



**FOUNDATION INVESTIGATION
AND DESIGN REPORT
HEIGHINGTON CREEK
CULVERT REPLACEMENT
HIGHWAY 652
TOWNSHIP OF HEIGHINGTON
AGREEMENT No.: 5010-E-0006
GWP: 5481-09-00
WP: 5123-07-01
GEOCRES NO.: 42H-45**

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

DST Consulting Engineers Inc. has been subcontracted by Genivar, who was retained by the Ministry of Transportation (MTO), Northeastern Region, to conduct a geotechnical investigation for the replacement of the Heighington Creek culvert on Highway 652. This work was carried out under Agreement No.: 5010-E-0006, Detailed Design for the Replacement / Rehabilitation of Various Culverts.

This report addresses the field investigation, laboratory test program, factual report on field findings (Part 1) and recommendations for design and construction for the proposed culvert replacement (Part 2).

2. SITE DESCRIPTION

The site is located on Highway 652, approximately 61.6 km north of the Highway 11 and Highway 652 intersection, Township of Heighington, Cochrane Area. The structural site number is 39E-198.

Existing structure at this location is a 3.78 m x 2.76 m by 33.00 m long Structural Plate Corrugated Steel Pipe Arch (SPCSPA) culvert built in 1983 with a depth of cover of approximately 5.0 m. The culvert was identified to be in poor condition with significant sagging and reverse curvature. Supports have been installed but deformation between points of support is evident. It is understood that the existing culvert will be replaced by a 3.6 x 2.4 x 39.19 m pre-cast box structure and replacement will be performed with staged construction involving the installation of roadway protection and utilize a widening of the existing road embankment.

The embankment slopes at this location are approximately 2H:1V, except the slopes close to the existing culvert inlet and outlet, which were identified to be approximately 1.2H:1V and 1H:1V respectively. Both sides of the embankment were sparsely vegetated granular material with exposed rockfill (Figures 2.1, 2.2, 2.5 and 2.6). The photographs shown in Figures 2.1 to 2.4 were taken by MTO and photographs shown in Figures 2.5 to 2.8 were taken by DST during a site visit September 23rd, 2010.

Geological information is available from *Northern Ontario Geology Terrain Study* published by the Ontario Ministry of Natural Resources for the Little Abitibi Area, District of Cochrane. This indicates that the local terrain for the area has been identified as a glaciolacustrine plain and primarily contains clays and silts. The area is typically of low local relief with undulating terrain and has a mix of wet and dry conditions. Rock knobs are a common subordinate landform in the area.



Figure 2.1 Culvert inlet (facing northwest)



Figure 2.2 Culvert outlet (facing southwest)



Figure 2.3 Culvert supports



Figure 2.4 Additional culvert supports



Figure 2.5 Vegetation at culvert inlet (facing southeast)



Figure 2.6 Vegetation at culvert outlet (facing west)



Figure 2.7 Facing south from culvert



Figure 2.8 Facing north from culvert

3. INVESTIGATION PROCEDURES AND LABORATORY TESTING

Site work was carried out between January 25th, 2011 and January 30th, 2011 utilizing a CME 750 drill rig that was operated by DST personnel. A total of four (4) boreholes were advanced for the purpose of foundation design at this site, two (2) using diamond drilling techniques and two (2) using hand augers. Boreholes were advanced to depths ranging from 3.0 to 21.6 m.

Two boreholes were advanced through the road structure at Station 9+996 offset 3.8 m right and at Station 10+004 offset 3.8 m left. Two boreholes were advanced at beyond the toe of slope near the existing culvert inlet and outlet at Station 9+991 offset 24 m right and Station 10+017 offset 33 m left respectively. Due to shallow refusals being encountered directly adjacent the inlet and outlet offsets were increased to 24 m and 33 m respectively. The minimum number of boreholes, and depths and locations of boreholes were chosen according to the given specification in Request for Quotation (RFQ) by MTO.

The borehole locations are referenced to the MTO Station numbering system as indicated in the RFQ. The centreline of the existing culvert was assumed as Station 10+000. The ground surface elevations at the borehole locations were surveyed by DST personnel. At approximately Station 9+974 offset 12 m left a benchmark with an elevation of 90.1 m was placed in a poplar tree and flagged. Elevations are correlated to surveyed elevation provided by Genivar. Borehole locations, stationing and benchmark location are shown on the Borehole Location Plan, Drawings 1. Table 3.1 summarizes the detail of borehole locations and depths.

Table 3.1 Detail of borehole locations

Borehole ID	Station	Elevation (m)	Depth (m)	Offset (m)
BH1	9+996	90.0	22.0	3.8 Rt
BH2	10+004	90.2	15.0	3.8 Lt
BH3	10+017	84.8	3.0	33 Lt
BH4	9+991	84.7	3.0	24 Rt

The fieldwork was supervised on a full-time basis by DST personnel who located the boreholes in the field, performed sampling and in-situ testing and logged the boreholes. Standard Penetration Testing (SPT) and Field Vane Shear testing were performed in each borehole. The soil

samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in Thunder Bay for further analyses.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of engineering properties. Laboratory tests included moisture contents, particle size analyses and Atterberg limits including plastic limit and liquid limit. A total of thirty nine (39) moisture contents, five (5) sieve analyses, one (1) particle size analyses and four (4) Atterberg limit tests have been carried out for this assignment. Laboratory test results are presented in the Boreholes Logs (Enclosures 1 to 4), and Plots (Enclosures 5 to 8). Fines contents obtained from sieve analysis, completed on base and subbase materials.

4. DESCRIPTION OF SUBSURFACE CONDITIONS

The subsurface conditions are presented based on the information obtained during field and laboratory testing.

The generalized stratigraphy of the existing embankment, based on the conditions encountered in boreholes, consists of surfacing (surface treatment) overlying sand fill that is underlain by a rock fill which is then underlain by sand backfill surrounding the existing culvert. This fill is then underlain in areas by clay with some sand lenses found in some areas. Beneath the clay a lower sand layer was encountered.

4.1 Topsoil

A topsoil layer of silt with trace sand, clay and organic material was encountered in Boreholes 3 and 4 at depths between surface and 0.5 m below surface; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 84.8 and 84.2 m respectively. The thickness of this layer in Borehole 3 and 4 was approximately 0.4 m and 0.5 m respectively.

4.2 Surface Treatment

Surface Treatment was encountered in Boreholes 1 and 2 with a thickness of between 30 and 50 mm.

4.3 Embankment Fill

Thickness of the embankment fill is approximately 6.8 m at this location with rock fill encountered between depths of 1.2 and 2.7 m below surface, corresponding to elevations of between 89.0 and 87.5 m. Within the sand fill, boulders and cobbles were noted during the drilling process. Grain size distributions of the fill material are reported in borehole logs (Enclosures 1 to 4) and grainsize plot (Enclosure 5 to 6).

A pavement structure of two materials over the rock fill was identified. Directly below the surface treatment a fill of predominantly sand materials was encountered at Boreholes 1 and 2 from 50 mm below surface to depths up to 0.27 m; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 90.1 and 89.8 m respectively. Gradation analyses conducted on a sample from Borehole 1 indicates gravel, sand, and fines contents of approximately

14%, 67% and 19% respectively. This material does not classify as Granular A meeting SSP 110S13 requirements. The moisture content of samples was 5%.

Directly below this sand with some crushed gravel and silt a fill of predominantly sand materials was encountered at Boreholes 1 and 2 from 0.25 m below surface to depths up to 1.25 m; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 89.9 and 88.8 m respectively. Gradation analyses conducted on a sample from Borehole 2 indicates gravel, sand, and fines contents of approximately 26%, 62% and 12% respectively. This material does not classify as Granular B, Type I meeting SSP 110S13 requirements. The moisture content of samples was between 3 and 4%.

Beneath the rock fill a very loose to compact culvert backfill material of predominantly sand materials was encountered at Boreholes 1 and 2 from 2.9 m below surface to depths up to 6.8 m; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 87.5 and 83.2 m respectively. Gradation analyses conducted on a sample from Borehole 1 indicates gravel, sand, and fines contents of approximately 22%, 74% and 4% respectively. This material classifies as Granular B, Type I meeting SSP 110S13 requirements. The moisture content of samples was between 6 and 22%.

4.4 Upper Sand

Dense sand material was identified between depths of 6.8 and 8.5 m below surface in Boreholes 1 and 2; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 83.4 and 81.5 m respectively. This material was also identified between depths of 0.5 and 1.7 m below surface in Boreholes 4; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 84.2 and 83.0 m respectively. The thickness of the stratum was determined to be between 1.2 and 1.7 m in thickness. Gradation analyses conducted on a sample from Borehole 1 indicates gravel, sand, and fines contents of approximately 30%, 59% and 11% respectively. The moisture content of samples was from 4 to 20%.

4.5 Clay

Stiff to very stiff clay was identified between depths of 8.3 and 16.5 m below surface in Boreholes 1 and 2; this corresponds to maximum and minimum upper and lower boundary elevations of approximately 81.9 and 73.5 m respectively. This material was also identified below depths of 0.4 m below surface in Boreholes 3 and 1.7 m below surface in Boreholes 4; this corresponds to

maximum upper boundary elevations of approximately 84.4 and 83.0 m respectively. The thickness of this stratum was found to be approximately 8.0 m as determined in Borehole 1. Atterberg limit tests carried out on samples from Boreholes 1, 3 and 4 indicate this clay has a low to medium plasticity with liquid limits and plasticity indexes from 33 to 42 and 15 to 21 respectively. In-situ field vane tests taken in Boreholes 1 and 2 indicate undrained shear strengths between 66 and 172 kPa with sensitivities ranging from 3 to 5. Gradation analyses conducted on a sample from Borehole 2 indicates gravel, sand, silt and clay contents of approximately 0%, 0%, 11% and 89% respectively. Moisture contents of samples range from 24% to 34%.

4.6 Lower Sand

Loose to very dense sand material was identified below a depth of 16.5 m, corresponding to an elevation of 73.5 m, in Borehole 1. The thickness of the sand was not determined as borehole terminus was reached before the end of the stratum. Gradation analyses conducted on a sample from Borehole 1 indicates gravel, sand, and fines contents of approximately 11%, 79% and 10% respectively. The moisture content of samples was 12 to 13%.

4.7 Groundwater

The groundwater table was identified below the ground surface during the field investigation and visual identification of soil samples. The estimated depth of groundwater level below the ground surface elevation is given in Table 4.2. The water level in the creek at the culvert was at an elevation of approximately 84.6 m during the field investigation. The groundwater levels and water level at the culvert can be expected to vary with season and precipitation events.

Table 4.1 Depth of water table at boreholes

Borehole ID	Borehole elevation (m)	Water table elevation (m)	Depth of water table below the ground surface (m)
BH1	90.0	83.6	6.4
BH2	90.2	83.7	6.5
BH3	84.8	84.3	0.5
BH4	84.7	83.7	1.0

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PART 2: ENGINEERING DISCUSSIONS AND RECOMMENDATIONS

5. PROJECT DESCRIPTION

DST Consulting Engineers Inc. has been subcontracted by Genivar who was retained by the Ministry of Transportation (MTO), Northeastern Region, to conduct a geotechnical investigation for the replacement of the Heighington Creek culvert on Highway 652. This work was carried out under Agreement No.: 5010-E-0006, Detailed Design for the Replacement/Rehabilitation of Various Culverts.

This proposed culvert is to be replaced by a pre-cast box structure (3.6 x 2.4 x 39.19 m). The proposed culvert invert elevations for the inlet and outlet are 83.28 and 83.11 m respectively.. A staged method involving installation of roadway protection and widening the embankment is the preferred replacement approach

The generalized stratigraphy of the existing embankment, based on the conditions encountered in boreholes, consists of surfacing (surface treatment) overlying sand fill that is underlain by a rock fill which is then underlain by sand backfill surrounding the existing culvert. This fill is then underlain clay with sand lenses in some areas. Beneath the clay a lower sand layer was encountered. The water table in the creek at the culvert was at an elevation of approximately 84.6 m at the time of the investigation.

This section presents interpretation of the geotechnical data presented in the factual report and presents geotechnical design recommendations and construction concerns for the proposed culvert replacement.

5.1 Precast Concrete Box Culvert

For this culvert replacement, a precast concrete box culvert is to be used. Open cut excavation has been considered for the replacement of the structure.

The design of the culvert must be in accordance with the Canadian Highway Bridge Design Code CAN/CSA-S6-06 (CHBDC, 2006) and all relevant Ministry of Transportation specification and guidelines.

5.1.1 Earth Excavation

An open cut operation along the proposed culvert alignment is proposed by MTO for the culvert replacement. This method of construction may result in traffic disturbances and may require temporary surface water ditch diversion and temporary support for traffic. It can more readily accommodate excavation of large boulders with this method, if encountered during excavation. As a minimum, the procedures should be in accordance with OPSS 902 "Construction Specifications for Excavating and Backfilling-Structures". Where temporary protection systems are required they shall be constructed in accordance with OPSS 539 "Construction Specification for Temporary Protection Systems" and Section 5.1.6 Roadway Protection.

If organic materials are encountered during excavation, the excavations to remove these organics and wood should be completed in accordance with OPSD 203.040. It is anticipated that the existing groundwater table will be above the invert level. Excavation below the water table can be undertaken by either dewatering of the excavation or in the wet without lowering the water table. If excavation is completed in the wet, any sub-excavated materials can be replaced with 19 mm Type I or II clear stone as defined in OPSS 1004.05.02. If fine materials are present beneath the clear stone a non-woven geotextile (OPSS 1860.07.05.01 Class II) with the filtration opening size (FOS) less than 135 μm may be required for separation. No compaction is required for placement of the clear stone.

5.1.2 Staged Construction

Staged construction has been identified by prime consultant, Genivar, as the preferred approach to maintain traffic during the construction of the culvert at this site. The proposed staged construction includes two (2) stages as given in Genivar Staging Drawings in Appendix B. Slope stability analyses for the proposed slope geometries for stages and final stage have been conducted and are presented in Section 5.1.4 Embankment Design.

Stage 1 is a temporary lane diversion which involves temporary detour of traffic to the southbound lane of 6.26 m width with temporary fill foreslopes of 2H:1V and 1.5H:1V in the granular and rock fill materials respectively as well as the installation of level II roadway protection.

Excavation adjacent the roadway protection is anticipated to an elevation of approximately 82 m to allow for placement of bedding materials. Use of temporary concrete barriers will be required.

Stage 2 is a temporary lane diversion which involves temporary detour of traffic to the northbound lane of 6.26 m width with temporary fill foreslopes of 2H:1V and 1.5H:1V in the granular and rock fill materials respectively as well as the installation of level II roadway protection. Excavation adjacent the roadway protection is anticipated to an elevation of approximately 82 m to allow for placement of bedding materials. Use of temporary concrete barriers will be required.

The final embankment foreslopes should be reinstated as presented in Section 5.1.12 Embankment Foreslopes.

5.1.3 Foundation Design

The culvert will be located at the same location as the existing culvert. As the proposed culvert is not expected to be heavily loaded, a shallow foundation is considered suitable for this site. As the cross sectional area of the box culvert structure will be slightly larger than the existing structure, the overall effect on the culvert foundation soils will be a small decrease in stress of approximately 10 kPa at the base of the culvert.

The geotechnical resistance was estimated for the ultimate limit state (ULS) and serviceability limit state (SLS) for a maximum settlement of 25 mm. The resistance at ULS was calculated by applying load resistance factor of 0.5 according to the Bridge Design Code (CHBDC) CAN/CSA-S6-06 section 6.6.3.6, Table 6.1. The geotechnical resistance was estimated assuming a strip footing consisting of a width equal to the width of the culvert (3.6 m) and a depth of the culvert base equal to 0 m, which is a temporary worst condition prior to backfill that will be encountered during construction. Settlement of the structure can be considered negligible due to the marginal increase in net loading. While ULS is not relevant at final condition due to excessive soil cover SLS is not relevant for temporary condition. Therefore SLS reported here are for final condition.

Table 5.1 Geotechnical resistances and reactions

Footing Size	Ultimate bearing capacity (kPa)	Factored Resistance at ULS (kPa)	Resistance at SLS (kPa)
B = 4.1 m	250	125	40

The width of the sub-excavation should be twice the width of the culvert and where

unsuitable or unstable soils are encountered, the foundation soils must be removed to a firm or hard soils and replaced to the foundation grade. If sub-excavation for frost effects is carried out in the dry (with adequate dewatering controls), the material can be replaced with Granular A material meeting SSP 110S13 specifications and compacted to a minimum of 95 % of standard Proctor maximum dry density in accordance with OPSS 501. If sub-excavation for frost effects is carried out in the wet (water is maintained at or above adjacent groundwater table) All foundation preparation should be completed as required by OPSS 422, as specified in the contract documents and as indicated in Section 5.1.7 Bedding.

5.1.4 Embankment Design

Slope stability analyses were carried out with limit equilibrium methods using Geoslope version 2004 software applying Morgenstern and Price methods. Targeted factor of safety for slope stability analyses was 1.3 for permanent stability analyses. Slope stability analyses were performed under the following slope conditions with an embankment height of up to 6.5 and 7.0 m at the inlet and outlet respectively:

- Stage 1 temporary embankment with minimum 2H:1V and 1.5H:1V in granular and rock fill foreslopes over existing southbound lane,
- Stage 2 temporary embankment with minimum 2H:1V and 1.5H:1V in granular and rock fill foreslopes over reinstated northbound lane,
- Reinstated embankment southbound lane after culvert replacement with 2.0H:1V foreslopes,
- Reinstated embankment northbound lane after culvert replacement with 2.0H:1V foreslopes,

Results for both undrained and drained conditions of the evaluated slope configurations and are presented in Table 5.2 despite drained condition may not relevant for some temporary conditions.

Table 5.2 Summary of stability analyses

Slope Condition	Foreslope Gradient	Drained or Undrained Analyses	Factor of Safety
Stage 1: Temporary widening of southbound lane with rock fill foreslopes, excavation of northbound lane	1.5H:1V	Drained	1.3
		Undrained	1.4
Stage 2: Temporary widening of northbound lane with rock fill foreslopes, excavation of southbound lane	1.5H:1V	Drained	1.3
		Undrained	1.4
Embankment after culvert replacement with granular foreslopes, southbound lane	2.0H : 1V	Drained	1.4
		Undrained	1.5
Embankment after culvert replacement with granular foreslopes, northbound lane	2.0H : 1V	Drained	1.5
		Undrained	1.5

This analyses considered the soil parameters as defined in Table 5.3 and a water table at 4.0 m and 7.0 m below the top of embankment in reinstated and temporary embankment conditions respectively.

Excavation of temporary side slopes above the water table that do not support traffic should not be steeper than 1.0H:1.0V, although, flatter slopes may be required depending on construction methods. Temporary rock fill slopes above the water table supporting traffic during the construction stages should not be steeper than 1.5H:1V. Temporary granular slopes above the water table supporting traffic during the construction stages should not be steeper than 2H:1V. Design of temporary slopes below the water table will depend on the dewatering method. Embankment foreslopes should be reinstated as indicated in Section 5.1.12 Embankment Foreslopes.

The trench width must be sufficient to permit proper use of compaction equipment suited for the material to be compacted, to reach the degree of compaction required, and to accommodate within the space available as per OPSS 501, "Construction Specification for Compaction".

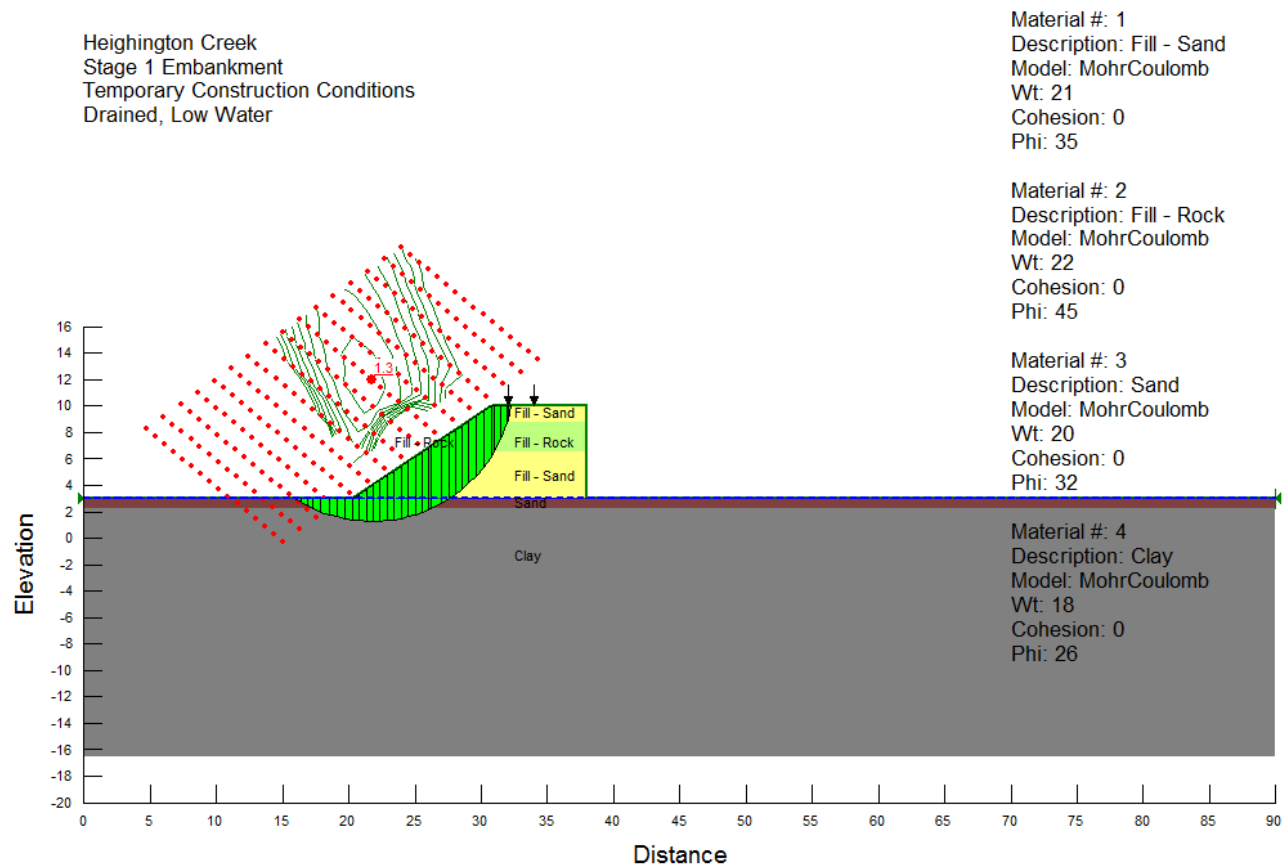


Figure 5.1 Slope stability analysis Stage 1 cutting at right side with minimum 2H:1V granular and 1.5H:1V rock fill foreslopes over existing southbound lane under drained condition

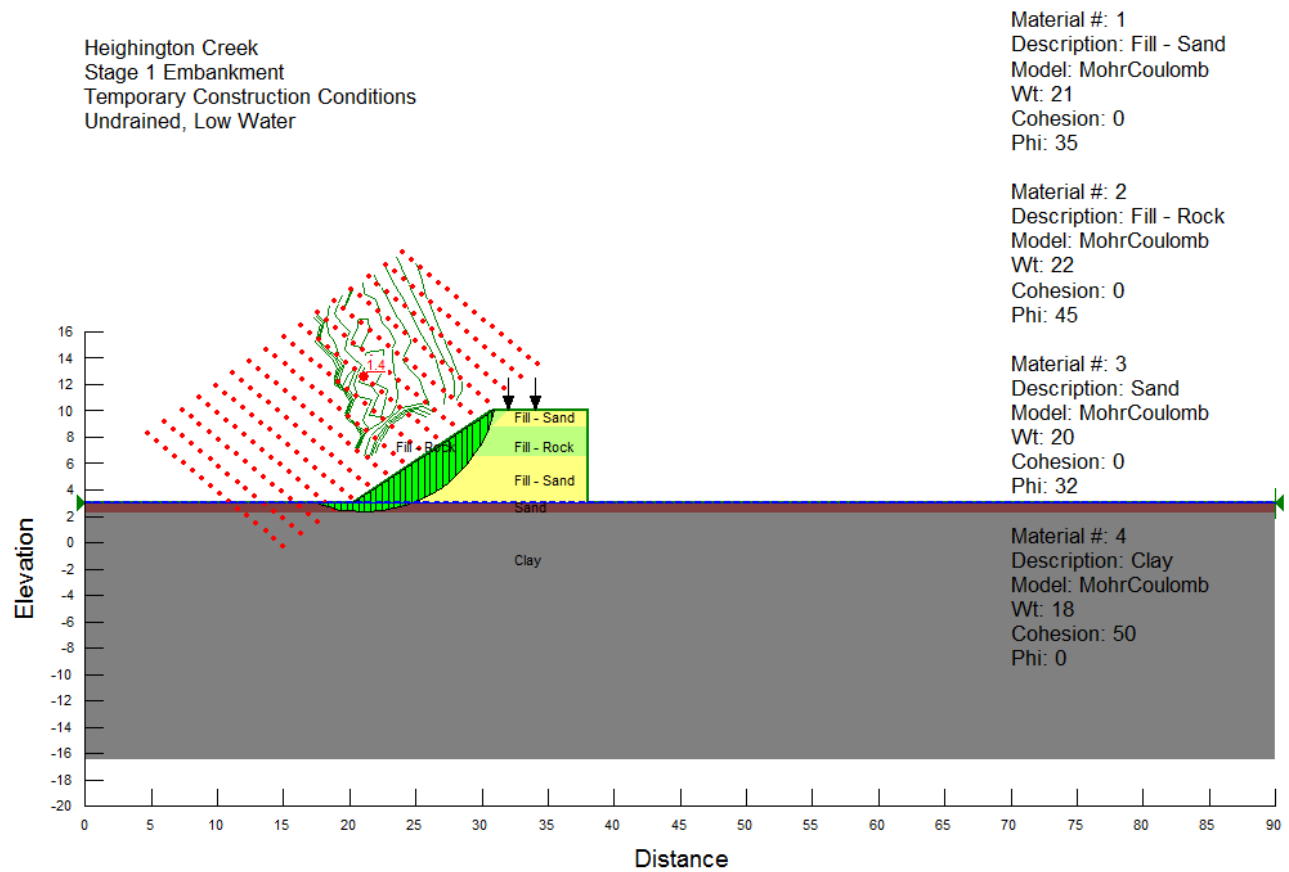


Figure 5.2 Slope stability analysis Stage 1 cutting at right side with minimum 2H:1V granular and 1.5H:1V rock fill foreslopes over existing southbound lane under undrained condition

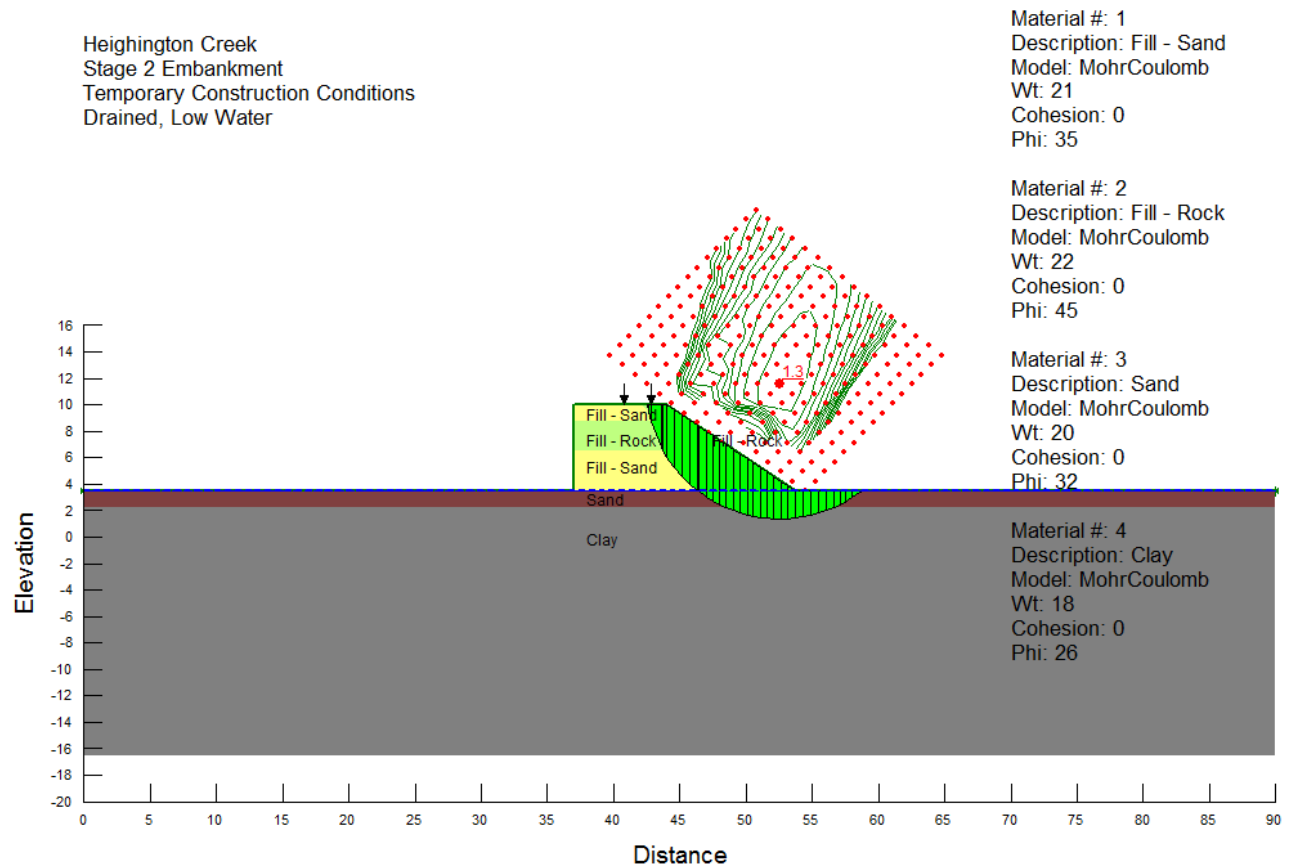


Figure 5.3 Slope stability analysis Stage 2 cutting at left side with minimum 2H:1V granular and 1.5H:1V rock fill foreslopes over reinstated northbound lane under drained condition

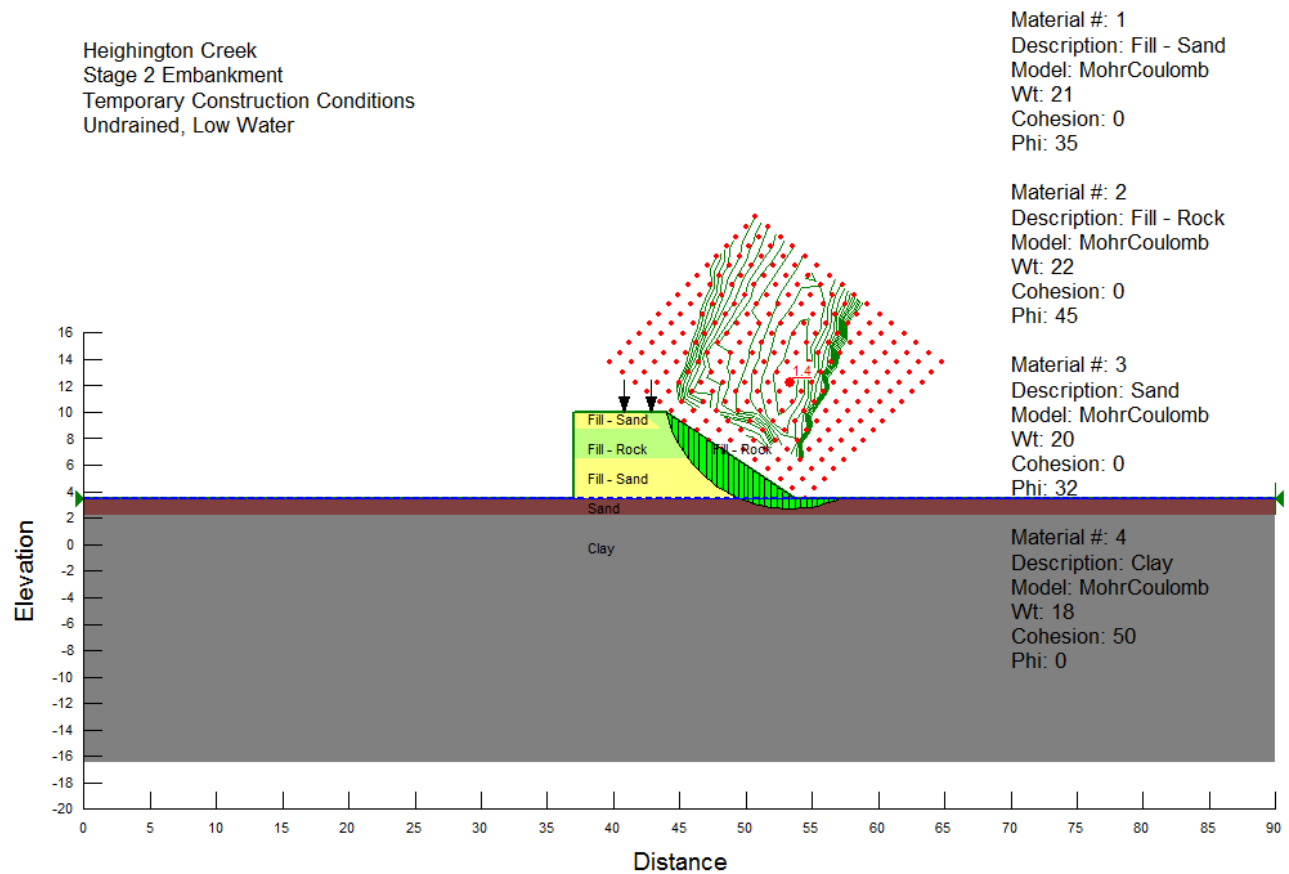


Figure 5.4 Slope stability analysis Stage 2 cutting at left side with minimum 2H:1V granular and 1.5H:1V rock fill foreslopes over reinstated northbound lane under undrained condition

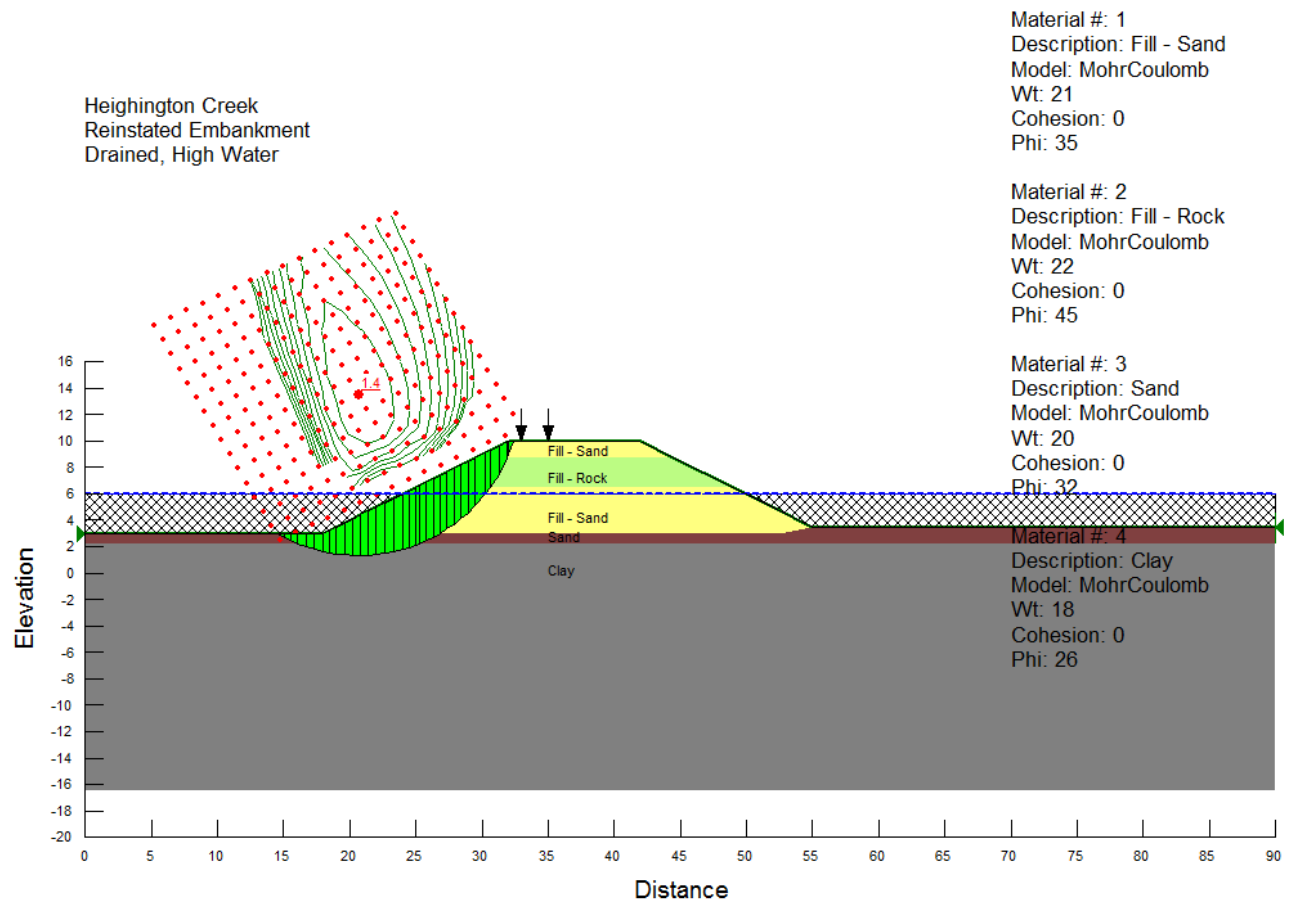


Figure 5.5 Slope stability analysis after culvert replacement left side reinstated embankment with 2H:1V foreslopes under drained condition

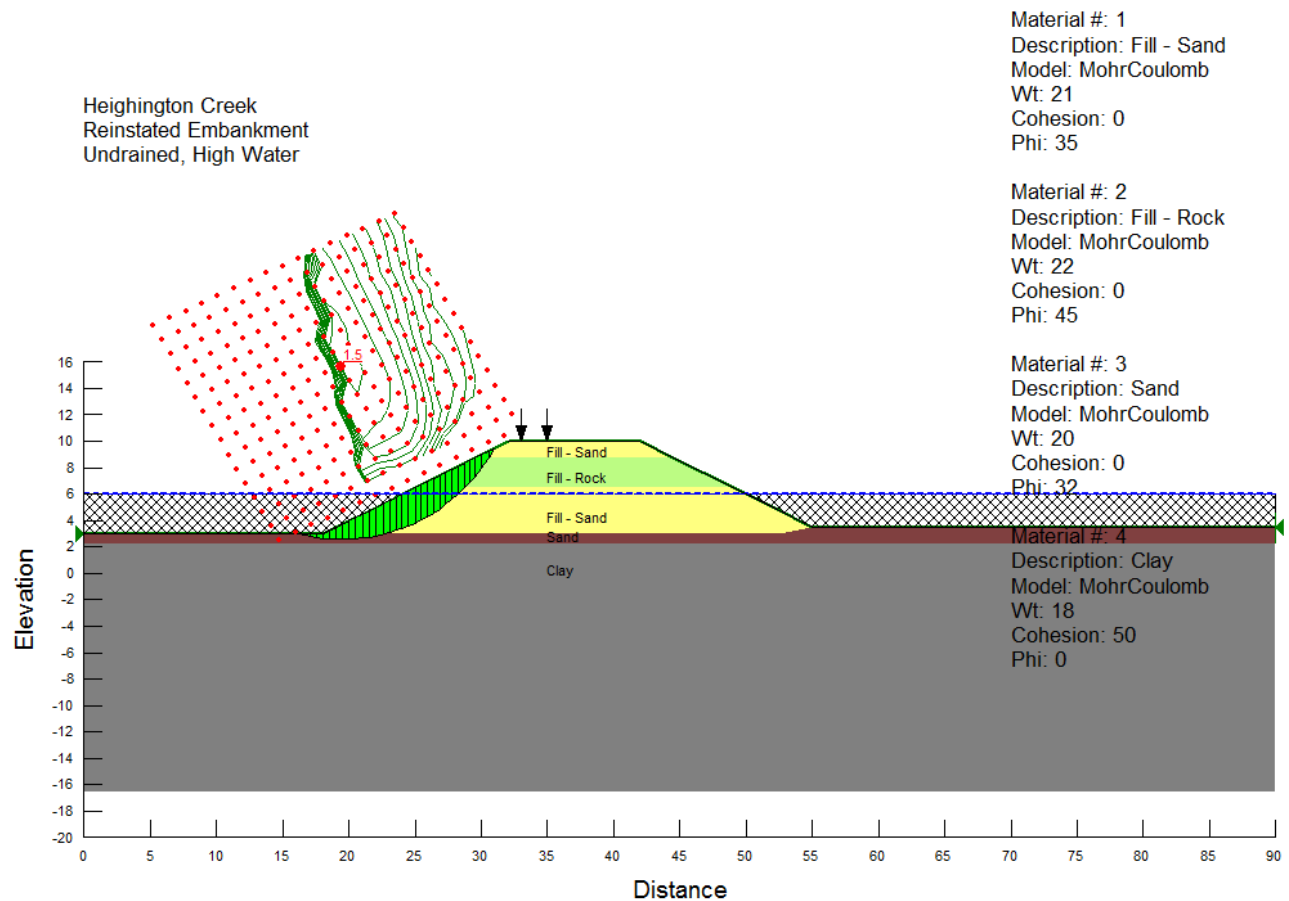


Figure 5.6 Slope stability analysis after culvert replacement left side reinstated embankment with 2H:1V foreslopes under undrained condition

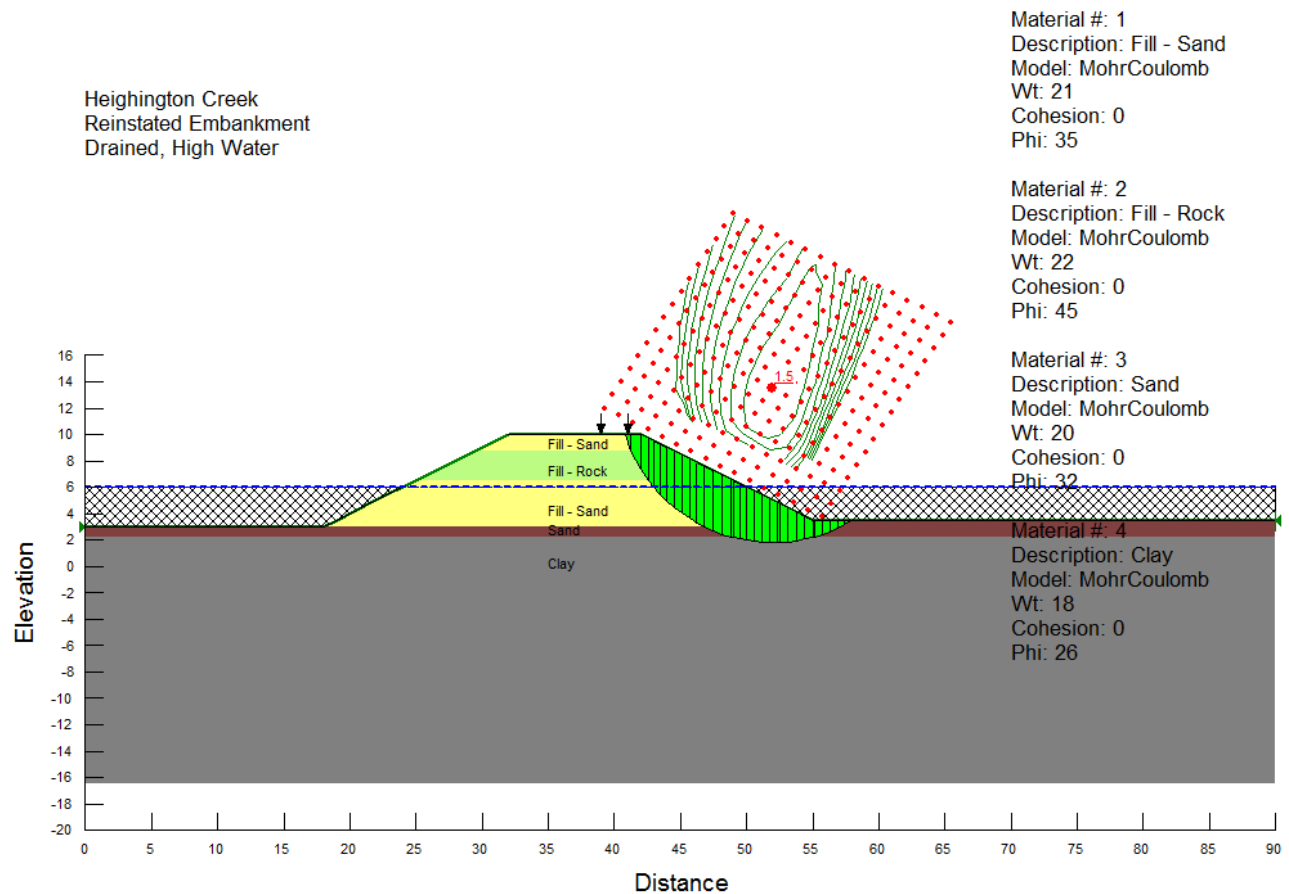


Figure 5.7 Slope stability analysis after culvert replacement right side reinstated embankment with 2H:1V granular fill foreslopes under drained condition

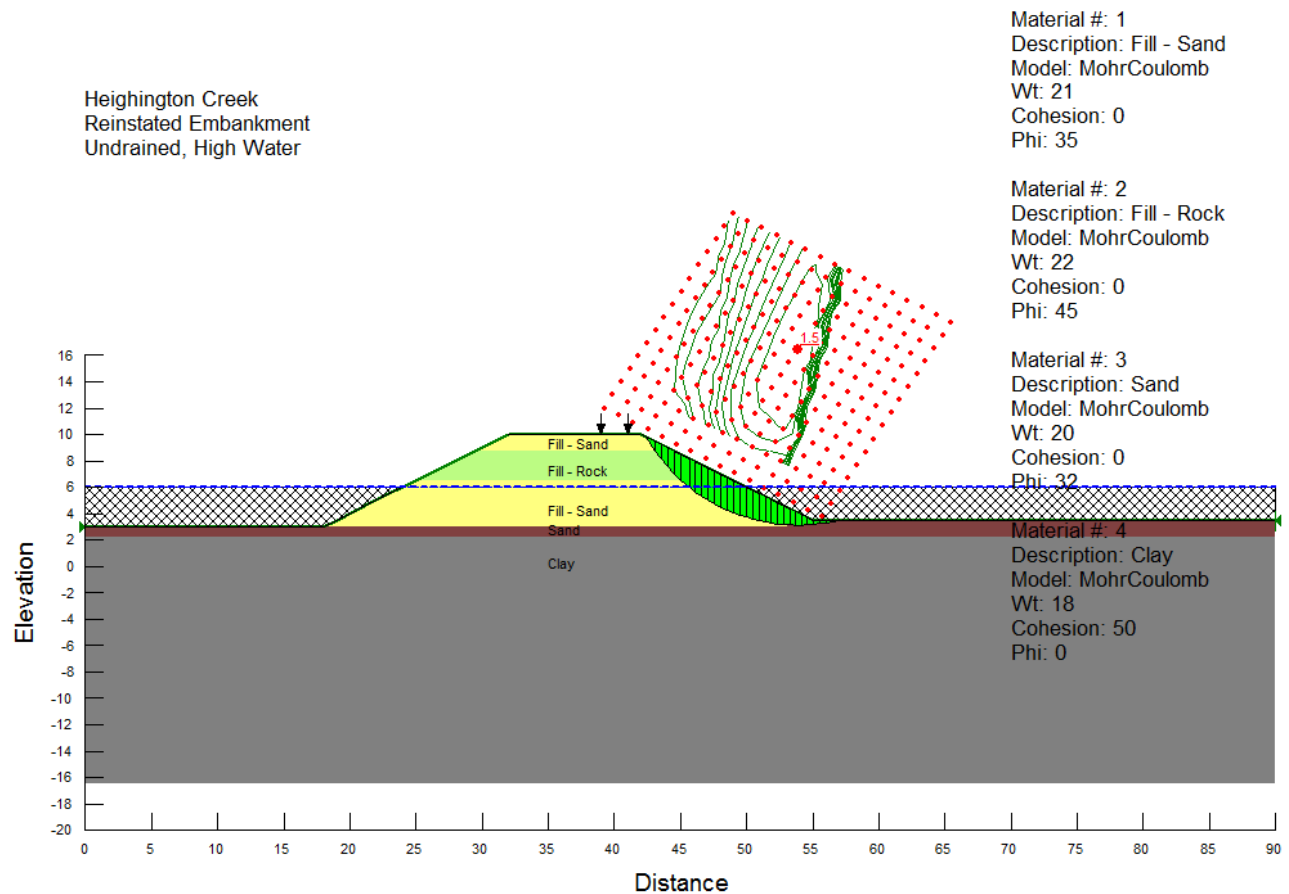


Figure 5.8 Slope stability analysis after culvert replacement right side reinstated embankment with 2H:1V granular fill foreslopes under undrained condition

5.1.5 Lateral and Sliding Resistances

The analysis of horizontal and vertical effects of earth pressures on the culvert can be performed considering soil parameters given in Table 5.3 and assuming linearly variation of stress change with the depth as described in Section 7.8.5.3.2 in Canadian Highway Bridge Design Code. Temporary shoring may be designed using the typical soil parameters given in Table 5.3, but the designer/contractor should verify the appropriate soil parameters for the designs of specific shoring system.

Concrete toe walls are proposed by the prime consultant to be constructed at the inlet and outlet of the culvert and should be constructed in accordance with OPSD 3120.100.

It is recommended that all excavations be either adequately sloped or securely shored and braced to prevent earth caving and to provide a safe and stable work area. The design should incorporate the effects of hydrostatic pressure, traffic surcharge and retained sloping earth conditions in the bracing design.

Resistance to lateral forces/sliding resistance between the base slab for the replacement of culvert and subgrade should be calculated in accordance with section 6.7.5 of the CHBDC.

The coefficients for lateral earth pressure can be calculated using equations provided in Table 5.4. Where no significant earth movements are expected, the coefficient K_0 should be used.

Table 5.3 Typical soil parameters for earth loads

Soil type	Unit weight (kN/m ³)	Internal friction angle (Deg)	Interface friction angle, δ (Deg)	Adhesion factor	Intact undrained shear strength (kPa)	Sensitivity
Rock Fill	22	45	-	-	-	-
Granular A	21	35	17	-	-	-
Granular B	21	35	17	-	-	-
Sand	20	32	15	-	-	-
Clay	18	26	-	0.5	50	5.0

Table 5.4 Lateral Earth Pressure Coefficients

Earth Pressure Coefficient	Equation*
Active Earth Pressure (K_a)	$\frac{(1 - \sin\phi)}{(1 + \sin\phi)}$
Passive Earth Pressure (K_p)	$\frac{(1 + \sin\phi)}{(1 - \sin\phi)}$
At rest (K_0)	$(1 - \sin\phi)$

* ϕ is an angle of internal friction

5.1.6 Roadway Protection

Roadway protection for this project should be constructed in accordance with the requirements of the Occupational Health and Safety Act of Ontario (OHSA), O.Reg. 213/91. According to O.Reg. 213/91, s.226, the soils in the area of interest classify as Type 3 and Type 4 if located above and below the water table respectively. Type 3 soils generally are stiff to firm and compact to loose or are previously excavated soil, exhibit signs of surface cracking, exhibit signs of seepage, if it is dry, may run easily into a conical pile and have a low degree of internal strength. Type 4 soils generally are soft to very soft and very loose in consistency, very sensitive and upon disturbance are significantly reduced in natural strength, run easily or flow unless it is completely supported before excavation procedure, have almost no internal strength, are wet or muddy and exerts substantial fluid pressure on its supporting system. In accordance with O. Reg. 213/91, s.227 (3), if an excavation contains more than one type of soil, the soil shall be classified with the highest number as described in section 226. These should be assessed and confirmed in the field as construction progresses.

Since roadway protection is required during the culvert replacement, installation of a cantilevered sheet pile system may be considered to ensure the stability of the bank and is a feasible option. Alternatively, the use of soldier piles with lagging installed as the excavation progresses may also be considered. Soldier piles, properly designed, will be more capable of accommodating the presence of cobbles and rock fill expected to be encountered within the embankment fill. The design of sheet pile or soldier pile walls may be performed using the typical soil parameters given in Table 5.3, but the designer/contractor should verify the appropriate soil parameters for the designs. Since the embankment is not to be reduced in height, the potential of encountering rock fill, cobbles and boulders is likely. The contractor should be prepared to handle the presence of rock fill with the selection of adequate driving or vibratory equipment as well as steel

thickness.

The construction methodology must be in accordance with OPSS 539 “Construction Specification for Temporary Protection Systems” as well as all Ministry of Transportation, Ministry of Environment, Ministry of Natural Resources and Department of Fisheries and Oceans guidelines, and also the Occupational Health and Safety Act of Ontario. The contractor’s method and equipment must be suitable for the site conditions and materials used.

5.1.7 Bedding

The bedding for the structure should be designed in accordance with the contract documents, Section 7.8.3 of the CHBDC and as specified in OPSS 422 “Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut”.

The foundation soils, sensitive clay in particular, will be very susceptible to disturbance and weakening as a result of traffic, standing water and frost. Any foundation soils that could be disturbed shall be protected. The bottom of the excavation on which the culvert or granular pad is to rest shall not be disturbed. The bedding placement should commence immediately after the final removal of material to the foundation level has been completed.

The bedding shall be a minimum of 0.5 m thick and extend to a minimum width (half of the width of culvert) beyond all sides of the culvert. The bedding material should consist of Granular A as per Soil Group I in accordance with Table 7.4 of the Canadian Highway Bridge Design Code. The Granular A shall be in accordance to SSP 110S13. The Granular A should be placed in layers not exceeding 200 mm in thickness, loose measurement, and each layer compacted to a minimum of 95 % of standard Proctor maximum dry density in accordance with OPSS 501. The middle one-third of the culvert width of the top bedding layer, having minimum thickness of 75 mm, shall be loosely placed and uncompacted.

If construction is performed without dewatering bedding material should consist of 19 mm Type I or II clear stone as defined in OPSS 1004.05.02. If fine materials are present beneath the clear stone a non-woven geotextile (OPSS 1860.07.05.01 Class II) with the filtration opening size (FOS) less than 135 µm may be required for separation. No compaction is required of the clear stone.

5.1.8 Sidefill and Overfill

The sidefill and overfill for the structure should be designed in accordance the contract documents, Section 7.8.3 of the CHBDC and as specified in OPSS 422 “Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut”.

The material used for culvert sidefill should not contain debris, organic matter, frozen materials, or large stones, must meet SSP110S13 Granular A requirements and be compacted to 95% of standard Proctor maximum dry density in accordance with OPSS 501. Soils shall be deposited uniformly on each side of the structure in order to prevent lateral displacement. The minimum width of the sidefill should be at least half of the culvert width in each side.

Overfill should consist of Granular A and should be compacted to a minimum of 90 or 95 % of Standard Proctor Maximum Dry Density (SPMDD) respectively but not greater than the compaction or equivalent stiffness of soils in the sidefill and bedding zones. All compaction shall be completed in accordance with OPSS 501. Each layer should not exceed 200 mm in thickness, loose measurement. The backfill materials should be separated from the adjacent soil with a non-woven Class II geotextile specified in OPSS 1860.

When a concrete culvert is installed on the undisturbed original ground and fill material is placed around and over the culvert, relative settlements between the fill adjacent to the sides of the culvert and the fill directly over the culvert generates downward frictional forces on the culvert, also effecting a load transfer. This vertical load on the culvert can be determined by multiplying the weight of earth over the top of the box section by the vertical arching factor, λ_v . Vertical arching factors for Type B1 and B2 box culverts in standard installations can be considered 1.20 and 1.35 respectively as indicated in Section 7.8.4.2.3 of the CHBDC.

$$q = \gamma h b \lambda_v, \text{ where}$$

q = vertical load on the culvert

γ = unit weight of soil

h = thickness of soil above the culvert

b = width of the culvert, and

λ_v = vertical arching factor

However, due to the marginal change in net loading above and directly adjacent the culvert replacement, settlements should be considered to be occurring under a recompression condition. Therefore, relative settlements between the fill adjacent the sides of the culvert and the fill directly over the culvert can be considered negligible which results in no or little downdrag force.

5.1.9 Channel Diversion and Dewatering

The culvert shall be replaced by diverting the creek through a temporary bypass adjacent to the existing culvert. It is important to ensure that a flood in the bypass does not cause damage to the partly constructed permanent works, to the temporary works or to plant. Floods can occur quickly and can cause significant financial consequences if adequate containment strategies are not present.

If the creek has comparatively a small amount of flow that may depend on the season, it may be feasible for the creek flow to be directed by staging construction. In order to prevent back up of water from upstream and downstream, a dyke made of sand bags has sometimes been used as a hydraulic barrier. However, a sheet pile vertical cut-off wall will provide better control of both surface and groundwater. An adequately designed and properly installed sump and pump system will be sufficient to dewater as excavation is within low permeable soil layer and stabilize the excavation without risk of soil disturbance. It should be noted that depending on the season, depth of excavation and amount of water flow through the creek may vary. The contractor should be prepared to tackle this situation. The contractor should be alerted of the high water table and surface water, for example through a non standard special provision (NSSP).

Where dewatering is performed, all dewatering operations should be completed in accordance with OPSS 517 "Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation". If construction is to be completed in the dry a continuous dewatering operation must be provided to keep the excavation stable and free of water. The excavation must be monitored daily throughout the duration of excavation until the completion of backfilling to confirm this. The dewatering system must be maintained and the surrounding area monitored for impacts to items such as, but not limited to, settlement and groundwater usage. The control of water from the dewatering operation should be accordance with OPSS 518 "Construction Specification for Control of Water from Dewatering Operations".

Water shall be disposed of so as not to be injurious to public health or safety, property, the environment, fisheries, or any part of the work completed or under construction. Dewatering

operations shall be directed to a sediment control device or natural attenuation area prior to discharge to watercourses. If a natural attenuation area is used, a minimum 15 m setback shall be maintained from the receiving watercourse. When water is discharged to a watercourse, the water discharged shall be done in a manner that does not cause erosion or other damage to adjacent lands.

When required, a permit issued by the Ministry of the Environment (MOE) for taking water from a groundwater source shall be obtained.

5.1.10 Erosion Control

Erosion control is essential at inlet and outlet for the successful performance of a culvert. Generally, rip-rap is used to avoid the erosion at inlet and outlet of the culvert. The rip-rap slows down the flow close to the channel bed and prevents culvert failure by the undermining.

To prevent erosion of the surrounding soils at the inlet, rip-rap Treatment shall be applied accordance with OPSD 810.020 "Rip-Rap Treatment for Ditch Inlets" and OPSS 511 and SP511S01 "Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting".

The outlet shall be rip-rapped to prevent erosion of the surrounding soils accordance with OPSD 810.010 "Rip-Rap treatment for Sewer and Culvert Outlets" and OPSS 511 and SP511S01 "Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting".

To prevent undermining of the bedding, cutoff walls shall be installed along the entrance and exit end bottom sides of culvert. Cutoff wall should be designed based on velocity of the water flow and the type of soil underneath.

Considering the replacement of Granular A material underneath and in front of the inlet and replacement of cover material with clear stone or granular material, a clay seal should be considered to minimize underflow. A blanket clay seal should be at minimum 300 mm thick and extend 2 m beyond the fill materials. Clay seals should be constructed in accordance with OPSS 422 and have material properties as specified in OPSS 1205. Alternatively, a geosynthetic clay liner or an ethylene propylene diene monomer (EPDM) liner installed to manufacturer's specifications may also be suitable.

The temporary erosion and sedimentation measures during the construction of culvert shall be controlled as described in OPSS 805 "Construction Specification for Temporary Erosion and

Sedimentation Control Measures”.

5.1.11 Frost Protection

In accordance with OPSD 3090.100 “Foundation Frost Depths for Northern Ontario”, the frost penetration at this location is approximately 2.5 m. The frost susceptible soils shall not be used adjacent to the culvert wall within the depth of frost penetration from the road surface. The soils present under the culvert are frost susceptible (capable of forming thick ice lenses with the associated pressures and heave).

During winter season, ice may form inside the culvert and a low flow rate may assist the ice formation. It is expected that ice may extend to the culvert invert and frost could therefore extend into the soils below the culverts, possibly as deep as 2.5 m. The frost heave may generate additional stresses on the culvert foundation and walls.

Three design approaches are commonly applied; designing the culvert with enough strength and rigidity to tolerate these pressures (recognizing that the maximum differential pressures and movements as a result of frost lensing cannot be accurately quantified); removing the frost susceptible soils within the frost zone; or providing adequate insulation to reduce frost penetration. As the frost penetration is extended below the invert level of the culvert, the frost protection should be in accordance with OPSD 803.030 “Backfill and Cover for Concrete Culverts, Frost Penetration Line below Top of Culvert”.

If sub-excavation for frost effects is carried out in the dry (with adequate dewatering controls), the material can be replaced with Granular B Type I material meeting SSP 110S13 requirements compacted to 95% of standard proctor maximum dry density in accordance with OPSS 501. If the excavation is in the wet (water is maintained at or above adjacent groundwater table) then the material should be rock fill or clear stone surrounded by geotextile, without the need for compaction. Depending on the structural design of the culvert, partial sub-excavation (less than 2.5 m) may also be considered to reduce differential stresses associated with frost; however the exact pressures and movements cannot be accurately quantified.

Acceptable insulation to prevent frost penetration would be 150 mm Dow Styrofoam Highload 40 Insulation or an equivalent material with a compressive strength of approximately 275 kPa or greater. For a region that has a freezing index greater than 3000 Fahrenheit Degree-Days it is recommended that the insulation be placed beneath the structure and extend 2.44 m from the

concrete face of the buried structure.

5.1.12 Embankment Foreslopes

Existing culvert foreslopes are approximately 1H:1V and 1.2H:1V on the west and east embankment respectively. The foreslopes should be reinstated with a slope not steeper than 2H:1V if being constructed with granular materials. The foreslopes should be reinstated with a slope not steeper than 1.5H:1V if being constructed with rock fill.

5.1.13 Construction Concerns

The main construction issues that need to be addressed for this site are removal of cover/embankment materials, staged removal of the existing culvert, provisions required for temporary roadway protection, diversion of the channel, excavation below the water table and reinstatement of the embankment fill. These items are important for the successful installation of the new culvert. Particular attention should be paid to maintain the integrity of the existing culvert during the staged method of construction as well as the ability of the chosen roadway protection to accommodate the presence of cobbles and rock fill within the embankment fill.

A Quality Verification Engineer shall be required to inspect the condition of the foundation and surrounding soils before installation of bedding and other backfills and ensure the width of trench and trench slope walls are suitable, and ensure compliance with materials placed and compaction methods.

6. CLOSURE

Based on the information collected from field investigation and parameters interpreted from laboratory test results, groundwater monitoring data and information provided by the client, culvert replacement options considered were replacement with precast concrete culvert with the use of roadway protection in the dry as well as in the wet. Table 6.1 below summarizes the advantages and disadvantages of construction in the dry versus construction in the wet. Table 6.2 below summarizes the advantages and disadvantages of the use of sheet pile roadway protection versus soldier pile roadway protection.

Table 6.1 Advantages and disadvantages comparison of construction in the dry versus in the wet

Replacement Option	Advantages	Disadvantages
Precast Concrete Culvert installed with Roadway Protection in the Dry	<ul style="list-style-type: none"> • Allows for inspection of subgrade • Allows for careful preparation of steam bed • Prevention of migration of fines between culvert sections during installation • Allows for proper sealing of culvert sections • Ease of erosion control 	<ul style="list-style-type: none"> • Additional construction cost • Potential of piping of materials if granular materials encountered and inadequate dewatering design used • Specialized construction and design required
Precast Concrete Culvert installed with Roadway Protection in the Wet	<ul style="list-style-type: none"> • Ease of construction 	<ul style="list-style-type: none"> • Unconfirmed subgrade • Increase in erosion and sedimentation due to flowing water through construction site

Table 6.2 Advantages and disadvantages comparison of sheet pile versus soldier pile roadway protection

Roadway Protection Option	Advantages	Disadvantages
Sheet Pile	<ul style="list-style-type: none"> • Relatively non permeable • Increased erosion control 	<ul style="list-style-type: none"> • Lightweight material may not accommodate presence of cobbles • Higher installation cost • Specialized construction and design required
Soldier Pile	<ul style="list-style-type: none"> • Heavier gauge materials may be better able to accommodate presence of cobbles • Lower cost 	<ul style="list-style-type: none"> • Permeable • Potential for erosion of retained materials • longer installation time

7. REFERENCES

Canadian Highway Bridge Design Code (2006), CAN/CSA-S6-06, A National Standard of Canada, Canadian standards Association.

Municipal and Provincial Common, Volume 1 - General & Construction Specifications, "*Ontario Provincial Standard for Roads & Public Works*" Spec No. OPSS 422, 501, 510, 511, 517, 518, 539, 805, 902.

Municipal and Provincial Common, Volume 3 - Drawings for Roads, Barriers, Drainage, Sanitary Sewers, Watermains and Structures, "*Ontario Provincial Standard for Roads & Public Works*" Spec No. OPSD 203.040, 803.010, 810.010, 810.020, 3090.100.

Municipal and Provincial Common, Volume 2 - Material Specifications, "*Ontario Provincial Standard for Roads & Public Works*" Spec No. OPSS 1860.

Special Provisions, Ontario Provincial Standards, SSP110S13.

8. LIMITATIONS OF REPORT

A description of limitations which are inherent in carrying out site investigation studies is given in Appendix 'A', and this forms an integral part of this report.

For DST CONSULTING ENGINEERS INC.

Prepared by:



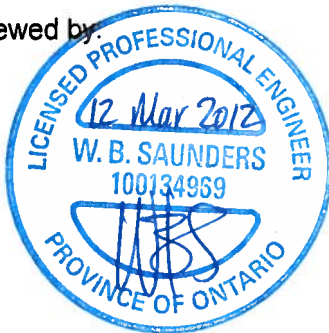
Deep Bansal, M.Eng
Jr. Project Manager

Reviewed by:



Dr. M W Bo, PhD., P. Eng, P.Geo, Int PE,
C.Geol, C. Eng, Eur Geol, Eur Eng
Senior Principal / Director (GeoServices)

Reviewed by:



Wesley Saunders, P. Eng
Project Manager

APPENDIX 'A'

LIMITATIONS OF REPORT

LIMITATIONS OF REPORT

GEOTECHNICAL STUDIES

The data, conclusions and recommendations which are presented in this report, and the quality thereof, are based on a scope of work authorized by the Client. Note that no scope of work, no matter how exhaustive, can identify all conditions below ground. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the specific locations tested, and conditions may become apparent during construction which were not detected and could not be anticipated at the time of the site investigation. Conditions can also change with time. It is recommended practice that a Quality Verification Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavation, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Unless otherwise noted, the information contained herein in no way reflects on environmental aspects of either the site or the subsurface conditions.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs, e.g. the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

Any results from an analytical laboratory or other subcontractor reported herein have been carried out by others, and DST Consulting Engineers Inc. cannot warranty their accuracy. Similarly, DST cannot warranty the accuracy of information supplied by the client.

APPENDIX 'B'
DESCRIPTIVE TERMS
FOR SOIL CLASSIFICATION

Descriptive Terms for soil classification:

As per the soil classification manual by MTO, the descriptive terms based on percent by mass of the whole sample, are described as per following table

Descriptive Term	Example	Percent by Mass of Sample
And (with two major soil types)	Sand and gravel	40-60
Adjective (silty)	Silty	30-40
With	Silt with fine sand	20-30
Some	Silt, some fine sand	10-20
Trace	Sand, trace of gravel	0-10

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:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	KN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	KN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	KN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	$w_{s.}$	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	KN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	KN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	KN/m^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

APPENDIX 'C'

GENIVAR STAGING DRAWINGS

METRIC


DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No 2012-5121
WP No 5123-07-01

HEIGHINGTON CREEK CULVERT
(39E-198)

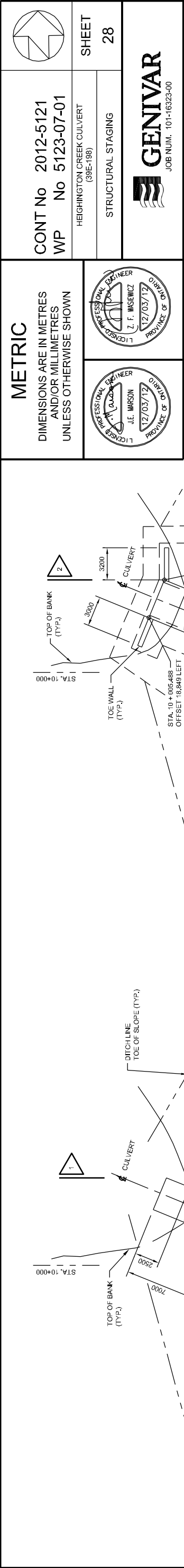
STRUCTURAL STAGING

SHEET 28



GENIVAR

JOB NUM. 101-16323-00



NOTE :

- THE COMPLETE DESIGN OF ROADWAY PROTECTION IS THE RESPONSIBILITY OF THE CONTRACTOR. ROADWAY PROTECTION TO BE DESIGNED TO PERFORMANCE LEVEL 2.
- ROADWAY DETAILS, SEE SHEET NO. 16 AND 17.
- ROADWAY PROTECTION SHOWN SCHEMATICALLY ONLY.

STAGE 1A:

- CONSTRUCT WIDENING FOR STAGE 1 TRAFFIC AND DIVERT TRAFFIC INCLUDING INSTALLATION OF TEMPORARY CULVERT.
- INSTALL ROADWAY PROTECTION.
- EXCAVATE ROADWAY AND EMBANKMENT.
- REMOVE EXISTING CULVERT.

STAGE 1B:

- PLACE TEMPORARY GABIONS.
- BACKFILL CULVERT AND CONSTRUCT PLATFORM FOR STAGE 2 TRAFFIC.

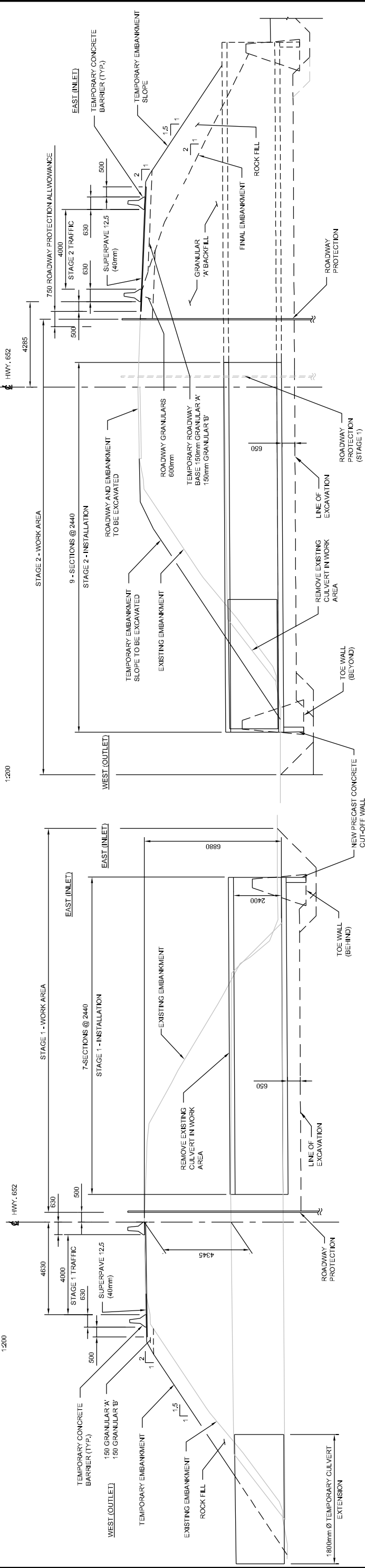
STAGE 2A:

- DIVERT TRAFFIC TO STAGE 2.
- INSTALL ROADWAY PROTECTION.
- EXCAVATE ROADWAY AND EMBANKMENT.
- REMOVE EXISTING CULVERT.
- PLACE BEDDING, RIGID INSULATION, CUT-OFF WALLS, CULVERT AND RETAINING WALLS.

STAGE 2B:

RECONSTRUCT ROADWAY. (SEE ROADWAY DRAWINGS)

PLAN - STAGE 2



REVISIONS		DESCRIPTION			
DATE	BY	CHK	Z.F.W.	CODE	LOAD CL-675-ONT/DATE
					MAR. 2012
DRAWN	AM.	CHK	MLB	SITE	38E-198
					STRUCT
					SCHEME
					DWG.
					04

A P P E N D I X ‘ D ‘
N O N - S T A N D A R D
S P E C I A L P R O V I S I O N S

NOTICE TO CONTRACTOR

Special Provision

FOUNDATION CONDITIONS

The Contractor is advised of the following foundation conditions:

Peterson Creek Culvert (Site # 39E-257)

Cobbles and rock fill were identified within the sand fill layer within the advanced borehole locations.

The foundation soils, sensitive soil in particular, will be very susceptible to disturbance and weakening as a result of traffic, standing water and frost. Any foundation soils that could be disturbed should be protected. The bottom of the excavation on which the culvert or granular pad is to rest shall not be disturbed. The bedding placement shall commence immediately after the final removal of material to the foundation level has been completed.

The contractor shall be notified of the high water table and surface water elevation as noted in the Foundation Investigation Report for Peterson Creek.

Heighington Creek Culvert (Site # 39E-198)

Cobbles and rock fill were identified within the sand fill layer within the advanced borehole locations.

The foundation soils, sensitive soil in particular, will be very susceptible to disturbance and weakening as a result of traffic, standing water and frost. Any foundation soils that could be disturbed should be protected. The bottom of the excavation on which the culvert or granular pad is to rest shall not be disturbed. The bedding placement shall commence immediately after the final removal of material to the foundation level has been completed.

The contractor shall be notified of the high water table and surface water elevation as noted in the Foundation Investigation Report for Heighington Creek.

DEWATERING STRUCTURE EXCAVATION - Item No.

Special Provision

902.01 SCOPE

Section OPSS 902.01 of OPSS 902 is amended by the addition of the following:

As part of the work under this item, the Contractor shall:

- Carry out any additional field investigation the Contractor deems necessary in order to engineer the dewatering systems;
- Design and install dewatering systems to construct the work in the dry;
- Provide temporary bypass for watercourse;
- Carry out works necessary for the dewatering system that may include fish salvage/relocation, sheet piling, tremie concrete seal, sand bagging, etc.;

The Contractor shall provide a continuous dewatering operation to keep the excavation stable and free of water. The excavation must be monitored throughout the duration of excavation until the completion of backfilling. The dewatering system must be maintained and the surrounding area monitored for impacts to items such as, but not limited to, settlement and groundwater usage.

The contractor shall also maintain flow in watercourse through the use of a temporary water bypass system which shall be designed to accommodate the design flow rate. The design flows are provided in the contract drawings.

Fish are resident year round in this water body. Wherever a pump is used for dewatering in an area where there possibly may be fish the pump inlet must be suitably screened (with 30 mm clear stone or equivalent) to prevent fish entrainment.

This item includes all installation, modification, and removal of the dewatering system and temporary water passage system as outlined in Operational Constraints: Waterbody/Fisheries in Waterbodies and on Waterbody Banks. All additional excavation and backfill, roadway protection or other temporary works required to provide the temporary bypass shall be included.

The Contractor must satisfy himself with the local conditions and anticipated water flows, levels and flow velocity to be met with during construction. He shall make his own estimate of the facilities required and difficulties to be encountered including the nature of subsurface materials and conditions.

902.03 DEFINITIONS

Section OPSS 902.03 of OPSS 902 is amended by the addition of the following definitions and the deletion of the current definitions of these items, as applicable:

Stamped:	Refers to drawings or details that have been reviewed and stamped “Conforms With Contract Documents”. The stamp shall include the date and signature of the Quality Verification Engineer (QVE).
Quality Verification Engineer (QVE):	An Engineer licensed to practice in the Province of Ontario who has a minimum of five (5) years of experience in the field of design and/or construction of dewatering systems. The Contractor shall retain the QVE to ensure conformance with the contract document.
Dewatering System Design Engineer:	An Engineer licensed to practice in the Province of Ontario who has a minimum of five (5) years of experience in the field of design and/or construction of bridges. In addition, the Dewatering System Design Engineer shall have had responsible experience in the design of at least 5 other dewatering systems. The Contractor shall retain the Dewatering System Design Engineer to ensure conformance with the contract documents and issue certificate(s) of conformance for the design.
Certificate of Conformance	The certificate of conformance shall mean a document issued by the dewatering system design engineer confirming that the specified components of the work are in general conformance with the requirements of the contract documents. Certificate shall be signed and sealed by the Dewatering System Design Engineer.

902.04 SUBMISSION AND DESIGN REQUIREMENTS

Section OPSS 902.04 of OPSS 902 is amended by the addition of the following:

Design of components of the dewatering systems shall be in accordance with CAN/CSA-S6-00 and standard referenced therein.

Submission of Shop Drawings

All shop drawings submissions shall bear the seal and signature of the Dewatering System Design Engineer.

The Contractor shall submit to the Quality Verification Engineer shop drawings for review and stamping.

At least two weeks prior to the commencement of dewatering system construction, the Contractor shall submit to the Contract Administrator, for information purposes only, four (4)

sets of stamped drawings/calculations of the dewatering system.

The Contractor shall, at least three (3) weeks prior to the commencement of the dewatering system installation, submit to the QVE for review, four sets of drawings and calculations indicating:

- the dewatering system design, including design criteria and loading;
- the location, type and dimensions of each dewatering system to be used;
- a schematic showing the configuration of all dewatering systems;
- the material and dimensions of dewatering system components to ensure stability of the design excavation and the dewatering system, and the construction sequence and schedule of each component for which the dewatering system is designed.

The QVE shall review all calculations, construction details, shop drawings and procedures.

All submissions shall bear the seal and signature of the Dewatering System Design Engineer and QVE.

Certificates of Conformance

The Dewatering System Design Engineer shall inspect the installation of each component prior to the executing of the next stage in that dewatering system. After the installation/construction of each component, the Contractor shall submit a Certificate of Conformance to the Contract Administrator, sealed and signed by the Dewatering System Design Engineer. The Certificates of Conformance shall state that the dewatering system is in place, and has been installed in conformance with the stamped shop drawings and the Contract Drawings.

The Contractor will note that several Certificates of Conformance may be required, each to coincide with each dewatering system installation.

902.07 CONSTRUCTION

Section OPSS 902.07 of OPSS 902 is amended by the addition of the following:

All concrete work must be carried out in the dry.

Minimum dimensions for the inside face of the dewatering system shall be sufficient for installation of the new culvert.

902.07.04 Dewatering Structure Excavation

Section OPSS 902.07.04 of OPSS 902 is amended by the addition of the following:

If the Contractor's design requires any portion of the bypass culvert to be left in place following backfill operations, the bypass culvert shall be installed at a distance from the new culvert sufficient to ensure the new culvert can be properly backfilled. The portion of the bypass culvert left in place shall be filled with lean concrete following decommissioning.

902.07.08 Certificate of Conformance

Section OPSS 902.07.08 of OPSS 902 is deleted.

902.10 BASIS OF PAYMENT

Section OPSS 902.10 of OPSS 902 is amended by the addition of the following:

Payment at the contract price for the dewatering systems shall be full compensation for all labour, equipment and materials to carry out the work.

CLAY SEAL - Item No.

Special Provision

OPSS 902 shall apply as amended herein:

902.01 SCOPE

Section 902.01 shall be amended by the addition of the following:

Peterson Creek Culvert (Site #39E-257)

The Contractor shall utilize an Ethylene Propylene Diene Monomer (EPDM) membrane barrier at the inlet of the culvert.

The EPDM membrane shall conform to ASTM D412 and the following:

Thickness: 60 mils
Minimum Tensile Strength: 1300 psi
Minimum Ultimate Elongation: 300%
Minimum Tear Resistance: 150 lbs/in

The EPDM membrane shall be installed in accordance with the manufacturer's instructions. The membrane shall be securely connected to the fascia of the bottom slab or apron wall and the concrete toe walls or retaining walls as applicable. This connection shall be impermeable. The membrane shall be laid flat over the backfill material and extend 2.0m beyond the extents of the backfill onto native material. The edges of the membrane shall be keyed into the native material 500mm vertically and horizontally and a protective layer of sand backfill, 300mm thick, shall be placed over top of the membrane prior to the placement of scour protection.

Heighington Creek Culvert (Site #39E-198)

Under this Tender Item, the Contractor shall supply and install the clay seal at the inlet of the culvert.

Alternatively the Contractor may substitute an Ethylene Propylene Diene Monomer (EPDM) membrane barrier in its place.

The EPDM membrane shall conform to ASTM D412 and the following:

Thickness: 60 mils
Minimum Tensile Strength: 1300 psi
Minimum Ultimate Elongation: 300%
Minimum Tear Resistance: 150 lbs/in

The EPDM membrane shall be installed in accordance with the manufacturer's instructions. The membrane shall be securely connected to the fascia of the bottom slab or apron wall and the concrete toe walls or retaining walls as applicable. This connection shall be impermeable. The membrane shall be laid flat over the backfill material and extend 2.0m beyond the extents of the backfill onto native material. The edges of the membrane shall be keyed into the native material 500mm vertically and

horizontally and a protective layer of sand backfill, 300mm thick, shall be placed over top of the membrane prior to the placement of scour protection.

3600 MM X 2400 MM PRECAST CONCRETE BOX CULVERT - Item No.

Special Provision

OPSS 904 shall apply except as amended herein:

904.01 SCOPE

Under this Tender Item, the Contractor shall fabricate, deliver and install the precast concrete box culvert sections as shown on the Contract Drawings; this tender item also includes the fabrication, delivery and installation of the precast concrete cut-off wall as shown on the Contract Drawings.

Under this Tender Item, the Contractor shall

- pick-up at the designated pick-up location, deliver and install the precast concrete box culvert units as shown on the Contract Documents, including the supply and placement of the rigid insulation and the placement of the geotextile at the culvert joints.
- include the fabrication, delivery and installation of two additional precast concrete box culvert sections as shown on the Contract Drawings,
- include the fabrication, delivery and installation of the precast concrete cut-off walls as shown on the Contract Drawings.

Heighington Creek Culvert (Site #39E-198) is a 3600 mm x 2400 mm precast concrete box culvert that can be picked up at the following location:

MTO Detour Patrol Yard
West side of Hwy 652, 88 km North of Cochrane

Contractor shall notify Steve Gauvin, Maintenance Coordinator, phone number (705) 335-2237 - 48 hours prior to the Contractor picking up the culvert.

The units shall be fabricated in accordance with OPSS 422 except as otherwise specified herein.

904.03 DEFINITIONS

Section 904.03 shall be amended by the addition of the following paragraph:

Quality Verification Engineer: An engineer who has a minimum of five (5) years experience in the construction and inspection of culverts and associated appurtenances. The Quality Verification Engineer shall be retained by the Contractor to ensure conformance with the contract documents and issue of certificate(s) of conformance.

904.04 SUBMISSION AND DESIGN REQUIREMENTS

Section 904.04 shall be amended by the addition of subsection 904.04.02 and 904.04.03:

904.04.02 Submission of Shop Drawings

The design, and shop drawings and erection drawings shall bear the seal and signature of a Professional Engineer who is licensed by the Association of Professional Engineers of Ontario.

The Contractor shall submit to the Owner for review, three complete sets of design and shop drawings, two weeks after Contract Award for review.

904.04.03 Submission of Erection Procedures

The erection drawings shall bear the seal and signature of a Professional Engineer who is licensed by the Association of Professional Engineers of Ontario.

The Contractor shall submit 3 sets of the erection procedures to the Contract Administrator at least 2 weeks prior to commencement of erection, for information purposes only. The Quality Verification Engineer shall affix his seal and signature on the erection procedures verifying that the procedures are consistent with the Contract Documents and sound engineering practices.

The erection procedures shall include at least the following:

1. Lifting points locations
2. Details of all temporary supports

904.05 MATERIALS

904.05.05 Mortar

Subsection 904.05.05 shall be deleted in its entirety and replaced with the following:

Mortar for joints shall be composed of one part normal Portland cement and two parts mortar sand wetted with only sufficient water to make the mixture plastic. The normal Portland cement shall be according to OPSS 1301, mortar sand shall be according to OPSS 1004, and water shall be according to OPSS 1302.

Section 904.05 shall be amended by the addition of the following subsections:

904.05.12 Geotextile

Geotextile to be non-woven, Class II, with a thickness greater than 1mm and a FOS of 50 to 100 microns and shall be according to OPSS 1860.

904.05.13 Rigid Insulation

Rigid Insulation shall be Dow Styrofoam Highload 40 Insulation (minimum compressive strength of 275 kPa) or an equivalent material as per OPSS 1605.

904.05.14 Preformed Gasket

Preformed gaskets shall be as specified by the manufacturer of the box units.

904.05.15 Grout

Grout shall be non-shrink and non-staining.

422.05.13 Bedding

Bedding shall be as specified in the Contract Documents. Earth bedding shall be classified as Group I or Group II according to Table 1.

The maximum particle size for bedding shall not exceed 25 mm in diameter, unless the bedding layer has a thickness of 150 mm or greater, in which case the maximum particle size shall not exceed 38 mm in diameter.

422.05.14 Backfill

Backfill shall be as specified in the Contract Documents. Earth backfill shall be classified as Group I, Group II, or Group III according to Table 1.

Earth backfill shall be free of boulders over 100 mm in diameter, topsoil, frozen materials, organic matter, and other deleterious material.

422.05.15 Cover

Cover shall be as specified in the Contract Documents. Earth cover shall be classified as Group I or Group II according to Table 1.

Cover shall be free of boulders having a diameter greater than 100 mm, debris, organic matter, or frozen materials.

904.07 CONSTRUCTION

Section 904.07 shall be amended by the addition of the following subsections:

904.07.19 CCIL Certification

The precast concrete culvert units shall be fabricated by a manufacturer certified in conformance to the "Prequalification Requirements for Manufacturers of Precast Concrete Drainage Products - May 1998", by the MTO/MEA/OCPA/OPS Prequalification Advisory Committee.

Units are to be designed in accordance with the CHBDC 2006 for highway loads with a minimum of 600 mm, to a maximum of 4000 mm of granular fill and roadbase.

904.07.20 Delivery

Not less than seven days before any shipping begins, the Contractor shall provide the Owner with his delivery schedule.

Transportation and storage of the precast culvert segments shall be performed in such a manner that the loading, transportation, and unloading does not impart additional stresses to the elements that they were not designed.

The Contractor shall perform an inspection of all precast elements supplied by the Owner for the presence of defects. A detailed description of any defects shall be provided to the Contract Administrator prior to loading the elements for delivery. The Contractor is fully responsible for any damage to the culvert during loading, delivery and storage on site.

904.07.21 Erection

904.07.21.01 General

The work shall consist of the installation of the precast concrete cut-off walls, erection of the concrete culvert segments, and the installation of geotextile at all joints between segments.

The Contractor shall keep a copy of the signed and sealed erection procedures on the site during erection of the members.

The Contractor shall notify the Contract Administrator in writing of the starting date at least 1 week prior to the commencement of field operations and erection work shall not be carried out until the Contract Administrator is on the site.

Precast concrete cut-off walls units shall be installed to the alignment and grade shown on the Contract Documents. The installation tolerance is ± 5 mm horizontally and vertically.

Precast concrete box culvert units shall be installed to the alignment and grade shown on the Contract Documents. The installation tolerance is ± 5 mm horizontally and vertically.

The box units shall be placed with the base of each box unit in uniform contact with the prepared bedding throughout its full length. The ends of the box units shall be joined so there is no unevenness along the inside. The box units and joint surfaces shall be kept clean as work progresses. Water shall not be allowed to flow through the box units during installation.

The Contractor shall ensure that the joints are effectively covered to prevent influx of material from the backfill through the joints. A 600 mm wide strip of geotextile shall be placed to form a continuous barrier centred on the exterior of all buried joints.

The geotextile shall be free of folds, tears and wrinkles. The geotextile shall be joined so that the material laps a minimum of 500 mm and shall be pinned together. Alternatively, the geotextile shall be joined to conform to the seam requirements of OPSS 1860.

Cementitious grout shall be placed to completely fill the recess. All excess grout shall be removed.

904.07.21.02 Bedding

Bedding shall be placed to the dimensions shown in the Contract Documents.

The bedding shall be placed as uniformly as possible. Bedding under the middle third of the box unit base shall be loosely placed and uncompacted. Bedding requiring compaction shall be placed in layers not exceeding 200 mm in thickness, loose measurement, and each layer shall be compacted according to OPSS 501.

Bedding shall not be placed on frozen earth grade.

904.07.21.03 Levelling

The surface prepared to support the box units shall have a 75 mm minimum thickness top levelling course of uncompacted Granular A or fine aggregates.

904.07.21.04 Installing Box Units

422.07.09.01 Box Units

Box units shall be installed to the alignment and grade specified in the Contract Documents. Box units shall not be installed on bedding containing frozen material.

End units to accommodate concrete appurtenances shall be as specified in the Contract Documents.

The box units shall be installed to make a continuous line forming a box culvert or box sewer. The gap at box unit joints shall not exceed 20 mm.

For box units placed in parallel for multiple cell installations, a 60 mm \pm 10 mm gap filled with grout between adjacent cells shall be provided.

Installation of the box units shall commence at the outlet end and proceed in the upstream direction with the bell ends of the box units facing upgrade. The box units shall be placed with the base of each box unit in uniform contact with the prepared bedding throughout its full length. The ends of the box units shall be joined so there is no unevenness along the inside. The box units and joint surfaces shall be kept clean as work progresses. Water shall not be allowed to flow through the box units during installation. The excavation shall be kept dry and the box units shall not be installed in water.

904.07.21.05 Geotextile at Joints

A 600 mm wide strip of geotextile shall be placed to form a continuous barrier centered around the exterior of all buried joints.

Geotextile shall be free of folds, tears, and wrinkles. The geotextile shall be joined so that the material laps a minimum of 500 mm and shall be pinned together. Alternatively, the geotextile shall be joined according to the seam requirements of OPSS 1860.

904.07.21.06 Mortared Joints

When mortared joints are specified in the Contract Documents, all joints shall be thoroughly cleaned and wetted. Mortar shall then be applied over the joint around the inner and outer perimeter. After the mortar joint is complete the joint inside shall be wiped clean and smooth.

904.07.21.07 Preformed Gasket

When a preformed gasket is specified in the Contract Documents for sealing the joint between the box units, it shall be placed according to the manufacturer's recommendations.

904.07.21.08 Joint Sealing Compound

When joint sealing compound is specified in the Contract Documents for sealing the joint between the box units, it shall be applied according to the manufacturer's recommendations.

904.07.21.09 Lift Holes

All lift holes shall be filled with mortar after installation of the box unit.

904.07.21.10 Concrete Appurtenances

Concrete placement, sampling, and testing shall be according to OPSS 904. Reinforcing steel shall be placed according to OPSS 905. Steel grating shall be provided as specified in the Contract Documents.

904.07.21.11 Backfill

Backfill shall be placed in layers not exceeding 200 mm in thickness, loose measurement. Compaction shall be according to OPSS 501.

Backfilling on each side of the box units shall be completed simultaneously. At no time shall the levels on each side differ by more than 400 mm.

When native material is specified as backfill in the Contract Documents, earth material may be substituted, when approved by the Contract Administrator. In areas within the roadway, for a depth equal to the frost treatment, earth backfill shall have frost susceptibility characteristics similar to the native material. The Contract Administrator shall decide on the suitability of the earth backfill that the Contractor proposes to substitute.

Rock may be used as backfill provided the installed box units are protected by a minimum thickness of cover material as specified in the Contract Documents.

Box unit installation and backfill shall be completed prior to the start of any subbase and base course construction over the box unit location.

Shoring and bracing shall be withdrawn and removed as the excavation is being backfilled.

904.07.21.12 Cover

Cover shall be placed in layers not exceeding 200 mm in thickness, loose measurement, and each layer shall be compacted according to OPSS 501.

Cover in trenches and in other locations where pavements require controlled differential settlement shall be of a type and compaction level to control pavement differential settlement within acceptable limits for the specified type of pavement.

904.08 QUALITY ASSURANCE

Section 904.08 shall be amended by the addition of the following subsection:

904.08.05 Certificate of Conformance

The Contractor shall submit to the Contract Administrator a certificate of conformance signed and sealed by the Quality Verification Engineer upon completion of each of the following operations and prior to the commencement of each subsequent operation:

- Precast Culvert Fabrication
- Precast Cut-off Fabrication
- Precast Culvert Installation

The certificate shall state that the work has been executed according to the specification and /or stamped working drawings.

904.10**BASIS OF PAYMENT**

Section 904.10 shall be deleted and replaced with the following paragraph:

Payment at the Contract price for the above tender item shall be full compensation for all labour, equipment and material to do the work and includes but not limited to surveying, plastic shims, grouting, geotextile, and rigid insulation.

D R A W I N G S

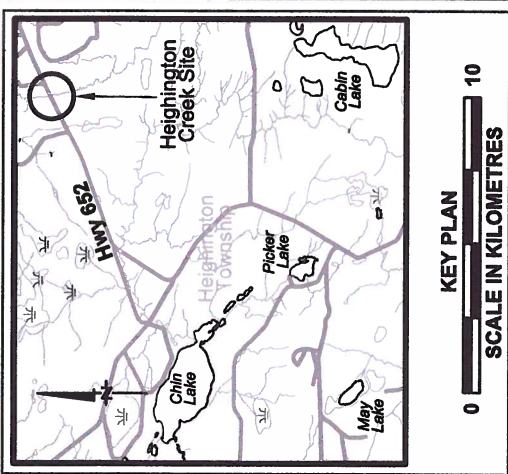
METRIC
DIMENSIONS ARE IN METRES
UNLESS OTHERWISE SPECIFIED
DIMENSIONS SHOWN IN METRES
IN KILOMETERS + METERS

CONT

No 2012-5121
GWP No 5481-09-00
WP No 5123-07-01
Site No 39E-198
GeoCres No 42H-45

CULVERT REPLACEMENT
AT HEIGHINGTON CREEK
Hwy 652 – Heighington Twp.
Borehole Locations

SHEET



LEGEND

Borehole/Hand Auger

Borehole with DCPT

Dynamic Cone Penetration Test (DCPT)

Rock Probes

Blows/0.3m (Std. Pen Test, 475 J/Blow)

Water level at time of investigation

Benchmark

Fill

Organics

Topsoil

Till

Bedrock

Sand

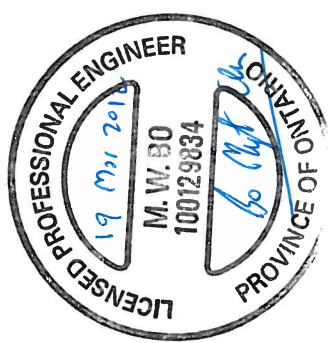
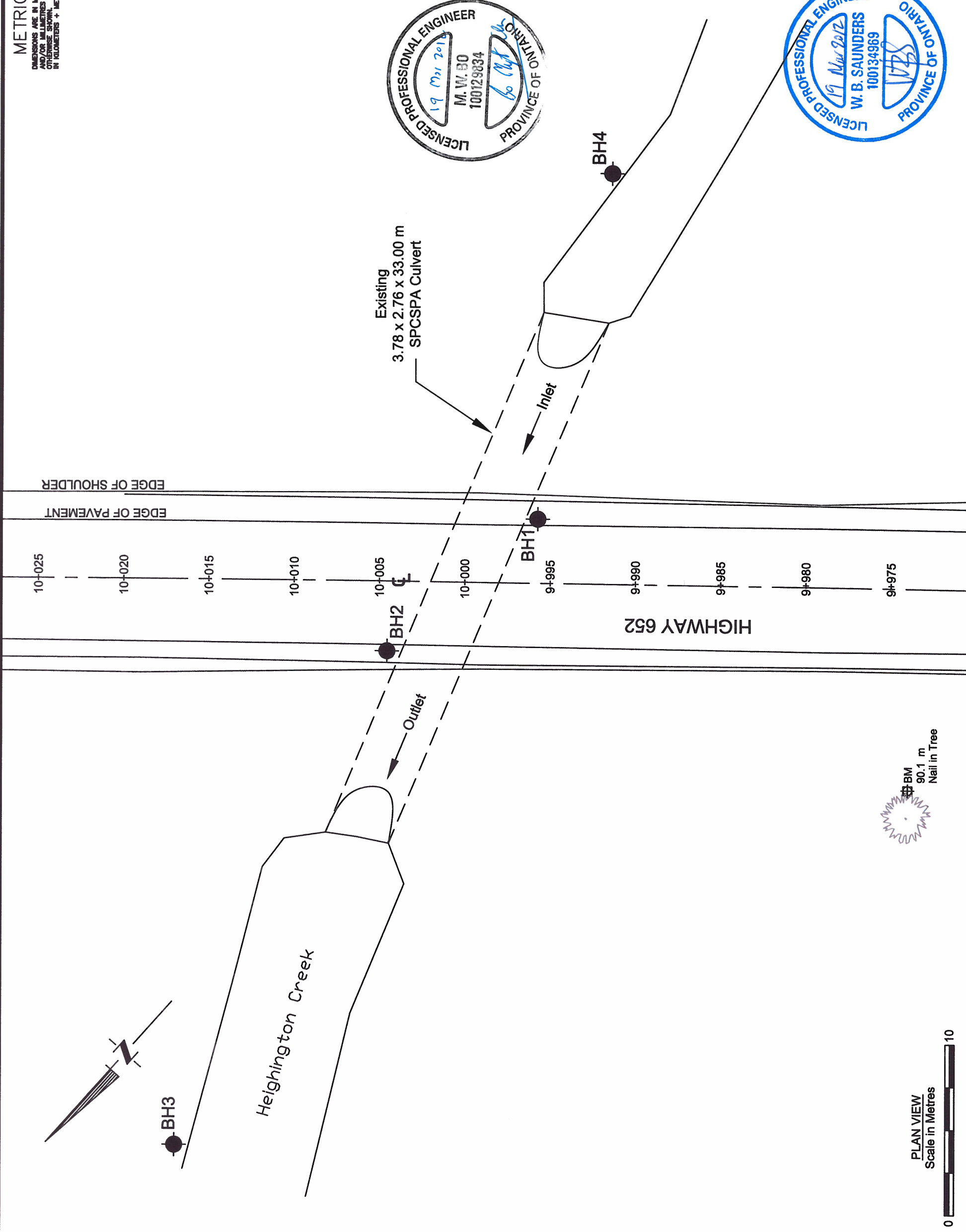
Silt

Clay

Sand & Gravel

Boulders

No.	Elevation	Northing	Easting	Station	Offset
BH1	90.03	5458326	528883	9+888	3.4 m RT
BH2	90.15	5458337	528887	10+004	3.9 m LT
BH3	84.82	5458347	528879	10+017	33 m LT
BH4	84.72	5458311	528891	9+891	24 m RT



NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

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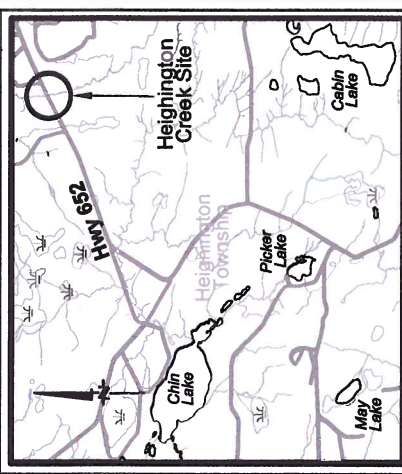
PLAN VIEW
Scale in Metres

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETERS + METERS

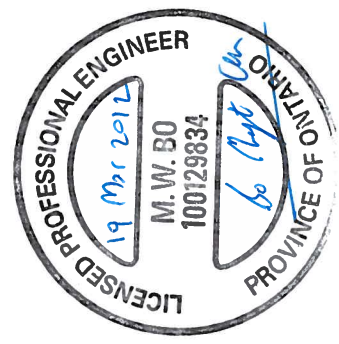
CONT No 2012-5121
GWP No 5481-09-00
WP No 5123-07-01
Site No 39E-198
GeoCres No 42H-45

CULVERT REPLACEMENT
AT HEIGHINGTON CREEK
Hwy 652 - Heighington Twp.
Boreholes and Stratigraphy

SHEET
26



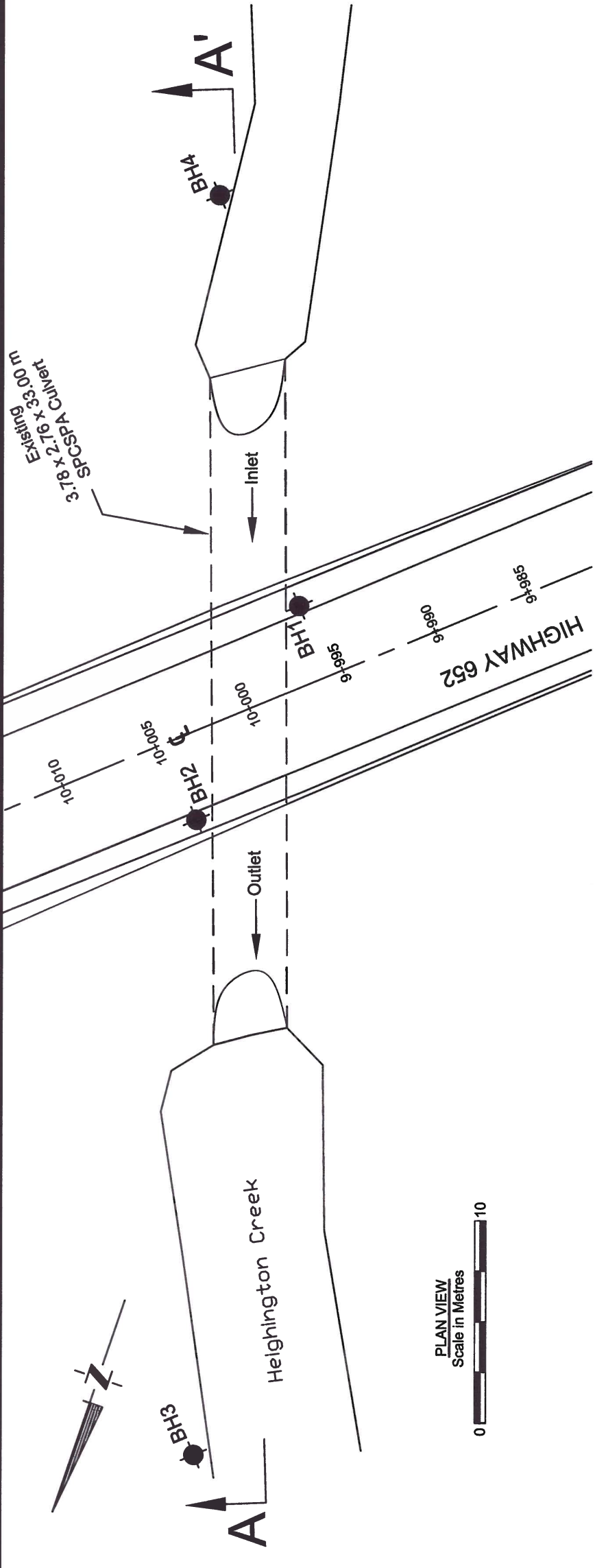
LEGEND				
◆	Borehole/Hand Auger			
⊙	Borehole with DCPT			
⊕	Dynamic Cone Penetration Test (DCPT)			
●	Rock Probe			
N'	Blows/0.3m (Std. Pen Test, 475 J/Blow)			
▽	Water level at time of investigation.			
#	Benchmark			
⊠	Fill	⊠	Sand	
⊞	Organics	⊞	Silt	
⊡	Topsoil	⊡	Clay	
⊢	Till	⊢	Sand & Gravel	
⊣	Bedrock	⊣	Boulders	
No.	Elevation	Northing	Eastng	Station
BH1	90.03	5455324	525953	9+886
BH2	90.15	5455337	525987	10+004
BH3	84.82	5455347	525979	10+017
BH4	84.72	5455311	525991	9+891



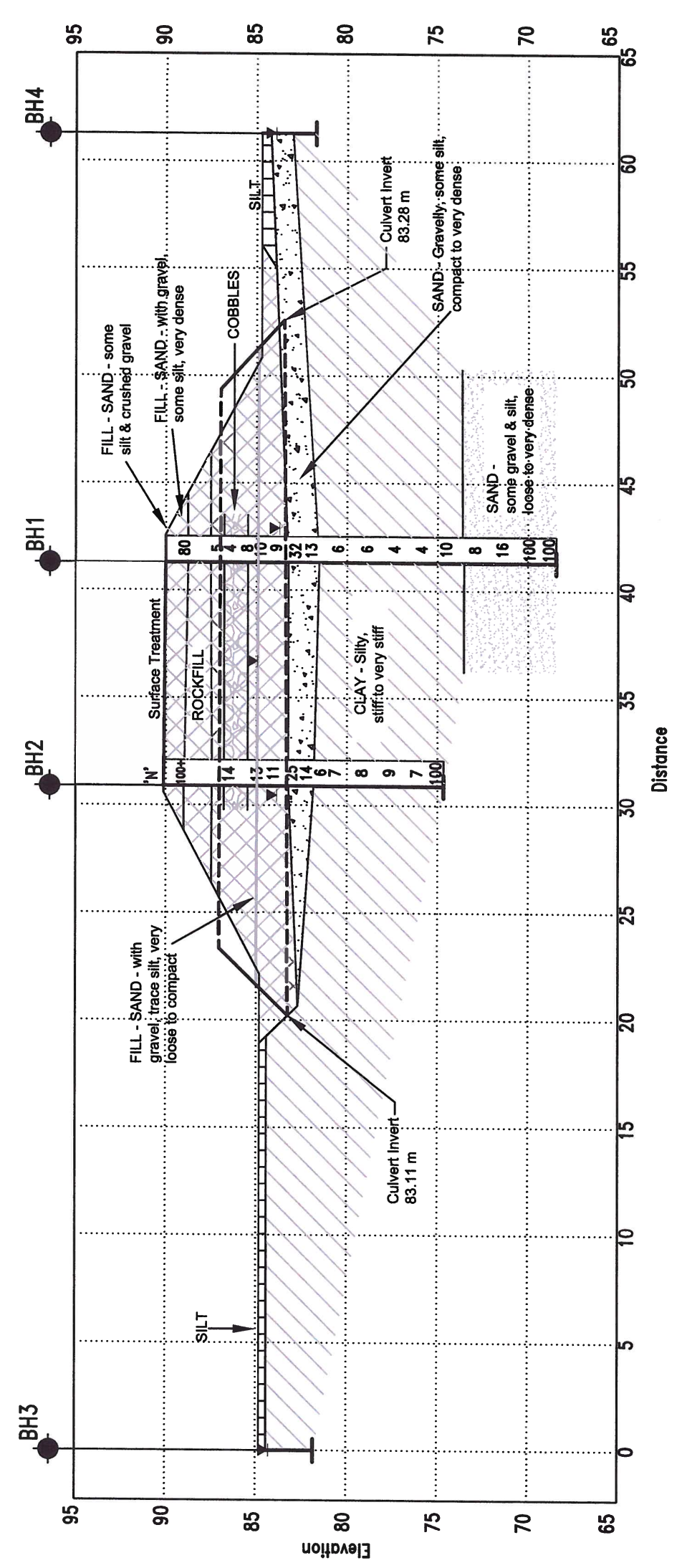
NOTE:
The boundaries between soil areas have been established only at borehole locations. Soil conditions between boreholes are assumed by interpolation and may not represent actual conditions.

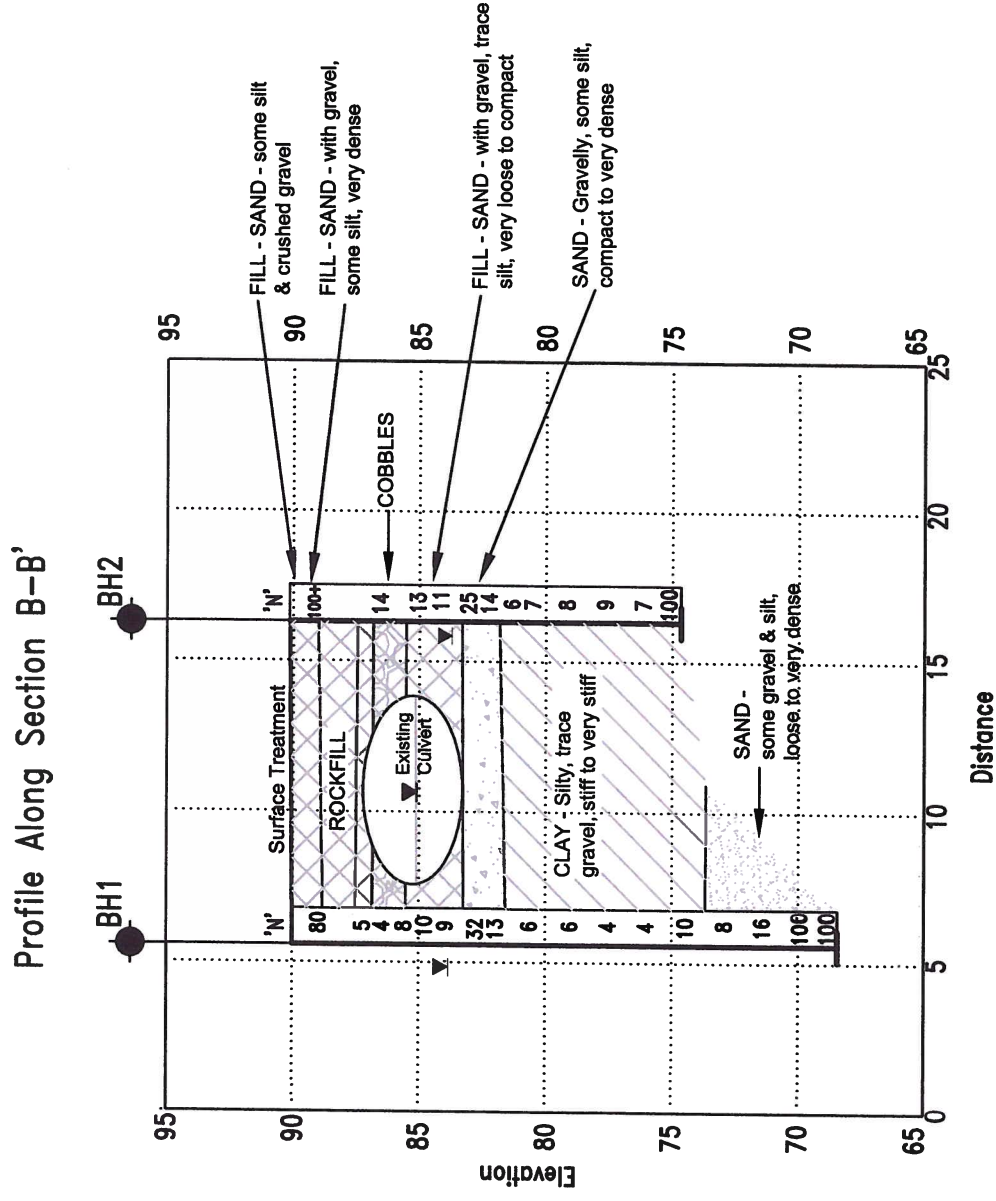
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DRAWING 2

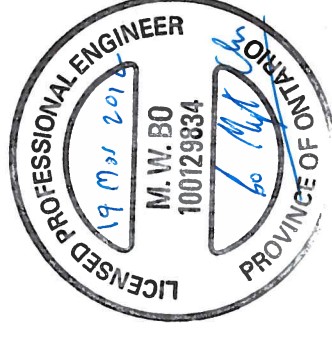


Profile Along Section A-A'





LEGEND					
	Borehole/Hand Auger				
	Borehole with DCPT				
	Dynamic Cone Penetration Test (DCPT)				
	Rock Probe				
	Blows/0.3m (Std. Pen Test, 475 J/Blow)				
	Water level at time of investigation.				
	Benchmark				
	Fill		Sand		
	Organics		Silt		
	Topsoil		Clay		
	Till		Sand & Gravel		
	Bedrock		Boulders		
No.	Elevation	Noting	Easting	Sission	Offset
BH1	90.03	5458324	529583	8+286	3.9 m RT
BH2	90.16	5468337	529867	10+004	3.8 m LT
BH3	94.22	5458347	529870	10+017	33 m LT
BH4	94.72	5458311	529891	8+091	24 m RT



NOTE: The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

DST
consulting engineers

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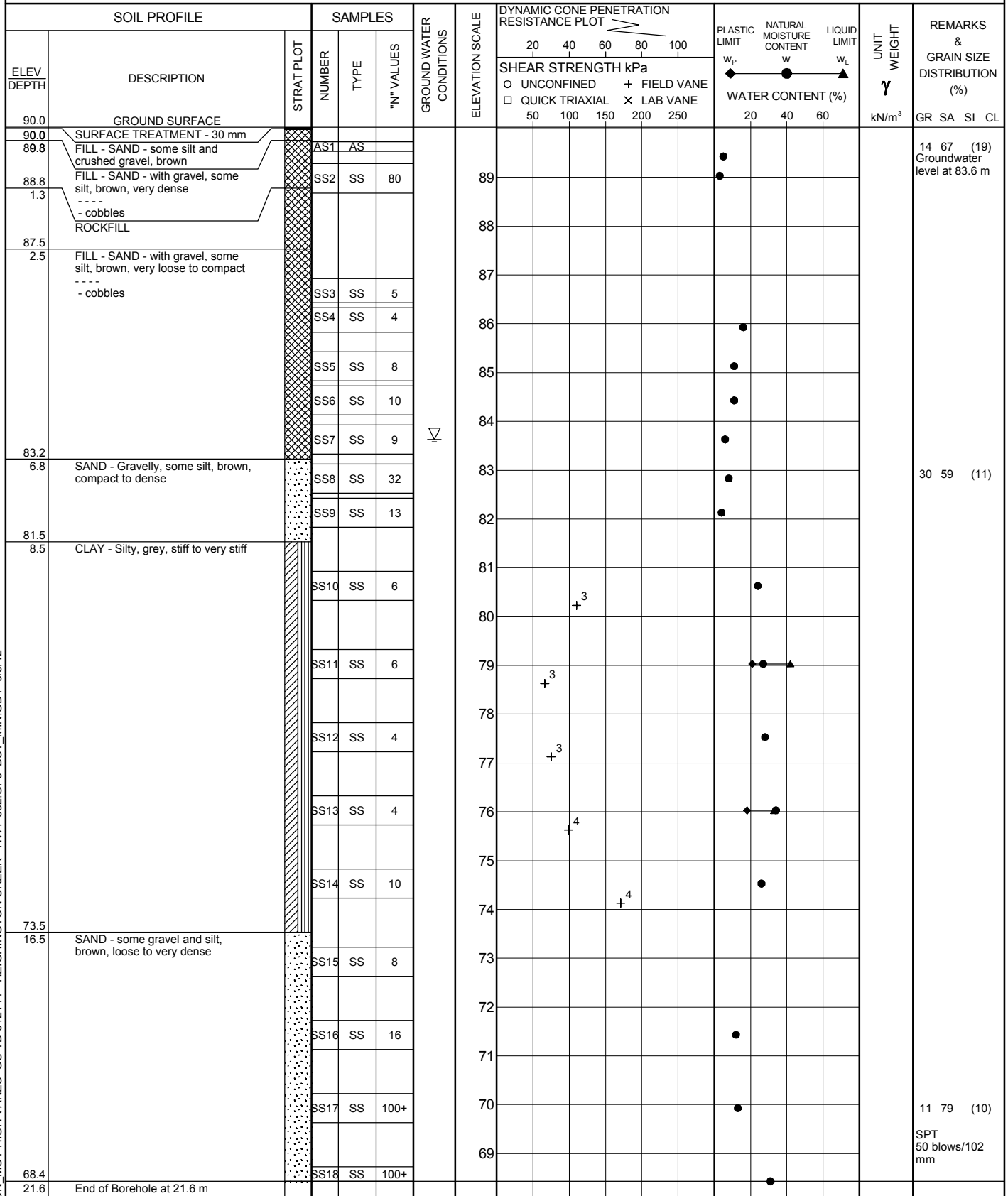
E N C L O S U R E S

RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W.P. #5123-07-01 LOCATION STA. 9+996, 3.8 m RT (5458324 m N, 529883 m E) ORIGINATED BY WS/PR
 DIST HWY 652 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML
 DATUM Assumed DATE 2010 01 25 CHECKED BY WS/MWB




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

RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. #5123-07-01 LOCATION STA. 10+004, 3.8 m LT (5458337 m N, 529887 m E) ORIGINATED BY PR
DIST HWY 652 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML
DATUM Assumed DATE 2010 01 29 CHECKED BY WS/MWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			GR	SA	SI	CL
								20 40 60 80 100						W _P W W _L						
																				
90.2	GROUND SURFACE																			
90.1	SURFACE TREATMENT - 50 mm		AS1	AS			90													
89.9	FILL - SAND - some silt and crushed gravel, brown																			
89.0	FILL - SAND - with gravel, some silt, brown		SS2	SS	100+		89											26 62 (12)		
1.2	ROCKFILL																	SPT 50 blows/64 mm		
							88													
87.5							88													
							87											Groundwater level at 83.7 m		
2.7	FILL - SAND - with gravel, trace silt, brown, compact ----- - cobbles		SS3	SS	14		86													
							85											22 74 (4)		
			SS4	SS	13		84													
			SS5	SS	11		83													
83.4							82													
6.8	SAND - Gravelly, some silt, brown, compact		SS6	SS	25		81													
							80													
			SS7	SS	14		79											0 0 11 89		
81.9							78													
8.3	CLAY - Silty, grey, stiff to very stiff		SS8	SS	6		77													
			SS9	SS	7		76													
							75													
			SS10	SS	8															
			SS11	SS	9															
			SS12	SS	7															
															</					

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

ENCLOSURE 2

RECORD OF BOREHOLE No BH3

1 OF 1

METRIC

W.P. #5123-07-01 LOCATION STA. 10+017, 33 m LT (5458347 m N, 529879 m E) ORIGINATED BY WS/PR
 DIST HWY 652 BOREHOLE TYPE Hand Auger COMPILED BY ML
 DATUM Assumed DATE 2010 01 27 CHECKED BY WS/MWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE □ QUICK TRIAXIAL x LAB VANE							PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	
84.8	GROUND SURFACE							20	40	60	80	100				
84.4	SILT - trace sand and organics, brown		AS1	AS			84								Groundwater level at 84.3 m	
0.4	CLAY - Silty, brown		AS2	AS												
			AS3	AS												
			AS4	AS												
			AS5	AS												
			AS6	AS												
81.8	End of Borehole at 3.0 m						82									
3.0																

ON_MOT-HIGH VANES GS-TB-012144 - HEIGHINGTON CREEK - HWY 652.GPJ DST_MIN.GDT 6/3/12

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

ENCLOSURE 3

RECORD OF BOREHOLE No BH4

1 OF 1

METRIC

W.P. #5123-07-01 LOCATION STA. 9+991, 24 m RT (5458311 m N, 529891 m E) ORIGINATED BY WS/PR
 DIST HWY 652 BOREHOLE TYPE Hand Auger COMPILED BY ML
 DATUM Assumed DATE 2010 01 27 CHECKED BY WS/MWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
84.7	GROUND SURFACE													
84.2	SILT - trace sand, clay and organics, brown		AS1	AS										Groundwater level at 83.7 m
0.5	SAND - trace silt and clay, brown		AS2	AS										
			AS3	AS										
			AS4	AS										
83.0			AS5	AS										
1.7	CLAY - Silty, brown		AS6	AS										
			AS7	AS										
81.7														
3.0	End of Borehole at 3.0 m													

ON_MOT-HIGH VANES GS-TB-012144 - HEIGHINGTON CREEK - HWY 652.GPJ DST_MIN.GDT 6/3/12

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

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

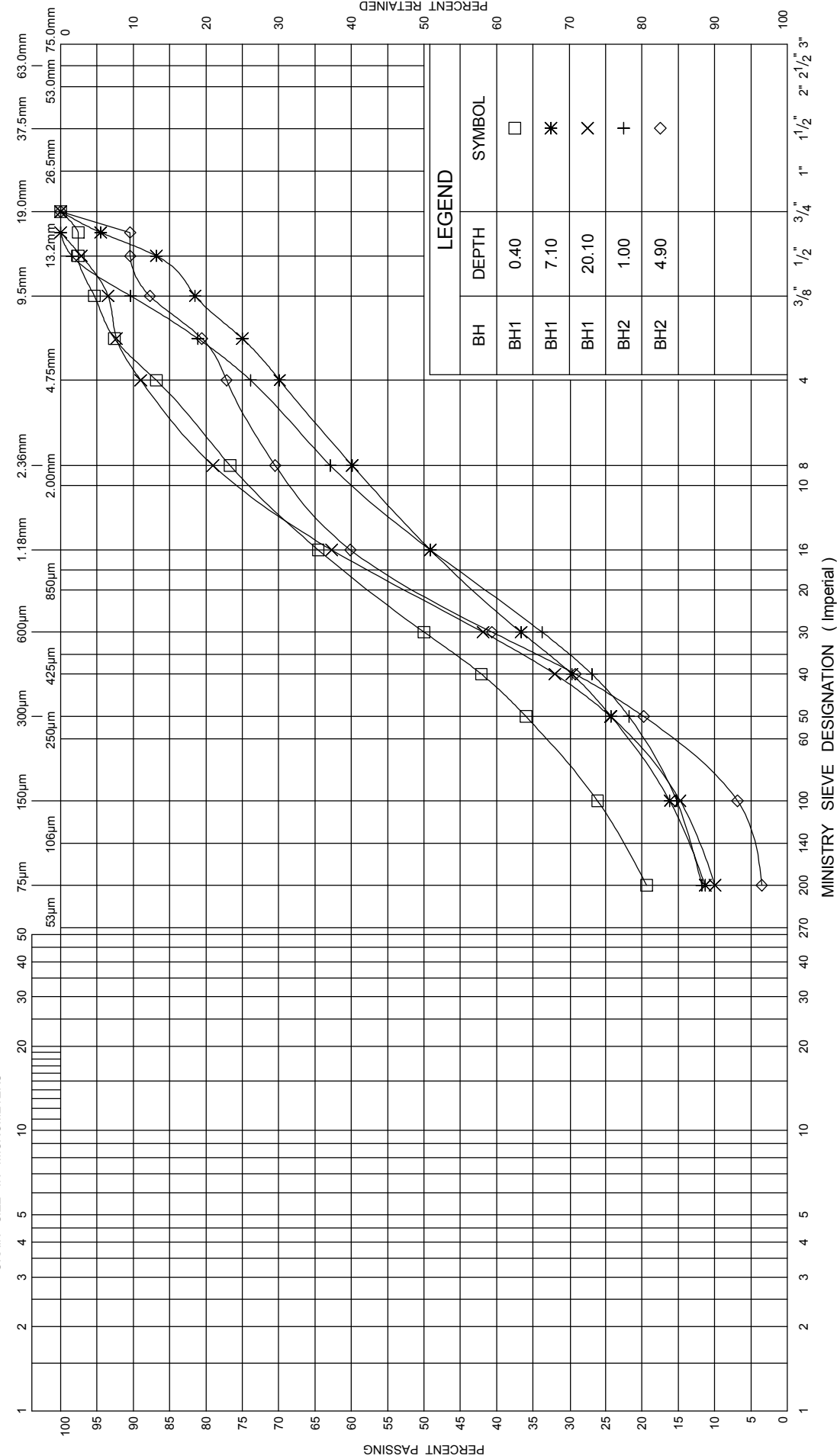
Medium

Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS



GRAIN SIZE DISTRIBUTION
SAND

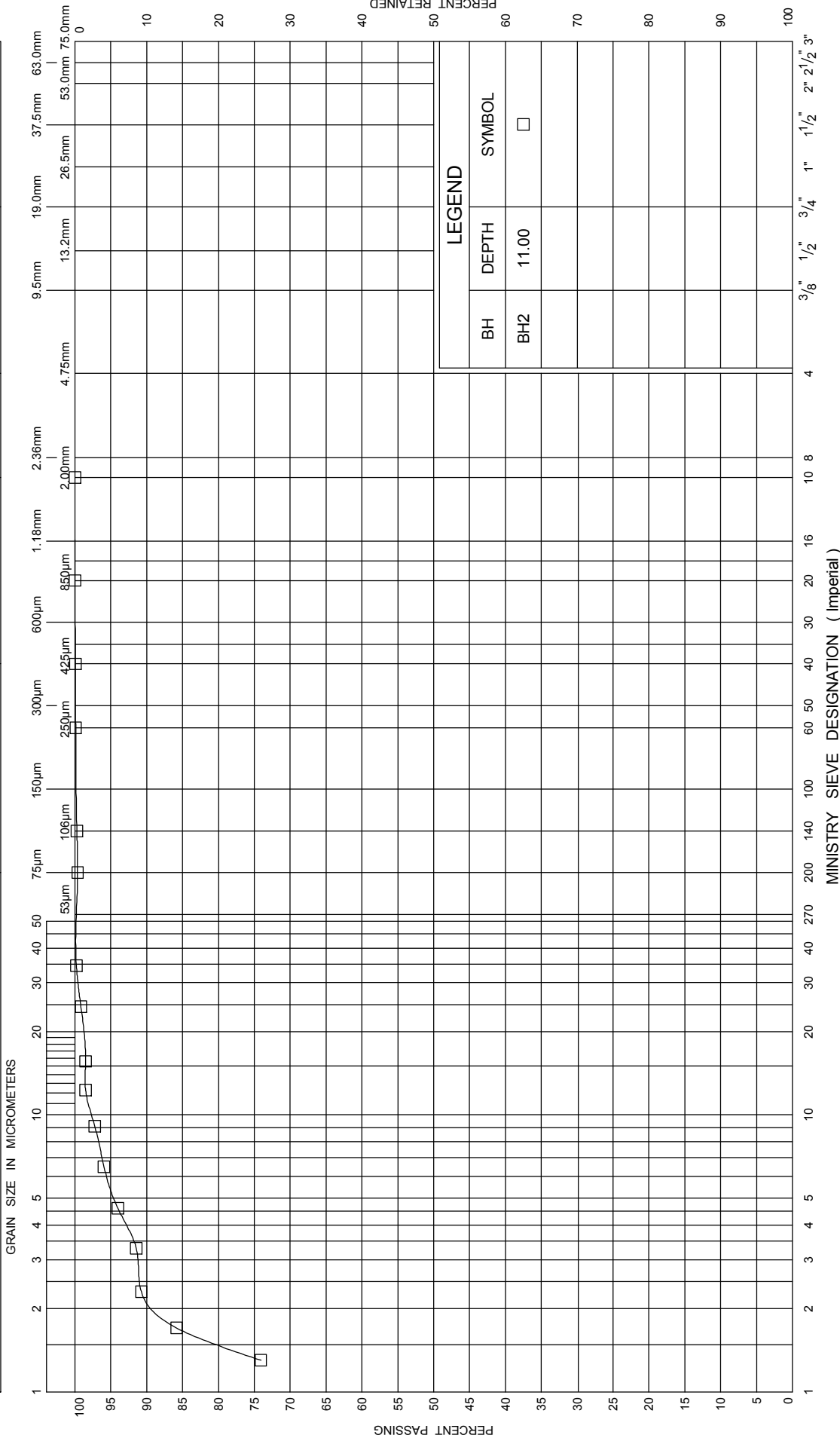
ENCLOSURE 5

W P #5123-07-01

HIGHWAY 652

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine		Medium	Fine	Coarse



GRAIN SIZE DISTRIBUTION
CLAY

ENCLOSURE 6
W P #5123-07-01
HIGHWAY 652



