



**FOUNDATION INVESTIGATION
REPORT
DECEPTION CREEK
CULVERT REPLACEMENT
HIGHWAY 11
TOWNSHIP OF CALDER
AGREEMENT No.: 5010-E-0006
GWP: 5149-11-00
WP: 5112-09-01
GEOCRES NO.: 39E-236**

March 2012

DST Reference No. GS-TB-012144

Prepared for:

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DST CONSULTING ENGINEERS INC.

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

DST Consulting Engineers Inc. has been subcontracted by Genivar who was retained by the Ministry of Transportation (MTO), Northeastern Region, to conduct a geotechnical investigation for the replacement of the Deception Creek culvert on Highway 11, 18.5 km west of Hwy 579, Township of Calder. This work was carried out under Agreement No.: 5010-E-0006, Detailed Design for the Replacement / Rehabilitation of Various Culverts.

This report addresses the field investigation, laboratory test program, factual report on conditions (Part 1) and recommendations for design and construction for the proposed culvert replacement (Part 2).

Geological information is available from published *Ontario Geological Survey Map # 5036* by the *Ontario Ministry of Natural Resources* for the Smooth Rock area, District of Cochrane. The map indicates a ground moraine formation with till and clay materials, subordinate landforms of organic terrain with peat and muck are also present. The topography in the area landform is mainly moderate local relief, the dominant land surface is undulating to rolling, and the subordinate organic terrain is plain like. The surface drainage conditions are mixed wet and dry within the ground moraine terrain, and wet in the organic terrain.

2. SITE DESCRIPTION

The site is located on Highway 11, approximately 18.5 km west of Hwy 579 and Highway 11 intersection, Township of Calder, Cochrane Area. The structural site number is 39E-236.

Existing structure at this location is a 6.3 x 2.0 x 26.0 m three-cell timber box culvert. The culvert was identified to be in fair to poor condition and timber elements appeared to be rotting and checking with some elements missing completely. Significant settlement and rotation of the central support were also noted. The area was identified to be swamp/ muskeg. The depth of the cover is 2.0 m and minor erosion and loss of embankment fill were also documented.

The embankment slopes at this location are approximately 2.5H:1V to as steep as 1H:1V. Both sides of the embankment were sparsely vegetated and covered with grass (Figures 2.1, 2.2). The photographs shown in Figures were taken by MTO.



Figure 2.1 Culvert Inlet (facing northeast)



Figure 2.2 Culvert Outlet (facing northeast)



Figure 2.3 Culvert Buckling



Figure 2.4 Culvert Deteriorating



Figure 2.5 Inside View of Culvert

3. INVESTIGATION PROCEDURES AND LABORATORY TESTING

Site work was carried out between March 27th, 2011 and April 3rd, 2011 utilizing a CME 750 drill rig that was operated by DST personnel. A total of four (4) boreholes were advanced for the purpose of foundation design at this site, two (2) using hollow stem augers and diamond drilling techniques and other two (2) using hand augers. Boreholes were advanced to depths ranging from 3.3 to 20.7 m.

Two boreholes were advanced through the road structure at Station 20+005 offset 4.5 m right and at Station 19+995 offset 4.5 m left. Two auger boreholes were advanced at beyond the toe of slope near the existing culvert inlet and outlet at Station 20+005 offset 20.0 m left and Station 19+995 offset 18.6 m right respectively. The minimum number of boreholes, and depths and locations of boreholes were chosen according to the given specification in Request for Quotation (RFQ) by MTO.

The borehole locations are referenced to the MTO Station numbering system as indicated in the RFQ. The centreline of the existing culvert was assumed as Station 20+000. The ground surface elevations at the borehole locations were surveyed by DST personnel. At approximately Station 19+980 offset 23 m left a benchmark with an assigned elevation of 273.1 m was placed in a pole northerly near culvert. Borehole locations, stationing and benchmark location are shown on the Borehole Location Plan, Drawings 1. Table 3.1 summarizes the detail of borehole locations and depths.

Table 3.1 Detail of borehole locations

Borehole ID	Station	Elevation (m)	Depth (m)	Offset (m)
BH1	19+995	274.20	20.4	4.5 Lt
BH2	20+005	274.20	20.7	5.0 Rt
HA1	20+002	270.90	3.1	20.0 Lt
HA2	19+995	270.90	3.3	18.6 Rt

The fieldwork was supervised on a full-time basis by DST personnel who located the boreholes in the field, performed sampling and in-situ testing and logged the boreholes. Standard Penetration Testing (SPT) was performed in each borehole. Field vane test (FVT) was performed to estimate undrained shear strength of the cohesive soils. The soil samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in

Thunder Bay for further analysis.

Dynamic Cone Penetrometer Test (DCPT) was carried out in Borehole 2 from 16.1 to 20.7 m. DCPT test used 63.5kg hammer falling from a height of 760 mm and recorded number of blows to drive 300 mm cone penetration. DCPT test provided indication of soil type encountered at the depth.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of engineering properties. Laboratory tests included moisture contents, particle size analyses and Atterberg limits including plastic limit and liquid limit. A total of forty four (44) moisture contents, five (5) sieve analysis, six (6) particle size analyses and eight (8) Atterberg limit tests have been carried out for this assignment. Laboratory test results are presented in the Boreholes Logs (Enclosures 1 to 4), and Plots (Enclosures 5 to 10).

4. DESCRIPTION OF SUBSURFACE CONDITIONS

The subsurface conditions are presented based on the information obtained during field and laboratory testing.

The generalized stratigraphy of the existing embankment, based on the conditions encountered in boreholes, consists of surfacing (hot mix asphalt) overlying sand with crush gravel fill that is underlain by sand backfill surrounding the existing culvert. This fill is then underlain by clay and in some areas (Borehole 1) clay is underlain by gravel layer.

4.1 Top Soil and Organic Soil

A topsoil layer of up to 100 mm in thickness was encountered in hand auger-hole 1 and 2.

Organic soil was found in the hand auger holes 1 and 2. Thickness of organic soil was 0.6 – 1.2 m; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 270.9 and 269.5 m respectively. The thickness of this layer in auger hole 1 and 2 was approximately 0.6 m and 1.2 m respectively.

4.2 Asphalt

Asphalt was encountered at the top in Boreholes 1 and 2 with a thickness of approximately 80 mm.

4.3 Embankment Fill

Embankment fill layer was encountered in Borehole 1 and 2 below the asphalt layer. Embankment fill layer was encountered at depths from 0.08 m up to 4.0 m in Boreholes 1 and 2; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 274.2 and 270.3 m respectively. The thickness of this layer in Borehole 1 and 2 was approximately 3.6 m and 3.9 m respectively. Within the sand fill cobbles were noted during the drilling process. Grain size distributions of the fill material are reported in borehole logs (Enclosures 1 to 4) and plots (Enclosure 5 and 7). A pavement structure of two materials over the native soil (silty clay) was identified.

Directly below the asphalt, a fill of predominantly gravelly sand materials was encountered at Boreholes 1 and 2 at depths of between 0.080 and 0.5 m below ground surface; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 274.1 and 273.7 m respectively. The thickness of this layer in both Borehole 1 and 2 was approximately 0.5 m. This

layer is roadbed granular layer. Gradation analyses conducted on a sample from Borehole 2 indicate gravel, sand and fines contents of approximately 36%, 56% and 8% respectively. Moisture content ranged from 7 to 9%. This material does not classify as Granular A meeting SSP 110S13 requirements.

Directly below this gravelly sand layer, a fill of predominantly loose to dense sand materials was encountered at Boreholes 1 and 2 at depths between 0.5 m and up to 4.0 m below surface; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 273.7 and 270.3 m respectively. The thickness of this layer in Borehole 1 and 2 was approximately 3.2 m and 3.5 m respectively. Gradation analyses conducted on samples from Borehole 1 and 2 indicate gravel, sand, and fines contents of approximately 2 to 4%, 84 to 86% and 10 to 14% respectively. SPT values of 7 and 21 per 0.3 m indicate a state of variable compactness from loose to compact. An SPT value of 54 was encountered in Borehole 2, however, this is attributed to the presence of cobbles within this stratum. This material does not classify as Granular B, Type I meeting SSP 110S13 requirements. The moisture content of samples was between 3 and 14%.

In Borehole 1 wood debris was encountered within the fill at an elevation of approximately 271.1 m.

4.4 Sand

Silty Sand was encountered in Auger Hole 1. It was encountered at depths between 0.7 and 1.0 m below surface; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 270.3 and 270.0 m respectively. The thickness of this layer in auger hole 1 was approximately 0.3 m. Gradation analyses conducted on sample from Auger Hole 1 indicated gravel, sand and fine contents of approximately 7%, 57% and 36% respectively. The moisture content of the sample tested was 43%

4.5 Upper Silty Clay

Upper silty clay was encountered in Boreholes 1, 2, and Hand Auger Hole 1, 2. It was encountered at depths between 3.7 and 6.0 m below surface in Boreholes 1 and 2; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 270.5 and 268.2 m respectively. This material was also identified between depths of 1.0 and 3.1 m below surface in Auger holes 1 and 2; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 270.0 and 267.9 m respectively. The thickness of this stratum was found

to be approximately 2.3 m as determined in Borehole 1 and 2. For Auger Holes 1 and 2 the thickness of this stratum is not determined as borehole terminus was reached within this stratum. In Borehole 1 trace wood and organics were encountered within the clay layer at elevation of 270.5 m.

Atterberg limit test carried out on samples from Boreholes 1, 2 and Auger Hole 1, 2 indicate this silty clay has a low plasticity with liquid limits and plasticity indexes from 28 to 34 % and 12 to 18 % respectively. In-situ field vane tests taken in Boreholes 1 and 2 indicate undrained shear strengths between 25 and 88 kPa with sensitivities ranging from 3 to 6 which indicates consistencies of firm to stiff. Gradation analyses conducted on samples from Borehole 1 and Auger Hole 1 indicated gravel, sand, silt and clay content of approximately 0 to 2 %, 13 to 30 %, 45 to 48 % and 24 to 37 % respectively. Moisture contents of samples ranged from 13 to 26 %.

4.6 Clay

Clay was encountered in Boreholes 1 and 2. It was encountered at depths between 6.0 and 9.1 m below surface in Boreholes 1 and 2; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 268.2 and 275.1 m respectively. The thickness of this stratum was found to be approximately 3.1 m as determined in Borehole 1 and 2.

Atterberg limit test carried out on samples from Boreholes 1 and 2 indicate this clay has an intermediate to high plasticity with liquid limits and plasticity indexes from 49 to 61 % and 27 to 37 % respectively. In-situ field vane tests taken in Boreholes 1 and 2 indicate undrained shear strengths between 17 and 35 kPa with sensitivities ranging from 3 to 4 indicate consistencies of soft to firm. Gradation analyses conducted on samples from Boreholes 1 and 2 indicated gravel, sand, silt and clay content of approximately 0 %, 0 to 1 %, 10 to 16 % and 83 to 90 % respectively. Moisture contents of samples ranged from 46 to 74 %.

4.7 Lower Silty Clay

Lower silty clay was encountered in Boreholes 1 and 2. It was encountered at depths between 9.1 and 19.2 m below surface in Boreholes 1 and 2; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 268.2 and 255.0 m respectively. The thickness of this stratum was found to be approximately 10.1 m as determined in Borehole 1. For Borehole 2 the thickness of this stratum is not determined as borehole terminus was reached within this stratum.

Atterberg limit test carried out on samples from Boreholes 1 and 2 indicate this silty clay has

a low to intermediate plasticity with liquid limits and plasticity indexes from 27 to 39 % and 7 to 19 % respectively. In-situ field vane tests taken in Boreholes 1 and 2 indicate undrained shear strengths between 19 and 42 kPa with sensitivities ranging from 1 to 4 indicate consistencies of soft to firm.. Gradation analyses conducted on samples from Borehole 1 and 2 indicated gravel, sand, silt and clay content of approximately 0 %, 0 %, 52 to 79 % and 21 to 48 % respectively. Moisture contents of samples ranged from 22 to 38 %.

4.8 Gravel

Compact sandy gravel with silt was encountered in Borehole 1. It was encountered below a depth of 19.2 m; this corresponds to an elevation of 255.0 m. The thickness of this stratum is not determined as borehole terminus was reached within this stratum. Gradation analyses conducted on sample from Borehole 1 indicated gravel, sand and fine contents of approximately 40%, 35% and 25% respectively. An SPT value of 18 per 0.3 m indicates a state of compactness of compact. Moisture content of sample was 20%.

4.9 Groundwater

The groundwater table was identified below the ground surface during the field investigation and visual identification of soil samples. The estimated depth of groundwater level below the ground surface elevation is given in Table 4.1. The water level in the creek at the culvert was at an elevation of approximately 270.6 m during the field investigation. The groundwater levels and water level at the culvert can be expected to vary with season and precipitation events.

Table 4.1 Depth of water table at boreholes

Borehole ID	Borehole elevation (m)	Water table elevation (m)	Depth of water table below the ground surface (m)
BH1	274.2	271.1	3.1
BH2	274.2	270.9	3.3
HA1	271.0	271.3	-0.3 (Standing Water)
HA2	270.9	271.1	-0.2 (Standing Water)

5. REFERENCES

Canadian Highway Bridge Design Code (2006), CAN/CSA-S6-06, A National Standard of Canada, Canadian standards Association.

Municipal and Provincial Common, Volume 1 - General & Construction Specifications, "*Ontario Provincial Standard for Roads & Public Works*" Spec No. OPSS 422, 501, 510, 511, 517, 518, 539, 805, 902.

Municipal and Provincial Common, Volume 3 - Drawings for Roads, Barriers, Drainage, Sanitary Sewers, Watermains and Structures, "*Ontario Provincial Standard for Roads & Public Works*" Spec No. OPSD 203.040, 803.010, 810.010, 810.020, 3090.100.

Municipal and Provincial Common, Volume 2 - Material Specifications, "*Ontario Provincial Standard for Roads & Public Works*" Spec No. OPSS 1010, 1860.

Special Provisions, Ontario Provincial Standards, SP110S13.

The Surveys and Design Office, Highway Engineering Division, Ministry of Transportation, 1990, Pavement Design and Rehabilitation Manual.

6. LIMITATIONS OF REPORT

A description of limitations which are inherent in carrying out site investigation studies is given in Appendix 'A', and this forms an integral part of this report.

For DST CONSULTING ENGINEERS INC.

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Foundation Investigation Report

Agreement # 5010-E-0006, GWP: 5149-11-00, WP: 5113-09-01

Deception Creek Culvert Replacement, Highway 11, 18.7 km west of Hwy 579, Township of Calder

DST Reference No.: GS-TB-012144

APPENDIX 'A'

LIMITATIONS OF REPORT

LIMITATIONS OF REPORT

GEOTECHNICAL STUDIES

The data, conclusions and recommendations which are presented in this report, and the quality thereof, are based on a scope of work authorized by the Client. Note that no scope of work, no matter how exhaustive, can identify all conditions below ground. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the specific locations tested, and conditions may become apparent during construction which were not detected and could not be anticipated at the time of the site investigation. Conditions can also change with time. It is recommended practice that a Quality Verification Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavation, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Unless otherwise noted, the information contained herein in no way reflects on environmental aspects of either the site or the subsurface conditions.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs, e.g. the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

Any results from an analytical laboratory or other subcontractor reported herein have been carried out by others, and DST Consulting Engineers Inc. cannot warranty their accuracy. Similarly, DST cannot warranty the accuracy of information supplied by the client.

Foundation Investigation Report

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Deception Creek Culvert Replacement, Highway 11, 18.7 km west of Hwy 579, Township of Calder

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APPENDIX 'B'

DESCRIPTIVE TERMS

FOR SOIL CLASSIFICATION

Descriptive Terms for soil classification:

As per the soil classification manual by MTO, the descriptive terms based on percent by mass of the whole sample, are described as per following table

Descriptive Term	Example	Percent by Mass of Sample
And (with two major soil types)	Sand and gravel	40-60
Adjective (silty)	Silty	30-40
With	Silt with fine sand	20-30
Some	Silt, some fine sand	10-20
Trace	Sand, trace of gravel	0-10

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 63.5kg, 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 475 J 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

JOINTING 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

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

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_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

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
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

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 = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

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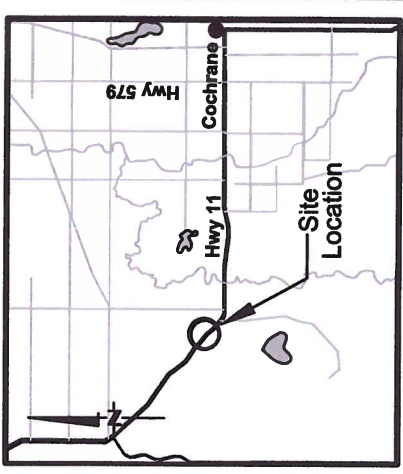
D R A W I N G S

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

CONT No 2012-5119
GWP No 5149-11-00
WP No 5112-09-01
Site No 39E-236
Geocres No 42H-49

CULVERT REPLACEMENT
AT DECEPTION CREEK
Highway 11 - Calder Twp.
Geotechnical Investigation

SHEET



KEY PLAN
SCALE IN KILOMETRES
0 20

LEGEND

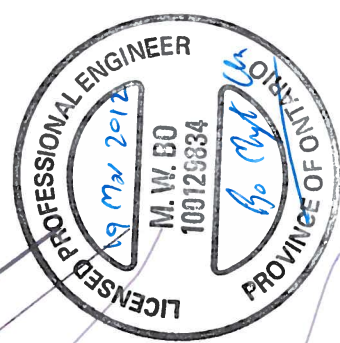
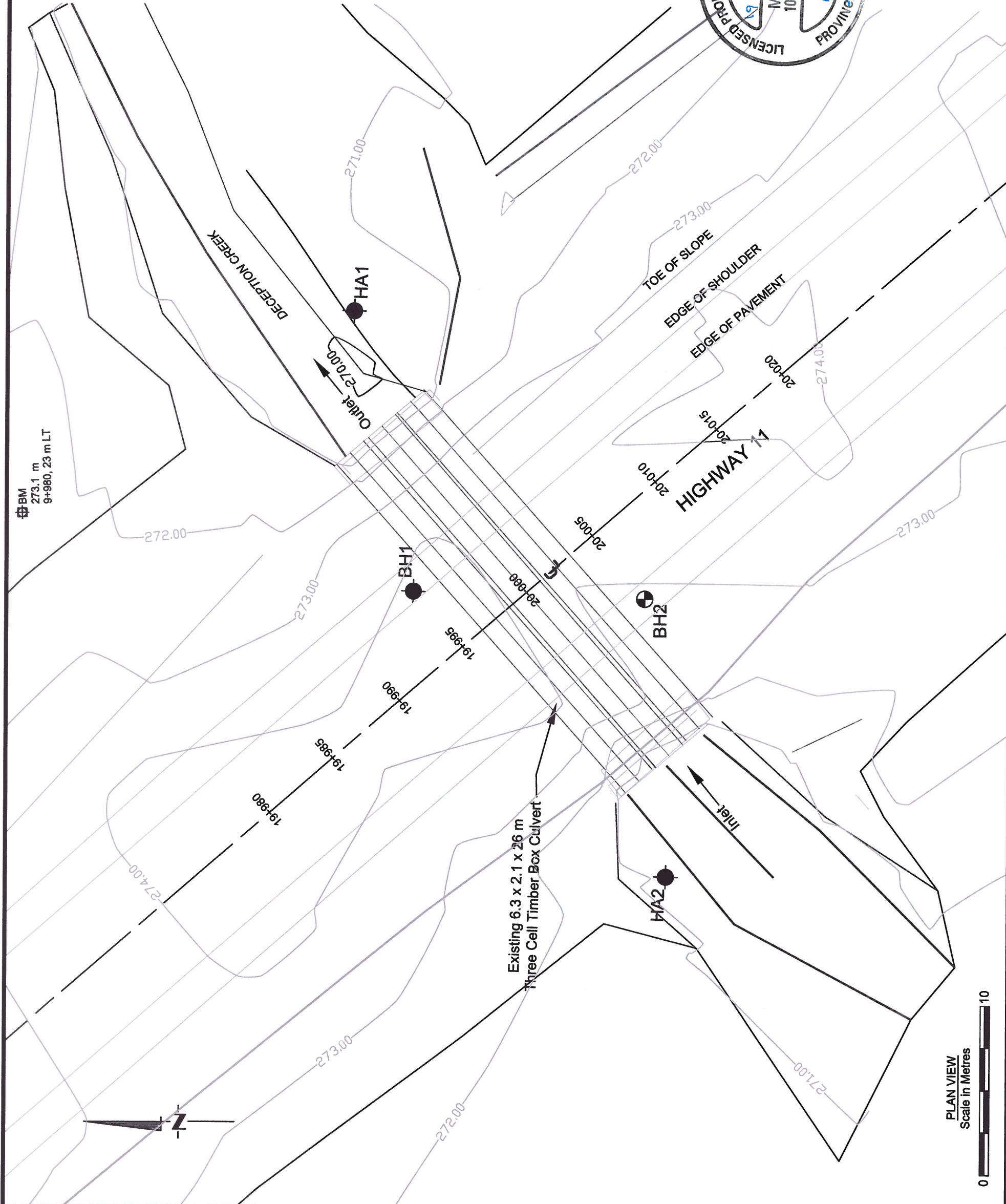
- Borehole/Hand Auger
- Borehole with DCPT
- Dynamic Cone Penetration Test (DCPT)
- Rock Probe
- Blows/0.3m (Std. Pen Test, 475 J/Blow)
- Water level at time of investigation.
- Benchmark
- Fill
- Organics
- Topsoil
- Till
- Bedrock
- Sand
- Silt
- Clay
- Sand & Gravel
- Boulders

No.	Elevation	Northing	Easting	Station	Offset
BH1	274.340	5435038	47887	19+985	4.5 LT
BH2	274.220	5435025	47888	20+005	5.0 RT
HA1	270.885	5435040	478703	20+002	20.0 LT
HA2	270.910	5435020	478870	19+985	18.55 RT



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605 Hewison Street
Thunder Bay, ON P7B 5V5
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Email: thunderbay@dstgroup.com

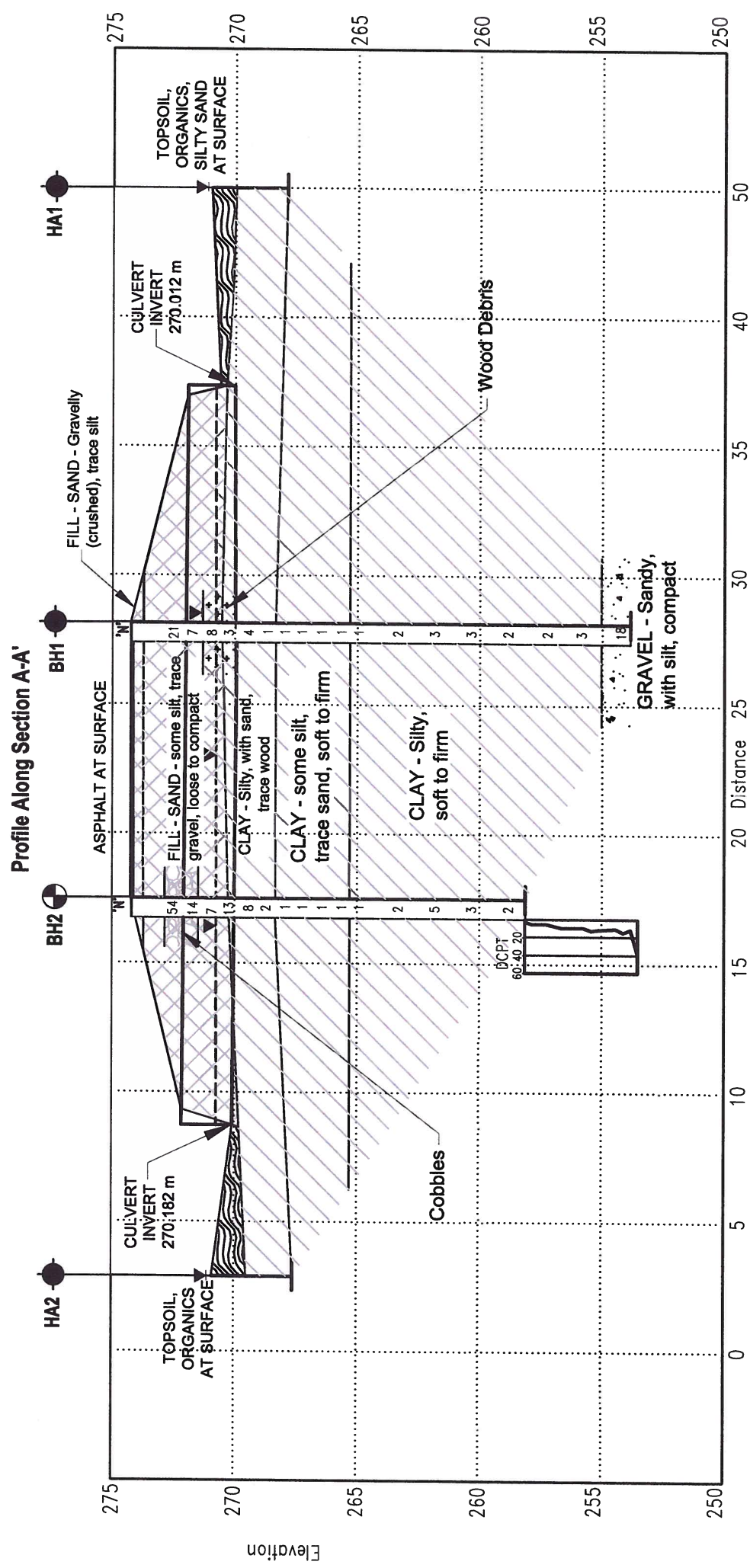
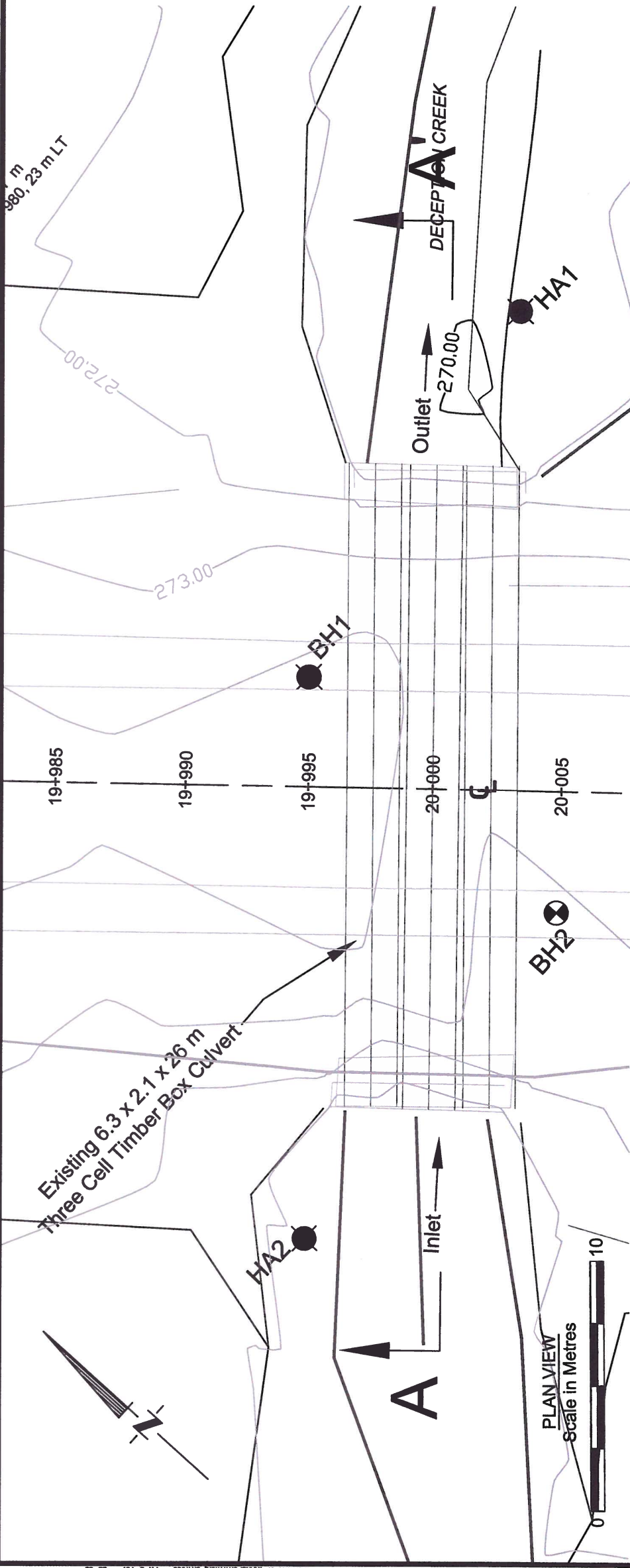
NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.



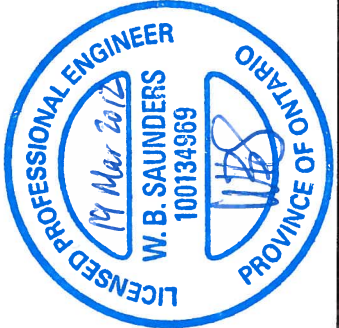
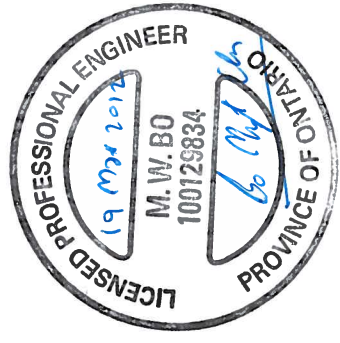
PLAN VIEW
Scale in Metres
0 10

METRIC
DIMENSIONS ARE IN METRES
AND FOR ALL DIMENSIONS
OTHERWISE SHOWN
IN KILOMETRES + METERS

CONT	No 2012-5119	
GWP	No 5149-11-00	
WP	No 5112-09-01	
Site	No 39E-236	
Geocres No	42H-49	
CULVERT REPLACEMENT AT DECEPTION CREEK Highway 11 - Calder Twp. Geotechnical Investigation		SHEET 10



LEGEND				
	Borehole/Hand Auger		Sand	
	Borehole with DCPT		Silt	
	Dynamic Cone Penetration Test (DCPT)		Clay	
	Rock Probe		Sand & Gravel	
	Blows/0.3m (Std. Pen Test, 475 J/Blow)		Boulders	
	'N'			
	Water level at time of investigation.			
	Benchmark			
	Fill			
	Organics			
	Topsoil			
	Till			
	Bedrock			
No.	Elevation	Northing	Easting	Station
BH1	274.340	5435039	47887	19+985
BH2	274.220	5435025	47886	20+005
HA1	270.885	5435040	478763	20+002
HA2	270.910	5435026	478670	19+985

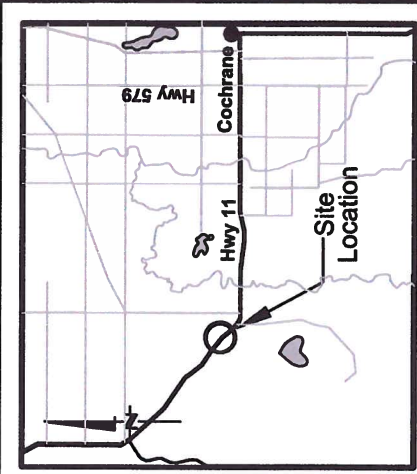


NOTE:
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METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETERS + METERS

CONT	No 2012-5119	
GWP	No 5149-11-00	
WP	No 5112-09-01	
Site	No 39E-236	
Geocres No	42H-49	
CULVERT REPLACEMENT AT DECEPTION CREEK Highway 11 - Calder Twp. Geotechnical Investigation		SHEET 11



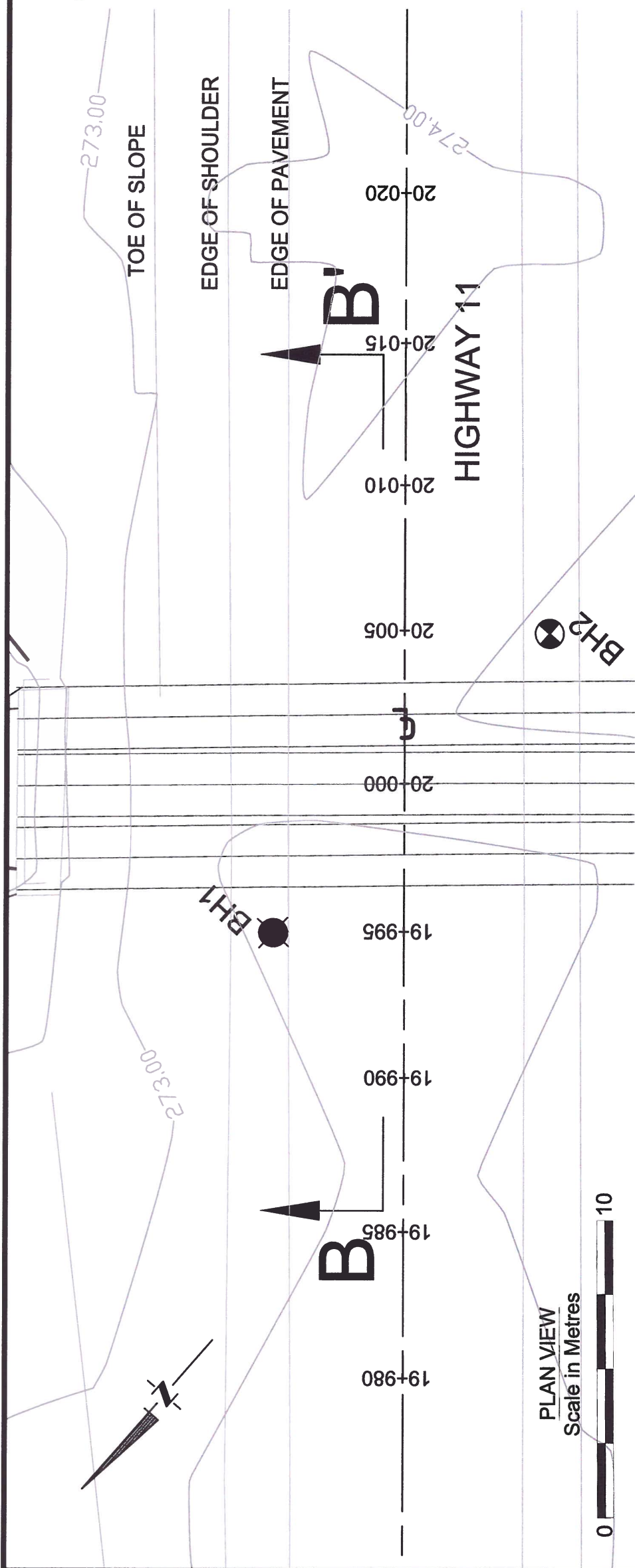
0 20
SCALE IN KILOMETRES

LEGEND				
	Borehole/Hand Auger		Borehole with DCPT	
	Dynamic Cone Penetration Test (DCPT)		Rock Probe	
	'N'		Blows/0.3m (Std. Pen Test, 475 J/Blow)	
	Water level at time of investigation		Benchmark	
	Fill		Organics	
	Topsoil		Till	
	Bedrock		Sand	
	Silt		Clay	
	Sand & Gravel		Boulders	
No.	Elevation	Horthing	Easting	Offset
BH1	274.240	6435038	478887	19+885
BH2	274.220	6435025	478666	20+005
HA1	270.985	6435040	478703	20+002
HA2	270.910	6435020	478670	19+885



NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

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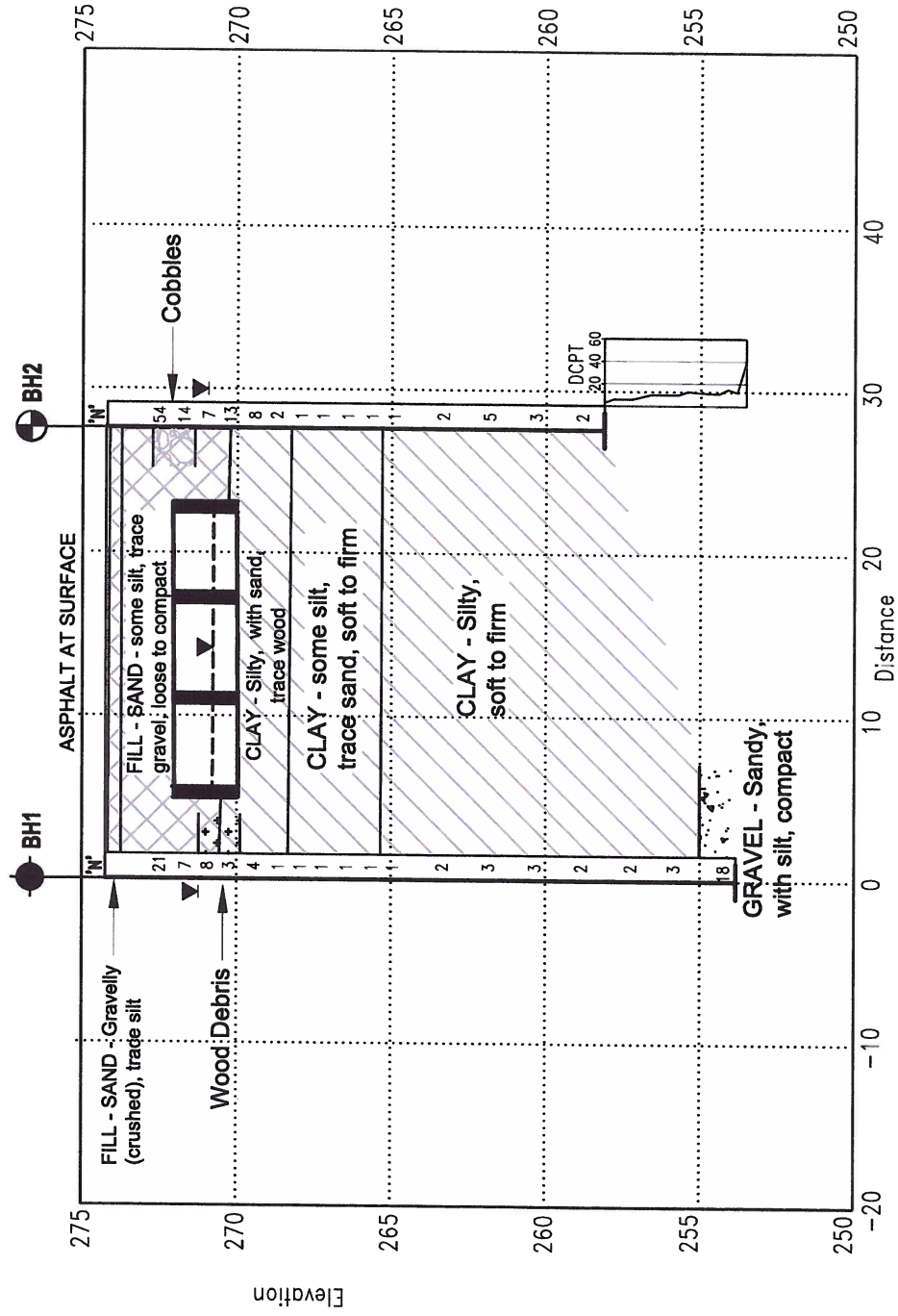


PLAN VIEW

Scale in Metres

0 10

Profile Along Section B-B'



Foundation Investigation Report

Agreement # 5010-E-0006, GWP: 5149-11-00, WP: 5113-09-01

Deception Creek Culvert Replacement, Highway 11, 18.7 km west of Hwy 579, Township of Calder

DST Reference No.: GS-TB-012144

E N C L O S U R E S

RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W.P. 5112-09-01 LOCATION STA. 19+995.4.5 m LT (5435039 m N, 478687 m E) ORIGINATED BY KS/JF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML
DATUM NAD83 UTM Zone 17U DATE 2011 04 01 CHECKED BY WS/BV

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			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								20 40 60 80 100	20 40 60 80 100							
274.2	GROUND SURFACE															
274.4	ASPHALT - 80 mm		AS1	AS			274							Water at 271.1 m on completion. Cave at 2.1 m.		
273.7	FILL - SAND - Gravelly (crushed), trace silt, brown		AS2	AS			273									
0.5	FILL - SAND - some silt, trace gravel, brown, loose to compact		SS3	SS	21		272							4 86 (10)		
			SS4	SS	7		271									
270.5	----- - wood debris		SS5	SS	8		270									
3.7	CLAY - Silty, with sand, trace wood and organics, grey, firm to stiff		SS6	SS	3		269							0 31 45 24		
			SS7	SS	4		268									
268.2	CLAY - some silt, grey, firm to stiff		SS8	SS	1		267									
6.0			SS9	SS	1		266									
			SS10	SS	1		265									
265.1	CLAY - Silty, grey, firm		SS11	SS	1		264									
9.1			SS12	SS	1		263									
			SS13	SS	1		262									
			SS14	SS	2		261									
			SS15	SS	3		260									
			SS16	SS	3		259									
			SS17	SS	2		258							0 0 79 21		
			SS18	SS	2		257									
			SS19	SS	3		256									
255.0	GRAVEL - Sandy, with silt, occasional cobbles, grey, compact						255									
19.2							254							40 35 (25)		
253.8	End of Borehole at 20.4		SS20	SS	18											
20.4																

ON MOT GS-TB-012144 - DECEPTION CREEK - HWY 11.GPJ DST_MIN.GDT 6/3/12

✕³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 1

RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. 5112-09-01 LOCATION STA. 20+005, 5.0 m RT (5435025 m N, 478686 m E) ORIGINATED BY KS/JF
 DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML
 DATUM NAD83 UTM Zone 17U DATE 2011 04 02 CHECKED BY WS/BV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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 W _L	WATER CONTENT (%)			
274.2	GROUND SURFACE					▽	274							36 56 (8) Water level at 270.9 m on completion. Cave at 3.2 m.
274.1	ASPHALT - 80 mm		AS1	AS			273							
273.7	FILL - SAND - Gravelly (crushed), trace silt, brown		AS2	AS			272							
0.5	FILL - SAND - some silt, trace gravel, brown, loose to compact		SS3	SS	54		271							
	- cobbles		SS4	SS	14		270							
			SS5	SS	7		269							
270.5	CLAY - Silty, with sand, grey, soft to stiff		SS6	SS	13		268							
3.7			SS7	SS	8		267							
			SS8	SS	2		266							
268.2	CLAY - some silt, trace sand, grey, soft to firm		SS9	SS	1		265							
6.0			SS10	SS	1		264							
			SS11	SS	1		263							
			SS12	SS	1		262							
265.1	CLAY - Silty, grey, soft to firm		SS13	SS	1		261							
9.1							260							
			SS14	SS	2		259							
			SS15	SS	5									
			SS16	SS	3									
			SS17	SS	2									
258.1	End of Borehole at 16.1 m Start DCPT													
16.1														
253.5	End of Dynamic Cone Penetration Test													
20.7														

Numbers refer to
Sensitivity

3% STRAIN AT FAILURE

ENCLOSURE 2

RECORD OF BOREHOLE No HA1

1 OF 1

METRIC

W.P. 5112-09-01 LOCATION STA. 20+002, 20.0 m LT (5435040 m N, 478703 m E) ORIGINATED BY KS/JF
 DIST HWY 11 BOREHOLE TYPE Hand Auger COMPILED BY ML
 DATUM NAD83 UTM Zone 17U DATE 2011 03 27 CHECKED BY WS/BV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
271.0	GROUND SURFACE							20 40 60 80 100						
270.9	TOPSOIL		SA29	AS				20 40 60 80 100						
270.3	ORGANICS - fibrous, some sand and gravel, dark brown		SA30	AS				20 40 60 80 100						
270.0	SAND - Silty, trace gravel, brown							20 40 60 80 100						
1.0	CLAY - Silty, some sand, trace gravel, grey		SA31	AS				20 40 60 80 100						
267.9			SA32	AS				20 40 60 80 100						
3.1	End of Borehole at 3.1 m							20 40 60 80 100						
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✕³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 3

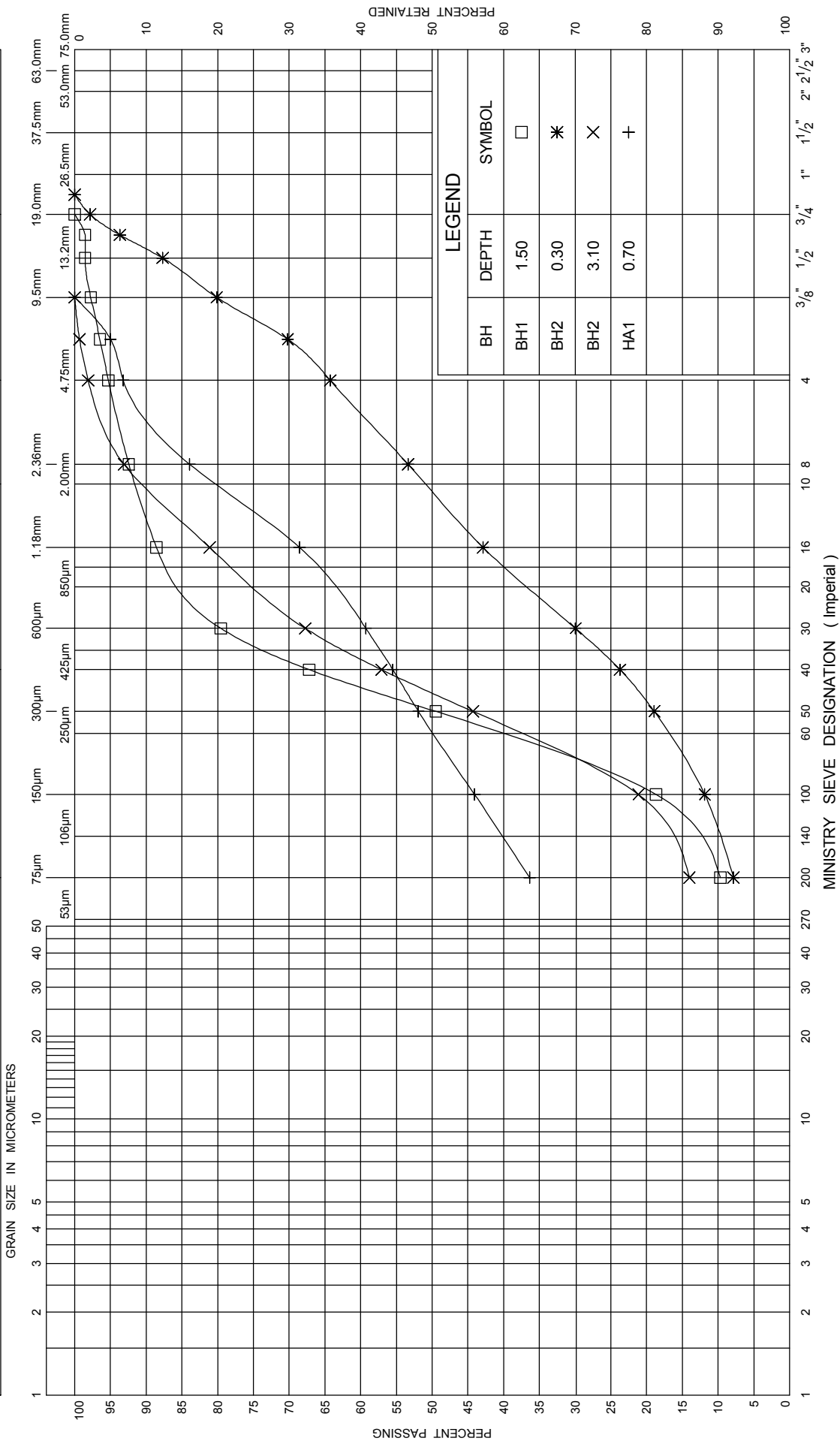
METRIC

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ENCLOSURE 4

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine		Medium	Coarse	Fine	Coarse



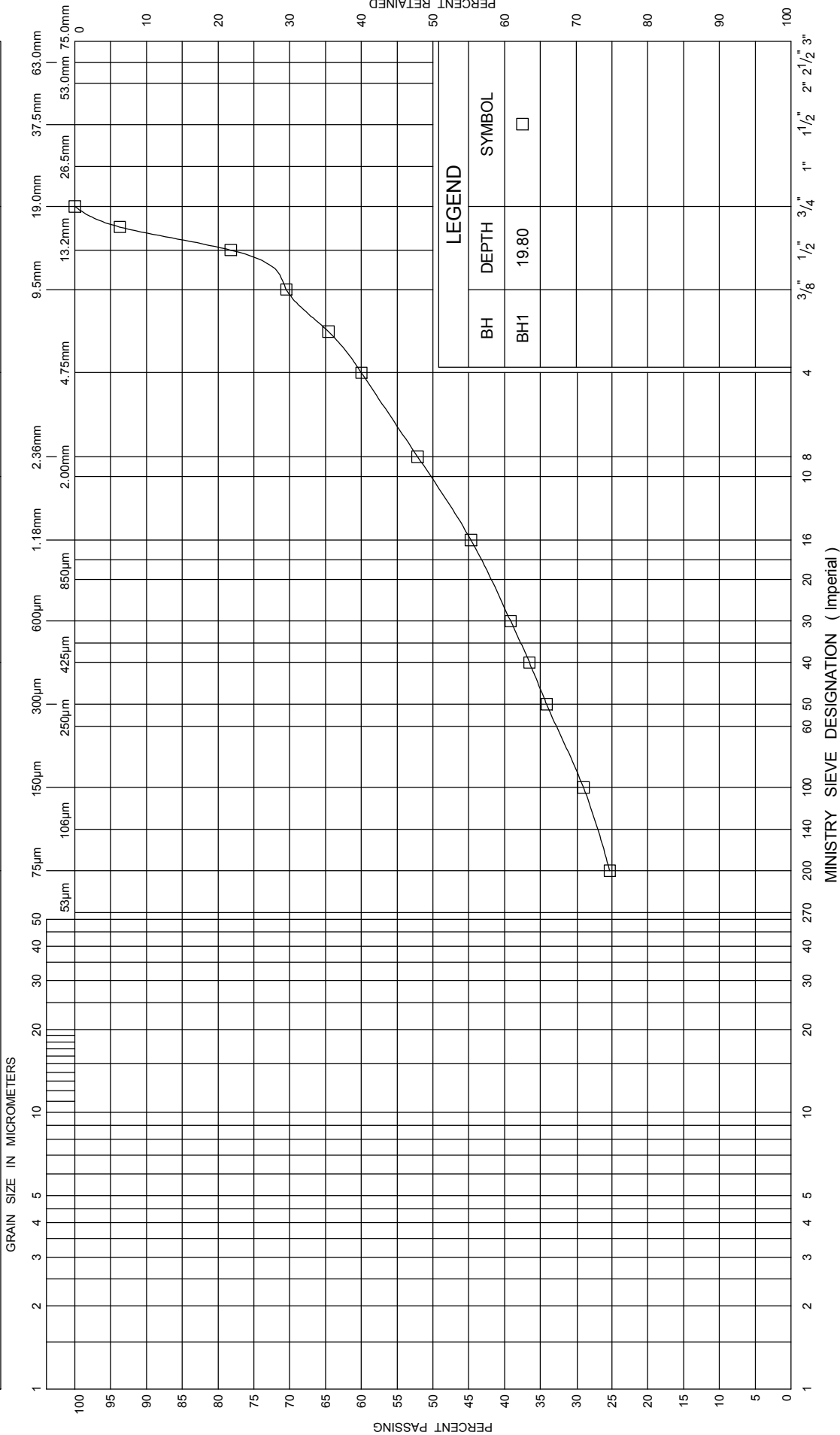
GRAIN SIZE DISTRIBUTION
SAND

ENCLOSURE 5
W P 5112-09-01
HIGHWAY 11



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine		Medium	Coarse	Coarse

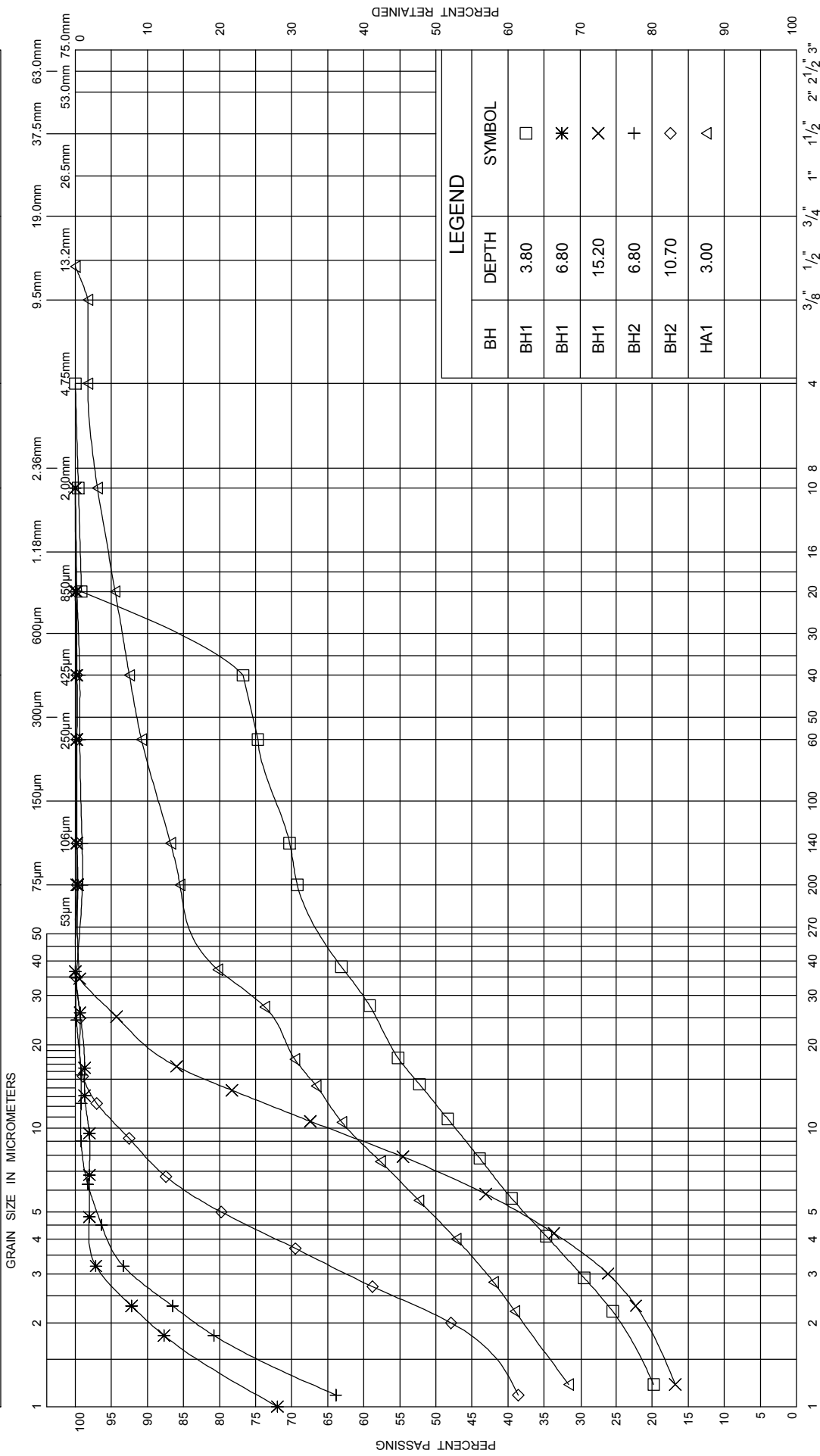


GRAIN SIZE DISTRIBUTION
GRAVEL

ENCLOSURE 6
W P 5112-09-01
HIGHWAY 11

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION
CLAY

ENCLOSURE 7
W P 5112-09-01
HIGHWAY 11



