

**FOUNDATION INVESTIGATION REPORT
CULVERT REPLACEMENT AT HOLLAND CREEK
SITE NO. 39W-129
HIGHWAY 11
WEST OF HEARST, ONTARIO
G.W.P. No. 5195-13-00**

GEOCRES Number: 42G-50

Report to

AECOM

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) in the immediate vicinity of the box culvert carrying Holland Creek under Highway 11, located in the township of Hanlan near Hearst, Ontario.

The purpose of this investigation was to obtain subsurface information at the culvert location and, based on the data obtained, to provide a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by URS Canada Inc. (URS) to carry out this foundation investigation under the MTO Agreement Number 5012-E-0033. There is no record available of any previous foundation investigation carried out at or near the subject culvert.

2 SITE DESCRIPTION

The culvert site is located on Highway 11 in the Township of Hanlan, approximately 12.8 kilometres west of Highway 583 near Hearst, Ontario. The culvert allows Holland Creek to flow from south to north under Highway 11.

The existing culvert, constructed in 1938, consists of a single 3.0 m span by 1.5 m high by 30 m long concrete rigid frame culvert. It is understood that the culvert is in poor condition with deterioration of the barrel. The grade of the existing Highway 11 in the vicinity of the culvert is at approximately Elevation 247.5 m. The embankment fill height above the culvert ranges between 3 and 4 m.

The site is located in a rural area with swamps, creeks and other watercourses nearby. The surrounding areas are covered by trees, low shrubs and bushes with no visible bedrock outcrops. Local relief is relatively flat with poor drainage resulting in low-lying swampy areas. There are a few residential properties in the vicinity of the culvert crossing. Selected photographs of the site are included in Appendix E.

Based on published geological information, the general area of the project is covered by glacial outwash deposits of silts, sands, and gravel, all underlain by Early Precambrian (Superior Province) granitic rock.

3 SITE INVESTIGATION AND FIELD TESTING

The first phase of borehole investigation and field testing program was carried out on November 5, 2013. The program consisted of drilling and sampling two boreholes identified as HC13-01 and HC13-02 to depths of 4.1 and 4.3 m (Elevations 240.1 and 240.6 m), respectively. Both boreholes were located in the vicinity of the culvert inlet. The second phase of borehole investigation and field testing program was carried out from September 8 to September 10, 2014. The program consisted of drilling and sampling five boreholes identified as HC14-03 to HC14-07. The boreholes were drilled to depths ranging from 3.4 to 6.9 m (Elevations 237.8 to 242.5 m). The Record of Borehole sheets are included in Appendix A.

The borehole locations were marked in the field and utility clearances were obtained prior to commencement of the drilling operations. The co-ordinates and elevation of the as-drilled boreholes were subsequently provided by Callon Dietz utilizing Digital Terrain Model (DTM), based on borehole location sketches provided by Thurber. The approximate locations and elevations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix C.

The drilling was carried out using a track-mounted CME45 drill rig using hollow stem auger drilling techniques until refusal to further auger advance. Soil samples were obtained at select intervals using a 50 mm diameter split spoon sampler in conjunction with the Standard Penetration Testing (SPT).

The drilling and sampling operations were supervised on a full time basis by an experienced member of Thurber's technical staff. The recovered soil samples were logged in the field and processed for transportation to Thurber's geotechnical laboratory in Oakville, Ontario for further examinations and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. The details of standpipe piezometer installation and borehole completion are summarized in Table 3-1.

Table 3-1. Borehole Completion and Standpipe Piezometer Installation Details

Borehole Number	Tip Location (Depth / Elevation)	Monitoring Well Installations			Completion Details
		Sand Screen Depth (m)	Sand Screen Elevation (m)	Sand Filter Stratum	
HC13-01	4.1 / 240.1	2.1 – 4.1	242.1 – 240.1	Sand	Bentonite holeplug above sand screen to surface
HC13-02	None Installed				Bentonite holeplug and cuttings to surface

HC14-03	None Installed				Bentonite holeplug and cuttings to surface
HC14-04	None Installed				Bentonite holeplug and cuttings to surface
HC14-05	2.4 / 240.9	0.2 – 2.4	243.1 – 240.9	Sand	Bentonite holeplug above sand screen to surface
HC14-06	3.4 / 242.5	0.9 – 3.4	245.0 – 242.5	Sand	Bentonite holeplug above sand screen to surface
HC14-07	5.6 / 240.2	3.2 – 5.6	242.6 - 240.2	Sand	Bentonite holeplug above sand screen to surface

Results of field drilling and sampling are presented on the Record of Borehole sheets in Appendix A.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing. The results of this laboratory testing program are included on the Record of Borehole sheets in Appendix A and on the figures in Appendix B.

A sample of surface water was submitted to AGAT Laboratories in Mississauga, a qualified analytical laboratory, for testing against selected corrosivity parameters.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A and the Borehole Locations and Soil Strata Drawing included in Appendix C for details of the soil stratigraphy encountered in the boreholes. An overall description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

In general, the subsurface stratigraphy encountered in the boreholes, located in the vicinity of the culvert consists of a thin, surficial layer of topsoil overlying a deposit of silty clay containing some sand which is underlain by silty sand containing trace to some gravel. Probable bedrock is inferred below the silty sand layer. Bedrock was confirmed by coring in Borehole 14-05. More detailed descriptions of the individual strata encountered within the boreholes are presented below.

5.2 Asphalt and Topsoil

A layer of asphalt between 200 and 225 mm in thickness was encountered at ground surface in Boreholes HC14-03 and HC14-04 located on the road embankment, respectively.

Topsoil 50 to 150 mm in thickness was encountered at ground surface in Boreholes HC14-05, HC14-06, HC13-01 and HC13-02. The topsoil thickness may vary between and beyond the borehole locations, and the limited data is not intended for the purpose of estimating quantities.

5.3 Fill

Embankment fill was encountered below the asphalt in Boreholes HC14-03 and HC14-04. This fill typically consists of layers of grey to brown gravelly sand. In these boreholes, the fill was found extending to depths of 1.3 m to 2.8 m (Elevations 246.1 to 244.7 m).

SPT N-values measured in the cohesionless fill ranged from 13 to 93 blows per 0.3 m penetration, indicating a compact to very dense state. A loose zone indicated by an N-value of 8 blows for 0.3 m penetration was encountered in Borehole HC14-04. Measured moisture contents of the recovered fill samples ranged between 4% and 10%.

Results of grain size analyses conducted on a sample of the fill are presented on Figure B1 in Appendix B and are summarized in the following table:

Soil Particles	%
Gravel	21
Sand	73
Silt and Clay	6

5.4 Silty Clay

Silty clay, trace to some sand was encountered beneath the topsoil or fill in all boreholes except for Borehole HC14-05. The silty clay was brown to grey in colour and contained trace gravel and the upper zone included trace to some organics. The silty clay layer ranged from 2.3 to 4.5 m in thickness (base Elevation 241.2 to 242.9 m). A 1 m thick layer of sand and gravel was observed in borehole HC14-03 within the silty clay.

SPT N-values measured in the silty clay typically ranged from 3 to 12 blows per 0.3 m penetration, indicating soft to stiff consistency. Higher values of 16 to 27 blows per 0.3 m and 50 blows for less than 0.3 m penetration recorded in Borehole HC13-01 and HC14-03 indicated very stiff to hard zones. The moisture contents typically ranged between 15% and 56% with a single moisture content recorded at 79% for a sample containing organics in Borehole HC13-02.

Laboratory grain size distribution analyses were performed on samples of the silty clay. The results of these tests are presented on the corresponding Record of Borehole Sheets in Appendix A and the grain size distribution curves are plotted in Figures B2 to B3 of Appendix B. The results are summarized in the following tables.

Soil Particles	(%)
Gravel	0 to 3
Sand	3 to 30
Silt	25 to 78
Clay	17 to 56

Atterberg Limits tests were performed on samples of the silty clay. Liquid limits were in the range of 42 to 46. The plasticity index ranged from 21 to 23 indicating a medium plasticity. The results of these tests are plotted in Figure B7 of Appendix B and summarized below.

Soil Particles	(%)
Liquid Limit	42 to 45
Plasticity Index	21 to 23

5.5 Sand and Gravel

A layer of sand and gravel with silt and clay was encountered below the silty clay in Boreholes HC14-04 and HC14-06 and within the silty clay in Borehole HC14-03. In Boreholes HC14-04 and HC-14-06, the sand and gravel layer was 0.4 to 0.7 m in thickness with an underside depth of 3.4 to 6.8 m (Elevation 240.7 to 242.5). The sand and gravel layer within the silty clay in Borehole HC14-03 was 1.0 m thick and was encountered at a depth of 1.8 m (Elevation 245.7).

The sand and gravel layer was compact in Borehole 14-03 as indicated by an SPT N-value of 17 blows per 0.3 m penetration. An SPT N-value of 74 blows per 0.3 m of penetration to greater than 100 blows for less than 0.3 m penetration indicated a very dense condition in Boreholes 14-04 and 14-06. A high blow count was likely due to the presence of probable bedrock immediately below the soil. The moisture contents of samples ranged from 4% to 18%.

One laboratory grain size distribution analysis was performed on a sample of the sand and gravel. The results of this test are presented on the corresponding Record of Borehole Sheet in Appendix A and the grain size distribution curves are plotted in Figure B4 of Appendix B. The results are summarized in the following table.

Soil Particles	(%)
Gravel	36
Sand	35
Silt and Clay	29

5.6 Sandy Silt

A layer of sandy silt with trace clay and some organics was encountered below the topsoil in borehole HC14-05. The sandy silt layer was 2.3 m in thickness with an underside depth of 2.4m (Elevation 240.9).

The SPT N-values of 3 to 23 blows per 0.3 m of penetration indicated a very loose to compact condition. A higher value of greater than 50 blows for less than 0.3 m of penetration was encountered at the bedrock surface. The moisture contents of samples ranged from 21% to 32%.

One laboratory grain size distribution analysis was performed on a sample of the sandy silt. The results of this test are presented on the corresponding Record of Borehole Sheet in Appendix A and the grain size distribution curves are plotted in Figure B5 of Appendix B. The results are summarized in the following table.

Soil Particles	(%)
Gravel	0
Sand	33
Silt	62
Clay	5

5.7 Silty Sand

A layer of silty sand with gravel and trace to some clay was encountered below the silty clay in Boreholes HC13-01, HC13-02, HC14-03 and HC14-07. The sand layer ranged from 0.8 to 1.8 m in thickness with an underside depth of 4.1 to 6.9 m (Elevations 240.1 to 240.6 m).

The SPT N-values of 3 to 86 blows per 0.3 m of penetration indicated a very loose to very dense condition. Higher values of 50 blows for less than 0.3 m penetration in Borehole HC13-01 and HC13-02 indicate the presence of probable bedrock, cobbles or boulders. The moisture contents of samples ranged from 5% to 21%.

Three laboratory grain size distribution analyses were performed on samples of the silty sand. The results of these tests are presented on the corresponding Record of Borehole Sheets in Appendix A and the grain size distribution curves are plotted in Figure B6 of Appendix B. The results are summarized in the following table.

Soil Particles	(%)	
Gravel	4 to 26	
Sand	33 to 81	
Silt	24	15 to 20
Clay	17	

5.8 Bedrock

Boreholes were terminated upon refusal to auger advance on inferred bedrock or boulders in most boreholes. Bedrock was proven by coring in Borehole 14-05. In Borehole HC14-06, auger refusal was probably met on obstructions such as cobbles or boulders. The depths and elevations of auger refusal encountered at the borehole locations are summarized below in Table 5-1.

Table 5-1. Depths and Elevation of Auger Refusal

Borehole	Probable Bedrock or Boulders (unless otherwise noted)	
	Depth (m)	Elevation(m)
HC13-01	4.1	240.1
HC13-02	4.3	240.6
HC14-03	6.9	240.6
HC14-04	6.8	240.7
HC14-05	2.4*	240.9*
HC14-06	3.4**	242.5**
HC14-07	5.6	240.2

* Bedrock proven by coring

** Possibly cobbles or boulders

Bedrock was encountered and proven by coring in Borehole HC14-05 at a depth of 2.4 m, or Elevation 240.9 m. The rock is identified as granite of the Archean Formation occurring as a felsic intrusive contact as part of the Pre-Cambrian Canadian Shield. The rock cores are generally in a fresh state with slight weathering at the joints. No exposed bedrock was observed in the general vicinity of the site.

The measured Total Core Recovery (TCR) was 100% in all three runs of the granite. The Rock Quality Designation (RQD) values ranged from 87 to 100% indicating good to excellent rock quality. The Fracture Indices (FI) were typically between 0 and 3 fractures per 0.3 m core run.

The estimated Unconfined Compressive Strength (UCS) for the cores ranged from 109 to 145 MPa indicating a very strong rock. These estimated rock strength values are based on point load tests that were conducted on selected rock cores recovered from Borehole BH-05.

5.9 Groundwater Conditions

Free water was observed in borehole HC14-04. Standpipe piezometers were installed in Boreholes HC14-07, HC14-05, HC14-06 and HC13-01. The short term water levels measured in the piezometers are summarized in the following table.

Borehole (screen location)	Date of Reading	Water Level Depth (m)	Water Level Elevation (m)
HC13-01 (Silty Sand)	November 7, 2013	0.5	243.7
HC14-05 (Sandy Silt)	September 9, 2014	1.2	242.1
	September 10, 2014	1.1	242.2
HC14-06 (Sand and Gravel)	September 9, 2014	Dry	Dry
	September 10, 2014	2.8	243.1
HC14-07 (Silty Sand)	September 9, 2014	2.9	242.8
	September 10, 2014	4.4	241.3

The localized groundwater level is expected to be governed by the creek water level. Local high water levels, spring snowmelt and periods of significant and/or prolonged precipitation events must also be taken into consideration.

6 MISCELLANEOUS

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Joe Gurzanski, and Mr. Alistair Hall of Thurber Engineering Ltd. Routine laboratory testing was carried out by Thurber Engineering Ltd. geotechnical laboratory in Oakville, Ontario. A sample of surface water was submitted to AGAT Laboratories in Mississauga, Ontario for testing against corrosivity parameters. Sulphate concentration in the creek water is less than 1 mg/L which is considered negligible in terms of sulphate attack on concrete.

Borehole locations were selected by Thurber. Callon Dietz provided the northing and easting coordinates and ground surface elevations utilizing their DTM based on a borehole location sketch provided by Thurber.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated the track-mounted drill rig to carry out the drilling, sampling, in-situ testing operations and standpipe installation.

Overall project management was provided by Dr. Sydney Pang, P.Eng. Direction of the field and laboratory programs was provided by Mr. Lukasz Gilarski, P.Eng. Interpretation of the field data and preparation of this report was completed by Mr. Lukasz Gilarski, P.Eng and Dr. Pang. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.



Sydney Pang, P.Eng.,
Associate, Senior Foundations Engineer



P. K. Chatterji, P.Eng.,
Review Principal, Designated MTO Contact

Appendix A

Record of Borehole Sheets

19-4406-9

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$



Water Level

C_{pen}






Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION		SYMBOLS	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.

TERMS					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No HC13-01

1 OF 1

METRIC

GWP# 5195-13-00 LOCATION Holland Creek N 5 508 822.3 E 316 685.9 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.11.05 - 2013.11.05 CHECKED BY SKP

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	W _P W W _L	WATER CONTENT (%)	20 40 60			
244.2	GROUND SURFACE													
0.0	TOPSOIL: (50mm)													
	Silty CLAY , with sand, trace gravel, some organics Soft to Hard Brown Moist		1	SS	4		244							
			2	SS	50/ 0.150		243							0 25 42 33
			3	SS	27									
241.9							242							
2.3	Silty SAND , trace to some gravel, trace clay Very Loose to Compact Brown Wet		4	SS	3									
			5	SS	19		241							18 62 20 (SI+CL)
			6	SS	50/ 0.150									
240.1														
4.1	END OF BOREHOLE AT 4.1m UPON AUGER REFUSAL ON PROBABLE BEDROCK Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov. 7/13 0.5 243.7													

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

RECORD OF BOREHOLE No HC13-02

1 OF 1

METRIC

GWP# 5195-13-00 LOCATION Holland Creek N 5 508 826.0 E 316 671.3 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE Hollow Setm Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.11.05 - 2013.11.05 CHECKED BY SKP

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			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No HC14-03

1 OF 1

METRIC

GWP# 5195-13-00 LOCATION Holland Creek N 5 508 839.4 E 316 692.3 ORIGINATED BY ADH
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY LPG

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 (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								20 40 60 80 100									20 40 60		
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
247.5	GROUND SURFACE																		
0.0	ASPHALT: (200mm)																		
0.2	Gravelly SAND Very Dense to Dense Grey Moist (FILL)		1	SS	93		247									21 73 6 (SI+CL)			
246.1			2	SS	37														
1.3	Silty CLAY Grey Moist						246												
245.7			3	SS	32														
1.8	SAND and GRAVEL Compact Moist																		
244.7			4	SS	17		245												
2.8	Silty CLAY, trace sand Very Stiff to Stiff Grey Moist		5	SS	22		244												
			6	SS	12											0 3 41 56			
			7	SS	19		243												
	Occasional cobbles						242												
241.4																			
6.1	Silty SAND, some gravel Very Dense Grey Wet		8	SS	86		241												
240.6																			
6.9	END OF BOREHOLE AT 6.9m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																		

ONTMT4S 4069.GPJ 2012TEMPLATE(MTO).GDT 11/12/14

RECORD OF BOREHOLE No HC14-04

1 OF 1

METRIC

GWP# 5195-13-00 LOCATION Holland Creek N 5 508 839.7 E 316 672.3 ORIGINATED BY ADH
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY LPG

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
247.5	GROUND SURFACE															
0.0	ASPHALT: (225mm)															
0.2	Gravelly SAND Very Dense to Compact Brown Moist (FILL)		1	SS	88											
			2	SS	25											
			3	SS	13											
245.3																
2.2	Loose		4	SS	8											
244.7																
2.8	Silty CLAY, trace sand Stiff Grey Moist		5	SS	12											
			6	SS	11											
	Organic inclusion		7	SS	10											
241.4																
6.1	SAND and GRAVEL, with silt and clay Very Dense Grey Wet		8	SS	74											
240.7																
6.8	END OF BOREHOLE AT 6.8m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE OPEN AND WATER LEVEL AT 6.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.															

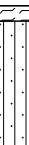

ONTMT4S 4069.GPJ 2012TEMPLATE(MTO).GDT 11/12/14

RECORD OF BOREHOLE No HC14-05

1 OF 1

METRIC

GWP# 5195-13-00 LOCATION Holland Creek N 5 508 860.7 E 316 679.6 ORIGINATED BY ADH
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.09 - 2014.09.09 CHECKED BY JPL

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											
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)							
243.3	GROUND SURFACE						20	40	60	80	100						GR SA SI CL		
0.0	TOPSOIL, some organics: (100mm) Sandy SILT, trace clay, some organics Very Loose to Compact Grey Wet		1	SS	5												0 33 62 5		
0.1																			
			2	SS	3														
			3	SS	23														
240.9	GRANITE, fresh, slightly weathered at joints, medium grained, very strong, grey Horizontal fracture at 2.8m		4	SS	52/											FI	RUN #1 TCR=100% SCR=79% RQD=87% UCS=109MPa		
2.4			1	RUN	0.125													3	
			2	RUN														0	RUN #2 TCR=100% SCR=100% RQD=100% UCS=145MPa
			3	RUN														0	
237.8																	0	RUN #3 TCR=100% SCR=100% RQD=97% UCS=117MPa	
5.5	END OF BOREHOLE AT 5.5m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep. 9/14 1.2 242.1 Sep. 10/14 1.1 242.2																1		

ONTMT4S 4069.GPJ 2012TEMPLATE(MTO).GDT 11/12/14

RECORD OF BOREHOLE No HC14-06

1 OF 1

METRIC

GWP# 5195-13-00 LOCATION Holland Creek N 5 508 863.5 E 316 645.4 ORIGINATED BY ADH
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY LPG

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			SHEAR STRENGTH kPa						
245.9	GROUND SURFACE							20	40	60	80	100		
0.0	TOPSOIL: (150mm)													
0.2	Silty CLAY , trace sand		1	SS	10									
245.3	Stiff													
0.7	Brown													
	Moist													
	Very Stiff		2	SS	16		245							0 8 64 28
244.5														
1.4			3	SS	11		244							
			4	SS	11									0 4 78 18
242.9							243							
3.0	SAND and GRAVEL , with silt and clay		5	SS	46/									
242.5	Loose													
3.4	Brown													
	Wet													
END OF BOREHOLE AT 3.4m UPON AUGER REFUSAL ON COBBLES OR BOULDERS. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.														
WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep. 9/14 Dry Sep. 10/14 2.8 243.1														

RECORD OF BOREHOLE No HC14-07

1 OF 1

METRIC

GWP# 5195-13-00 LOCATION Holland Creek N 5 508 835.3 E 316 750.0 ORIGINATED BY ADH
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.09 - 2014.09.09 CHECKED BY LPG

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
245.7	GROUND SURFACE															
0.0	TOPSOIL: (75mm) Silty CLAY , trace sand, trace organics Stiff to Firm Brown Moist <															

ONTMT4S 4069.GPJ 2012TEMPLATE(MTO).GDT 11/12/14

Appendix B

Laboratory Test Results

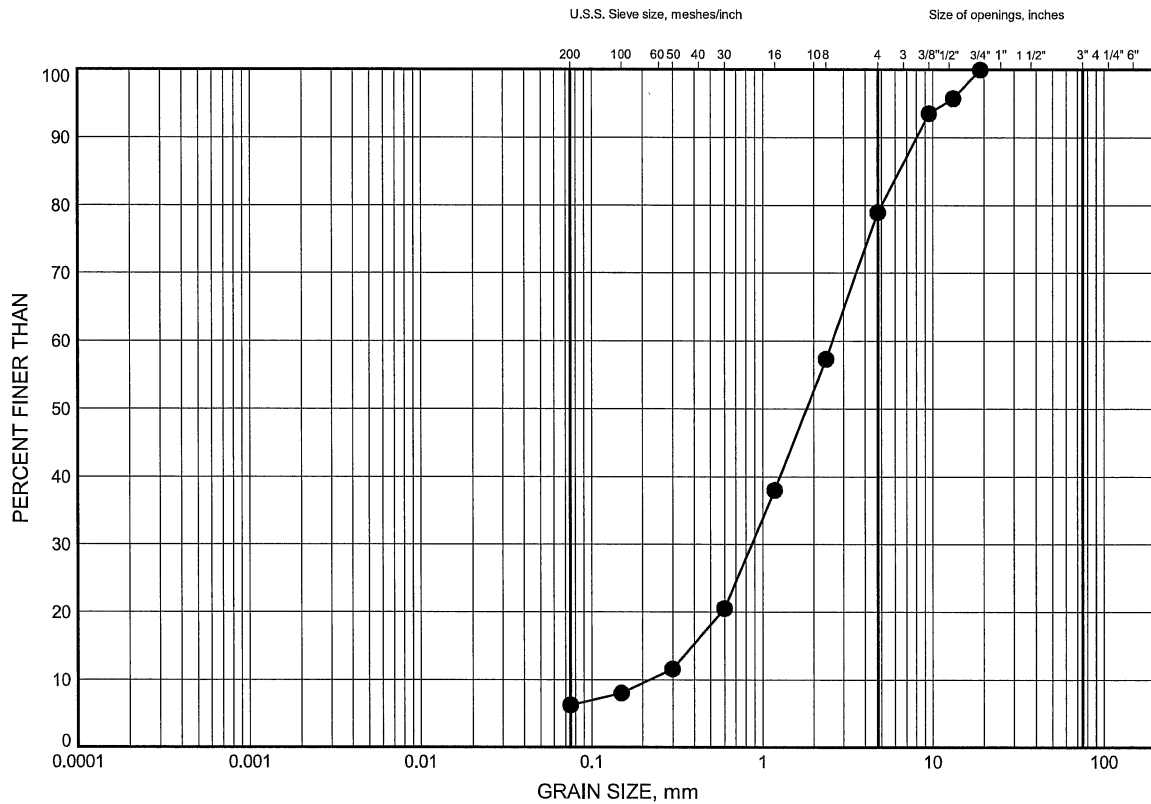
19-4406-9

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B1

GRAVELLY SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HC14-03	1.12	246.37

GRAIN SIZE DISTRIBUTION - THURBER 4069.GPJ 10/27/14

Date ..October 2014.....
GWP# ..5195-13-00.....



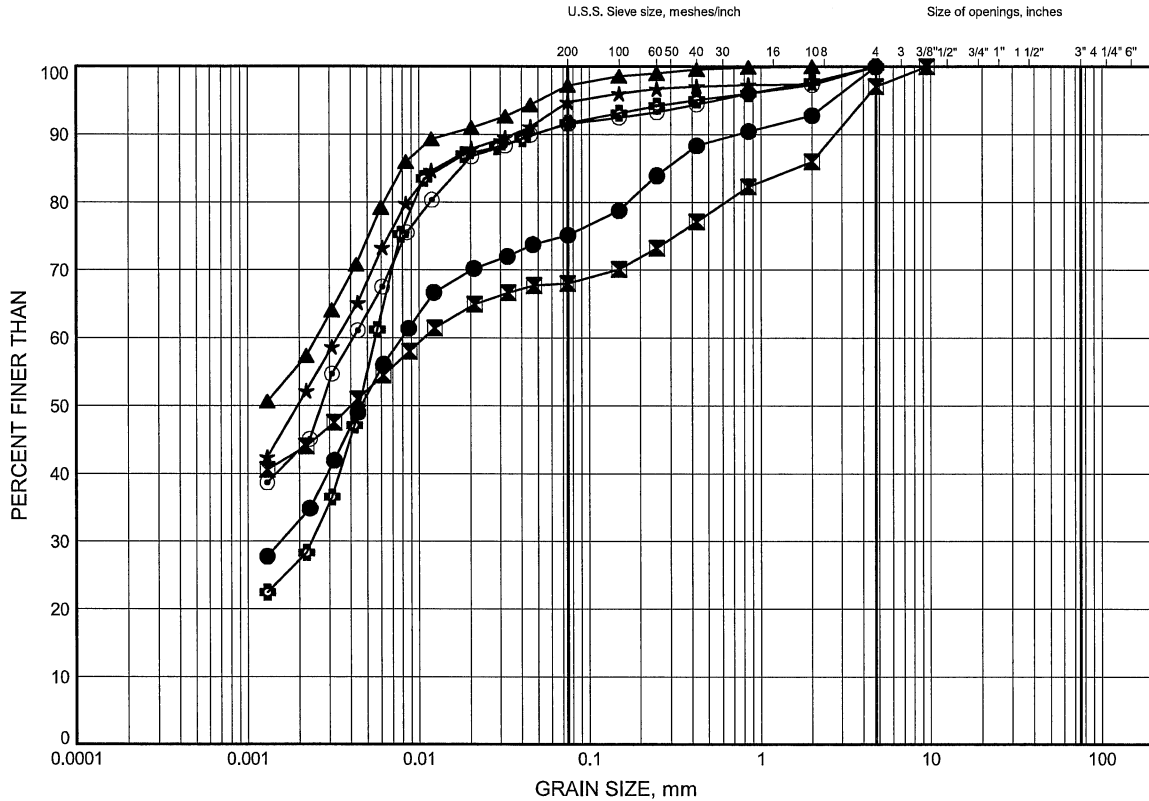
Prep'dAN.....
Chkd.LPG.....

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY CLAY



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HC13-01	0.91	243.29
⊠	HC13-02	0.30	244.60
▲	HC14-03	4.11	243.37
★	HC14-04	3.28	244.21
⊙	HC14-04	4.88	242.61
⊞	HC14-06	0.99	244.96

GRAIN SIZE DISTRIBUTION - THURBER 4069.GPJ 10/27/14

Date ..October 2014.....

GWP# ..5195-13-00.....



Prep'dAN.....

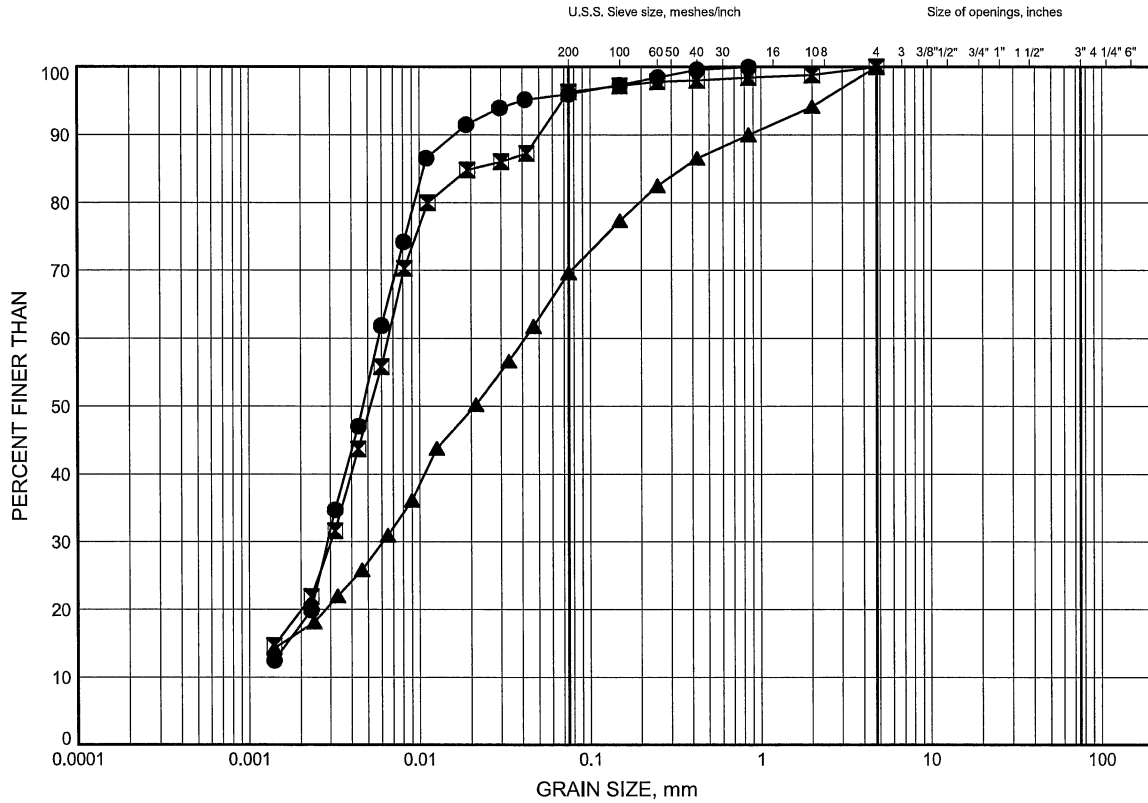
Chkd.LPG.....

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HC14-06	2.59	243.36
⊠	HC14-07	1.07	244.68
▲	HC14-07	3.35	242.39

GRAIN SIZE DISTRIBUTION - THURBER 4069.GPJ 10/27/14

Date ..October 2014.....
GWP# ..5195-13-00.....



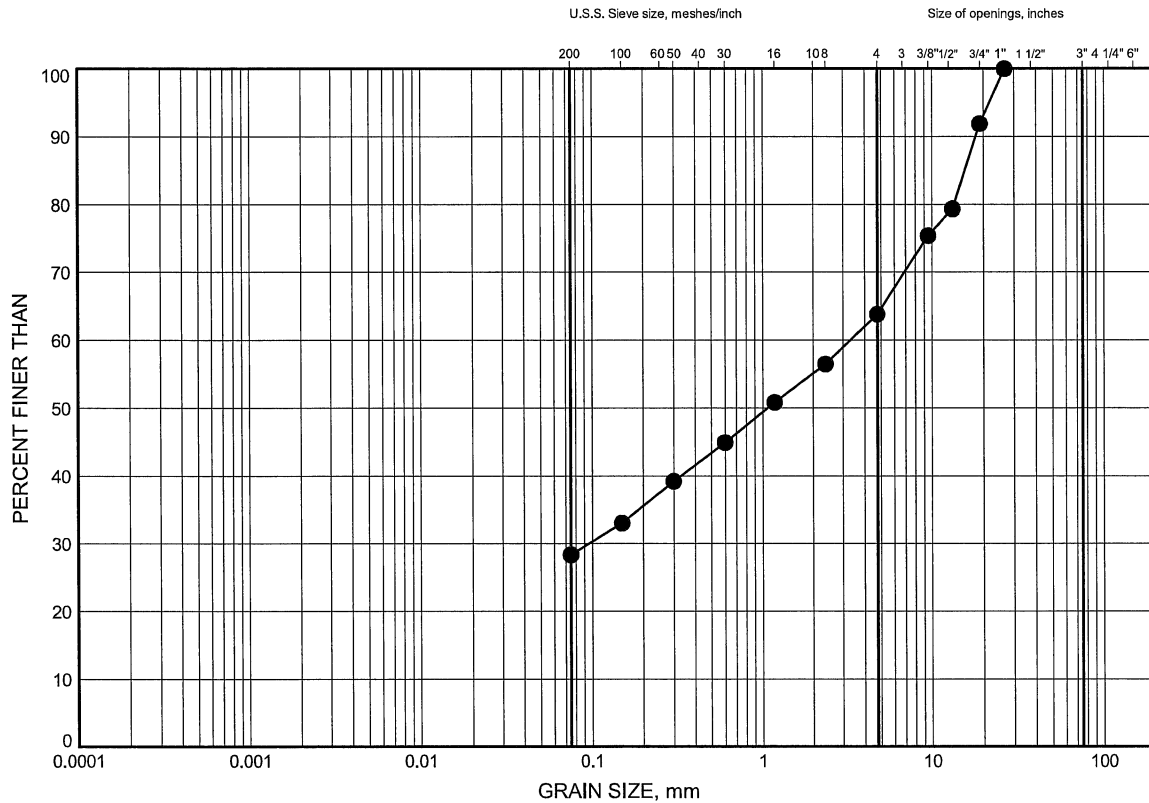
Prep'dAN.....
Chkd.LPG.....

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND & GRAVEL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HC14-04	6.39	241.10

Date ..October 2014.....

GWP# 5195-13-00



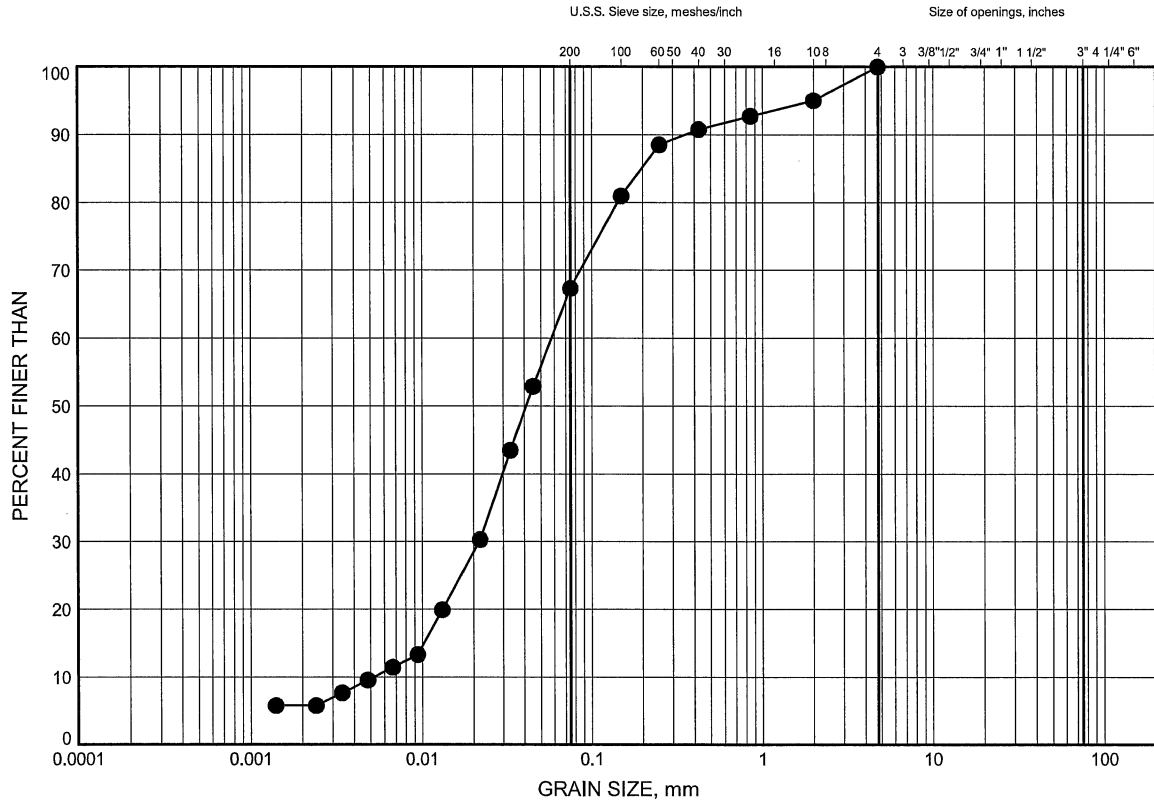
Prep'dAN.....

Chkd.LPG.....

Hwys 11, 583, 652 Culverts - Foundations
GRAIN SIZE DISTRIBUTION

FIGURE B5

SANDY SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HC14-05	1.68	241.66

GRAIN SIZE DISTRIBUTION - THURBER 4069.GPJ 10/27/14

Date ..October 2014.....
 GWP# ..5195-13-00.....



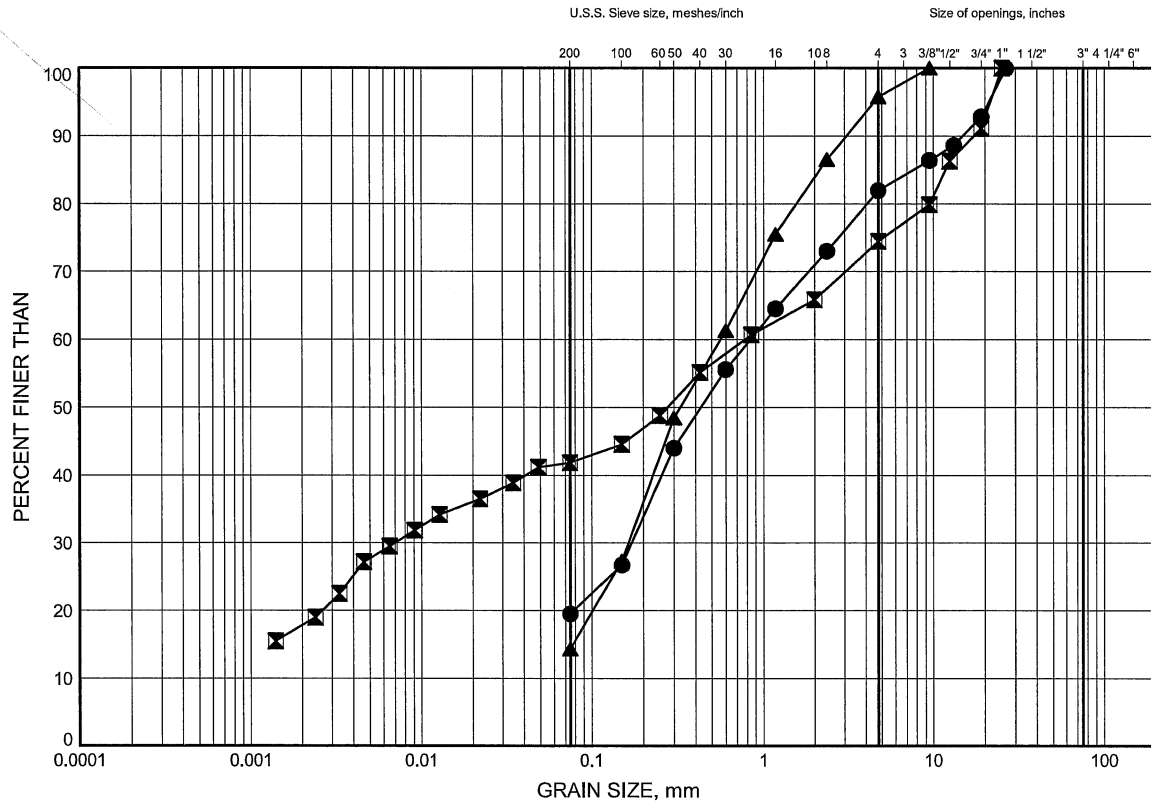
Prep'dAN.....
 Chkd.LPG.....

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILTY SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	HC13-01	3.35	240.85
■	HC13-02	3.12	241.78
▲	HC14-07	4.88	240.87

Date ..October 2014.....

GWP# ..5195-13-00.....



Prep'dAN.....

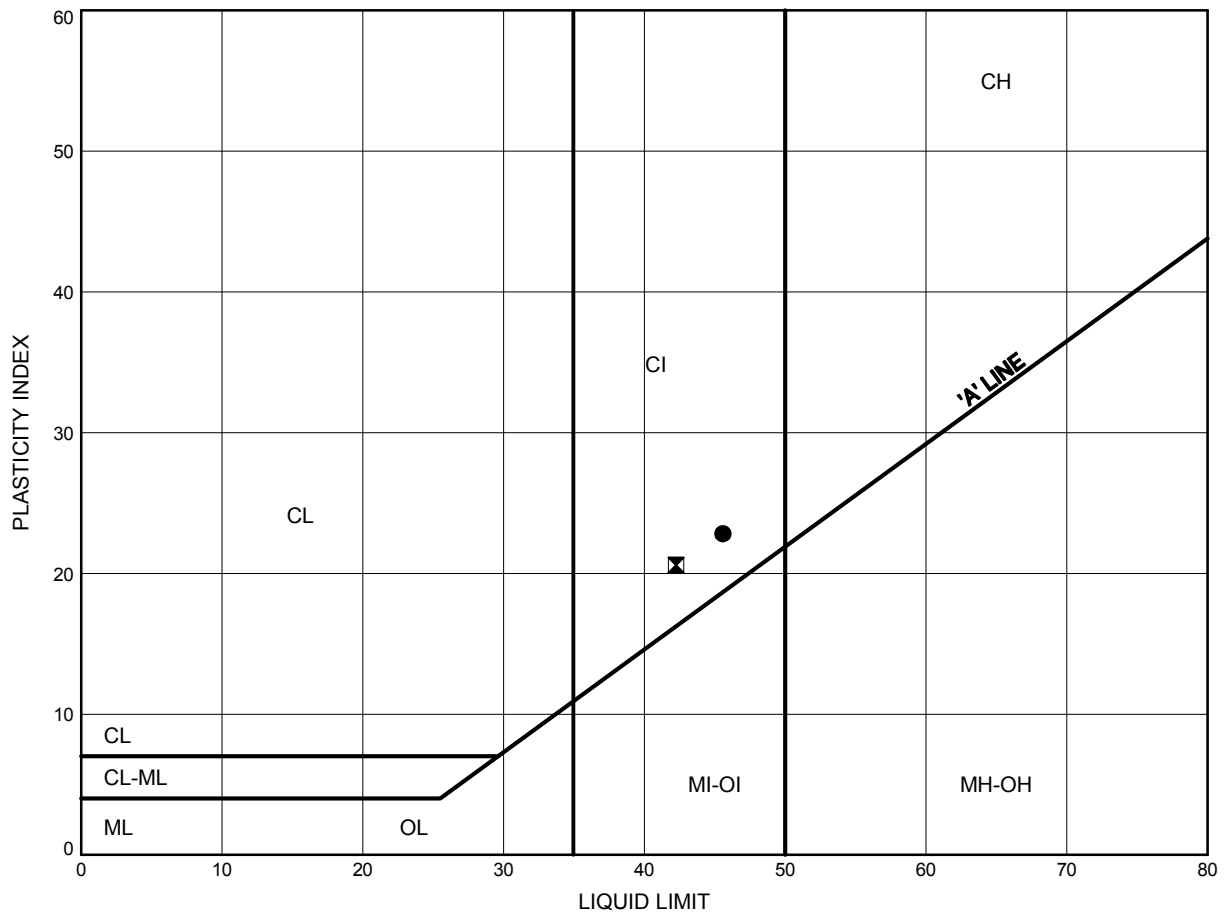
Chkd.LPG.....

Hwys 11, 583, 652 Culverts - Foundations

ATTERBERG LIMITS TEST RESULTS

FIGURE B7

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BH-04	4.11	243.37
⊠	BH-06	3.28	244.21

Date October 2014
GWP# 5195-13-00



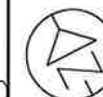
Prep'd AN
Chkd. LPG

Appendix C

Borehole Locations and Soil Strata Drawings

19-4406-9

CONT No
GWP No 5195-13-00

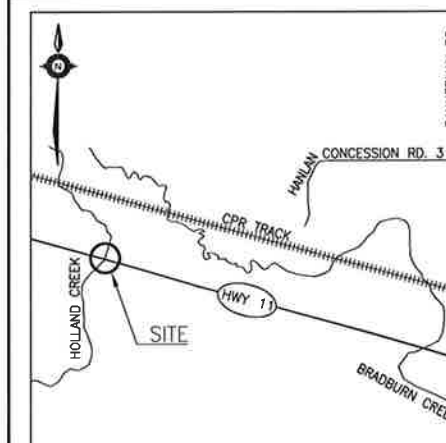


HIGHWAY 11
HOLLAND CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET








THURBER ENGINEERING LTD



KEYPLAN

LEGEND

- | | |
|---|---------------------------------------|
|  | Borehole |
|  | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
|  | Water Level |
|  | Head Artesian Water |
|  | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

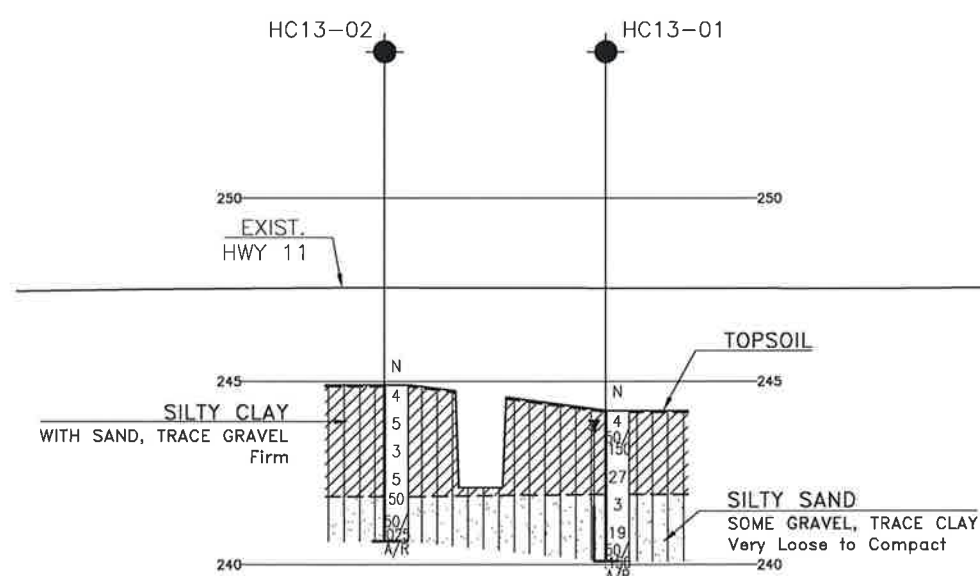
NO	ELEVATION	NORTHING	EASTING
HC13-01	244.2	5 508 822.3	316 685.9
HC13-02	244.9	5 508 826.0	316 671.3
HC14-03	247.5	5 508 839.4	316 692.3
HC14-04	247.5	5 508 839.7	316 672.3
HC14-05	243.3	5 508 860.7	316 679.5
HC14-06	245.9	5 508 863.5	316 645.4
HC14-07	245.7	5 508 835.3	316 750.0

-NOTES-

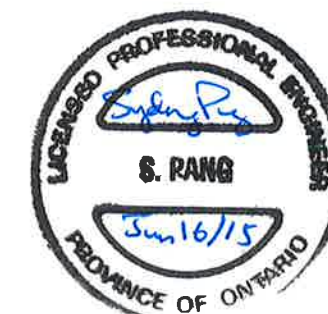
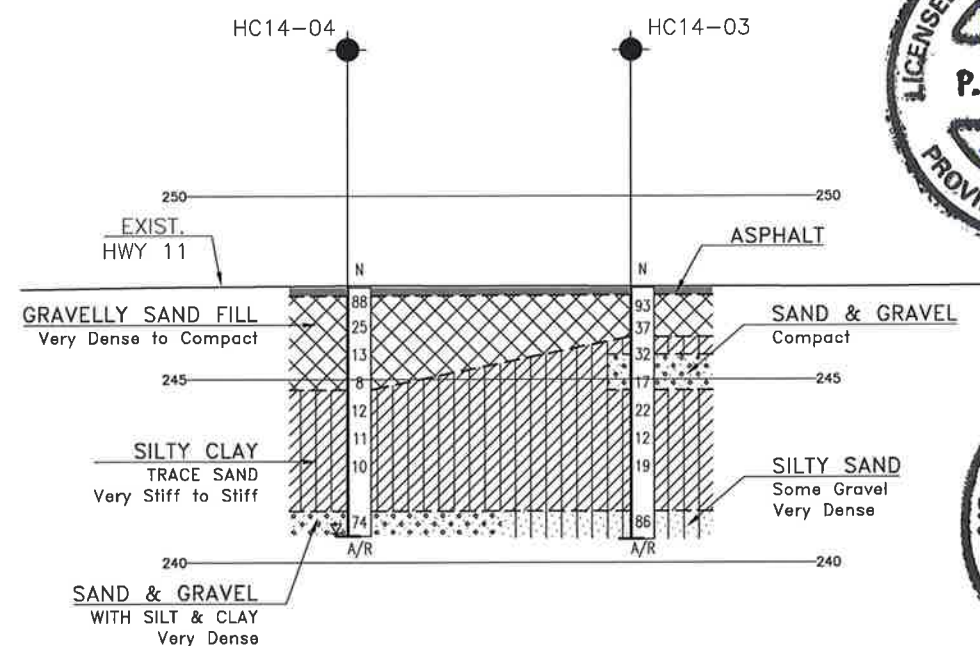
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Embankment outline is approximate.

GEOCRES No. 42G-50

SECTION ALONG A-A



SECTION ALONG C HWY 11

[illegible]

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

CONT No
GWP No 5195-13-00

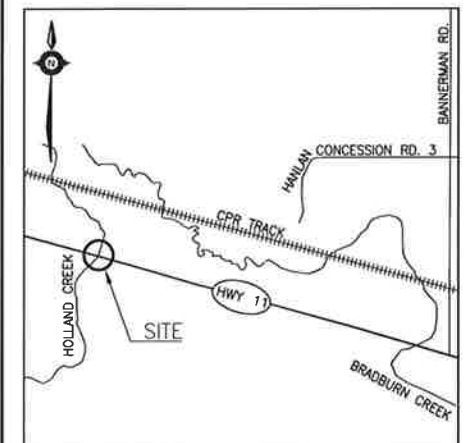
HIGHWAY 11
HOLLAND CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

AECOM



THURBER ENGINEERING LTD.



KEYPLAN
LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
HC13-01	244.2	5 508 822.3	316 685.9
HC13-02	244.9	5 508 826.0	316 671.3
HC14-03	247.5	5 508 839.4	316 692.3
HC14-04	247.5	5 508 839.7	316 672.3
HC14-05	243.3	5 508 860.7	316 679.5
HC14-06	245.9	5 508 863.5	316 645.4
HC14-07	245.7	5 508 835.3	316 750.0

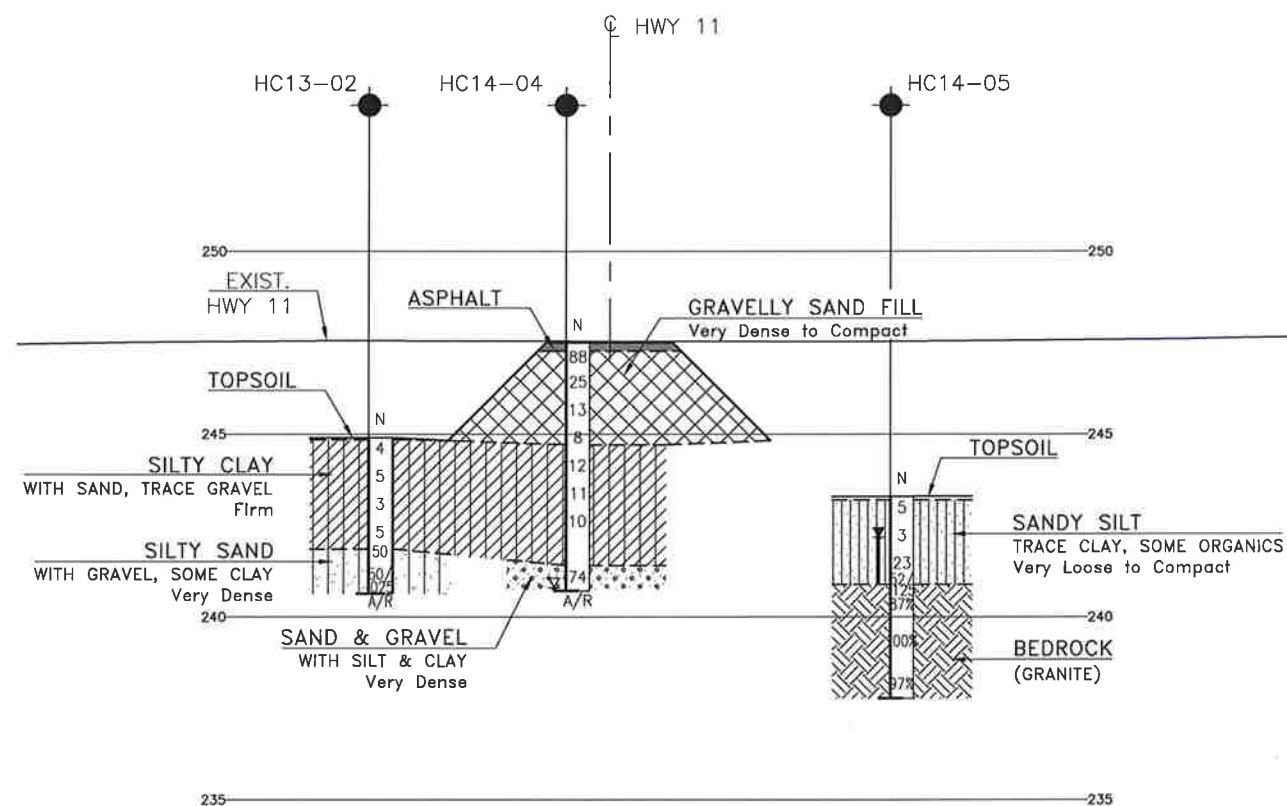
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Embankment outline is approximate.

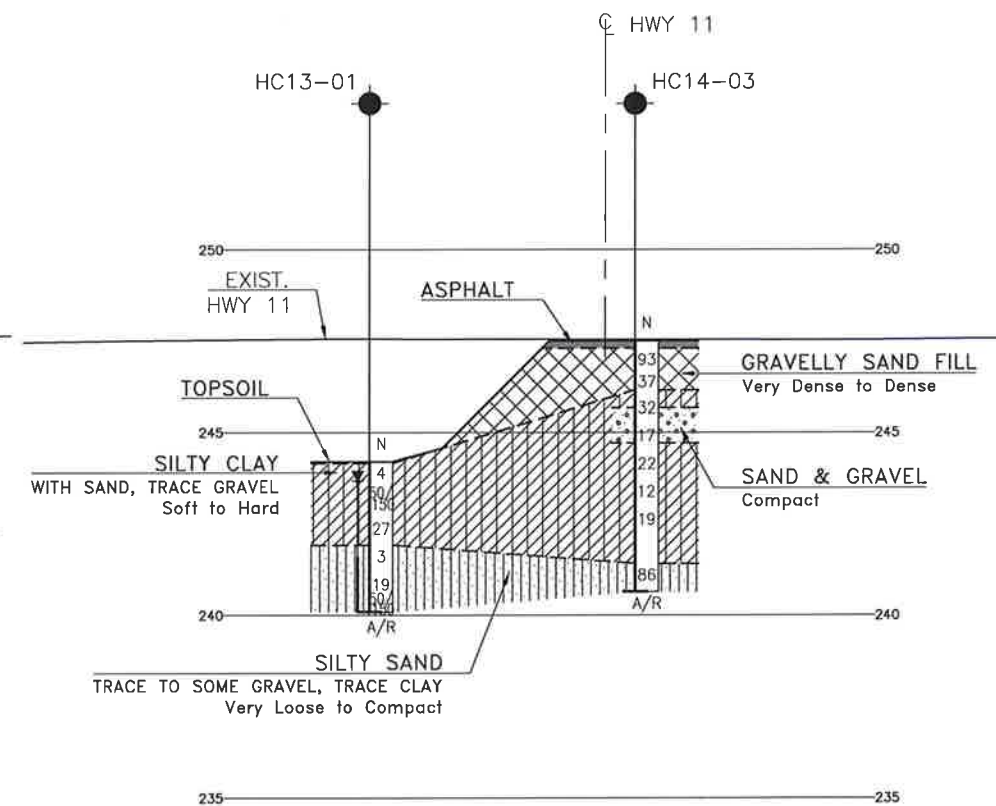
GEOCRES No. 42G-50

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