

DATE February 27, 2014**PROJECT No.** 12-1121-0193-1230**TO** Brad Craig, P.Eng.
Dillon Consulting Limited**FROM** Kevin Nelson, P.Eng.
Fin Heffernan, P.Eng.**EMAIL** Kevin_Nelson@golder.com
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**PRELIMINARY FOUNDATION INVESTIGATION (PHASE 1 DESKTOP STUDY)
HAMILTON/HOPE BOUNDARY LINE UNDERPASS REHABILITATION
PORT HOPE, ONTARIO
W.P. 4028-12-11
GEOCRE 30M16-54**

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 provide preliminary foundation engineering services associated with numerous culvert and bridge rehabilitations and/or replacements 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 assessment of the rehabilitation strategies for the existing underpass structure located at Site No. 21-233 which is located at the crossing of Hamilton/Hope Boundary Line over Highway 401 in Port Hope, Ontario (WP 4028-12-11).

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 of the underpass rehabilitation.

Site Description and Existing Bridge Structure

The existing underpass structure carries Hamilton-Hope Boundary Line over Highway 401 and is located to the northeast of Port Hope, Ontario approximately 1.2 m to the east of the Highway 401 and Ontario Street (Regional Road 28) interchange as shown on Drawing 1.

The original ground surface elevation at the site varied from approximately Elevation 114 m to 115 m. Highway 401 is located slightly above original grade and has a top of asphalt surface of approximately Elevation 116 m to 116.5 m in the vicinity of the existing structure. The Hamilton-Hope Boundary Line road grade on the underpass is at an elevation of approximately 122 m to 123 m (increasing towards the north). Approach embankments up to about 6 m in height have been constructed on either side of the underpass.



During a site visit completed on October 30, 2013, differential settlement was noted between the top surface of the curb/sidewalk located on the bridge deck relative to portions of the curb/sidewalk located above the abutment/approach embankments; typically the bridge deck portions of the curb were approximately 10 mm to 15 mm higher than abutment/approach embankment sections. Based on available structural drawings, the curb/sidewalk located above the abutments in these areas appear to be structurally connected to the abutment foundations. No signs of embankment instability were observed during the site visit.

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 GEOCRE database, as described below:

- Report titled "Foundation Report on New Bridge at Highway 401 crossing the township line between Hope and Hamilton, about one mile north of Port Hope", W.P. 54-58, circa July 1958.

Two boreholes and four dynamic cone penetration tests were advanced as part of the above noted investigation. The information contained in MTO GEOCRE system for this site, including borehole and dynamic cone penetration test records, is included in Attachment A. The locations of the boreholes/penetration tests are displayed on the Borehole Location and Soil Strata drawing based on their locations shown on the General Plan and Elevation structural drawing 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 1958 investigation:

- **Fill**

A layer of 'Road Shoulder' Fill was encountered at ground surface at both of the sampled boreholes. The fill layer was 0.3 m thick at the borehole locations and extended to elevations of 113.8 m to 114.4 m.

- **Sandy Clay**

The borehole records indicate that a deposit of grey or brown clay was encountered beneath the shoulder fill materials.

Atterberg limit testing carried out on two samples of this deposit measured liquid limits of approximately 21 and 31 percent, plastic limits of approximately 11 and 23 percent and plasticity indices of about 8 and 10 percent. The text of the investigation report identified that a grain size analysis of this material indicated it consisted of about 70 percent binder material (inferred to mean silt and clay) and 30 percent fine aggregate (inferred to mean sand) suggesting this deposit is comprised of sandy clay.

The sandy clay extended to about Elevation 111 m to 111.5 m. In situ shear strength values measured within the clay ranged from about 3600 to 6000 psf (~172 to 287 kPa) suggesting the sandy clay has a very stiff to hard consistency. A Standard Penetration Test (SPT) 'N' resistance value of 86 blows per 0.3 m was measured within the clay deposit.

■ **Glacial Till**

Glacial till was encountered below the sandy clay in both boreholes. The text of the investigation report identified that a grain size analysis of this material indicated it consisted of about 40 percent binder material (inferred silt and clay), 38 percent fine aggregate (inferred sand) and 22 percent coarse aggregate (inferred gravel); based on this information, this deposit is considered to be a clayey sand till. SPT 'N' resistance values measured within the till varied from 56 to 107 blows per 0.3 m while DCPT resistance values were typically in excess of 100 blows per 0.3 m of penetration indicating that the till is very dense.

The till materials were encountered to depths of approximately 9 m to 9.5 m below original ground surface (corresponding to Elevations of about 104.5 m to 105.5 m.) at which depth the boreholes were terminated.

■ **Groundwater Conditions**

No information on groundwater conditions was included in the investigation report.

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 Hamilton/Hope Boundary Line over Highway 401 (Site No. 21-233).

The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the previous subsurface investigation at the site, information contained on the available structural drawings for the underpass structure as well as information provided to us by Dillon. 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 available structural design drawings, the following provides details on the foundations of the existing structure:

- The existing underpass is a three-span structure constructed in the late 1950's (Contract No. 85-41) which has an overall length of approximately 66 m.
- Each abutment for the structure is supported on a series of sixteen BP 12 x 53 (HP 310x79) piles that are situated in two lines of 8 piles per abutment. The tips of the piles in the front line (nearest Highway 401) are inclined/battered towards the highway at angle of 1 horizontal to 3 vertical (1H:3V). The abutment pile cap bases are located at elevations of approximately 118.5 m (north abutment) and 117.4 m (south abutment). The piles are understood to be 32 feet (~9.8 m) in length.
- The pier foundations consist of spread footings with dimensions of approximately 3.1 m by 11.9 m founded at elevations of approximately 110 m to 111 m.

Notes contained on the Abutment Reinforcement & Details drawing dated October 1958 indicate that the piles were to support a load of 40 tons (~356 kN) per pile. The available structural drawings do not indicate the bearing pressure used in the design of the pier footings. The MTO Foundation Report suggests that the soils below an elevation of 112.8 m can support a bearing value of 3 t.s.f. (~287 kPa) but that large settlements (greater than 95 mm) could occur and suggested constructing the footings at or below an elevation of 111.2 m to avoid hazards due to differential settlement.

Based on information provided by Dillon, the rehabilitation work is planned to include the construction of new semi-integral abutments supported on the existing abutment foundations (if feasible), repairs to the bridge deck including installation of new asphalt and waterproofing system, as well as removal of the existing railings and replacement with new concrete parapet walls and railings.

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

- The maximum loads to be supported by the abutment piles at Serviceability Limit States (SLS) will increase from 250 kN per pile (existing conditions) to 300 kN per Pile (post rehabilitation conditions). These loads are understood to be unfactored;
- The maximum factored load to be support by an individual abutment pile at Ultimate Limit States (ULS) conditions will increase from 335 kN (existing conditions) to 400 kN (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.

Shallow Footings (Existing Pier Foundations)

The piers of the existing underpass structure are supported on 11.9 m long by 3.1 m wide spread/pad footings founded at elevations of approximately 110 m to 111 m. The foundation subgrade soils present below this level are expected to be comprised of very dense clayey sand till.

Based on the available information, these spread/pad footings are considered capable of supporting a factored geotechnical resistance at Ultimate Limit States (ULS) of 800 kPa and a geotechnical resistance at Serviceability Limit States (SLS; for 25 mm of settlement) of 400 kPa. With respect to the SLS resistance value, it is noted that the proposed underpass rehabilitation activities are understood to result in only a nominal increase in loads; therefore, new/additional settlements of the spread footings are expected to be less than 5 mm.

These preliminary geotechnical resistances values described above relate to 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*.

The founding levels of the existing pier foundations are in the range of 5 m below the Highway 401 grade, and therefore, satisfy the minimum founding depth of 1.4 m for frost protection purposes.

As the calculated geotechnical resistances at SLS and ULS are higher than the recommended design bearing pressure identified in the MTO foundation investigation report and there is a minimal increase in loads on the piers, the existing pier footings are considered suitable for support of the loadings required for the rehabilitated structure.

Driven Steel H-Piles (Abutment Foundations)

Each of the abutments of the existing underpass structure are supported by sixteen BP 12 x 53 (HP 310x79) piles that were driven in two lines of 8 piles. The MTO Foundation report suggests that the piles were expected to meet refusal in the vicinity of elevation 360 ft (~110 m) which would result in the pile tips penetrating into the upper portion of the very dense till deposit.

The abutment pile caps have underside elevations of approximately 117.4 m (south abutment) and 118.5 m (north abutment) and the piles are understood to be 9.8 m long. The very dense glacial till deposit was encountered at elevations of approximately 111 m to 111.5 m. Based on this information, the piles are inferred to have been driven up to 2 m to 3 m into the till deposit or to have encountered effective refusal to driving in the till.

Based on the available information, the existing HP 310x79 piles that are understood to have been driven to refusal within the very dense till are considered capable of supporting a factored geotechnical resistance at Ultimate Limit States (ULS) of 400 kN.

The geotechnical reaction at SLS will not govern and may be higher than the factored geotechnical resistance at ULS. Furthermore, it is understood that the proposed rehabilitation will result in a load increase of about 50 kN per pile under SLS. The incremental settlement of the abutment pile foundations resulting from this proposed load increase is expected to be less than 5 mm for these piles founded in the very dense till.

Based on the above, the existing abutment piles are considered capable of support of the loadings at SLS and ULS that are required for the rehabilitated structure.

CLOSURE

This technical memorandum was prepared by Mr. Kevin Nelson, P.Eng. with technical input from Mr. Murty Devata, P.Eng., a specialist foundations consultant to Golder. Mr. Fin Heffernan, P.Eng., a Designated MTO contact for Golder, conducted an independent review of the technical memorandum.

We trust this memo meets with your current requirements. If you have any questions concerning this memo, please contact the undersigned.

Yours truly,

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 i - hamilton hope site site 21-223\12-1121-0193-1230 tm-001 dillon mega 3 hamilton hope final feb 2014.docx

Attachments: Drawing 1 – Hamilton/Hope Boundary Line Underpass – Borehole Locations and Soil Strata
Attachments A – MTO GEOCRETS Information

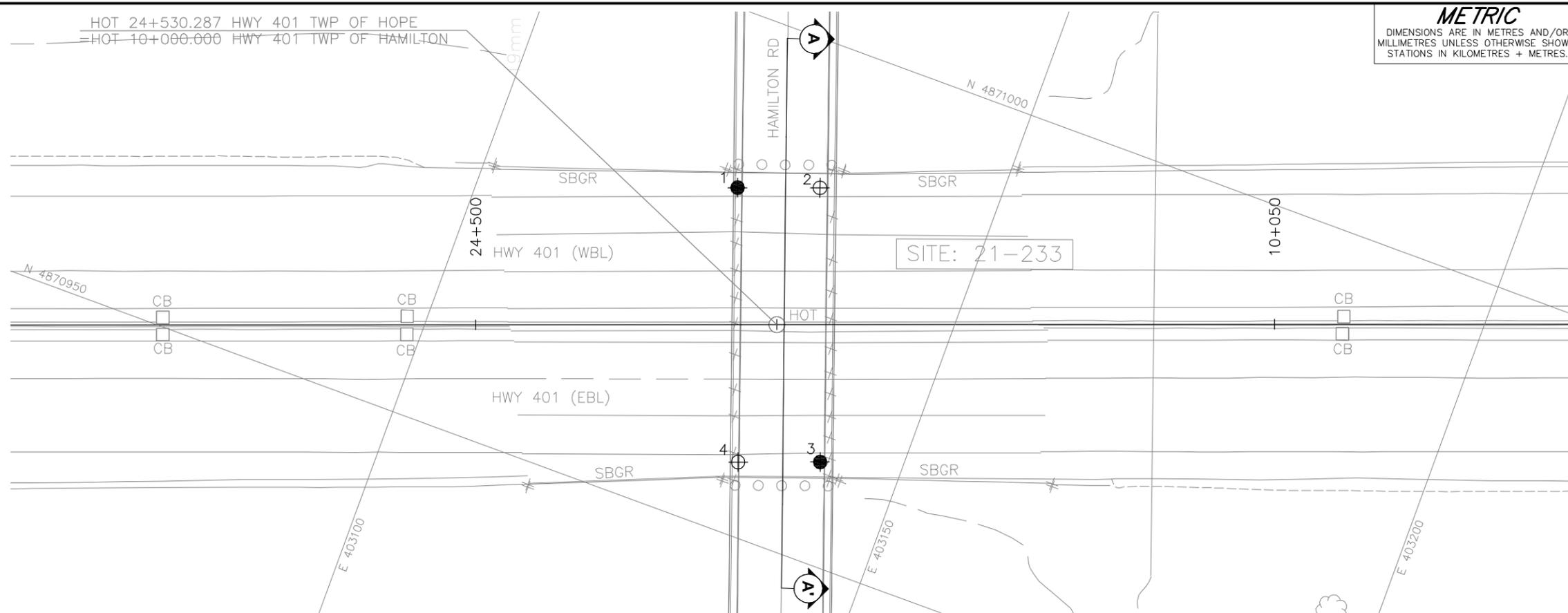
HOT 24+530.287 HWY 401 TWP OF HOPE
 =HOT 10+000.000 HWY 401 TWP OF HAMILTON

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

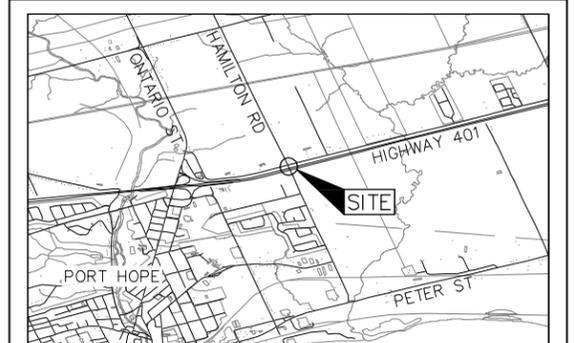
CONT No.
WP No. 4028-12-11



UNDERPASS REHABILITATION
 HAMILTON/HOPE BOUNDARY LINE UNDERPASS
 BOREHOLE LOCATIONS AND SOIL STRATA

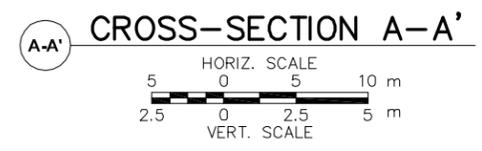
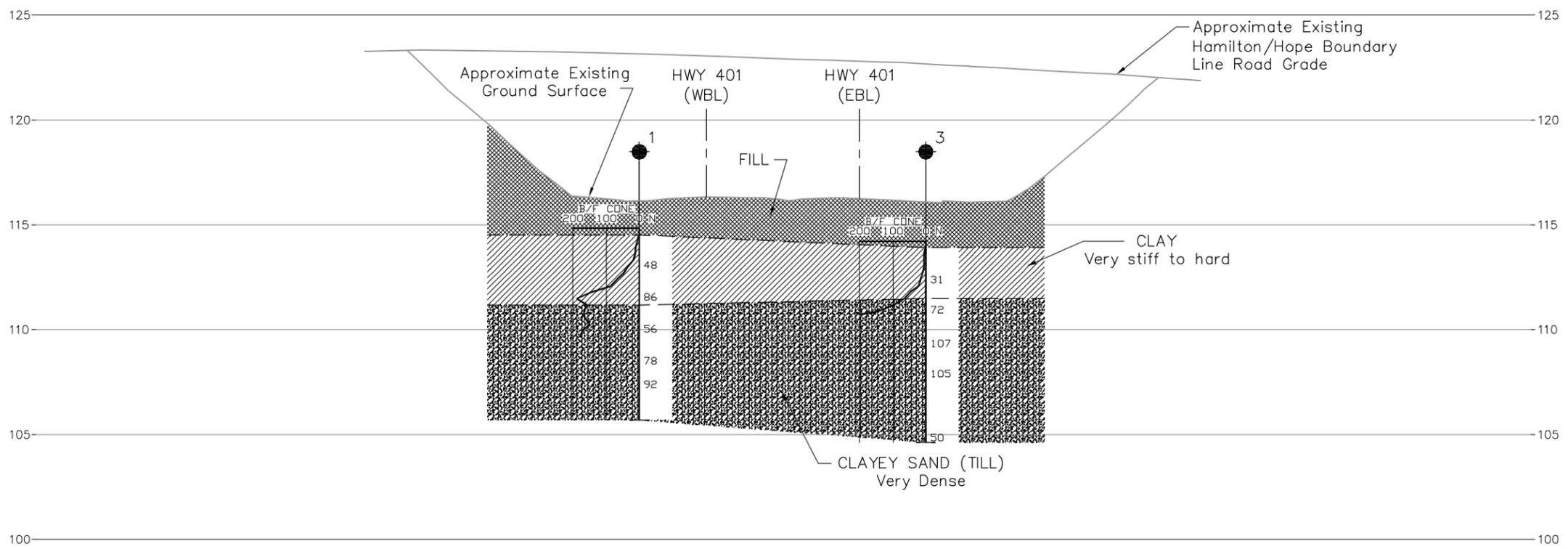


SITE: 21-233



LEGEND

- Borehole - Previous Investigation
- DCPT - Previous Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- Dynamic Cone Penetration Test



BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
1	114.8	4870983.0	403124.8
2	115.0	4870957.2	403134.3
3	114.22	4870960.1	403142.1
4	114.4	4870985.9	403132.6

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.

REFERENCE

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

NO.	DATE	BY	REVISION

Geocres No. 30M16-54

HWY. 401	PROJECT NO. 12-1121-0193-1230	DIST.
SUBM'D. KN	CHKD. KN	DATE: 2/28/2014
DATE: 2/28/2014	SITE: 21-233	
DRAWN: JM	CHKD. KN	APPD. FJH
		DWG. 1



ATTACHMENT A

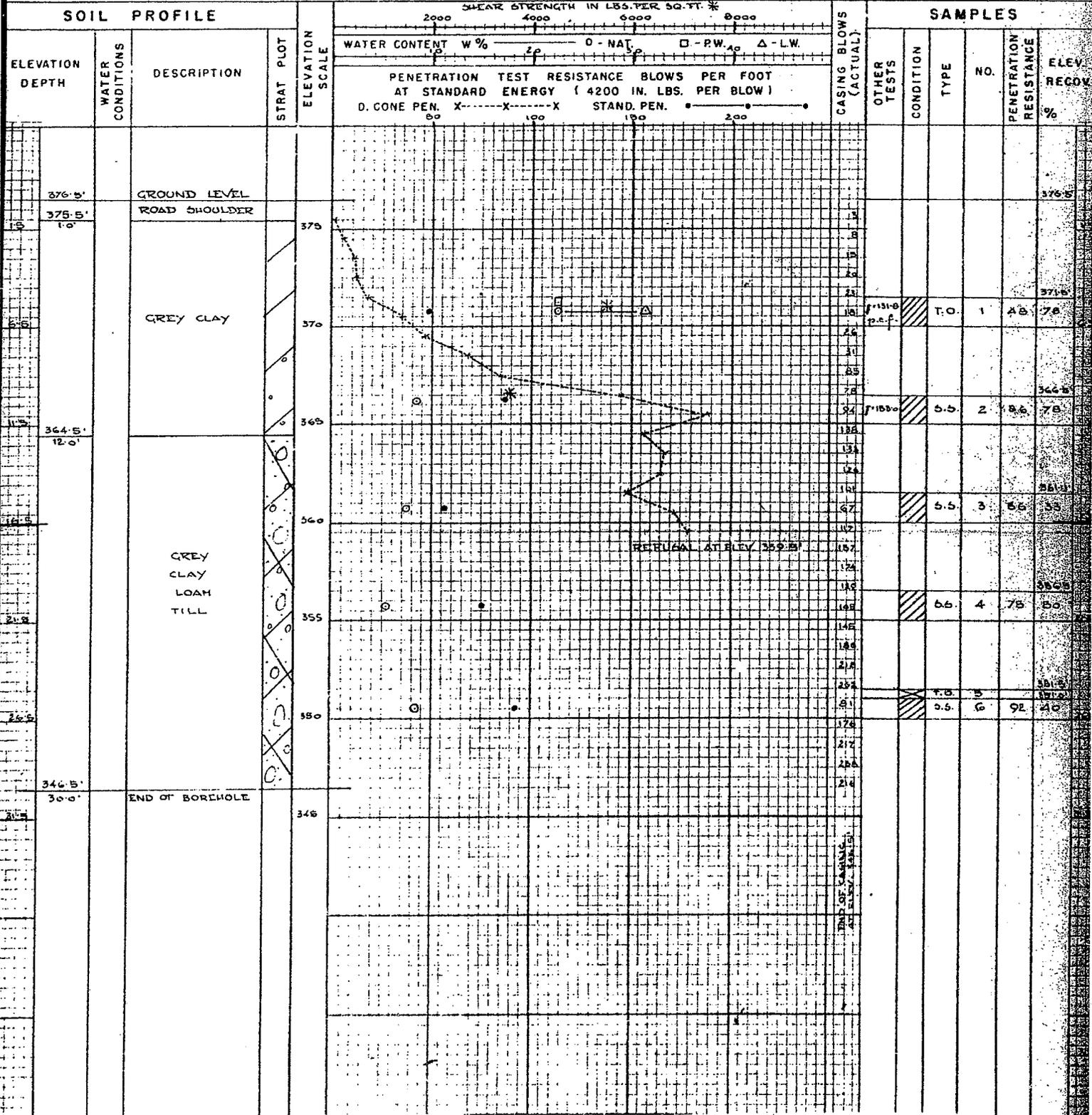
MTO GEOCRE Information

DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW
OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-1 OPERATION BORE & PENET'N JOB F-58-10 WP 54-5B BORING 1 STA. 476+57 (45 LT)
 CASING 3X (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT MAY 1958
 SAMPLER HAMMER WT. 250 LBS. DROP 12 INCHES COMPILED BY H.S. CHECKED BY A.L. DATE BORING 15 APRIL 1958

ABBREVIATIONS
 V - INSITU VANE SHEAR TEST Q - TRIAXIAL QUICK K - PERMIABILITY C.S. - CHUNK S.S. - SLEEVE SAMPLE
 M - MECHANICAL ANALYSIS S - TRIAXIAL SLOW C - CONSOLIDATION D.O. - DRIVE OPEN P.S. - PISTON SAMPLE
 U - UNCONFINED COMPRESSION WL - WATER LEVEL IN CASING CA - CASING D.F. - DRIVE FOOT VALVE WS - WASHED SAMPLE
 Q_c - TRIAXIAL CONSOLIDATED QUICK W.T. - WATER TABLE IN SOIL γ - UNIT WEIGHT T.O. - THIN WALLED OPEN R.C. - ROCK CORE

SAMPLE CONDITION
 - DISTURBED
 - FAIR
 - GOOD
 - LOST



DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW
OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-1 OPERATION BORE & PENET'N JOB F-58-10 WP 54-58 BORING 3 STA. 476+87(45' RT)
 CASING BX (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT MAY 1958
 SAMPLER HAMMER WT. 250 LBS. DROP 19 INCHES COMPILED BY H.S. CHECKED BY A.L. DATE BORING 18 APRIL 1958

ABBREVIATIONS

V - INSITU VANE SHEAR TEST Q - TRIAXIAL QUICK K - PERMIABILITY
 M - MECHANICAL ANALYSIS S - TRIAXIAL SLOW C - CONSOLIDATION
 U - UNCONFINED COMPRESSION WL - WATER LEVEL IN CASING CA - CASING
 Q_c - TRIAXIAL CONSOLIDATED QUICK WT - WATER TABLE IN SOIL γ - UNIT WEIGHT

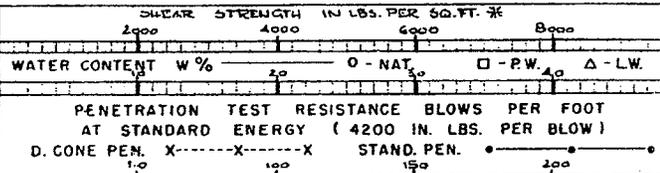
SAMPLE TYPES

C.S. - CHUNK S.S. - SLEEVE SAMPLE
 D.O. - DRIVE OPEN P.S. - PISTON SAMPLE
 D.F. - DRIVE FOOT VALVE W.S. - WASHED SAMPLE
 T.O. - THIN WALLED OPEN R.C. - ROCK CORE

SAMPLE CONDITION

 - DISTURBED
 - FAIR
 - GOOD
 - LOST

SOIL PROFILE



SAMPLES

OTHER TESTS	CONDITION	TYPE	NO.	PENETRATION RESISTANCE	ELEV. RECOVER
					374.5
					373.5
					370
					369.5
T-1480 P.C.P.		T.Q.	1	31	100
					364.5
		T.O.	2	72	72
					359.5
		D.O.	3	107	45
					354.5
		D.O.	4	105	50
					344.5
T-1420		S.S.	5	50	100

ELEVATION DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT PLOT	ELEVATION SCALE
374.5'		GROUND LEVEL		
373.5'		ROAD SHOULDER		
370'		BROWN CLAY		
365'				
360'		GREY CLAY LOAM TILL		
355'				
350'				
345'				
341.5'		END OF BOREHOLE		
340'				

END OF CASING AT ELEV. 341.5'

DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW
OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-1 OPERATION PENETRATION JOB F-58-10 W.P. 54-58 BORING 4 STA. 476+88 (45' RT.)
 CASING Bx (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT MAY 1958
 SAMPLER HAMMER WT. 250 LBS. DROP 19 INCHES COMPILED BY H.S. CHECKED BY A.L. DATE BORING 21 APRIL 1958

ABBREVIATIONS

V - INSITU VANE SHEAR TEST
 M - MECHANICAL ANALYSIS
 U - UNCONFINED COMPRESSION
 Qc - TRIAXIAL CONSOLIDATED QUICK
 Q - TRIAXIAL QUIK
 S - TRIAXIAL SLOW
 WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL
 K - PERMIABILITY
 C - CONSOLIDATION
 CA - CASING
 γ - UNIT WEIGHT

SAMPLE TYPES

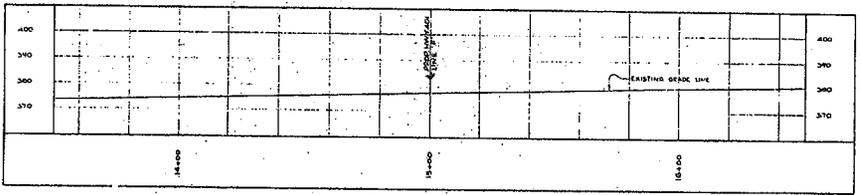
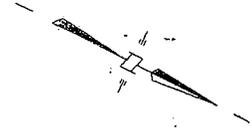
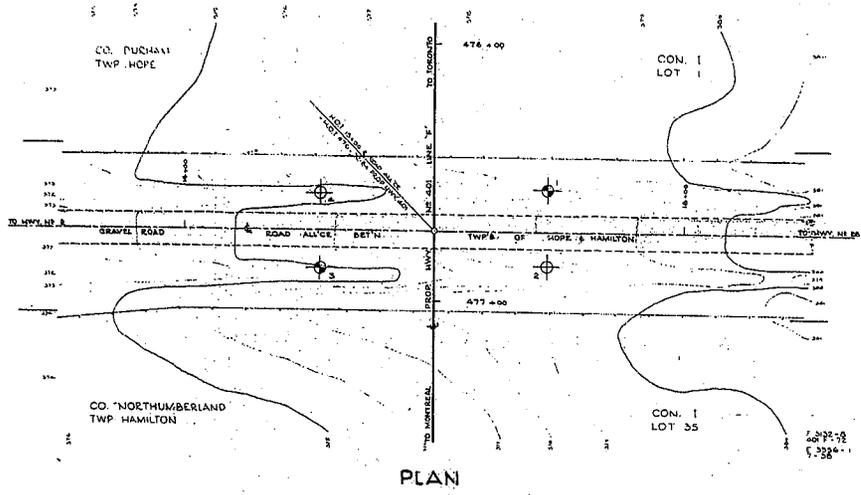
C.S. - CHUNK
 D.O. - DRIVE OPEN
 D.F. - DRIVE FOOT VALVE
 T.O. - THIN WALLED OPEN
 S.S. - SLEEVE SAMPLE
 P.S. - PISTON SAMPLE
 W.S. - WASHED SAMPLE
 R.C. - ROCK CORE

SAMPLE CONDITION

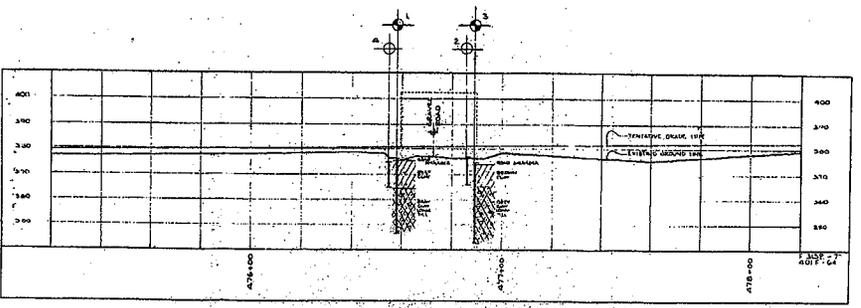


- DISTURBED
 - FAIR
 - GOOD
 - LOST

SOIL PROFILE				SAMPLES										
ELEVATION DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT. PLOT	ELEVATION SCALE	WATER CONTENT W %			CASING BLOWS (ACTUAL)	OTHER TESTS	CONDITION	TYPE	NO.	PENETRATION RESISTANCE %	ELEV. RECOV.
					○ - NAT.	□ - P.W.	△ - L.W.							
					PENETRATION TEST RESISTANCE BLOWS PER FOOT AT STANDARD ENERGY (4200 IN. LBS. PER BLOW)									
					D. CONE PEN. X-----X-----X STAND. PEN. ●-----●-----●									
					50 100 150 200									
375'		GROUND LEVEL		375										
5				370	(Graph showing penetration resistance curve)									
10				365	(Graph showing penetration resistance curve)									
					REFUSAL AT ELEV. 363 1/2'									



PROFILE OF GRAVEL ROAD



PROFILE OF HWY. NO. 401

LEGEND			
ALDER HOLE			
BORE HOLE			
PENETRATION HOLE			
ROCK & PENETRATION HOLE			

HOLE NO.	ELEVATION	STATION	DISTANCE FROM S.
I	376.5'	476+57'	45' LT
E	377.0'	476+01'	45' LT
J	374.6'	476+07'	45' RT
A	372.0'	476+68'	45' RT

— NOTE —
 THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BORE HOLE LOCATIONS. BOUNDARIES BETWEEN BORE HOLES THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE AND MAY BE SUBJECT TO CONSIDERABLE ERROR.

DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & RESEARCH SECTION - DOWNSVIEW

**GRAVEL ROAD
 PROPOSED CROSSING
 1 MILE N. OF PORT HOPE**
 SHOWING POSITION & ELEVATION OF HOLES

HWY. NO. 401	NR. 56-59	BY. NO. 7
CO. DURHAM & NORTHUMBERLAND	LOTS 34 & 1	CON. 1
TWP. HOPE & HAMILTON		

SCALE 1 IN. = 20 FT.	SUBMITTED BY	DATE 18 MAY 1958
DRAWN BY G.E.E.	APPROVED BY	DRAWING NO. E-58-10A