FOUNDATION INVESTIGATION AND DESIGN REPORT

for

PHILLIPS CREEK CULVERT REPLACEMENT
HIGHWAY 129
SAULT STE. MARIE, ONTARIO
GWP 5222-05-00
SITE # 38S-199/C
WP 5222-05-01

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email:toronto@petomaccallum.com

Distribution:
1 cc: AECOM for distribution to MTO Project Manager + 1 digital copy (PDF)
1 cc: AECOM for distribution to MTO Pavements and Foundations Section + 1 digital copy (PDF)
1 cc: AECOM + 1 digital copy (PDF)
1 cc: PML Toronto

PML Ref.: 14TF038
Index No.: 031FIR and 032FDR
GEOCRES No.: 41J-98
March 29, 2016

TABLE OF CONTENTS

Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION INVESTIGATION REPORT

for

PHILLIPS CREEK CULVERT REPLACEMENT
HIGHWAY 129
SAULT STE. MARIE, ONTARIO
GWP 5222-05-00
SITE # 38S-199/C
WP 5222-05-01

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email:toronto@petomaccallum.com

Distribution:
1 cc: AECOM for distribution to MTO Project Manager + 1 digital copy (PDF)
1 cc: AECOM for distribution to MTO Pavements and Foundations Section + 1 digital copy (PDF)
1 cc: AECOM + 1 digital copy (PDF)
1 cc: PML Toronto

PML Ref.: 14TF038
Index No.: 031FIR
GEOCRES No.: 41J-98
March 29, 2016

PART A – FOUNDATION INVESTIGATION REPORT
Phillips Creek Culvert Replacement
Highway 129
Sault Ste. Marie, Ontario
GWP 5222-05-00, WP 5222-05-01, Site # 38S-199/C

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the proposed Phillips Creek culvert replacement. The culvert is located at Sta. 10+004.5 on Highway 129, approximately 13 km north of the Highway 129/Highway 17 intersection, in the Township of Bridgeland and Sault Ste. Marie in Algoma District. The investigation was carried out by Peto MacCallum Ltd. (PML) for AECOM Canada Ltd (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

2. SOURCES OF PREVIOUS INFORMATION

The following previous report (referred to as Reference 1) is available for the referenced culvert site and is included in Appendix B.

Reference 1: Foundation Investigation and Design Report for proposed crossing at Phillips Creek and Highway 129, Township of Bridgeland, Algoma District No. 18, Sault Ste. Marie, Ontario, WP 5222-05-01, by Foundation Section, Material and Testing Office, Ministry of Transportation and Communication – dated June 27, 1969, GEOCRES 41J-005, Site No. 38S-199.

3. SITE DESCRIPTION AND GEOLOGY

Refer to Appendix A, Photographs P1 to P4 for general views of the site. The site is located in a valley surrounded by steeply sloping hills. The existing Phillips Creek Culvert consists of twin 3.35 m diameter, 34.3 m long CSP's. The Highway 129 embankment is approximately 4.0 m high at the site. A hydro power line runs along the west side of Highway 129. The site is surrounded by trees. Philips Creek is approximately 8.0 m to 10.0 m wide at the crossing and flows in a south east direction towards Philips Bay. The water level in the creek was at Elevation 225.0 m at the time of the current investigations.

Based on terrain mapping by the Ontario Geological Survey (Northern Ontario Engineering Geology Terrain Study, OGS Survey Map 5007) the site is located within Glaciolacustrine plain. The subsurface soils at the site consist of glaciolacustrine plain deposits including sandy silts and silty clay deposits.

Based on bedrock geology mapping by the Ministry of Northern Development and Mines (Ministry of Northern Development and Mines, Bedrock Geology of Ontario, S Sheet, Map 2544), the typical rock types in the project area are Mafic intrusive rocks with diabase dikes (Marathon swarm).

4. CURRENT INVESTIGATION PROCEDURES

The previous Foundation Investigation and Design Report, designated as Reference 1 (Appendix B), was reviewed. The previous test holes were advanced along a proposed Highway 129 re-alignment and some soil replacement was recommended to allow the construction of the existing twin culverts. As-built drawings were not available at the time of this investigation. The Reference 1 report required a surficial layer of soft organic soils (muck) to be excavated and replaced with granular fill for the construction the existing culvert and highway platform. The subsurface conditions encountered at depth in the current boreholes are consistent with those encountered during the previous investigation.

The field work for the current foundation investigation consisted of five (5) boreholes that were advanced during the period of December 2014 to November 2015. The boreholes were drilled at the approximate locations shown on Drawing PC-1 (Appendix C) to depths of 7.7 m to 19.8 m.

The boreholes were advanced using various types of equipment including truck and track-mounted D-53 drill rigs equipped with continuous flight 75 to 200 mm diameter solid and hollow stem augers, respectively. Due to access constraints, the boreholes at the inlet and outlet were advanced by washboring within a 75 mm diameter casing with portable tripod drilling equipment. The equipment was supplied and operated by specialist drilling contractors working under the full-time supervision of a PML field supervisor.

Soil samples were obtained at selected intervals using a split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedures described in the ASTM D1586, Standard Test Method for Standard Penetration Test. The drill rigs were equipped with 63.5 kg (140 lb) automatic hammers with calibrated 760 mm (30 in.) falls. In-situ vane tests using an MTO ‘N’-size vane (ASTM D2573 Standard Test Method for Field Vane Shear Test) and dynamic cone penetration (DCP) tests were also conducted to assess the strength characteristics of the substrata. The results of the field tests and observations during and at completion of drilling are reported on the Record of Borehole sheets.

The groundwater conditions were assessed at the borehole locations during and at completion of drilling by observation of the groundwater levels in the open holes and the condition of the drilling rods and sampler as the samples were retrieved and by examination of the soil samples.

The boreholes were backfilled with a bentonite/cement mixture in accordance with the MTO guidelines and MOE Reg. 903 for borehole abandonment.

The boreholes were laid out by PML and subsequently surveyed in MTM NAD 83 northing and easting coordinates by exp Geomatics under contract to AECOM. The survey provided to AECOM was used by PML for this report.

The recovered soils were identified in the field in accordance with the MTO Soil Classification procedures. The soil samples were returned to PML Toronto laboratory for detailed visual examination, classification and routine moisture content determination. A total of 25% of the recovered samples were tested in the PML laboratories including seventeen (17) grain size distribution analyses, ten (10) Atterberg limit tests and fifty-two (52) moisture content determinations.

5. SUMMARIZED SUBSURFACE CONDITIONS

Refer to Appendix C for relevant drawings, record of borehole sheets and results of laboratory analyses as itemized below illustrating the subsurface conditions including soil classifications, groundwater observations and inferred stratigraphy for the current investigation:

- Borehole Locations Plan and Soil Stratigraphic Profile: (Drawings PC-1 and PC-2) Boundaries between soil strata are transitional and have been established at the borehole locations only. The boundaries between and beyond boreholes are assumed and may vary.
- Record of Borehole sheets: Boreholes PC-1 to PC-5
  The laboratory test results are shown on the Record of Borehole sheets.
- Laboratory grain size distribution charts presented in Figures PH-GS-1 to PH-GS-5
- Laboratory plasticity charts presented in Figures PH-PC-1 to PH-PC-3

The existing twin culverts are located within an approximately 4.0 m high granular material embankment placed over the native soils. In summary, the subsurface stratigraphy consist of 300 mm to 500 mm thick organic layers at the inlet and outlet of the culvert underlain by an approximately 1.1 m to 3.0 m thick non-cohesive deposit of silty/sandy soils along the culvert alignment. A typically firm to very stiff cohesive deposit of silty clay to clay silt with soft upper zones was encountered along the culvert alignment. The thickness of the cohesive layer varies between 2.4 m to 8.4 m, increasing in thickness towards the outlet of the culvert. A cohesionless silty sand/sandy silt deposit with a minimum thickness of 2.1 m to 7.8 m was encountered below the cohesive layer.

The strata encountered are summarised below:

5.1 Fill

A 3.0 m to 3.7 m thick layer of sand and gravel fill was encountered surficially in Boreholes PC-2, PC-3 and PC-5 drilled from top of the highway embankment (approximately Elevation 228.6 m) and extends to elevations ranging from 225.6 m to 225.0 m.

The SPT "N"-values ("N"-values) measured within the non-cohesive fill typically range from 11 to 53 blows, indicating a compact to very dense compactness. One "N"-value of 4 was measured in Borehole PC-3 at an approximate depth of 3.5 m, indicating a local loose condition at the base of the embankment fill platform. This may be attributable to the location of the water table or some sampling disturbance. The results of grain size distribution analyses completed on two selected samples are shown on Figure PH-GS-1.

5.2 Silty Sand to Sand

In Boreholes PC-1 and PC-4 (culvert inlet and outlet locations), a continuous 1.1 m to 1.6 m thick deposit of silty sand to sand was encountered below 300 to 500 mm thicknesses of organic soil between Elevations 225.4 m and 224.8 m and below the overlying fill layers in Boreholes PC-2, PC-3 and PC-5 at 3.0 m to 3.7 m depths, Elevations 225.6 m to 225.0 m. The deposit extends to 1.4 m to 6.0 m depths, Elevations 224.3 m to 222.6 m.

The "N"-values measured within this deposit range from 1 to 12 blows, indicating a very loose to compact compactness. The results of a grain size distribution analysis completed on a sample of this deposit are shown on Figure PH-GS-2.

5.3 Silty Clay to Clayey Silt

A 2.4 m to 8.4 m thick deposit of silty clay to clayey silt with interbedded silt layers was encountered below silty sand to sand deposit in all boreholes at 1.4 m to 6.0 m depths, Elevations 224.3 m to 222.6 m. The deposit extends to depths of 3.8 m to 12.0 m, Elevations 221.9 m to 214.8 m.

The "N"-values measured within this deposit range from 0 (weight of hammer) to 15 blows and field Vane shear strengths ranged from 15 to 100 kPa suggesting a soft to stiff consistency.

The results of grain size distribution analyses and Atterberg limits tests of selected samples of this deposit obtained during the current investigation are shown on Figures PH-GS-3, PH-PC-1 and PH-PC-2.

The Atterberg liquid limit of the silty clay samples ranged from 38 to 40 and the plastic limits 19 to 22 with plasticity indices of 18 to 19. The natural water content of the silty clay ranged from 34% to 52 %.

The liquid limit of the clayey silt ranged from 20 to 32 and the plastic limits 18 to 19 indicating plasticity indices of 9 to 14. The natural water content of the clayey silt samples ranged from 18% to 25%.

The interbedded silt layers exhibited a liquid limit of 20 and a plastic limit of 16 for a plasticity index of 4. The natural water content of the silt sample was 30%.

5.4 Silty Sand / Sandy Silt

A continuous deposit of silty sand / sandy silt at least 1.4 m to 7.8 m thick was encountered below silty clay to clayey silt deposit in all boreholes at depths varying from 3.0 m to 12.0 m, Elevations 221.9 m to 214.8 m. All boreholes were terminated within this deposit at 7.7 to 19.8 m depths, Elevations 218.0 m to 208.6 m.

The “N”-values measured within this deposit typically range from 14 to 114 blows, indicating a compact to very dense compactness, with scattered loose layers exhibiting “N”-values of 4 to 10 blows. The compactness generally increases with depth, as shown on the previous boreholes and in boreholes PC-1, 2, 3 and 5. The results of grain size distribution analyses of selected samples are shown on Figure PH-GS-4 and the result of an Atterberg Limits test on a slightly plastic sample of the sandy silt deposit is shown on Figure PH-PC-2.

5.5 Groundwater

The water level in the creek flows from west to east and was at Elevation 225.0 m at the time of the current investigations. The water level in the creek governs the water level at the site in view of the existing pervious upper soil layers.

In the process of augering and upon completion of drilling, groundwater was encountered at 0.5 m to 3.7 m depths, Elevations 225.0 m to 224.8 m.

The groundwater level of the creek is subject to seasonal fluctuations and rainfall patterns.

6. CLOSURE

Mr. F. Portela carried out the field investigations under the supervision of Ms. M. Kamranzadeh, MSc, EIT, Project Supervisor and Mr. C. M. P. Nascimento, P. Eng., Project Manager. LandCore Drilling Ltd. supplied the drill equipment for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Ms. Marzieh Kamranzadeh, MSc, Project Supervisor, EIT and reviewed by Mr. David Dundas, P.Eng, Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

Marzieh Kamranzadeh, MSc, EIT
Project Supervisor, Geotechnical Services

David Dundas, P.Eng.
Senior Engineer, Geotechnical Services

Carlos M.P. Nascimento, P.Eng
Project Manager and
MTO Designated Principal Contact

MK/DD/CN:mk-jk

APPENDIX A

Sites Photographs

Photograph P1: Looking north from the centre of Highway 129 WBL at the location of Borehole PC-2. (December 2, 2014)

Photograph P2: Looking north from the south side of the Phillips Creek at the location of Borehole PC-4. Two existing CSP culverts are visible. (January 13, 2015)

Photograph P3: Looking south west from Highway 129 northbound lane shoulder. Borehole PC-1 advanced by using a track mount at this location. (January 13, 2015)

Photograph P4: Looking south from Highway 129 northbound lane shoulder. The slope was covered with low vegetation at the time of the investigation. (November 16, 2015)

APPENDIX B

Geocres Report 41J-005

#69-F-5

W.P. 246-66

H.W.Y. #129, LINE 'D'

PHILLIPS CREEK

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ — UNIT WEIGHT OF SOIL (BULK DENSITY)

γ_s — UNIT WEIGHT OF SOLID PARTICLES

γ_w — UNIT WEIGHT OF WATER

γ_d — UNIT DRY WEIGHT OF SOIL (DRY DENSITY)

γ' — UNIT WEIGHT OF SUBMERGED SOIL

G — SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$

e — VOID RATIO

n — POROSITY

w — WATER CONTENT

S_r — DEGREE OF SATURATION

w_L — LIQUID LIMIT

w_p — PLASTIC LIMIT

I_p — PLASTICITY INDEX

s — SHRINKAGE LIMIT

I_L — LIQUIDITY INDEX $= \frac{w - w_p}{I_p}$

I_c — CONSISTENCY INDEX $= \frac{w_L - w}{I_p}$

e_{max} — VOID RATIO IN LOOSEST STATE

e_{min} — VOID RATIO IN DENSEST STATE

I_D — DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$

RELATIVE DENSITY D_r IS ALSO USED

h — HYDRAULIC HEAD OR POTENTIAL

q — RATE OF DISCHARGE

v — VELOCITY OF FLOW

i — HYDRAULIC GRADIENT

k — COEFFICIENT OF PERMEABILITY

j — SEEPAGE FORCE PER UNIT VOLUME

m_v — COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta\sigma'}$

c_v — COEFFICIENT OF CONSOLIDATION

C_c — COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma}$

T_v — TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)

U — DEGREE OF CONSOLIDATION

τ_f — SHEAR STRENGTH

c' — EFFECTIVE COHESION INTERCEPT

ϕ' — EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION

(IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$)

c_u — APPARENT COHESION

ϕ_u — APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION

(IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$)

μ — COEFFICIENT OF FRICTION

S_t — SENSITIVITY

GENERAL

π — $= 3.1416$

e — BASE OF NATURAL LOGARITHMS 2.7183

$\log_e a$ OR $\ln a$ — NATURAL LOGARITHM OF a

$\log_{10} a$ OR $\log a$ — LOGARITHM OF a TO BASE 10

t — TIME

g — ACCELERATION DUE TO GRAVITY

V — VOLUME

W — WEIGHT

M — MOMENT

F — FACTOR OF SAFETY

STRESS AND STRAIN

u — PORE PRESSURE

σ — NORMAL STRESS

σ' — NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)

τ — SHEAR STRESS

ε — LINEAR STRAIN

γ — SHEAR STRAIN

ν — POISSON'S RATIO (μ IS ALSO USED)

E — MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)

G — MODULUS OF SHEAR DEFORMATION

K — MODULUS OF COMPRESSIBILITY

η — COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d — DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE

δ — ANGLE OF WALL FRICTION

K — DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFFRRING TO NORMAL STRESS ON WALLS

K_o — COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B — BREADTH OF FOUNDATION

L — LENGTH OF FOUNDATION

D — DEPTH OF FOUNDATION BENEATH GROUND

N — DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY

k_s — MODULUS OF SUBGRADE REACTION

SLOPES

H — VERTICAL HEIGHT OF SLOPE

D — DEPTH BELOW TOE OF SLOPE TO HARD STRATUM

β — ANGLE OF SLOPE TO HORIZONTAL

RM. 110 – LAB. BLDG

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. B. R. Davis,
Bridge Engineer,
Bridge Office,
Admin. Bldg.

Attention: Mr. S. McCombie

From: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

Date: June 27, 1969

Our File Ref.

In Reply To:

JUL - 4 1969

Subject:

FOUNDATION INVESTIGATION REPORT
For
Proposed Crossing at Phillips Creek
& Hwy. #129, Line 'D', Lot 2, Con. I
Twp. of Bridgland, District: Algoma
District #18 (Sault Ste. Marie)
W.J. 69-F-5 -- W.P. 246-66

Attached, we are forwarding to you, our detailed foundation investigation report on the subsoil conditions existing at the above structure site.

We believe that the factual data and recommendations contained therein, will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

AGS/MdeF
Attach.
cc: Messrs. B. R. Davis (2)
H. A. Tregaskes
D. W. Farren
H. W. Hurrell
J. H. Blevins
E. R. Saint
S. B. Davidson
B. A. Singh
Foundations Files
Gen. Files

TABLE OF CONTENTS

FOUNDATION INVESTIGATION REPORT
For
Proposed Crossing at Phillips Creek
& Hwy. #129, Line 'D', Lot 2, Con.I
Twp. of Bridgland, District: Algoma
District #18 (Sault Ste. Marie)
W.J. 69-F-5 -- W.P. 246-66

1. INTRODUCTION:

A request for a foundation investigation at the site of the proposed crossing of Hwy. #129, Line 'D' and Phillips Creek, was received from Mr. F. De Visser, Regional Bridge Location Engineer, in a memo dated January 28, 1969.

A field investigation was subsequently carried out by the Foundation Section to determine the subsoil conditions existing at the site. This report contains the results of this investigation and our recommendations pertaining to the design of the proposed structure foundation and the stability of the proposed embankment.

2. DESCRIPTION OF THE SITE:

The site is located approx. 8 miles north of the junction of Hwy. #17 and Hwy. #129. The proposed crossing is situated in a valley, surrounded by steeply sloping hills.

3. FIELD AND LABORATORY INVESTIGATION PROCEDURES:

A total of five sampled boreholes and nine dynamic cone penetration tests was carried out during the course of the field investigation. Boring was achieved by means of conventional diamond drilling equipment adapted for soil sampling purposes. During the field work, disturbed and 'undisturbed' samples were obtained. 'Undisturbed' samples were recovered using 2-inch I.D. Shelby tubes which were pushed into the soil by hand. Disturbed samples were recovered by means of a standard split-spoon sampler,

..... 2

3. FIELD AND LABORATORY INVESTIGATION PROCEDURES: (cont'd.) ...

and the energy used in driving it, conformed to the requirements of the Standard Penetration Test. Dynamic cone penetration tests were carried out adjacent to each borehole and at four other locations. Driving energy to advance the cone was 350 ft.-lbs. per blow. In-situ vane tests were carried out wherever possible, at elevations 12 inches below the various sample depths. The locations and elevations of all boreholes are shown on the attached Drawing #69-F-5A.

Samples were visually examined and classified at the site as well as in the laboratory. Tests were carried out in the laboratory to determine the following physical properties:

Atterberg Limits
Organic Content
Moisture Content
Undrained Shear Strength
Grain-Size Distribution
Bulk Density
Consolidation Characteristics

The test results are summarized on the Record of Borehole sheets in the Appendix of this report.

4. SOIL TYPES AND SOIL CONDITIONS:

4.1) General:

The subsoil at the site consists of a surficial layer of very soft organic muck, overlying deposits of very soft to soft silty clay, very soft to very stiff clayey silt, followed by compact to very dense silty sand to sandy silt, and in some boreholes, sand and gravel.

The boundaries of the different deposits as determined in the boreholes, are shown on the accompanying Record of Borehole sheets and the estimated stratigraphical profile contained in Dwg. #69-F-5A is based on this information.

..... 3

4. SOIL TYPES AND SOIL CONDITIONS: (cont'd.) ...

4.1) General: (cont'd.) ...

From ground level downward, the various soil types, discussed in detail, are as follows:

4.2) Muck:

This deposit was observed in all boreholes, and extends from ground level to a minimum depth of 2.0 ft. The thickness varies from 2.0 to 4.5 ft. It is possible that the observed thickness may differ to a great extent at other locations. The material in the deposit consists mainly of black-coloured decayed and undecayed organic substances mixed with sand. The consistency may be described as very soft. The organic content was found to be in the order of 39%. The moisture content was found to be as high as 62%.

4.3) Silty Clay:

This stratum underlies the surficial muck deposit in all boreholes. The lower boundary was found to be at El. 729.

The material in the deposit is predominantly a mixture of clay and silt with traces of sand. In B.H. #8, layers of silt and clayey silt were encountered within this deposit.

Physical properties of the material as determined from field and laboratory tests, are as follows:

Natural Moisture Content (%)	.....	45 to 55
Liquid Limit (%)	....	42 to 53
Plastic Limit (%)	....	22 to 32
Bulk Density (PCF)	....	103 to 121

The shear strength of the material was found to vary from 250 to 500 PSF. The consistency may be described as very soft to soft.

4. SOIL TYPES AND SOIL CONDITIONS: (cont'd.) ...

4.4) Clayey Silt:

This deposit was observed in all boreholes immediately below the silty clay zone. The lower boundary was found to be between El. 704 and El. 723.

The material was found to consist of clayey silt with occasional layers of sand, silt, and clay, and also some fine gravel.

Field and laboratory tests indicated that the shear strength of the material increases with depth, being in the order of 400 PSF, in the extreme upper zone, and over 1000 PSF at the bottom. For design purposes, an average value of 600 PSF may be used. The consistency of the overall stratum may be described as soft to stiff.

In general, the natural moisture content was found to exceed the liquid limit.

Physical properties of the material in the deposit are summarized as follows:

Natural Moisture Content (%)	15	to	35
Liquid Limit (%)	22	to	34
Plastic Limit (%)	15	to	22
Bulk Density (PCF)	120	to	131
Unconfined Shear Strength (PSF)	400	to	1350
Field Vane Test (PSF)	350	to	1850

Typical grain-size distribution curves are shown on Figure 1 of the Appendix.

..... 5

4. SOIL TYPES AND SOIL CONDITIONS: (cont'd.) ...

4.5) Sandy Silt to Silty Sand:

This zone was found to underlie the clayey silt material at all borehole locations. The observed thickness was about 10 ft.

The material consists of sand and silt in varying proportions, and also contains traces of gravel. The moisture content ranges from 10 to 19%. The 'N' values obtained from standard penetration tests ranged from 14 to over 100 blows per foot, which indicates the relative density of the stratum to vary from compact to very dense.

Results of mechanical analyses are summarized in the accompanying Record of Borehole sheets.

4.6) Sand and Gravel:

A very dense sand and gravel stratum was encountered in B.H.'s #2 and #3 at El. 701 and El. 713, respectively. The lower boundary was not determined, since the borings were terminated in this layer.

5. DISCUSSION AND RECOMMENDATIONS:

It is proposed to build a new structure at the crossing of Phillips Creek and Hwy. #129, Line 'D'. The proposed profile grade will be about 16 ft. above the existing creek bed.

As can be seen from the previous paragraphs of this report, the subsoil consists of very soft organic muck deposits, overlying very soft to soft silty clay and very soft to very stiff clayey silt, overlying compact to very dense silty sand to sandy silt. The depth of the soft deposits ranges from 6 to 11 ft.

To ensure stability of the proposed embankments, it is necessary to excavate all the soft material down to approx. El. 730.0 and replace it with suitable granular material. If organic soil is found below this depth, it must also be removed.

..... 6

5. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

The width of this excavation should extend for at least the full width of the proposed embankment, toe to toe, as per Fig. 2, and should continue across the stream bed. The length of the excavation should extend from Sta. 215+00 - 216+80. Outside of these limits, the excavation and backfill should be as per D.H.O. Standard DD-406.

Stability analyses, which have been carried out in terms of total stresses, indicated that the proposed 16-ft. high embankments constructed with standard 2:1 slopes, will be stable, provided the foregoing recommendations are carried out. The underlying soft to very stiff stratum will settle due to the load imposed by the weight of embankment fill. It is estimated that the magnitude of this settlement will be in the order of 12 to 18 inches.

The proposed two 11-ft. diameter round C.I.P. culverts may be installed as shown on the Bridge Site Plan E-4565-1, ensuring that a granular pad of minimum thickness 12 inches, is provided under the pipes.

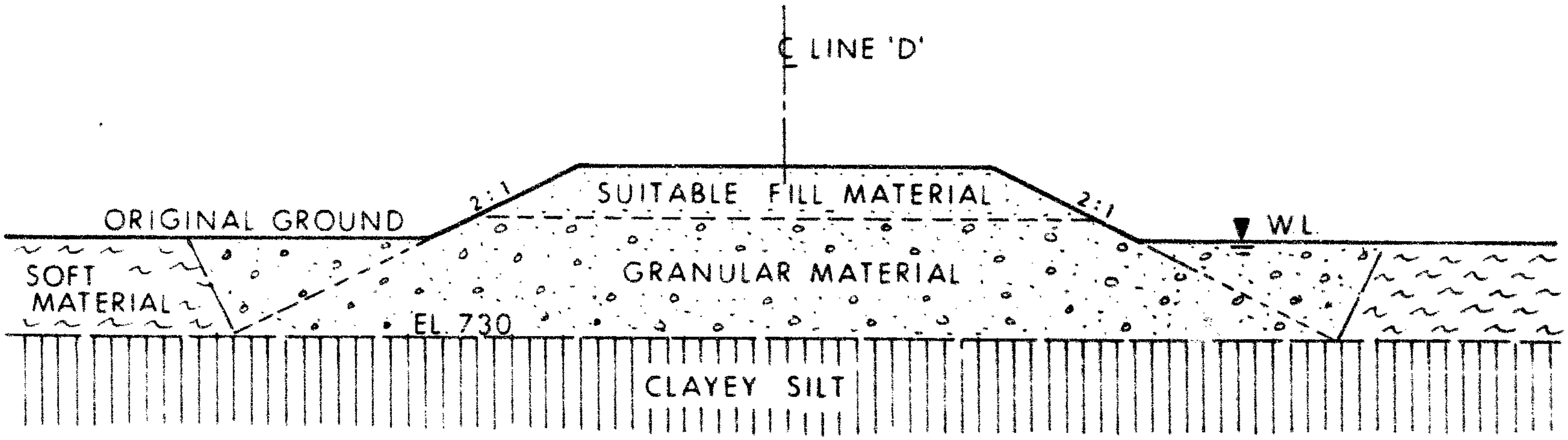
As an alternative, a new bridge structure may be built. The abutments of the bridge should be supported on end-bearing piles driven to approximate El. 705.0. The maximum allowable load for the particular pile used may be assumed for design purposes. In the case of 12 BP @ 53 steel H-piles, this load would be 70 tons per pile.

6. MISCELLANEOUS:

The field work was carried out during the period February 11 to February 17, 1969. Equipment used was owned and operated by Dominion Soil Investigation Ltd.

The supervision of the field work, together with the preparation of this report, was carried out by Mr. P. Payer, Project Foundation Engineer. The report was reviewed by Mr. K. G. Selby, Supervising Foundation Engineer.

June 1969.



TYPICAL SECTION THROUGH EMBANKMENT
SHOWING SUBEXCAVATION OF SOFT MATERIAL
BETWEEN STA. 215+00 & STA. 216+80

FIG. 2

APPENDIX I

FORM OB-MT-126 (REV 1969)

OFFICE REPORT ON SOIL EXPLORATION

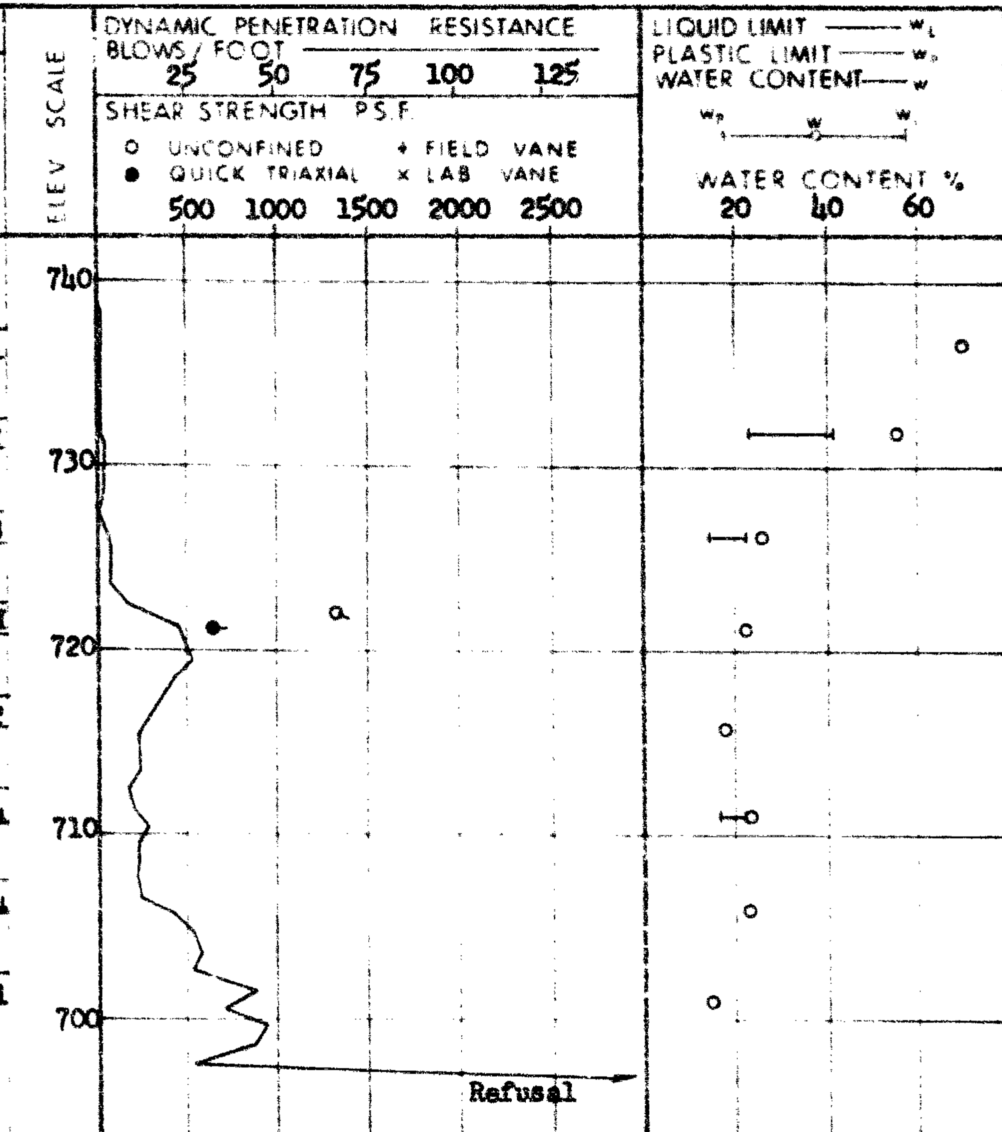
DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 69-F-5 LOCATION Sta. 215 + 98 48' Rt. ORIGINATED BY PP
W.P. 246-66 BORING DATE February 11 & 12, 1969 COMPILED BY PP
DATUM Geodetic BOREHOLE TYPE Washbore - NX Casing CHECKED BY [signature]

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
742.3	Water Level					
0.0 / 739.3	Ground Level					
3.0 / 737.3	Muck. Very soft.					
5.0 / 734.8	Muck and sand. Very soft.	1	SS	1		
7.5 / 729.3	Silty Clay Very soft to soft	2	SS	2		0 1 (99)
13.0	Clayey silt with occasional layers of clay, silt and sand, and some gravel. Soft to firm	3	SS	3		
		4	TW	PM	127	0 8 85 7
		5	SS	22		16 16 67 1
		6	SS	4		
704.3		7	SS	14		2 9 88 1
38.0 / 698.5	Sandy silt Compact to very dense	8	SS	21		6 41 52 1
43.8	End of Borehole					



FORM OB-MT-126 (REV 1969) OFFICE REPORT ON SOIL EXPLORATION

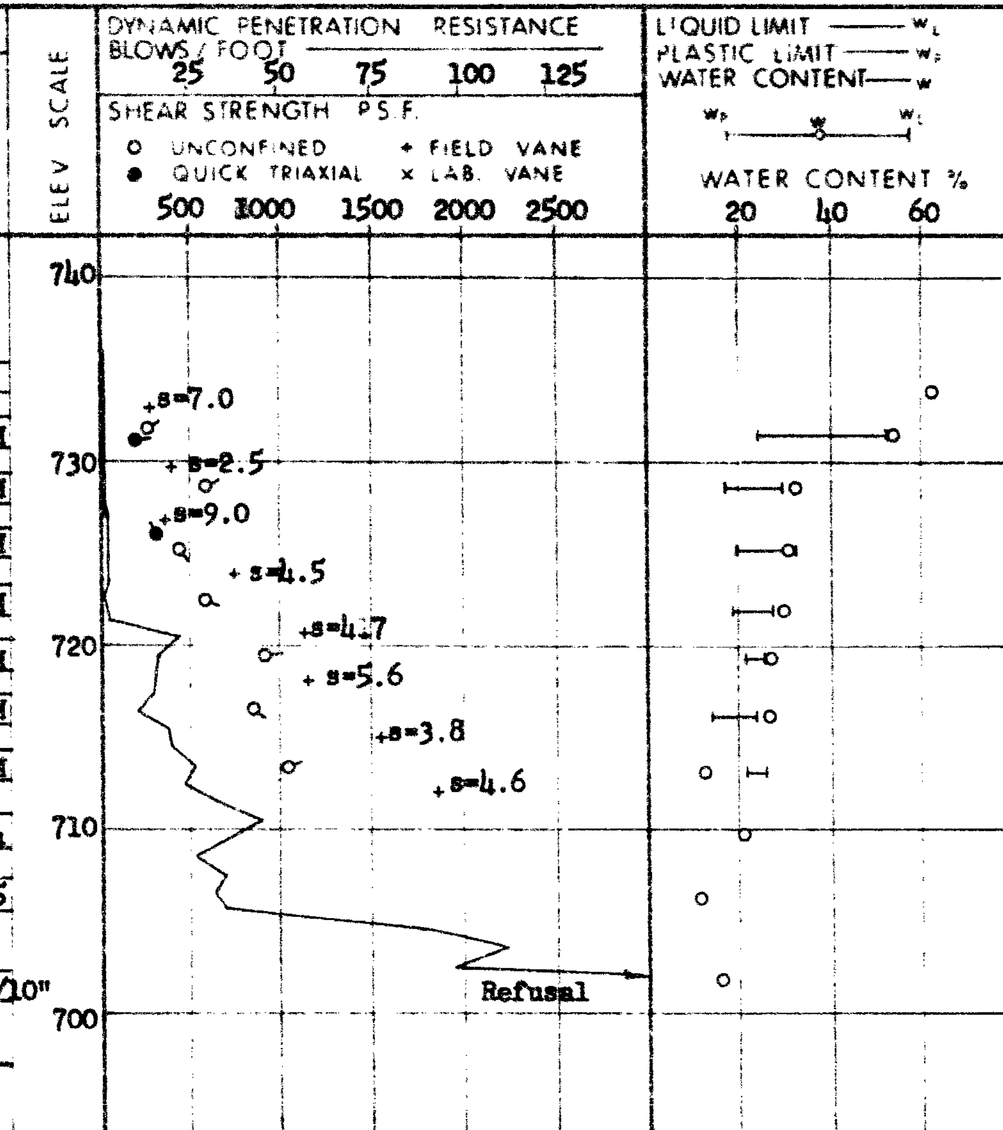
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB	69-F-5	LOCATION	Sta. 215 + 98 o/s 3' ~~Lt.~~ RT	ORIGINATED BY	PP
W.P.	240-66	BORING DATE	February 12 and 13, 1969	COMPILED BY	PP
DATUM	Geodetic	BOREHOLE TYPE	Washbore - NX Casing	CHECKED BY	[illegible]

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FOOT	BULK DENSITY γ P.C.F.	REMARKS GR SA SI CL
742.3	Water (Ice) Level					
0.0	Water					
736.8 / 5.5	Ground Level					
733.3	Muck - Very soft	1	SS	-		0 8 37 55
9.0 / 730.3	Silty clay / Very soft to soft	2	TW	PM	103	0 3 53 44
12.0	Clayey silt with occasional layers of silt, clay & sand. Soft to stiff	3	TW	PM	120	
		4	TW	PM	120	
		5	TW	PM	120	0 5 82 13
		6	TW	PM	128	
		7	TW	PM	126	
711.8		8	TW	PM	128	0 5 86 9
30.5	Silty sand with traces of gravel. Compact to very dense	9A	SS	14		
		10	SS	35		15 64 20 1
701.3		11	SS	74/10"		1 31 59 9
41.0 / 697.3	Sand & Gravel / Very dense	12	RC	-		
45.0	End of Borehole					



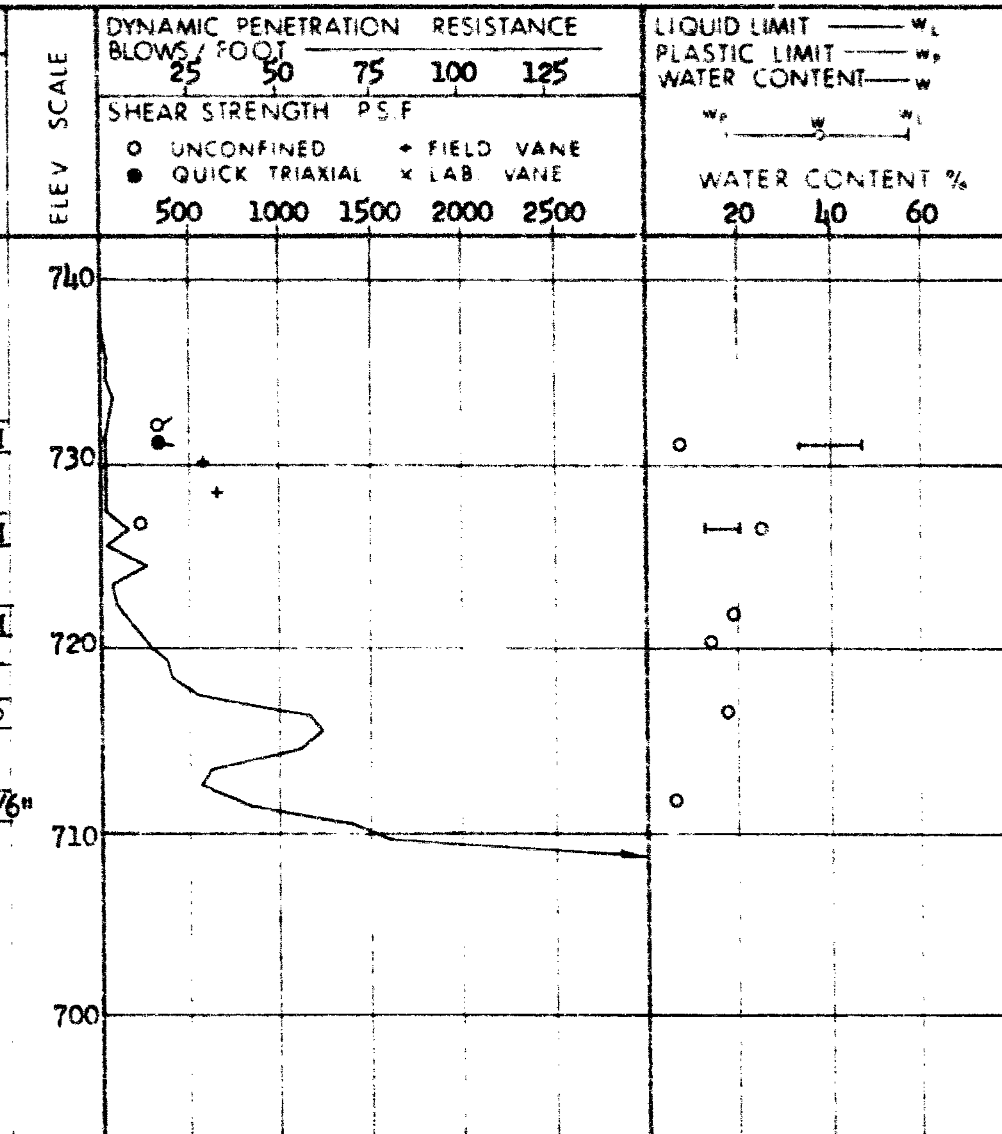
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 69-F-5 LOCATION Sta. 216 + 11 o/s 44' Lt. ORIGINATED BY PP
W.P. 246-66 BORING DATE February 14, 1969 COMPILED BY PP
DATUM Geodetic BOREHOLE TYPE Washbore - NX Casing CHECKED BY [signature]

ELEV. DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	BLOWS/FOOT	BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
742.3	Water (Ice) Level					
0.0	Water					
737.3	Ground Level					
5.0	Muck - very soft					
734.3						
8.0	Silty clay Soft	1	TW	PM	106	0 1 58 41
729.3						
13.0	Clayey silt with occ. layers of clay, silt and gravel. Soft to Firm.	2	TW	PM	127	
723.3						
19.0	Silty sand, traces of gravel.	3	TW	PM		0 58 38 4
		4	SS	21		
		5	SS	26		7 20 72 1
713.3	Compact to very dense					
29.0	Sand & gravel Very dense	6	SS	74/6"		
710.1						
32.2	End of Borehole					



FORM OB-MT-126 (REV. 1969)

OFFICE REPORT ON SOIL EXPLORATION

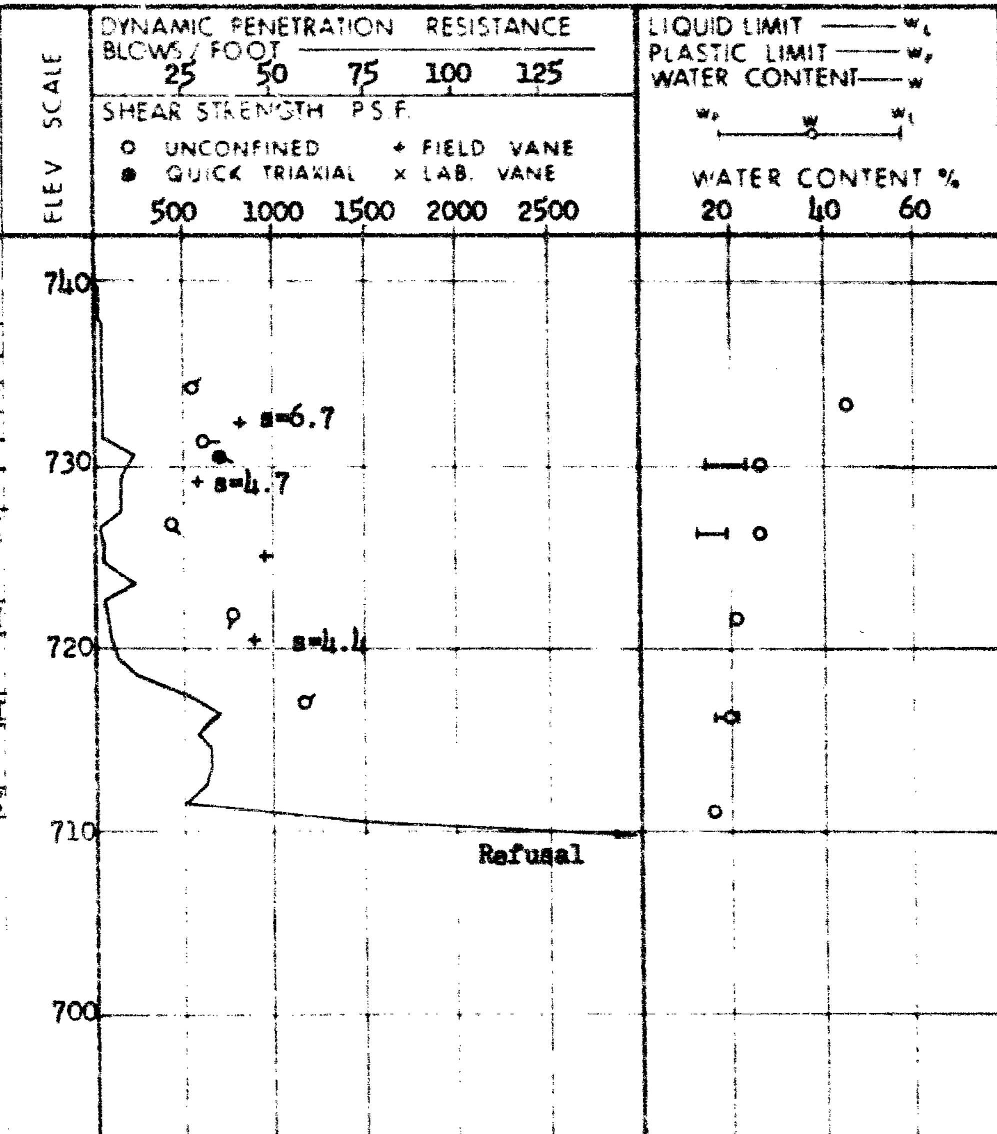
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB	69-F-5	LOCATION	Sta. 215 + ~~49~~ 59 o/s 34' Lt.	ORIGINATED BY	PP
W.P.	246-66	BORING DATE	February 14 and 15, 1969	COMPILED BY	PP
DATUM	Geodetic	BOREHOLE TYPE	Washbore - NX Casing	CHECKED BY	[signature]

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FOOT	BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
742.3	Water (Ice) Level					
0.0	Water					
739.8	Ground Level					
2.5	Muck - very soft					
737.3 / 5.0	Silty clay	1	TW	PM		
732.3	Very soft to soft	2	TW	PM	108	0 7 56 37
10.0	Clayey silt with occ. layers of silt and sand. Soft to firm	3	TW	PM	125	
		4	TW	PM	129	
		5	TW	PM	129	
715.3		6	TW	PM	131	2 15 82 1
27.0	Sandy silt, traces of gravel.					
709.8	Dense to very dense.	7	SS	135		3 30 63 4
32.5	End of Borehole					



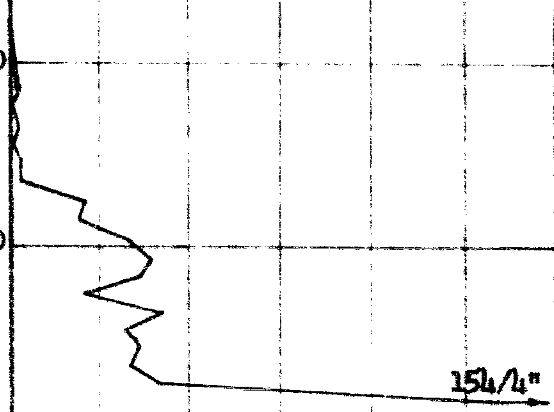
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 69-F-5	LOCATION Sta. 215 + 10 56' Lt.		ORIGINATED BY PP
W.P. 246-66	BORING DATE Feb. 15, 1969		COMPILED BY HR
DATUM Geodetic	BOREHOLE TYPE Cone Penetration Test		CHECKED BY

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (25, 50, 75, 100, 125); SHEAR STRENGTH P.S.F. (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB. VANE)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
742.3	Ice Level									
0.0	Water					740				
						730				
						720				
711.0 / 31.3	End of Cone Test					710				



FORM OB-MT-126 (REV. 1969)

OFFICE REPORT ON SOIL EXPLORATION

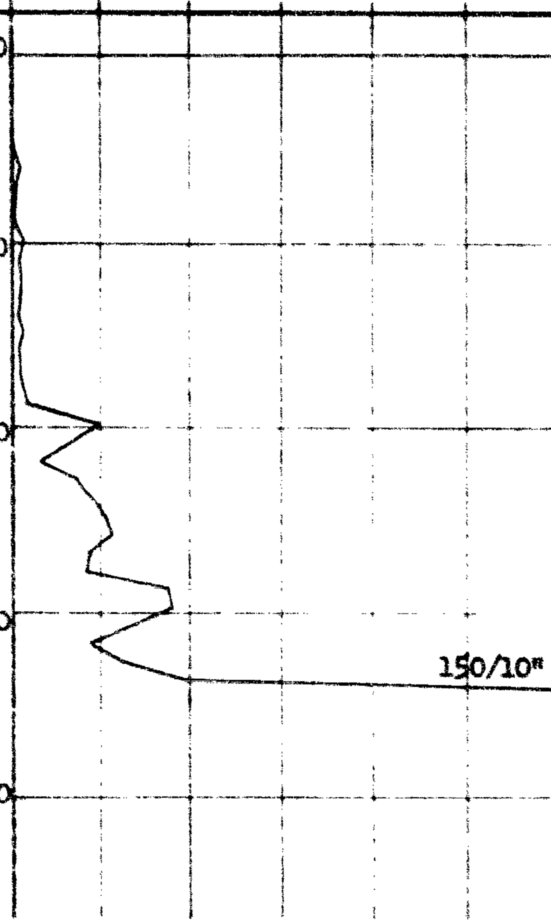
DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 6

FOUNDATION SECTION

JOB 69-F-5 LOCATION Sta. 215 + 20 16' Lt. ORIGINATED BY PP
W.P. 246-66 BORING DATE February 15, 1969 COMPILED BY HR
DATUM Geodetic BOREHOLE TYPE Cone Penetration Test CHECKED BY [signature]

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 25 50 75 100 125; SHEAR STRENGTH P.S.F. O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE	LIQUID LIMIT — w_L PLASTIC LIMIT — w_P WATER CONTENT — w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE				
742.[illegible]	Ice Level									
0.0						740				
						730				
						720				
						710	150/10"			
705.5										
36.8	End of Cone Test					700				



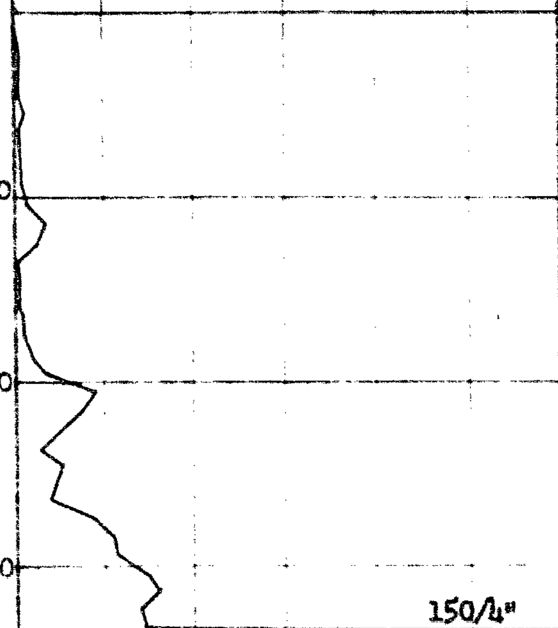
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOB 69-F-5	LOCATION Sta. 215 + 69 ⌀	ORIGINATED BY	PP
W P 246-66	BORING DATE February 15, 1969	COMPILED BY	HR
DATUM Geodetic	BOREHOLE TYPE Cone Penetration Test	CHECKED BY	[illegible]

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	BLOWS/FOOT	ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT 25 50 75 100 125; SHEAR STRENGTH P.S.F ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT —— w_L; PLASTIC LIMIT —— w_P; WATER CONTENT —— w; WATER CONTENT %	BULK DENSITY γ P.C.F	REMARKS GR.SA.SI.CL.
742.8	Ground Level									
0.0						740				
						730				
						720				
						710				
706.5 / 36.3	End of Cone Test						150/4"			
						700				



FORM OB-MT-126 (REV 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB	69-F-5	LOCATION	Sta. 216 + 50 o/s 7' Lt.
W.P.	246-66	BORING DATE	February 15, 16, 1969
DATUM	Geodetic	BOREHOLE TYPE	Washbore - NX Casing

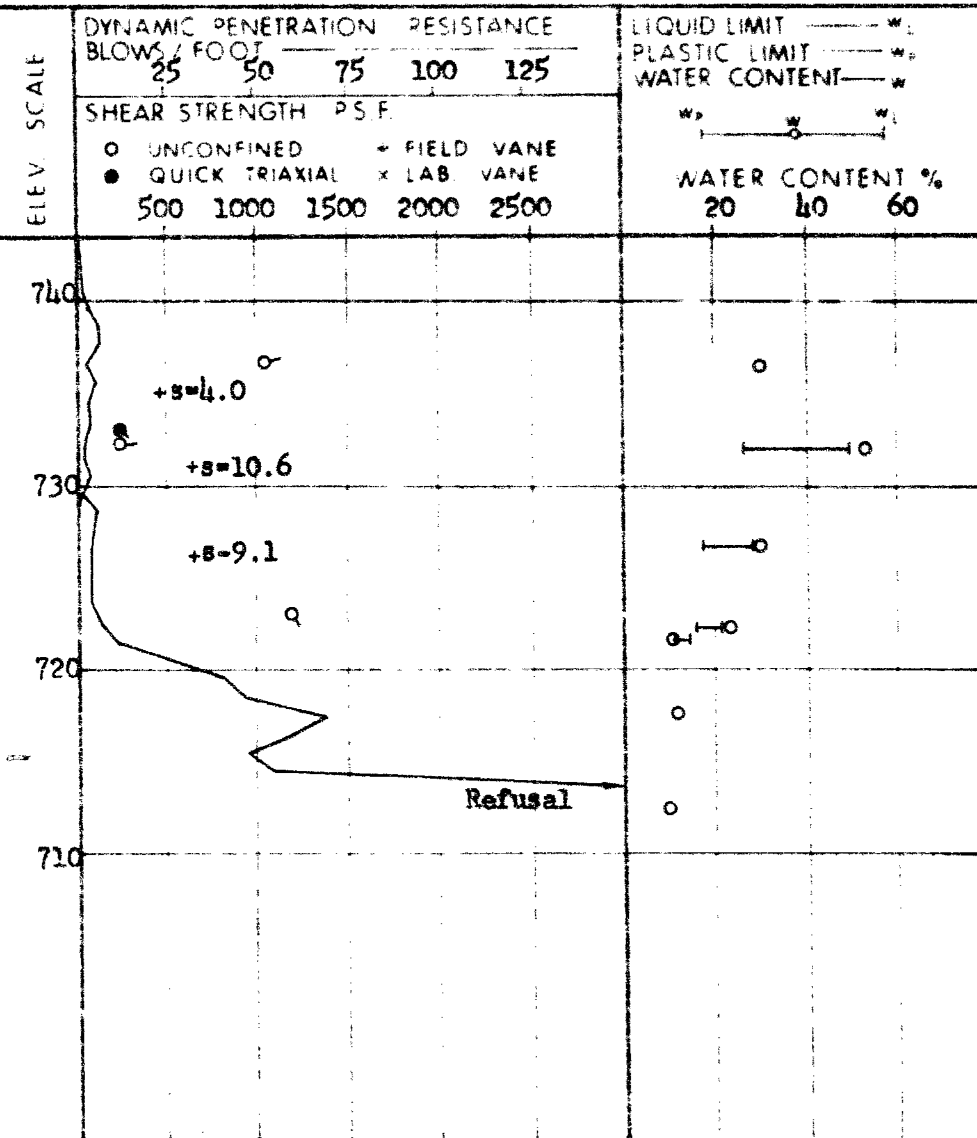
ORIGINATED BY PP
COMPILED BY PP
CHECKED BY [illegible]

SOIL PROFILE

ELEV. DEPTH	DESCRIPTION
743.3	Ground Level
741.3 / 2.0	Muck & sand. Very soft
730.3 / 13.0	Silty clay with layers of silt & clayey silt. Very soft to firm
723.3 / 20.0	Clayey silt with occ. layers of sand, silt & clay. Firm
712.3 / 31.0	Silty sand with gravel and traces of clay. Compact to very dense
	End of Borehole

SAMPLES

NUMBER	TYPE	BLOWS/FOOT	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
1	TW	PM		
2	TW	PM	121	
3	TW	PM	106	
4	TW	PM		0 11 65 24
5	TW	PM	127	
6	SS	26		20 44 33 3
7	SS	116		



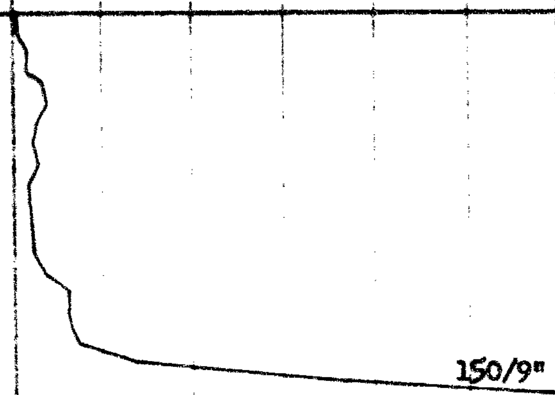
FORM OB-MT-126 (REV 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

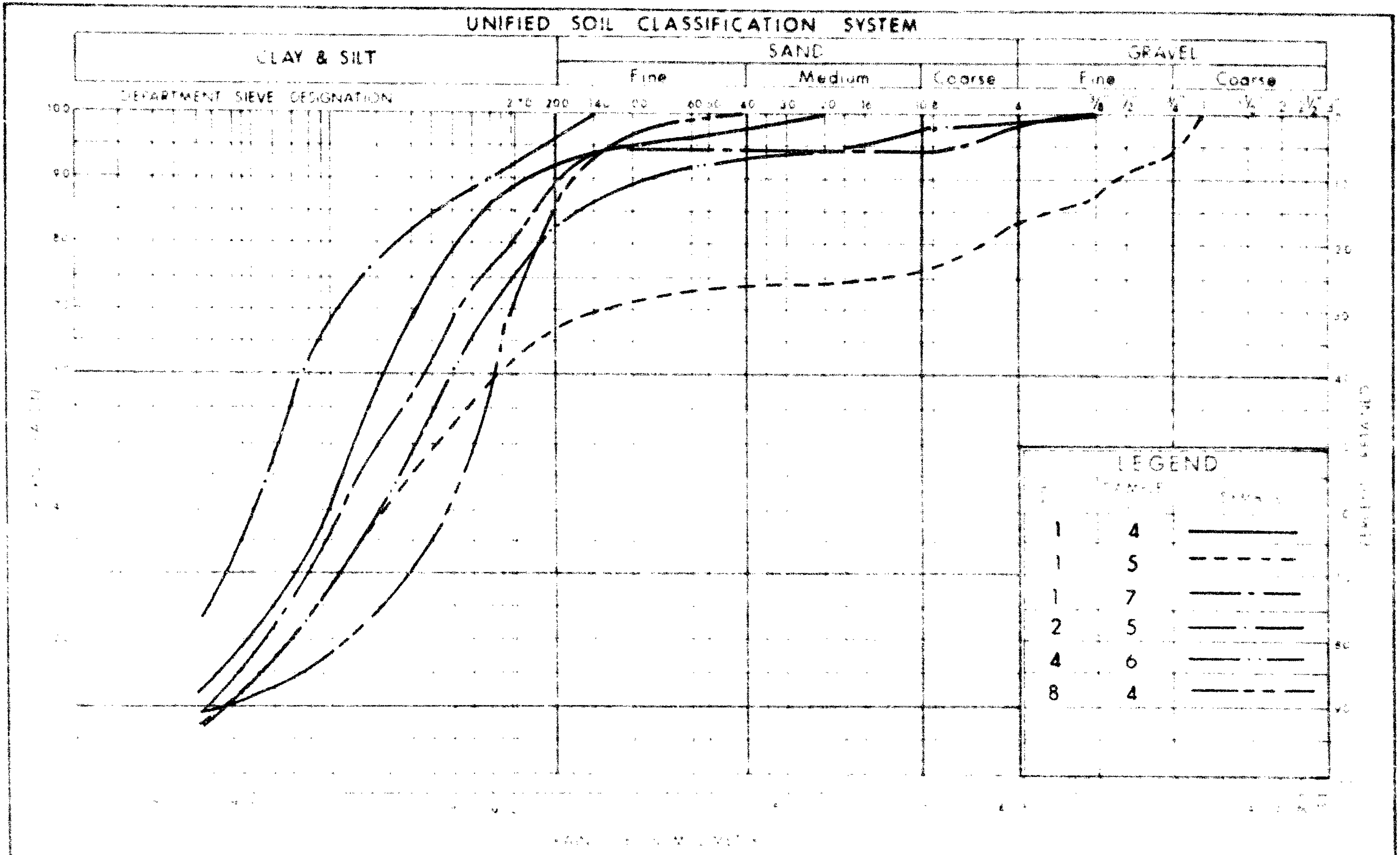
RECORD OF BOREHOLE No. 9

FOUNDATION SECTION

JOB	69-F-5	LOCATION	Sta. 217 + 00 5' Rt.	ORIGINATED BY	PP
W P	240-66	BORING DATE	February 16, 1969	COMPILED BY	HR
DATUM	Geodetic	BOREHOLE TYPE	Cone Penetration Test	CHECKED BY	[illegible]

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 25 50 75 100 125; SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
743.3	Ground Level									
0.0										
722.6							150/9"			
20.7	End of Cone Test									

FORM DB MT-12
REV APR 196



MATERIALS TESTING DIVISION

GRAIN SIZE DISTRIBUTION

CLAYEY SILT

246 - 66

69 - F - 5

FIG. 1

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

CONSISTENCY	'N' BLOWS / FT.	c LB. / SQ. FT.	DENSENESS	'N' BLOWS / FT.
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

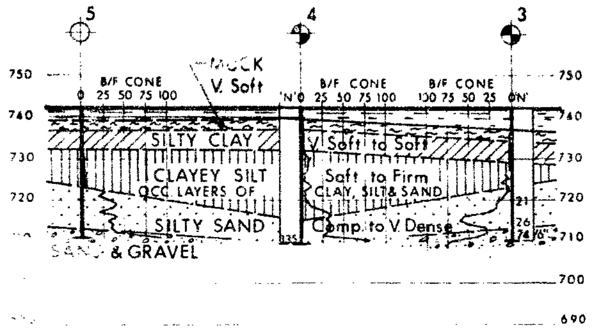
S S	SPLIT SPOON	T W	THINWALL OPEN
W S	WASHED SAMPLE	T P	THINWALL PISTON
S B	SCRAPER BUCKET SAMPLE	O S	OESTERBERG SAMPLE
A S	AUGER SAMPLE	F S	FOIL SAMPLE
C S	CHUNK SAMPLE	R C	ROCK CORE
S T	SLOTTED TUBE SAMPLE		

P H SAMPLE ADVANCED HYDRAULICALLY

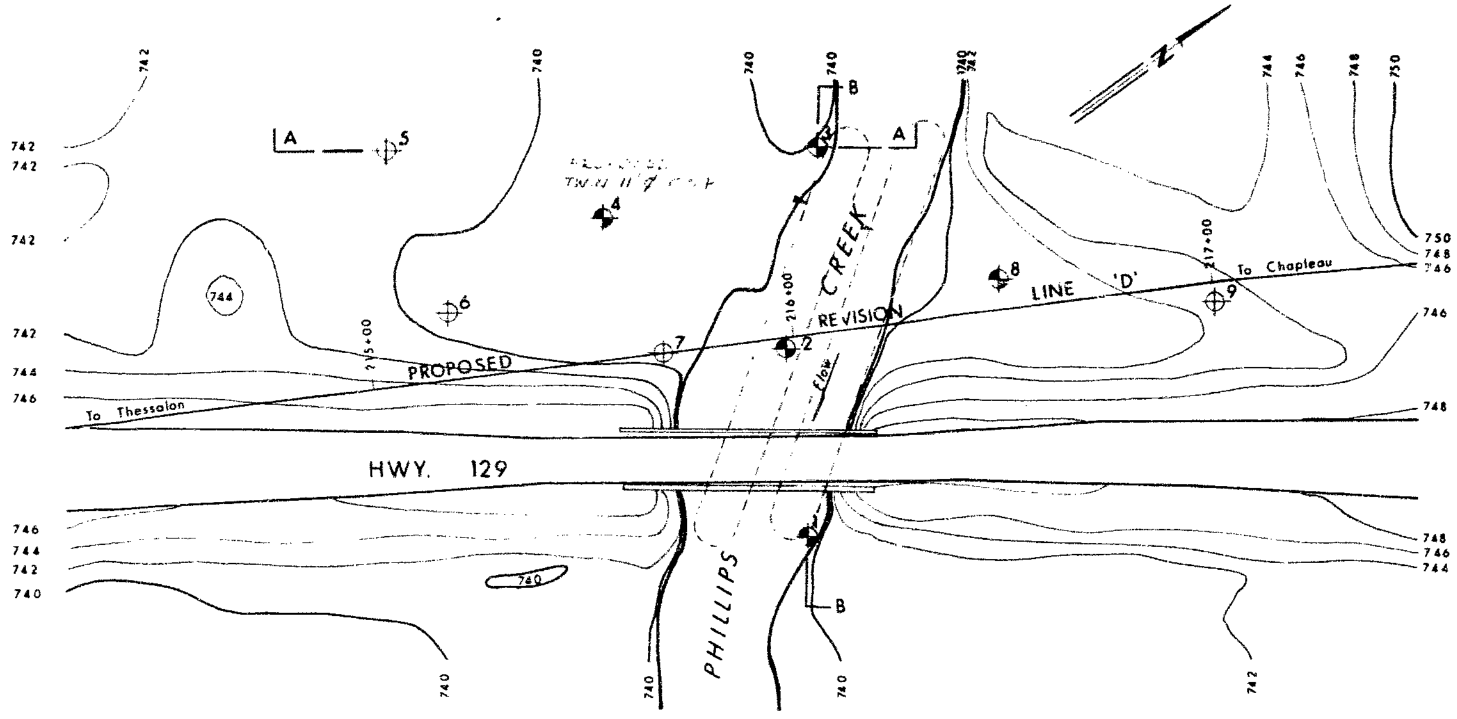
P M SAMPLE ADVANCED MANUALLY

SOIL TESTS

Q_u	UNCONFINED COMPRESSION	L V	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F V	FIELD VANE
Q_{cu}	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q_d	DRAINED TRIAXIAL	S	SENSITIVITY

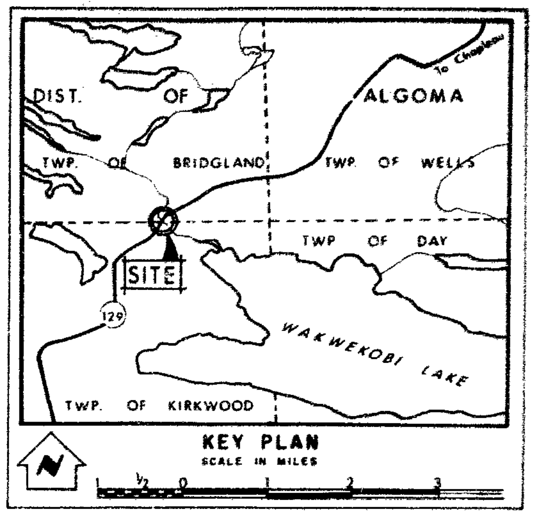


SECTION A - A



PLAN

SCALE 20 10 0 20 40 60 FT



KEY PLAN

SCALE IN MILES

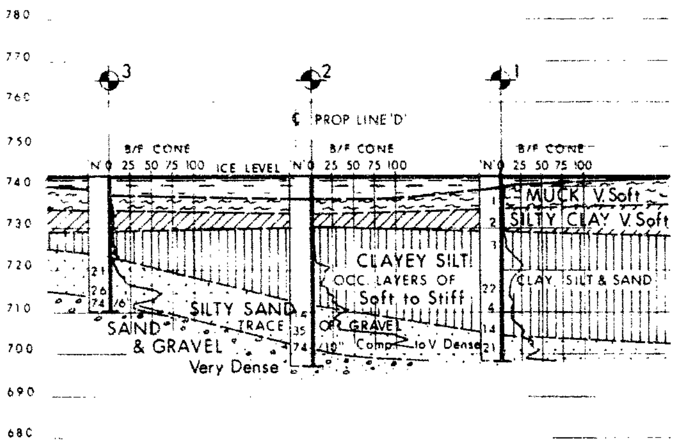
LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation. Feb. 1969

NO.	ELEVATION	STATION	OFFSET
1	742.3	215+98	48' RT
2	742.3	215+98	3' RT
3	742.3	216+11	44' LT.
4	742.3	215+59	34' LT
5	742.3	215+10	56' LT.
6	742.3	215+20	16' LT
7	742.8	215+69	℄
8	743.3	216+50	7' LT
9	743.3	217+00	5 RT

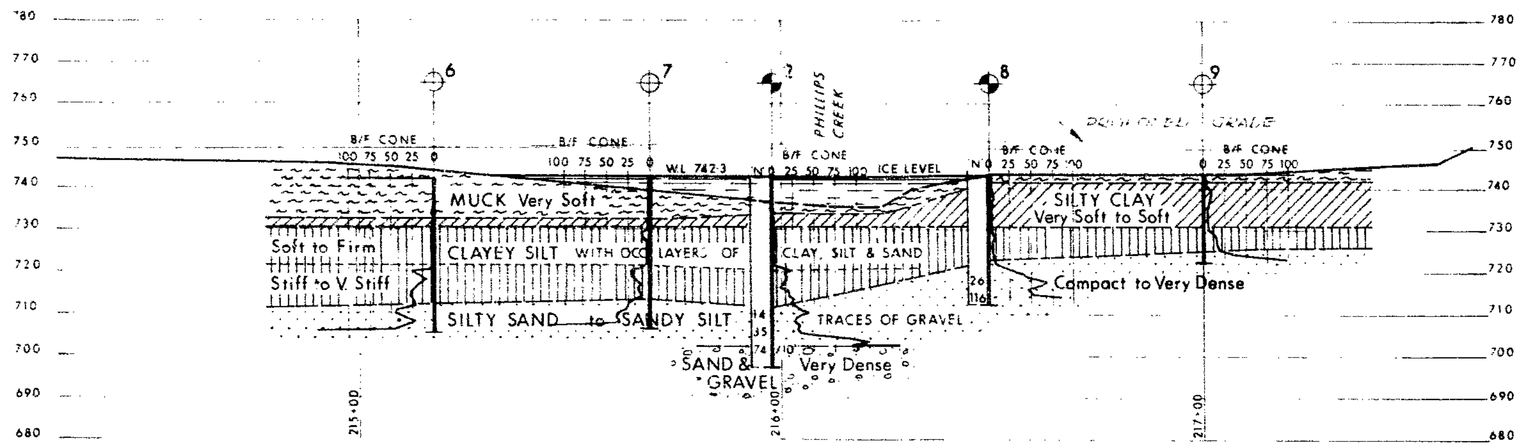
- NOTE -

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.



SECTION B - B

SCALE 20 10 0 20 40 60 FT



℄ PROFILE LINE 'D'

SCALE 20 10 0 20 40 60 FT.

REVISIONS		
DATE	BY	DESCRIPTION

PRINT RECORD

NO	FOR	DATE

REF. NO. E-4565-1

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION - FOUNDATION SECTION

PHILLIPS CREEK

KING'S HIGHWAY NO. 129 LINE 'D' DIST. NO. 18

DIST. OF ALGOMA

TWP. BRIDGLAND LOT 2 CON. 1

BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D. P.P.	CHECKED	W.P. NO. 246-66	M.B.T. DRAWING NO. 69-F-5A
DRAWN A.N.	CHECKED	JOB NO. 69-F-5	
DATE 27 MAY 1969		SITE NO	BRIDGE DRAWING NO.
APPROVED (signature) PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	

cc: Found[illegible]ons Files (Rm. 110)

280

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. J. H. Blevins,
District Engineer,
District #18,
SAULT STE. MARIE, ONT.

Attention: Mr. H. Potts,
Construction Engineer

Our File Ref.

From: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

Date: July 18, 1969

In reply to

Subject: Re: Phillips Creek (Stewart Creek) - Site 38S-199,
Hwy. 129 -- District #18 (Sault Ste. Marie)
W.P. 246-66 - Contract 69-108 - W.J. 69-F-5

We have recently reviewed the Contract Drawings for the above mentioned project. We note that the recommendations given in our memo dated March 19, 1969, to Mr. B. R. Davis, Bridge Engineer, relating to excavation of soft material, have not been followed. We have discussed this matter with the Regional Road Design Office and apparently there has been some misinterpretation - (see Teletype - June 25th - H. McArthur to A. G. Stermac). In any event, the Region has suggested that the District take the necessary steps to ensure that our recommendations are followed correctly. These you will find in Report 69-F-5, a copy of which has already been sent to you.

If we can be of any further assistance in this matter, please contact this Office.

K. G. Selby,
SUPERVISING FOUNDATION ENGR.
For:
A. G. Stermac,
PRINCIPAL FOUNDATION ENGR.

KGS/MdeF

cc: Messrs. B. R. Davis
H. A. Tregaskes
D. W. Farren
H. W. Hurrell
S. B. Davidson
F. Norman

Foundations Files
Gen. Files

1969 JUN 25 PM 3:26

MX NBAR JUNE 25/69 3:01 PM

DOWN 6 A G STERMAC PRINCIPAL FOUNDATION ENG

ATTN K SELBY

CC

SAUL 1 J H BLEVINS DIST ENG

FTWR 1 F NORMAN MATERIALS AND TESTING

RE: PHILLIPS CREEK, HWY. 129, DISTRICT NO. 13

FURTHER TO OUR TELEPHONE CONVERSATION, THE CONTRACT WAS PREPARED ACCORDING TO SOILS REPORT. TO INCREASE MUSKEG EXCAVATION SHOULD NOT PRESENT A PROBLEM OTHER THAN OVERRUN ON EQUIPMENT RENTAL AND BACKFILL QUANTITIES. WE WOULD THEREFORE SUGGEST THAT YOU ADVISE THE DISTRICT AND REGIONAL SOILS OF YOUR RECOMMENDATIONS TO ENSURE PROPER CONSTRUCTION PROCEDURES.

J G VANDEKAA FOR H MCARTHUR REG RD DES ENG

LS

TELETYPE

TELETYPE

APPENDIX C

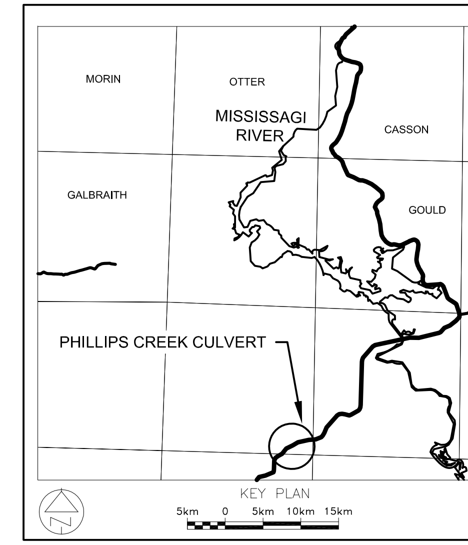
Current Borehole Locations Plan and Soil Strata
Record of Borehole Sheets and
Results of Laboratory Analyses

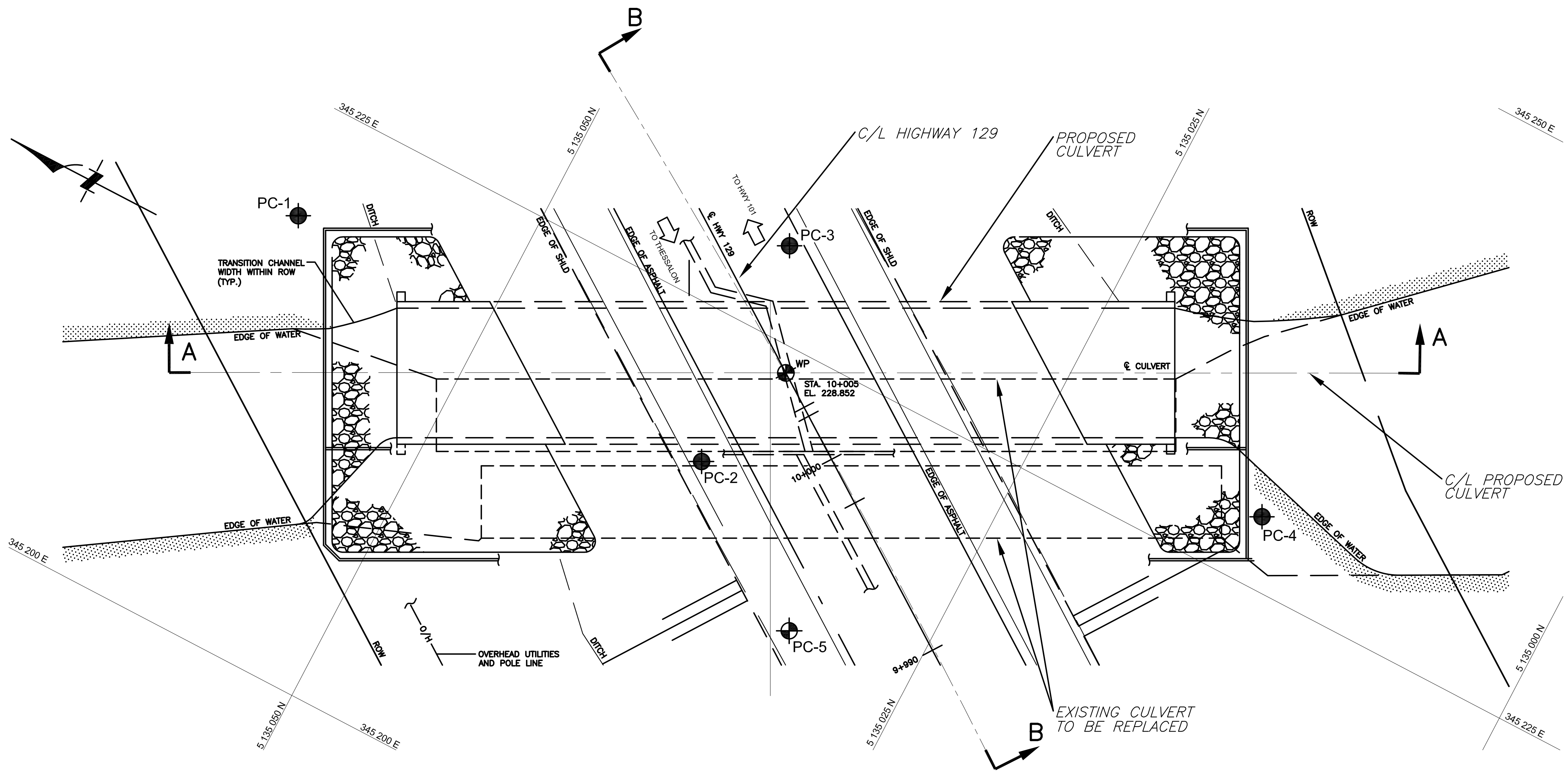
GWP No 5222-05-00
WP No 5222-05-01

PHILLIPS CREEK CULVERT REPLACEMENT
STA. 10+005 HIGHWAY 129 BRIDGELAND TWP
BOREHOLE LOCATIONS

SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS





PLAN
SCALE
2.5 0 2.5 5m

LEGEND

- Borehole
- Cone
- Borehole and Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation Dec. 2014 to Nov. 2015
- WH Penetration due to weight of rods and hammer
- PH Pushed hydraulically

BH No	ELEVATION	NORTHINGS	EASTINGS
PC-1	225.7	5 135 060.0	345 219.8
PC-2	228.6	5 135 038.2	345 218.4
PC-3	228.7	5 135 039.3	345 229.1
PC-4	225.3	5 135 014.1	345 228.6
PC-5	228.4	5 135 031.0	345 213.3

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

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. REFER TO DRAWING PC-2 FOR PROFILE A-A AND SECTION B-B.
3. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
4. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

LICENSED PROFESSIONAL ENGINEER D. H. DUNDAS Mar 29, 2016 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER C M P Nascimento Mar. 29 '16 PROVINCE OF ONTARIO

REF. AECOM Drawing: 160333079-P1-Phillips.dwg dated Dec. 2015

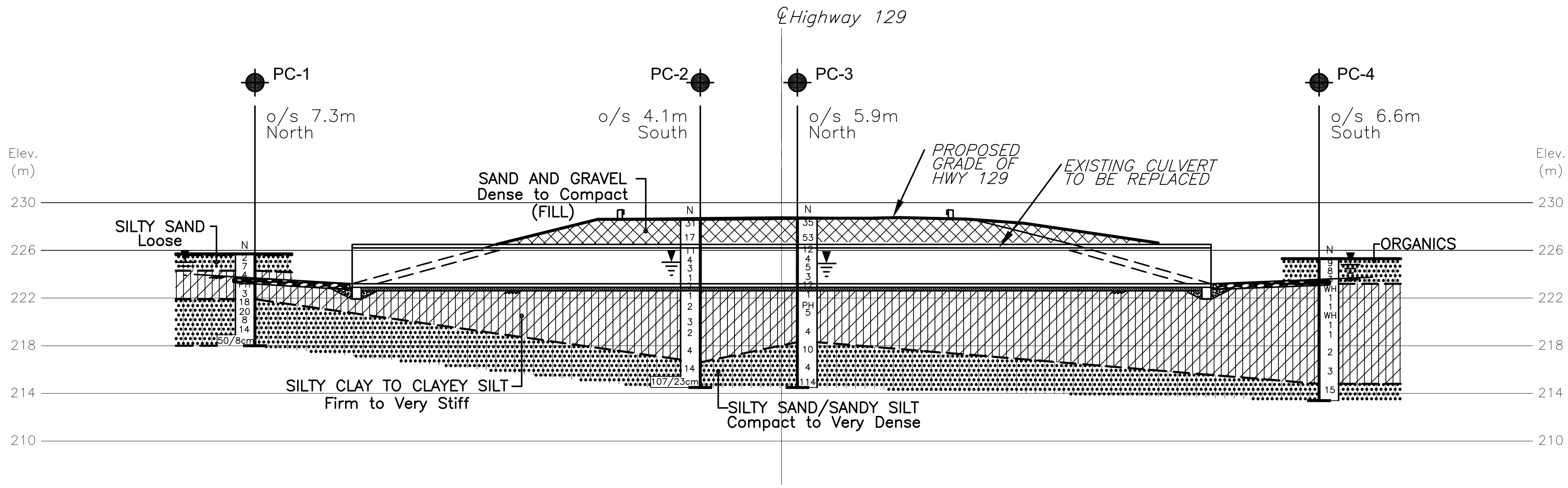
REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 41J-98

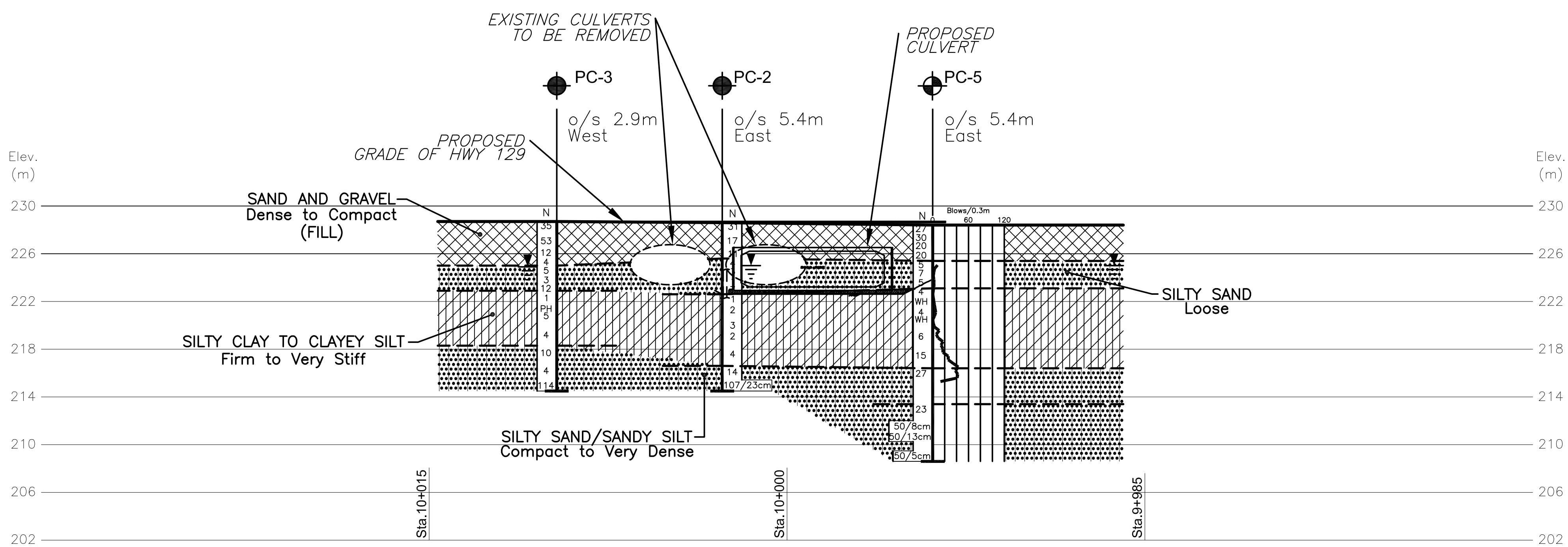
HWY No 129			DIST ALGOMA
SUBM'D NA	CHECKED MK	DATE MAR. 29 2016	SITE 38S-199/C
DRAWN NA	CHECKED DD	APPROVED CN	DWG PC-1

GWP No 5222-05-00 WP No 5222-05-01	
PHILLIPS CREEK CULVERT REPLACEMENT STA. 10+005 HIGHWAY 129 BRIDGELAND TWP BOROHOLE LOCATIONS AND SOIL STRATA	SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS

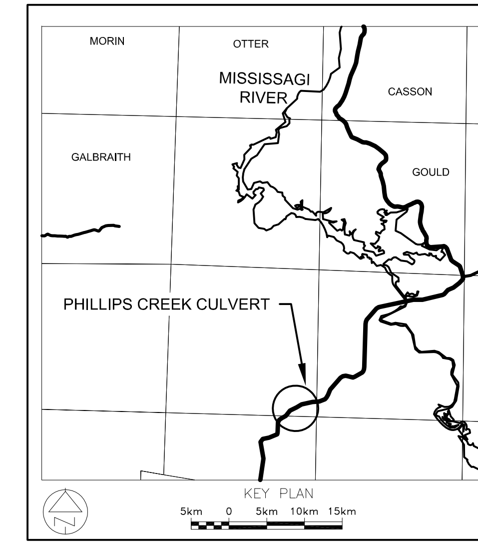


PROFILE A-A ALONG C/L PHILLIPS CREEK CULVERT



SECTION B-B ALONG C/L HIGHWAY 129

SCALE
HORIZONTAL
2.5 0 2.5 5m
VERTICAL
5 0 5 10m



LEGEND
Borehole
Cone
Borehole and Cone
N Blows/0.3m (Std. Pen Test, 475 J/blow)
CONE Blows/0.3m (60 Cone, 475 J/blow)
WL at time of investigation Dec. 2014 to Nov. 2015
WH Penetration due to weight of rods and hammer
PH Pushed hydraulically

BH No	ELEVATION	NORTHINGS	EASTINGS
FOR DETAILS REFER TO DRAWING PC-1			

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

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. REFER TO DRAWING PC-1 FOR BOREHOLE LOCATIONS PLAN.
3. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
4. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

REF. AECOM Drawing: 160333079-P1-Phillips.dwg dated Dec. 2015

REVISIONS		
DATE	BY	DESCRIPTION

Geocres No. 41J-98

HWY No 129			DIST ALGOMA
SUBM'D NA	CHECKED MK	DATE MAR. 29 2016	SITE 38S-199/C
DRAWN NA	CHECKED DD	APPROVED CN	DWG PC-2

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 (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1,%	VOID RATIO

n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
DTPL		DRIER THAN PLASTIC LIMIT
APL		ABOUT PLASTIC LIMIT
WTPL		WETTER THAN PLASTIC LIMIT

e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_u	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No PC-1

METRIC

G.W.P. 5222-05-00 LOCATION Coords: 5 135 060.0 N; 345 219.8 E ORIGINATED BY F.P.

DIST Algoma HWY 129 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.K.

DATUM Geodetic DATE January 13, 2015 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	FIELD VANE (kPa)	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
225.7	Ground Surface							
225.4 / 0.0	Organics							
0.3	Silty sand to sand, trace clay. Loose, Grey, Wet	1	SS	2	▽* (approx. El. 225.1)			
		2	SS	7			~23	
224.3 / 1.4	Silty clay, trace sand. Firm to stiff, Brown, Wet	3	SS	4			Wp ~19, w ~30, WL ~29	0 1 52 47
			FV			~55 (sensitivity 5)		
		4	TW	PH				
			FV			~40 (sensitivity 6)		
		5	SS	3			~30	
221.9 / 3.8	Silty sand, trace clay, trace gravel. Compact to very dense, Brown, Moist to wet	6	SS	18			~15	5 59 33 3
		7	SS	20			~16	
		8	SS	8			~19	6 66 27 1
		9	SS	14				
	cobbles							
218.0 / 7.7	End of borehole	10	SS	50/8cm			~25	

* 2015 01 13

▽* Water level observed during drilling

NOTE: Borehole caved-in at 4.6m

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20, 40, 60; UNIT WEIGHT γ kN/m³. Elevation scale 225 to 218.

+7, ×5: Numbers refer to Sensitivity

20 / 15–○–5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No PC-2

METRIC

G.W.P. 5222-05-00	LOCATION Coords: 5 135 038.2 N; 345 218.4 E		ORIGINATED BY F.P.
DIST Algoma	HWY 129	BOREHOLE TYPE Continuous Flight Hollow Stem Augers	COMPILED BY M.K.
DATUM Geodetic		DATE December 02 & 03, 2014	CHECKED BY C.N.

SOIL PROFILE

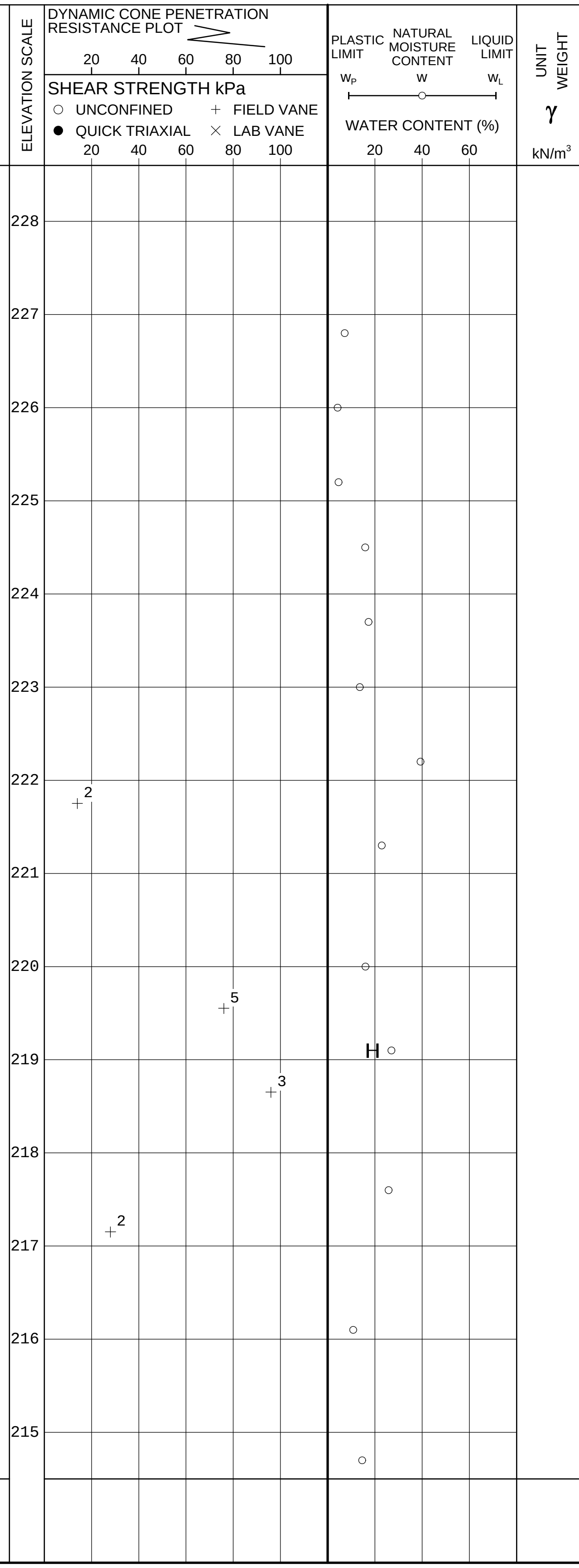
ELEV / DEPTH	DESCRIPTION	STRAT PLOT
228.6	Ground Surface	
0.0	Sand and gravel to gravelly sand trace silt, trace clay. Dense to compact, Grey, Moist (FILL)	Fill
225.6 / 3.0	Silty sand to sand trace clay, trace gravel. Loose, Grey, Moist to wet	Silty sand
222.6 / 6.0	Silty clay to clayey silt trace to some sand with silt layers. Firm to very stiff, Brown, Moist to wet	Silty clay
216.6 / 12.0	Silty sand trace clay, trace gravel. Compact to very dense, Brown, Wet	Silty sand
214.5 / 14.1	End of borehole. * 2014 12 02 & 03	

Cont'd

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	31	
2	SS	17	
3	SS	11	
4	SS	4	
5	SS	3	
6	SS	1	10 88 (2)
7	SS	7	
8	SS	1	
	FV		
9	SS	2	
10	SS	3	
	FV		
11	SS	2	0 12 74 14
	FV		
12	SS	4	
	FV		
13	SS	14	5 66 26 3
14	SS	107/23cm	

GROUND WATER CONDITIONS: ▽* at approx. elev. 225



+7, ×5 : Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No PC-2

METRIC

G.W.P. 5222-05-00 LOCATION Coords: 5 135 038.2 N; 345 218.4 E ORIGINATED BY F.P.

DIST Algoma HWY 129 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.K.

DATUM Geodetic DATE December 02 & 03, 2014 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
213.6											
	▽* Water level observed during drilling NOTE: No cave-in after completion of drilling										

ON MTO_VER3 NEW LOGO_HWY129 14TF038.GPJ ON_MOT.GDT 02/03/2016 12:16:04 PM

$+^{7}, \times^{5}$: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No PC-3

METRIC

G.W.P. 5222-05-00	LOCATION Coords: 5 135 039.3 N; 345 229.1 E		ORIGINATED BY F.P.
DIST Algoma	HWY 129	BOREHOLE TYPE Continuous Flight Hollow Stem Augers	COMPILED BY M.K.
DATUM Geodetic	DATE December 01 & 02, 2014		CHECKED BY C.N.

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
228.7	Ground Surface
0.0	Sand and gravel to gravelly sand trace silt, trace clay. Very dense to loose, Brown, Moist (FILL)
225.0 / 3.7	Silty sand to sand trace clay, trace gravel. Loose to compact, Brown, Moist to wet
222.9 / 5.8	Silty clay to clayey silt some sand, trace gravel. Firm to stiff, Brown, Wet
218.3 / 10.4	Sandy silt trace clay, trace gravel. Loose to very dense, Brown, Wet
214.5 / 14.2	End of borehole. * 2014 12 01 & 02 ∇* Water level observed during drilling

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	35	
2	SS	53	
3	SS	12	15 81 (4)
4	SS	4	
5	SS	5	
6	SS	3	
7	SS	12	
8	SS	1	2 15 51 32
	FV		
9	TW	PH	
10	SS	5	
11	SS	4	
	FV		
12	SS	10	1 39 54 6
13	SS	4	
14	SS	114	

GROUND WATER CONDITIONS: ∇* at approx. elevation 225

ELEVATION SCALE: 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

Field vane results: +4 (at approx. elev. 222), +1 (at approx. elev. 219)

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

+7, ×5: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Ontario | Peto MacCallum Ltd. CONSULTING ENGINEERS | Foundation Design

RECORD OF BOREHOLE No PC-4

METRIC

G.W.P. 5222-05-00 | LOCATION Coords: 5 135 014.1 N; 345 228.6 E | ORIGINATED BY F.P.

DIST Algoma | HWY 129 | BOREHOLE TYPE Tripod + Casing | COMPILED BY M.K.

DATUM Geodetic | DATE January 13, 2015 | CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
225.3	Ground Surface					
0.0	Organics	1	SS	9	▽*	Top 0.4m is frozen
224.8 / 0.5	Silty sand to sand trace clay. Loose to very loose, Brown, Wet	2	SS	8		
		3	SS	3		
223.2 / 2.1	Silty clay to clayey silt trace to some sand. Firm to very stiff, Brown, Wet	4	SS	WH**		0 1 43 56
			FV			
		5	SS	1		
			FV			
		6	SS	1		
		7	SS	WH		0 8 66 26
			FV			
		8	SS	1		
			FV			
		9	SS	1		0 3 71 26
			FV			
	occasional silt layers; soft					
		10	SS	2		
		11	SS	3		0 10 76 14
214.8 / 10.5	Silty sand, trace gravel. Compact, Brown, Wet	12	SS	15		
213.4 / 11.9	End of borehole					

Elevation scale: 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215, 214

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE (20 40 60 80 100)

Field vane sensitivity values plotted: 5, 8, 8, 5, 7

PLASTIC LIMIT w_P – NATURAL MOISTURE CONTENT w – LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; value off scale at sample 1: 96.7

UNIT WEIGHT γ kN/m³

* 2015 01 13

▽* Water level observed during drilling

WH** Penetration due to weight of rods and hammer

NOTE: Borehole caved-in at 4.3m

$+^7$, $\times^5$: Numbers refer to Sensitivity

20 / 15 –○– 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No PC-5

METRIC

G.W.P. 5222-05-00	LOCATION Coords: 5 135 031.0 N; 345 213.3 E		ORIGINATED BY F.P.
DIST Algoma	HWY 129	BOREHOLE TYPE C.F.S.S.A. + Casing	COMPILED BY M.K.
DATUM Geodetic	DATE November 16 & 17, 2015		CHECKED BY C.N.

SOIL PROFILE

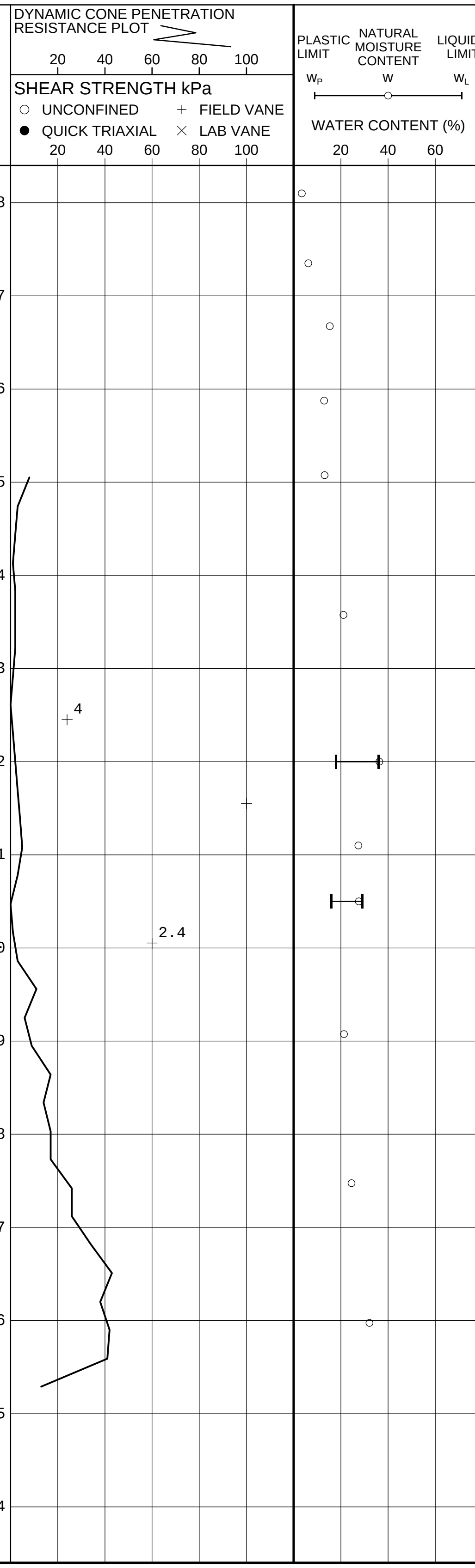
ELEV / DEPTH	DESCRIPTION	STRAT PLOT
228.4	Ground Surface	
0.0	Sand and gravel to gravelly sand trace silt, trace clay Compact Brown Moist (FILL)	Fill
225.4 / 3.0	Silty sand to sand trace clay, trace gravel Loose Brown/grey Wet	Silty sand
223.1 / 5.3	Silty clay to clayey silt trace sand, trace gravel occasional silt layers Firm to very stiff Brown Wet	Silty clay
216.4 / 12.0	Silty sand trace to some gravel Compact to very dense Brown Wet	Silty sand
213.4	Cont'd	

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	27	
2	SS	30	
3	SS	20	
4	SS	20	25 72 (3)
5	SS	5	
6	SS	7	
7	SS	5	
8	SS	4	
	FV		
9	SS	WH**	0 8 48 44
	FV		
10	SS	4	
11	SS	WH	0 11 59 30
	FV		
12	SS	6	
13	SS	15	
14	SS	27	

GROUND WATER CONDITIONS: ∇* at approx. elev. 225.0

ELEVATION SCALE: 228 to 214



UNIT WEIGHT γ kN/m³

+7, ×5 : Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No PC-5

METRIC

G.W.P. 5222-05-00 LOCATION Coords: 5 135 031.0 N; 345 213.3 E ORIGINATED BY F.P.

DIST Algoma HWY 129 BOREHOLE TYPE C.F.S.S.A. + Casing COMPILED BY M.K.

DATUM Geodetic DATE November 16 & 17, 2015 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (WATER CONTENT %)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
213.4 15.0	(Cont'd) Silty sand trace to some gravel Compact to very dense Brown Wet											
		15	SS	23		213	o		19	68	(13)	
						212						
		16	SS	50/8cm			o					
						211						
		17	SS	50/13cm								
						210						
						209						
208.6 19.8	End of borehole	18	SS	50/5cm								

Column headings also printed: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100); W_P W W_L; WATER CONTENT (%) 20 40 60; REMARKS & GRAIN SIZE DISTRIBUTION (%).

* 2015 11 16&17

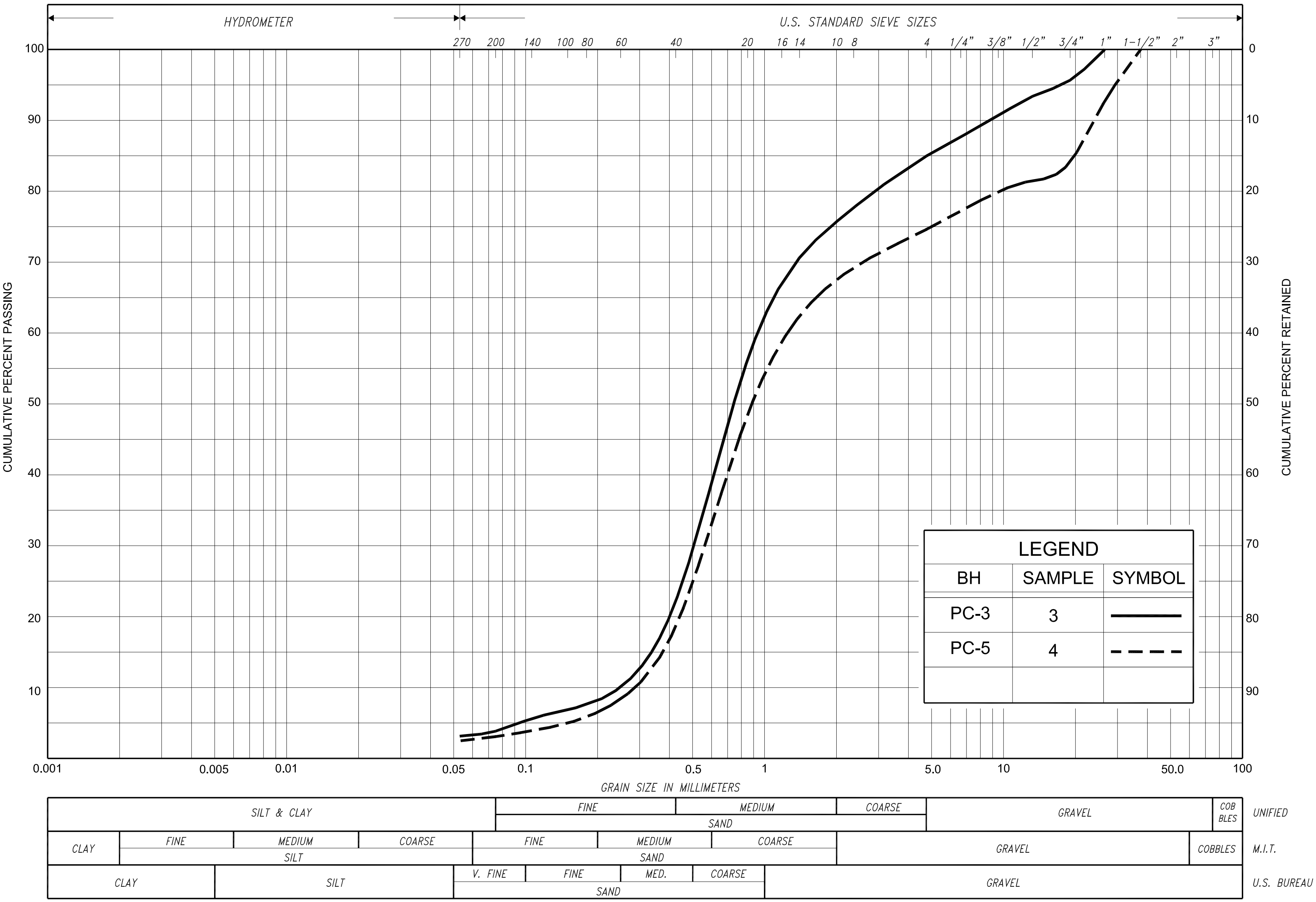
▽* Water level observed during drilling

WH** Penetration due to weight of rods and hammer

NOTE: No cave-in after completion of drilling

+7, ×5: Numbers refer to Sensitivity

20 / 15 ○ 5 / 10 (%) STRAIN AT FAILURE

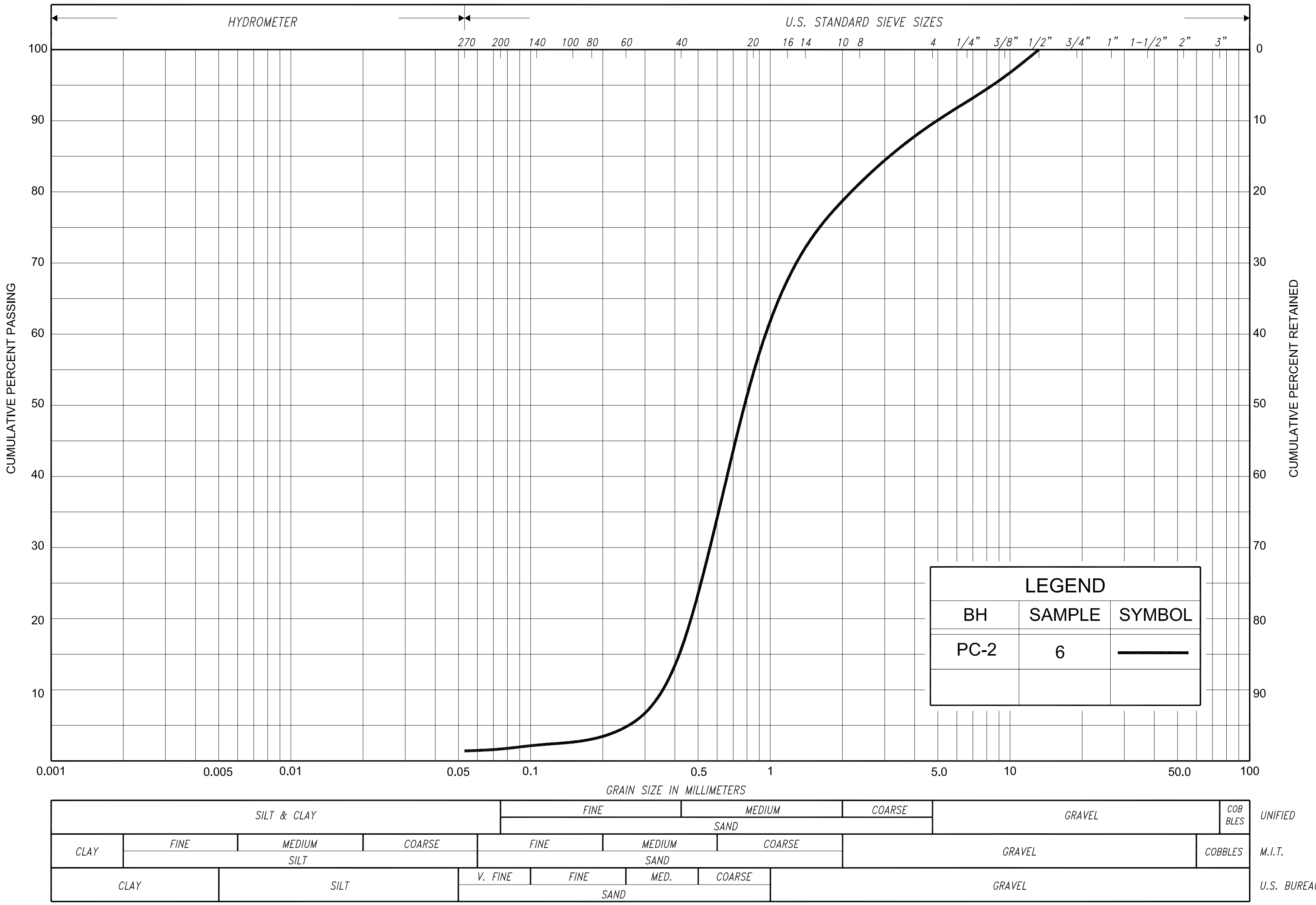


Ontario

GRAIN SIZE DISTRIBUTION

SAND and GRAVEL (FILL)

FIG No.	PH-GS-1
HWY:	129
Project No.	14TF038

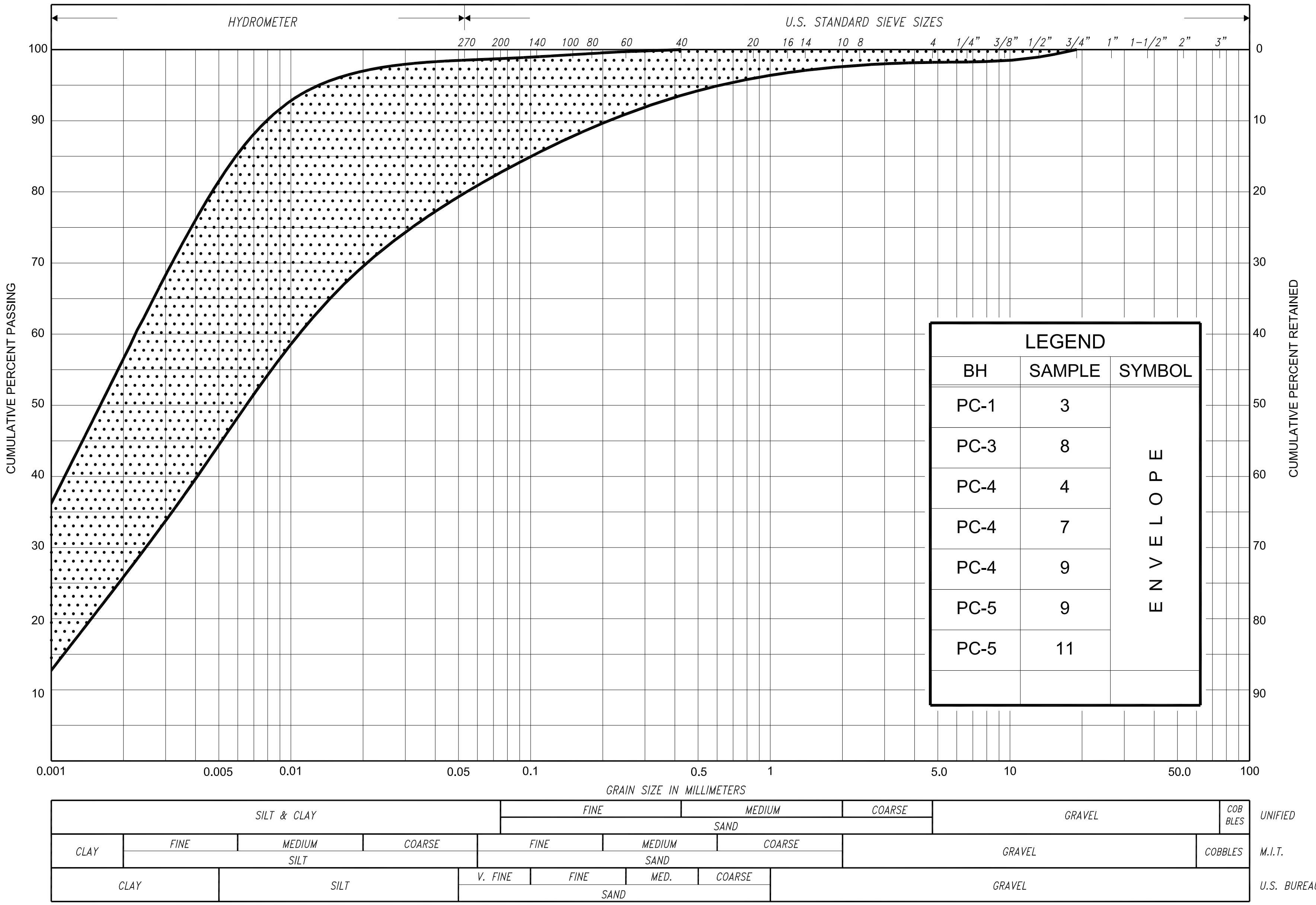


Ontario

GRAIN SIZE DISTRIBUTION

SILTY SAND to SAND

FIG No.	PH-GS-2
HWY:	129
Project No.	14TF038



LEGEND

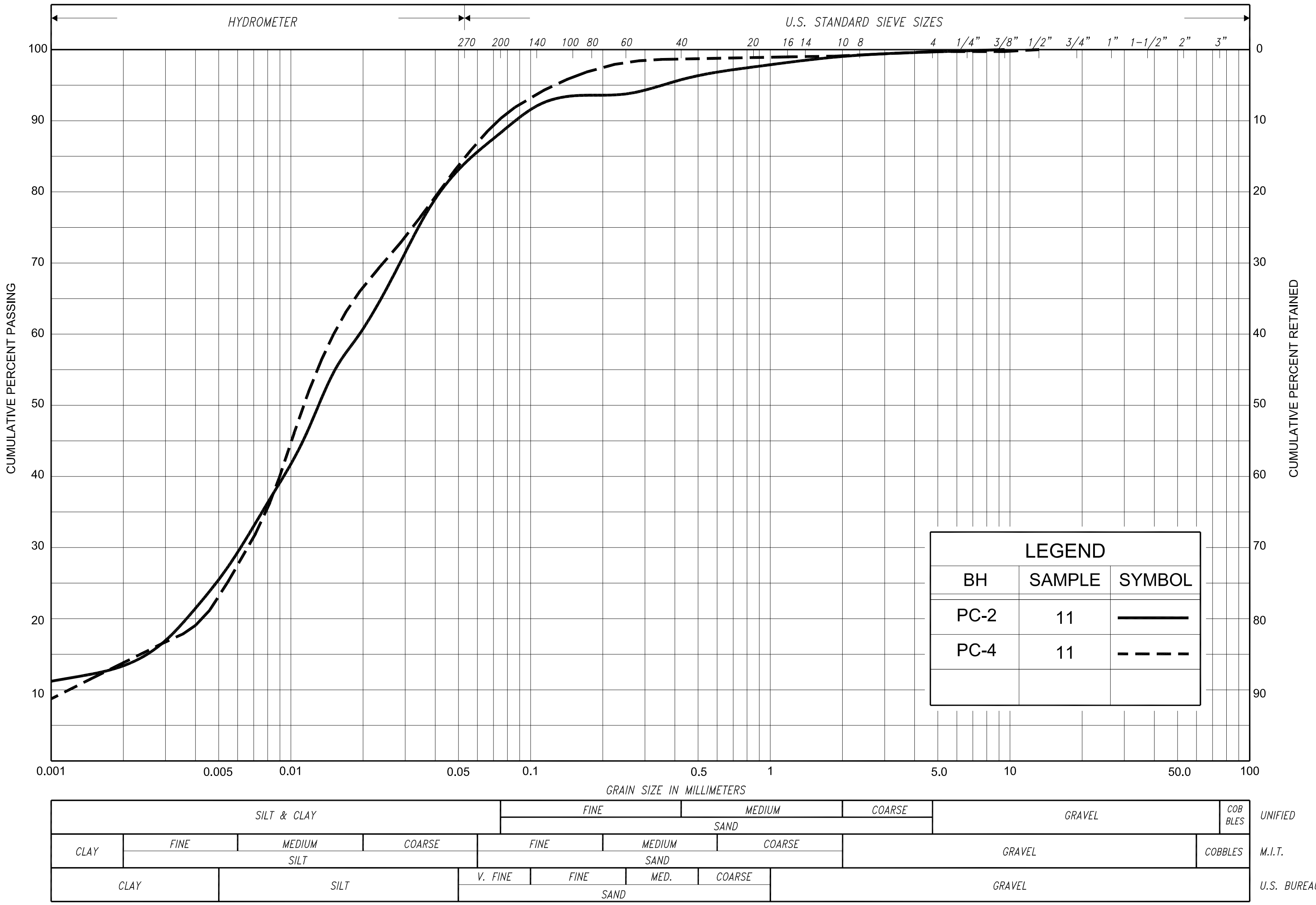
BH	SAMPLE	SYMBOL
PC-1	3	ENVELOPE
PC-3	8	
PC-4	4	
PC-4	7	
PC-4	9	
PC-5	9	
PC-5	11	

Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY to CLAYEY SILT (CL to CI)

FIG No.	PH-GS-3
HWY:	129
G.W.P. No.	14TF038

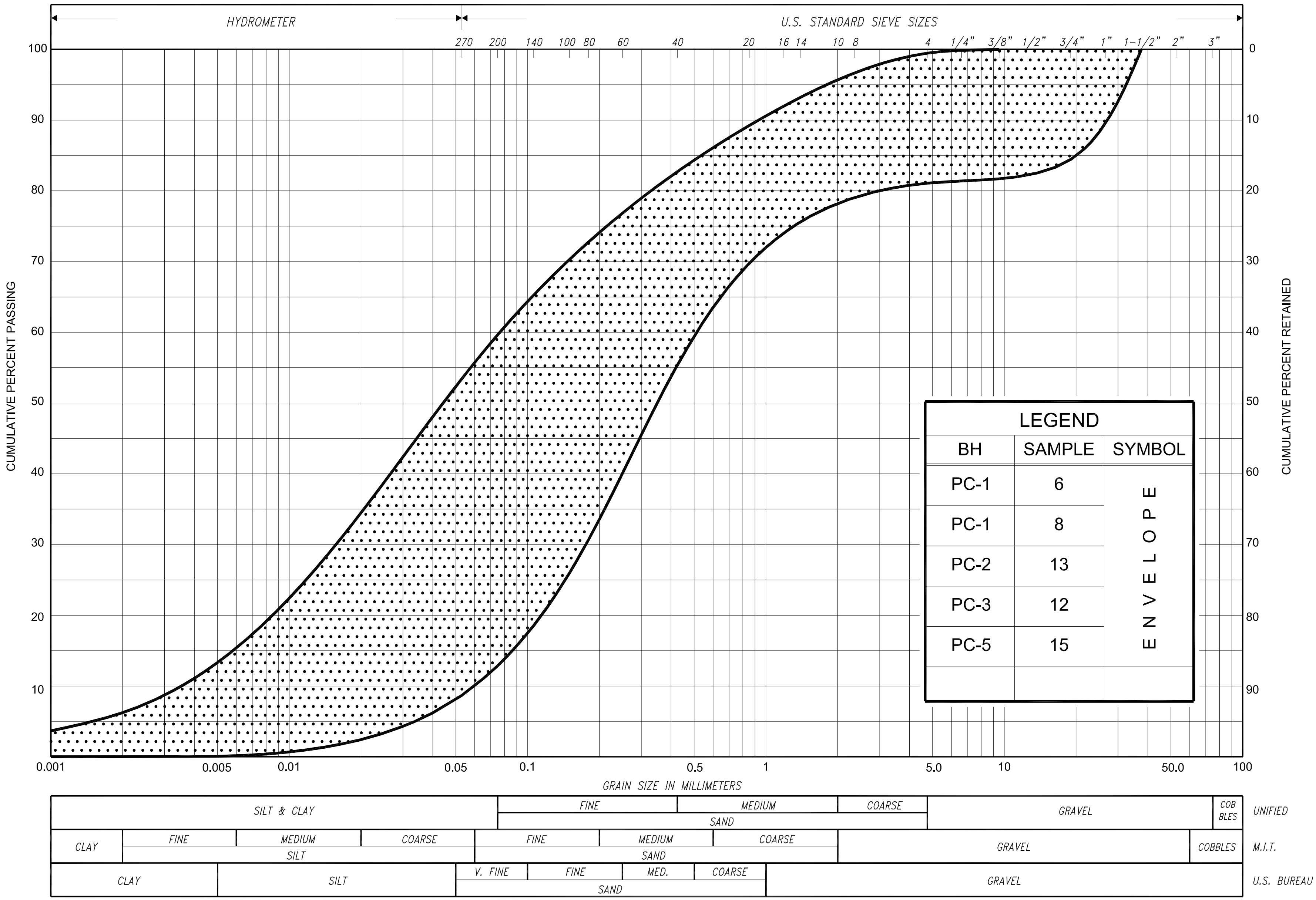


Ontario

GRAIN SIZE DISTRIBUTION

SILT (Layers) (CL-ML)

FIG No.	PH-GS-4
HWY:	129
Project No.	14TF038

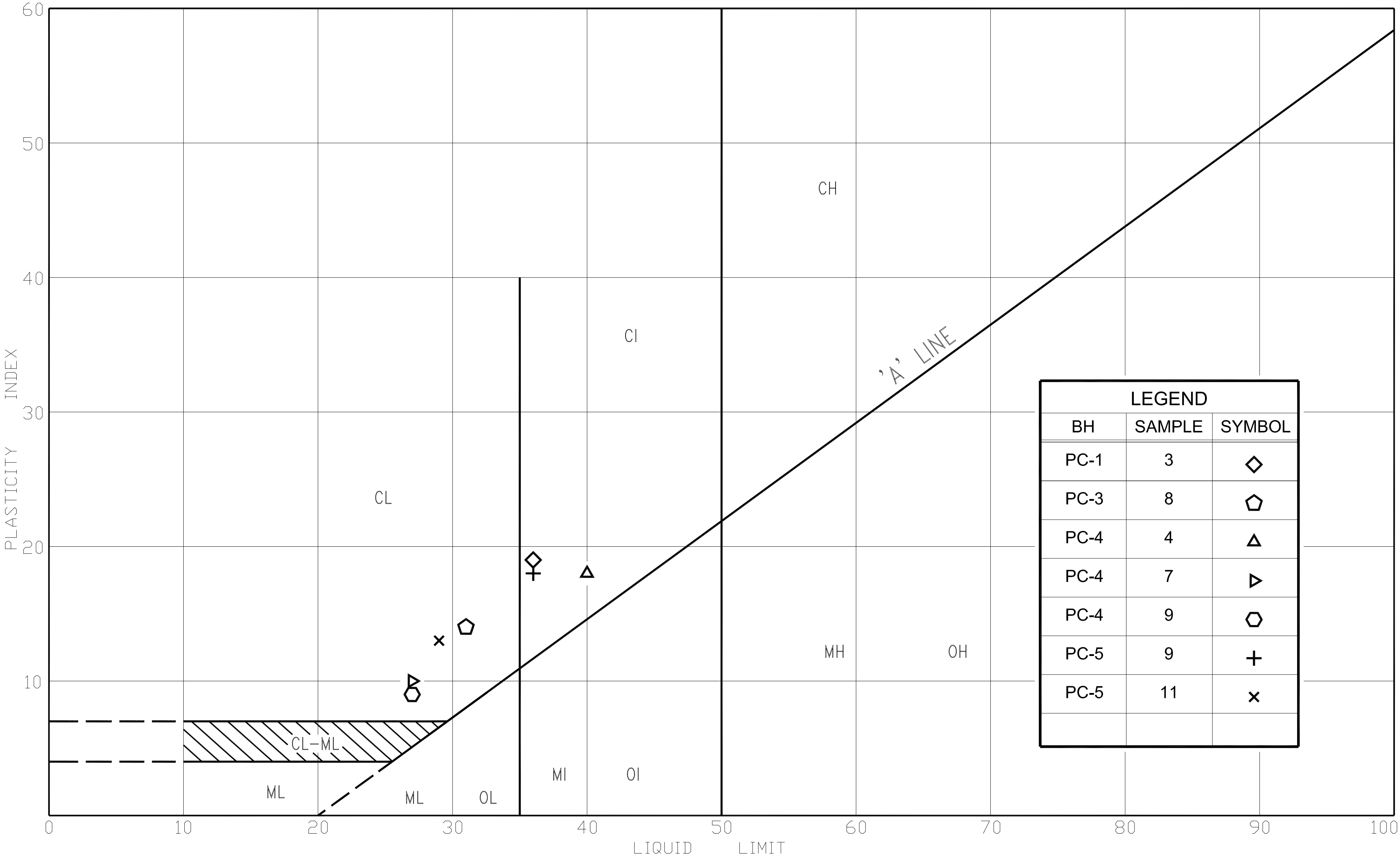


Ontario

GRAIN SIZE DISTRIBUTION

SILTY SAND/SANDY SILT (ML)

FIG No.	PH-GS-5
HWY:	129
G.W.P. No.	14TF038



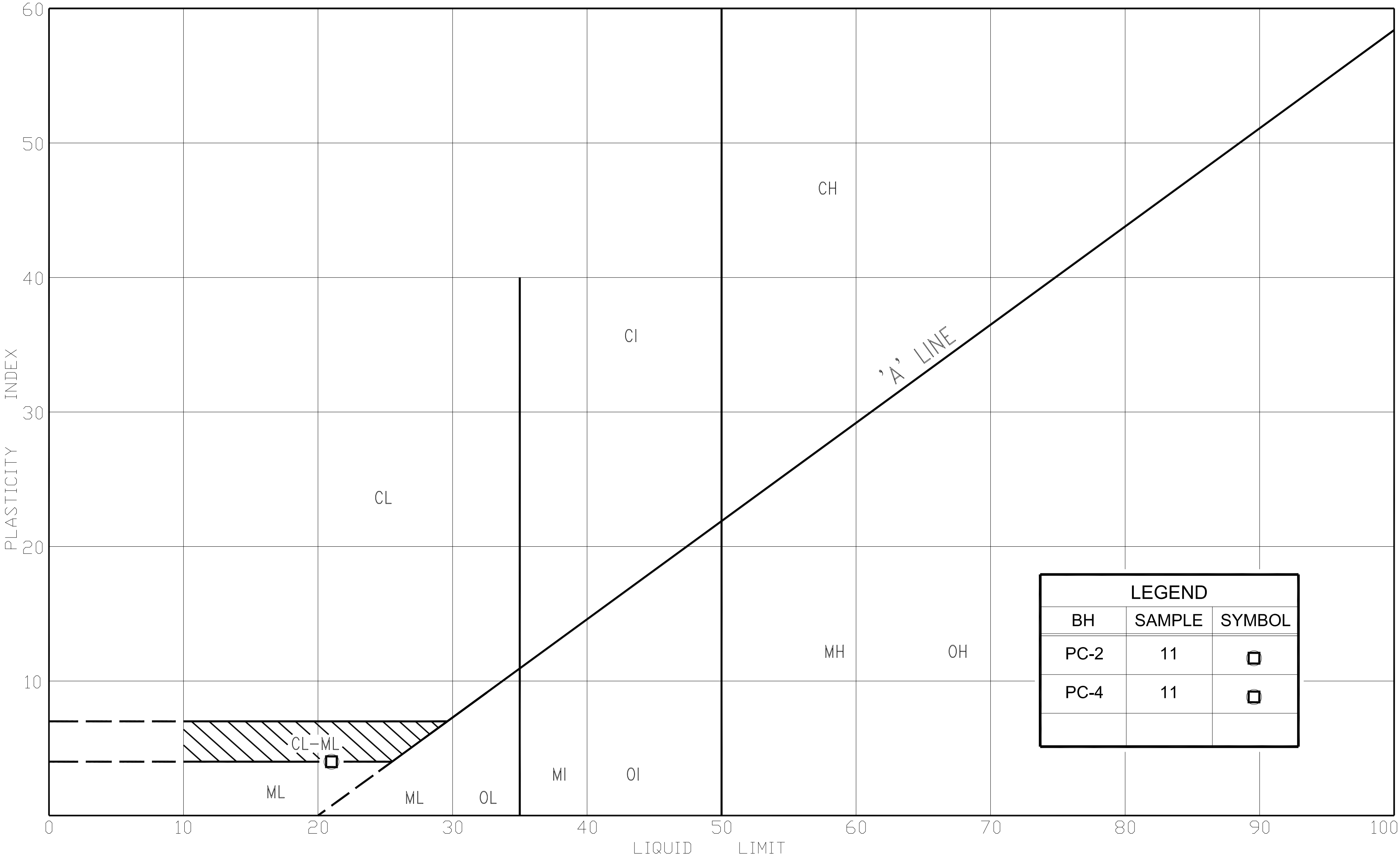
LEGEND		
BH	SAMPLE	SYMBOL
PC-1	3	◇
PC-3	8	⬠
PC-4	4	△
PC-4	7	▷
PC-4	9	⬡
PC-5	9	+
PC-5	11	×

Ontario

PLASTICITY CHART

SILTY CLAY to CLAYEY SILT (CL to CI)

FIG No.	PH-PC-1
HWY:	129
Project No.	14TF038

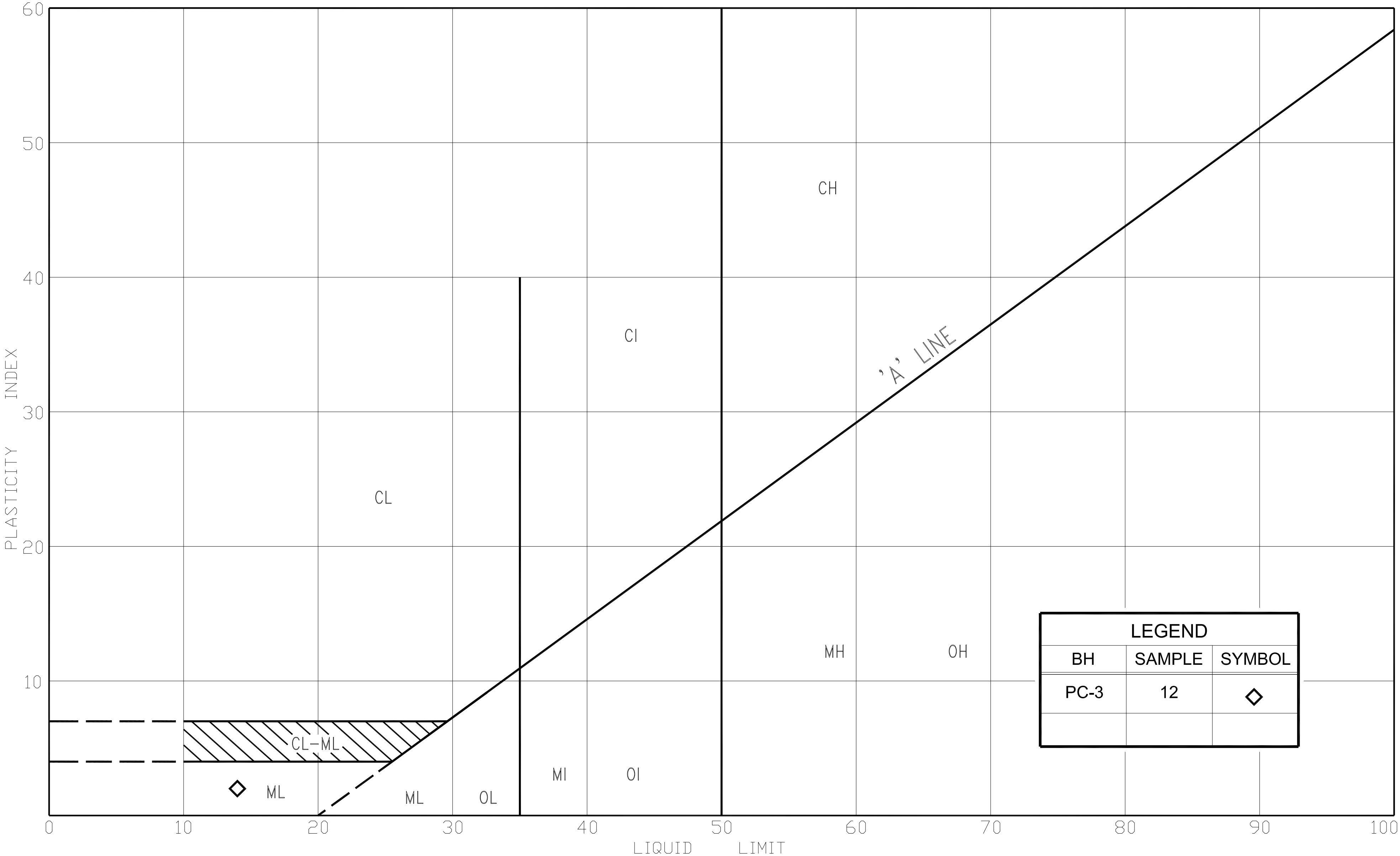


Ontario

PLASTICITY CHART

SILT (Layers) (CL-ML)

FIG No.	PH-PC-2
HWY:	129
Project No.	14TF038



LEGEND		
BH	SAMPLE	SYMBOL
PC-3	12	◇

Ontario

PLASTICITY CHART

SILTY SAND/SANDY SILT (ML)

FIG No.	PH-PC-3
HWY:	129
Project No.	14TF038

FOUNDATION DESIGN REPORT

for

PHILLIPS CREEK CULVERT REPLACEMENT
HIGHWAY 129
SAULT STE. MARIE, ONTARIO
GWP 5222-05-00
SITE # 38S-199/C
WP 5222-05-01

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email:toronto@petomaccallum.com

Distribution:
1 cc: AECOM for distribution to MTO Project Manager + 1 digital copy (PDF)
1 cc: AECOM for distribution to MTO Pavements and Foundations Section + 1 digital copy (PDF)
1 cc: AECOM 1 digital copy (PDF)
1 cc: PML Toronto

PML Ref.: 14TF038
Index No.: 032FDR
GEOCRES No.: 41J-98
March 29, 2016

PART B – FOUNDATION DESIGN REPORT
Phillips Creek Culvert Replacement
Highway 129
Sault Ste. Marie, Ontario
GWP 5222-05-00, WP 5222-05-01, Site # 38S-199/C

7. GENERAL

This Foundation Design Report is solely for the use of AECOM Canada Ltd. for the detail design of this specific project on behalf of the Ministry of Transportation and shall not be used for any other purposes or by any other parties including the construction contractor. Refer to the associated contract drawings for design requirements.

Where comments are made on construction, they are provided solely to identify aspects that could affect the design of the project. Construction contractors should make their own assessment of the factual information provided in the Foundation Investigation portion of this report for their decisions related to construction including, but not limited to, equipment selection, proposed construction methods and scheduling.

8. PROJECT DESCRIPTION

It is proposed to replace the existing Philips Creek twin culverts with a single concrete culvert. Refer to the Appendix E for the General Arrangement, Conceptual Flow Management and Construction Staging drawings for conceptual project details. According to the General Arrangement drawing dated February 2016, the existing Philips Creek culvert consists of twin 3.35 ×37.43 m Structural Plate Corrugated Steel Pipes (CSP's) located within the 3.0 to 3.2 m high embankment fill. The twin CSP culverts will be replaced with a single box culvert that will be constructed along the alignment of the most northerly of the existing twin culverts in order to utilize the most southerly CSP culvert for the creek flow during the new construction. It is proposed to replace the existing culvert with a single precast 5.0 × 3.0 m concrete box culvert with a total length of 36 m constructed at a skew angle of 27° 51' 36" towards south at the Highway 129 centreline. It is proposed to use staged construction with centerline roadway protection to facilitate construction. No grade raise has been proposed for the highway.

Staged construction will be required to remove the existing culvert and to install the new Phillip Creek culvert while maintaining traffic on the Highway 129. AECOM provided the preliminary staged construction drawings (Philip Creek Culvert Sta. 10+004.5, Bridgland Twp) in

Construction Staging Dated February 2016) for the one Single Line Traffic that is included in Appendix E. Four construction stages are identified for dewatering and traffic control for replacing and removing the existing culvert. A summary is provided below. However refrenced should be made to Appendix E for details.

Stage 1:

a) Install dewatering system and flowing water from south barrel
b) Excavation and removing west part of north barrel
c) Installation of box culvert in designated place

Stage 2:

d) Excavation and removing east part of north barrel,
e) Installation of remaining new box culvert

Stage 3:

f) Divert flow of the water from replaced culvert
g) Extending the excavation to south
h) Removing the east part of south barrel

Stage 4:

i) Excavate the west south of the construction site to remove the west part of south barrel

9. EVALUATION OF ALTERNATIVES

In general, the critical foundations engineering challenges for this project are maintaining slope stability at excavations for construction, managing settlement of the replacement culvert and the reinstated highway embankments, dewatering, roadway protection and staging and establishing a founding subgrade with adequate bearing resistance for the culvert.

The following Table 9.1 summarizes evaluations of the culvert types considered, their advantages and disadvantages as well as their risks/consequences and relative costs.

Table 9.1: Evaluation of Culvert Type Alternatives

Culvert Type (Alternatives)		Advantages	Disadvantages	Risks/Consequences	Relative Costs
#	Type				
1	Precast Concrete Box Culvert	Ease of installation. Less time required for construction. Less complex dewatering and potential to utilize partial dewatering with installation in the wet. More tolerant to settlement than CIP options.	Transportation of culvert segments. Limitation of width and height of culvert sections in comparison to other options.	Construction in-the-wet, if adopted, carries some risk along with advantages.	Less costly construction due to shorter construction time, but cost of transportation of segments has to be considered.
2	Cast-in-Place Concrete Box Culvert	More flexibility in sizing than precast option. Less transportation cost for materials than precast option.	More dewatering required than precast concrete box culvert. Longer culvert construction schedule than for precast concrete box culvert construction. Less tolerant to settlement than precast option.	Differential settlement could cause cracking of concrete in the culvert base and walls.	More costly than precast concrete box culvert due to longer construction time. May require excavation below water level with risk of flooding into excavation. Higher cost for dewatering than for concrete precast box culverts due to requirements for construction in the dry.

Table 9.1: Evaluation of Culvert Type Alternatives

Culvert Type (Alternatives)		Advantages	Disadvantages	Risks/Consequences	Relative Costs
#	Type				
3	CIP Open Footing Concrete Culvert	More flexibility in sizing. Less transportation cost for materials than precast option.	Longer culvert construction schedule than precast option. Requires footing depth to provide frost protection. More complex dewatering required than precast concrete box culvert for footing construction below water table. Less tolerant to settlement than CIP concrete box culvert	Due to deeper footings, increased risk of flooding of excavation and undermining existing culvert that remains in place during construction.	Higher cost for dewatering than for concrete precast box culverts due to requirements for construction in the dry.

Culvert type options that minimize dewatering and excavation would be preferable from a foundation engineering perspective. Option selection will also depend on the construction staging and traffic interruption constraints, the hydraulic capacity and size of the existing and proposed culvert and other considerations. From a foundations engineering perspective, the precast box culvert alternative is preferred because this option will be less susceptible to differential settlements and will be most appropriate for the relatively weak foundation ground at this site.

The following Table 9.2 summarizes evaluations of foundation types and related measures to provide bearing resistances and settlement performance of foundations, their advantages and disadvantages as well as their risks/consequences and relative costs.

Table 9.2: Evaluation of Foundation Types and Related Measures

Foundation Type (Alternatives)		Advantages	Disadvantages	Risks/Consequences	Relative Costs
#	Type				
1	Shallow Foundation on cohesive ground at invert level with normal backfill	Conventional construction.	Safety margin for settlement performance and slope stability less than ideal.	Very small risk of inadequate settlement performance since the existing embankment configuration has preloaded the site. However, the safety margin is less than ideal as increases in load would result in equivalent consolidation settlements. Risk of slope instability during construction excavation since the depth of excavation is greater than the height of the existing stable embankment about existing ground. This risk can be mitigated by proper design of construction slopes by the contractor.	Low cost.
2	Shallow Foundation on cohesive ground at invert level with lightweight water cooled blast furnace slag backfill	Reduces risk of inadequate settlement performance of culvert.	Requirement to import lightweight water cooled blast furnace slag. The water cooled blast furnace slag should not be placed below the groundwater level. Special requirements for compaction per NSSP in Appendix F.	More complex separation of backfill and pavement subgrade materials.	Medium cost due to cost of purchase and transport of lightweight water cooled blast furnace slag.

Table 9.2: Evaluation of Foundation Types and Related Measures

Foundation Type (Alternatives)		Advantages	Disadvantages	Risks/Consequences	Relative Costs
#	Type				
3	Shallow Foundation on rock fill replacing subexcavated soft cohesive ground with normal backfill	Eliminates risk of inadequate settlement performance of culvert.	Complexity of deep excavation and impact on slope stability of existing highway embankment.	Significant complexity of required deep excavation that would require careful design of temporary slope geometry to avoid slope failure.	High cost due to impacts on the required temporary slope geometries to prevent slope instability.
4	Shallow Foundation on improved ground geopiers	Eliminates risk of inadequate settlement performance of culvert.	Complexity of operation.	Management of heavy construction equipment within excavation into soft clay.	High cost due to transport of specialized equipment to relatively small site.
5	Deep Foundations (Driven H-Piles)	Eliminates risk of inadequate settlement performance of culvert.	Complexity of operation.	Management of heavy construction equipment within excavation into soft clay.	High cost due to transport of specialized equipment to relatively small site.

Based on the evaluation in Table 9.2, it is recommended that Options 3, 4 and 5 can be eliminated from further consideration. The selection of Option 1 or Option 2 will be dependent on the risk tolerance. Option 1 is feasible if the existing less than optimum safety margin against settlement performance is acceptable.

10. FOUNDATION RECOMMENDATIONS

The invert levels of the proposed culvert are Elevation 223.1 m at the east end (outlet) and Elevation 223.2 m at the west end (inlet). The proposed road grade at the proposed 3.0 m high culvert will be about Elevation 228.8 m indicating that the soil cover above the culvert will be approximately up to 2.8 m.

The following foundation recommendations assume that the selected option will be a precast concrete box culvert with conventional backfill.

10.1 Staged Construction

Staged construction will be required to remove the existing culvert and to install the new culvert while maintaining traffic on Highway 129. Refer to Appendix E for details.

Temporary roadway protection will be required near the centreline in the longitudinal direction of the Hwy 129 to maintain traffic.

Shoring will probably be required in the transverse direction to protect the existing CSP that is proposed to be left in place for stream diversion while the other existing CSP culvert is removed to facilitate construction of portions of the new concrete box culvert.

10.2 Excavation and Slope Stability

The minimum depth of excavation should allow for the levelling and base course requirements.

Excavation can be carried out in-the-wet or in-the-dry.

Excavation of the soils should be feasible using conventional excavation equipment. All excavations should be undertaken in accordance with OPSS 902 (Excavation and Backfilling of Structures).

According to the Occupational Health and Safety Act (Ontario Regulation 213/91) criteria, native loose to compact noncohesive soils are classified as Type 3 soils necessitating temporary cut slopes to be inclined at 1H:1V. However, this geometry is not suitable for this site due to the underlying soft clays and the associated risks of deep seated slope instability. The very soft to soft cohesive soils and very loose noncohesive soils are classified as Type 4 soils necessitating temporary cut slopes to be inclined at 3H:1V or flatter.

A site specific slope stability analysis was carried out to determine a safe excavation geometry at this site due to the underlying soft clay and the risk of slope instability. Refer to Appendix D for a conceptual slope stability analysis that illustrate the slope instability risk at this site and indicates that excavation slopes up to 6 m high should be sloped at 2H:1V or flatter. The factor of safety of 1.2 is considered to be adequate for this temporary slope stability condition. The design water level is at approximate Elevation 223.0 m for the analyses.

The Contractor should be responsible for carrying out the detailed design for the temporary roadway protection. Temporary roadway protection shall be designed in accordance with OPSS 539 (Construction Specification for Temporary Protection Systems) and provide a minimum performance level 2.

10.3 Subgrade Preparation

Preparation of the subgrade for construction of the culvert should be carried out in accordance with OPSS 902 and SP 902S01 (Excavation and Backfilling of Structures).

For the box culvert, it is recommended to provide a 300 mm thick granular bedding below the culvert. The bedding material should comprise Granular A or Granular B Type II material, satisfying the specifications within OPSS.PROV 1010 (Material Specification for Aggregates - Base, Subbase, Select Subgrade, and Backfill Material), compacted to 95% of the ASTM D-698 (standard Proctor) maximum dry density in conformance to OPSS 501 (Construction Specification for Compacting).

Alternatively, 19 mm diameter clear stone can be utilized for granular bedding and levelling course provided that this material is wrapped with filter fabric to prevent migration of fines from the native soil and ultimately potential failure of the culvert. Clear stone should satisfy the specifications in OPSS.PROV 1004 (Material Specification for Aggregates) meeting the physical properties and gradation requirements of 19 mm Type 2 Clear Stone and placed in accordance with OPSS 501 (Construction Specification for Compacting).

Levelling course and granular bedding can be placed below water level if the material is sufficiently self-compacting or by overbuilding above the water level by 1 m and then compacting and trimming to the bedding level.

The granular bedding material should be separated from the underlying ground by a geosynthetic filter fabric. The filter fabric should conform to OPSS 1860 (Material Specification for Geotextiles) and comprise a Class II non-woven geotextile with a filtration opening size (FOS) of 105 to 210 µm. The filter fabric should be placed beneath the bedding and extend up each side and to the top of the bedding and/or granular cover material.

10.4 Bearing Resistance

The recommended factored geotechnical bearing resistance, computed according with the CHBDC, at ultimate limit states (ULS) and the geotechnical reaction at serviceability limit states (SLS) for the proposed 5.0 m high and 3.0 m wide concrete box culvert constructed on the native cohesive soils are as provided in Table 10.4.

Table 10.4: Recommended Maximum Bearing Resistances

Foundation Type	Subgrade material Category	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Resistance at SLS (kPa) Assuming Settlements Up To 50mm
Box Culvert	Clay	100	80

The bearing resistance values were derived in consideration of the adequate settlement performance of the existing culvert/embankment configuration and the pressure relief from removing the existing embankment.

Watertight flexible joints to accommodate the indicated settlement for the identified subgrade material category in the above table should be provided between culvert segments.

10.5 Lateral Resistance

The lateral earth and water pressure, p (kPa), will only be applicable for retaining structures such as head walls and wing walls (if any) and for the design of shoring and should be computed using the following equation assuming a triangular pressure distribution:

$$P = K(\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + C_p + C_s$$

Where K = lateral earth pressure coefficient
γ = unit weight of free draining granular material above the design water level (kN/m3)
γ' = unit weight of backfill submerged below the design water level (kN/m3)
h_1 = depth below final grade (m), above the design water level
h_2 = depth below the design water level (m)
q = any surcharge load (kN/m2)
γ_w = unit weight of water equal to 9.8 kN/m3
C_p = compaction pressure (refer to clause 6.9.3 of CHBDC)
C_s = earth pressure induced by seismic events, kPa (refer to clause 4.6.4 of CHBDC)

Where Ø = angle of internal friction of retained soil (35º for Granular A)
δ = angle of friction between soil and wall (23.5º for Granular A)

The following parameters are recommended for design:

Table 10.5: Lateral Earth Pressure Parameters

Parameter	Granular A, Granular B Type II	Noncohesive Embankment Fill	Cohesive Ground
Angle of Internal Friction, degrees	35	30	26
Unit Weight, kN/m^3	22.8	20	17
Active Earth Pressure Coefficient (K_a)	0.27	0.33	0.39
At-Rest Earth Pressure Coefficient (K_o)	0.43	0.5	0.56
Passive Earth Pressure Coefficient (K_p)	3.69	3.0	2.57

The design should consider both the maximum water level and the stabilised groundwater level condition.

The coefficient of earth pressure at rest should be employed to design rigid and unyielding walls and the active earth pressure coefficient for unrestrained structures. Concrete culverts are considered to be constrained.

10.6 Settlement

Since the existing Philip Creek culvert has been in place and the underlying cohesive soils have been loaded with some 3.0 m of fill for a substantial period of time (estimated to be over 40 years) the estimated additional settlement under the new culvert is expected to be less than 50 mm but could be negligible provided that the load imposed on the ground is not increased. However, the underlying cohesive soil that has not been preloaded by the highway embankment is normally consolidated and will experience settlement generally directly related to any increase in load over existing conditions. If the culvert is extended or if Hwy 129 is widened in future, additional settlements will occur with estimated magnitude of 10% of the additional fill height assuming fill with unit weight in the order of 20 kN/m^3.

10.7 Camber

The base of the culvert should be placed at the inlet invert elevation from the invert to the culvert centre and then slope down to the outlet invert elevation in order to minimize the effect of any settlements that do occur under the culvert.

10.8 Culvert Backfill

Backfill adjacent to the box culvert should be placed in accordance with OPSS 501 (Construction Specification for Compacting), OPSS 422 (Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut), OPSD 803.010 (Backfill and Cover for Concrete Culverts), MTO SP 422S01 (Precast Concrete Box Culvert) and MTOD 803.021 (Bedding and Backfill for Precast Concrete Box Culverts).

Backfill should be brought up simultaneously on each side of the box culvert. The operation of heavy equipment within a horizontal distance defined as 0.5 times the height of the culvert should be restricted to minimise the potential for movement and/or damage of the culvert due to the lateral earth pressure induced by compaction.

The box culverts must be designed to resist the unbalanced lateral earth pressure and compaction pressure exerted by the backfill adjacent to the box culvert walls.

10.9 Embankment Fill

Embankment fill should be comprised of suitable earth fill or granular fill.

All embankment fill, above the prevailing groundwater, should be placed and compacted in accordance with OPSS.PROV 206 (Construction Specification for Grading).

The placement below the prevailing groundwater will be in-the-wet, and as such materials should be end-dumped without compaction and up to a minimum of 1 m above the groundwater level. The material should be then compacted in accordance with OPSS 501 (Construction Specification for Compacting).

The earth embankment side slopes should be inclined no steeper than 2H:1V. If earth slope flattening is indicated, a vegetation cover over slope flattening material or other measures to control surface runoff and minimise erosion of the embankment slopes should be implemented.

10.10 Erosion Control

The protective measures noted in the OPSD 800 series to deal with erosion (inlet/outlet treatment, headwalls, cut-off walls etc.) are considered to be appropriate. The backfill should comprise OPSS Granular A or Granular B Type II.

Inlet and outlet protection in accordance with OPSS 511 (Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting), OPSS. PROV 1004 (Material Specification for Aggregates) and OPSD 810.010 (General Rip-Rap Layout Sewer and Culvert Outlets) is recommended to prevent erosion adjacent to the culvert as well as scour.

It is recommended that horizontal inlet cut-offs and rock protection and outlet erosion protection should be considered instead of vertical cut-offs and structural head walls in order to minimize excavation into bedrock and construction below the groundwater level. In this case, the following recommendations are minimum requirements from a foundations engineering perspective that should be reviewed by the hydrologist and enhanced as required for hydrological purposes:

- The length and width of horizontal cut-off aprons shall be a minimum of 2.0 m or twice the diameter of the culvert, whichever is less.
- The rock protection shall conform to OPSS 511 (Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting) with a minimum dimension of 0.3 m and a minimum thickness of 0.5 m and extend to a minimum of 0.3 m above the culvert obvert level.
- Clay seals at the inlet shall be in conformance with OPSS 1205 (Material Specification for Clay Seal) and extend over the area defined under rock protection.
- Drainage and/or filter blankets at the outlet shall extend over the area defined under rock protection and may consist of a natural filter consisting of a minimum thickness of 0.3 m of Granular A or non-woven Class II geotextile with an FOS of 75-150 μm according to OPSS 1860 (Material Specification for Geotextiles). The filter shall be placed below the rock protection to minimize the potential for erosion of fine particles from below the treatment.

Where embankments are composed of earth, they should be covered with topsoil or suitable excess earth material from swamps or muskeg areas and seeded in accordance with OPSS 802 (Construction Specification for Topsoil) and OPSS 804 (Construction Specification for Topsoil) as soon after grading as possible to prevent erosion.

Refer to OPSS 511 - Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting, for design and installation requirements for these types of erosion control treatments.

Refer to OPSS.PROV 804 - Construction Specification for Seed and Cover, for design and installation requirement for Matrix Bonded Fabric (BMF) for erosion control.

10.11 Sliding Resistance

The following parameters should be used to compute the sliding resistance of precast box culvert. The friction angles have been reduced by a factor of 0.67 for precast box culvert foundations to account for the smooth concrete base.

Soil Type	**Foundation Friction Angle (Degrees)**	**Unit Weight (kN/m^3)**
	Cast-In-Place	
Granular A or Granular B Type II or 19 mm Clear Stone	35	22.8
Very Soft to Firm Clayey Soils	26	20.0

The structural designer should use a factor of 0.8 for the above values of friction angle and cohesion when performing the sliding resistance check.

10.12 Frost Depth

Although the foundation frost depth for structure foundations at this site is 1.8 m, according to the OPSD 3090.100 (Foundation, Frost Penetration depths for Northern Ontario), the frost depths for design should be 2.0 m to be consistent with pavement design report recommendations. Frost protection is not required for concrete box culverts provided that the box culvert has sufficient structural strength to withstand pressures imposed by frost action.

10.13 Seismic Considerations

The Peak Ground Acceleration (PGA) for the project site is 0.036 for the City of Sault Ste. Marie, Ontario (National Building Code of Canada, 2015). The soil at this site for seismic design purposes is classified as Type E, in accordance with Clause 4.4.3.2, CHBDC 2014.

11. CONSTRUCTION CONSIDERATIONS

11.1 Groundwater Control

For construction in-the-dry, it would be necessary to implement measures to control the surface water flow and the groundwater. Conventional procedures such as dam and pump and/or diversion of the stream may be sufficient to control surface water flow. It is noted that the groundwater levels are subject to seasonal fluctuations and precipitation patterns. The contract documents should include an NSSP stating that the groundwater level should be lowered to a minimum 0.5 m below the proposed founding levels for construction in-the-dry. Refer to Appendix F for related specifications and NSSP's. Dewatering along the culvert alignment would be challenging due to the nature of the ground and may require an enclosed cofferdam for construction in-the-dry.

However, construction in-the-wet is feasible by excavating without dewatering, overbuilding the levelling course/bedding and compacting, then trimming to the required top of bedding elevation. Construction in-the-wet should be considered in order to avoid the challenges and costs associated with construction in-the-dry.

In accordance with the Ontario Water Resources Act, the Water Taking and Transfer Regulation 387/04, a Permit to Take Water (PTTW) from the Ministry of Environment is required if the dewatering discharge is greater than 50,000 L/day. The expected daily flows at the culvert location should be assessed to determine if this permit will be necessary. It may be prudent to obtain the PTTW to avoid delays should the PTTW become necessary during construction.

11.1.1 Planned Staging for Temporary Stream Diversion

Refer to Appendix E for details of proposed staging and temporary stream diversion.

11.1.2 'Red Flag' Issues

The "red-flag" issues outlined and the recommended methods of overcoming these issues noted in the following sections of this report are intended to alert and aid the designer and where appropriate to alert the Contractor through subsequent contract specification. It is noted that no responsibility or liability is assumed by the MTO or its design consultants for alerting the contractor to all "red-flag" issues. The requirement to deliver acceptable construction quality remains the responsibility of the Contractor.

The red-flag issues for this project consist of challenging slope stability and settlement conditions and potentially complex dewatering challenges.

All construction work should be carried out in accordance with the Occupational Health and Safety Act and with local/MTO regulations.

11.2 Contract Specifications

A list of standard specifications and draft NSSP's relevant to this report are compiled in Appendix F.

12. CLOSURE

The Foundation Design portion of this report was prepared by Ms. Marzieh Kamranzadeh, MSc, Project Supervisor, EIT and reviewed by Mr. David Dundas, P.Eng, Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

Marzieh Kamranzadeh, MSc, EIT
Project Supervisor, Geotechnical Services

David Dundas, P.Eng.
Senior Engineer, Geotechnical Services

Carlos M.P. Nascimento, P.Eng
Project Manager and
MTO Designated Principal Contact

MK/DD/CN:mk-jk

APPENDIX D

Slope Stability Analysis Figure

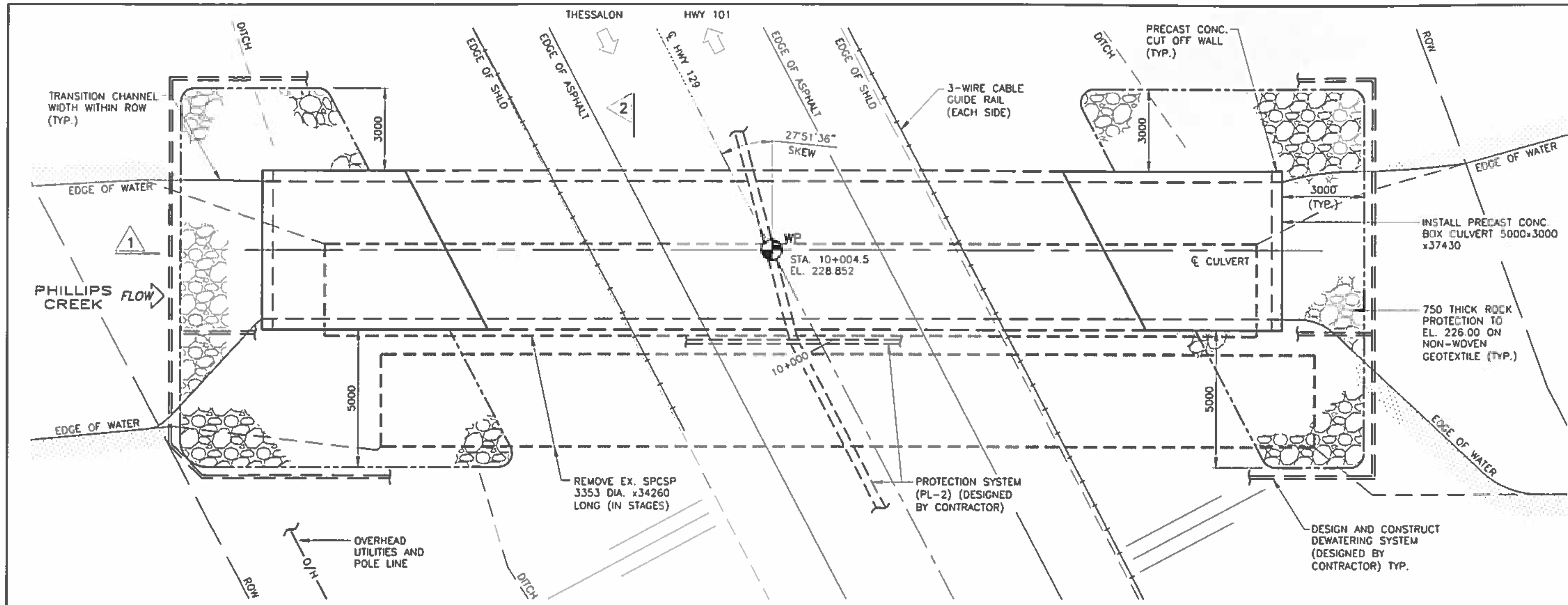
Figure 1: Slope Stability Analysis (2H:1V)

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface
Compact Sand		21	Mohr-Coulomb	0	32	Water Surface
Very Soft To Soft Clay		17	Mohr-Coulomb	26	0	Water Surface
Loose Sand		19	Mohr-Coulomb	0	30	Water Surface
Non-Cohesive Fill		20	Mohr-Coulomb	0	30	Water Surface

APPENDIX E

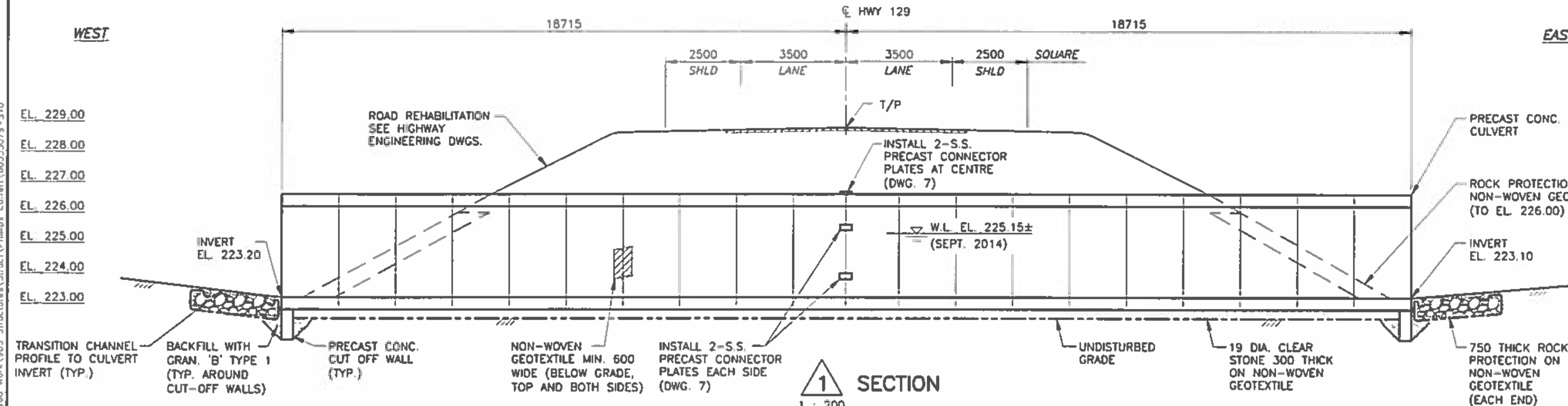
General Arrangement Drawing and Staging Procedure

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

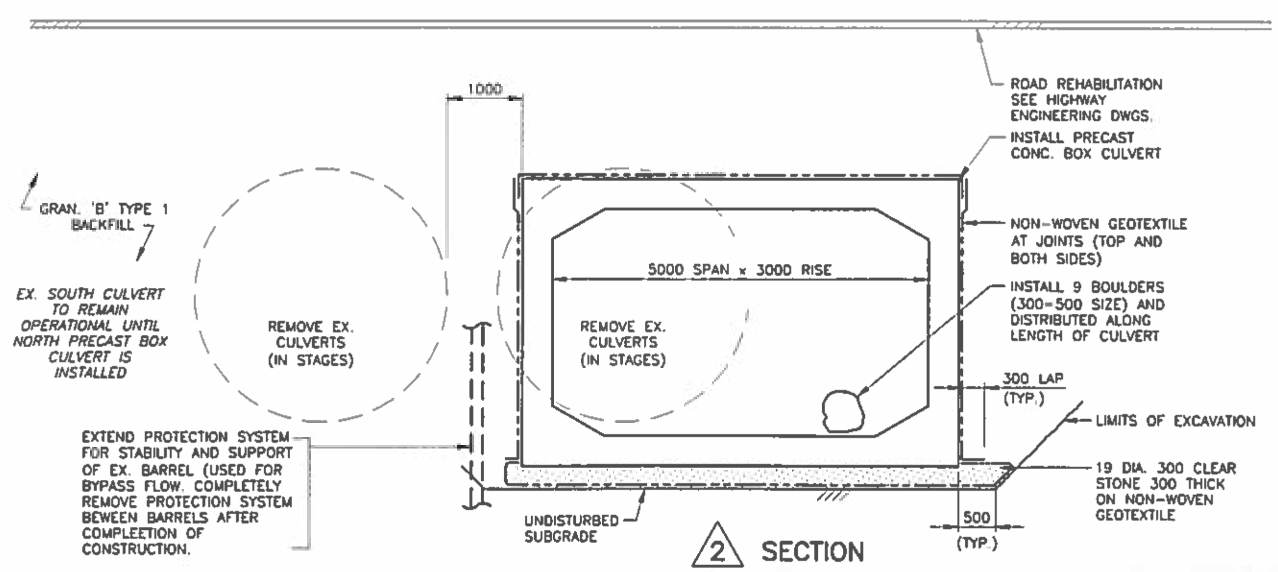


CONSTRUCTION NORTH

PLAN
1 : 200



1 SECTION
1 : 200



2 SECTION
1 : 100

B.M. ELEVATION 226.868
HWY 129 STA 9+948.438
N&W IN ROOT OF POPULAR
O/S 42.221 LT

HWY 129
CONT No 2016-5142
WP No 5222-05-01

PHILLIPS CREEK CULVERT
STA. 10+004.5, BRIDGLAND TWP.
GENERAL ARRANGEMENT

SHEET 9

AECOM

GENERAL NOTES :

1. CLASS OF CONCRETE
   PRECAST 40 MPa
2. CLEAR COVER TO REINFORCING STEEL :
   PRECAST 50 ± 10
   REMAINDER 70 ± 20 (UNLESS NOTED OTHERWISE)
3. REINFORCING STEEL :
   1. REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
   2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL SHALL BE CLASS B
   3. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1 UNLESS INDICATED OTHERWISE.
4. GEOTEXTILE :
   1. NON-WOVEN, CLASS II, FOS 50 TO 100um.

CONSTRUCTION NOTES :

1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF WORK REQUIRED TO MATCH EXISTING STRUCTURE SHALL BE SUBMITTED FOR APPROVAL.
2. THE CONTRACTOR SHALL CARRY OUT SITE SURVEYS TO DETERMINE THE EXISTING ELEVATIONS PRIOR TO REMOVALS.
3. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH CULVERT WALLS, KEEPING THE HEIGHT OF BACKFILL APPROXIMATELY THE SAME, AT NO TIME SHALL THE DIFFERENCE IN BACKFILL HEIGHTS BE GREATER THAN 500mm.
4. ALL SITE ACCESS TO COMPLETE THE WORK IS THE RESPONSIBILITY OF THE CONTRACTOR.
5. THE CONTRACTOR SHALL SELECT EQUIPMENT, MATERIALS AND TYPES OF CONSTRUCTION TO SUIT CONSTRAINTS (SUCH AS OVERHEAD UTILITIES) AND TEMPORARY WORKS.
6. ALL PRECAST CONCRETE FOR THIS STRUCTURE WILL BE SUPPLIED BY MTO.

APPLICABLE STANDARD DRAWINGS :

OPSD 3941.200 FIGURES IN CONCRETE, SITE NUMBER, AND DATE, LAYOUT

LIST OF DRAWINGS :

1 GENERAL ARRANGEMENT
2 BOREHOLE LOCATIONS AND SOIL STRATA
3 BOREHOLE LOCATIONS AND SOIL STRATA
4 CONSTRUCTION STAGING
5 PRECAST CONCRETE DETAILS
6 CONCEPTUAL FLOW MANAGEMENT
7 MISCELLANEOUS DETAILS

LIST OF ABBREVIATIONS :

℄	CENTRELINE	SBGR	STEEL BEAM GUIDE RAIL
CONC.	CONCRETE	SPCSP	STRUCTURAL PLATE CORRUGATED STEEL PIPE
c/w	COMPLETE WITH	STA	STATION
DIA.	DIAMETER	TYP.	TYPICAL
DWG.	DRAWING	T/P	TOP OF PAVEMENT
EL.	ELEVATION (METRES)	W.L.	WATER LEVEL
EX.	EXISTING	U.N.O.	UNLESS NOTED OTHERWISE
MIN.	MINIMUM		
ROW	RIGHT OF WAY		
SHLD	SHOULDER		

DRAWING NOT TO BE SCALED
50 mm ON ORIGINAL DRAWING

REVISIONS DATE	BY	DESCRIPTION

DESIGN J.P.	CHK G.M.	CODE CHBDC 2014	LOAD CL-625-ONT	DATE MAR 2016	
DRAWN T.G.	CHK J.P.	SITE 38S-199/C	STRUCT	SCHEME	DWG 1

DATE: 3/1/2016 11:00:37 AM DRAWING FILE: O:\PROJECTS\60333079 Hwy 129\900 Work\903 Structures\Struct\Phillips Culvert\60333079-S10

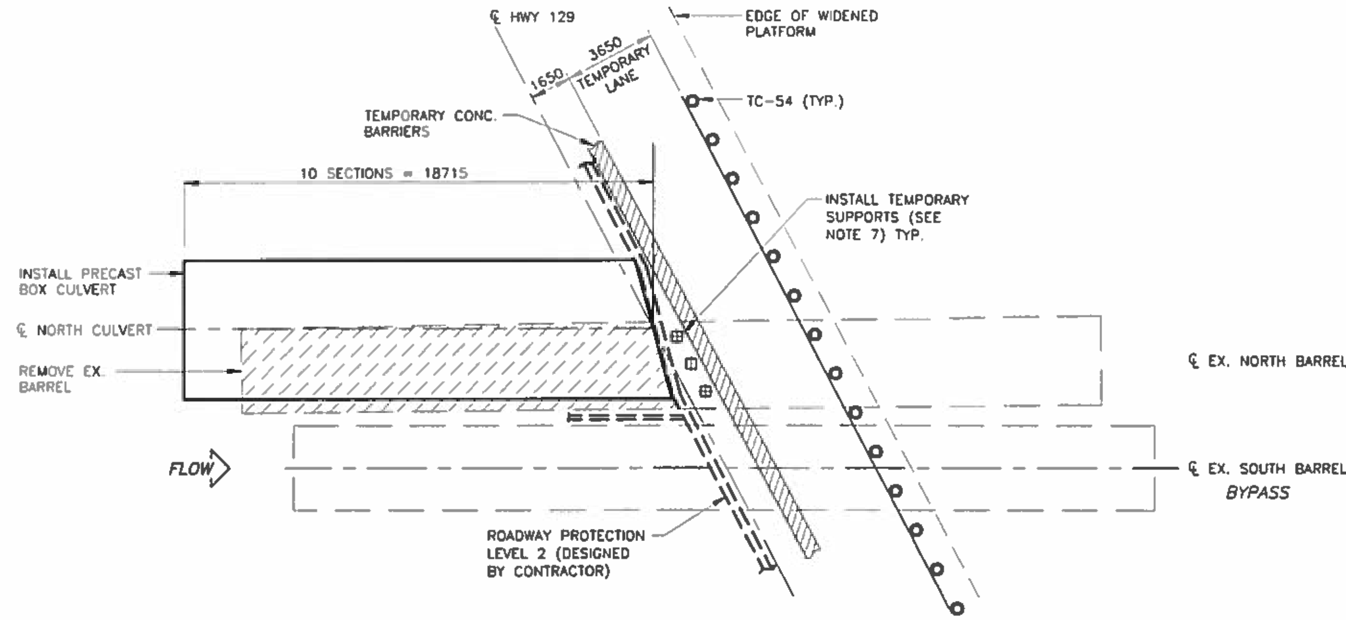
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY 129
CONT No 2016-5142
WP No 5222-05-01

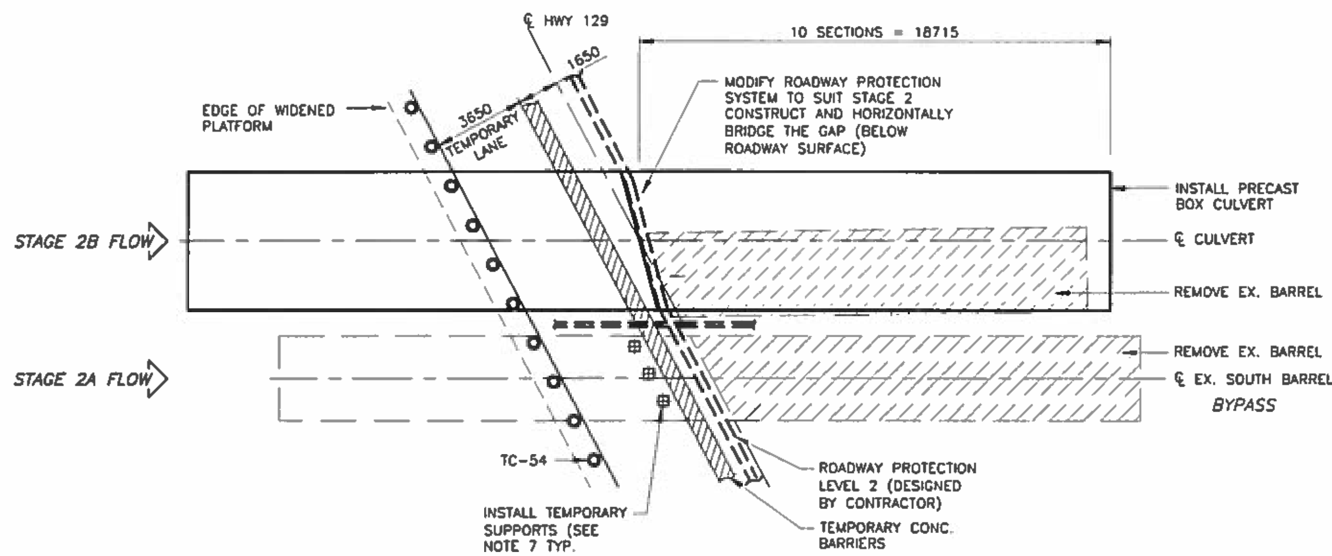
PHILLIPS CREEK CULVERT
STA. 10+004.5, BRIDGLAND TWP.
CONSTRUCTION STAGING

SHEET 12

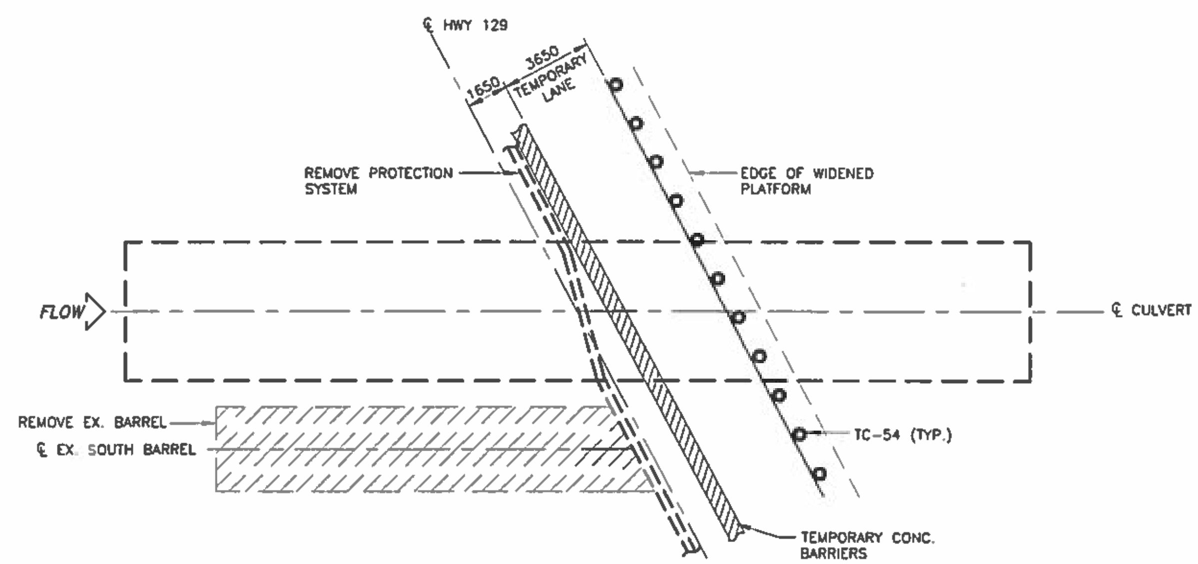
AECOM



PLAN – STAGE 1
N.T.S.



PLAN – STAGE 2
N.T.S.



PLAN – STAGE 3
N.T.S.

NOTES :

1. FOR GENERAL NOTES SEE DRAWING 1.
2. THE LAYOUT AND DETAILS OF THE CONSTRUCTION STAGING ARE SCHEMATIC AND SHOWN FOR REFERENCE PURPOSES ONLY. THE CONTRACTOR SHALL DESIGN AND CONSTRUCT THE TRAFFIC/CONSTRUCTION STAGING TO SUIT THE FULL REQUIREMENTS OF THE WORK.
3. INSTALL TOP OF PROTECTION SYSTEM 50mm BELOW EXISTING GRADE TO PERMIT FULL TRAFFIC LANES AT END OF WORKING DAY.
4. THE CONTRACTOR SHALL PLAN THE CONSTRUCTION SEQUENCE AND CULVERT ARRANGEMENT TO ACCOMMODATE THE SKEW OF THE PROTECTION SYSTEM. THIS MAY INCLUDE THE REMOVAL AND MODIFICATIONS OF THE BOTTOM PORTION OF THE PROTECTION SYSTEM.
5. ROADWAY PROTECTION TO BE DESIGNED BY THE CONTRACTOR TO PERFORMANCE LEVEL 2.
6. EXTEND PROTECTION SYSTEM WITH LOCAL STEEL PLATES AND ATTACHMENTS ABOVE GRADE ADJACENT TO EXCAVATION, TO LATERALLY RESTRICT MOVEMENT AT THE TEMPORARY CONCRETE BARRIER. MODIFY FOR EACH STAGE.
7. THE CONTRACTOR SHALL DESIGN AND INSTALL VERTICAL SUPPORTS IN BARREL TO MAINTAIN STRUCTURAL INTEGRITY OF CUT BARREL. FIELD MEASURE FOR TIGHT FIT, AND FIT TIMBER WEDGES TO FIRMLY SECURE.
8. ARRANGEMENT OF THE DEWATERING SYSTEM CONCEPT IS NOT SHOWN IN THIS DRAWING, SEE DRAWING 6.
9. FOR USE OF SKEWED BOX UNITS SEE NOTE 5, DRAWING 5.
10. FOR ROAD WORKS SEE HIGHWAY ENGINEERING DRAWINGS.

SEQUENCE OF WORK :

STAGE 1 :

- INSTALL DEWATERING SYSTEM AND MAINTAIN FLOW THROUGH SOUTH BARREL.
- INSTALL TRAFFIC CONTROL MEASURES TO MAINTAIN SINGLE LANE TRAFFIC ON EAST SIDE OF HIGHWAY.
- REMOVE WEST PORTION OF EXISTING NORTH CULVERT.
- INSTALL WEST PORTION OF NORTH BOX CULVERT.
- COMPLETE ALL OTHER WORK DETAILED AND SPECIFIED IN THE CONTRACT DOCUMENTS.

STAGE 2A :

- MAINTAIN DEWATERING SYSTEM AND FLOW THROUGH SOUTH BARREL.
- MODIFY TRAFFIC CONTROL MEASURES TO MAINTAIN SINGLE LANE TRAFFIC ON WEST SIDE OF HIGHWAY.
- REMOVE EAST PORTION OF EXISTING NORTH CULVERT.
- INSTALL EAST PORTION OF NORTH BOX CULVERT.
- ALL OTHER WORK DETAILED AND SPECIFIED IN THE CONTRACT DOCUMENTS.

STAGE 2B :

- MODIFY DEWATERING SYSTEM AND DIVERT FLOW THROUGH NORTH BOX CULVERT.
- MAINTAIN TRAFFIC CONTROL MEASURERS WITH SINGLE LANE TRAFFIC ON WEST SIDE OF HIGHWAY.
- REMOVE EAST PORTION OF EXISTING SOUTH BARREL.
- COMPLETE ALL OTHER WORK DETAILED AND SPECIFIED IN THE CONTRACT DOCUMENTS.

STAGE 3 :

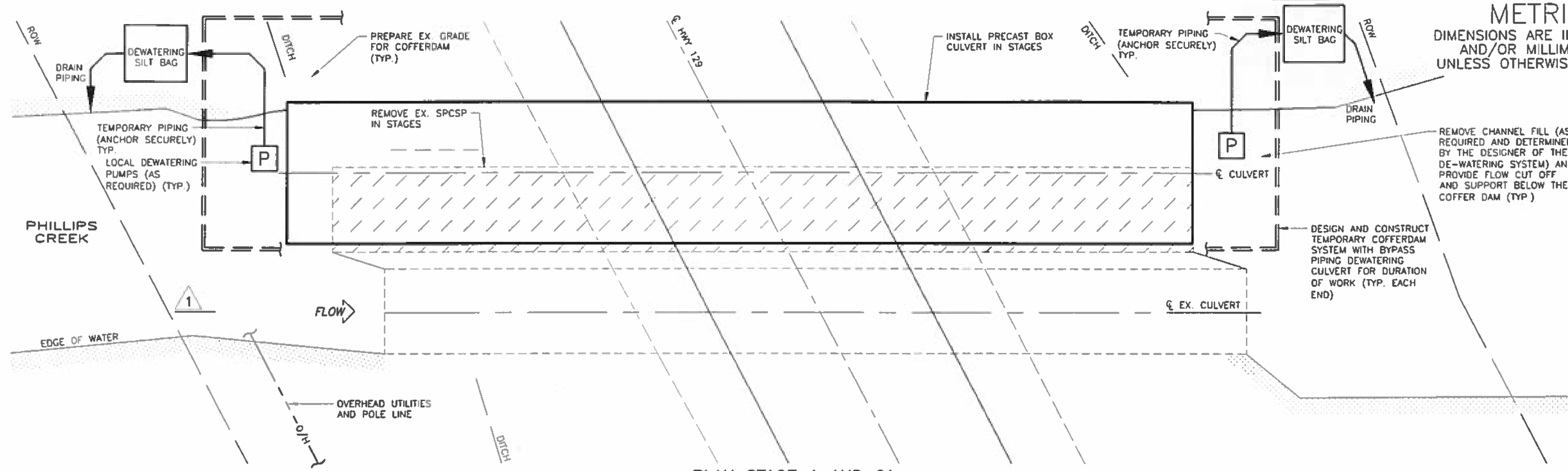
- MAINTAIN DEWATERING SYSTEM AND FLOW THROUGH NORTH BOX CULVERT.
- MODIFY TRAFFIC CONTROL MEASURES TO MAINTAIN SINGLE LANE TRAFFIC ON EAST SIDE OF HIGHWAY.
- REMOVE WEST PORTION OF EXISTING SOUTH BARREL.
- COMPLETE ALL OTHER WORK DETAILED AND SPECIFIED IN THE CONTRACT DOCUMENTS. REMOVE DEWATERING SYSTEM.

DRAWING NOT TO BE SCALED
50 mm ON ORIGINAL DRAWING

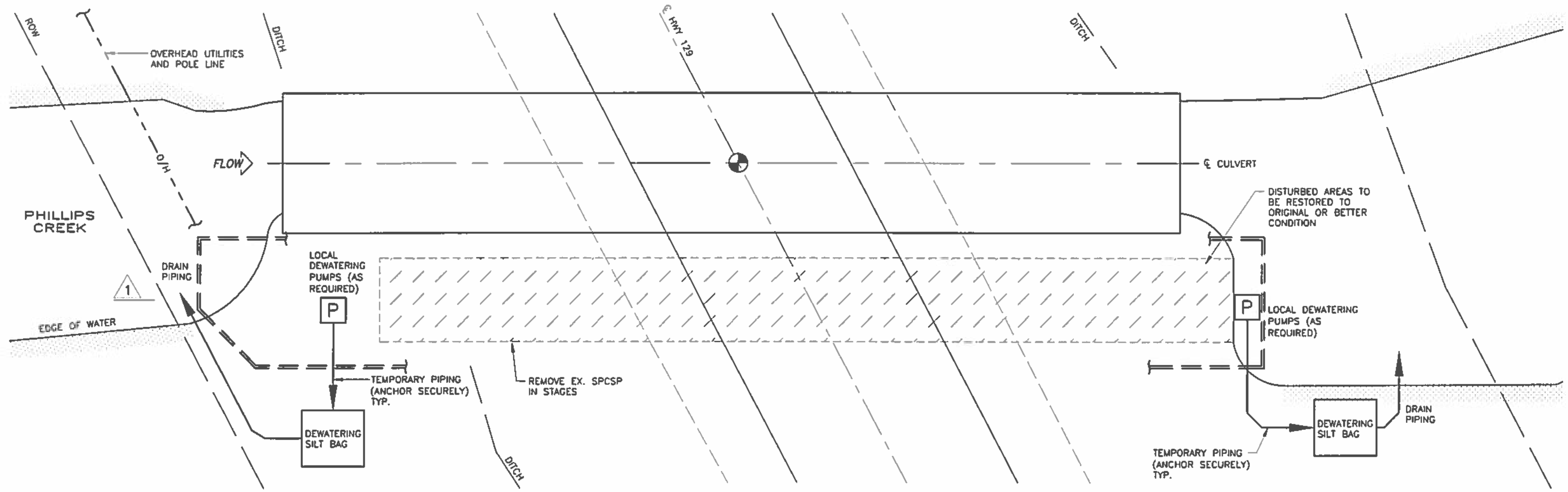
REVISIONS		
DATE	BY	DESCRIPTION

DESIGN J.P.	CHK G.M.	CODE CHBDC 2014	LOAD CL-625-ONT	DATE MAR 2016
DRAWN T.G.	CHK J.P.	SITE 38S-199/C	STRUCT SCHEME	DWG 4

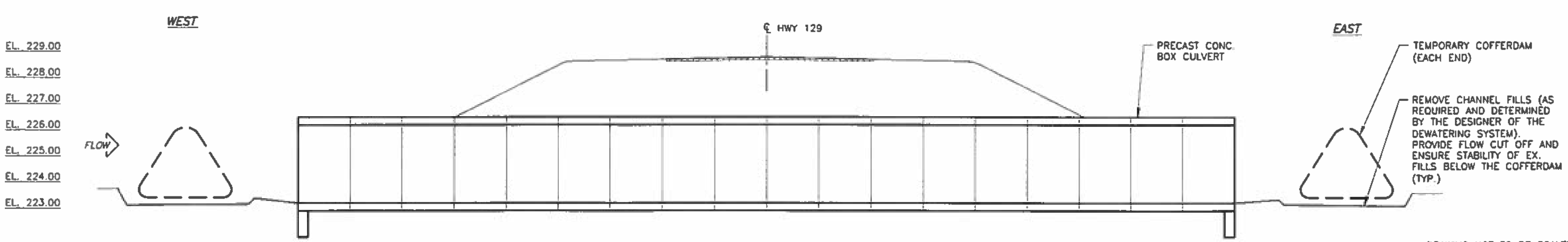
DATE 2/29/2016 12:35:33 PM DRAWING FILE O:\PROJECTS\60333079 Hwy 129\800 Work\903 Structures\Struct\Phillips Culvert\60333079-S11



PLAN STAGE 1 AND 2A
1 : 200



PLAN STAGE 2B AND 3
1 : 200



1 SECTION
1 : 200

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

CONT No 2016-5142
WP No 5222-05-01

PHILLIPS CREEK CULVERT
STA. 10+004.5, BRIDGLAND TWP.
CONCEPTUAL FLOW MANAGEMENT

SHEET 14

AECOM

NOTES :

1. THE ARRANGEMENT SHOWN ON THIS DRAWING IS A CONCEPT PLAN. THE CONTRACTOR SHALL SUBMIT A CONSTRUCTION DEWATERING PLAN FOR INFORMATION.
2. THE EXISTING SOUTH BARREL SHALL BE USED FOR FLOW CONVEYANCE DURING STAGES 1 AND 2A. THE NEW CONCRETE BOX CULVERT SHALL BE USED FOR FLOW CONVEYANCE DURING STAGES 2B AND 3.
3. ALL ENVIRONMENTAL PROTECTION MEASURES SHALL BE INSTALLED PRIOR TO UNDERTAKING CONSTRUCTION.
4. DEWATERING DESIGN SHALL INCLUDE MEASURES TO REMOVE GROUND WATER WITHIN THE EXCAVATION FLOWING THROUGH NATIVE FILLS.
5. THE CONTRACTOR SHALL ASSUME THAT WATER IS PRESENT IN ALL FILLS AND ROADWAY EMBANKMENT AT OR ABOVE THE WATER LEVEL (EDGE OF WATER ILLUSTRATED ON PLAN DOES NOT IMPLY THE EXTENT OF DEWATERING REQUIRED).
6. INTEGRATE THE DESIGN OF ROADWAY PROTECTION SYSTEMS, DEWATERING SYSTEMS AND COFFERDAM.
7. ONCE THE WORK HAS BEEN COMPLETED, INSPECTED AND ACCEPTED, THE CONTRACTOR SHALL REMOVE THE DOWN STREAM COFFERDAM FOLLOWED BY THE UPSTREAM COFFERDAM.

DEWATERING AND FLOW PARAMETERS :

1. BYPASS DESIGN FLOW : 3.2 CMS
2. MINIMUM BYPASS PIPING DIAMETER : N/A (EXISTING CULVERT)
3. TOP ELEVATION OF PROTECTION MEASURES/COFFERDAM ELEVATION 225.5m.

DEWATERING CONSTRUCTION SEQUENCE :

- PREPARE BANKS AND WATERCOURSE FOR COFFERDAMS AND DEWATERING EQUIPMENT. REMOVE ANY OBSTRUCTIONS (DEBRIS AND ROCKS) AND OTHER MATERIALS AS REQUIRED.
- SLOWLY DEWATER THE AREA INTERIOR TO THE COFFERDAMS. RELOCATE STRANDED FISH IN RESIDUAL POOLS SAFELY BACK TO THE DOWNSTREAM WATERCOURSE.
- INSTALL TEMPORARY PUMPS, DEWATERING DEVICES AND SILT BAGS.
- CONTINUE DEWATERING INTERIOR TO THE COFFERDAMS TO MAINTAIN A DRY WORK AREA THROUGH THE DURATION OF CONSTRUCTION.
- FOLLOWING COMPLETION OF CULVERT CONSTRUCTION, ACQUIRE PERMISSION IN WRITING FROM THE CONTRACT ADMINISTRATOR, TO REMOVE DEWATERING MEASURES.
- REMOVE SEDIMENT AND OTHER MATERIAL ACCUMULATED BEHIND COFFERDAMS.
- REMOVE ALL OTHER TEMPORARY PROTECTION MEASURES AND DISPOSE OF ACCUMULATED SEDIMENT.
- REMOVE UPSTREAM AND DOWNSTREAM COFFERDAMS.
- REPEAT PROCESS FOR MULTIPLE STAGES, AS APPLICABLE.

LEGEND :

P — SECONDARY PUMPS FOR LOCAL DEWATERING AND CONTROL OF SURFACE RUN OFF

DRAWING NOT TO BE SCALED
50 mm ON ORIGINAL DRAWING

REVISIONS

DATE	BY	DESCRIPTION

DESIGN J.P.	CHK G.M.	CODE CHBDC 2014	LOAD CL.-625-ONT	DATE MAR 2016	
DRAWN T.G.	CHK J.P.	SITE 38S-199/C	STRUCT	SCHEME	DWG 6

DRAWING FILE: O:\PROJECTS\60335079 Hwy 129\900 Work\903 Structures\Struct\Phillips Culvert\60335273-S13
DATE: 3/1/2016 10:08:37 AM

APPENDIX F

List of Ontario Provincial Standard Documents Relevant to Report

Non-Standard Specific Provision (NSSP)

LIST OF STANDARD SPECIFICATIONS RELEVANT TO REPORT

DOCUMENT	TITLE
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 539	Construction Specification For Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS 804	Construction Specification for Seed and Cover
OPSS 902	Excavation and Backfilling of Structures
OPSS 1205	Material Specification for Clay Seal
OPSS 1860	Material Specification for Geotextiles
OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV.804	Construction Specification for Seed and Cover
OPSS.PROV.1004	Material Specification for Aggregates - Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates - Base, Subbase, Select Subgrade, And Backfill Material
OPSD 803.010	Backfill and Cover for Concrete Culverts
OPSD 810.010	General Rip-Rap Layout Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Depth for Northern Ontario
SP 902S01	Excavation and Backfilling of Structures

NON-STANDARD SPECIAL PROVISIONS (NSSP)

NSSP – Surface Water Control and Dewatering (Addition to OPSS 902)

The Contractor shall take measures for necessary surface water diversions and drainage. For construction in-the-dry, the Contractor shall implement dewatering to lower the prevailing groundwater level a minimum of 0.5 m below the base of excavations.

NSSP – Excavations and Slope Stability (Addition to OPSS 902 and OPSS 539)

The Contractor is advised that the weak subsoils at the site require careful design of excavation and fill slope geometries and shoring schemes including slope and excavation protection for the removal of one barrel of the existing CSP culvert to maintain the stability of the CSP culvert that will be left in place for water diversion. The Contractor is also advised to restrict the stockpiling of material and the placement of heavy equipment near slope crests in order to prevent slope instabilities. The analyses and discussions in the Foundation Design Report are provided for conceptual illustration of the issue. The Contractor is responsible for carrying out slope stability analyses and design of excavation and slope geometries and temporary roadway protection schemes and shoring schemes required for their operations.

NSSP – Settlement Management (Addition to OPSS 902)

The Contractor is advised that their design and construction should minimize additional loading on foundation soil over existing levels as increases in loading over existing levels will cause related settlements that may be excessive.

NSSP - Lightweight Blast Furnace Slag Material And Placement

SCOPE

This non standard special provision covers the requirements for the supply and placement of the lightweight blast furnace slag.

DEFINITIONS

Quality Verification Engineer: means an Engineer with a minimum of five (5) years experience related to embankment materials and construction , or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and issue of certificate(s)of conformance.

SUBMISSION AND DESIGN REQUIREMENTS

The Contractor shall submit to the Contract Administrator Certificates of Conformance sealed and signed by the Quality Verification Engineer stating that:

1. the material satisfies the requirements of this specification

and

2. the material satisfies the requirements of this specification and work has been carried out in general conformance with the contract documents and specifications.

The Contractor shall submit to the Contractor the Certificate of Conformance for the material properties prior to the placement of the lightweight fill material on the contract. The material properties shall be determined using the test procedure specified in Table 1.

The Contractor shall submit to the Contract Administrator, for information only, all Quality Control Test Results.

MATERIAL

The Lightweight Blast Furnace Slag shall satisfy the physical, mechanical and chemical property requirements specified in Table 1:

Table 1 – Material Properties

Material Property	Test Procedure	
In-Situ Wet Unit Weight	< 14 kN/m^3	ASTM 4914-89
Angle of Internal Friction	> 35 °	ASTM 2850-95
Hydraulic Conductivity	> 8 E-03 cm/s	ASTM 5856-95, Method A
Chemical Composition		The material shall meet the leachate criteria established under Ontario Regulation 347.

The Contractor shall retain a certified laboratory that has been inspected and accepted by the MTO to undertake the testing of the material properties.

CONSTRUCTION

The intention is to achieve adequate compaction without crushing the material since crushing would increase its unit weight. The contractor is advised that lightweight blast furnace slag is susceptible to crushing if overcompacted and that careful construction supervision is required.

For embankment construction, the Contractor shall build a trial area consisting of two equal lifts of 300mm each, to establish a placement procedure capable of achieving compaction that will provide the specified in situ wet unit weight without evidence of crushing. Gradation as per ASTM D422-63 before and after compaction effort shall be performed to determine that crushing is kept within 5%. In situ unit weight testing shall be as per ASTM 4914-89 and results will be used to determine that the specification is met.

QUALITY ASSURANCE

General

QA will be carried out by the Owner for purposes of ensuring that the materials used in the work conform to the physical, mechanical and chemical property requirements of this special provision. Notwithstanding the requirements for QA sampling as indicated below, the Owner reserves the right to obtain a sample at any time without notice for any purpose.

Sampling

QA samples shall be taken in accordance with the individual test procedure requirements under the supervision of the Quality Verification Engineer(QVE). QA samples shall be obtained by the Contractor in the presence of the Contract Administrator

All Quality Assurance samples shall be delivered by the Contractor to a laboratory designated by the Owner within 500 km of the contract limits no later than 2 business days from the date of sampling.

For QA sampling, the Contractor shall provide new sample bags or containers that are constructed to prevent the loss of any part of the material or contamination or damage to the contents during shipment. The sample bags or containers shall be sufficiently strong and shall be securely fastened.

Testing of Samples

Samples shall be tested as summarized in the Table 1 below.

TABLE 1

Property	Test Procedure	# of tests per lot
Gradation(Before and After Compaction)	ASTM D422-63	*2 from each lift*
Insitu Density	ASTM 4914-89	*2 from each lift*
Leachate	Acetic Acid Leach Test according to O. Regulation 347	*1 prior to initial placement*

MEASUREMENT OF PAYMENT

The unit measurement will be cubic metres for the lightweight fill material placed in situ as per the requirements of the contract.

BASIS OF PAYMENT

Payment at the contract price for the above tender item shall be full compensation for all labour equipment and materials required to do the work.