

# Foundation Investigation and Design Report

## Culvert #17 Highway 101

Station 25+929 Township of Foleyet

GWP 5383-11-00

Geocres No.: 42B-11

### SUBMITTED TO:

Hatch Mott MacDonald  
200 South Syndicate  
Thunder Bay, Ontario  
P7E 1C9



### SUBMITTED BY:

#### TBT ENGINEERING LIMITED

1918 Yonge Street  
Thunder Bay, On  
P7E 6T9

### CONTACT PERSON:

Wayne Hurley, P.Eng.  
Steven Seller, P.Eng  
Phone: (807) 624-5160

### SUBMISSION DATE:

Mach 13, 2015



**TBT ENGINEERING**  
CONSULTING GROUP

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## **Part A - FOUNDATION INVESTIGATION REPORT**

### **1 Introduction**

TBT Engineering Limited (TBTE) has been retained by Hatch Mott MacDonald (HMM) to provide foundation investigation and design services for the proposed culvert replacements on Highway 101 at four separate locations. These sites are a part of the Highway 101, Highway 101 Resurfacing, from 0.3 km west of Young Street in Foleyet, easterly for 20.9 km, to 0.7 km east of Horwood Lake Road. The foundation investigations were conducted to provide subsurface data for the proposed culvert replacements.

This report addresses the conditions for Culvert #17 located at Sta. 25+929 in the Township of Foleyet. The remaining foundation sites (Culvert 21, Culvert 34 and Culvert 48) are addressed under separate covers.

This investigation consisted of two midpoint boreholes drilled adjacent to the existing culvert, two boreholes drilled for roadway protection, two boreholes drilled at the culvert openings, laboratory testing and geotechnical analysis of the data. This report (Part A) describes the subsurface conditions encountered during the investigation. The boreholes are labeled from 400 to 405.

The foundation section has assigned GEOCRES No. 42B-11 to this site.

## 2 Site Description

The foundation investigations were carried out to investigate subsurface conditions for Culvert #17 located at Sta. 25+929 along Hwy 101 in the Township of Foleyet, County of New Liskeard Area. The culvert located at this site is a 1500 mm centreline CSP which is to be replaced with an 1800 mm pipe culvert. The culvert services the Black creek.

The culvert site is located in a rural area of moderate terrain relief. The area is generally tree covered with bedrock outcrops.

The road embankment at this location is approximately 5.5 m high with side slopes of approximately 2 horizontal to 1 vertical on both the right and left side. The left side of road embankment side slope steepens to approximately 1 horizontal to 1 vertical from 3.5 m below the top of the embankment to the original ground elevation. A low lying swamp area was encountered at both ends of the existing culvert along Highway 101. There is a bedrock outcrop westerly on the right side of the highway. The water level in the water course at the culvert inlet was measured at approx. elevation of 323.4 on September 11, 2013.

**Photo 2.1 – Looking Easterly from Culvert**



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## **2.1 Surficial Geology**

Available surficial geology mapping (OGS NOEGTS Map 5102 . Foleyet) indicates the site is located in a terrain unit comprised of bedrock knob with a subordinate landform of sand and boulder till ground moraine. The surrounding terrain is of moderate local relief which is rolling to undulating.

## **3 Investigation Procedures**

A geotechnical site investigation was undertaken from September 11 to the 21, 2013 for Boreholes 400 . 404 and November 26, 2013 for Borehole 405. The borehole locations are illustrated on the Borehole Location and Soil Strata Drawing found in Appendix D.

The borehole locations were identified in the field by TBTE personnel and service clearances were completed prior to mobilizing the drill rig to site. The boreholes were advanced using an all-terrain mounted drill rig equipped with hollow stem augers and a cat head used to carry out Standard Penetration Testing (SPT). Where auger drilling methods proved unsatisfactory, casing was advanced using wash boring techniques. Soil samples were obtained from the auger flights and using a split spoon sampler as a part of the Standard Penetration Testing . Refusal material was sampled using diamond coring techniques. Due to poor ground conditions swamp mats were used to gain access to drill the borehole at the culvert outlet (Borehole 405).

Surveys were completed by HMM and were based on North American Datum 1983, MTM CSRS Zone 12. HMM has indicated control was established from existing published Horizontal Control Monuments and a Geodetic Benchmark using the Canadian Geodetic Vertical Datum 1928. The following horizontal control points and vertical control points were utilized throughout this project (as provided by HMM):

- HCM #00820020065, #00820020066, #00820020067, #00820020068, #00820020071, #00820020072 and #00820020073
- VCM (GBM) #00819728231 Elev. 329.411, #00819728232 Elev. 328.108, #00819728233 Elev. 343.051, #00819728235 Elev. 345.516, #00819728236 Elev. 349.557 and #00819728239 Elev. 336.635

All boreholes were backfilled with a bentonite mixture following drilling. Temporary standpipes have been removed and decommissioned.

#### **4 Laboratory Testing**

Samples which were obtained during the field investigation were subjected to routine laboratory testing. The routine testing included moisture content, Atterberg limits and grain size analysis (where appropriate). The results of this testing are shown on the Borehole Logs (Appendix A) and on the laboratory data reports (Appendix B).

#### **5 Sub-Surface Conditions**

Details of the subsurface conditions are provided on the borehole and core logs (Appendix A) and on the Soil Strata Drawing (Appendix D).

The subsurface soils at this site typically consist of fills (through the embankment) which overlie silts over bedrock. All boreholes with the exception of Borehole 400 extended to refusal material which was drilled and/or sampled using diamond casing/coring techniques.

##### **5.1 Asphalt**

Asphalt was encountered at ground surface at Boreholes 401, 402, 403, and 404. The asphalt thickness is 45 mm.

##### **5.2 Organic Matter**

Organic matter was encountered at the ground surface of Borehole 400 and 405. The material thickness ranged between 0.2 to 0.5 m.

##### **5.3 Fill - Sand**

Sand and gravel fill to sand and silt with trace gravel was encountered beneath the asphalt at Boreholes 401, 402, 403, and 404, and beneath the organic matter at Boreholes 400 and 405. The fill was encountered at elevations 328.1 to 328.3 and varied in thicknesses from 3.9 to 5.9 m at Boreholes 401, 402, 403 and 404. At Boreholes 400 and 405 the fill was encountered at elevations 323.4 and 324.4 with thickness of 2.9 and 0.2 m, respectively.



Four samples were selected for grain size distribution testing. The fill ranges from silt and sand with trace gravel; sand with some silt; to sand and gravel with trace silt. The test results indicate a grain size distribution of 0 to 35 % gravel, 37 to 84 % sand, and 8 to 58 % silt/clay sized particles. The presence of cobbles was noted within the fill. At several locations casing was used to advance the borehole through coarser materials following auger refusal.

Some organics were observed in the fill at Borehole 400 which was drilled near the toe of the slope.

The sand is typically compact to very dense as indicated by  $N_{60}$  values ranging from 16 to 48 blows/0.3 m. The fill is in a very loose to loose condition at Borehole 400 as indicated by  $N_{60}$  values ranging from 2 to 9 blows/0.3m.

#### **5.4 Silt**

Silt was encountered beneath the fill in all six boreholes. The silt layer was encountered at elevations ranging from 321.0 to 324.5 and varied in thickness from 4.2 to 10.3 m.

Nine samples were selected for grain size distribution testing. The material ranges from silt with trace to some sand. The test results indicate a grain size distribution of 0 % gravel, 1 to 12 % sand, and 88 to 100 % silt/clay sized particles. Atterberg limit tests conducted on selected samples of the silt indicates the material is non plastic.

The silt is typically loose to compact as indicated by  $N_{60}$  values ranging from 5 to 23 blows/0.3 m. A single  $N_{60}$  value of 3 blows/0.3 m was recorded at Borehole 405 at a depth of 9.1 m. At Borehole 401 at a depth of 13.6 m a very dense silt layer was encountered as indicated by an  $N_{60}$  value of 100+ blows/0.3 m.

#### **5.5 Sand**

Silty sand was encountered below the silt in Borehole 400. The sand layer was encountered at an elevation 316.8 with a thickness of 1.5 m. The sand is very loose indicated by an  $N_{60}$  value of 1 blows/0.3m.

## 5.6 Gravel

A silty, sandy gravel layer with occasional cobbles was encountered below the sand in Borehole 400 and below the silt in Borehole 404. The gravel layer was encountered at an elevation of 315.3 with a thickness of 0.3 m. Grain size analysis conducted on selected samples of the gravel layer indicate the layer consist of 55% gravel , 22 % sand and 24% silt/clay size particles. The gravel is dense to very dense as indicated by an  $N_{60}$  value of 49 blows/0.3m.

## 5.7 Bedrock

Bedrock was encountered at all borehole locations with the exception of Borehole 400. The following table indicates the recorded bedrock elevation and depth at each borehole. Bedrock was encountered underlying the silt at Borehole 401,402,403 and 405 and underlying gravel at Borehole 400. Bedrock was sampled using diamond coring techniques. The bedrock in Boreholes 401,402,403,404 and 405 is composed of medium grained monzodiorite, with Borehole 400 composed of fine grained biotite granite. Detailed core logs and photos of the rock cores are provided in Appendix A.

**Table 5.1: Bedrock**

Borehole Number	Bedrock Depth (m)	Bedrock Elevation
401	1.4	314.2
402	1.3	314.6
403	1.5	313.5
404	1.5	314.7
405	1.7	314.0

The rock quality designation (RQD) is an indirect measure of the number of fractures and the amount of jointing in the rock mass. The RQD is expressed as a percentage of the ratio of summed core lengths (greater than 100 mm) to the total length cored. The RQD index is used to provide a classification for the rock quality according to the following limits.



**Table 5.2: RQD/ Rock Quality Correlation**

RQD %	ROCK QUALITY
0 . 25	Very Poor
25 . 50	Poor
50 . 75	Fair
75 . 90	Good
90 . 100	Excellent

The RQD as presented on the borehole and core logs varies from 38 to 100 %. The majority of RQDs were measured to be 68 to 100 % and can be described as fair to excellent, with one sample with an RQD of 38 % indicating poor quality at Borehole 402. In order to classify the bedrock with respect to strength, point load tests were conducted on selected core samples. The test results are tabulated below.

**Table 5.3: Estimated Uniaxial Compressive Strength**

Borehole Number	Depth (m)	Elevation	*Estimated Uniaxial Compressive Strength (MPa)
401	14.3	314.1	265
	14.80	313.6	271
402	13.80	314.5	245
	14.70	313.6	172
403	15.40	312.8	85
	15.90	312.3	232
404	13.80	314.6	215
	14.90	313.5	272

\* Estimated based on published correlations.

Based on the range in estimated uniaxial compressive strength, the intact bedrock is classified as strong to extremely strong.

## **5.8 Ground Water**

The ground water levels were observed upon completion of drilling from September 11 to November 26, 2013 are provided below. Ground water levels will vary from season to season and from the effects of heavy precipitation events. The water level at the culvert inlet was measured at approx. elevation of 323.4 on September 11, 2013.

**Table 5.4: Ground Water Level**

Borehole	Depth below Ground Surface (m)	Elevation
400	0.5	323.4
405	0.9	323.7

## **6 Miscellaneous**

Laboratory testing was carried out at the TBT Engineering Limited laboratory in Thunder Bay. The drill equipment for this investigation was operated by TBT Engineering. The field operations were supervised by Alan Finke and Peter Pilgrim. Laboratory testing was supervised by T. Fummerton C.E.T. This report was prepared by Steven Seller, P.Eng, and reviewed by W. Hurley, P.Eng (TBTE designated principal contact identified for MTO Foundation Engineering projects).

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## **Part B - FOUNDATION DESIGN RECOMMENDATIONS**

### **7 Introduction**

TBT Engineering Limited (TBTE) has been retained by Hatch Mott MacDonald (HMM) to provide foundation investigation and design services for the proposed culvert replacements on Highway 101. There are four culvert sites along Highway 101, which require investigation for the Highway 101 Resurfacing, from 0.3 km west of Young Street in Foleyet, easterly for 20.9 km, to 0.7 km east of Horwood Lake Road. This report addresses the conditions at Culvert 17 located at Sta. 25+929 in the Township of Foleyet. The final design of the proposed culverts could include the use of closed bottom culverts and/or open footing culverts.

The foundation investigations as described in Part A, was completed to investigate subsurface conditions at this site. The investigation at Culvert #17 consisted of six boreholes; BH 400, 401, 402, 403, 404 and 405.

The subsurface soils at this site typically consist of fills which overlie silt over bedrock. Gravel with occasional cobbles was present in the fill and native silt.

The purpose of this section of the report (Part B) is to provide foundation design recommendations for various foundation options. These are based on the conditions encountered at the borehole locations and TBTE's interpretation of the subsurface conditions at the sites.

## 8 Structure Foundations

The culvert located at this site is a 1500 mm centreline CSP which is to be replaced with an 1800mm pipe culvert. The culvert services the Black creek.

The culvert site is located in a rural area of moderate terrain relief. The area is generally tree covered with bedrock outcrops.

The road embankment at this location is approximately 5.5 m high with side slopes of approximately 2 horizontal to 1 vertical on both the right and left side. The left side of road embankment side slope steepens to approximately 1 horizontal to 1 vertical from 3.5 m below the embankment crest to the original ground elevation. A low lying swamp area was encountered at both ends of the existing culvert along Highway 101. There is a bedrock outcrop westerly on the right side of the highway. The water level in the water course at the culvert inlet was measured at approx. elevation of 323.4 on September 11, 2013.

### 8.1 Initial Foundation Option Considerations

Multiple foundation systems have been considered for the proposed culvert replacement. The foundation systems considered are presented in the following table:

**Table 8.1: Foundation Options**

Option		Advantages	Disadvantages	Comments
Closed Bottom Culvert	Timber, steel or concrete culvert with appropriate bedding. Similar to existing culvert.	<ul style="list-style-type: none"> <li>- Least costly option</li> <li>- Least excavation required</li> </ul>	<ul style="list-style-type: none"> <li>- Requires removal of existing culvert and any associated channel bedding material</li> <li>- Requires construction within the creek</li> </ul>	Recommended.
Open Footing Culvert	Footings on Native Sand	<ul style="list-style-type: none"> <li>- Longer spans may be considered to minimize construction within the existing channel.</li> <li>- Existing culvert can be left in place.</li> <li>- Least excavation required of footing options.</li> <li>- Less costly than footings on rock fill.</li> <li>- No rock fill required.</li> </ul>	<ul style="list-style-type: none"> <li>- Excavation below water is required.</li> <li>- Low geotechnical resistance and reactions.</li> <li>- Potential disturbance of subgrade during construction.</li> <li>- Mitigation of frost effects requires extensive fill cover..</li> </ul>	Not Recommended.
	Footing on Rock Fill	<ul style="list-style-type: none"> <li>- Longer spans may be considered to minimize construction within the existing channel.</li> <li>- Highest geotechnical capacities for footings.</li> <li>- Allows for construction of shallow footings.</li> <li>- Less costly than piled options.</li> <li>- Rock fill cover and pad below footing</li> </ul>	<ul style="list-style-type: none"> <li>- Excavation below water is required.</li> <li>- Additional cost for rock fill</li> <li>- Rock fill cannot be compacted below water</li> <li>- Potential disturbance of subgrade during construction.</li> </ul>	Not Recommended.

		can be considered to reduce / limit frost effects.		
	Driven Piles	<ul style="list-style-type: none"> <li>- Typically high geotechnical capacity is achieved.</li> <li>- Excavation below water level may be reduced or eliminated.</li> <li>- Longer spans may be considered to minimize construction within the existing channel.</li> </ul>	<ul style="list-style-type: none"> <li>- Driven piles are expected to encounter shallow refusal.</li> <li>- Short piles are more likely to wander/walk+during driving.</li> <li>- Additional costs for cranes.</li> <li>- Additional property required for laydown areas for materials.</li> </ul>	Not Recommended.
	Drilled Piles	<ul style="list-style-type: none"> <li>- Typically high geotechnical capacity is achieved.</li> <li>- Excavation below water level may be reduced or eliminated.</li> </ul>	<ul style="list-style-type: none"> <li>- Additional costs for speciality contractor.</li> </ul>	Not Recommended.
Sheet Pile Structure	Sheet piles with structural slab.	<ul style="list-style-type: none"> <li>- Limited excavation required.</li> <li>- Can be constructed outside of channel footprint.</li> <li>- Construction within the existing channel can be minimized.</li> </ul>	<ul style="list-style-type: none"> <li>- Driven/Vibrated piles are expected to encounter shallow refusal.</li> <li>- Additional costs for cranes.</li> <li>- Additional property required for laydown areas for materials.</li> <li>- Anticipated inadequate penetration and toe resistance.</li> </ul>	Not Recommended.

Design parameters for the above recommended foundation system are presented below. It is understood that there will be no horizontal or vertical realignment at the culvert location and the anticipated replacement structure is a closed bottom corrugated steel pipe. Design recommendations are provided for this culvert configuration.

## **8.2 Closed Bottom Culverts**

Closed bottom culverts can be placed on compacted granular material either in an earth excavation, or natural embankment. The culvert shall be placed on appropriate bedding fill material and backfilled in accordance with the appropriate OPSD 800 series drawings. Any organic materials encountered at the culvert location shall be removed as indicated in OPSD 203.040.

The soil through the embankment and the native silt can be preliminarily classified as Type 3 soils, as defined by the Occupational Health and Safety Act and Regulations for Construction Projects. The soil types should be reassessed as excavations proceed and adjustments to construction methodologies should be taken as required.

## **9 Culvert Camber**

The provision of culvert camber is not anticipated as the final vertical alignment of the highway will not be increased, and therefore settlements of the embankment will be negligible.

## **10 Culvert Replacement - Staging**

### **10.1 Staging - General**

The replacement of the culvert must be completed utilizing a staged construction methodology. In order to provide a single trafficable lane (during construction) and expose sufficient length of existing culvert the existing roadway must be temporarily widened. The placement of the temporary widening can induce up to a maximum of 25 mm of settlement, which may not be fully realized during construction operations. Any organics encountered beneath the widening shall be removed both along the existing slope and along the native ground.

The staging is understood to incorporate three stages:



- " Stage 1 . Temporary trafficable lane on the left side.
- " Stage 2 . Temporary trafficable lane on the right side.
- " Stage 3 . Final roadway configuration.

## 10.2 Staging - Geotechnical Model

Stability modeling was carried out using Slope/W software and limit equilibrium analysis using the Morgenstern-Price method.

The soil properties established for the embankment and foundation soils are presented in Table 10.1. The estimated strength properties of the native soils have been based on published correlations with index tests.

Stability analyses have been completed to investigate potential configurations for the proposed embankments (based on provided drawings) during construction for the proposed culvert replacement. The design was based on providing a minimum calculated factor of safety (FoS) of 1.3 during construction (staging embankments), a (FoS) of 1.3 for final configuration. A uniformly distributed traffic load of 20 kPa over the traversable lane(s) was applied in both cases.

**Table 10.1: Stability Analyses Soil Properties**

Soil	Effective Shear Strength Properties		Unit Weight, (kN/m <sup>3</sup> )
	Effective Angle of Internal Friction, $\phi$ (degrees)	Effective Cohesion Intercept, $C_q$ (kPa)	
Granular B Type I	35	0	20
Compact Sand/Gravel Fill	33	0	20
Existing Sand and Gravel Fill	32	0	20
Native Silt	29	0	20

Granular B Type 2 and/or rock fill were not considered for this project due to a lack of availability.

## 10.3 Stability Analysis Results and Recommendations

Slope stability modeling was completed based on the staging drawings provided by HMM. The culvert will be replaced in two stages, with traffic maintained over alternate

sections. This may require a significant longitudinal section of temporary road construction. The final roadway embankment will then be restored at its current location (Stage 3).

Various slope configurations were analyzed to determine sections which would meet the design stability requirements. The results of the stability analyses for suitable sections have been included in Appendix C and are summarized below.

**Table 10.2 – Stability Analysis Results**

Stage	Seismic Load	Minimum FoS	Target Fos	Comment
1	No	1.3	1.3	-
2	No	1.3	1.3	-
3	No	1.3	1.3	Constructed from Compact Sand
3	No	1.4	1.3	Constructed from Compact Granular B Type 1

The following recommendations have been derived from the analysis:

- Slopes through existing embankment fills shall be constructed at 2(H):1(V) or flatter.
- Temporary slopes constructed of compacted reworked embankment fill (sand fill to sandy gravel fill) shall be constructed at 2(H):1(V) or flatter (FoS 1.3).
- Permanent slopes constructed of compacted reworked embankment fill (sand fill to sandy gravel fill) shall be constructed at 2(H):1(V) or flatter (FoS 1.3).
- Permanent slopes constructed of compacted Granular B Type 1 shall be constructed at 2(H):1(V) or flatter (FoS 1.4).
- Culvert extensions will be required to accommodate the temporary trafficable lanes, for Stage 1.

## **11 Temporary Roadway Protection**

Staging configurations may require shallow roadway protection. The presence of cobbles within the fill and limited depth of bedrock may limit the use of conventional sheet piling. Bracing may be required to provide lateral support. . Pre-excavation may be required due to the presence of cobbles and potentially boulders within the fill

Gravity wall designs may be considered where space is available.

Vertical roadway protection may be completed using soldier pile and lagging systems. The soldier piles could be installed in drilled holes in the bedrock to provide toe support. The wall system should be designed to provide support in both directions (i.e. as each side of the embankment is constructed).

Lateral support of the system may be attained using anchors into the soils behind the wall system. The anchor system would have to be designed to provide support from beyond the active zone behind the wall system. There may be insufficient soil section available in all sections of the embankment for conventional embedded soil supported anchors. Methods using deadmen, rakers or other form of support may be needed.

These systems may be designed using the methods provided in the CHDBC. Lateral loads should include active or at-rest pressures as appropriate for soil and traffic loadings and the compaction surcharge as described in Section 12. Active loads are appropriate for yielding conditions while at-rest pressures should be used for non-yielding cases

## **12 Backfill and Bedding Material**

The existing site materials may not be suitable for use as structural backfill or bedding. Testing and sorting of the existing embankment materials will be required to ensure that they are acceptable and do not contain frost susceptible soils. Granular ~~%B+~~ Type I or Granular ~~%A+~~ may be specified as structural backfill in specific zones. Placement of backfill material around the culvert should be completed in accordance with the manufacturer's recommendations. The culvert must also be designed to resist hydrostatic pressures where applicable.

Lateral earth pressure coefficients for potential granular backfill at level ground conditions have been provided in Table 12.1.

**Table 12.1: Lateral Earth Pressure Coefficients**

Lateral Earth Pressure Coefficients (K)					
Compacted Granular Backfill	Phi' (°)	Bulk Unit Weight of Soil, (kN/m <sup>3</sup> )	Active Ka	At Rest Ko	Passive Kp
Granular A,	35	20 - 22	0.27	0.43	3.7
Granular B Type I	35	20 - 22	0.27	0.43	3.7

No factor of safety or resistance factor has been included in the above coefficients.

A compaction surcharge should be accounted for in accordance with the Canadian Highway Bridge Design Code (CHBDC) Section 6.9.3 when calculating lateral pressures.

### 13 Seismic Considerations

The following seismic parameters have been based on Section 4.4 of the Canadian Highway Bridge Design Code and Figure A3.1.6, and the data provided in Table A3.1.1 based on Timmins, Ontario:

- Peak Horizontal Acceleration of 0.04 to 0.08 g
- Zonal Acceleration Ratio of 0.05
- Zonal Velocity Ratio of 0.05
- Velocity Related Seismic Zone of 0
- Acceleration Related Seismic Zone of 1

Based on the subsurface soil stratigraphy at this site the site has been determined to be Soil Profile Type 1. Therefore, according to Table 4.4 of the Canadian Highway Bridge Design Code, a Site Coefficient  $S_s$  (ground motion amplification factor) of 1 should be used in seismic design.

Retaining structures (if any) should be designed using earth pressure coefficients that incorporate the effects of earthquake loading. The seismic component of the earth pressure distribution is additional to the static earth pressure distribution. The seismic distribution may be taken as an inverted triangle with the maximum pressure at the top of the wall/structure and the minimum pressure at the toe. These earth pressure coefficients should be determined as per the Canadian Highway Bridge Design Code Section 4.6.4.

The foundation soils at the site are assessed as not being prone to liquefaction

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## **14 Dewatering, Excavations and Channel Diversion**

Excavations should be excavated and sloped in accordance with the requirements of the Occupational Health and Safety act. Potential obstructions such as the cobbles within the embankment materials should be noted as described in the nonstandard provision provided in Appendix E. The soils below the ground water level are fined grained and of low permeability. Flows in to open excavations below the ground water level may be rapid if zones of more permeable soils are encountered.

Channel diversion is not anticipated to be required during construction.

Improvements/revisions to the channel may be required following removal of the existing culvert. It is anticipated the excavations will be carried out using conventional construction with dam and pump methods to allow culvert construction in the dry. Foundation implications are expected to be minimal, providing the new culvert spans the full channel width.

## **15 Scour Protection**

Where appropriate, foundation elements should be provided with sufficient scour protection in the event of elevated river levels. Scour protection should be designed taking into account hydrologic and hydraulic concerns and in accordance with Section 1.10.5 of the Canadian Highway Bridge Design Code.

## **16 Estimated Frost Depth and 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 2.4 m. The embankment soils anticipated within the frost depth are considered to be of low frost susceptibility (MTO Pavement Design and Rehabilitation Manual). Frost treatments should conform to OPSD 803.031.

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## **17 Potential Construction Issues**

No major construction difficulties are foreseen at this site. Issues which may require consideration include:

- Control of surface water during construction. Permanent positive drainage will be ensured during the design phase.
- Control of groundwater during excavation below the creek/groundwater level.
- Excavation through existing fill material may be difficult due to the presence of cobbles. The contractor should have adequate equipment on site.



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## **18 Limitations**

Conclusions and recommendations presented in this report are based on the information determined at the borehole 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 comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

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.

## 19 Closure

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

Yours truly,

For TBT ENGINEERING



Steven Seller, P.Eng  
Project Engineer



Wayne Hurley, P.Eng.  
Senior Engineer  
Principal Contact for MTO Foundations

## **APPENDIX A**

### **Borehole Logs**

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING		MECHANICAL PROPERTIES OF SOIL	
S S SPLIT SPOON	T P THINWALL PISTON	$m_v$	$\text{kPa}^{-1}$ COEFFICIENT OF VOLUME CHANGE
W S WASH SAMPLE	O S OSTERBERG SAMPLE	$C_c$	1 COMPRESSION INDEX
S T SLOTTED TUBE SAMPLE	R C ROCK CORE	$C_s$	1 SWELLING INDEX
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY	$C_a$	1 RATE OF SECONDARY CONSOLIDATION
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY	$C_v$	$\text{m}^2/\text{s}$ COEFFICIENT OF CONSOLIDATION
T W THINWALL OPEN	F S FOIL SAMPLE	H	m DRAINAGE PATH
<b>STRESS AND STRAIN</b>		$T_v$	1 TIME FACTOR
		U	% DEGREE OF CONSOLIDATION
$u_w$	kPa PORE WATER PRESSURE	$\sigma'_{vo}$	kPa EFFECTIVE OVERBURDEN PRESSURE
$i$	PORE PRESSURE RATIO	$\sigma'_p$	kPa PRECONSOLIDATION PRESSURE
$\sigma$	kPa TOTAL NORMAL STRESS	$\tau_f$	kPa SHEAR STRENGTH
$\sigma'$	kPa EFFECTIVE NORMAL STRESS	$c'$	kPa EFFECTIVE COHESION INTERCEPT
$\tau$	kPa SHEAR STRESS	$\phi'$	-° EFFECTIVE ANGLE OF INTERNAL FRICTION
$\sigma_1, \sigma_2, \sigma_3$	kPa PRINCIPAL STRESSES	$C_u$	kPa APPARENT COHESION INTERCEPT
$\epsilon$	% LINEAR STRAIN	$\phi_u$	-° APPARENT ANGLE OF INTERNAL FRICTION
$\epsilon_1, \epsilon_2, \epsilon_3$	% PRINCIPAL STRAINS	$\tau_R$	kPa RESIDUAL SHEAR STRENGTH
E	kPa MODULUS OF LINEAR DEFORMATION	$\tau_r$	kPa REMOULDED SHEAR STRENGTH
G	kPa MODULUS OF SHEAR DEFORMATION	$S_i$	1 SENSITIVITY = $\frac{C_u}{\tau_r}$
$\mu$	1 COEFFICIENT OF FRICTION		
<b>PHYSICAL PROPERTIES OF SOIL</b>			
$\rho_s$	$\text{kg}/\text{m}^3$ DENSITY OF SOLID PARTICLES	e	1, % VOID RATIO
$\gamma_s$	$\text{kN}/\text{m}^3$ UNIT WEIGHT OF SOLID PARTICLES	n	1, % POROSITY
$\rho_w$	$\text{kg}/\text{m}^3$ DENSITY OF WATER	w	1, % WATER CONTENT
$\gamma_w$	$\text{kN}/\text{m}^3$ UNIT WEIGHT OF WATER	$S_r$	% DEGREE OF SATURATION
$\rho$	$\text{kg}/\text{m}^3$ DENSITY OF SOIL	$w_L$	% LIQUID LIMIT
$\gamma$	$\text{kN}/\text{m}^3$ UNIT WEIGHT OF SOIL	$w_p$	% PLASTIC LIMIT
$\rho_d$	$\text{kg}/\text{m}^3$ DENSITY OF DRY SOIL	$w_s$	% SHRINKAGE LIMIT
$\gamma_d$	$\text{kN}/\text{m}^3$ UNIT WEIGHT OF DRY SOIL	$I_p$	% PLASTICITY INDEX = $w_L - w_p$
$\rho_{sat}$	$\text{kg}/\text{m}^3$ DENSITY OF SATURATED SOIL	$I_L$	1 LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
$\gamma_{sat}$	$\text{kN}/\text{m}^3$ UNIT WEIGHT OF SATURATED SOIL	$I_C$	1 CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
$\rho'$	$\text{kg}/\text{m}^3$ DENSITY OF SUBMERGED SOIL	$e_{max}$	1, % VOID RATIO IN LOOSEST STATE
$\gamma'$	$\text{kN}/\text{m}^3$ UNIT WEIGHT OF SUBMERGED SOIL	$e_{min}$	1, % VOID RATIO IN DENSEST STATE
		$I_D$	1 DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
		D	mm GRAIN DIAMETER
		$D_n$	mm n PERCENT - DIAMETER
		$C_u$	1 UNIFORMITY COEFFICIENT
		h	m HYDRAULIC HEAD OR POTENTIAL
		q	$\text{m}^3/\text{s}$ RATE OF DISCHARGE
		v	m/s DISCHARGE VELOCITY
		i	1 HYDRAULIC GRADIENT
		k	m/s HYDRAULIC CONDUCTIVITY
		j	$\text{kn}/\text{m}^2$ SEEPAGE FORCE

TBT Engineering Consulting Group			<b>RECORD OF Borehole No 400</b>			1 OF 1		<b>METRIC</b>											
W.P. <b>5383-11-00</b>			PROJECT <b>Culvert Investigation</b>			SITE NO. <b>Culvert #17</b>		ORIGINATED BY <b>C.H.</b>											
TWP <b>Foleyet</b> HWY <b>101</b>			LOCATION <b>MTM N5347486.648, E200325.713</b>			TBTE JOB# <b>13-121</b>		COMPILED BY <b>T.B.</b>											
DATE <b>2013 September 11</b>			BOREHOLE TYPE <b>Hollow Stem Auger</b>			DATUM <b>Geodetic</b>		CHECKED BY <b>S.S.</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>	20 40 60	20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60 80 100	20 40 60	20 40 60 80 100	20 40 60 80 100	GR SA SI CL
323.9 0.0	ORGANIC - some silt, grey		1	AS			323												5 37 465812
323.4 0.5	FILL - SILT & SAND - some organics, trace gravel, very loose to loose, grey		2	SS	2		322												Non Plastic. Water level @ 0.5 m on September 20, 2013.
			3	SS	9		321												0 3 649733
321.0 2.9	SILT - trace sand, grey, loose		4	SS	7		320												0 0 720028
		5	SS	5	319													Non Plastic.	
316.8 7.1	SAND - Silty, very loose	6	SS	5	318													0 1 749924	
		7	SS	5	317													Non Plastic.	
315.3 8.9	GRAVEL - Silty, Sandy, grey, very dense	8	SS	1	316													55 22 (24)	
	End of Borehole @ 8.9 m.	9	SS	49	315														

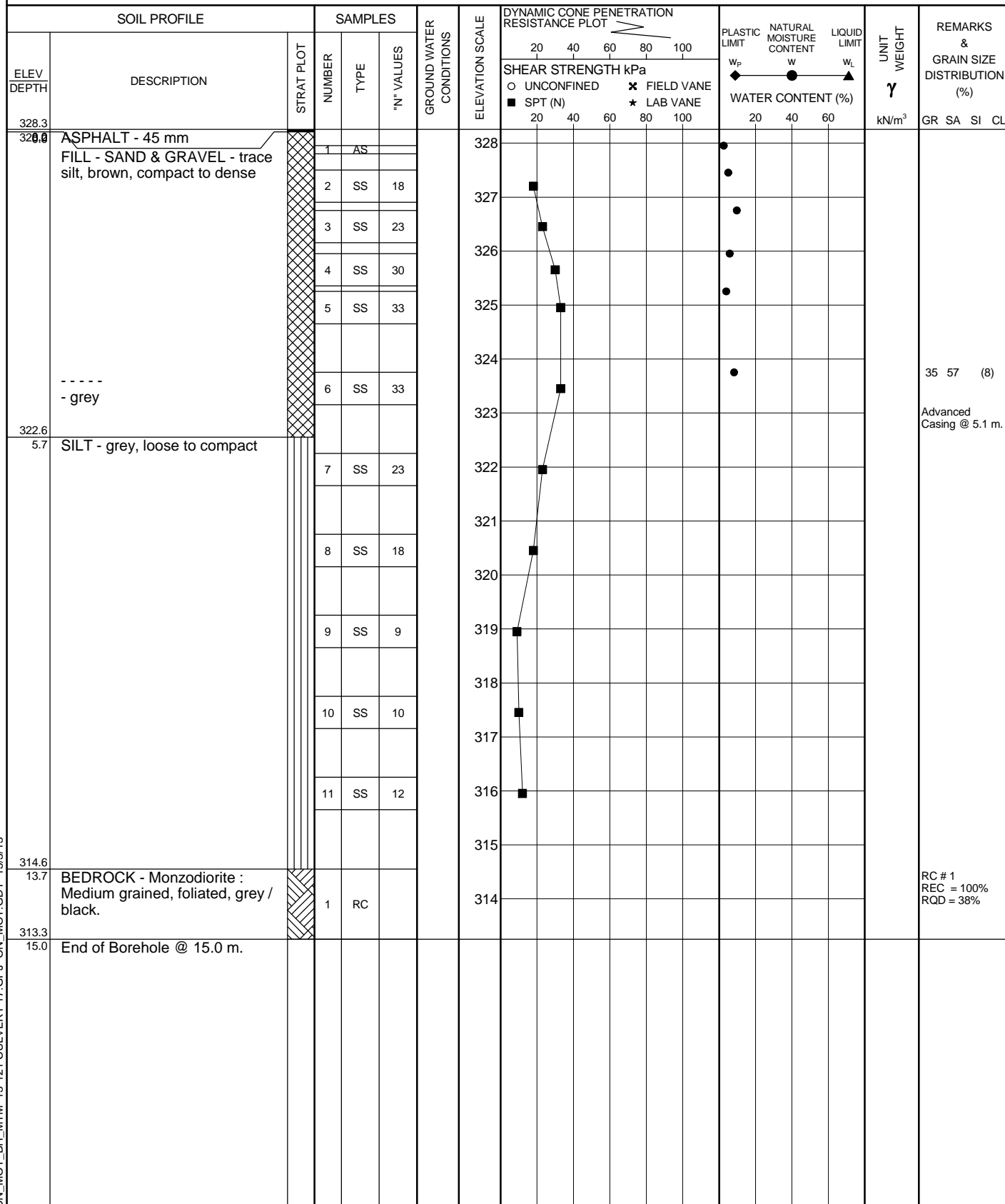
x<sup>3</sup>, \*<sup>3</sup>: Numbers refer to Sensitivity  
 NP Non Plastic  
 ○ 3% STRAIN AT FAILURE

ONL\_MOT\_BH\_MTM 13-121 CULVERT 17.GPJ ONL\_MOT\_GDT 15/3/13



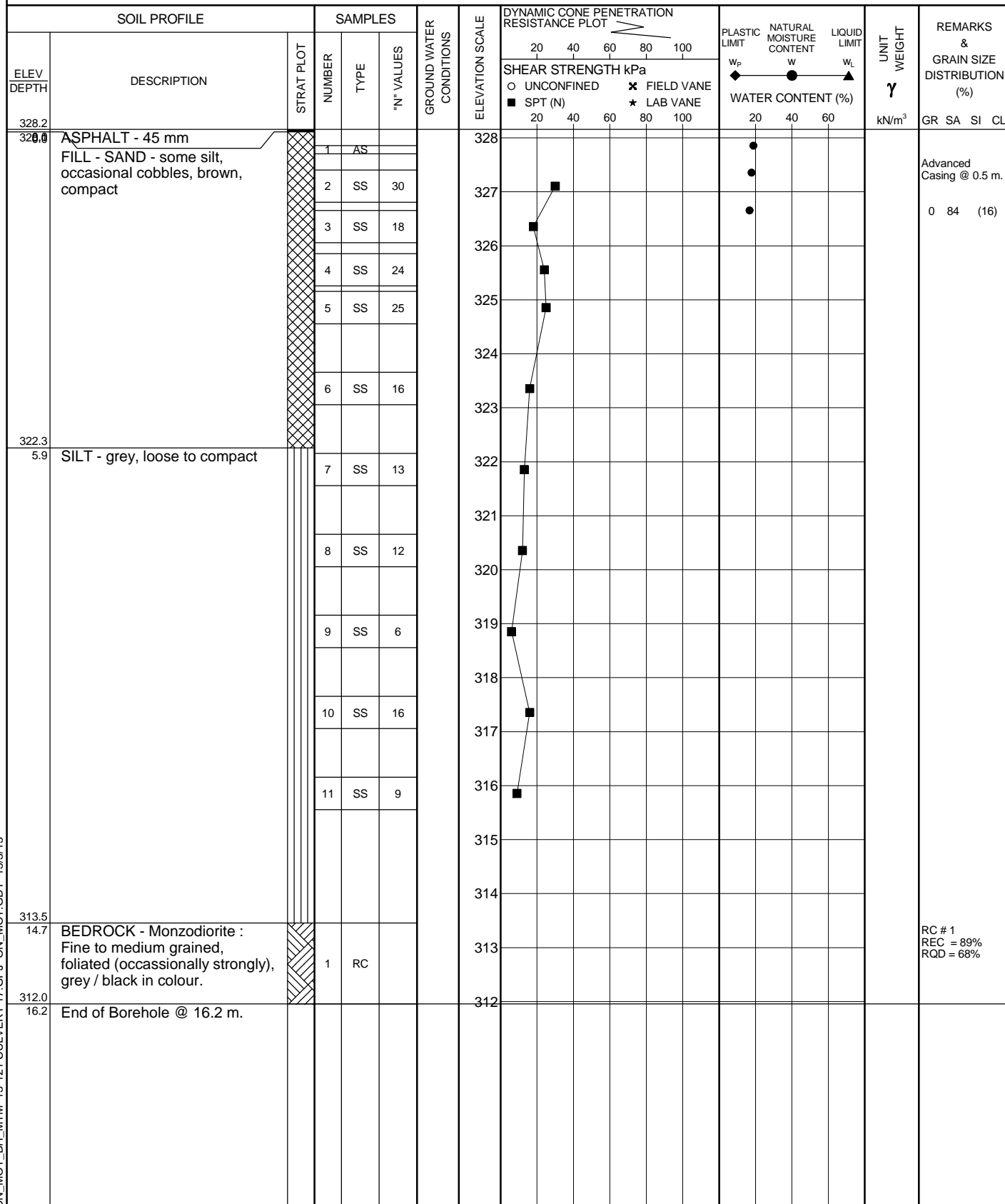


TBT Engineering Consulting Group		<b>RECORD OF Borehole No 402</b>		1 OF 1	<b>METRIC</b>
W.P. <b>5383-11-00</b>		PROJECT <b>Culvert Investigation</b>		SITE NO. <b>Culvert #17</b>	ORIGINATED BY <b>P.P.</b>
TWP <b>Foleyet</b> HWY <b>101</b>		LOCATION <b>MTM N5347471.325, E200320.691</b>		TBTE JOB# <b>13-121</b>	COMPILED BY <b>T.B.</b>
DATE <b>2013 September 19</b>		BOREHOLE TYPE <b>Hollow Stem Auger/Casing/Core</b>		DATUM <b>Geodetic</b>	CHECKED BY <b>S.S.</b>



ONL\_MOT\_BH\_MTM 13-121 CULVERT 17.GPJ ONL\_MOT\_GDT 15/3/13

<b>TBT Engineering Consulting Group</b>		<b>RECORD OF Borehole No 403</b>		1 OF 1	<b>METRIC</b>
W.P. <b>5383-11-00</b>	PROJECT <b>Culvert Investigation</b>	SITE NO. <b>Culvert #17</b>	ORIGINATED BY <b>P.P.</b>		
TWP <b>Foleyet</b> HWY <b>101</b>	LOCATION <b>MTM N5347478.09, E200307.297</b>	TBTE JOB# <b>13-121</b>	COMPILED BY <b>T.B.</b>		
DATE <b>2013 September 19</b>	BOREHOLE TYPE <b>Hollow Stem Auger/Casing/Core</b>	DATUM <b>Geodetic</b>	CHECKED BY <b>S.S.</b>		



ONL\_MOT\_BH\_MTM 13-121 CULVERT 17.GPJ ONL\_MOT\_GDT 15/3/13

x<sup>3</sup>, \*<sup>3</sup>: Numbers refer to Sensitivity  
 NP Non Plastic  
 O 3% STRAIN AT FAILURE

TBT Engineering Consulting Group			<b>RECORD OF Borehole No 404</b>			1 OF 1		<b>METRIC</b>	
W.P. <b>5383-11-00</b>			PROJECT <b>Culvert Investigation</b>			SITE NO. <b>Culvert #17</b>		ORIGINATED BY <b>P.P.</b>	
TWP <b>Foleyet</b> HWY <b>101</b>			LOCATION <b>MTM N5347462.419, E200326.44</b>			TBTE JOB# <b>13-121</b>		COMPILED BY <b>T.B.</b>	
DATE <b>2013 September 21</b>			BOREHOLE TYPE <b>Hollow Stem Auger/Casing/Core</b>			DATUM <b>Geodetic</b>		CHECKED BY <b>S.S.</b>	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		DYNAMIC CONE PENETRATION RESISTANCE PLOT	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED    ✕ FIELD VANE ■ SPT (N)       ★ LAB VANE 20 40 60 80 100	
328.4	ASPHALT - 45 mm FILL - SAND & GRAVEL - occasional cobbles, brown, compact to dense		1	AS			328	PLASTIC LIMIT    NATURAL MOISTURE CONTENT    LIQUID LIMIT W <sub>p</sub> W                      W <sub>L</sub> WATER CONTENT (%) 20 40 60	
2			SS	18		327			
3			SS	21		326			
4			SS	38		325			
5			SS	27		324			
324.2	SILT - grey, loose to compact		6	SS	17		323		
4.2						322			
			7	SS	15		321		
			8	SS	14		320		
						319			
			9	SS	12		318		
						317			
			10	SS	8		316		
						315			
			11	SS	13		314		
315.0	GRAVEL - Silty, Sandy, occasional cobbles, grey BEDROCK - Monzodiorite : Medium grained, foliated (occasionally strongly), grey / black.		12	SS	100+		315	>>>	
313.7									
313.2	End of Borehole @ 15.2 m.		1	RC			314		
15.2									

RC # 1  
REC = 98%  
RQD = 94%

TBT Engineering Consulting Group			<b>RECORD OF Borehole No 405</b>			1 OF 1		<b>METRIC</b>										
W.P. <b>5383-11-00</b>			PROJECT <b>Culvert Investigation</b>			SITE NO. <b>Culvert #17</b>		ORIGINATED BY <b>P.P.</b>										
TWP <b>Foleyet</b> HWY <b>101</b>			LOCATION <b>MTM N5347452, E200323</b>			TBTE JOB# <b>13-121</b>		COMPILED BY <b>T.B.</b>										
DATE <b>2013 November 26</b>			BOREHOLE TYPE <b>Hollow Stem Auger/Casing/Core</b>			DATUM <b>Geodetic</b>		CHECKED BY <b>S.S.</b>										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED    ✕ FIELD VANE ■ SPT (N)       ★ LAB VANE		WATER CONTENT (%) W <sub>p</sub> W    W <sub>L</sub>		γ		GR	SA	SI	CL	
324.6 324.1 0.5	ORGANIC FILL - SAND & GRAVEL & PEAT - brown/black SILT - trace sand, brown, very loose to compact ----- - grey		1	AS			324											Water level @ 0.9 m on completion.
			2	SS	11		323											0 9 (91)
			3	SS	12		322											
			4	SS	8		321											
			5	SS	7		320											
			6	SS	6		319											
			7	SS	6		318											
			8	SS	8		317											
			9	SS	8		316											
			10	SS	3		315											
314.0 10.6	BEDROCK - Monzodiorite : Medium grained, strongly foliated, grey / black in colour.		1	RC			314											RC # 1 REC = 94% RQD = 78%
312.3 12.3	End of Borehole @ 12.3 m.						313											

ONL\_MOT\_BH\_MTM 13-121 CULVERT 17.GPJ ONL\_MOT\_GDT 15/3/13

**ROCK CORE LOG**

Page 1 of 1

Project #: 13-121

Borehole# 401

Lab# 13-0893

Client: Hatch Mott Macdonald

Logger: TD / SD

Site: Highway 101

Date: October 23, 2013

<div>TBT ENGINEERING CONSULTING GROUP</div>														<div>Strength (MPa) VH = Very High = &gt;200 H = High = 50-200 M = Medium = 15-50 L = Low = 4-15 VL = Very Low = 1-4</div>										<div>Discontinuity type B = Bedding joint J = Cross joint F = Fault S = Shear Plane</div>										<div>Roughness RU = Rough undulating RP = Rough planar SU = Smooth undulating SP = Smooth planar LU = Slicken sided undulating LP = Slicken sided planar</div>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
<div>ROCK CORE LOG</div>														<div>Project #: 13-121 Borehole# 401 Lab# 13-0893</div>										<div>Page 1 of 1</div>										<div>Weathering U = Unweathered (No signs) S = Slightly (Oxidized) M = Moderately (Discoloured) H = Highly (Friable) C = Completely (Soil-like)</div>										<div>Orientation F = Flat (0-20°) D = Dipping (20-50°) V = Near Vertical (&gt;50°)</div>										<div>Aperture O = Open C = Closed F = Filled</div>										<div>Filling T = Tight, hard O = Oxidized SA = Slightly altered, clay free S = Sandy, Clay free SI = Sandy, silty, minor clay NC = Non-softening clay SC = Swelling, softening clay N = No filling</div>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									





**ROCK CORE LOG**

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Project #: 13-121

Borehole# 403

Lab# 13-0895

Client: Hatch Mott Macdonald

Logger: TD / SD

Site: Highway 101

Date: October 24, 2013

Strength (MPa)				Discontinuity type				Roughness			
VH = Very High = >200 H = High = 50-200 M = Medium = 15-50 L = Low = 4-15 VL = Very Low = 1-4				B = Bedding joint J = Cross joint F = Fault S = Shear plane				RU = Rough undulating RP = Rough planar SU = Smooth undulating SP = Smooth planar LU = Slickensided undulating LP = Slickensided planar			
Weathering				Orientation				Aperture			
U = Unweathered (No signs) S = Slightly (Oxidized) M = Moderately (Discoloured) H = Highly (Friable) C = Completely (Soil-like)				F = Flat (0-20°) D = Dipping (20-50°) V = Near Vertical (>50°)				O = Open C = Closed F = Filled			
Spacing				Weathering				Filling			
VW = Very wide = >3m W = Wide = 1-3m M = Moderate = 0.3-1m C = Close = 5-30cm VC = Very close = <5cm				U = Unweathered (No signs) S = Slightly (Oxidized) M = Moderately (Discoloured) H = Highly (Friable) C = Completely (Soil-like)				T = Tight, hard O = Oxidized SA = Slightly altered, clay free S = Sandy, Clay free SI = Sandy, silty, minor clay NC = Non-softening clay SC = Swelling, softening clay N = No filling			
GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)				DISCONTINUITIES				OCCASIONAL FEATURES			

**ROCK CORE LOG**

Page 1 of 1

Project #: 13-121

Borehole# 404

Lab# 13-0896

Client: Hatch Mott Macdonald

Logger: TD / SD

Site: Highway 101

Date: October 24, 2013

**GENERAL DESCRIPTION**  
(Rock type(s), %, colour, texture, etc.)

Monzodiorite : Medium grained, foliated (occasionally strongly), grey / black in colour.  
Occasional coarse grained, pink or white, felsic intervals.

% RQD

94.0%

% REC

98.0%

BOX/RU  
N

1/1

DEPTH FROM  
SURFACE  
(m)

From

13.7

To

15.2

From

To

From

To

From

To

**Strength (MPa)**

VH = Very High = >200  
H = High = 50-200  
M = Medium = 15-50  
L = Low = 4-15  
VL = Very Low = 1-4

**Weathering**

U = Unweathered (No signs)  
S = Slightly (Oxidized)  
M = Moderately (Discoloured)  
H = Highly (Friable)  
C = Completely (Silt-like)

**Discontinuity type**

B = Bedding joint  
J = Cross joint  
F = Fault  
S = Shear Plane

**Orientation**

F = Flat (0-20°)  
D = Dipping (20-50°)  
V = Near Vertical (>50°)

**Spacing**

VW = Very wide = >3m  
W = Wide = 1-3m  
M = Moderate = 0.3-1m  
C = Close = 5-30cm  
VC = Very close = <5cm

**Filling**

T = Tight, hard  
O = Oxidized  
SA = Slightly altered, clay free  
S = Sandy, Clay free  
SI = Sandy, silty, minor clay  
NC = Non-softening clay  
SC = Swelling, softening clay  
N = No filling

**Roughness**

RU = Rough undulating  
RP = Rough planar  
SU = Smooth undulating  
SP = Smooth planar  
LU = Slickensided undulating  
LP = Slickensided planar

**OCCASIONAL FEATURES**

**DISCONTINUITIES**

# OF SETS

TYPE(S)

Orientation

SPACING

Roughness

APERTURE

FILLING

WEATHERING

STRENGTH

**ROCK CORE LOG**

Page 1 of 1

Project #: 13-121

Borehole# 405

Lab# 13-1206

Client: Hatch Mott Macdonald

Logger: Terry Dupuis

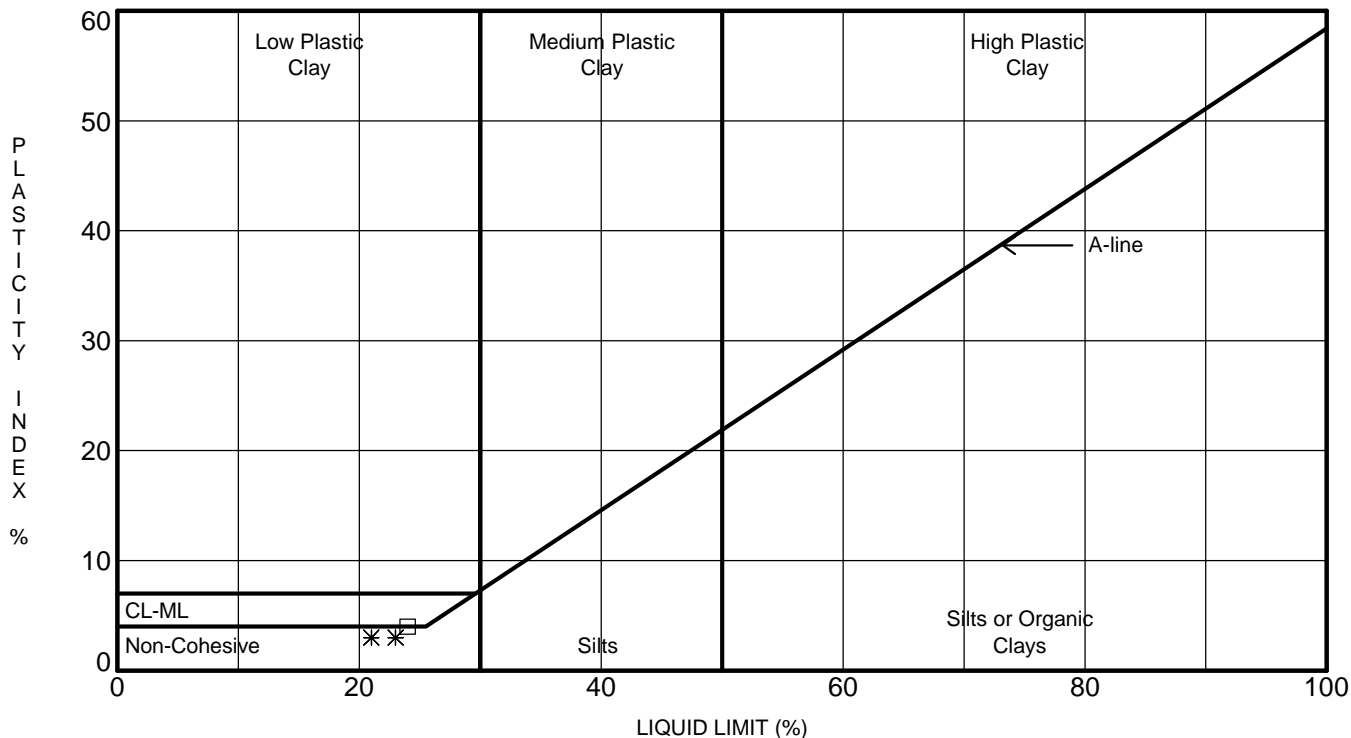
Site: Highway 101

Date: December 1, 2013

<div>TBT ENGINEERING CONSULTING GROUP</div>										<div>Strength (MPa) VH = Very High = &gt;200 H = High = 50-200 M = Medium = 15-50 L = Low = 4-15 VL = Very Low = 1-4</div>										<div>Discontinuity type B = Bedding Joint J = Cross Joint F = Fault S = Shear Plane</div>										<div>Roughness RU = Rough undulating RP = Rough planar SU = Smooth undulating SP = Smooth planar LU = Slickensided undulating LP = Slickensided planar</div>																													
<div>ROCK CORE LOG</div>										Page 1 of 1										<div>Weathering U = Unweathered (No signs) S = Slightly (Oxidized) M = Moderately (Discoloured) H = Highly (Friable) C = Completely (Soil-like)</div>										<div>Orientation F = Flat (0-20°) D = Dipping (20-50°) V = Near Vertical (&gt;50°)</div>										<div>Aperture O = Open C = Closed F = Filled</div>										<div>Filling T = Tight, hard O = Oxidized SA = Slightly altered, clay free S = Sandy, clay free SI = Sandy, silty, minor clay NC = Non-softening clay SC = Swelling, softening clay N = No filling</div>									
										Borehole# 405					Lab# 13-1206																																												
										Client: Hatch Mott Macdonald					Logger: Terry Dupuis																																												
Site: Highway 101					Date: December 1, 2013																																																						
DEPTH FROM SURFACE (m)		DEPTH (m)		BOX/RUN		% REC		% RQD		GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)		STRENGTH		WEATHERING		# OF SETS		TYPE(S)		Orientation		SPACING		Roughness		APERTURE		FILLING		OCCASIONAL FEATURES																													
From		From		1/1		94.1%		78.2%		Monzodiorite : Medium grained, strongly foliated, grey / black in colour. Occasional fine grained intervals.		H		U		2		J		F		M		RU		O		O																															
10.6		0.0																																																									
To		To																																																									
12.3		1.7																																																									
From		From																																																									
To		To																																																									
From		From																																																									
To		To																																																									
From		From																																																									
To		To																																																									

## **APPENDIX B**

### **Laboratory Test Data**



	Borehole No.	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%	
□	400		3.00	24	20	4	31	
✱	400		6.00	21	18	3	25	
×	401		7.50	23	20	3	24	
+	401		9.00	23	20	3	23	



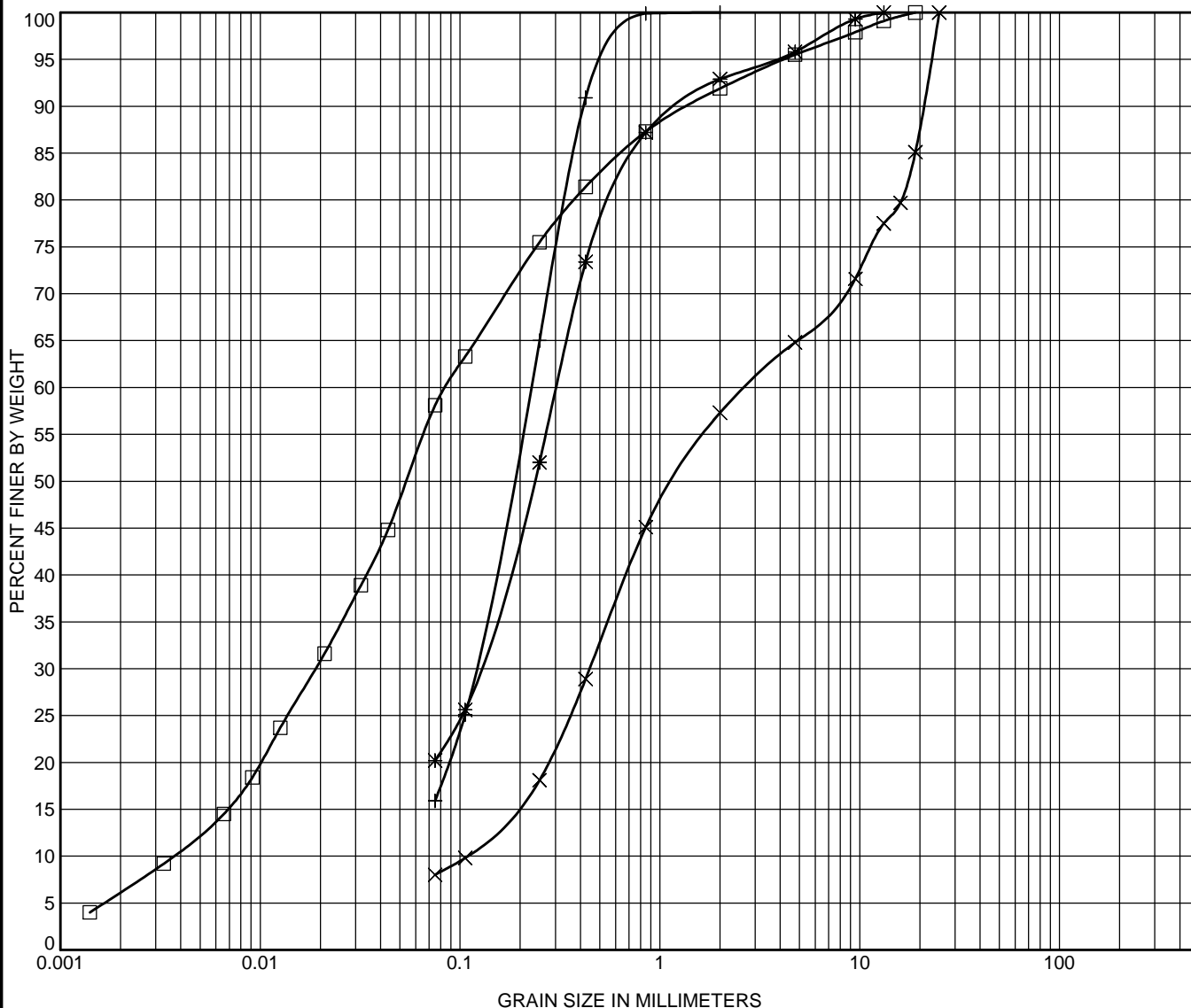
**TBT Engineering Ltd.**  
 1918 Yonge Street  
 Thunder Bay, Ontario P7E 6T9  
 Telephone: 807-624-5160  
 Fax: 807-624-5161

## ATTERBERG LIMIT RESULTS

W P: 5383-11-00

District: Foleyet

Highway: 101



Remarks:  
FILL - SAND/SILT & SAND/SAND & GRAVEL

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ 400	0.30	19	0.085	0.019	0.004	4.5	37.4	58.1	
* 401	1.50	13.2	0.305	0.122		4.2	75.6	20.2	
× 402	4.50	25	2.731	0.445	0.108	35.2	56.8	8.0	
+ 403	1.50	2	0.225	0.118		0.0	84.1	15.9	



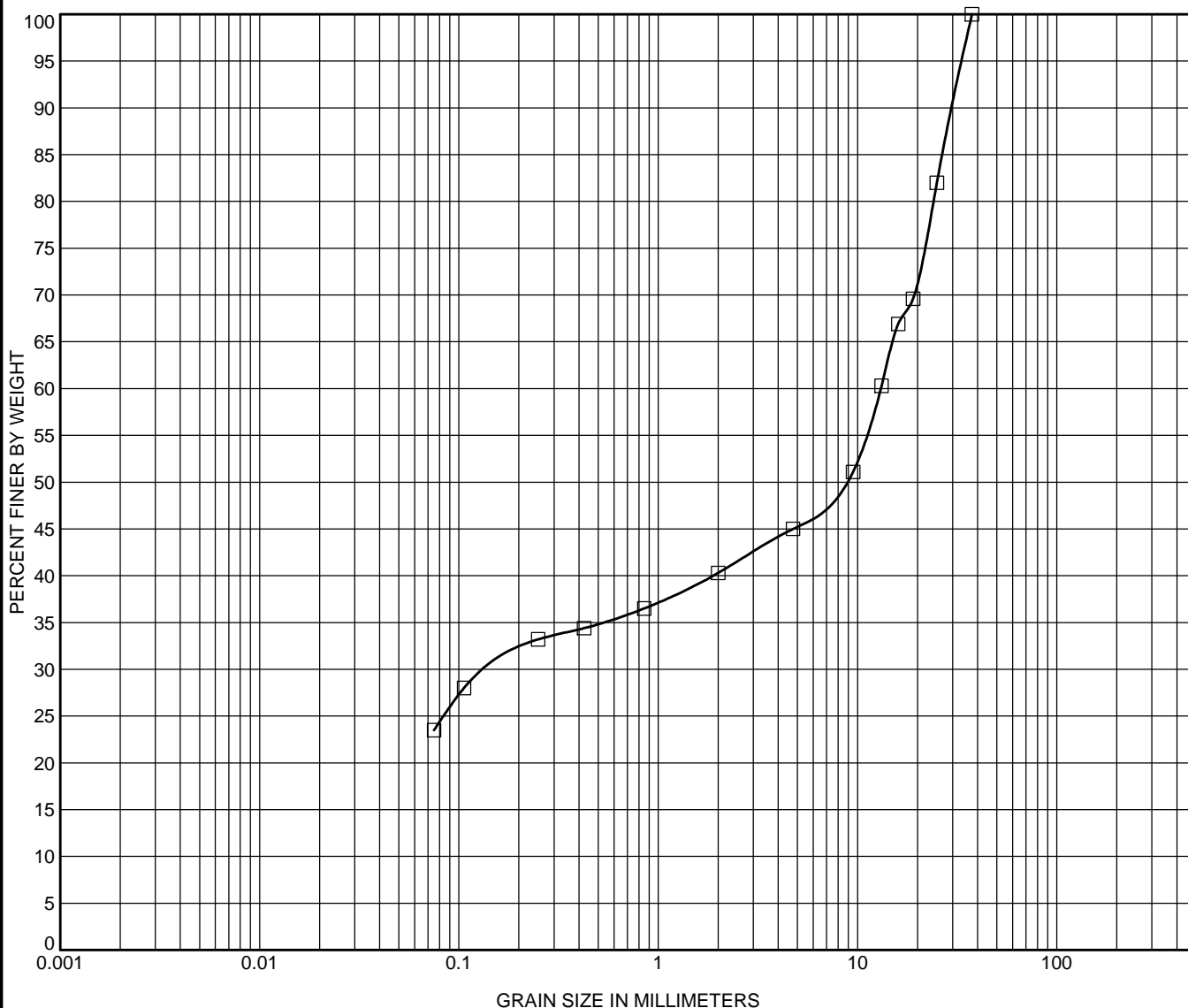
TBT Engineering Ltd.  
1918 Yonge Street  
Thunder Bay, Ontario P7E 6T9  
PH: 807-624-5160  
FX: 807-624-5161  
Email: tbte@tbte.ca  
Web: www.tbte.ca

## GRAIN SIZE DISTRIBUTION

Project: Culvert Investigation

W P: 5383-11-00

DIST: Foleyet HWY: 101



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:  
GRAVEL

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
400	8.80	37.5	13.059	0.147		55.0	21.5	23.5	



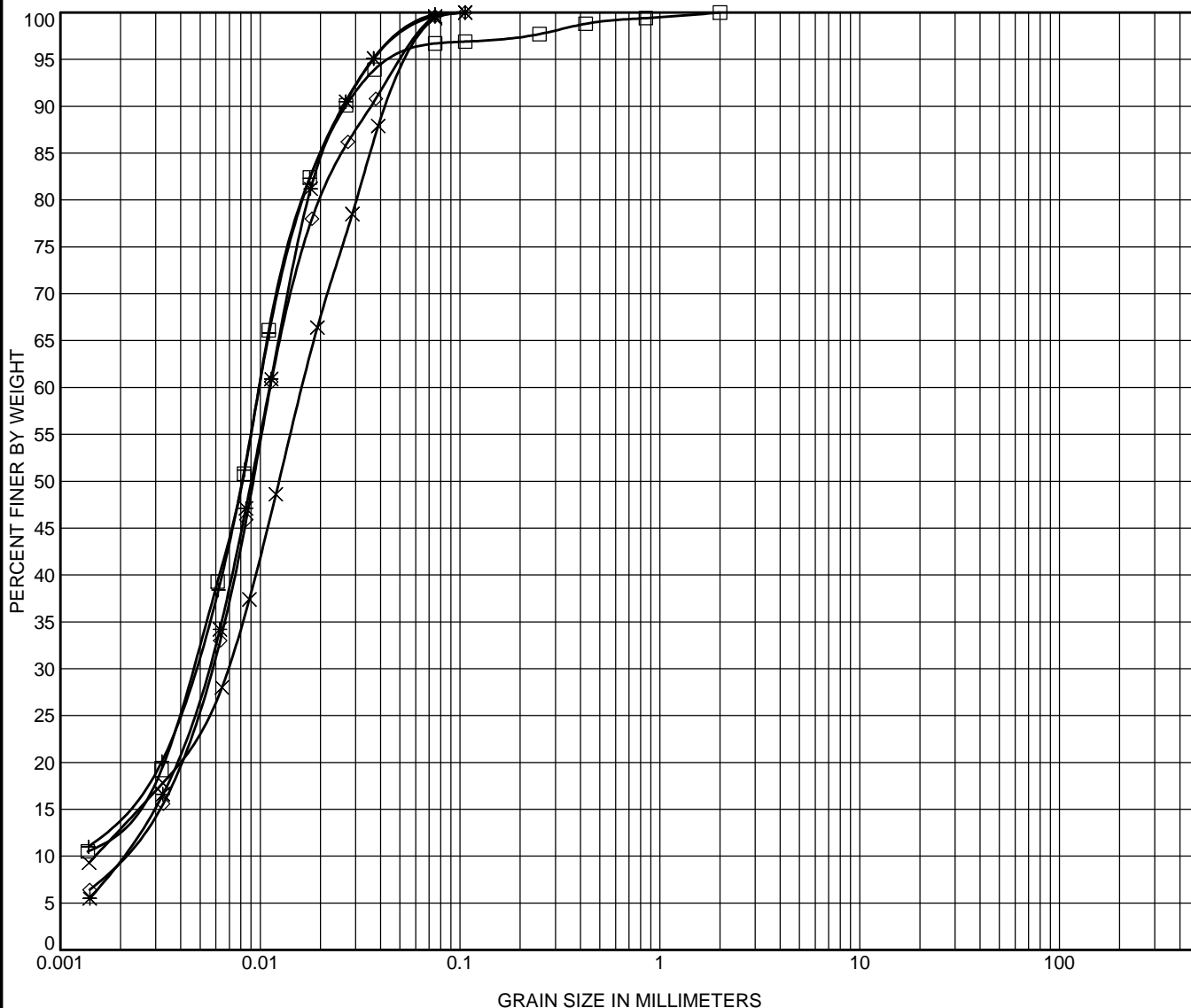
TBT Engineering Ltd.  
1918 Yonge Street  
Thunder Bay, Ontario P7E 6T9  
PH: 807-624-5160  
FX: 807-624-5161  
Email: [tbte@tbte.ca](mailto:tbte@tbte.ca)  
Web: [www.tbte.ca](http://www.tbte.ca)

## GRAIN SIZE DISTRIBUTION

Project: Culvert Investigation

W P: 5383-11-00

DIST: Foleyet HWY: 101



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:  
SILT

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ 400	3.00	2	0.01	0.005		0.0	3.3	96.7	
* 400	4.50	0.106	0.011	0.005	0.002	0.0	0.4	99.6	
× 400	6.00	0.106	0.016	0.007	0.001	0.0	0.6	99.4	
+ 401	7.50	0.106	0.01	0.005		0.0	0.2	99.8	
◇ 401	9.00	0.106	0.011	0.006	0.002	0.0	0.4	99.6	



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Thunder Bay, Ontario P7E 6T9  
PH: 807-624-5160  
FX: 807-624-5161  
Email: tbte@tbte.ca  
Web: www.tbte.ca

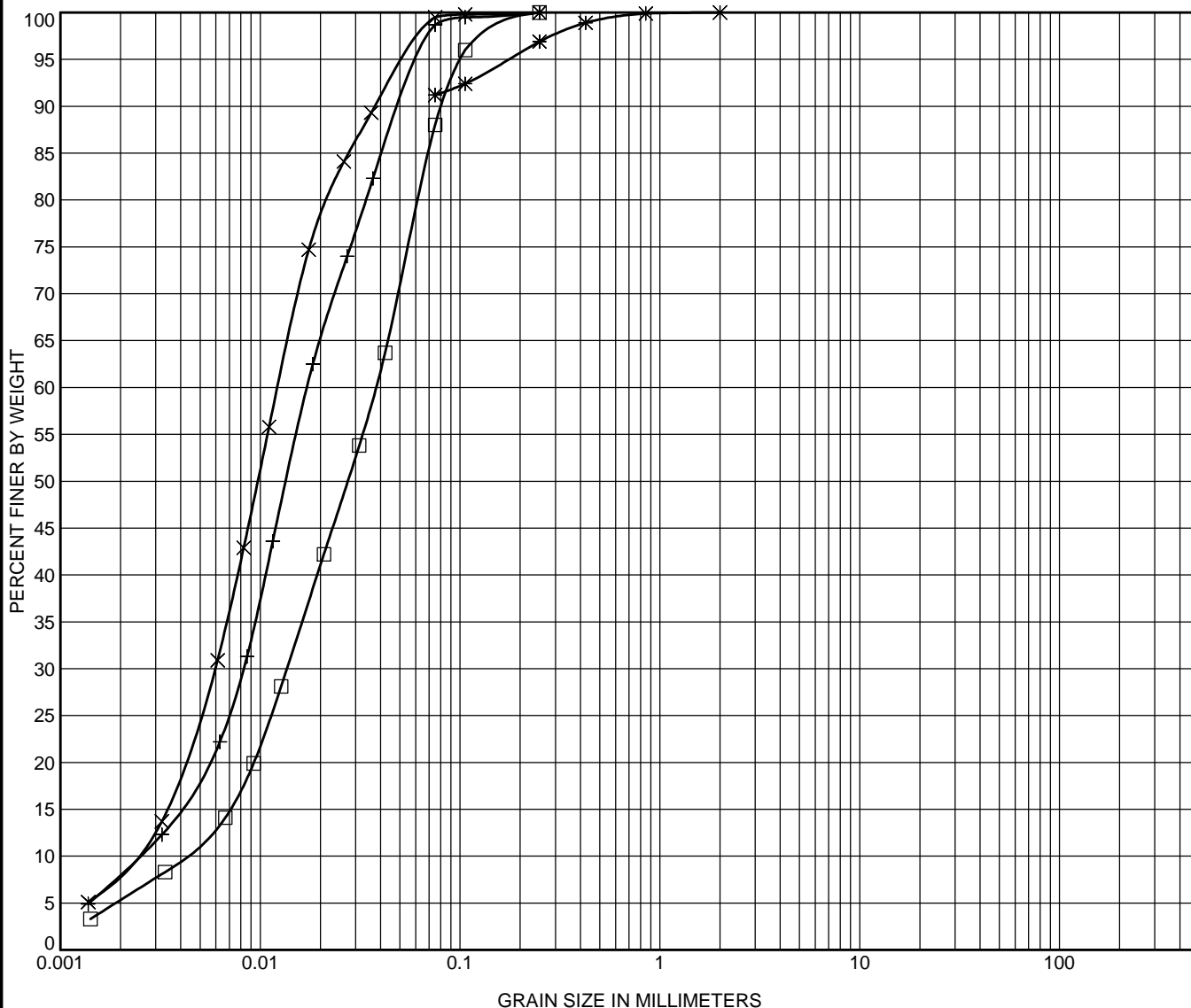
## GRAIN SIZE DISTRIBUTION

Project: Culvert Investigation

W P: 5383-11-00

DIST: Foleyet HWY: 101





SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:  
SILT

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ 401	12.00	0.25	0.038	0.014	0.004	0.0	12.0	88.0	
* 405	1.50	2				0.0	8.8	91.2	
x 405	3.80	0.25	0.012	0.006	0.002	0.0	0.5	99.5	
+ 405	9.10	0.25	0.017	0.008	0.002	0.0	1.3	98.7	



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Thunder Bay, Ontario P7E 6T9  
PH: 807-624-5160  
FX: 807-624-5161  
Email: tbte@tbte.ca  
Web: www.tbte.ca

## GRAIN SIZE DISTRIBUTION

Project: Culvert Investigation

W P: 5383-11-00

DIST: Foleyet HWY: 101

## **APPENDIX C**

### **Staging Stability Models**

Culvert #17 - Stage 1 - Widening Slope 2(H):1(V)

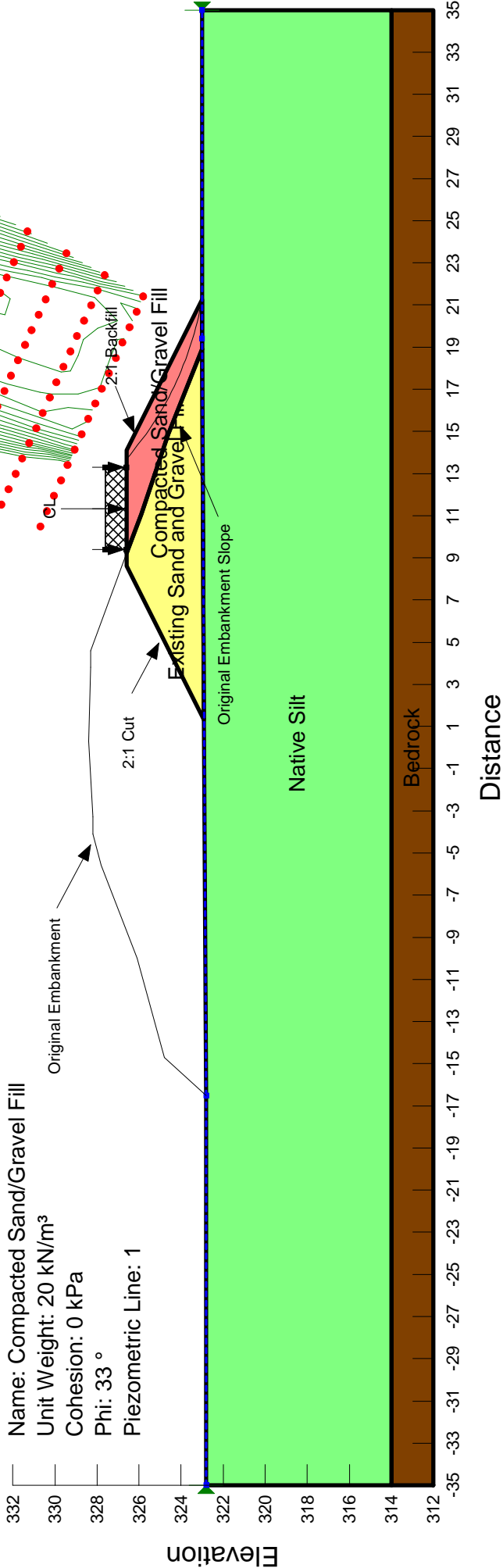
Method: Morgenstern-Price  
PWP Conditions Source: Piezometric Line  
Surcharge (Unit Weight): 20 kN/m<sup>3</sup>  
FOS: 1.37

Name: Existing Sand and Gravel Fill  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Phi: 32 °

Name: Native Silt  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Phi: 29 °  
Piezometric Line: 1

Name: Bedrock  
Piezometric Line: 1

Name: Compacted Sand/Gravel Fill  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Phi: 33 °  
Piezometric Line: 1



Culvert #17 - Stage 1 - Widening Slope 2(H):1(V)

Method: Morgenstern-Price  
PWP Conditions Source: Piezometric Line  
Surcharge (Unit Weight): 20 kN/m³  
FOS: 1.31

Name: Existing Sand and Gravel Fill

Unit Weight: 20 kN/m³

Cohesion: 0 kPa

Phi: 32 °

Name: Native Silt

Unit Weight: 20 kN/m³

Cohesion: 0 kPa

Phi: 29 °

Piezometric Line: 1

Name: Bedrock

Piezometric Line: 1

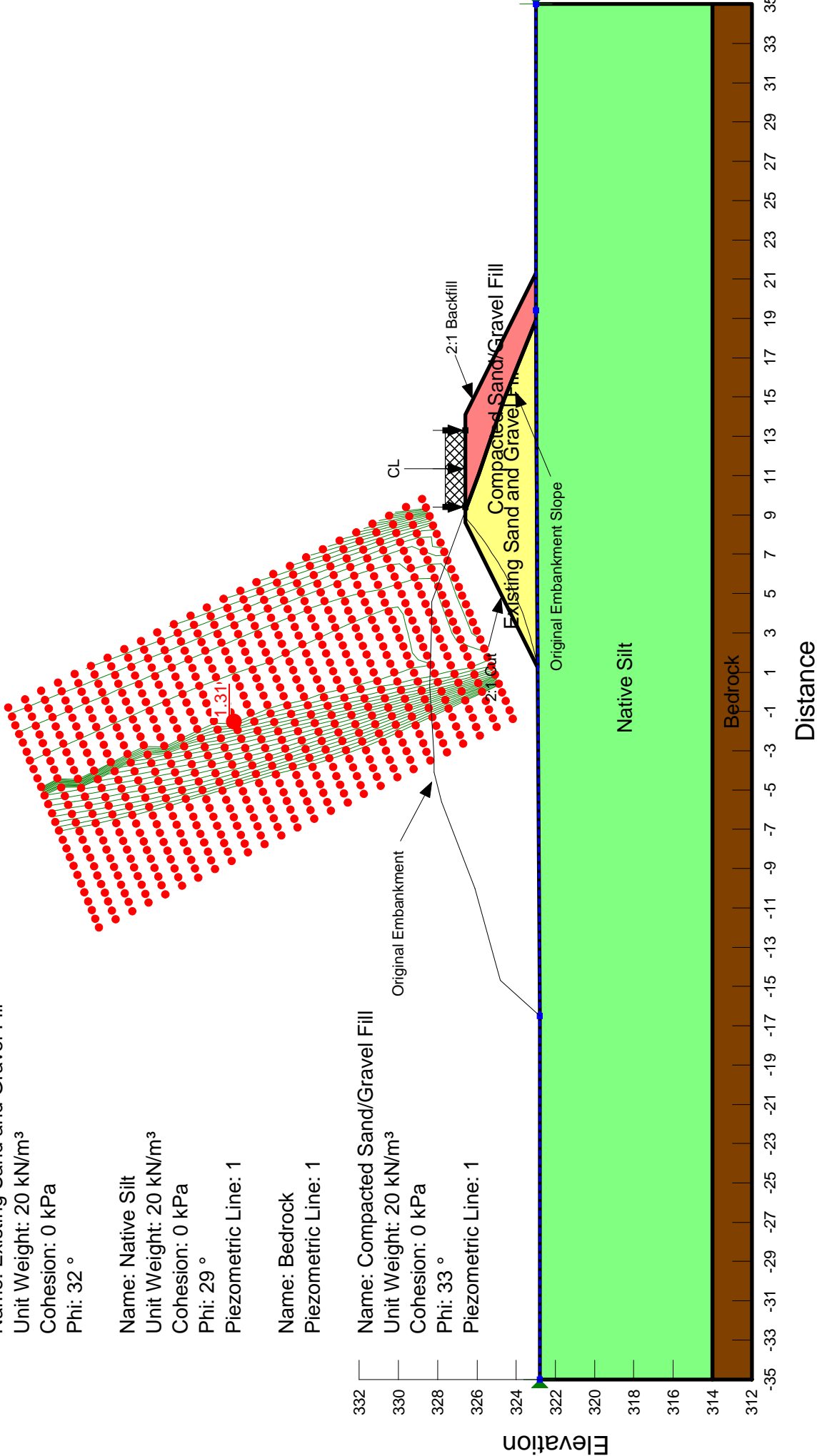
Name: Compacted Sand/Gravel Fill

Unit Weight: 20 kN/m³

Cohesion: 0 kPa

Phi: 33 °

Piezometric Line: 1



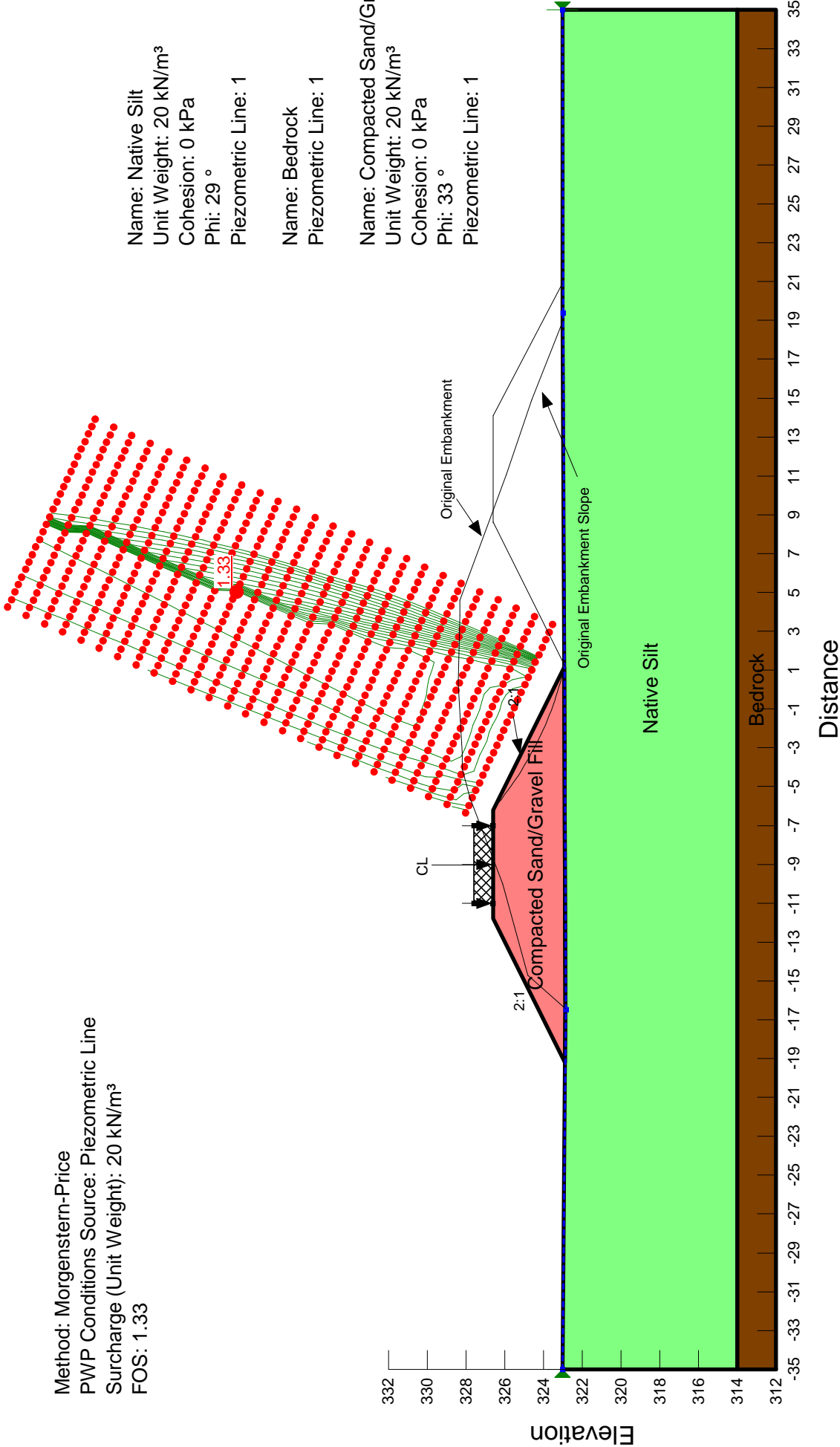
Culvert #17 - Stage 2 - Widening Slope 2(H):1(V)

Method: Morgenstern-Price  
PWP Conditions Source: Piezometric Line  
Surcharge (Unit Weight): 20 kN/m³  
FOS: 1.33

Name: Native Silt  
Unit Weight: 20 kN/m³  
Cohesion: 0 kPa  
Phi: 29 °  
Piezometric Line: 1

Name: Bedrock  
Piezometric Line: 1

Name: Compacted Sand/Gravel Fill  
Unit Weight: 20 kN/m³  
Cohesion: 0 kPa  
Phi: 33 °  
Piezometric Line: 1



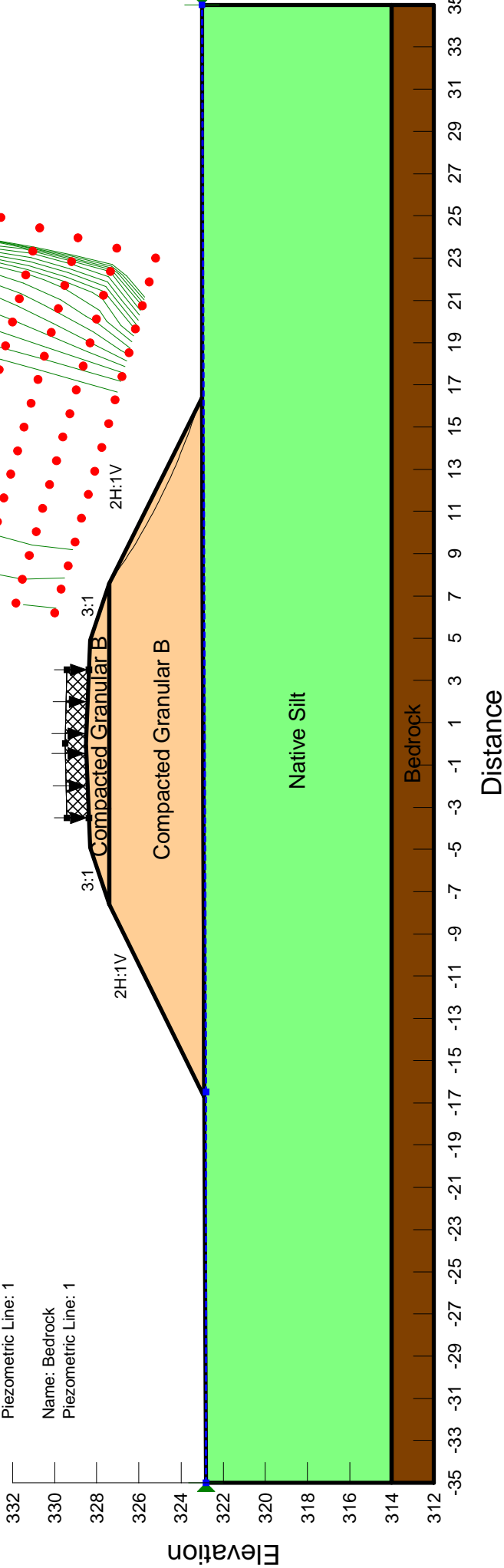
# Culvert # 17 - Final Stage - Side Slopes 2H:1V

Method: Morgenstern-Price  
PWP Conditions Source: Piezometric Line  
Surcharge (Unit Weight): 20 kN/m³  
FOS: 1.42

Name: Compacted Granular B  
Unit Weight: 20 kN/m³  
Cohesion: 0 kPa  
Phi: 35 °

Name: Native Silt  
Unit Weight: 20 kN/m³  
Cohesion: 0 kPa  
Phi: 29 °  
Piezometric Line: 1

Name: Bedrock  
Piezometric Line: 1



# Culvert # 17 - Final Stage - Side Slopes 2H:1V

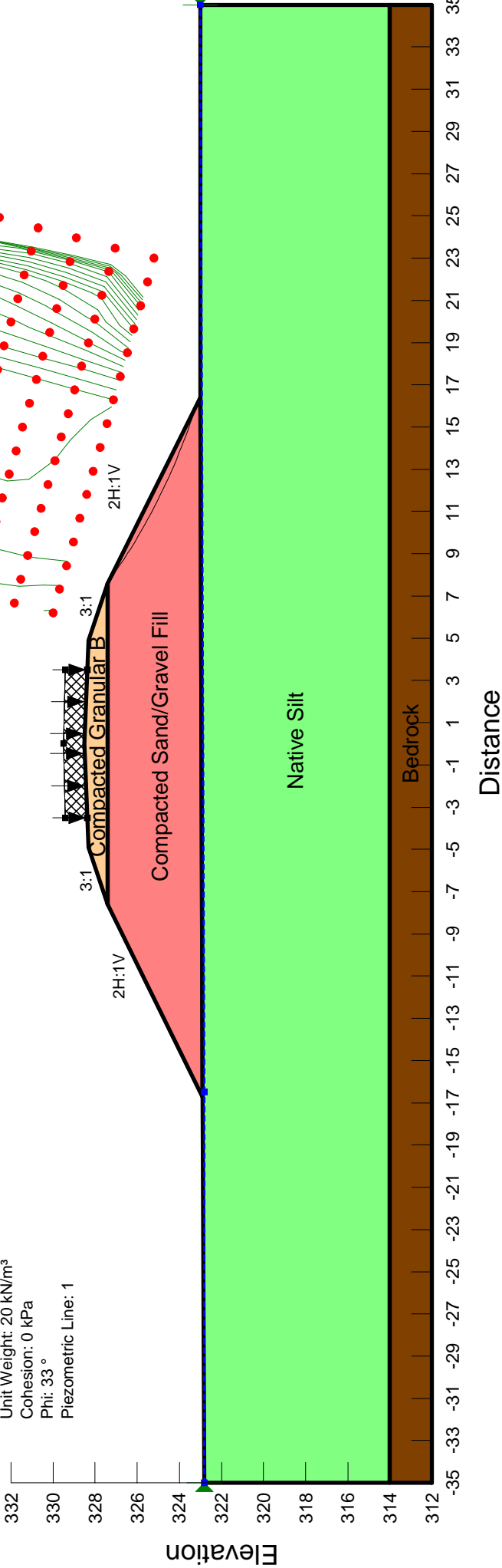
Method: Morgenstern-Price  
PWP Conditions Source: Piezometric Line  
Surcharge (Unit Weight): 20 kN/m³  
FOS: 1.3

Name: Compacted Granular B  
Unit Weight: 20 kN/m³  
Cohesion: 0 kPa  
Phi: 35 °

Name: Native Silt  
Unit Weight: 20 kN/m³  
Cohesion: 0 kPa  
Phi: 29 °  
Piezometric Line: 1

Name: Bedrock  
Piezometric Line: 1

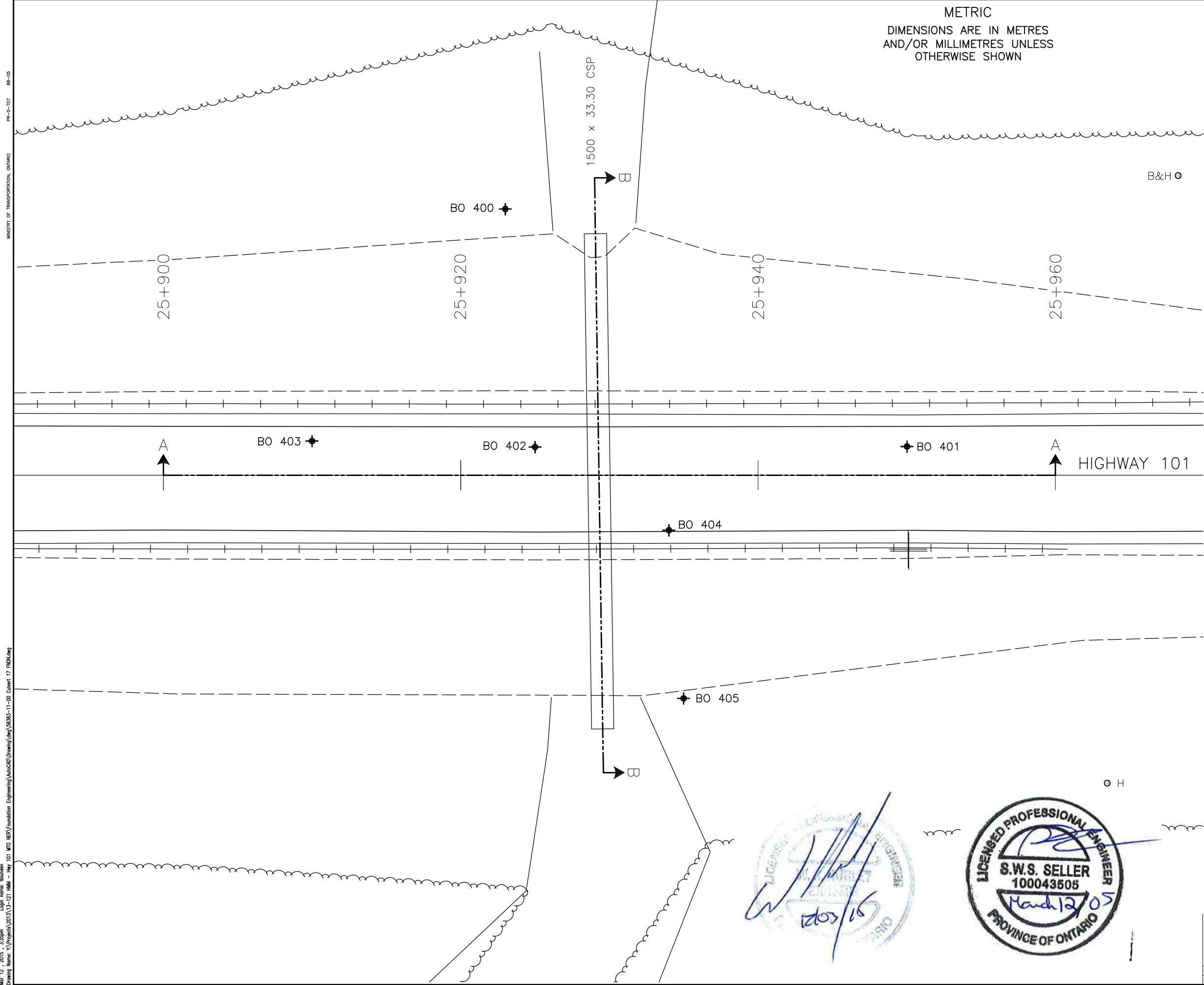
Name: Compacted Sand/Gravel Fill  
Unit Weight: 20 kN/m³  
Cohesion: 0 kPa  
Phi: 33 °  
Piezometric Line: 1




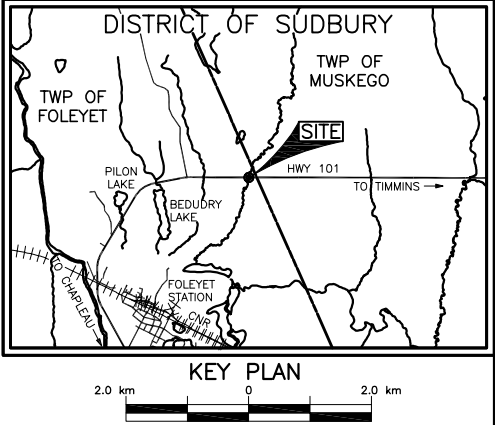
## **APPENDIX D**

### **Borehole Locations and Soil Strata Drawing**





GEOCRES No.	42B-11		
CONT	No.		.
GWP	No.		5383-11-00
CULVERT 17 AT HWY 101 CULVERT INVESTIGATION BOREHOLE LOCATIONS AND SOIL STRATA		SHEET  .	



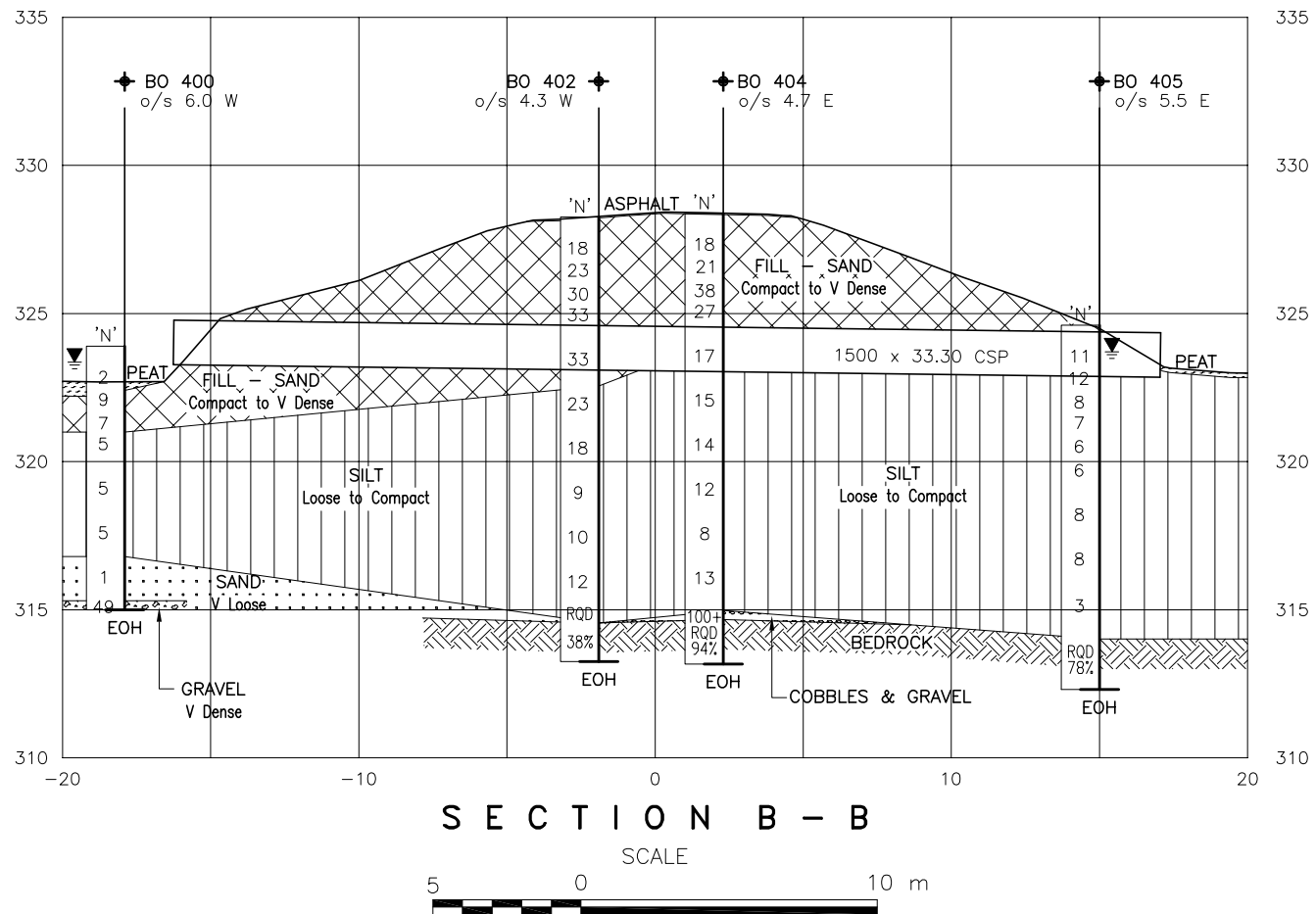
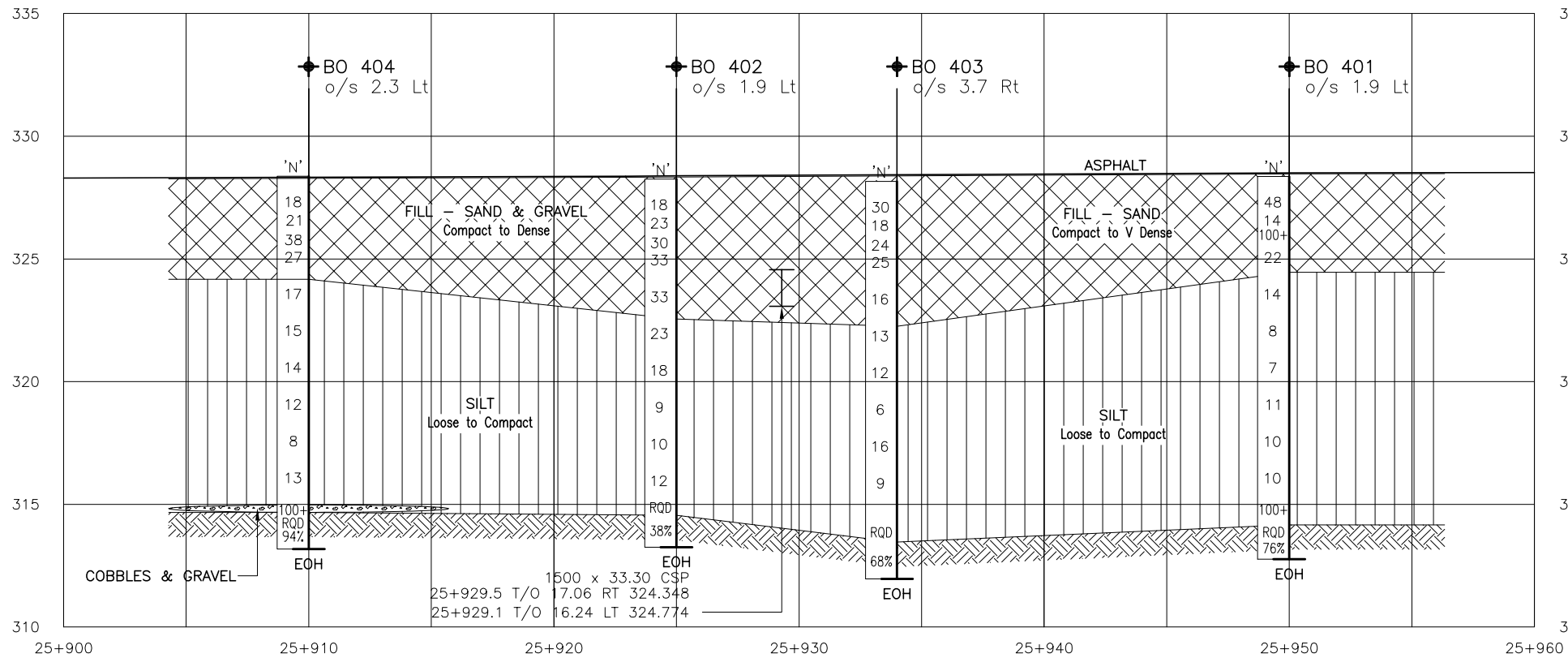
LEGEND				
◆ Borehole				
No	ELEVATION	CO-ORDINATES (MTM)		
		NORTH	EAST	
400	323.9	12 5 347 487	200 326	
401	328.4	12 5 347 461	200 343	
402	328.3	12 5 347 471	200 321	
403	328.2	12 5 347 478	200 307	
404	328.4	12 5 347 462	200 326	
405	324.6	12 5 347 452	200 323	

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

REVISIONS		WH		ISSUED IN DRAFT		DESCRIPTION	
DESIGN	SS	CHK	WH	CODE	XXXXX-XX	LOAD XX-XX-XX	DATE 2013/12/23
DRAWN	TB	CHK	WH	SITE	N/A		DWG 1

Mar 12, 2015 3:35pm  
Drawing Name: \\projects\2013\3-121 HMM - Hwy 101 MTD NERY\Foundation Engineering\AutoCAD\Drawings\5383-11-00 Culvert 17 PLAN.dwg  
Login name: ibanden  
PR-D-707 88-05  
MINISTRY OF TRANSPORTATION, ONTARIO

Mar 12, 2015, 3:36pm  
Drawing Name: \\projects\2013\3-121 MM - Hwy 101 MTD NER\Foundation Engineering\AutoCAD\Drawing\dwg\58383-11-00 Culvert 17 FNDM.dwg  
Login name: iblandin  
PR-D-707 88-05 MINISTRY OF TRANSPORTATION, ONTARIO



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

GEOCREs No. 42B-11  
CONT No. .  
GWP No. 5383-11-00

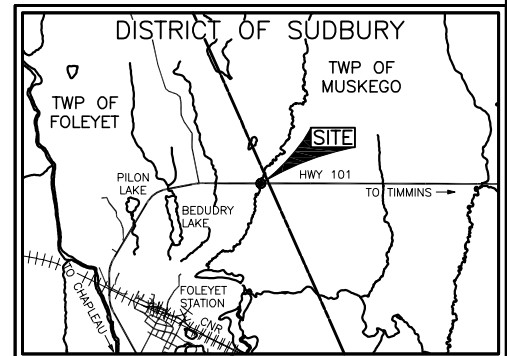


CULVERT 17  
AT HWY 101  
CULVERT INVESTIGATION  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



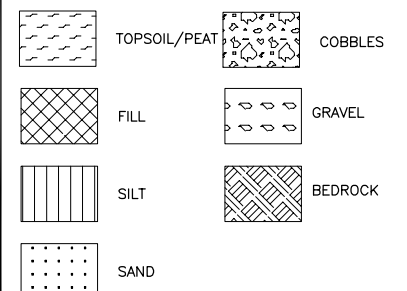
**TBT ENGINEERING**  
CONSULTING GROUP



KEY PLAN

2.0 km 0 2.0 km

#### SOIL STRATA SYMBOLS



#### LEGEND

- ◆ Borehole
- 'N' Std Pen Test (Blows/0.3m)
- 100% Rock Quality Designation (RQD)
- Water Level
- EOH End of Hole

No	ELEVATION	CO-ORDINATES (MTM)	
		NORTH	EAST
400	323.9	12 5 347 487	200 326
401	328.4	12 5 347 461	200 343
402	328.3	12 5 347 471	200 321
403	328.2	12 5 347 478	200 307
404	328.4	12 5 347 462	200 326
405	324.6	12 5 347 452	200 323

#### NOTE

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

REVISIONS	13/12/10		WH		ISSUED IN DRAFT		DESCRIPTION	
	DESIGN	SS	CHK	W/H	CODE	XXXXX-XX	LOAD XX-XX-XX	DATE 2013/12/23
	DRAWN	TB	CHK	W/H	SITE	N/A		DWG 2

## **APPENDIX E**

### **Non Standard Special Provisions**

**NOTICE TO CONTRACTOR – Presence of Coarse Aggregates in Existing Embankment**

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Special Provision

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**The contractor is advised that cobbles and boulders as well as zones of loose granular materials were encountered in the embankment fills and sub-grade during the foundation and geotechnical investigations at various borehole locations.**