

DATE February 27, 2014**PROJECT No.** 12-1121-0193-1330**TO** Brad Craig, P.Eng.
Dillon Consulting Limited**FROM** Kevin Nelson, P.Eng.
Fin Heffernan, P.Eng.**EMAIL** Kevin_Nelson@golder.com
Fin_Heffernan@golder.com

**PRELIMINARY FOUNDATION INVESTIGATION (DESKTOP STUDY)
REHABILITATION OF NORTHUMBERLAND ROAD 26 UNDERPASS AT HIGHWAY 401
NORTH OF BRIGHTON, ONTARIO
W.P. 4051-11-01
GEOCRES 31C-224**

PART A – PRELIMINARY FOUNDATION INVESTIGATION (DESKTOP STUDY)

Scope of Work

Golder Associates Ltd. (Golder) has been retained by Dillon Consulting Limited (Dillon) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with numerous culvert and bridge replacements and rehabilitations at various locations in the Eastern Region of Ontario as part of the 23 Structures MEGA 3 project.

This technical memorandum provides the results of a preliminary foundation investigation (desktop study) completed as input to Dillon's preliminary assessment of the rehabilitation strategies for the existing underpass structure at Site No. 21-297 which is located at the crossing of Northumberland Road 26 over Highway 401 in Northumberland County, Ontario (WP 4051-11-01).

The purpose of the preliminary foundation investigation (desktop study) was to carry out a site visit and compile and review existing information related to subsurface conditions at the site and provide preliminary foundation engineering input for use by Dillon and MTO to determine strategy for the detail design stage.

Site Description and Existing Bridge Structure

The existing underpass structure carries Northumberland Road 26 over Highway 401 and is located to the north of Brighton, Ontario approximately 2 m to the east of the Highway 401 and County Road 30 interchange as shown on Drawing 1.

Available information indicates that Highway 401 was developed in a cut through a drumlin at the site. The original ground surface sloped across the site from south to north. The travelled lanes of Highway 401 have an asphalt surface elevation of approximately 195.5 m in the vicinity of the existing structure. The Northumberland Road 26 grade on the underpass is at an elevation of approximately 201.5 m. An approach embankment up to about 6.5 m in height was constructed on the north side of the underpass while the south embankment is understood to have been constructed above an existing cut slope.



During a site visit completed on October 30, 2013, no significant differential settlement of the structure was noted. Cracking of the asphalt was noted above the north abutment as well as above and near the ends of the approach slabs. New asphalt appeared to have recently been placed at the joint between the bridge deck and south approach slab.

Significant movement of, and damage to, the concrete slope paving erosion protection (e.g., buckling of slab panels, broken panels present at toe of slope, settlement and potential loss of ground beneath the panels near the south abutment etc.) present on the slope faces beneath the bridge abutments was noted during the site visit. In addition, gaps/voids were noted beneath the panels near the front edges of the abutments suggesting that some material may have been lost in these areas; this may have been a result of localized excavations as there were small piles of soil above some of the panels in this area as shown in the photo below.



Based on information provided by Dillon, it is understood that consideration is being given to constructing new semi-integral abutments supported by the existing abutment foundations.

Previous Investigation

The subsurface information used in the preparation of this memorandum was obtained from a previous Foundation Investigation Report prepared by the Ministry of Transportation Ontario (MTO), available from MTO Pavement and Foundations Section's GEOCRES database system, follow-up correspondence to the report and structural drawings for the bridge, as described below:

- Report prepared by the Ontario Department of Highways Materials & Research Section titled "Foundation Report on Highway 401 Line 'E' & County Rd. Revision Crossing, Lot 34, Con. II, Twp. Of Brighton, Approx. 2 Miles North of Brighton", W.P. 24-59, circa October 1959;

- April 7 and May 19, 1961 letters prepared by the Department of Highways Foundations Office addressed to the Bridge Division; and,
- Structural Drawing Nos. D-5045-1 to D-5045-10 (W.P. 24-59).

Four boreholes and three dynamic cone penetration tests were advanced as part of a 1959 subsurface investigation at the site. The information contained in MTO GEOCRE system for this site, including borehole and dynamic cone penetration test records, is included in Attachment A of this memo. The locations of the boreholes/penetration tests are displayed on the Borehole Location and Soil Strata drawing based on their locations shown on the Foundation Layout and Borehole Data structural drawing (Drawing D-5045-2) for the underpass and the northings and easting coordinates for the boreholes were then obtained from the current drawing.

Subsurface Conditions

The following provides a summary of the subsurface conditions encountered during the 1959 investigation:

- **Clayey Silt/Silty Clay**

A layer of clay silt and silty clay was encountered at ground surface at the location of Borehole BH2 located near the northern pier. This layer of clayey soil was approximately 2.4 m thick at the borehole location and extended to an elevation of 192.6 m.

Standard Penetration Test (SPT) 'N' resistance values of between 29 and 40 blows per 0.3 m were measured within the clay deposit. The borehole record describes this unit as being dense; however, based on the clayey nature of this material it is considered to have a very stiff to hard consistency.

- **Fine Sand**

Deposits of fine sand containing some gravel, traces of clay and interbeds/thin bands of clay silt and silt were encountered beneath the clayey silt/silty clay deposit at Borehole BH2 and at ground surface at the remainder of the borehole locations. Frequent bands of clayey silt and clay were encountered within the sand to depths of up to 2.4 m below ground surface with occasional bands encountered below 2.4 m.

SPT 'N' resistance values varying from 21 to 40 blows per 0.3 m were measured within the sand deposit within approximately 3 m of ground surface indicating these materials are compact to dense. SPT 'N' values ranging from 37 to 140 blows per 0.3 m of penetration were measured below about 3 m indicating the sand deposit is dense to very dense at depth.

The sand deposit was encountered to a depth of up to 6.5 m to 12.6 m below original ground surface (corresponding to Elevations of about 188.8 m to 182.3 m) at which depth the boreholes were terminated.

- **Groundwater Conditions**

Groundwater was encountered at an elevation of approximately 184.7 m during the investigation.

Follow-up correspondence to the foundation report was provided in a letter dated May 19, 1961. This letter identified that the existing fill at the location of the North Abutment was in a very dense state based on the results of a May 17, 1961 investigation at the site. No borehole records or further details of this investigation were included in the available information.

PART B – PRELIMINARY FOUNDATION DESIGN

This section of the technical memorandum provides preliminary foundation design recommendations for the proposed rehabilitation of the underpass structure located at the crossing of Northumberland Road 26 over Highway 401 (Site No. 21-297).

The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the previous subsurface investigation at the site and other available information about the underpass (i.e., available structural drawings for the underpass structure, follow-up correspondence to foundation report) as well as information provided to us by Dillon regarding the proposed rehabilitation works. The interpretation and recommendations provided in this report are intended only to provide the designers with information to assess the feasible foundation alternatives for the proposed underpass rehabilitation. As such, where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

Existing Structure and Proposed Rehabilitation

Based on information contained on the available structural design drawings, the following provides details on the existing structure:

- The existing underpass is a three-span structure constructed in the early 1960's which has an overall length of approximately 79.5 m. The bridge is skewed approximately 59 degrees from the highway alignment.
- The abutments for the structure are each supported on a spread footing perched within the lower to middle portions of the approach embankment fill. The abutment foundations are approximately 11 m long by 2.5 m wide and founded at elevations of approximately 194.8 m (north abutment) and 196.6 m (south abutment).
- The pier foundations consist of spread footings with dimensions of approximately 2.4 m by 8.8 m founded at elevations of approximately 193 m.

Based on information provided by Dillon, the rehabilitation work is planned to include repairing abutment bearing seats and the construction of new semi-integral abutments supported on the existing abutment foundations (if feasible), repairs to the bridge deck including concrete repairs and installation of new asphalt and waterproofing system, as well as removal of the existing railings and replacement with new concrete parapet walls and railings. The concrete slope paving present on the embankment slope face below the abutments is also proposed to be reconstructed.

Dillon has provided the following preliminary information regarding the existing and post-rehabilitation loading conditions for the underpass structure:

- The maximum toe pressures to be supported by the abutment foundations at Serviceability Limit States (SLS) will increase from 275 kPa (existing conditions) to 280 kPa (post rehabilitation conditions). These pressures are understood to be unfactored;
- The maximum toe pressures to be supported by the abutment foundations for Ultimate Limit States (ULS) conditions will increase from 281 kPa (existing conditions) to 290 kPa (post rehabilitation conditions); and,
- There will be only a nominal increase in loads on the pier foundations.

Preliminary Foundation Engineering Design Input

The following provides preliminary comments regarding the geotechnical resistance values that can be supported by the existing underpass foundations. The information in this memo is preliminary in nature and should be reviewed, and modified as necessary during detail design, once the loading conditions for the rehabilitation works have been finalized.

Abutment Foundations

The existing abutment foundations consist of 2.5 m by 11 m pad foundations founded in the lower to middle portions of the approach embankments on either side of the structure. The north abutment foundation is understood to be founded within very dense fill materials overlying native soils comprised of dense to very dense sand and potentially hard clayey silt. The south approach embankment was constructed in the area of a pre-existing cut slope and, as such, the south abutment footing may be founded either within the native sand deposits or partially within the approach embankment fill.

Based on the available information, the existing abutment foundations are considered to be capable of supporting a factored geotechnical resistance at Ultimate Limit States (ULS) of 300 kPa and a geotechnical resistance at Serviceability Limit States (SLS) of 300 kPa for 25 mm of settlement.

The above geotechnical resistances are provided for loads applied perpendicular to the surface of the footings; where applicable, inclination of the load should be taken into account in accordance with Section 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC 2006)* and its *Commentary*.

Based on information provided by Dillon, the proposed structural rehabilitation (i.e., conversion of existing abutment foundations to support semi-integral abutments) will result in maximum toe pressures of 280 kPa at SLS and 290 kPa at ULS.

Available structural drawings suggest that the foundations are founded a minimum of 2 m below the surface of the approach embankment slope face adjacent site grades. This founding level satisfies the minimum founding depth of 1.4 m for frost protection purposes.

Based on the above, the existing abutment footings are considered suitable for support of the loadings required for the rehabilitated structure.

Pier Foundations

The existing pier foundations consist of 2.4 m by 8.8 m pad foundations founded at depth of approximately 2.4 below Highway 401 road grades. At this level, the pier footings are expected to be founded within the dense to very dense native sand deposit.

Based on the available information, the existing pier foundations are considered to be capable of supporting a factored geotechnical resistance at Ultimate Limit States (ULS) of 500 kPa and a geotechnical resistance at Serviceability Limit States (SLS) of 350 kPa for 25 mm of settlement.

Available structural drawings suggest that the foundations are founded a minimum of 2 m below adjacent ground surface. This founding level satisfies the minimum founding depth of 1.4 m for frost protection purposes.

Based on information provided by Dillon, the proposed structural rehabilitation will result in nominal changes in the loads applied to the pier footings. Provided the final loads do not exceed the calculated geotechnical resistances at SLS and ULS for the pier footings identified above, the existing pier footings would be suitable for support of the loadings required for the rehabilitated structure.

OTHER CONSIDERATIONS

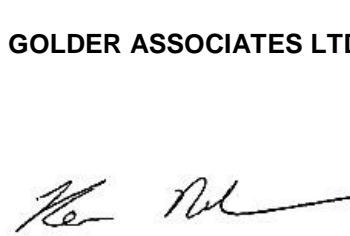
Deformation of the existing concrete embankment slope face protection panels, including buckling, sliding and cracking, was noted during the site reconnaissance. In addition, gaps beneath the panels near the front edges of the abutments suggest that some material appears to have been lost in this area; these gaps may have been a result of excavations in these areas.

Ongoing deterioration of the slope face protection could eventually impact the performance of the perched abutment footings. Therefore, it is recommended that slope protection measures be reinstated; the new slope face protection should be designed and constructed in accordance with the details provided on MTO Standard Drawing SS116-10 (Details of Concrete Slope Paving).

CLOSURE

This preliminary foundation investigation (desktop study) technical memorandum was prepared by Mr. Kevin Nelson, P.Eng. and reviewed by Mr. Fintan Heffernan P.Eng., the designated MTO contact for this project.

GOLDER ASSOCIATES LTD.



Kevin Nelson, P.Eng.
Associate, Geotechnical Engineer



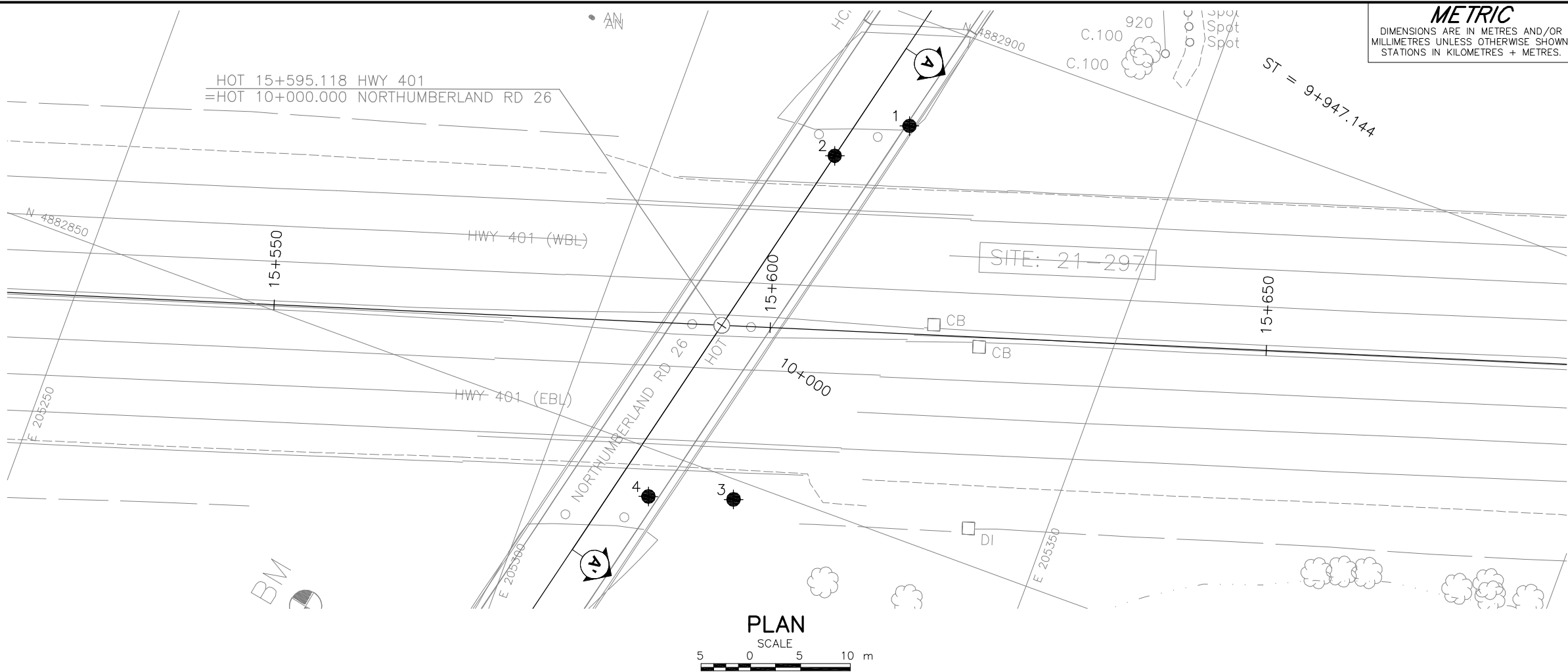
Fintan Heffernan, P.Eng.
Designated MTO Foundations Contact



KN/FJH/bg

n:\active\2012\1121 - geotechnical\12-1121-0193 dillon mega 3 eastern region\foundations\5 - reports\contract o - northumberland 21-297\12-1121-0193-1330 tm-001 dillon mega 3 northumberland final feb 2014.docx

Attachments: Drawing 1 – Northumberland Road 26 – Borehole Locations and Soil Strata
Attachment A – MTO GEOCRETS Information

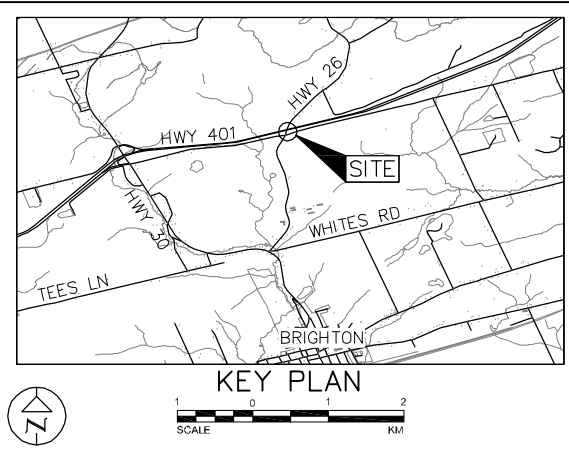


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 4122-09-01

BRIDGE REHABILITATION
NORTHUMBERLAND ROAD 26 UNDERPASS
BOREHOLE LOCATIONS AND SOIL
STRATA

Golder Associates Ltd.
OTTAWA ONTARIO, CANADA



LEGEND

Borehole - Previous Investigation

N Standard Penetration Test Value

16 Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
1	194.9	205323.0	4882889.5
2	195.1	205317.0	4882884.1
3	194.9	205319.4	4882848.1
4	195.4	205311.2	4882845.4

NOTES

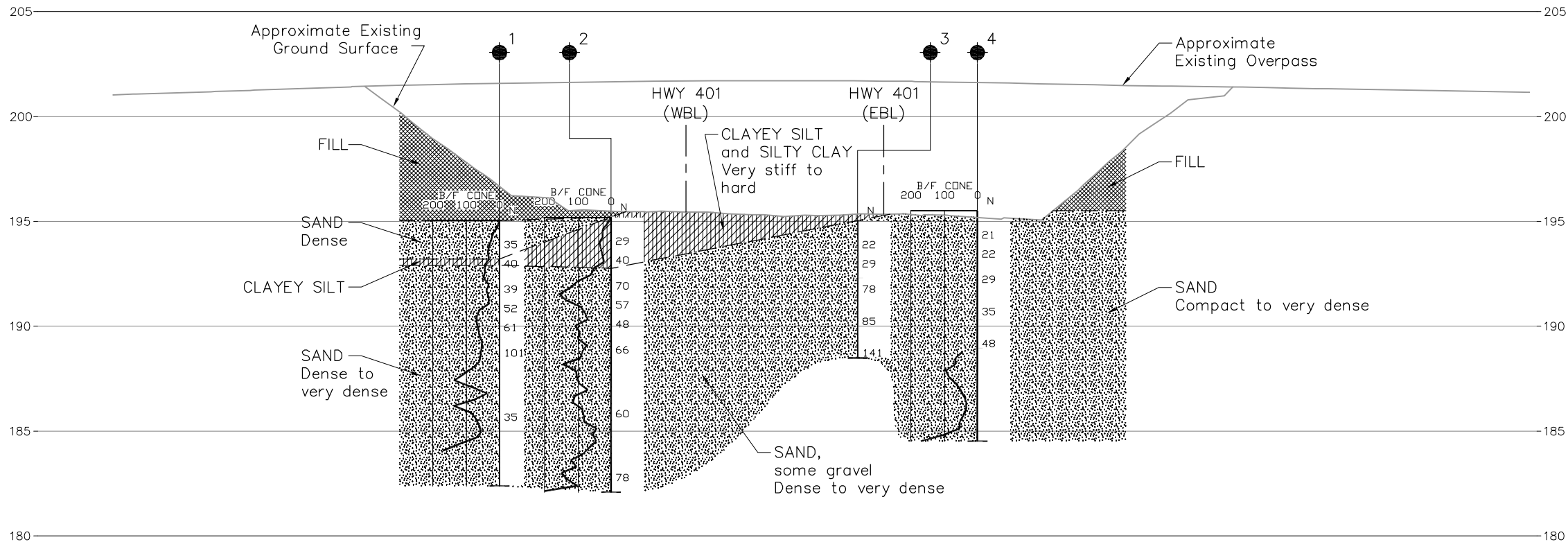
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plan provided in digital format by Dillon, drawing file no. B Plan.dwg and Photogrammetry.dwg, received October 20, 2013.



A-A'

HORIZ. SCALE
0 5 10 m

VERT. SCALE
0 2.5 5 m

NO.	DATE	BY	REVISION
Geocres No. 31C-224			
HWY. 401		PROJECT NO. 12-1121-0193-1330	
SUBM'D. KN		CHKD. KN	
DATE: 2/28/2014		SITE: 21-297	
DRAWN: JM		APPD. FJH	
DWG. 1			

ATTACHMENT A

MTO GEOCRES Information

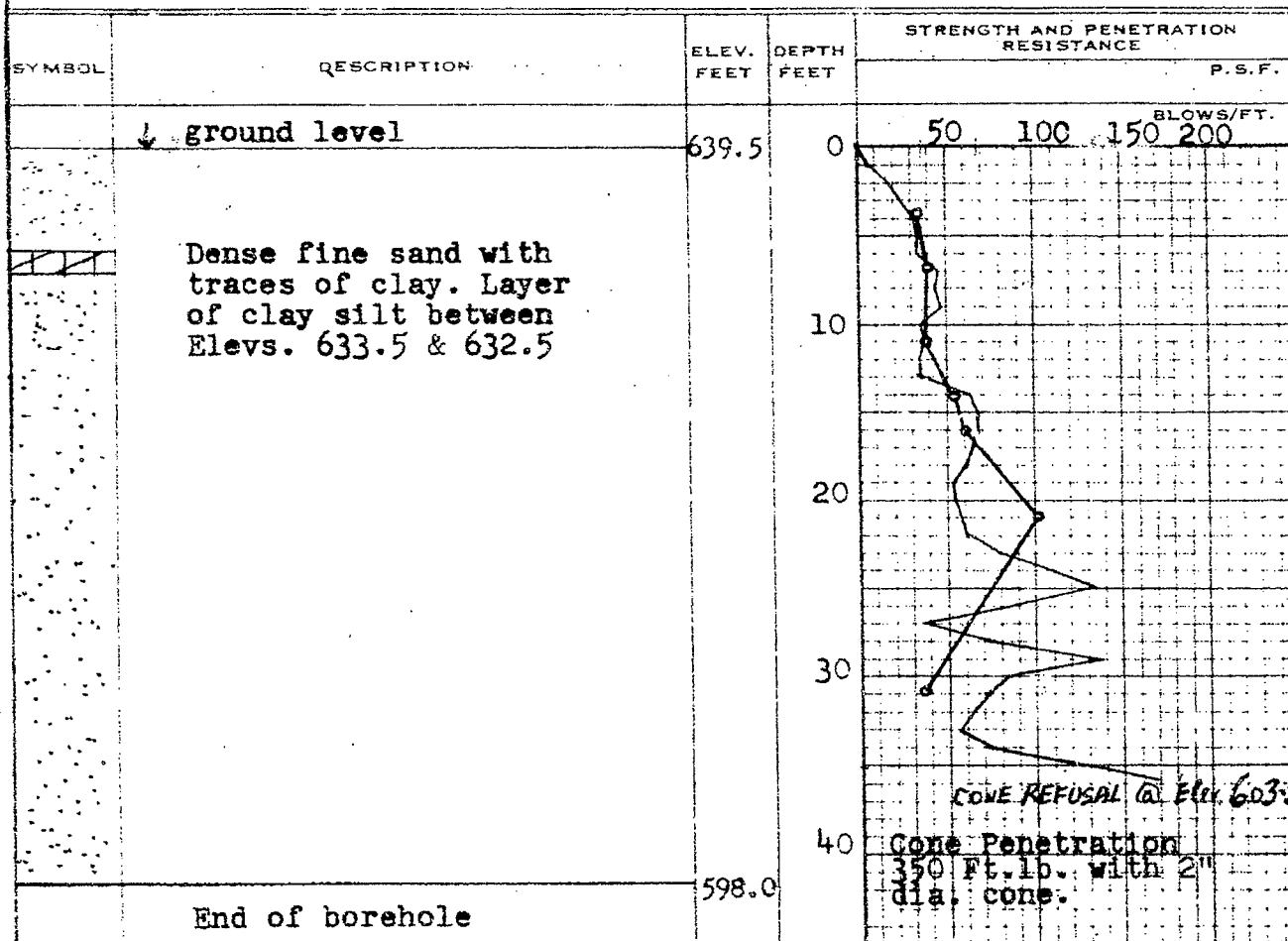
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS AND RESEARCH SECTION

W.P. 24-59 BORE HOLE NO. 1
JOB F 59-52 STATION See Drawing
DATUM Elev. 640' COMPILED BY BK
BORING DATE June 2/59 CHECKED BY AL

LEGEND

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

1/2 UNCONFINED COMPRESSION (Qu)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT



CONSISTENCY		SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.			
10 20 30			
x		S1	-
	x	S2	-
		S3	-
		S4	-
x		S5	-
	x	S6	-
		S7	-
x			
		S8	-

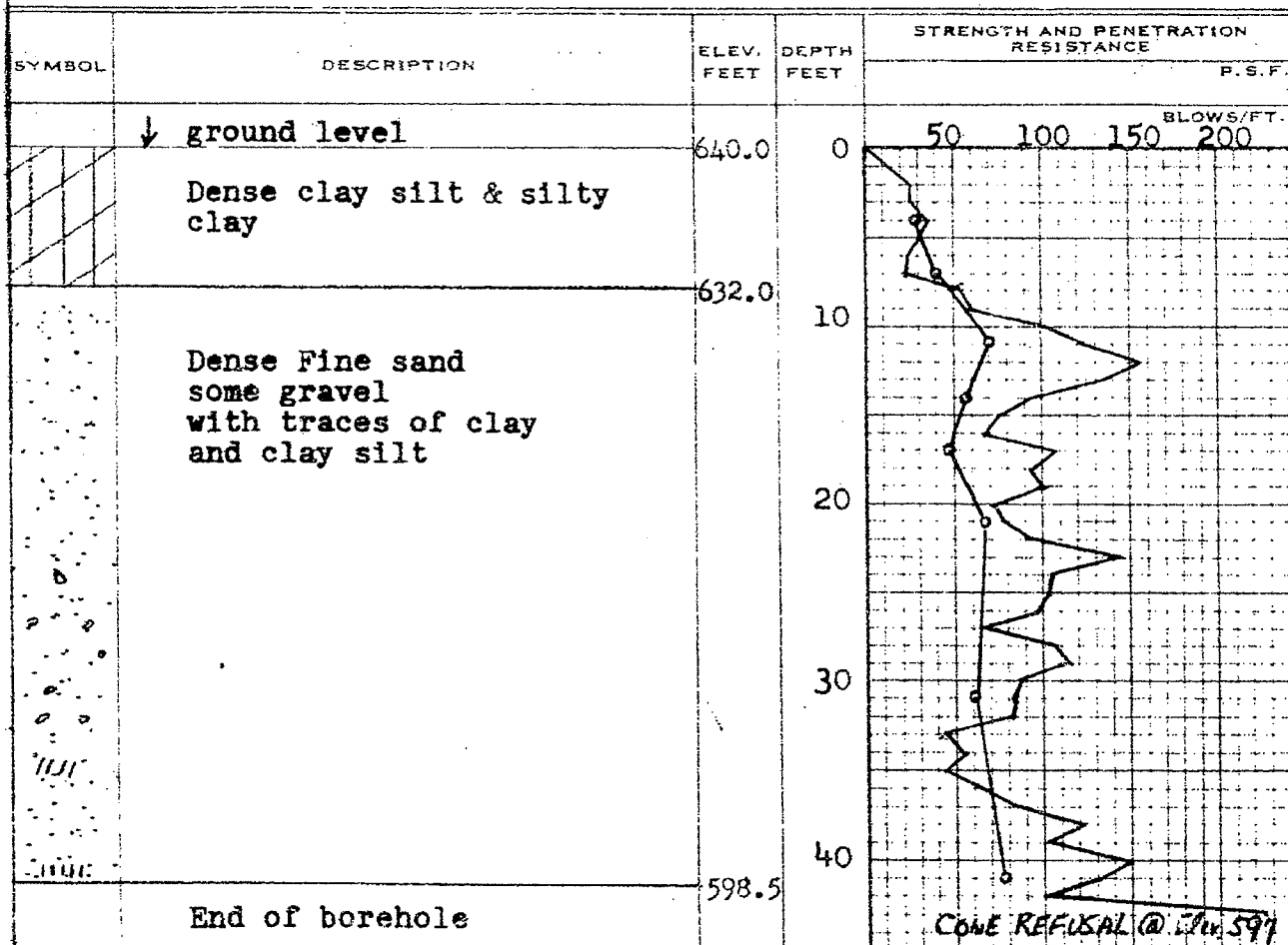
DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS AND RESEARCH SECTION

W.P. 24-59 BORE HOLE NO. 2
JOB F 59-52 STATION See Drawing
DATUM Elev. 640' COMPILED BY BK
BORING DATE June 2/59 CHECKED BY AL

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) O
VANE TEST (C) AND SENSITIVITY (S) +s
NATURAL MOISTURE AND LIQUIDITY INDEX LI
LIQUID LIMIT X
PLASTIC LIMIT



CONSISTENCY			SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.				
10	20	30		
			S1	-
			S2	137.5
			S3	-
			S4	-
			S5	-
			S6	-
			S7	-

DEPARTMENT OF HIGHWAYS - ONTARIO

W.P. 24-59 _____ BORE HOLE NO. 3 _____

JOB F 59-52 STATION See Drawing


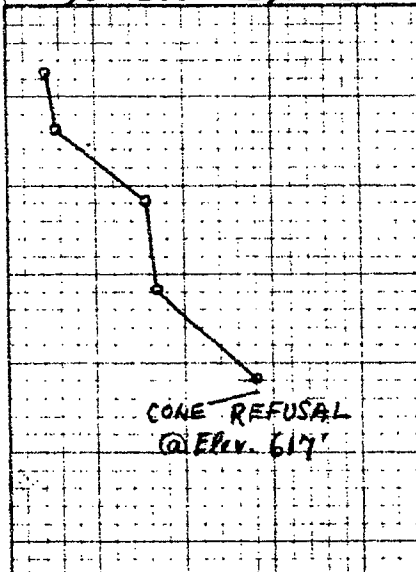

DATUM Elev. 640' _____ COMPILED BY BK _____

BORING DATE June 3/59 CHECKED BY AL

2" DIA. SPLIT TUBE _____
 2" SHELBY TUBE _____
 2" SPLIT TUBE _____
 2" DIA. GONE _____
 2" SHELBY _____
 CASING _____

LEGEND

1/2 UNCONFINED COMPRESSION (Qu)	---	0
VANE TEST (C) AND SENSITIVITY (S)	---	+s
NATURAL MOISTURE AND		
LIQUIDITY INDEX	---	X
LIQUID LIMIT	---	o
PLASTIC LIMIT	---	

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE	
				P.S.F.	
	↓ ground level	639.5	0	50 100 150 200 BLOWS/FT.	
	Dense Fine Sand with bands of clay and clay silt	630.5	10		
	Dense fine sand	618.0	20		
	End of borehole		30		

CONE REFUSAL
@ Elev. 617'

Cone Penetration
350 Ft. lb. with 2"
Dia. cone

[illegible]

B.H. # 3

OFFICE REPORT ON SOIL EXPLORATION

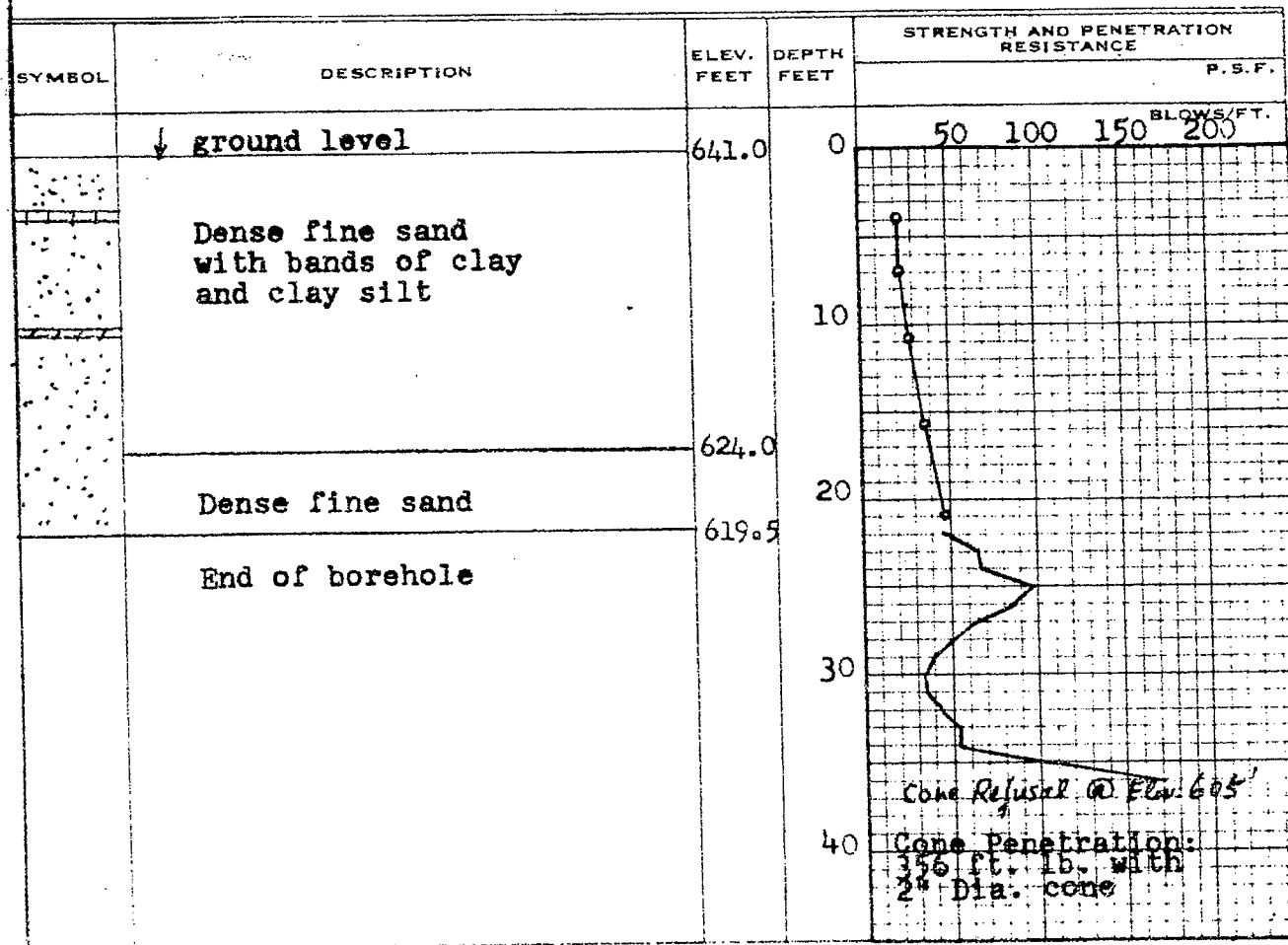
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS AND RESEARCH SECTION

W.P. 24-59 BORE HOLE NO. 4
 JOB F 59-52 STATION See Drawing
 DATUM Elev. 640' COMPILED BY BK
 BORING DATE June 3/59 CHECKED BY AL

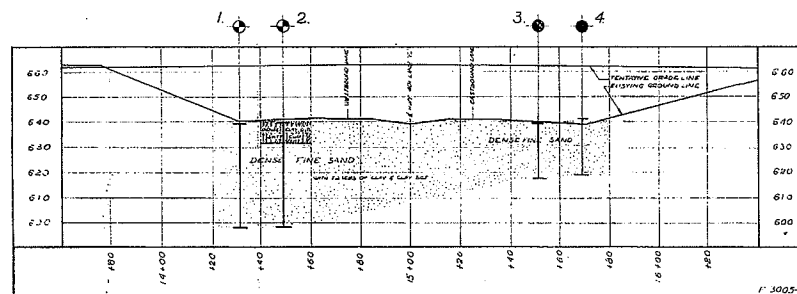
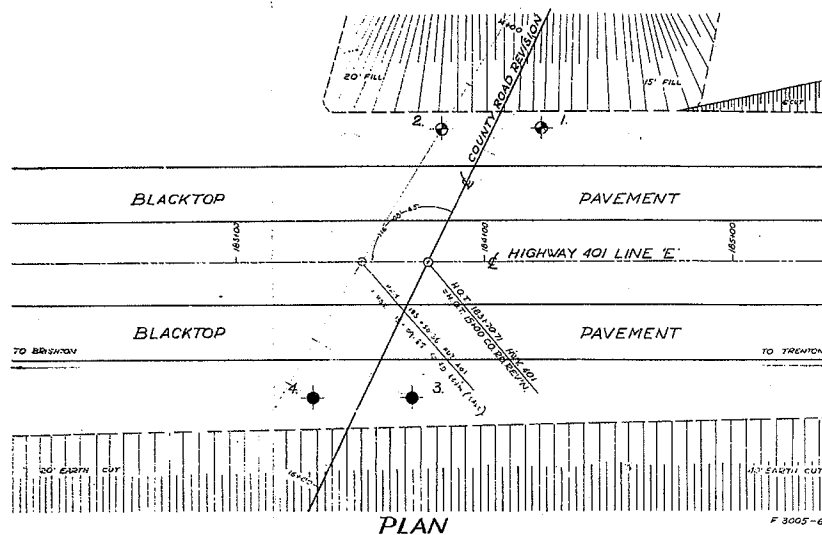
2" DIA. SPLIT TUBE
 2" SHELBY TUBE
 2" SPLIT TUBE
 2" DIA. CONE
 2" SHELBY
 CASING

LEGEND

1/2" UNCONFINED COMPRESSION (Qu) — O
 VANE TEST (C) AND SENSITIVITY (S) — +
 NATURAL MOISTURE AND LIQUIDITY INDEX — LI
 LIQUID LIMIT — X
 PLASTIC LIMIT —



CONSISTENCY			SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.				
10	20	30		
			S1	-
			S2	-
			S3	-
			S4	-
			S5	-



LEGEND			
DORE HOLE			
DORE & PENETRATION HOLE			
NO.	Elevation	Station	Distance from E
1	639.5	14+51	10.17
2	640.0	14+49	18.27
3	639.5	15+14	18.17
4	641.0	15+68	13.87

NOTE

THE DOWNSAMPLES OF SOILS TAKEN HAVE BEEN TESTED FOR THE DORE HOLE LOCATION BETWEEN HOLE 1 AND HOLE 2 AND HOLE 3 AND HOLE 4. THE RESULTS ARE SHOWN IN THE ADJACENT TABLES AND MAY BE SUBJECT TO CONSIDERABLE LAG.

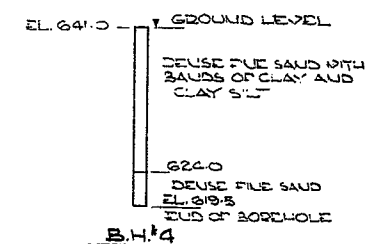
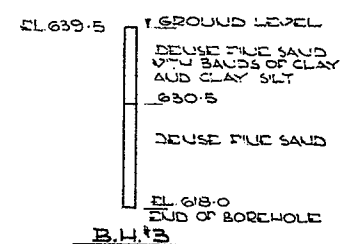
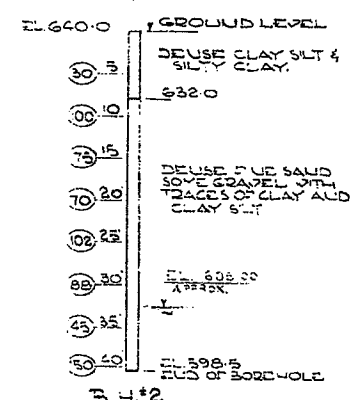
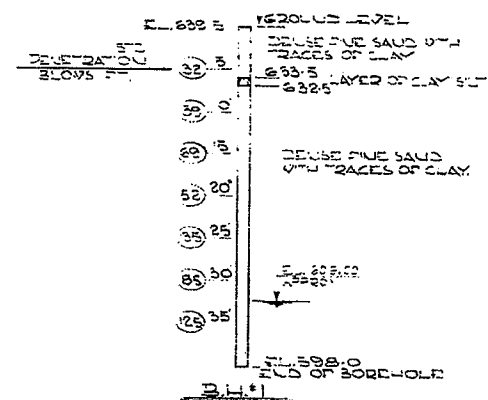
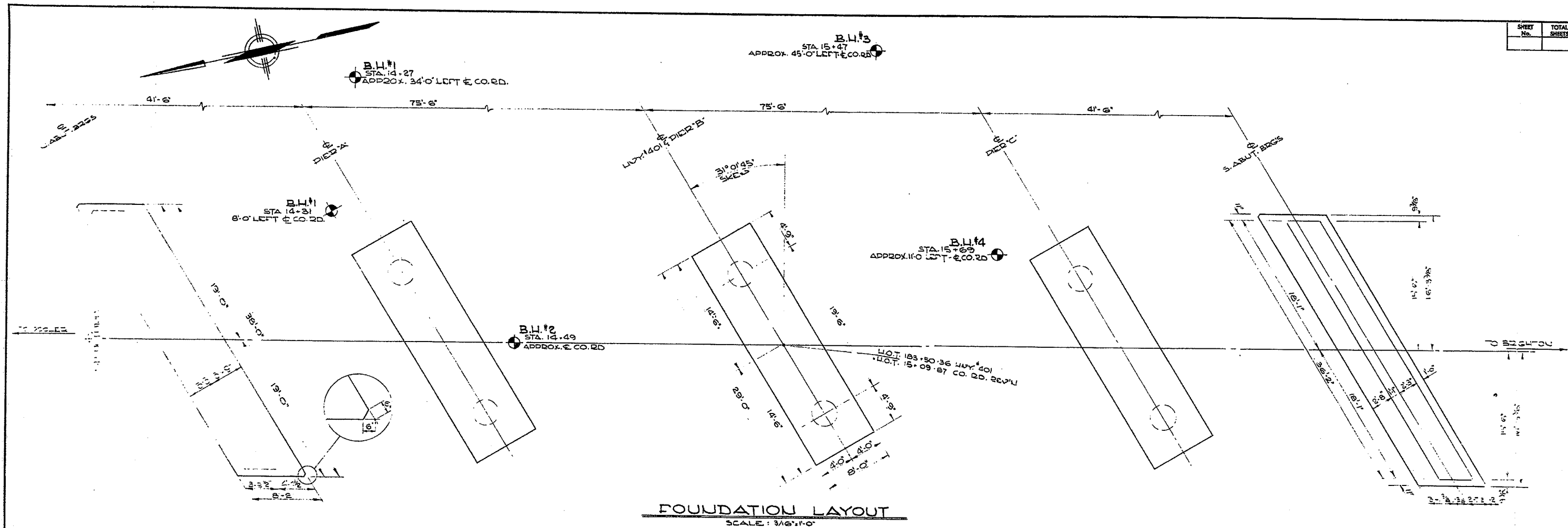
DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & INVENTORY SECTION

COUNTY ROAD REVISION CROSSING

SHOWING PORTIONS A ELEVATIONS OF HOLES

LINE	401 LINE E	CROSSING	7	COUNTY ROAD	281/201
TOWN	BRIGHTON	CON	36	CON	11
LOCATION	3 MILE NORTH OF BRIGHTON				
DESIGNED BY	J. J. McQuinn	DESIGNED BY		W.D.	11-50
DATE	10 AUG 1959	APPROVED		DATE	59-52A
SCALE	1 in = 30 FEET				



STANDARD PENETRATION RESISTANCE.
THE NO OF BLOWS BY A 140 POUND HAMMER DROPPED 30"
REQUIRED TO DRIVE A 2" DRIVE OPEN SAMPLER 1.0' INTO
THE GROUND.

BOREHOLES
N.T.S

REVISIONS			
	DATE	BY	DESCRIPTION

<p align="center">DEPARTMENT OF HIGHWAYS ONTARIO BRIDGE DIVISION</p>			
<p align="center">BRIDGE AT CO. RD. #26 UNDERPASS <u>15' x 15' 6" x 25' 6" OF HWY. #26</u></p>			
KING'S HIGHWAY No. 20		DIST. No. 1	
CO. NORTHUMBERLAND		BRIGLTON 72 30 52 25	
TWP. BRIGLTON		LOT 34	CON. 1
<p align="center">FOUNDATION LAYOUT & BORE-HOLE DATA</p>			
APPROVED <i>W. L. L.</i> REGIONAL ENGINEER		SITE No. 22-237	W.P. No. 24-53
DESIGN B.C. CHECK <i>W. S. L.</i>	CONTRACT No.		155 24 53 575
DRAWING <i>E. A.</i> CHECK B.C.	25-25 52-25		52-25
DATE JULY 1962	LOADING	H-20 S-16	DRAWING No. D-5045-2