



# **Foundation Investigation and Design Report**

## **South Trout Creek Bridge Replacement**

**GWP 0476-00-00**

**Highway 11/17**  
**14 km west of the Town of Nipigon**

**Geocres No.: 52A-140**

**Prepared for**  
**Ministry of Transportation, Northwestern Region**

**Prepared By:**  
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## Part A - **FOUNDATION INVESTIGATION REPORT**

### **1 Introduction**

TBT Engineering has been retained by the Ministry of Transportation to provide foundation investigation services for the bridge replacement at South Trout Creek.

The site is located on Highway 11/17 approximately 14 km west of the town of Nipigon where it crosses the South Trout Creek, within Nipigon Township, Ontario.

The foundation investigation was carried out to investigate subsurface conditions at the site. This investigation consisted of six boreholes drilled in the vicinity of the proposed bridge replacement, and laboratory testing. This report provides a summary of that work and of the conditions encountered.

The site is identified as Site No. 48C – 010, and has been assigned the MTO GEOCREs No. 52A-140.

## 2 Site Description

The site is located on Highway 11/17, approximately 14 km west of the Town of Nipigon. At this location Highway 11/17 runs locally in an east-west direction.

The existing bridge is a double lane timber structure and is approximately 28 m long. The approach embankments have side slopes of approximately 1.5 horizontal to 1 vertical or steeper as the highway approaches the South Trout Creek.

The site is within Ontario's boreal forest region. Highway 11/17 at the bridge location is generally higher than the surrounding area. The South Trout Creek water level at the time of the survey was approximately of 3.5 m (elevation 213.5 m) below the bridge deck (elevation 217 m).



South Trout Creek Bridge  
Nipigon Township

### **3 Investigation Procedures**

A site investigation was undertaken on July 15 to 21, 2008. Six boreholes were drilled for this project along the approaches (three on either side of the creek). The investigation was carried out using a CME drill rig equipped for geotechnical testing. The boreholes were drilled to depths ranging between 7.3 and 12.2 m below existing ground surface. Borehole locations and depths were determined through consultation with the client during an onsite meeting. Refer to the Drill Summary Table for specific depths and comments concerning each borehole.

Soil samples were obtained at the boreholes with a split spoon sampler as a part of the Standard Penetration Testing (SPT). The SPT involves driving a thick walled sampler into the soils under a standardized energy (63.5 kg, falling 760 mm). The number of blows required to drive the sampler 0.3 m, known as the SPT blow count (N), was recorded. In addition to SPTs, shear vane testing was conducted within cohesive soils. Thin walled tube samples were taken within cohesive materials to obtain relatively undisturbed samples.

Borehole locations and elevations were surveyed in the field by Hatch Mott MacDonald and referenced to a local benchmark. The local benchmark is a nut and washer in a root of a 0.4 m diameter spruce tree located at station 13+545.433, 27.979 m Lt.

A summary of the borehole location data is provided on the enclosed Borehole Location Plan and Soil Strata Drawing 1.

The borehole characteristics and drill techniques utilized are summarized for the various borehole locations in Table 1 below:

**Table 1 - Drill Summary**  
South Trout Creek Bridge  
Nipigon Township

Location	Borehole Depth (metres)	Comments
STC08-01	10.8	Hollow Stem Augers to 8.3 m, Casing advanced to 10.8 m in material with SPT "N" values of 100+blows/0.3 m
STC08-02	8.5	Hollow Stem Augers
STC08-03	7.3	Hollow Stem Augers
STC08-04	12.2	Hollow Stem Augers to 7.3 m, Casing advanced to 12.2 m in material with SPT "N" values of 100+blows/0.3 m
STC08-05	10.0	Hollow Stem Augers
STC08-06	9.6	Hollow Stem Augers

The boreholes were backfilled to ensure the environmental integrity of the site, utilizing appropriate bentonite/cement mixtures for the soils encountered (at individual locations).

Soil samples were transported to TBT Engineering's laboratory in Thunder Bay for testing. Routine testing included moisture content, grain size analysis, and liquid and plastic limits. The results of this testing are shown on the Borehole Logs (Appendix A) and on the laboratory data reports (Appendix B).

## **4 General Site Geology and Sub-Surface Conditions**

### **4.1 Site Geology**

The South Trout Creek flows approximately south-southeast at the Highway 11/17 bridge site, joining the Big Trout Creek approximately 2.8 km to the southeast. Flows from the creek report to Lake Superior, near the mouth of the Nipigon River, approximately 4 km east of this confluence.

Available surficial geology mapping (OGS NOEGTS Map 5046 – Black Bay) shows the northern extent of a peat/organic terrain deposit filling the creek basin near the site, and covering a large area south of the site. This deposit overlies a silty-clayey lacustrine plain deposit, associated with a former Lake Superior (glacial lake Minong) shoreline. Sandier units may also occur in the area, associated with an abandoned glacial spillway along the Black Sturgeon River valley, just west of the site. Relief is generally low and planar in the area of the bridge and south, while elevated bedrock hills exist to the north and northwest.

The site is adjacent to the erosional contact between the Proterozoic-aged Southern geologic province, and the underlying Archean-aged Quetico subprovince of the Superior geologic province. Available mapping (OGS Map 2232 – Nipigon-Schreiber Compilation) shows Sibley Group sedimentary rocks of the Southern province at surface in the area of the bridge, with metasedimentary rocks of the Quetico subprovince immediately to the north. The site's proximity to this contact suggests that at the bridge site bedrock may be composed of members of the Sibley Group, such as the Pass Lake red sandstone/conglomerate formation. The thickness of the Sibley Group and depth to the lower contact is unknown. Nearby regional and local faults are aligned approximately north-south; the South Trout Creek traces one such local fault north of the bridge site.

### **4.2 Subsurface Conditions**

Details of the subsurface conditions are provided on the Borehole Logs, Appendix A, and on the Borehole Location Plan and Strata Drawing 1.

In general, the natural subsurface stratigraphy consists of clay overlying silt and sand till. The highway surface is constructed on a sand and gravel fill embankment.

The subsurface stratigraphy has been interpreted based on the findings at the boreholes and is illustrated on the Borehole Location and Soil Strata Drawing and on the borehole logs.

#### **4.2.1 Asphalt**

Asphalt was encountered at surface at all boreholes with the exception of Borehole 3. The asphalt thickness varied from 90 to 180 mm.

#### **4.2.2 Fill**

Granular fill was encountered at surface of Borehole 3 and beneath the asphalt at all remaining boreholes. Based on samples from Boreholes 1, 2, 3 and 5 the fill varies from sand to sand and gravel and can consist of 2 – 39 % gravel, 55 – 87 % sand, 4 – 12 % silt/clay sized particles. The fill varies in thickness from 1.2 to 2.2 m and extends to elevations ranging from 214.8 to 215.9 m. The condition of this material varies from very loose to compact as indicated by “N” values ranging from 4 to 14 blows per 0.3 m.

#### **4.2.3 Clay**

Clay was encountered beneath the sand and gravel fill. The clay varies in thickness from 1.9 to 6.2 m, extending to elevations ranging from 209.7 to 213.2 m. The clay has a firm to very stiff consistency as indicated by field vanes ranging from 50 to greater than 110 kPa. Atterberg limits tests conducted on samples from Boreholes 1, 3, 4, 5 and 6 indicate the clay is of medium to high plasticity with natural moisture contents below the liquid limits, with the exception of the sample taken from Borehole 6 where the natural moisture content exceeded the liquid limit.

#### **4.2.4 Glacial Till**

Silt and sand glacial till with trace to some gravel was encountered beneath the clay to the limits of the investigation at all boreholes. Based on selected samples from Boreholes 1, 2, 4 and 6 the till can consist of 2 – 11 % gravel, 28 – 52 % sand, 41 – 70 % silt sized particles. Occasional cobbles and boulders were also encountered. The material extends to the termination of each borehole. The upper metre of this stratum is



generally loose to compact with “N” values ranging from 4 to 17 blows /0.3 m. Below this, the till becomes dense to very dense as indicated by “N” values ranging from 34 to greater than 100 blows per 0.3 m. The till becomes very dense within Boreholes 1 to 5 below depths ranging from 6.1 to 7.6 m (elevations 209.4 to 211 m).

#### **4.2.5 Refusal**

Auger refusal, defined as SPT “N” values in excess of 100, was met at Boreholes 1, 2, 3, 4, and 5, within the till layer at elevations ranging from 207.1 to 211.0 m (depths from 6.1 to 10.0 m). Auger refusal may be on bedrock, cobbles and/or boulders. BW casing was advanced at Boreholes 1 and 4 below the auger refusal depths (8.3 and 7.3 m respectively) until borehole termination. The investigations were terminated at Boreholes 1 and 4 after “N” values in excess of 100 were recorded for three consecutive STP tests over a 3 m depth.

#### **4.2.6 Ground Water**

The water level of the South Trout Creek at the time of the survey was at elevation 213.5 m. Groundwater levels upon completion of drilling had not stabilized but were observed to range from 4.8 to 5.5 m from ground surface (elevations 211.4 to 212.3 m). Ground water levels will reflect the water level within the river, and will generally rise in elevation away from the river. Ground water levels will also fluctuate with precipitation events.

### **5 Miscellaneous**

The field drilling services for this project were provided by TBT Engineering. Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The field operations were supervised by H. Finke. This report was prepared by S Seller, P.Eng. and G. Maki, P.Eng., and reviewed by W. Hurley, P.Eng.

## **Part B FOUNDATION DESIGN RECOMMENDATIONS**

### **6 Discussions and Engineering Recommendations**

#### **6.1 Introduction**

The existing bridge was constructed in 1956 and is a six span, laminated timber and concrete deck structure supported on timber pile bents. The bridge is 28 m (approx.) in length. The proposed replacement structure will be a single span structure along the existing alignment. A detour will not be utilized during the construction of the replacement bridge.

It is understood that the proposed replacement structure will be a single span composite timber concrete deck. The abutments will consist of a single row of H-piles with a steel beam header. Sheet piles will be used for the ballast and wing walls.

The foundation investigation as described in Part A, was carried out to investigate subsurface conditions at the site. This investigation consisted of a number of boreholes advanced in the vicinity of the new structure, laboratory testing and geotechnical analysis of the data. The purpose of this section of the report (Part B) is to provide geotechnical design recommendations for the project. These are based on the conditions encountered at the test locations and interpretation of the subsurface conditions at the site.

#### **6.2 Bridge Foundations**

The foundation system for the proposed structure must support the design loads within acceptable settlement tolerances and must accommodate all anticipated loadings. The existing soil strata at this site includes fills, over clay which lies over till. In general:

- The fill varies in thickness from 1.2 to 2.2 m and extends to elevations ranging from 214.8 to 215.9 m
- The clay varies in thickness from 1.9 to 6.2 m, extending to elevations ranging from 209.7 to 213.2 m.

- The till extends from below the clay to the termination of each borehole at elevations ranging from 207.1 to 211.0 m

Bedrock was not encountered during drilling operations. All boreholes were advanced to or below auger refusal ( $N > 100$ ).

Deep driven piles may be designed to bear within the till. It is expected the piles will vary considerably (several metres) in length. The actual depth of pile penetration will depend on pile type, pile size, localized till conditions and thickness and potentially the under lying bedrock conditions and elevations.

### 6.3 Driven Piles

For the anticipated design loads and with the presence of compressible overburden soils over till, the most feasible foundation will consist of piles driven into the underlying till. Several pile configurations were considered for this site. It is understood H-piles (HP310 x 110) are the preferred foundation type with a design ULS pile capacity of 1000 kN .

Piles should be installed in accordance with Special Provision 903S01, July 2007. The piles are to be driven to a specified set as defined within SS103-11( $R > 2500$  kN).

For design purposes the pile capacities indicated in Table 3 are appropriate. (Higher capacities are available with deeper piles, but are understood not to be required)

**Table 3 - Pile Design Capacities**

Pipe Pile Designation	Ultimate Geotechnical Resistance	ULS Factored Geotechnical Axial Resistance	SLS Geotechnical Resistance for 25 and 50 mm of Settlement
HP 310x110	2500 kN	1000 kN	Does not govern

For design quantity purposes only, the pile tip elevations indicated in Table 4 may be used.

**Table 4 – Estimated Pile Tip Elevation**

Pile Type	Abutment	Estimated Pile Tip from Road Surface	
		Depth m	Elevation m
H - Pile	East	11	206
H - Pile	West	12	205

The installed depth of the piles may vary significantly. The contractor must be prepared to drive piles of varying length.

Due to the high stresses induced during driving through very dense till the piles should be equipped with a driving shoe to prevent damage to the pile tip. A pile tip as depicted in OPSD 3001.100 Type II should be employed. The behaviour of the piles should be monitored during driving for any signs indicative of pile damage. The presence of numerous cobbles and boulders within the till and fill may cause the piles to “walk” laterally during driving. Displaced piles will require review and potential replacement.

It is understood that the existing timber piles will be removed. It is not known to what extent they will be removed, (fully removed or cut off). If the existing piles are simply cut off the new piles must avoid existing foundations during driving.

Piles should be spaced at least 2.5 pile widths apart (centre to centre). No load reduction is required for this pile spacing.

Drag loads caused by negative skin friction are not anticipated at this site since no significant new embankment or surface loads are anticipated.

## **7 Embankments**

It is understood the approach embankments will not be raised above their existing elevations and no revisions/upgrades to the existing embankments will be done. Based on the survey data provided, the existing embankment slopes are steeper than Ministry standards. The embankments should be periodically monitored for any sign of instability.

If any alteration/upgrading of the existing embankments/slopes are considered, additional investigation and testing of the embankment will be required as well as hydraulic investigations of the River. Caution should be taken during construction as to not disturb and/or degrade the stability of the existing embankment/slope configurations.

## **8 Frost Protection**

Based on the Ontario Provincial Standard Drawing 3090.1 "Foundation Frost Depth for Northern Ontario" the estimated frost depth penetration within the expected embankment fill is 2.6 m.

The soils within the frost depth at the proposed abutment locations are considered to be of low frost susceptibility (MTO Pavement Design and Rehabilitation Manual).

## **9 Dewatering and Excavations**

Excavations for pile installations, if required, should be carried out and sloped in accordance with the requirements of the Occupational Health and Safety act. Based on the foundation configuration no requirement for dewatering is anticipated.

## **10 Limitations**

Conclusions and recommendations presented in this report are based on the information determined at the test hole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The design recommendations provided in this report are based on the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Benchmarks and elevations referred to in this report are used primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of dewatering procedures which may be considered cannot readily be determined from boreholes. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

## 11 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate to contact us at your convenience.

Yours truly,

For TBT ENGINEERING



Steven Seller, P. Eng  
Geotechnical Engineering



Wayne Hurley, P. Eng  
Vice-President, Engineering



Gordon Maki, P. Eng  
Geotechnical Engineering

## References

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2. Mollard, D.G., 1979, Northern Ontario Engineering Geology Terrain Study, Data Base Map, Frazer Lake. Ontario Geological Survey, Map 5046
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4. Canadian Geotechnical Society, Canadian Foundation Engineering Manual, Fourth Edition, BiTech Publishers Ltd., 1992, ISBN 0-920505-28-7
5. Hunt, Roy E., Geotechnical Engineering Analysis and Evaluation, McGraw Hill Inc, 1986, ISBN 0-07-031310-5
6. CSA International, Canadian Highway Bridge Design Code, CSA International, CAN/CSA S6-06, ISBN 1-55436-252-0

## MTO Special Provisions and Drawings

Special Provision 903.S01 (Pile Installations)



## **APPENDIX A**

### **BOREHOLE LOGS**

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

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

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

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

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

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

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

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

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

### JOINTING AND BEDDING:

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

## FIELD SAMPLING

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

## STRESS AND STRAIN

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

## MECHANICAL PROPERTIES OF SOIL

$m_v$	$kPa^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$C_v$	$m^2/s$	COEFFICIENT OF CONSOLIDATION
$U$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U_c$	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	$^\circ$	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	$^\circ$	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_r$	kPa	RESIDUAL SHEAR STRENGTH
$T_r$	kPa	REMOVED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{C_u}{\tau_f}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$e$	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$n$	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$w$	1, %	WATER CONTENT	$D_n$	mm	GRAIN DIAMETER
$\rho_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	$n$ PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_U$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$v$	m/s	DISCHARGE VELOCITY
$\gamma_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$i$	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$k$	m/s	HYDRAULIC CONDUCTIVITY
$\rho$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	$j$	kn/m <sup>2</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

## **APPENDIX B**

### **Laboratory Test Data**

## **APPENDIX C**

### **Borehole Locations and Soil Strata Drawings**

## **APPENDIX A**

### **BOREHOLE LOGS**

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

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

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

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

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

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

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

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

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

### JOINTING AND BEDDING:

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

## FIELD SAMPLING

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

## STRESS AND STRAIN

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

## MECHANICAL PROPERTIES OF SOIL

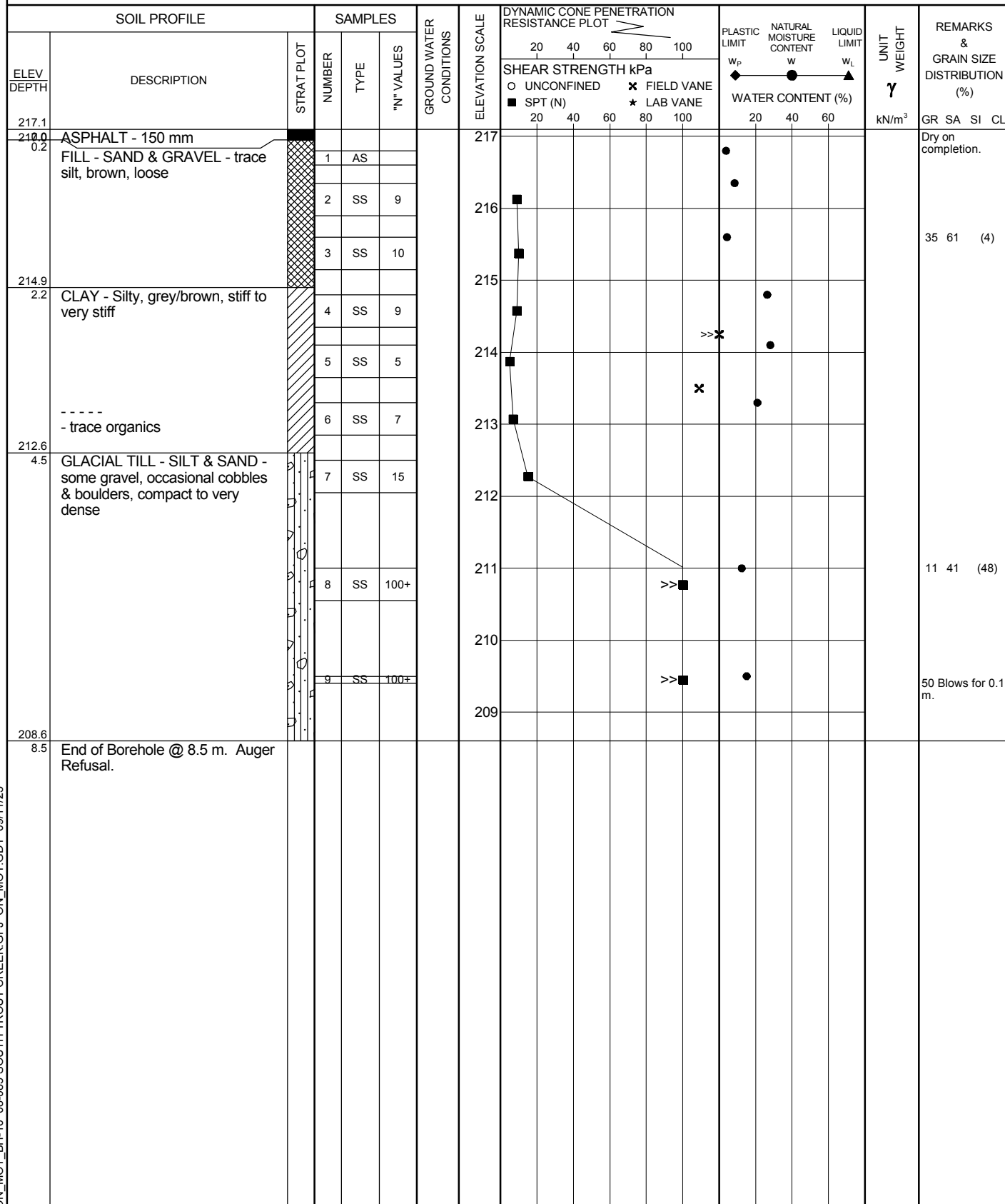
$m_v$	$kPa^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$C_v$	$m^2/s$	COEFFICIENT OF CONSOLIDATION
$U$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U_c$	%	DEGREE OF CONSOLIDATION
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$T_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	$^\circ$	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	$^\circ$	APPARENT ANGLE OF INTERNAL FRICTION
$T_R$	kPa	RESIDUAL SHEAR STRENGTH
$T_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY $= \frac{C_u}{T_f}$

## PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$e$	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$n$	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$w$	1, %	WATER CONTENT	$D$	mm	GRAIN DIAMETER
$\rho_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	$n$ PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\rho_{dsat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$v$	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$i$	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL				$k$	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$j$	kN/m <sup>2</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE			



<b>TBT Engineering Consulting Group</b>		<b>RECORD OF Borehole No STC08-2</b>		1 OF 1	<b>METRIC</b>
W.P. <b>496 00 00</b>	PROJECT <b>South Trout Creek</b>	SITE NO. <b>48-C-010</b>	ORIGINATED BY <b>HF</b>		
DIST <b>61</b>	HWY <b>11/17</b>	LOCATION <b>Sta. 13+599 o/s 5.6 Lt</b>	TBTE JOB# <b>08-085</b>	COMPILED BY <b>TB</b>	
DATE <b>2008 July 17</b>	BOREHOLE TYPE <b>Hollow Stem Auger</b>	DATUM <b>Geodetic</b>	CHECKED BY <b>WH</b>		



$\times^3, \star^3$ : Numbers refer to Sensitivity  
 NP Non Plastic  
 O 3% STRAIN AT FAILURE

ON\_MOT\_BH-10 08-085 SOUTH TROUT CREEK.GPJ ON\_MOT\_GDT 09/11/23



TBT Engineering Consulting Group		<b>RECORD OF Borehole No STC08-3</b>				1 OF 1		<b>METRIC</b>						
W.P. <b>496 00 00</b>		PROJECT <b>South Trout Creek</b>		SITE NO. <b>48-C-010</b>		ORIGINATED BY <b>HF</b>								
DIST <b>61</b> HWY <b>11/17</b>		LOCATION <b>Sta. 13+607 o/s 6 Lt</b>		TBTE JOB# <b>08-085</b>		COMPILED BY <b>TB</b>								
DATE <b>2008 July 17</b>		BOREHOLE TYPE <b>Hollow Stem Auger</b>		DATUM <b>Geodetic</b>		CHECKED BY <b>WH</b>								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
217.1	FILL - SAND - some silt, trace gravel, loose		1	AS										Water level @ 4.8 m on completion.  2 87 (12)
0.0			2	SS	9									
			3	SS	4									
214.9	CLAY - Silty, trace organics, stiff		4	SS	7									
2.2			5	TW										
			6	SS	5									
212.6	GLACIAL TILL - SILT & SAND - trace gravel, occasional cobbles & boulders, grey, compact to very dense		7	SS	15									100 Blows for 0.15 m.
4.5			8	SS	100+									
209.8	End of Borehole @ 7.3 m. Auger Refusal.													
7.3														

TBT Engineering Consulting Group			<b>RECORD OF Borehole No STC08-4</b>			1 OF 1		<b>METRIC</b>	
W.P. <b>496 00 00</b>			PROJECT <b>South Trout Creek</b>			SITE NO. <b>48-C-010</b>		ORIGINATED BY <b>HF</b>	
DIST <b>61</b> HWY <b>11/17</b>			LOCATION <b>Sta. 13+599 o/s 5.4 Rt</b>			TBTE JOB# <b>08-085</b>		COMPILED BY <b>TB</b>	
DATE <b>2008 July 17</b>			BOREHOLE TYPE <b>Hollow Stem Auger</b>			DATUM <b>Geodetic</b>		CHECKED BY <b>WH</b>	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		ELEVATION SCALE	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				
217.1						DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	
216.9	ASPHALT - 160 mm		1	AS		SHEAR STRENGTH kPa		W <sub>p</sub> W W <sub>L</sub>	
0.2	FILL - SAND & GRAVEL - brown, loose to compact		2	SS	14	○ UNCONFINED × FIELD VANE		WATER CONTENT (%)	
			3	SS	9	■ SPT (N) ★ LAB VANE			
215.1			4	SS	8				
2.0	CLAY - Silty, grey/brown, very stiff		5	SS	5				
			6	SS	5				
213.2			7	SS	17				
3.9	- trace organics		8	SS	36				
	GLACIAL TILL - SILT & SAND - some to trace gravel, occasional cobbles & boulders, grey, loose to very dense		9	SS	62				
			10	SS	100+				
			11	SS	100+				
			12	SS	100+				
204.9	End of Borehole @ 12.2 m.								
12.2									

217

216

215

214

213

212

211

210

209

208

207

206

205

11 40 (49)

Auger Refusal @ 7.3 m advanced with casing to 12.2 m.

7 52 (41)

50 Blows for 0.1 m.

50 Blows for 0.07 m.

UNIT WEIGHT γ kN/m<sup>3</sup>

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

ON\_MOT\_BH-10 08-085 SOUTH TROUT CREEK.GPJ ON\_MOT\_GDT 09/11/23

TBT Engineering Consulting Group			<b>RECORD OF Borehole No STC08-5</b>			1 OF 1		<b>METRIC</b>					
W.P. <b>496 00 00</b>			PROJECT <b>South Trout Creek</b>			SITE NO. <b>48-C-010</b>		ORIGINATED BY <b>HF</b>					
DIST <b>61</b> HWY <b>11/17</b>			LOCATION <b>Sta. 13+568 o/s 4.9 Rt</b>			TBTE JOB# <b>08-085</b>		COMPILED BY <b>TB</b>					
DATE <b>2008 July 21</b>			BOREHOLE TYPE <b>Hollow Stem Auger</b>			DATUM <b>Geodetic</b>		CHECKED BY <b>WH</b>					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		DYNAMIC CONE PENETRATION RESISTANCE PLOT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    ✕ FIELD VANE ■ SPT (N)        ★ LAB VANE 20 40 60 80 100		WATER CONTENT (%) W <sub>p</sub> W    W <sub>L</sub> PLASTIC LIMIT    NATURAL MOISTURE CONTENT    LIQUID LIMIT		γ kN/m <sup>3</sup>	GR SA SI CL
217.1	ASPHALT - 180 mm		1	AS									Water level @ 4.8 m on completion. 21 73 (7)
216.9	FILL - SAND - Gravelly, trace silt, brown, loose		2	SS	10								
215.7	CLAY - Silty, grey, firm to very stiff		3	SS	9								
215.0			4	SS	3								
214.4			5	TW									
213.8			6	SS	1								
213.2			7	TW									
212.6													
212.0													
211.2	GLACIAL TILL - SILT & SAND - trace gravel, occasional cobbles & boulders, grey, compact to very dense		8	SS	12								
210.6			9	SS	100+								
209.9			10	SS	100+								
209.3			11	SS	100+								
207.1	End of Borehole @ 10 m. Auger Refusal.												50 Blows for 0.05 m.

✕<sup>3</sup>, ★<sup>3</sup>: Numbers refer to Sensitivity    ○ 3% STRAIN AT FAILURE  
NP Non Plastic

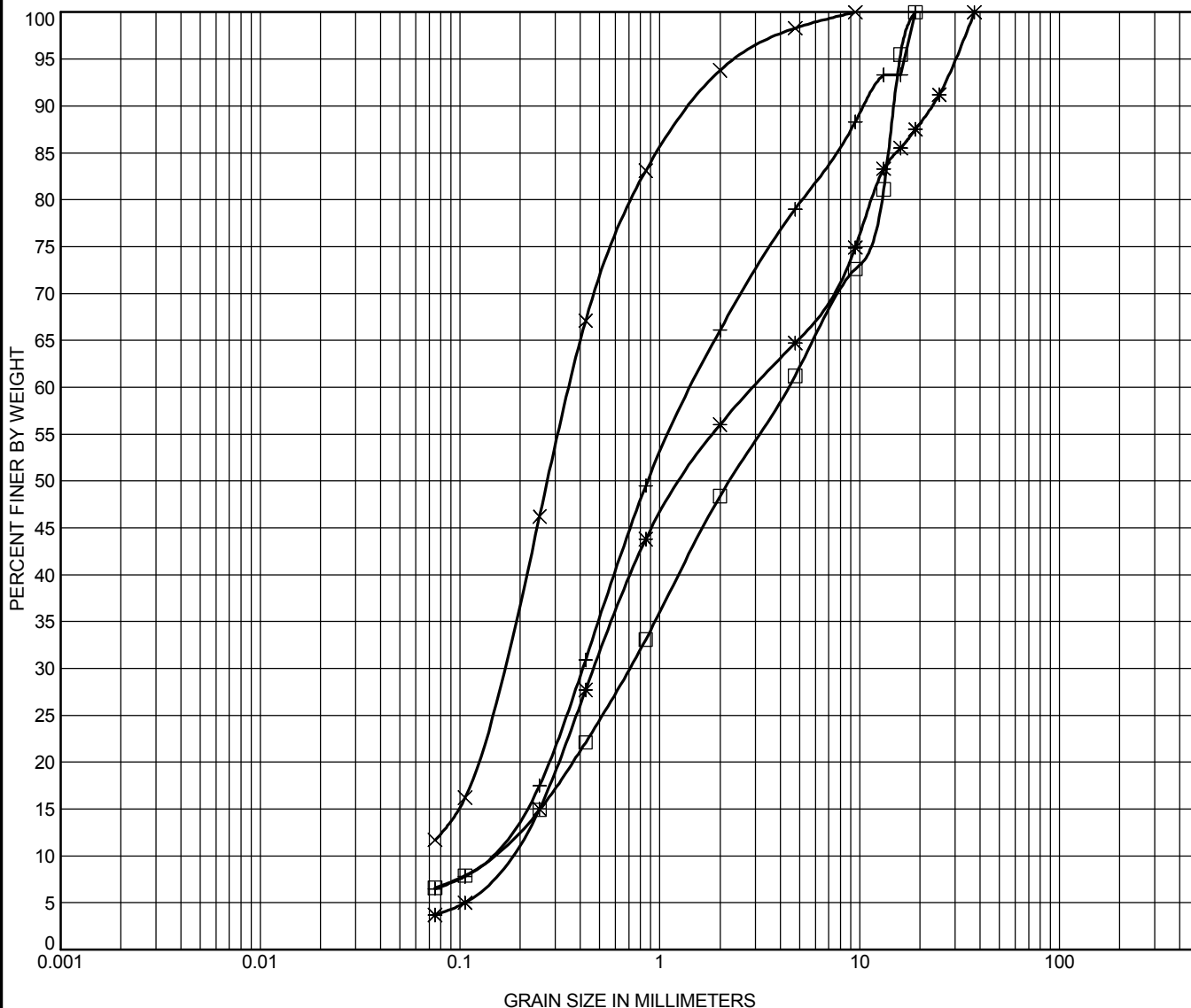
ON\_MOT\_BH-10 08-085 SOUTH TROUT CREEK.GPJ ON\_MOT\_GDT 09/11/23

TBT Engineering Consulting Group			<b>RECORD OF Borehole No STC08-6</b>			1 OF 1		<b>METRIC</b>											
W.P. <b>496 00 00</b>			PROJECT <b>South Trout Creek</b>			SITE NO. <b>48-C-010</b>		ORIGINATED BY <b>HF</b>											
DIST <b>61</b> HWY <b>11/17</b>			LOCATION <b>Sta. 13+559 o/s 5 Rt</b>			TBTE JOB# <b>08-085</b>		COMPILED BY <b>TB</b>											
DATE <b>2008 July 21</b>			BOREHOLE TYPE <b>Hollow Stem Auger</b>			DATUM <b>Geodetic</b>		CHECKED BY <b>WH</b>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		SHEAR STRENGTH kPa		WATER CONTENT (%)		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	UNCONFINED	FIELD VANE	SPT (N)	LAB VANE		γ	GR SA SI CL
217.1	ASPHALT - 90 mm		1	AS			217												Water level @ 4.8 m on completion.
216.0	FILL - SAND & GRAVEL - brown, compact		2	SS	15		216												
215.9	CLAY - Silty, brown, firm to very stiff		3	SS	4		215												
			4	TW			214												
			5	SS	1		213												
			6	TW			212												
			7	SS	2		211												
			8	SS	3		210												
			9	SS	12		209												
209.7	GLACIAL TILL - SILT - Sandy, trace gravel, occasional cobbles & boulders, grey, compact		10	SS	34		208												2 28 (70)
207.5	End of Borehole @ 9.6 m. Auger Refusal.																		

ON\_MOT\_BH-10 08-085 SOUTH TROUT CREEK.GPJ ON\_MOT\_GDT 09/11/23

## **APPENDIX B**

### **Laboratory Test Data**



Remarks:  
FILL

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ STC08-1	0.75	19	4.38	0.699	0.137	38.8	54.6	6.6	
* STC08-2	1.50	37.5	2.977	0.469	0.163	35.3	61.0	3.7	
× STC08-3	0.75	9.5	0.355	0.157		1.7	86.6	11.7	
+ STC08-5	0.75	19	1.46	0.41	0.129	21.0	72.5	6.5	



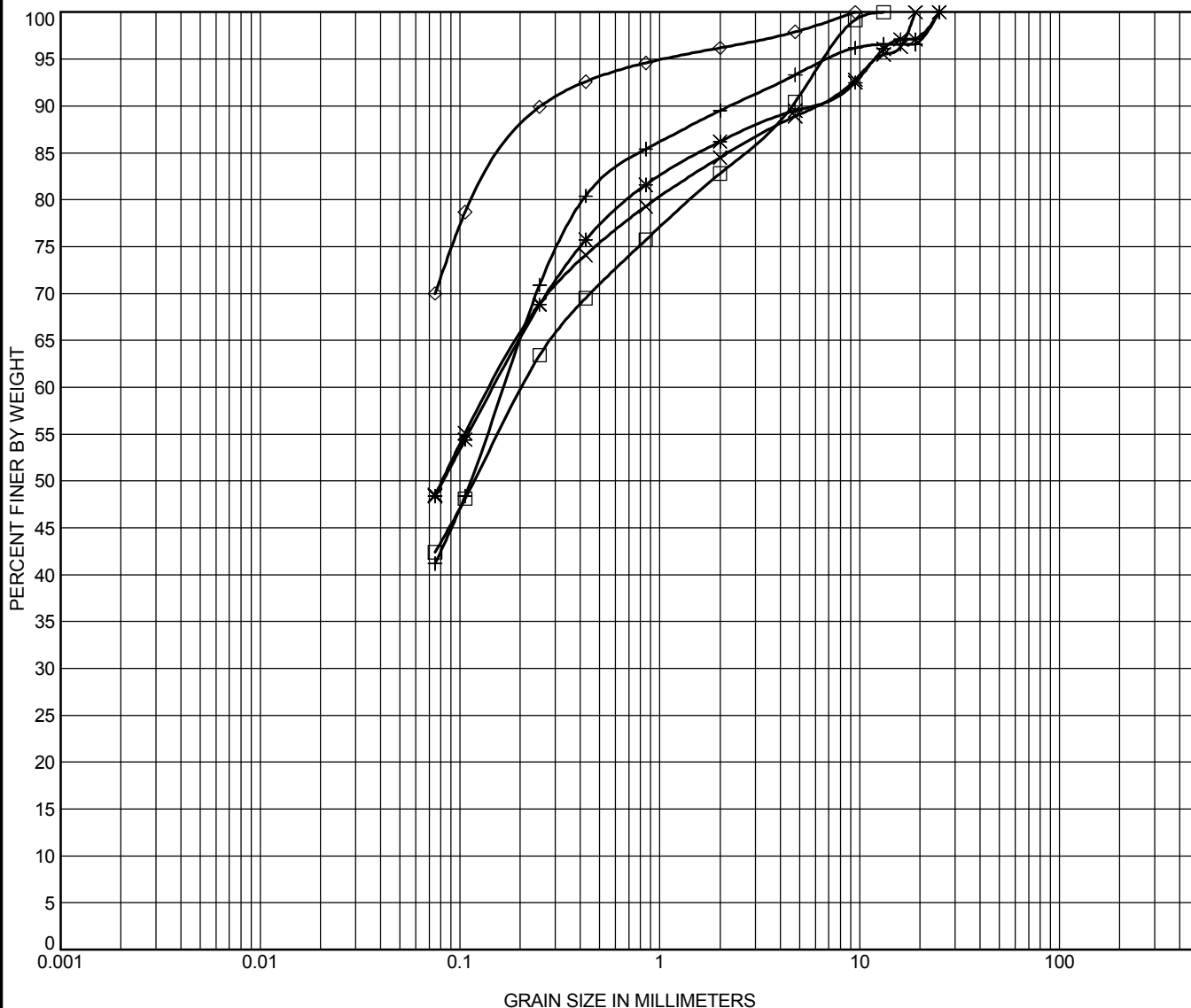
TBT Engineering Ltd.  
Suite 200, 101 Syndicate Ave. N.  
Thunder Bay, Ontario P7C 3V4  
PH: 807-624-5160  
FX: 807-264-5161  
Email: [tbte@tbte.ca](mailto:tbte@tbte.ca)  
Web: [www.tbte.ca](http://www.tbte.ca)

## GRAIN SIZE DISTRIBUTION

Project: South Trout Creek

W P: 496 00 00

DIST: 61 HWY: 11/17



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:  
TILL

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ STC08-1	7.60	13.2	0.207			9.6	48.0	42.4	
* STC08-2	6.10	25	0.148			10.5	41.1	48.4	
× STC08-4	6.10	19	0.144			11.1	40.4	48.5	
+ STC08-4	9.10	25	0.165			6.7	52.1	41.2	
◇ STC08-6	7.60	9.5				2.1	27.9	70.0	



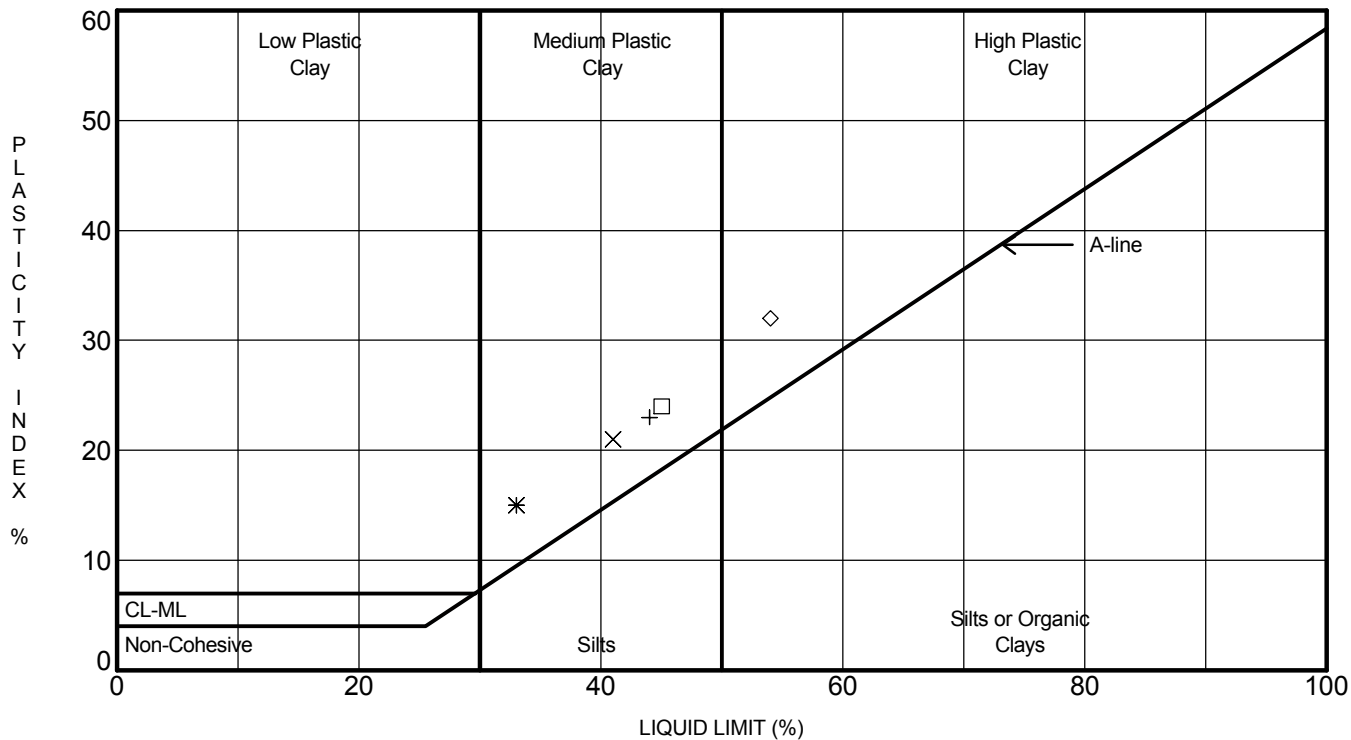
TBT Engineering Ltd.  
Suite 200, 101 Syndicate Ave. N.  
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PH: 807-624-5160  
FX: 807-264-5161  
Email: [tbte@tbte.ca](mailto:tbte@tbte.ca)  
Web: [www.tbte.ca](http://www.tbte.ca)

## GRAIN SIZE DISTRIBUTION

Project: South Trout Creek

W P: 496 00 00

DIST: 61 HWY: 11/17



TBT ATTARBURG MTO 08-085 SOUTH TROUT CREEK GPJ TBT MIN.GDT 09/9/25

Borehole No.	Sample No.	Depth (m)	LL %	PL %	PI %	M/C %
□ STC08-1		3.80	45	21	24	28
* STC08-3		2.30	33	18	15	24
× STC08-4		3.00	41	20	21	29
+ STC08-5		1.50	44	21	23	9
◇ STC08-6		4.60	54	22	32	56



**TBT Engineering Ltd.**  
 Suite 200, 101 Syndicate Ave. N.  
 Thunder Bay, Ontario P7C 3V4  
 Telephone: 807-624-5160  
 Fax: 807-264-5161

## ATTERBERG LIMIT RESULTS

W P: 496 00 00

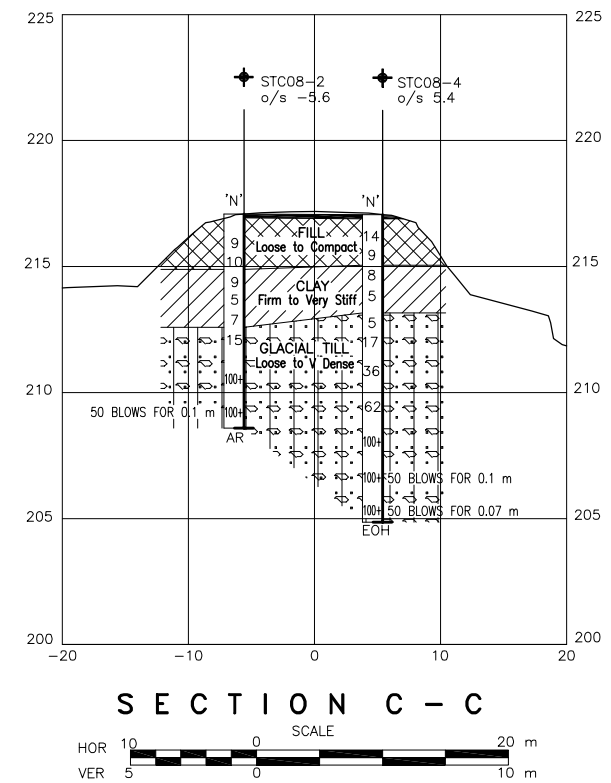
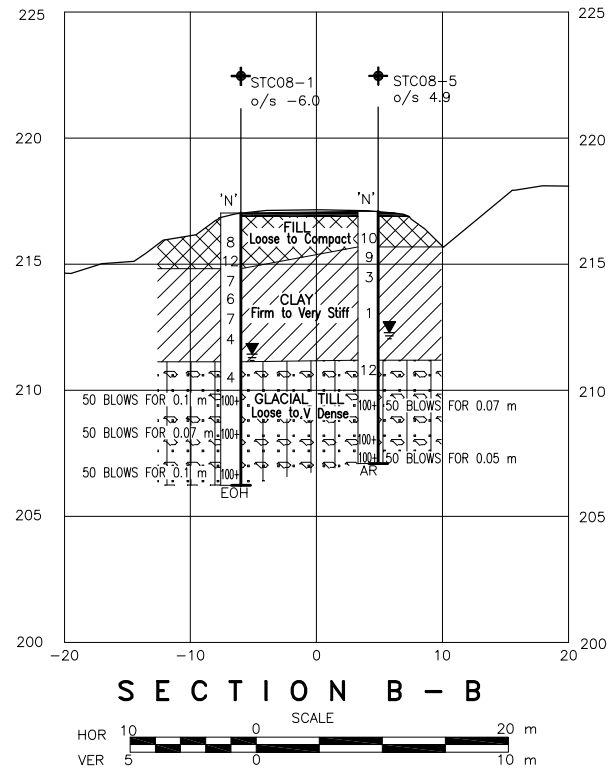
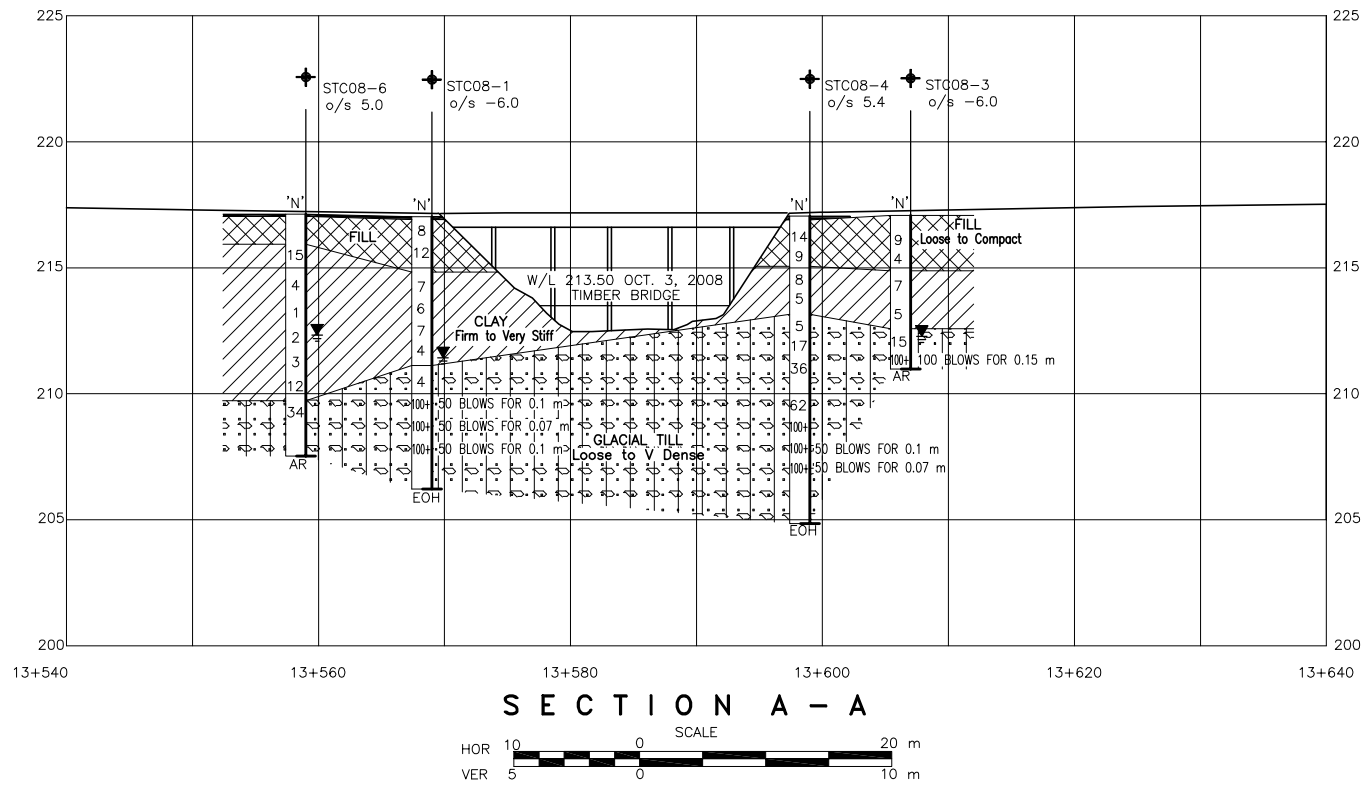
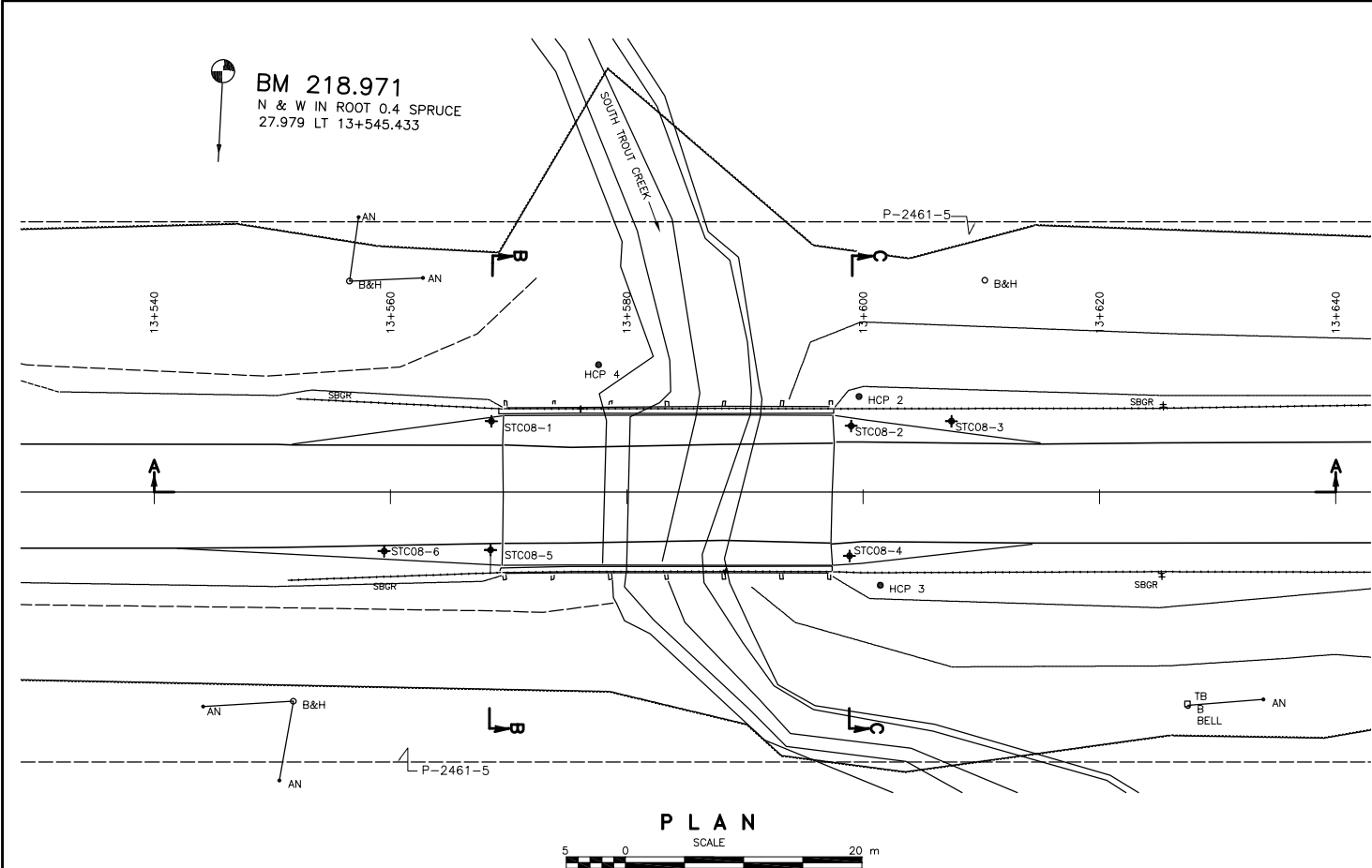
District: 61

Highway: 11/17



## **APPENDIX C**

### **Borehole Locations and Soil Strata Drawings**

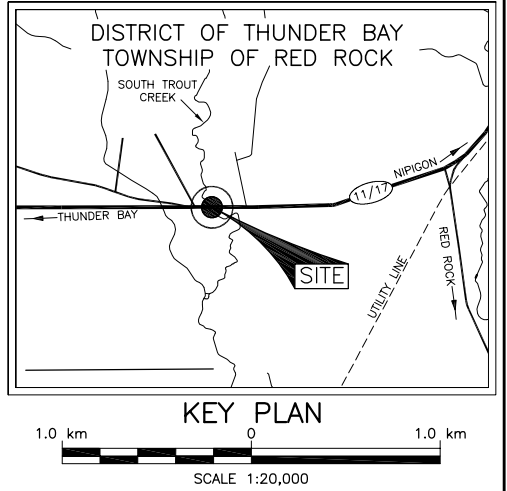


METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No xxxxxx  
GWP No 476-00-00  
GEOCRES No xxx-xxx

SOUTH TROUT CREEK BRIDGE  
TOWNSHIP OF RED ROCK  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



SOIL STRATA SYMBOLS

ASPHALT	CLAY
FILL	GLACIAL TILLS Non Cohesive

LEGEND

- Borehole
- 'N' Std Pen Test (Blows/0.3m)
- WL at time of investigation
- AR Auger Refusal
- EOH End of Borehole

—NOTE—

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

No	ELEVATION	CO-ORDINATES (MTM)	
		NORTH	EAST
STC08-1	217.0	14 5 424 476	205 910
STC08-2	217.1	14 5 424 490	205 937
STC08-3	217.1	14 5 424 494	205 945
STC08-4	217.1	14 5 424 480	205 942
STC08-5	217.1	14 5 424 467	205 915
STC08-6	217.1	14 5 424 463	205 907

REVISIONS					
	2009/11/23	DS	ISSUE FOR FINAL		
	2009/09/25	DS	OUT IN DRAFT		
	DATE	BY	REVISION		
STCB				DIST	THUNDER BAY
SUBM'D	..	CHECKED	DATE	HWY	11/17
DRAWN	DS	CHECKED	WH	APPROVED	DWG
					1

BASE DRAWING SUPPLIED BY HATCH MOTT MACDONALD.