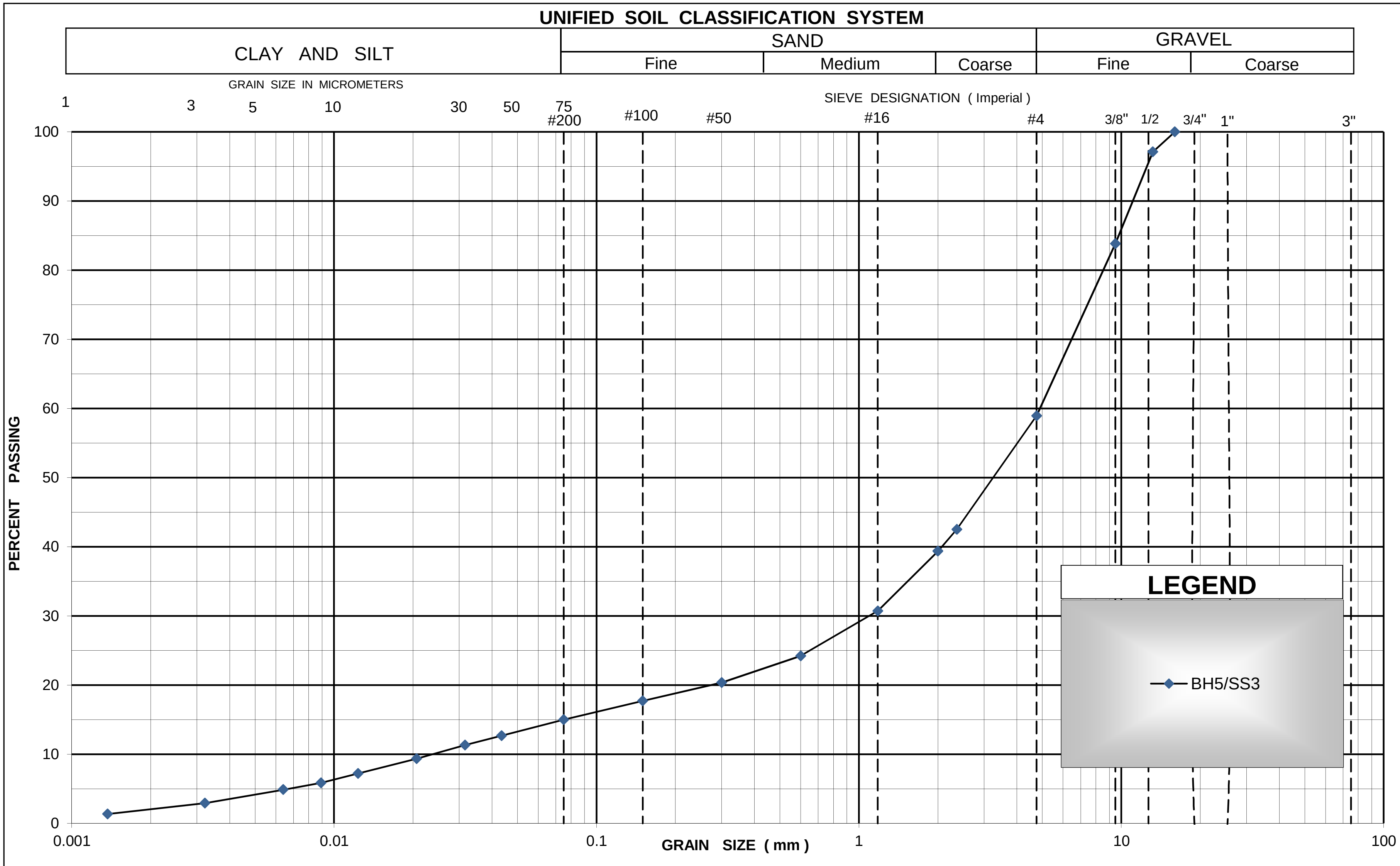
GRAIN SIZE DISTRIBUTION

EMBANKMENT FILL: Sandy Silt, trace to some clay, trace gravel

Figure: B-3

PROJECT # : TRANETOB20462AA

DATE : JULY, 2013

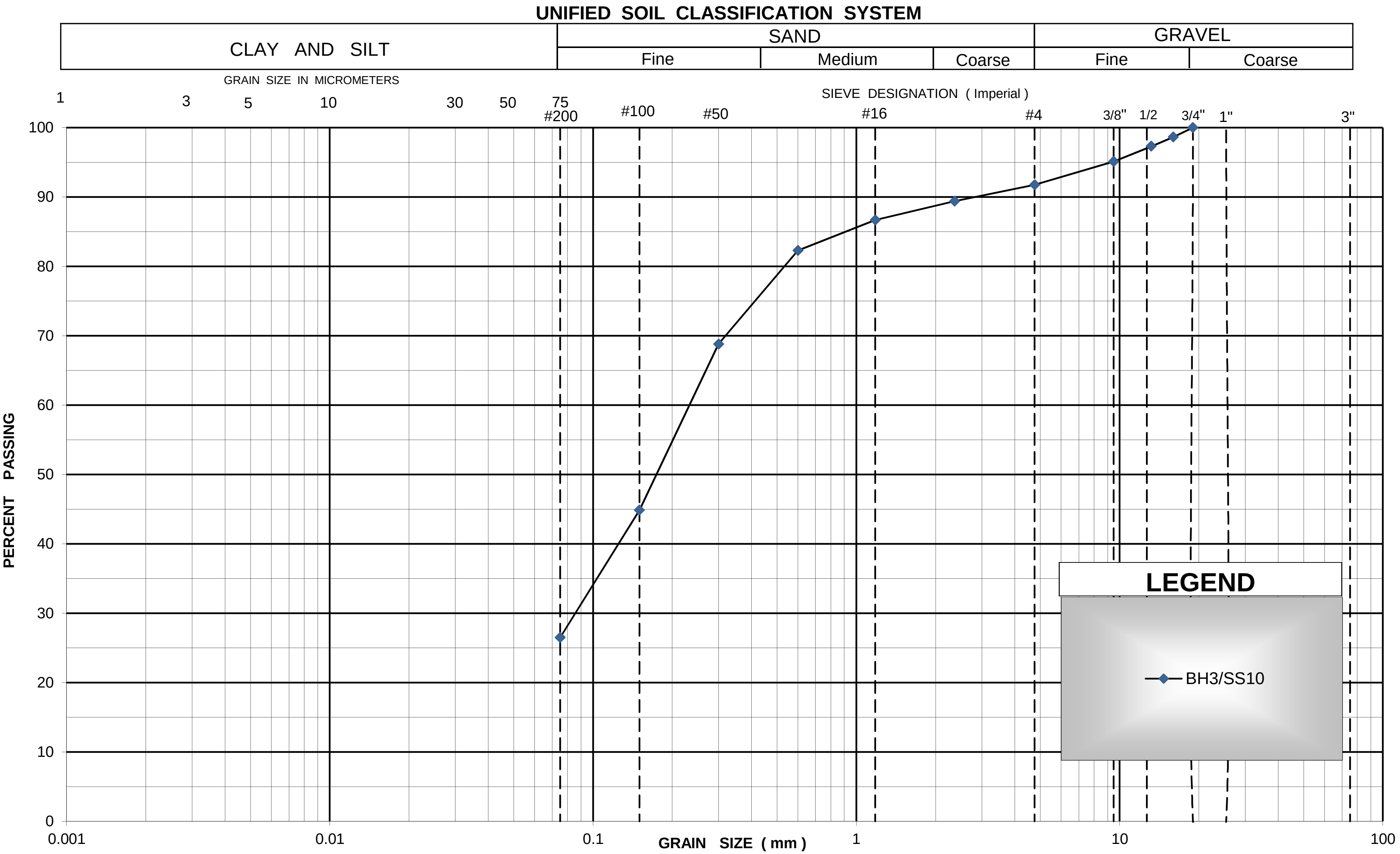


coffey geotechnics SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

EMBANKMENT FILL: Sand and Gravel, trace silt

Figure B-4	
PROJECT # : TRANETOB20462AA	
DATE :	JULY, 2013



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

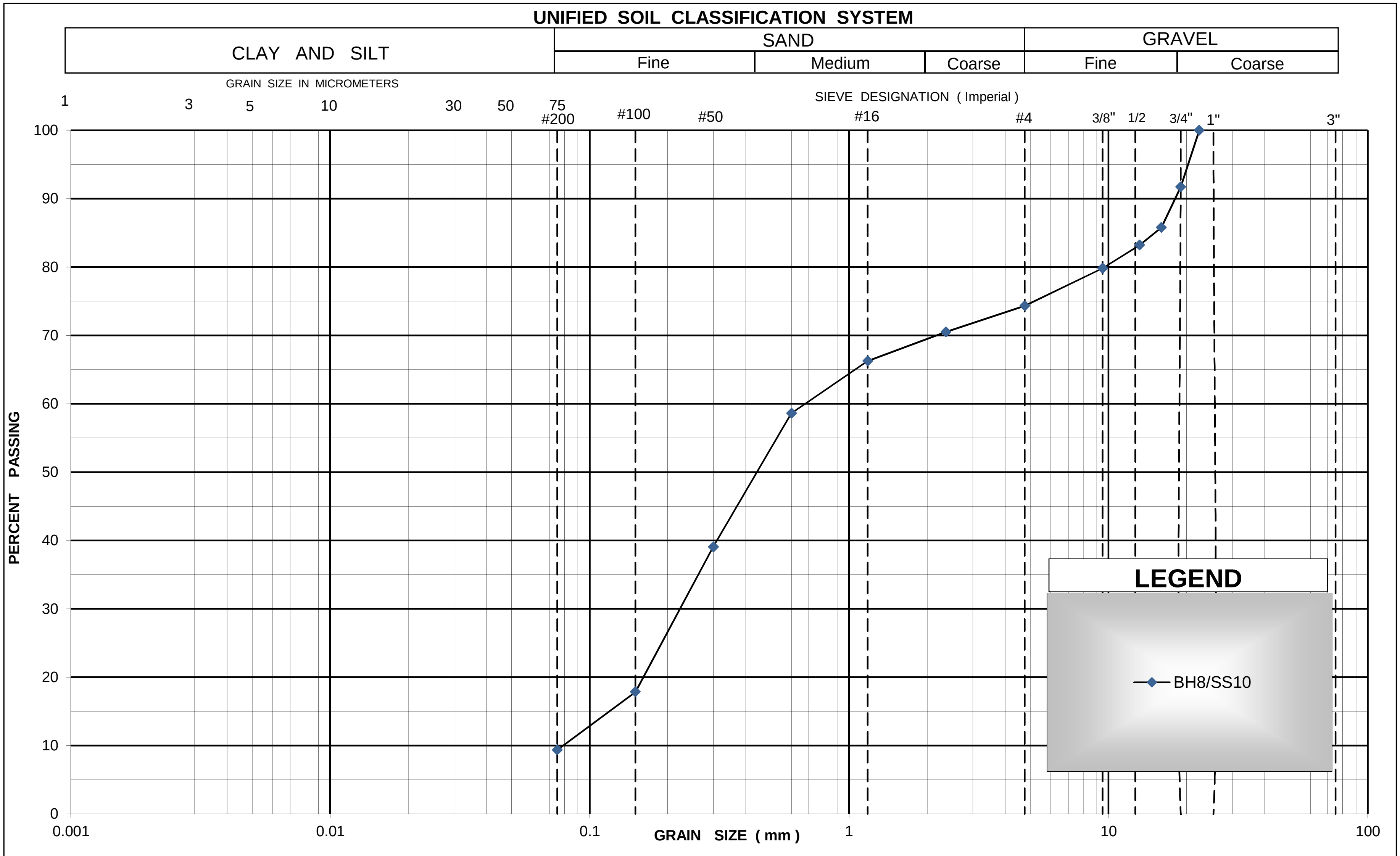
GRAIN SIZE DISTRIBUTION

SILTY SAND

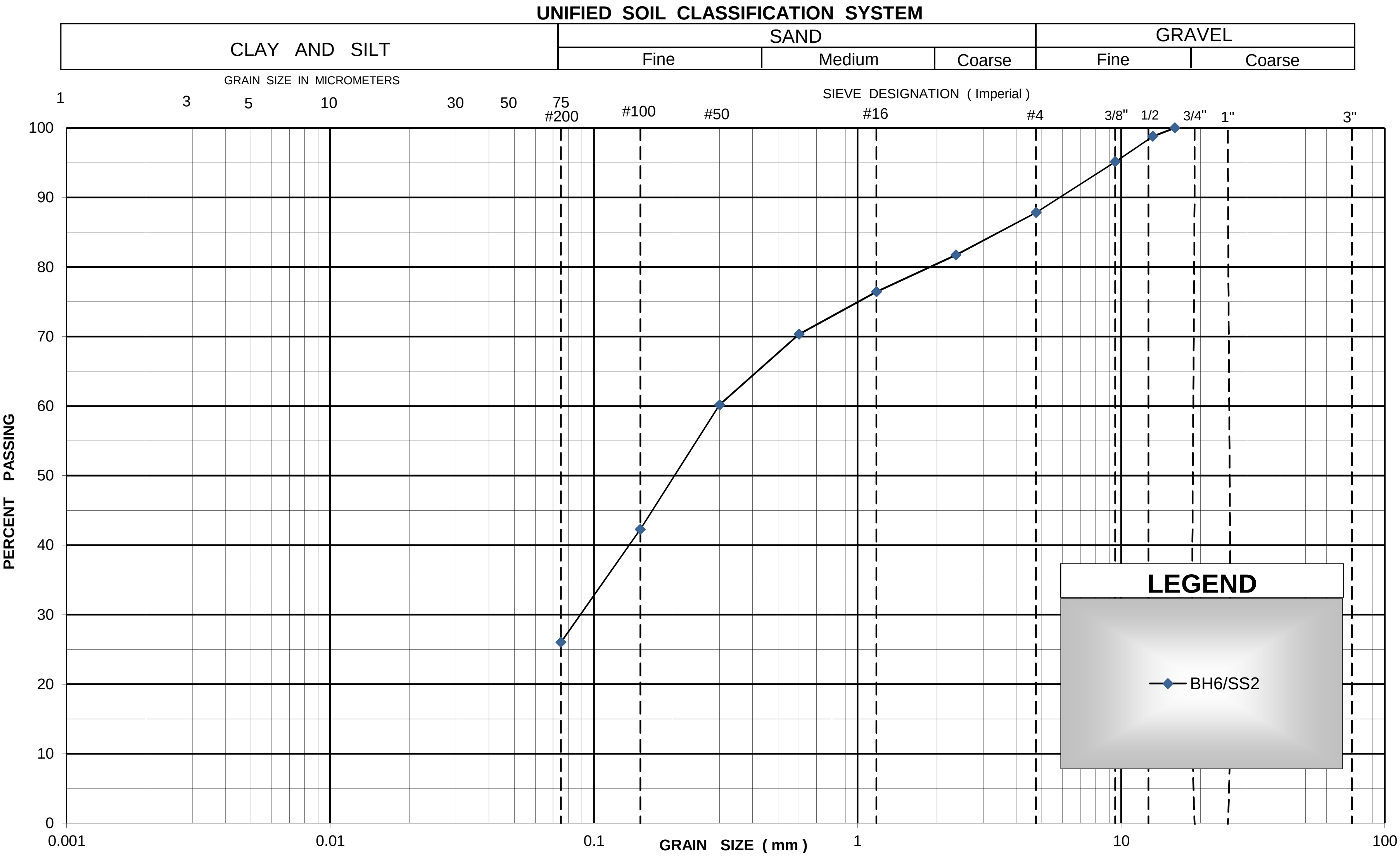
Figure B-5

PROJECT # : TRANETOB20462AA

DATE : JULY, 2013



coffey geotechnics SPECIALISTS MANAGING THE EARTH	GRAIN SIZE DISTRIBUTION GRAVELLY SAND	Figure B-6 PROJECT # : TRANETOB20462AA DATE : JULY, 2013



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

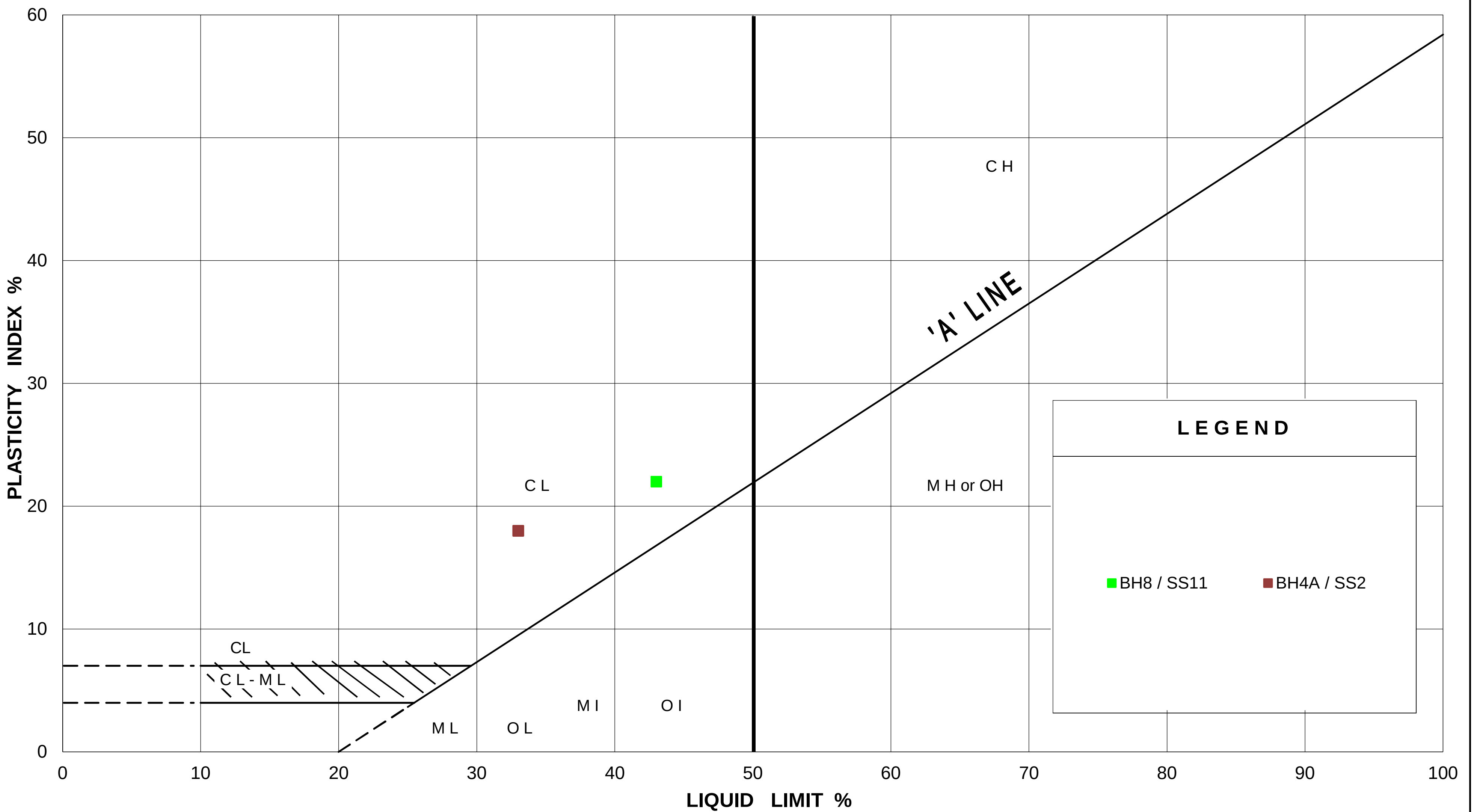
GRAIN SIZE DISTRIBUTION

SILTY SAND TILL

Figure B-7

PROJECT # : TRANETOB20462AA

DATE : JULY, 2013



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

Silty Clay

PROJECT NO. TRANETOB20462AA

Figure B-8

DATE JULY, 2013

Appendix C

Site Photographs

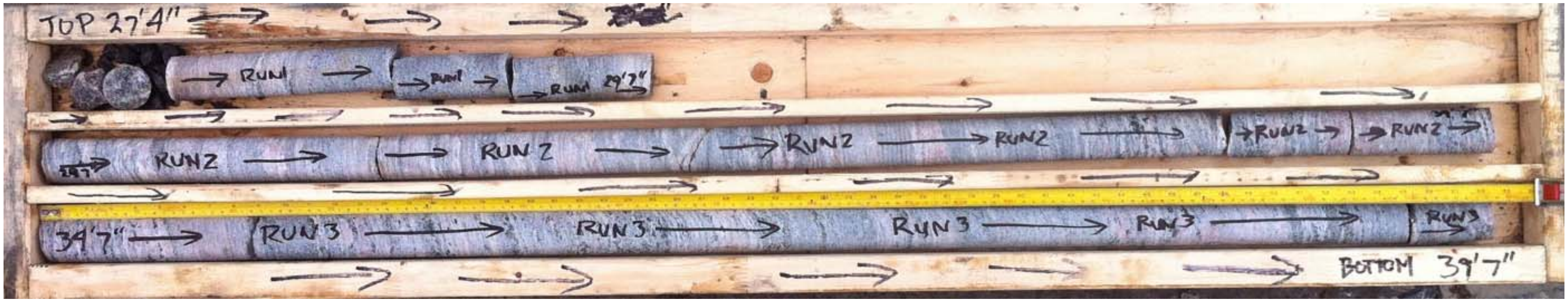
Photograph 1. Borehole 3 looking east (south)

Photograph 2. Borehole 2 looking west (north)

Photograph 3. Boreholes 4 and 4A looking east (south)

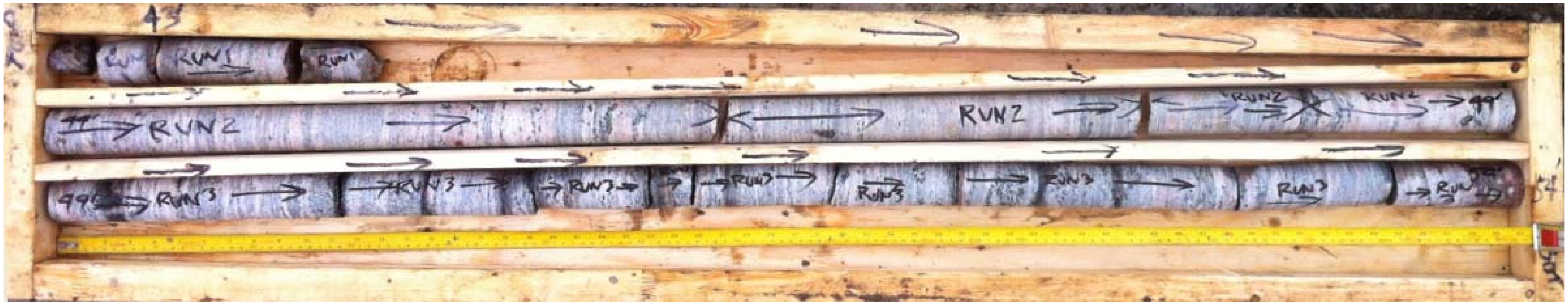
Appendix D

Rock Core Photographs and Test Results



BH 3 (wooden box is 5 feet long)

BH 4 (wooden box is 5 feet long)



BH 5 (wooden box is 5 feet long)

BH 6 (wooden box is 5 feet long)

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	13-1183-0082	SAMPLE NUMBER	-
BOREHOLE NUMBER	3	SAMPLE DEPTH, m	8.7-9.0

TEST CONDITIONS

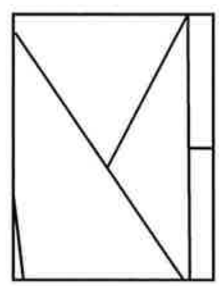
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.24

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.55	WATER CONTENT, (specimen) %	0.08
SAMPLE DIAMETER, cm	4.72	UNIT WEIGHT, kN/m^3	26.52
SAMPLE AREA, cm^2	17.47	DRY UNIT WT., kN/m^3	26.50
SAMPLE VOLUME, cm^3	184.29	SPECIFIC GRAVITY	-
WET WEIGHT, g	498.56	VOID RATIO	-
DRY WEIGHT, g	498.16		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	104.4

REMARKS:

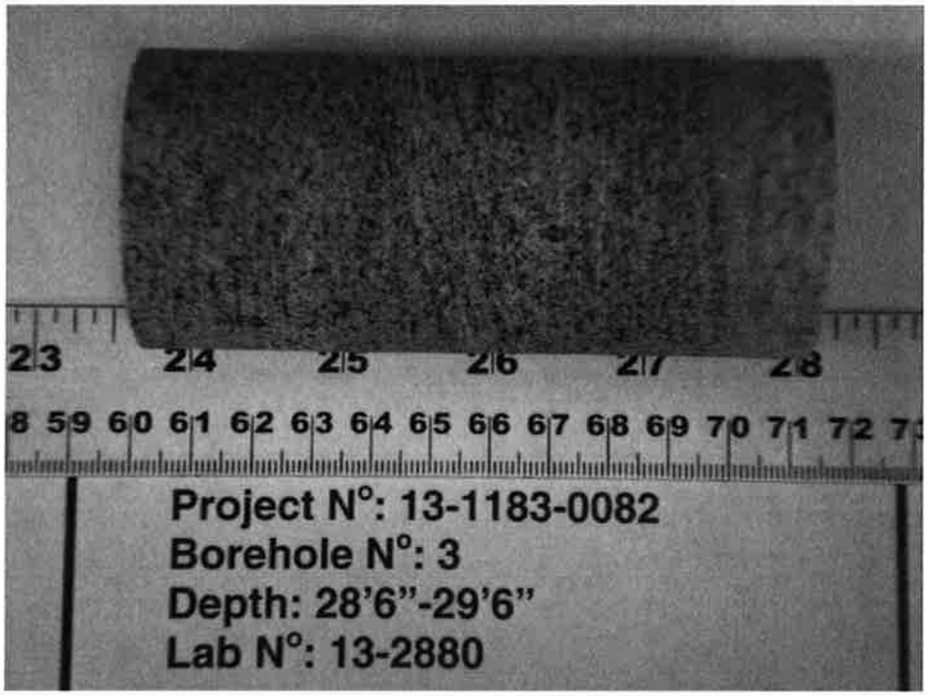
DATE: 7/24/2013

Checked By: Ro

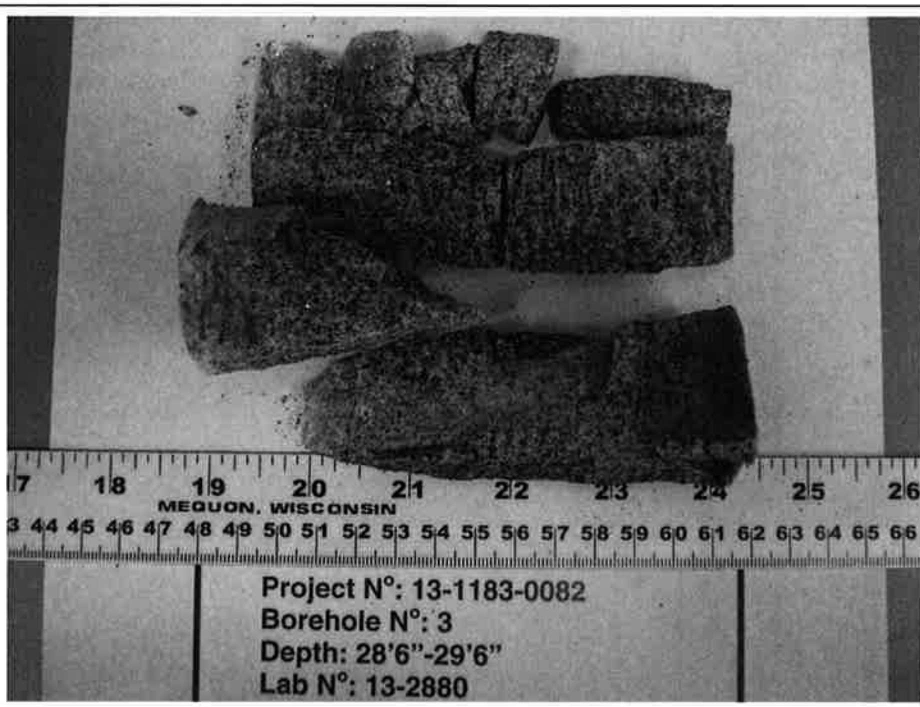
Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd. RO

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	13-1183-0082	SAMPLE NUMBER	-
BOREHOLE NUMBER	4	SAMPLE DEPTH, m	2.1-2.4

TEST CONDITIONS

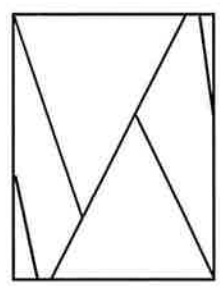
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.23

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	8.06	WATER CONTENT, (specimen) %	0.13
SAMPLE DIAMETER, cm	3.62	UNIT WEIGHT, kN/m^3	25.54
SAMPLE AREA, cm^2	10.30	DRY UNIT WT., kN/m^3	25.50
SAMPLE VOLUME, cm^3	82.98	SPECIFIC GRAVITY	-
WET WEIGHT, g	216.17	VOID RATIO	-
DRY WEIGHT, g	215.89		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	131.7

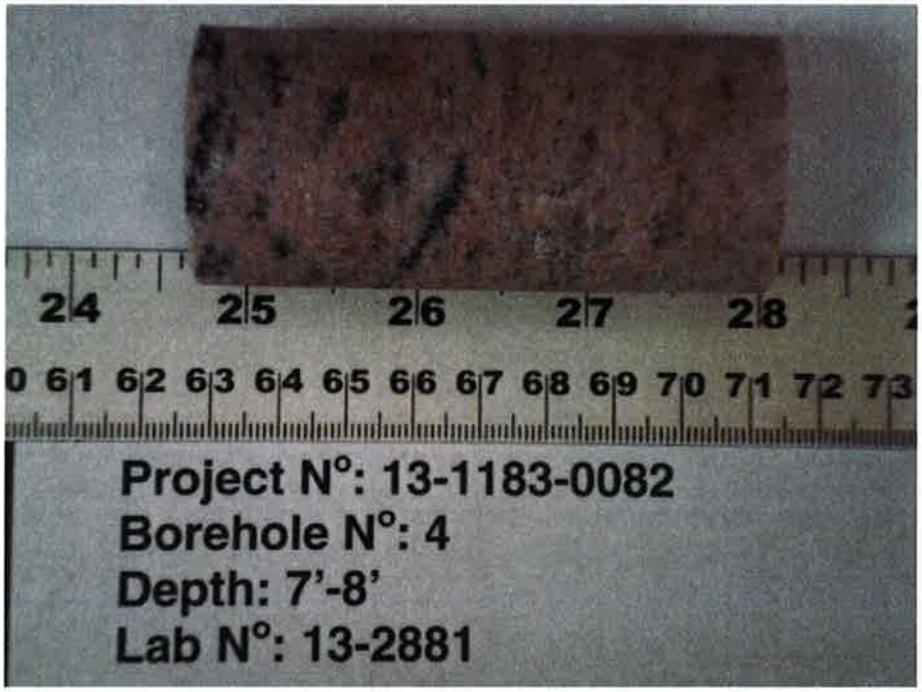
REMARKS:		DATE:	7/24/2013

Checked By: RO

Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION

AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd. RO

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	13-1183-0082	SAMPLE NUMBER	-
BOREHOLE NUMBER	5	SAMPLE DEPTH, m	13.2-13.4

TEST CONDITIONS

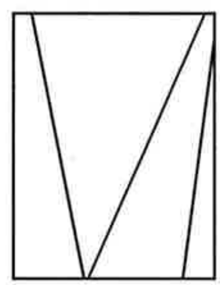
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.20

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.41	WATER CONTENT, (specimen) %	0.08
SAMPLE DIAMETER, cm	4.73	UNIT WEIGHT, kN/m^3	26.09
SAMPLE AREA, cm^2	17.56	DRY UNIT WT., kN/m^3	26.07
SAMPLE VOLUME, cm^3	182.84	SPECIFIC GRAVITY	-
WET WEIGHT, g	486.64	VOID RATIO	-
DRY WEIGHT, g	486.25		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	105.1

REMARKS:

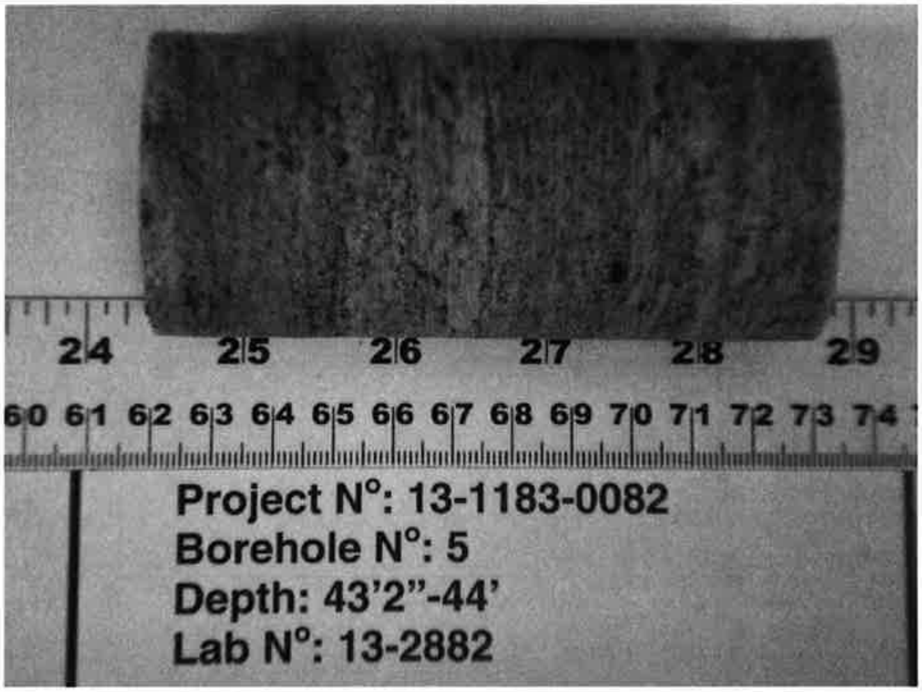
DATE: 7/24/2013

Checked By: ko

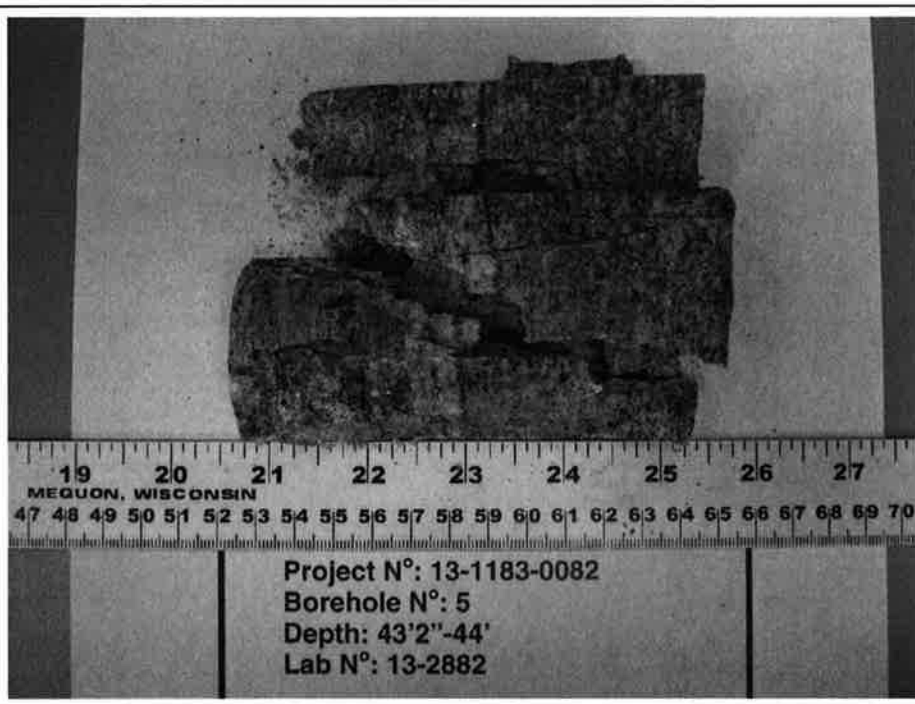
Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd. RO

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	13-1183-0082	SAMPLE NUMBER	-
BOREHOLE NUMBER	5	SAMPLE DEPTH, m	13.7-14.3

TEST CONDITIONS

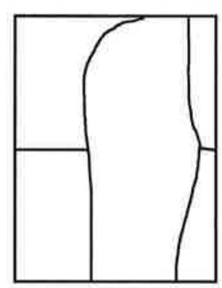
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.23

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.59	WATER CONTENT, (specimen) %	0.07
SAMPLE DIAMETER, cm	4.74	UNIT WEIGHT, kN/m^3	26.25
SAMPLE AREA, cm^2	17.64	DRY UNIT WT., kN/m^3	26.24
SAMPLE VOLUME, cm^3	186.70	SPECIFIC GRAVITY	-
WET WEIGHT, g	500.04	VOID RATIO	-
DRY WEIGHT, g	499.69		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	99.6

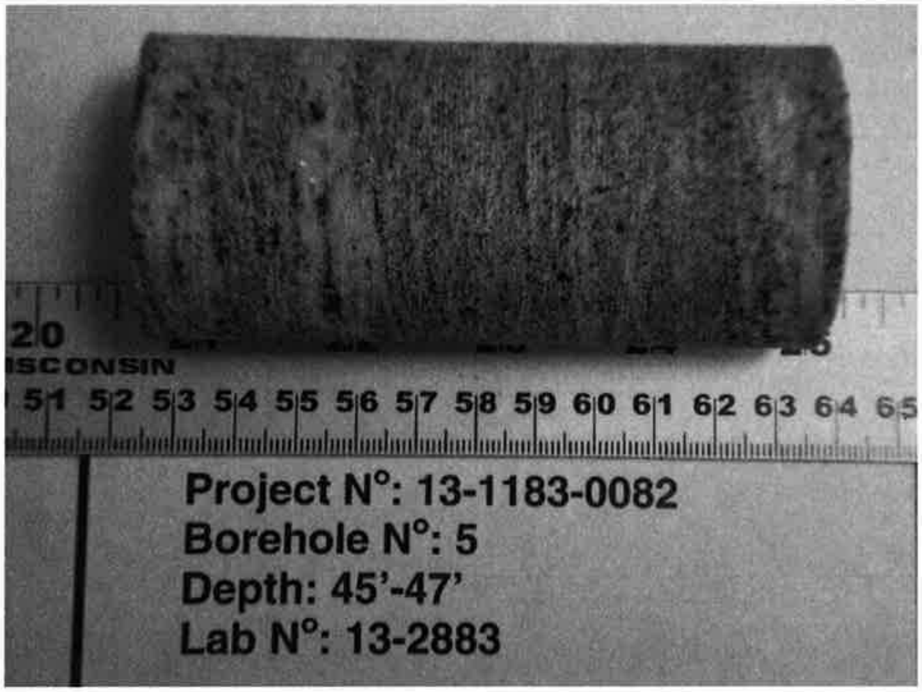
REMARKS:		DATE:	7/24/2013

Checked By: Ro

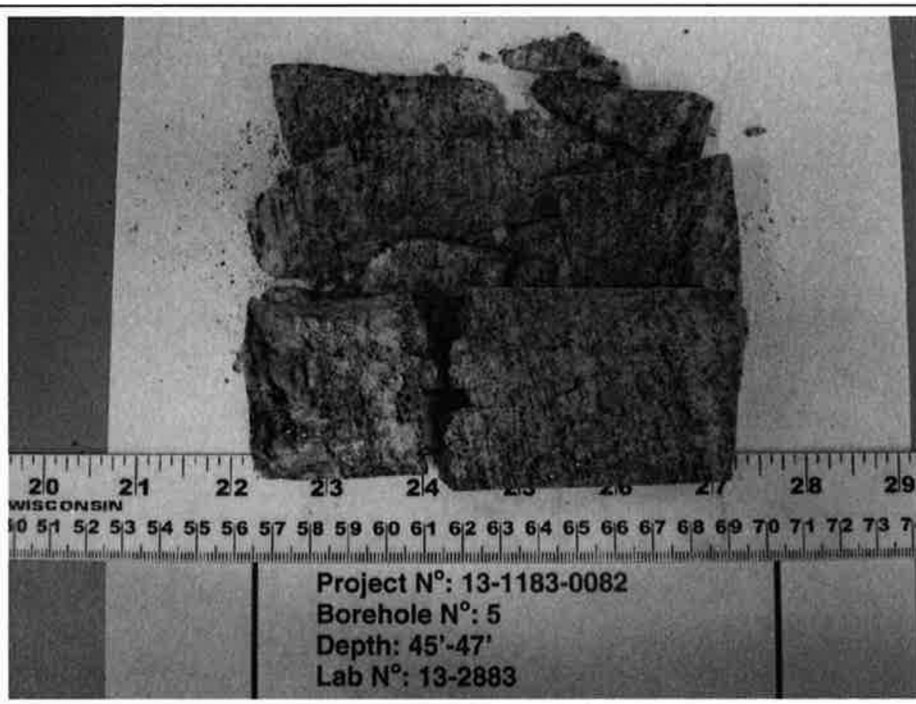
Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd. RO

UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	13-1183-0082	SAMPLE NUMBER	-
BOREHOLE NUMBER	6	SAMPLE DEPTH, m	2.9-3.4

TEST CONDITIONS

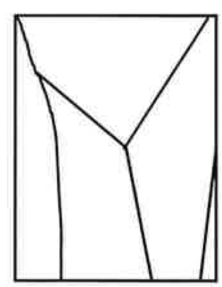
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.21

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	8.00	WATER CONTENT, (specimen) %	0.09
SAMPLE DIAMETER, cm	3.62	UNIT WEIGHT, kN/m^3	26.15
SAMPLE AREA, cm^2	10.28	DRY UNIT WT., kN/m^3	26.13
SAMPLE VOLUME, cm^3	82.21	SPECIFIC GRAVITY	-
WET WEIGHT, g	219.28	VOID RATIO	-
DRY WEIGHT, g	219.08		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	116.8

REMARKS:

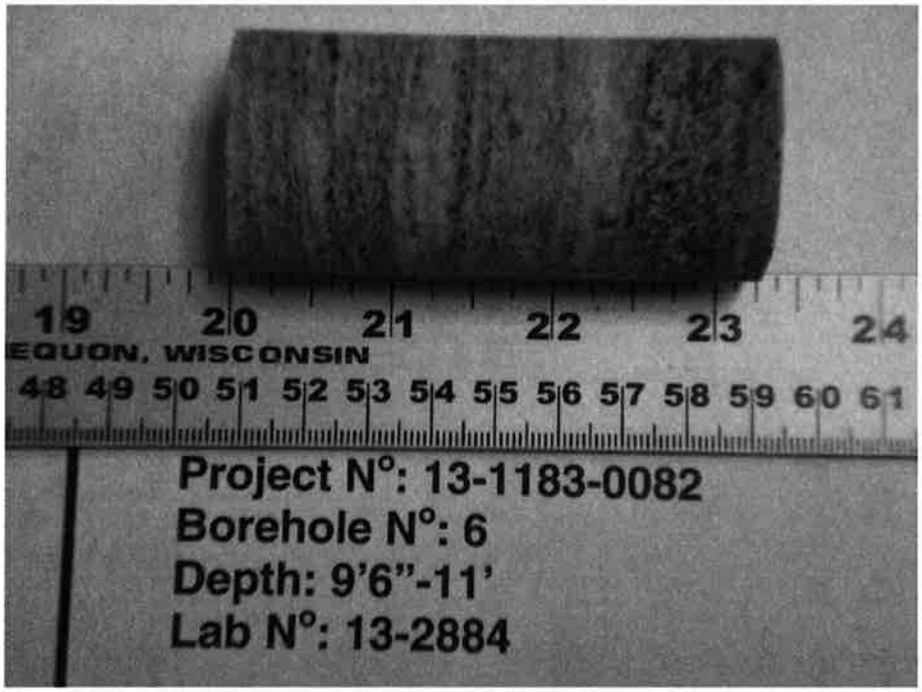
DATE: 7/24/2013

Checked By: Ro

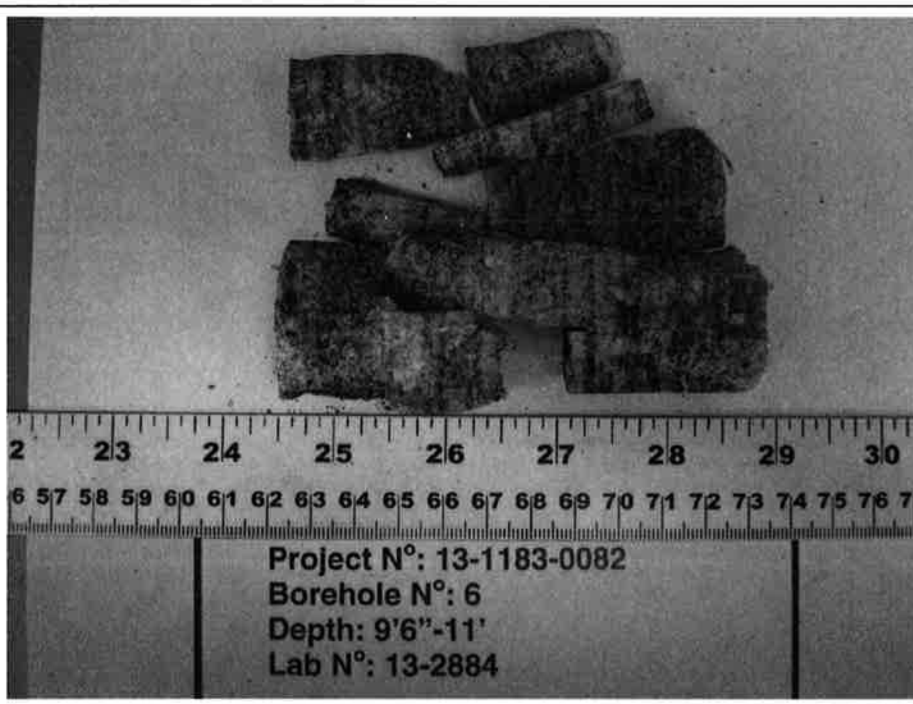
Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE



BEFORE COMPRESSION



AFTER COMPRESSION

Date 7/26/2013
Project 13-1183-0082

Golder Associates

Drawn Frank
Chkd. RO

Borehole No.	Run No.	Depth (ft)	Depth (m)	Test Type	Length (mm)	Core Diameter (mm)	Force (kN)	Rock Type	Is (MPa)	Is(50) (MPa)	Equivalent UCS (MPa)
BH3	2	29.67	9.04	A	42	48	17.348	GNEISS	6.758	6.799	163.2
	2	29.83	9.09	D		48	12.238	GNEISS	5.215	5.2	125.2
	3	34.67	10.57	A	47	48	20.28	GNEISS	7.060	7.3	174.8
	3	34.83	10.62	D		48	9.72	GNEISS	4.142	4.1	99.4
BH4	1	6.5	1.98	A	37	37	9.803	GNEISS	5.624	5.2	124.5
	1	6.58	2.01	D		37	5.761	GNEISS	3.675	3.7	88.2
	1	6.75	2.06	A	37	37	15.379	GNEISS	8.823	8.1	195.2
	2	12.67	3.86	D		37	8.981	GNEISS	5.729	5.7	137.5
	2	12.83	3.91	A	36	37	10.975	GNEISS	6.471	5.9	142.3
	3	15.33	4.67	D		37	5.88	GNEISS	3.751	3.8	90.0
	3	15.5	4.72	A	40	37	14.578	GNEISS	7.736	7.3	174.2
BH5	1	43.25	13.18	A	40	48	20.153	GNEISS	8.244	8.2	196.9
	1	43.75	13.34	D		48	6.206	GNEISS	2.645	2.6	63.5
	2	44.08	13.44	A	53	48	26.871	GNEISS	8.296	8.8	211.0
	2	44.25	13.49	D		48	14.044	GNEISS	5.985	6.0	143.6
	3	51.25	15.62	D		48	12.029	GNEISS	5.126	5.1	123.0
	3	51.67	15.75	A	46	48	15.025	GNEISS	5.344	5.5	131.7
BH6	1	9.75	2.97	A	29	37	11.876	GNEISS	8.693	7.6	182.1
	1	9.92	3.02	D	37	37	1.798	GNEISS	1.147	1.1	27.5
	2	14.42	4.40	A	31	37	6.806	GNEISS	4.660	4.1	99.1
	2	14.58	4.44	D	37	37	7.356	GNEISS	4.692	4.7	112.6
	3	17.58	5.36	A	28	37	11.402	GNEISS	8.644	7.5	179.7
	3	17.75	5.41	D	37	37	8.625	GNEISS	5.502	5.5	132.0

Appendix E

Explanation of Terms Used in the Report

EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS $\overline{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSION AND STRUCUTRAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINT AND BEDDING:

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICALL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
Φ.	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
Φ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1,%	VOID RATIO	e_{min}	1,%	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1,%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_P	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_P	%	PLASTICITY INDEX = $(W_L - W_L)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W - W_P)/ I_P$	i	1	HYDAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $(W_L - W) / 1_P$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERED SOIL	e_{max}	1,%	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						