



# Englobe

Soils Materials Environment

**Submitted to AECOM Canada Ltd.  
189 Wyld Street Suite 103, North Bay, Ontario P1B 1Z2  
On Behalf of the Ontario Ministry of Transportation**

**Culvert Replacement of Riberdy Tributary Culvert  
Highway 64  
Site No. 43-310  
Stations 15+052 and 15+055 – Township of Caldwell  
GWP 5166-13-10**

## **FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT**

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## Final Foundation Investigation and Design Report



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## 1 INTRODUCTION

Englobe Corp. (Englobe) has been retained by AECOM Canada Ltd., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation at the existing Riberdy Tributary Creek culvert site. The site has been identified as Site No. 43-310 and is located on Highway 64 at Stations 15+052 and 15+055 in the Township of Caldwell, some 6.1km south of the intersection between Highway 64 and Highway 17 in Verner, Ontario.

The foundation investigation location was specified by the MTO in the Terms of Reference for work under Agreement No. 5014-E-0058: GWP 5166-13-00. The terms of reference for the scope of work are outlined in Englobe's Proposal P-15-111 dated October 22, 2015. The purpose of this investigation was to determine the subsurface conditions in the area of the existing culverts. Englobe investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on select samples.

## 2 SITE DESCRIPTION

The twin Corrugated Steel Pipe Arch (CSPA) culverts are located on Highway 64 at Stations 15+052 and 15+055 in the Township of Caldwell, Ontario. The topography of this site is generally flat. The existing highway embankment currently supports two undivided lanes of highway, running in a west-east direction. The existing highway, at the culvert location, is supported on an embankment consisting of sand fills some 3.7 m in height, with centreline Elevation of 203.8 m at the culvert location. The existing embankment slopes in the area of the culverts have been built between inclination angles ranging from approximately 1H:1V to 3.2H:1V along the north side, and about 2.3H:1V along the south side.

The culverts at this location have been described in the RFP as twin 2x1.8 m Corrugated Steel Pipe (CSP) culverts built in 1976. A profile sheet (Plate No. 627-64/10b-0) dated December 1997 included in the previous Contract package of WP 115-88-00 indicates the culverts as twin 1.6x1.1 m Corrugated Steel Pipe Arch (CSPA) with approximate length of 29.4 m. The current survey has indicated the culverts are 1.6x1.2 m Corrugated Steel Pipe Arch (CSPA) culverts some 29.6 m in length and will be noted as such in this report. The flow through the culverts is from the north to the south (left to right).

Infrastructure at this site consists of overhead and underground communication and power lines running parallel to the highway embankment on both sides.

### 2.1 SITE PHYSIOGRAPHY AND SURFICIAL GEOLOGY

This project is located in the Geomorphic Sub-province known as the Eastern Sandy Uplands. The topography on this section of Highway 64 is generally flat. Significant layers of earth overlay the bedrock. Within the project area native overburden primarily consists of fine grained soils (silty clays and silts) overlying bedrock.

Bedrock in the area, as indicated on OGS Map MRD-126, consists of migmatitic rocks and gneisses of undetermined protolith of the late to middle Precambrian period.

### 3 INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out between April 29th and May 4th, 2016 during which time a total of six (6) sampled boreholes were advanced. Two (2) boreholes were advanced through the embankment at locations adjacent the culverts, and one (1) borehole was advanced adjacent to each inlet (north) and outlet (south) ends of the culverts (total of four (4) inlet boreholes).

The field investigation was carried out using a bombardier track mounted CME drilling rig equipped with hollow stem augers, standard augers, casing equipment and routine geotechnical sampling equipment. The drill equipment is owned by Chrisdamat Management Ltd. and was operated by an Englobe drill crew. Soil samples were obtained at the borehole locations at regular intervals of depth using the standard 50 mm O.D. split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures (ASTM D-1586). The SPT method involves advancing a 50 mm O.D. split spoon sampler with the force of a 63.5 kg hammer freely dropping 760 mm. The number of blows per 300 mm penetration was recorded as the “N” value. When cohesive deposits were encountered, the in-situ strength was measured using an “N” size field vane, vane collar, and calibrated torque meter. All samples taken during this investigation were stored in labeled airtight containers for transport to our North Bay laboratory for visual examination and select laboratory testing.

Groundwater conditions in the open boreholes were observed during the advancement of, and immediately following, completion of the individual boreholes. A single 19 mm diameter standpipe was installed in Borehole Nos. 1 and 3 prior to backfilling to allow for monitoring of the shallow groundwater levels post borehole completion. All open boreholes were backfilled upon completion with compacted auger cuttings in the general order they were removed, and where necessary, bentonite pellet backfill was added to the boreholes to bring them up to grade in accordance with requirements of Ontario Regulation 903. At the boreholes through the embankment, the upper portion of the borehole, where necessary, was backfilled with an asphalt cold patch to seal the existing asphalt surface. The two standpipes installed at Borehole Nos. 1 and 3 were decommissioned on June 2, 2016 as per the requirements of Ontario Regulation 903.

The fieldwork for this investigation was carried out under the full time direction of a senior member of the Englobe engineering staff, who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transport to our North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in our laboratory. Laboratory testing of select samples included routine testing for

natural moisture content determination and particle size analysis. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix 2), with a summary of results presented on the laboratory sheets in Appendix 3 (Figures Nos. L-1 to L-6 and Table No. L-7).

Section 6.8.2.2 of the RFP states that a minimum of 1 chemical test package (including PH, water soluble sulphate, chloride, resistivity and electrical conductivity analyses) is required at each foundation element at the culverts. In accordance with requirements stated in the RFP, two soil chemical tests were carried out by AGAT Laboratories in Mississauga. Results of chemical tests are presented in Appendix 3.

The location of the individual boreholes was determined in the field using highway chainage established by Callon Dietz Inc. (Callon Dietz) and offset relative to highway centreline. The MTO co-ordinates, northing and easting, were then established for the boring locations using coordinates from MTM Zone 10, NAD 83 CSRS. Elevations contained in this report are referenced to a geodetic datum. The borehole elevations are based on a survey carried out by Callon Dietz.

## **4 SUBSURFACE CONDITIONS**

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Records of Borehole Logs (Appendix 2) and on Drawing Nos. 2A and 2B (Appendix 3). Please note that the stratigraphic delineations presented on the borehole logs and soil strata plot are the results of non-continuous sampling, response to drilling progress, the results of SPT, plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location, and are shown on the drawings for illustration purposes only.

### **4.1 CULVERT STATIONS 15+052 AND 15+055, TWP OF CALDWELL**

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Drawing Nos. 2A and 2B, Appendix 3. During the course of the exploration program, six (6) sampled boreholes were put down at this site, with Borehole Nos. 2 and 3 advanced through the embankment adjacent to the culverts, Borehole Nos. 1 and 6 advanced adjacent to the culvert inlets, and Borehole Nos. 4 and 5 advanced adjacent to the culvert outlets. At the time of the subsurface investigation, the ground surface elevations at Borehole Nos. 1 to 6, inclusive, were recorded at Elevations 201.0, 203.8, 203.8, 200.6, 200.6, and 201.5 m, respectively.

#### 4.1.1 Pavement Structure

Borehole Nos. 2 and 3 were advanced through the embankment shoulder where 50 to 100 mm of asphalt concrete overlying a layer of crushed gravel base/subbase approximately 150 to 300 mm thick was penetrated.

#### 4.1.2 Sand Fill

Underlying the pavement structure at Borehole Nos. 2 and 3, a layer of sand fill consisting of brown sand with to trace gravel, trace silt, trace clay was penetrated. A 300 mm boulder-sized rock was encountered at a depth of 1.2 m below grade at Borehole No.2 (Elevation 202.6 m). The natural moisture content measured on samples of this deposit ranged from 4 to 21%. Gradation (hydrometer) analyses were carried out on four (4) samples of this deposit from Boreholes 1 and 2, the results of which indicated 0 to 24% gravel size particles, 60 to 86% sand size particles, 8 to 12% silt size particles, and 3 to 4% clay size particles (Figure No. L-1, Appendix 3). Results of this grain size distribution testing indicate that the sand fill generally meets gradation requirements for Granular “B” Type I stated in OPSS.PROV 1010. Based on SPT ‘N’ values of 8 to 42 blows per 300 mm penetration, the relative density of this deposit was described as loose to dense, generally compact. This sand fill layer was encountered to a depth of 3.7 m below grade at Borehole Nos. 2 and 3 (Elevation 200.1 m).

#### 4.1.3 Topsoil

At the ground surface at Borehole Nos. 4 and 5, a layer of topsoil of organic silty clay, trace gravel, with sand was penetrated. This topsoil layer was encountered to depths of 0.2 to 0.3 m below ground surface at Borehole Nos. 4 and 5, respectively (Elevations 200.4 and 200.3 m, respectively). The natural moisture content measured on samples of this deposit was 48 to 49%. Gradation (hydrometer) analyses were carried out on one (1) sample of this deposit, the results of which indicated 8% gravel size particles, 22% sand size particles, 35% silt size particles, and 35% clay size particles (Figure No. L-2, Appendix 3). Atterberg Limits testing was carried out on two (2) samples of this deposit, the results of which indicated a Plastic Limit in the order of 30 to 39% and a Liquid Limit in the order of 51 to 55% (Figure No. L-5, Appendix 3). Based on a SPT ‘N’ value of 4 blows per 300 mm penetration, the consistency of this deposit was described as soft. The stratum was not sufficiently thick to allow for in-situ vane shear testing.

#### 4.1.4 Silty Clay to Clay

Underlying the soil fill at Borehole Nos. 2 and 3, and at ground surface of Borehole Nos. 1 and 6, a deposit of brownish grey to grey silty clay to clay, trace sand was penetrated. This deposit was encountered to depths of 7.2, 4.6, 10.1, and 8.5 m below grade at Borehole Nos. 1, 2, 3 and 6, respectively (Elevations 193.8, 199.2, 193.7 and 193.0 m, respectively). The natural moisture content measured on samples of this deposit was in the order of 28 to 85%. Gradation (hydrometer) analyses were carried out on six (6) samples of this deposit, the results



of which indicated 0% gravel size particles, 0 to 2% sand size particles, 7 to 83% silt size particles, and 17 to 93% clay size particles (Figure No. L-4, Appendix 3). Atterberg Limits testing was carried out on seven (7) samples of this deposit, the results of which indicated a Plastic Limit in the order of 17 to 43% and a Liquid Limit in the order of 28 to 71% (Figure No.

L-5, Appendix 3). Results of Atterberg Limits testing indicate medium to high degrees of plasticity of the deposit of. Based on in-situ shear strengths ranging from greater than 100 kPa to 24 kPa, the consistency of this deposit was described as very stiff to soft.

#### 4.1.5 Sand

Underlying the silty clay to clay at Borehole Nos. 1 and 6, a deposit of grey sand, trace to some gravel, some silt, trace clay was penetrated. The natural moisture content measured on samples of this deposit was in the order of 19 to 20%. Gradation (hydrometer) analyses were carried out on two (2) samples of this deposit, the results of which indicated 4 to 19% gravel size particles, 57 to 78% sand size particles, 11 to 16% silt size particles, and 7 to 8% clay size particles (Figure No. L-4, Appendix 3). Based on SPT 'N' values ranging from 10 blows per 300 mm penetration to 20 blows per 150 mm penetration, the compactness of the deposit was described as loose to very dense. This deposit was encountered to a depth of 7.9 m below grade at Borehole No. 1 (Elevation 193.1 m). Borehole No. 6 was terminated in this deposit at a depth of 9.6 m below grade (Elevation 191.9 m).

#### 4.1.6 Bedrock

Underlying the sand deposit at Borehole No.1, underlying the silty clay to clay deposit at Borehole Nos. 2 and 3, and underlying the organic soil deposit at Borehole Nos.4 and 5, the bedrock was proven by diamond core drilling. The bedrock was described as black gneiss with pink granite. Based on RQD values of 67 to 95%, the bedrock was described as fair to excellent quality. Sampling in the bedrock was terminated at depths of 11.0, 7.6, 13.2, 3.4 and 3.4 m below grade at Borehole Nos. 1 to 5, respectively (Elevations 190.0, 196.2, 190.6, 197.2, and 197.2 m, respectively). Photos of rock core recovered at Borehole Nos. 1 to 5 are shown in Enclosure No. 8, Appendix 4. A bedrock outcrop was observed to the southeast adjacent to the culvert outlet during the foundation investigation period. It should be noted that, when encountered, the underlying bedrock surfaces in this area can be very erratic in nature, varying substantially in elevation over short horizontal distances.

### 4.2 GROUNDWATER DATA

During the period of investigation (April 29th to May 4th, 2016), the creek water level was measured at about Elevation 200.5 m at the culverts.

Measurements of the groundwater table and cave-in levels were undertaken, where possible, in the open boreholes during the advance of the individual borings and upon completion. Standpipes were installed in Borehole Nos. 1 and 3 to obtain post borehole completion water levels. These levels are recorded on the individual Record of Borehole Sheets (Appendix 2).



The groundwater levels were measured at Elevations 200.1 and 201.3 m on June 2, 2016 at Borehole Nos. 1 and 3, respectively. The groundwater levels were encountered at Elevations 201.8, 200.6, 200.4 and 200.6 m at Borehole Nos. 2, 4, 5 and 6 upon completion of sampling at each borehole, respectively; however these water levels likely had not stabilized at the time of recording.

The groundwater and creek water levels will fluctuate seasonally/yearly.

## 5 DISCUSSION AND RECOMMENDATIONS

### 5.1 GENERAL

A foundation investigation was carried for the proposed replacement of twin CSPA culverts as identified by the MTO.

The existing culverts, located at Stations 15+052 and 15+055, in the Township of Caldwell, are twin 1.6x1.2 m CSPA culverts some 29.6 m long. The existing culvert inverts are established at approximately Elevations 200.3 to 200.0 m. The existing highway embankment currently supports two undivided lanes of highway, running in a west-east direction. The flow through the existing culverts is from the north to the south (left to right). Based on the data from this foundation investigation, the embankment supporting the existing pavement structure at this site has been constructed using a granular pavement structure overlying sand fills. The native material underlying the embankment fill generally consists of stiff to soft silty clays overlying sands.

As noted, based on the previous Contract drawings, the culverts have been described as twin 1.6x1.1 m CSPA culverts.. However, the current survey has indicated the culverts are 1.6x1.2m CSPA culverts some 29.6 m in length. Deterioration of several elements and the structural steel coating were observed on the culverts during the foundation investigation periods.

It is understood that a new precast Rigid Frame Box (RFB) culvert is currently being proposed to be constructed at the location of the existing twin Corrugated Steel Pipe Arch (CSPA) culverts at a similar alignment. Based on a preliminary design drawing prepared by AECOM in October, 2016, the inlet invert of the new RFB culvert will be at Elevation 200.55 m and the outlet invert of the new RFB culvert will be at Elevation 200.4 m. .

#### 5.1.1 Frost Penetration

Generally, culverts within the depth of frost penetration below the pavement structure are included in the pavement structure frost treatment (see OPSD 803.010 and OPSD 803.030). However, closed culverts are not designed in consideration of frost penetration below the culvert. Culverts with footings, (i.e. open culverts, culvert retaining walls, etc.) require the footings to be designed for frost penetration.

At this site, the frost penetration depth below cleared pavement surfaces is approximately 2 m. The culvert at this location is not located within the depth of frost penetration below the pavement surface and as such, will not require frost treatments.

### 5.2 FOUNDATION CONSIDERATIONS

The native subgrade present below the existing embankment, consisting of stiff silty clays, is considered adequate for support of a culvert and for a conventional highway embankment of this height. Geotechnical bearing resistance should not be a major issue provided the natural

bearing surface is not unduly disturbed during construction and groundwater is controlled throughout construction, as discussed in Section 5.5. Adequate dewatering is required to avoid the potential development of heave and disturbance of subgrade at the founding level.

Based on the characteristics of the native silty clay subgrade present below the culverts, the response of the existing embankment, and a founding level not lower than Elevation 200 m, similar to the existing culverts, a factored bearing resistance at ULS of 140 kPa on the stiff silty clay subgrade can be used for a closed culvert (i.e. precast concrete box culvert or CSP culvert). In consideration of the width of the culvert, depth of overburden, and response of the existing embankment, a geotechnical reaction at SLS of 90 kPa on the stiff silty clay subgrade can be used for design, in consideration of 25 mm settlement total, and 19 mm differential, depending on structure rigidity.

If open culverts (i.e. concrete frame open culverts, with wall footings, or pipe arch culverts on footings) are considered at founding level approximately at Elevation 200 m similar to that of the existing culverts, then a factored bearing resistance at ULS of 120 kPa on the stiff silty clay subgrade would be applicable, and a geotechnical reaction at SLS of 80 kPa on the stiff silty clay subgrade would apply for design, in consideration of 25 mm settlement and taking into consideration the limited depth of overburden and smaller footing width.

A local soft silty clay overlying bedrock was encountered between Elevations 119.2 and 200.1 m at Borehole No. 2; therefore the soft silty clay should be subexcavated during construction to the surface of bedrock and replaced by the Engineered Granular B Type II material per OPSS.PROV 1010 to 100% Standard Proctor Maximum Dry Density (SPMDD) to the founding level and/or the bottom of bedding of the proposed new culvert.

Bedrock was encountered at Borehole Nos. 4 and 5 located adjacent to the outlets of the existing culverts. Depending on the location and founding level of the new culvert, bedrock may be within the anticipated depth of excavation. After the rock levelled (mechanically or by blasting) if required, the new culvert may be partially seated on the bedrock. The bedrock is described as described as fair to excellent quality, based on RQD data. As such, a geotechnical resistance at ULS not less than 1,000 kPa is appropriate with a minimum footing width of 600 mm. Since the bedrock is essentially an unyielding subgrade, a geotechnical reaction at SLS does not apply.

### 5.2.1 Slope Stability

The maximum height of the embankment above the stream bed at this location is some 3.6 to 3.8 m below the centreline of highway. The inclination angles of existing slopes ranging from approximately 1H:1V to 3.2H:1V at the north slopes and some 2.3H:1V at the south slopes. Stability analyses, using the GEO-SLOPE computer program, Slope/W (GeoStudio 2007, version 7.17, Geo-Slope International Ltd.), were carried out at this location for the north and

the south slopes with existing inclinations in the embankment fills. For the purposes of these analyses, the materials were modeled using the following parameters:

MATERIAL	PARAMETER		
	UNIT WEIGHT (KN/M3)	EFFECTIVE FRICTION ANGLE (DEGREES)	SHEAR STRENGTH (KPA)
Sand Fill	19.0	31	-
Topsoil (undrained)	10.0	-	10
Silty Clay to Clay above Elevation 199 m (undrained)	17.0	-	60
Silty Clay to Clay below Elevation 199 m (undrained)	17.0	-	35
Silty Clay to Clay (drained)	17.0	26	5
Sand	18.5	30	-

The unit weights and friction angles for the slope calculations are based on general representative values for the various soil types, obtained through laboratory testing and tactile analysis. The results of the analyses indicate factors of safety on the marginally stable against minor surficial slippage, and in the orders of 3.1 against the short term deep seated failure and 2.0 against the long term deep seated failure on the existing south embankment slope at Station 15+055 (see Figure Nos. S-1 and S-2, Appendix 5). It is recommended that the finished slopes of embankment be established not steeper than 2H:1V to result in the factors of safety of 1.6 against surficial slippage and 2.1 against the long term shallow seated failure at Station 15+055 (see Figure Nos. S-3 and S-4, Appendix 5). Lower factors of safety will occur during excavation and backfilling as discussed in Section 5.5. Short term stability should not be an issue if construction is carried out as described herein.

### 5.3 CULVERT DESIGN, BEDDING AND EMBEDMENT

The embankment consists of sand fills. The results of this investigation indicate that, below the culvert invert, the native soils encountered at Boreholes No. 1 to 6 consisted of very stiff to soft silty clays to clays overlying sands, with bedrock at variable depths. A review of the condition of the pavement surface, at the culvert locations, revealed minor asphalt cracking; however, in general, the embankment appears to have performed well. The existing embankment has preloaded the soils at the culvert locations and since there will be no change in the height of the embankment for the proposed culvert replacement; therefore no increases in embankment load, no appreciable long term settlement of the embankment is anticipated. As such, installing the culverts on a camber will not be required at this site.

### 5.3.1 Rigid Frame Box Culvert

It is understood that a precast concrete rigid frame box culvert is the preferred culvert replacement option at this site. Bedding for a rigid frame box culvert shall consist of OPSS-PROV 1010 Granular A with a thickness of 300 mm. The bedding under the middle third of the box unit base should be loosely placed and uncompacted. The upper 75 mm portion of the Granular A bedding should be uncompacted throughout the length/width of the box and incorporated as the top levelling course in conformance with OPSS 422. Alternatively, specifically if construction is carried out under wet conditions, a bedding and levelling course consisting of 19 mm clear stone per OPSS.PROV 1004 should be used, which would aid in dewatering applications. During backfilling, the bedding, cover and backfill materials shall be placed in uniform layers not exceeding uncompacted thickness of 200 mm. Backfilling shall be placed in a balanced manner in layers not exceeding 200 mm in thickness on each side of the box unit. The elevation difference of backfilling on either side of the box unit shall be limited to a maximum 400 mm as per OPSS 422. Backfilling and construction of pre-cast concrete box culverts shall be in accordance with OPSS 422. Cover material for concrete box culverts can consist of Granular A, placed to the dimensions as shown on MTOD-803.021.

The joints between precast box units should be covered with a strip of Non-Woven Class II Geotextile (per OPSS 1860) 600 mm in width, centered over the joint, covering the top of the culvert and extending down the sides of the culvert to prevent the infiltration of fines.

Apron (cut-off) walls, 1.2 m deep, must be added to the ends of the rigid frame box culvert in accordance with the MTO Concrete Culvert Design Manual.

The inlet and outlet stream bed shall be protected with a rip-rap (R-50 size as per OPSS.PROV 1004) apron. The apron shall be minimum 3 m in length, minimum 400 mm thick and extend across the stream bed to a minimum 3 m beyond the outside edges of the culvert. Clay seals are generally used only where significant head differences exist between the inlet and outlet of the culverts to prevent flow through the bedding/embedment granulars. Considering the head difference between the inlet and outlet, it is recommended that clay seals not be used at this culvert location.

### 5.3.2 Rigid Concrete Culvert

Concrete pipes can be considered for culvert replacement at this site. A Class B Bedding for the concrete pipes shall consist of Granular A with a thickness of 300 mm. Alternatively, specifically if construction is carried out under wet conditions, a bedding and levelling course consisting of 19 mm clear stone per OPSS.PROV 1004 should be used, which would aid in dewatering operations. During backfilling, the material of bedding and cover shall be placed in uniform layers not exceeding uncompacted thickness of 200 mm. The elevation difference of backfilling on either side of the rigid pipe shall be limited to a maximum 200 mm per OPSS 401.

Cover material for concrete pipes can consist of Granular A and placed to the dimensions as shown on OPSD 802.031. If circular concrete pipes are used, compaction of the haunch is critical and should be constructed in accordance with OPSS 501.

The inlet and outlet stream bed shall be protected with a rip-rap (R-50 size as per OPSS.PROV 1004) apron. The apron shall be minimum 3 m in length, minimum 400 mm thick and extend across the stream bed to a minimum 3 m beyond the outside edges of the culvert. Clay seals are generally used only where significant head differences exist between the inlet and outlet of the culverts to prevent flow through the bedding/embedment granulars. Considering the head difference between the inlet and outlet, it is recommended that clay seals not be used at this culvert location.

### 5.3.3 Flexible Culvert

Flexible culverts (i.e. CSP/SPCSP/HDPE) can also be considered for culvert replacement at this site. If flexible pipes are used for replacement, embedment material should consist of Granular B Type I per OPS.PROV 1010 provided the maximum size of stone inclusions is limited to 25 mm or less in size and placed in accordance with OPSD 802.010 for a Type 3 soil. The material in the haunch area must be compacted to 100% of Standard Proctor Maximum Dry Density prior to placing the remainder of the embedment material. During backfilling, the embedment material shall be placed in uniform layers not exceeding uncompacted thickness of 200 mm. The elevation difference of the embedment fill on either side of the flexible pipe must be limited to a maximum 200 mm per OPSS 401. The backfill should be placed to a minimum depth of 900 mm above the crown of the pipe before power tractors or rolling equipment can be used for compacting per OPSS 401.

Considering the porous nature of the embankment fill, inlet clay seals along the culvert or outlet cut-off walls are not required; however, the inlet and outlet stream bed shall be protected with a rip-rap (R-50 size as per OPSS.PROV 1004) apron. The apron shall be minimum 3 m in length, minimum 400 mm thick and extend across the stream bed to a minimum 3 m beyond the outside edges of the culvert.

## 5.4 CHEMICAL TESTING

Two (2) soil samples recovered at Borehole Nos. 2 and 3 during the foundation investigation was submitted to AGAT analytical laboratory and tested for corrosivity potential to determine the potential for degradation of concrete in the presence of soluble sulphates used in foundations and buried infrastructure. The results of chemical testing (including PH, water soluble sulphate, chloride, resistivity and electrical conductivity analyses) is tabulated below and are provided in Appendix 3.

SAMPLE LOCATION	SAMPLE NO.	DEPTH BELOW GRADE ± (m)	pH	Soluble Sulphate (ppm)	Chloride (ppm)	Resistivity (Ohm.cm)	Electrical Conductivity (mS/cm)
BH 2	5	3.3	7.31	4	88	4780	0.209
BH 3	7	4.8	7.67	8	194	2390	0.418

In order to estimate the corrosivity of soils, the resistivity can be used to give a general assessment as to the risk of corrosion. Sandy soils are high up on the resistivity scale; therefore considered the least corrosive. Clayey soils, especially those contaminated with saline water are on the opposite end of the spectrum. The results soil chemical testing indicate that concrete made with Type 10 Portland cement should be acceptable for substructures. The test results also indicate a significant potential for corrosion of exposed ferrous metal for soil at shallow depths below the present ground surface based on the standard of C105/A21.5 published by ANSI/AWWA and ASTM Special Technical Publication 965.

## 5.5 CULVERT INSTALLATION AND CONSTRUCTION CONSIDERATIONS

The invert of the proposed precast rigid frame box culvert has not yet been determined. It is assumed that the founding level of the new box culvert is to be located approximately at Elevation 200.3 m (at a depth of some 3.4 m below centreline); therefore, a minimum 3.7 m deep excavation (i.e. to Elevation 200.0 m) will be required in consideration of a 300 mm thick layer of bedding/embedment material. If the fills are encountered below the culvert invert during construction, it is recommended that they should be sub-excavated to the subgrade of stiff native silty clay.

The present platform width at this location is some 15 m as can be seen on the cross sections on Drawing No. 2B. The platform width at this location, as is, will not be sufficient to carry out an open excavation using staged construction unless local lowering of the grade and/or sliver widening is undertaken. In general, an open cut excavation can be considered if the platform is temporarily lowered by some 0.9 m below the centreline of highway. If this lowering cannot be accommodated, then consideration can be given to a combination of lowering and widening or to constructing a temporary vertical wall for use as a protection system.

### 5.5.1 Staged Construction

As noted, the platform at this location, as is, is of insufficient width to carry out an open excavation using staged construction, unless temporarily lowering the vertical alignment is carried out. To carry out an open cut excavation, locally lowering the grade to allow for staged construction using staged sequencing and limiting traffic flow to one lane would be required (see Figure No. SK-5, Appendix 5).



A possible staging plan for a continuous open cut excavation under a 24/7 traffic control operation, as shown on Figure No. SK-3, Appendix 5, is as follows:

- Locally lower the grade at the culvert to an elevation of approximately 202.8 m.
- Limit traffic to a single lane on the left (north), with a minimum platform width of 6 m, under 24/7 traffic control.
- Open cut excavate, to the right (south), and install approximately 13 m in length of new culvert.
- Reconstruct the embankment on the right (south), allowing for a minimum platform width of 6 m for traffic.
- Divert the single lane of traffic to the right and continue open excavation to install the remainder of the culvert on the left (north).
- As the width of the platform increases on the left, the vertical alignment can be raised, and the traffic can revert back to two lanes when sufficient width permits.

#### 5.5.2 Temporary Protection System

As noted above, consideration could be given to constructing a vertical wall, along centreline, for use as a temporary protection system.

Considering the nature of this foundation investigation, only two boreholes were advanced through the embankment. Depending upon the type of protection system proposed by the contractor, additional borehole information, beyond the existing embankment boreholes, may be required, if the variation in elevation of the silty clay till deposit could impact their design of a protection system.

The installation of a temporary protection system for use in the culvert replacement operation will require penetration through some 4 m of embankment fills. A 300 mm boulder sized rock was encountered at a depth of 1.2 m below grade at location of Borehole No. 2 (Elevation 202.6 m); as such, the potential presence of additional cobble and boulder sized material should be anticipated. The embankment fill is generally underlain by firm to stiff silty clays to clay overlying bedrock. Considering the embankment generally consists of sand fills, the recommended method of constructing a temporary vertical wall for a protection system along the centreline of the highway alignment would be to construct the shoring wall through the embankment fill into the underlying silty clay to clay and/or into the bedrock, respectively. Conceptual shoring locations and sections are illustrated on Figure Nos. SK-6 and SK-7, Appendix 5.

Based on the results of this investigation, the embankment fill may contain cobble/boulder size obstructions. The sheet piles are not considered for the temporary protection installed along the centerline of highway due to difficulty in driving into the relatively shallow bedrock encountered

below the invert level adjacent to the east edge of the existing east culvert. One method to construct a protection system would be to advance H piles (soldier piles) through the embankment into the underlying silty clay to clay deposit and/or into bedrock, and install lagging. If a boulder is encountered during driving, the pile could be left high until the boulder is removed during excavation and then driving continued. Alternatively, pre-drilling may be considered to advance the H piles through the boulder(s) in the embankment fills and into the bedrock underlying the silty clay to clay deposit. The H piles would be installed at an interval of 2.5 to 3 m apart and the lagging would be installed as the excavation progresses. Alternatively, a caisson wall with an intermediate support system could be considered for roadway protection at this site. A waler and raker system or tie-back anchor system would have to be installed as the excavation advances. The contractor must be prepared to address the boulders and control groundwater as the excavation progresses, without compromising the adjacent active lane of traffic.

The resistance (R) for grouted anchors, located outside the active failure wedge, in cohesionless soils can be estimated from the following equation as supplied in Section 26.12.4.1 of the Canadian Foundation Manual (4th Edition):

$$R = \sigma'_z * A_s * L_s * \alpha_g \quad \text{Where:} \quad \sigma'_z = \text{effective vertical stress at the midpoint of the load carrying length}$$

$$A_s = \text{effective unit surface area of the anchor}$$

$$L_s = \text{effective embedment length of the anchor}$$

$$\alpha_g = \text{anchorage coefficient use 1.0 for granular backfill}$$

Unless the pull-out resistance (capacity) of the anchor is proven with a load test program, the allowable anchor load (as suggested by the Canadian Foundation Engineering Manual, 4th Edition), is commonly obtained by dividing the computed capacity of the anchor by a factor of safety of 3. Alternatively, proprietary anchor systems can be used.

The granular pavement structure over sand fills are considered cohesionless, as such, a rectangular apparent pressure distribution over the height of the cut would be appropriate for design of the temporary shoring in granular fills. The width of the apparent rectangular pressure distribution, over the height of excavation, can be considered equal to  $0.65 * K_a * \gamma * H$ , where:

$K_a$  = active earth pressure coefficient, as described in Section 5.6,

$\gamma$  = unit weight, as described in Section 5.6, and

H = height of wall above the base of excavation.

The native soils, underlying the sand fill at Borehole Nos. 2 and 3, is composed of cohesive materials (silty clay). As such, the rectangular apparent pressure distribution would apply to

some Elevation 200 m; however, the presence of the cohesive soils below Elevation 200 m will require that the protection system be designed using the “layered strata” method, as outlined in the Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition, Section 26.10.7.

Surcharge loads from the active lane of traffic must also be considered during design of the temporary protection system with sufficient embedment depth into the silty clay deposit and the bedrock to provide sufficient geotechnical resistance for the lateral pressure during construction. The contractor’s protection system design must be carried out by a geotechnical engineer with appropriate experience.

A table outlining the possible temporary excavation protection/flexible retaining systems and their relative advantages, disadvantages, and costs, as well as comments on the viability of the methods is provided in Table A in Appendix 5. A conceptual shoring location is illustrated on Figure No. SK-6 in Appendix 5.

The protection system can be designed using the lateral earth pressure parameters as outlined in Section 5.6. The temporary protection system should be designed and constructed to comply with OPSS.PROV 539. In consideration of the location of the protection system and traffic volume, a Performance Level 2 is considered appropriate. The protection system should be removed upon completion of the work.

## **5.6 EXCAVATION, DEWATERING AND EMBANKMENT CONSTRUCTION**

All temporary excavations greater than 1.2 m in depth must, at a minimum, be sloped or shored in accordance with the Occupational Health and Safety Act Regulations for Construction Projects. The embankment material, above the water table, is considered a Type 3 soil as defined in the Occupational Health and Safety Act and Regulations for Construction Projects. Temporary open excavations above the groundwater table, could be cut back at an angle of 1H:1V, provided they are monitored continuously; however, below the groundwater table, the side slopes in fill an/or native materials will have to be cut back to an angle of 2H:1V, possibly shallower, dependent upon the Contractors’ chosen method of controlling the groundwater.

The excavation backfill above the culvert bedding/cover should consist of granular fills per OPSS.PROV 1010, up to the underside of the pavement structure. Frost tapers should be constructed at 10H:1V on both sides of the trench from a depth of 2 m up to a depth of 1 m, and 1H:1V tapers from that point up to surface, as per Englobe Pavement Design Report Reference No. 16/03/16019-P2 prepared under separate cover.

Final (permanent) embankment side slopes in granular fills should be established to match the existing slopes or as per OPSD 200.010. Final slopes should be treated with a seed and mulch to prevent ravelling.

Excavations must be maintained in a dewatered condition during excavation and foundation construction, and every reasonable effort must be made to prevent disturbing (piping/boiling) at

the founding subgrade. Considering the silty clay subgrade, there is a low risk of boiling, however basal stability must be considered during design of the excavation and groundwater control plan. Groundwater control, in accordance with OPSS 517 and 518, will be required to maintain a stable subgrade during culvert installation.

The water level in the creek was recorded at about Elevation 200.5 m at the inlet and the outlet of culvert during the period of this investigation and the groundwater levels at Borehole Nos. 1, and 3 had stabilized at Elevations of 200.1 and 201.3 m, respectively, at the time of this investigation. All excavations extending below the groundwater table, present at the time of construction, will have to be maintained in a dewatered condition. During construction, installation of filtered sumps and pumping from the base of the excavation will, at a minimum, be required to maintain the excavation in a dewatered condition during subgrade preparation and culvert installation. Considering the silty clay subgrade, lowering the groundwater table through convensional pumping will not be feasible. If the excavation must penetrate to a greater depth below the prevailing groundwater table a more effective, designed, groundwater control system, such as a vacuum well point system, in combination with sheeted excavations, should be considered by the contractor to maintain a stable excavation base.

A cofferdam, constructed of earth fill, sand bags, or water filled bag (i.e. aquadam) can be considered at this site. Steel sheet piles may also be considered for controlling stream flow; however, the very shallow bedrock at the outlet (i.e. at depths of 0.2 to 0.3 m below ground surface at Borehole Nos. 4 and 5), may limit the penetration of a steel sheet pile type cofferdam. For base design, sheet piles should extend a minimum depth below the base of proposed excavation equal to half the height of the excavation. By-pass pumping can be carried out to divert the stream flow at the time of construction. It is recommended that by-pass pumping, through a temporary culvert installed through the embankment, be carried out to divert the stream flow past the work area isolated with the cofferdam system.

Ultimately, the method of excavation, dewatering, and stream flow diversion will be the choice of the contractor; however the importance of maintaining the subgrade in a stable and dewatered condition during excavation and construction operations cannot be stressed enough.

#### 5.6.1 **Bedrock Excavation**

Bedrock was proven at five (5) boreholes and was encountered at two boreholes located within the anticipated depth of excavation adjacent to the outlets of the existing culverts; therefore local bedrock excavation and/or blasting operations may be anticipated. Depending on the location and founding levels of the new culvert, bedrock may be within the anticipated depth of excavation. Therefore bedrock excavation/hoe ramming and/or blasting operations may be required.

If blasting is required, reference shall be made to OPSS 120. A blast design is required to be provided by the blasting contractor before blasting operations are carried out. A pre-blast

survey (OPSS 120.07.03) and/or blast monitoring may be required considering the location of the residential properties relative to the culvert location.

## 5.7 LATERAL EARTH PRESSURES

Lateral earth pressures should be computed in accordance with the Canadian Highway Bridge Design Code (CHBDC). The design parameters for the bedding/embedment and backfill materials are as follows:

PARAMETER	GRANULAR A	GRANULAR B TYPE I	SAND FILL	CLAYEY ORGANICS	SILTY CLAY TO CLAY	SAND
Unit Weight ( $\text{kN/m}^3$ )	22	21	19	17.0	17.0	18.5
Angle of Internal Friction	34°	33°	31°	-	-	30°
Undrained Shear Strength (kPa)	-	-	-	10	60 kPa above EL. 199 m  35 kPa below EL. 199 m	-
Coefficient of Active Earth Pressure ( $K_a$ )	0.28	0.29	0.32	-	-	0.33
Coefficient of Passive Earth Pressure ( $K_p$ )	3.54	3.39	3.12	-	-	3.0
Coefficient of Earth Pressure at Rest ( $K_o$ )	0.44	0.46	0.52	-	-	0.5

For rigid structures, such as a precast rigid frame box culvert, the “at-rest” condition ( $K_o$ ) applies. For flexible structures, such as CSP/HDPE culverts, the “active” condition ( $K_a$ ) applies. The “passive” condition ( $K_p$ ) applies when the wall is in compression (in a direction opposite to the wall loading).

## 5.8 CONSTRUCTION CONCERNS

Considering the nature of the embankment sand fills, containing occasional boulder(s), no major construction concerns are anticipated if construction is carried out in general conformance with the above discussion. However the bedrock was encountered at relatively shallow depth below the invert of the existing east culvert, and at shallow depths adjacent to the outlets of the existing culverts. The Contractor must be prepared to excavate and advance protection systems considering the presence of these materials. As noted in Section 5.6, the culvert subgrade must be adequately dewatered to maintain the bearing resistance of the foundation subgrade. The Contractor must also be prepared to deal with seasonal and yearly fluctuations of ground/surface water. A Special Provision of Notice to Contractor is included in Appendix 5.

## 6 STATEMENT OF LIMITATIONS

The design recommendations given in this geotechnical report are applicable only to the project described in the text and only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known, in our analysis certain assumptions had to be made. The actual conditions may however, vary from those assumed, in which case changes and modifications may be required to our geotechnical recommendations. We recommend, therefore, that we be retained and provided the opportunity during the design stage to review the design drawings, site survey information, proposed elevations, etc. to verify that they are consistent with our recommendations or the assumptions made in our analysis. It is further recommended that we be retained to review the final design drawings and specifications relative to the geotechnical recommendations.

If, during construction, conditions in the field vary from those assumed at the design stage, an engineer from this office must be notified immediately.

Proper subgrade preparation, groundwater control, compaction, etc. are all critical aspects of the bearing capacity of native soils. It must be noted that different aspects of the geotechnical design are based on the assumption that Englobe will be retained during site preparation and construction of the proposed works to ensure that both the geotechnical site characteristics and the construction operations/techniques are consistent with our recommendations. Should Englobe not be involved during the full construction phase, our liability is strictly limited to the factual information contained herein only.

The comments in this report are intended solely for the guidance of the design engineer and address the geotechnical conditions only. The number of boreholes required to determine the localized conditions between boreholes directly affecting construction costs, equipment, scheduling, etc. would in fact be greater than what has been carried out for design purposes. Therefore, contractors bidding on this project or undertaking this work should make their own interpretations of the factual borehole results and carry out further work as they deem necessary to assess the scope of the project.

Section 5 of this reported is intended for the use of the client and the design team only and is not intended to be included in the tender documents. Inclusion of the factual information (Sections 1 to 5 inclusive) in the tender documents is furnished merely for the general information of bidders and is not in any way warranted or guaranteed by or on behalf of the owner or the owner's consultants and its subconsultants or the consultants' or subconsultants' employees, and neither the owner nor its consultants or its employees shall be liable for any representations negligent or otherwise contained in the documents.

## Appendix 1   Key Plan

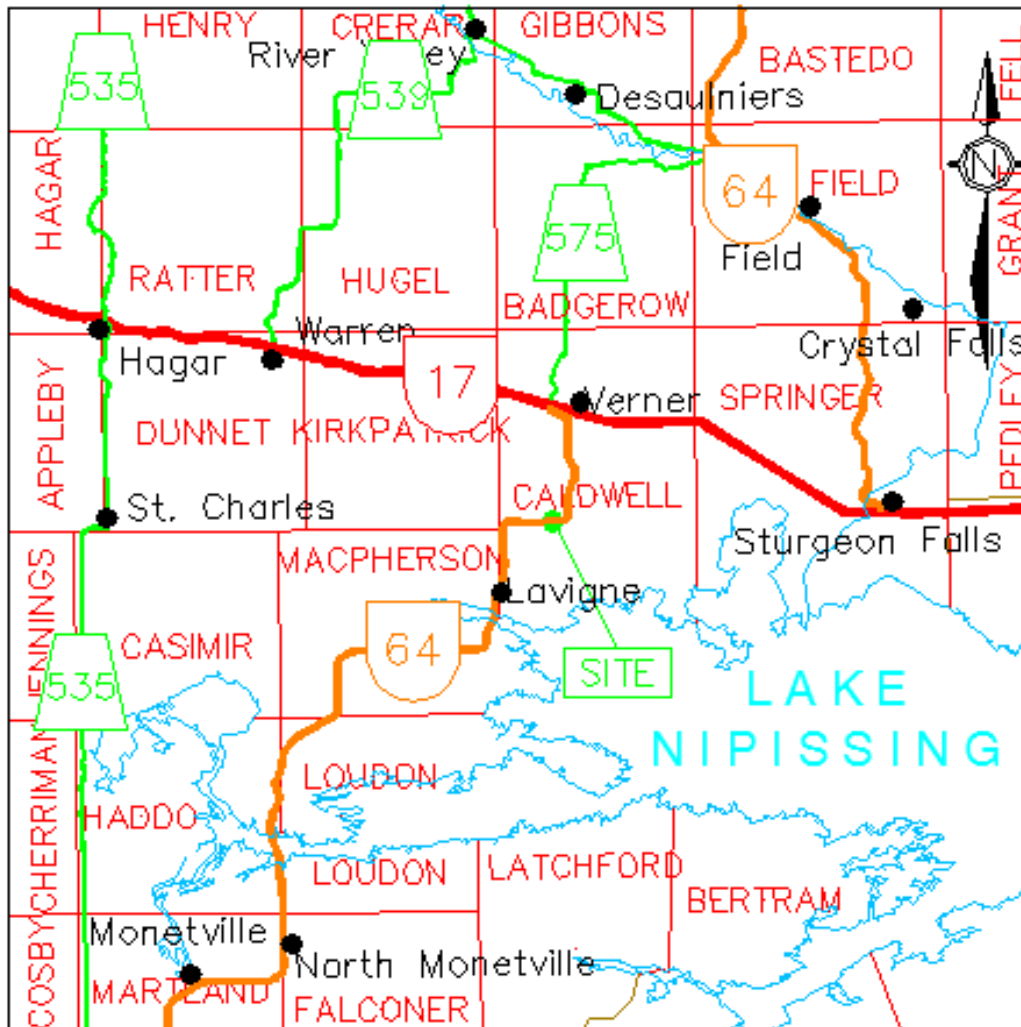
Drawing No. 1

Key Plan

# MACRO KEY PLAN

Drawing No.1

NOT TO SCALE



## FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 5166-13-00

Highway 64

Stations 15+052 and 15+055

Riberdy Tributary Culvert

Site No. 43-310

Township of Caldwell, Ontario



Reference No: 16/03/16019

November 2016



## **Appendix 2    Subsurface Data**

Enclosure No. 1	List of Abbreviations and Symbols
Enclosure Nos. 2 to 7	Record of Borehole Sheet

## LIST OF ABBREVIATIONS & DESCRIPTION OF TERMS

The abbreviations and terms, used to describe retrieved samples and commonly employed on the borehole logs, on the figures and in the report are as follows:

### 1. ABBREVIATIONS

AS	Auger Sample
CS	Chunk Sample
DS	Denison type sample
FS	Foil Sample
NFP	No Further Progress
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
RC	Rock core with size & percentage of recovery
SS	Split Spoon
ST	Slotted Tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash Sample
WH	Sampler advanced by static weight of hammer and/or rods
Rec	% recovery from individual run of rock core
RQD	Rock quality designation (%)

### 2. PENETRATION RESISTANCE/"N"

*Dynamic Cone Penetration Test (DCPT):*

A continuous profile showing the number of blows for each 300 mm of penetration of a 50 mm diameter 60° cone attached to AW rod driven by a 63 kg hammer falling 760 mm.

Plotted as —●—●—●—●—●—

*Standard Penetration Test (SPT) or "N" Values*

The number of blows of a 63 kg hammer falling 760 mm required to advance a 50 mm O.D. drive open sampler 300 mm.

### 3. SOIL DESCRIPTION

a) *Cohesionless Soils:*

"N" (blows/0.3 m)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

b) *Cohesive Soils:*

Undrained Shear Strength (kPa)	Consistency
Less than 12	very soft
12 to 25	soft
25 to 50	firm
50 to 100	stiff
100 to 200	very stiff
over 200	hard

### 3. SOIL DESCRIPTION (Cont'd)

c) *Bedrock:*

RQD (%)	Classification
Less than 25	Very poor quality
25 to 50	Poor quality
50 to 75	Fair quality
75 to 90	Good quality
90 to 100	Excellent quality

d) *Method of Determination of Undrained Shear Strength of Cohesive Soils:*

+ 3.2 - Field Vane test in borehole.  
The number denotes the sensitivity to remoulding.

D - Laboratory Vane Test

" - Compression test in laboratory

For a saturated cohesive soil the undrained shear strength is taken as one-half of the undrained compressive strength.

e) *Soil Moisture:*

Moisture	Described as
Dry	Below optimum moisture content
Moist	Near optimum moisture content
Wet	Above optimum moisture content

### 4. TERMINOLOGY

Terminology used for describing soil strata is based on the proportion of individual particle sizes present in the samples (please note that, with the exception of those samples subject to a grain-size analysis, all samples were classified visually and the accuracy of visual examination is not sufficient to determine exact grain sizing):

Trace, or occasional	Less than 10%
Some	10 to 20%
With	20 to 30%
Adjective (i.e. silty or sandy)	30 to 40%
And (i.e. sand and gravel)	40 to 60%

Terminology for cobbles and boulders is based on auger response and field observations:

Occasional	Obstructions encountered in borehole, however advance is not impeded
Numerous	Obstructions are essentially continuous over drilled length

**SAMPLE DESCRIPTION NOTES:**

1. **FILL:** The term fill is used to designate all man-made deposits of natural soil and/or waste materials. The reader is cautioned that fill materials can be very heterogeneous in nature and variable in depth, density and degree of compaction. Fill materials can be expected to contain organics, waste materials, construction materials, shot rock, rip-rap, and/or larger obstructions such as boulders, concrete foundations, slabs, abandoned tanks, etc.; none of which may have been encountered in the borehole. The description of the material penetrated in the borehole therefore may not be applicable as a general description of the fill material on the site as boreholes cannot accurately define the nature of fill material. During the boring and sampling process, retrieved samples may have certain characteristics that identify them as 'fill'. Fill materials (or possible fill materials) will be designated on the Borehole Logs. If fill material is identified on the site, it is highly recommended that testpits be put down to delineate the nature of the fill material. However, even through the use of testpits defining the true nature and composition of the fill material cannot be guaranteed. Fill deposits often contain pockets or seams of organics, organically contaminated soils or other deleterious material that can cause settlement or result in the production of methane gas. It should be noted that the origins and history of fill material is frequently very vague or non-existent. Often fill material may be contaminated beyond environmental guidelines and the material will have to be disposed of at a designated site (i.e. registered landfill). Unless requested or stated otherwise in this report, fill material on this site has not been tested for contaminants however, environmental testing of the fill material can be carried out at your request. Detection of underground storage tanks cannot be determined with conventional geotechnical procedures.
2. **TILL:** The term till indicates a material that is an unstratified, glacial deposit, heterogeneous in nature and, as such, may consist of mixtures and pockets of clay, silt, sand, gravel, cobbles and/or boulders. These heterogeneous deposits originate from a geological process associated with glaciation. It must be noted that due to the highly heterogeneous nature of till deposits, the description of the deposit on the borehole log may only be applicable to a very limited area and therefore, caution must be exercised when dealing with a till deposit. When excavating in till, contractors may encounter cobbles/boulders or possibly bedrock even if they are not indicated on the borehole logs. It must be appreciated that conventional geotechnical sampling equipment does not identify the nature or size of any obstruction.
3. **BEDROCK:** Auger refusal may be due to the presence of bedrock, but possibly could also be due to the presence of very dense underlying deposits, boulders or other large obstructions. Auger refusal is defined as the point at which an auger can no longer be practically advanced. It must be appreciated that conventional geotechnical sampling equipment does not differentiate between nature and size of obstructions that prevent further penetration of the boring below grade. Bedrock indicated on the borehole logs will be labeled 'possibly' or 'probable' etc. based on the response of the boring and sampling equipment, surrounding topography, etc. Bedrock can be proven at individual borehole locations, at your request, by diamond core drilling operations or, possibly, by testpits. It must also be appreciated that bedrock surfaces can be, and most times are, very erratic in nature (i.e. sheer drops, isolated rock knobs, etc.) and caution must be used when interpreting subsurface conditions between boreholes. A bedrock profile can be more accurately estimated, at the clients' request, through a series of closely positioned unsampled auger probes combined with core drilling.
4. **GROUNDWATER:** Although the groundwater table may have been encountered during this investigation and the elevation noted in the report and/or on the record of boreholes, it must be appreciated that the elevation of the groundwater table will fluctuate based upon seasonal conditions, localized changes, erratic changes in the underlying soil profile between boreholes, underlying soil layers with highly variable permeabilities, etc. These conditions may affect the design and type and nature of dewatering procedures. Cave-in levels recorded in borings give a general indication of the groundwater level in cohesionless soils however, it must be noted that cave-in levels may also be due to the relative density of the deposit, drilling operations etc.

**METRIC****RECORD OF BOREHOLE NO. 1**

REFERENCE 16019 DATUM Geodetic LOCATION N 5136187.7 E 256244.5 - Twp. of Caldwell, Station 15+066 ORIGINATED BY JL  
 PROJECT GWP 5166-13-00, Highway 64 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY DM  
 CLIENT AECOM DATE (Started) 2016 April 29 TIME   
 DATE (Completed) 2016 April 29 (Completed) 10:40:00 AM CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV. DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE						
201.0	Ground Surface									
0.0	SILTY CLAY (probable FILL) - some sand, some grass rootlets grey (stiff)		1	SS	2					
200.4	SILTY CLAY to CLAY - trace sand, trace grass rootlets to depth of 1.4 m brownish grey to grey		2	SS	2					
0.6	occasional reddish brown varved clay (stiff/firm)		3	SS	WH					
			4	SS	PM					
			5	SS	PM					
			6	SS	PM					
			7	SS	PM					
			8	SS	PM					
	organic CLAY									
193.8	SAND - trace gravel, some silt, trace clay grey (loose/very dense)		9	SS	20/150mm					
193.1	Auger Refusal Start Rock Coring		10	RC	REC=100% ROD=83%					
7.9	BEDROCK - black gneiss with pink granite good quality		11	RC	REC=100% ROD=83%					
190.0	End of Sampling									
11.0	End of Borehole									
COMMENTS							+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE			
							WATER LEVEL RECORDS Date (dd/mm/yy)/Time      Water Depth (m)      Cave In (m) 1) 16/4/29 3:20:00 PM      0      - 2) 16/5/4 1:35:00 PM      0.9      - 3) 16/6/2 4:00:00 PM      0.9      -			

The stratification lines represent approximate boundaries. The transition may be gradual.

**Englobe Corp.**

120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@englobecorp.com

MEL-GEO 16019 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 16/11/1

**METRIC****RECORD OF BOREHOLE NO. 2**

REFERENCE 16019 DATUM Geodetic LOCATION N 5136169.2 E 256233.4 - Twp. of Caldwell, Station 15+055 ORIGINATED BY JL  
 PROJECT GWP 5166-13-00, Highway 64 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY DM  
 CLIENT AECOM DATE (Started) 2016 May 2 TIME   
 DATE (Completed) 2016 May 2 (Completed) 5:20:00 PM CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40					
203.8	Ground Surface													
0.0	50 mm asphalt 150 mm crushed gravel SAND FILL - with to trace gravel, some to trace silt, trace clay  brown to brownish grey (compact)  300 mm boulder encountered at depths from 1.2 m to 1.5 m below grade		1	SS	16									
			2	SS	28									24 60 12 4
			3	SS	11									
			4	SS	27									
			5	SS	13									0 86 10 4
200.1														
3.7	SILTY CLAY to CLAY - trace sand grey soft		6	SS	PM									
199.2														
4.6	Start Rock Coring  BEDROCK - black geiss fair quality		7	RC	REC=95% RQD=67%									
			8	RC	REC=100% RQD=68%									
196.2														
7.6	End of Sampling End of Borehole													

COMMENTS		WATER LEVEL RECORDS		
		Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
		1) 16/5/2 5:20:00 PM	2	5.8
		2)	-	-
		3)	-	-

The stratification lines represent approximate boundaries. The transition may be gradual.

MEL-GEO 16019 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 16/11/1

**METRIC****RECORD OF BOREHOLE NO. 3**

REFERENCE 16019 DATUM Geodetic LOCATION N 5136178.6 E 256231.5 - Twp. of Caldwell, Station 15+053 ORIGINATED BY JL  
 PROJECT GWP 5166-13-00, Highway 64 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY DM  
 CLIENT AECOM DATE (Started) 3016 May 3 TIME   
 DATE (Completed) 2016 May 3 (Completed) 3:00:00 PM CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)												
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES																				
203.8	Ground Surface																								
0.0	100 mm asphalt 300 mm crushed gravel		1	SS	15																				
	SAND FILL - some to trace gravel, trace silt, trace clay																								
	brown		2	SS	9																				
	(loose/dense)																								
			3	SS	42								3 85 8 4												
			4	SS	11																				
	brownish grey		5	SS	8								13 75 9 3												
200.1																									
3.7	SILTY CLAY to CLAY - trace sand grey (stiff/firm)		6	SS	3																				
			7	SS	WH								0 2 37 61												
			8	SS	PM																				
	reddish brown clay varves encountered to a depth of approximately 7.3 m																								
			9	SS	PM								0 0 17 83												
			10	SS	PM																				
193.7																									
10.1	Auger Refusal Start Rock Coring																								
	BEDROCK - black gneiss good quality		11	RC	REC=100% RQD=80%																				
	black gneiss with pink granite excellent quality		12	RC	REC=100% RQD=92%																				
	Continued Next Page																								
COMMENTS								+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE																	
								WATER LEVEL RECORDS <table border="1"> <thead> <tr> <th>Date (dd/mm/yy)/Time</th> <th>Water Depth (m)</th> <th>Cave In (m)</th> </tr> </thead> <tbody> <tr> <td>1) 16/5/3 3:00:00 PM</td> <td>0</td> <td>▽</td> </tr> <tr> <td>2) 16/5/4 1:30:00 PM</td> <td>0.9</td> <td>▽</td> </tr> <tr> <td>3) 16/6/2 4:00:00 PM</td> <td>2.5</td> <td>▽</td> </tr> </tbody> </table>						Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)	1) 16/5/3 3:00:00 PM	0	▽	2) 16/5/4 1:30:00 PM	0.9	▽	3) 16/6/2 4:00:00 PM	2.5	▽
Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)																							
1) 16/5/3 3:00:00 PM	0	▽																							
2) 16/5/4 1:30:00 PM	0.9	▽																							
3) 16/6/2 4:00:00 PM	2.5	▽																							
The stratification lines represent approximate boundaries. The transition may be gradual.																									

MEL-GEO 16019 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 16/11/1

**Englobe Corp.**

120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@englobecorp.com

**METRIC****RECORD OF BOREHOLE NO. 3**

REFERENCE 16019 DATUM Geodetic LOCATION N 5136178.6 E 256231.5 - Twp. of Caldwell, Station 15+053 ORIGINATED BY JL  
 PROJECT GWP 5166-13-00, Highway 64 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY DM  
 CLIENT AECOM DATE (Started) 3016 May 3 TIME   
 DATE (Completed) 2016 May 3 (Completed) 3:00:00 PM CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W			
190.6	Continued from Previous Page	X															
13.2	End of Sampling End of Borehole																

MEL-GEO 16019 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 16/11/1

**METRIC****RECORD OF BOREHOLE NO. 4**

REFERENCE 16019 DATUM Geodetic LOCATION N 5136157.4 E 256221.4 - Twp. of Caldwell, Station 15+043 ORIGINATED BY JL  
 PROJECT GWP 5166-13-00, Highway 64 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY DM  
 CLIENT AECOM DATE (Started) 2016 May 2 TIME   
 DATE (Completed) 2016 May 3 (Completed) 7:00:00 PM CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)												
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						WATER CONTENT (%)											
200.6	Ground Surface		1	SS	10/50mm								GR SA (SI CL)												
200.4	Topsoil - silty clay, trace gravel, with sand, some grass rootlets brownish grey		2	RC	REC=100% RQD=93%								8 22 35 35												
0.2	Auger Refusal Start Rock Coring		3	RC	REC=100% RQD=95%																				
	BEDROCK - black gneiss with pink granite excellent quality																								
197.2	End of Sampling End of Borehole																								
3.4																									
COMMENTS							+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE																		
							WATER LEVEL RECORDS <table border="1"> <thead> <tr> <th>Date (dd/mm/yy)/Time</th> <th>Water Depth (m)</th> <th>Cave In (m)</th> </tr> </thead> <tbody> <tr> <td>1) 16/5/3 7:00:00 AM</td> <td>0</td> <td>3.4</td> </tr> <tr> <td>2)</td> <td>-</td> <td>-</td> </tr> <tr> <td>3)</td> <td>-</td> <td>-</td> </tr> </tbody> </table>							Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)	1) 16/5/3 7:00:00 AM	0	3.4	2)	-	-	3)	-	-
Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)																							
1) 16/5/3 7:00:00 AM	0	3.4																							
2)	-	-																							
3)	-	-																							

The stratification lines represent approximate boundaries. The transition may be gradual.

MEL-GEO 16019 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 16/11/1

**Englobe Corp.**

120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@englobecorp.com



**METRIC****RECORD OF BOREHOLE NO. 5**

REFERENCE 16019 DATUM Geodetic LOCATION N 5136159.6 E 256277.4 - Twp. of Caldwell, Station 15+049 ORIGINATED BY JL  
 PROJECT GWP 5166-13-00, Highway 64 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY DM  
 CLIENT AECOM DATE (Started) 2016 May 4 TIME 12:00:00 PM CHECKED BY   
 DATE (Completed) 2016 May 4

SOIL PROFILE		STRATA PLOT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)		NUMBER	TYPE			"N" VALUES	20					
200.6	Ground Surface		1	SS	4								
0.0 200.3 0.3	Topsoil - silty clay, some gravel, sandy, some grass rootlets brownish grey (soft) Auger Refusal Start Rock Coring BEDROCK - black gneiss with thin pink granite good quality		2	RC	REC=100% RQD=78%								
			3	RC	REC=100% RQD=90%								
197.2	End of Sampling End of Borehole												
3.4													

WATER LEVEL RECORDS	
Date (dd/mm/yy)/Time	Water Depth (m) / Cave In (m)
1) 16/5/4 12:00:00 PM	0.2
2)	-
3)	-

COMMENTS

+ 3, × 3 : Numbers on right refer to Sensitivity  
 Numbers on left refer to values greater than 120 kPa  
 ○ 3% STRAIN AT FAILURE

The stratification lines represent approximate boundaries. The transition may be gradual.

**Englobe Corp.**

120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@englobecorp.com

MEL-GEO 16019 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 16/11/1

**METRIC****RECORD OF BOREHOLE NO. 6**

REFERENCE 16019 DATUM Geodetic LOCATION N 5136187.3 E 256233.5 - Twp. of Caldwell, Station 15+055 ORIGINATED BY JL  
 PROJECT GWP 5166-13-00, Highway 64 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY DM  
 CLIENT AECOM DATE (Started) 2016 May 4 TIME   
 DATE (Completed) 2016 May 4 (Completed) 2:00:00 PM CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
201.5	Ground Surface												
0.0	SILTY CLAY - trace sand, trace grass rootlets and organics to a depth of 0.5 m brown varved clay encountered brownish grey (very stiff) SILTY CLAY to CLAY- trace sand  Reddish brown varved clay to depth of 5.5 m  grey (very stiff/firm)		1	SS	6								
200.9			2	SS	6								
0.6			3	SS	4								
			4	SS	WH								
			5	SS	WH								
			6	SS	PM								
			7	SS	PM								
			8	SS	PM								
			9	SS	PM								
193.0	SAND - some gravel, some silt, trace clay grey, wet (loose)		10A	SS	10								
191.9	End of Sampling End of Borehole		10B										
9.6													

COMMENTS		WATER LEVEL RECORDS	
The stratification lines represent approximate boundaries. The transition may be gradual.  + 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE	Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
	1) 16/5/4 2:00:00 PM	0.9	8
	2) -	-	-
	3) -	-	-

MEL-GEO 16019 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 16/11/1

## **Appendix 3      Borehole Plan and Laboratory Data**

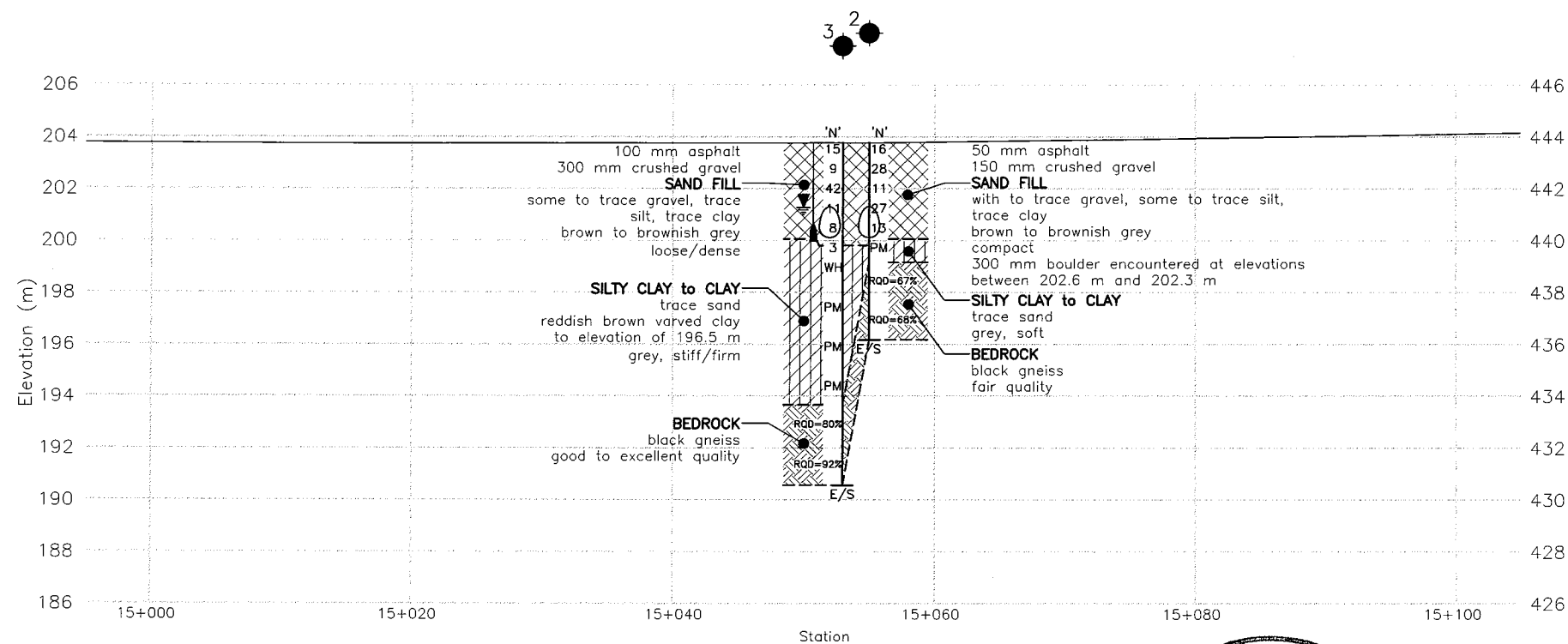
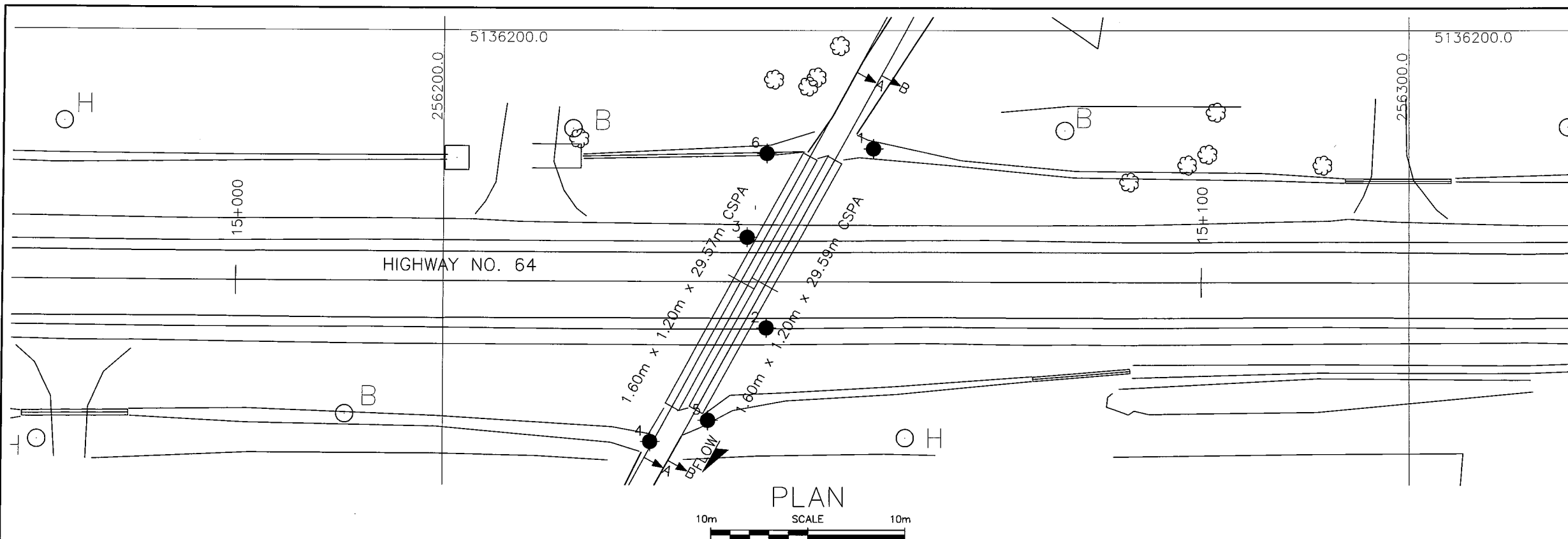
Drawing No. 2A and 2B: Borehole Location and Soil Strata

Figure Nos. L-1 to L-6:      Grain Size Distribution Curves

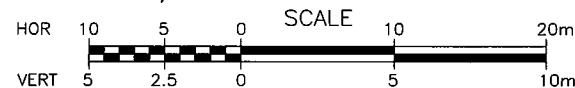
Figure No. L-7:      Atterberg Limits

Table No. L-8: Geotechnical Laboratory Test Summary Sheet

Results of Soil Chemical Tests



C/L PROFILE HWY 64



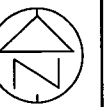
This drawing is for subsurface information only. Surface details and features are for conceptual illustration. The proposed structure location is shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contract Documents.



2016-11-04

DISTRICT  
CONT. No.  
GWP No. 5166-13-10

HWY 64, STA. 15+052 & 15+055 RIBERDY TRIBUTARY CULVERT SITE NO. 43-310	D
BOREHOLE LOCATIONS AND SOIL STRATIGRAPHY	



RAWING

2A



KEY PLAN  
N.T.S.

### LEGEND



Borehole

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

Water Level at Time of Investigation

End of Sampling

Piezometer

BOREHOLE No.	ELEVATION	O/S	NORTHING	EASTING
1	201.0	13.8m Lt	5136187.7	256244.5
2	203.8	4.8m Rt	5136169.2	256233.4
3	203.8	4.6m Lt	5136178.6	256231.5
4	200.6	16.6m Rt	5136157.4	256221.4
5	200.6	14.4m Rt	5136159.6	256277.4
6	201.5	13.3m Lt	5136187.3	256233.5

NOTES:

The boundaries between soil strata have been established at the borehole locations only. The boundaries illustrated and stratigraphy between boreholes on this drawing are assumed based on borehole data and may vary. They are intended for design only.

Base plan and alignment provided in digital format by Callon Dietz on May 12, 2016

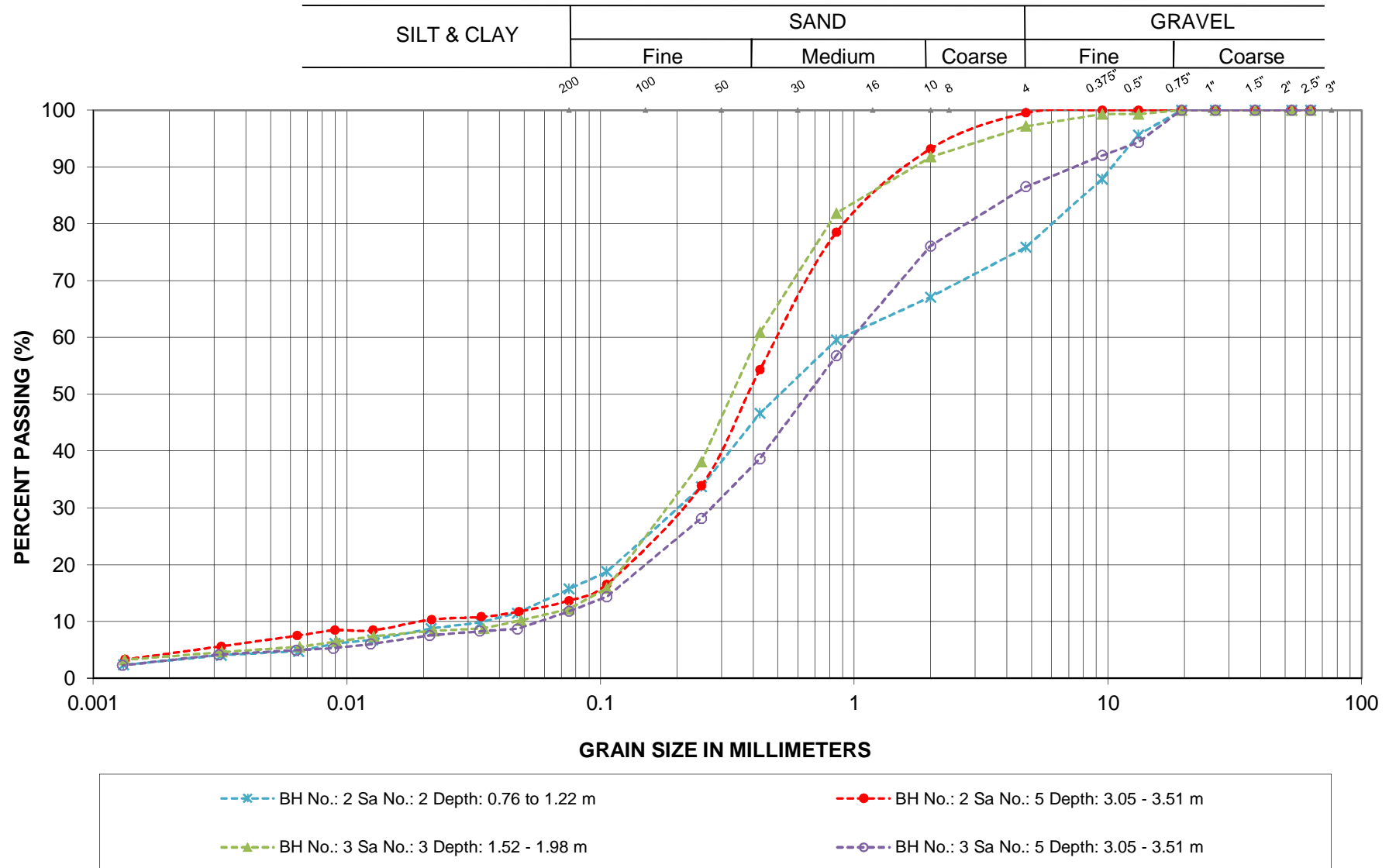
Coordinates based on MTM Zone 10 NAD83 CSRS

GEOCRES No. 411-343

REVISIONS	JUN/16		DM	DRAFT					
	NOV/16		DM	FINAL					
DESCRIPTION									
DESIGN		CHK		CODE		LOAD		DATE NOV/16	
DRAWN	DM	CHK	SH	SITE 43-310		STRUCT		SCHEME	DWG 2A



## GRAIN SIZE ANALYSIS

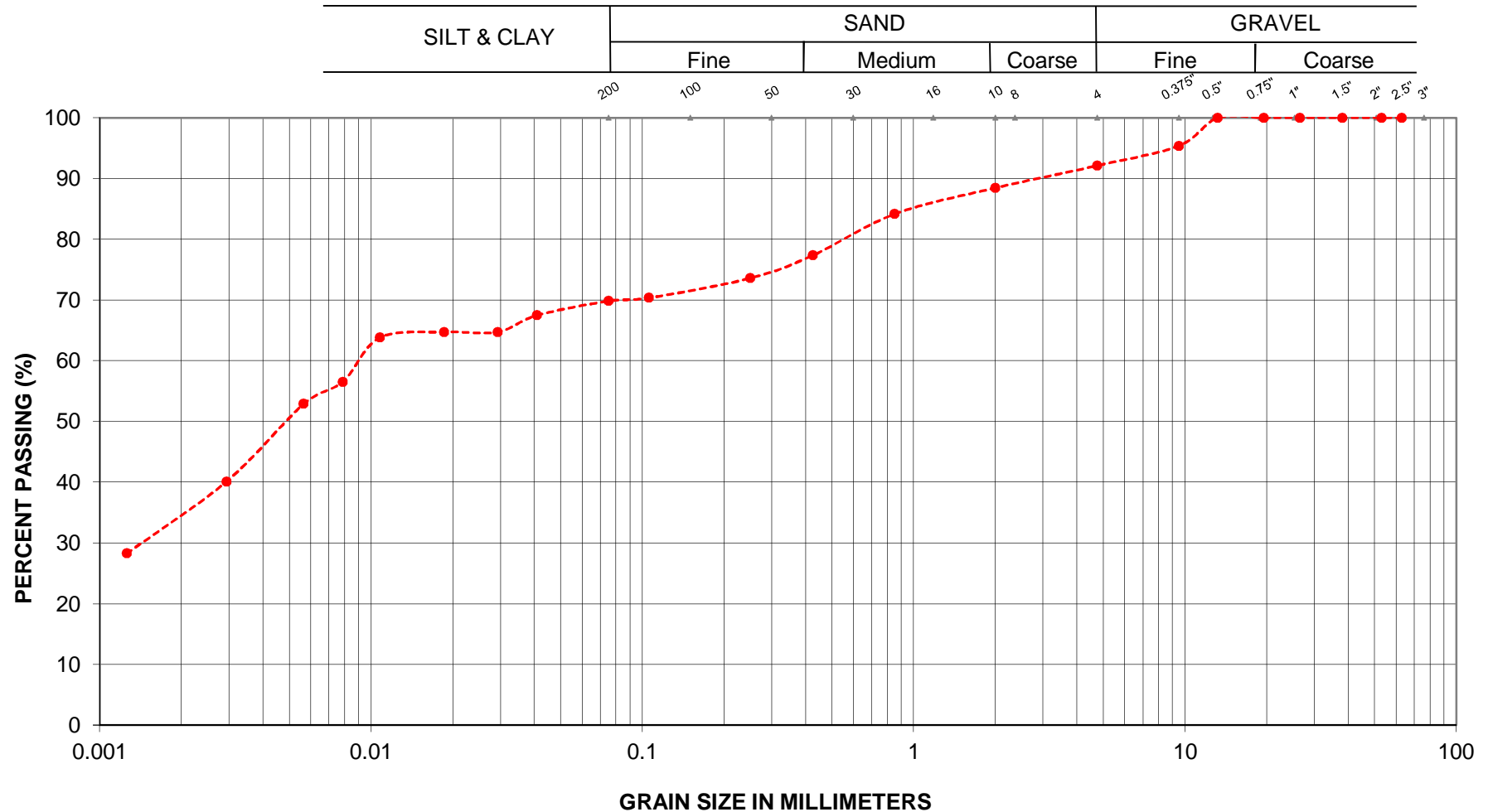


LOCATION: Hwy 64,  
Ribudy Creek Culvert at Stations 15+052 to 15+055  
TWP of Caldwell

SAND FILL  
Englobe Corp.

FIGURE L-1

# GRAIN SIZE ANALYSIS



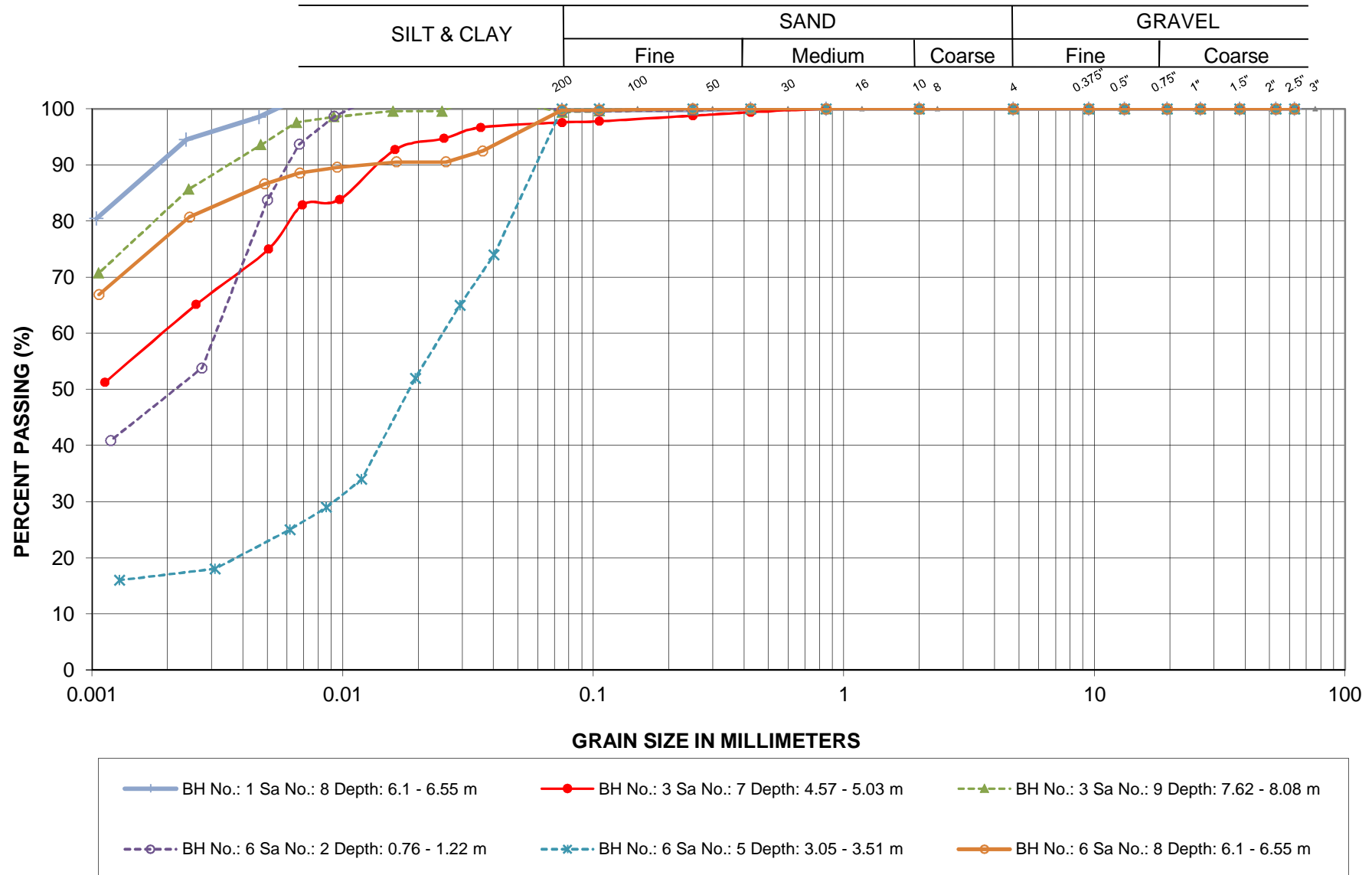
---●--- BH No.: 4 Sa No.: 1 Depth: 0 - 0.2 m

LOCATION: Hwy 64,  
Ribudy Creek Culvert at Stations 15+052 to 15+055  
TWP of Caldwell

TOPSOIL  
Englobe Corp.

FIGURE L-2

## GRAIN SIZE ANALYSIS



LOCATION: Hwy 64,  
Ribudy Creek Culvert at Stations 15+052 to 15+055  
TWP of Caldwell

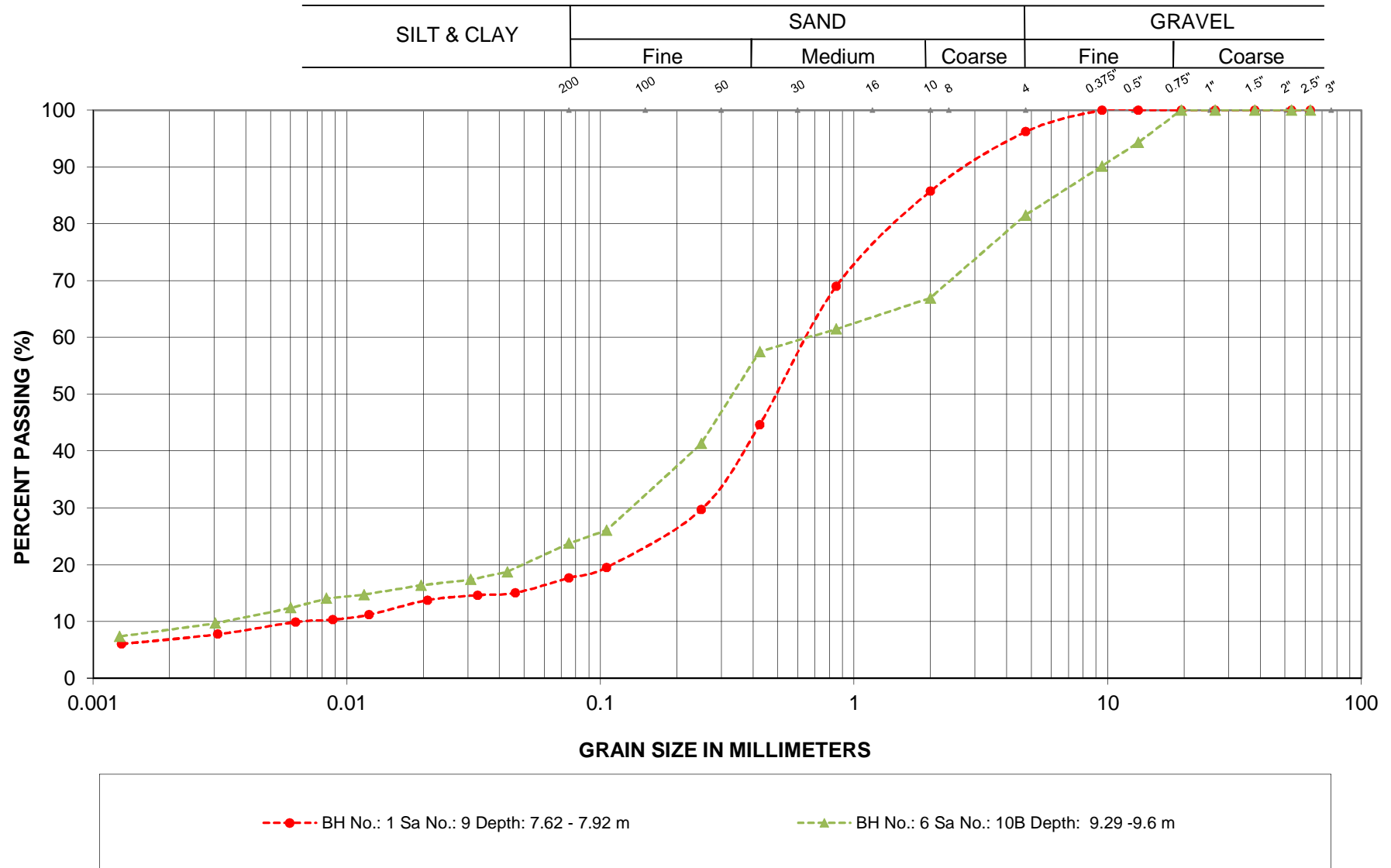
Silty CLAY to CLAY

Englobe Corp.

FIGURE L-3



# GRAIN SIZE ANALYSIS



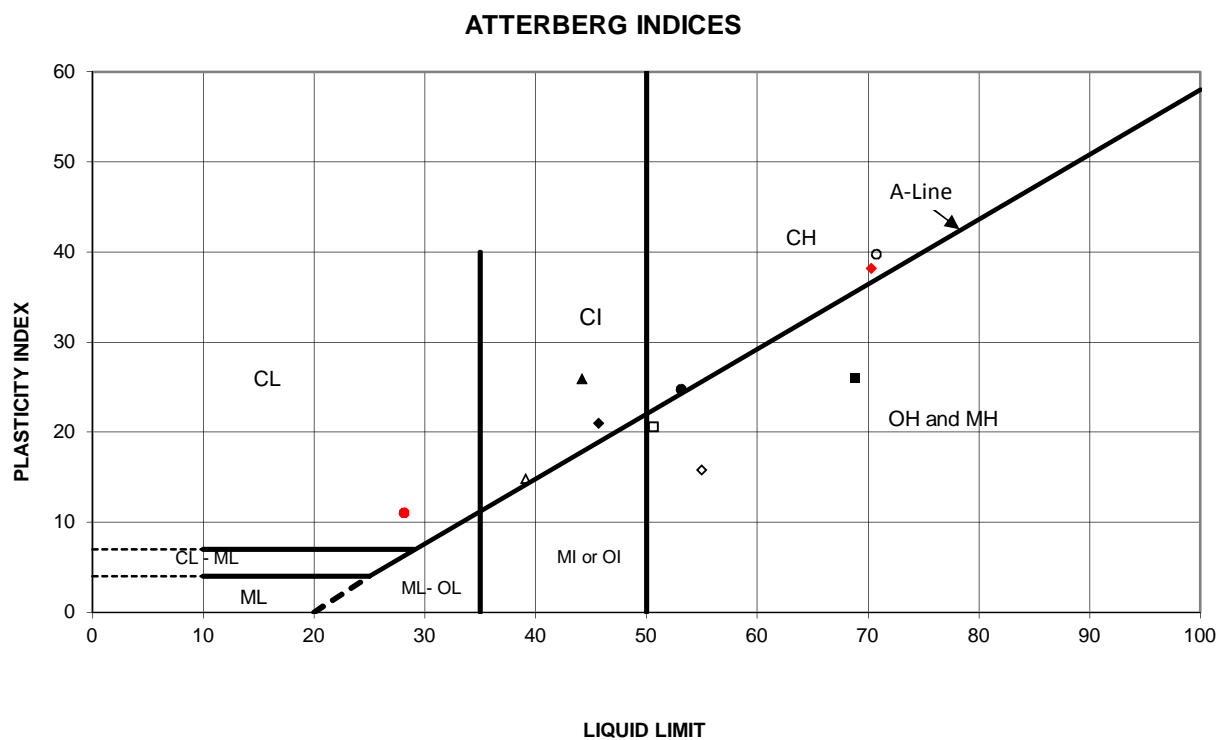
LOCATION: Hwy 64,  
Ribudy Creek Culvert at Stations 15+052 to 15+055  
TWP of Caldwell

SAND  
Englobe Corp.

FIGURE L-4

# ATTERBERG LIMITS TEST RESULTS

FIGURE L-5

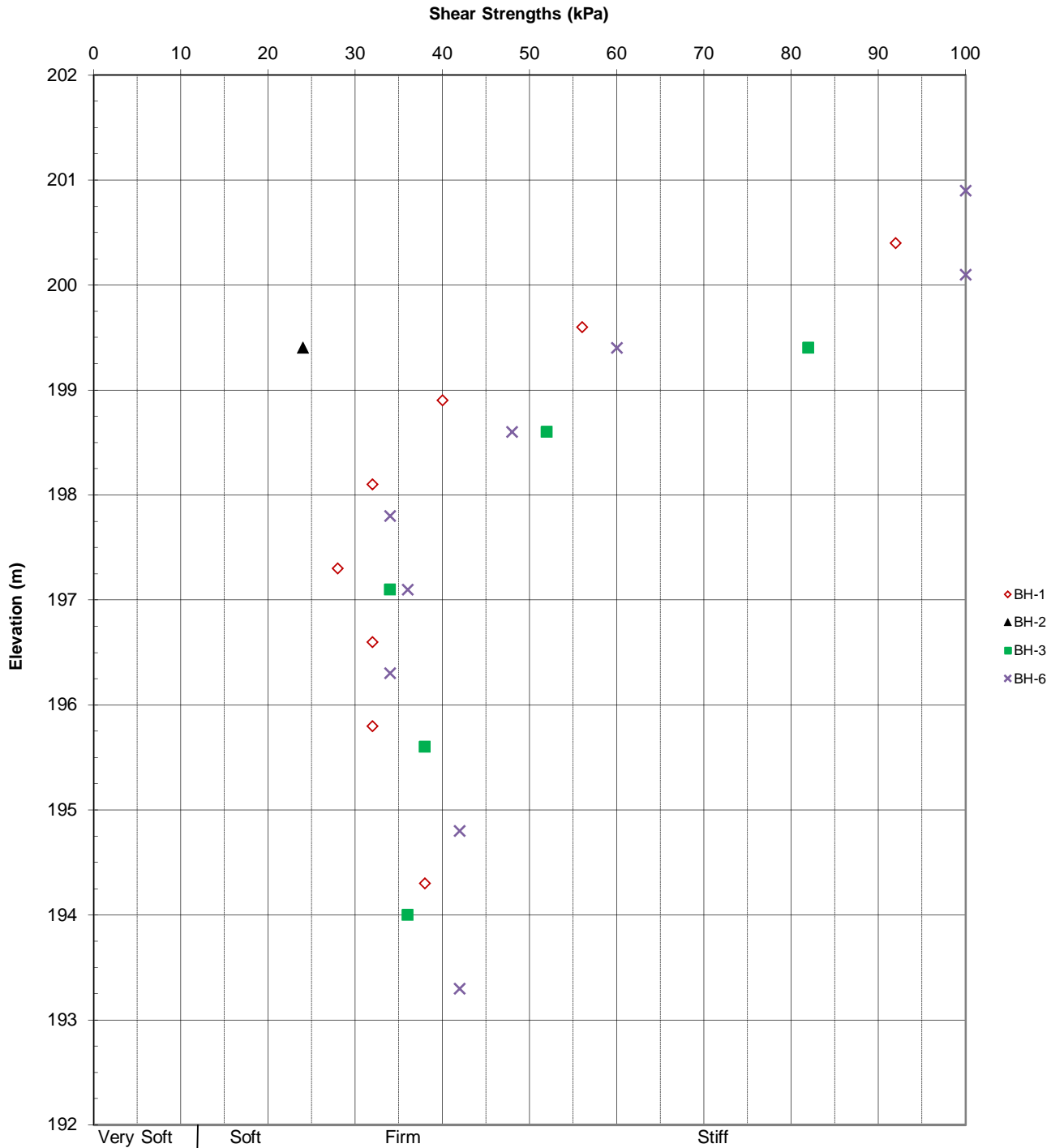


SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plastic Limit	Plasticity Index	NMC %
●	1	2	1.0	200.0	53.2	28.5	24.7	49.3
◆	1	5	3.3	197.7	45.7	24.7	21.0	51.8
■	1	8	6.3	194.7	68.9	42.9	26.0	84.7
▲	3	7	4.8	199.0	44.2	18.3	25.9	41.1
○	3	9	7.85	195.95	70.8	31.1	39.7	70.0
◇	4	1	0.1	200.5	55.0	39.2	15.8	47.5
□	5	1	0.15	200.45	50.7	30.2	20.5	49.3
△	6	2	1.0	200.5	39.1	24.3	14.8	36.0
●	6	5	3.3	198.2	28.2	17.2	11.0	27.9
◆	6	8	6.3	195.2	70.3	32.1	38.2	63.9

Date: Jun-16  
 Project: Hwy 64, Ribudy Creek Tributary Culvert  
 Location: Sta. 15+052 and 15+055, TWP. of Caldwell

Prep'd: SH  
 Chkd: MHM  
 Ref. No.: 16/03/16019

## In-Situ Shear Strengths vs. Depth



Note: Shear strength greater than 100 kPa is shown as 100 kPa

Ref No.: 16/03/16019

Project: Hwy 64

Culvert at Stations 15+052 to 15+055  
TWP of Caldwell

Englobe Corp.

Date: June 2016

Checked:MHM

## Laboratory Tests - Summary Sheet



Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m3)	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
1	1	0.2					39.8				2			
	2	1.0					49.3	53.2	28.5	24.7	2			
	3	1.8					56.3				WH			
	4	2.5					34.8				PM			
	5	3.3					51.8	45.7	24.7	21.0	PM			
	6	4.0					53.9				PM			
	7	4.8					63.2				PM			
	8	6.3	0	0	7	93	84.7	68.9	42.9	26.0	PM			
	9	7.8	4	78	11	7	19.2				20/150mm			
2	1	0.2					9.3				16			
	2	1.0	24	60	12	4	4.3				28			
	3	1.8					13.8				11			
	4	2.5					12.2				27			
	5	3.3					20.6				13			
	6	4.0	0	86	10	4	65.3				PM			
3	1	0.23					4.5				15			
	2	1					9.6				9			
	3	1.75	3	85	8	4	4.9				42			
	4	2.5					7.9				11			
	5	3.3	13	75	9	3	11.4				8			
	6	4.0					31.9				3			
	7	4.8	0	2	37	61	41.1	44.2	18.3	25.9	WH			
	8	6.3					48.2				PM			
	9	7.9	0	0	17	83	70.0	70.8	31.1	39.7	PM			
	10	9.4					54.7				PM			

## Laboratory Tests - Summary Sheet



Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m <sup>3</sup> )	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
4	0.1	0.5	8	22	35	35	47.5	55.0	39.2	15.8	10/50mm			
5	1	0.2					49.3	50.7	30.2	20.5	4			
6	1	0.2					34.5				6			
	2	1.0	0	0	59	41	36.0	39.1	24.3	14.8	6			
	3	1.8					38.4				4			
	4	2.5					49.4				WH			
	5	3.3	0	0	83	17	27.9	28.2	17.2	11.0	WH			
	6	4					65.9				PM			
	7	4.8					63.2				PM			
	8	6.3	0	0	23	77	63.9	70.3	32.1	38.2	PM			
	9	7.9					48.2				PM			
	10A	9.2					45.0				10			
	10B	9.5	19	57	16	8	19.8							

CLIENT NAME: ENGLOBE CORP  
120 PROGRESS CRT.  
NORTH BAY , ON P1A0C2  
(705) 476-2550

ATTENTION TO: Victoria Steuernol

PROJECT: 16019

AGAT WORK ORDER: 16T092251

SOIL ANALYSIS REVIEWED BY: Parvathi Malemath, Data Reviewer

DATE REPORTED: May 12, 2016

PAGES (INCLUDING COVER): 5

VERSION\*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

\*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



# AGAT Laboratories

## Certificate of Analysis

AGAT WORK ORDER: 16T092251

PROJECT: 16019

5835 COOPERS AVENUE  
MISSISSAUGA, ONTARIO  
CANADA L4Z 1Y2  
TEL (905)712-5100  
FAX (905)712-5122  
<http://www.agatlabs.com>

CLIENT NAME: ENGLOBE CORP

SAMPLING SITE:

ATTENTION TO: Victoria Steuernol

SAMPLED BY:

### Inorganic Chemistry (Soil)

DATE RECEIVED: 2016-05-06

DATE REPORTED: 2016-05-12

		SAMPLE DESCRIPTION:		BH3 Sa7	BH2 Sa5
		SAMPLE TYPE:		Soil	Soil
		DATE SAMPLED:		5/5/2016	5/5/2016
Parameter	Unit	G / S	RDL	7540273	7540274
Chloride (2:1)	µg/g	2	194	88	
Sulphate (2:1)	µg/g	2	8	4	
pH, 2:1 CaCl2 Extraction	pH Units		7.67	7.31	
Electrical Conductivity (2:1)	mS/cm	0.005	0.418	0.209	
Resistivity (2:1)	ohm.cm	1	2390	4780	

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

7540273-7540274 EC/Resistivity, Chloride & Sulphate were determined on a DI water extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part dry soil). PH was determined on the 0.01M CaCl2 extract obtained from the 2:1 leaching (2 parts extraction fluid 1 part wet soil).

Certified By:





## Quality Assurance

CLIENT NAME: ENGLOBE CORP

PROJECT: 16019

SAMPLING SITE:

AGAT WORK ORDER: 16T092251

ATTENTION TO: Victoria Steuernol

SAMPLED BY:

### Soil Analysis

RPT Date: May 12, 2016			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Inorganic Chemistry (Soil)															
Chloride (2:1)	7540274	7540274	88	92	4.4%	< 2	103%	80%	120%	105%	80%	120%	99%	70%	130%
Sulphate (2:1)	7540274	7540274	4	5	NA	< 2	98%	80%	120%	107%	80%	120%	102%	70%	130%
pH, 2:1 CaCl2 Extraction	7546685		6.56	6.64	1.2%	NA	100%	80%	120%	NA			NA		
Electrical Conductivity (2:1)	7540274	7540274	0.209	0.211	1.0%	< 0.005	97%	90%	110%	NA			NA		

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By: \_\_\_\_\_







## Method Summary

CLIENT NAME: ENGLOBE CORP

PROJECT: 16019

SAMPLING SITE:

AGAT WORK ORDER: 16T092251

ATTENTION TO: Victoria Steuernol

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH, 2:1 CaCl <sub>2</sub> Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B, SSA #5 Part 3	CALCULATION



## **Appendix 4    Photo Essay**

Enclosure No. 8:

Photo Essay

Existing Embankment of Highway 63– Looking East

Photo: 1



Culvert Inlet – Looking North

Photo: 2



Project: Hwy 64– Riberdy Tributary Creek Culvert, Stations 15+052 to 15+055, Township of Caldwell

Photos Provided by:Englobe

Date: April and May 2016



Culvert Outlet – Looking South next to Borehole No. 4

Photo: 3



Bedrock Outcrop Observed at Southeast next to Culvert Outlet – Looking Southwest

Photo: 4



Project: Hwy 64– Riberdy Tributary Creek Culvert, Stations 15+052 to 15+055, Township of Caldwell

Photos Provided by:Englobe

Date: April and May 2016

Rock Cores – Borehole 1 (left) and Borehole 2 (right)

Photos: 5 and 6



Project: Hwy 64– Riberdy Tributary Creek Culvert, Stations 15+052 to 15+055, Township of Caldwell

Photos Provided By: Englobe

Date: May 2016



## Rock Cores – Borehole 3 (left) and Borehole 4 (right)

Photos: 7 and 8



Project: Hwy 64– Riberdy Tributary Creek Culvert, Stations 15+052 to 15+055, Township of Caldwell

Photos Provided By: Englobe

Date: May 2016

## Rock Cores – Borehole 5 (left)

Photo: 9



Project: Hwy 64– Riberdy Tributary Creek Culvert, Stations 15+052 to 15+055, Township of Caldwell

Photos Provided By: Englobe

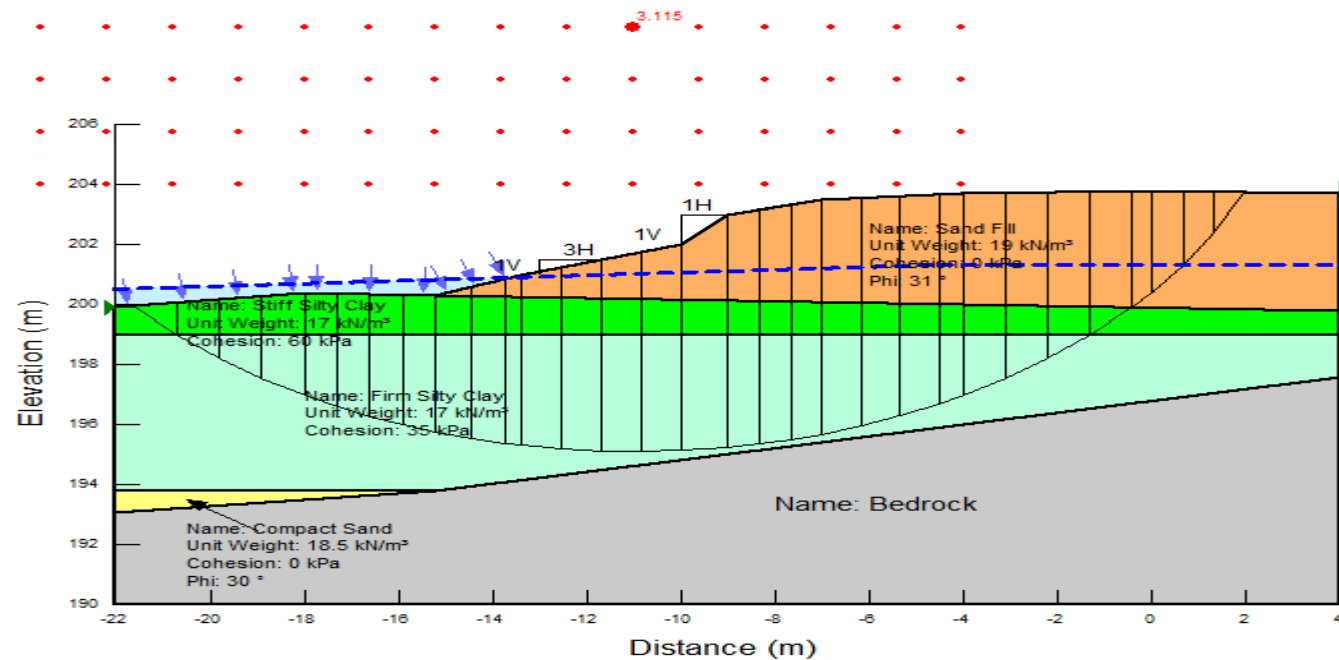
Date: May 2016



## Appendix 5    Design Data

Figure Nos. S-1 to S-4:	Slope Stability Analyses
Table A:	Comparison of Shoring Alternatives
Figure No. SK-5:	Conceptual Staging Plan
Figure No. SK-6:	Conceptual Shoring Locations
Figure No. SK-7:	Conceptual Shoring Sections
	Notice to Contractor

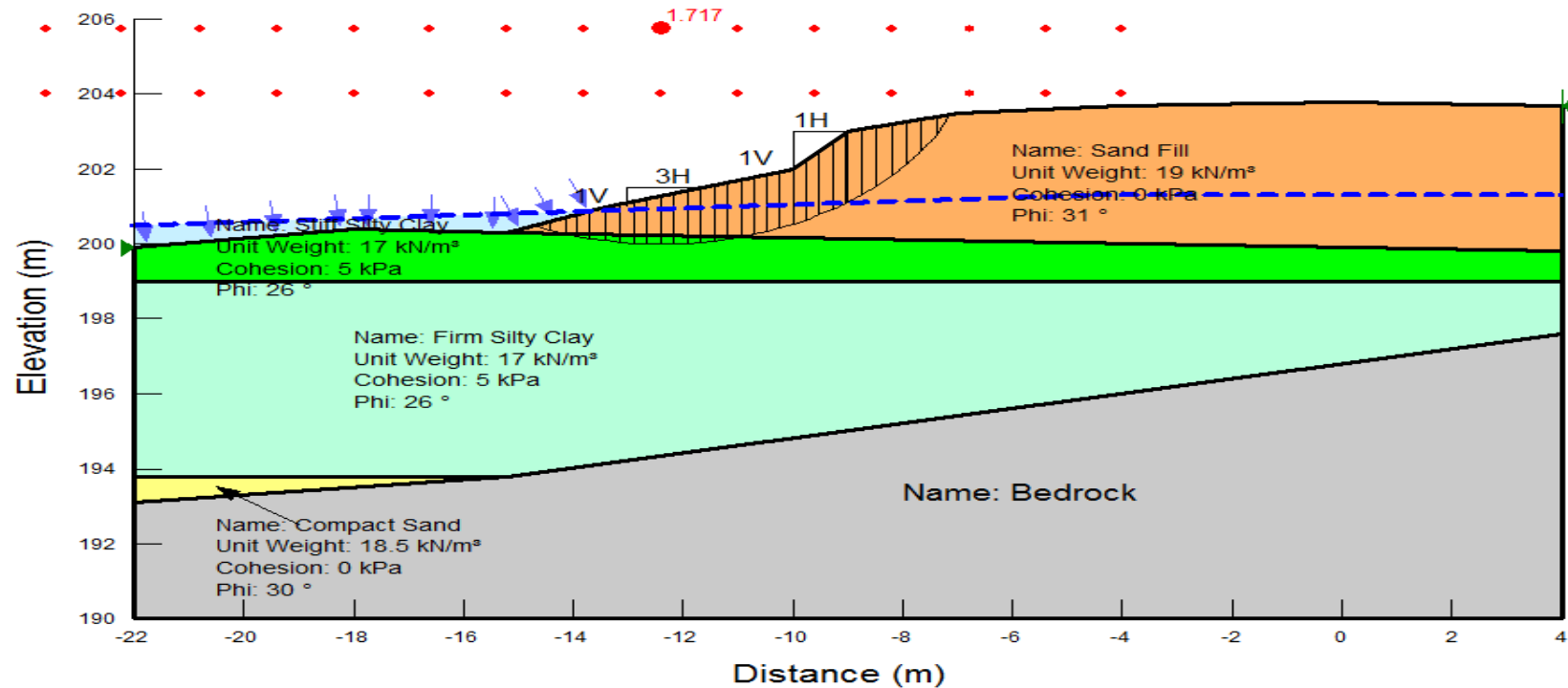
**Stability Analysis**  
**Existing Embankment at**  
**Station 15+055**  
**North Slope**  
**Short Term Stability**  
**Deep Failure Mode**



North Slope

Culvert Station 15+052 and 15+055

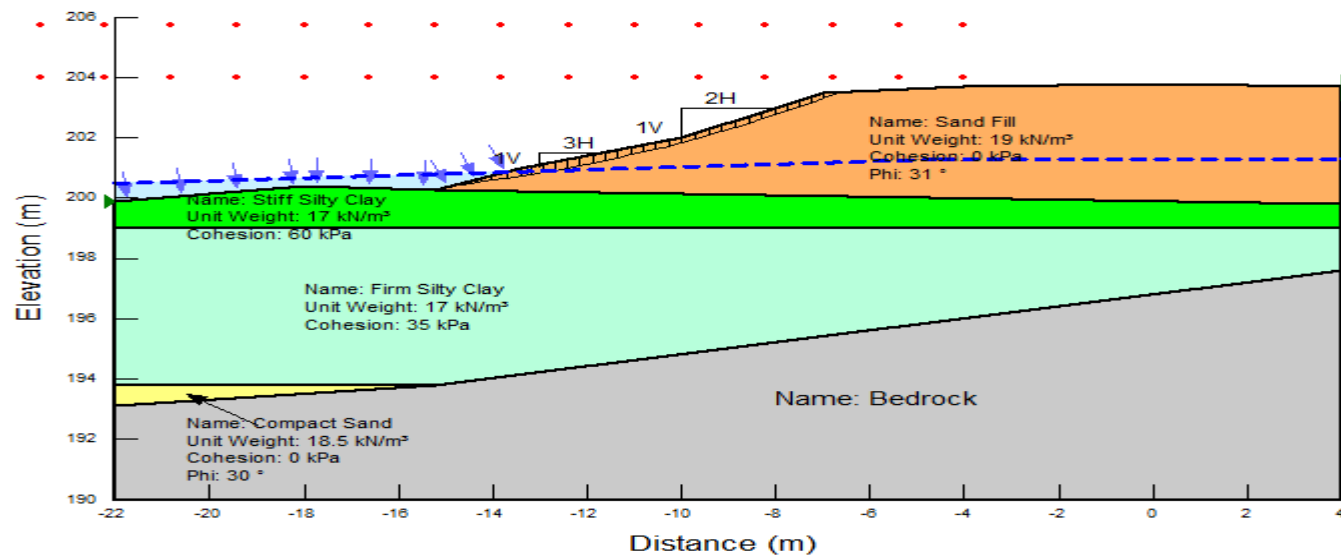
**Stability Analysis  
Existing Embankment at  
Station 15+055  
North Slope  
Long Term Stability  
Shallow Failure Mode**



North Slope

Culvert Station 15+052 and 15+055

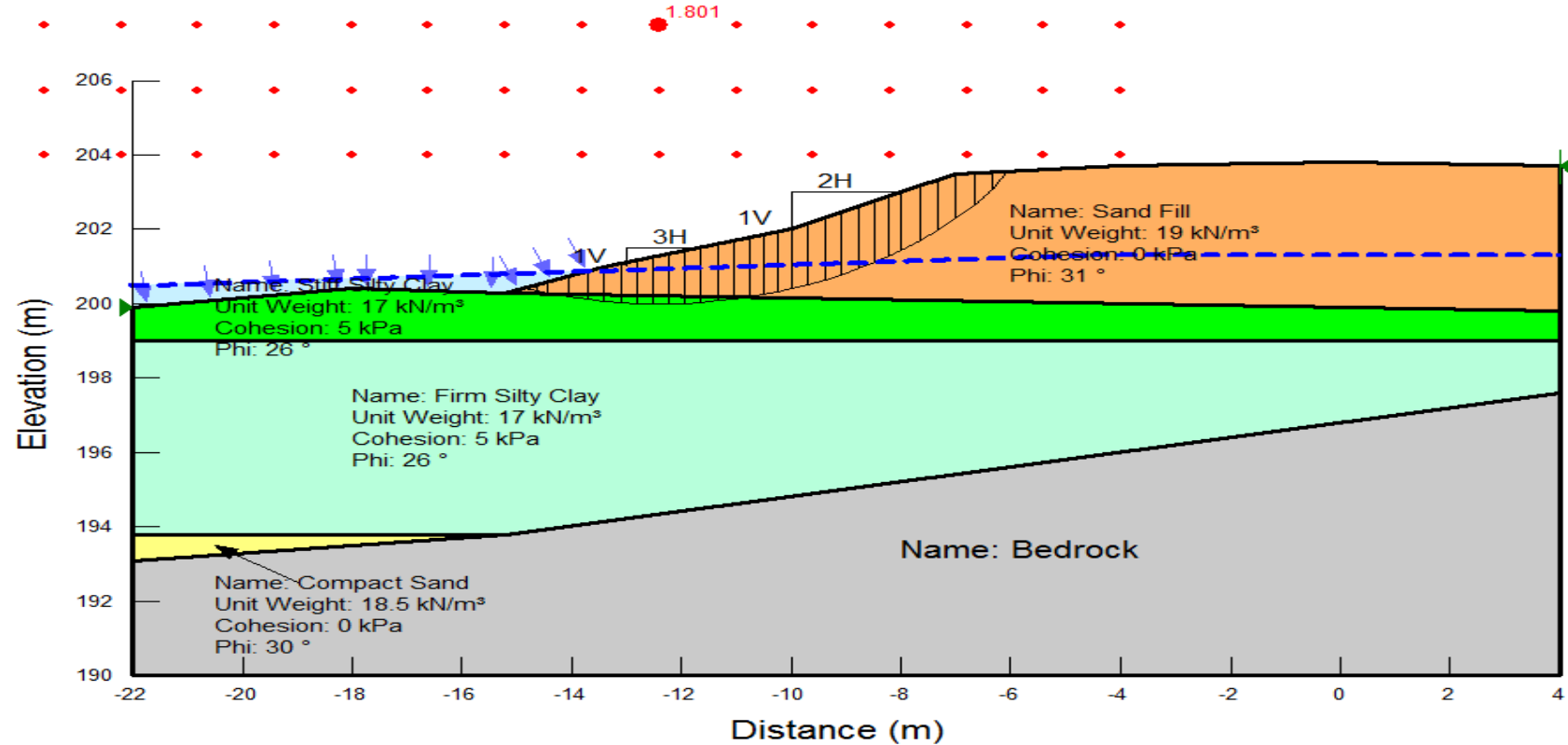
**Stability Analysis  
Embankment at  
Station 15+055  
New North Slope  
Short Term Stability  
Surficial Failure Mode**



North Slope

Culvert Station 15+052 and 15+055

Stability Analysis  
Embankment at  
Station 15+055  
New North Slope  
Long Term Stability  
Shallow Failure Mode



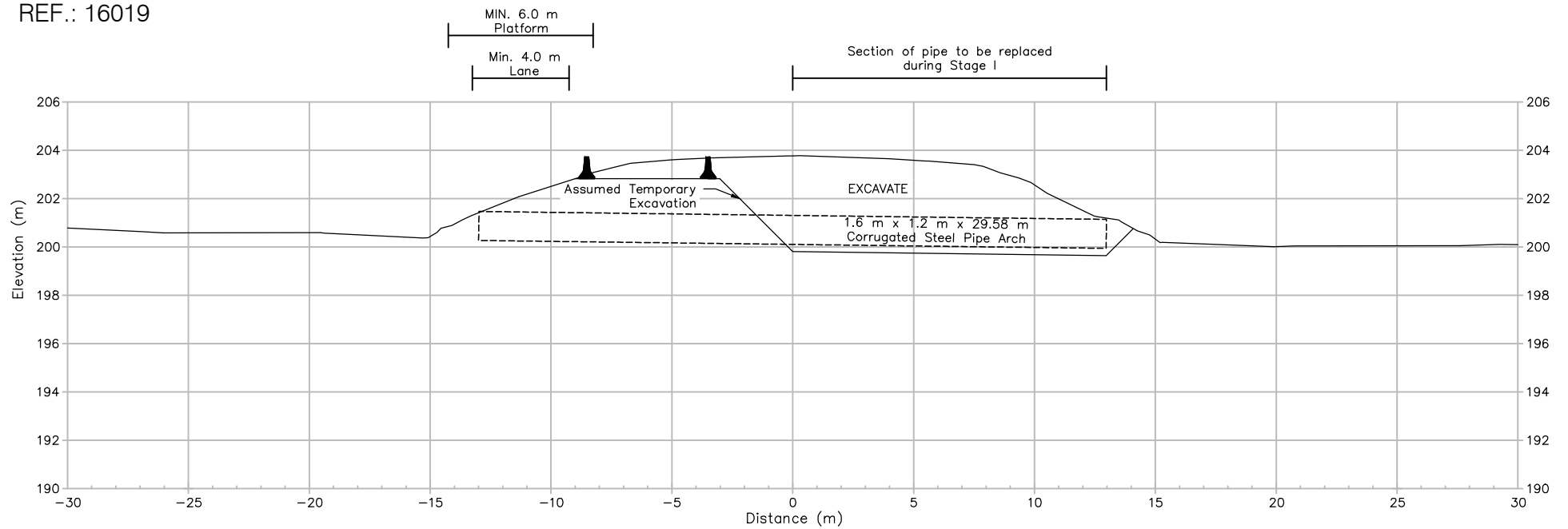
North Slope

Culvert Station 15+052 and 15+055

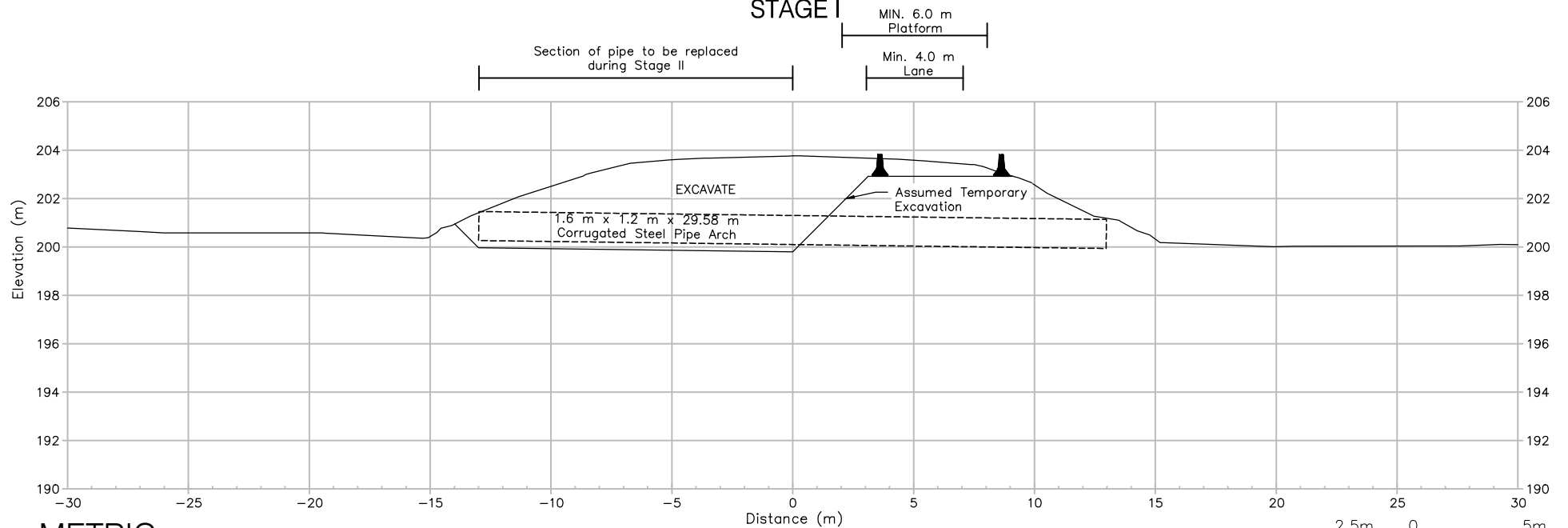
**Table A – Comparison of Shoring Alternatives**

Method	Depth Range (m)	Advantages	Disadvantages	Remarks	Estimated Costs
Wood Sheeting	1.5 – 5	-Low cost, -Easily installed in good ground conditions	-Limited by soil conditions, -Limited depth of installation, -Low strength, -discontinuous	Not Considered due to shallow bedrock at east of existing west culvert	\$ 650/m <sup>2</sup>
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Not Considered due to shallow bedrock at east of existing west culvert	\$ 650/m <sup>2</sup>
Pre-cast concrete panels	3 – 10	-Durable -Assists in minimizing seepage	-Limited depths -Can be damaged during installation -Limited by soil conditions (i.e. obstructions)	Not considered due to ground conditions and higher cost	
Soldier piles	5 – 25	-Easy installation -Readily available -Adaptable to various ground conditions	-Pre-drilling may be required -Possible ground loss	Recommended for protection system at this site	\$ 725/m <sup>2</sup> Predrilling \$ 1,500/m <sup>2</sup>
Tangent/ Secant/ Staggered Drilled Piles	10 – 18	-Readily available -Adaptable to various ground conditions	-Possible ground loss and/or seepage -Poor alignment tolerance	Considered as alternative for protection system with higher cost	
Concrete Diaphragm	10 – 30	-High Strength -Durable -Can be permanent	-High cost -Requires specialized equipment/control	Not Recommended due to shallow bedrock at east of existing west culvert and higher cost	
Micropiles with reinforced shotcrete face		-Can be installed in various ground conditions -High strength -Good tolerance	-High Cost -Requires specialized equipment	Not Recommended due to higher cost	\$ 1,200 – 1,500/m <sup>2</sup>

REF.: 16019



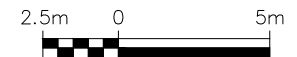
STAGE I



STAGE II

METRIC

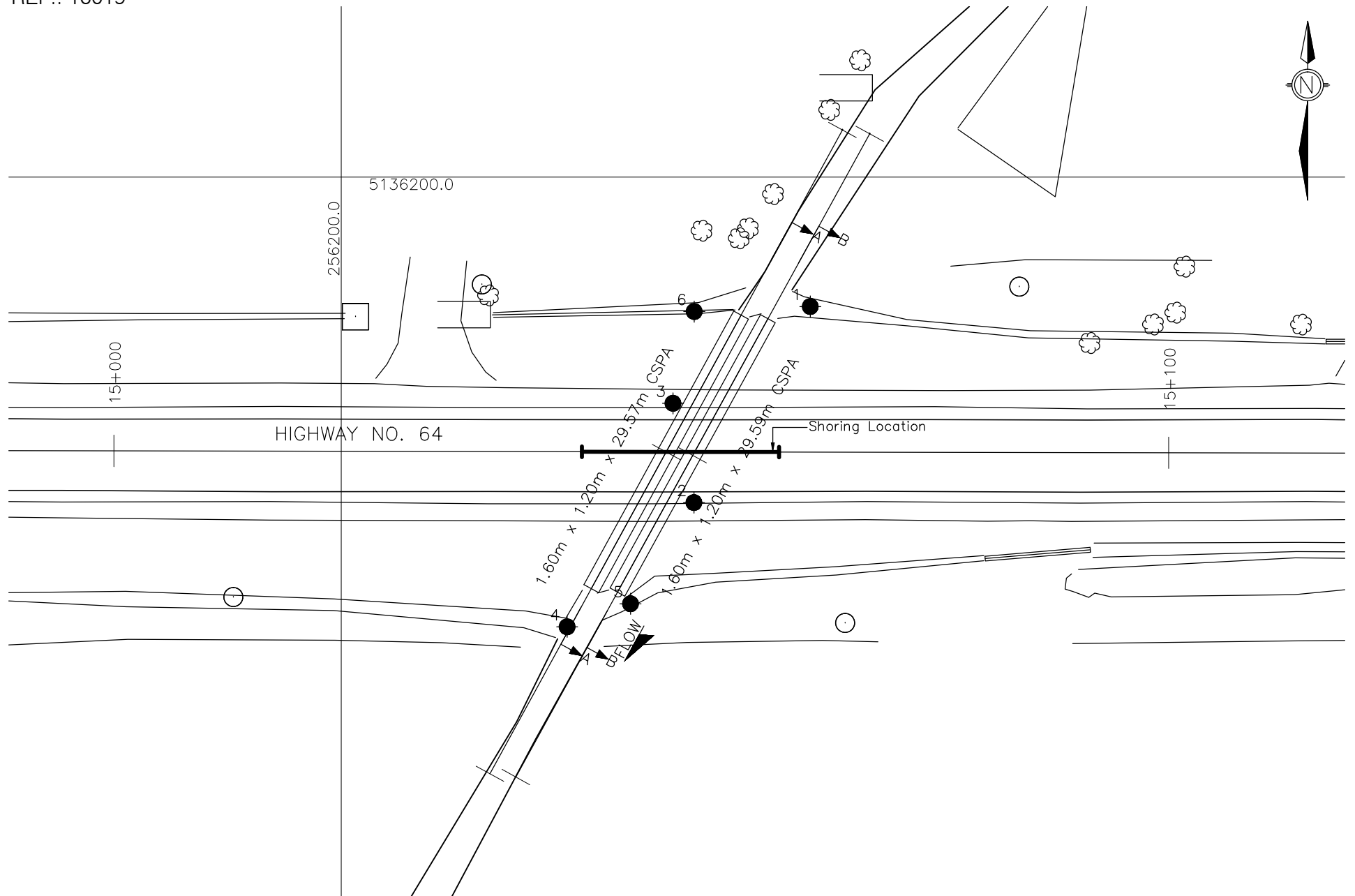
Dimensions are in meters  
and/or millimeters unless  
otherwise shown. Stations are  
in kilometers + meters.



Highway 64, Township of Caldwell - Culverts at Station 15+052 to 15+055  
Conceptual Staging Sections

FIGURE SK-5

REF.: 16019



## METRIC

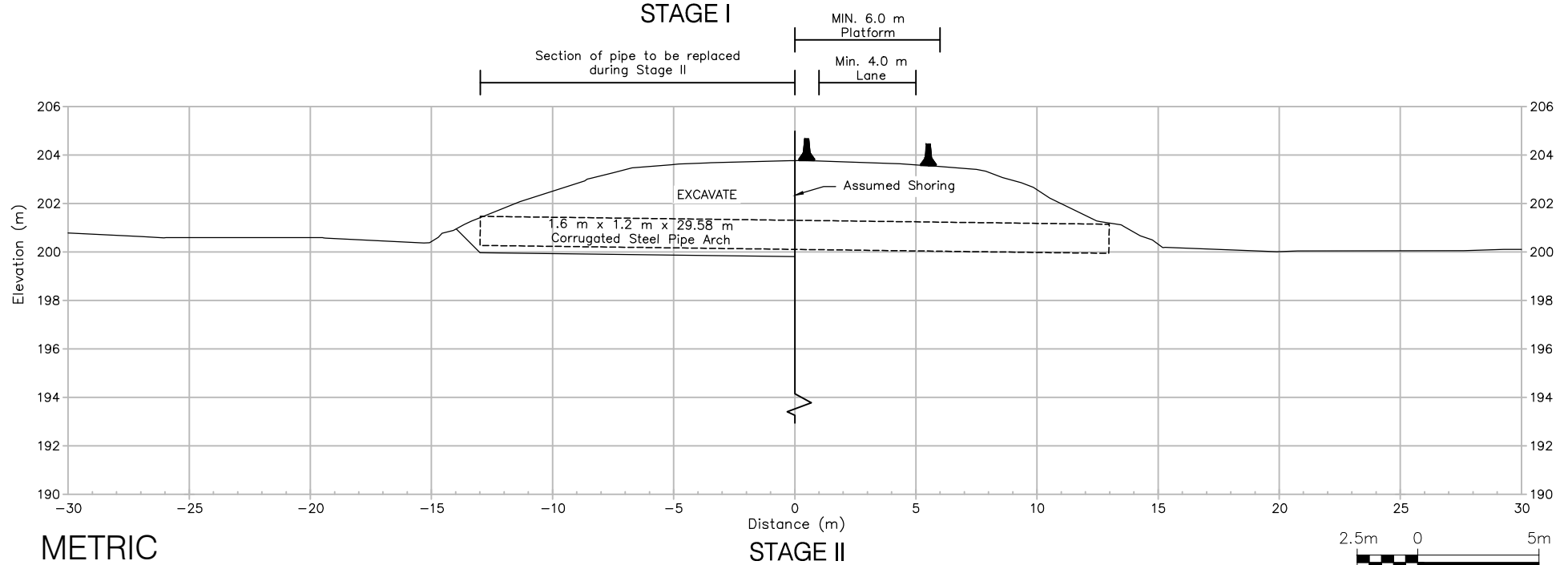
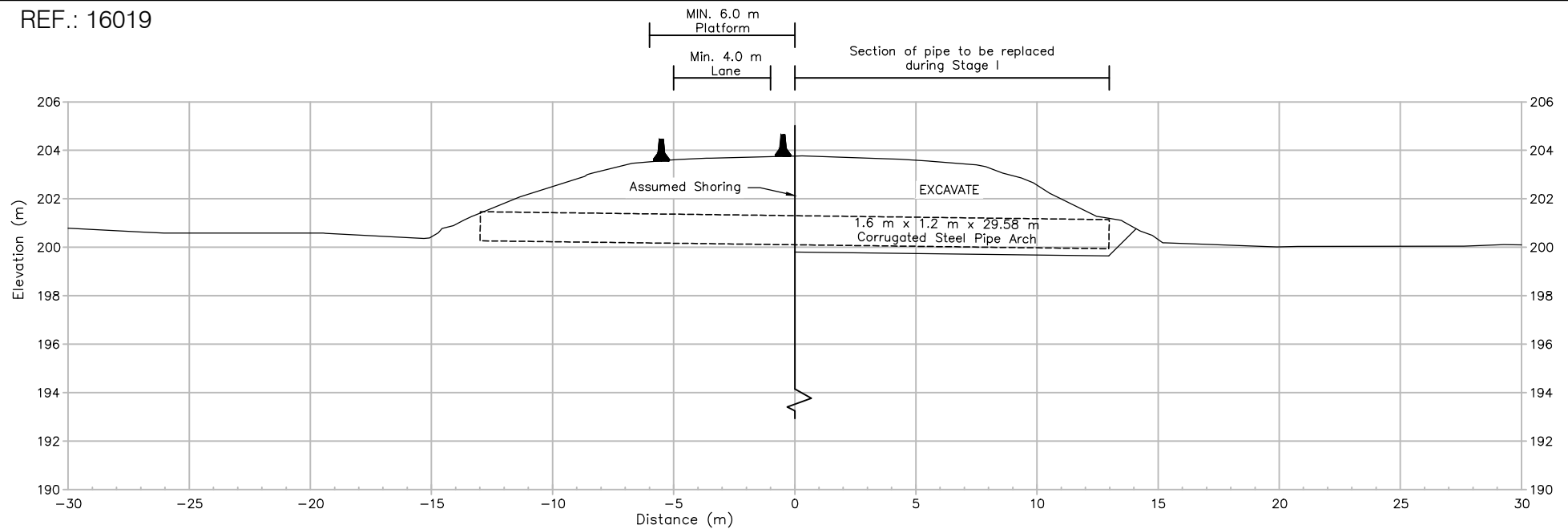
Dimensions are in meters  
and/or millimeters unless  
otherwise shown. Stations are  
in kilometers + meters.

Highway 64, Township of Caldwell - Culverts at Station 15+052 to 15+055  
Conceptual Shoring Location Plan

FIGURE SK-6

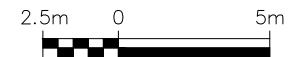


REF.: 16019



## METRIC

Dimensions are in meters  
and/or millimeters unless  
otherwise shown. Stations are  
in kilometers + meters.



Highway 64, Township of Caldwell - Culverts at Station 15+052 to 15+055  
Conceptual Shoring Sections

FIGURE SK-7

## **NOTICE TO CONTRACTOR – Obstructions in Fills and Bedrock Refusal**

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### **Special Provision**

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The Contractor is notified that, during foundation field investigations for the Riberdy Tributary Culvert at Stations 15+052 and 15+055, Township of Caldwell, on Highway 64, cobble/boulder sized rock fragment was encountered in the embankment fills. The bedrock was encountered at depth of 4.6 m below ground surface (Elevation 199.2 m) in the area next to the east culvert, and at depths of 0.2 to 0.3 m below ground surface (Elevations 200.3 to 200.4 m) in the area of outlets of existing culverts. The Contractor shall take into account the refusal for excavations and for designing, constructing the temporary protection system, and coffer dams. The Contractor must also be prepared to deal with seasonal and yearly fluctuations of ground/surface water.