



**PRELIMINARY FOUNDATION INVESTIGATION
REPORT FOR THE REHABILITATION OF
HIGHWAY 400 / COUNTY ROAD 23
OVERPASS, TOWNSHIP OF COLDWATER,
ONTARIO, G.W.P. 2190-10-02,
SITE NO. 30/455-1/2, GEOCRETS 31D-562**

McCormick Rankin Corporation

TRANETOB20462AA
September 16, 2013

REPORT

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**PRELIMINARY FOUNDATION INVESTIGATION REPORT
REHABILITATION OF HIGHWAY 400 / COUNTY ROAD 23 OVERPASS,
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1 INTRODUCTION

The existing bridges, which carry Highway 400 North Bound and South Bound lanes over County Road 23, will be rehabilitated at the site. Coffey was retained by McCormick Rankin Corporation (MRC) to carry out a desktop study using existing borehole information at the site for the proposed bridge rehabilitation, and a preliminary foundation investigation at the site (MTO Site No. 30-455-1/2) for the proposed bridge widening. It should be noted that the original project scope included rehabilitation and widening of the bridge. After completion of the field investigations, the scope was changed to rehabilitation only. However the investigation data provided in the following sections include that for widening for information.

The purpose of the current investigations was to obtain information about the subsurface conditions at the widening location (toward median) by means of boreholes, and to determine the engineering characteristics of the subsurface soils by means of field and laboratory tests.

The findings of the previous and current investigation are presented in this report.

2 SITE DESCRIPTION AND GEOLOGY

The site is located at the intersection of Highway 400 and County Road 23 in Coldwater, Ontario. The topography at the site can be described as gently rolling.

According to the Physiography of Southern Ontario by L.J. Chapman and D.F. Putnam, 1984 edition, the project site is located within the Physiographic Region known as the Simcoe Uplands at the confluence with Carden Plain and Georgian Bay Fringe. The Simcoe Uplands comprises a series of broad curved ridges, separated by steep-sided, flat-floored valleys.

Previous investigations carried out in 1959 and 1974 by Geocon and in 1981 by MTO in the vicinity revealed the presence of a post-glacial clay plain underlain by sand and gravel, then granitic metamorphic gneiss bedrock. At or near the bridge site however the clay plain was not encountered and the site was found to be underlain by granular overburden. These deposits were found to vary from basically granular glacial tills to unstratified or stratified deposits of granular material, the difference being dependant on the part played by meltwater in their deposition. It is of interest to note that the 1959 Report mentions the presence of a gravel pit and an adjacent pond in the general area; pond elevation being at about 648 ft. (El. 197.5 m). However, the construction of structures and permanent drainage measures appear to have depressed the groundwater table.

3 COMPILED SUBSURFACE CONDITIONS BASED ON PREVIOUS INVESTIGATIONS

Based on the available information (GEOCRE 31D-218, 31D-294, GA drawings, MTO bridge inspection reports), it is assumed that Co. Rd 23 interchange overpass Highway 400 NBL and SBL may be the current northbound and southbound County Road 23/Highway 400 Overpasses. In 1974, GEOCON carried out two site investigations consisting of eight boreholes (i.e. Boreholes 1, 2, 3, 4, 5, and 6 for Site 30-455, NBL, and Boreholes 5 and 6 for Site 30-455B, SBL) for the existing bridge structures. Exact locations of the boreholes cannot be defined since borehole location plan were not available in MTO GEOCRE information system. Record of borehole sheets and laboratory testing results are included in Appendix A and B.

In general, the bridge sites are underlain by a dense to very dense granular soil deposit. Shallow veneer of topsoil and loose to compact granular soil (up to 1.8 m-6 feet) was found near the ground surface at the time of investigation. Cobbles and boulders were also noted within the overburden.

Groundwater condition at the time of investigation was noted close to the ground surface (north abutment location) and 6 to 8 feet (about 1.8 to 2.4 m) below the ground surface (south abutment location) at the NBL overpass location. Groundwater was encountered at 5 to 10 feet (about 1.5 to 3.0 m) below the grade at the time of investigation at the SBL overpass location.

4 CURRENT INVESTIGATION

4.1 Current Investigation Procedures

The fieldwork for the proposed bridge rehabilitation (focused on the widening option) was performed during the period of February 12-15 and March 4 (Borehole 1), 2013. The fieldwork consisted of drilling and sampling of eight boreholes (Boreholes 1 through 8). The following table summarizes the borehole locations and drilling depths.

Table 3.1
Borehole Locations and Drilling Depths

Borehole No.	Location	Depth of Borehole Below Existing Ground Surface (m)	Piezometer
1	NBL	9.4	-
2	NBL	7.8	-
3	NBL	7.3	Yes
4	NBL	4.1	-
5	SBL	7.8	-
6	SBL	8.2	-
7	SBL	4.7	-
8	SBL	6.8	-

Marathon Drilling of Ottawa, Ontario carried out the drilling, testing and sampling work, under the direction and supervision of a Geotechnical Engineer from Coffey. The boreholes were advanced using a CME 55 track 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, wash boring in the overburden and coring) depending on the ground conditions.

Samples in the boreholes 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 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil which is indicative of the compactness condition of cohesionless granular soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey silts).

Groundwater conditions in the boreholes were observed during drilling and upon completion in the open boreholes. In addition, a piezometer was installed in Borehole 3 to enable groundwater level monitoring in the borehole 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. The piezometer in Borehole 3 was not decommissioned as it will be useful during construction to monitor the groundwater table. It should however be decommissioned at that time.

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. This survey information was provided to us.

The soil samples were transported to our geotechnical laboratory in Toronto for further examination and classification. A laboratory testing programme consisting of natural moisture content tests and grain size analyses was performed on selected representative soil samples. The results of laboratory tests are presented on the appropriate Record of Borehole Sheets (Appendix A) and also in Appendix B.

4.2 Subsurface Conditions

The subsurface conditions were explored by means of eight boreholes. Details of subsurface conditions encountered at each borehole location including the results of in-situ testing, groundwater observations in the open boreholes and laboratory test results, are presented on the Record of Borehole sheets in the Appendix B. Explanation of Terms Used in the Report is presented in Appendix D.

Four of the boreholes were advanced from the upper road (i.e. Highway 400) level at elevations ranging from 203.9 to 198.0 m and contacted embankment fill to depths of 6.0 to 7.4 m or to elevations ranging between 197.2 and 192.0 m.

The remaining four boreholes were advanced from the lower (Country Road 23) level, from El. 195.7 to 192.8 m and these boreholes contacted fill to depths 1.5 – 2.2 m below the ground surface or to El. 194.0 – 191.0 m. This is probably the result of construction activities that took place when the existing structures were first built.

Underlying the fill materials, the native soils were found to be granular in nature, ranging from glacial tills (silty sand to sandy silt, but typically silty sand till) to stratified and unstratified (deposited by glacial meltwaters) granular soils. The composition of these latter soils ranged from sandy silt/silty sand, sand with variable gravel content to basically cobbles and boulders within a sandy matrix. The tills and other granular deposits appeared to contain an unusually high cobble & boulder content, judging from the difficulties encountered in advancing the boreholes during augering and, in some instances, the necessity for coring.

It should be pointed out that because the fill is similar in nature to the underlying granular deposits, in many cases it was found that distinguishing the two from each other was difficult based solely upon split-spoon samples.

The Record of Borehole Sheets and sections indicate the subsurface conditions only at the borehole locations. Note that the material boundaries indicated on the logs are approximate and based on visual observations. These boundaries typically represent a transition from one material type to another and should not be regarded as an exact plane of geological change. It should be pointed out that the subsurface conditions may vary across this site.

The following paragraphs summarize the surface condition encountered in the boreholes.

4.2.1 Asphalt

Boreholes 1, 5 and 6 were drilled from the paved surface of Highway 400 and contacted 155 to 300 mm thick asphaltic concrete. Borehole 2 was also drilled from the paved surface of Highway 400 but from the top of the approach slab and contacted 110 mm of Asphaltic concrete, underlain by 450 mm thick concrete (i.e. approach slab).

4.2.2 Embankment Fill

Boreholes 1, 2, 5 and 6, which were advanced from the top of Highway 400 embankment, contacted embankment fill to depths ranging between 6.0 and 7.4 m below the ground surface or to El. 197.2 – 195.3 m at Boreholes 5 and 6 at SBL and El. 192.3 - 192.0 m at Boreholes 1 and 2 at the NBL.

The fill appears to have been derived from indigenous granular overburden and while its composition ranges from sandy silt to sand & gravel. In general, it consists of sand with some silt and gravel. The grain-size distribution of seven samples from the deposit is presented in an envelope form in Figure B-1 in Appendix B.

These show the following grain-size distribution

Gravel:	2 – 45 %
Sand:	48 – 91 %
Silt and Clay:	7 – 44 %

The embankment fill and the overlying pavement fill (immediately underlying the asphalt) are non-cohesive, granular soils.

The N-values recorded in the fill in Boreholes 1 and 2 (i.e. NBL embankment) range from 11 to 39 blows/0.3 m (except for gravelly layer where N value exceeded 50 blows/0.3 m). These results indicate that the fill received a reasonably good degree of compaction when it was first constructed. In Boreholes 5 and 6 (i.e. SBL boreholes), the recorded N-values show a greater degree of variation, ranging from 3 to 86 blows/0.3 m. From the recorded results it can be surmised that the lower half of the embankment in Borehole 5 received little or no compaction as evidenced by N-values 3-11 blows/0.3 m, while the upper zones were compacted to a reasonable degree of compaction. It also appears that in Borehole 6, the upper and lower zones were compacted but the middle half was irregularly compacted (i.e. contains loose zones).

4.2.3 Lower Fill

Boreholes 3, 4, 7 and 8 were advanced from County Road 23 (lower) level, near the toe of the embankment from El. 195.7 and 195.1 m (Boreholes 7 and 8, SBL) and 193.2 and 192.8 m (Boreholes 3 and 4, NBL) and encountered fill extending to depths ranging from 1.5 to 2.2 m below the ground surface or to El. 194.0

- 191.0 m. These fills appear to be derived from the indigenous granular overburden and as such it is difficult to distinguish them from the underlying native soils and the interface elevations shown on the Record of Borehole Sheets should be considered approximate only. These fills are believed to be related to the foundation construction of the existing structures at the site.

The grain-size distribution curves of three representative samples from the materials are given in Figure B-2 in Appendix B. These indicate the following grain-size distribution

Gravel:	8 – 20 %
Sand:	56 – 65 %
Silt and Clay:	19 – 30 %

These materials are considered to be non-cohesive, granular soils.

Standard Penetration tests performed in these previous construction backfill materials yielded N-values which ranged from 4 to 53 blows/0.3 m, indicating a very loose to very dense condition.

4.2.4 Silty Sand to Sandy Silt Till

As was mentioned before, the native overburden soils contacted in the boreholes are basically of two types, based on their depositional history; namely, non-cohesive glacial tills and granular interglacial or washed glacial soils. In terms of composition, the glacial tills consist of a heterogeneous mixture of sand and silt with some gravel, while the interglacial and washed glacial soils consist of stratified (interglacial) or relatively homogeneous (washed glacial) granular soils. In many cases these native deposits are interlayered.

The glacial till was contacted in Boreholes 1, 4, 5, 7 and 8 (i.e. it was not contacted in Boreholes 2, 3 and 6 within the depths drilled, but will likely be contacted throughout at greater depths during the detail investigation).

In Boreholes 1, 4, 5 and 8, the glacial till was contacted immediately underlying fill at elevations ranging from 195.3 to 191.7 m, while in Borehole 7, the deposit was encountered at El. 190.8 m, underlying a layer of sand & gravel. In most cases, the glacial till extended to the remaining depth of the boreholes at El. 194.4 - 189.0 m where refusal to further augering was experienced on boulders/cobbles. In Borehole 1 the till was found to be underlain by a sand deposit at El. 189.5 m. It should be pointed out that the interglacial deposits were frequently found to be interbedded with the till.

The grain-size distribution of seven samples from the till is given in Figure B-3 (Appendix B) in an envelope form. The results are also shown on the Record of Borehole Sheets and are as follows:

Gravel:	5 – 16 %
Sand:	36 – 79 %
Silt and Clay:	14 – 49 %

The presence of cobbles & boulders was inferred during the drilling operations.

The deposit is considered to be a basically non-cohesive (granular) type of soil.

N-values recorded in the deposit are generally in excess of 50 blows/0.3 m and this indicates a very dense relative density, except for a compact zone (N-value of 16 blows/0.3 m) in the upper zone of the till (immediately underlying the embankment fill) in Borehole 5. While some of the N-values may be on the

high side due to the presence of oversize gravel and cobbles/boulders. Nevertheless, the denseness condition of the till can be described as generally very dense.

4.2.5 Granular (non-till) Overburden

Granular overburden, ranging composition for sandy silt to cobbles/boulders in a sand matrix, was contacted in Boreholes 1, 2, 3, 6 and 7. In addition, layers of such 'interglacial' or 'washed till' origin soils were noted interbedded with the till deposits. In Boreholes 2, 3, 6 and 7, these granular overburden soils were contacted immediately underlying the fill deposits at El. 197.2 and 191.0 m. Boreholes 1, 2, 3 and 6 were terminated in these deposits at El. 195.7 - 185.6 m, upon encountering refusal on inferred boulders.

As mentioned, the grain-size of these deposits were found to be highly variable, ranging from silty sand/sandy silt; sand with some gravel-sand & gravel to cobbles & boulders in a sand matrix. On several occasions coring was resorted to advance the borehole in coarse zones containing cobbles/boulders.

The grain-size distributions of two typical samples are presented in Figures B-4 and B-5 (Appendix B). Figure B-4 represents a finer soil consisting of silty fine sand with traces of gravel (10 % gravel, 53 % sand and 37 % silt size particles), while in Figure B-5, a more typical soil is shown, consisting of sand with some gravel and traces of silt (11 % gravel, 80 % sand and 9 % silt size particles).

These deposits are considered to be non-cohesive, granular soil types. Standard Penetration tests performed in these deposits gave N-values generally ranging from 24 to in excess of 100 blows/0.3 m. Even though some of the recorded values may be too high due to the presence of over-sized particles which tend to distort the actual penetration values during testing nevertheless, the relative density of these soils can be considered to be dense to very dense, with some compact zones.

4.2.6 Groundwater Conditions

Water levels in the open boreholes were observed during drilling and upon completion of each borehole. The observations are given on the individual Record of Borehole Sheets in Appendix A.

In general the soil became wet, holes caved-in (wet cave), and the colour of the soil changed from brown to grey between El. 192.5 and 190.0 m.

For and on behalf of Coffey

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



Zuhtu Ozden, P.Eng.
Senior Principal



Drawings

METRIC

FOR DETAILED SUBSURFACE
CONDITIONS REFER TO RECORD
OF BOREHOLE SHEETS.

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

CONT No. -
WP: 2190-10-02

HWY 400 / COUNTY ROAD 23 INTERCHANGE
OVERPASS BRIDGES REHABILITATION
BOREHOLE LOCATION PLAN



SHEET

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SPECIALISTS MANAGING THE EARTH



KEY PLAN
N.T.S.

LEGEND

- Borehole
- ⊙ Borehole & Cone

No	ELEVATION	STATION	OFFSET
BH1	198.026	30+524	0.88m Lt C/L
BH2	199.694	30+586	0.72m Lt C/L
BH3	192.837	30+537	8.2m Lt C/L
BH4	193.159	30+560	10.4m Lt C/L
BH5	202.269	30+498	2.80m Rt C/L
BH6	203.901	30+539	0.39m Rt C/L
BH7	195.067	30+498	10.8m Rt C/L
BH8	195.728	30+519	8.27m Rt 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.

REVISIONS	DATE	BY	DESCRIPTION

Geotecs No - 31D-562			
TRANET020462AA		DIST	
SUBMD	CHECKED	DATE September, 2013	SITE
DRAWN SSH	CHECKED G R	APPROVED ZO	DWG 1



BOREHOLE LOCATION PLAN



METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
ARE IN KILOMETRES + METRES.
FOR DETAILED SUBSURFACE
CONDITIONS REFER TO RECORD
OF BOREHOLE SHEETS.

CONT No.
WP: 2190-10-02

HWY 400 NBL COUNTY ROAD 23
INTERCHANGE OVERPASS BRIDGE
REHABILITATION
BOREHOLE LOCATION PLAN
AND SOIL STRATA

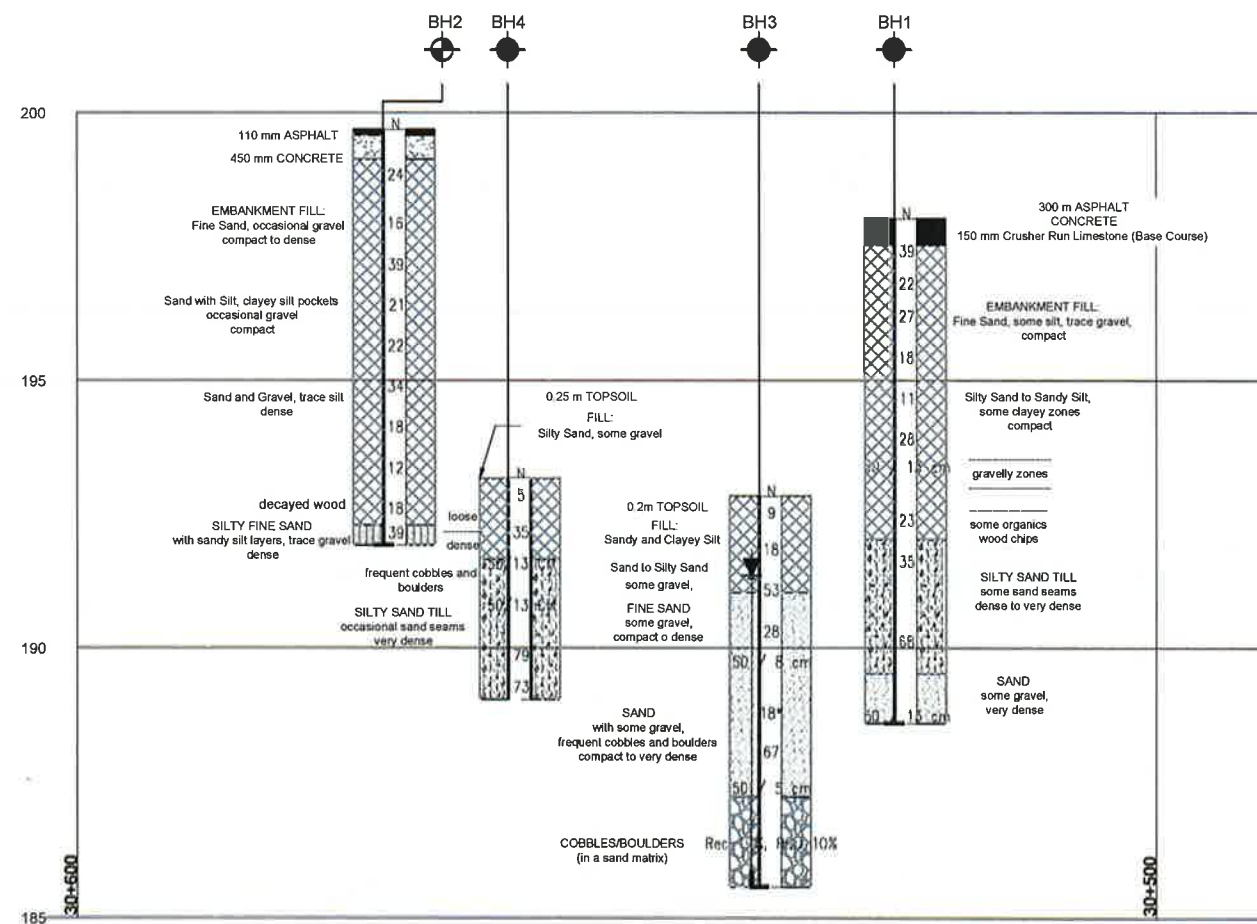
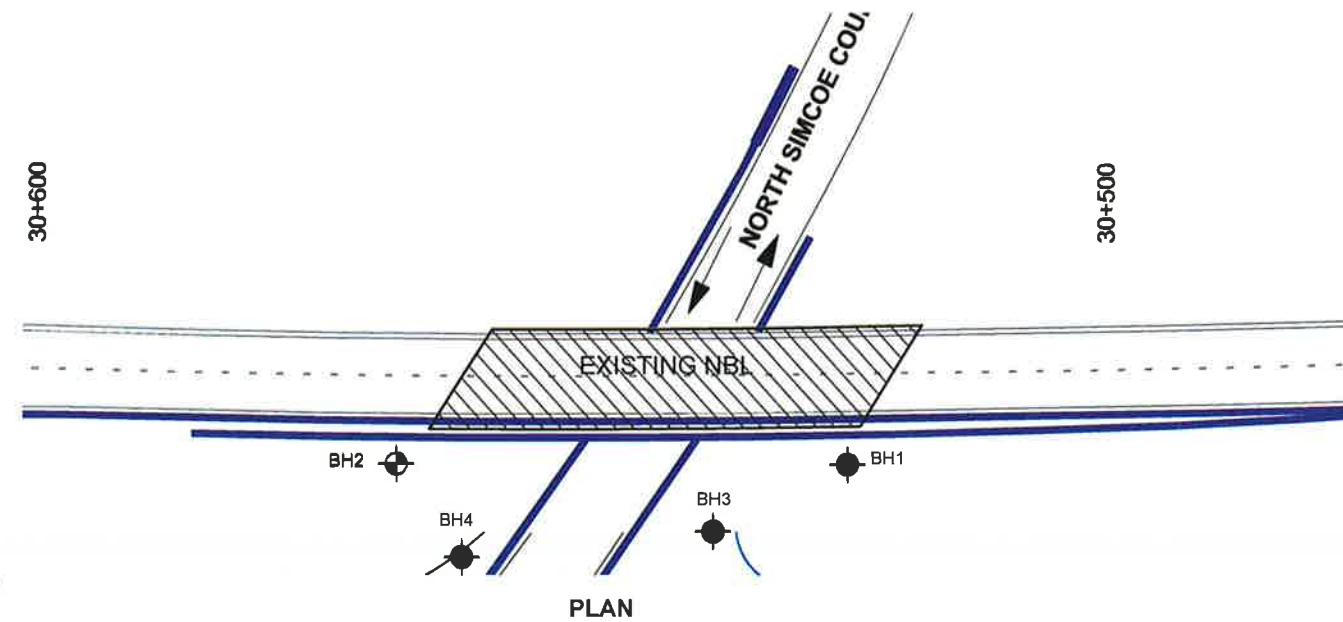


SHEET

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KEY PLAN
N.T.S.



LEGEND

- Borehole
- Borehole & Cone
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level in Piezometer
- Piezometer

No	ELEVATION	STATION	OFFSET
BH1	198.026	30+524	0.68m Lt C/L
BH2	199.594	30+586	0.72m Lt C/L
BH3	192.837	30+537	8.2m Lt C/L
BH4	193.159	30+580	10.4m 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.



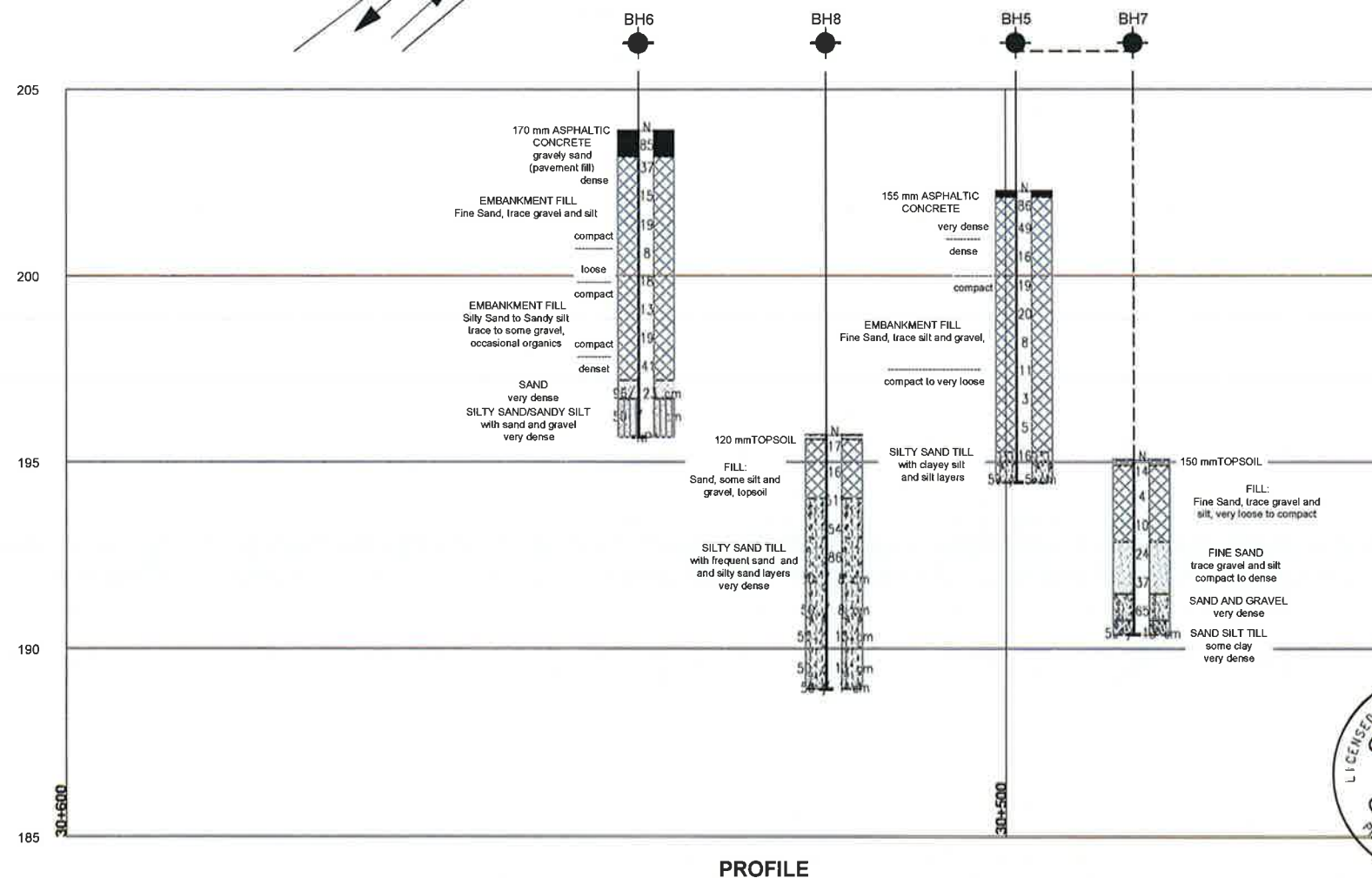
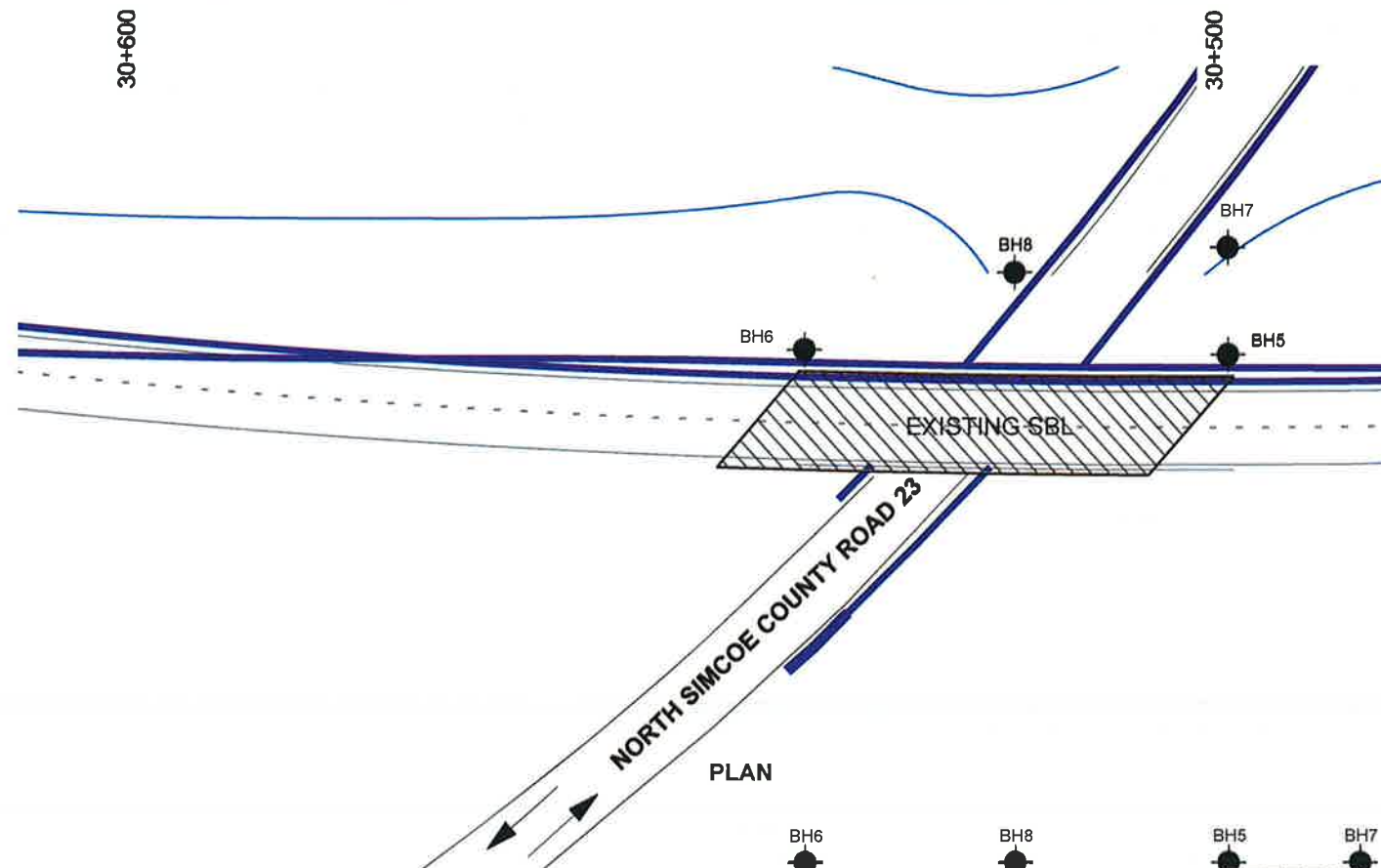
PROFILE



REVISIONS	DATE	BY	DESCRIPTION

Geocres No - 31D-562

TRANET020482AA	DIST
SUBMD	CHECKED
DATE September, 2013	SITE
DRAWN SSH	CHECKED G.R.
APPROVED ZO	DWG
2	2



METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
ARE IN KILOMETRES + METRES.
FOR DETAILED SUBSURFACE
CONDITIONS REFER TO RECORD
OF BOREHOLE SHEETS.

CONT No.
WP: 2190-10-02

HWY 400 SBL COUNTY ROAD 23
INTERCHANGE OVERPASS BRIDGE
REHABILITATION
BOREHOLE LOCATION PLAN
AND SOIL STRATA



SHEET

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KEY PLAN
N.T.S.

LEGEND

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

No	ELEVATION	STATION	OFFSET
BH5	202.269	30+498	2.80m Rt C/L
BH6	203.901	30+539	0.39m Rt C/L
BH7	195.087	30+498	10.83m Rt C/L
BH8	195.728	30+519	8.27m Rt 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.

REVISIONS	DATE	BY	DESCRIPTION



Geores No - 31D-562	TRANETO820462AA	DIST
SUBM'D	CHECKED	DATE September, 2013
DRAWN	SSH	CHECKED G.R.
		APPROVED ZO
		DWG
		3

Appendix A

Record of Borehole Sheets

TRANETO20482AA Highway 400, County Rd 23 Overpass, Coldwater

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

GWP G W P 2190-10-02 LOCATION (E 292099 807, N 4951764 734) ORIGINATED BY LG
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SSH
 DATUM Geodetic DATE 04/03/2013 04/03/2013 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
198.0	GROUND SURFACE												
0.0	300 mm ASPHALTIC CONCRETE												
197.8	150 mm Crusher Run Limestone (Base Course)		1	SS	39								
0.5			2	SS	22								
	EMBANKMENT FILL: Fine Sand, some silt, trace gravel some silt lenses brown, compact, damp		3	SS	27								
195.7			4	SS	18								
2.3			5	SS	11								
	EMBANKMENT FILL: Silty Sand to Sandy Silt, some clayey zones brown, compact, moist		6	SS	28								
			7	SS	50 / 13 cm								
	some organics wood chips		8	SS	23								
192.0			9	SS	35								
6.0	SILTY SAND TILL some sand seams brown, dense to very dense, wet		10	SS	68								
189.5													
8.5	SAND some gravel brown, v. dense, wet		11	SS	60 / 13 cm								
188.6													
9.4	End of Borehole Augers grinding, refusal to augering @ 9.4 m *Wet Cave @ 6.0 m upon completion, not stabilized												

+ 3, x 3: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

TRANETO020462AA Highway 400, County Rd 23 Overpass, Coldwater

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

GWP GWP 2190-10-02 LOCATION (E 292058 524, N 4951792 641) ORIGINATED BY LG
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger, DCPT COMPILED BY SSH
 DATUM Geodetic DATE 13/02/2013 13/02/2013 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			2C 40 60 80 100	40 60 80 100	100 200 300		
199.7	GROUND SURFACE											
199.0	110 mm ASPHALTIC CONCRETE											
199.1	450 mm CONCRETE											
199.0			1	SS	24		199					
	EMBANKMENT FILL: Fine Sand, occasional gravel brown, compact to dense, damp		2	SS	16		198					
			3	SS	39		197					2 91 (7)
195.7			4	SS	21		196					
3.0	EMBANKMENT FILL: Sand with Silt, clayey silt pockets occasional gravel brown, compact, moist		5	SS	22		195					
195.2			6	SS	34		194					45 48 (7)
4.5	EMBANKMENT FILL: Sand and Gravel, trace silt brown, wet		7	SS	18		193					
			8	SS	12		192					
192.5			9	SS	18							
7.2	FILL: sand, gravel, decayed wood		10	SS	39							
192.3												
7.4	SILTY FINE SAND with sandy silt layers, trace gravel greyish brown, dense, wet											
191.9												
7.8												
	End of Borehole @ 7.8 m Sampler bouncing @ 7.8 m Dynamic cone penetration test (DCPT) performed from 7.3 to 8.4 m, hammer bouncing @ 8.4 m, no advance on tri-cone drilling (on boulder) Borehole cave-in @ 1.5 m upon completion, not stabilized											

+³, ×³: Numbers refer to Sensitivity 20 16 10 6 10 (%) STRAIN AT FAILURE

TRANETO820462AA Highway 400, County Rd 23 Overpass, Coldwater

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

GWP GWP 2130-10-02 LOCATION (E 292086 267, N 4951768 376) ORIGINATED BY LG
DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Coring COMPILED BY SSH
DATUM Geodetic DATE 14/02/2013 14/02/2013 CHECKED BY ZO

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20 40 60 80 100	20 40 60 80 100	W _P W _L	W _N		
192.8 0.0	GROUND SURFACE											
192.1 0.7	0.2 m TOPSOIL brown, loose, moist FILL: Sandy and Clayey Silt		1	SS	9							
191.0 1.8	FILL: Sand to Silty Sand, some gravel brown, compact to dense, moist		2	SS	18							
190.0 2.8	FINE SAND some gravel, some silty zones (possible fill) brown, compact to very dense, wet		3	SS	53							
189.0 3.8	SAND with some gravel frequent cobbles and boulders brown, compact to very dense, wet		4	SS	28							
188.0 4.8			5	SS	20/18							
187.2 5.6			6	SS	18*							
186.0 7.0			7	SS	67							
185.6 7.3	COBBLES/BOULDERS (in a sand matrix)		8	SS	40/15							
			9	NQ Rec 19% RC RQD 10%								
	End of Borehole Water level @ 1.5 m on completion, not stabilized											

+ 3, x 3

Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

TRANETOB20462AA: Highway 400, County Rd 23 Overpass, Coldwater

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

GWP G.W.P 2190-10-02 LOCATION (E 292067 243, N 4951782 08) ORIGINATED BY LG
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SSH
 DATUM Geodetic DATE 15/02/2013 15/02/2013 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w _n	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
193.2 0.0	GROUND SURFACE 0.25 m TOPSOIL		1	SS	5		193										
	loose																
	FILL: Silty Sand, some gravel brown, moist	dense	2	SS	35		192										8 62 (30)
191.7 1.5	freqent cobbles and boulders		3	SS	50/13 cm												
	SILTY SAND TILL occasional sand seams very dense, moist		4	SS	50/13 cm		191										5 59 28 8
	brown																Refusal on auger
	grey		5	SS	79		190										@ 2.6 m on a boulder relocate 0.6 m and re drill
189.0 4.1	End of Borehole Refusal to further augering (probable boulder) no free-standing water in open borehole upon completion, not stabilized		6	SS	73												

+ 3 x 3

Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

TRANETO20402AA Highway 400, County Rd 23 Overpass, Coldwater

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

GWP G.W.P 2190-10-02 LOCATION (E 292049 921, N 4951756 508) ORIGINATED BY LG
DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SSH
DATUM Geodetic DATE 12/02/2013 12/02/2013 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
202.3 202.4 0.2	GROUND SURFACE													
	155 mm ASPHALTIC CONCRETE		1	SS	86		202							
	very dense													
	dense		2	SS	49		201							
	compact													
			3	SS	16									
	EMBANKMENT FILL: Fine Sand, trace silt and gravel brown, damp						200							
			4	SS	19									
			5	SS	20		199							2 88 (10)
	compact to very loose													
			6	SS	8		198							
			7	SS	11									
			8	SS	3		197							
			9	SS	5		196							16 67 (17)
195.3 7.0	SILTY SAND TILL		10	SS	16		195							
	compact													
194.4 7.8	with clayey silt and silt layers gray / brown, moist		11	SS	50 / 5 cm									7 61 25 7
	very dense													
	End of Borehole Sampler bouncing and auger refusal @ 7.8 m Borehole dry and open on completion, not stabilized													

+ 3 x 3 Numbers refer to 20
Sensitivity 15 5
10 (%) STRAIN AT FAILURE

TRANETO20462AA: Highway 400, County Rd 23 Overpass, Coldwater

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

GWP GWP 2190-10-02 LOCATION (E 292020.186, N 4951783.741) ORIGINATED BY LG
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SSH
 DATUM Geodetic DATE 12/02/2013 12/02/2013 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
203.9 0.0	GROUND SURFACE																
203.2 0.7	170 mm ASPHALTIC CONCRETE gravelly sand, brown, (pavement fill)		1	SS	85												
			2	SS	37		203										9 76 (15)
	EMBANKMENT FILL Fine Sand, trace gravel and silt brown, damp	dense	3	SS	15		202										
		compact	4	SS	19		201										
		loose	5	SS	8		200										
		compact	6	SS	16		199										13 63 (24)
199.6 4.3	EMBANKMENT FILL Silty Sand to Sandy Silt trace to some gravel, occasional organics greyish brown, moist		7	SS	13		198										
		compact	8	SS	19		197										
197.2 6.7	SAND brown, very dense, moist	dense	9	SS	41		196										
196.7 7.2	SILTY SAND / SANDY SILT with sand and gravel layers brown, very dense, moist		10	SS	95/23 cm		195										
195.7 8.2	End of Borehole sampler bouncing and auger refusal @ 8.2 m no free standing water observed on completion in open borehole, not stabilized		11	SS	5/11 cm												
			12	SS	NP*												*NP: no penetration

+ 3 x 3

Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

TRANETO B20462AA Highway 400, County Rd 23 Overpass, Coldwater

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

GWP G W.P. 2190-10-02 LOCATION (E 292056 714, N 4951764 171) ORIGINATED BY LG
DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SSH
DATUM Geodetic DATE 14/02/2013 14/02/2013 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
195.1 194.6 0.5	GROUND SURFACE													
	150 mm TOPSOIL		1	SS	14		195							
	FILL: Fine Sand, trace gravel and silt brown, very loose to compact, moist		2	SS	4		194							
			3	SS	10									
192.9 192.2 0.7	FINE SAND trace gravel and silt brown, compact to dense		4	SS	24		193							
			5	SS	37		192							10 53 (37)
191.5 190.8 0.7	SAND AND GRAVEL brown, very dense, wet		6	SS	65		191							
190.4 190.4 0.0	SANDY SILT TILL some clay brown, very dense, wet		7	SS	130									15 36 (45)
190.4 190.4 0.0	End of Borehole Auger refusal at 4.7 m *wet cave at 3.6 m upon completion, not stabilized													

+ 3 . X 3 = Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

TRANETOB20462AA: Highway 400, County Rd 23 Overpass, Coldwater

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

GWP G W P 2190-10-02 LOCATION (E 292040 036, N 4951775 882) ORIGINATED BY LG
DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SSH
DATUM Geodetic DATE 15/02/2013 15/02/2013 CHECKED BY ZO

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
195.7 195.6 0.1	GROUND SURFACE 120 mm TOPSOIL brown, moist to damp	1	SS	17									
	FILL: Sand, some silt and gravel, topsoil brown, compact, moist	2	SS	16		195							16 65 (19) refusal @ 2.1 m (probable boulder) Relocate and re-auger borehole
194.0 1.7		3	SS	51**		194							**N- value may not be reliable due to large gravel
	SILTY SAND TILL with frequent sand and silty sand layers very dense, wet	4	SS	54		193							
		5	SS	86		192							
		6	SS	70 / 8 cm		191							16 63 (21)
		7	SS	50 / 8 cm		190							
		8	SS	57 / 13 cm		189							14 67 11 8
		9	SS	50 / 13 cm									
188.9 6.8	End of Borehole sampler bouncing and auger refusal @ 6.8 m. *water level @ 5.5 m (not stabilized)	10	SS	50 / 13 cm									

+³ ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

NBL

7

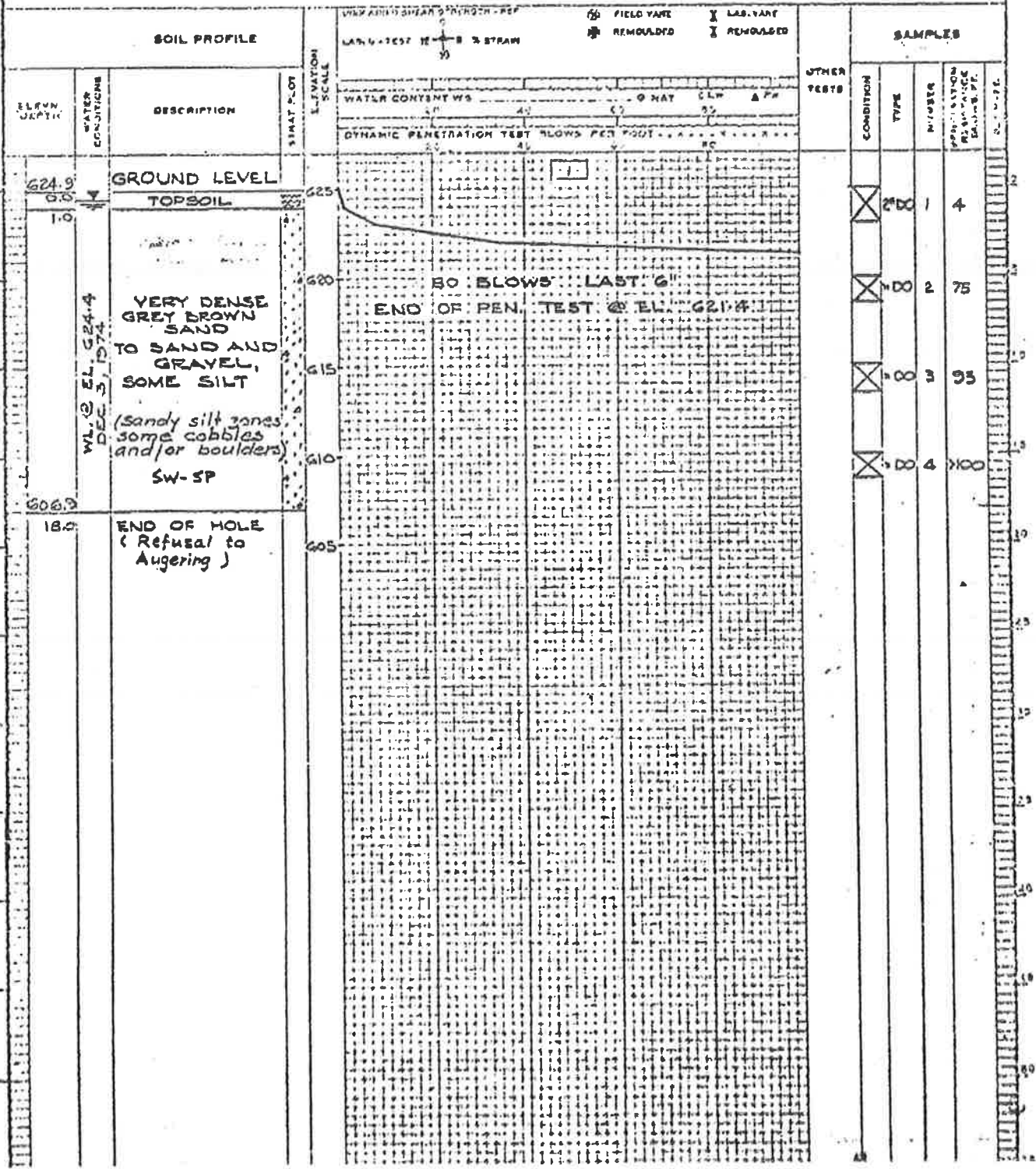
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W.P. 906-66-09

OFFICE REPORT ON SOIL EXPLORATION

BORING NO. 1 DATUM GEODETIC CARING
 BORING DATE DEC. 3, 1974 REPORT DATE DEC. 9, 1974 COMPILED BY NL CHECKED BY Fbo
 SAMPLER HAMMER WT 140 LBS DRCP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN. LBS. ENERGY)

SAMPLE CONDITION	SAMPLE TYPES	ABBREVIATIONS
<input checked="" type="checkbox"/> UNDISTURBED <input type="checkbox"/> DISTURBED <input type="checkbox"/> LOOSE <input type="checkbox"/> LOST	AS - AUGER SAMPLE ST - SLOTTED TUBE WS - WANNING SAMPLE DO - DRIVE FOOT VALVE OF - DRIVE FOOT VALVE CS - CHURCH SAMPLE FS - FOIL SAMPLE SO - SLEEVE OPEN SF - SIEVE FOOT VALVE TO - THIN WALL FOOT VALVE RC - ROCK CORE	V - IN-SITU VANE TEST M - MECHANICAL ANALYSIS U - UNCONFINED COMPRESSION UC - TRIAXIAL CONSOLIDATED UNDRAINED UG - TRIAXIAL UNDRAINED S - TRIAXIAL DRAINED T - TEST UNIT WEIGHT R - PERMEABILITY C - CONSOLIDATION WL - WATER LEVEL IN CARING WT - WATER TABLE IN SOIL



W.P. 906-66-09

GEOCON

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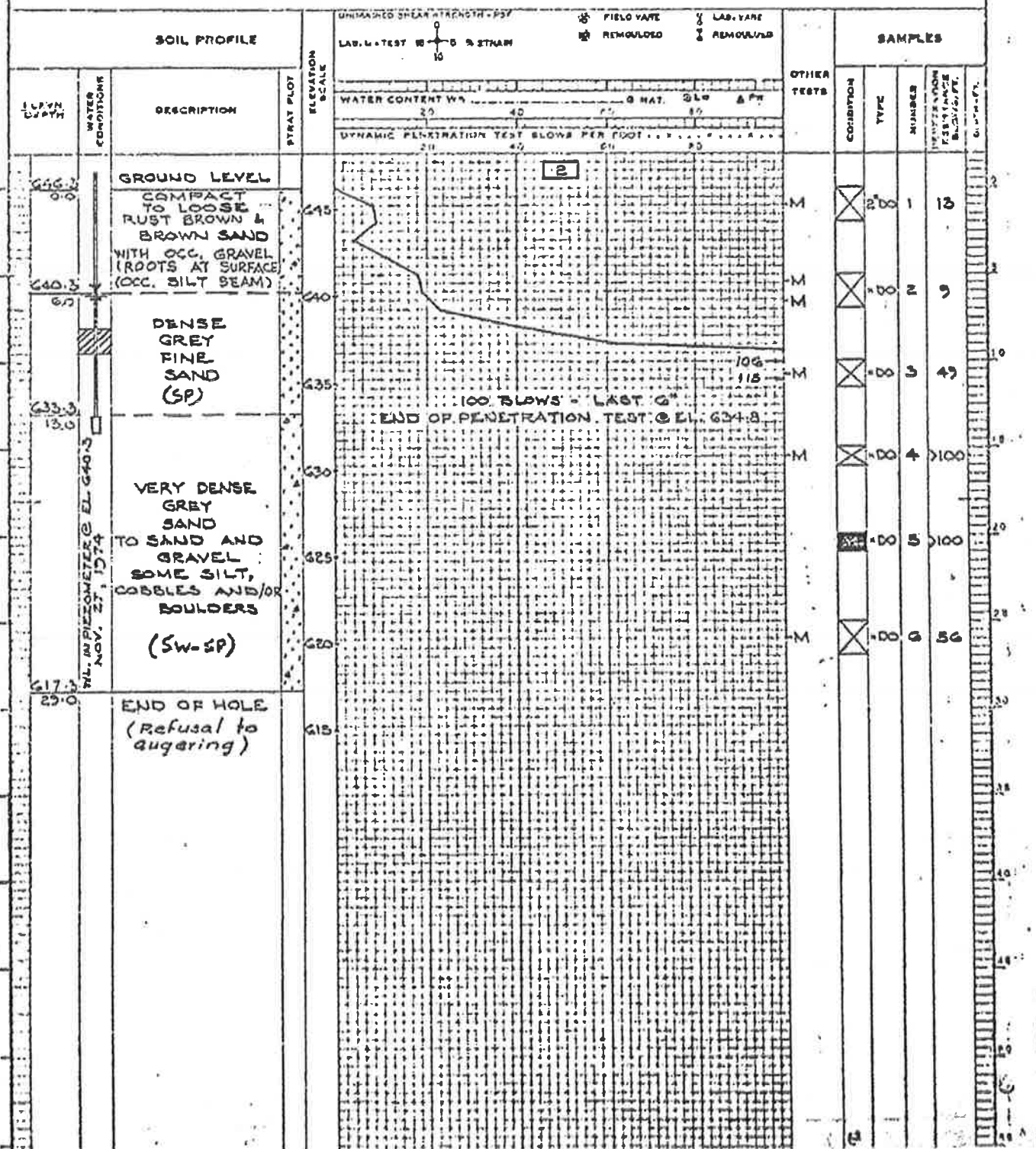
OFFICE REPORT ON SOIL EXPLORATION

BORING NO. 2 DATUM GEODETIK CASING BX-4
 BORING DATE NOV. 27, 1974 REPORT DATE DEC. 2, 1974 COMPILED BY ABL CHECKED BY 1/70
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN. LBS. ENERGY)

SAMPLE CONDITION
☒ DISTURBED
☐ FAIR
☐ GOOD
☐ LOSE

SAMPLER TYPES
 A.S. - AUGER SAMPLE
 S.T. - SLOTTED TUBE
 W.S. - WASHED SAMPLE
 D.O. - DRIVE OPEN
 D.P. - DRIVE FOOT VALVE
 C.S. - CHURN SAMPLE
 F.T. - FOIL SAMPLE
 S.O. - SLEEVE OPEN
 S.F. - SLEEVE FOOT VALVE
 T.O. - THIN WALLED OPEN
 R.C. - ROCK CORE

ABBREVIATIONS
 V - IN SITU VANE TEST
 M - MECHANICAL ANALYSIS
 U - UNCONFINED COMPRESSION
 CC - TRIAXIAL CONSOLIDATION
 O - TRIAXIAL UNDRAINED
 S - TRIAXIAL DRAINED
 W - WET UNIT WEIGHT
 P - PERMEABILITY
 C - CONSOLIDATION
 WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL



W.F. 906-66-09

GEOCON

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OFFICE REPORT ON SOIL EXPLORATION

BORING # 3 DATUM GEODETIC CASING BY 130
 PILING DATE DEC. 2, 1974 REPORT DATE DEC. 12, 1974 COMPILED BY ALL CHECKED BY _____
 SAMPLER MANNER WT. 140 LBS. SNOF 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 2800 IN. LBS. ENERGY)

SAMPLE CONDITION

☒ DISTURBED
☐ FAIR
☐ GOOD
☐ LOST

SAMPLE TYPES

A 2. - AUGER SAMPLE
B 7. - SLOTTED TUB
W 3. - WAREHOUSE SAMPLE
D 0. - DRIVE SHAFT
D F. - DRIVE FOOT VALVE
C 3. - CHLOR SAMPLE

FB - FOIL SAMPLE
SO - SLEEVE OPEN
SF - SLEEVE FOOT VALVE
TO - THIN WALLED OPEN
RC - ROCK CORE

ABBREVIATIONS

- Y . IN-SITU YANG TEST
- M . MECHANICAL ANALYSIS
- U . UNCONFINED COMPRESSION
- OC . TRIAXIAL CONSOLIDATED UN
- O . TRIAXIAL UNDRAINED
- S . TRIAXIAL GRAINED

Y - WET UNIT WEIGHT
 K - PERMEABILITY
 C - CONSOLIDATION
 MED
 WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL

[illegible]

NBL

10

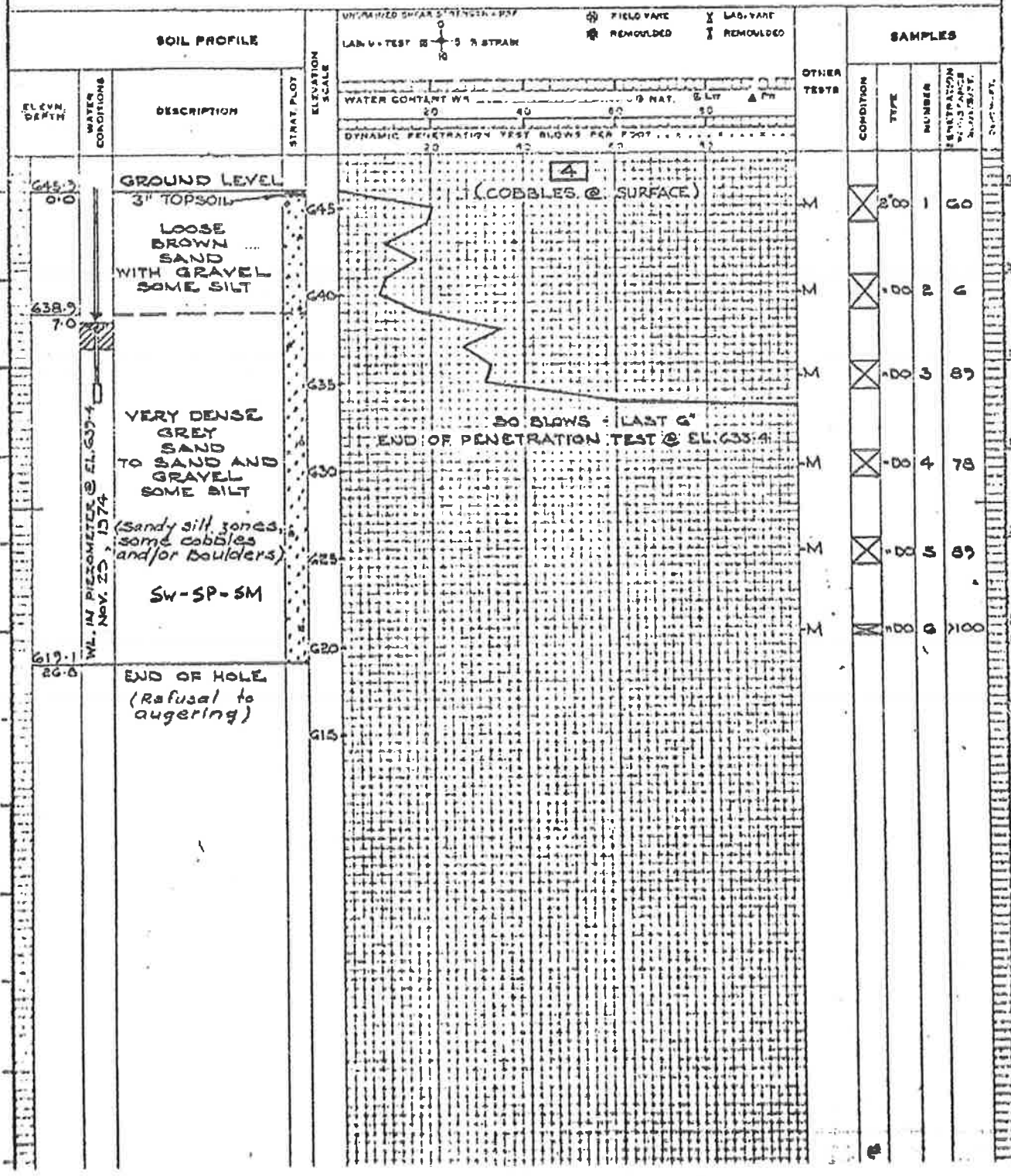
W.P. 906-66-09

GEOCON

OFFICE REPORT ON SOIL EXPLORATION

BORING # 4 DATUM GEODETIC CASINO YIP
 BORING DATE NOV. 23, 1974 REPORT DATE DEC. 2, 1974 COMPILED BY AEL CHECKED BY YIP
 SAMPLER HAMMER WT. 140 LBS DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN-LBS. ENERGY)

SAMPLE CONDITION	SAMPLE TYPES	ABBREVIATIONS
DC - DISTURBED FA - FAIR GO - GOOD LO - LOST	AS - AUGER SAMPLE ST - SLOTTED TUBE WS - WASHED SAMPLE DO - DRIVE-UP DF - DRIVE FOOT VALVE CS - CHURN SAMPLE	FS - FOIL SAMPLE SO - SLEEVE OPEN SF - SLEEVE FOOT VALVE TO - THIN WALLED OPEN RC - ROCK CORE
		V - IN-SITU VANE TEST M - MECHANICAL ANALYSIS U - UNCONFINED COMPRESSION UC - TRIAXIAL CONSOLIDATED UNDRAINED UO - TRIAXIAL UNCONSOLIDATED S - TRIAXIAL UNRAINED
		Y - WET UNIT WEIGHT R - PERMEABILITY C - CONSOLIDATION WL - WATER LEVEL IN CASINO WT - WATER TABLE IN SOIL



NBL

GEOCON

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W.P. 906-66-09

OFFICE REPORT ON SOIL EXPLORATION

BORING NO. 5 DATUM GEODETIC CASING 7/8"
 BORING DATE NOV. 28, 1974 REPORT DATE DEC. 2, 1974 COMPILED BY AEU CHECKED BY YH
 SAMPLER MAKE/WT 140 LBS DEEP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4500 IN-LBS. ENERGY)

SAMPLE CONDITION

☒ DISTURBED
☐ FATH
☐ 100%
☒ LOSS

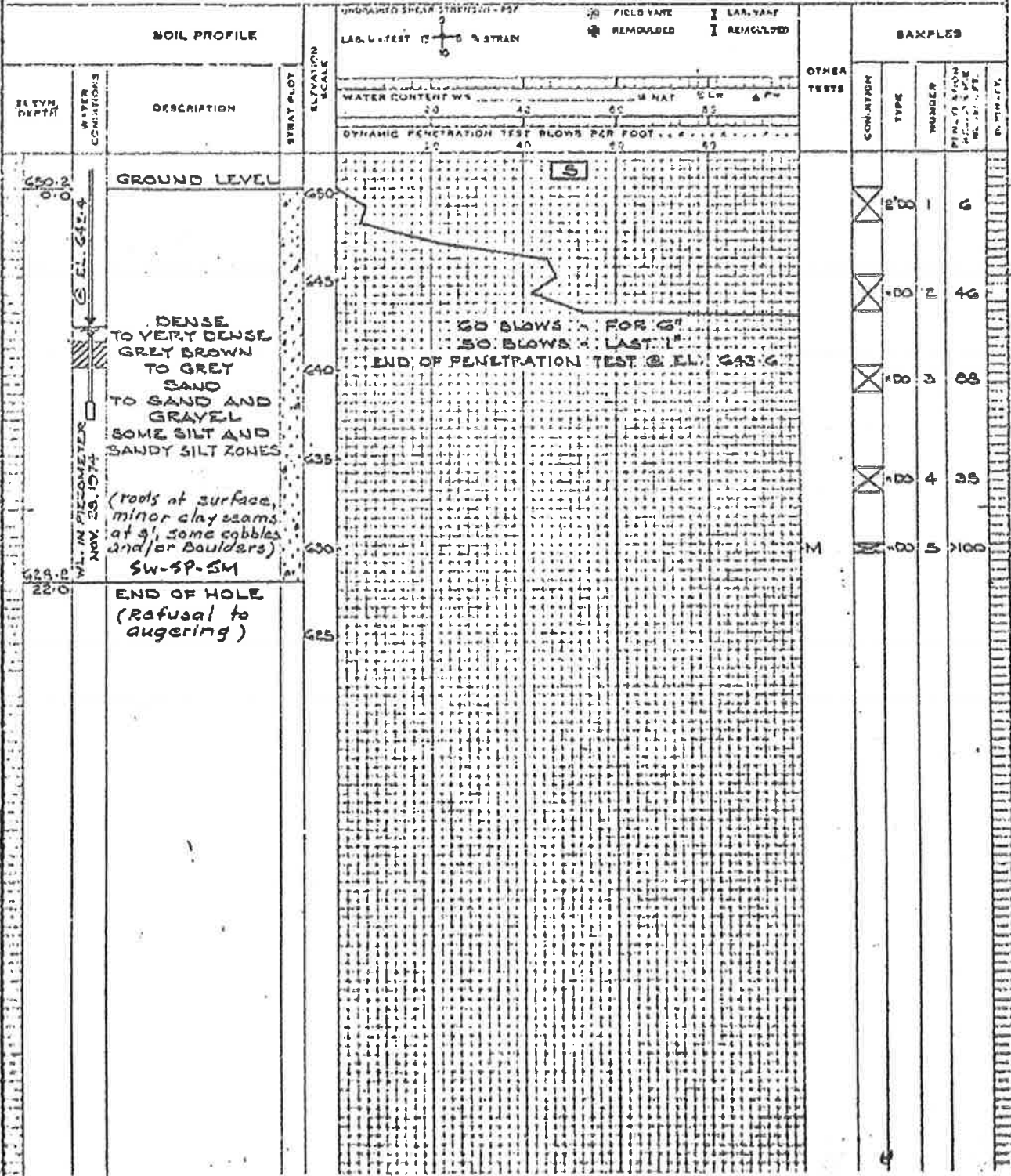
AS - AUGER SAMPLE
 ST - SLOTTED TUBE
 WS - WASHED SAMPLE
 DO - DRIVE-OPEN
 OF - DRIVE FOOT VALVE
 CS - CHUNK SAMPLE

SAMPLE TYPES

FS - FOIL SAMPLE
 SO - SLEEVE-OPEN
 SF - SLEEVE FOOT VALVE
 TO - THIN WALLED OPEN
 RC - ROCK CORE

ABBREVIATIONS

V - IN-SITU VANT TEST
 M - MECHANICAL ANALYSIS
 UC - UNCONFINED COMPRESSION
 QC - TRIAXIAL CONSOLIDATED UNDRAINED
 U - TRIAXIAL UNDRAINED
 S - TRIAXIAL GRAINED
 W - WET UNIT WEIGHT
 R - PERMEABILITY
 C - CONSOLIDATION
 WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL



NBL

W.P. 906-66-09

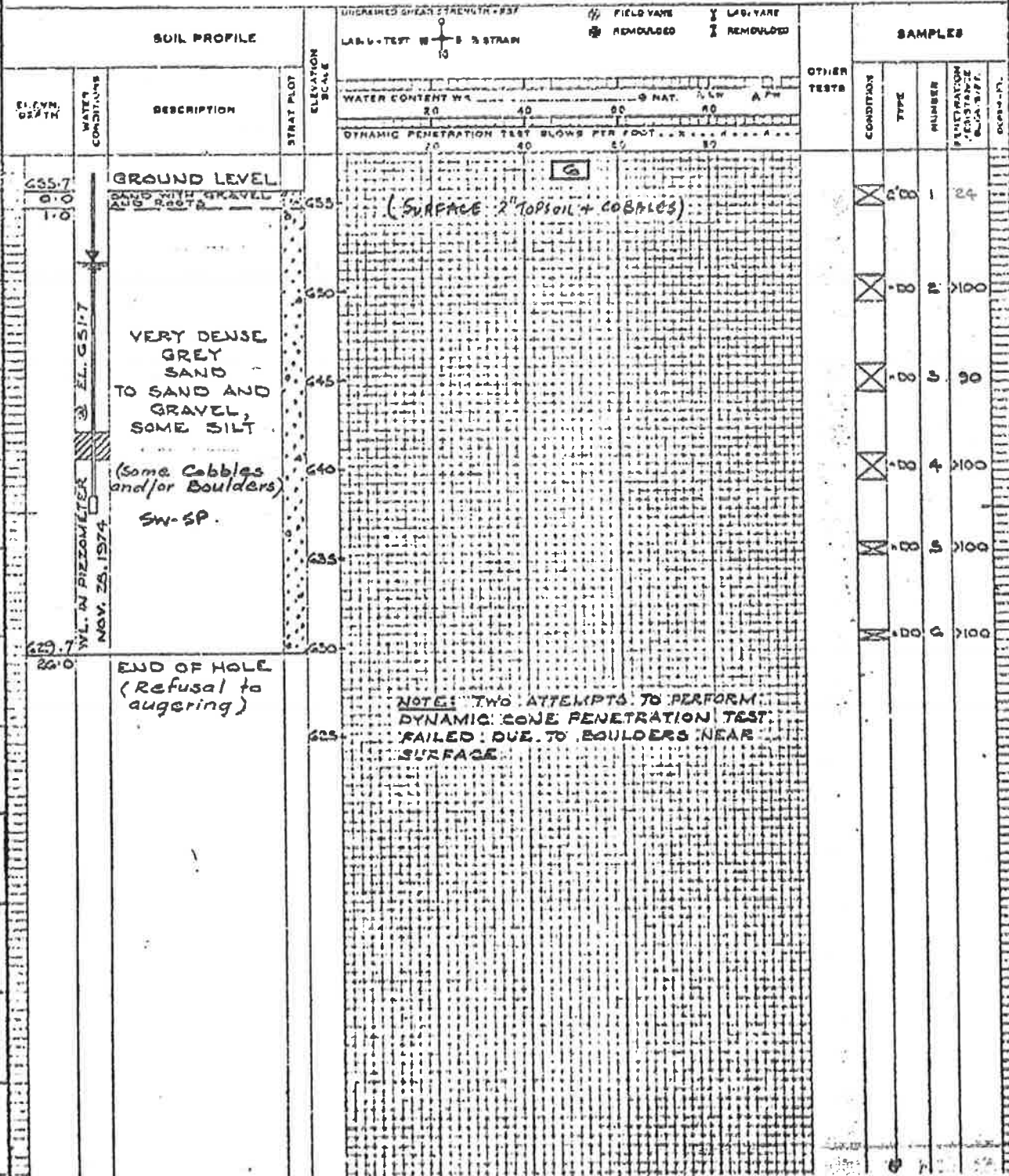
GEOCON

12

OFFICE REPORT ON SOIL EXPLORATION

BORING # G DATUM GEODETIC CASING 750
 BORING DATE NOV. 23, 1974 REPORT DATE DEC. 2, 1974 COMPILED BY AEH CHECKED BY AEH
 SAMPLER MAXIMUM WT. 140 LBS DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 1400 IN. LBS. ENERGY)

SAMPLE CONDITION	SAMPLE TYPES	ABBREVIATIONS
DISTURBED FAIR GOOD LOST	AS - AUGER SAMPLE ST - SLOTTED TUBE WS - WATHEO SAMPLE DO - DRIVE-OPEN SF - DRIVE FOOT VALVE CS - CHUCK SAMPLE FS - FOIL SAMPLE SO - SLEEVE OPEN SF - SLEEVE FOOT VALVE TO - THIN WALLED OPEN RC - ROCK CORE	V - IN SITU VANE TEST M - MECHANICAL ANALYSIS U - UNCONFINED COMPRESSION Q - TRIAXIAL CONSOLIDATED UNDRAINED q - TRIAXIAL UNCONSOLIDATED UNDRAINED S - TRIAXIAL UNRAINED W - WET UNIT WEIGHT R - PERMEABILITY C - CONSOLIDATION WL - WATER LEVEL IN CASING WT - WATER TABLE IN SOIL



GEOCON

OFFICE REPORT ON SOIL EXPLORATION

WP 906-66-14

BORING #

G

DATE

GEODETC

CARTON

NOV. 23, 1974

REPORT DATE DEC. 2, 1974

COMPILED BY

AZL

CHECKED BY

PJO

SAMPLER HAMMER #7

140

LBS

DROPP

30

INCHES

PENETRATION RESISTANCE CONVERTED TO BLOWN OF 4200 IN. LBS ENERGY

SAMPLE CONDITION		SAMPLE TYPE		ABBREVIATIONS	
1. UNDISTURBED 2. DISTURBED 3. SOIL 4. ROCK	AS AUGER SAMPLE BT BUTTED TUBE WS WASHED SAMPLE DC DRIVE FOOT VALVE DS DRIVE FOOT VALVE CS CLEAR SAMPLE	FT FOOT SAMPLE SU SLEEVE SAMPLE SF SLEEVE FOOT VALVE TO THIN WALL OPEN RC ROCK CORE	VV VIBRO VANE TEST M MECHANICAL ANALYSIS U UNCONFINED COMPRESSION UC TRIAXIAL COMPRESSION UNDRAINED UO TRIAXIAL UNCONFINED S TRIAXIAL DRAINED	WU WET UNIT WEIGHT WU WET UNIT WEIGHT C CONSOLIDATION WL WATER LEVEL IN CASING WT WATER TABLE IN SOIL	

SOIL PROFILE		LAB. TEST		FIELD TEST		LAB. TEST		OTHER TESTS		SAMPLES	
EL. IN FEET	WATER CONTENT (%)	DESCRIPTION	WATER CONTENT (%)	WATER CONTENT (%)	WATER CONTENT (%)	WATER CONTENT (%)	WATER CONTENT (%)	WATER CONTENT (%)	WATER CONTENT (%)	WATER CONTENT (%)	WATER CONTENT (%)
655.7	0.0	GROUND LEVEL									
655.7	0.0	(SURFACE 2" TOPSOIL + COBBLES)									
655.7	0.0	VERY DENSE GREY SAND TO SAND AND GRAVEL, SOME SILT									
655.7	0.0	(Some Cobbles and/or Boulders)									
655.7	0.0	SW-SP									
655.7	0.0	END OF HOLE (Refusal to augering)									

NOTE: TWO ATTEMPTS TO PERFORM DYNAMIC CONE PENETRATION TEST. FAILED DUE TO BOULDERS NEAR SURFACE.

Appendix B

Test Results

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT				SAND			GRAVEL		
GRAIN SIZE IN MICROMETERS				Fine	Medium	Coarse	Fine	Coarse	Coarse

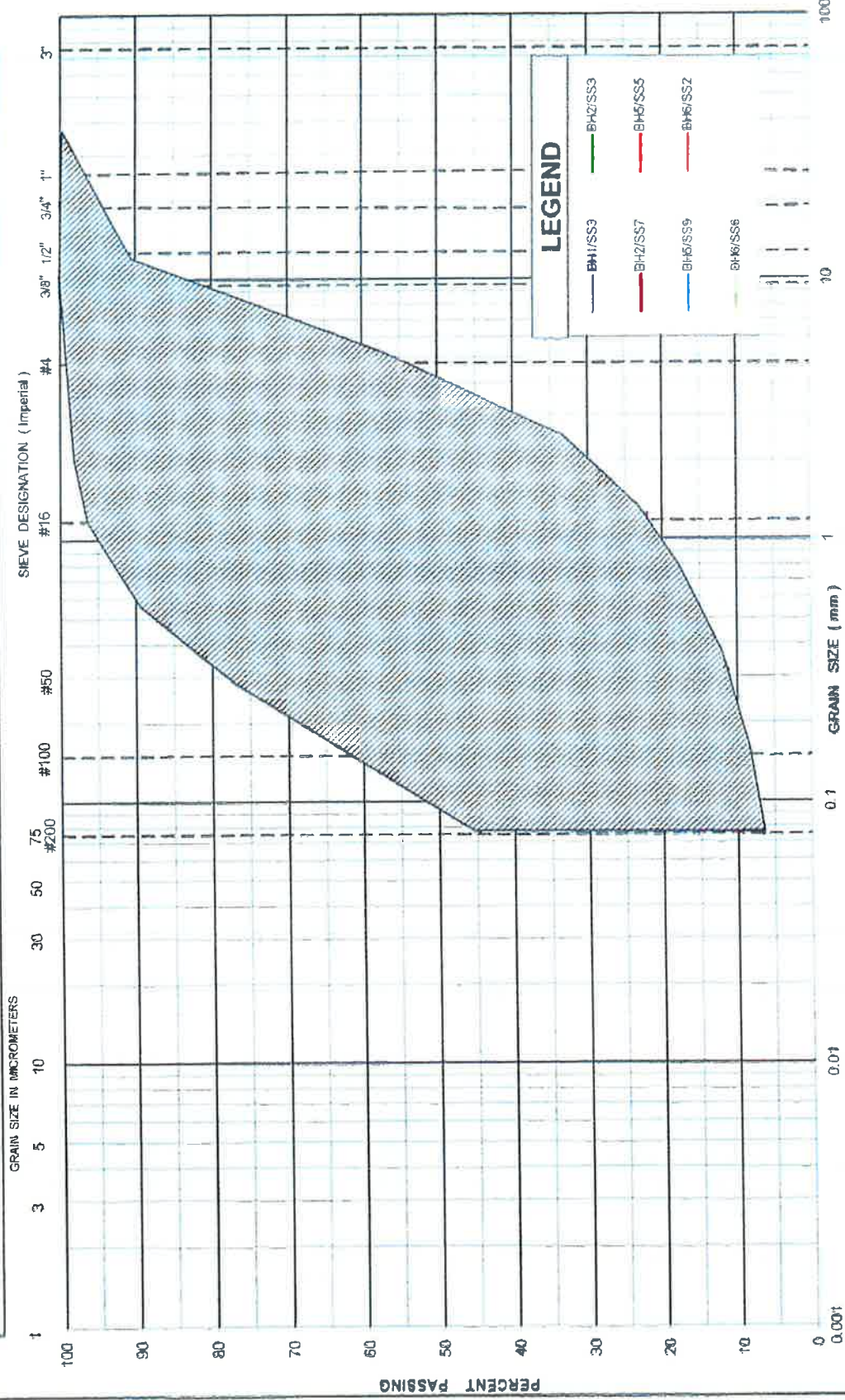
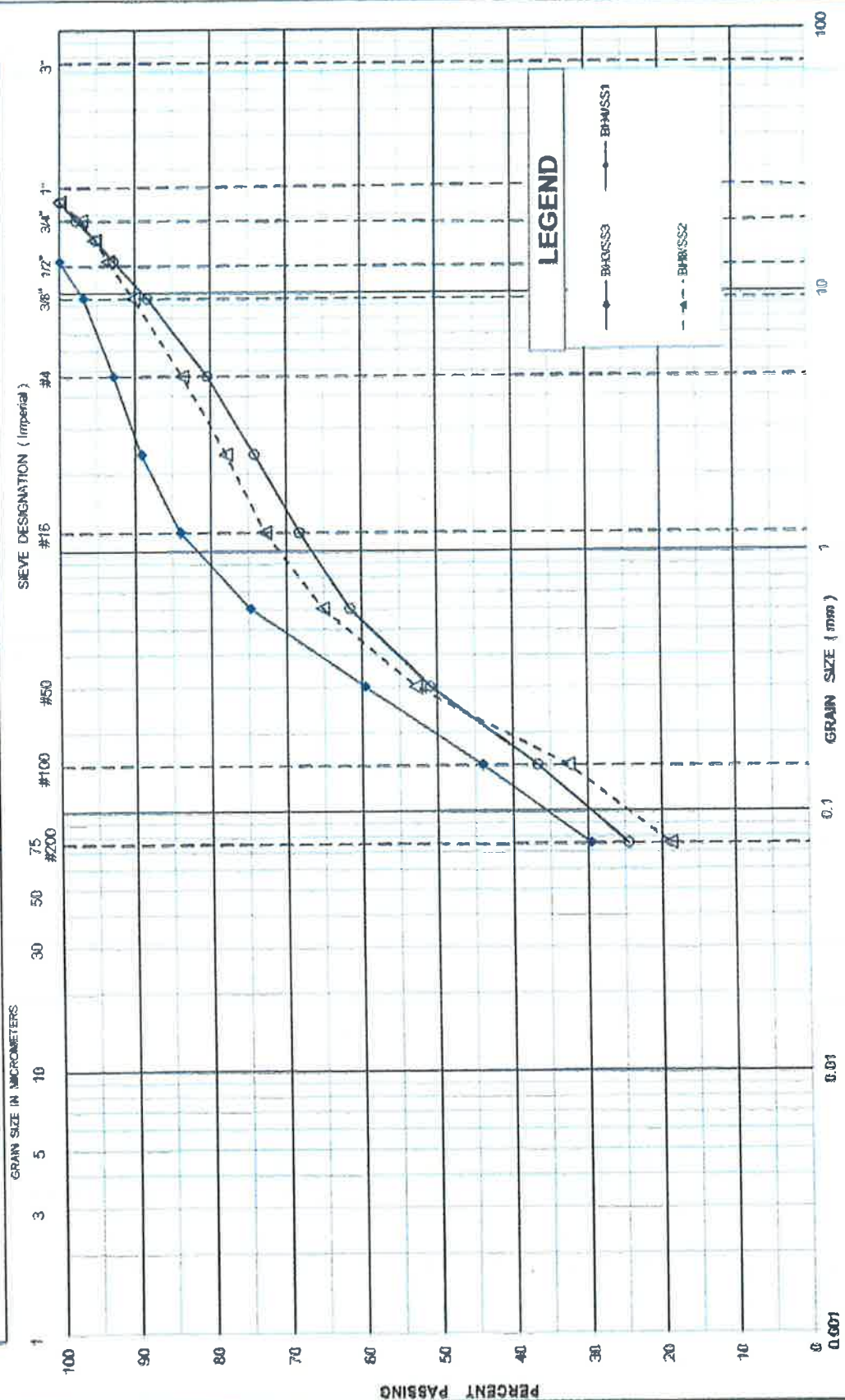


Figure: B-1
PROJECT # : TRANET082062AA
DATE : MARCH, 2013

GRAIN SIZE DISTRIBUTION
EMBANKMENT FILL: Silty Sand to Sand & Gravel

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



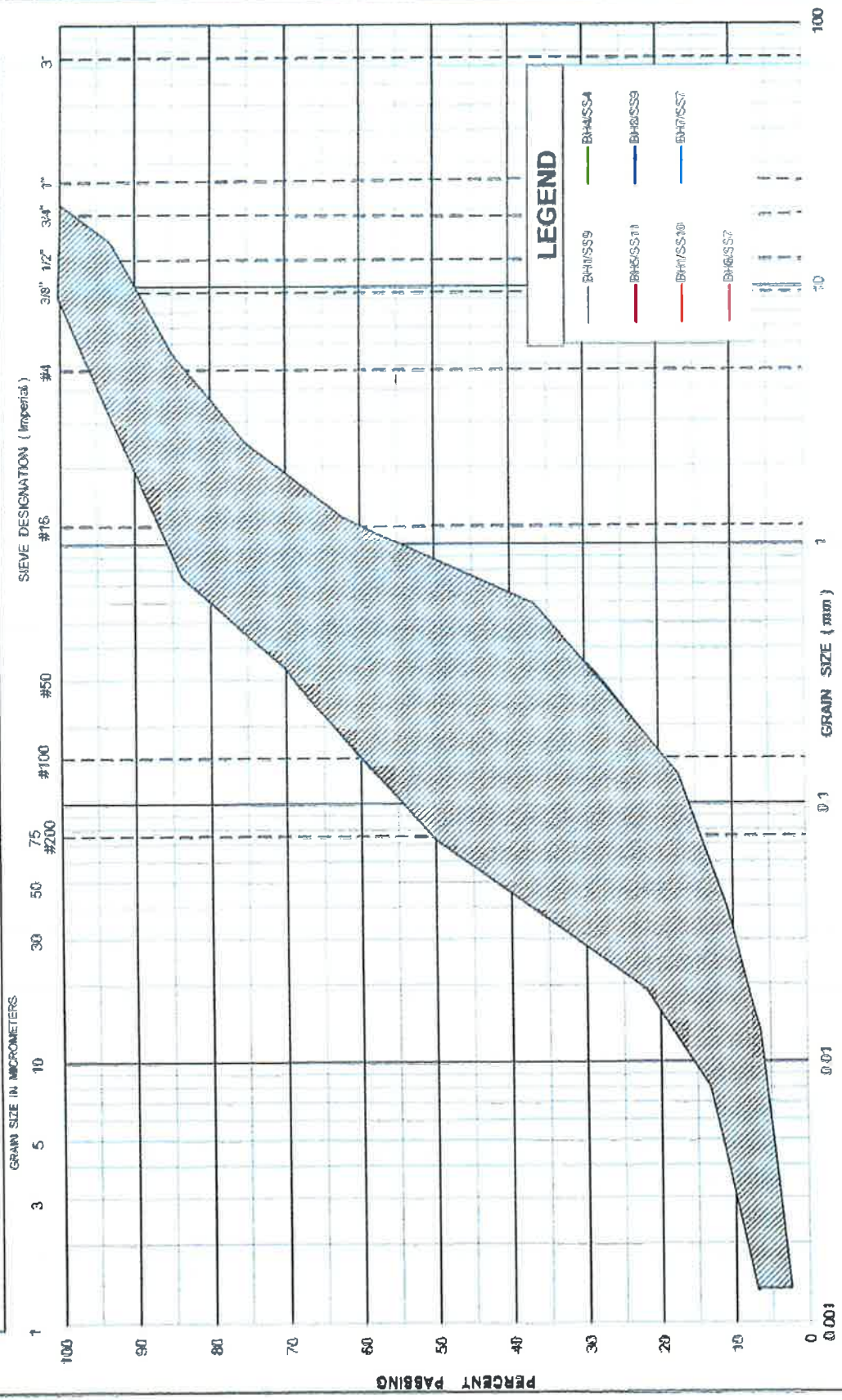
coffey  **geotechnics**
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
FILL: Sand, some silt & gravel

Figure: B-2	
PRG.MECT # : TRANET08Z0482AA	
DATE	MARCH 2013

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	

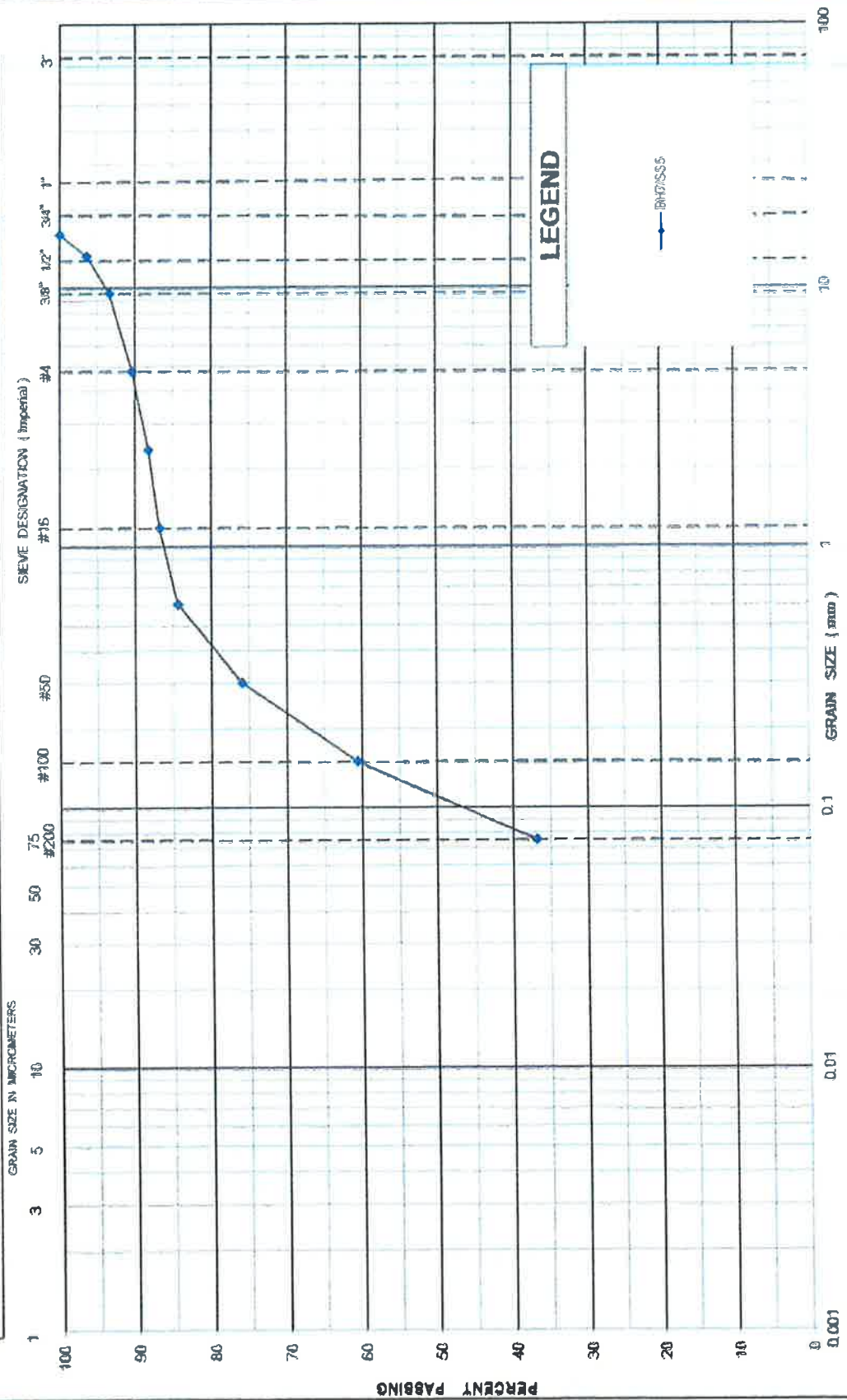


GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT TILL

Figure: B-3
 PROJECT # : TRANET020462AA
 DATE : MARCH, 2013

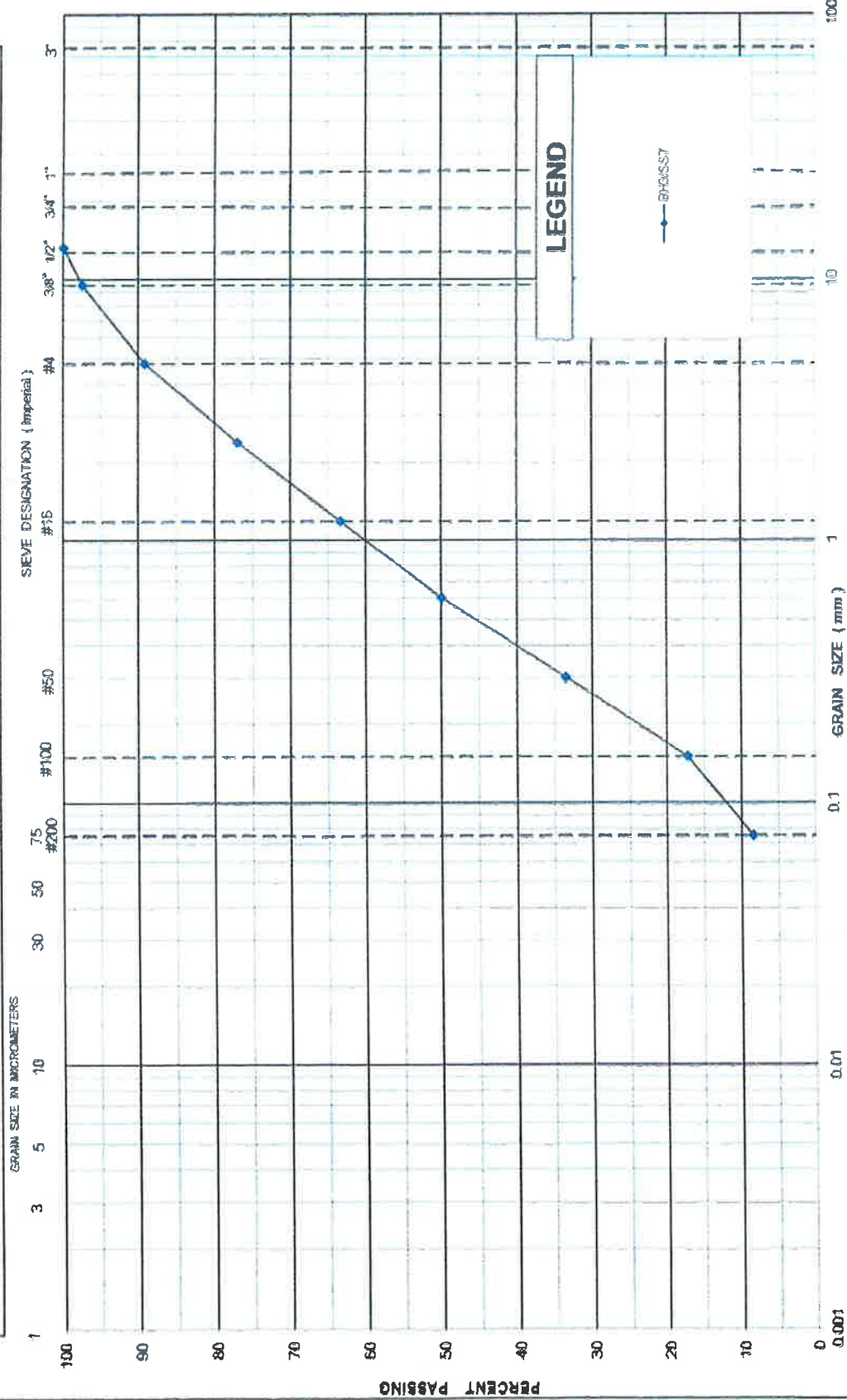
UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	



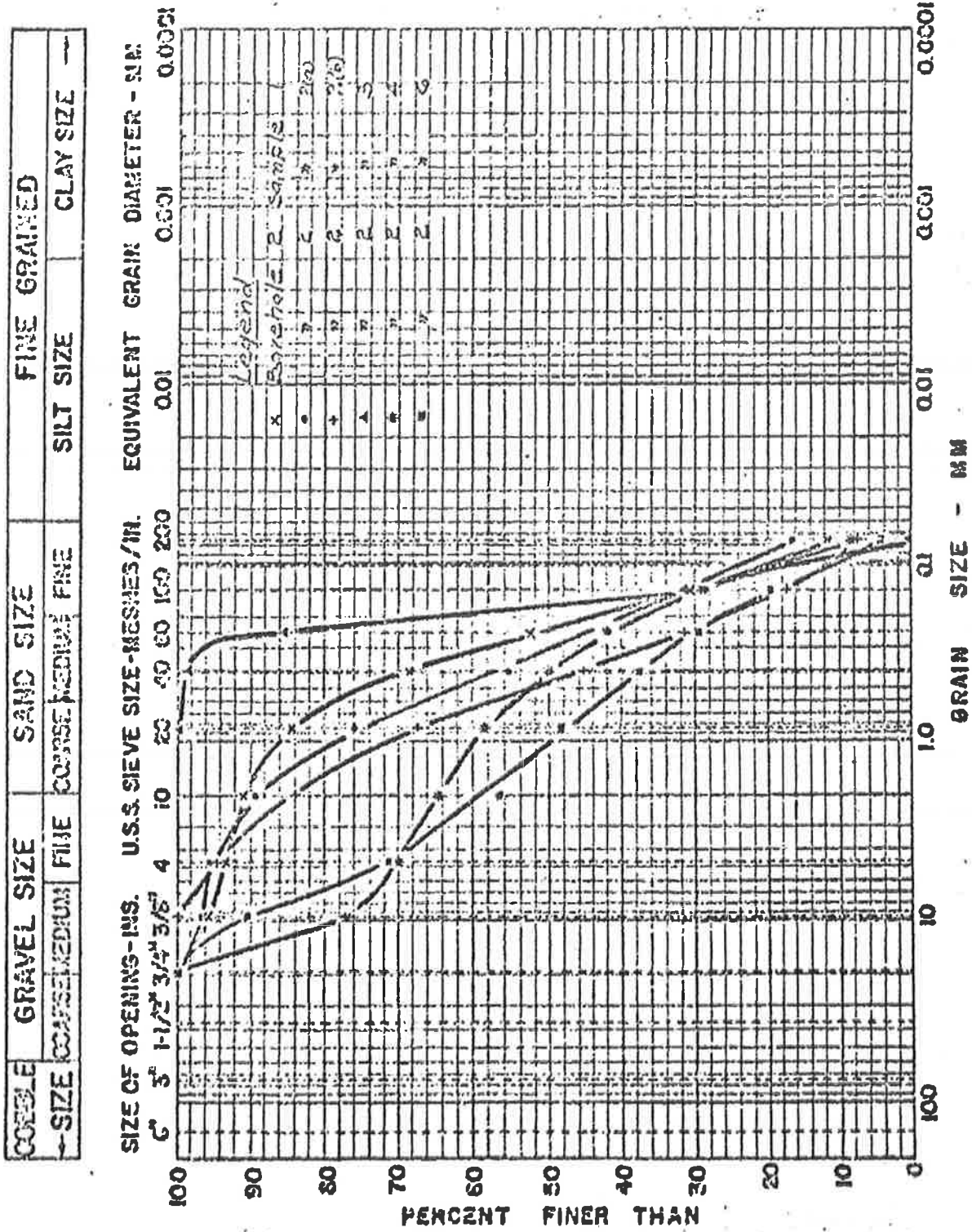
UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	



GRAIN SIZE DISTRIBUTION

FIGURE 1
PROJECT T9864



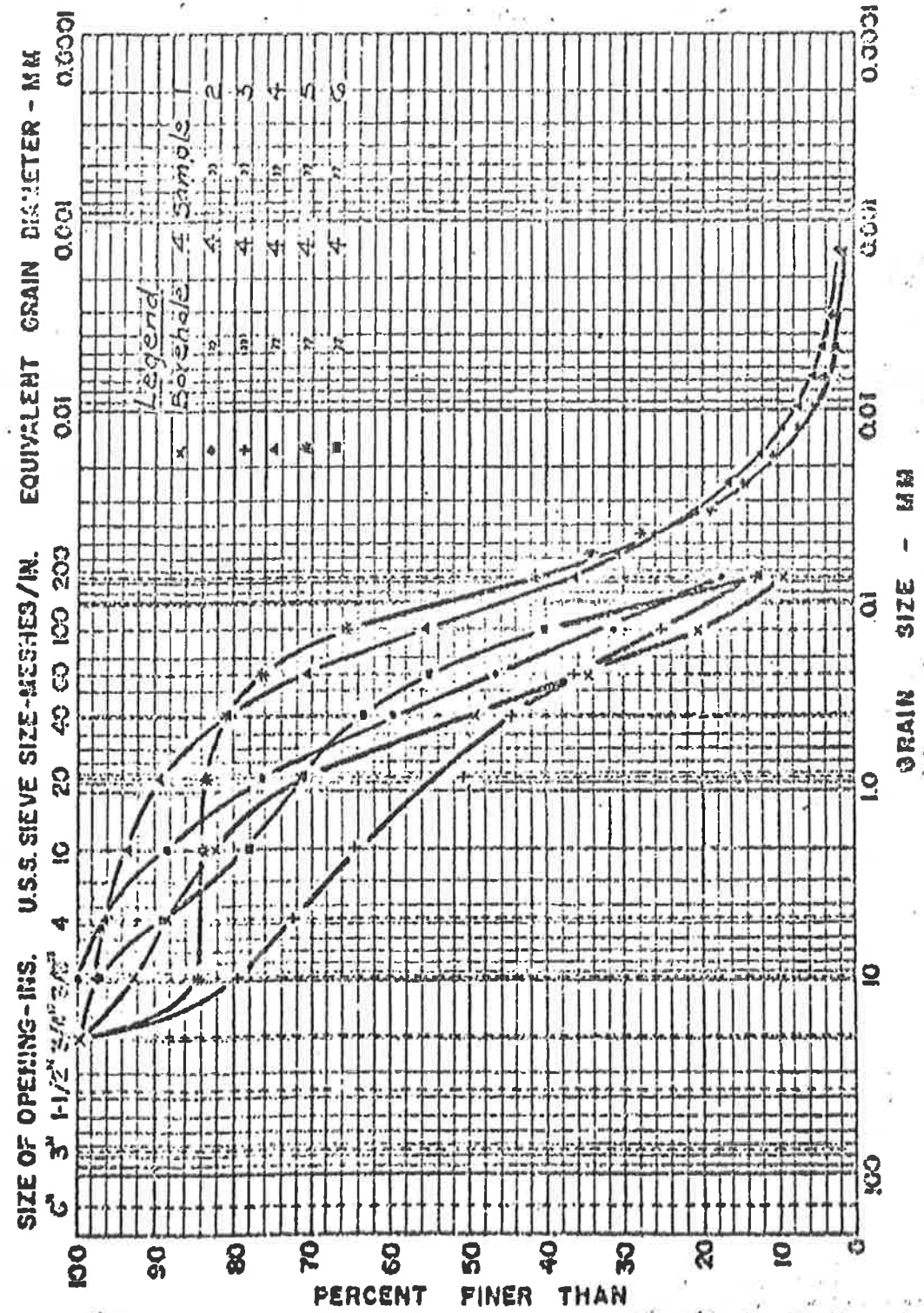
GEOCON

M.I.T. GRAIN SIZE SCALE

GRAIN SIZE DISTRIBUTION

FIGURE 2
PROJECT T9864

COARSE	GRAVEL SIZE	SAND SIZE	FINE GRAINED
SIZE	COARSE	FINE	CLAY SIZE



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M.I.T. GRAIN SIZE SCALE

UNIFIED SOIL CLASSIFICATION SYSTEM

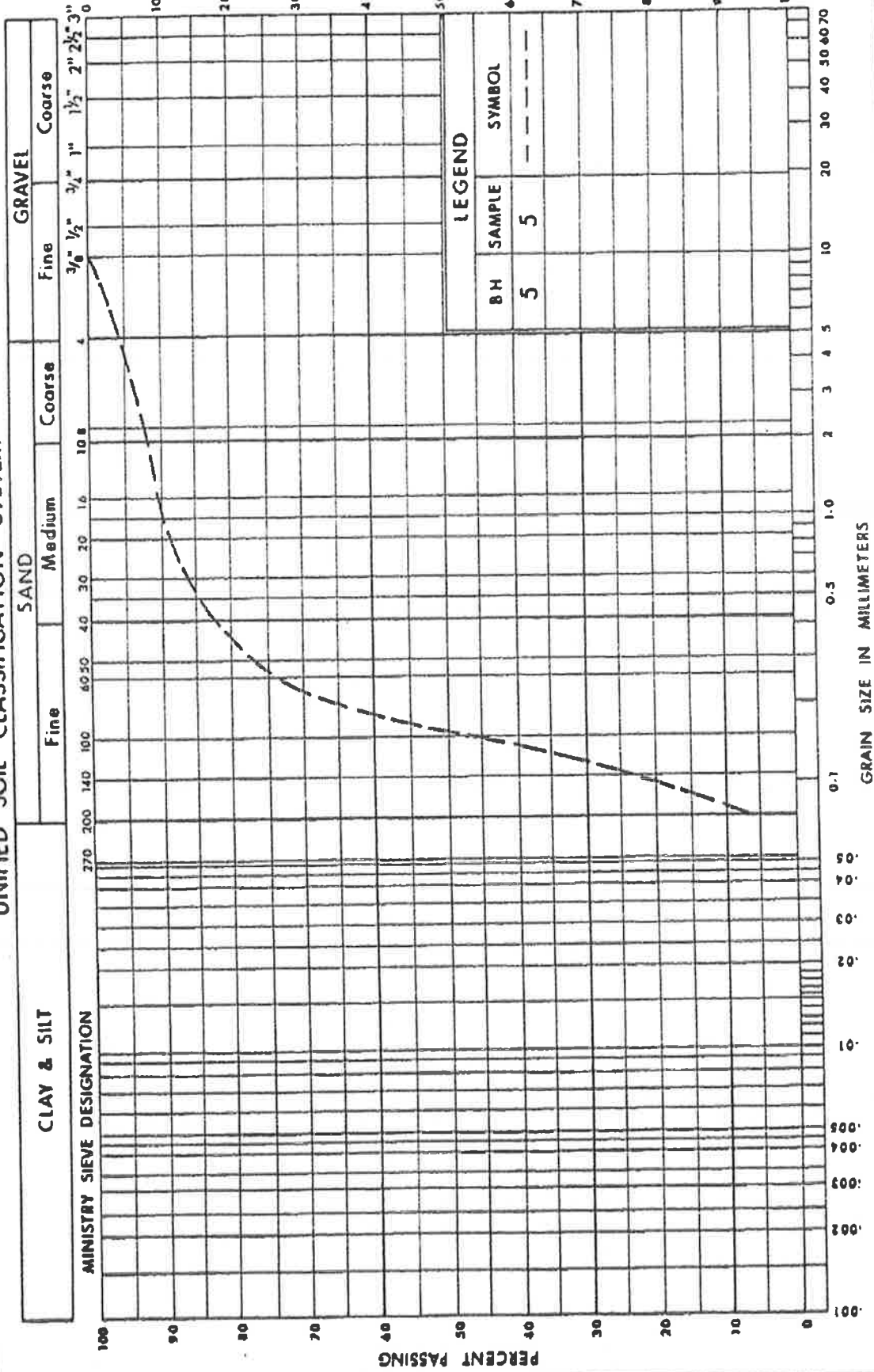


FIG No 1
GRAIN SIZE DISTRIBUTION
SAND & GRAVEL

Ministry of
Transportation and
Communications



WP 906-66-14

00

S&L

Appendix C

Site Photographs



Photograph 1. NBL Bridge



Photograph 2. SBL Bridge

Appendix D

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 \bar{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 COMPOSITION AND STRUCTURAL 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
f_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
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_α	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_i	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1.0%	VOID RATIO	e_{min}	1.0%	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1.0%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1.0%	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_a	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(w_L - w_P)$	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	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $(w_L - w) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1.0%	VOID RATIO IN LOOSEST STATE	j	kN/m ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						