



**DETAIL DESIGN  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
for  
WIDENING OF McDOUGALL DRAIN BRIDGES  
Site Nos. 13X-0190/B1 & B2  
Highway 401 – Station 26+965  
Township of Tilbury, Chatham-Kent, Ontario  
GWP 3034-19-00, WP 3042-19-01 & 3044-19-01  
Assignment No. 3017-E-0006/0007  
Work Item No. 06  
Latitude and Longitude: 42.299410, -82.332389**

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**DETAIL FOUNDATION INVESTIGATION AND DESIGN REPORT**

Widening of McDougall Drain Bridges  
Site No. 13X-0190/B1 & B2  
Highway 401 –Station 26+965  
Township of Tilbury, Chatham-Kent, Ontario  
GWP 3034-19-00, Assignment No. 3017-E-0006/0007, Work Item No. 06

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**PART A – FOUNDATION INVESTIGATION PORTION OF THE REPORT**

**1. INTRODUCTION**

The Ministry of Transportation Ontario (MTO) has retained WSP as the Prime Consultant, to provide services for the widening of EBL and WBL structures at two sites on Highway 401 under MTO Assignment No. 3017-E-0006/0007, Work Item No. 06. WSP retained Peto MacCallum Ltd. (PML) on behalf of MTO to provide foundation engineering services for this assignment. The Terms of Reference and Scope of Work for the Foundation Engineering services are outlined in MTO Assignment No. 3017-E-0006/0007, Work Item No. 06.

This report is a Detail Design Foundation Investigation and Design Report for McDougall Drain EBL and WBL Bridges located along Highway 401 at the crossing of McDougall Drain in the Township of Tilbury, Chatham-Kent, Ontario. The subsurface investigation was limited to previously available boreholes supplemented by an additional two (2) boreholes drilled for the current assignment.

**2. SITE DESCRIPTION**

Highway 401 in the area of the bridge site is elevated slightly above the natural topography, and accommodates two (2) lanes of vehicular traffic in each direction. The site is generally a flat area, with the exception of the highway embankments. The study area is surrounded by agricultural developments, and is located approximately 9.3 km east of the residential community of Tilbury.

**3. FIELD INVESTIGATION PROCEDURES**

The field work for the current foundation investigation involved two (2) boreholes drilled to supplement subsurface information from the previous investigation. The new boreholes are identified as MEB and MWB, located within the Highway 401 median, east and west of McDougall Drain, respectively. The boreholes were drilled to depth of 30 m below the existing ground surface. The locations, ground elevations and depths of drilling are summarized in Table 3.



**Table 3: Borehole Location and Termination Depth**

BOREHOLE NO.	LOCATION				DEPTH (m)	GROUND ELEVATION (m)
	NORTHING	EASTING	LATITUDE	LONGITUDE		
MEB	4 684 458.4	318 641.1	42.299581	-82.332134	30.0	179.2
MWB	4 684 439.4	318 620.1	42.299410	-82.332389	30.0	179.1

PML staff visited the site on August 17, 2019 to mark out the borehole locations. The appropriate utility companies cleared the underground services at the borehole locations. Public and private utility authorities were informed and all of the utility clearance documents were obtained before the commencement of drilling work.

PML staff used a portable GPS device to establish the borehole locations in the field. Subsequently, PML carried out the survey of the borehole locations using a Sokkia SHC5000 Differential GPS unit, equipped with a GCX3 (Network RTK rover) GNSS Receiver. The vertical and horizontal accuracy of this equipment are within 0.1 m and 0.5 m, respectively. All elevations (EL.) reported in this report are referred to in MTM NAD 83 Northing and Easting (MTM Zone - ON11) Geodetic datum and expressed in meters.

The equipment used for the borehole drilling work was owned and operated by London Soil Test Inc. (London Soil), of London, Ontario. London Soil is a specialist drilling contractor and worked under the full-time supervision of a PML field supervisor. Boreholes MEB and MWB were drilled between September 27 and October 1, 2019. The boreholes were advanced using a D50-Turbo Track-mounted drilling rig equipped with 200 mm diameter hollow stem augers.

Refer to Drawings MD-1 and MD-2 in Appendix A for borehole location details.

Representative soil samples were recovered from the boreholes at 0.75 m intervals to a depth of 6.0 m and at 1.5 m intervals to a depth of 20 m, and at 3.0 m interval to the termination depth, using a conventional 51 mm OD split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. In addition, attempt was made to measure in-situ vane shear strength of clayey soil at depths where SPT values were below about 8 blows/300 mm, using a N-size (MTO) vane.



The groundwater conditions at the borehole locations were observed during the drilling operations by visual examination of the soil samples, sampler and drill rods as the samples were retrieved. In addition, water level measurements were taken in the open boreholes upon completion of drilling. A monitoring well, consisting of 50 mm outside diameter rigid PVC pipe, was installed adjacent to each borehole for groundwater level measurement. Water levels were measured using a Solinst flat tape water level reader.

The boreholes and monitoring wells were constructed and abandoned/decommissioned in conformance with the requirements of MTO guidelines and Ontario Regulation 903, amended by Ontario Regulation 372.

The McDougall Drain water level was observed approximately at EL. 175.7 during the fieldwork on September 27, 2019.

The recovered soil samples were returned to the PML laboratory for detailed visual examination, and index tests.

#### **4. LABORATORY TEST PROCEDURES**

Laboratory testing was carried out on representative SPT samples recovered during the fieldwork at PML's laboratory facility in Toronto, Ontario. The laboratory testing program included the following:

- Natural moisture content determinations (42)
- Grain size distribution analyses (12)
- Atterberg limit tests (11)
- Consolidation test (1)

All the laboratory tests to determine index properties were performed in accordance with the MTO test procedures, which follow the American Society for Testing Materials (ASTM) standards, with the exception of hydrometer tests (LS-702). The results of the grain size distribution analyses are presented on Figures GS-MD-1 to GS-MD-3. The results of the Atterberg Limit tests are presented in Figures PC-MD-1 to PC-MD-2. One-dimensional consolidation (ASTM D-2435) test was conducted on one Shelby tube sample from borehole MEB and the results are presented in



Figure M-1. All of the test results are summarized in the attached Record of Borehole Logs provided in Appendix A.

## **5. SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **5.1 Site Geology**

In general, the project area is located within the St. Clair Clay Plains physiographic region. The Quaternary Geology map published by the Ontario Ministry of Northern Development and Mines (MNDM), indicates that the surface conditions in the area of the bridge site consist of Tavistock Till deposits; silty clay matrix. Based on the Bedrock Geology map (MRD126-REV1, 2011) published by the MNDM, the project area consists of Middle Devonian limestone, dolostone and shale of the Hamilton Group rock formation.

### **5.2 Previous Investigation**

The field investigation for the existing bridges was carried out between February 5 and 9, 1959, and consisted of six (6) boreholes drilled to depths ranging from 6.7 m to 11.3 m (EL.172.2 to EL.167.9) below the ground surface existed at the time of investigation. Based on the foundation investigation and design report (FIDR, Geocres No. 40J08-006), representative soil samples were recovered from the boreholes at frequent intervals to the termination depth of the boreholes, using a conventional 51 mm OD split spoon sampler, simultaneously conducting SPT to assess the strength characteristics of the substrata. In addition, 51 mm diameter thin wall tube (Shelby) undisturbed samples were also recovered to conduct complex laboratory tests. The laboratory tests consisted of index tests such as moisture content, Atterberg limits and grain size distribution. The report indicates that complex tests on undisturbed samples consisted one-dimensional consolidation and shear strength measurements. However, laboratory records are not available with the report to evaluate or verify the test results.

Based on the previous investigation, the subsoil conditions in the area of the proposed structure is expected to consist of about 0.9 m to 1.2 m thick sandy clayey fill underlain by firm to very stiff silty clay deposit to the maximum borehole termination depth of 11.3 m (EL.167.9). The upper most part of this silty clay deposit to a depth of 1.5 m (EL. 176.4) to 3.4 m (EL. 175.6) appears to be desiccated and the SPT 'N'-values reported were ranging from 12 blows to 31 blows, with the



exception of one sample (N value of 7), indicating stiff to very stiff consistency. Below these depths, the silty clay deposit encountered to the maximum borehole termination depth of 11.3 m (EL. 169.4) was classified as firm to stiff consistency.

Based on the report, groundwater was not encountered in any of the boreholes advanced. The groundwater table was assumed at or slightly below the existing ground surface, based on the moisture content of the samples recovered.

### **5.3 Current Investigation**

The subsurface conditions encountered during the current investigation along with the field and laboratory test results are shown on the attached Record of Borehole Sheets. The borehole locations and stratigraphic profile sections are shown on Drawings MD-1 and MD-2. The boundaries between soil strata have been established at the borehole locations only. The boundaries of soil strata between and beyond the boreholes are assumed and may vary from location to location.

In general, the subsoil conditions immediately below the ground surface on the proposed structures consist of fill (approximately 3.1 m thick) composed of clayey silt to silty clay, with varying proportions of sand and gravel, which is underlain by approximately 27.0 m thick deposit of very stiff to stiff silty clay to clayey silt till deposit. A layer of gravelly sand deposit was encountered within the clayey silt till deposit in borehole MEB at a depth of 13.7 m (EL. 165.5) and that extends to a depth of 15.8 m (EL. 163.4) below the existing ground surface. Boreholes MEB and MWB were terminated to firm to stiff clayey silt till at a maximum depth of 30.0 m below the existing ground surface. For classification purposes, the soils encountered at this site can be divided into two (2) distinct zones:

- a) Clayey Silt, Some Sand, Trace Gravel (Fill)
- b) Silty Clay to Clayey Silt, Some Sand, Trace Gravel (Till)





#### 5.3.1 Clayey Silt, Some Sand, Trace Gravel (Fill)

A layer of clayey silt fill was encountered just below the existing ground surface. The layer extends to depths of 3.1 m (EL. 176.1 to 176.0) below the existing ground surface in boreholes MEB and MWB, respectively.

The SPT 'N'-value recorded in this fill ranged between 10 and 16 blows, indicating stiff to very stiff consistency. The moisture content of samples tested from this fill ranged between 10.3% and 23.7%.

#### 5.3.2 Silty Clay to Clayey Silt, Some Sand, Trace Gravel (Till)

The fill in boreholes MEB and MWB is underlain by this silty clay to clayey silt till with varying proportions of sand and gravel. This till deposit was encountered at depths ranging from 3.1 m (EL. 176.1 to 176.0) and extends to the termination depths of 30.0 m (EL. 149.2 to 149.1) below the existing ground surface. The SPT 'N'-values in this deposit generally vary from 5 to 27 blows from EL. 176.1 to EL. 168.0, indicating firm to very stiff consistency. Between EL. 168.0, the SPT 'N'-values ranges from 4 to 12 blows, indicating firm to stiff consistency. Within this depth, in-situ vane shear tests were carried out. The vane tests were performed at eleven (11) locations and the uncorrected vane shear strengths ( $C_u$ ) typically varied from 50 kPa to more than 120 kPa, with a sensitivity ratio value between 1 and 2, indicating stiff to very stiff consistency, compared to firm to stiff based on SPT 'N'-values. Generally, from EL. 176.0 to EL. 168.5, the  $C_u$  measured was more than 100 kPa, indicating very stiff consistency. Below EL. 168.5, the  $C_u$  measured typically ranged between 50 kPa and 68 kPa, indicating stiff consistency. The moisture contents of the samples tested from this till deposit were between 14.5% and 26.1%.

The grain size distribution results of selected silty clay to clayey silt samples from this till deposit are provided on Figures GS-MD-1 and GS-MD-2, and the results of Atterberg limits for the same samples are provided on Figures PC-MD-1 and PC-MD-2 in Appendix A.

Sieve analysis tests were performed on eleven (11) representative samples and the test results indicate that this deposit consists of 1 to 4% gravel, 7% to 22% sand, 36% to 66% silt, and 18% to 53% clay. Atterberg limit tests were performed on eleven (11) representative samples and the test results indicate liquid limit values ranging from 21 to 40, plastic limit values ranging from 16 to 20,



and corresponding plasticity index values ranging from 4 to 20. Based on the test results, the clayey soil may be classified as clay of low to medium plasticity (CL/CI) in the Unified Soil Classification System (USCS), i.e., clayey silt/silty clay and classified as clayey silt to silty clay in the MTO Soil Classification.

One-dimensional consolidation testing was conducted on one Shelby tube sample obtained from borehole MEB that was considered to be representative of the site conditions. As part of the one-dimensional consolidation and particle size analysis of soils (LS-702), specific gravity test was performed on one sample from the clayey silt till deposit. The specific gravity of the clayey silt sample determined was 2.706. Bulk unit weight of sample determined was  $20.3 \text{ kN/m}^3$  and corresponding dry unit weight of the sample was  $16.7 \text{ kN/m}^3$ .

The test results are provided in Appendix A. The following table summarizes the consolidation characteristics of the sample.

BOREHOLE NO./ DEPTH (m)	EFFECTIVE OVERBURDEN PRESSURE (kPa)	PRE- CONSOLIDATION PRESSURE (kPa)	OVER CONSOLIDATION RATIO (OCR)	INITIAL VOID RATIO ( $e_o$ )	COMPRESSION INDEX ( $C_c$ )
MEB/17.1	230	310	1.3	0.589	0.170

A layer of gravelly sand deposit was encountered within the clayey silt till deposit in borehole MEB at a depth of 13.7 m (EL. 165.5) and that extends to a depth of 15.8 m (EL.163.4) below the existing ground surface. The SPT 'N'-value recorded in this fill were 16 and 39 blows, indicating compact to dense in compactness. The moisture content of samples tested from this till were 6.2% and 13.9%.

The grain size distribution result of selected samples from this till deposit is provided on Figure GS-MD-3 in Appendix A. Sieve analysis test result indicates that this deposit consists of 33% gravel, 51% sand, 10% silt, and 6% clay.



### 5.3.3 Groundwater

Groundwater was not encountered in boreholes MWB and MEB during and upon completion of drilling. The water level in the creek, which may ultimately control the groundwater level, was observed approximately at EL. 175.7 during the fieldwork.

A monitoring well consisting of 50 mm diameter PVC pipe was installed adjacent to boreholes MEB and MWB. Water level readings from the monitoring wells are summarized in Table 5.3.3.

**Table 5.3.3: Water Level Readings in Monitoring Wells**

MONITORING WELL (MW)	GROUND SURFACE ELEVATION (m)	TOP OF CASING ELEVATION (m)	MID-SCREEN DEPTH (m) (ELEVATION, m)	WATER LEVEL MEASURED IN MONITORING WELL, DEPTH (m) (ELEVATION, m)		
				2019/10/11	2019/10/24	2019/10/28
MEB	179.2	180.0	6.9 (EL. 172.3)	7.5 (EL. 171.7)	7.5 (EL. 171.7)	7.4 (EL. 171.8)
MWB	179.1	179.9	6.9 (EL. 172.2)	Dry	Dry	7.4 (EL. 171.7)

Groundwater levels may fluctuate due to the influence of precipitation and seasonal change. The groundwater measurements were observed and measured prior to backfilling the boreholes. Groundwater levels are shown on the Borehole Logs in Appendix A.

### 5.3.4 Soil Corrosivity

Four (4) representative soil samples were sent to SGS Canada Inc.'s (SGS) laboratory located in Toronto, Ontario, which is accredited by Canadian Analytical Laboratory Association (CALA). The corrosivity test results provided by SGS are presented in Appendix A. A summary of the test results is presented in the Table 5.3.4.



**Table 5.3.4: Summary of Corrosivity Results**

BOREHOLE ID	SAMPLE NO.	CORROSIVITY INDEX	SULPHIDE (%)	SOIL REDOX POTENTIAL (mV)	pH	RESISTIVITY (Ohm-cm)	CONDUCTIVITY (µS/cm)	SULPHATE (µg/g)	CHLORIDE (µg/g)
MEB	3	2	<0.02	228	7.79	2520	397	130	210
MEB	5	1	<0.02	222	7.98	3100	323	70	130
MWB	4	1	<0.02	280	8.01	3340	299	52	140
MWB	6	4.5	0.30	383	8.08	3160	316	340	54



The Foundation Investigation portion of the report was prepared by Mr. K. Amatya, P.Eng. and Mr. N. Rahman P. Eng., Project Engineers and reviewed by Mr. G. Uwimana, MEng, P.Eng., Senior Engineer. Mr. R. Ng, MBA, PhD, P.Eng. Principal Consultant conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.



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NR/GU/RN:nr-nk



## **APPENDIX A**

Borehole Locations Plan and Soil Strata Drawings MD-1 and MD-2

Explanation of Terms Used in Report

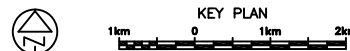
Record of Borehole Sheets

Results of Grain Size Distribution Analyses – Figures GS-MD-1 to GS-MD-3

Results of Atterberg Limit Tests – Figures PC-MD-1 to PC-MD-2

Consolidation Test Results – Figure No. M-1

Results of Chemical Tests provided by SGS Canada Inc.



LEGEND

- MEB
- Borehole Location
- N
- Blows/0.3m (Std. Pen Test, 475 J/blow)
- Monitoring Well
- Water Level in Monitoring Well (October 2019)

BH No	ELEVATION	NORTHINGS	EASTINGS
MWB	179.1	4 684 439.4	318 620.0
MEB	179.2	4 684 458.4	318 641.0

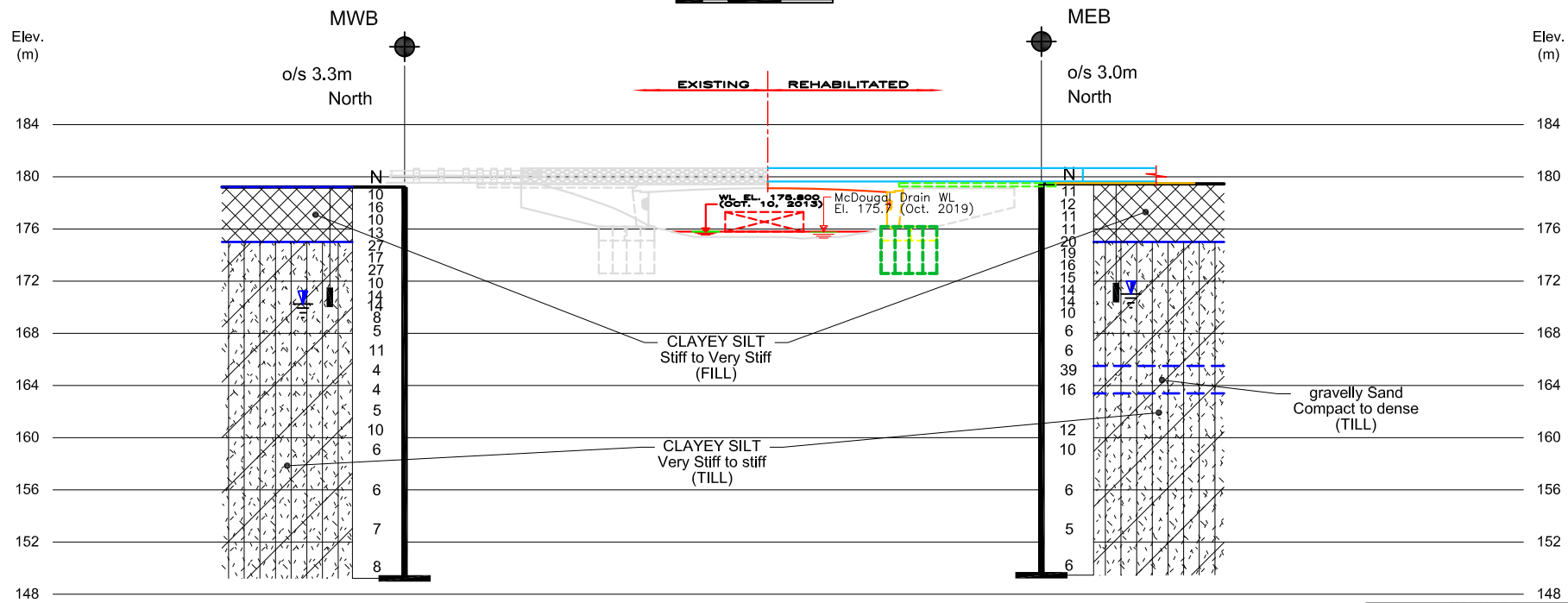
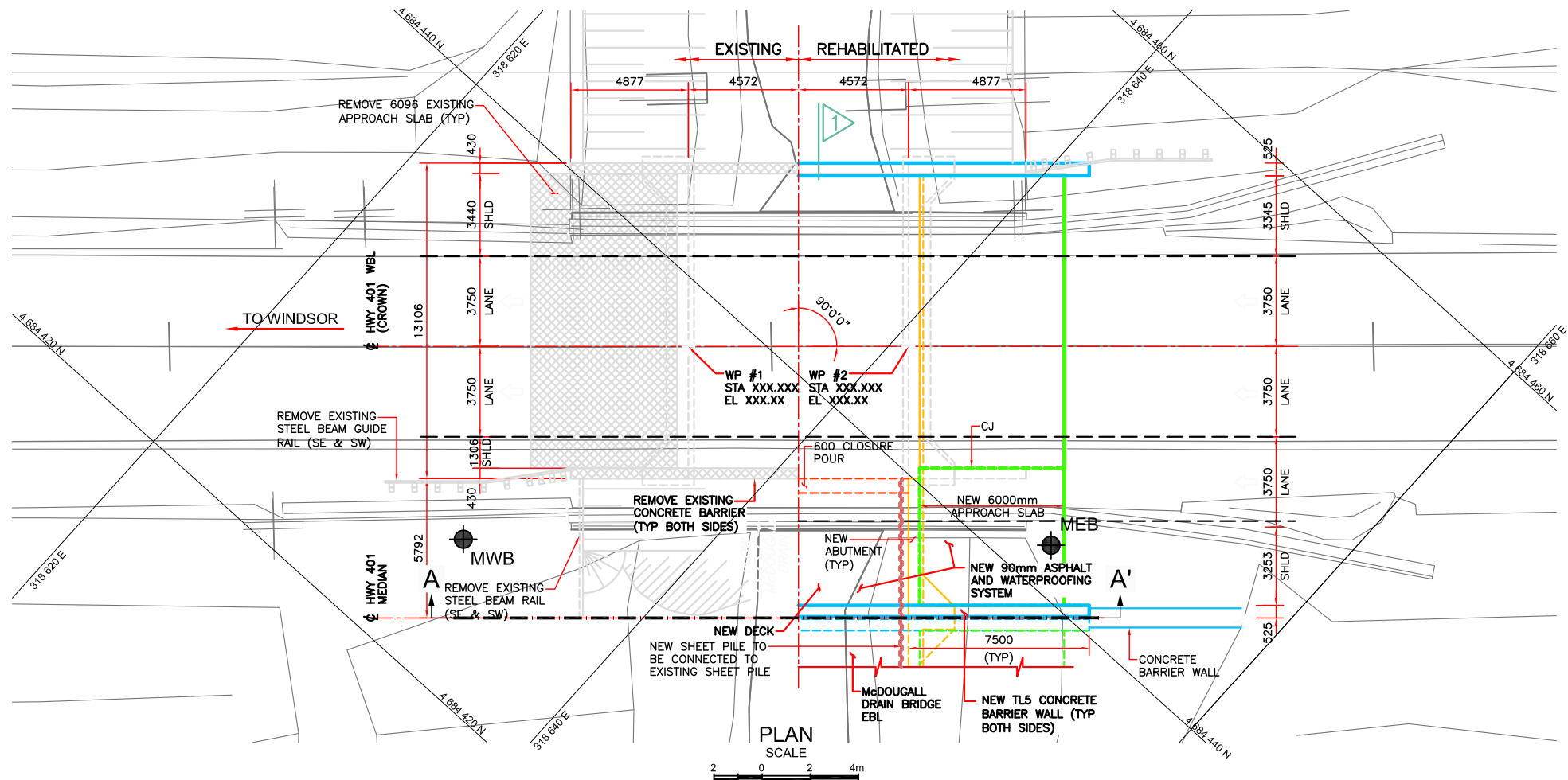
NOTE

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

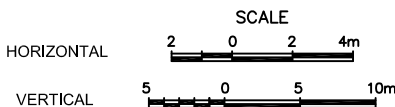
DATE	BY	DESCRIPTION

Geocres No. 40J8-74

HWY No	401	DIST	WEST REGION
SUBM'D	NL	CHECKED	KA
DATE	DEC. 16, 2019	SITE	13-190/1
DRAWN	NL	CHECKED	NR
APPROVED	RN	DWG	MD-1



PROFILE ALONG A-A'



NOTES:

- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



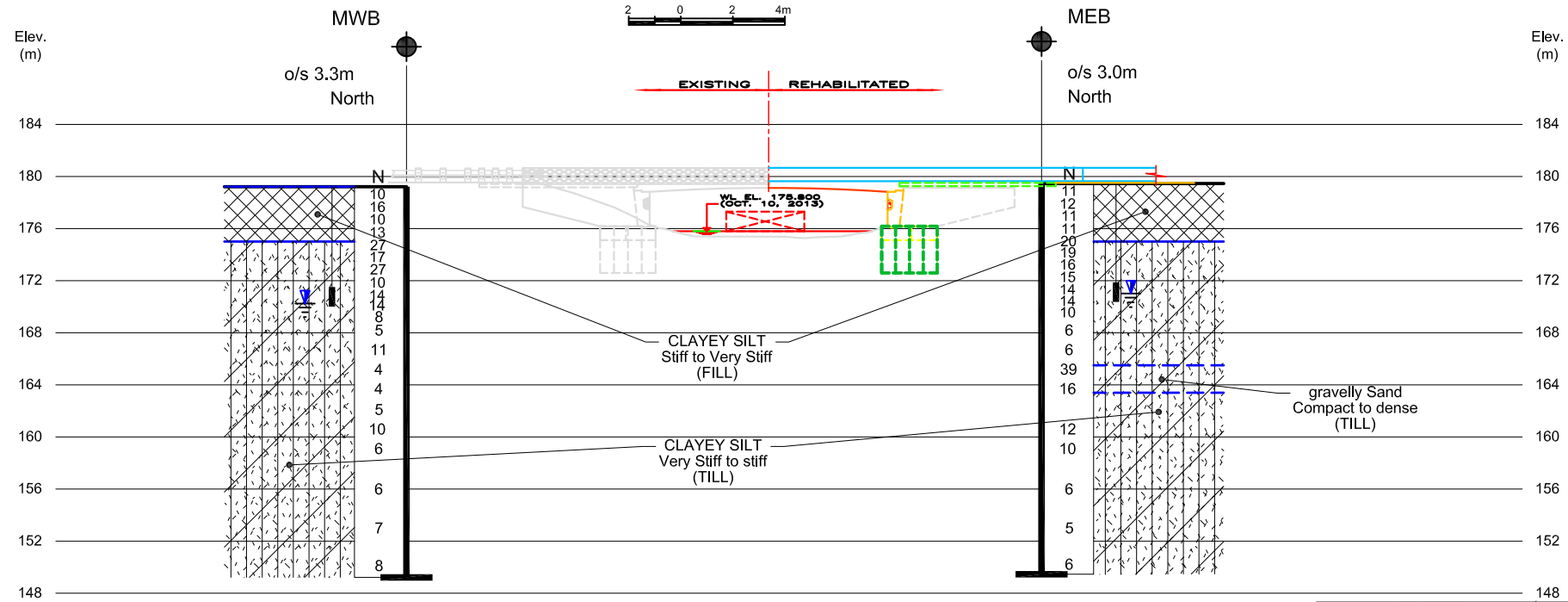
Reference WSP Ltd. Drawing: S18M-02111-06-300-001GA-WBL.dwg, dated October 2019.



- NOTE -

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

REVISIONS									
	DATE	BY	DESCRIPTION						
Geocres No. 40J8-74									
	HWY No. 401							DIST WEST REGION	
	SUBM'D	NL	CHECKED	KA	DATE	DEC. 16, 2019	SITE 13-190/2		
	DRAWN	NL	CHECKED	NR	APPROVED	RN	DWG MD-2		



### PROFILE ALONG A-A'

Reference WSP Ltd. Drawing: S18M-02111-06-300-001GA-EBL.dwg,  
dated October 2019.



## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**COMPOSITION:** SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm\* IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S SPLIT SPOON	T P THINWALL PISTON
W S WASH SAMPLE	O S OSTERBERG SAMPLE
S T SLOTTED TUBE SAMPLE	R C ROCK CORE
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY
T W THINWALL OPEN	F S FOIL SAMPLE
F V FIELD VANE	

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL





$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$S_r$	%	DEGREE OF SATURATION	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$w_L$	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_p$	%	PLASTIC LIMIT	$D_n$	mm	n PERCENT - DIAMETER
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_s$	%	SHRINKAGE LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL	WTPL		WETTER THAN PLASTIC LIMIT	j	kN/m <sup>3</sup>	SEEPAGE FORCE
e	1, %	VOID RATIO						

# RECORD OF BOREHOLE No MEB

1 OF 3

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 684 458.4 N; 318 641.1 E ORIGINATED BY J.O.  
DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.  
DATUM Geodetic DATE 2019.09.30 - 2019.10.01 LATITUDE 42.299581 LONGITUDE -82.332134 CHECKED BY N.R

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA
179.2 0.0	Ground CLAYEY SILT, some sand, trace gravel  Stiff, Brown, Moist  (FILL)		1	SS	11		179															
			2	SS	12		178															
			3	SS	11																	
			4	SS	11																	
176.1 3.1	CLAYEY SILT TO SILTY CLAY, some sand, trace gravel  Very stiff to stiff, Grey, Moist  (TILL)		5	SS	20		176															
			6	SS	19														4	19	42	35
			7	SS	16																	
			8	SS	15																	
			9	SS	14																	
																			2	20	44	34
			10	SS	14																	
			11	SS	10																	
			12	SS	6																	
				VANE																		
			13	SS	6																	
				VANE																		
	 gravelly SAND, trace silt		14	SS	39																	
164.2																						

Continued Next Page

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

# RECORD OF BOREHOLE No MEB

2 OF 3

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 684 458.4 N; 318 641.1 E ORIGINATED BY J.O.  
DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.  
DATUM Geodetic DATE 2019.09.30 - 2019.10.01 LATITUDE 42.299581 LONGITUDE -82.332134 CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										W <sub>p</sub> W      W <sub>L</sub> WATER CONTENT (%)		
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE												
164.2 15.0								20	40	60	80	100								
	<div>(Cont'd)</div> <div>CLAYEY SILT to SILTY CLAY, trace/some sand, trace gravel</div> <div>Very stiff to stiff, Grey, Moist</div> <div>(TILL)</div>		15	SS	16		164													
							163													
			16	TW			162													
				VANE			161													
			17	SS	12		160													
							159													
				18	SS	10		158												
							157													
				19	SS	6		156												
					VANE		155													
							154													
				20	SS	5		153												
					VANE		152													
							151													
				21	SS	6		150												
					VANE															
149.2																				

Continued Next Page







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

# RECORD OF BOREHOLE No MEB

3 OF 3

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 684 458.4 N; 318 641.1 E ORIGINATED BY J.O.  
 DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.  
 DATUM Geodetic DATE 2019.09.30 - 2019.10.01 LATITUDE 42.299581 LONGITUDE -82.332134 CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>												
149.2 30.0	End of borehole   Groundwater level measured in monitoring well  NOTES: 1. Groundwater was not encountered during or upon completion of drilling. 2. No cave-in was noted upon extraction of hollow stem augers.  <u>Monitoring Well Readings:</u> <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev.</th> </tr> </thead> <tbody> <tr> <td>Oct.11/'19</td> <td>7.5</td> <td>171.7</td> </tr> <tr> <td>Oct.24/'19</td> <td>7.5</td> <td>171.7</td> </tr> <tr> <td>Oct.28/'19</td> <td>7.4</td> <td>171.8</td> </tr> </tbody> </table>  <u>Monitoring Well Legend:</u>  Stick-up Monument  Bentonite  Filter Sand  19 mm PVC Screen  Filter Bottom	Date	Depth (m)	Elev.	Oct.11/'19	7.5	171.7	Oct.24/'19	7.5	171.7	Oct.28/'19	7.4	171.8														
Date	Depth (m)	Elev.																									
Oct.11/'19	7.5	171.7																									
Oct.24/'19	7.5	171.7																									
Oct.28/'19	7.4	171.8																									

ONTARIO MTO 19KF029A - WO6 (NOV 11), GPJ ONTARIO MTO.GDT 11-14-19

# RECORD OF BOREHOLE No MWB

1 OF 3

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 684 439.4 N; 318 620.1 E ORIGINATED BY J.O.  
 DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.  
 DATUM Geodetic DATE 2019.09.27 - 2019.09.30 LATITUDE 42.299410 LONGITUDE -82.332389 CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa									
179.1	Ground								20	40	60	80	100					
0.0	CLAYEY SILT, some sand, trace gravel  Stiff to very stiff, Brown to grey, Moist  (FILL)		1	SS	10													
			2	SS	16													
			3	SS	10													
			4	SS	13													
176.0	SILTY CLAY TO CLAYEY SILT, some sand, trace gravel  Very stiff to firm, Grey, Moist  (TILL)		5	SS	27													
3.1			6	SS	17													
			7	SS	27													
			8	SS	10													
			9	SS	14													
			10	SS	14													
			11	SS	8													
				VANE														
			12	SS	5													
				VANE														
			13	SS	11													
			14	SS	4													
				VANE														
164.1																		

Continued Next Page


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No MWB

2 OF 3

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 684 439.4 N; 318 620.1 E ORIGINATED BY J.O.  
 DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.  
 DATUM Geodetic DATE 2019.09.27 - 2019.09.30 LATITUDE 42.299410 LONGITUDE -82.332389 CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub> W W <sub>L</sub>				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
164.1	<i>(Cont'd)</i> CLAYEY SILT TO SILTY CLAY, some sand, trace gravel  Stiff, Grey, Moist  (TILL)		15	SS	4		164								2 15 40 43			
15.0																		
							VANE		163									
					16		SS	5	162									
							VANE		161									
					17		SS	10	160									
					18		SS	6	159									
							VANE		158									
					19		SS	6	157									
							VANE		156									
					20		SS	7	155									
							VANE		154									
					21		SS	8	153									
							VANE		152									
									151									
									150									
149.1							VANE											

Continued Next Page







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

# RECORD OF BOREHOLE No MWB

3 OF 3

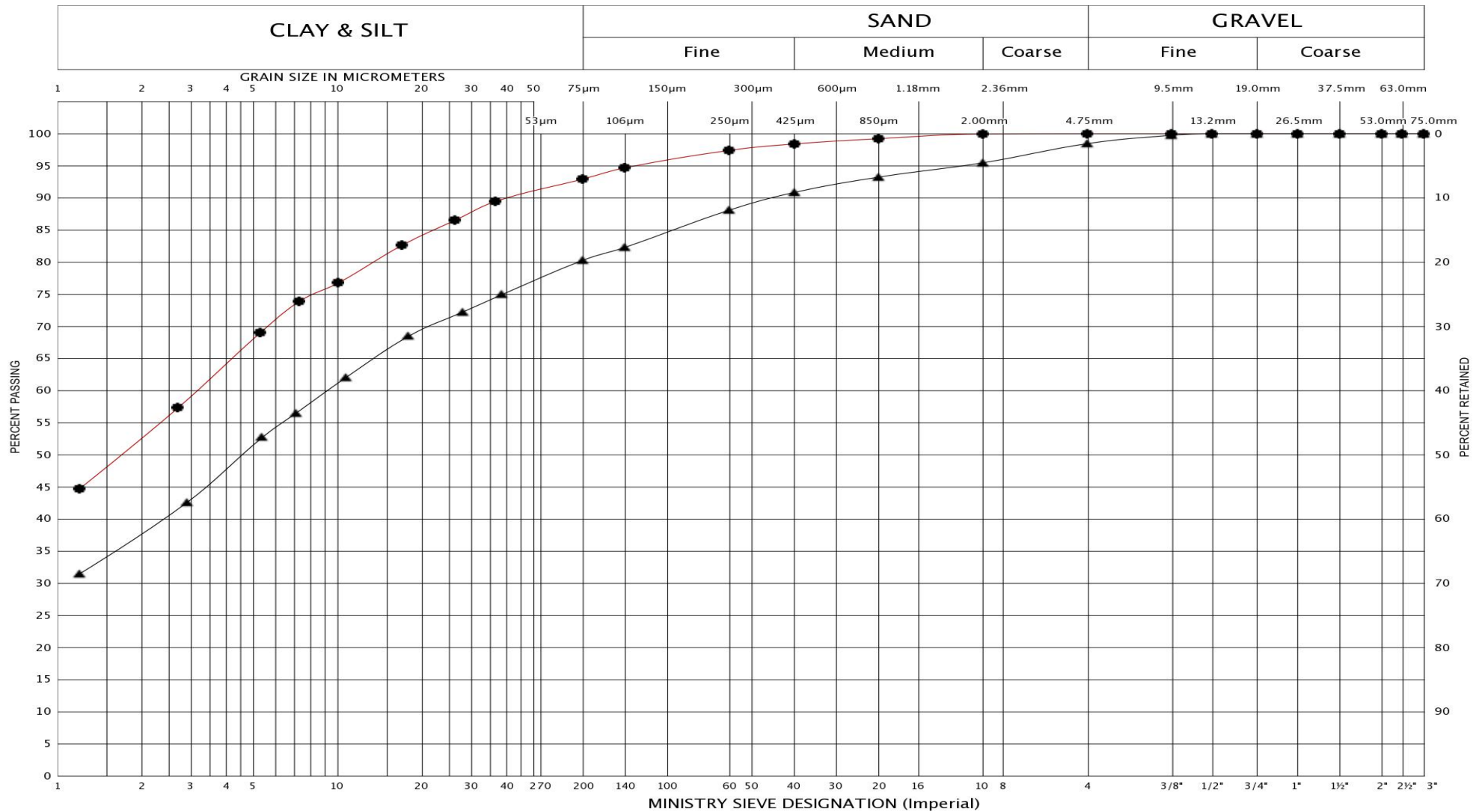
METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 684 439.4 N; 318 620.1 E ORIGINATED BY J.O.  
DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A.  
DATUM Geodetic DATE 2019.09.27 - 2019.09.30 LATITUDE 42.299410 LONGITUDE -82.332389 CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	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													
149.1 30.0	End of borehole																									
	 Groundwater level measured in monitoring well  NOTES: 1. Groundwater was not encountered during or upon completion of drilling. 2. No cave-in was noted upon extraction of hollow stem augers.  <u>Monitoring Well Readings:</u> <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev.</th> </tr> </thead> <tbody> <tr> <td>Oct.11/19</td> <td>DRY</td> <td>-</td> </tr> <tr> <td>Oct.24/19</td> <td>DRY</td> <td>-</td> </tr> <tr> <td>Oct.28/19</td> <td>7.4</td> <td>171.7</td> </tr> </tbody> </table>  <u>Monitoring Well Legend:</u>  Stick-up Monument  Bentonite  Filter Sand  19 mm PVC Screen  Filter Bottom	Date	Depth (m)	Elev.	Oct.11/19	DRY	-	Oct.24/19	DRY	-	Oct.28/19	7.4	171.7													
Date	Depth (m)	Elev.																								
Oct.11/19	DRY	-																								
Oct.24/19	DRY	-																								
Oct.28/19	7.4	171.7																								

ONTARIO MTO 19KF029A - W06 (NOV 11), GPJ ONTARIO MTO.GDT 11-14-19

# UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	MEB	MWB
	SAMPLE	17	5
	SYMBOL	●	▲

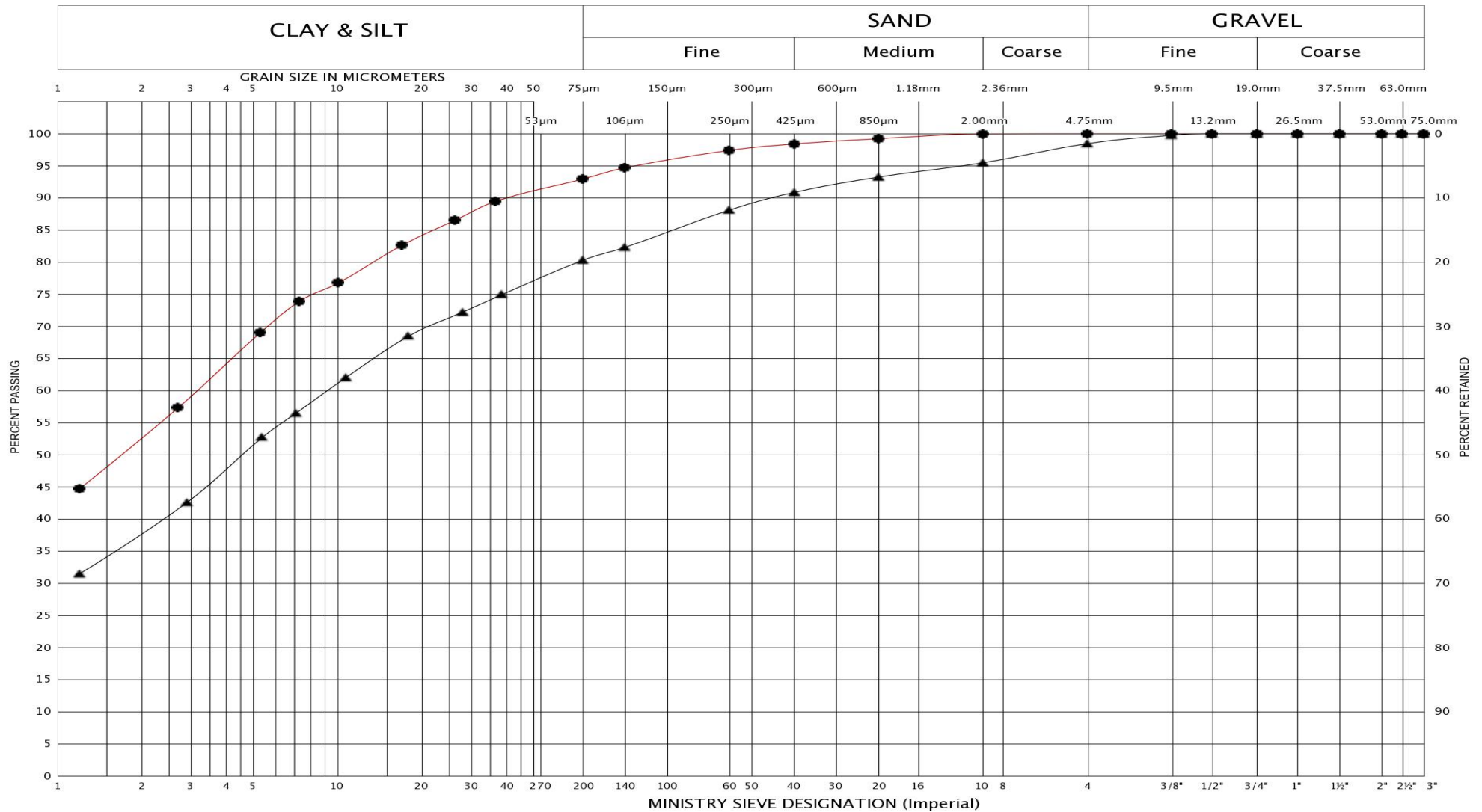


**GRAIN SIZE DISTRIBUTION**  
 SILTY CLAY , Some Sand , Trace Gravel (Till)

FIG No.:	GS-MD-1
HWY :	401
GWP	3034-19-00



# UNIFIED SOIL CLASSIFICATION SYSTEM



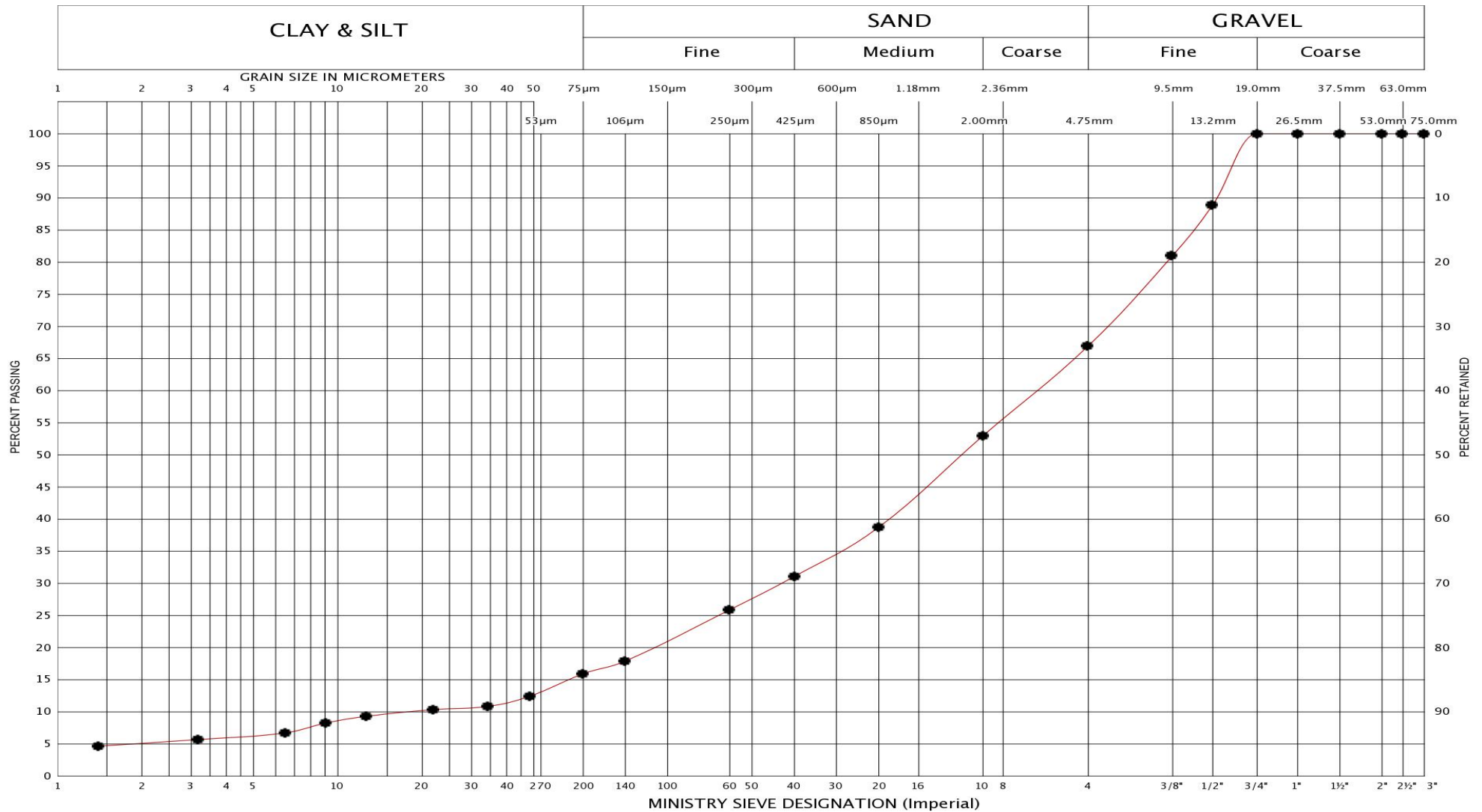
LEGEND	BH	MEB	MWB	MEB	MWB	MWB	MEB	MWB	MEB	MWB
	SAMPLE	6	8	9	12	15	16	17	20	21
	SYMBOL	▲	■	●	■	□	▼	◆	★	▲



**GRAIN SIZE DISTRIBUTION**  
CLAYEY SILT, Some Sand , Trace Gravel (Till)

FIG No.: GS-MD-2  
HWY : 401  
GWP 3034-19-00

# UNIFIED SOIL CLASSIFICATION SYSTEM

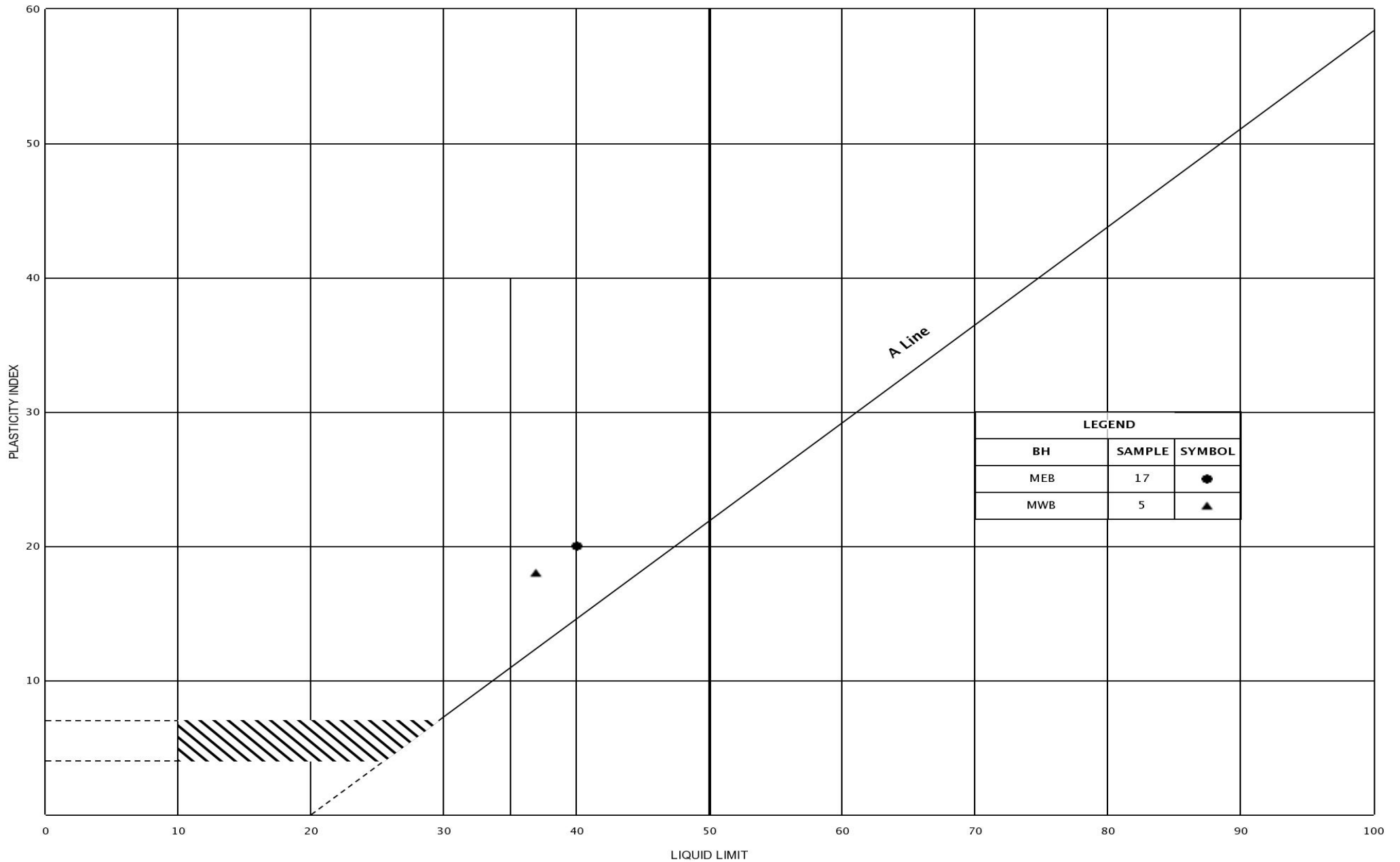


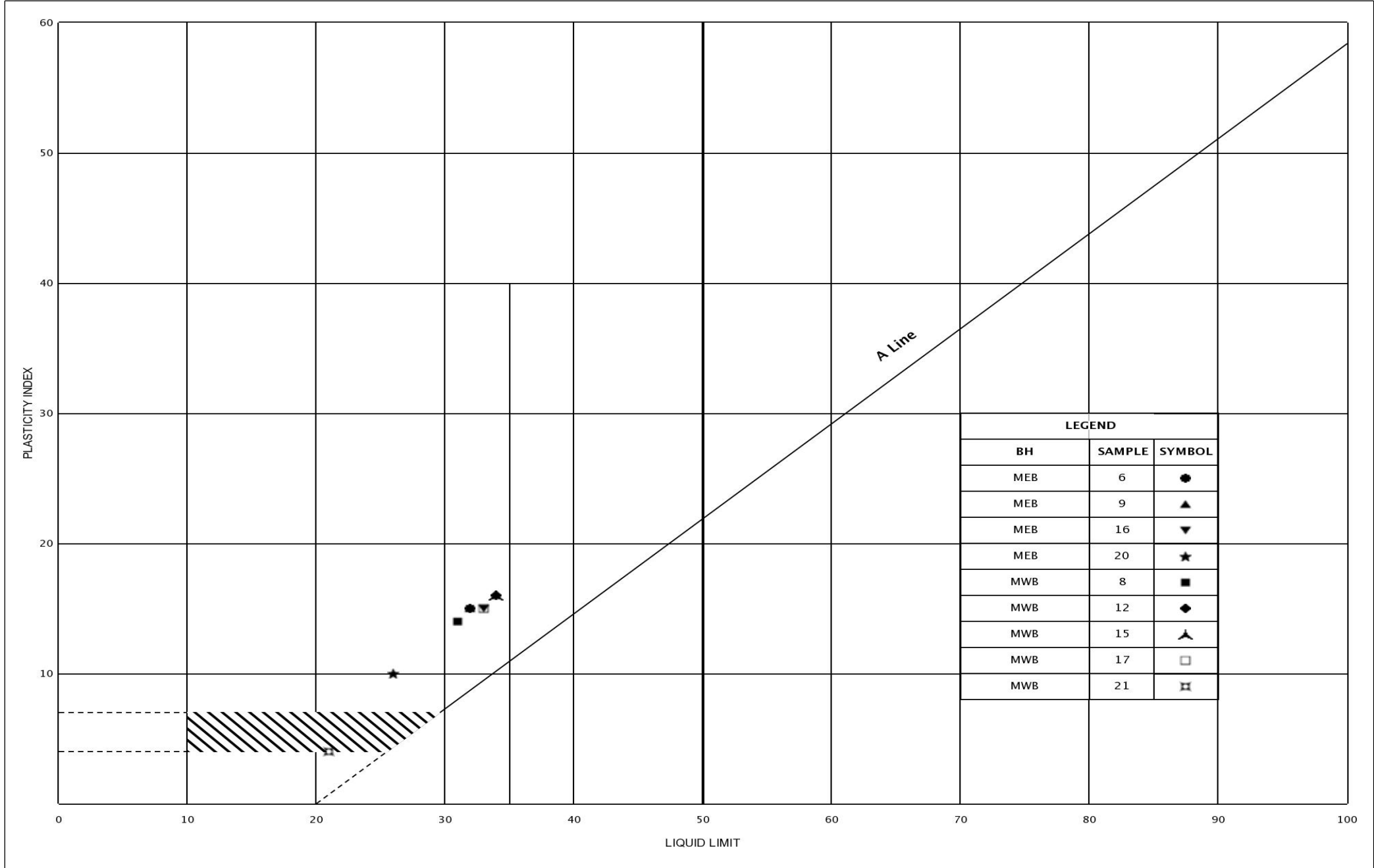
LEGEND	BH	MEB
	SAMPLE	14
	SYMBOL	•



**GRAIN SIZE DISTRIBUTION**  
Gravelly SAND, Trace Silt, Trace Clay (Till)

FIG No.:	GS-MD-3
HWY :	401
GWP	3034-19-00





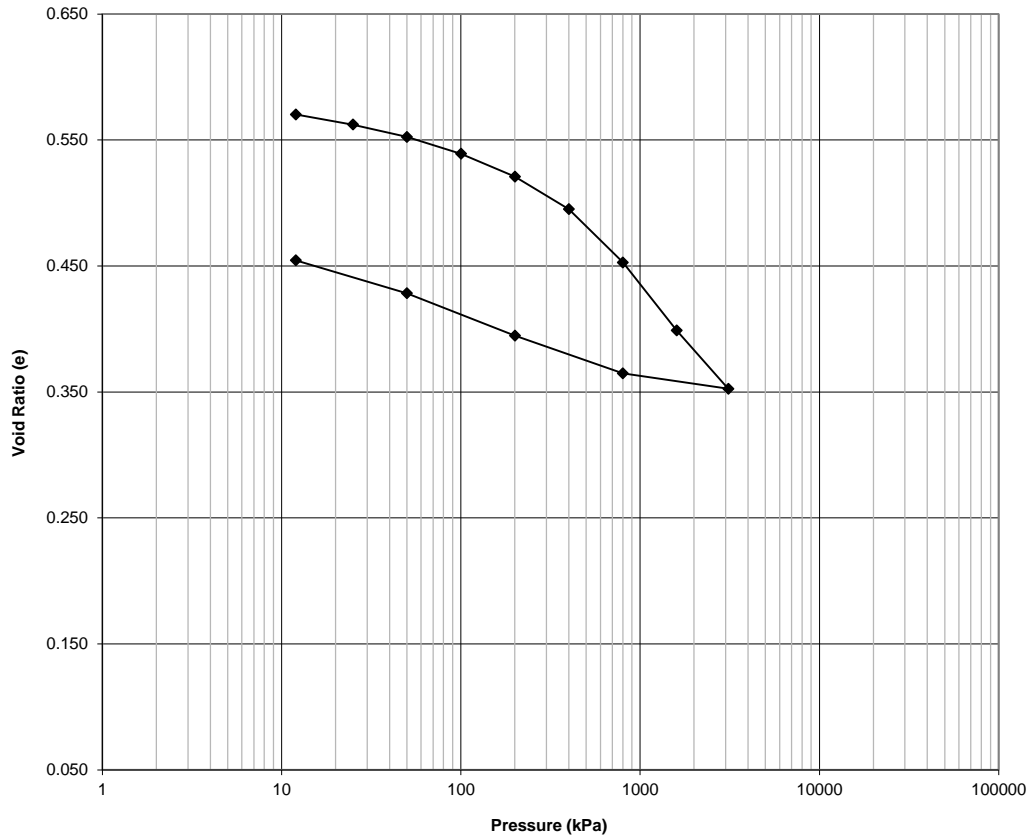
**PLASTICITY CHART**  
CLAYEY SILT, Some Sand, Trace Gravel (Till)

FIG No.:	PC-MD-2
HWY.:	401
GWP	3034-19-00

Consolidation Test Results  
(ASTM D2435)  
Highway 401 ,CA 3017-E-0006,Task 006 - 4 Bridges Detail Design

Borehole MEB, Sample TW 16, Depth 16.8-17.4 m

**Void Ratio versus Log of Pressure**



SOIL TYPE: Grey Clayey Silt Till			
$e_0$	= 0.589	$W_L$	= 33
$W_0$	= 21.5 %	$W_P$	= 18
$\gamma$	= 20.3 kN/m <sup>3</sup>	PI	= 15
		FIGURE No: M-1	
		Highway 401 ,CA 3017-E-0006,Task 006 - 4 Bridges Detail Design	
		PML Ref: 19KF029A	



## FINAL REPORT

CA14407-OCT19 R1

19KF029A Hwy 401, Tilbury (M/Q)

Prepared for

**Peto MacCallum Ltd**

## First Page

### CLIENT DETAILS

Client Peto MacCallum Ltd

Address 165 Cartwright Ave  
Toronto, ON  
M6A 1V5, Canada

Contact Nazibur Rahman

Telephone 416-785-5110

Facsimile 416-785-5120

Email nrahman@petomacallum.com

Project 19KF029A Hwy 401, Tilbury (M/Q)

Order Number

Samples Soil (8)

### LABORATORY DETAILS

Project Specialist Brad Moore Hon. B.Sc

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2143

Facsimile 705-652-6365

Email brad.moore@sgs.com

SGS Reference CA14407-OCT19

Received 10/11/2019

Approved 10/17/2019

Report Number CA14407-OCT19 R1

Date Reported 10/17/2019

### COMMENTS

Temperature of Sample upon Receipt: 7 degrees C

Cooling Agent Present:Yes

Custody Seal Present:Yes

Chain of Custody Number:007603

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

### SIGNATORIES

Brad Moore Hon. B.Sc

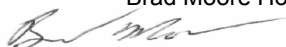




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# FINAL REPORT

CA14407-OCT19 R1

**Client:** Peto MacCallum Ltd

**Project:** 19KF029A Hwy 401, Tilbury (M/Q)

**Project Manager:** Nazibur Rahman

**Samplers:** Jinsuko

## PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	MEB, SS3 (5'-7')	MEB, SS5 (10'-12')	MWB, SS4 (7.5'-9.5')	MWB, SS6 (12.5'-14.5')	QWB, SS4 (7.5'-9.5')	QWB, SS6 (12.5'-14.5')	QEB, SS5 (10'-12')	QEB, SS7 (15'-17')
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019

Parameter	Units	RL		Result	Result	Result	Result	Result	Result	Result	Result
Corrosivity Index											
Corrosivity Index	none	1		2	1	1	4.5	7.5	4	6.5	9.5
Soil Redox Potential	mV	-		228	222	280	383	452	416	290	275
Sulphide	%	0.02		< 0.02	< 0.02	< 0.02	0.30	0.03	< 0.02	0.10	0.08
pH	pH Units	0.05		7.79	7.98	8.01	8.08	8.62	8.61	8.33	7.75
Resistivity (calculated)	ohms.cm	-9999		2520	3100	3340	3160	8870	5690	2160	2060

## PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	MEB, SS3 (5'-7')	MEB, SS5 (10'-12')	MWB, SS4 (7.5'-9.5')	MWB, SS6 (12.5'-14.5')	QWB, SS4 (7.5'-9.5')	QWB, SS6 (12.5'-14.5')	QEB, SS5 (10'-12')	QEB, SS7 (15'-17')
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019

Parameter	Units	RL		Result	Result	Result	Result	Result	Result	Result	
General Chemistry											
Conductivity	uS/cm	2		397	323	299	316	113	176	464	485

## PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	MEB, SS3 (5'-7')	MEB, SS5 (10'-12')	MWB, SS4 (7.5'-9.5')	MWB, SS6 (12.5'-14.5')	QWB, SS4 (7.5'-9.5')	QWB, SS6 (12.5'-14.5')	QEB, SS5 (10'-12')	QEB, SS7 (15'-17')
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019

Parameter	Units	RL		Result	Result	Result	Result	Result	Result	Result	
Metals and Inorganics											
Moisture Content	%	0.1		17.5	14.2	14.1	13.8	7.0	8.2	16.6	17.4



# FINAL REPORT

CA14407-OCT19 R1

**Client:** Peto MacCallum Ltd

**Project:** 19KF029A Hwy 401, Tilbury (M/Q)

**Project Manager:** Nazibur Rahman

**Samplers:** Jinsuko

## PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	MEB, SS3 (5'-7')	MEB, SS5 (10'-12')	MWB, SS4 (7.5'-9.5')	MWB, SS6 (12.5'-14.5')	QWB, SS4 (7.5'-9.5')	QWB, SS6 (12.5'-14.5')	QEB, SS5 (10'-12')	QEB, SS7 (15'-17')
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019

Parameter	Units	RL	Result	Result	Result	Result	Result	Result	Result	Result
-----------	-------	----	--------	--------	--------	--------	--------	--------	--------	--------

## Metals and Inorganics (continued)

Sulphate	µg/g	0.4		130	70	52	340	3.2	6.9	290	270
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## PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	MEB, SS3 (5'-7')	MEB, SS5 (10'-12')	MWB, SS4 (7.5'-9.5')	MWB, SS6 (12.5'-14.5')	QWB, SS4 (7.5'-9.5')	QWB, SS6 (12.5'-14.5')	QEB, SS5 (10'-12')	QEB, SS7 (15'-17')
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019	10/10/2019

Parameter	Units	RL	Result	Result	Result	Result	Result	Result	Result	Result
-----------	-------	----	--------	--------	--------	--------	--------	--------	--------	--------

## Other (ORP)

Chloride	µg/g	0.4		210	130	140	54	11	26	130	100
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FINAL REPORT

CA14407-OCT19 R1

QC SUMMARY

Anions by IC  
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0296-OCT19	µg/g	0.4	<0.4	1	20	99	80	120	106	75	125
Sulphate	DIO0296-OCT19	µg/g	0.4	<0.4	6	20	97	80	120	97	75	125

Carbon/Sulphur  
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0023-OCT19	%	0.02	<0.02	3	20	116	80	120			



FINAL REPORT

CA14407-OCT19 R1

QC SUMMARY

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-1ENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0294-OCT19	uS/cm	2	0.002	0	10	99	90	110	NA		
Conductivity	EWL0295-OCT19	uS/cm	2	0.002	0	10	98	90	110	NA		

pH

Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0294-OCT19	pH Units	0.05	NA	0		100			NA		
pH	EWL0295-OCT19	pH Units	0.05	NA	0		100			NA		

## QC SUMMARY

---

**Method Blank:** a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

**Duplicate:** Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

**LCS/Spike Blank:** Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

**Matrix Spike:** A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

**Reference Material:** a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

**RL:** Reporting limit

**RPD:** Relative percent difference

**AC:** Acceptance criteria

**Multielement Scan Qualifier:** as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

**Duplicate Qualifier:** for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

**Matrix Spike Qualifier:** for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

## LEGEND

## FOOTNOTES

**NSS** Insufficient sample for analysis.

**RL** Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

**NA** The sample was not analysed for this analyte

**ND** Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at [http://www.sgs.com/terms\\_and\\_conditions.htm](http://www.sgs.com/terms_and_conditions.htm). The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --



## **APPENDIX B**

Previous Borehole Logs and Drawings (GEOCRES No. 40J08-006)

# 59-F-12  
W.P. # 9-59  
Hwy. # 401  
CROSSING  
GRAVEL RD.  
CON. # 6  
5½ MILES N.E.  
OF TILBURY



DRILL RIG PENN DRILL JONSTON OPERATION BORE \_\_\_\_\_ JOB F-59-12 WP 9-59 \_\_\_\_\_ BORING 1 STA. 60+48.40 40  
CASING \_\_\_\_\_ (standard samplers to fit unless noted) \_\_\_\_\_ DATUM GEODETIC \_\_\_\_\_ DATE REPORT MARCH 1959 \_\_\_\_\_  
SAMPLER HAMMER WT. 140 \_\_\_\_\_ LBS. DROP 30 \_\_\_\_\_ INCHES COMPILED BY TJ CHECKED BY AL \_\_\_\_\_ DATE BORING FEBRUARY 9 1959 \_\_\_\_\_

### SAMPLE CONDITION



- DISTURBED
- FAIR
- GOOD
- LOST

[illegible]

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

DRILL RIG PENN. DRILL JOHNSTON COOPERATION BORE JOB E-59-12 W.P. 9-59 BORING 2 STA. 60+48-40 ft.  
CASING \_\_\_\_\_ (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT MARCH 1959  
SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES COMPILED BY JJ CHECKED BY AL DATE BORING FEBRUARY 9, 1959.

## 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       $\gamma$  - 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

[illegible]



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

DRILL RIG PEN. DRILL JOHNSON OPERATION BORE PENETRATION NOBF-59-12 WP 9-59 BORING 4 STA. 60+83 (43 RT)  
CASING (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT MARCH 1959  
SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES COMPILED BY J.J. CHECKED BY A.L. DATE BORING FEBRUARY 6, 1959

## ABBREVIATIONS

- INSITU VANE SHEAR TEST Q - TRIAXIAL QUICK K - PERMIABILITY  
- MECHANICAL ANALYSIS S - TRIAXIAL SLOW C - CONSOLIDATION  
- UNCONFINED COMPRESSION WL - WATER LEVEL IN CASING CA - CASING  
- TRIAXIAL CONSOLIDATED QUICK WT - WATER TABLE IN SOIL  $\gamma$  - UNIT WEIGHT

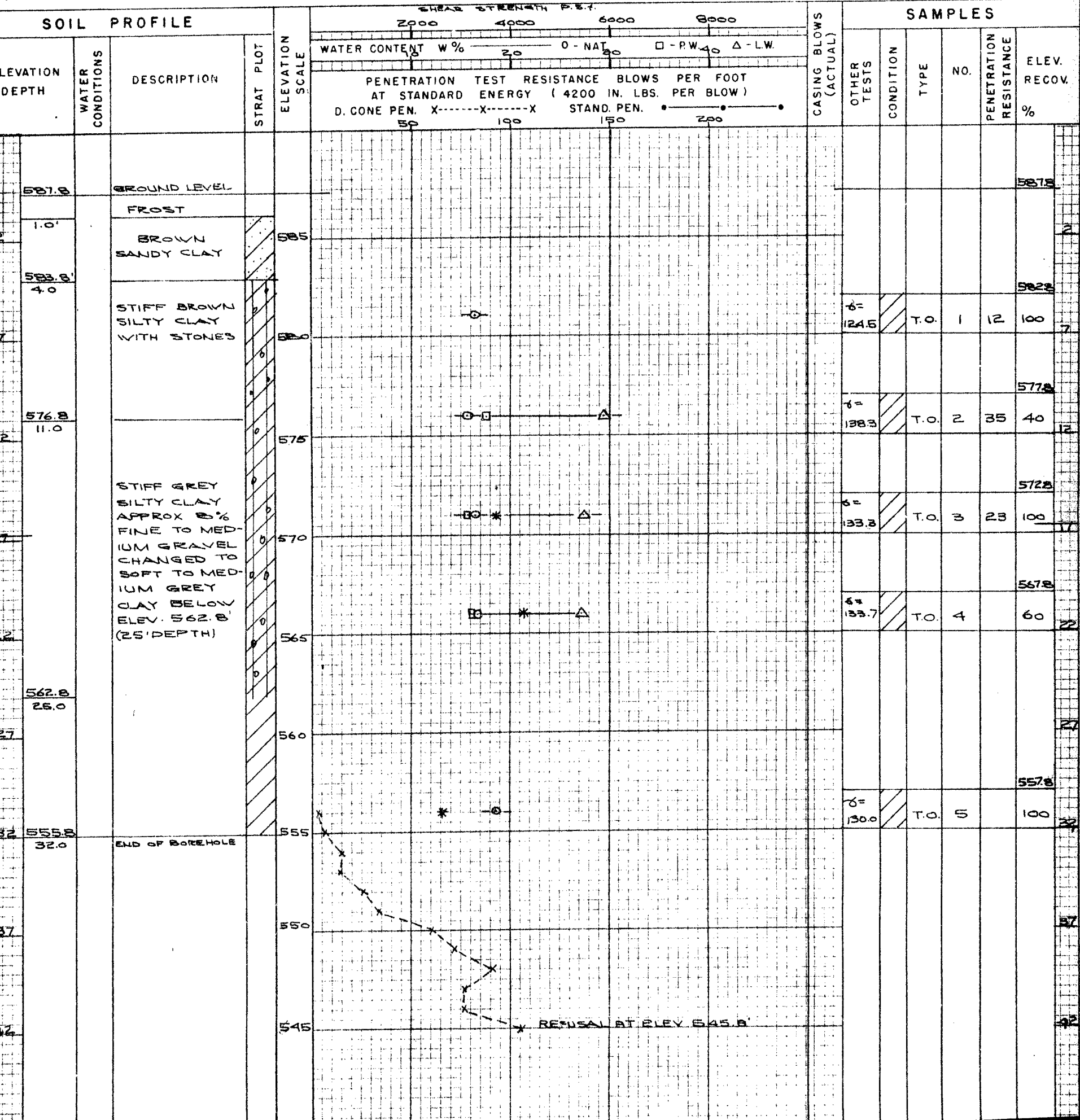
## SAMPLE TYPES

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



DRILL RIG PENN. DRILL JOHNSTON OPERATION BORE JOB F-59-12 W.P. 9-59 BORING 5 STA. 60+10 (40' RT)  
CASING --- (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT MARCH 1959  
SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES COMPILED BY L.W. CHECKED BY A.E. DATE BORING FEBRUARY 6, 1959

## SAMPLE TYPES

**SAMPLE CONDITION**

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

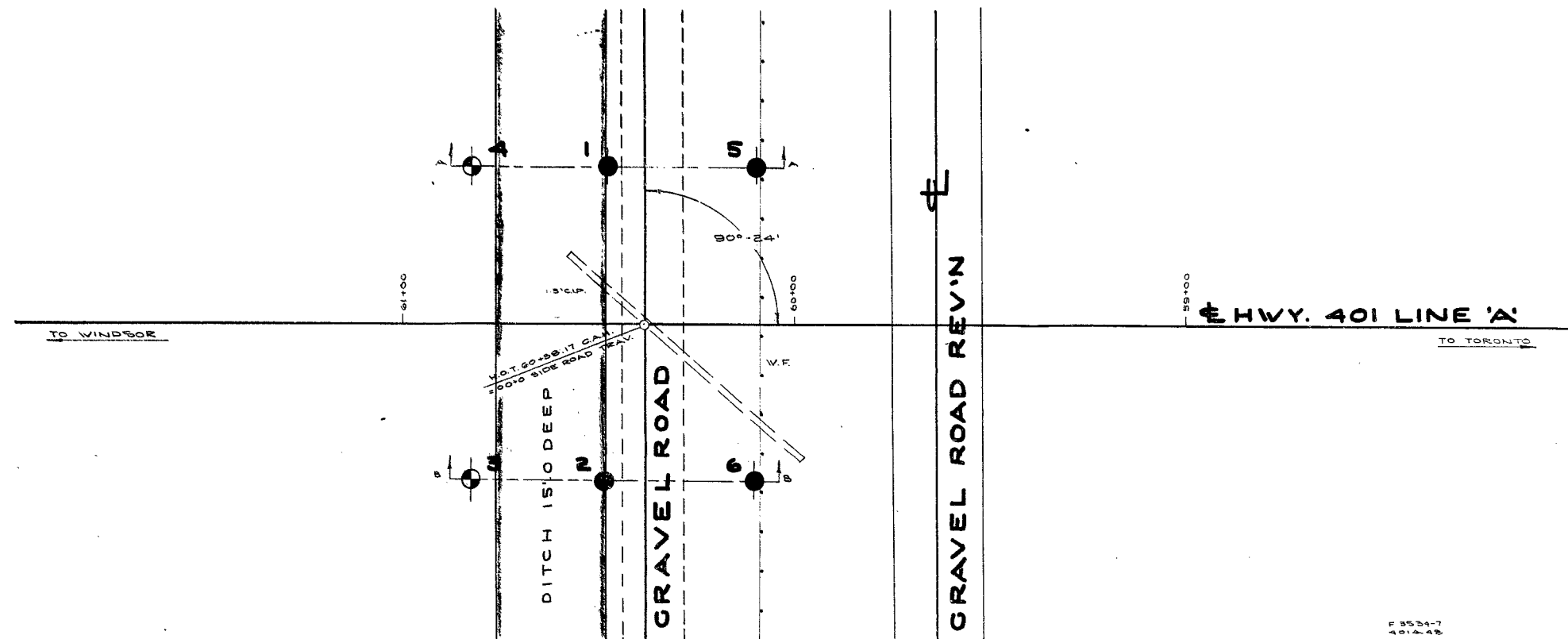


- DISTURBED
- FAIR
- GOOD
- LOST

[illegible]

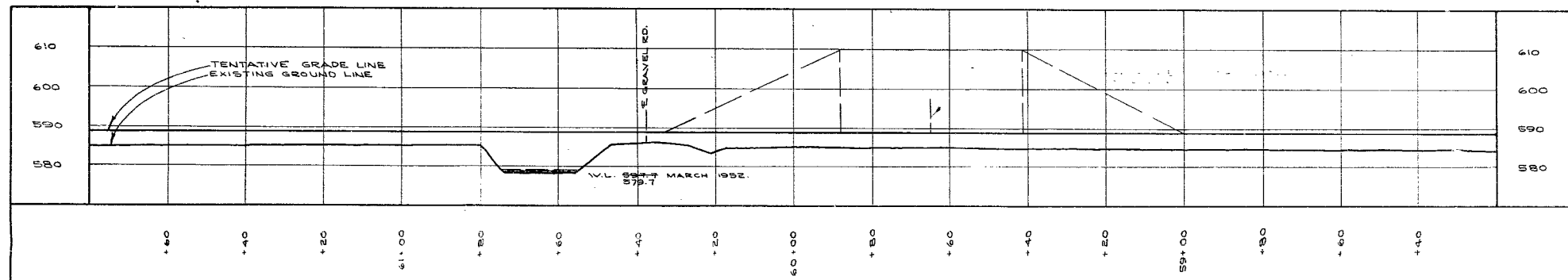






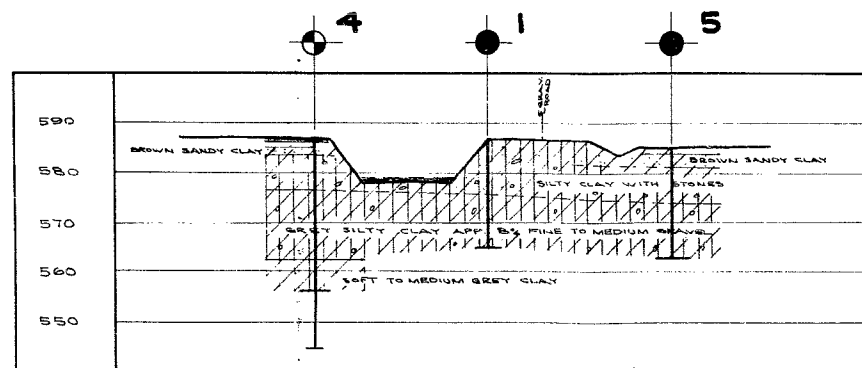
PLAN

F 5534-7  
401A-48

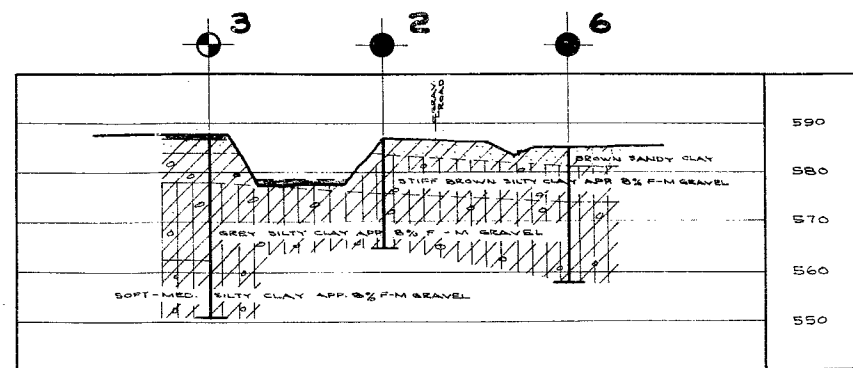


PROFILE

F 5534-3  
401A-39



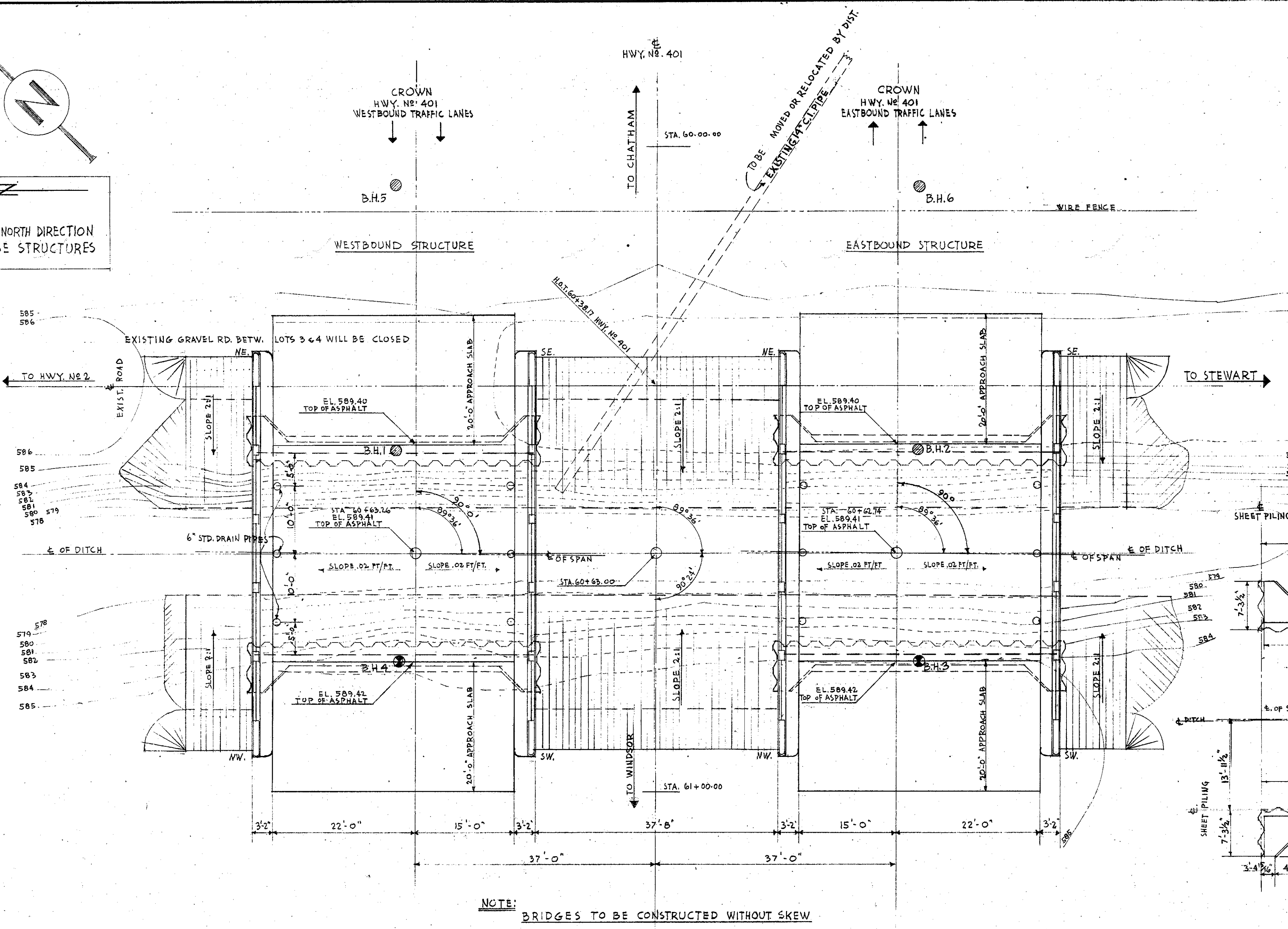
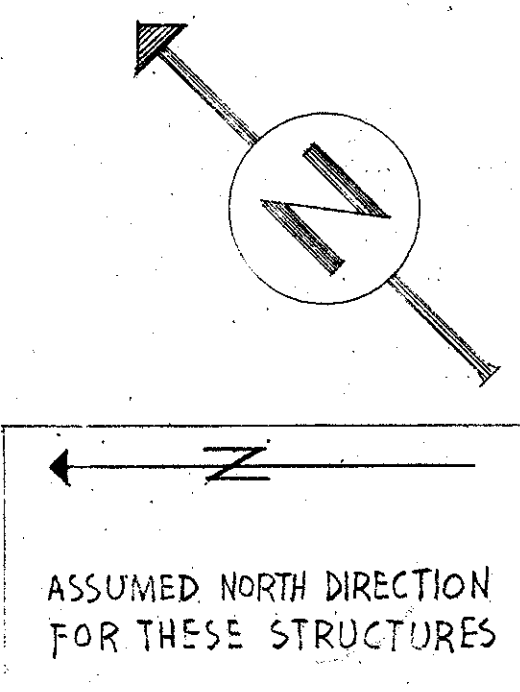
A-A



B-B

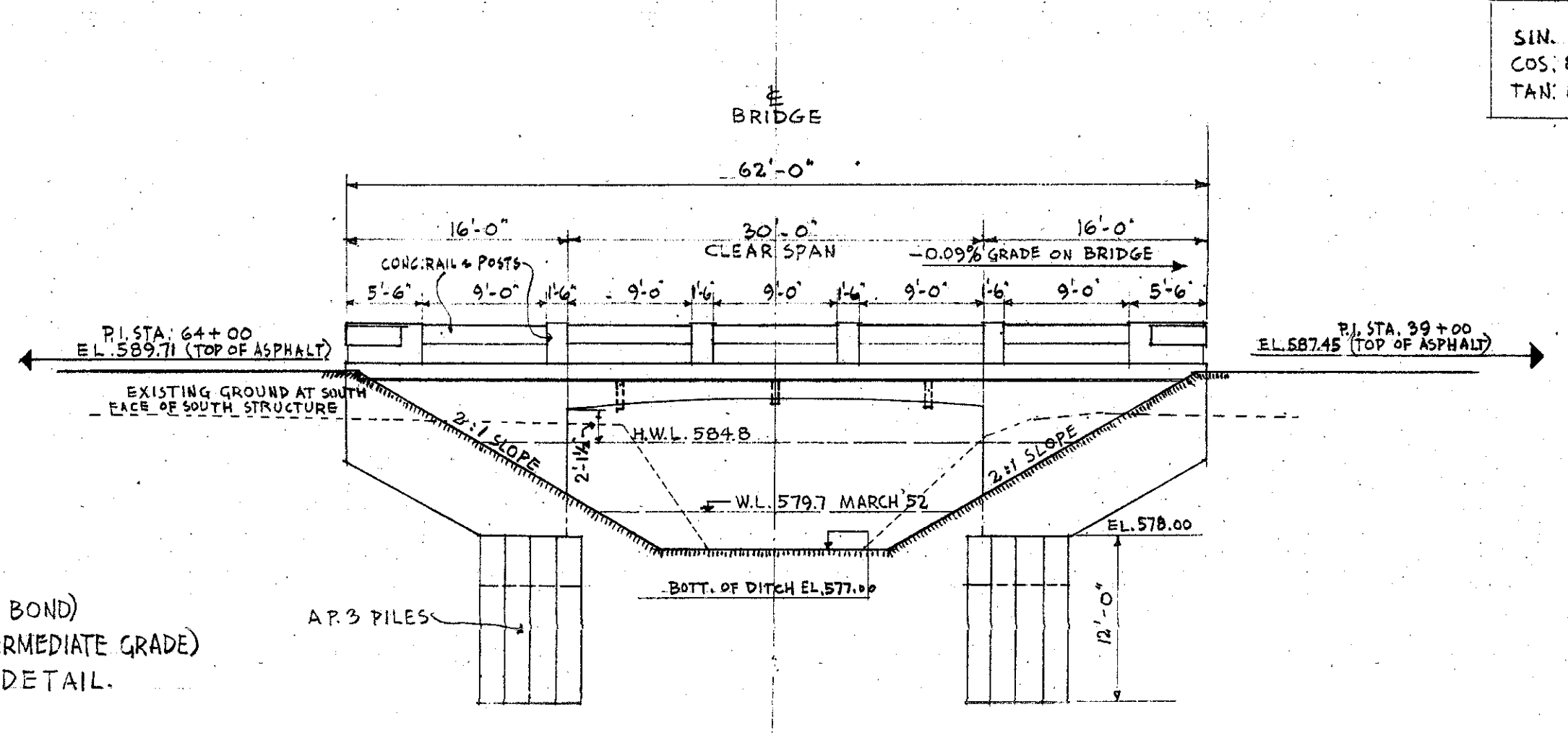
LEGEND			
BORE HOLE			
PENETRATION HOLE			
BORE & PENETRATION HOLE			
HOLE NO.	ELEVATION	STATION	DISTANCE FROM E.
1	587.0	60+48	40' RT.
2	587.0	60+48	40' LT.
3	587.8	60+83	40' LT.
4	587.8	60+83	40' RT.
5	585.0	60+10	40' RT.
6	585.0	60+10	40' LT.

DEPARTMENT OF HIGHWAYS-ONTARIO MATERIALS RESEARCH SECTION			
<b>GRAVEL ROAD PROPOSED CROSSING</b>			
SHOWING POSITIONS & ELEVATIONS OF HOLES			
HWY. 401	DISTRICT	COUNTY	KENT
TOWNSHIP	TILBURY EAST	LOT	4 CON. II
LOCATION 5 1/2 MI. N.E. TILBURY			
DRAWN BY: T. MELLORS	CHECKED BY:	W.P. 9-59	
DATE MAR. 16/59	APPROVED BY:	DRAWING NO.	
SCALE 1" = 20'		<b>F59-12A</b>	



NOTE: BRIDGES TO BE CONSTRUCTED WITHOUT SKEW

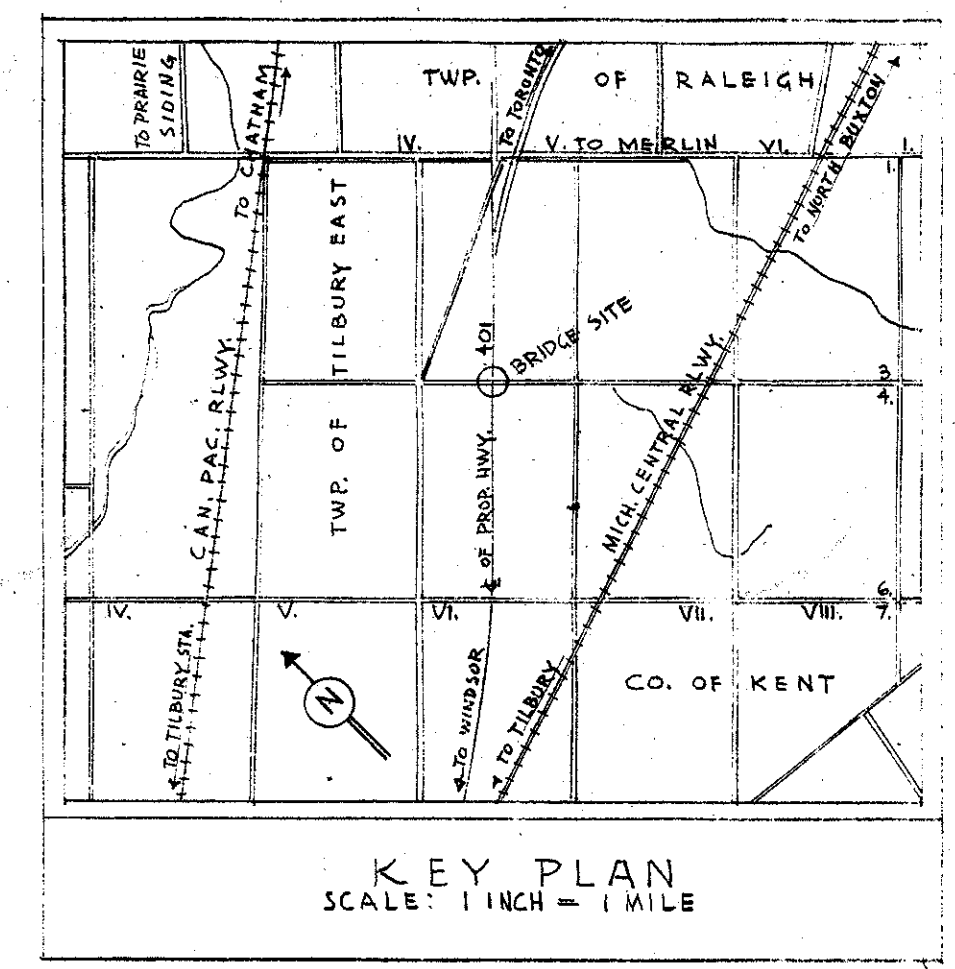
PLAN OF DECK  
SCALE: 1 INCH = 10'-0"



SOUTH ELEVATION OF SOUTH STRUCTURE  
SCALE: 1 INCH = 10'-0"

SIN. 89°36' = 0.99998  
COS. 89°36' = 0.00698  
TAN. 89°36' = 143.23712

- CONSTRUCTION NOTES
1. ALL EXPOSED EDGES TO BE GIVEN 1" CHAMFER, OR AS SPECIFIED.
  2. BACK OF FOOTING TO BE POURED AGAINST UNDISTURBED GROUND.
  3. CONTRACTOR TO CUT OFF DRAINS 3" BELOW BOTTOM OF DECK.
  4. FALSEWORK SUPPORTING THE DECK AND CANTILEVERED WINGWALLS MUST NOT BE REMOVED UNTIL THE CONCRETE HAS REACHED 80% OF THE DESIGN STRENGTH.
  5. THE BACKFILL BEHIND BOTH ABUTMENTS SHALL BE PLACED SIMULTANEOUSLY AND BY THOROUGHLY COMPACTING 6 INCH HORIZONTAL LAYERS AS SPECIFIED IN FORM NO. 9 AND THE GENERAL GRADING SPECIFICATIONS C1. 214.



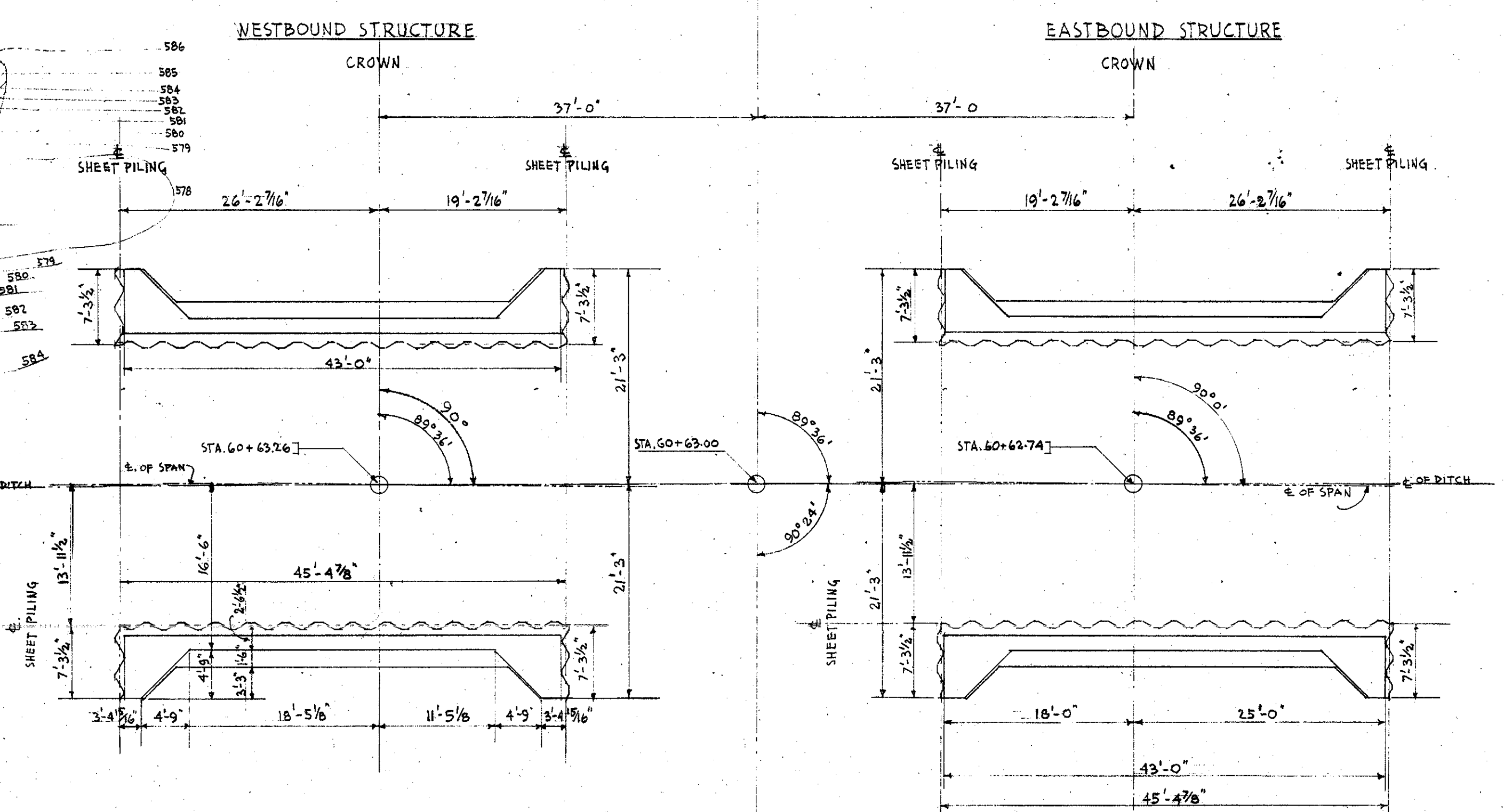
NOTE TO DISTRICT ENGINEERS  
CONCRETE WORK ON THIS STRUCTURE MUST NOT BE COMMENCED UNTIL MONUMENTS TO FIX CONTROL POINTS HAVE BEEN ERECTED AND CHECKED BY THE DISTRICT ENGINEER.

NOTE TO CONTRACTOR  
STRUCTURE TO BE BUILT IN ACCORDANCE WITH FORM 9 AND THE SPECIAL PROVISIONS, EXTRA C OF WHICH MAY BE OBTAINED FROM THE DISTRICT. ALL CONSTRUCTION JOINTS MUST BE APPROVED BY THE BRIDGE ENGINEER.

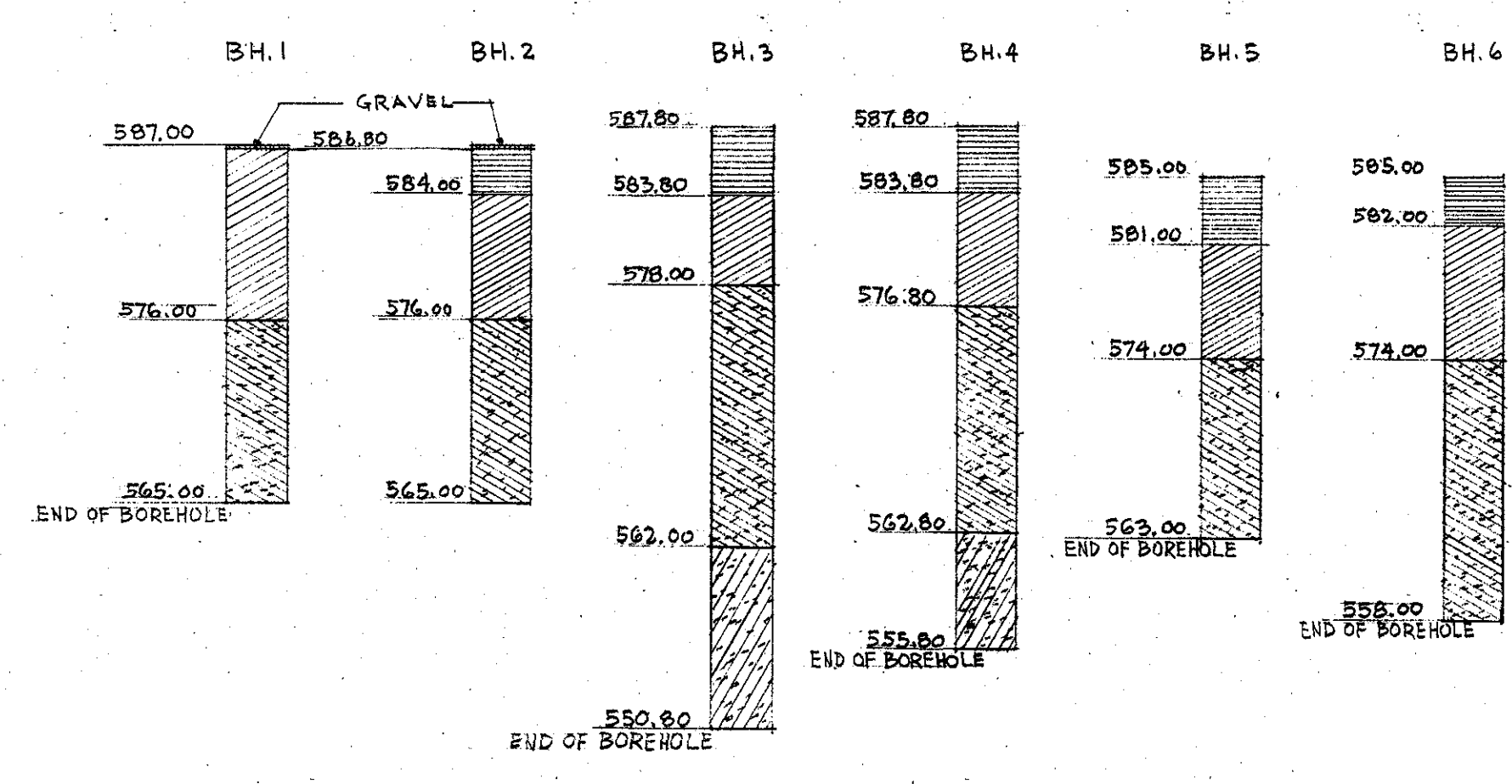
CONCRETE MIX  
FOOTINGS: MINIMUM STRENGTH AT 28 DAYS  
REMAINDER: MAXIMUM SIZE AGGREGATE 3/4" FOR DECK. REMA STRUCTURE NOT TO EXCEED 1 1/2" IN SIZE.  
AN APPROVED ADMIXTURE SUPPLIED BY THE DEPARTMENT BE ADDED TO ALL CONCRETE AS SPECIFIED BY THE ENGINEER.

BORING DATA  
THE COMPLETE SOIL INVESTIGATION REPORT BA 879 MAY BE EXAMINED AT THE BRIDGE OFFICE 280 DAVENPORT ROAD (TORONTO). THE DEPARTMENT DOES NOT GUARANTEE THE ACCURACY OF THIS REPORT OR THE ABRIDGED VERSION SHOWN ON THESE PLANS.

REINFORCING STEEL  
CLEAR COVER IN: FOOTINGS, ABUTMENTS, 3"  
DECK, 2"  
ENDPOSTS, 1 1/2" OR AS SPECIFIED



FOOTING LAYOUT  
SCALE: 1 INCH = 10'-0"



BOREHOLE DETAILS  
SCALE: 1 INCH = 10'-0"

- LEGEND
- BROWN SANDY CLAY.
  - STIFF BROWN SILTY CLAY.
  - STIFF GREY SILTY CLAY APPROX. 8% FINE TO MEDIUM GRAVEL.
  - SOFT TO MEDIUM GREY SILTY CLAY APPROX. 8% FINE TO MEDIUM GRAVEL.

PRINT RECORD		
NO.	FOR	DATE
7	100 & 111	17-11-57
20	200 & 210	14-6-58
10	100 & 111	11-9-58
20	200 & 210	21-11-58
10	100 & 111	20-11-58

- LIST OF DRAWINGS
- D 4368-1 GENERAL LAYOUT
  - D 4368-2 REINFORCEMENT DETAILS
  - D 4368-3 REINFORCING STEEL TABLE (HIGH BOND)
  - D 4368-4 REINFORCING STEEL TABLE (INTERMEDIATE GRADE)
  - D 4368-5 APPROACH SLABS & CURB DETAIL.

WP. 9-59

DEPARTMENT OF HIGHWAYS-ONTARIO  
BRIDGE OFFICE-TORONTO

TILBURY EAST TWP. BRIDGE NO. 4

THE KING'S HIGHWAY No. 401 DIST. No. 1.  
CO. KENT  
TWP. TILBURY EAST LOT 3 & 4 CON. VI.

GENERAL LAYOUT

APPROVED  
BRIDGE ENGINEER  
DESIGN ENGINEER

DATE: OCT. 1959

REVISIONS

NO.	DATE	DESCRIPTION
1		
2		
3		
4		
5		

REFERENCE PLANS

DESIGN	D.E.O.M.	CHECK	G.B.	CONTRACT NUMBER	61-207
DRAWING	SIEGERT	CHECK	G.B.	LOADING	63-254
TRACING		CHECK		DRAWING NUMBER	60-35

DATE: OCT. 1959

TWP. RD. 190-1-A