



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
Highway 63
Station 10+495 - Township of Clarkson
GWP 5203-14-00**

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

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Prepared by:

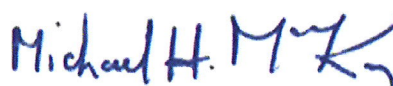



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1 INTRODUCTION

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 an existing centreline culvert site. The culvert is located at Station 10+495 in the Township of Clarkson on Highway 63, about 1.8 km west of McConnell Lake Road (see Drawing No. 1, Appendix 1).

The foundation investigation location was specified by the MTO in the Terms of Reference for work under Agreement No. 5014-E-0055: GWP 5203-14-00 for Detail Design. The terms of reference for the scope of work are outlined in Englobe's Proposal P-15-168, dated November 20, 2015. The purpose of this investigation was to determine the subsurface conditions in the area of the existing culvert for the contract preparation of the Detail Design package. 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

An 1800 mm diameter Corrugated Steel Pipe (CSP) culvert is located on Highway 63 at Station 10+495 in the Township of Clarkson, Ontario. The topography in the area of this site is generally rolling. The existing highway embankment currently supports two undivided lanes of highway, running in a south-north direction. The existing highway at the culvert location is constructed on a fill embankment approximately 5.5 m in height above the culvert invert (at centreline), with centreline at Elevation 289.8 m at the culvert location. At the west slope, the maximum height of the embankment is approximately 5.3 m above the culvert invert below the centerline of highway. At the east slope, the maximum height of embankment fill is approximately 5.6 m above the culvert invert. The existing embankment slopes in the area of the culvert have been generally established at inclination angles of approximately 2.3H:1V to 2.5H:1V at the west and the east slopes, respectively. The culvert at this location is an 1800 mm diameter Corrugated Steel Pipe (CSP) culvert, some 34.2 m in length. Flow through the culvert is from the west to the east (left to right).

Observed infrastructure at the culvert location includes overhead wires to the east of the highway embankment.

2.1 SITE PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The topography on this section of Highway 63 is generally rolling. Layers of earth overlie bedrock. Organic materials were also observed in the region. Within the project area, the native overburden consists primarily of sands overlying bedrock.

Bedrock, based on Ontario Geologic Survey (OGS) Map MRD-126, in the area consists of magmatic rocks and gneisses.

3 INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out on May 12th, 16th, 17th, and 19th, 2016 during which time four (4) sampled boreholes were advanced. Two (2) boreholes were advanced through the embankment, and one (1) borehole was advanced adjacent to both the inlet (west) and the outlet (east) ends of the culvert (total of two (2) inlet and outlet boreholes).

The field investigation was carried out by Englobe's drilling team using both truck and bombardier mounted CME drilling rigs equipped with hollow stem augers, standard augers, casing equipment, and routine geotechnical sampling equipment. 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. If refusal to further advance of the augers was encountered within the proposed depth of borehole, the boring was advanced through diamond drilling using NQ size coring equipment. Dynamic Cone Penetration testing (DCPT) was carried out from the bottom of a sampled borehole to practical refusal (described as >100 blows per 300 mm penetration). 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 19 mm diameter standpipe was installed in Borehole Nos. 1 and 3 prior to backfilling to allow for further monitoring of the shallow groundwater levels. All open boreholes were backfilled upon completion in accordance with requirements of Ontario Regulation 903. Where applicable, boreholes were backfilled with compacted auger cuttings in the same general order in which they were removed, and where necessary, bentonite pellet backfill was added to the boreholes to bring them up to grade. At the boreholes through the embankment, the upper portion of the hole, where necessary, was backfilled with an asphalt cold patch to seal the existing asphalt surface.

The fieldwork for this investigation was under the full time direction of a senior member of the Englobe engineering staff (Jame Lavigne), 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 the Englobe North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in the 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-5, and Table No. L-6).

The location of the individual boreholes was determined in the field using highway chainage established by Tulloch Engineering (Tulloch) and offsets 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. The borehole elevations are based on coordinating the borehole locations with the highway survey carried out by Tulloch. Elevations contained in this report are referenced to geodetic datum.

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 No. 2 (Appendix 3). Please note that the stratigraphic delineation 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 STATION 10+495, TWP OF CLARKSON

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Drawing No. 2, Appendix 3. During the course of the exploration program four (4) sampled boreholes were put down at this site, with Borehole Nos. 1 and 2 advanced through the embankment, Borehole No. 3 advanced adjacent to the culvert inlet, and Borehole No. 4 advanced adjacent to the culvert outlet. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 4 were recorded at Elevations 289.8, 289.8, 286.0, and 285.2 m, respectively.

4.1.1 Pavement Structure

Borehole Nos. 1 and 2, were advanced through the embankment. Borehole Nos. 1 and 2 established that the pavement structure consisted of 200 to 280 mm asphalt concrete overlying a layer of crushed gravel base/subbase approximately 100 to 120 mm thick.

4.1.2 Embankment Fill

Underlying the pavement structure at Borehole Nos. 1 and 2, a layer of embankment fill described as brown sand, gravelly to trace gravel, with to some silt, trace clay was penetrated. A layer of asphalt concrete, 50 mm thick, was encountered within the embankment fill at a depth of 2.7 m below grade at Borehole No. 1. The natural moisture content measured on samples recovered from this deposit ranged from 3 to 17%. Gradation (sieve) analyses were

carried out on three (3) samples of this deposit, the results of which indicated 16 to 34% gravel size particles, 50 to 68% sand size particles, and 13 to 16% silt and clay size particles (Figure No. L-1, Appendix 3). Gradation (hydrometer) analyses were carried out on two (2) samples of this deposit, and the results indicated 8 to 10% gravel size particles, 59 to 61% sand size particles, 29% silt size particles 2% and clay size particles (Figure No. L-1, Appendix 3). Based on SPT 'N' values of 0 (static weight of hammer) to 60 blows per 300 mm penetration and 28 blows per 180 mm penetration, the relative density/compactness of this deposit was described as very loose to very dense, but generally compact on average. This embankment fill was encountered to depths of 5.3 and 4.7 m below grade at Borehole Nos. 1 and 2, respectively (Elevations 284.5 and 285.1 m, respectively).

4.1.3 Organic Soils

Underlying the embankment fill at Borehole No. 2, and at surface at Borehole No. 4, a layer of silty to sandy organic soils trace gravel to fine fibrous organic soils was penetrated. The natural moisture content measured on samples recovered from this deposit ranged from 55 to 81%. The organic soils were encountered to depths of 5.1 and 0.3 m below grade at Borehole Nos. 2 and 4, respectively (Elevations 284.7 and 284.9 m, respectively).

4.1.4 Silt and Sand

Underlying the embankment fill at Borehole No. 1, at surface at Borehole No. 3, and underlying the organic soils at Borehole No. 4, a deposit of silt and sand, some gravel, trace clay was penetrated. Trace organics and some grass rootlets were encountered in the deposit. The natural moisture content measured on samples of this deposit was in the order of 21 to 51%. A gradation (hydrometer) analysis was carried out on one (1) sample of this deposit, and the results indicated 0% gravel size particles, 47% sand size particles, 49% silt size particles, and 4% clay size particles (Figure No. L-2, Appendix 3). Based on SPT 'N' values of 15 to 60 blows per 300 mm penetration, the relative density/compactness of this deposit was described as compact to very dense, generally compact on average. This silt and sand layer was encountered to depths of 5.9, 0.6, and 1.4 m below grade at Borehole Nos. 1, 3, and 4, respectively (Elevations 283.9, 285.4, and 283.8 m, respectively).

4.1.5 Sandy Gravel

Underlying the organic soils at Borehole No. 2, a deposit of sandy gravel, some silt was penetrated. The natural moisture content measured on samples recovered from this deposit were in the order of 10%. Cobble and boulder sized rock pieces were encountered within this deposit. A gradation (sieve) analysis was carried out on one (1) sample of this deposit, and the results indicated 55% gravel size particles, 31% sand size particles, and 14% silt and clay size particles (Figure No. L-3, Appendix 3). Based on a SPT 'N' value of 50 blows per 300 mm penetration, the relative density/compactness of this deposit was described as dense. This deposit was encountered to a depth of 7.3 m below grade at Borehole No. 2 (Elevation 282.5 m).

4.1.6 Sand

Underlying the sand and silt deposit at Borehole Nos. 1, 3, and 4, a deposit of sand, with to trace gravel, with to trace silt, trace clay, was penetrated. The natural moisture content measured on samples of this deposit ranged from 8 to 20%. Gradation (sieve) analyses were carried out on four (4) samples of this deposit, and the results indicated 7 to 25% gravel size particles, 54 to 78% sand size particles, and 15 to 25% silt and clay size particles (Figure No. L-4, Appendix 3). Gradation (hydrometer) analyses were carried out on three (3) samples of this deposit, and the results indicated 6 to 23% gravel size particles, 56 to 69% sand size particles, 19 to 24% silt size particles and 1 to 2% and clay size particles (Figure No. L-4, Appendix 3). Based on SPT 'N' values of 15 to 58 blows per 300 mm penetration and 50 blows per 50 mm penetration, the relative density/compactness of this deposit was described as compact to very dense, but generally dense on average. The sand deposits were encountered to depths of 7.2 and 6.4 m below grade at Borehole Nos. 1 and 3, respectively (Elevations 282.6 and 279.6 m, respectively). Sampling was terminated in the sand deposit at a depth of 9.6 m below grade at Borehole No. 4 (Elevation 275.6 m).

4.1.7 Sand to Silty Sand Till

Underlying the sand at Borehole No. 1 and underlying the sandy gravel at Borehole No. 2, a deposit of till described as sand, with to trace gravel, silty to some silt, trace clay, was penetrated. The natural moisture content measured on samples of this deposit ranged from about 4 to 13%. Gradation (hydrometer) analyses were carried out on three (3) samples of this deposit, and the results indicated 2 to 30% gravel size particles, 53 to 56% sand size particles, 16 to 40% silt size particles and 1 to 2% clay size particles (Figure No. L-5, Appendix 3). Based on SPT 'N' values of 80 to 104 blows per 300 mm penetration and 50 blows per 75 mm penetration, the relative density/compactness of this deposit was described as very dense. Sampling was terminated in the sand to silty sand till deposit at depths of 12.7 and 12.3 m below grade at Borehole Nos. 1 and 2, respectively (Elevations 277.1 and 277.5 m, respectively).

4.1.8 DCPT

A Dynamic Cone Penetration Test (DPCT) was carried out from the end of sampling at Borehole No. 4. The DCPT practical refusal was encountered at a depth of 10.8 m below grade at Borehole No. 4 (Elevation 274.4 m).

4.1.9 Bedrock

Underlying the sand at Borehole No. 3, bedrock was proven by diamond core drilling. The bedrock was described as pink granite. Based on RQD values of 58 to 71%, the bedrock was described as fair quality. Based on visual review, the bedrock generally showed negligible weathering. Sampling in the bedrock was terminated at a depth of 9.5 m below grade at Borehole No. 3 (Elevation 276.5 m). Photos of rock cores recovered at Borehole No. 3 are

shown in Enclosure No. 6, Appendix 4. 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

At the time of this investigation (May 17, 2016), surface water was recorded at Elevation 284.9 m at the culvert inlet.

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. A standpipe was installed in Borehole Nos. 1 and 3 to obtain post borehole completion water levels. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix 2).

The groundwater level was measured at Elevation 285.0 m at Borehole Nos. 1 and 3 during the foundation investigation periods. The groundwater level was measured in the standpipes at Elevation 286.0 m at Borehole Nos. 1 and 3 before decommissioning on June 27th, 2016. The groundwater level was encountered at Elevation 288.2 and 285.2 m at Borehole Nos. 2 and 4, respectively, upon completion of sampling at the boreholes; however the groundwater level at Borehole No. 2 likely had not stabilized at the time of recording.

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

5 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

A foundation investigation was carried out for the proposed replacement of a CSP culvert as identified by the MTO.

The existing culvert, located at Station 10+495 in the Township of Clarkson, is an 1800 mm diameter CSP culvert approximately 34.2 m long. The existing culvert invert, at centreline, is estimated at a depth of 5.5 m (Elevation 284.3 m). The culvert inverts at the inlet and outlet are established at Elevations 284.5 and 284.2 m, respectively. The existing highway embankment currently supports two undivided lanes of highway, running in a south-north direction. Flow through the culvert is from the left to the right (west to east). Based on data from this foundation investigation, the embankment supporting the existing pavement structure at this site has been constructed using sand fill. The native material underlying the embankment fill generally consists of compact to dense sands to sandy gravel and very dense sand tills.

The type of culvert (concrete, CSP, or High Density Polyethylene (HDPE)) proposed to replace the existing culvert is currently unknown. It is understood that the new culvert will be constructed along a similar skew and alignment. It is further understood that the final vertical alignment of the highway is to remain essentially the same for either replacement or rehabilitation options.

The existing culvert was scheduled for replacement, as detailed in the RFP; however, following submission of the Draft Foundation Investigation and Design Report, it is understood that the culvert will be rehabilitated using a 1,520 mm smooth wall liner. The discussion culvert replacement have been left in this report for completeness.

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 2.0 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 founding native sands and silts to sandy gravels overlying sand tills present below the existing embankment are 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 disturbed during construction and groundwater is controlled throughout construction, as discussed in Section 5.6.

5.2.1 Closed Culvert

Based on the characteristics of the native sands and silts to sands to sandy gravel subgrade present below the culverts and the response of the existing embankment, a factored geotechnical resistance at ULS of 275 kPa is applicable for a closed culvert (i.e. precast concrete rigid frame box culvert, precast concrete pipe or CSP culvert). In consideration of the width of the culvert, depth of overburden, and response of the existing embankment slopes, a geotechnical reaction at SLS of 185 kPa can be used for design, in consideration of 25 mm total settlement, and 19 mm of differential settlement depending on structure rigidity.

The geotechnical resistance for a closed culvert assumes a founding elevation and culvert size the same as that of the existing culvert (i.e. 1800 mm diameter CSP, invert level at Elevation 284.3 m at centreline). Additionally, the bearing resistances provided assume that the subgrade and bedding is properly prepared, as per Section 5.3. If the organic soils are encountered at the founding levels, subexcavation shall be required down to the native soils and replaced with engineered fill consisting of Granular B Type II per OPSS.PROV 1010 with compaction to 100% Standard Proctor Maximum Dry Density (SPMDD).

5.2.2 Open Culvert

If an open culvert (i.e. concrete frame open culverts, with wall footings, or pipe arch culverts on footings) is considered, then a factored bearing resistance at ULS of 225 kPa, and a geotechnical reaction at SLS of 150 kPa would apply for design, in consideration of 25 mm total settlement and 19 mm of differential settlement, depending on structure rigidity and taking into consideration the limited depth of overburden and smaller footing width.

The geotechnical resistance for an open culvert assumes a founding elevation at a depth of a minimum 1.5 m below creek bed (Elevation 282.7 m) with footings a minimum 0.5 m in width. It should be noted that foundation levels at 1.5 m depth below grade will be above the depth of frost penetration (2.0 m), as such, the footings should be insulated.

5.2.3 Slope Stability

The maximum height of the embankment above the culvert inverts at this location is about 5.3 m at the west side of the embankment, and up to about 5.6 m at the east side of the embankment. A stability analysis was carried out using the GEO-SLOPE computer software, Slope/W (GeoStudio 2007, Version 7.17, Geo-Slope International Ltd.) for this location with 2.3H:1V to 2.5H:1V embankment slopes in the embankment fills. For the purposes of these analyses, the materials were modeled using the following parameters:

PARAMETER	MATERIAL			
	EMBANKMENT FILL	SAND AND SILT	SANDY GRAVEL	SANDS AND SAND TILL
Unit Weight (kN/m ³)	19.0	18.0	19.0	19.0
Effective Friction Angle (degrees)	32	30	34	34
Cohesion (kPa)	-	-	-	-

The above 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 groundwater levels used for the analyses are shown on Figure No. S-1, Appendix 5. The results of the analyses indicate factors of safety against long-term shallow depth failures/sloughing in the order of 1.6 for the existing east embankment slope at an inclination angle of 2H:1V (see Figure No. S-1, 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 generally consists of sand fills. The results of this investigation indicate that, below the culvert invert, the native subgrade soils generally consisted of very dense sand tills. A review of the condition of the pavement surface at the culvert locations revealed that the embankment appears to have performed satisfactorily. The existing embankment has preloaded the soils at the culvert locations and since there will be no appreciable change in the height of the embankment and correspondingly, no increase in embankment load, no appreciable settlement of the embankment is anticipated. As such, installing the culvert on a camber will not be required at this site.

In order to ensure the subgrade is properly prepared for the foundation work, it is recommended that a Quality Verification Engineer (QVE) be required to be retained by the Contractor to carry out subgrade inspections.

5.3.1 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, placed on a non-woven geotextile should be used, which would aid in dewatering operations. During backfilling, the material of bedding (including haunches) and cover shall be placed in uniform layers not exceeding loose thickness of 200 mm, as per OPSS.PROV 401. The elevation difference of backfilling on either side of the rigid pipe shall be limited to a maximum 200 mm per OPSS.PROV 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 and compacted in accordance with OPSS.PROV 501.

A precast concrete rigid frame box culvert can also be considered for culvert replacement at this site. Bedding for a rigid frame box culvert shall consist of 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 to prevent overstressing the middle third (bottom span) as the box sides settle, in accordance with OPSS 422.07.07. 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. Alternatively, specifically if construction is carried out under wet conditions, a 19 mm clear stone bedding and levelling coarse placed on a non-woven geotextile should be used, which would aid in dewatering applications. During backfilling the embankment fill should be placed in a balanced manner on the outer sides of the box unit. The elevation difference of the backfill on either side of the box unit must be limited to a maximum of 400 mm. 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 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 1004) apron. The apron shall be 5 m in length, 400 mm thick and extend across the stream bed to 5 m beyond the outside edges of the culvert. Clay seals are generally used where significant head differences exist between the inlet and outlet of the culverts to prevent flow through the bedding/embedment granular materials. Considering the head difference between the inlet and outlet, clay seals are not required at this culvert location.

5.3.2 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 OPSS.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% Standard Proctor Maximum Dry Density (SPMDD) prior to placing the remainder of the embedment material. During backfilling, the embedment material shall be placed in uniform layers not exceeding loose 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.PROV 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.PROV 401.

In consideration of the culvert size and anticipated flow, clay seals are not considered necessary at this location, provided embedment/bedding materials are properly compacted in the haunch area and rip rap over a Class II geotextile is placed around the inlet end of the culvert. 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 3 m in length, a minimum 400 mm thick and extend across the stream bed to 3 m beyond the outside edges of the culvert.

5.4 CULVERT INSTALLATION AND CONSTRUCTION STAGING CONSIDERATIONS

At the centreline, the invert elevation of the existing culvert is at Elevation 284.3 m, with the top of the embankment at Elevation 289.8 m. As such, the embankment at this location is about 5.5 m in height above the culvert invert at the centreline. The culvert inverts at the inlet and the outlet are established at Elevations 284.5 and 284.2 m, respectively. Therefore, a minimum 5.8 m deep excavation (i.e. to Elevation 284.0 m) will be required (at centreline) in consideration of a 300 mm thick layer of bedding/embedment material. At the inlet and outlet of the culvert, the excavations will be required to depths of about 5.6 and 5.9 m below the centreline of embankment, respectively (Elevations 284.2 and 283.9 m, respectively). The present platform width at this location is approximately 12 m as can be seen on the cross section presented on Drawing No. 2. 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 1.8 m. 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.

5.4.1 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 of 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-3, 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 288.0 m.
- Limit traffic to a single lane on the left, with a minimum platform width of 6 m, under 24/7 traffic control.
- Open cut excavate, to the right, and install approximately 18 m of new culvert.

- Reconstruct the embankment on the right, with 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.
- As the width of the platform increases on the right, the vertical alignment can be raised, and the traffic can revert back to two lanes when sufficient width permits.

It should be noted that additional subsurface information may be required if widening beyond the existing embankment toe is required.

5.4.2 Temporary Protection System

The installation of a protection system for use in the culvert replacement operation will require penetration through approximately 5.5 m of fills above the culvert invert (at centreline). The embankment fills are generally underlain by compact sands and silts to dense sands to sandy gravels overlying very dense tills.

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 drive steel sheet piles with a sufficiently robust strength of sheeting through the embankment fill into the underlying native soils. If a cobble/boulder is encountered during driving, the sheet pile could be left high until the boulder is removed during excavation and then driving continued. Conceptual shoring locations and sections are illustrated on Figure Nos. SK-4 and SK-5, Appendix 5.

The protection system can be designed using the lateral earth pressure parameters as outlined in Section 5.5. Considering the cohesionless nature of the embankment fills (granular pavement structure over sand fills) a rectangular apparent pressure distribution over the height of the cut would be appropriate for design of the temporary shoring. The width of the apparent rectangular pressure distribution, over the height of excavation, can be considered equal to $0.65 \cdot K_a \cdot \gamma \cdot H$, where:

K_a = active earth pressure coefficient, as described in Section 5.5,

γ = unit weight, as described in Section 5.5, and

H = height of wall above the base of excavation.

Surcharge loads from the active lane of traffic must also be considered during design of the temporary shoring system.

The contractor's shoring/protection system design must be carried out by a geotechnical engineer with appropriate experience.

The temporary protection system should be designed and constructed to comply with OPSS 539. In consideration of the location of the protection system and traffic volume, a Performance Level 2 is considered appropriate.

5.5 LATERAL EARTH PRESSURES

Lateral earth pressures should be computed in accordance with the Canadian Highway Bridge Design Code (CHBDC). The parameters for bedding, cover, embedment and backfill materials are based on compaction levels of 100% SPMDD. The design parameters for the bedding/embedment and backfill materials are as follows:

PARAMETER	GRANULAR A	GRANULAR B TYPE I	EMBANKMENT FILL	SAND AND SILT
Unit Weight (kN/m^3)	22.8	21.2	19.0	18.0
Angle of Internal Friction	35°	33°	32°	30°
Coefficient of Active Earth Pressure (K_a)	0.27	0.29	0.31	0.33
Coefficient of Passive Earth Pressure (K_p)	3.69	3.39	3.23	3.00
Coefficient of Earth Pressure at Rest (K_o)	0.43	0.46	0.47	0.50
PARAMETER	SANDY GRAVEL	SAND	SAND TILL	
Unit Weight (kN/m^3)	19.0	19.0	19.0	
Angle of Internal Friction	34°	34°	34°	
Coefficient of Active Earth Pressure (K_a)	0.28	0.28	0.28	
Coefficient of Passive Earth Pressure (K_p)	3.57	3.57	3.57	
Coefficient of Earth Pressure at Rest (K_o)	0.44	0.44	0.44	

For rigid structures, such as a precast concrete culverts, deflection cannot occur, as such the “at-rest” condition (K_o) applies. For flexible structures, such as CSP/HDPE culverts, deflection can occur, as such 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).

For concrete footings supported on the very dense native sand soils or properly prepared engineered fill, an interface friction coefficient ($\tan\delta$) of 0.45 can be used in the design.

5.6 EXCAVATION, DEWATERING AND EMBANKMENT RECONSTRUCTION

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 may slough to angles as flat as 3H:1V or possibly shallower, dependent upon the Contractors' chosen method of controlling the groundwater.

The excavation backfill above the culvert bedding/cover should consist of granular fill per OPSS.PROV 1010 up to the underside of the pavement structure.

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.

Bedrock was not encountered at the borehole locations within the anticipated depth of excavation, therefore bedrock excavation and/or blasting operations are not anticipated.

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. Groundwater control, in accordance with OPSS 517 and 518, will be required to maintain a stable subgrade during culvert installation.

At the time of investigation, the surface water was encountered at Elevation 284.9 m at the culvert inlet. Groundwater was encountered measured at Elevation 285.0 m at Borehole Nos. 1 and 3, respectively. Excavations to minimum Elevation 283.6 will likely be required to install the culvert and bedding at location of the proposed culvert outlet. As such dewatering will likely be required during excavation and culvert installation.

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. The effectiveness of this method of groundwater control would be limited to conditions where excavations of less than 1 m into the prevailing groundwater table are anticipated, and the soil is such that the groundwater can be drawn down a minimum of 500 mm below the working surface. If the excavation must penetrate to a greater depth below the prevailing groundwater table a more effective groundwater control method, such as a vacuum well point system, or sheet pile cut-off wall, should be considered by the contractor to maintain a stable excavation base. Considering the native sand subgrades, piping may result in disturbed subgrades. The Contractor's dewatering method must be designed to prevent piping.

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 it should be noted that the very dense native soils containing cobbles/boulders may limit the depth of penetration of sheet piles. 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. The by-pass culvert can be installed either through open excavation either up or down chainage from the existing culvert. Depending on the Contractor's by-pass culvert design, trenchless methods may also be appropriate, if required.

A Permit to take Water (PTTW) is required by the MOE when more than 50,000 litres/per day will be removed for consumptive use. If open excavation is undertaken, a PTTW will likely be required, however, this will depend upon the Contractors proposed methodology and schedule.

It is understood that the culvert is considered to be rehabilitated using a 1,520 mm smooth wall liner; therefore A PTTW is not anticipated to be required for the rehabilitation work.

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 dewatered stable condition during excavation and construction operations cannot be stressed enough.

5.7 CHEMICAL TESTING

One (1) soil sample recovered at Borehole No. 1 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 1	8	5.3	6.70	271	133	1760	0.567

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 indicates that concrete made with Type 10 Portland cement should be acceptable for substructures. The test results also indicate a moderate to high potential for corrosion of exposed ferrous metal.

5.8 CONSTRUCTION CONCERNS

Considering the nature of the embankment fills, no major construction concerns are anticipated if construction is carried out in general conformance with the above discussion. The Contractor



must be prepared to excavate and advance protection systems through compact to dense 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 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

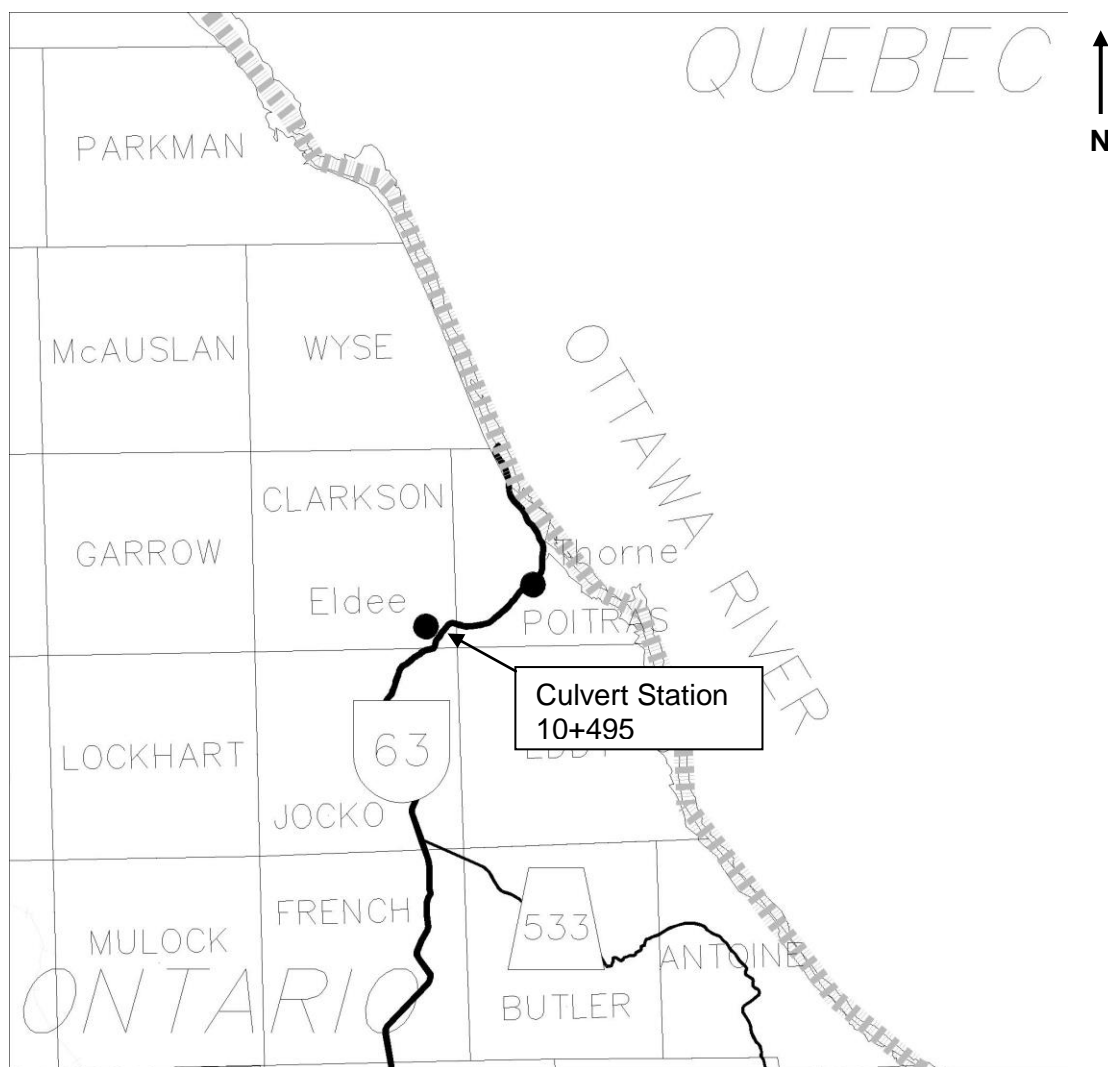
Drawing No. 1

Key Plan

MACRO KEY PLAN

Drawing No.1

NOT TO SCALE



FOUNDATION INVESTIGATION AND DESIGN REPORT GWP 5203-14-00

Highway 63
Stations 10+495
Township of Clarkson



Reference No: 16/02/16014-F6

December 2016

Appendix 2 Subsurface Data

Enclosure No. 1	List of Abbreviations and Symbols
Enclosure Nos. 2 to 5	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 16/02/16014-F6 DATUM Geodetic LOCATION N 5165580.4 E 332179.2 - Clarkson Twp., Station 10+492 ORIGINATED BY AT

PROJECT GWP 5203-14-00, Highway 63 BOREHOLE TYPE Truck Mounted CME 75 - Hollow Stem Augers COMPILED BY DM

CLIENT AECOM DATE (Started) 2016 May 12 TIME CHECKED BY SH

DATE (Completed) 2016 May 12 (Completed)

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40					
289.8	Asphalt Surface													
0.0	200 mm asphalt 100 mm crushed gravel EMBANKMENT FILL - sand, gravelly to with gravel, some silt brown to dark brown (very dense/very loose) asphalt layer, 50 mm thick, encountered at 2.7 m depth dark grey		1	AS										
			2	SS	28/180 mm									28 59 (13)
			3	SS	35									
			4	SS	36									
			5	SS	18									34 50 (16)
			6	SS	16									
			7	SS	1									
284.5														
5.3	SAND AND SILT - some gravel, trace organics dark grey, wet		8	SS	60									
283.9	(very dense)													
5.9	SAND - with gravel, some silt		9	SS	38									25 54 (21)
	grey													
282.6	(dense)													
7.2	SAND TILL - with to trace gravel, silty to some silt, trace clay		10	SS	47/180 mm									
	grey													
	(very dense)													
			11	SS	104									30 53 16 1
			12	SS	24/75 mm									
	gravels and 110 mm to 290 mm cobble sized rock pieces encountered at depths of 10.7 m to 12.2 m													
277.1			13	SS	80									2 56 40 2
12.7	End of Sampling 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) 16/5/12 3:00:00 PM 4.4 ▽ - 2) 16/6/27 3:32:00 PM 3.8 ▽ - 3) - ▼ -					

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

Englobe Corp.

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MEL-GEO 16014 - BOREHOLE LOGS - F6.GPJ MEL-GEO.GDT 16/12/22

METRIC**RECORD OF BOREHOLE NO. 2**

REFERENCE 16/02/16014-F6 DATUM Geodetic LOCATION N 5165572.0 E 332179.0 - Clarkson Twp., Station 10+485 ORIGINATED BY ELS

PROJECT GWP 5203-14-00, Highway 63 BOREHOLE TYPE Truck Mounted CME 75 - Hollow Stem Augers COMPILED BY DM

CLIENT AECOM DATE (Started) 2016 May 16 TIME CHECKED BY SH

DATE (Completed) 2016 May 16 (Completed)

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE			"N" VALUES	20					
289.8	Asphalt Surface												
0.0	280 mm asphalt 120 mm crushed gravel												
	EMBANKMENT FILL - sand, some to trace gravel, with to some silt, trace clay		1	AS									
	brown, damp		2	SS	33								16 68 (16)
	(very loose/very dense)		3a	SS	60								
			3b										
			3c										
			4	SS	6								8 61 29 2
			5	SS	4								
			6	SS	WH								
285.1			7a	SS	2								10 59 29 2
4.7	ORGANIC SOIL - silty to sandy, trace gravel, trace grass rootlets		7b										
284.7	black, wet												
5.1	SANDY GRAVEL - some silt												
	180 mm cobble sized rock pieces encountered at depth of 5.1 m to 5.7 m												
	grey, wet		8	SS	50								55 31 (14)
	(dense)												
282.5	300 mm boulder encountered at depth of 6.9 m												
7.3	SAND TILL - with to some gravel, with silt, trace clay		9	SS	50/90 mm								
	grey, wet												
	(very dense)												
	230 mm boulder sized rock pieces encountered at depth of 8.0 m												
	50 mm gravel and 100 mm to 125 mm cobble sized rock pieces encountered at depths of 9.1 m to 10.1 m		10	SS	65/150 mm								
			11	SS	50/75 mm								
			12	SS	50/0 mm								
			13	SS	63/150 mm								20 53 26 1
277.5	End of Sampling												
12.3	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					
Auger Refusal encountered at depth of 5.2 m, advanced with casing using wash boring method.						Date (dd/mm/yy)/Time		Water Depth (m)		Cave In (m)			
								1) 16/5/16 4:34:00 PM		1.6		4.5	
								2) -		-		-	
The stratification lines represent approximate boundaries. The transition may be gradual.						3) -		-		-			

Englobe Corp.

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MEL-GEO 16014 - BOREHOLE LOGS - F6.GPJ MEL-GEO.GDT 16/12/22

METRIC**RECORD OF BOREHOLE NO. 3**

REFERENCE 16/02/16014-F6 DATUM Geodetic LOCATION N 5165589.6 E 332169.9 - Clarkson Twp., Station 10+494 ORIGINATED BY JL

PROJECT GWP 5203-14-00, Highway 63 BOREHOLE TYPE Truck Mounted CME 45 - Hollow Stem Augers COMPILED BY DM

CLIENT AECOM DATE (Started) 2016 May 17 TIME CHECKED BY SH

DATE (Completed) 2016 May 17 (Completed)

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
286.0	Ground Surface													
0.0	SAND AND SILT - some gravel, some grass rootlets brown, damp (compact)		1	SS	15									
285.4	SAND - some to trace gravel, with silt, trace clay		2	SS	23									
0.6	grey, wet (compact/very dense)		3	SS	64/230 mm									
			4	SS	35									
			5	SS	40									
			6	SS	44									
			7	SS	58									
279.6	Auger Refusal		8	SS	50/50mm									
6.4	Start Rock Coring													
	BEDROCK - pink granite fair quality		9	RC	REC=100% RQD=58%									
			10	RC	REC=100% RQD=71%									
276.5	End of Sampling													
9.5	End of Borehole													
COMMENTS							$+^3, \times^3$: Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa \bigcirc 3% STRAIN AT FAILURE		WATER LEVEL RECORDS Date (dd/mm/yy)/Time Water Depth (m) Cave In (m) 1) 16/5/17 11:30:00 AM 0.9 ∇ - 2) 16/5/19 11:38:00 AM 0.6 ∇ - 3) 16/6/27 3:25:00 PM 0 ∇ -					

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 16014 - BOREHOLE LOGS - F6.GPJ MEL-GEO.GDT 16/12/22

METRIC**RECORD OF BOREHOLE NO. 4**

REFERENCE 16/02/16014-F6 DATUM Geodetic LOCATION N 5165574.6 E 332201.1 - Clarkson Twp., Station 10+500 ORIGINATED BY JL

PROJECT GWP 5203-14-00, Highway 63 BOREHOLE TYPE Truck Mounted CME 45 - Hollow Stem Augers COMPILED BY DM

CLIENT AECOM DATE (Started) 2016 May 19 TIME (Completed) CHECKED BY SH

DATE (Completed) 2016 May 19

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
285.2	Ground Surface													
0.0	ORGANIC SOIL - fine fibrous organics, some grass rootlets black, wet		1	SS	22/180 mm									
0.3	SILT and SAND - trace clay, trace organics		2	SS	22									0 47 49 4
283.8	black													
1.4	(compact) SAND - with to trace gravel, with to some silt, trace clay		3	SS	21									
	grey, wet		4	SS	35									23 56 19 2
	occasional cobble sized rock pieces encountered		5	SS	45									
	(compact/very dense)		6	SS	21									
			7	SS	50/150 mm									
			8	SS	29									16 60 22 2
			9	SS	50/125 mm									
			10	SS	15									7 78 (15)
275.6	End of Sampling													
9.6														
274.4	End of Borehole													
10.8														
COMMENTS							$+3, \times 3$: Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa \circ 3% STRAIN AT FAILURE		WATER LEVEL RECORDS Date (dd/mm/yy)/Time Water Depth (m) Cave In (m) 1) 16/5/19 6:00:00 PM 0 ∇ 2.4 ∇ 2) - ∇ - 3) - ∇ -					

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 16014 - BOREHOLE LOGS - F6.GPJ MEL-GEO.GDT 16/12/22

Appendix 3 Borehole Plan and Lab Data

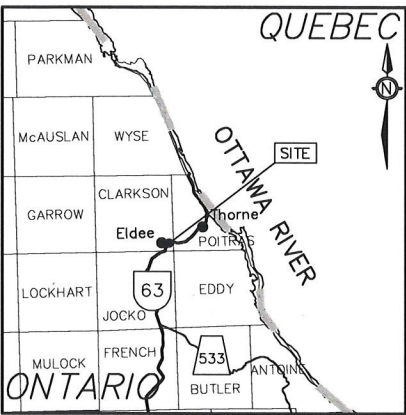
Drawing No. 2: Borehole Location and Soil Strata
Figure Nos. L-1 to L-5: Grain Size Distribution Curves
Table No. L-6: Lab Test Summary Sheet
 Soil Chemical Tests

10+400
10+450
10+500
10+550
HIGHWAY NO. 63
Shoring Location
1800 mm x 34.17 m CSP
PLAN
10m SCALE 10m
5165500.0 m
5165600.0 m
332200.0 m

DISTRICT
CONT. No.
GWP No. 5203-14-00

DRAWING
2

HWY 63 CULVERT
STA. 10+495
TWP OF CLARKSON
BOREHOLE LOCATIONS
AND SOIL STRATIGRAPHY



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
- End of Borehole
- Piezometer

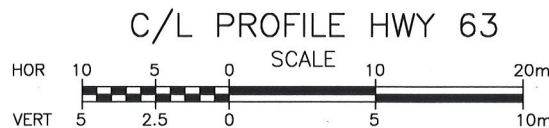
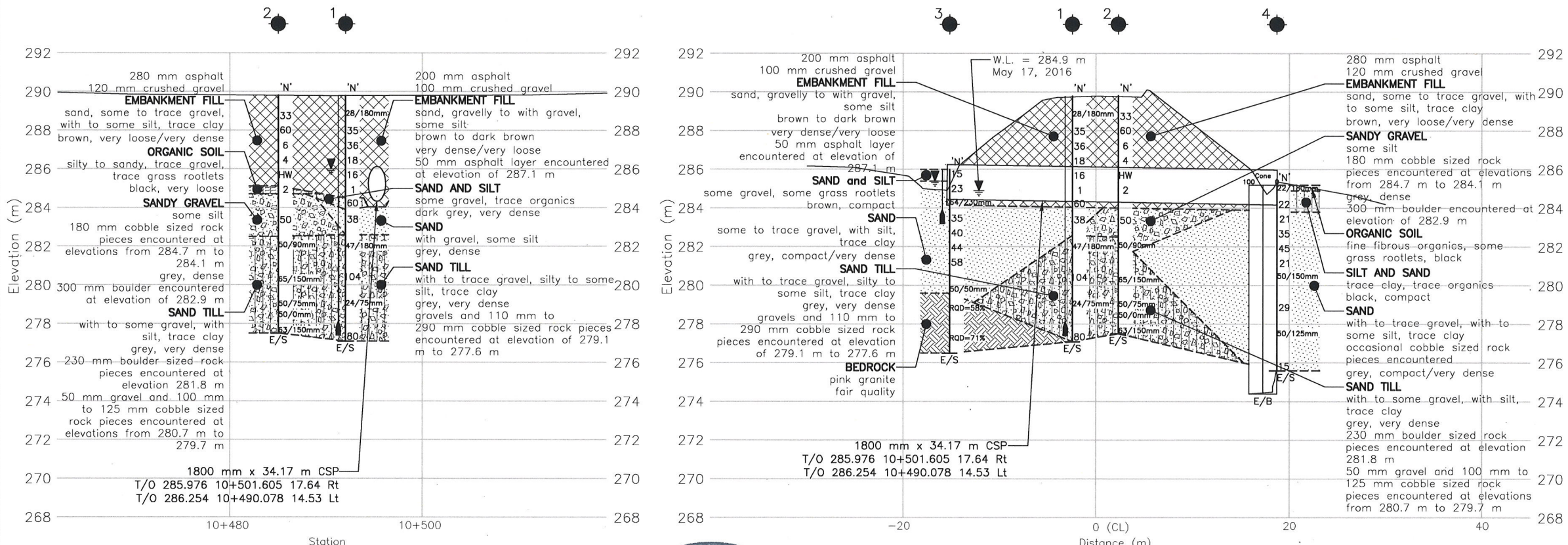
BOREHOLE No.	ELEVATION	O/S	NORTHING	EASTING
1	289.8	2.5m Lt	5165580.4	332179.2
2	289.8	2.3m Rt	5165572.0	332179.0
3	286.0	15.4m Lt	5165589.6	332169.9
4	285.2	18.7m Rt	5165574.6	332201.1

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 Aecom on June 29, 2016

Coordinates based on MTM Zone 10 NAD83 CSRS

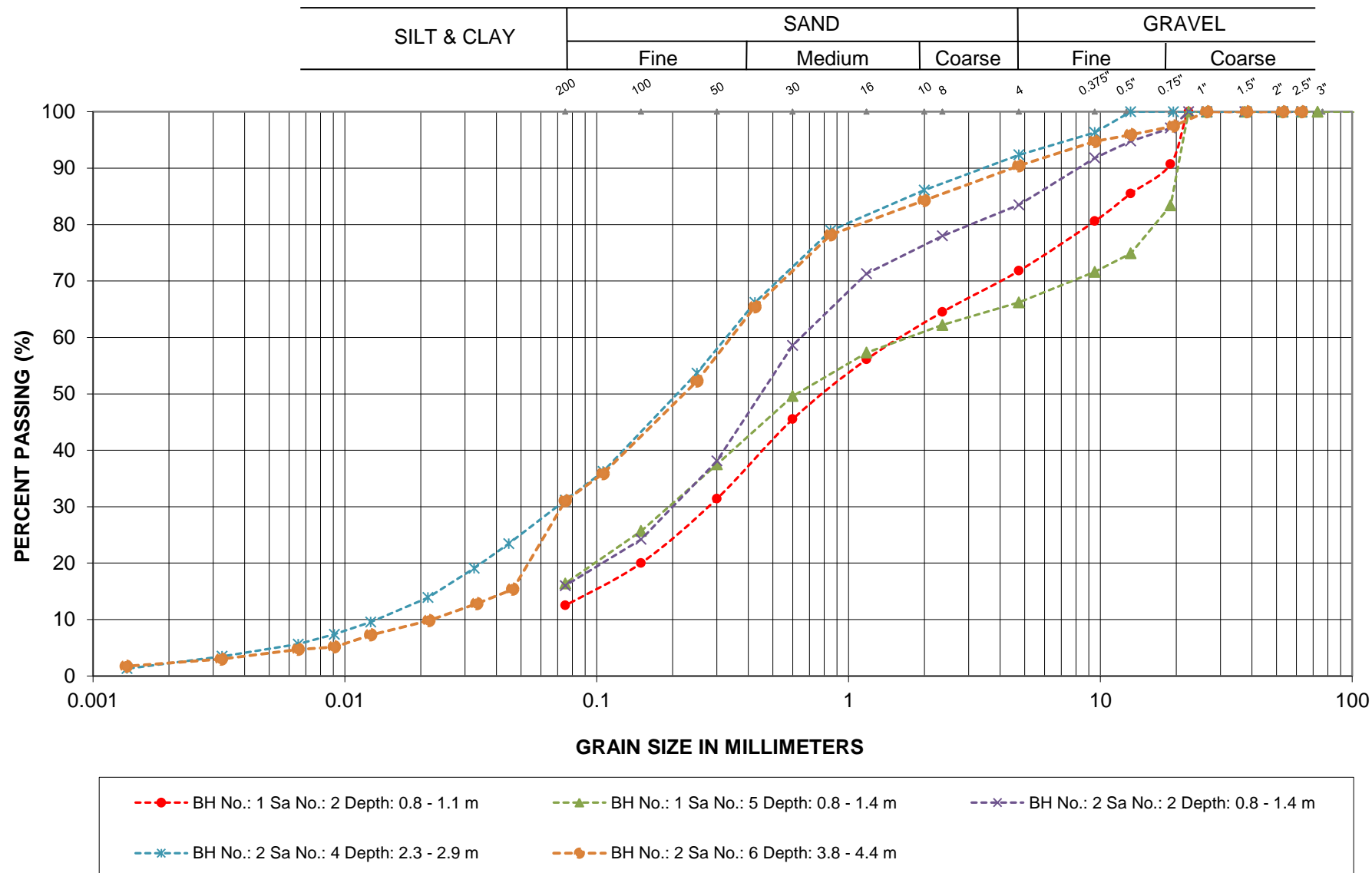
GEOCRES No. 31L-200



2016-12-22

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.

DESIGN	CHK	CODE	LOAD	DATE DEC/16
DRAWN DM	CHK SH	SITE	STRUCT	SCHEME DWG 2

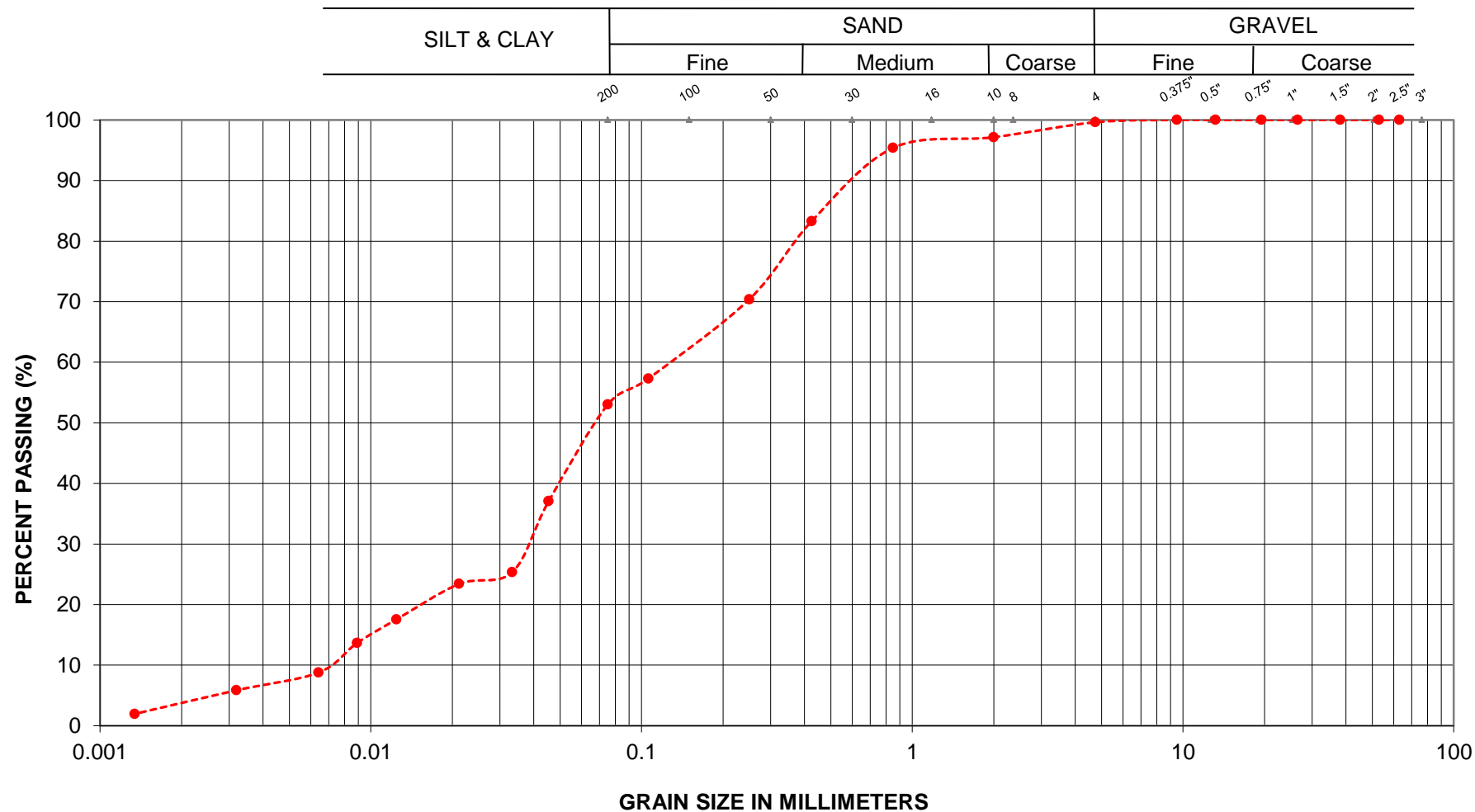
GRAIN SIZE ANALYSIS

EMBANKMENT FILL

LOCATION: Hwy 63, Station 10+495
TWP of Clarkson

Englobe Corp.

FIGURE L-1

GRAIN SIZE ANALYSIS

---●--- BH No.: 4 Sa No.: 2 Depth: 0.8 - 1.2 m

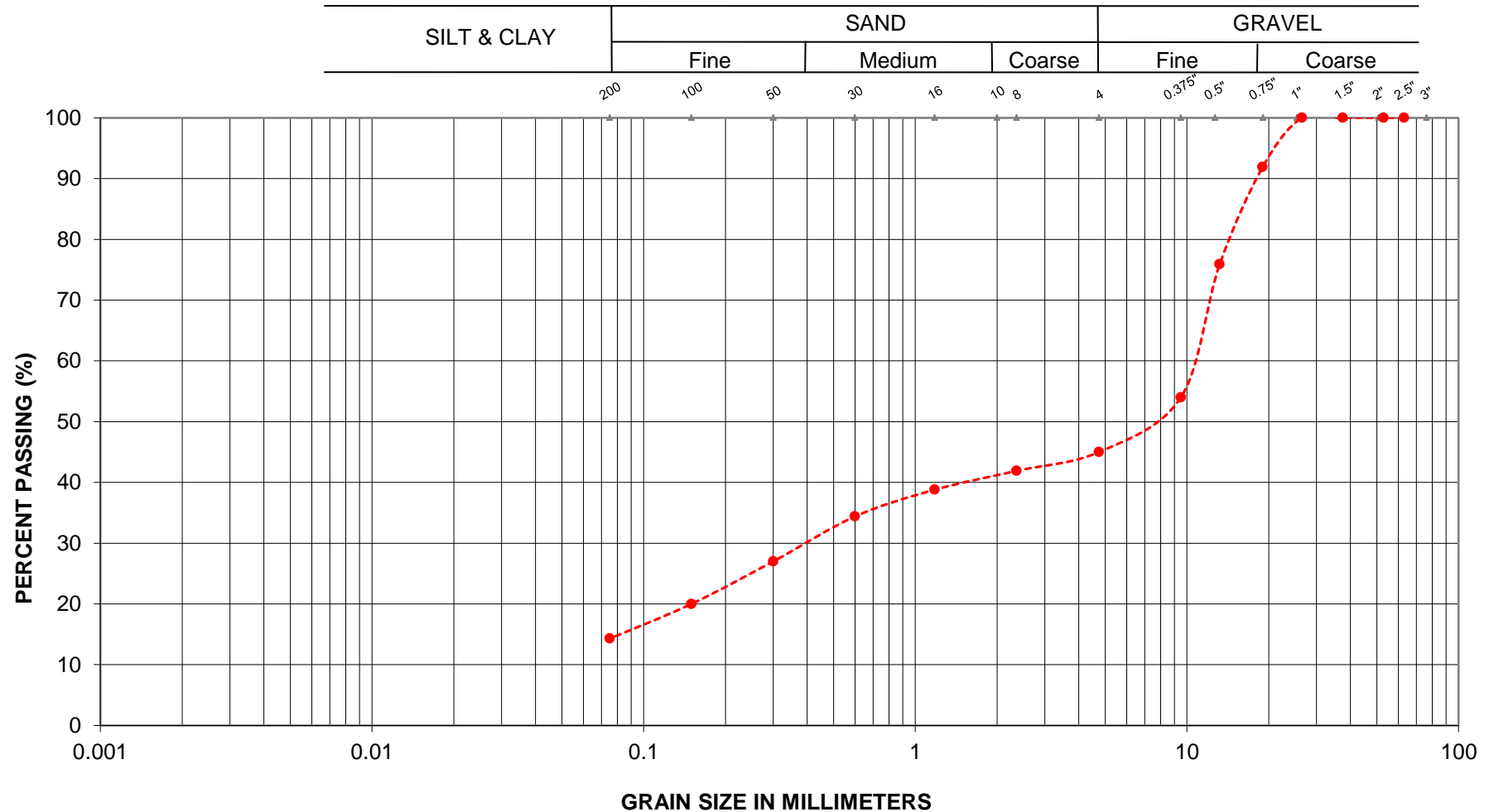
SILT AND SAND

LOCATION: Hwy 63, Station 10+495
TWP of Clarkson

Englobe Corp.

FIGURE L-2

GRAIN SIZE ANALYSIS



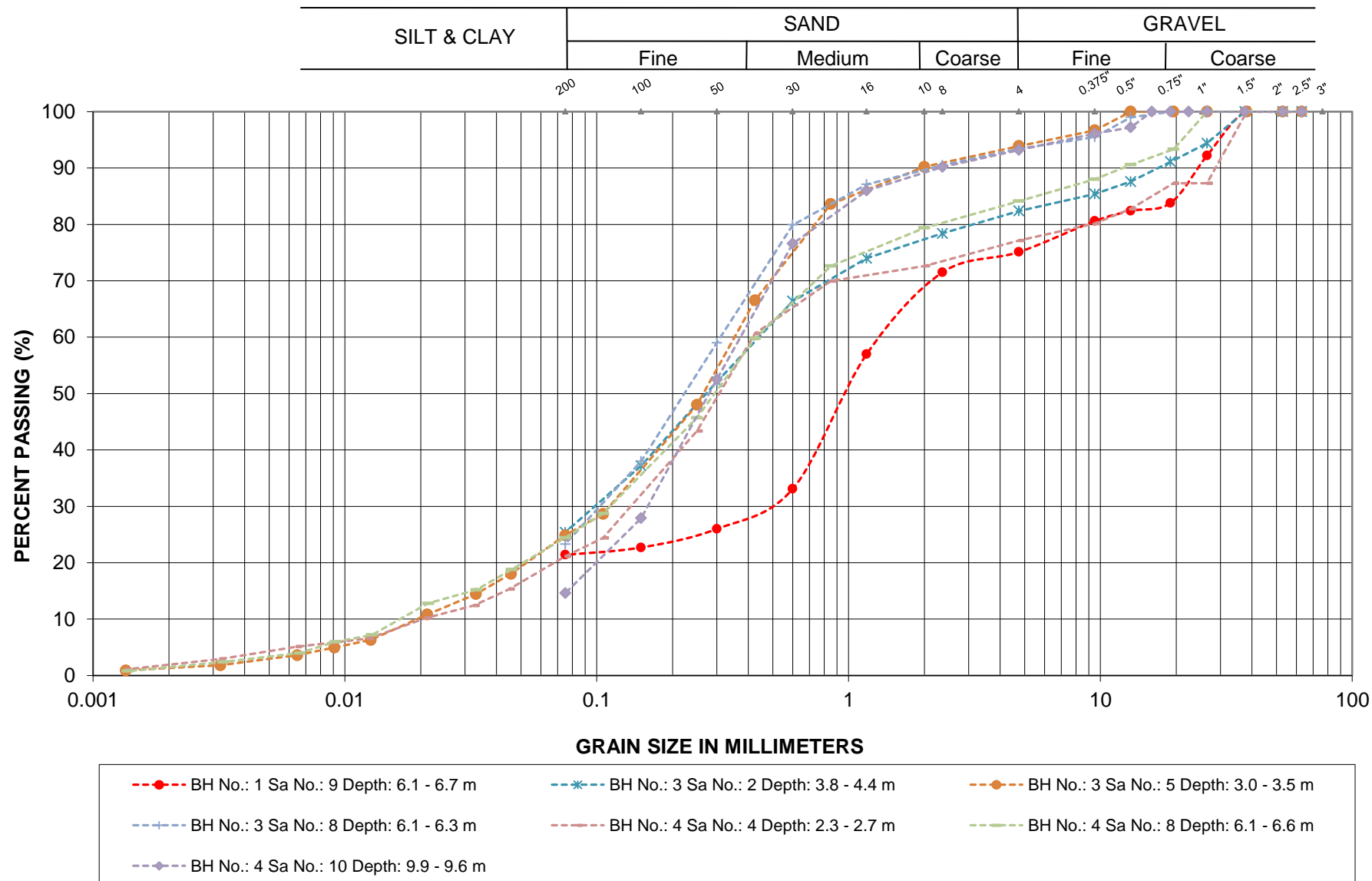
---●--- BH No.: 2 Sa No.: 8 Depth: 6.2 - 6.7 m

SANDY GRAVEL

LOCATION: Hwy 63, Station 10+495
TWP of Clarkson

Englobe Corp.

FIGURE L-3

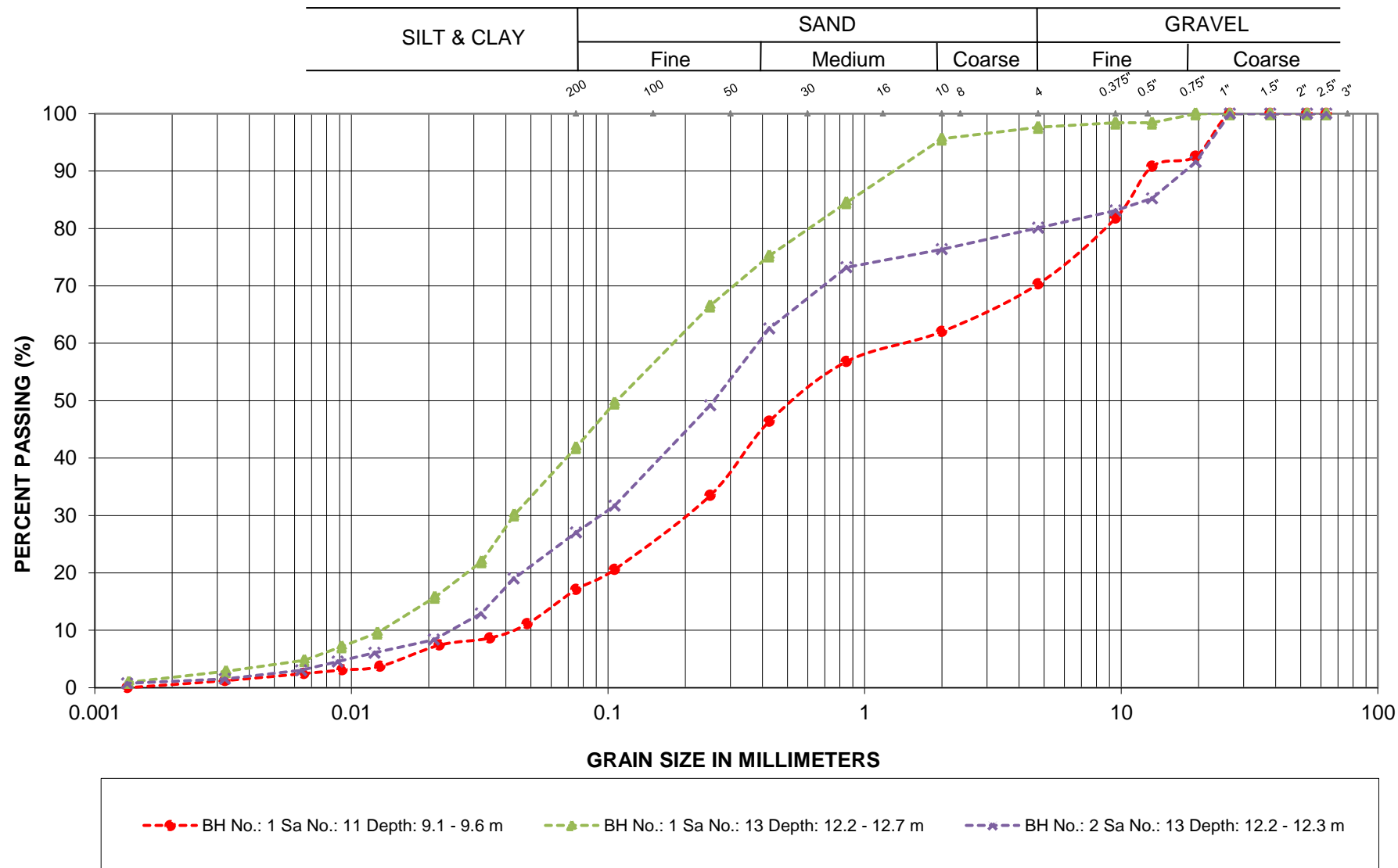
GRAIN SIZE ANALYSIS

SAND

LOCATION: Hwy 63, Station 10+495
TWP of Clarkson

Englobe Corp.

FIGURE L-4

GRAIN SIZE ANALYSIS

SAND to SILTY SAND TILL

LOCATION: Hwy 63, Station 10+495
TWP of Clarkson

Englobe Corp.

FIGURE L-5

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	0.0					2.7							
	2	0.8	28	59	13		5.0				28/180 mm			
	3	1.5					5.6				35			
	4	2.3					10.1				36			
	5	3.1	34	50	16		7.4				18			
	6	3.8					8.8				16			
	7	4.6									1			
	8	5.3					21.3				60			
	9	6.1	25	54	21		8.8				38			
	10	7.6					9.6				47/180 mm			
	11	9.1	30	53	16	1	8.4				104			
	12	10.7									24/75 mm			
	13	12.2	2	56	40	2	13.4				80			
2	1	0.5					2.9							
	2	0.8	16	68	16		6.3				33			
	3a	1.5					5.5				60			
	3b	1.7					2.8							
	3c	1.9					7.5							
	4	2.3	8	61	29	2	10.0				6			
	5	3.1					11.1				4			
	6	3.8	10	59	29	2	17.0				WH			
	7a	4.6					13.7				2			
	7b	4.8					54.8							
	8	6.17	55	31	14		9.8				50			
	9	7.62					7.6				50/90 mm			
	10	9.45					4.0				65/150 mm			

Laboratory Tests - Summary Sheet



Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m ³)	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
2	11	10.7					11.2				50/75 mm			
	12	11.3									50/0 mm			
	13	12.0	20	53	26	1	11.1				63/150mm			
3	1	0.0					29.2				15			
	2	0.8	18	57	25		11.5				23			
	3	1.5					10.6				64/230 mm			
	4	2.3					10.8				35			
	5	3.1	6	69	24	1	11.8				40			
	6	3.8					14.6				44			
	7	4.6					19.3				58			
	8	6.1	7	70	23		10.2				50/50mm			
	9	6.4												Rec= 100%, RQD= 58%
	10	8.0												Rec= 100%, RQD= 71%
4	1	0.0					80.6				22/180 mm			
	2	0.8	0	47	49	4	51.4				22			
	3	1.5					12.9				21			
	4	2.3	23	56	19	2	8.0				35			
	5	3.1					7.7				45			
	6	3.8					9.3				21			
	7	4.6					7.9				50/150 mm			
	8	6.1	16	60	22	2	9.8				29			
	9	7.6									50/125 mm			
	10	9.14	7	78	15		20.1				15			

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

ATTENTION TO: Victoria Steuernol

PROJECT: 16014

AGAT WORK ORDER: 16T117690

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Coordinator

DATE REPORTED: Jul 27, 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: 16T117690

PROJECT: 16014

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:

Corrosivity Package

DATE RECEIVED: 2016-07-20

DATE REPORTED: 2016-07-27

		SAMPLE DESCRIPTION: F6, BH 1, Sa 8		F3, BH 2, Sa4-B		F4, BH 4, Sa 2		F1, BH 1, Sa 9		F5, BH 2, Sa 6	
		SAMPLE TYPE: Soil		Soil		Soil		Soil		Soil	
		DATE SAMPLED: 7/18/2016		7/18/2016		7/18/2016		7/18/2016		7/18/2016	
Parameter	Unit	G / S	RDL	7717962	7718034	7718036	7718038	RDL	7718040		
Sulphide*	%		0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05		
Chloride (2:1)	µg/g		2	133	12	<2	61	4	868		
Sulphate (2:1)	µg/g		2	271	61	<2	19	4	37		
pH (2:1)	pH Units		NA	6.70	7.93	6.88	7.42	NA	8.26		
Electrical Conductivity (2:1)	mS/cm		0.005	0.567	0.188	0.047	0.164	0.005	1.54		
Resistivity (2:1)	ohm.cm		1	1760	5320	21300	6100	1	649		
Redox Potential (2:1)	mV		5	370	292	357	354	5	286		

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

7717962-7718038 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

7718040 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Elevated RDL indicates the degree of sample dilution prior to the analysis for Anions in order to keep analyte within the calibration range of the instrument and to reduce matrix interference.

Certified By:

Quality Assurance

CLIENT NAME: ENGLOBE CORP

PROJECT: 16014

SAMPLING SITE:

AGAT WORK ORDER: 16T117690

ATTENTION TO: Victoria Steuernal

SAMPLED BY:

Soil Analysis

RPT Date: Jul 27, 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
Corrosivity Package															
Sulphide*	7717962	7717962	<0.05	<0.05	NA	< 0.05	110%	80%	120%	NA			NA		
Chloride (2:1)	7718040	7718040	868	860	0.9%	< 2	97%	80%	120%	100%	80%	120%	105%	70%	130%
Sulphate (2:1)	7718040	7718040	37	36	2.7%	< 2	94%	80%	120%	100%	80%	120%	108%	70%	130%
pH (2:1)	7718040	7718040	8.26	8.34	1.0%	NA	101%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	7718040	7718040	1.54	1.54	0.0%	< 0.005	99%	90%	110%	NA			NA		
Redox Potential (2:1)	7718040	7718040	286	286	0.0%	< 5	100%	70%	130%	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: 16014

SAMPLING SITE:

AGAT WORK ORDER: 16T117690

ATTENTION TO: Victoria Steuernol

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulphide*	MIN-200-12025	ASTM E1915-09	GRAVIMETRIC
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)	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
Redox Potential (2:1)		McKeague 4.12 & SM 2510 B	REDOX POTENTIAL ELECTRODE

Appendix 4 Photo Essay

Enclosure No. 6:

Photo Essay

Culvert Inlet – Looking West

Photo: 1



Culvert Outlet – Looking East

Photo: 2



Project: Hwy 63 – Culvert Station 10+495, Twp of Clarkson

Photos Provided By: Englobe

Date: May 2016

Rock Cores – Borehole 3 (left)

Photo: 3



Project: Hwy 63 – Culvert Station 10+495, Twp of Clarkson

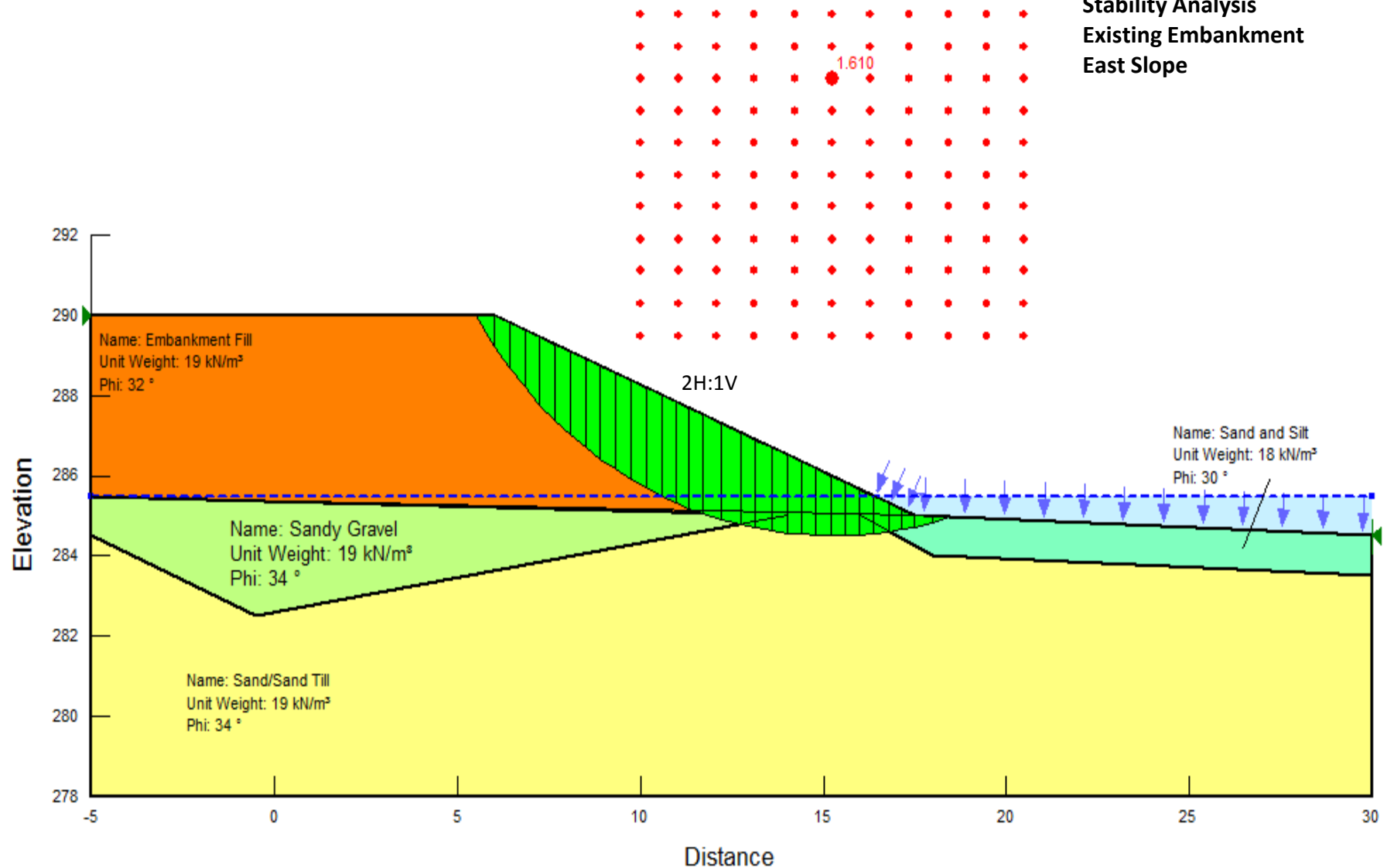
Photos Provided By: Englobe

Date: May 2016

Appendix 5 Design Data

Figure Nos. S-1:	Slope Stability
Table A:	Comparison of Shoring Alternatives
Figure No. SK-3:	Conceptual Staging Plan
Figure No. SK-4:	Conceptual Shoring Locations
Figure No. SK-5	Conceptual Shoring Sections
	Notice to Contractor

**Stability Analysis
Existing Embankment
East Slope**



Culver Station 10+495

Project: G.W.P 5203-14-00

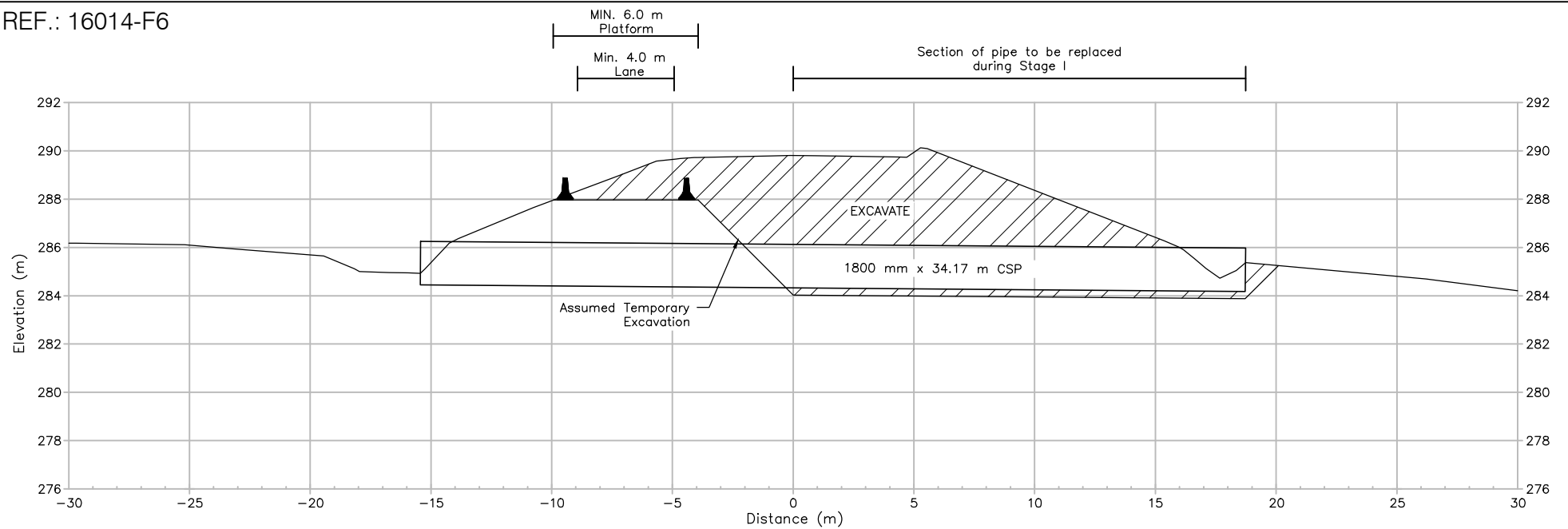
Location: Hwy 63, Township of Clarkson

Figure No. S-1

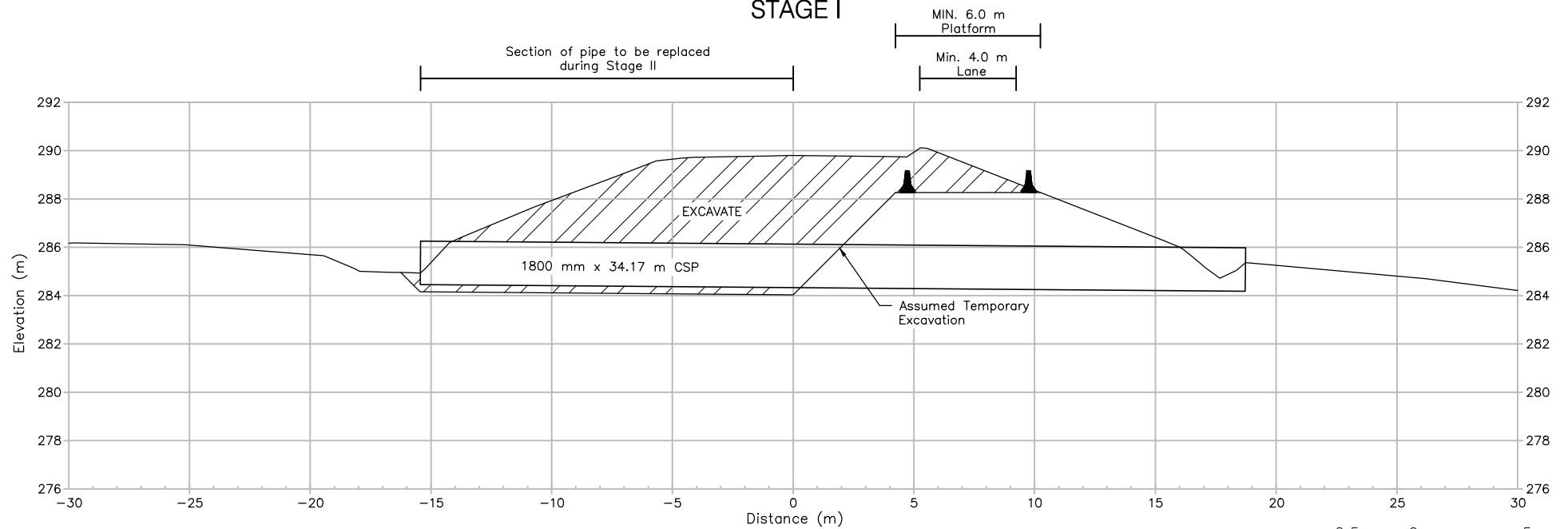
Table A – Comparison of Shoring Alternatives

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 recommended due to cobble/boulder sized rock pieces encountered in native soils	\$ 650/m ²
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Recommended if a sufficiently robust sheet pile wall with dewatering is used.	\$ 650/m ²
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 higher cost	
Soldier piles	5 – 25	-Easy installation -Readily available -Adaptable to various ground conditions	-Pre-drilling may be required -Possible ground loss	Considered as alternative to sheet piles with adequate dewatering. Predrilling may be required if cobble/boulder sized rock pieces are encountered.	\$ 725/m ² Predrilling 1500/m ²
Tangent/ Secant/ Staggered Drilled Piles	10 – 18	-Readily available -Adaptable to various ground conditions	-Possible ground loss and/or seepage -Poor alignment tolerance	Not recommended due to higher cost	
Concrete Diaphragm	10 – 30	-High Strength -Durable -Can be permanent	-High cost -Requires specialized equipment/control	Not considered due to higher costs	
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	\$ 1200 to 1500/m ²

REF.: 16014-F6



STAGE I



STAGE II

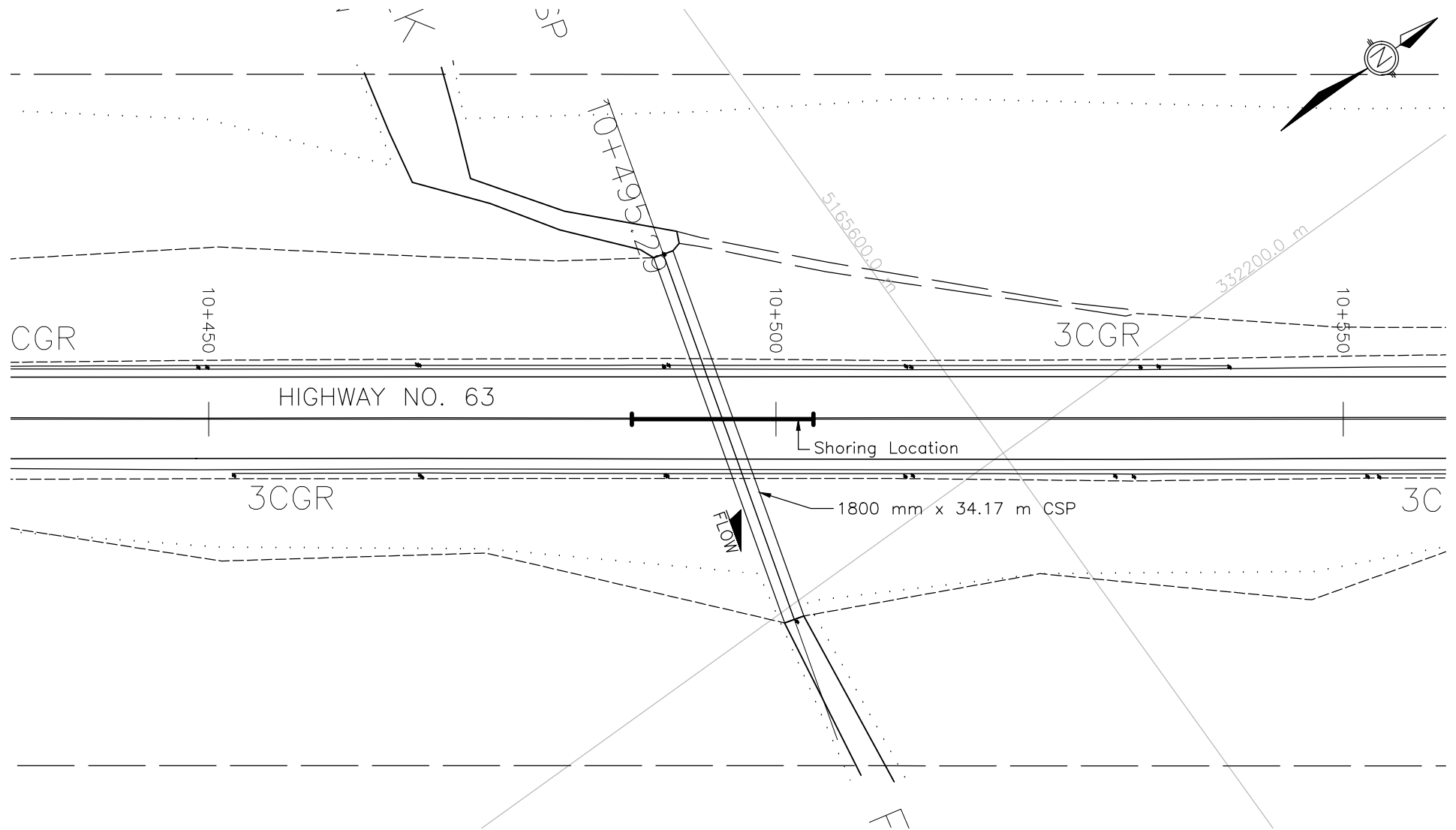
METRIC

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



Highway 63, Township of Clarkson - Culvert at Station 10+495
Conceptual Shoring Location Plan

FIGURE SK-3



METRIC

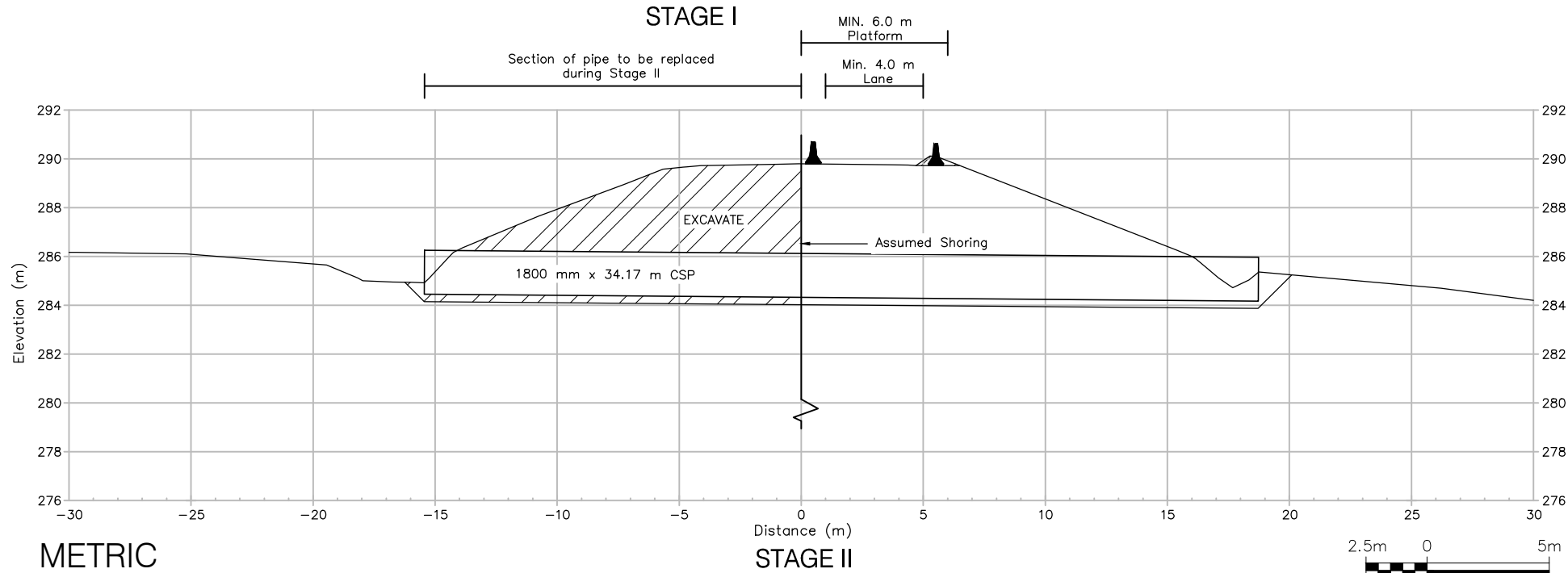
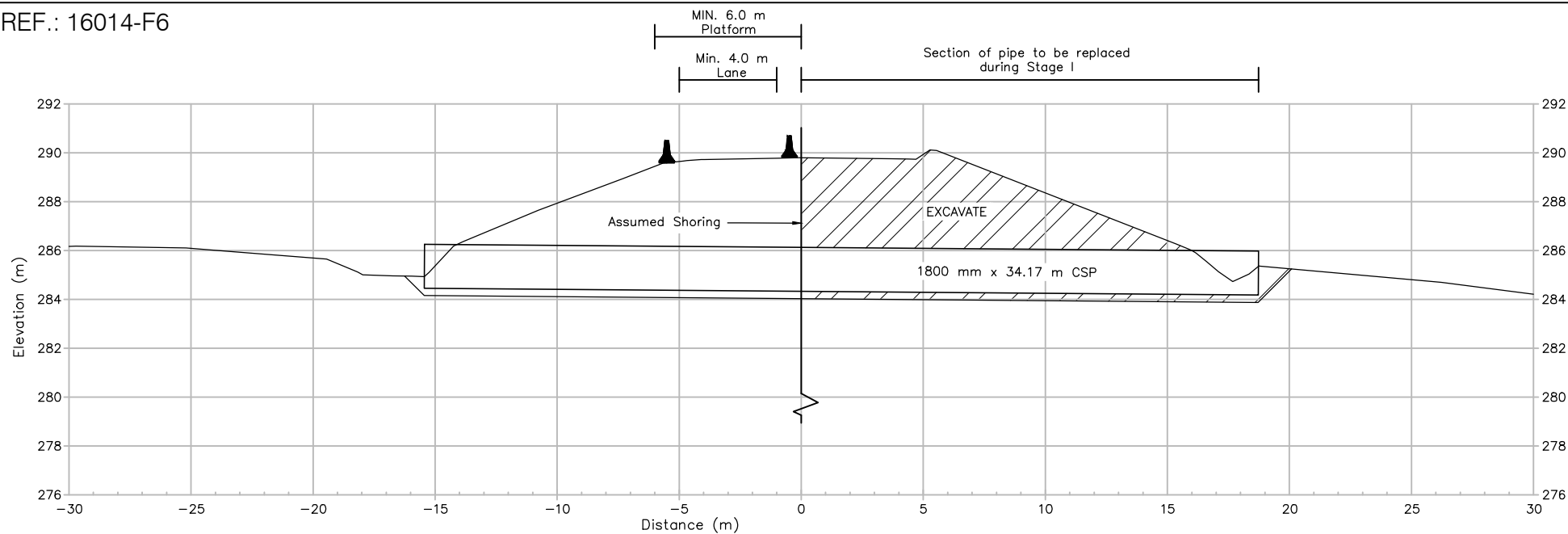
Dimensions are in meters
and/or millimeters unless
otherwise shown. Stations are
in kilometers + meters.



Highway 63, Township of Clarkson - Culvert at Station 10+495
Conceptual Shoring Location Plan

FIGURE SK-4

REF.: 16014-F6

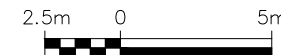


METRIC

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

Highway 63, Township of Clarkson - Culvert at Station 10+495
Conceptual Shoring Location Plan

FIGURE SK-5



NOTICE TO CONTRACTOR – Obstructions in Native Soils

Special Provision

The Contractor is notified that, during foundation field investigations for the Structural Culvert at Station 10+495, Township of Clarkson, on Highway 63, cobble/boulder sized rock pieces were encountered in the native soils. The Contractor shall take into account the obstructions in native soils for designing and constructing the temporary protection system.