

CONTRACT NO. 201x-xxxx

G.W.P. 3022-15-00

FOUNDATION INVESTIGATION REPORT

HWY 4, LITTLE AUSABLE RIVER BRIDGE REHABILITATION

(SITE No. 19-69)

CONTRACT 5C
STRUCTURE REHABILITATION

Ministry Of Transportation





July 2017

FOUNDATION INVESTIGATION REPORT

**Little Ausable River Bridge Rehabilitation
Site 19-69, Highway 4
Contract 5 Structure Replacements and Rehabilitation
GWP 3022-14-00
Ministry of Transportation, Ontario - West Region**

Submitted to:
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REPORT



**Report Number: 1534424-5002A-R01
Geocres No.: 40P3-52
Distribution:**

8 Copies - Stantec Consulting Ltd.
1 E-Copy - Golder Associates Ltd.





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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 a foundation investigation at the Little Ausable River bridge on Highway 4 as part of the detail design work for GWP 3022-14-00. The project involves detailed design of the replacement and rehabilitation of thirty-nine structures along multiple highways in Southwestern Ontario. This report addresses the proposed rehabilitation of the Little Ausable River bridge (Site 19-69) on Highway 4 in the Township of Lucan-Biddulph in Middlesex County, Ontario.

The purpose of the work described in this report is to explore the subsurface conditions at the location of the proposed bridge rehabilitation 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 P1534424 dated September 2, 2016 and change order 1534424-5002A-C03 dated September 2, 2016. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering dated October 26, 2015.

2.0 SITE DESCRIPTION

The subject site is located on Highway 4 approximately 300 metres northwest of Coursey Line in the Township of Lucan-Biddulph in Middlesex County, Ontario. The approximate location of the bridge site is shown on the Key Plan, Figure 1.

This section of Highway 4 is currently a two lane, undivided highway with gravel shoulders, the bridge is oriented approximately northwest-southeast, although for the purpose of this report the bridge is considered to be oriented north-south. The Little Ausable River flows beneath the bridge generally from northeast to southwest. Highway 4 has a pavement surface elevation of about 277 metres at the bridge site. The existing precast concrete girder structure was constructed in 1969 as a replacement for the original bridge, located to the east of the existing structure. The bridge was rehabilitated in 2000, and according to the Structure Maintenance and Repair History records provided by the MTO, minor rehabilitation was also carried out in 2005, 2006 and 2011. The rehabilitation carried out in 2000 consisted of the addition of a concrete overlay and asphalt waterproofing system over the original exposed concrete deck, adding a thickness of about 150 millimetres. The bridge has three spans with a total length of about 67 metres and crosses the Little Ausable River at a skew of 85 degrees from the bridge centreline to the centre of the river. The area immediately surrounding the site generally consists of flat lying land which slopes down to the river at the site. Nearby land use consists of agricultural and residential lands. Site photographs are provided in Appendix D.

3.0 INVESTIGATION PROCEDURES

The initial phase of field work was carried out on July 11 and 27, 2016 during which time two boreholes, labelled as BH-101 and BH-102 were drilled on Highway 4. Additional field work was carried out between October 11 and 14, 2016 during which time two boreholes, labelled as BH-201 and BH-202, were drilled on the former Highway 4 easement. The boreholes were drilled at the approximate locations shown on the Borehole Location Plan, Drawing 1.



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The boreholes were drilled using track-mounted D50T and D120 drilling equipment supplied and operated by a specialist drilling contractor. Samples of the overburden were typically obtained at depth intervals of 0.75 metres in boreholes BH-101 and BH-102 and 1.5 metres in boreholes BH-201 and BH-202 using 50 millimetre outside diameter split spoon automatic hammer sampling equipment in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586).

The recorded SPT N values are noted on the Record of Borehole sheets. The results of the SPT testing, as presented on the Record of Borehole sheets, Drawing 1, Drawing 2 and in Section 5.0 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 represented in the grain size distributions. Larger particle sizes, including cobbles and boulders, are known to be present in the glacial tills and native granular deposits as discussed in the text of this report. An attempt was made to obtain an undisturbed thin-wall sample of the glacial till. The attempt was unsuccessful due to the high relative density of the soils encountered.

Groundwater conditions in the boreholes were observed throughout the drilling operations and vibrating wire piezometers (VWPs) were installed in boreholes BH-201 and BH-202 as indicated on the corresponding Record of Borehole sheets. The boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 903 (as amended). Boreholes BH-201 and BH-202 were fully grouted in conjunction with the VWP installations.

Field work was monitored on a full-time basis by experienced members of our staff who located the boreholes in the field, obtained utility clearances, 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 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 results of the 2016 investigation carried out by Golder was supplemented with information from Geocres Report No. 40P03-031 titled "Foundation Investigation Report For Proposed Crossing At Little Ausable River and Hwy. #4, County of Middlesex, Twp. Of Biddulph, Lot 2, Con. II, District No. 2 (London), W.J. 67-F-8 – W.P. 152-63", dated March 7, 1967. The Records of Boreholes and related laboratory test data are attached to this report in Appendices B and C, respectively.

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.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
BH-101	4 784 844	391 935	278.38	18.50
BH-102	4 784 867	391 856	277.30	9.60



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Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
BH-201	4 784 886	391 932	273.51	30.54
BH-202	4 784 924	391 863	273.60	30.24
BH-1 (40P03-031)	4 784 865	391 883	265.05	7.68
BH-2 (40P03-031)	4 784 844	391 904	265.24	10.49
BH-3 (40P03-031)	4 784 857	391 907	265.48	2.90
BH-4 (40P03-031)	4 784 858	391 860	269.75	6.31

4.0 SITE GEOLOGY

The project area is located within the Horseshoe Moraines physiographic region. This region is characterized by irregular, stoney knobs and ridges which are composed mostly of glacial till and with some sand and gravel deposits, and sand and gravel terraces and swampy valley floors.¹ The quaternary mapping indicates that the overburden in the area of the site may consist of predominantly gravel outwash with some sand or clayey silt till of the Seaforth Moraine overlain locally by a thin veneer of silt loam till.²

The site is reportedly underlain by middle Devonian-age limestone of the Dundee Formation of the Hamilton Group. The upper member consists of microcrystalline limestone and the lower member consists of crinoidal limestone containing quartz sand grains and chert. The bedrock surface at the site is at about elevation 236 metres³ and the overburden thickness is reported to be about 55 metres⁴.

5.0 SUBSURFACE CONDITIONS

5.1 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the in situ testing and the 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. In addition, construction activities

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

² Sado, E.V. and Vagners, U.J. 1975: Quaternary Geology of the Lucan Area, Southern Ontario; Ontario Div. of Mines, Prelim. Map P.1048. Geol. Ser., scale: 1:50, 000. Geology 1971, 1972.

³ Sado, E.V. and Jones, D. 1980: Bedrock Topography of the Lucan Area, Southern Ontario; Ontario Geological Survey Preliminary Map P.291 (Rev). Bedrock Topography Series, scale: 1:50 000. Compilation 1978-1980.

⁴ Sado, E.V. and Jones, D. 1980: Drift Thickness of the Lucan Area, Southern Ontario; Ontario Geological Survey Preliminary Map P.2359. Drift Thickness Series, scale: 1:50 000. Geology 1980.



carried out at the site since the previous investigation was performed for Geocres Report No. 40P03-031 may have altered the subsurface conditions from those shown on the previous Records of Boreholes.

The soil descriptions on the previous Records of Boreholes have been interpreted to correspond to standard MTO soil descriptions, using the original laboratory data, where available. The standard MTO soil descriptions are used in the discussion below and in the profile and sections on Drawing 1 and 2, respectively. The boreholes drilled at the site generally encountered the existing pavement structure or surficial topsoil overlying embankment fill materials, buried topsoil, silty clay till and clayey silt till (cohesive glacial tills), sandy silt glacial till and native granular deposits ranging from sand and gravel to sandy silt to silty fine sand.

The locations and elevations of the boreholes, together with the interpreted stratigraphic profile and sections, are shown on Drawings 1 and 2. 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.

5.2 Soil Conditions

Asphaltic concrete pavement (asphalt) was encountered in BH-101, BH-102 and BH-201 and ranged in thickness from 330 to 690 millimetres. The asphalt in BH-102 was underlain by a 50 millimetre thick crushed granular base. A 130 millimetre thick layer of granular base materials was encountered below the topsoil in BH-202.

A 50 millimetre thick layer of surficial topsoil was encountered at the ground surface in borehole BH-202 and a 490 millimetre thick buried topsoil layer was encountered between fill layers in borehole BH-101 at elevation 272.4 metres. Variable amounts of topsoil were also noted in several of the fill layers in all of the boreholes. The buried topsoil in BH-101 exhibited an SPT N value of 15 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.

Granular fill comprising primarily of sand and gravel with a sandy silt layer in BH-202 was encountered beneath the pavement structure in BH-101, BH-102 and BH-201 and beneath the granular base in BH-202. The granular fill layers were 0.4 to 2.4 metres thick. The sand and gravel fill in BH-101 was dense to very dense with recorded SPT N values of 38 and 64 blows per 0.3 metres. The water content of this fill was 3 per cent. A grain size analysis carried out on a sample of the sand and gravel fill is presented on Figure A-1 in Appendix A. The sandy silt fill was very loose with an N value of 2 blows per 0.3 metres. Cobbles were encountered in the granular fill in BH-102, BH-201 and BH-202.

Layers of firm to hard clayey silt fill were encountered in BH-101 beneath the granular fill and the buried topsoil layer at elevations of 276.3 and 272.0 metres, respectively, in BH-102 beneath the granular fill at elevation 276.5 metres and in BH-201 beneath the granular fill at elevation 272.4 metres. The cohesive fill layers were 3.8 to 8.1 metres thick. Several of the cohesive fill layers had variable amounts of topsoil, and cobbles were inferred in the fill in borehole BH-101. The layers of cohesive fill exhibited SPT N values ranging from 9 to over 100 blows per 0.3 metres and water contents of about 9 to 13 per cent. Liquid limits ranged from about 25 to 33 per cent, plastic limits ranged from about 15 to 20 per cent and plasticity indices ranged from about 10 to 16 per cent based on Atterberg limits determinations carried out on selected samples. Grain size analyses carried out on samples of



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the clayey silt fill are presented on Figure A-2 and the results of the Atterberg limits determinations are presented on Figure A-9.

A layer of stiff clayey silt was encountered in borehole BH-102 beneath the fill at elevation 271.7 metres. The clayey silt was about 0.4 metres thick and had an SPT N value of 14 blows per 0.3 metres.

Layers of stiff to hard cohesive glacial till (silty clay till and clayey silt till) were encountered in BH-102 beneath the clayey silt at elevation 271.4 metres, in BH-202 beneath the fill at elevation 271.1 metres and in BH-1 and BH-4 (40P03-031) beneath the sand and gravel at elevations 263.6 and 268.2 metres, respectively. Boreholes 102 and 4 (40P03-031) were terminated in the cohesive glacial till after exploring it for about 3.7 and 4.8 metres, respectively. The layers of cohesive glacial till in BH-202 and BH-1 (40P03-031) were about 3.6 and 0.8 metres thick, respectively. Standard penetration test N values ranged from 13 to over 100 blows per 0.3 metres and water contents ranged from about 7 to 19 per cent. Cobbles and boulders should be expected in the cohesive glacial till materials. Liquid limits ranged from about 18 to 37 per cent, plastic limits ranged from about 9 to 19 per cent and plasticity indices ranged from about 6 to 24 per cent based on Atterberg limits determinations carried out on selected samples. Grain size analyses carried out on samples of the cohesive glacial till are presented on Figure A-3 and Atterberg limits determinations are presented on Figure A-9. Grain size analyses carried out on samples of the clayey silt glacial till from Geocres Report No. 40P03-031 are presented in Appendix C.

A layer of dense to very dense sandy silt glacial till was encountered at elevation 267.5 metres beneath the clayey silt till in BH-202. The layer was about 4.1 metres thick and had SPT N values of 31 to over 100 blows per 0.3 metres and a measured water content of 8 per cent. Cobbles were inferred to be present in the sandy silt glacial till and the presence of boulders should be anticipated based on the depositional history. An Atterberg limits determination was carried out on a sample of the sandy silt glacial till. It exhibited a liquid limit of about 16 per cent, a plastic limit of about 11 per cent and a plasticity index of about 5 per cent. A grain size analysis carried out on a sample of the sandy silt glacial till is presented on Figure A-4 and the results of the Atterberg limits determinations are presented on Figure A-9.

Native granular deposits were encountered in BH-101 and BH-201 at elevation 264.3 metres beneath the fill, in BH-202 at elevation 263.5 metres beneath the sandy silt glacial till, in borehole 1 (40P03-031) at elevation 262.8 metres beneath the clayey silt glacial till and in BH-1, BH-2 and BH-4 (40P03-031) at elevation 265.1, 265.2 and 269.8 metres at the ground surface, respectively. The granular deposits generally consisted of layered sand and gravel to sandy silt. Each of the boreholes except BH-4 (40P03-031) were terminated in the native granular deposits after exploring them for between 1.5 and 21.3 metres. Standard penetrating test N values ranged from 28 to over 100 blows per 0.3 metres and measured water contents ranged from about 2 to 20 per cent. Cobbles and boulders were inferred to be present in the native granular deposits. Grain size analyses carried out on samples of the granular deposits obtained during the 2016 explorations are presented on Figures A-5, A-6, A-7 and A-8, in Appendix A. Grain size analyses carried out on samples of the granular deposits from Geocres Report No. 40P03-031 are presented in Appendix C.



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5.3 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling and sampling. Vibrating wire piezometers were installed in BH-201 and BH-202. The installation details are provided on the corresponding Record of Borehole sheets following the text of this report. Groundwater was not encountered in boreholes BH-101 and BH-102 during drilling. Boreholes BH-201 and BH-202 encountered groundwater at depths of 15.5 and 16.2 metres, or at elevations of 258.0 and 257.4 metres, respectively, during drilling on October 11 to 14, 2016. The groundwater level was encountered in borehole 1 (40P03-031) at a depth of about 0.6 metres, or elevation 264.5 metres. It was not possible to record an encountered groundwater level in the 1967 boreholes due to the use of washbore drilling techniques. Geocres Report No. 40P03-031 did note that the water level in the boreholes corresponded with the adjacent river water level. A summary of the encountered groundwater levels, vibrating wire piezometer installation details and vibrating wire elevation readings is provided in the tables below.

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Elevation (m)
BH-101	278.38	-
BH-102	277.30	-
BH-201	273.51	258.0
BH-202	273.60	257.4
BH-1 (40P03-031)	265.05	264.5
BH-2 (40P03-031)	265.24	-
BH-3 (40P03-031)	265.48	-
BH-4 (40P03-031)	269.75	-

Borehole	Ground Surface Elevation (m)	Vibrating Wire Piezometer Tip Elevation (m)	Measured Water Level Depth/Elevation (m)			
			Oct. 25, 2016	Nov. 2, 2016	Nov. 15, 2016	May. 6, 2017*
BH-201, Shallow	273.51	251.6	16.21 / 257.31	16.32 / 257.20	16.32 / 257.20	12.33 / 261.18
BH-201, Deep		244.6	16.79 / 256.72	16.95 / 256.56	16.90 / 256.61	12.87 / 260.64
BH-202, Shallow	273.60	266.3*	7.97 / 265.63*	8.18 / 265.42*	8.32 / 265.27*	3.68 / 269.91**
BH-202, Deep		254.4	15.55 / 258.04	15.67 / 257.93	15.67 / 257.92	11.92 / 261.68

*Measured after period of heavy rainfall

**This VWP installed in sandy silt till. Measured water levels are considered to be indicative of pore water pressure



The above-noted encountered water levels are not considered to be representative of the long-term, stabilized groundwater conditions.

The water level of the Little Ausable River was measured at about elevation 264.6 metres on November 15, 2016. In Geocres Report No. 40P03-031, the river level was reported to be at elevation 264.5 metres in January 1967. It was also noted in the previous report that the water level had risen to an elevation of 265.9 metres during a snow melt event.

Based on the observed groundwater levels, the measured river water level and the surrounding topography, the groundwater level is inferred to typically be at about elevation 265.0 metres. The groundwater levels are expected to fluctuate seasonally and are expected to be higher during periods of sustained precipitation or during spring snow melt conditions.

6.0 SITE RECONNAISSANCE


A site reconnaissance and inspection was carried out at the site on June 28, 2016 and a brief additional site visit was carried out on December 20, 2016 by Golder Associates. Consistent with the information provided by Stantec, the abutments appeared to have rotated with the top of the abutments further away from the river than the observable lower parts of the abutments. Photographs 5 to 8 show the apparent rotation and are presented in Appendix D. In addition to the rotation, scour and erosion were noted around the abutments as shown in Photographs 3 and 9. There appeared to be settlement around the abutments and the pile caps were exposed as shown in Photograph 3. Severe concrete spalling and delaminations and exposed reinforcing steel were noted at the ends of some of the concrete girders at the abutments. The concrete rail, curbs and piers were in generally fair to good condition. No signs of slope instability were noted based on visual inspection. The asphalt riding surface was in generally fair condition with some moderate cracking. Additional photographs from the site reconnaissance and inspection are presented in Appendix D.






7.0 MISCELLANEOUS

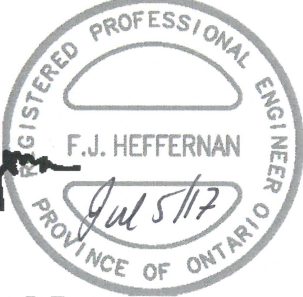
Field work was carried out using equipment supplied and operated by London Soil Test Ltd., an Ontario Ministry of Environment and Climate Change licensed water well contractor. The field operations were supervised by Mr. Daniel Hyland, E.I.T. and Mr. Jordan Kiss, E.I.T. under the direction of the Field 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 Dr. Storer J. Boone, P.Eng., a Principal 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.

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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
ν	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

(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

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

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



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, 60° 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 cm² 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	N
Relative Density	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	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

PROJECT <u>1534424</u>		RECORD OF BOREHOLE No 101		1 OF 2	METRIC
W.P. <u>3022-14-00</u>	LOCATION <u>N 4784843.8 , E 391935.2</u>	ORIGINATED BY <u>DH</u>			
DIST <u> </u> HWY <u>4</u>	BOREHOLE TYPE <u>POWER AUGER, HOLLOW STEM</u>	COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>	DATE <u>July 11, 2016</u>	CHECKED BY <u>[Signature]</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	W _p			W	W _L	
278.38	PAVEMENT SURFACE													GR SA SI CL			
0.00	ASPHALT																
278.00																	
0.38	FILL, sand and gravel, trace to some silt Dense to very dense Brown		1	SS	64												
			2	SS	38					○				50 38 (12)			
276.25																	
2.13	FILL, clayey silt, some sand, trace gravel, with cobbles and boulders from about elev. 274.3m to about elev. 274.1m Stiff to hard Brown		3	SS	9												
			4	SS	14					○				1 18 46 35			
			5	SS	100/ 100mm												
			6	SS	23												
			7	SS	11												
272.44																	
5.94	TOPSOIL, silty Compact Brown		8	SS	15												
271.95																	
6.43	FILL, clayey silt, some sand, trace gravel, with topsoil layers and pockets, inferred cobble at about elev. 270.5m Very stiff to hard Brown		9	SS	22												
			10	SS	70/ 75mm												
			11	SS	16					○				3 23 43 31			
			12	SS	28												
			13	SS	17												
			14	SS	19												
			15	SS	25					○				3 19 41 37			
			16	SS	28												
			17	SS	19												
			18	SS	34												
264.30																	
14.08	SILTY SAND, some gravel, trace to some clay Dense to very dense Brown																

LDN_MTO_06 1534424.GPJ LDN_MTO.GDT 14/06/17

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1534424</u>		RECORD OF BOREHOLE No 101		2 OF 2		METRIC	
W.P. <u>3022-14-00</u>		LOCATION <u>N 4784843.8 , E 391935.2</u>		ORIGINATED BY <u>DH</u>			
DIST <u> </u> HWY <u>4</u>		BOREHOLE TYPE <u>POWER AUGER, HOLLOW STEM</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>July 11, 2016</u>		CHECKED BY <u>[Signature]</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL	
								20	40	60	80	100	W _p	W						W _L
			19	SS	100/ 250mm															
			20	SS	77															
260.70																				
17.68																				
	SAND AND GRAVEL, some silt, with cobbles at about elev. 260.0m Very dense Brown																			
259.88			21	SS	37/ 50mm															
18.50																				
	END OF BOREHOLE																			
	Borehole dry during drilling on July 11, 2016.																			


LDN_MTO_06 1534424.GPJ LDN_MTO.GDT 14/06/17

RECORD OF BOREHOLE No 102

1 OF 1

METRIC

PROJECT 1534424
W.P. 3022-14-00 LOCATION N 4784867.5 , E 391855.7 ORIGINATED BY DH
DIST HWY 4 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY LMK
DATUM GEODETIC DATE July 27, 2016 CHECKED BY

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								<div><div></div><div>20406080100</div></div>										
								<div><div>○ UNCONFINED</div><div>+ FIELD VANE</div><div>● QUICK TRIAXIAL</div><div>× LAB VANE</div></div>										
								<div><div>20406080100</div></div>										
277.30	PAVEMENT SURFACE						277										2 16 47 35	
0.00	ASPHALT						276											
276.97							275											
0.38	FILL, sand and crushed gravel		1	SS	44		274											
276.54	Brown						273											
0.76	FILL, sand and gravel, some silt, with cobbles		2	SS	14		272											
	FILL, clayey silt, some sand, trace gravel, trace topsoil, with sandy silt layers		3	SS	11		271											
	Stiff to hard		4	SS	20		270											
	Brown		5	SS	15		269											
			6	SS	22		268											
271.72			7	SS	14											1 24 45 30		
5.58	CLAYEY SILT, some sand, some gravel, with topsoil layers	8	SS	13														
271.36	Stiff																	
5.94	Brown																	
	CLAYEY SILT TILL TO SILTY CLAY TILL, trace to some sand, trace gravel	9	SS	38														
	Stiff to hard															4 9 44 43		
	Brown	10	SS	61														
267.70	END OF BOREHOLE																	
9.60	Borehole dry during drilling on July 27, 2016.																	

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 201

1 OF 3

METRIC

PROJECT 1534424
W.P. 3022-14-00 LOCATION N 4784885.7, E 391932.1 ORIGINATED BY DH
DIST HWY 4 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY LMK
DATUM GEODETIC DATE October 11 - 12, 2016 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			w _p	w	w _L				
								20	40	60						80	100
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× LAB VANE	WATER CONTENT (%)
273.51	PAVEMENT SURFACE																
0.00	ASPHALT																
272.82							273										
0.69	FILL, sand and gravel, trace silt, with cobbles																
272.39	Brown																
1.12	FILL, clayey silt, some sand, trace to some gravel, trace topsoil																
	Firm to stiff		1	SS	8		272										
	Brown																
							271										
			2	SS	6		270										
			3	SS	5		269										
							268										
			4	SS	10		267										
			5	SS	10		266										
							265										
264.31																	
9.20	SAND AND GRAVEL, trace to some silt, trace clay, with cobbles		6	SS	28		264										
	Compact to very dense																
	Brown		7	SS	69		263			○				49 38 10 3			
							262										
			8	SS	100/ 200mm		261										
			9	SS	69		260										
							259										
258.73																	
14.78																	

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 201



2 OF 3

METRIC

PROJECT 1534424
W.P. 3022-14-00 LOCATION N 4784885.7, E 391932.1 ORIGINATED BY DH
DIST HWY 4 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY LMK
DATUM GEODETIC DATE October 11 - 12, 2016 CHECKED BY

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	GR	SA	SI	CL							
								SHEAR STRENGTH kPa														WATER CONTENT (%)						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																				
								20	40	60	80	100	10	20	30													
257.97		SAND, fine to coarse, trace silt Dense Brown		10	SS	35																						
15.54		SAND, fine to medium, trace silt Dense Brown																										
257.20																												
16.31		SILTY SAND AND GRAVEL, trace clay Dense Brown		11	SS	46							○					25	49	22	4							
				12	SS	46																						
253.70																												
19.81		SAND, fine to medium, some silt, trace clay Very dense Brown		13	SS	75																						
				14	SS	84							○					0	84	12	4							
				15	SS	64																						
249.64																												
23.87		SAND AND GRAVEL, some silt, with cobbles Very dense Brown		16	SS	100/ 165mm																						
248.12																												
25.39		SAND, fine to coarse, some silt, trace gravel, trace clay, with cobbles Very dense Brown		17	SS	100/ 230mm																						
				18	SS	100							○					2	76	18	4							
				19	SS	55							○					1	77	19	3							
243.55																												

PROJECT 1534424		RECORD OF BOREHOLE No 201		3 OF 3	METRIC
W.P. 3022-14-00		LOCATION N 4784885.7 , E 391932.1		ORIGINATED BY DH	
DIST _____ HWY 4		BOREHOLE TYPE POWER AUGER, HOLLOW STEM		COMPILED BY LMK	
DATUM GEODETIC		DATE October 11 - 12, 2016		CHECKED BY	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL				
													20	40	60						80	100	W _p	W
29.96	SAND AND GRAVEL, some silt, with cobbles Very dense Brown		20	SS	100/ 50mm		243																	
242.97																								
30.54																								
END OF BOREHOLE																								
Groundwater encountered at about elev. 258.0m during drilling on October 11 & 12, 2016.																								
Water level reading using vibrating wire piezometer:																								
Shallow (S/N 1602773):																								
Date Depth (m) Elev. (m)																								
Oct. 25/16 16.21 257.31																								
Nov. 2/16 16.32 257.20																								
Nov. 15/16 16.32 257.20																								
May 6/17 12.33 261.18																								
Deep (S/N 1602776):																								
Date Depth (m) Elev. (m)																								
Oct. 25/16 16.79 256.72																								
Nov. 2/16 16.95 256.56																								
Nov. 15/16 16.90 256.61																								
May 6/17 12.87 260.64																								

METRIC

PROJECT 1534424

W.P. 3022-14-00

LOCATION N 4784924.5 , E 391863.4

ORIGINATED BY DH

DIST _____ HWY 4BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE October 13 - 14, 2016

CHECKED BY _____

[illegible]

Continued Next Page

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

LDN_MTO_06 1534424.GPJ LDN_MTO.GDT 14/06/17

RECORD OF BOREHOLE No 202

2 OF 3

METRIC

PROJECT 1534424
W.P. 3022-14-00 LOCATION N 4784924.5 , E 391863.4 ORIGINATED BY DH
DIST HWY 4 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY LMK
DATUM GEODETIC DATE October 13 - 14, 2016 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL				
								○ UNCONFINED + FIELD VANE					○							w _p	w	w _L	
								● QUICK TRIAXIAL × LAB VANE															
							20	40	60	80	100												
257.45			10	SS	100/ 200mm																		
16.15																							
			11	SS	43																		
			12	SS	54																		
251.96			13	SS	51																		
21.64																							
251.26			14	SS	100/ 280mm																		
22.34																							
			15	SS	100/ 180mm																		
			16	SS	100/ 130mm																		
			17	SS	100/ 130mm																		
246.63																							
26.97			18	SS	100																		
			19	SS	100/ 150mm																		
244.34																							
29.26																							

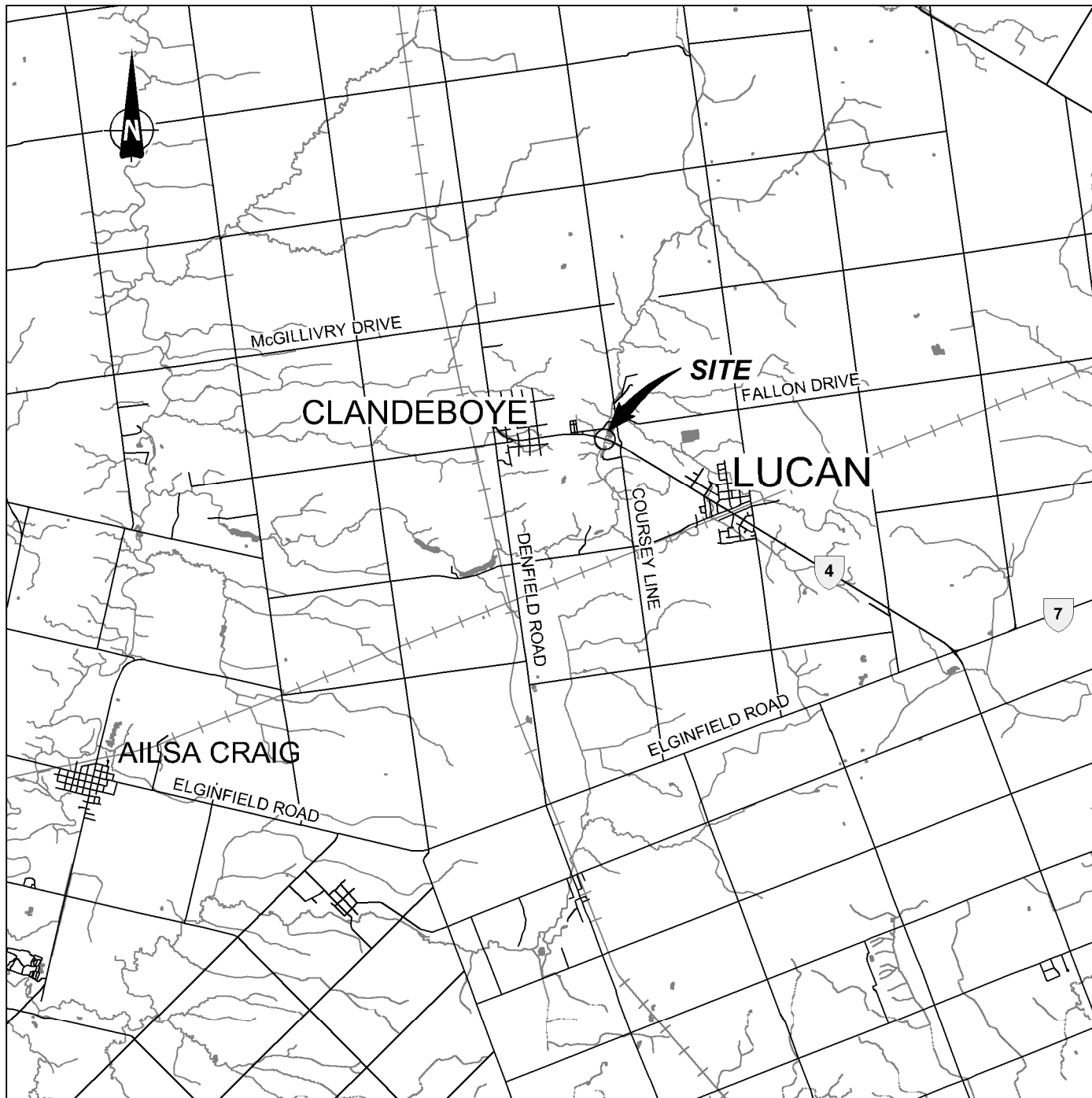
Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>1534424</u>		RECORD OF BOREHOLE No 202		3 OF 3		METRIC	
W.P. <u>3022-14-00</u>		LOCATION <u>N 4784924.5 , E 391863.4</u>		ORIGINATED BY <u>DH</u>			
DIST <u> </u> HWY <u>4</u>		BOREHOLE TYPE <u>POWER AUGER, HOLLOW STEM</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>October 13 - 14, 2016</u>		CHECKED BY <u>[Signature]</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					w _p w w _L				
243.36								20	40	60	80	100					
30.24	END OF BOREHOLE		20	SS	100/ 50mm												
	Groundwater encountered at about elev. 257.4m during drilling on October 13 & 14, 2016.																
	Water level reading using vibrating wire piezometer:																
	Shallow (S/N 16012775):																
	Date Depth (m) Elev. (m)																
	Oct. 25/16 7.97 265.63																
	Nov. 2/16 8.18 265.42																
	Nov. 15/16 8.32 265.27																
	May 6/17 3.68 269.91																
	Deep (S/N 1602774):																
	Date Depth (m) Elev. (m)																
	Oct. 25/16 15.55 258.04																
	Nov. 2/16 15.67 257.93																
	Nov. 15/16 15.67 257.92																
	May 6/17 11.92 261.68																

LDN_MTO_06 1534424.GPJ LDN_MTO.GDT 14/06/17



REFERENCE

CANMAP STREETFILES V2008.4.

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.
2. ALL LOCATIONS ARE APPROXIMATE ONLY.

SCALE IN METRES
0 2000 4000m
1:100,000

PROJECT

LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69
HIGHWAY 4
GWP 3022-14-00

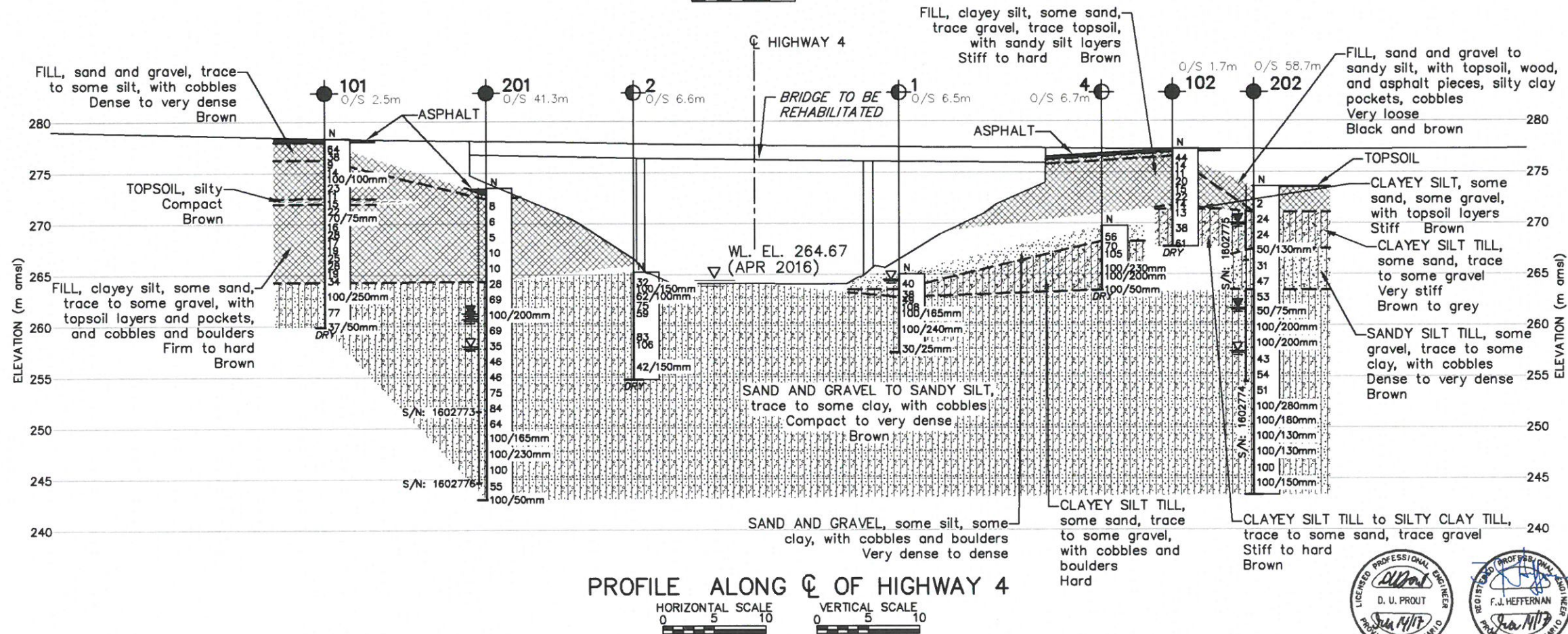
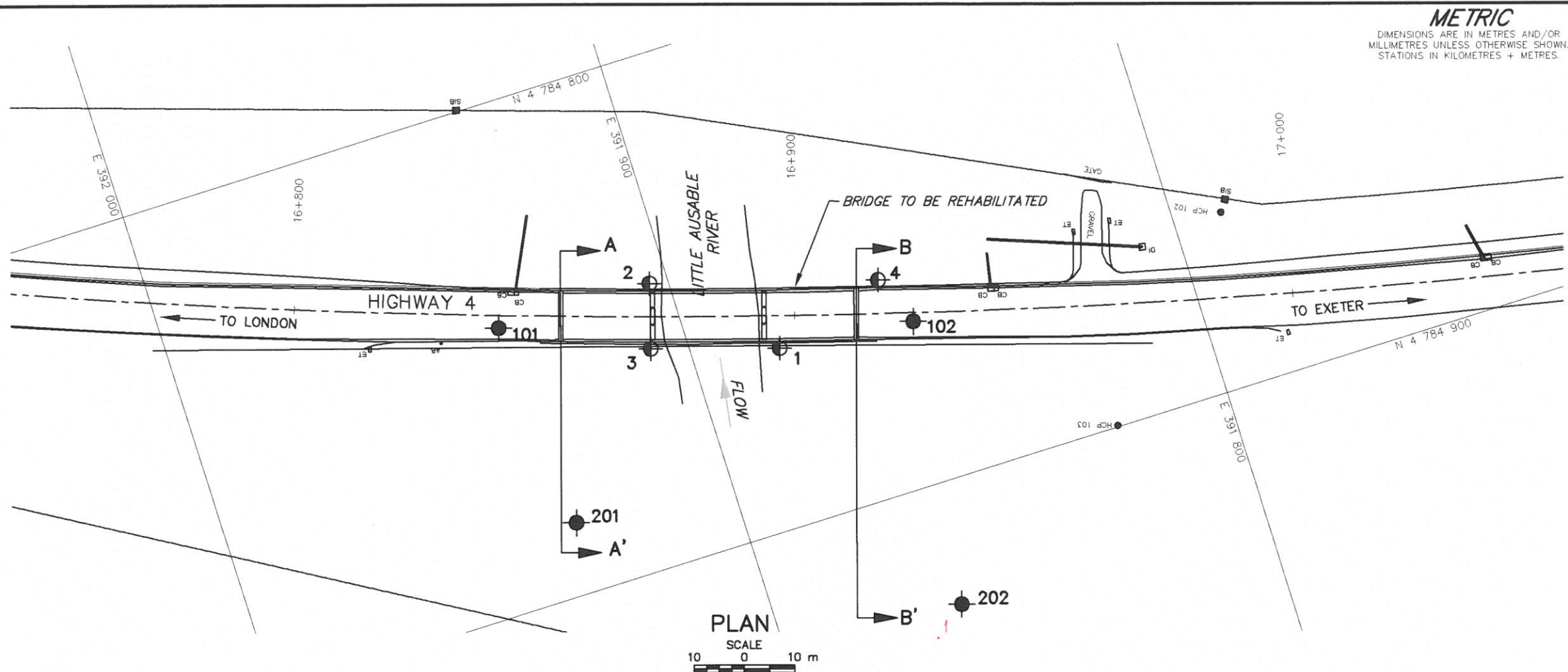
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KEY PLAN

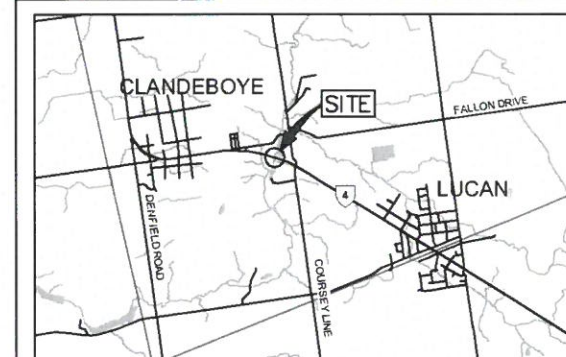


**Golder
Associates**

PROJECT No. 1534424			FILE No. 1534424-5002A-F01001	
CADD	DCH/LMK	Dec. 14/16	SCALE AS SHOWN	REV. 0
CHECK			FIGURE 1	

CONT No.
WP No. 3022-14-00

SHEET

LITTLE AUSABLE RIVER
BRIDGE REHABILITATION
HIGHWAY 4
BOREHOLE LOCATIONS AND SOIL STRATAGolder Associates Ltd.
LONDON, ONTARIO, CANADA

LEGEND

- Borehole
- Borehole (Geocres 40P03-031)
- Vibrating wire piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL measured on May 6, 2017
- WL encountered during drilling
- DRY Borehole dry during drilling

No.	ELEVATION	CO-ORDINATES (MTM ZONE 11)	
		NORTHING	EASTING
101	278.38	4 784 843.8	391 935.2
102	277.30	4 784 867.5	391 885.7
201	273.51	4 784 885.7	391 932.1
202	273.60	4 784 924.5	391 863.4
Geocres 40P03-031			
1	265.05	4 784 864.6	391 882.8
2	265.24	4 784 844.4	391 903.7
3	265.48	4 784 856.9	391 907.4
4	269.75	4 784 857.5	391 860.0

NOTES

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

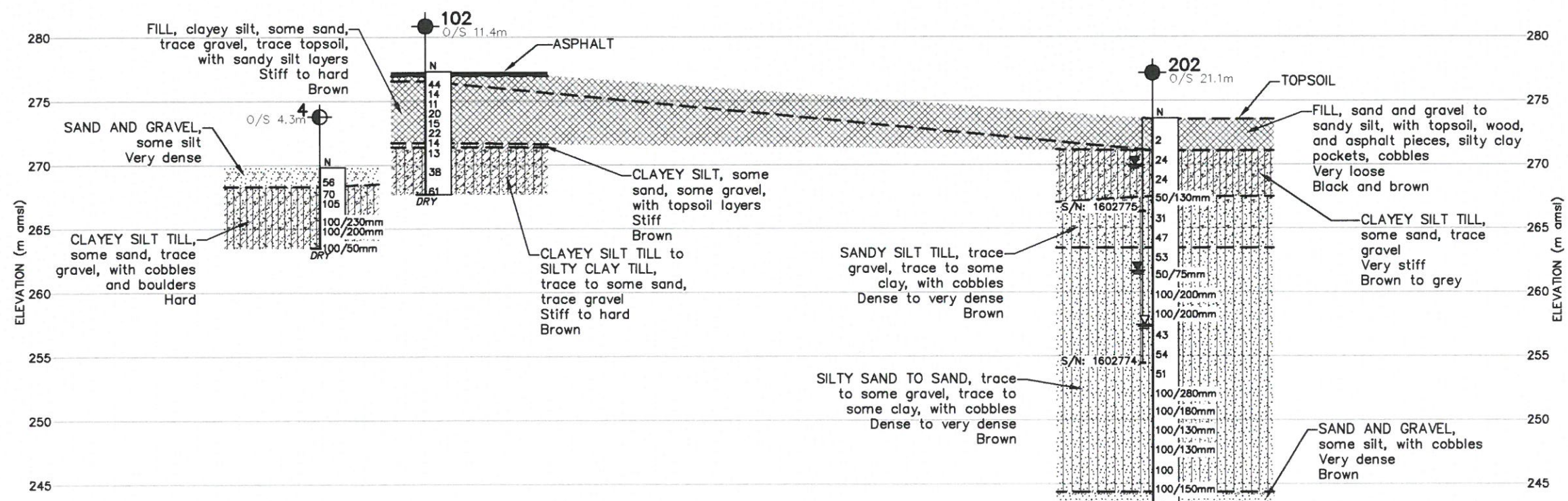
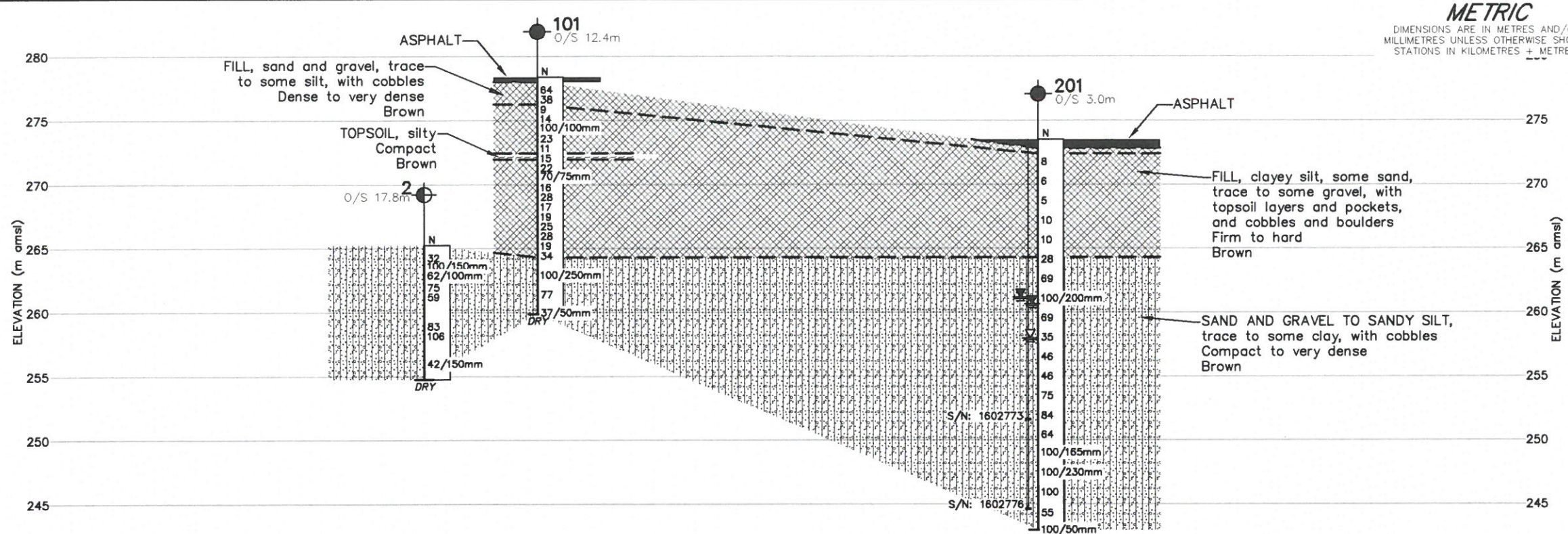
The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by Stantec.



NO.	DATE	BY	REVISION
Geocres No. 40P3-52			
HWY.	4	PROJECT NO. 1534424	DIST.
SUBM'D.	BT	CHKD. DH	DATE: Mar 1/17
DRAWN:	LMK	CHKD. DUP	APPD. FJH
SITE: 19-69		DWG. 1	



CONT No.
WP No. 3022-14-00

LITTLE AUSABLE RIVER
BRIDGE REHABILITATION
HIGHWAY 4
SOIL STRATA

SHEET



Golder Associates Ltd.
LONDON, ONTARIO, CANADA

LEGEND

- Borehole
- Borehole (Geocres 40P03-031)
- Vibrating wire piezometer
- N** Standard Penetration Test Value
- 16** Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL measured on May 6, 2017
- WL encountered during drilling
- DRY** Borehole dry during drilling

No.	ELEVATION	CO-ORDINATES (MTM ZONE 11)	
		NORTHING	EASTING
101	278.38	4 784 843.8	391 935.2
102	277.30	4 784 867.5	391 885.7
201	273.51	4 784 885.7	391 932.1
202	273.60	4 784 924.5	391 863.4
Geocres 40P03-031			
2	265.24	4 784 844.4	391 903.7
4	269.75	4 784 857.5	391 860.0

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.

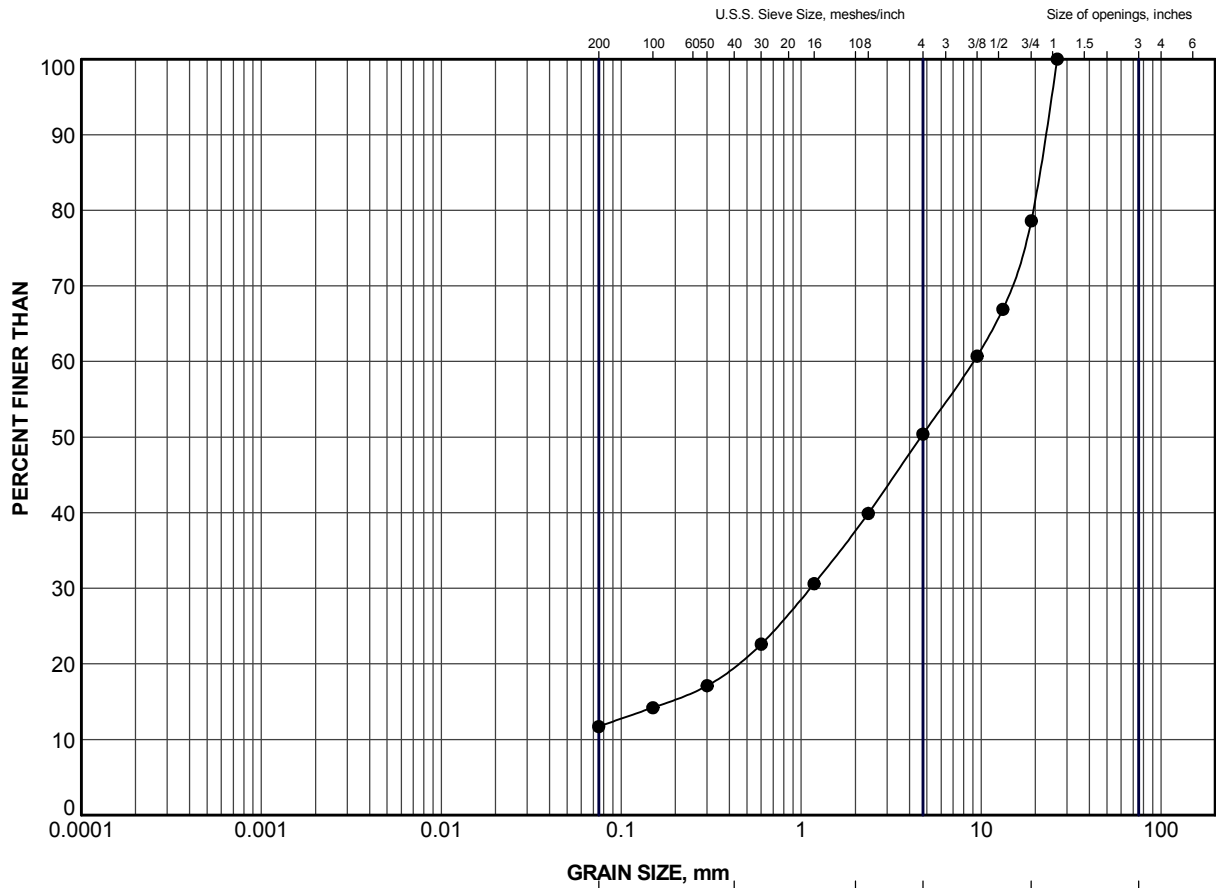


NO.	DATE	BY	REVISION
Geocres No. 40P3-52			
HWY. 4	PROJECT NO. 1534424		DIST.
SUBM'D. BT	CHKD. DH	DATE: June 14/17	SITE: 19-69
DRAWN: LMK/DCH	CHKD. DUP	APPD. FJH	DWG. 2



APPENDIX A


Laboratory Test Data

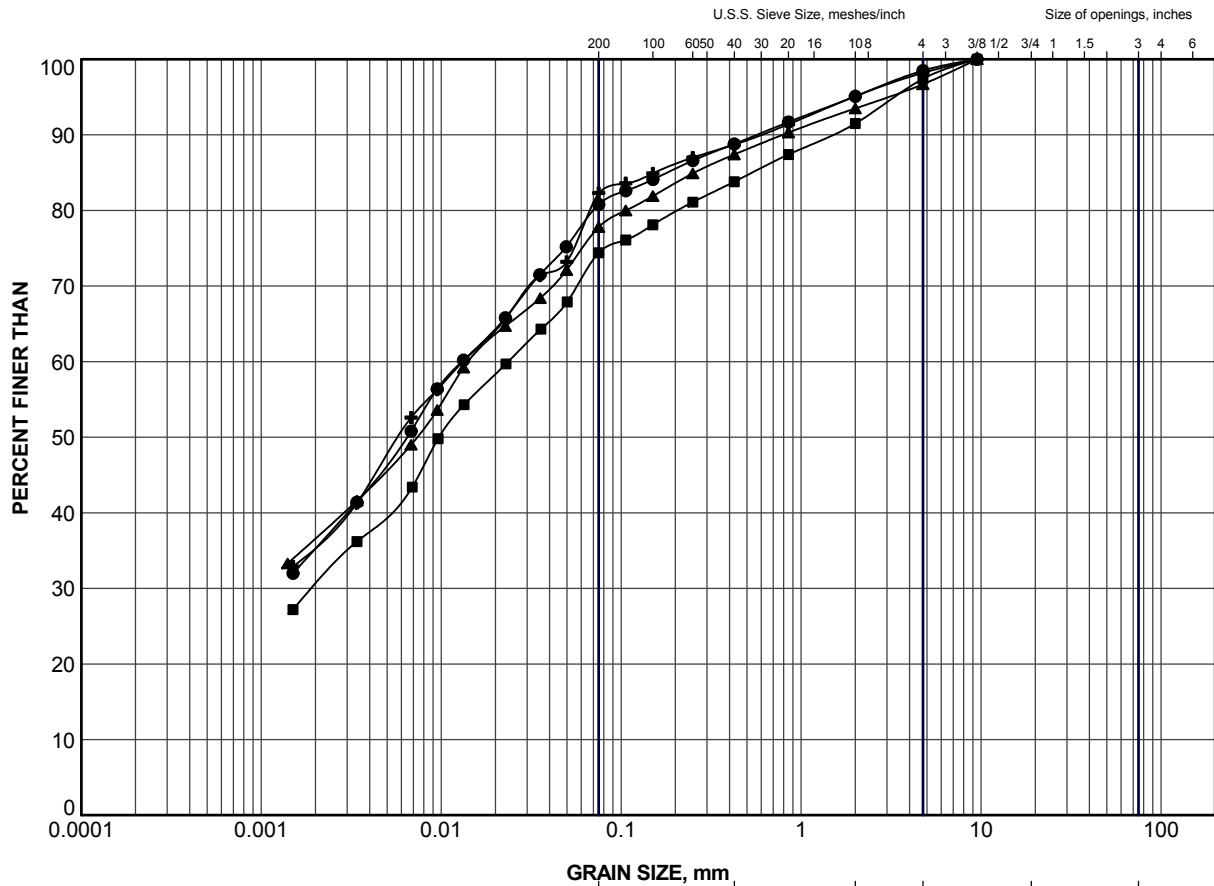


CLAY AND SILT	SAND SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	101	2	276.6


PROJECT				LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69 HIGHWAY 4 GWP 3022-14-00			
TITLE				GRAIN SIZE DISTRIBUTION FILL - SAND AND GRAVEL			
PROJECT No.		1534424		FILE No.		1534424-5002A-F010A1	
DRAWN		LMK		SCALE		N/A	
CHECK		Aug 19/16		REV.			
				FIGURE A-1			

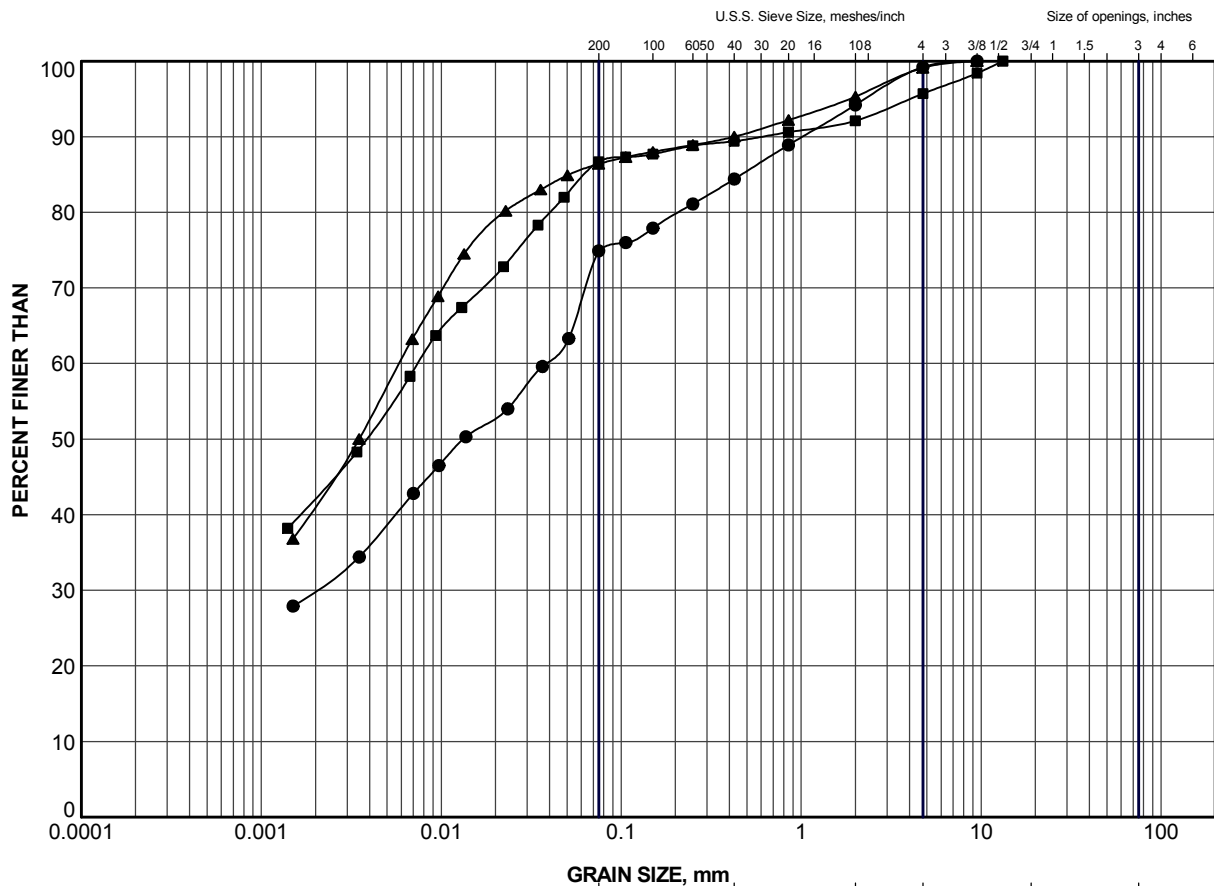


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	101	4	275.1
■	101	11	269.8
▲	101	15	266.7
+	102	3	274.8


PROJECT				LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69 HIGHWAY 4 GWP 3022-14-00			
TITLE				GRAIN SIZE DISTRIBUTION FILL - CLAYEY SILT			
PROJECT No.		1534424		FILE No.		1534424-5002A-F010A2	
DRAWN		LMK		SCALE		N/A	
CHECK		Sep 01/16		REV.			
				FIGURE A-2			

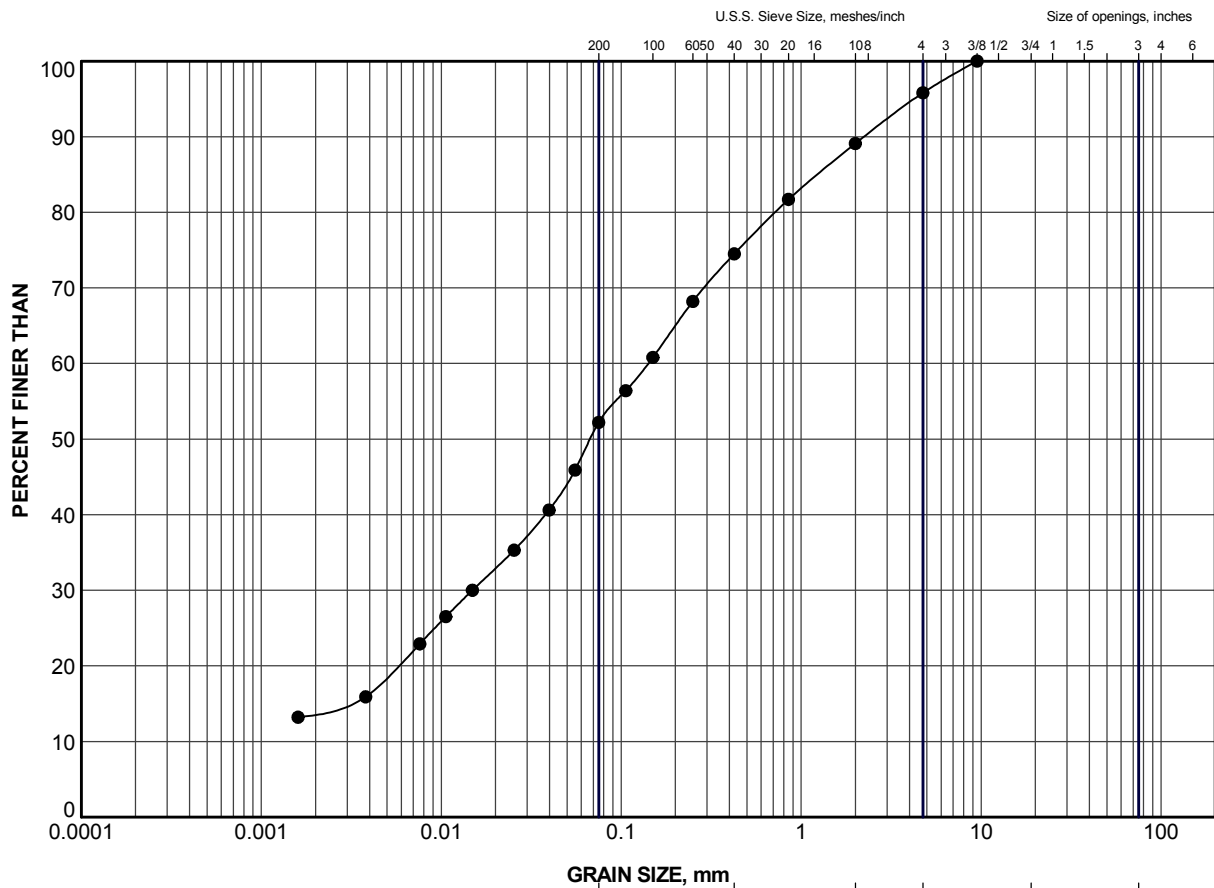


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	102	8	270.9
■	102	10	267.9
▲	202	2	270.3

PROJECT				LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69 HIGHWAY 4 GWP 3022-14-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL TO SILTY CLAY TILL			
PROJECT No.		1534424		FILE No.		1534424-5002A-F010A3	
DRAWN		DCH		SCALE		N/A	
CHECK		Mar 1/17		REV.			
				FIGURE A-3			

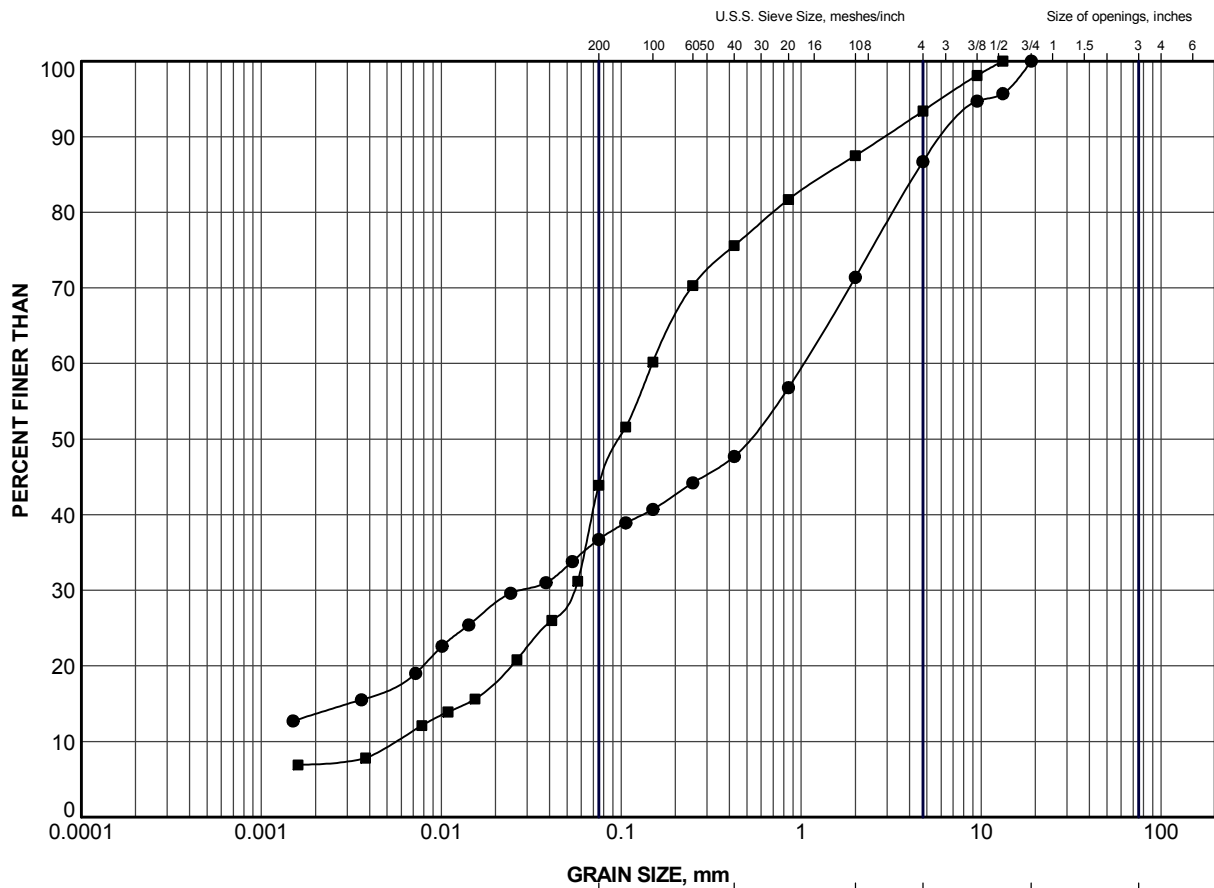


CLAY AND SILT	GRAIN SIZE, mm			Cobble Size	
	fine	medium	coarse	fine	coarse
SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	202	5	265.7


PROJECT	LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69 HIGHWAY 4 GWP 3022-14-00			
TITLE	GRAIN SIZE DISTRIBUTION SANDY SILT TILL			
	PROJECT No.	1534424	FILE No.	1534424-5002A-F010A4
	DRAWN	LMK	Nov 03/16	SCALE N/A
	CHECK			REV.
	FIGURE A-4			

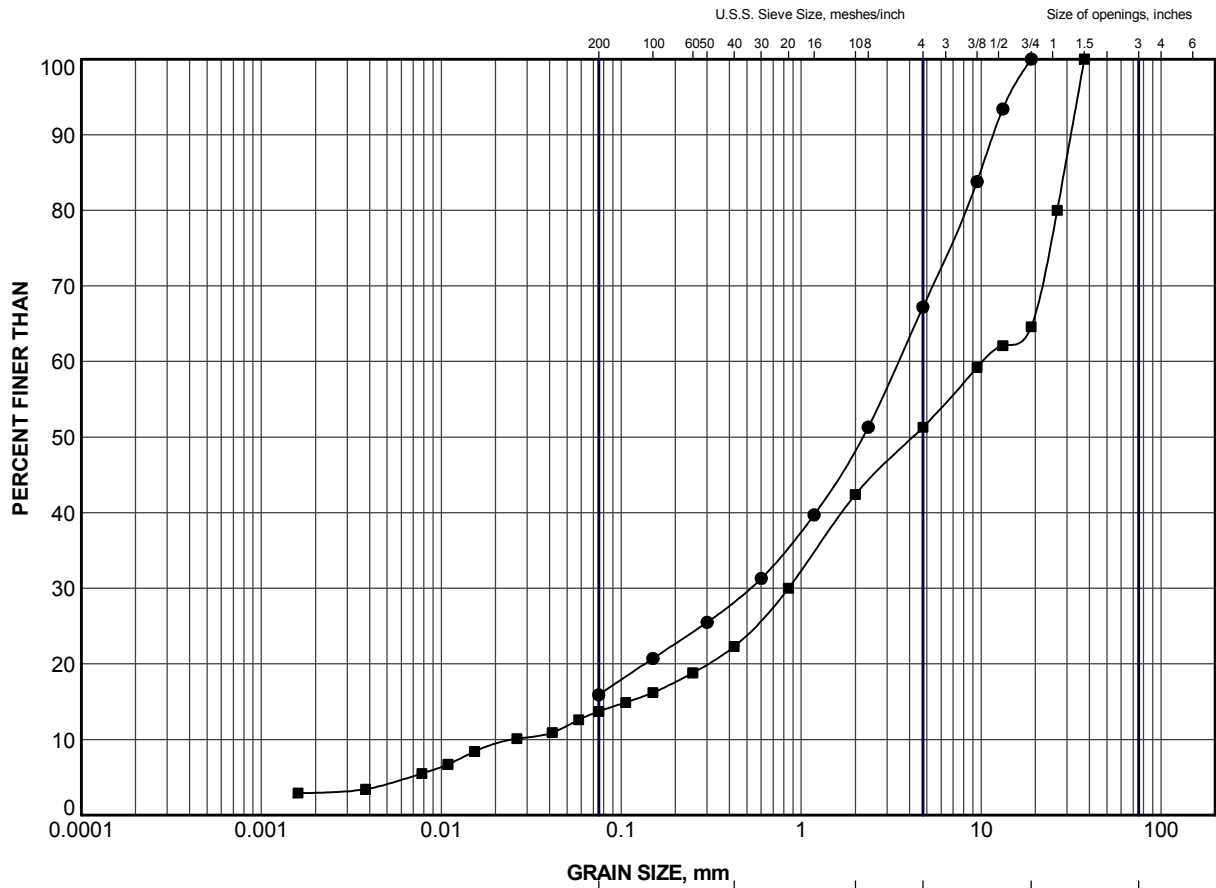


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	101	20	261.4
■	202	9	259.8

PROJECT				LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69 HIGHWAY 4 GWP 3022-14-00			
TITLE				GRAIN SIZE DISTRIBUTION SILTY SAND			
PROJECT No.		1534424		FILE No.		1534424-5002A-F010A5	
DRAWN		LMK		SCALE		N/A	
CHECK		Nov 17/16		REV.			
				FIGURE A-5			



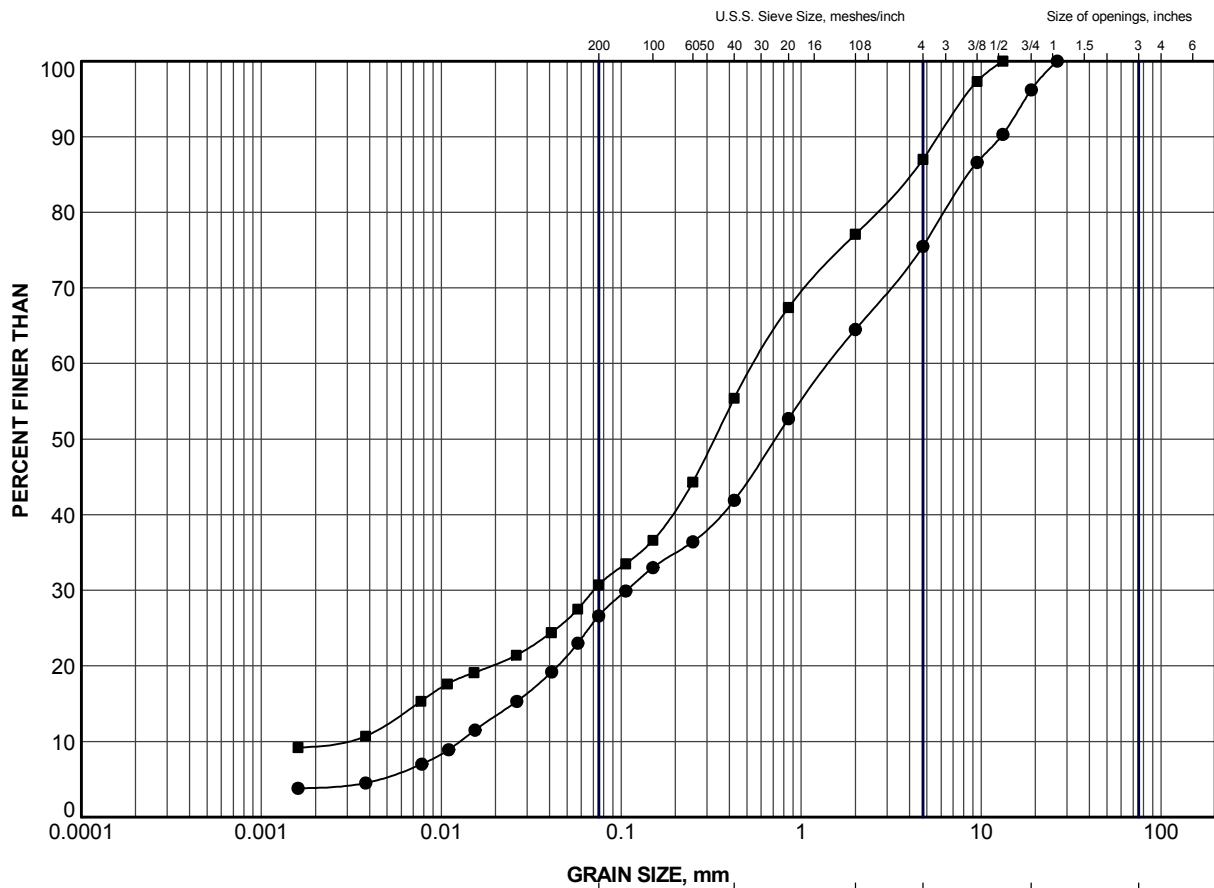
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	101	21	260.0
■	201	7	262.6

PROJECT				LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69 HIGHWAY 4 GWP 3022-14-00			
TITLE				GRAIN SIZE DISTRIBUTION SAND AND GRAVEL			
PROJECT No.		1534424		FILE No.		1534424-5002A-F010A6	
DRAWN		LMK		Nov 03/16		SCALE N/A REV.	
CHECK						FIGURE A-6	




LDN_MTO_GSD_GLDR_LDN.GDT 03/11/16

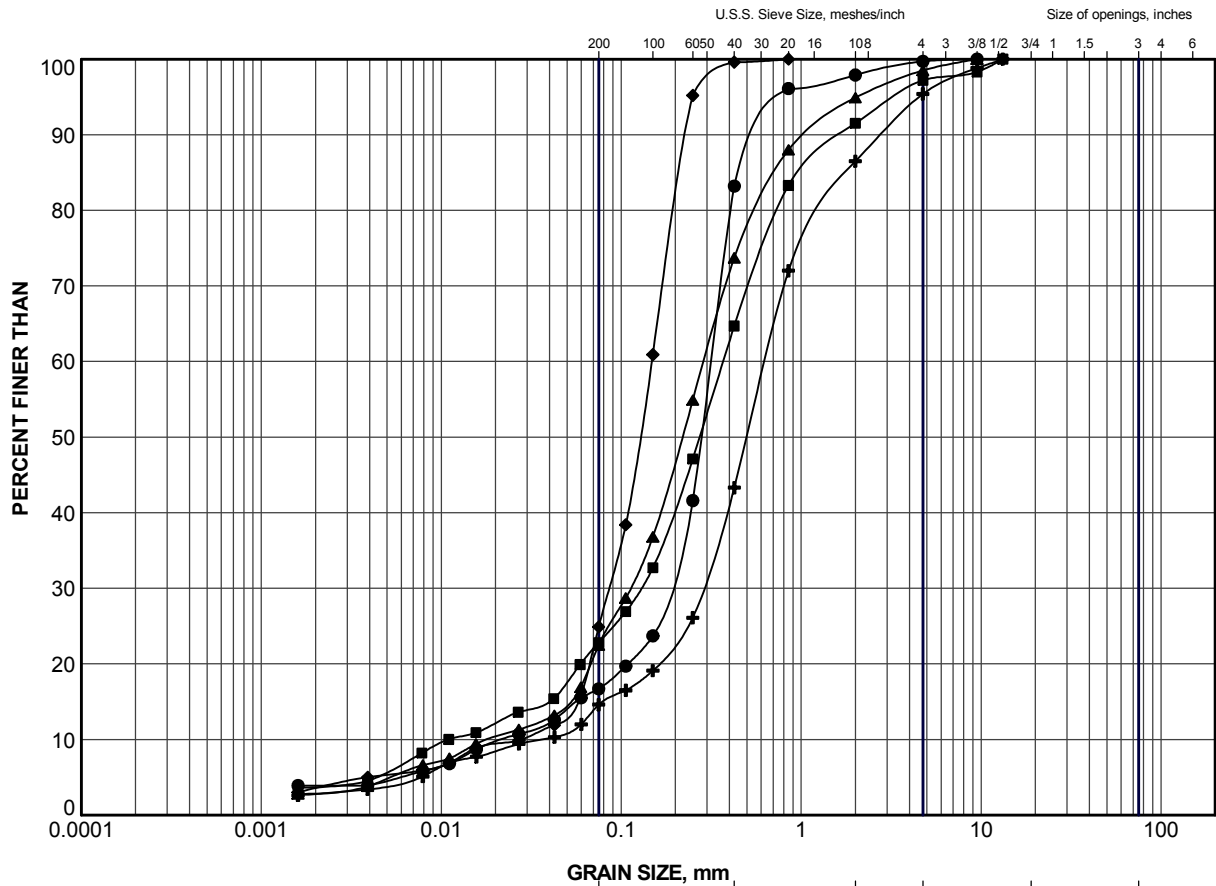


CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	201	11	256.5
■	202	15	250.6

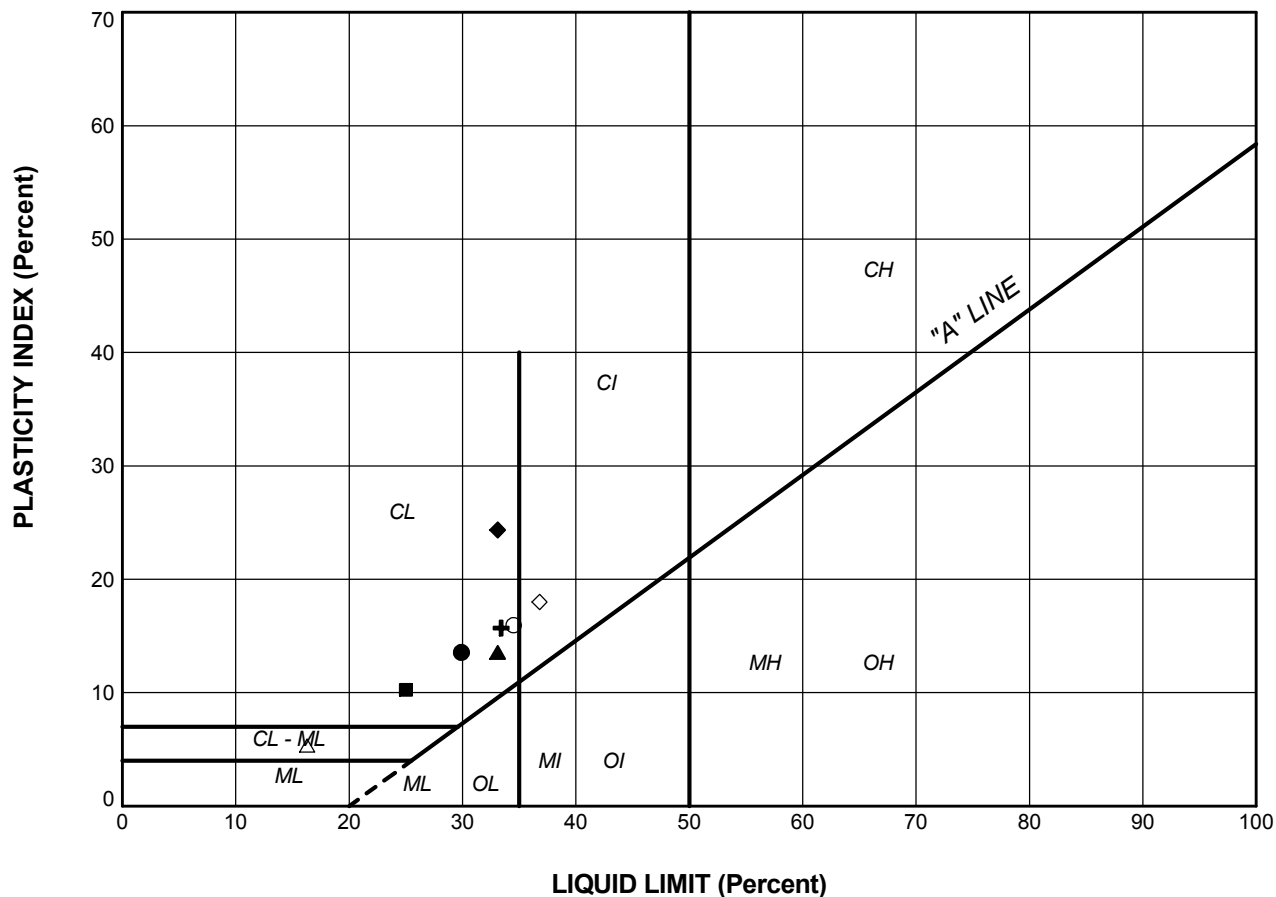
PROJECT				LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69 HIGHWAY 4 GWP 3022-14-00			
TITLE				GRAIN SIZE DISTRIBUTION SILTY SAND AND GRAVEL			
PROJECT No.		1534424		FILE No.		1534424-5002A-F010A7	
DRAWN		LMK		SCALE		N/A	
CHECK		Nov 17/16		REV.			
				FIGURE A-7			



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	201	14	251.9
■	201	18	245.9
▲	201	19	244.3
+	202	13	252.0
◆	202	18	246.0

PROJECT				LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69 HIGHWAY 4 GWP 3022-14-00			
TITLE				GRAIN SIZE DISTRIBUTION SAND			
PROJECT No.		1534424		FILE No.		1534424-5002A-F010A8	
DRAWN		LMK		SCALE		N/A	
CHECK		Nov 03/16		REV.			
				FIGURE A-8			



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
FILL					
●	101	4	29.9	16.4	13.6
■	101	11	25.0	14.8	10.3
▲	101	15	33.1	19.6	13.6
+	102	3	33.4	17.7	15.7
CLAYEY SILT TILL TO SILTY CLAY TILL					
◆	102	8	33.1	8.8	24.4
◇	102	10	36.8	18.8	18.0
○	202	2	34.5	18.6	16.0
SANDY SILT TILL					
△	202	5	16.3	11.0	5.4

PROJECT: LITTLE AUSABLE RIVER BRIDGE, SITE No. 19-69
 HIGHWAY 4
 GWP 3022-14-00

TITLE

PLASTICITY CHART



PROJECT No.	1534424	FILE No.	1534424-5002A-F010A9
DRAWN	LMK/DCH	Mar 1/17	SCALE N/A REV.
CHECK			

FIGURE A-9



APPENDIX B

Records of Boreholes - Geocres Report No. 40P03-031

(*Geocres Report No. 40P03-031*)

"Note: This Drawing has been Reduced and is in Imperial Units - metric conversion also shown"

DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS & TESTING DIVISION		<h2 style="margin: 0;">RECORD OF BOREHOLE NO. 1</h2>		FOUNDATION SECTION	
JOB	<u>67-F-8</u>	LOCATION	<u>Sta. 228 + 83 21' R</u>	ORIGINATED BY	<u>ACC</u>
W.P.	<u>152-63</u>	BORING DATE	<u>January 18, 1967</u>	COMPILED BY	<u>ACC</u>
DATUM	<u>Geodetic</u>	BOREHOLE TYPE	<u>Washboring, NX Casing, Cone</u>	CHECKED BY	<u>SL</u>

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

(*Geocres Report No. 40P03-031*)

"Note: This Drawing has been Reduced and is in Imperial Units - metric conversion also shown"

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 2

FOUNDATION SECTION

JOB 67-F-8

LOCATION Sta. 227 / 98 21' It.

ORIGINATED BY ACC

V. P. 152-63

BORING DATE January 20-26, 1967

COMPILED BY ACC

DATUM Geodetic

BOREHOLE TYPE Washboring, NX Casing, Cone

CHECKED BY

[illegible]

(*Geocres Report No. 40P03-031*)

"Note: This Drawing has been Reduced and is in Imperial Units - metric conversion also shown"

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

JOB 67-F-8

LOCATION Sta. 227 + 98 21' R

ORIGINATED BY ACC

W.P. 152-63

BORING DATE January 26, 1967

COMPILED BY ACC

DATUM Geodetic

BOREHOLE TYPE Dynamic cone penetration test

CHECKED BY AK

RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	Liquid Limit ——— w _L Plastic Limit ——— w _p Water Content ——— w	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.	WATER CONTENT % w _p w w _L		
871.0 0.0	GROUND LEVEL					870				
861.5	262.59m (2.90m)									
9.5	End of Cone test					860				

(*Geocres Report No. 40P03-031*)

"Note: This Drawing has been Reduced and is in Imperial Units - metric conversion also shown"

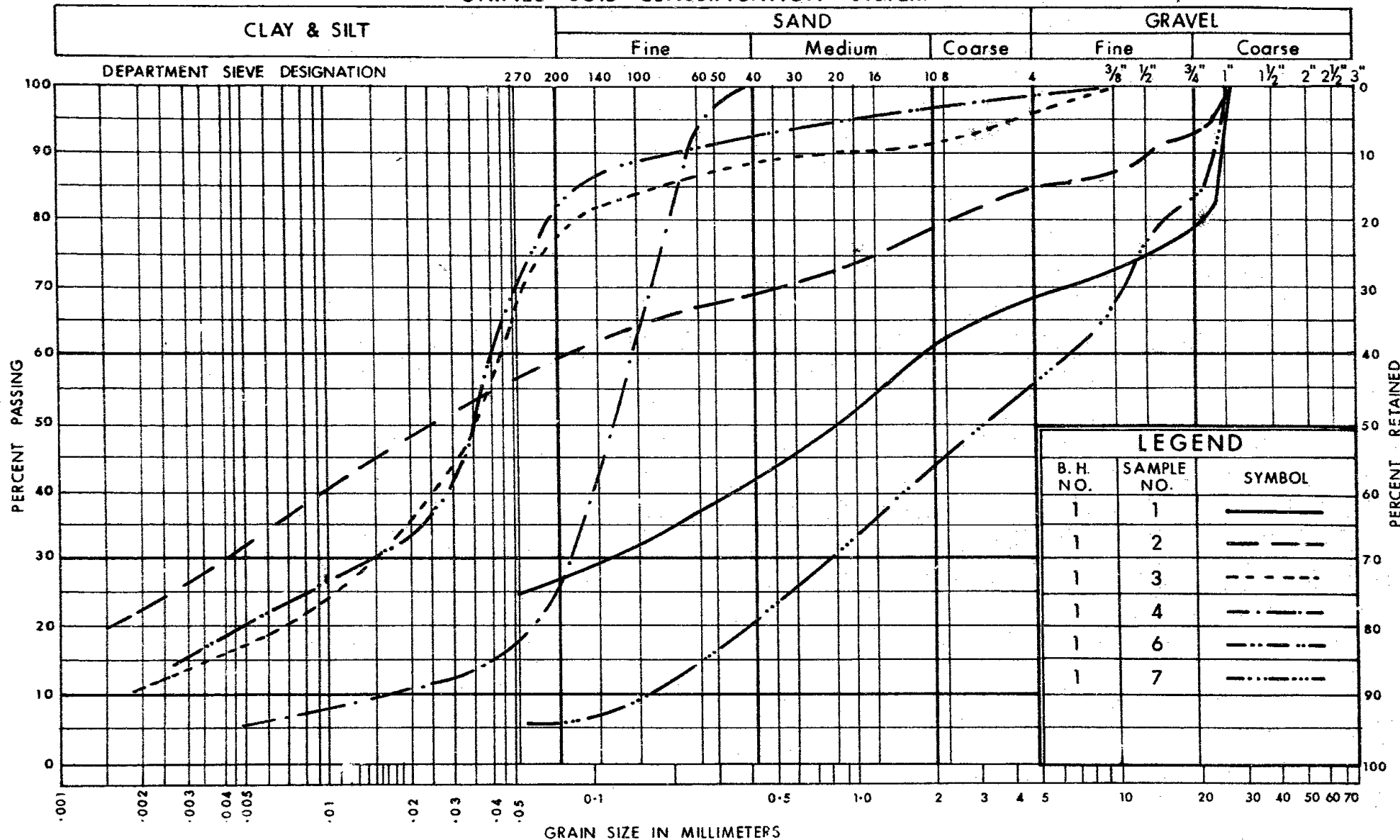
DEPARTMENT OF HIGHWAYS - ONTARIO						RECORD OF BOREHOLE NO. 4								FOUNDATION SECTION						
MATERIALS & TESTING DIVISION																				
JOB	67-F-8			LOCATION				Sta. 229 + 48 21' Lt.				ORIGINATED BY ACC								
W.P.	152-63			BORING DATE				January 31, 1967				COMPILED BY ACC								
DATUM	Geodetic			BOREHOLE TYPE				Washboring, BX Casing, Cone				CHECKED BY [Signature]								
ELEV. SCALE	SOIL PROFILE	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT															
885.0	GROUND LEVEL DESCRIPTION: 269.75m (0.0m)	[Symbol]																		
0.0	Silty sand & gravel. Very Dense.	[Symbol]	1	SS	56															
5.0	Boulder (8") Clayey silt with some sand and a trace of gravel. Occasional boulder	[Pattern]	2	SS	70															
			3	SS	105															
			4	SS	100/9"															
			5	SS	100/8"															
Hard			6	SS	100/2"															
End of borehole																				



APPENDIX C

Laboratory Data - Geocres Report No. 40P03-031

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION



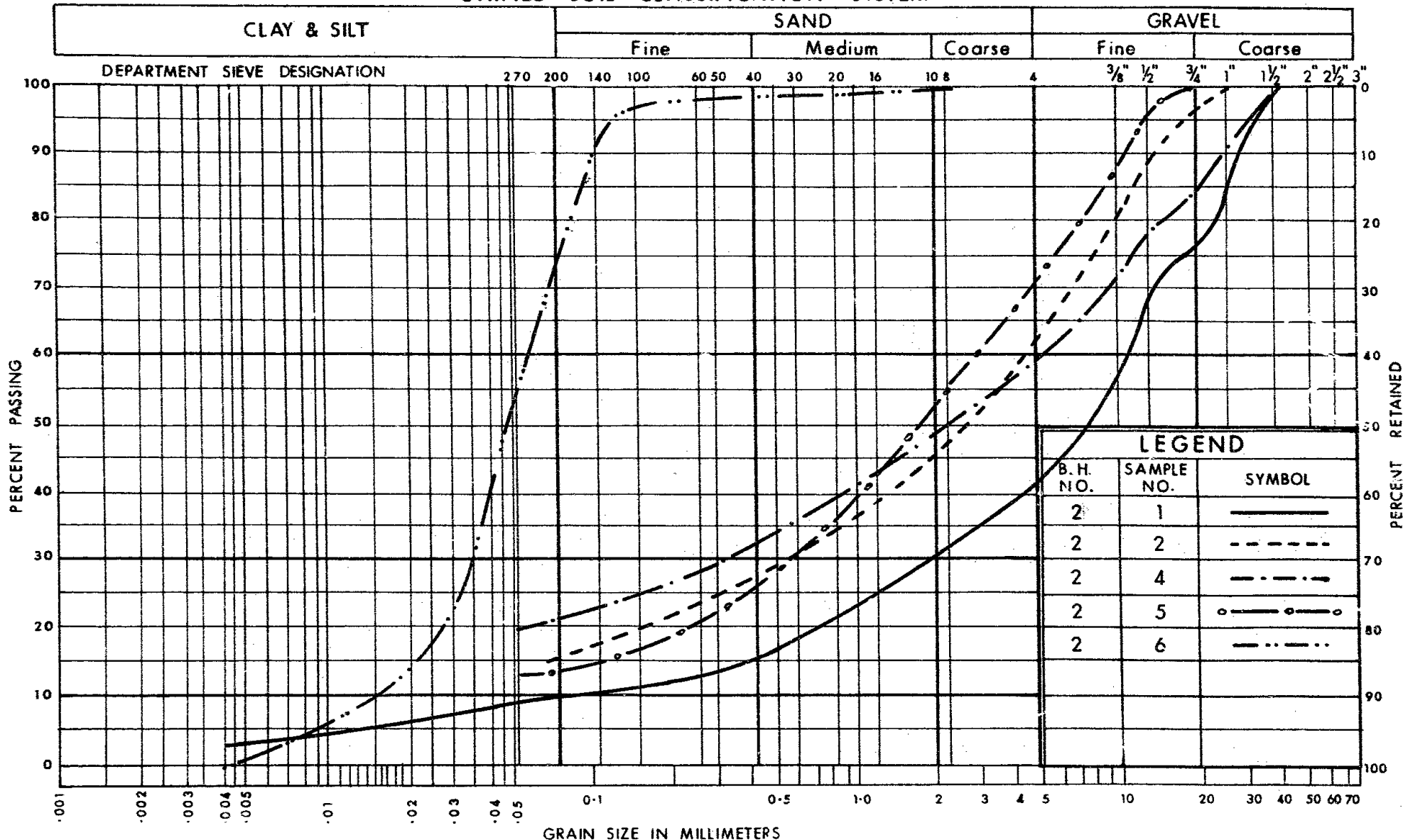
DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

ONTARIO

W.P. No. 152-63

JOB No. 67-F-8

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION

W.P. No. 152 - 63

JOB No. 67 - F - 8



APPENDIX D

Site Photographs



APPENDIX D

Site Photographs



Photograph 1: West elevation, looking southeast from northwest quadrant.



Photograph 2: West elevation at north end of bridge, looking north.



APPENDIX D

Site Photographs



Photograph 3: North abutment. Note exposed pile cap as well as erosion and settlement.



Photograph 4: Southwest approach, looking northwest.



APPENDIX D

Site Photographs



Photograph 5: South abutment at east end. Note apparent rotation.



Photograph 6: South abutment at west end. Note apparent rotation, spalled concrete and exposed rebar.



APPENDIX D

Site Photographs



Photograph 7: North abutment at east end. Note spalled concrete and exposed rebar.



Photograph 8: North abutment at west end. Note apparent rotation, spalled concrete and exposed rebar.



APPENDIX D

Site Photographs



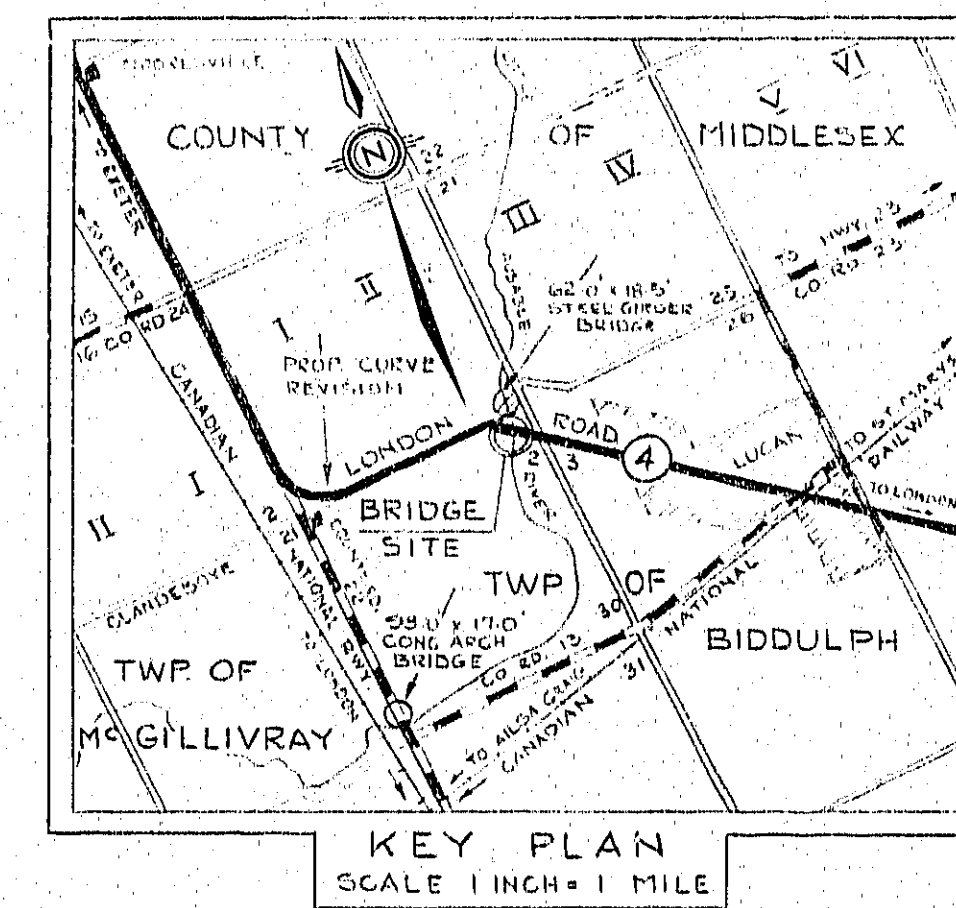
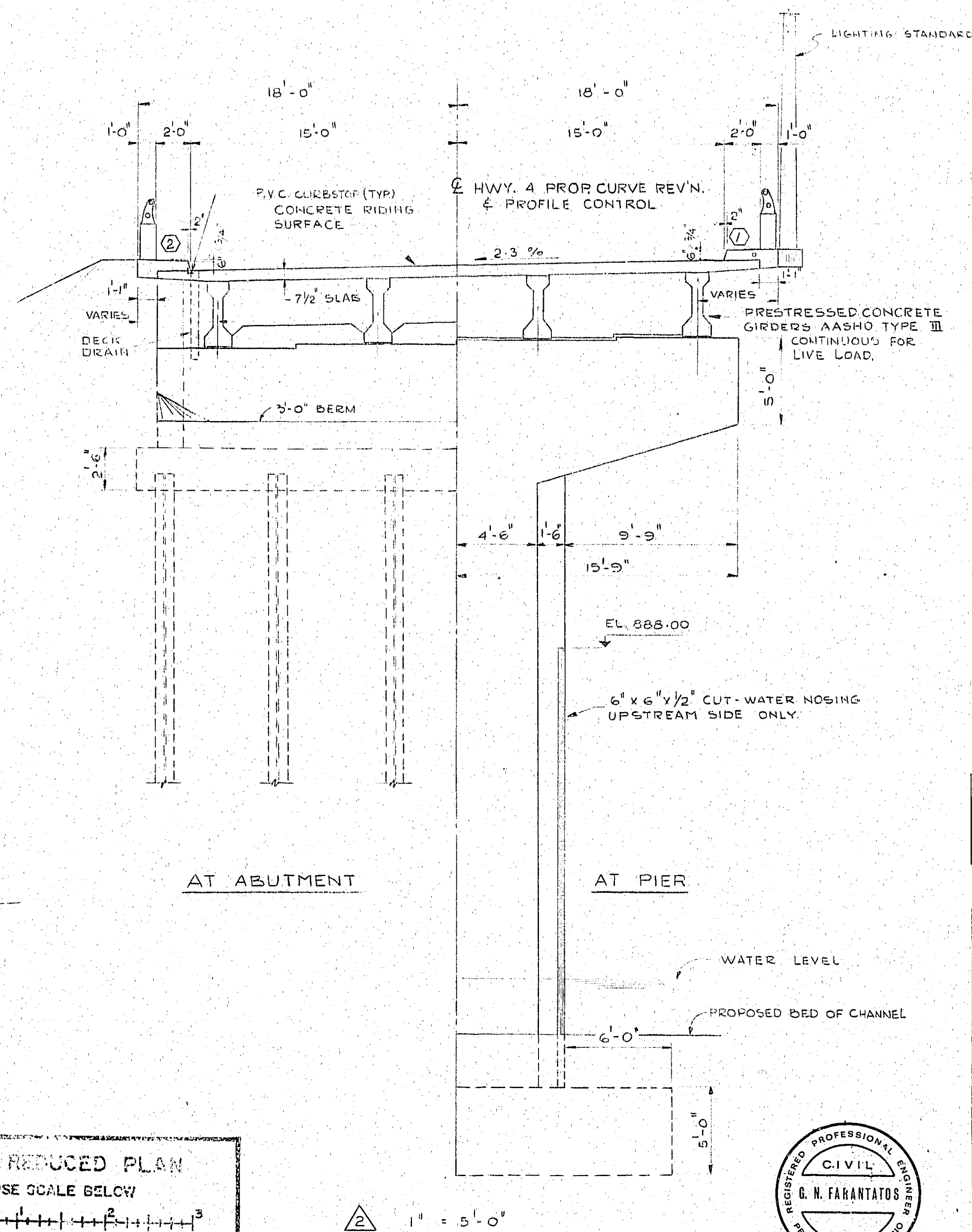
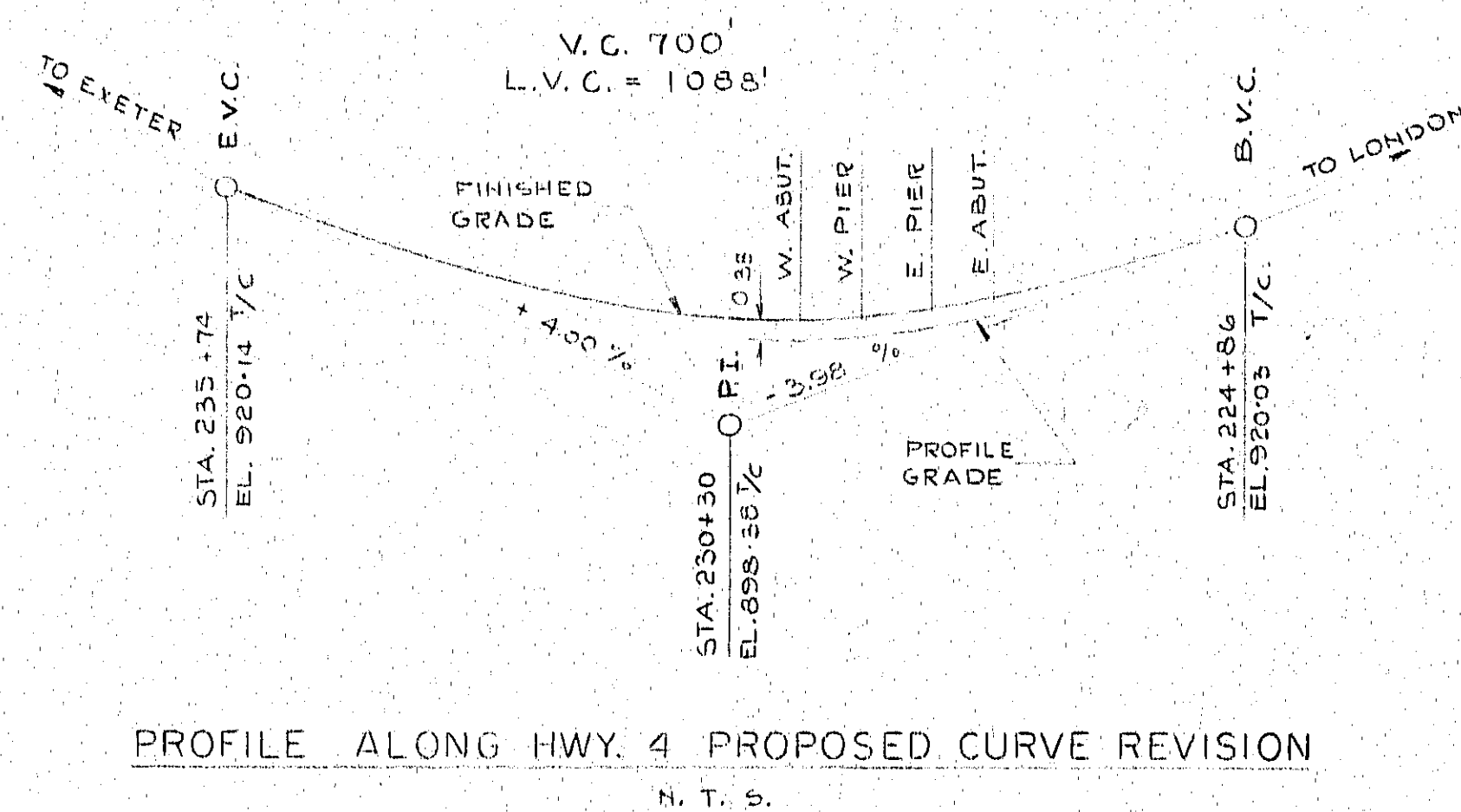
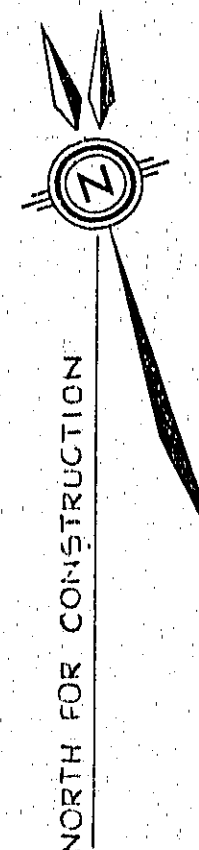
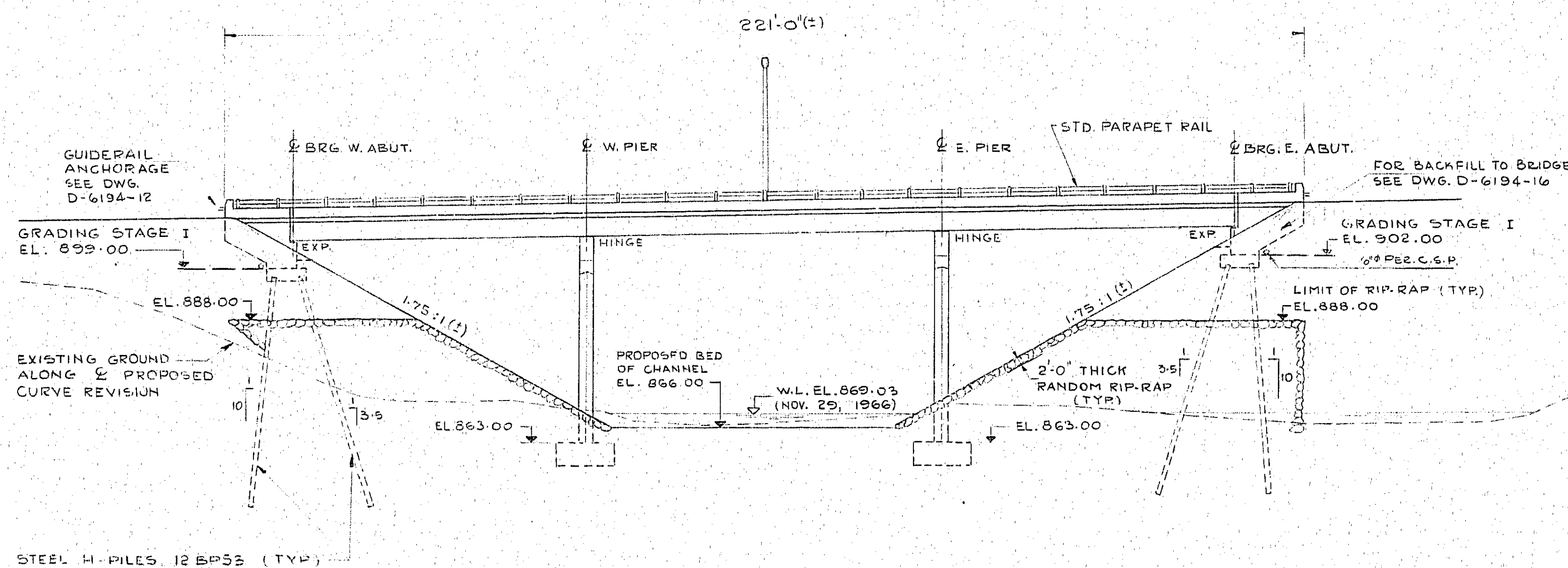
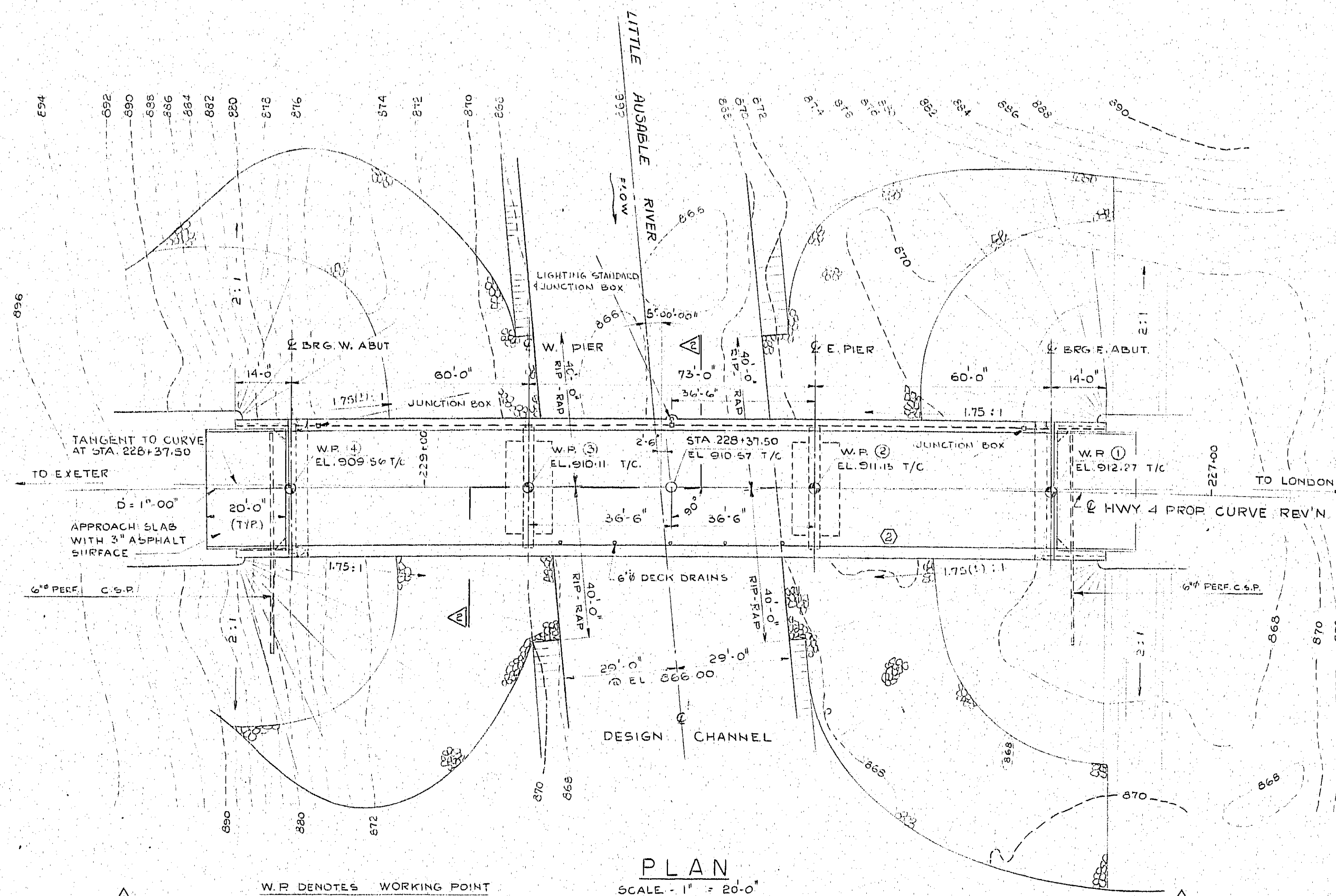
Photograph 9: North abutment on west side. Note erosion around abutment and under approach slab.

n:\active\2015\3 proj\1534424 stantec_mega 5 3015-e-0008_sw\ph 5000 cont 5 gwp 3022-14-00\ph 5002 fdns\2-cor\5-rpts\r01-ph 5002a site 19-69\1534424-5002a-r01 jul 5 17 (final)
appendix d photos.docx



APPENDIX E

General Arrangement and Foundation Drawings – W.P. 152-63



NOTES

CLASS OF CONCRETE:

PRESTRESSED CONCRETE GIRDERS	5000 P.S.I.
DECK SLAB, DIAPHRAGMS, PARAPET WALL & CURBS	4000 P.S.I.
REMAINDER	3000 P.S.I.

CLEAR COVER TO REINFORCING STEEL:

SURFACE IN CONTACT WITH EARTH OR WATER	3"
TOP OF DECK SLAB	1 1/2"
BOTTOM OF DECK SLAB	1"
PRESTRESSED GIRDERS	1 1/2" EXCEPT AS NOTED
PARAPET WALLS	1 1/2"
PIER CAPS	2"
REMAINDER	2"

CONSTRUCTION NOTES:

THE CONTRACTOR IS RESPONSIBLE FOR FINISHING ALL BEARING SEATS TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF $\pm 1/8"$.

LIST OF DRAWINGS

- D-6194-1 GENERAL ARRANGEMENT
- D-6194-2 BORE HOLE LOCATION & SOIL STATE
- D-6194-3 FOUNDATION LAYOUT & REINFORCEMENT
- D-6194-4 ABUTMENT LAYOUT
- D-6194-5 ABUTMENT REINFORCEMENT
- D-6194-6 WINGWALL REINFORCEMENT
- D-6194-7 PIER LAYOUT & REINFORCEMENT
- D-6194-8 DECK LAYOUT & DETAILS
- D-6194-9 GROUND ELEVATIONS AND CURVE OFFSETS
- D-6194-10 DECK REINFORCEMENT
- D-6194-11 PRESTRESSED GIRDERS & BEARINGS
- D-6194-12 PARAPET WALL DETAILS
- D-6194-13 STANDARD STEEL PARAPET RAIL
- D-6194-14 APPROACH SLAB
- D-6194-15 BRIDGE ELECTRICAL DETAILS
- D-6194-16 STANDARD BRIDGE DETAILS
- D-6194-17 STANDARD BRIDGE DETAILS
- D-6194-18 STANDARD BRIDGE DETAILS

G.B.M. ELEV. 864.961
C.N.R. SUBWAY AT STATION, WEST FACE OF STONE WING-WALL AT EAST SIDE OF LONDON-WINGHAM TRACK AND NORTH SIDE OF STRATFORD-BARNIA TRACK, 11 FEET FROM NORTH END OF WALL AND IN THE FIFTEENTH COURSE BELOW BRIDGE SEAT. BOLT SET HORIZONTALLY, N^o 337, PUBLICATION N^o 15, "LUGAN CROSSING."

REVISIONS	DATE	BY	DESCRIPTION
DEC. 8-69	H.H.	(2)	BELL TELEPHONE DUCTS REMOVED
MAY 1971	J.S.	(1)	P.V.C. CURBSTOP REMOVED FROM HIGH SIDE

DEPARTMENT OF HIGHWAYS ONTARIO
BRIDGE DIVISION

Giffels ASSOCIATES LIMITED

LITTLE AUSABLE RIVER BRIDGE

4.5 MILES NORTHWEST OF JCT. HWY. 7

KING'S HIGHWAY No. 4 DIST. No. 2
CO. OF MIDDLESEX
TWP. OF BIDDULPH LOT 2 CON. 2 S. OF LONDON RD.

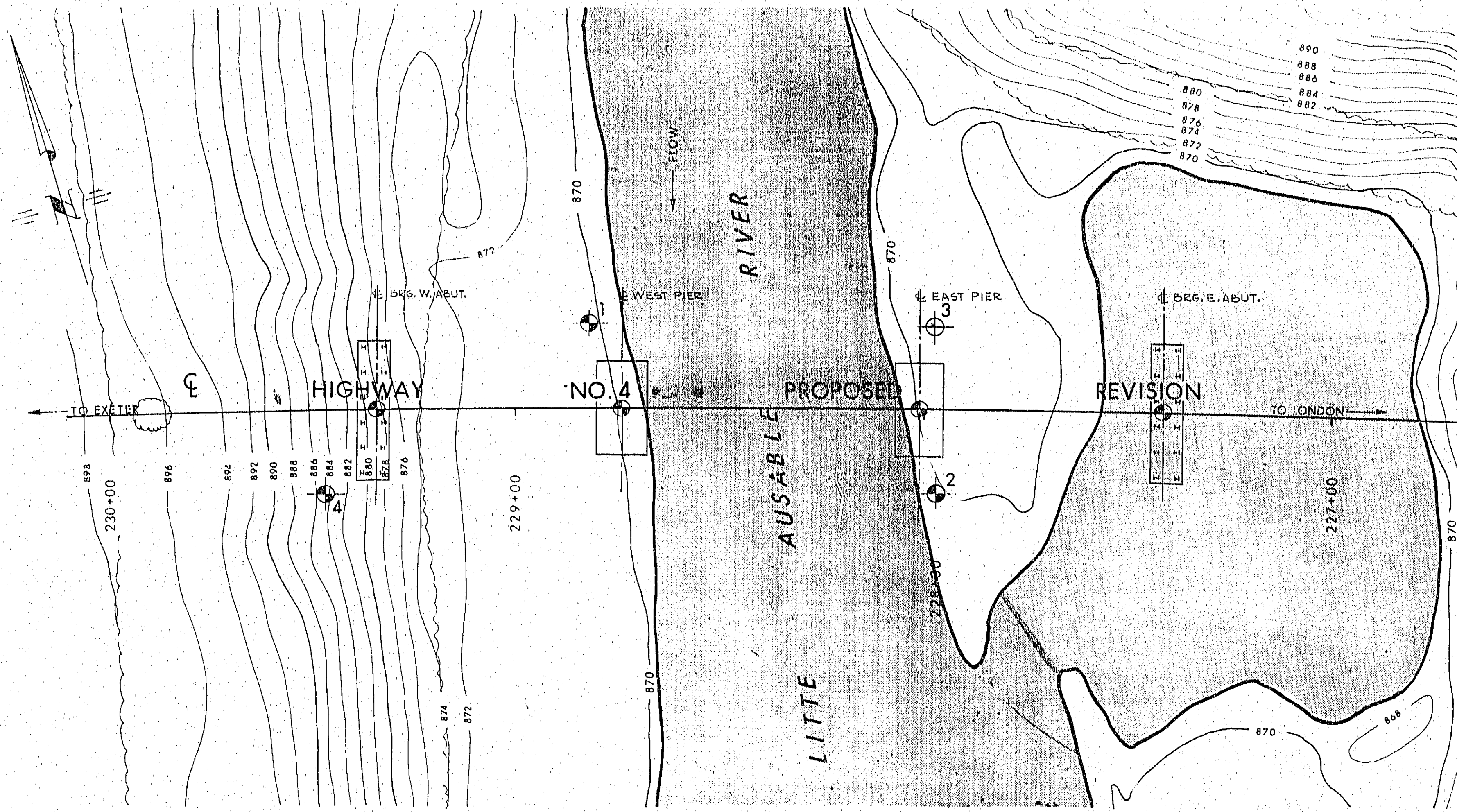
GENERAL ARRANGEMENT

APPROVED	BRIDGE ENGINEER	SITE No.	19-69	W.P. No.	152-63
DESIGN	R.H.	CHECK	C.H.	CONTRACT	No.
DRAWING	I.H.	CHECK	R.H.	DRAWING	No.
DATE	DEC. 1967	LOADING	HS20-44	D-6194-1	

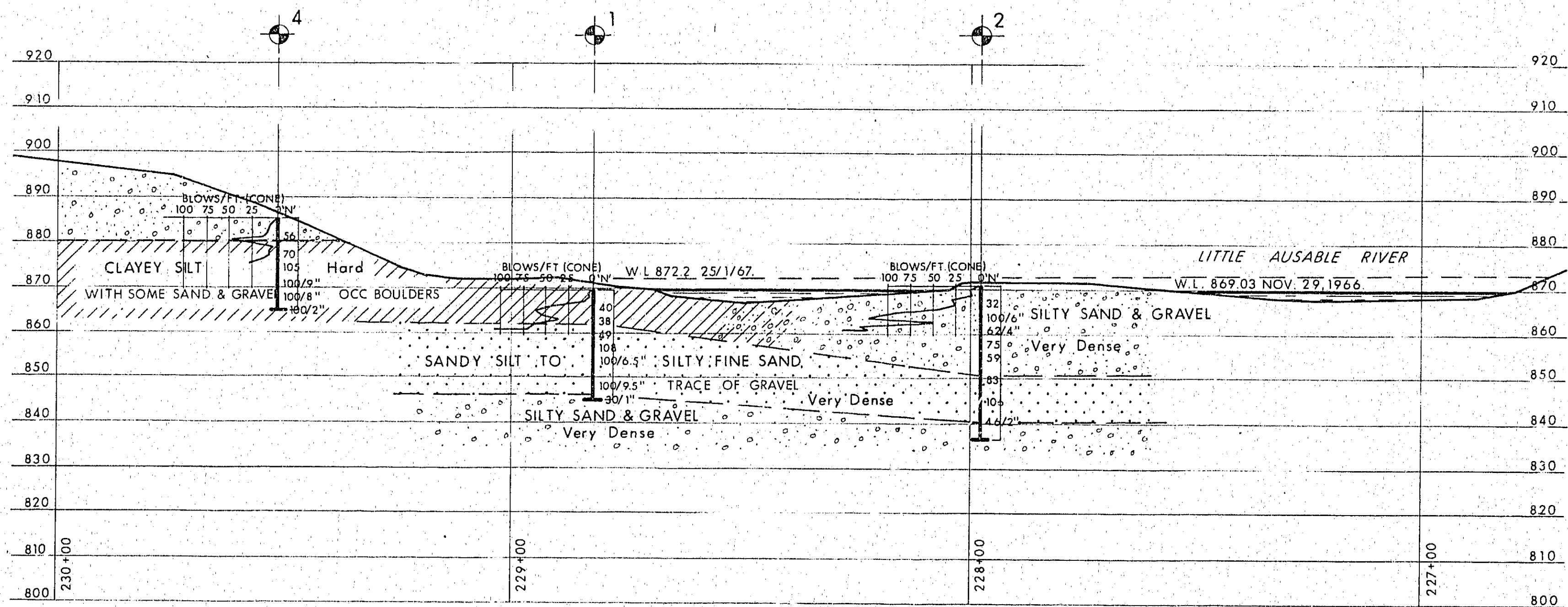


Twp. 93-64-1-B

PRINT RECORD	No.	FOR	DATE
	105	7/2/67	

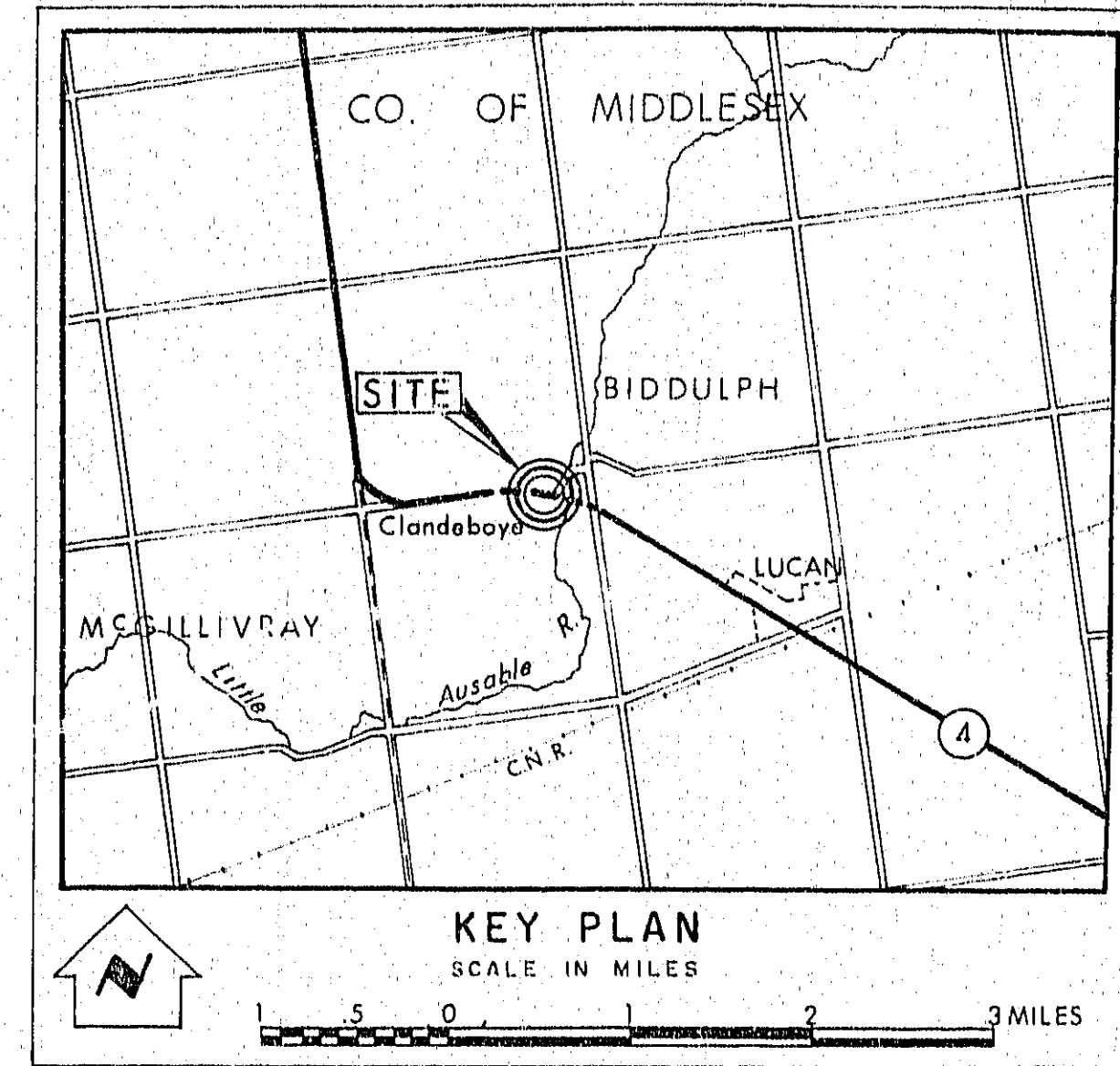


PLAN
SCALE
20 10 0 20 40 FT.



PROFILE
SCALE
20 10 0 20 40 FT.

NOTE
The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the London District Office.



LEGEND			
	Bore Hole		
	Cone Penetration Hole		
	Bore & Cone Penetration Hole		
	Water Levels established at time of field investigation.		

NO.	ELEVATION	STATION	OFFSET
1	869.6	228+83	21' RT.
2	870.2	227+98	21' LT.
3	871.0	227+98	21' RT.
4	885.0	229+48	21' LT.

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS - ONTARIO			
MATERIALS & TESTING DIVISION - FOUNDATION SECTION			
LITTLE AUSABLE RIVER			
KING'S HIGHWAY NO. 4 PROPOSED REVISION		DIST. NO. 2	
CO. MIDDLESEX		TWP. BIDDULPH	
LOT 2		CON. II S.L.R.	
BORE HOLE LOCATIONS & SOIL STRATA			
SUBM'D. A.C.C.	CHECKED <i>Asp</i>	W.P. NO. 152-63	M.B.T. DRAWING NO.
DRAWN B.S.	CHECKED <i>Asp</i>	JOB NO. 67-F-8	67-F-8A
DATE MARCH 61/67		SITE NO. 19-69	BRIDGE DRAWING NO.
APPROVED <i>Asp</i>	CONT. NO. 69-60	D-6194-2	

PRINT RECORD		
NO.	FOR	DATE
1	05	29/12/67

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