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FOUNDATION INVESTIGATION AND DESIGN REPORT

W.P. 545-93-00
HIGHWAY 60 –
CLARKE CREEK
BRIDGE REPLACEMENT

McCormick Rankin Corporation

PROJECT NO. 1023332
SITE NO. 43-149
GEOCRES NO. 31F-274

Jacques Whitford

An Environment of Exceptional Solutions

PROJECT NO. 1023332

FOUNDATION INVESTIGATION AND DESIGN REPORT

TO

McCormick Rankin Corporation
2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8

ON

W.P. 545-93-00
Highway 60 – Clarke Creek Bridge Replacement
County of Nipissing
District 43, Bancroft
Ministry of Transportation Ontario
Site No. 43-149
Geocres No. 31F-274

October 2007

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FOUNDATION INVESTIGATION REPORT

for

W.P. 545-93-00

Highway 60 – Clarke Creek Bridge

Township of Airy

District 43, Bancroft

1.0 INTRODUCTION

This report was prepared as part of the Total Project Management (TPM) assignment for the Detailed Design of Clarke Creek and Kearney Creek Bridge Replacements, Highway 60, G.W.P. 545-93-00.

This report presents the results of a foundation investigation carried out for the proposed replacement of the existing Clarke Creek Bridge on Highway 60 in Algonquin Park (Site No. 43-149).

The foundation investigation was carried out in general accordance with our proposal number 1019534 dated December 5, 2006. Authorization to proceed was provided by the Ministry of Transportation of Ontario (MTO) under Agreement Number 4006-E-0018 with McCormick Rankin Corporation (MRC), the Detailed Design Consultant for this project.

This report has been prepared specifically and solely for the project described herein. It contains factual information pertaining to the subsurface conditions which was obtained as part of this investigation.

It is noted that a Preliminary Foundation Investigation of this site was carried out by Jacques Whitford Limited. The relevant results from Report No. ONO11685 dated June 2006 have been included in the present report.

2.0 SITE DESCRIPTION AND GEOLOGY

The subject site is within the limits of MTO project W.P. 545-93-00 (Highway 60). The site location is shown on the Key Plan inset to Drawings No. 1 and No. 2 provided in Appendix A. It is noted that for project orientation purposes, Highway 60 will be assumed to run north-south at the Clarke Creek Bridge, with chainage increasing from north to south.

Physiographically, the Clarke Creek Crossing is located within the Algonquin Highlands. This region is characterized by rough rounded knobs and ridges with frequent outcrops of bare rock. The bedrock is generally shallow, however, the depth to bedrock varies greatly over short distances.

Many of the valleys are floored with outwash sand and gravel. There are frequent swamps and bogs.

Clarke Creek flows from east to west and is approximately 13 m in width at the centreline of Highway 60. Water depths were estimated to be less than 1 m at the time of the investigation.

The existing roadway embankments are approximately 3.8 m and 5.0 m high at the north and south abutments, respectively. The water level in Clarke Creek was approximately 6 m below the top of pavement on the existing bridge deck at the time of the investigation. The banks of the creek are steeply sloped for approximately 1 m above water level and then very gradually slope upwards away from the creek. No indications of significant erosion were noted at the time of the site inspection. The ground surface within the highway right-of-way is vegetated with grass. Mature trees are present beyond the edges of the cleared right-of-way. Drainage in the area consists of overland flow directed towards the creek.

A plan view and profile are shown on each of Drawings No. 1 and No. 2, provided in Appendix A.

3.0 PROCEDURE

3.1 Field Investigation

The preliminary investigation consisted of eight (8) boreholes designated as 05-9 through 05-16. The details concerning the field procedures for those boreholes is documented in the June 2006 Preliminary Foundation Investigation Report.

The site soil conditions were further investigated in 2007 with a borehole drilling investigation, piezocone (CPTu) investigation and laboratory testing program. The borehole drilling and CPTu testing was carried out using a combination of a truck-mounted CME-75 drill rig and a track-mounted CME-55 drill rig between April 18 and May 24, 2007.

A total of three (3) boreholes, designated as 07-2, 07-4 and 07-5 were put down during the field investigation. Borehole 07-2 was advanced at the south abutment location for the temporary bridge structure along the proposed detour alignment. Boreholes 07-4 and 07-5 were advanced at the north and south abutment locations, respectively, on the permanent alignment. Borehole 07-1, which was to have been drilled at the north abutment along the propose detour alignment was cancelled after discussions with MTO due to the depth to bedrock in Borehole 07-2 and the fact that a borehole (05-10) had been drilled at this abutment location during the preliminary investigation in 2005.

The boreholes were advanced though the overburden using casing and drilling mud in order to balance the pressure within the borehole and minimize sand coming up the augers. Despite the use of casing and thick drilling mud, frequent problems were encountered with sand/silt coming up inside the casing.

The subsurface conditions were identified in the field by Jacques Whitford Limited (JW) personnel from samples obtained while carrying out Standard Penetration Tests (SPT) (ASTM D1586) at regular intervals. The boreholes at the abutment locations on the permanent alignment were advanced to at least 3 m beyond SPT refusal in accordance with the Terms of Reference for this project. SPT refusal is defined as 100 or more blows for 300 mm of penetration. This required coring through boulders in Borehole 07-5 and into bedrock at Borehole 07-4. The casing became jammed at a depth of 47.2 in Borehole 07-2. Beyond this depth the hole was advanced by driving a cone to refusal (defined as greater than 100 blows per 300 mm of penetration). Refusal to the cone penetration was reached at a depth of 51.9 m below ground surface. The recovered soil samples were stored in moisture proof containers and returned to our laboratory. The subsurface conditions encountered are described in detail in the Borehole Records presented in Appendix B.

Standpipes were installed in Boreholes 07-2 and 07-4. The standpipes consisted of slotted flexible poly-pipe tube with a diameter of 25 mm. The slotted section was backfilled with native sand material. Above the slotted section, the annular space around the pipe was backfilled with a cement-bentonite mixture. Groundwater levels were measured upon completion of the drilling.

Two CPTu test holes, designated as CPT 07-3 and CPT 07-6, were put down on the permanent alignment approximately 10 m behind the north and south abutments, respectively. These test holes were started by drilling through the existing pavement and coarse embankment fill using hollow stem augers. The piezocone was then pushed through the native silt and sand materials using the hydraulic system on the drill rig until refusal (ASTM D3441). In this case, refusal was reached when the piezocone tip resistance was sufficient to cause the drill rig to start to lift up from the ground.

Prior to completing the investigation, the boreholes were grouted with a cement/bentonite mix. Asphalt surfaces were reinstated with a minimum of 100 mm of cold patch asphalt.

3.2 Survey

Borehole locations were established in the field by measurement by JW personnel relative to existing site features such as the existing bridge structure. The locations for Boreholes 05-9, 05-10, 05-11 and 05-12 were referenced to the centerline of the proposed detour. All other holes are referenced to the permanent alignment of Highway 60. The ground surface elevations at the borehole locations were surveyed relative to the top of asphalt on the deck of the existing Clarke Creek bridge structure. The top of pavement at this location has been identified as having a geodetic elevation of 397.8 m based on a profile included in the Structural Design Report.

3.3 Laboratory Testing

All samples returned to the laboratory were subjected to detailed visual classification by a geotechnical engineer. Routine testing, consisting of moisture content testing and grain size distribution analysis, was carried out on representative samples. One soil sample was submitted for pH, sulphate and resistivity testing to assess the potential for corrosion of buried steel and the potential for sulphate attack on buried concrete. Two samples had previously been analyzed as part of the preliminary investigation.

No complex testing was deemed to be necessary based on the soil conditions.

All soil samples will be stored for a period of one year after issuance of the final version of the foundation investigation report. Unless otherwise directed, the stored samples will be disposed of after this period.

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Profile

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided. The results of the CPTu testing are also presented in Appendix B along with an explanation of terminology used on CPTu/SCPTu Records.

Borehole Records from the preliminary foundation investigation report for this project have been included in this report for completeness.

In general, the subsurface profile beneath the proposed detour alignment (Boreholes 05-9 to 05-12 and 07-2) consists of a fill or a thin topsoil layer, overlying sand on top of silty sand, over silt with some sand over glacial till.

Bedrock was not proven within the maximum depth of investigation (51.9 m) along this alignment.

Within the existing roadway platform (Boreholes 05-13 to 05-16, 07-4, 07-5 and CPT 07-3 and 07-6), the subsurface profile consists of the pavement structure overlying the existing bridge approach fill, over native soils with significant particle size variations in the shallower zones, ranging from silty sand to sandy gravel, overlying silty sand and silt layers, over glacial till over bedrock at a depth of more than 58 m below ground surface.

Borehole location plans and stratigraphic sections of the soils encountered within the boreholes are provided on Drawings No. 1 and No. 2 in Appendix A.

4.1.1 Fill: Silty Sand to Gravelly Sand with Silt

Granular fill was encountered beneath the asphalt in all of the boreholes located along the existing Highway 60 alignment. The composition of the fill ranged from sand, trace silt, trace gravel to gravelly sand, with silt. The thickness of the fill varied from 1.0 m in Borehole 05-13 to 4.9 m in Borehole 07-4. The base of the fill ranged from elevation 392.9 m (borehole closest to the creek) to 396.7 m (borehole further from the creek). The upper portion of the fill was frozen to a depth of approximately 1.2 m at the time of the preliminary investigation in 2005. The moisture content of the 7 samples of fill tested ranged from 3% to 16% and averaged 7%. The SPT 'N' values ranged from 3 to 41 (excluding the results within the upper frozen zone) with an average value of 14 indicating that the fill was generally compact. The asphalt surface overlying the fill was observed to be 90 mm to 200 mm thick at the borehole locations. Borehole 07-4 encountered a 180 mm thick concrete slab (likely the approach slab) directly beneath the asphalt.

The results of two grain size analyses indicate that the tested samples of fill contained 6% and 16% gravel, 81% sand and 3% to 13% fines. The gradation results are provided on Figure 1 in Appendix B.

4.1.2 Poorly-Graded Sand (SP)/Poorly-Graded Sand with Silt (SP-SM)

A deposit of poorly-graded sand to poorly-graded sand with silt was observed directly beneath the fill or vegetation in all boreholes. The deposit contained gravel in Borehole 05-10 and 05-13 and occasional cobbles in 05-10, 05-11 and 05-13. The thickness of this deposit ranged from 2.9 m in Borehole 05-12 to 9.1 m in Borehole 05-14. The base of the unit varied from elevation 383.7 m to 390.2 m (geodetic). SPT 'N' values ranged from 1 to 45 and averaged 19, indicating that the deposit varies from a very loose to dense state but is on average, compact. The results of nine grain size analyses indicate that the deposit contained between 0 and 28 % gravel, 34 to 96% sand and 2 to 9% fines. The gradation results are provided on

Figures 2 and 3 in Appendix B. This material ranges from an SP to SP-SM soil using the MTO Soil Classification System.

4.1.3 Silty Sand (SM)

A layer of silty sand was observed beneath the poorly-graded sand deposit in all boreholes that fully penetrated the poorly-graded sand deposit. In some cases, the silty sand deposit was interrupted by layers of silt or sandy silt (ML). Where fully penetrated, the silty sand deposit ranged from 6.8 m thick to 38.7 m thick. The base of the unit varied from elevation 348.4 m to 383.1 m (geodetic). SPT 'N' values ranged from 4 to 100 and averaged 29, suggesting a generally compact state. The moisture content of the 32 samples tested ranged from 17% to 25% with an average of 21%. Grain size analysis of nine samples indicated that this deposit contained 0% to 1% gravel, 51% to 80% sand and 20% to 49% silt and clay sized particles. The results of the grain size distribution testing are shown on Figure 4 in Appendix B. This material corresponds to SM soil using the MTO Soil Classification System.

4.1.4 Silt / Silt with Sand / Sandy Silt (ML)

A layer of silt, silt with sand or sandy silt was encountered within seven of the eleven boreholes at this site. Three of the boreholes were terminated within these silt deposits.

Where this deposit was fully penetrated, the thickness ranged from 3.0 m to 23.5 m and the base of the unit varied from elevation 343.2 m to 368.8 m (geodetic). SPT 'N' values ranged from 5 to 116 and averaged 28, suggesting a generally compact state. The moisture content of the 9 samples tested ranged from 18% to 28% with an average of 22%. Grain size analysis of the six samples tested indicated that they contained 0% gravel, 11% to 50% sand and 50% to 89% silt and clay sized particles. The results of the grain size distribution testing are shown on Figure 5 in Appendix B. These materials correspond to an ML soil using the MTO Soil Classification System.

4.1.5 Silty Sand with Gravel, Cobbles and Boulders (TILL)

A glacial till deposit was encountered beneath the silt and sand deposits in Boreholes 07-4 and 07-5. The upper surface of the till deposit ranged from 54.6 m below ground surface (elev. 343.2 m) in Borehole 07-4 to 50.0 m below ground surface (elev. 347.7 m) in Borehole 07-5. The thickness of the till in Borehole 07-4 was 3.8 m. Borehole 07-5 was terminated upon SPT refusal (100 blows for <300 mm of penetration) on four occasions and after penetrating 12.2 m into the till deposit.

Split spoon sample recovery was very limited within the till deposit due to the coarse nature of the material. Five of the six standard penetration tests carried out within this deposit were terminated after 100 blows, typically for only 30 mm of penetration. Rock coring techniques were used to advance the holes through boulders within the till. Based on the limited sample recovery, the till deposit is inferred to consist of silty sand with gravel cobbles and boulders.

4.1.6 Bedrock

Bedrock was encountered in Borehole 07-4 at a depth of 58.4 m below ground surface (elev. 339.4 m). The bedrock was penetrated 2.9 m by coring with NQ-size coring equipment. The core recovery was between 98 ands 100 %. The rock quality designation (RQD) ranged from 63 % to 100%, indicating fair to excellent rock mass quality. The recovered rock core consisted of grey, black and pink biotite gneiss. The rock generally had a fair to excellent rock mass quality and was moderately to slightly weathered with close to moderately spaced fractures and dip angles ranging from 0 to 40 degrees from horizontal. The unconfined compressive strength of two samples of the recovered rock core were 40 MPa and 155 MPa, indicating medium strong to very strong rock.

A detailed description of the rock cores is provided in the Rock Core Summary Table in Appendix B.

4.2 Groundwater

Groundwater levels were measured in the standpipes installed during the preliminary investigation on February 10, 2005. The water levels ranged from 1.2 m to 6.0 m below ground surface (elevation 391.5 m to 392.2 m). Groundwater levels were observed in the open boreholes at the time of drilling during the 2007 investigation. The water levels ranged from 1.2 m to 6.0 m below ground surface (elevation 391.4 m to 391.8 m).

The water level in Clarke Creek was surveyed to be at elevation 392.2 m and 391.7 m on January 20, 2005, and May 17, 2007, respectively. The groundwater levels measured in the boreholes are very close to the water level in the creek, as would be expected considering the permeable nature of the upper sandy deposits.

Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

5.0 CLOSURE

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

Yours very truly,

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6.0 DISCUSSION

6.1 Proposed Development

It is noted that, for project orientation purposes, Highway 60 will be assumed to run north-south at the Clarke Creek Bridge site, with chainage increasing from north to south.

It is understood that the Ministry of Transportation of Ontario (MTO) plans to replace the existing Clarke Creek Bridge (Site No. 43-149). Based on the Structural Planning Report, the existing structure was constructed in 1939 and consists of a 36.6 m long six span slab-on-girder structure. It has a concrete deck and steel girders supported on timber piles. The bridge provides a roadway width of 9.2 m between concrete curbs and a 0.45 m concrete curb on each side. The wingwalls at the abutments are approximately 1 m long.

The proposed replacement structure has been developed as a 27 m single span CPCI 1600 girder bridge with integral abutments and wing walls. The proposed alignment will follow the existing vertical and horizontal highway alignment and the proposed abutments will be perpendicular to the centreline. The width of the bridge deck will be increased, providing 12.0 m between barriers. The abutment width of the proposed structure is approximately 13.25 m with 2H:1V foreslopes and sideslopes. No retaining walls adjacent to the abutments are proposed.

Traffic management during construction of the replacement structure will require a 2-lane detour to the east side, thereby requiring a temporary detour bridge structure. The detour structure will also be a single span structure. The proposed profile for the detour indicates that finished grades will be between 395.8 m and 395.9 m at the south and north edges of the structure respectively. This represents up to 3.3 m of fill in the approaches.

It is anticipated that the underside of the pile caps for the permanent structure will be at elevation 392.2 m and that the underside of the footings for the detour structure will be at elevation 393.14 m.

6.2 Soil Summary

The native soil conditions at this site consist of a deep deposit of non-cohesive materials ranging from poorly-graded sand to silt, overlying a bouldery till deposit over bedrock at a depth of greater than 55 m. Although the SPT N-values in the silt and sands suggest very loose to dense conditions, it is likely that the lower N-values observed are a reflection of the groundwater conditions. For design purposes, the soils will be considered to be compact to dense, with a design N-value of 15 blows/300 mm. To simplify the analyses and in recognition of the variable nature of the native non-cohesive soils at this site (silts and sands), the deposit has been considered to have a unit weight of 19.0 kN/m^3 and a minimum angle of internal friction of 29 degrees.

6.3 Foundation Options

6.3.1 Replacement Structure

The following table compares the available foundation options considered for this site:

Table 6.1: Foundation Comparison for Replacement Structure

Option	Advantages	Disadvantages	Relative Cost	Risk/Consequences
Spread Footings	▪ moderate geotechnical resistance ▪ allows for semi-integral abutment design	▪ incompatible with integral abutment design ▪ native soils easily disturbed when saturated	Low	▪ erosion of foundation cover / loss of geotechnical resistance
Spread Footings on Structural Fill Pad	▪ moderate geotechnical resistance; higher than spread footings on native soil ▪ allows for semi-integral abutment design	▪ requires excavation below water level ▪ incompatible with integral abutment design	Low	▪ excavation below waterline / do work in the wet ▪ erosion of foundation cover / loss of geotechnical resistance
Driven H-piles on Bedrock	▪ readily incorporated into integral abutment design ▪ high geotechnical resistance	▪ anticipated length of >55 m ▪ trouble penetrating through till	Moderate	▪ trouble penetrating through till / damaged piles or reduced capacity
Driven H-piles on Till	▪ readily incorporated into integral abutment design ▪ high geotechnical resistance but less than piles on rock	▪ anticipated length of approx. 45 m	Moderate	▪ pile tip damage
Driven H-piles in Silt and Sand	▪ readily incorporated into integral abutment design ▪ moderate geotechnical resistance	▪ anticipated length of 35 m to 45 m	Moderate	▪ design resistance not achieved at specified tip elevation / extra cost
Caissons on Rock	▪ high geotechnical resistance on bedrock ▪ allows for semi-integral abutment design	▪ require tremie concrete and cased holes ▪ incompatible with integral abutment design ▪ depth to rock > practical caisson length	High	▪ base instability in saturated sands may require use of drilling mud / extra cost
Caissons in Silt and Sand	▪ moderate geotechnical resistance ▪ allows for semi-integral abutment design	▪ require tremie concrete and cased holes ▪ incompatible with integral abutment design	High	▪ base instability in saturated sands may require use of drilling mud / extra cost

Given the potential concerns with groundwater control at this site and the desire to incorporate an integral abutment, it is recommended that the replacement structure be founded on H-piles driven to a set within the glacial till.

6.3.2 Detour Structure

The following table compares the available foundation options considered for the detour structure:

Table 6.2: Foundation Comparison for Detour Structure

Option	Advantages	Disadvantages	Relative Cost	Risk/Consequences
Spread Footings	▪ moderate geotechnical resistance	▪ native soils easily disturbed when saturated	Low	▪ erosion of foundation cover / loss of geotechnical resistance
Spread Footings on Structural Fill Pad	▪ moderate geotechnical resistance but higher than spread footings on native soil	▪ may require excavation below water level	Low	▪ excavation below flood waterline / delay or dewater ▪ erosion of foundation cover / loss of geotechnical resistance
Driven H-piles on Bedrock	▪ high geotechnical resistance on bedrock	▪ anticipated length of >50 m	Moderate	▪ bedrock depth not yet confirmed by coring ▪ piles reach refusal at greater depth / higher cost
Driven H-piles in Silt and Sand	▪ moderate geotechnical resistance	▪ anticipated length of >35 m	Moderate	▪ Design resistance not achieved at specified tip elevation / extra cost
Caissons	▪ high geotechnical resistance on bedrock	▪ require tremie concrete ▪ require cased holes	High	▪ base instability in saturated sands may require use of drilling mud / extra cost ▪ bedrock depth not yet confirmed by coring. Caisson length may need to be extended.

Given the temporary nature of the detour structure and relative cost advantage, it is recommended that the detour structure be supported on spread footings on a structural fill pad, provided the available geotechnical resistance is sufficient for the design loads. If the design loads are too great to allow for an economical spread footing design, the detour structure should be founded on H-piles driven to set within the overburden soils.

7.0 RECOMMENDATIONS

7.1 Structure Foundations

7.1.1 Replacement Structure

Axial Resistance

The replacement structure may be supported on steel H-piles. There is over 12 m of very dense glacial till (SPT N-values >100) with frequent cobbles and boulders at the south abutment location. It is not considered practical to fully penetrate the glacial till in order to drive the piles to bedrock. In addition, it is understood that the design requirements for the proposed structure can readily be achieved without utilizing the full structural capacity of the H-piles. Piles driven to a set elevation within the glacial till deposit and deriving their resistance from end-bearing are recommended. Due to the proposed embedment length (>45 m), and hard end-bearing conditions, it is recommended that a heavier pile section (HP 310x132) be used rather than the more commonly specified HP 310x110.

The following geotechnical parameters are recommended for the design of single piles:

Table 7.1: Recommended Pile Design Parameters for HP 310x132 Piles

Founding Material	Estimated Pile Tip Elevation	Factored Axial Geotechnical Resistance at ULS (kN)	Unfactored Geotechnical Resistance at SLS (kN)
Glacial Till	Below 347.0 m	1,800	1,600

A geotechnical resistance factor of 0.4 has been applied to generate the factored axial resistance at ULS for piles driven to the glacial till.

The toe of the pile is expected to settle less than 20 mm at the SLS value for piles end-bearing within the glacial till layer.

Downdrag forces are not anticipated at this site.

Lateral Resistance

The passive lateral resistance for vertical piles should be calculated as per the non-cohesive approach of Section C6.8.7.1 (a) Static Analysis and C6.8.7.2 Static Analysis of the CHBDC using the following unfactored geotechnical soil parameters:

Parameter	OPSS Granular B Type I	Sands and Silts
Bulk Unit Weight, kN/m3	21.2	19.0
Effective Friction Angle, degrees	35	29
Coefficient of Passive Earth Pressure	3.7	2.9

It is noted that it is common practice for integral abutment structures to pre-auger holes, install CSP's and then fill them with loose sand and pile installation in order to reduce resistance to lateral deflections when the piles are to be installed through dense of stiff soils. The upper silt and sand deposits at this site are generally loose to compact and therefore do not require this treatment.

Lateral Deflections

The coefficient of horizontal subgrade reaction, which may be used for deflection calculations, may be estimated for cohesionless soils using Terzaghi's method (1955) as follows:

$$ks = n_h \, z/d$$

where

ks = the coefficient of horizontal subgrade reaction (force per volume)

n_h = coefficient related to soil compactness

z = depth

d = pile diameter

The soil compactness, based on the SPT N-values, is highly variable at this site but is generally compact within the upper soils (above elevation 382 m). Therefore, an n_h value of 3,000 kN/m^3 is recommended for design calculations for the upper soils. Below elevation 382 m the soil is compact to dense and an n_h value of 11,000 kN/m^3 is recommended.

Group Effects on Lateral Deflections

As per section 6.8.9.2 of the CHBDC, the effects of interaction of the piles must be considered where the centre-to-centre spacing of the piles is less than 2.5 d (where d=pile width/diameter) or 750 mm. The interaction generally results in the lateral load at a specific deflection being decreased.

The nature of pile-soil-pile interaction is complex, however is generally broken down into the following main components:

- alteration of the soil state due to pile installation and the potential overlap of the alterations when nearby piles are driven; and,
- superposition of strains and alterations of the soil failure zones when nearby piles are simultaneously loaded.

Studies (Reese, Isenhower and Wang, 2006) have reported the following reduction between single piles and pile groups.

- Condition No. 1: Load is parallel to pile spacing

Pile Spacing c/c	Trailing Pile Group Pile Efficiency, e_T	Lead Pile Group Pile Efficiency, e_L
7d	1.0	1.0
4d	0.8	1.0
3d	0.7	0.9
2d	0.6	0.8

- Condition No. 2: Load is perpendicular to pile spacing

Pile Spacing c/c	Group Pile Efficiency, e_P
4d	1.0
3d	0.9
2d	0.75

Where piles are on a skew to each other relative to the direction of load the Group Pile Efficiency may be calculated based on

$$e_s = (e_B^2 \cos^2\alpha + e_p^2 \sin^2\alpha)^{½}$$

where

e_B = either e_T or e_L from above

α = angle between direction of loading and the skew

Note that when piles are more than 3.3 pile diameters apart perpendicular to the direction of the load, the skew correction is not necessary. The lateral load at a specific deflection for each individual pile must consider the interaction of all piles within the group.

The reduction factor applied to a pile is the product of the efficiencies of all of the interactions of piles within that pile group.

Tensile Resistance

Resistance to tensile loads should be calculated based on the shaft resistance of the piles in accordance with the CHBDC Section 6.8.5.

For this site, the soils primarily consist of a silt and sand mix and therefore the following parameters may be used for preliminary design purposes:

Submerged Unit Weight	9.2 kN/m^3
Effective friction angle, ø	29°
Shaft Resistance Factor, β	0.4 above elev. 365.0 m 0.5 below elev. 365.0 m
Resistance Factor	0.3

The following values have been calculated based on the above recommended parameters.

Table 7.2: Recommended Tensile Pile Design Parameters

Pile Type	Pile Tip Elevation (m)	Factored Geotechnical Resistance (Tension) at ULS (kN)
HP 310 x 132	347.0	1,500

Pile Notes

Pile tips should be reinforced with Titus H Bearing pile points.

Piles materials, splicing, installation and monitoring should be in accordance with SP 903S01 and Standard SS 103-11 using an Ultimate Geotechnical Resistance of twice the maximum factored design load at ULS per pile and should be driven to the elevation shown on the contract drawings. The Hiley Dynamic Formula should be used to monitor the pile installation

7.1.2 Detour Structure

The top of backfill around the temporary detour abutments will be no lower than 394.64 m. An underside of footing elevation of 393.14 m at both the north and south abutments is therefore recommended in order to provide a minimum of 1.5 m of foundation embedment. This founding elevation is higher than the existing grades at the south abutment. Therefore, a structural fill pad will be required at the south side. A structural fill pad is also recommended at the north abutment due to the modest bearing resistance available from the native soil.

Granular and rock fill pads were considered, however, rock fill is recommended since it will allow for steeper slopes and thereby eliminate the need for construction within the creek bed. A sketch showing the recommended structural fill pad configuration is provided in Appendix D. Structural fill pads should be a minimum of 1000 mm thick beneath the footings and should consist of compacted rock fill with a thin layer of Granular A directly beneath the footing. The structural fill pads should extend a minimum of 1000 mm laterally beyond the edges of the footing and the edge of the pad that slopes down toward the creek should be sloped at no steeper than 1.5H:1V. Rock fill should also be used as structural fill beneath the waterline where required. A non-woven Class II geotextile with a thickness greater than 1 mm and a typical FOS of 100 μm should be placed as shown in the detail.

Spread Footings – Geotechnical Resistance

The following geotechnical resistances may be used in the design provided the footings are placed on a bearing pad constructed as described above.

Table 7.3: Recommended Spread Footing Design Parameters

Founding Layer	Footing Elev. (m)	Footing Size (m x m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Resistance at SLS (kPa)
1000 mm thick Rock Fill Pad	393.14 393.14 393.14	1.5 x 2.5 2.0 x 2.5 1.5 x 10.0	490 525 410	490 425 300

In accordance with Section 6.6.1 of the CHBDC, a resistance factor of 0.5 has been applied to calculate the factored geotechnical resistance at ULS.

The geotechnical resistance at SLS corresponds to a maximum settlement of 25 mm.

Note that a reduction factor to account for inclined loads will need to be applied in accordance with Section 6.7.4 of the CHBDC.

The factored geotechnical resistance at ULS takes into account the proposed 1.5 m embedment and proximity of the edge of the footing to the slope down toward the creek. The presence of the slope results in lower ULS resistance in comparison to a similar footing located on horizontal ground.

It is noted that the proposed bridge replacement is intended to be completed within one construction season and therefore, the foundations for the detour structure will not be subjected to frost. The provision of frost protection is therefore not required.

Spread Footing – Horizontal Resistance

The unfactored horizontal resistance of spread footings may be calculated using an unfactored coefficient of friction of 0.6 between Granular A and cast in-place concrete.

7.2 Earth Pressure Design

The abutments and retaining walls should be backfilled with free-draining material such as OPSS Granular B Type II or OPSS Granular A to prevent hydrostatic pressure build-up.

Computation of earth pressures should be in accordance with Section 6.9 of the CHBDC. For abutments or retaining walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied and unyielding structures, the at-rest earth pressure should be used for design. For a structure with a horizontal backfill, the unfactored soil parameters provided in Table 7.5 may be used for design. The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6.6 of the CHBDC.

The total active (P_A) and passive (P_P) thrusts can be calculated using the following equations

$$P_A = ½ K_a \gamma H^2$$

$$P_P = ½ K_p \gamma H^2$$

Where H is the height of the wall. Values for Ka, Kp and γ are provided below. The thrust acts at a point one third up the height of the wall.

Table 7.4: Recommended Lateral Earth Pressure Parameters

Parameter	OPSS Granular B, Type I and III	OPSS Granular A and Granular B, Type II
Bulk Unit Weight, γ (kN/m3)	21.2	22
Effective Friction Angle	32 degrees	35 degrees
Coefficient of Active Earth Pressure (Ka)	0.31	0.27
Coefficient of Earth Pressure at Rest (Ko)	0.47	0.43
Coefficient of Passive Earth Pressure (Kp)	3.2	3.7

Compaction of the granular backfill near the walls should be carried out using hand-operated equipment to prevent over-stressing the abutment walls.

Drainage should be provided behind vertical walls to prevent hydrostatic pressure build-up. Drainage should be provided by installing a subdrain as per OPSD 3102.100 and should provide positive drainage to a frost-free outlet. Granular backfill should be designed as per OPSD 3101.150 using a depth of frost penetration, f, of 1.9 m.

7.3 Seismic Design Considerations

7.3.1 Zonal Acceleration Ratio

Table A3.1.1 of the CHBDC indicates that the Zonal Acceleration Ratio for Bancroft, which is 90 km southeast of the site, is 0.10. Reference is made to Section C4.6.4 of the CHBDC for the calculation of seismic forces on abutments and retaining walls. A seismic hazard calculation for the Clarke Creek site was obtained from Natural Resources Canada (copy provided in Appendix C). It indicates that the peak ground acceleration (PGA) value corresponding to a 10% probability of exceedance in 50 years is 0.083 g.

7.3.2 Soil Profile Type

It is recommended that a Soil Profile I as defined in CHBDC Section 4.4.6 be used in the seismic design of this site.

7.3.3 Liquefaction of Foundation Soils

An assessment of the potential for liquefaction of the foundation soils was carried out using the Seed and Idriss (1971) simplified procedure outlined in the CHBDC, Section C4.6.2 Liquefaction of Foundation Soils.

The cyclic stress ratios (CSR) generated by the design earthquake were calculated based on the PGA value of 0.083 g obtained from Natural Resources Canada. The profile of cyclic resistance ratios (CRR) available from the soil was calculated based on the CPTu tip resistance, actual fines content based on gradation results and a design earthquake magnitude of 6.0.

The results of the analysis indicate that liquefaction is not a concern at this site since the cyclic resistance ratios available from the soil are greater than the cyclic stresses that would be generated by the design earthquake, typically by a factor of at least three. The results are shown graphically as a profile of factor of safety against liquefaction versus elevation on the plots provided in Appendix C.

7.3.4 Seismic Forces on Abutments and Retaining Walls

Abutments and retaining walls should be designed to resist the earth pressures produced under earthquake conditions. CHBDC Clause 4.6.4 recommends the use of the combined coefficients of static and seismic earth pressure, referred to as K_{AE} for active conditions and K_{PE} for passive conditions, for routine design purposes.

The total active and passive thrusts under earthquake conditions can be calculated using the following equations:

$P_{AE} = ½ K_{AE} \gamma H^2 (1 - k_V)$

$P_{PE} = ½ K_{PE} \gamma H^2 (1 - k_V)$

where;

K_{AE} = active earth pressure coefficient (combined static and seismic)

K_{PE} = passive earth pressure coefficient (combined static and seismic)

H = height of wall

k_h = horizontal acceleration coefficient

k_v = vertical acceleration coefficient

γ = total unit weight

For this site, the following preliminary design parameters were used to develop the recommended K_{AE} and K_{PE} values.

- Zonal Acceleration Ratio, A 0.1
- Horizontal Acceleration Coefficient, k_h 0.05
- Vertical Acceleration Coefficient, k_v 0.033
- Horizontal Backslope to retaining wall
- Vertical back of wall
- For yielding abutments or walls

The above k_h value corresponds to ½ of the A value, and the k_v value corresponds to 0.67 of the k_h value. The angle of friction between the soil and the wall has been set at 0° to provide a conservative estimate.

Table 7.5: Combined Coefficients of Static and Seismic Earth Pressure

Parameter	OPSS Granular B, Type I and III	OPSS Granular A and Granular B, Type II
Bulk Unit Weight, γ (kN/m3)	21.2	22
Effective Friction Angle	32 degrees	35 degrees
Angle of Internal Friction between wall and backfill	0 degrees	0 degrees
Active Earth Pressure (K_{AE})	0.34	0.30
Height of Application of P_{AE} from base as a ratio of wall height (H)	0.349	0.350
Passive Earth Pressure (K_{PE})	3.16	3.59
Height of Application of P_{PE} from base as a ratio of wall height (H)	0.316	0.316

It is noted that the combined coefficients of static and seismic earth pressure presented in Table 7.6 deviate only slightly from the static coefficients presented in Table 7.5. This is due to the low zonal acceleration ratio at this site.

7.4 Embankment Design

The existing embankments are constructed at 2H:1V and exhibit no signs of instability.

7.4.1 Detour

Embankment side slopes for the detour should be constructed no steeper than 2H:IV. Embankment fill should consist of OPSS Select Subgrade Material or clean granular fill such as OPSS Granular B. The use of rock fill could also be considered. Rockfill should be sloped to be no steeper than 1.25H:1V generally and 1.5H:1V where the fill extends below water level.

Settlement of the underlying soil has been estimated using elastic theory. Stress distribution was assessed based on a Boussinesq distribution. As much as 3.3 m of fill will be required at some locations to achieve design grades at the approaches to the temporary detour structure. This will induce as much as 15 mm of settlement in the underlying native materials. Due to the non-cohesive nature of these materials, it is anticipated that settlement will occur rapidly. Post construction settlements of the underlying soils will be less than 5 mm. Self settlement of the embankment fill of as much as 10 mm for 3.3 m of fill will occur. This settlement will be complete at the completion of construction.

The construction of the roadway embankment along the proposed detour alignment will result in additional settlement of the existing embankment. It is estimated that settlement at the existing edge of shoulder will be less than 5 mm. Settlement of the existing embankment may result in similar settlement of the existing timber piles, depending on the length of the piles.

7.4.2 Existing Alignment

No significant changes to the plan or profile of the existing highway embankment are planned. Therefore no new settlement of the underlying soils is anticipated. As part of the construction, the existing backfill behind the abutments will be excavated and later replaced. Self settlement of the backfill of as much as 15 mm will occur. This settlement will be complete at the completion of construction.

7.5 Dewatering

The underside of the pile caps for the permanent structure will be at elevation 392.2 m. The underside of the footings for the detour structure will be at 393.14m and the base of excavation for the 1 m granular pad beneath these footings will be at 392.14 m.

The water level in Clarke Creek at the time of the investigation was 392.2 m. The Draft Structural Planning Report identifies the water level as elevation 391.54 m and the high water level (100-year storm) as elevation 392.40 m.

Based on the proposed founding elevations no excavations below the normal summer water levels are planned and no dewatering would be required except to remove surface water infiltration from rainfall. This type of dewatering would be carried out using conventional sump pumps.

It may be necessary to construct a working pad at the pile cap level for the permanent structure. Since the base of excavation will be just higher than the water level in the adjacent creek, it is likely that the soil at the base of the excavation will be wet and easily disturbed by construction activities. The working pad should consist of a minimum of 300 mm of OPSS Granular A.

The deepest planned excavation is just slightly below the 100-year flood level of 392.4 m. Under these flood conditions, the excavations would be within the creek. This would require stopping work and waiting for water levels to recede or provision of a coffer dam and dewatering system. Due to the permeable nature of the soils, the cofferdam and dewatering system would need to be designed to prevent basal instability (i.e. boiling). Such a dewatering system would generally involve sheet piles embedded to a depth below the planned excavation depth with relief wells located inside the excavation.

It is recommended that a NSSP be included in the contract to alert the contractor to the permeable soil conditions, water levels and the potential need for dewatering under high water levels in the creek.

7.6 Erosion Protection

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. The creek slopes within 3 m of the structures should be surfaced with rip-rap at least 300 mm thick placed on a Class II non-woven filter fabric. Where embankment construction includes earth fill, normal slope vegetation should be established as soon as possible after completion of the embankment fills in order to control surficial erosion.

The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediments from running off the site.

7.7 Frost Protection

The design frost penetration depth at the Clarke Creek site is 1.9 m. Pile caps, retaining walls and spread footings should be provided with the equivalent of 1.9 m of earth cover or equivalent insulation for frost protection.

Alternatively and provided a minimum of 0.9 m of soil cover is available, rigid polystyrene insulation having a minimum thickness of 75 mm and extending beneath the pile cap and a minimum of 1.2 m laterally out from the edges of the pile cap would provide equivalent frost protection. A site specific detail will need to be developed once the structure and grading geometry has been confirmed. The detail will need to ensure that the insulation does not become displaced due to buoyant forces under flood conditions.

7.8 Other Construction Considerations

Site Grading and Preparation

All organic soils and other deleterious materials must be removed from beneath the proposed foundation units. Where deleterious materials are encountered, the material should be excavated, wasted and replaced. The lateral extent of such excavation should include all deleterious material within the influence zone of the foundations.

Surficial vegetation, rootmat and topsoil should be removed beneath the approach embankments. Stripping of deleterious materials should be inspected by geotechnical personnel to ensure that all unsuitable materials are removed prior to placement of embankment fill.

Where required for grading purposes, fill should consist of Select Subgrade Material (SSM), placed in lifts and compacted in accordance with SP105S10.

Site preparation should be carried out in accordance with the requirements of *SP 902S01 Earth Excavation for Structure*.

Excavation

Earth excavation should be carried out in accordance with OPSS-206.07.03. Side slopes for open cut excavations should conform to Occupational Health and Safety Act regulations. The soils to be excavated for the proposed foundations should be considered as a Type 2 to 3 soil. Above the creek and ground water level, temporary cut slopes should be no steeper than 1 horizontal to 1 vertical from the base of the excavation. For excavations below creek and groundwater levels, shoring will be required.

Encroachment of excavations into the forward and side slopes of the existing structure will require special attention. Excavations will not be permitted within the influence zone of the existing abutments. The influence zone includes all materials below an imaginary line drawn at an angle of 1 horizontal to 1 vertical downward and away from the vertical edges of the abutments.

Shoring design should meet the requirements of Performance Level 2 as per SP105S19 and should consider sloping backfill and traffic loading. Protection systems would likely consist of a cantilevered steel sheet pile system or steel H-piles with timber lagging.

Cement Type and Corrosion Protection

Three soil samples were submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, resistivity, chloride and water soluble sulphate, in order to determine cement type and reinforcing steel protection requirements. The results are presented in the table below.

Table 7.6: Chemical Analysis Results

Location	Borehole	Sample	pH	Resistivity	Soluble Sulphate	Chloride
North Abutment Detour Alignment	05-10	SS 4	8.51	10,000 ohm cm	250 µg/g	15 µg/g
South Abutment Existing Alignment	05-15	SS 3	4.13	2,400 ohm.cm	40 µg/g	270 µg/g
South Abutment Existing Alignment	07-5	SS 18	6.35	18,400 ohm.cm	51 µg/g	<5 µg/g

The soluble sulphate results indicate that a Type GU (General Use) Portland cement would be suitable for use in concrete mixtures at this site. The chloride, pH, and resistivity results should be considered by the structural designer when designing corrosion protection system.

8.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

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

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Yours very truly,

JACQUES WHITFORD LIMITED

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Paul Carnaffan, M.Eng., P.Eng.

LICENSED PROFESSIONAL ENGINEER
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Fred Griffiths, Ph.D., P.Eng.
Designated Principal MTO Foundation Contact

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APPENDIX A

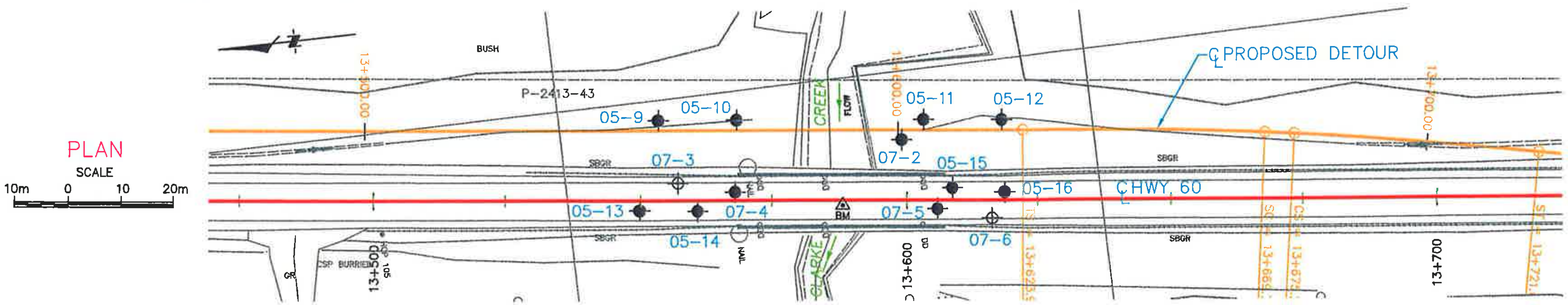
Borehole Location Plans and Profile Plots

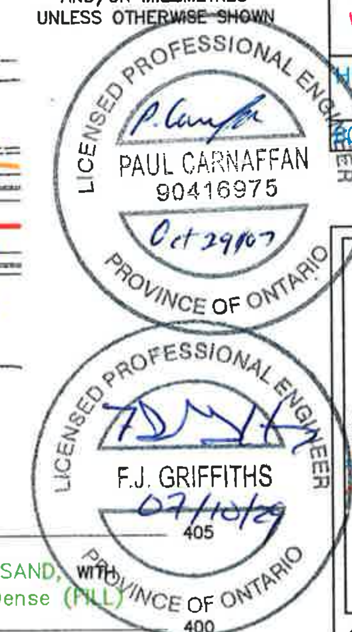
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

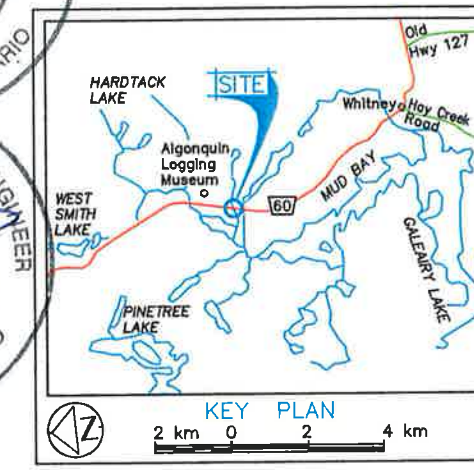
CONT No –
WP No 545–93–00

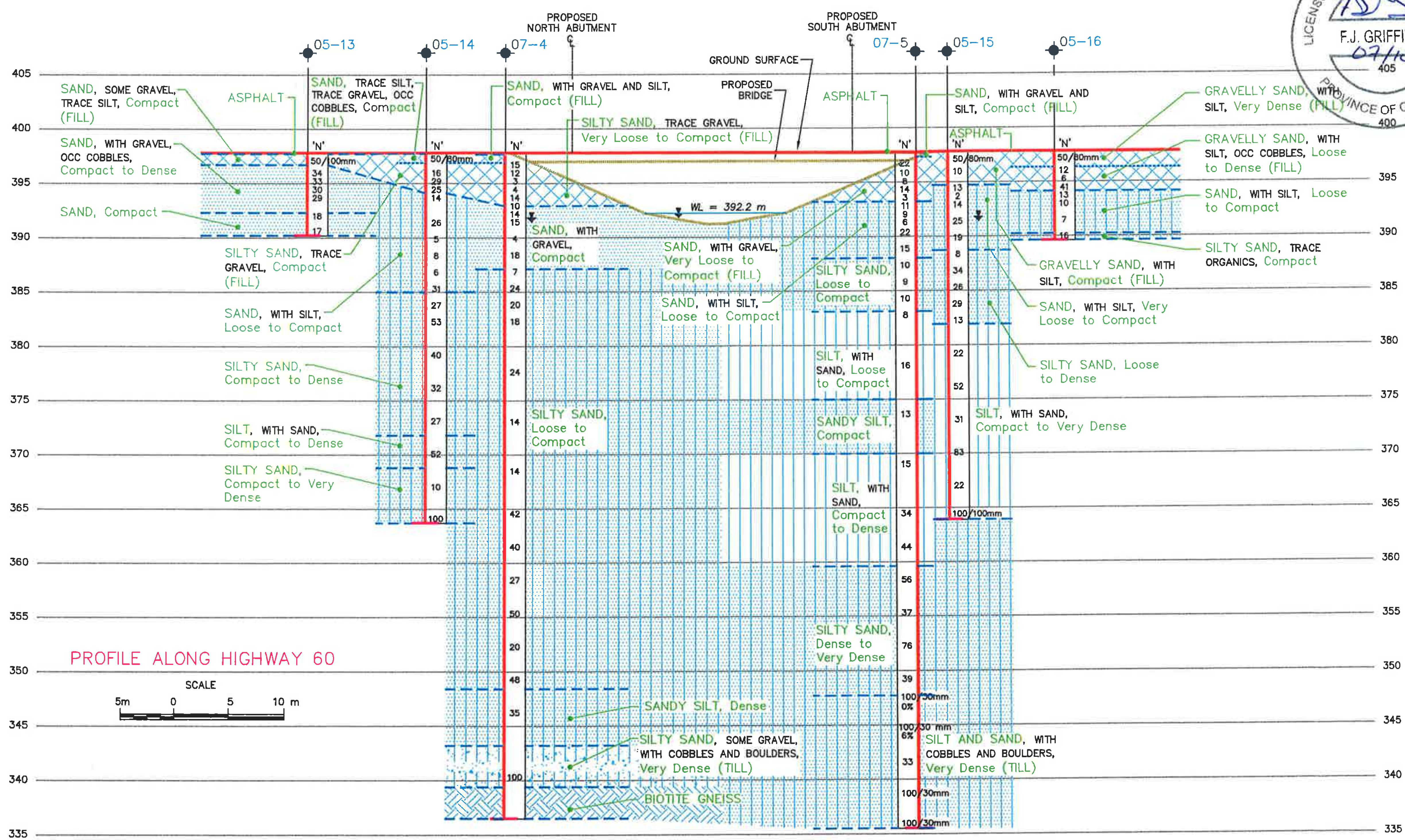
HWY 60 OVER CLARKE CREEK
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS & SOIL STRATA

SHEET
–









LEGEND

Symbol	Description
	Borehole
	Dynamic Cone Penetration Test (Cone)
	Borehole & 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
	WL in Piezometer
	Piezometer
BM	Benchmark (Top of Pavement) Elev = 397.8 m Reference: TSH profile plate CC-1

No	ELEVATION	NORTHING	EASTING
05-9	394.9	5 045 281.6	401 296.3
05-10	393.6	5 045 266.7	401 294.6
05-11	392.8	5 045 231.9	401 290.5
05-12	393.0	5 045 217.0	401 288.8
05-13	397.8	5 045 286.9	401 280.0
05-14	397.8	5 045 276.0	401 278.6
05-15	397.8	5 045 227.8	401 277.3
05-16	397.8	5 045 218.0	401 275.3
07-2	392.6	5 045 236.5	401 287.3
07-3	397.7	5 045 279.2	401 284.3
07-4	397.8	5 045 268.5	401 281.3
07-5	397.7	5 045 231.1	401 273.7
07-6	397.7	5 045 220.9	401 270.8

NOTE

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

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

REVISIONS DATE	BY	DESCRIPTION
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GEOCRES No 31F-148

HWY No 60			DIST 43
SUBM'D PC	CHECKED	DATE 2007-10-25	SITE –
DRAWN GBB	CHECKED	APPROVED	DWG 1

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

CONT No –
WP No 545–93–00

SHEET –

HWY 60 OVER CLARKE CREEK
TEMPORARY MODULAR BRIDGE
BOREHOLE LOCATIONS & SOIL STRATA

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Oct 29/07
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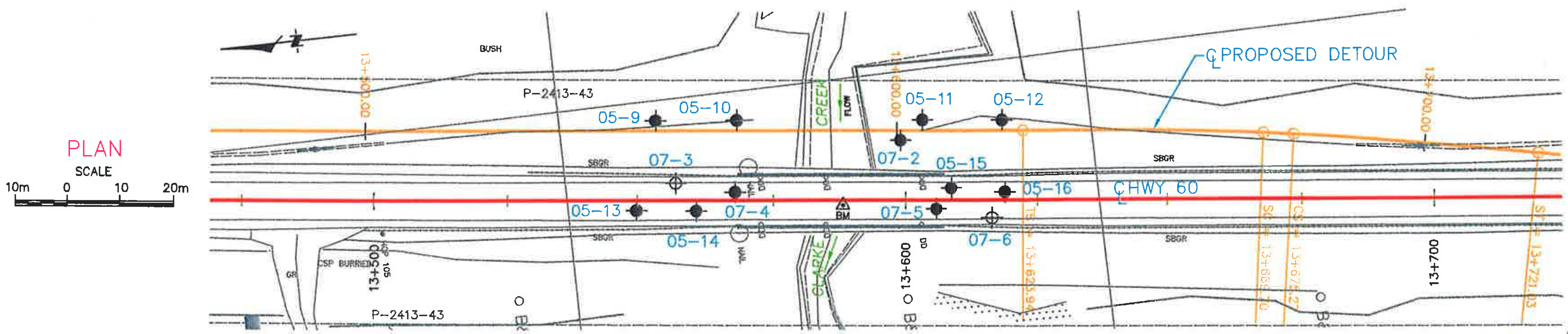
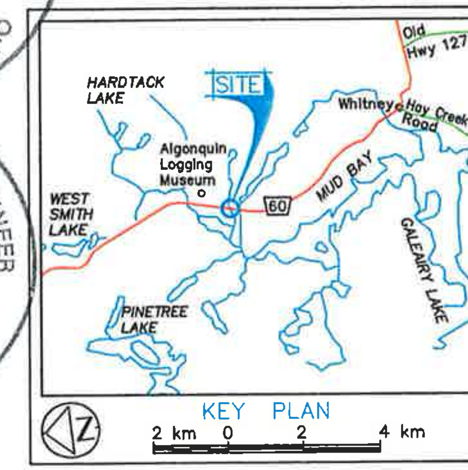
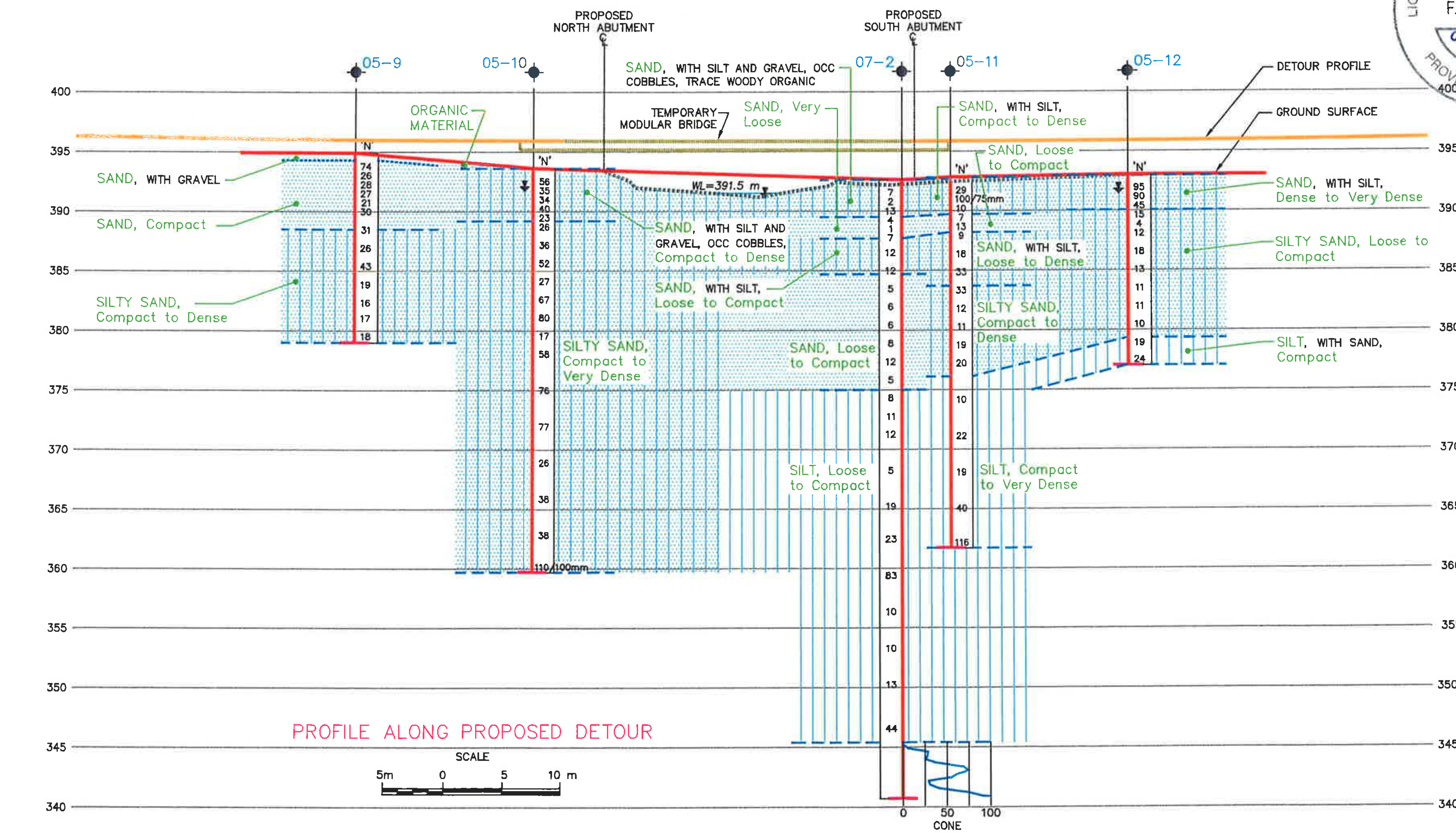
LICENSED PROFESSIONAL ENGINEER
F.J. GRIFFITHS
07/10/29
PROVINCE OF ONTARIO

Jacques Whitford

PLAN







LEGEND

(symbol)	Borehole
(symbol)	Dynamic Cone Penetration Test (Cone)
(symbol)	Borehole & Cone
N	Blows/0.3m (Std Pen Test, 475 J/blow)
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(symbol)	WL in Piezometer
(symbol)	Piezometer
BM	Benchmark (Top of Pavement) Elev = 397.8 m Reference: TSH profile plate CC–1

No	ELEVATION	NORTHING	EASTING
05–9	394.9	5 045 281.6	401 296.3
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05–12	393.0	5 045 217.0	401 288.8
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07–2	392.6	5 045 236.5	401 287.3
07–3	397.7	5 045 279.2	401 284.3
07–4	397.8	5 045 268.5	401 281.3
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07–6	397.7	5 045 220.9	401 270.8

NOTE

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

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REVISIONS	DATE	BY	DESCRIPTION
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GEOCRES No 31F–148

HWY No 60		DIST	43
SUBM'D PC	CHECKED	DATE 2007–10–25	SITE –
DRAWN GBB	CHECKED	APPROVED PC	DWG 2

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APPENDIX B

Symbols and Terms Used on Borehole Records
Borehole Records
Terminology Used on SCPTu Records
SCPTu Records
Grain Size Distribution Test Results
Rock Core Summary Table

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

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

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

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

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

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

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistency	Undrained Shear Strength	
	kips/sq.ft.	kPa
Very Soft	<0.25	<12.5
Soft	0.25 - 0.5	12.5 - 25
Firm	0.5 - 1.0	25 - 50
Stiff	1.0 - 2.0	50 – 100
Very Stiff	2.0 - 4.0	100 - 200
Hard	>4.0	>200

ROCK DESCRIPTION

Terminology describing rock quality:

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

Rock quality classification is based on a modified core recovery percentage (RQD) in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures. The terminology describing rock mass quality based on RQD is subjective and is underlain by the presumption that sound strong rock is of higher engineering value than fractured weak rock.

Terminology describing rock mass:

Spacing (mm)	Joint Classification	Bedding, Laminations, Bands
> 6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

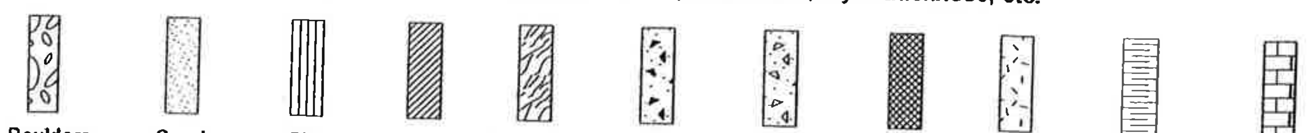
Strength Classification	Unconfined Compressive Strength (MPa)
Extremely Weak	< 1
Very Weak	1 – 5
Weak	5 – 25
Medium Strong	25 – 50
Strong	50 – 100
Very Strong	100 – 250
Extremely Strong	> 250

Terminology describing rock weathering:

Term	Description
Fresh	No visible signs of rock weathering. Slight discolouration along major discontinuities
Slightly Weathered	Discolouration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
Moderately Weathered	Less than half the rock is decomposed and/or disintegrated into soil.
Highly Weathered	More than half the rock is decomposed and/or disintegrated into soil.
Completely Weathered	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.

STRATA PLOT

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



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

▼ measured in standpipe, piezometer, or well

▽ inferred

RECOVERY

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

N-VALUE / RQD

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N value corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log. RQD is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability. Soil type may be inferred from adjacent boreholes and test pits.

OTHER TESTS

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

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 05-9

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045281.6 E401296.3 ORIGINATED BY AB

DIST Bancroft HWY 60 BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons COMPILED BY JF

DATUM Geodetic DATE 05.02.04 - 05.02.04 CHECKED BY PC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
394.9	Sand with gravel					
0.0	Poorly-graded SAND with gravel, brown (SP)					
394.3 / 0.6	Poorly-graded SAND, compact, brown (SP)	1	SS	74	394	
		2	SS	26		
		3	SS	28	392	
		4	SS	27		4 92 4
		5	SS	21		
		6	SS	30	390	
388.5 / 6.4	SILTY SAND, compact to dense, brown to grey (SM)	7	SS	31	388	
		8	SS	26	386	
		9	SS	43		
		10	SS	19	384	
		11	SS	16	382	
		12	SS	17		0 59 41
		13	SS	18	380	
379.1 / 15.9	End of Borehole					

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No 05-10

METRIC

W.P. 545-93-00
LOCATION Highway 60, Clarke Creek Bridge, N5045266.7 E401294.6
ORIGINATED BY AB

DIST Bancroft HWY 60
BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons
COMPILED BY JF

DATUM Geodetic
DATE 05.02.04 - 05.02.04
CHECKED BY PC

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
393.6	Grass
[illegible]	Organic material
	Poorly-graded SAND with silt and gravel, occasional cobbles, compact to dense, brown (SP)
389.2 / 4.4	SILTY SAND, compact to very dense, broen to grey (SM)

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	56	
2	SS	35	
3	SS	34	28 64 9
4	SS	40	
5	SS	23	
6	SS	26	
7	SS	36	
8	SS	52	
9	SS	27	
10	SS	67	
11	SS	80	
12	SS	17	0 77 23
13	SS	58	
14	SS	76	
15	SS	77	
16	SS	26	

GROUND WATER CONDITIONS: ∇

ELEVATION SCALE: 392, 390, 388, 386, 384, 382, 380, 378, 376, 374, 372, 370

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 (%): 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 05-10

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045266.7 E401294.6 ORIGINATED BY AB

DIST Bancroft HWY 60 BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons COMPILED BY JF

DATUM Geodetic DATE 05.02.04 - 05.02.04 CHECKED BY PC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	SILTY SAND, compact to very dense, broen to grey (SM) *(continued)*				368
		17	SS	38	366
					364
		18	SS	38	362
359.7		19	SS	110/100mm	360
33.9	End of Borehole Standpipe Installed (25 mm diameter flexible poly-tube)				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, FIELD VANE, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$\times^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 05-11

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045231.9 E401290.5 ORIGINATED BY AB

DIST Bancroft HWY 60 BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons COMPILED BY JF

DATUM Geodetic DATE 05.02.08 - 05.02.08 CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
392.8	Grass				
392.6 / 0.2	150 mm organic material				
	Poorly-graded SAND with silt, occasional cobbles, compact to dense, brown (SP-SM)	1	SS	29	392
		2	SS	100/75mm	
		3	SS	10	
389.8 / 3.1	Poorly-graded SAND, loose to compact, grey (SP)	4	SS	7	390
		5	SS	13	
388.2 / 4.6	Poorly-graded SAND with silt, loose to dense, brown (SP-SM)	6	SS	9	388
		7	SS	18	386
		8	SS	33	
383.7 / 9.1	SILTY SAND, compact to dense, grey to brown (SM)	9	SS	33	384
		10	SS	12	382
		11	SS	11	380
		12	SS	19	
		13	SS	20	378
376.1 / 16.7	SILT, compact to very dense, grey (ML)				376
		14	SS	10	374
					372
		15	SS	22	370
		16	SS	19	368

Column headings also printed: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa — ○ UNCONFINED, ● QUICK TRIAXIAL, ✖ FIELD VANE, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

RECORD OF BOREHOLE No 05-11

METRIC

W.P. 545-93-00
LOCATION Highway 60, Clarke Creek Bridge, N5045231.9 E401290.5
ORIGINATED BY AB
DIST Bancroft HWY 60
BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons
COMPILED BY JF
DATUM Geodetic
DATE 05.02.08 - 05.02.08
CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT, compact to very dense, grey (ML) *(continued)*										
							366				
			17	SS	40						
							364				
361.7 / 31.1			18	SS	116		362				
	End of Borehole										

Legend: SHEAR STRENGTH kPa — ○ UNCONFINED, ✖ FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L.

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

RECORD OF BOREHOLE No 05-12

METRIC

W.P. 545-93-00
LOCATION Highway 60, Clarke Creek Bridge, N5045217.0 E401288.8
ORIGINATED BY AB
DIST Bancroft HWY 60
BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons
COMPILED BY JF
DATUM Geodetic
DATE 05.02.09 - 05.02.09
CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
393.0	Grass					
393.0 / 0.0	Organic material					
	Poorly-graded SAND with silt, dense to very dense, brown (SP-SM)	1	SS	95	∇	392
		2	SS	90		
390.1 / 2.9	Silty SAND, loose to compact, grey to brown (SM)	3	SS	45		
		4	SS	15		390
		5	SS	4		
		6	SS	12		388
		7	SS	18		386
		8	SS	13		
		9	SS	11		384
382.3 / 10.7	SILT with sand, compact, grey (ML)	10	SS	11		382
		11	SS	10		380
		12	SS	19		378
377.2 / 15.9	End of Borehole Standpipe Installed (25 mm diameter flexible poly-tube)	13	SS	24		

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 (%): 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

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

RECORD OF BOREHOLE No 05-13

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045286.9 E401280.0 ORIGINATED BY AB

DIST Bancroft HWY 60 BOREHOLE TYPE Hollow Stem Augers with Split Spoons COMPILED BY JF

DATUM Geodetic DATE 05.01.23 - 05.01.23 CHECKED BY PC

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
397.8	Asphalt										
397.7 / 0.1	90 mm Asphalt										
	Sand, some gravel, trace silt, compact, brown (FILL)		1	GS							
396.7			2	SS	50/ 100mm						
1.1	Poorly-graded SAND with gravel, occasional cobbles, compact to dense, brown (SP)										
			3	SS	34		396				
			4	SS	33			18	79	3	
			5	SS	30						
			6	SS	29		394				
392.3 / 5.5	Poorly-graded SAND, compact, brown (SP)		7	SS	18		392	9	89	2	
390.2			8	SS	17						
7.6	End of Borehole Standpipe Installed (25 mm diameter flexible poly-tube)										

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 (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

$\times^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 05-14

METRIC

W.P. 545-93-00	LOCATION Highway 60, Clarke Creek Bridge, N5045276.0 E401278.6		ORIGINATED BY AB
DIST Bancroft	HWY 60	BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons	COMPILED BY JF
DATUM Geodetic		DATE 05.01.23 - 05.01.23	CHECKED BY PC

SOIL PROFILE / SAMPLES

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES
397.8	Asphalt				
397.7 / 0.1	100 mm Asphalt				
	Sand, trace silt, trace gravel, occasional cobbles, compact, brown (FILL)		1	GS	
396.9 / 0.9	Silty sand, trace gravel, compact, brown (FILL)		2	SS	50/ 80mm
			3	SS	16
			4	SS	29
			5	SS	25
394.1 / 3.7	Poorly-graded SAND with silt, loose to compact, brown to grey (SP)		6	SS	14
			7	SS	26
			8	SS	5
			9	SS	8
			10	SS	6
			11	SS	31
385.0 / 12.8	Silty SAND, compact to dense, brown to grey (SM)				
			12	SS	27
			13	SS	53
			14	SS	40
			15	SS	32
			16	SS	27

GROUND WATER CONDITIONS | ELEVATION SCALE: 396, 394, 392, 390, 388, 386, 384, 382, 380, 378, 376, 374

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

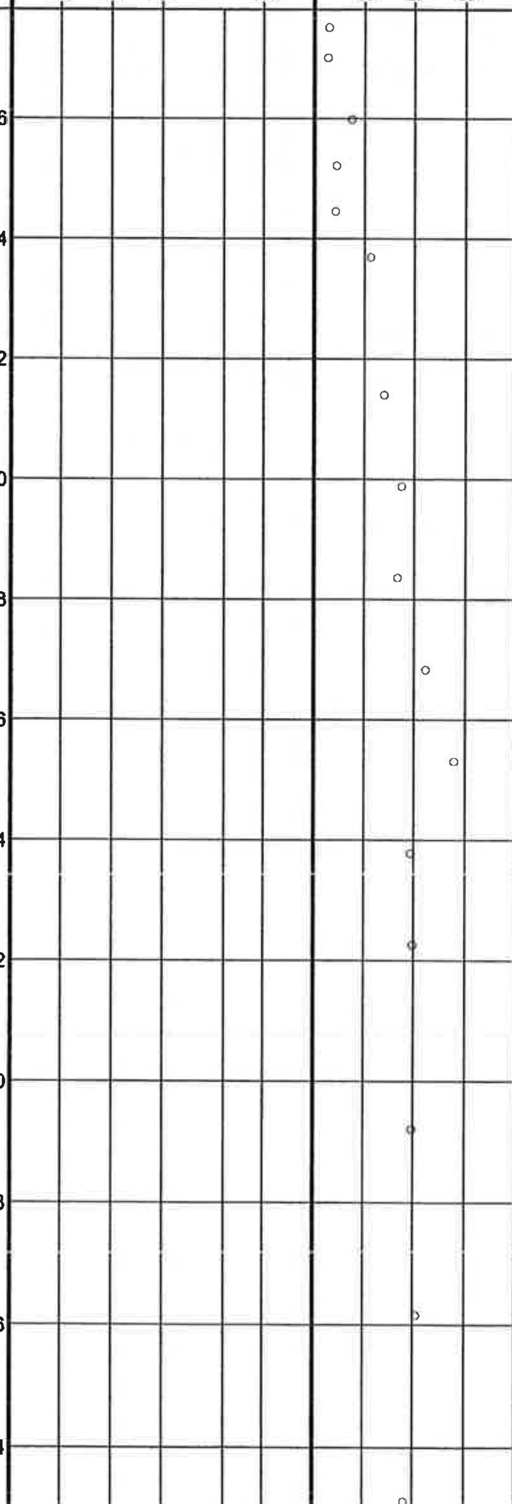
SHEAR STRENGTH kPa: ○ UNCONFINED ✖ FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

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

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL



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

RECORD OF BOREHOLE No 05-14

METRIC

W.P. 545-93-00
LOCATION Highway 60, Clarke Creek Bridge, N5045276.0 E401278.6
ORIGINATED BY AB
DIST Bancroft HWY 60
BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons
COMPILED BY JF
DATUM Geodetic
DATE 05.01.23 - 05.01.23
CHECKED BY PC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND, compact to dense, brown to grey (SM) *(continued)*						372				
371.8 / 26.0	SILT with sand, compact to dense, grey (ML)		17	SS	52		370				0 26 74
368.8 / 29.0	Silty SAND, compact to very dense, grey (SM)		18	SS	10		368 / 366				
			19	SS	100		364				
363.7 / 34.1	End of Borehole										

Legend: Dynamic cone penetration resistance plot scale 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, ✖ FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, scale 20 40 60 80 100. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30.

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

RECORD OF BOREHOLE No 05-15

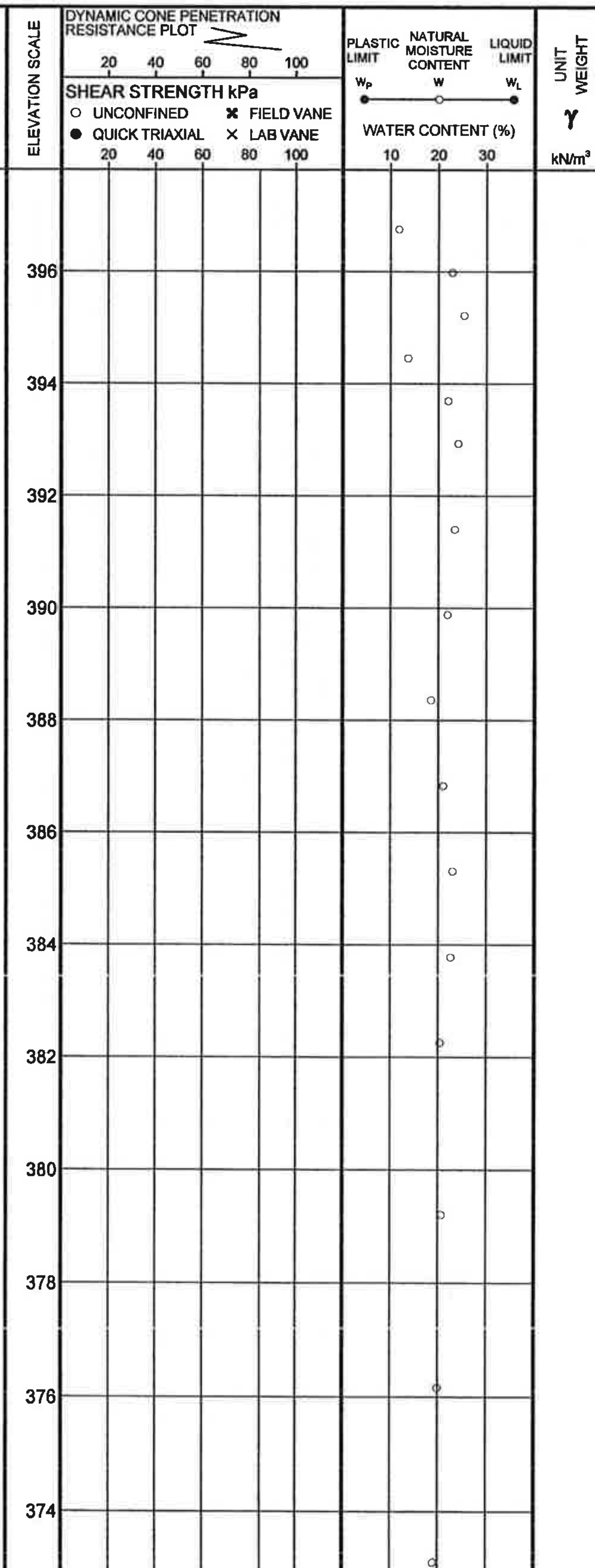
METRIC

W.P. 545-93-00 | LOCATION Highway 60, Clarke Creek Bridge, N5045227.8 E401277.3 | ORIGINATED BY AB

DIST Bancroft HWY 60 | BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons | COMPILED BY JF

DATUM Geodetic | DATE 05.01.24 - 05.01.24 | CHECKED BY PC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
397.8	Asphalt					
397.7 0.1	90 mm Asphalt Gravelly sand, with silt, compact, brown (FILL)	1	GS			
		2	SS	50/ 80mm		
		3	SS	10		
394.8 3.1	Poorly-graded SAND with silt, very loose to compact, brown to greyish-brown (SP-SM)	4	SS	13		
		5	SS	2		
		6	SS	14		0 91 9
					∇	
		7	SS	25		
		8	SS	19		0 92 9
388.7 9.1	Silty SAND, loose to dense, brown to grey (SM)	9	SS	8		
		10	SS	34		
		11	SS	26		
		12	SS	29		
		13	SS	13		
382.0 15.9	SILT with sand, compact to very dense, grey (ML)	14	SS	22		
		15	SS	52		0 14 86
		16	SS	31		



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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 05-15

METRIC

W.P. 545-93-00	LOCATION Highway 60, Clarke Creek Bridge, N5045227.8 E401277.3		ORIGINATED BY AB
DIST Bancroft	HWY 60	BOREHOLE TYPE Hollow Stem Augers/Casing with Split Spoons	COMPILED BY JF
DATUM Geodetic		DATE 05.01.24 - 05.01.24	CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
	SILT with sand, compact to very dense, grey (ML) *(continued)*				372	
		17	SS	83	370	~19
					368	
		18	SS	22	366	
363.9 / 33.9		19	SS	100/100mm	364	
	End of Borehole Standpipe Installed (25 mm diameter flexible poly-tube)					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

RECORD OF BOREHOLE No 05-16

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045218.0 E401275.3 ORIGINATED BY AB

DIST Bancroft HWY 60 BOREHOLE TYPE Hollow Stem Augers with Split Spoons COMPILED BY JF

DATUM Geodetic DATE 05.01.22 - 05.01.21 CHECKED BY PC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
397.8	Asphalt				
397.7 0.1	100 mm Asphalt				
	Gravelly sand, with silt, very dense, brown (FILL)	1	GS		
		2	SS	50/ 80mm	
396.3 1.5	Gravelly sand, with silt, occasional cobbles, loose to dense, brown (FILL)	3	SS	12	396
		4	SS	6	
394.1		5	SS	41	
3.7	Poorly-graded SAND with silt, loose to compact, brown (SP-SM)	6	SS	13	394
		7	SS	10	
					392
		8	SS	7	
390.2 7.6	Silty SAND, trace organics, compact, grey (SM)	9	SS	16	390
389.6 8.2	End of Borehole				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$\times^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-2

METRIC

W.P. 545-93-00
LOCATION Highway 60, Clarke Creek Bridge, N5045236.5 E401287.3
ORIGINATED BY JF

DIST 43 HWY 60
BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons
COMPILED BY JF

DATUM Geodetic
DATE 07.04.18 - 07.04.25
CHECKED BY PC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT w (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
392.6	Grass					
0.0	Poorly-graded SAND with silt, occasional cobbles, trace woody organic (SP-SM)	1	SS	7		
		2	SS	2	~33	3 85 (12)
		3	SS	13		
389.6 / 3.1	Poorly-graded SAND, very loose, grey (SP)	4	SS	4		
		5	SS	1	~21	1 96 (3)
387.7 / 4.9	Poorly-graded SAND with silt, loose to compact, brown (SP-SM)	6	SS	7		
		7	SS	12	~17	3 88 (9)
		8	SS	12		
384.7 / 7.9	Silty SAND, loose to compact, grey (SM)	9	SS	5	~17	1 76 (23)

Elevation scale: 392, 391, 390, 389, 388, 387, 386, 385, 384, 383

Column headings: SOIL PROFILE; STRAT PLOT; 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³.

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 07-2

METRIC

W.P. 545-93-00	LOCATION Highway 60, Clarke Creek Bridge, N5045236.5 E401287.3		ORIGINATED BY JF
DIST 43	HWY 60	BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons	COMPILED BY JF
DATUM Geodetic	DATE 07.04.18 - 07.04.25		CHECKED BY PC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	Silty SAND, loose to compact, grey (SM) *(continued)*				
		10	SS	6	382
					381
		11	SS	6	
					380
		12	SS	8	379
					378
		13	SS	12	
					377
		14	SS	5	376
375.0 17.6	SILT, loose to compact, grey (ML)				375
		15	SS	8	
					374
		16	SS	11	373

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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✖³, ×³: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

ONTARIO MTO 1023332.GPJ ONTARIO MOT.GDT 07/10/25

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 07-2

METRIC

W.P. 545-93-00	LOCATION Highway 60, Clarke Creek Bridge, N5045236.5 E401287.3		ORIGINATED BY JF
DIST 43	HWY 60	BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons	COMPILED BY JF
DATUM Geodetic	DATE 07.04.18 - 07.04.25		CHECKED BY PC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	SILT, loose to compact, grey (ML) *(continued)*											
						372						
		17	SS	12								
						371						
						370						
						369						
		18	SS	5			~20		0	11	87	2
						368						
						367						
						366						
		19	SS	19								
						365						
						364						
						363						

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; REMARKS & GRAIN SIZE DISTRIBUTION (%).

Continued Next Page

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

RECORD OF BOREHOLE No 07-2

METRIC

W.P. 545-93-00
LOCATION Highway 60, Clarke Creek Bridge, N5045236.5 E401287.3
ORIGINATED BY JF
DIST 43 HWY 60
BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons
COMPILED BY JF
DATUM Geodetic
DATE 07.04.18 - 07.04.25
CHECKED BY PC

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, ✖ FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT, loose to compact, grey (ML) *(continued)*		20	SS	23						
							362				
							361				
							360				
	- very dense		21	SS	83						
							359				
							358				
							357				
			22	SS	10						
							356				
							355				
							354				
			23	SS	10						
							353				

Continued Next Page

✖³, ×³: Numbers refer to Sensitivity   O ³% STRAIN AT FAILURE

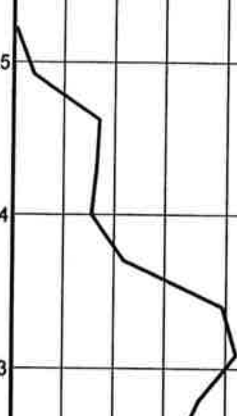
RECORD OF BOREHOLE No 07-2

METRIC

W.P. 545-93-00	LOCATION Highway 60, Clarke Creek Bridge, N5045236.5 E401287.3		ORIGINATED BY JF
DIST 43	HWY 60	BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons	COMPILED BY JF
DATUM Geodetic		DATE 07.04.18 - 07.04.25	CHECKED BY PC

Column headings: SOIL PROFILE (ELEV DEPTH; DESCRIPTION; STRAT PLOT) | SAMPLES (NUMBER; TYPE; "N" VALUES) | 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 (%) (10, 20, 30) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	SILT, loose to compact, grey (ML) *(continued)*				
					352
					351
		24	SS	13	
					350
	- grinding on possible cobbles				349
					348
					347
	- dense	25	SS	44	
					346
345.4 47.2	- dynamic cone penetration test				
					345
					344
					343



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

RECORD OF BOREHOLE No 07-2

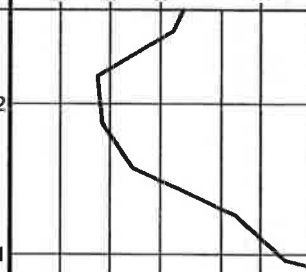
METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045236.5 E401287.3 ORIGINATED BY JF

DIST 43 HWY 60 BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons COMPILED BY JF

DATUM Geodetic DATE 07.04.18 - 07.04.25 CHECKED BY PC

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	- dynamic cone penetration test *(continued)*						342				
							341				
340.7 51.9	End of Borehole Standpipe Installed										



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

RECORD OF BOREHOLE No 07-4

METRIC

W.P. 545-93-00
DIST 43 HWY 60
DATUM Geodetic
LOCATION Highway 60, Clarke Creek Bridge, N5045268.5 E401281.3
BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons, NQ Core
DATE 07.05.14 - 07.05.18
ORIGINATED BY AO
COMPILED BY JF
CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
397.8	Asphalt								
397.6 / 0.0	130 mm ASPHALT								
397.5 / 0.1	180 mm CONCRETE								
0.3	Sand, with gravel and silt, compact, brown (FILL)	1	GS						
396.9 / 0.9	Silty sand, trace gravel, very loose to compact, brown (FILL)	2	SS	15	397				
		3	SS	12	396				
		4	SS	3	395				
		5	SS	4		6	81	(13)	
		6	SS	14	394				
392.9 / 4.9	Poorly-graded SAND with silt, compact, brown (SP)	7	SS	10	393				
		8	SS	14	392				
		9	SS	15	391				
		10	SS	4	390	3	91	(6)	
					389				
		11	SS	18	388				

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 (%): 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

RECORD OF BOREHOLE No 07-4

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045268.5 E401281.3 ORIGINATED BY AO

DIST 43 HWY 60 BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons, NQ Core COMPILED BY JF

DATUM Geodetic DATE 07.05.14 - 07.05.18 CHECKED BY PC

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	Poorly-graded SAND with silt, compact, brown (SP) *(continued)*											
387.1 / 10.7	Silty SAND, loose to compact, grey (SM)					387						
		12	SS	7			○		0	69	31	0
						386						
		13	SS	24		385						
		14	SS	20		384						
						383						
		15	SS	18		382						
						381						
						380						
						379						
						378						

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 (%) 10 20 30
REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

✖^{3}, ×^{3}: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No 07-4

METRIC

W.P. 545-93-00 | LOCATION Highway 60, Clarke Creek Bridge, N5045268.5 E401281.3 | ORIGINATED BY AO

DIST 43 HWY 60 | BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons, NQ Core | COMPILED BY JF

DATUM Geodetic | DATE 07.05.14 - 07.05.18 | CHECKED BY PC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT W (%)	GR	SA	SI	CL
	Silty SAND, loose to compact, grey (SM) *(continued)*	16	SS	24						
					377					
					376					
					375					
					374					
		17	SS	14	373	~20	0	51	47	2
					372					
					371					
					370					
					369					
		18	SS	14						
					368					

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; 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 (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

✖ ^{3}, × ^{3}: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-4

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045268.5 E401281.3 ORIGINATED BY AO

DIST 43 HWY 60 BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons, NQ Core COMPILED BY JF

DATUM Geodetic DATE 07.05.14 - 07.05.18 CHECKED BY PC

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND, loose to compact, grey (SM) *(continued)*										
							367				
							366				
							365				
			19	SS	42						
							364				
							363				
							362				
			20	SS	40						
							361				
							360				
							359				
			21	SS	57						
							358				

Continued Next Page

$\times^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-4

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045268.5 E401281.3 ORIGINATED BY AO

DIST 43 HWY 60 BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons, NQ Core COMPILED BY JF

DATUM Geodetic DATE 07.05.14 - 07.05.18 CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT w (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND, loose to compact, grey (SM) *(continued)*						
					357		
					356		
		22	SS	50			
					355		
					354		
					353		
		23	SS	20		~19	0 65 (35)
					352		
					351		
					350		
		24	SS	48			
					349		
348.4 / 49.4	Sandy SILT, dense, grey (ML)						
					348		

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

RECORD OF BOREHOLE No 07-4

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045268.5 E401281.3 ORIGINATED BY AO

DIST 43 HWY 60 BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons, NQ Core COMPILED BY JF

DATUM Geodetic DATE 07.05.14 - 07.05.18 CHECKED BY PC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS
	Sandy SILT, dense, grey (ML) *(continued)*					
					347	
		25	SS	35		
					346	
					345	
					344	
		26	NQ			
343.2 54.6	Silty sand, some gravel, with cobbles and boulders, very dense, grey : TILL				343	
					342	
					341	
		27	SS	100	340	
339.4 58.4	Biotite GNEISS, grey, black and pink, fair to excellent, moderate to slightly weathered, close to moderately spaced fractures, thin bedding, 0 to 40 degree dip	28	NQ		339	TCR = 100% RQD = 63%
						TCR = 98% RQD = 100%
		29	NQ		338	

Column headings (no data plotted): GROUND WATER CONDITIONS; 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

RECORD OF BOREHOLE No 07-4

METRIC

W.P. 545-93-00	LOCATION Highway 60, Clarke Creek Bridge, N5045268.5 E401281.3		ORIGINATED BY AO
DIST 43	HWY 60	BOREHOLE TYPE Hollow stem augers, NW casing, Split Spoons, NQ Core	COMPILED BY JF
DATUM Geodetic	DATE 07.05.14 - 07.05.18		CHECKED BY PC

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Biotite GNEISS, grey, black and pink, fair to excellent, moderate to slightly weathered, close to moderately spaced fractures, thin bedding, 0 to 40 degree dip *(continued)*		30	NQ			337				TCR = 100% RQD = 90%
336.5 61.3	End of Borehole Standpipe Installed to 7.62 m										

$\boldsymbol{\times}^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-5

METRIC

W.P. 545-93-00	LOCATION Highway 60, Clarke Creek Bridge, N5045231.1 E401273.7		ORIGINATED BY AO
DIST 43 HWY 60	BOREHOLE TYPE NQ casing, split casing, NQ Core		COMPILED BY JD
DATUM Geodetic	DATE 07.05.22 - 07.05.24		CHECKED BY PC

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 (%) 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL
397.7	Asphalt										
397.5 / 0.0	200 mm ASPHALT										
397.4 / 0.2	Sand, with gravel and silt, compact, brown: FILL										
0.4	Well-graded sand with gravel, very loose to compact, brown: FILL	1	GS								
		2	SS	22		397					
		3	SS	10		396					
		4	SS	8		395					
		5	SS	14		394					
		6	SS	3			○ (~18)	16	81	(3)	
393.2 / 4.5	Poorly-graded SAND with silt, loose to compact, brown (SP)					393					
		7	SS	11							
		8	SS	9		392					
					∇						
		9	SS	6		391					
		10	SS	22		390					
		11	SS	15		389					
388.0 / 9.7	Silty SAND, loose to compact, brown to grey (SM)					388					

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

ONTARIO MTO 1023332.GPJ ONTARIO MOT.GDT 07/10/25

RECORD OF BOREHOLE No 07-5

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045231.1 E401273.7 ORIGINATED BY AO

DIST 43 HWY 60 BOREHOLE TYPE NQ casing, split casing, NQ Core COMPILED BY JD

DATUM Geodetic DATE 07.05.22 - 07.05.24 CHECKED BY PC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Silty SAND, loose to compact, brown to grey (SM) *(continued)*	12	SS	10						
					387					
					386					
		13	SS	9		○	0	80	(20)	
					385					
		14	SS	10						
					384					
383.1 14.6	SILT with sand, loose to compact, grey (ML)				383					
		15	SS	8		○	0	21	75	4
					382					
					381					
					380					
					379					
		16	SS	16						
					378					

Continued Next Page

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

$\times^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 07-5

METRIC

W.P. 545-93-00 | LOCATION Highway 60, Clarke Creek Bridge, N5045231.1 E401273.7 | ORIGINATED BY AO
DIST 43 HWY 60 | BOREHOLE TYPE NQ casing, split casing, NQ Core | COMPILED BY JD
DATUM Geodetic | DATE 07.05.22 - 07.05.24 | CHECKED BY PC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) (w)	GR	SA	SI	CL
	SILT with sand, loose to compact, grey (ML) *(continued)*				377					
					376					
375.0 22.7	Sandy SILT, compact, grey (ML)				375					
					374					
		17	SS	13		~20	0	50	(50)	
					373					
					372					
					371					
370.0 27.7	SILT with sand, compact to dense, grey (ML)				370					
		18	SS	15	369	~22	0	19	79	2
					368					

Continued Next Page

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

RECORD OF BOREHOLE No 07-5

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045231.1 E401273.7 ORIGINATED BY AO

DIST 43 HWY 60 BOREHOLE TYPE NQ casing, split casing, NQ Core COMPILED BY JD

DATUM Geodetic DATE 07.05.22 - 07.05.24 CHECKED BY PC

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	NATURAL MOISTURE CONTENT w (%)	GR SA SI CL
	SILT with sand, compact to dense, grey (ML) *(continued)*								
							367		
							366		
							365		
			19	SS	34				
							364		
							363		
							362		
			20	SS	44				
							361		
							360		
359.6 38.1	Silty SAND, dense to very dense, grey (SM)								
							359		
			21	SS	56			~19 (o)	0 53 45 2
							358		

Chart headings: 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

RECORD OF BOREHOLE No 07-5

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045231.1 E401273.7 ORIGINATED BY AO

DIST 43 HWY 60 BOREHOLE TYPE NQ casing, split casing, NQ Core COMPILED BY JD

DATUM Geodetic DATE 07.05.22 - 07.05.24 CHECKED BY PC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND, dense to very dense, grey (SM) *(continued)*						
					357		
					356		
		22	SS	37			
					355		
					354		
					353		
		23	SS	76			
					352		
					351		
					350		
		24	SS	39		~17	0 72 (28)
					349		
					348		
347.7							

Continued Next Page

Plot 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No 07-5

METRIC

W.P. 545-93-00 LOCATION Highway 60, Clarke Creek Bridge, N5045231.1 E401273.7 ORIGINATED BY AO

DIST 43 HWY 60 BOREHOLE TYPE NQ casing, split casing, NQ Core COMPILED BY JD

DATUM Geodetic DATE 07.05.22 - 07.05.24 CHECKED BY PC

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 (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
50.0	Silt and sand, with cobbles and boulders, very dense, grey : TILL	25	SS	100/ 30 mm	
					347
		26	NQ	0%	
					346
					345
		27	SS	100/ 30 mm	
		28	NQ	6%	344
					343
					342
		29	SS	33	
					341
					340
					339
		30	SS	100/ 80 mm	
					338

Continued Next Page

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

RECORD OF BOREHOLE No 07-5

METRIC

W.P. 545-93-00	LOCATION Highway 60, Clarke Creek Bridge, N5045231.1 E401273.7		ORIGINATED BY AO
DIST 43	HWY 60	BOREHOLE TYPE NQ casing, split casing, NQ Core	COMPILED BY JD
DATUM Geodetic	DATE 07.05.22 - 07.05.24		CHECKED BY PC

ELEV / DEPTH	DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silt and sand, with cobbles and boulders, very dense, grey : TILL *(continued)*					337				
						336				
		31	SS	100/ 80 mm						
335.5 / 62.2	End of Borehole									

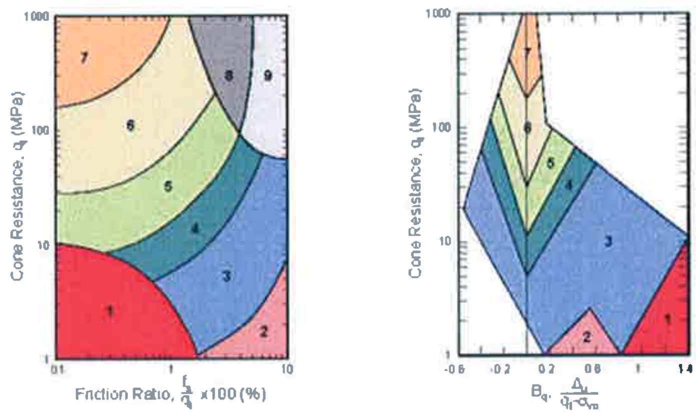
Legend: ○ UNCONFINED; ● QUICK TRIAXIAL; ✖ FIELD VANE; × LAB VANE. Dynamic cone scale: 20 40 60 80 100. Shear strength scale: 20 40 60 80 100. Water content (%): 10 20 30.

$\times^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Terminology and Key Engineering Relationships

Parameter	Description	Symbol/Equation	Reference
Depth	Depth of the centroid of the sensor		
Elevation	Elevation of centroid of the sensor	Ground Surface – Depth	
Sleeve Stress	Sleeve Stress – interpolated to the depth of the tip	f_s	
Tip Stress, Uncorrected	Measured Tip Stress	q_c	
Tip Stress COR	Tip Stress, corrected for probe geometry	$q_t = q_c + u_2 x(1-a)$	
Ratio COR	Friction Ratio	$R_f = \frac{f_s}{q_t} x100\%$	
Pore Pressure	Measured Pore Pressure	u_2	
Soil Behaviour Type	Soil Behaviour Type	*SBT*	Lunne, Roberson and Powell, 1997
Overburden Stress		$\sigma_{vo} = \sum_{i=1}^{n} \gamma_t x h_i$	
Effective Overburden Stress		$\sigma'_{vo} = \sigma_{vo} - u_o$	
Normalized Tip Stress		$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$	Lunne, Robertson and Powell, 1997
Normalized Friction Ratio		$F_r = \frac{f_s}{q_t - \sigma_{vo}}$	Lunne, Robertson and Powell, 1997
Normalized Pore Pressure		$B_q = \frac{\Delta u}{q_t - \sigma_{vo}}$ $where\ \Delta u = u_2 - u_0$	Lunne, Robertson and Powell, 1997

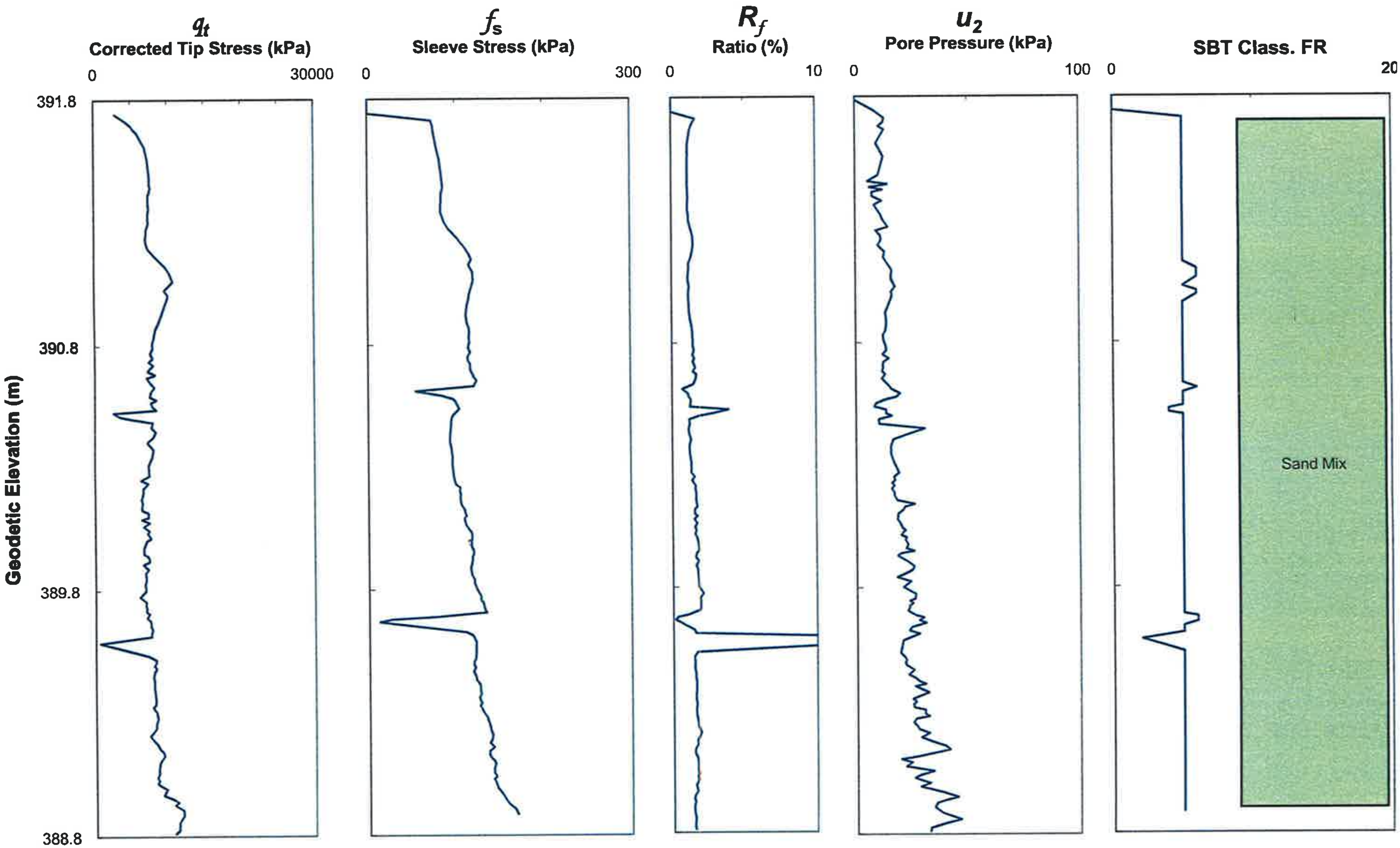
CPT Soil Behavior Type Legend
(Robertson et al. 1990)



Zone		Soil Behavior Type
1		Sensitive, Fine Grained
2		Organic Soils-Peats
3		Clays; Clay to Silty Clay
4		Silt Mixtures; Clayey Silt to Silty Clay
5		Sand Mixtures; Silty Sand to Sandy Silt
6		Sands; Clean Sands to Silty Sands
7		Gravelly Sand to Sand
8		Very Stiff Sand to Clayey Sand*
9		Very Stiff Fine Grained*
		*Overconsolidated or Cemented

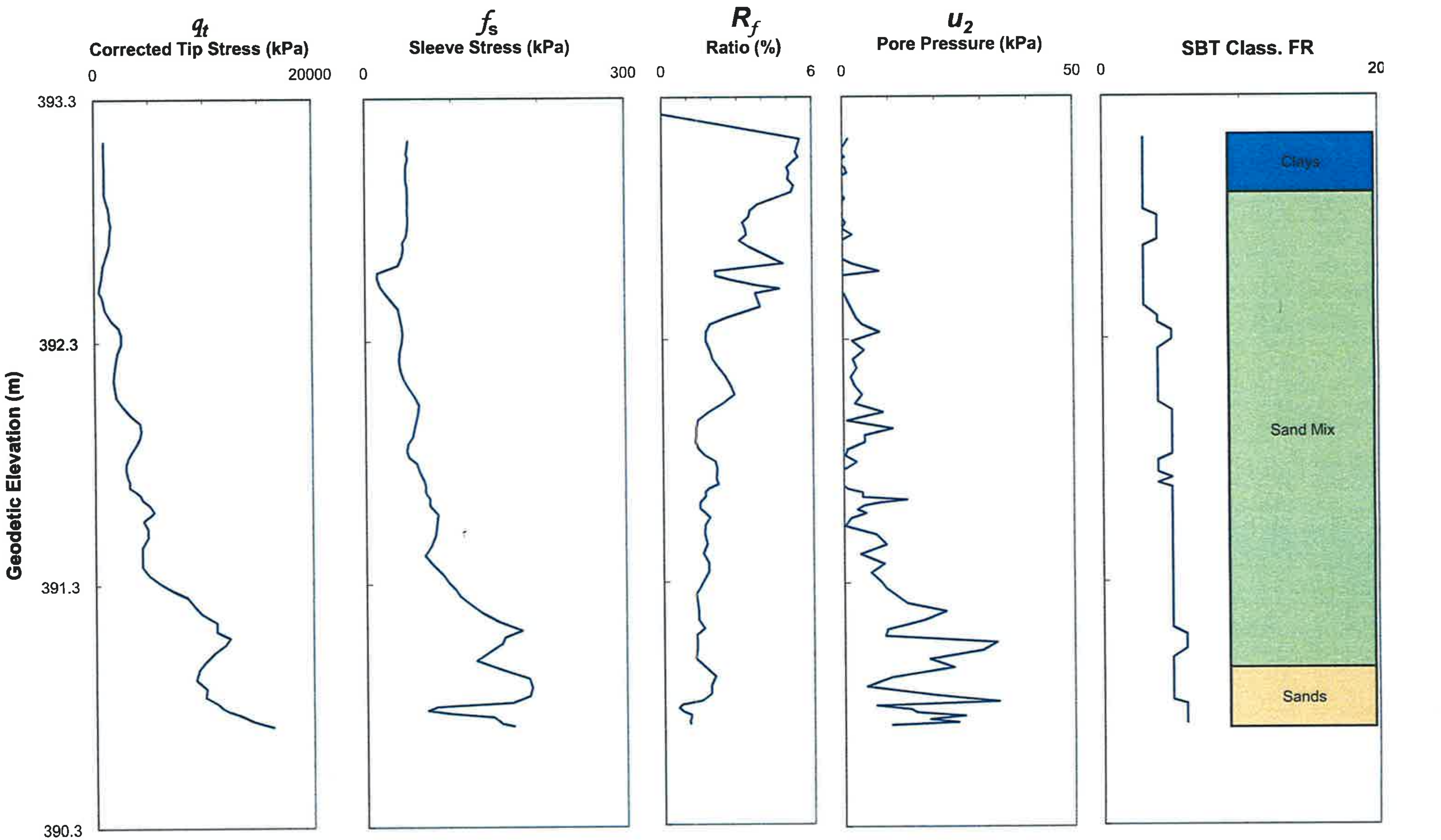
Jacques Whitford

Jacques Whitford	Ground Surface Elevation: 397.73 m CPTu Start Elevation: 391.79 m Groundwater Elevation: 391.66 m	Test Date: April 26, 2006 Project No. 1023332 N5045279.2 E401284.3	CPT 07-3
	Client: McCormick Rankin Corporation Project: MTO WP 545-93-00, Clarke Creek Bridge Replacement		



Class FR: Friction Ratio Classification (Robertson, 1990)

Jacques Whitford	Ground Surface Elevation: 397.68 m CPTu Start Elevation: 393.24 m Groundwater Elevation: 391.66 m	Test Date: May 11, 2006 Project No. 1023332 N5045220.9 E401270.8	CPT 07-6
	Client: McCormick Rankin Corporation Project: MTO WP 545-93-00, Clarke Creek Bridge Replacement		



Class FR: Friction Ratio Classification (Robertson, 1990)

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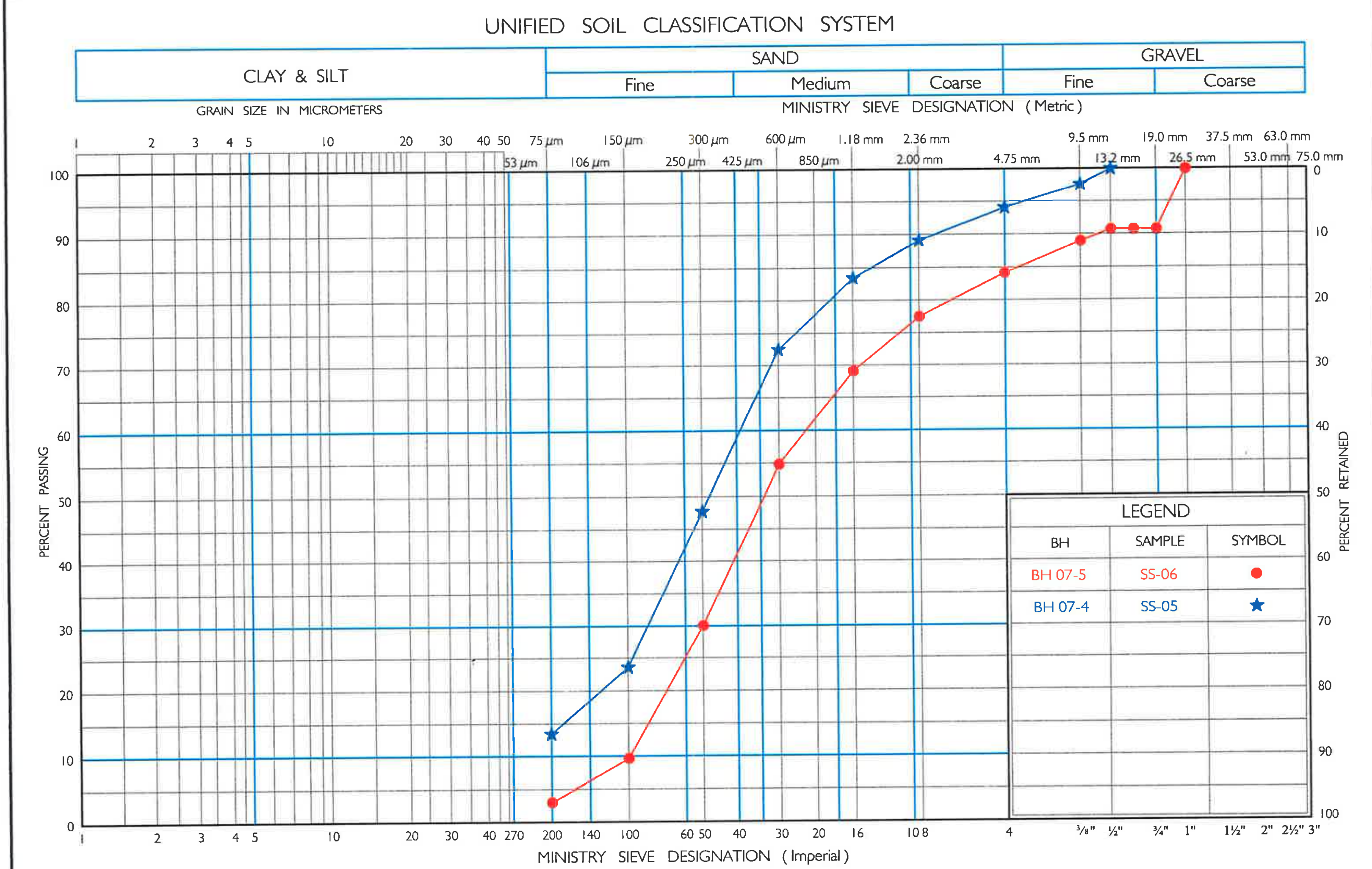
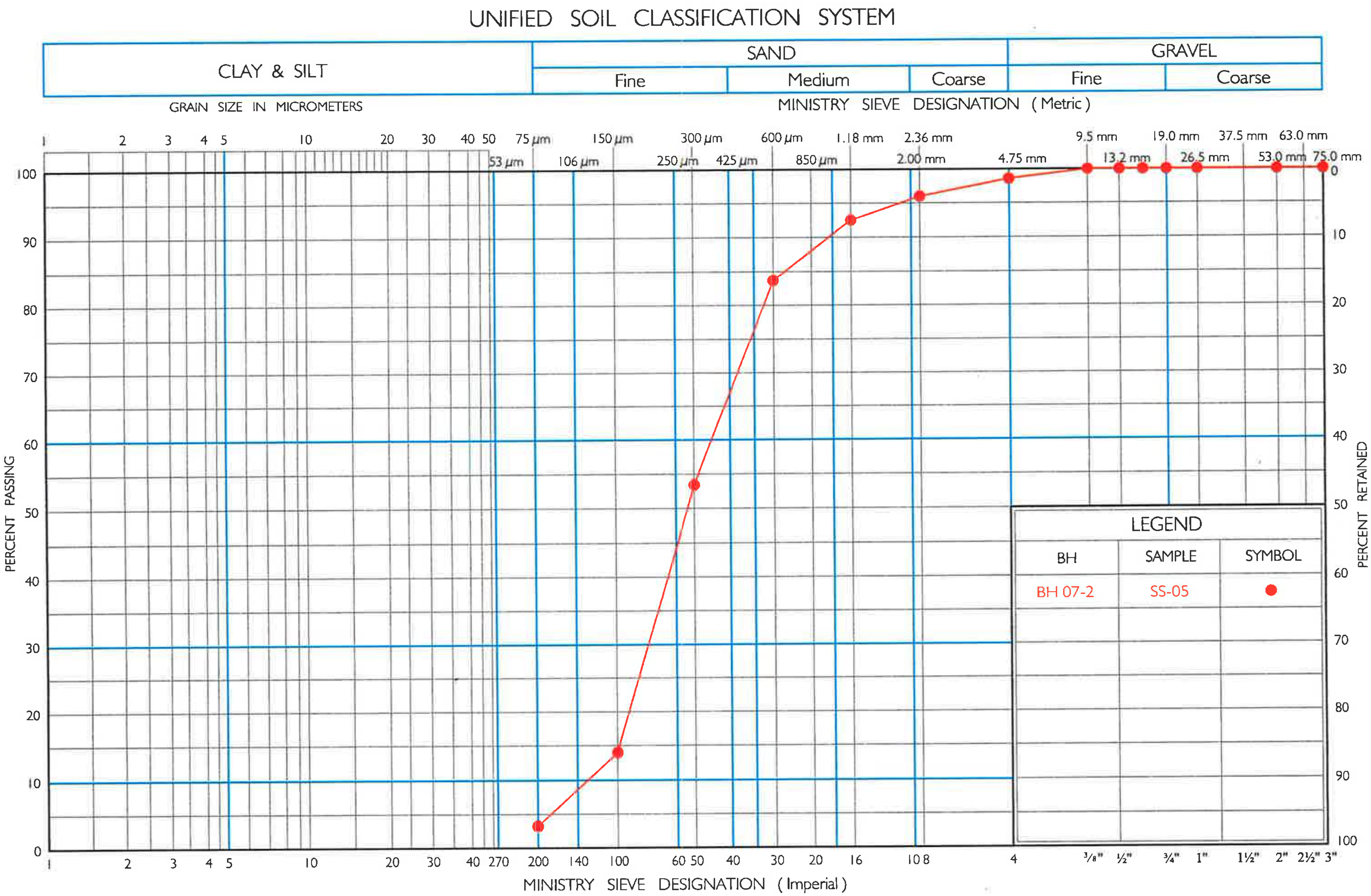
MTO-GSD JAN 2005



Ministry of Transportation Ontario	GRAIN SIZE DISTRIBUTION SILTY SAND TO WELL-GRADED SAND WITH GRAVEL (FILL)	FIG No 1 GWP 545-93-00



Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION

POORLY-GRADED SAND (SP)

FIG No 2

GWP 545-93-00

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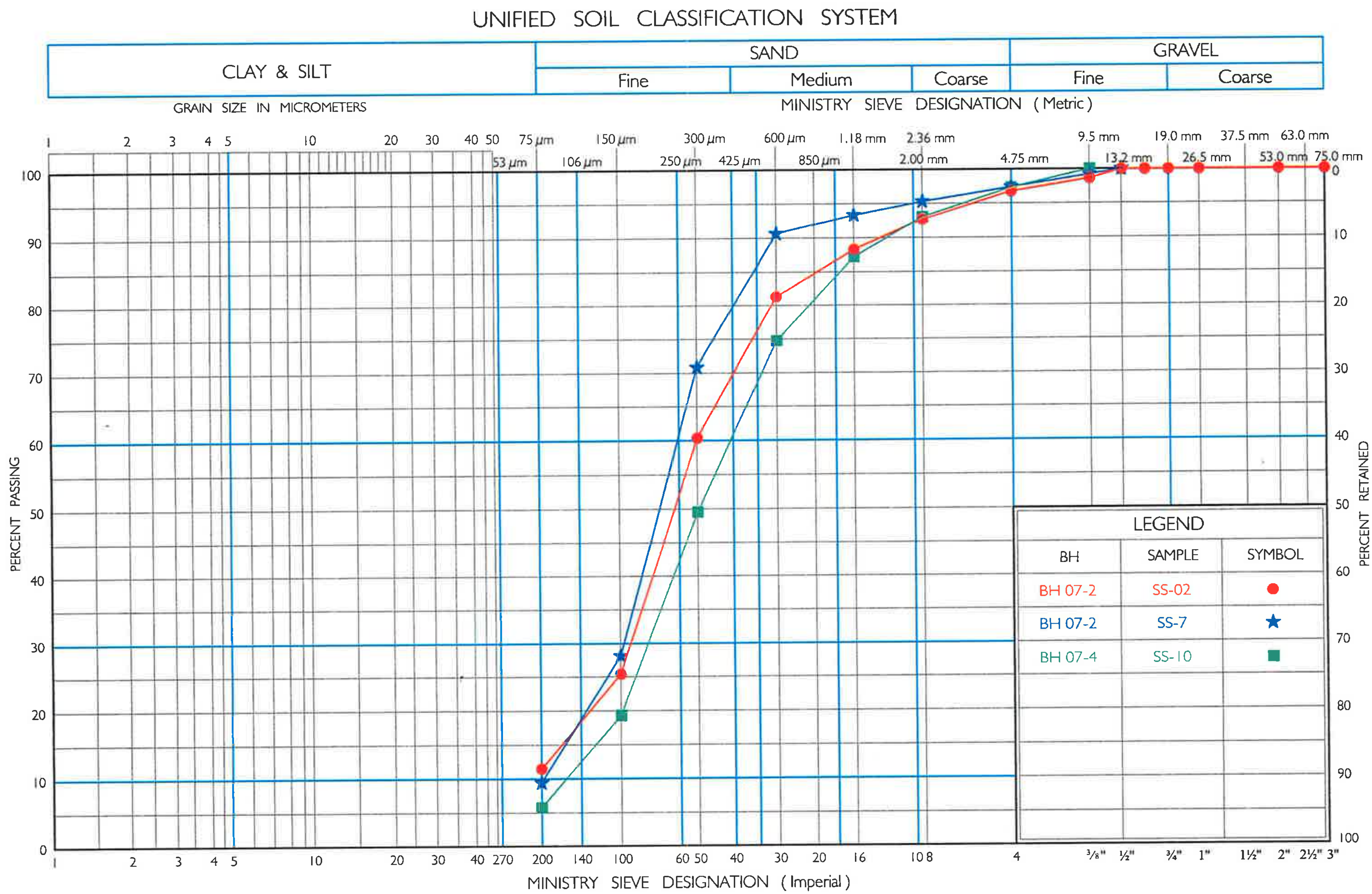
MTO-GSD JAN 2005



Ministry of Transportation

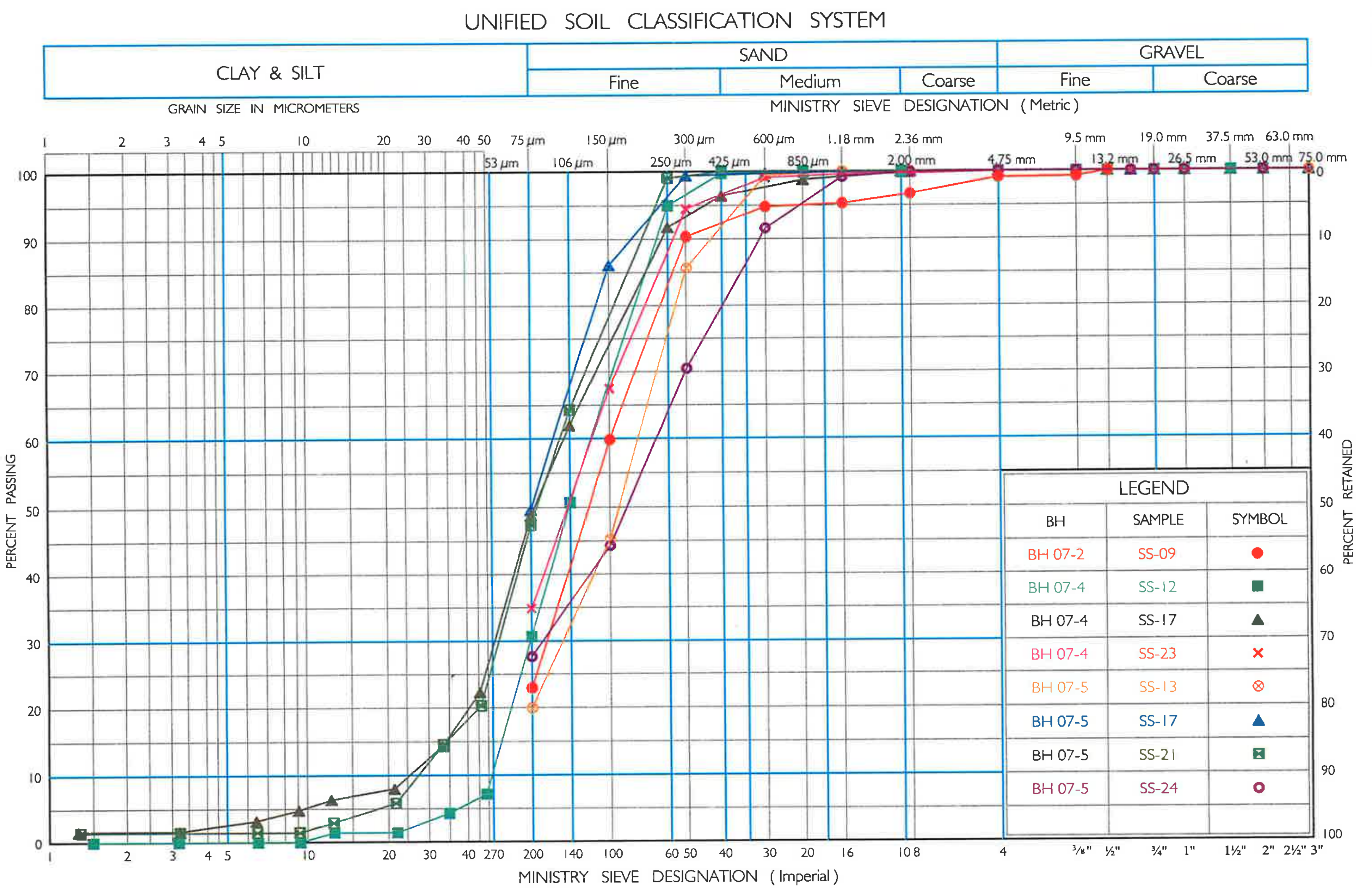
Ontario

GRAIN SIZE DISTRIBUTION

POORLY-GRADED SAND WITH SILT (SP-SM)

FIG No 3

GWP 545-93-00



Ministry of Transportation

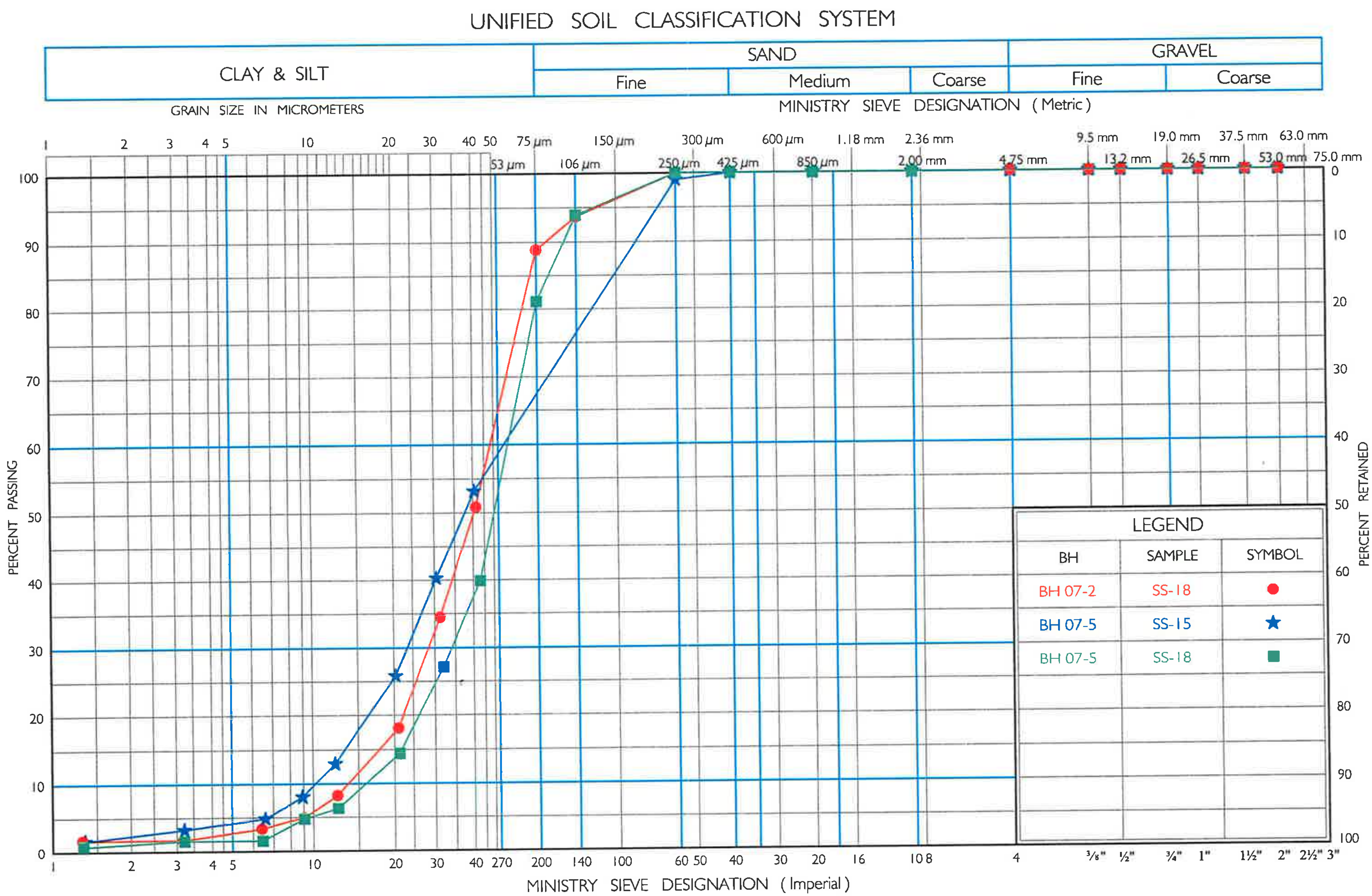
Ontario

GRAIN SIZE DISTRIBUTION

SILTY SAND (SM)

FIG No 4

GWP 545-93-00



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

SILT / SILT WITH SAND (ML)

FIG No 5

GWP 545-93-00

Jacques Whitford

Rock Core Summary Table
W.P. 302-89-00

Borehole #	Sample #	Recovery (%)	R.Q.D. (%)	Unconfined Compressive Strength (MPa)	Description
07-4	28	100	63	-	Biotite GNEISS, grey, black and pink, fair to excellent, moderate to slightly weathered, close to moderatley spaced fractures, 0 to 40 degree dip
	29	98	100	40, 155	
	30	100	90	-	

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APPENDIX C

NRCAN Seismic Hazard Calcuation
Characterization of Liquefaction Resistance

2005 National Building Code Seismic Hazard Calculation

INFORMATION: **Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836**
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: Paul Carnaffan, Jacques Whitford Limited June 15, 2007

Site Coordinates: 45.5401 North 78.2653 West

User File Reference: Hwy 60 - Clarke Creek

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**PGA (g)**
0.300	**0.162**	**0.075**	**0.025**	**0.174**

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2005 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.057	0.137	0.198
Sa(0.5)	0.027	0.069	0.103
Sa(1.0)	0.010	0.031	0.047
Sa(2.0)	0.003	0.009	0.015
PGA	0.035	0.083	0.118

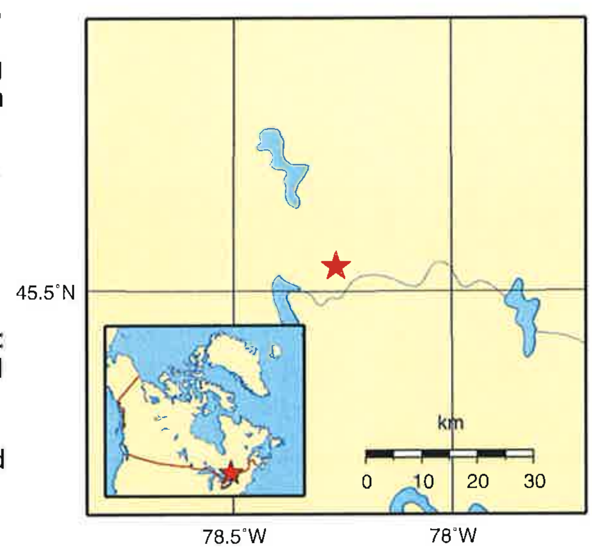
References

National Building Code of Canada 2005 NRCC no. 47666; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2005, Structural Commentaries NRCC no. 48192
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Grid values to be used with the 2005 National Building Code of Canada (in preparation)

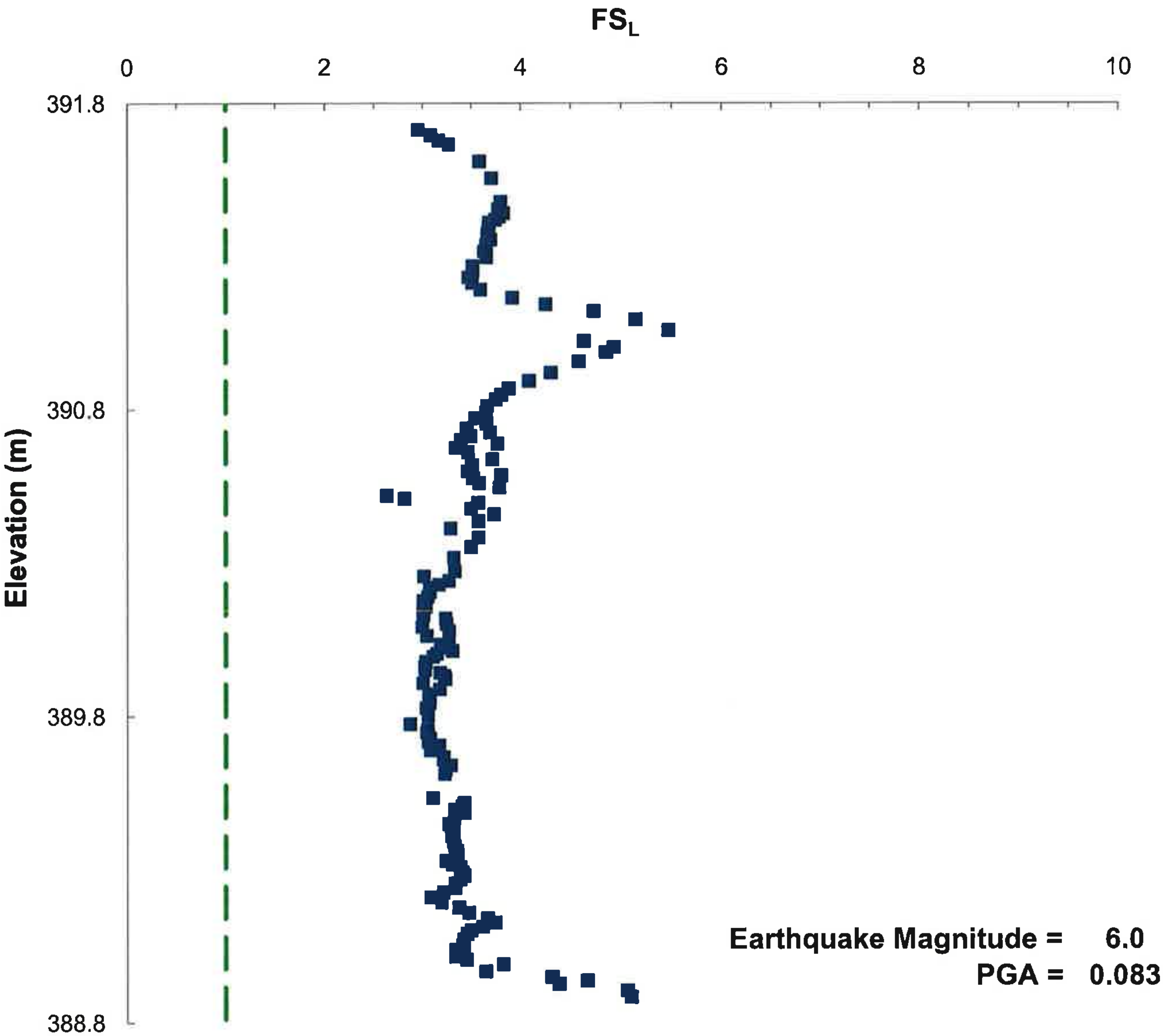
See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information



Aussi disponible en français

CHARACTERIZATION OF LIQUEFACTION RESISTANCE

Jacques Whitford



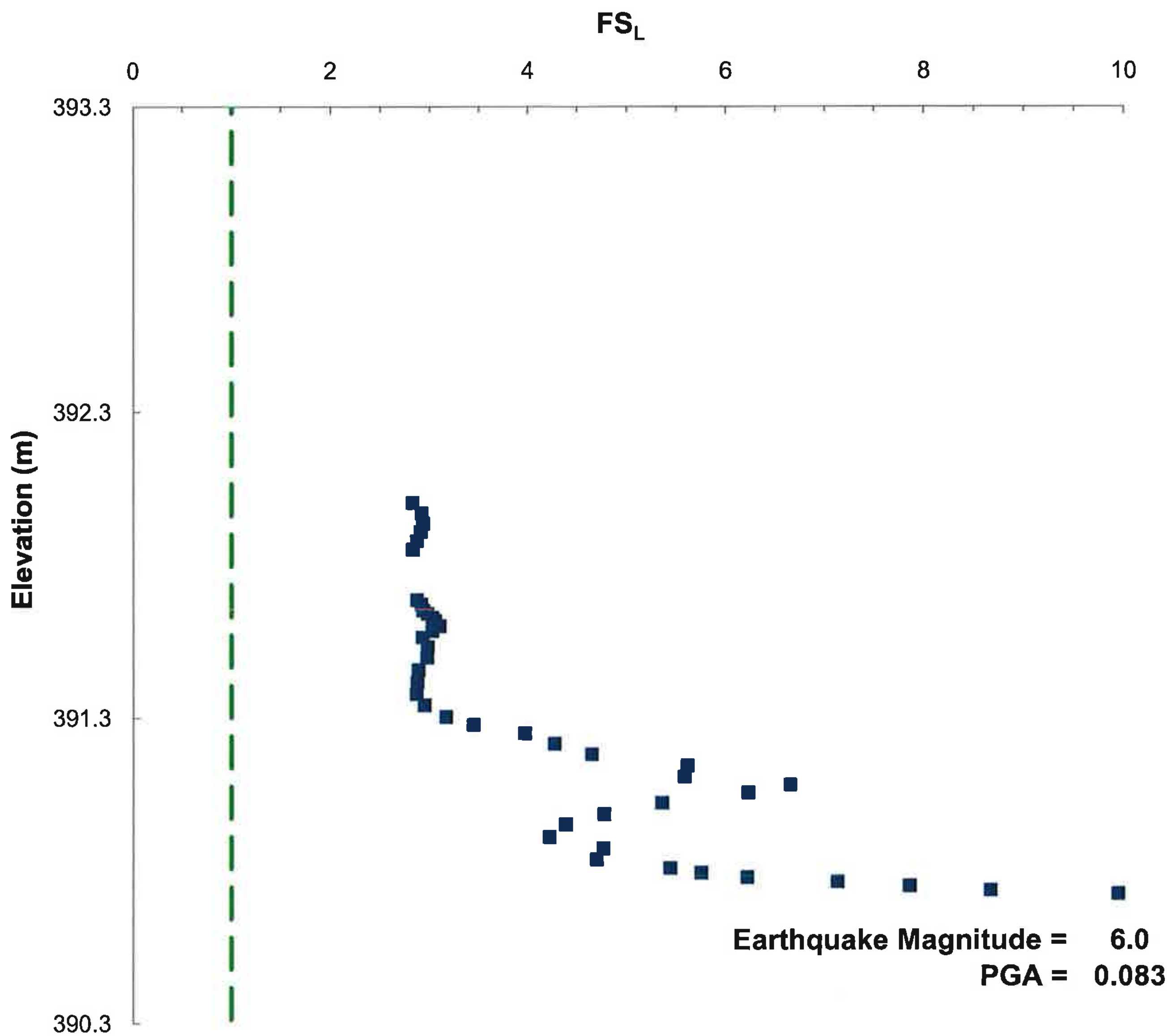
FS_L = Factor of Safety against Liquefaction

The Canadian Foundation Engineering Manual defines FS_L as the "soil deposit's cyclic resistance ratio (CRR)" divided by the "earthquake induced cyclic stress ratio (CSR)"

Project No. 1023332
CPT 07-3

Jacques
Whitford

CHARACTERIZATION OF LIQUEFACTION RESISTANCE



FS$_L$ = Factor of Safety against Liquefaction

The Canadian Foundation Engineering Manual defines FS$_L$ as the "soil deposit's cyclic resistance ratio (CRR)" divided by the "earthquake induced cyclic stress ratio (CSR)"

Project No. 1023332
CPT 07-6

APPENDIX D

Detail: StructuralFill Pad beneath Detour Structure Foundations

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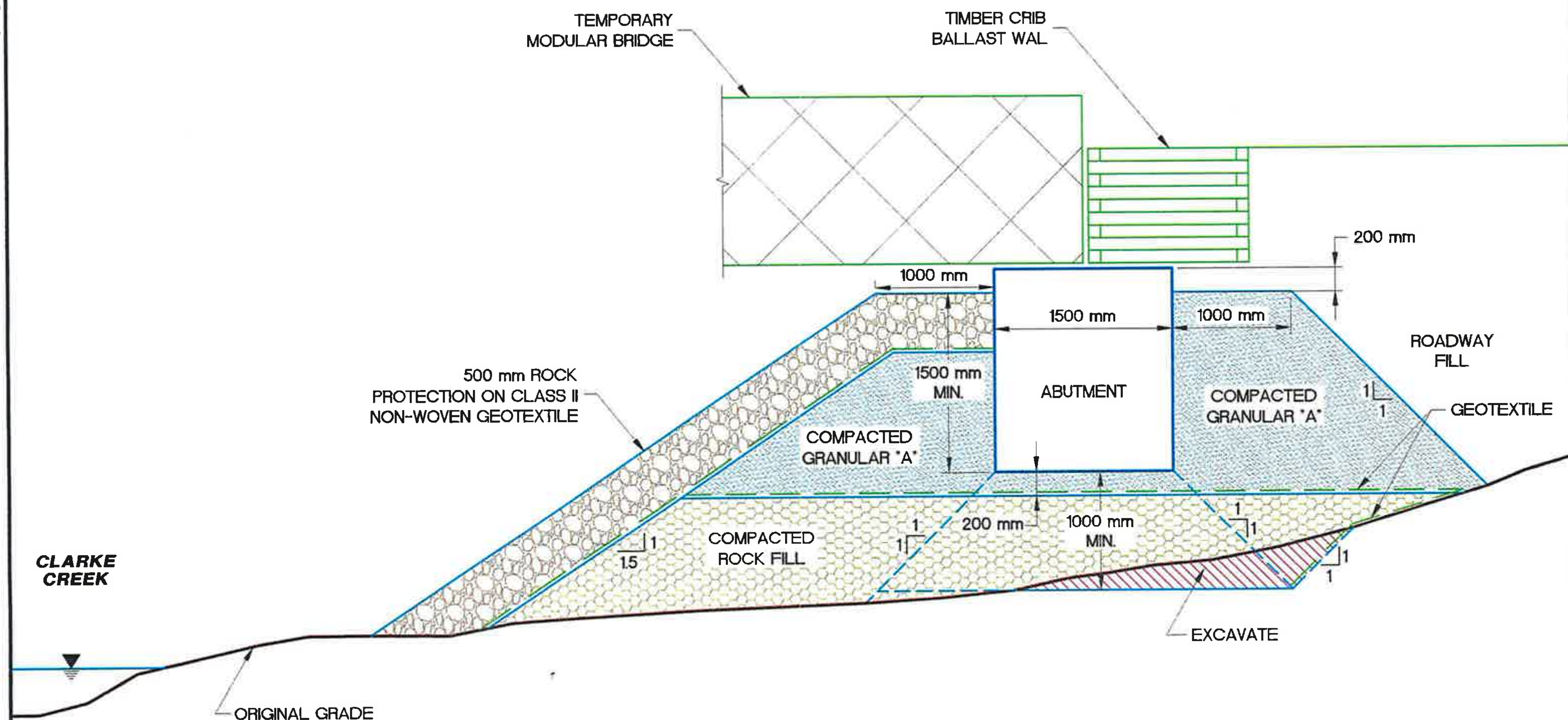

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A JACQUES WHITFORD LIMITED REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

STRUCTURAL PAD BENEATH TEMPORARY DETOUR STRUCTURE FOUNDATIONS DETAIL

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 60, CLARKE CREEK BRIDGE REPLACEMENT

Client: McCORMICK RANKIN CORPORATION

Job No.:	1023332
Scale:	N.T.S.
Date:	07/10/19
Dwn. By:	GBB
App'd By:	PC

Fig. No. 6

Jacques Whitford