



**Preliminary Foundation
Investigation Report
GWP 4059-17-00**

Nagle Road Interchange Study
Town of Cobourg, Ontario

MTO Site No. 21X-0248/B0

Latitude 43.9935

Longitude -78.1445

G.W.P. 4059-17-00

Geocres No. 30M16-72

Prepared for:

Ministry of Transportation Ontario

Prepared by:

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Project No. 165001106

April 2021

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PRELIMINARY FOUNDATION INVESTIGATION REPORT

For
G.W.P 4059-17-00

Nagle Road Interchange Study (Site No. 21X-0248/B0)

Northumberland County and Cobourg, Ontario

1.0 INTRODUCTION

The Ministry of Transportation, Ontario (MTO) and the Town of Cobourg have retained Stantec Consulting Ltd. (Stantec) to undertake a Planning, Preliminary Design, and Class Environmental Assessment Study on Highway 401 for a new interchange near Nagle Road in the Town of Cobourg and the Township of Hamilton. This study is being completed concurrently with the Highway 401 Planning Study from Cobourg to Colborne (GWP 4060-11-00).

The project involves the replacement of the existing two-lane, three-span underpass on the same alignment as the existing bridge. The new underpass, which is being designed to accommodate the future widening of Highway 401 to an eight-lane configuration, is planned to consist of a two-span structure that will be longer and wider, to accommodate four lanes plus two turning lanes, than the existing bridge.

The purpose of the preliminary foundation investigation was to assess the subsurface conditions at the site of the bridge replacement by drilling 2 boreholes and carrying out in-situ testing to supplement existing borehole information and completing a laboratory testing program on selected soil samples obtained from the boreholes.

This Preliminary Foundation Investigation and Design Report (FIDR) has been prepared specifically and solely for the proposed bridge replacement project described above. This Preliminary Report is not to be used for the detail design of this project. A Detailed Foundation Investigation and Design Report will follow in the future after more site investigation is completed. The preliminary foundation recommendations presented in this preliminary report are subject to change, if necessary, based on the findings of the future site investigation.

2.0 SITE DESCRIPTION

2.1 SITE LOCATION

Nagle Road crosses over Highway 401 at approximately Station 13+429, approximately 4 km east of Cobourg, Ontario. The site location is shown on the Key Plan inset on the Borehole Locations and Soil Strata Plan, Drawing No. 1 in Appendix A.



2.2 SITE DESCRIPTION

Nagle Road is a two-lane undivided roadway that crosses over Highway 401 on a three-span underpass structure. At the bridge location, Highway 401 is a six-lane divided freeway with three lanes in each direction that is aligned in an approximate east-west orientation; as such, the structure will be referenced as being orientated south to north. The chainage on Highway 401 increases from west to east.

The elevations of the Nagle Road pavement surface at the underpass vary from approximately 146.7 m on the south side of the bridge to 150.1 m on the north side. At the bridge site, the asphalt surface on Highway 401 is at an elevation of just below 140.5 m. The original grade in the vicinity of the bridge was approximately 141 to 146 m indicating that the Highway 401 corridor was developed within a cut.

The existing bridge is a three-span structure constructed in the late 1950's (W.P. 88-57). The bridge has an overall length of approximately 78.8 m. The bridge north abutment and piers are supported on spread footings, while the south abutment is supported on piles. The structure underwent rehabilitation about 6 years ago. Additional details related to the existing bridge foundations are included in Section 8.2 of this report.

The ground surface at the Nagle Road underpass site is surrounded by relatively flat terrain within an overall slope towards the south. The lands surrounding the bridge site are undeveloped, typically contain grass and/or mature trees and are generally used for agricultural purposes.

Recent air-photos of the site show that ground modification work was carried out west/northwest of the existing underpass bridge, adjacent to the west bound lanes. The ground modification begins approximately 30 m west of the bridge and extends 200 m further to the west. This ground modification is associated with a cut slope (including construction access to the slope) that was constructed as part of the recent widening of the highway.

2.2.1 Site Reconnaissance

The following items were noted during a site visit on November 29th, 2019:

- No visible signs of settlement or deformation of the existing structure was noted. Areas of previous rehabilitation/patching were visible at numerous locations on the exposed concrete of the underpass structure.
- The asphalt on the bridge surface appeared to have been installed relatively recently and displayed minor cracking (longitudinal crack at centerline, transverse cracks near abutments). A photograph of the bridge looking north is provided below.





- No signs of embankment settlement or significant instability were observed. Some minor erosion of the embankment was noted in areas where surface water originating from the road appeared to have flowed over the slope face.
- The slope erosion protection beneath the abutments was in poor condition (e.g. overgrown with vegetation, displaced materials etc.).

2.2.2 Site Drainage

Regionally, surface water flow in the area of the site is typically from north to south towards Lake Ontario.

2.2.3 Geological Information

The site is located within the Iroquois Plain physiographic lowland region which borders the Lake Ontario and specifically within the subsection extending from Newcastle to Trenton. Chapman and Putnam (1984) states the following regarding this physiographic region: "From Cobourg to a point a few miles east of Colborne, the Iroquois Plain is about three and half miles wide and has a peculiar belted pattern. Through the center along Highway 2, numerous drumlins can be seen. They are large drumlins, some of them reaching heights of 150 feet or more, while some slopes have been over steepened by the waves of post-Iroquois waters. They have a southward alignment and the hollows between them are floored with silt. To the north along the route of Highway 401, the high shoreline of Lake Iroquois may be seen, the old waterplane rising steadily from 565 feet a.s.l. near Baltimore to 600 feet a.s.l. near Biddy Lake".

Existing geological mapping suggests the Nagle Road underpass structure is underlain by a sandy silt to silty sand-textured till. Coarse textured glaciolacustrine deposits consisting of sand and gravel with minor silt and clay are present to the north of the site.



Review of available water well records for wells located to the south of the bridge site indicates that bedrock was encountered at depths of approximately 25 m to 40 m below ground surface.

3.0 PREVIOUS INVESTIGATIONS / AVAILABLE INFORMATION

Prior to carrying out the subsurface investigation, Stantec reviewed subsurface information available within the MTO GEOCRE database. The following provides a summary of reports that provided information near to the proposed underpass replacement location.

- GEOCRE Report titled “Foundation Report on New Bridge at Highway No. 401, Line ‘E’ Underpassing Gravel Road between Lots 9 and 10, Township of Hamilton, Northeast of Cobourg” prepared by the Materials & Research Section – Downsview of the Department of Highways – Ontario in 1958 (GEOCRE Reference No. 30M16-019).

The investigation consisted of advancing two boreholes with adjacent dynamic cone penetration tests and an additional two dynamic cone penetration tests at the site between the dates of November 12th and 25th, 1957. Borings 1 and 3 were drilled by advancing BX casing using a skid-mounted core drill machine. A series of sleeve samples were collected at these locations. Borings 2 and 3 consisted solely of dynamic cone penetration tests. The borehole records indicate that a 250 lb (~113.6 kg) hammer was used with a drop height of 19.5 inches (~0.50 m) during sampling; it is noted that this is not the standard hammer size or drop height used for Standard Penetration Tests (SPTs) which uses a 140 lb (~63.5 kg) hammer with a 30 inch drop (~0.76 m). Therefore, the penetration resistances measured are considered to be similar to, but do not represent, SPT ‘N’ values. Penetration resistances of greater than 100 blows for 0.3 m of penetration of the sleeve sampler were measured at all except one location where a resistance of 44 blows per 0.3 m of penetration was recorded.

The subsurface stratigraphy encountered at the boreholes consisted of a surficial layer of topsoil underlain by an extensive deposit of glacial till. The till was encountered to the maximum depths investigated which extended to depths of 9.4 m below the original ground surface. The till deposit is described as a boulder “gravel - sandy loam till”. The deposit is reported to be made up of about 20% cohesive material, 45% fine aggregate, and 35% coarse aggregate with a moisture content of about 5.5%.

Dynamic cone penetration tests (DCPTs) were performed by driving a cone to refusal at each of the testing locations. As noted above, the borehole records indicate that a 250 lb (~113.6 kg) sampling hammer and a drop height of 19.5 inches (~0.50 m) was used during the testing. These tests were terminated upon encountering refusal at elevations ranging from approximately 137.7 m to 144.4 m. The DCPT records indicate that bouncing of the hammer was observed at the refusal depth at all locations; this may have been due to the presence of cobbles and/or boulders in the till soil at the site. Lower penetration resistances were recorded within the upper portions of the DCPTs, up to about 3 m from the original ground surface at some locations, however, these looser materials were removed as part of the original construction of the highway in order to attain the pavement subgrade level.

Piezometers/monitoring wells were not installed as part of this investigation.

The approximate locations of the boreholes and cone penetration tests are shown on the Borehole Location Plan (Drawing No. 1) provided in Appendix A based on the Drawing No. F-57-46A from the above-mentioned GEOCRE



report. The borehole records from the investigation and the original borehole location plan are included in Appendix B for reference.

4.0 SUBSURFACE CONDITIONS

4.1 FIELD INVESTIGATION PROCEDURES

The current subsurface investigation program consisted of advancing two boreholes, identified as BH20-1 and BH20-2, with one borehole advanced at each side of highway. Borehole BH20-1 was drilled to the east of the existing bridge in the south shoulder of the highway (i.e. immediately south of the east-bound lanes of Highway 401) while Borehole BH20-2 was drilled on east side of the Nagle Road at the north abutment of the proposed bridge. The locations of these boreholes are shown on the Borehole Locations and Soil Strata Plan, Drawing No. 1, in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of both private and public utilities.

The boreholes were advanced using truck or track-mounted drill rigs equipped for soil sampling between the dates of April 29th and May 5th, 2020. Borehole BH20-1 was carried out using continuous flight solid-stem augers while Borehole BH20-2 was advanced using continuous flight hollow-stem augers up to approximately 7.5 m depth and wash boring methods were used thereafter. Coring methods were used to advance this borehole from 8.5 m to 9.1 m below ground surface after casing refusal was encountered on an inferred boulder.

The subsurface stratigraphy encountered in each borehole was recorded in the field by a member of Stantec's geotechnical staff. Standard Penetration Tests (SPTs) were carried out in the boreholes and split spoon samples were collected at regular intervals. All recovered SPT samples were returned to our Ottawa laboratory for detailed classification and testing.

Groundwater conditions were observed during drilling and on completion of drilling of each borehole. After completion of drilling, the boreholes were sealed with bentonite. Borehole BH20-1 was provided with a surficial layer of cold patch asphalt.

4.2 LOCATION AND ELEVATION SURVEY

The boreholes were located in the field relative to the existing site features and the borehole locations and elevations were subsequently determined by Tulloch Geomatics, a licensed survey firm. The borehole coordinates and ground surface elevation information are considered accurate to 0.1 m. Table 4.1 below summarizes the borehole location information with the borehole ground surface elevations, depths and termination elevations.

Table 4.1: Borehole Coordinate and Elevation Information

Borehole	MTM Zone 11 Coordinates		Approximate Ground Surface Elevation (m)	Borehole Depth (m)	Borehole Termination Elevation (m)
	Northing	Easting			
BH20-1	4873498.6	413530.6	140.6	11.3	129.3
BH20-2	4873554.4	413513.4	149.0	12.8	136.2



4.3 LABORATORY TESTING

All samples were transported to Stantec's Ottawa laboratory where they were visually examined by a geotechnical engineer. The geotechnical laboratory testing program completed on the borehole samples is summarized in Table 4.2.

Table 4.2: Geotechnical Laboratory Testing Program

Test Description	Number of Tests
Moisture Content	25
Atterberg Limits	2
Grain Size Distribution (sieve & hydrometer)	8

Two soil samples, one from each borehole location, were also tested for pH, soluble sulphate content, chloride content, and resistivity by Paracel Laboratories Ltd. of Ottawa.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

4.4 OVERBURDEN STRATIGRAPHY

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are displayed on the Record of Borehole sheets contained in Appendix C. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix C. The results of geotechnical laboratory testing are presented in Appendix D. Drawing No. 1 in Appendix A illustrates the borehole locations and includes a stratigraphic section of the soils encountered in the boreholes.

The stratigraphic boundaries on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact boundaries between geological units.

In general, the subsurface stratigraphy encountered at the borehole locations consisted of a surficial layer of topsoil or asphalt underlain by a fill layer (Highway 401 pavement structure and approach embankments) underlain by a deposit of glacial till. The till is well-graded and predominantly generally granular in nature, ranging in composition from silty sand to silty sandy gravel, with the exception of the upper portion of the till at Borehole BH20-1 which is comprised of clayey silt with sand. Both boreholes were terminated within the till at depths of 11.3 m to 12.8 m below existing ground surface.

The following sections provide a summary of the subsurface conditions encountered during the investigation.

4.4.1 Surficial Materials

Boreholes BH20-1 was drilled through the existing asphalt in the south shoulder of the highway. The asphalt thickness at this borehole location was approximately 300 mm.

An approximately 75 mm thick, surficial deposit of topsoil was encountered at ground surface at the location of Borehole BH20-2.



4.4.2 Fill

Cohesionless fill materials were encountered beneath the asphalt in Borehole BH20-1 and below the topsoil in Borehole BH20-2.

The fill material encountered in BH20-1 is associated with the Highway 401 pavement structure and consists of silty sandy gravel fill. Standard Penetration Test (SPT) N-values ranging from 25 to 49 blows per 0.3 m of penetration were measured within the pavement structure fill indicating it is in a compact to dense state. This pavement structure fill is approximately 1.0 m thick and extends to 1.3 m depth or an elevation of approximately 139.2 m.

The fill material encountered in BH20-2, which is inferred to be associated with the approach embankment to the Nagle Road underpass structure, varies in composition from silty sand near ground surface to gravelly sand near the base of the fill. The fill was noted to contain trace clay and rootlets and is inferred to contain cobbles and boulders based on grinding of augers noted at multiple locations within the fill. SPT 'N' values of between 5 and 9 blows per 0.3 m of penetration were measured within these fill materials indicating these materials are in a loose state. The fill at BH20-2 is approximately 3.0 m thick with the base of the fill at an elevation of approximately 146.0 m.

Laboratory testing of samples of the fill materials yielded moisture contents that ranged from approximately 4 to 10%, expressed as a percentage of the dry weight of the soil. Gradation analyses were carried out on two (2) representative samples of the fill materials. The results of the tests are illustrated on the gradation curves on Figure No. D1 in Appendix D. Based on the laboratory results, the USCS group symbol for this fill material will be silty sandy gravel (GM) or gravelly silty sand (SM).

4.4.3 Clayey Silt with Sand (TILL)

A cohesive till layer comprised of clayey silt with sand containing cobbles and boulders was encountered below pavement structure fill layer in Borehole BH20-1. This cohesive till extended to approximately 1.3 m depth corresponding to a base elevation of about 138.4 m.

A SPT 'N' value of 19 blows per 0.3 m of penetration was measured within this deposit. Based on the SPT 'N' value and manual/tactile examination of a sample of this material, the clayey silt till is considered to have a very stiff consistency.

Laboratory testing of a sample of this deposit yielded a moisture content of 9%. The results of grain size distribution carried out on a sample of this material are shown on Figure No. D2 in Appendix C. The results of Atterberg Limit testing on the same sample, displayed on Figure D3, measured a Plastic Limit of 8 percent and Liquid Limit of 14 percent and corresponding Plasticity Index of 6. Based on the Atterberg Limit testing, the USCS group symbol for this deposit is CL-ML.

4.4.4 Sandy Silt to Silty Sandy Gravel (TILL)

A predominantly granular glacial till deposit typically consisting of gravel, cobbles, and boulders in a matrix of silty sand to sandy silt was encountered beneath the fill materials or clayey silt till deposit at depths of approximately 2.2 m and 3.0 m below ground surface. The composition of this till varies from silty sand/sandy silt containing varying amounts of gravel to silty sandy gravel in Borehole BH20-1 and sandy silt/silty sand in Borehole BH20-2. The till also contains zones of sandy clayey silt.



Typically, cobbles and boulders are present throughout the till deposits of Southern Ontario. The presence of cobbles and/or boulders in the till deposit at this site is inferred based on frequent grinding of the augers/drill equipment throughout the deposits during drilling. In Borehole BH20-2, coring methods were used to advance the borehole from 8.5 m to 9.1 m below ground surface after encountering auger refusal was encountered. The coring confirmed the presence of cobbles and/or boulders within this deposit.

SPT 'N' values measured in this deposit ranged from 11 blows per 0.3 m of penetration to greater than 100 blows per 0.3 m of penetration. The lower SPT 'N' values were typically recorded within the upper portion of the deposit with 'N' values of 11 and 16 blows per 0.3 m of penetration recorded in the upper 1.5 m of the till in BH20-2 and a SPT 'N' value of 47 measured at a depth of about 2.5 m in Borehole BH20-1; these resistance values indicate the upper portion of the till is in a compact to dense state. The remainder of SPT 'N' values measured at greater depths were typically greater than 100 blows per less than 0.3 m of penetration indicating the till becomes very dense at depth.

Laboratory testing of samples of the till materials yielded moisture contents that ranged from approximately 3 to 14%. The results of grain size distribution testing carried out on five samples of this deposit are shown on Figure No. D4 in Appendix C.

The results of an Atterberg Limit test carried out on a finer-grained portion of the till from Borehole 20-2 is shown on Figure No. D5 in Appendix C. This test measured a Plastic Limit of 10 percent and Liquid Limit of 15 percent and corresponding Plasticity Index of 5.

The USCS group symbol for the till is considered to vary from silty sandy gravel (GM) to silty sand/sandy silt (SM to ML). The till also contains zones of sandy clayey silt (CL-ML).

The till extended to the termination depths of boreholes at 11.3 m and 12.8 m below ground surface (corresponding to elevations of 129.3 m and 136.2 m in Boreholes BH20-1 and BH20-2, respectively).

4.5 GROUNDWATER

After completion of drilling of Borehole BH20-1, groundwater was observed at 2.4 m (~Elevation 138.2 m), while sloughing/cave-in was encountered at 6.1 m (~Elevation 134.4 m). No groundwater seepage was noted prior to initiation of coring/wash boring at depth of 7.8 m in Borehole BH20-2.

Groundwater levels at the site will be subject to fluctuations due to seasonal changes, snowmelt and precipitation events. The water levels should be expected to be higher during the spring season and during and following periods of heavy precipitation or snow melt. As Highway 401 was developed within a cut at the bridge site, groundwater levels are anticipated to be near ground surface and controlled by the water levels in the roadside ditches at the site.

5.0 CHEMICAL TESTING

One representative sample of the subsurface soils was collected from each of the boreholes and was tested for pH, sulphate and chloride concentrations, and resistivity. The analysis results are provided in Table 6.1.



Table 5.1: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Resistivity (Ohm-m)	Chloride (µg/g)	Sulphate (µg/g)
BH20-1	SS04	2.3-2.9	7.9	15.5	377	38
BH20-2	SS08	5.3-5.9	7.7	70.3	27	22

6.0 MISCELLANEOUS

The field work was carried out under the supervision of Kirby Lales under the direction of Kevin Nelson, P.Eng.

The utility locates for the boreholes were arranged by Stantec personnel.

The drilling equipment was supplied and operated by Downing Drilling Ltd. of Grenville-sur-la-Rouge, Quebec.

The location and elevation survey of the boreholes was completed by Tulloch Geomatics Inc.

Traffic control service was provided by On Track Safety Ltd. of Thornhill, Ontario.

Geotechnical laboratory testing was carried out at Stantec's Ottawa laboratory. The chemical testing for pH, soluble sulphate and chloride contents, and soil resistivity was carried out by Paracel Laboratories Ltd. of Ottawa.

This report was prepared by Ramin Ghassemi, P.Eng., Ph.D., and reviewed by Kevin Nelson, P.Eng., and Raymond Haché, M.Sc., P.Eng., Designated Principal MTO Foundation Contact.



7.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectfully Submitted;

STANTEC CONSULTING LTD.



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Geotechnical Engineer



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Principal, Senior Geotechnical Engineer



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MTO Designated Principal Foundation Contact



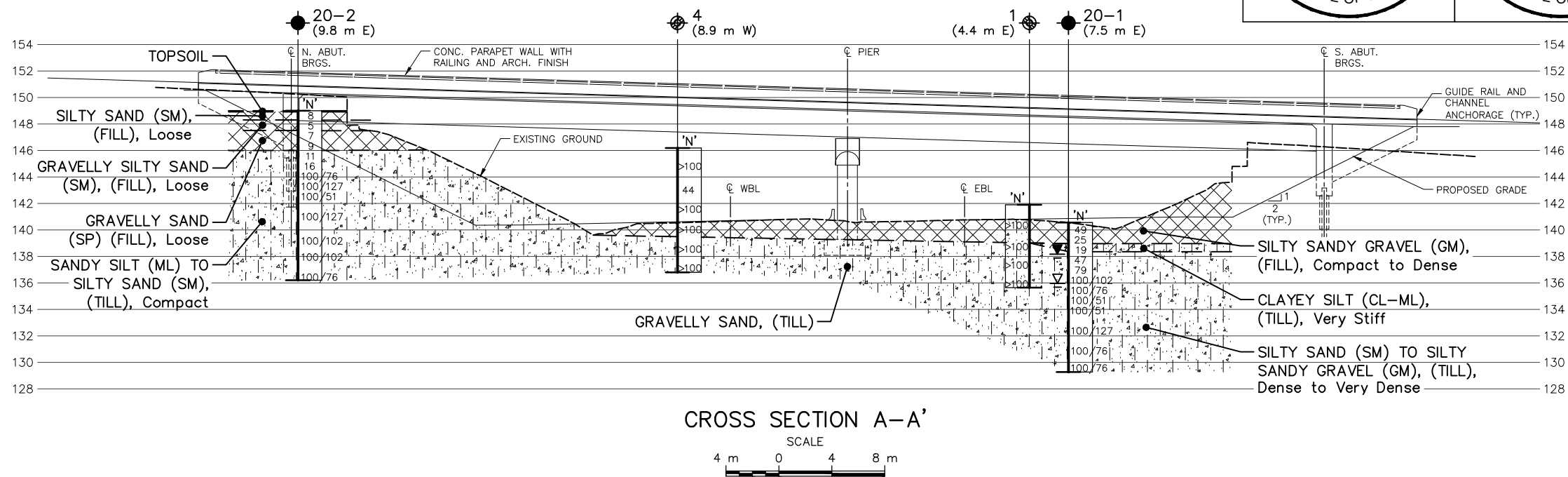
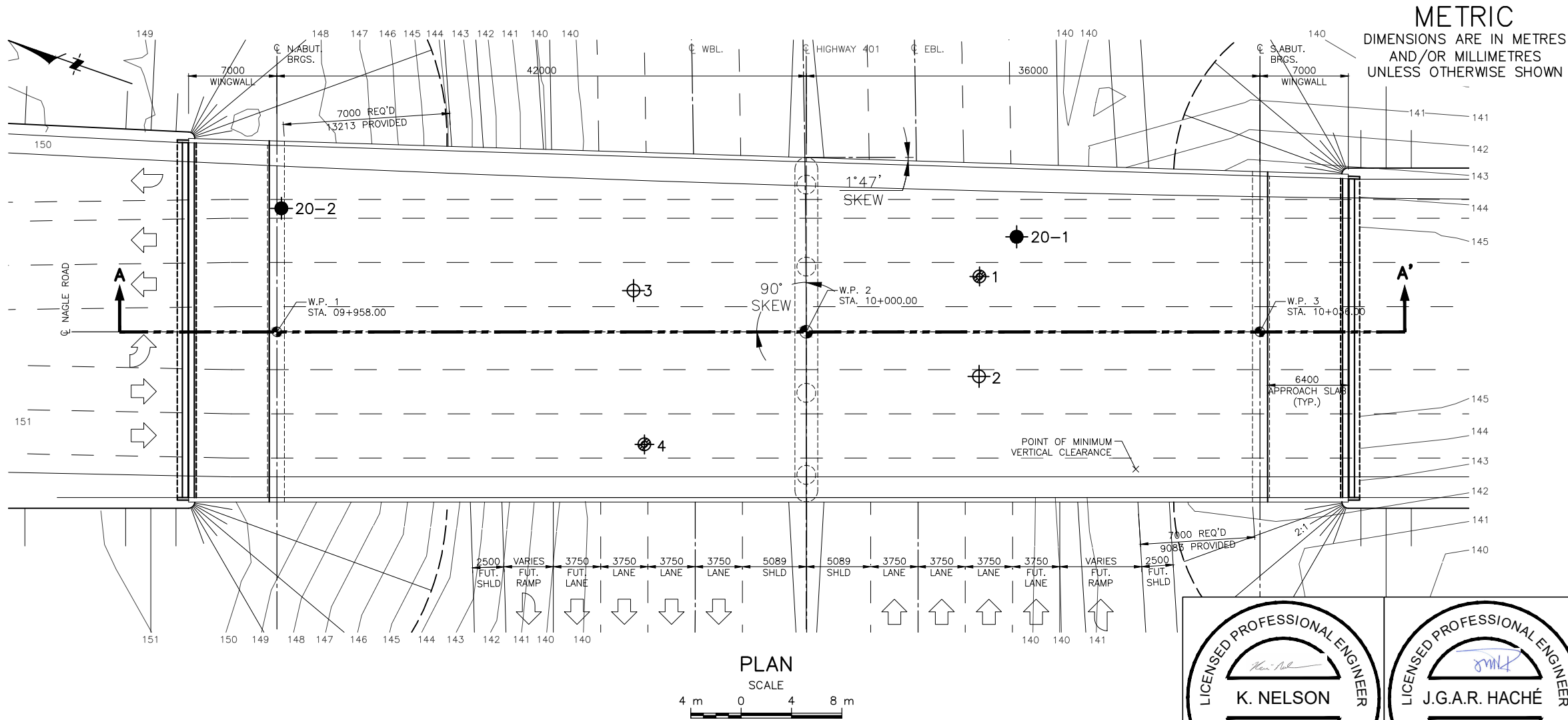
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APPENDIX A

A.1 DRAWING NO. 1 – BOREHOLE LOCATION PLAN AND SOIL STRATA PLOT





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

PLATE No
CONT
GWP 4059-17-00

HIGHWAY 401
NAGLE ROAD
BOREHOLE LOCATIONS & SOIL STRATA

LEGEND				
	Borehole (Stantec, 2020)			
	Borehole (MTO, 1958)			
	Dynamic Cone Penetration Test (MTO, 1958)			
(x.x m)	Offset from Cross Section Line in meters			
N	Blows/0.3m (Std Pen Test, 475 J/blow)			
	WL at time of investigation May 2020			
	WL Measured on May 2020			
No	ELEVATION	MTM ZONE 10 NORTH	COORDINATES EAST	
20-1	140.6	4 873 498.6	413 530.6	
20-2	149.0	4 873 554.4	413 513.4	
1	145.3	4 873 500.4	413 526.7	
2	145.4	4 873 497.8	413 519.2	
3	145.6	4 873 525.9	413 516.5	
4	145.7	4 873 521.0	413 505.3	

NOTES
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS
DATE BY DESCRIPTION

GEOCREs No 30M16-72

HWY No 401
SUBM'D KN
DRAWN GGB

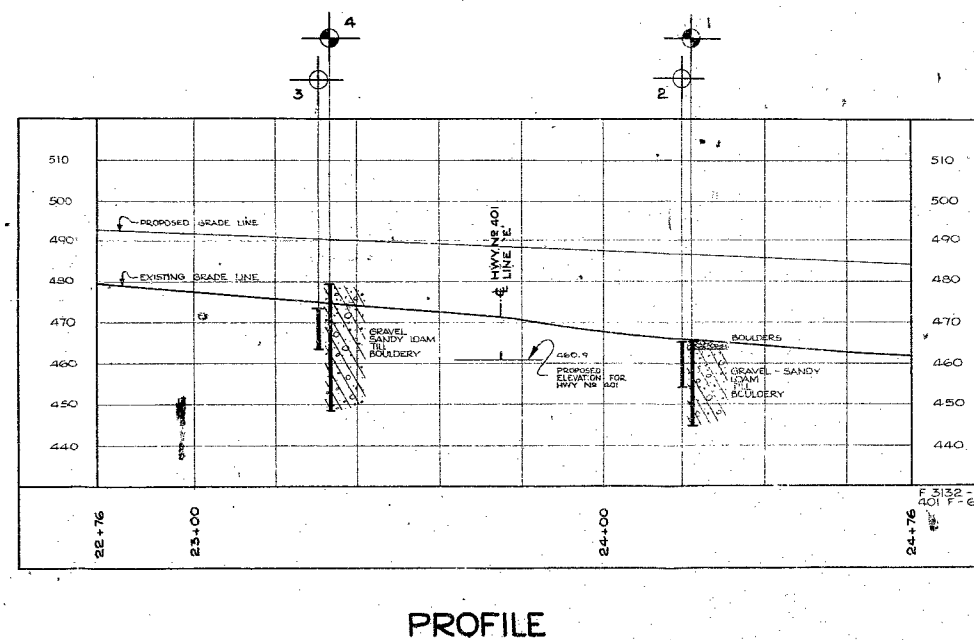
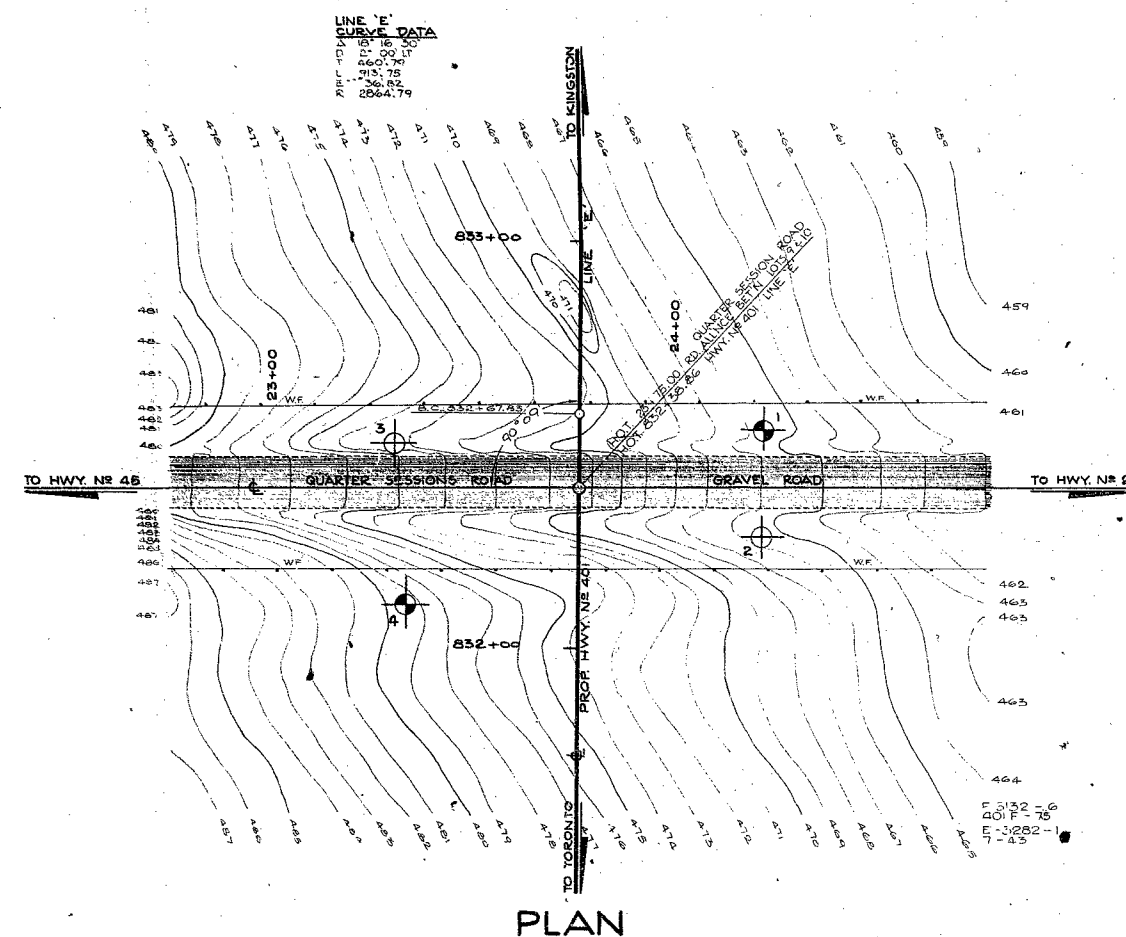
CHECKED
DATE 2021-04-16
APPROVED

DIST
SITE 21X-0248/B0
DWG 1

APPENDIX B

B.1 AVAILABLE GEOCRETS INFORMATION INCLUDING SOIL STRATA PLOT AND BOREHOLE RECORDS





LEGEND			
BORE HOLE			
PENETRATION HOLE			
BORE & PENETRATION HOLE			
HOLE NO.	ELEVATION	STATION	DISTANCE FROM Q.
1	465.5'	832+54'	45' RT.
2	465.5'	832+28'	45' RT.
3	473.5'	832+50'	45' LT.
4	479.5'	832+10'	42' 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.

DEPARTMENT OF HIGHWAYS - ONTARIO		
MATERIALS & RESEARCH SECTION - DOWNSVIEW		
GRAVEL ROAD PROPOSED CROSSING 2 MILES N.E. OF COBourg SHOWING POSITION & ELEVATION OF HOLES		
HWY. NR. 401	W.P. 88-57	DIV. NR. 7
CO. NORTHUMBERLAND	LOT 10	CON. 1
TWP. HAMILTON		
SCALE 1 IN. = 20 FT.	SUBMITTED BY	DATE 3 MARCH 58
DRAWN BY R.E.F.	APPROVED BY	DRAWING NO. F-57-46A

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

DRILL RIG 54-1 OPERATION BORE & PENET'N JOB T-57-46 W.P. 88-57 BORING L STA. 832+54 (45' RT)
 CASING 3X (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT DEC 1957
 SAMPLER HAMMER WT. 250 LBS. DROP 19 1/2 INCHES COMPILED BY H.S. CHECKED BY A.L. DATE BORING 13 NOV 1957

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
 QC - TRIAXIAL CONSOLIDATED QUICK WT - WATER TABLE IN SOIL γ - UNIT WEIGHT

SAMPLE TYPES

CS - CHUNK S.S. - SLEEVE SAMPLE
 DO - DRIVE OPEN PS - PISTON SAMPLE
 DF - DRIVE FOOT VALVE WS - WASHED SAMPLE
 TO - THIN WALLED OPEN RC - ROCK CORE

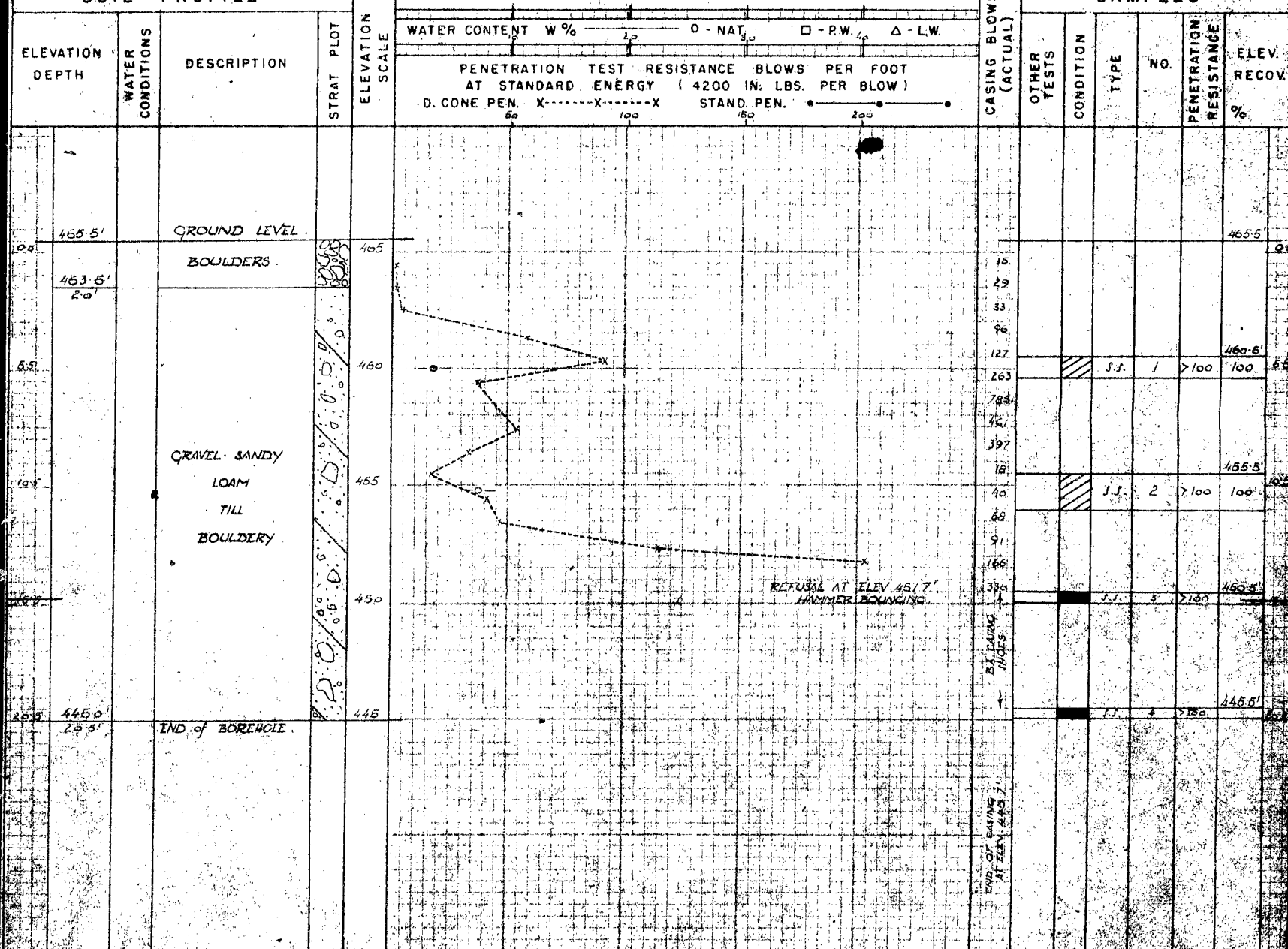
SAMPLE CONDITION



- DISTURBED
 - FAIR
 - GOOD
 - LOST

SOIL PROFILE

SAMPLES



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

DRILL RIG 54-1 OPERATION PENETRATION JOB F-57-46 W.P. 88-37 BORING 2 STA. 832+28 (45' RT)
CASING BK (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT DEC. 1957
SAMPLER HAMMER WT. 250 LBS. DROP 19 1/2 INCHES COMPILED BY H.S. CHECKED BY A.L. DATE BORING 19. NOV. 1957

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
QC - 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

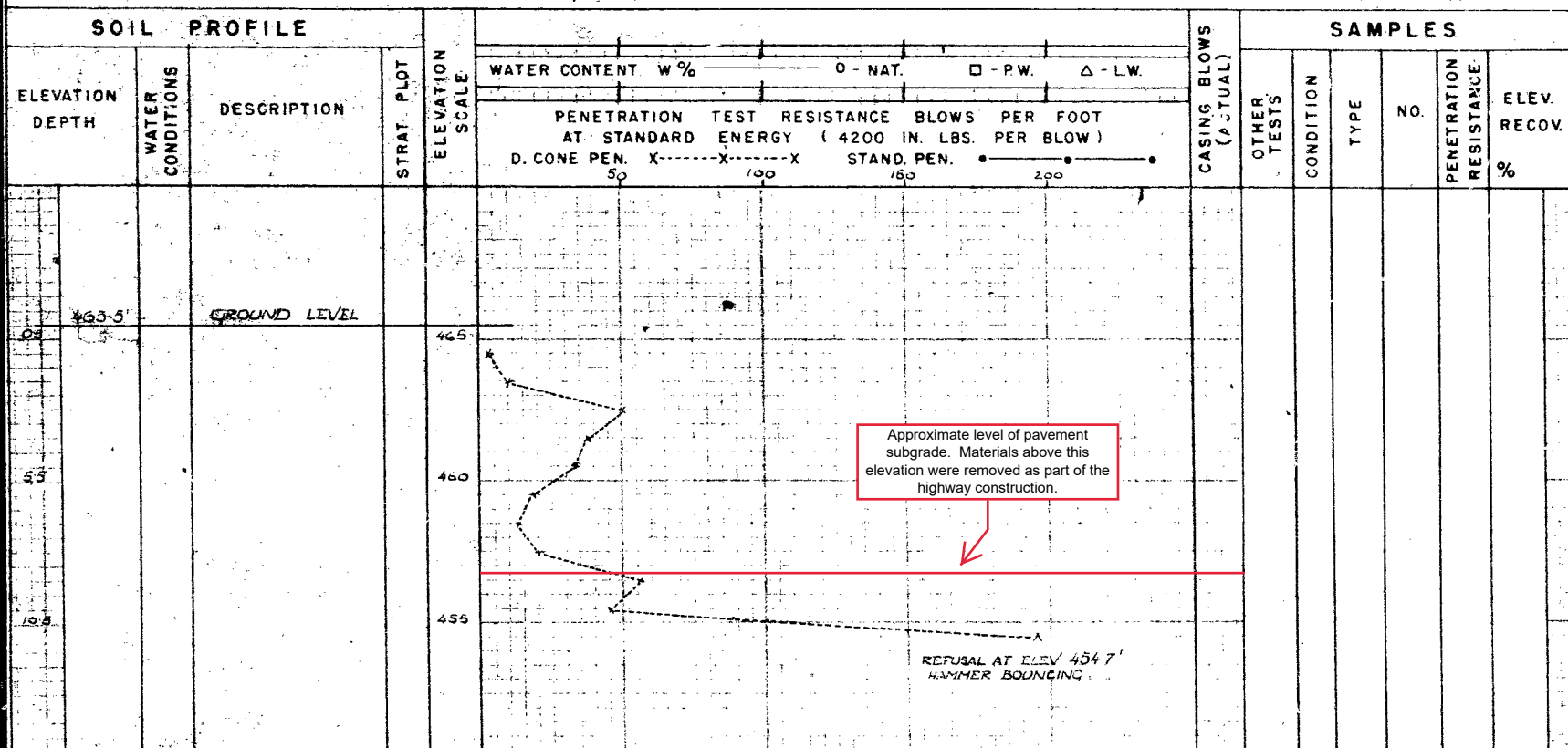
SAMPLE CONDITION



- DISTURBED
- FAIR
- GOOD
- LOST

SOIL PROFILE

SAMPLES



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

DRILL RIG 54-1 OPERATION PENETRATION JOB F-57-46 W.P. 88-57 BORING 3 STA. 832.50 (45' LT)
 CASING BX (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT DEC. 1957
 SAMPLER HAMMER WT. 250 LBS. DROP 19 1/2 INCHES COMPILED BY HJ CHECKED BY AL DATE BORING NOV. 19 1957

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
 QC - 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

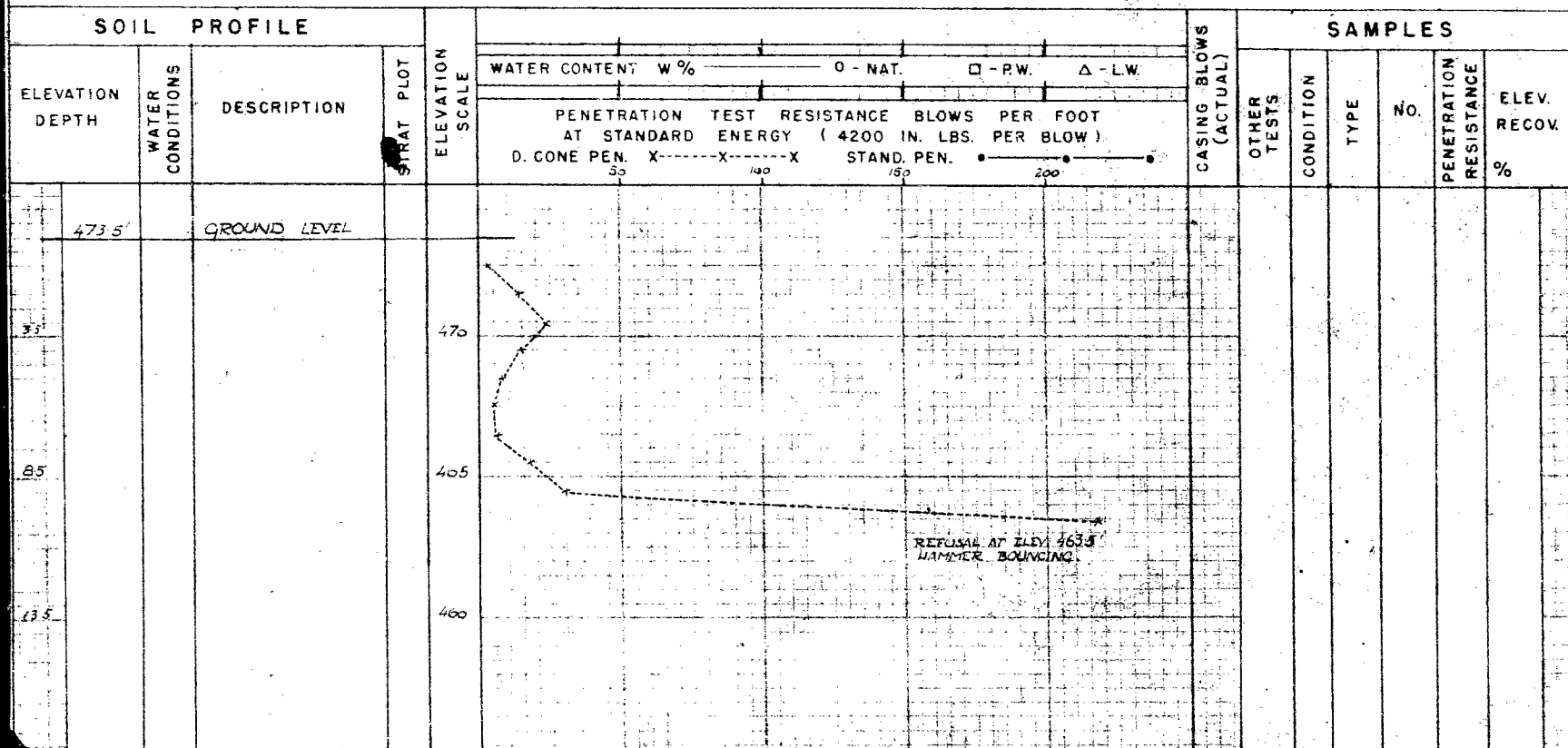
SAMPLE CONDITION



- DISTURBED
 - FAIR
 - GOOD
 - LOST

SOIL PROFILE

SAMPLES



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

DRILL RIG 54-1 OPERATION BORE & PENET'N JOB T-57-46 WP 88-57 BORING 4 STA 832+10 (42' LT.)
 CASING BX (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT DEC. 1957
 SAMPLER HAMMER WT. 250 LBS. DROP 19 1/4 INCHES COMPILED BY H.S. CHECKED BY A.L. DATE BORING 21 NOV. 1957

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
 Qc - TRIAXIAL CONSOLIDATED QUICK WT - WATER TABLE IN SOIL γ - UNIT WEIGHT

SAMPLE TYPES

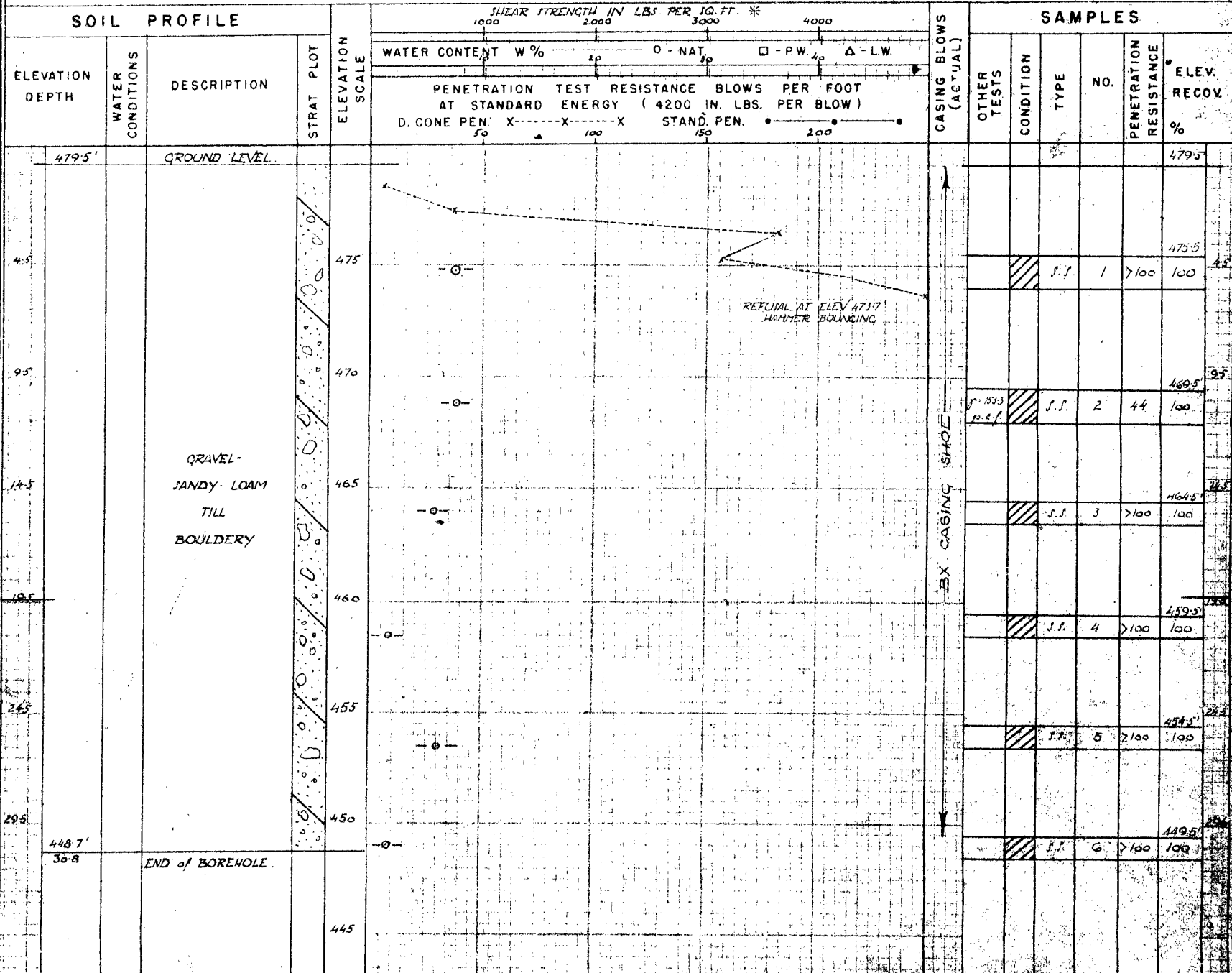
C.S. - CHUNK S.S. - SLEEVE SAMPLE
 D.O. - DRIVE OPEN P.S. - PISTON SAMPLE
 D.F. - DRIVE FOOT VALVE W.S. - WASHED SAMPLE
 T.O. - THIN WALLED OPEN R.C. - ROCK CORE

SAMPLE CONDITION



- DISTURBED
 - FAIR
 - GOOD
 - LOST

SOIL PROFILE



APPENDIX C

C.1 SYMBOLS AND TERMS USED ON BOREHOLE RECORDS

C.2 BOREHOLE RECORDS (CURRENT INVESTIGATION)



SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Rootmat</i>	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
<i>Topsoil</i>	- mixture of soil and humus capable of supporting vegetative growth
<i>Peat</i>	- mixture of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	- having cracks, and hence a blocky structure
<i>Varved</i>	- composed of regular alternating layers of silt and clay
<i>Stratified</i>	- composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	- > 75 mm in thickness
<i>Seam</i>	- 2 mm to 75 mm in thickness
<i>Parting</i>	- < 2 mm in thickness

Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 20%

Terminology describing compactness of cohesionless soils:

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>50

Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
<i>Very Soft</i>	<0.25	<12.5	<2
<i>Soft</i>	0.25 - 0.5	12.5 - 25	2-4
<i>Firm</i>	0.5 - 1.0	25 - 50	4-8
<i>Stiff</i>	1.0 - 2.0	50 - 100	8-15
<i>Very Stiff</i>	2.0 - 4.0	100 - 200	15-30
<i>Hard</i>	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	Very Poor Quality
25-50	Poor Quality
50-75	Fair Quality
75-90	Good Quality
90-100	Excellent Quality

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	Crushed
Severely Fractured	Shattered or Very Blocky
Fractured	Blocky
Moderately Jointed	Sound
Intact	Very Sound

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	Extremely Wide	-
2000-6000	Very Wide	Very Thick
600-2000	Wide	Thick
200-600	Moderate	Medium
60-200	Close	Thin
20-60	Very Close	Very Thin
<20	Extremely Close	Laminated
<6	-	Thinly Laminated

Terminology describing rock strength:

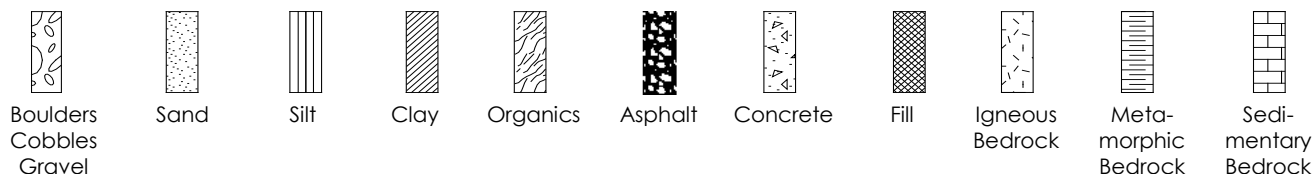
Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

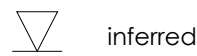
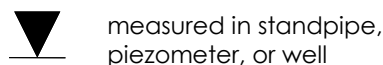
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT



RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

RECORD OF BOREHOLE No BH20-1

1 OF 1

METRIC

W.P. 4059-17-00 LOCATION Highway 401 - Nagle Road Underpass ORIGINATED BY KL
 DIST East HWY 401 BOREHOLE TYPE 150 mm SOLID STEM AUGERS COMPILED BY RG
 DATUM Geodetic DATE 2020.04.29 LATITUDE 43.99343043 LONGITUDE -78.14437991 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE											
140.6	ASPHALTIC CONCRETE							20	40	60	80	100										
0.0	300 mm ASPHALTIC CONCRETE																					
140.3																						
0.3	Silty SANDY GRAVEL (GM) (FILL) Compact to dense Brown Moist		1	SS	49		140										36	33	30	1		
			2	SS	25																	
139.2							139															
1.3	CLAYEY SILT with sand (CL-ML) (TILL) Contains frequent cobbles and boulders Very stiff Brown		3	SS	19												0	45	38	17		
138.4	Dry to moist																					
2.2	Silty SAND (SM), trace to some clay, trace gravel to silty sandy GRAVEL (GM), trace clay (TILL) Contains frequent cobbles and boulders Dense to very dense Brown Moist Auger grinding at 3.5 m depth		4	SS	47		138															
			5	SS	79		137										8	42	33	17		
			6	SS	100/ 102 mm																	
			7	SS	100/ 76 mm		136															
	Grey below 4.6 m depth																					
			8	SS	100/ 61 mm		135															
			9	SS	100/ 61 mm		134															
	Auger grinding at 6.9 m depth																					
			10	SS	100/ 127 mm		133										51	25	17	7		
	Auger grinding at 7.9 m depth																					
	Auger grinding at 8.5 m depth						132															
			11	SS	100/ 76 mm		131										3	64	26	7		
	SS11 contains 0.25 m thick pocket of SAND with silt, trace gravel																					
	Auger grinding at 10.4 m depth						130															
			12	SS	100/ 76 mm																	
129.3																						
11.3	End of Borehole																					
	After completion of drilling groundwater was observed at 2.4 m (~Elev. 138.2 m) and sloughing of borehole sidewalls occurred at 6.1 m (~Elev. 134.4 m).																					

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

ONTARIO MTO 165001106 HWY_401_NAGLE_RD.GPJ ONTARIO MTO.GDT 7/10/20

RECORD OF BOREHOLE No BH20-2

1 OF 1

METRIC

W.P. 4059-17-00 LOCATION Highway 401 - Nagle Road Underpass ORIGINATED BY KL
 DIST East HWY 401 BOREHOLE TYPE 200 mm HOLLOW STEM AUGERS; Wash Boring below 7.8 m. COMPILED BY RG
 DATUM Geodetic DATE 2019.05.05 LATITUDE 43.99393486 LONGITUDE -78.14458308 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
							WATER CONTENT (%)										
							20	40	60	80	100	20	40	60			
149.0	TOPSOIL & GRASS																
0.1	75 mm TOPSOIL																
148.3	SILTY SAND (SM), trace clay, gravel, and rootlets (FILL)		1	SS	8												
0.7	Loose Brown Moist																
147.5	Gravelly SILTY SAND (SM), trace clay and rootlets (FILL)		2	SS	5		148								22 48 23 7		
1.5	Loose Brown Moist																
	Auger grinding at 0.8 m depth		3	SS	7		147										
	GRAVELLY SAND (SP), trace silt (FILL)																
	Loose Brown Moist		4	SS	9												
146.0	Auger grinding at 2.7 m depth																
3.0	SANDY SILT (ML) to Silty SAND (SM), trace to some clay and gravel (TILL)		5	SS	11		146								18 45 26 11		
	Contains frequent cobbles and boulders																
	Compact Brown Moist		6	SS	16		145										
	Auger grinding at 3.7 m depth																
	Very dense below 4.4 m depth Auger grinding from 4.7 m to 5.2 m depth		7	SS	100/ 76 mm		144										
	Auger grinding at 5.6 m depth		8	SS	100/ 127 mm		143										
	Auger grinding from 6.1 m to 7.6 m depth		9	SS	100/ 61 mm		142										
	Auger grinding at 7.6 m depth Become grey below 7.6 m depth		10	SS	100/ 127 mm		141										
	Borehole advanced from 8.5 m to 9.1 m by coring after encountering casing refusal		11	SS	100/ 102 mm		140										
			12	SS	100/ 102 mm		139										
			13	SS	100/ 76 mm		138										
136.2	End of Borehole						137										
12.8	No groundwater seepage noted prior to initiation of wash boring.																

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

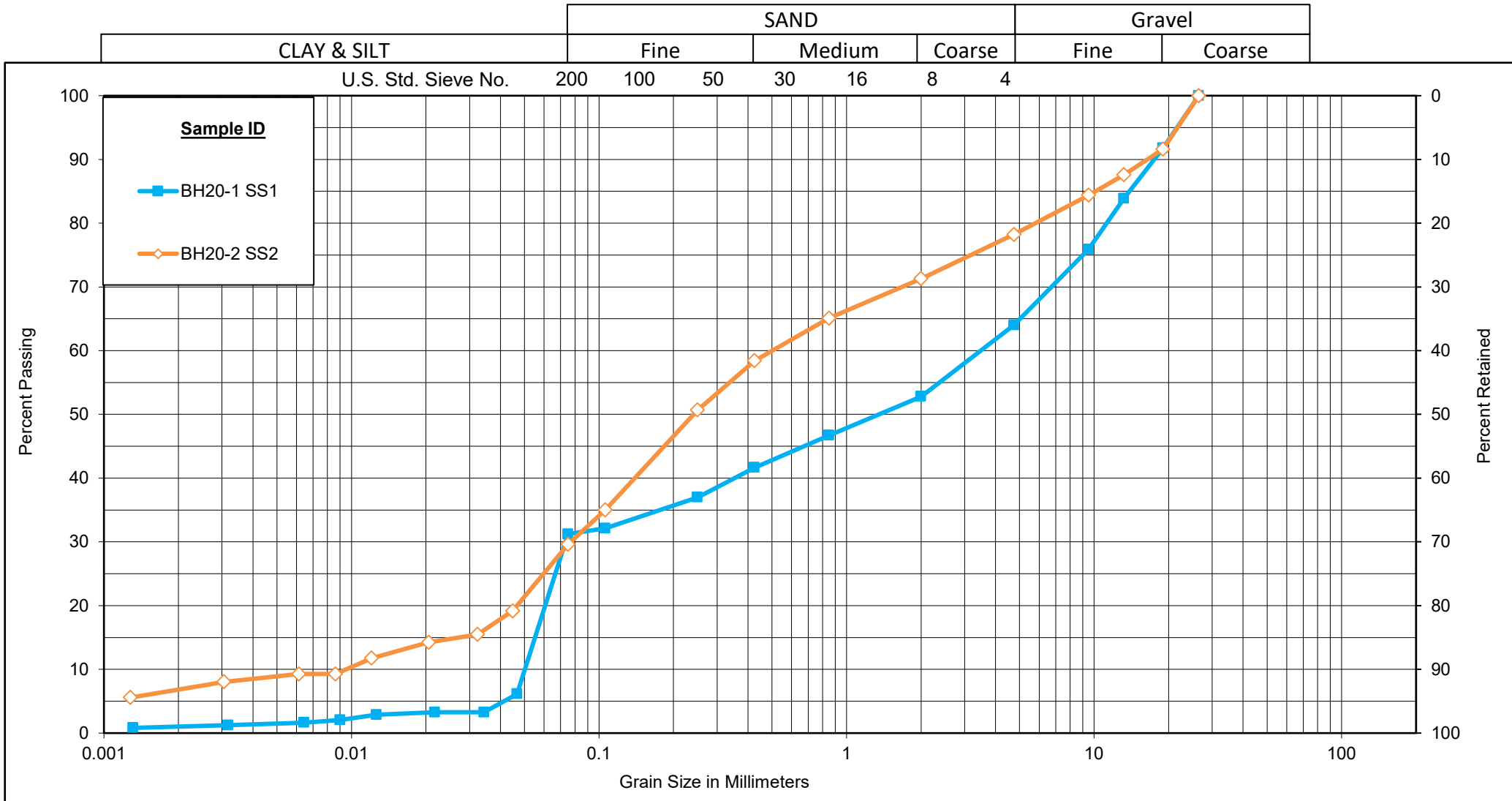
ONTARIO MTO 165001106 HWY 401_NAGLE_RD.GPJ ONTARIO MTO.GDT 7/10/20

APPENDIX D

D.1 LABORATORY TEST RESULTS



Unified Soil Classification System



Sample ID	Depth	% Gravel	% Sand	% Silt	% Clay
BH20-1 SS1	0'-2'	36.0	32.8	30.2	1.0
BH20-2 SS2	5'-7'	22.0	48.4	22.6	7.0



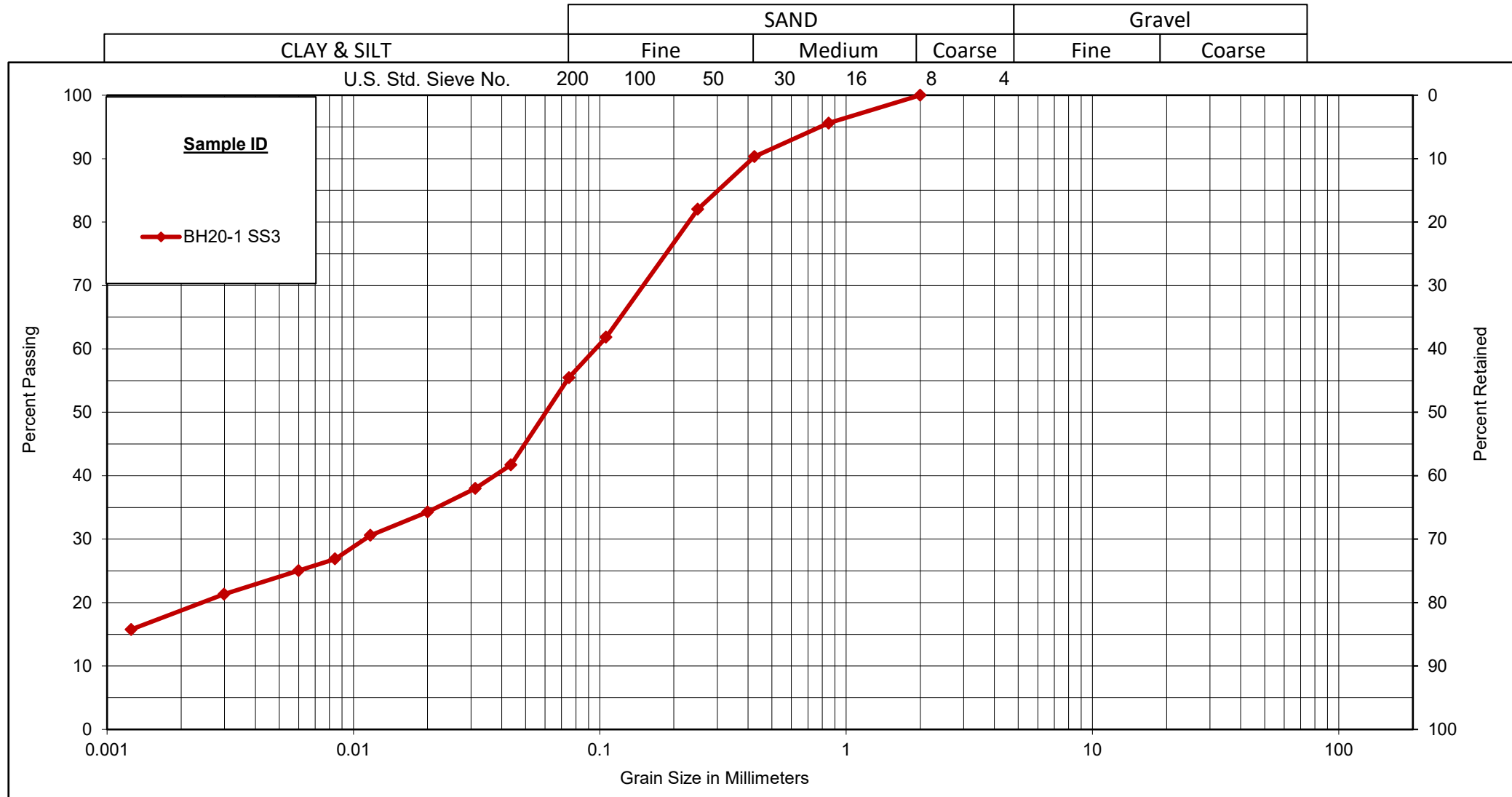
GRAIN SIZE DISTRIBUTION

FILL: Silty Sandy GRAVEL (GM) to Gravelly Silty SAND (SM)
Highway 401/Nagle Road Underpass

Figure No. D1

Project No. 165001106

Unified Soil Classification System



Sample ID	Depth	% Gravel	% Sand	% Silt	% Clay
BH20-1 SS3	5'-7'	0.0	44.5	37.5	18.0

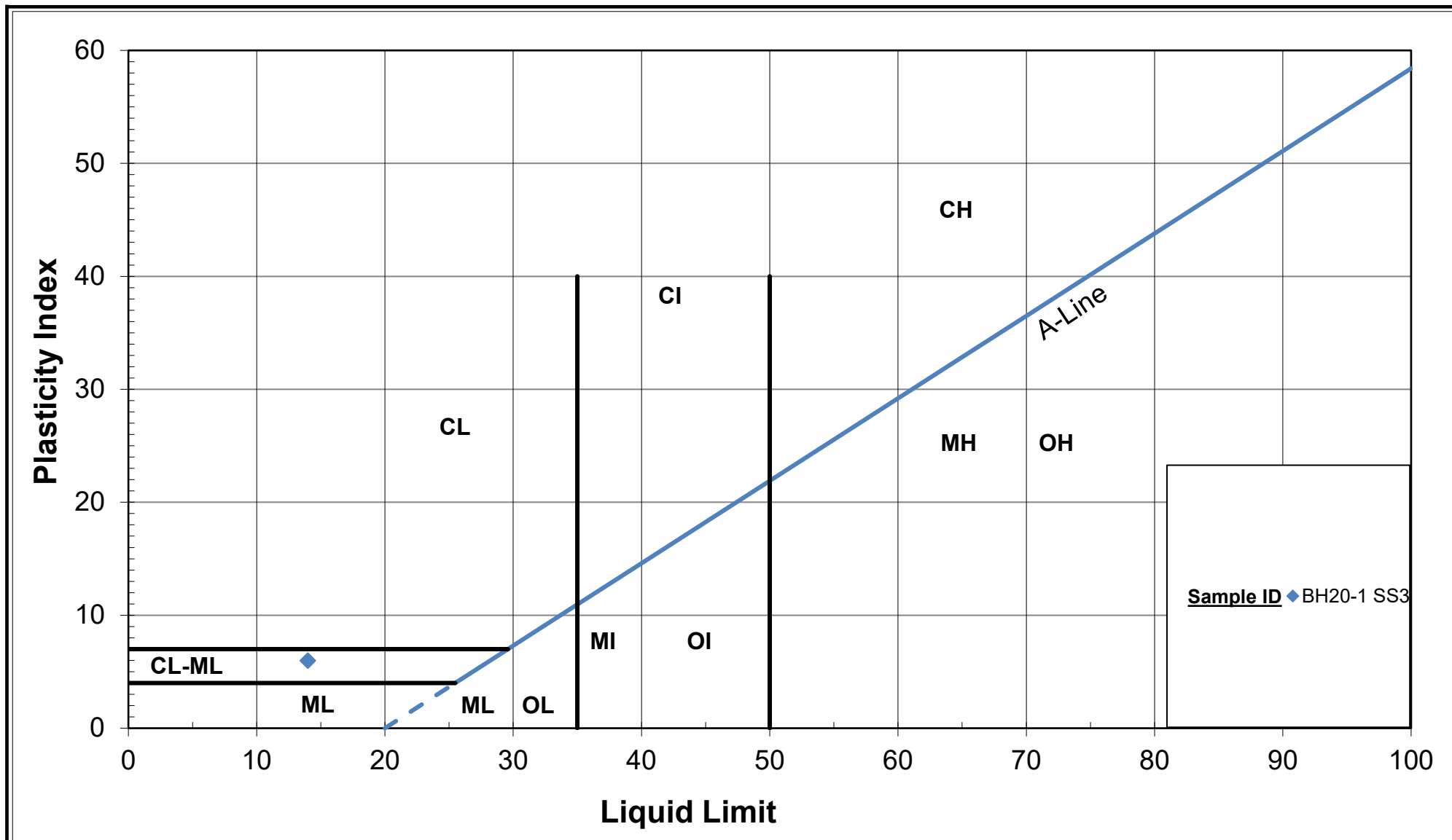


GRAIN SIZE DISTRIBUTION

CLAYEY SILT with Sand (TILL) - (CL-ML)
Highway 401/Nagle Road Underpass

Figure No. D2

Project No. 165001106



CLAYEY SILT with Sand (TILL) - (CL-ML)

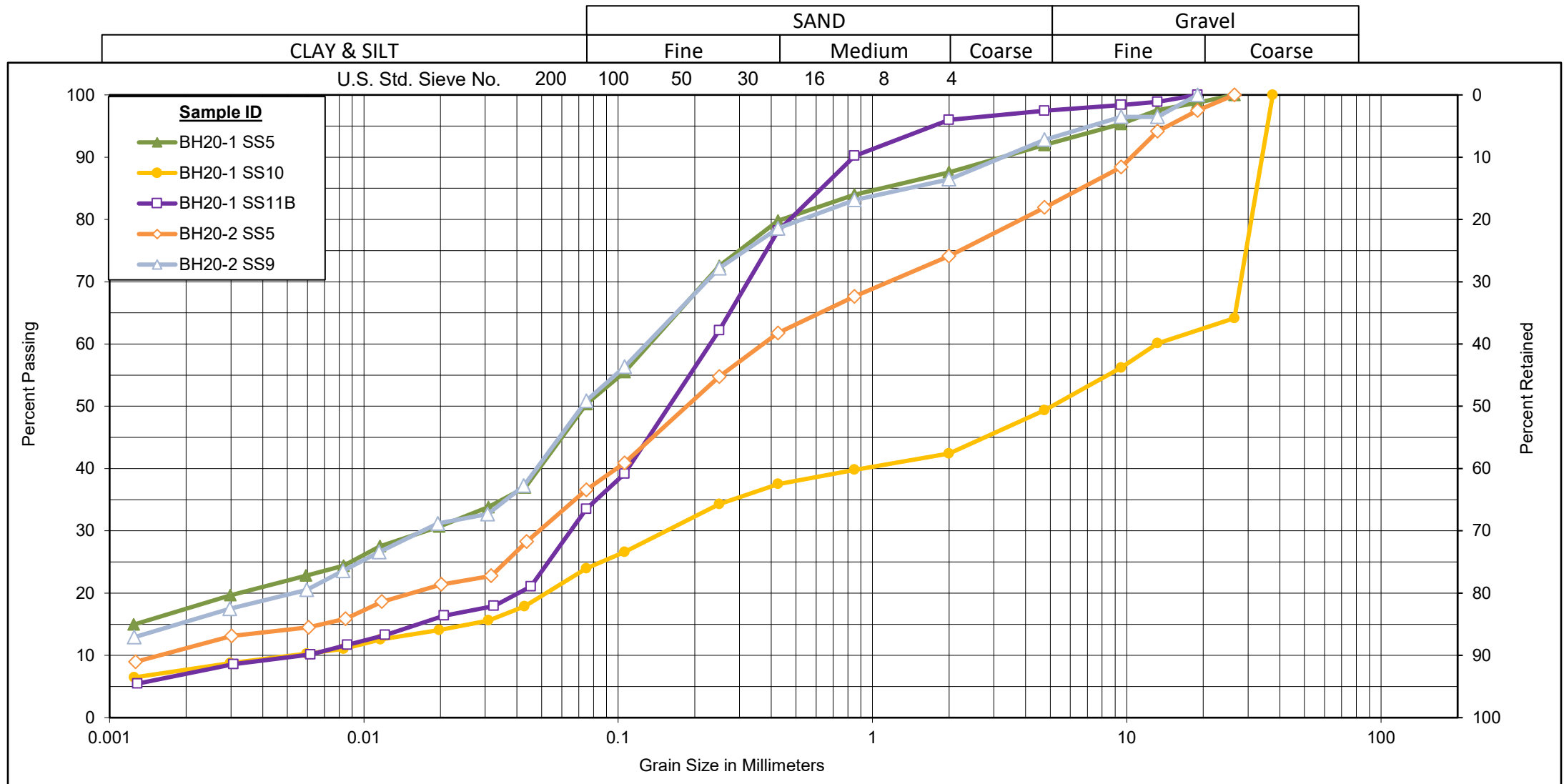
Highway 401 / Nagle Road Underpass

PLASTICITY CHART

Figure No. D3

Project No. 165001106

Unified Soil Classification System



Sample ID	Depth	% Gravel	% Sand	% Silt	% Clay
BH20-1 SS5	10'-12'	8.0	41.6	33.4	17.0
BH20-1 SS10	22'6"-24'6"	51.0	25.0	17.0	7.0
BH20-1 SS11B	27'6"-29'6"	3.0	63.5	26.5	7.0
BH20-2 SS5	10'-12'	18.0	45.4	25.6	11.0
BH20-2 SS9	20'-22'	7.0	42.1	35.9	15.0

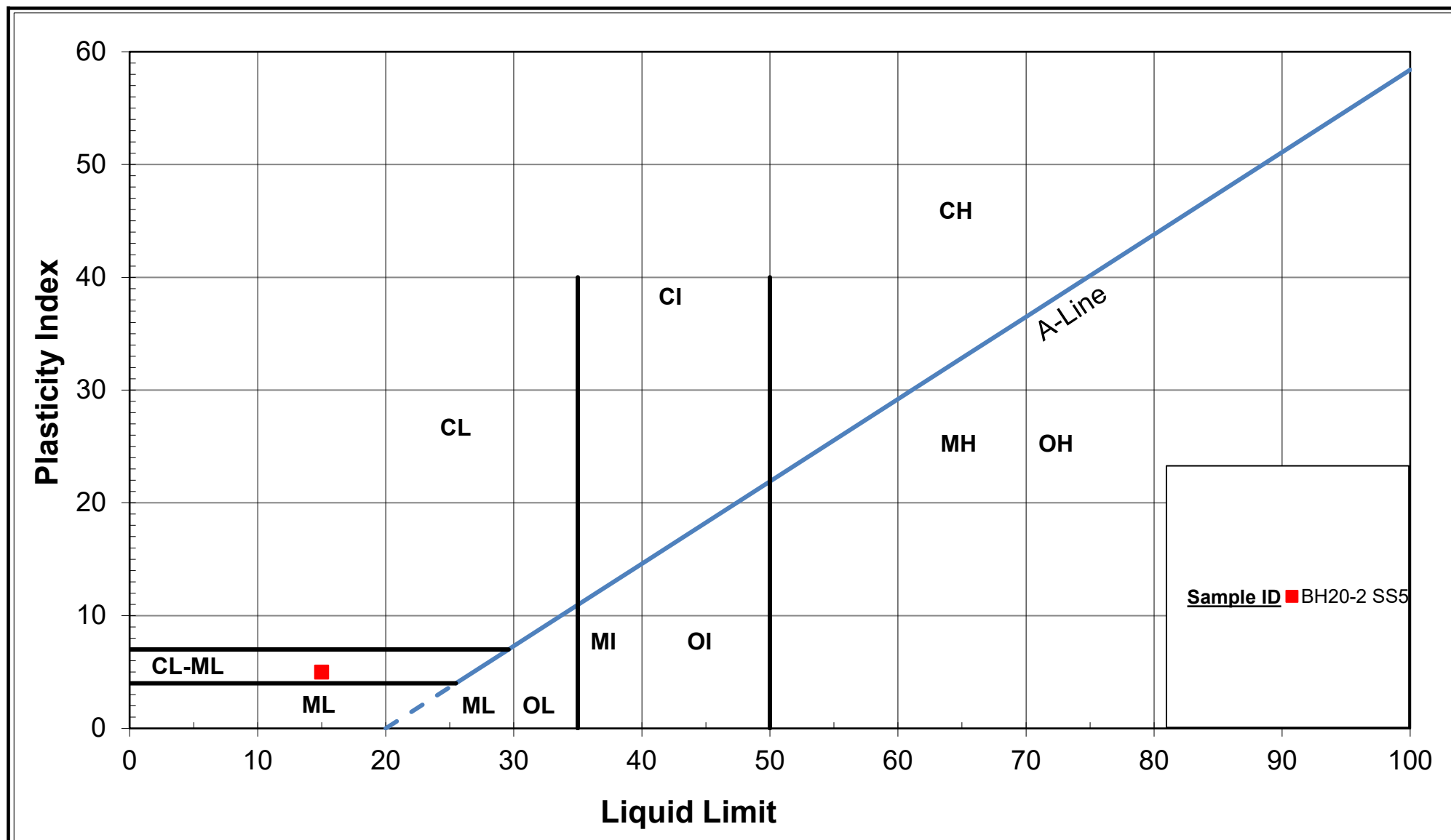


GRAIN SIZE DISTRIBUTION

TILL: Silty Sandy Gravel (GM) to Silty Sand/Sandy Silt (SM to ML)
Highway 401/Nagle Road Underpass

Figure No. D4

Project No. 165001106



Sandy CLAYEY SILT (TILL) - (CL-ML)

Highway 401 / Nagle Road Underpass

PLASTICITY CHART

Figure No. D5

Project No. 165001106