CONTRACT NO. 2017-3003

G.W.P. 3042-11-00

FOUNDATION INVESTIGATION REPORT

HWY 9, DRAIN 1 CULVERT

(SITE No. 35-594/C)

CONTRACT 4
STRUCTURE REPLACEMENTS
AND REHABILITATIONS

Ministry Of Transportation

Ontario

REPORT

April 2017

FOUNDATION INVESTIGATION REPORT

Culvert Replacement
Site No. 35-594/C, Highway 9
Contract 4 Structure Replacements and Rehabilitation
GWP 3042-11-00
Ministry of Transportation, Ontario - West Region

Submitted to:
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Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Stantec Consulting Ltd. (Stantec) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the detail design work for GWP 3042-11-00. The project involves the detailed design of the replacement and rehabilitation of several structures along multiple highways in southern Ontario. This report addresses the proposed replacement of the Drain 1 culvert (Site 35-594/C) at Station 20+011 on Highway 9 in the Geographic Township of Minto in Wellington County, Ontario.

The purpose of the foundation investigation is to explore the subsurface conditions at the location of the proposed culvert replacement by drilling boreholes and carrying out in situ testing and laboratory testing on selected samples. The terms of reference for the scope of work are outlined in the MTO's Request for Proposal and in Golder Associates' proposal P2-1132-0163 dated February 25, 2013 and change order 12-1132-0163-4000-CO3 dated September 16, 2016. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering dated March 26, 2013.

2.0 SITE DESCRIPTION

For the purposes of this report, Highway 9 has been assumed to be oriented east-west and Drain 1 to be flowing beneath Highway 9 from north to south. The culvert is located at about Station 20+011 on Highway 9 approximately 650 metres east of Ayton Road in Wellington County, Ontario. The Community of Harriston is located approximately 3.4 kilometres to the east of the site. The approximate location of the culvert is shown on the Key Plan, Figure 1. Photographs of the culvert are provided in Appendix B.

This section of Highway 9 is currently a two lane, undivided highway with gravel shoulders. Based on the information provided, the existing open footing, non-rigid frame culvert was previously extended to the north and south. A concrete floor slab was constructed and miscellaneous concrete repairs were carried out circa 2001. The existing culvert has an overall length of about 18.1 metres.

Dimensions (m)	Obvert Elevation (m)		Construction
	Lt[1]	Rt[1]	
3.05 x 2.24 x 18.1	375.80	375.79	Concrete Open Footing

NOTE: 1. When facing the direction of increasing chainage, Lt and Rt are defined as Left and Right of centreline, respectively.

Gabion retaining walls are located adjacent to the culvert in each of the four quadrants. There is some slight bulging in the retaining walls and some longitudinal and transverse cracking of the asphalt riding surface. The banks of Drain 1 and the embankments along Highway 9 adjacent to the culvert are grass covered.

2.1 Site Geology

The site lies within the Teeswater Drumlin Field physiographic region[1]. The till is characterized as loamy in texture, moderately compact, highly calcareous and pale brown or yellowish brown in colour. Valleys are typically filled with broad terraces of sand and gravel. The quaternary geology mapping indicates that the surficial soils in the area of the site generally consist of glaciofluvial outwash deposits of sand with minor gravel.[2] The underlying bedrock surface is typically found at about elevation 358 metres and the overburden thickness is typically some 16 to 19 metres. The rock formation is mapped and described as dolomite of the Bass Islands Formation of Upper Silurian age[3].

3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out on September 27, 2016, during which time three boreholes were drilled at the approximate locations shown on the Borehole Location Plan, Drawing 1.

The boreholes were drilled using a D50T track mounted drill rig supplied and operated by a specialist drilling contractor. Samples of the overburden were typically obtained at intervals of 0.75 metres to 6 metres depth and at 1.5 metre intervals thereafter using 50 millimetre outside diameter split spoon sampling equipment in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). The results of the SPT testing, as presented on the Record of Borehole sheets, Drawing 1 and in Section 4.0 of this report, are unmodified (not standardized for hammer efficiency, borehole diameter, rod length, etc.). The samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 40 millimetres; therefore, particles or objects that may exist within the soils that are larger than this dimension will not be sampled or represented in the grain size distributions. Larger particle sizes, including cobbles and boulders, were inferred in the fill and native deposits as discussed in the text of this report.

Groundwater conditions in the boreholes were observed throughout the drilling operations and a piezometer was installed in BH-603 as indicated on the corresponding Record of Borehole sheet. The boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 903 (as amended).

The field work was monitored on a full-time basis by a member of our staff who located the boreholes in the field, obtained utility locates, monitored the drilling, sampling and in situ testing operations and logged the boreholes. The samples were identified in the field, placed in labelled containers and transported to our London laboratory for further examination and testing. Index and classification tests, consisting of water content determinations, grain size distribution analyses and an Atterberg limits determinations, were carried out on selected samples. The results of the testing are shown on the Record of Borehole sheets and in Appendix A.

The as-drilled borehole locations and ground surface elevations at the borehole locations are shown on the Record of Borehole sheets and on Drawing 1. The table below summarizes the coordinates, ground surface elevations and depths of the boreholes.

[1] Chapman, L.J., and Putnam, D.F., 1984: Physiography of Southern Ontario; Ontario Geological Survey, Special Volume 2, 270p.

[2] Quaternary Geology of the Palmerston Area, Southern Ontario; Ontario Div. Mines, Prelim. Map. P.1185, Geol. Ser., Scale 1:50,000. Geology 1972, 1973.

[3] Ontario Division of Mines, Map 2254, Paleozoic Geology of Southern Ontario Showing Bedrock Industrial Mineral Producers, Scale 1:1,013,760.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
BH-601	4 866 684	191 903	376.47	11.13
BH-602	4 866 686	191 890	376.48	11.13
BH-603	4 866 665	191 904	374.49	8.08

4.0 SUBSURFACE CONDITIONS

4.1 Site Stratigraphy

The subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the in situ testing and laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets following the text of this report and in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous samples and observations of drilling resistance and, therefore, may represent transitions between soil types rather than exact planes of geological change. Further, the subsurface conditions will vary between and beyond the borehole locations.

The boreholes drilled at the site generally encountered the existing pavement structure or surficial topsoil and embankment fill materials overlying native granular soils, clayey silt, sandy silt till and clayey silt till.

The locations and elevations of the boreholes, together with the interpreted stratigraphic profile, are shown on Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes is provided on the Record of Borehole sheets and is summarized in the following sections.

4.2 Soil Conditions

The existing pavement structure was encountered in BH-601. The pavement consisted of about 70 millimetres of asphalt and 630 millimetres of crushed granular base. About 430 millimetres of granular base was encountered at the shoulder surface in BH-602.

Surficial topsoil, about 430 millimetres thick, was encountered at ground surface in BH-603. In addition, a layer of buried topsoil, about 0.8 metres thick, was encountered at about elevation 374.3 metres in BH-601. The buried topsoil had an N value, as determined in the standard penetration testing, of 8 blows per 0.3 metres. Materials designated as topsoil in this report were classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

Loose to compact silty sand to sandy silt fill, was encountered in BH-601 at elevation 375.8 metres and in BH-602 at elevation 376.1 metres. The fill was 1.4 and 2.5 metres thick in BH-601 and BH-602, respectively. The fill had N values, ranging from 5 to 16 blows per 0.3 metres. A sample of the fill from BH-601 had a water content of about 19 per cent. Cobbles were inferred in the fill in BH-602 and wood pieces and topsoil were noted. A grain size distribution curve for a sample of the fill from BH-601 is presented on Figure A-1 in Appendix A.

A layer of stiff clayey silt was encountered at elevation 373.6 metres in BH-601. The clayey silt was about 0.8 metres thick and had an N value of 9 blows per 0.3 metres. Topsoil layers were noted in the clayey silt.

Layers of compact to very dense silty sand and gravel were encountered in BH-601 at elevation 372.8 metres, in BH-602 at elevation 373.6 metres and in BH-603 at elevation 373.4 metres. The silty sand and gravel layers ranged in thickness from 1.5 to 3.4 metres. The silty sand and gravel had N values of 17 to 60 blows per 0.3 metres. Samples of the silty sand and gravel had water contents of about 8 and 10 per cent. Cobbles and boulders should be expected in the silty sand and gravel deposits. Grain size distribution curves for samples of the silty sand and gravel from BH-601 and BH-603 are presented on Figure A-2.

Compact sandy silt was encountered at elevation 372.8 metres in BH-602 within the silty sand and gravel and beneath the topsoil in BH-603 at elevation 374.1 metres. The sandy silt layers in BH-602 and BH-603 were about 0.8 and 0.6 metres thick, respectively. The sandy silt had N values of 16 and 22 blows per 0.3 metres with a water content of about 10 per cent. A grain size distribution curve for a sample of the sandy silt from BH-602 is presented on Figure A-3.

Compact to very dense sandy silt glacial till was encountered beneath the silty sand and gravel in all of the boreholes between elevation 370.1 and 371.3 metres. BH-602 was terminated in the sandy silt till after exploring it for about 5.2 metres. The sandy silt till was about 4.9 and 2.6 metres thick in BH-601 and BH-603, respectively. The sandy silt till had N values of 22 to over 100 blows per 0.3 metres and water contents of about 8 and 9 per cent. Cobbles were noted and boulders should be expected in the sandy silt till. Grain size distribution curves for samples of the sandy silt till are presented on Figure A-4.

Hard clayey silt glacial till was encountered beneath the sandy silt till in BH-601 at elevation 366.4 metres. This borehole was terminated in the clayey silt till after exploring it for about 1.1 metres. The clayey silt till had an N value of 31 blows per 0.3 metres and a water content of about 16 per cent. The clayey silt till had plastic and liquid limits of about 13 and 21 per cent, respectively, based on a single Atterberg limits determination. These data are shown on Figure A-6. Cobbles and boulders should be expected in the clayey silt glacial till. A grain size distribution curve for a sample of the clayey silt glacial till is presented on Figure A-5.

Beneath the sandy silt till, a layer of very dense silt was encountered in BH-603 at elevation 367.5 metres. BH-603 was terminated in the silt after exploring it for about 1.1 metres. The silt had an N value of 64 blows per 0.3 metres.

4.3 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling and a groundwater observation piezometer was installed in BH-603. The installation details are provided on the corresponding Record of Borehole sheet following the text of this report. Groundwater was encountered in the boreholes during drilling between depths of 1.5 and 3.7 metres or between elevation 372.8 and 373.6 metres. The water level in Drain 1 was measured at elevation 373.56 metres on September 27, 2016. The General Arrangement Drawing indicated an approximate drain water level of 373.66 metres on November 2, 2015. On October 25, 2016 and January 5, 2017, the water level in the piezometer installed in BH-603 was about 0.7 and 0.6 metres below ground surface or at about elevation 373.8 and 373.9 metres, respectively. A summary of the encountered and measured groundwater levels is provided in the table below.

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Elevation (m)	Measured Groundwater Level Elevation (m)	
			October 25, 2016	January 5, 2017
BH-601	376.47	372.8	-	-
BH-602	376.48	373.6	-	-
BH-603	374.49	373.0	373.80	373.91

The above-noted encountered and measured groundwater levels are not considered to be representative of the long-term, stabilized groundwater conditions. Based on the observed groundwater levels, the surrounding topography and the changes in soil colour, the long-term groundwater level is inferred to typically be at about elevation 374 metres. The groundwater levels should be expected to fluctuate seasonally and be higher during periods of sustained precipitation or during spring snow melt conditions.

5.0 MISCELLANEOUS

The investigation was carried out using equipment supplied and operated by London Soil Test Ltd., an Ontario Ministry of Environment and Climate Change licensed well contractor. The field operations were supervised by Mr. Daniel Hyland, E.I.T. under the direction of the Field Investigation Manager, Mr. Brett Thorner, P.Eng. The laboratory testing was carried out at Golder Associates' London laboratory under the direction of Mr. Michael Arthur. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates. This report was prepared by Mr. Daniel Hyland, E.I.T. under the direction of the Project Engineer, Ms. Dirka U. Prout, P.Eng. The report was reviewed by Mr. Michael E. Beadle, P.Eng., an Associate with Golder Associates. Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment, conducted an independent quality review of the report.

GOLDER ASSOCIATES LTD.

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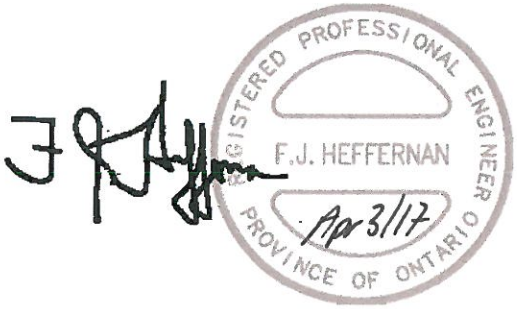

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MTO Designated Contact

DH/DUP/MEB/FJH/CR

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LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils

Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

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London, Ontario

RECORD OF BOREHOLE No BH-601

1 OF 1

METRIC

PROJECT 12-1132-0163
W.P. 3042-11-00
DIST _____ HWY 9
DATUM GEODETIC
LOCATION N 4866683.7 , E 191903.2
BOREHOLE TYPE POWER AUGER, HOLLOW STEM
DATE September 27, 2016
ORIGINATED BY DH
COMPILED BY ZJB/LMK
CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
376.47	PAVEMENT SURFACE										
0.07	ASPHALT										
375.77	FILL, sand and crushed gravel Brown						376				
0.70	FILL, silty sand, trace to some clay, trace gravel, with topsoil layers Loose Brown		1	SS	5				○		3 44 44 9
374.34			2	SS	5		375				
2.13	TOPSOIL, silty Loose Brown		3	SS	8		374				
373.57											
2.90	CLAYEY SILT, some sand, with topsoil layers Stiff Brown and grey		4	SS	9	▽	373				
372.81											
3.66	SILTY SAND AND GRAVEL Very dense Brown		5	SS	51		372				
371.29			6	SS	56				○		29 48 19 4
5.18	SANDY SILT TILL, trace to some clay, trace to some gravel, with cobbles Compact to very dense Brown		7	SS	40		371				
			8	SS	26		370		○		7 40 44 9
			9	SS	100/ 76mm		369				
			10	SS	100/ 279mm		368				
366.41							367				
10.06	CLAYEY SILT TILL, some sand, trace gravel, with silt seams Hard Brown						366				
365.34			11	SS	31				⊢○⊣		0 10 61 29
11.13	END OF BOREHOLE Groundwater encountered at about elev. 372.8m during drilling on September 27, 2016.										

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

LDN_MTO_06 1211320163-4000.GPJ LDN_MTO.GDT 16/02/17

Golder Associates
London, Ontario

RECORD OF BOREHOLE No BH-602

1 OF 1

METRIC

PROJECT 12-1132-0163
W.P. 3042-11-00
DIST _____ HWY 9
DATUM GEODETIC
LOCATION N 4866686.1 , E 191889.7
BOREHOLE TYPE POWER AUGER, HOLLOW STEM
DATE September 27, 2016
ORIGINATED BY DH
COMPILED BY ZJB/LMK
CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
376.48	GROUND SURFACE										
0.00 / 376.05	FILL, sand and crushed gravel Brown										
0.43	FILL, sandy silt, some clay, trace to some gravel, with topsoil layers, wood pieces and cobbles Loose to compact Brown		1	SS	15		376				
			2	SS	6		375				
			3	SS	16		374				
373.58						▽					
2.90	SILTY SAND AND GRAVEL Compact Brown		4	SS	20		373				
372.82											
3.66	SANDY SILT, trace to some clay, trace gravel Compact Brown		5	SS	22				○		3 39 50 8
372.06							372				
4.42	SILTY SAND AND GRAVEL Dense to very dense Brown		6	SS	60						
			7	SS	38		371				
370.54											
5.94	SANDY SILT TILL, trace to some clay, trace to some gravel, with cobbles Dense to very dense Brown to grey at about elev. 369.8m		8	SS	41		370				
			9	SS	91		369		○		2 29 54 15
			10	SS	50/50mm		368				
							367				
365.35			11	SS	70		366				
11.13	END OF BOREHOLE Groundwater encountered at about elev. 373.6m during drilling on September 27, 2016.										

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

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London, Ontario

RECORD OF BOREHOLE No BH-603

1 OF 1

METRIC

PROJECT 12-1132-0163
W.P. 3042-11-00
DIST _____ HWY 9
DATUM GEODETIC
LOCATION N 4866665.4 , E 191903.5
BOREHOLE TYPE POWER AUGER, HOLLOW STEM
DATE September 27, 2016
ORIGINATED BY DH
COMPILED BY ZJB/LMK
CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
374.49	GROUND SURFACE										
0.00 / 374.06	TOPSOIL, silty, some gravel, Black										
0.43 / 373.42	SANDY SILT, some clay, some gravel, Compact, Grey		1	SS	16		374				
1.07	SILTY SAND AND GRAVEL, Compact to dense, Brown		2	SS	40		373				
	Cobbles and boulders inferred at about elev. 373.0m and 371.4m based on drilling resistance		3	SS	49		372		○		31 48 17 4
			4	SS	28		371				
370.07			5	SS	17						
4.42	SANDY SILT TILL, some clay, trace to some gravel, with cobbles, Compact to very dense, Brown to grey at about elev. 369.3m		6	SS	22		370				
			7	SS	48		369		○		3 29 52 16
367.48			8	SS	35/50mm		368				
7.01	SILT, some clay, some sand, with clayey silt and sandy silt layers, Very dense, Grey						367				
366.41			9	SS	64						
8.08	END OF BOREHOLE										

Granular Bentonite
Filter Sand
Piezometer
Caved Material

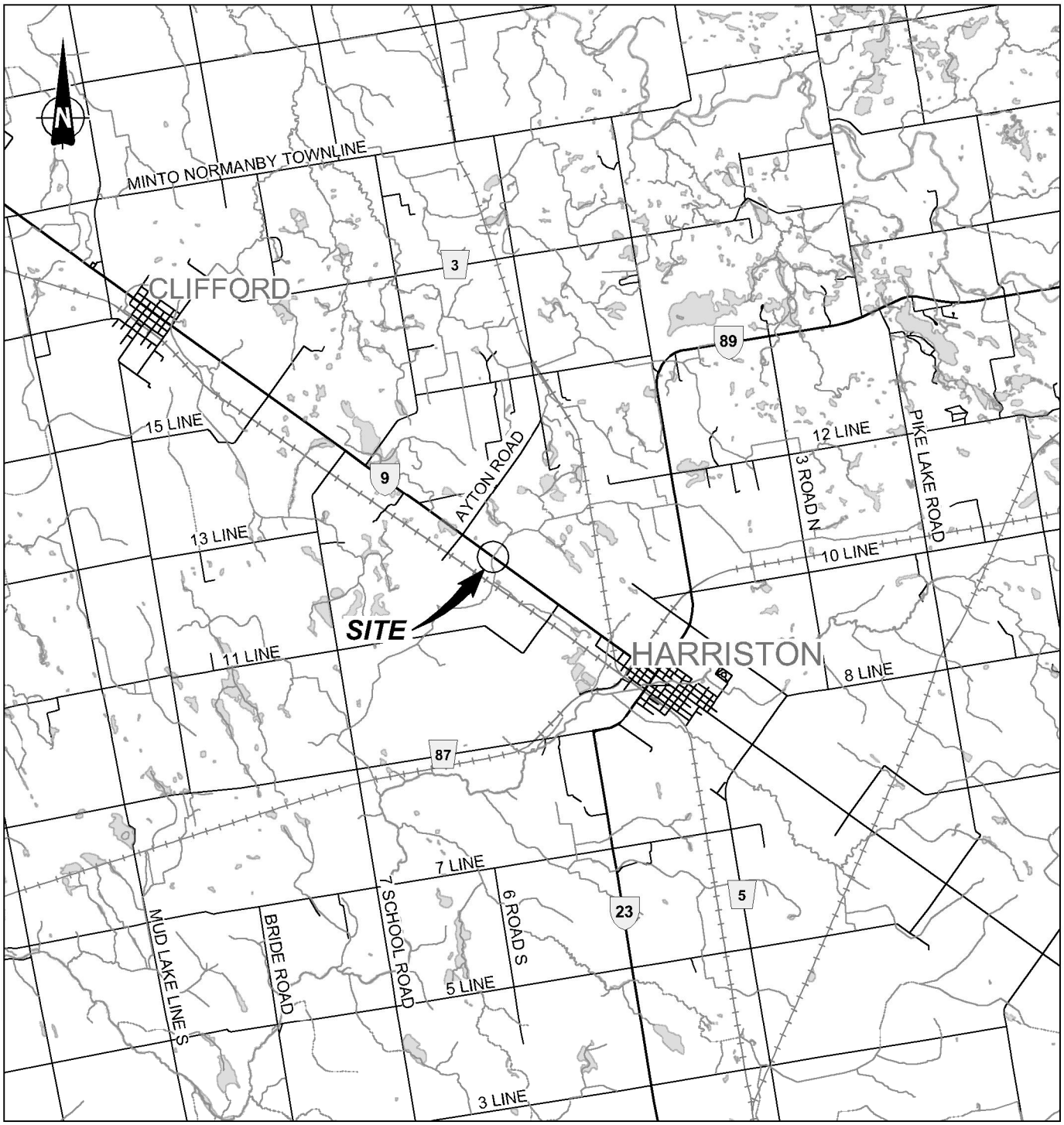
Groundwater encountered at about elev. 373.0m during drilling on September 27, 2016.

Water level measured in piezometer at elev. 373.80m on October 25, 2016.

Water level measured in piezometer at elev. 373.91m on January 5, 2017.

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

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



SCALE
0 2000 4000m
1:100,000

REFERENCE

PLAN BASED ON CANMAP STREETFILES V.2008.5.

NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT

DRAIN 1 CULVERT REPLACEMENT, SITE 35-594/C
HIGHWAY 9
GWP 3042-11-00

TITLE

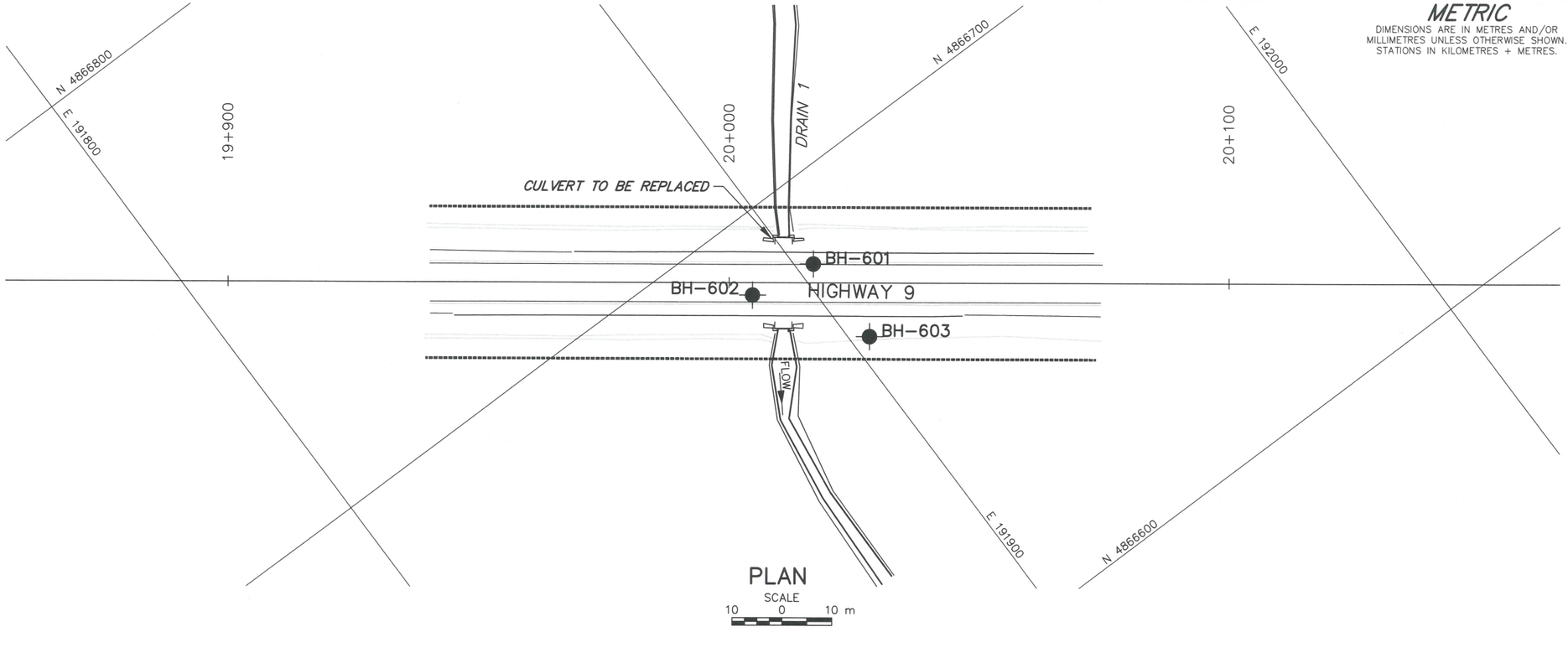
KEY PLAN

Golder Associates

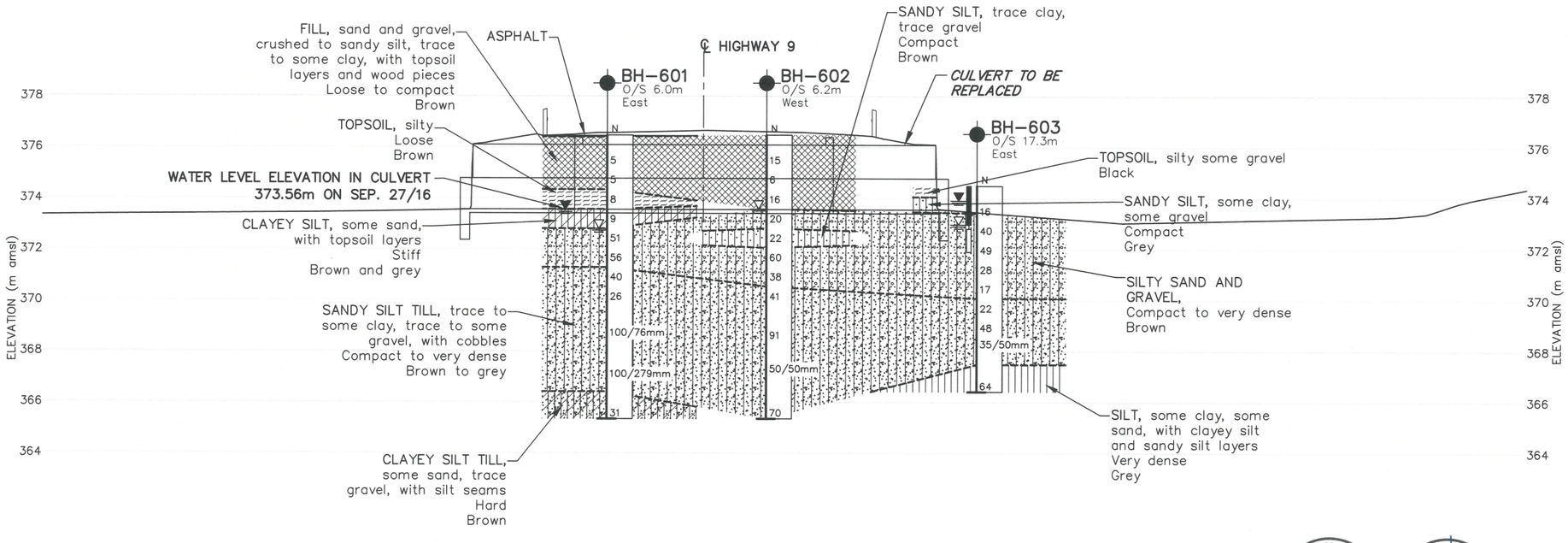
PROJECT No.	12-1132-0163		FILE No.	1211320163-4000-F06001
			SCALE	AS SHOWN REV. 0
CADD	ZJB/LMK	Jan. 12/17		
CHECK				FIGURE 1

Drawing file: 1211320163-4000-F06001.dwg Jan 12, 2017 - 9:06am

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
SCALE
10 0 10 m



PROFILE ALONG ℄ OF CULVERT
HORIZONTAL SCALE 2 0 2 m
VERTICAL SCALE 2 0 2 m

METRIC

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

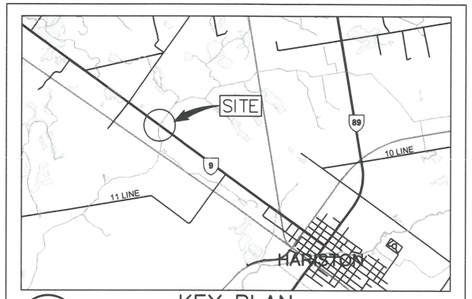
CONT No.
WP No. 3042-11-00

SHEET

DRAIN 1 CULVERT REPLACEMENT

HIGHWAY 9
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates
Golder Associates Ltd.
LONDON, ONTARIO, CANADA



LEGEND

- Borehole – Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL measured on January 5, 2017
- WL encountered during drilling

No.	ELEVATION	CO-ORDINATES (MTM ZONE 10)	
		NORTHING	EASTING
BH-601	376.47	4 866 683.7	191 903.2
BH-602	376.48	4 866 686.1	191 889.7
BH-603	374.49	4 866 665.4	191 903.5

NOTES

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

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

REFERENCE

Base plans provided in digital format by Stantec.

LICENSED PROFESSIONAL ENGINEER D. U. PROUT Apr 3/17 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER F. J. HEFFERNAN Apr 3/17 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

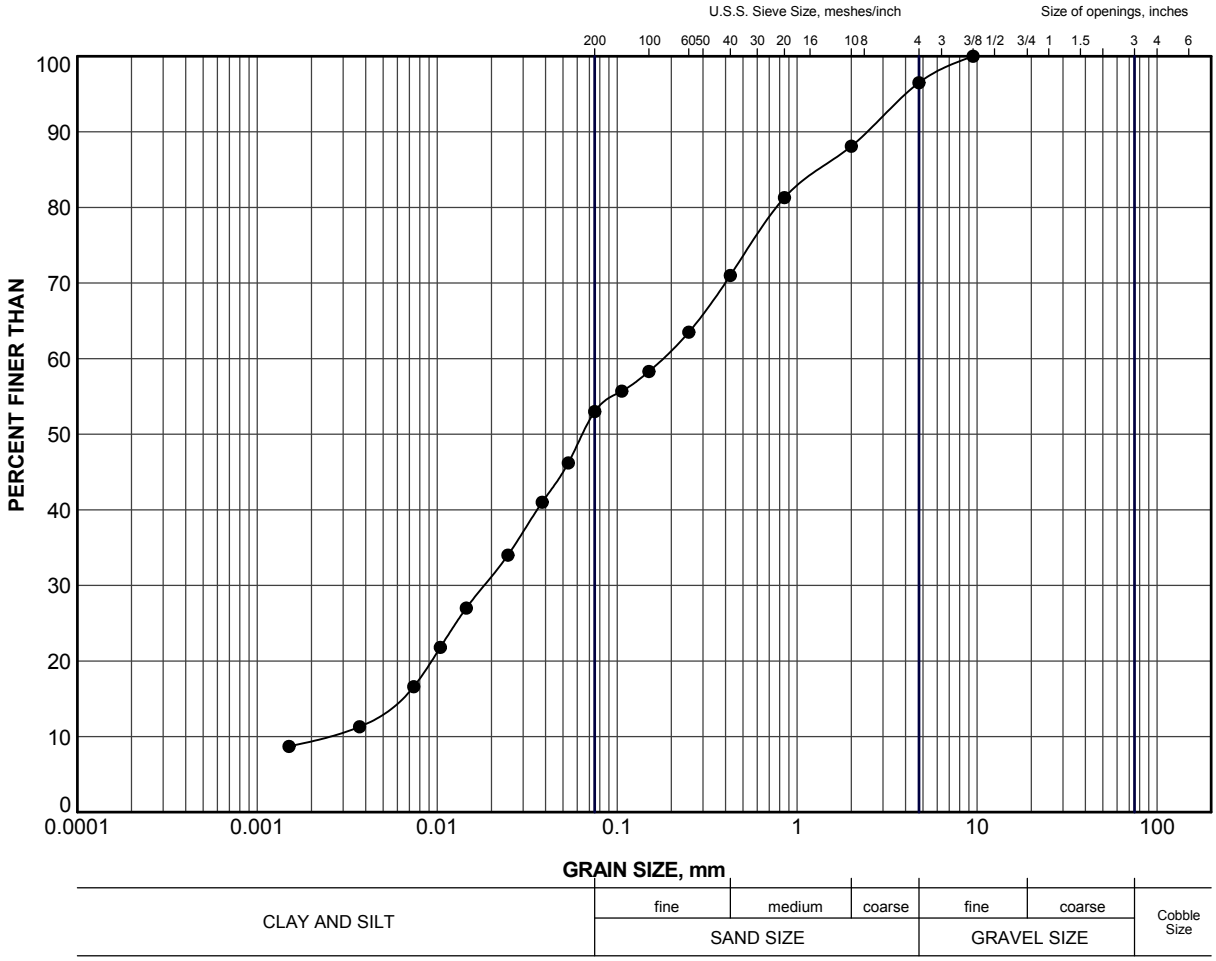
Geocres No. 40P15-48

HWY. 9		PROJECT NO. 12-1132-0163	DIST.
SUBM'D. BT	CHKD. DH	DATE: Mar 16/17	SITE: 35-594/C
DRAWN: LMK	CHKD. DUP	APPD. FJH	DWG. 1

PLOT DATE: March 31, 2017
FILENAME: \\golder.gds\gal\london\active\2012\1132 - Geo\1132-0100\12-1132-0163 STANTEC-FINS-MEGA CULVERTS-2011-E-0041\Drafting\AutoCAD files\1211320163-4000-006001.dwg

APPENDIX A

Laboratory Test Data



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-601	1	375.5

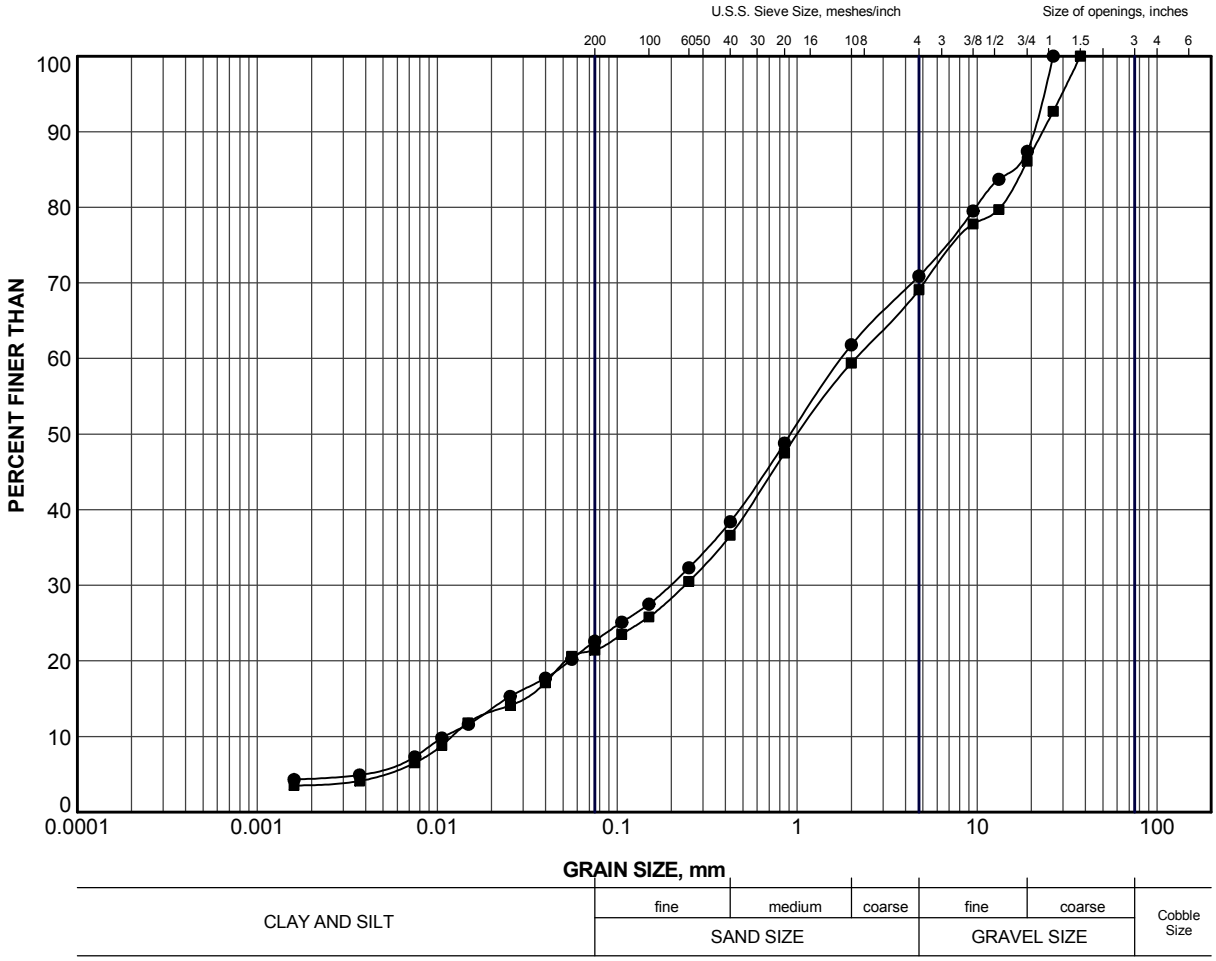
PROJECT
DRAIN 1 CULVERT REPLACEMENT, SITE NO. 35-594/C
HIGHWAY 9
GWP 3042-11-00

TITLE
GRAIN SIZE DISTRIBUTION
FILL

Golder Associates

PROJECT No.		12-1132-0163	FILE No.	1211320163-4000-F060A1
			SCALE	N/A REV.
DRAWN	ZJB	Oct 21/16		
CHECK				**FIGURE A-1**

LDN_MTO_GSD_GLDR_LDN.GDT 21/10/16



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-601	6	371.7
■	BH-603	3	372.0

PROJECT
DRAIN 1 CULVERT REPLACEMENT, SITE NO. 35-594/C
HIGHWAY 9
GWP 3042-11-00

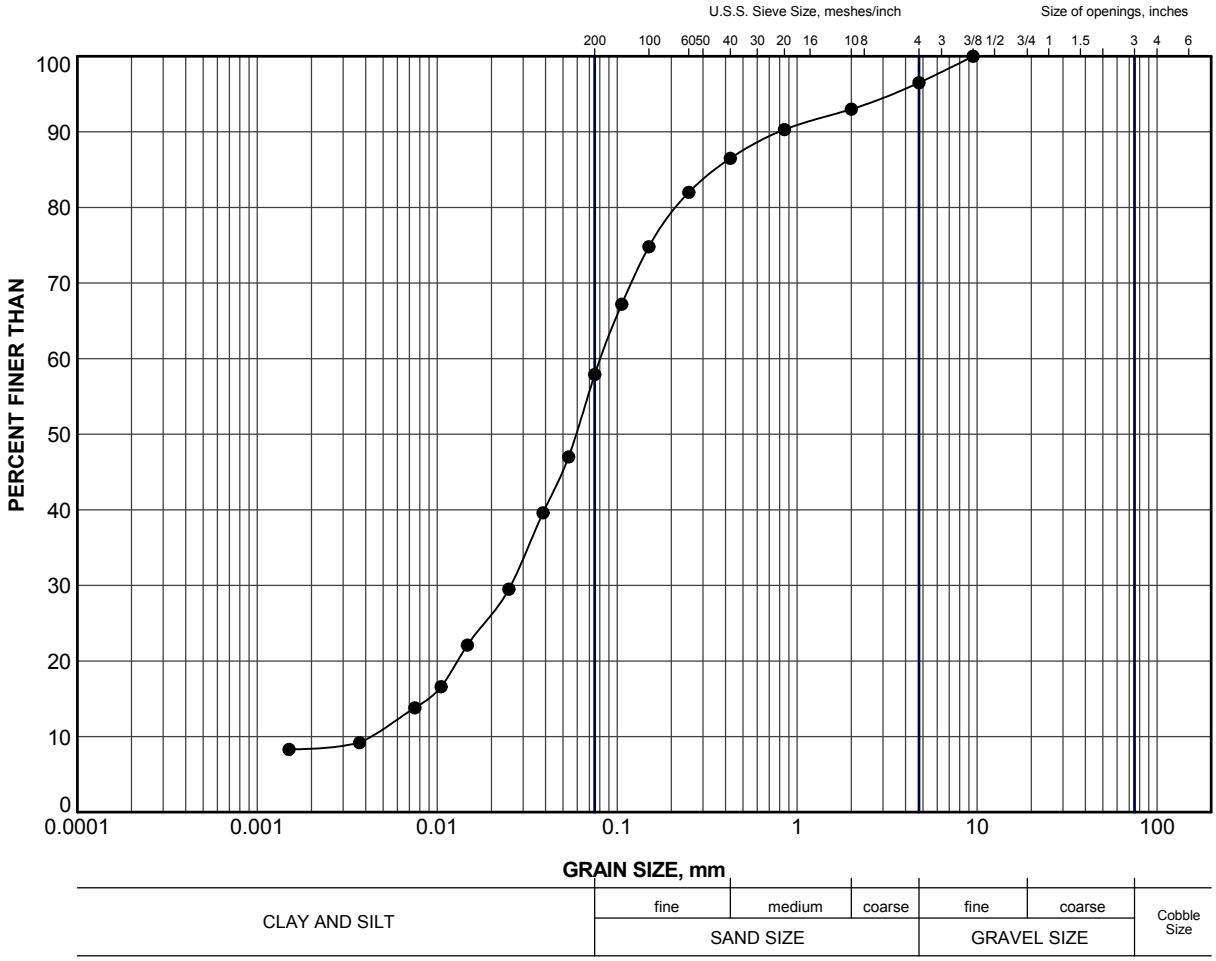
TITLE
GRAIN SIZE DISTRIBUTION
SILTY SAND AND GRAVEL

Golder Associates

PROJECT No.	12-1132-0163	FILE No. 1211320163-4000-F060A2
		SCALE N/A REV.
DRAWN	ZJB	Feb 13/17
CHECK		

FIGURE A-2

LDN_MTO_GSD_GLDR_LDN.GDT 21/10/16



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-602	5	372.4

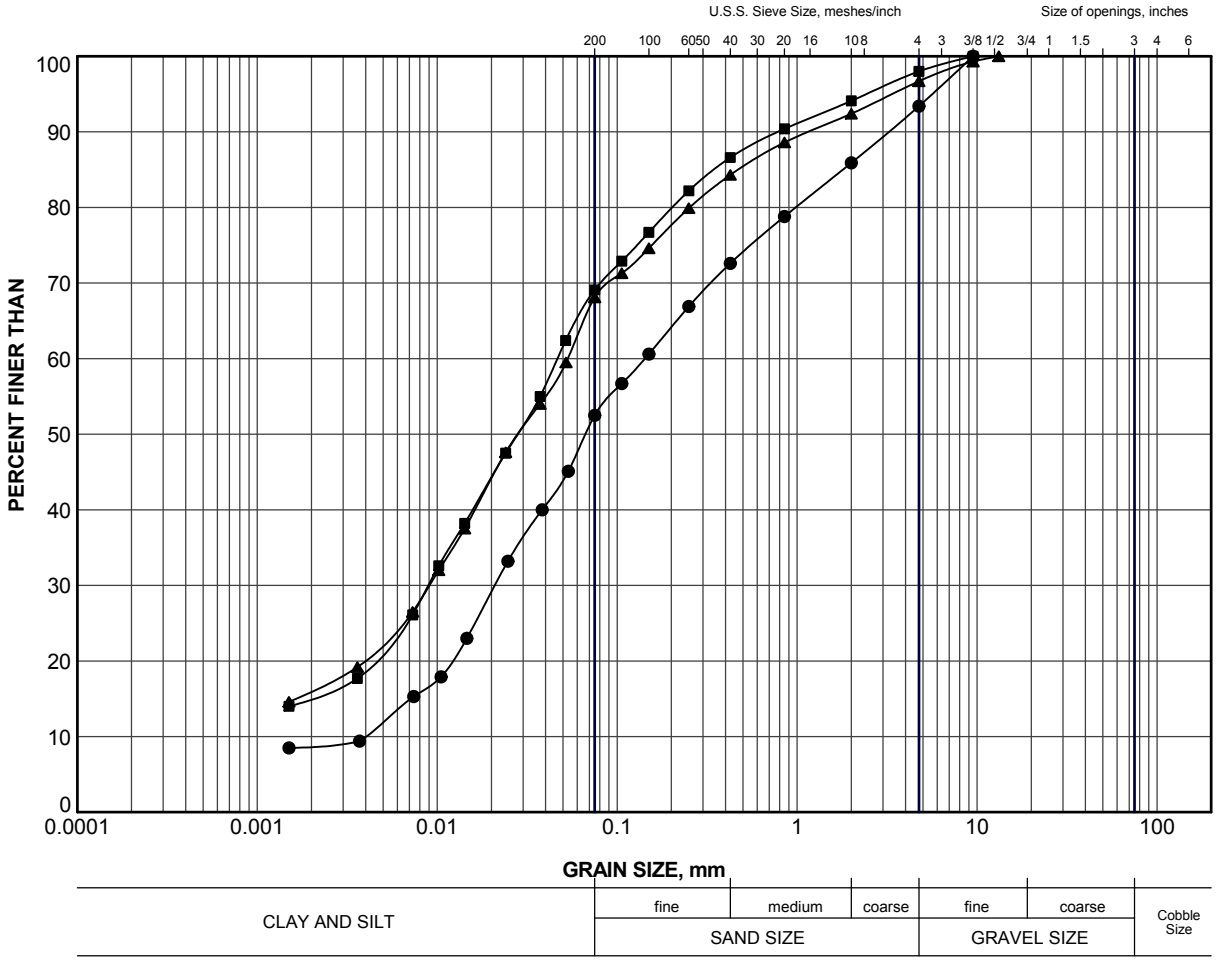
PROJECT
DRAIN 1 CULVERT REPLACEMENT, SITE NO. 35-594/C
HIGHWAY 9
GWP 3042-11-00

TITLE
GRAIN SIZE DISTRIBUTION
SANDY SILT

Golder Associates

PROJECT No.		12-1132-0163	FILE No.	1211320163-4000-F060A3
			SCALE	N/A REV.
DRAWN	ZJB	Oct 21/16		
CHECK				FIGURE A-3

LDN_MTO_GSD_GLDR_LDN.GDT 21/10/16



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-601	8	370.2
■	BH-602	9	368.6
▲	BH-603	7	368.9

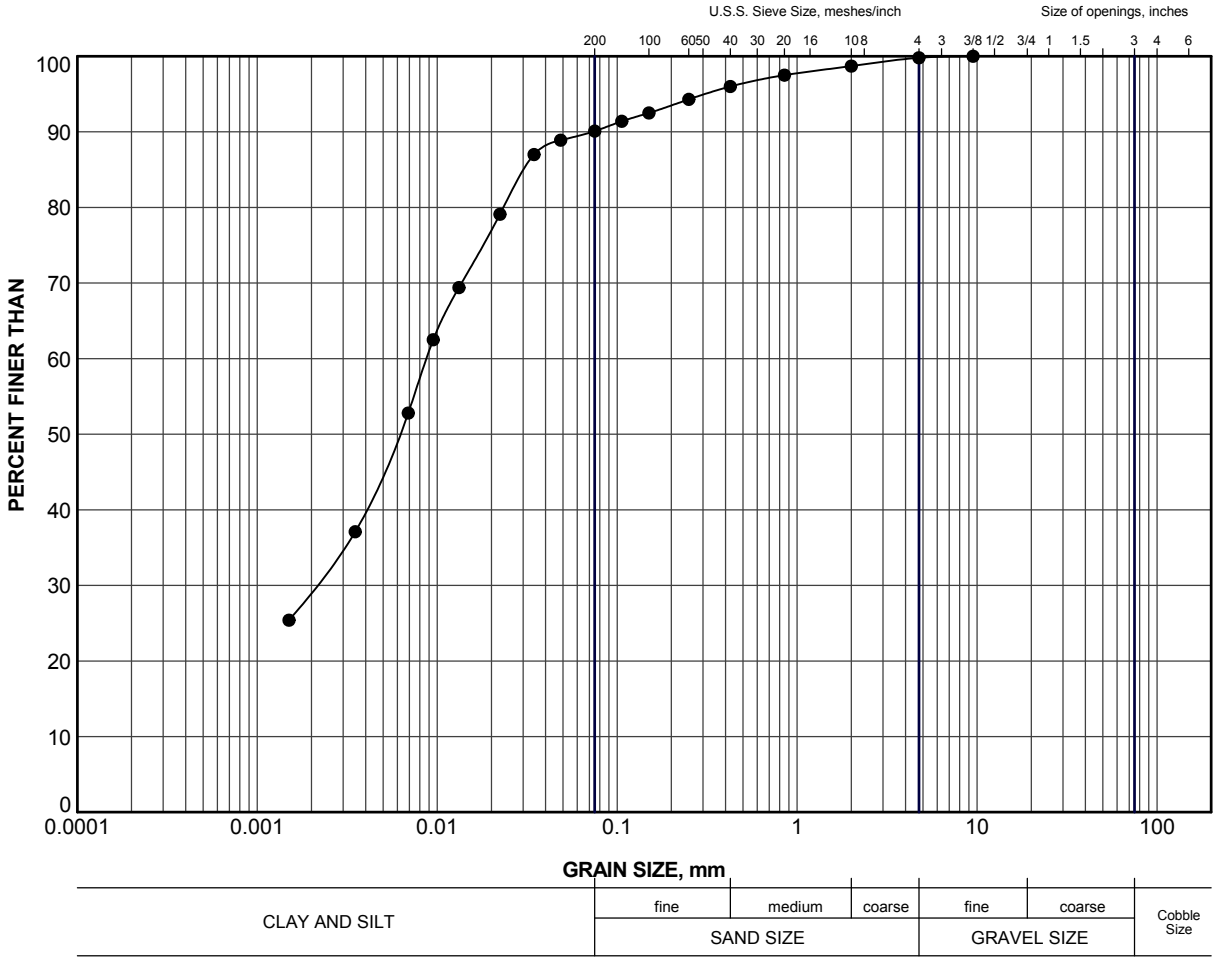
PROJECT
DRAIN 1 CULVERT REPLACEMENT, SITE NO. 35-594/C
HIGHWAY 9
GWP 3042-11-00

TITLE
GRAIN SIZE DISTRIBUTION
SANDY SILT TILL

Golder Associates

PROJECT No. 12-1132-0163			FILE No.1211320163-4000-F060A4	
			SCALE N/A	REV.
DRAWN	ZJB	Oct 21/16	FIGURE A-4	
CHECK				

LDN_MTO_GSD_GLDR_LDN.GDT 21/10/16



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-601	11	365.6

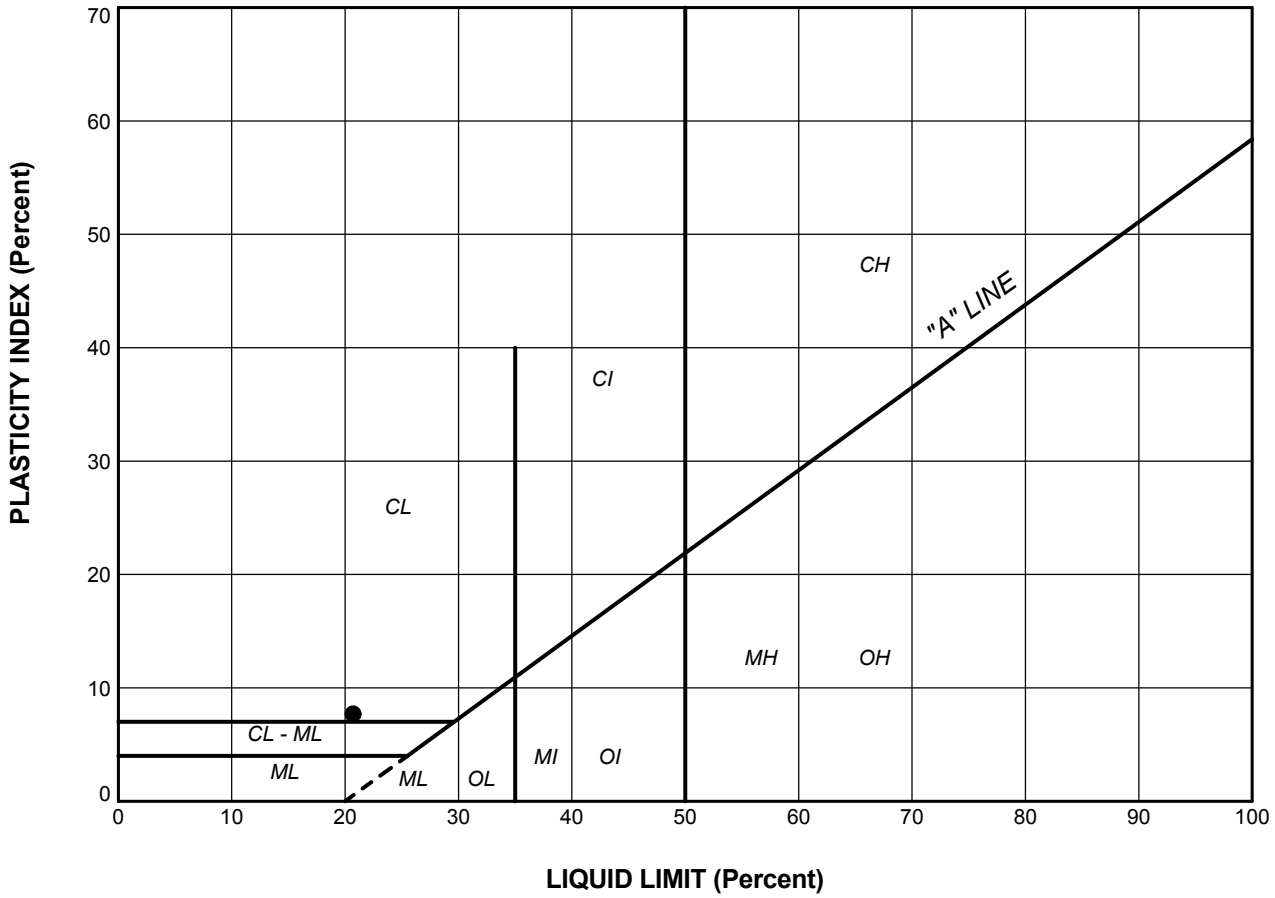
PROJECT
DRAIN 1 CULVERT REPLACEMENT, SITE NO. 35-594/C
HIGHWAY 9
GWP 3042-11-00

TITLE
GRAIN SIZE DISTRIBUTION
CLAYEY SILT TILL

Golder Associates

PROJECT No.		12-1132-0163	FILE No. 1211320163-4000-F060A5
			SCALE N/A REV.
DRAWN	ZJB	Oct 21/16	
CHECK			**FIGURE A-5**

LDN_MTO_GSD_GLDR_LDN.GDT 21/10/16



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
CLAYEY SILT TILL					
●	BH-601	11	20.7	13.0	7.7

PROJECT
DRAIN 1 CULVERT REPLACEMENT, SITE NO. 35-594/C
HIGHWAY 9
GWP 3042-11-00

TITLE
PLASTICITY CHART

Golder Associates

PROJECT No.	12-1132-0163		FILE No.	1211320163-4000-F060A6
			SCALE	N/A REV.
DRAWN	ZJB	Oct 21/16		
CHECK			**FIGURE A-6**	

LDN_MTO_PI GLDR_LDN.GDT 21/10/16

APPENDIX B

Site Photographs

Photograph 1: North elevation (inlet) of Culvert Site 35-594/C.

Photograph 2: South elevation (outlet) of Culvert Site 35-594/C.

Photograph 3: Looking west along Highway 9 at Culvert Site 35-594/C.

n:\active\2012\1132 - geo\1132-0100\12-1132-0163 stantec-fdns-mega culverts-3011-e-0041\ph 4000-gwp 3042-11-00\rpts\r06 35-594c drain 1\1211320163-4000-r06 apr 3 17 (final) app b - photos.docx

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