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 11
Station 21+918 – Township of Idington
GWP 163-98-00

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

Date: February 23, 2016
Ref. Nº: 15/05/15059-F6

Geocres No. 42G-59

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TABLE OF CONTENTS

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REVISION AND PUBLICATION REGISTER		
Revision N°	**Date**	**Modification And/Or Publication Details**
00	2015-11-25	DRAFT FIDR Issued
01	2016-02-23	Final FIDR Issued

REPORT DISTRIBUTION	
2 hard copies	AECOM
5 hard copies and 1 digital copy	MTO Project Manager
1 hard copy, 1 digital copy	MTO Pavement and Foundations Section, Foundation Group
1 hard copy	File

1 INTRODUCTION

Englobe Corp. (Englobe), formerly LVM-Merlex, a Division of Englobe Corp., 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 culvert site. The site is located on Highway 11 at Station 21+918 in the Township of Idington, some 4.0 km east of the intersection between Highway 11 and Belanger Road.

The foundation investigation location was specified by the MTO in Change Order Number 2 for the work under Agreement No. 5014-E-0001: GWP 163-98-00. The terms of reference for the scope of work are outlined in Englobe's Proposal 15/05/15059-A2 dated July 17, 2015. The purpose of this investigation was to determine the subsurface conditions in the area of the existing culvert for the detailed design of the culvert replacement. 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 Corrugated Steel Pipe (CSP) culvert is located on Highway 11 at Station 21+918 in the Township of Idington. 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 of granular fill overlying silty clay fill embankment some 5.0 m in height, with centerline elevation of 231.8 m at the culvert location. The existing embankment slopes in the area of the culverts have been built at angles ranging between approximately 1.8H:1V (right side) to 2.4H:1V (left side). The culvert at this location has been described as a 0.9 m diameter Corrugated Steel Pipe (CSP) culvert, some 29 m long. The flow through the culvert is from the south to the north (right to left).

Infrastructure at this site consists of overhead and underground communication lines running parallel to the highway embankment. An Ontario Northland Rail Line runs adjacent to the south of the highway embankment.

2.1 SITE PHYSIOGRAPHY AND SURFICIAL GEOLOGY

This project is located in the Geomorphic Sub-province known as the Cochrane Clay Plain. The topography on this section of Highway 11 is generally flat. Significant layers of earth overlay the bedrock. Within the project area native overburden primarily consists of silty clay till to silt till deposits.

Bedrock in the area, as indicated on OGS Map 2506, is of the Early Precambrian felsic igneous and metamorphic rocks consisting of granitic, metasedimentary, and minor metavolcanic migmatite.

3 INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out between the period of July 23rd and 27th, 2015 during which time four (4) sampled boreholes were advanced. Two (2) boreholes were advanced through the embankment at the location of the culvert, and one (1) borehole was advanced at each of the inlet (south) and outlet (north) ends of the culvert.

The field investigation was carried out using a 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. 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 selected open boreholes prior to backfilling to allow for post borehole completion monitoring of the shallow groundwater levels. 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 borehole 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, 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-5 and Table No. L-6).

The location of the individual boreholes was determined in the field using highway chainage (established by others) and offset relative to highway centerline. The MTO co-ordinates, northing and easting, were then established for the boring locations. Elevations contained in this report are referenced to a geodetic datum. The borehole elevations are based on a survey carried out by others.

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 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 21+918, TWP OF IDINGTON

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 adjacent to the culvert, Borehole No. 3 advanced in the area adjacent to the culvert outlet, and Borehole No. 4 advanced adjacent the culvert inlet. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 4, inclusive, were recorded at elevations 231.7, 231.7, 227.2, and 227.4 m, respectively.

4.1.1 Pavement Structure

Borehole No. 1 and 2 were advanced through the embankment shoulder where a layer of crushed gravel some 203 to 305 mm thick was penetrated.

4.1.2 Granular Fill

Underlying the pavement structure at Borehole Nos. 1 and 2, a layer of fill consisting of brown sand trace to some gravel, trace to some silt was penetrated. The natural moisture content measured on samples of this deposit was in the order of 3 to 5%. Gradation analyses were carried out on two (2) samples of this deposit, the results of which indicated 1 to 17% gravel size particles, 73 to 86% sand size particles, and 10 to 13% silt and clay size particles (Figure No. L-1, Appendix 3). Based on SPT ‘N’ values of 18 to 29 blows per 300 mm penetration, the compactness of this deposit was described as compact. This fill layer was encountered to depths of 0.9 and 1.4 m below grade at Borehole Nos. 1 and 2, respectively (elevations 230.8 and 230.3 m, respectively).

4.1.3 Silty Clay Fills

Underlying the granular fill at Borehole Nos. 1 and 2, a layer of fills consisting of silty clay, trace to some gravel, trace to with sand, was penetrated. The natural moisture content measured on samples of this deposit was in the order of 11 to 18%. Gradation (hydrometer) analyses were carried out on two (2) samples of this deposit, the results of which indicated 3 to 5% gravel size particles, 23% sand size particles, 42 to 47% silt size particles, and 27 to 30% clay size particles (Figure No. L-2, Appendix 3). Atterberg Limits testing was carried out on two (2) samples of this deposit, indicating a Plastic Limit in the order of 14 to 15% and a Liquid Limit in the order of 24 to 25%, indicating a clay of low plasticity (Figure No. L-5, Appendix 3). Based on SPT 'N' values ranging from 5 to 17 blows per 300 mm penetration of greater than 100 kPa, the consistency of this deposit was described as firm to very stiff. This fill layer was encountered to depths of 4.1 and 4.0 m below grade at Borehole Nos.1 and 2, respectively (elevations 227.6 and 227.7 m, respectively).

4.1.4 Organic Soils

Underlying the silty clay fills at Borehole Nos. 1 and 2, and at ground surface Borehole Nos. 3 and 4, a layer of silty organic soils, including fibrous peat, trace decayed wood, was penetrated. This organic soil layer was encountered to depths of 4.3, 4.7, 0.3, and 0.4 m below ground surface at Borehole Nos. 1 to 4, respectively (elevations 227.4, 227.0, 226.9, and 227.0 m, respectively).

4.1.5 Tills

Underlying the organic soils at Borehole No. 1 to 4, deposits of native tills were encountered. Sampling was terminated in the till deposits at a depth of 9.8 m below grade at Borehole Nos. 1 to 4 (elevations 221.9, 221.9, 217.4, and 217.6 m). The till deposit consisted of interbedded layers of till ranging from silty clay tills to silt tills, and have been described as follows.

4.1.5.1 *Silty Clay Till*

The silty clay portion of the till deposit was described as silty clay, trace to some gravel, with sand. The natural moisture content measured on samples of the silty clay portions of the deposit was in the order of 10 to 30%. Gradation (hydrometer) analyses was carried out on five (5) single sample of this deposit, the results of which indicated 2 to 13% gravel size particles, 19 to 33% sand size particles, 46 to 50% silt size particles, and 18 to 32% clay size particles (Figure No. L-3, Appendix 3). Atterberg Limits testing was carried out on five (5) sample of this deposit, the results of which indicated a Plastic Limit in the order of 13 to 16% and a Liquid Limit in the order of 23 to 26% (Figure No. L-5, Appendix 3). The consistency of this deposit was described as very stiff.

4.1.5.2 *Silt Till*

The silt portion of the till deposit was described as silt, trace to with gravel, with sand to sandy, trace to some. The natural moisture content measured on samples of this deposit was in the order of 12 to 18%. Gradation (hydrometer) analyses were carried out on five (5) sample of this deposit, the results of which indicated 3 to 26% gravel size particles, 16 to 41% sand size particles, 42 to 66% silt size particles, and 3 to 12% clay size particles (Figure No. L-4,

Appendix 3). Atterberg Limits testing was attempted on five (5) samples of this deposit. The results generally indicated a non-plastic material, however, the result of one test indicated a Plastic Limit in the order of 15% and a Liquid Limit in the order of 18% (Figure No. L-5, Appendix 3). Based on STP 'N' values of 20 to 72 blows per 300 mm penetration, the compactness of this deposit was described as compact to very dense.

4.2 GROUNDWATER DATA

During the period of investigation (July 27th, 2015), the creek water levels were measured at an elevation of some 227.0 m at the culvert outlet.

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 4 to obtain post borehole completion water levels. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix 2).

The groundwater levels were measured at elevations 225.5, 219.7, and 227.4 m at Borehole Nos. 2, 3, and 4, respectively. The water level encountered at Borehole Nos. 2 and 3, likely had not stabilized at the time of recording.

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

5 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

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

The existing culvert, located at Station 21+918, in the Township of Idington, is a 0.9 m diameter CSP culvert some 29 m long. The culvert invert is established at approximately elevation 226.8 m. The existing highway embankment currently supports two undivided lanes of highway, running in a west-east direction. The flow through the existing culvert is from the south to the north (right to left). Based on data from this foundation investigation, the embankment supporting the existing pavement structure at this site has been constructed using a granular pavement structure overlying granular fills and silty clay fills. The native material, underlying the embankment fill, generally consisted of clay tills.

The type of culvert (concrete, CSP, or High Density Polyethylene (HDPE)) that will replace the existing culverts is currently unknown. It is assumed that the new culvert(s) will be of similar size and constructed along a similar skew and vertical alignment as the existing condition.

5.2 FOUNDATION CONSIDERATIONS

The founding native stiff to hard silty clay and silt tills present below the existing embankment are considered adequate for support of a culvert and for a conventional highway embankment of this height. The 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 boiling condition and disturbance of subgrade at the founding level.

Based on the characteristics of the native clay till subgrades present below the culvert, the response of the existing embankment, and a founding elevation similar to that of the existing culverts, a factored bearing resistance at ULS of 260 kPa 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 150 kPa can be used for design, in consideration of 25 mm settlement.

If open culverts (i.e. concrete frame open culverts, with wall footings, or pipe arch culverts on footings) are considered, then a factored bearing resistance at ULS of 210 kPa, and a geotechnical reaction at SLS of 100 kPa would apply for design, in consideration of 25 mm settlement and taking into consideration the limited depth of overburden and smaller footing width.

5.2.1 Slope Stability

The maximum height of the embankment above the stream bed at this location is some 5.0 m. The angles of existing slopes ranging from approximately 1.8H:1V to 2.4H:1V. 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 granular fill. For the purposes of these analyses, the materials were modeled using the following parameters;

MATERIAL	PARAMETER		
	UNIT WEIGHT (KN/M3)	EFFECTIVE FRICTION ANGLE (DEGREES)	UNDRAINED SHEAR STRENGTH (KPA)
Granular Fill	19.0	32	-
Silty Clay Fill (undrained)	17.0	-	75
Silty Clay Fill (drained)	17.0	28	5
Organic Soil	10.0	-	10
Silty Clay Till (undrained)	18.0	-	100
Silty Clay Till (drained)	18.0	28	8
Silt Till	19.0	32	-

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 factor of safety against deep seated failures is in the order of 1.6 to 4.4 with the existing slopes (long and short term, respectively) (see Figure Nos. S-1 and S-2, Appendix 5). It is recommended that the finished slopes of embankment be established at 2H:1V. 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 granular fills overlying silty clay fills. The results of this investigation indicate that, below the culvert invert, the native soils encountered at Boreholes No. 1 to 4 consisted of silty clay and silt tills. A review of the condition of the pavement surface, at the culvert locations, revealed asphalt cracking and patching; however, in general, the embankment appears to have performed fairly to 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, and 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 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.

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 upcompacted. 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 material of bedding, cover and backfill 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 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% Standard Proctor 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 impermeable nature of the lower 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 CULVERT INSTALLATION AND CONSTRUCTION CONSIDERATIONS

The culvert invert has been established at a depth of some 5.0 m below centreline (i.e. elevation 226.8 m). Therefore, a minimum 5.3 m deep excavation (i.e. to elevation 226.5 m) will be required in consideration of a 300 mm thick layer of bedding/embedment material.

The present platform width at this location is some 13.5 m as can be seen on the cross sections 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. It is understood that lowering the embankment by this height is not feasible at this location, due to the existing Solomon Creek Bridge located some 160 m west of the culvert location. As such, a temporary vertical wall will be required for use as a protection system. Alternatively, in consideration of the embankment height, trenchless techniques could also be used for culvert replacement. However, due to underground services and proximity of the ONR embankment, installing the culvert using trenchless techniques is not considered feasible, as such trenchless techniques have not been discussed further.

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 the vertical alignment is carried out. While lowering the grade to carry out open excavation is not considered feasible at this site, the method of carry out the lowering and staged construction has been provided for information purposes.

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 230.0 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 12 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.

5.4.2 Protection System

As noted above, constructing a vertical wall, along centerline, for use as a temporary protection system is the preferred method of culvert replacement.

Considering the nature/extent of this foundation investigation, as outlined in the RFP, only two boreholes were advanced through the embankment. It is unknown what type of protection system will be employed by the contractor and considering the possibility of variations in subsurface conditions up and down chainage from the culvert, the contractor should be afforded the opportunity to further investigate if they feel that the conditions could adversely impact their chosen protection system design.

The installation of a protection system for use in the culvert replacement operation will require penetration through some 0.9 to 1.4 m of granular fills and some 2.6 to 3.2 m of silty clay fills. The embankment fill is generally underlain by some stiff to hard silty clay tills and compact to dense silt tills. Considering the embankment generally consists of granular fills overlying silty clay 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 through the embankment fill into the underlying native soils. A sufficiently robust sheet would be required to penetrate the native very stiff clay tills. Conceptual shoring locations and sections are illustrated on Figure Nos. SK-4 and SK-5, Appendix 5.

The granular pavement structure overlies sandy and clayey fills, and the recommended trench backfills, are considered cohesionless, as such, a rectangular apparent pressure distribution over the height of the cut would be appropriate for the second stage design of the temporary shoring (i.e. when the trench has been backfilled with granular fills, see Section 5.5). 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,

γ' = effective unit weight, as described in Section 5.6, and

H = height of wall, in the cohesionless soils, above the base of excavation.

The existing silty clay fill, underlying the granular fill, is largely composed of cohesive materials (silty clay). This will be replaced with granular fill during the backfilling of Stage 1. As such, the rectangular apparent pressure distribution would apply. However, the presence of the cohesive backfill during Stage 1 may require that the shoring be design using the “layered strata” method, as outlined in the Canadian Foundation Engineering Manual, 4^{th} Edition, Section 26.10.7.

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 geostructural 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-4 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.

5.5 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 2.5 m up to a depth of 0.8 m, and 1:1 tapers from that point up to surface, see Englobe's Pavement Design Report Reference No. 15/05/15059-P1, provided under a 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. 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 were recorded at elevations some 227.0 m at the culvert during the period of this investigation and the groundwater level at Borehole Nos. 4 had stabilized at elevations of 227.4 m, 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. This method of groundwater control is generally only effective when the groundwater in the excavation is less than a depth of some 1 m above the final base of the excavation to maintain subgrade stability and to allow for the placement of bedding, engineered fill, and/or construction of structures in the dry.

To effectively lower the groundwater to a greater depth, a more sophisticated groundwater control system in fine grained soils (i.e. silty clay), such as vacuum well points, would have to be considered. To provide a stable working surface the groundwater level must be controlled to below the base of excavation. When wet, silty clay subgrade can become easily disturbed, and can lose a portion of its natural bearing capacity.

A cofferdam, constructed of earth fill, sand bags, or water filled bag (i.e. aquadam) can be considered at this site for controlling flow. 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. Temporary erosion control should be carried out in accordance with OPSS 805 requirements.

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.

5.6 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	GRANULAR FILL	SILTY CLAY FILL	ORGANIC SOILS
Unit Weight (kN/m^3)	22	21	19	17.0	10.0
Angle of Internal Friction	34°	33°	32°	-	-
Shear Strength (kPa)	-	-	-	75	10
Coefficient of Active Earth Pressure (K_a)	0.28	0.29	0.31	-	-
Coefficient of Passive Earth Pressure (K_p)	3.54	3.39	3.23	-	-
Coefficient of Earth Pressure at Rest (K_o)	0.44	0.46	0.47	-	-
PARAMETER	**SILTY CLAY TILL**	**SILT TILL**			
Unit Weight (kN/m^3)	18.0	19.0			
Angle of Internal Friction	-	32			
Shear Strength (kPa)	100	-			
Coefficient of Active Earth Pressure (K_a)	-	0.31			
Coefficient of Passive Earth Pressure (K_p)	-	3.23			
Coefficient of Earth Pressure at Rest (K_o)	-	0.47			

For rigid structures, such as a precast concrete culvert, 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.

5.7 CONSTRUCTION CONCERNS

Considering the nature of the embankment fill, no major construction concerns are anticipated if construction is carried out in general conformance with the above discussion. As noted in Section 5.5 the culvert subgrade must be adequately dewatered to maintain the bearing resistance of the foundation subgrade. Additionally, sufficiently robust sheet piles must be used due to the dense/hard native till deposits.

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.

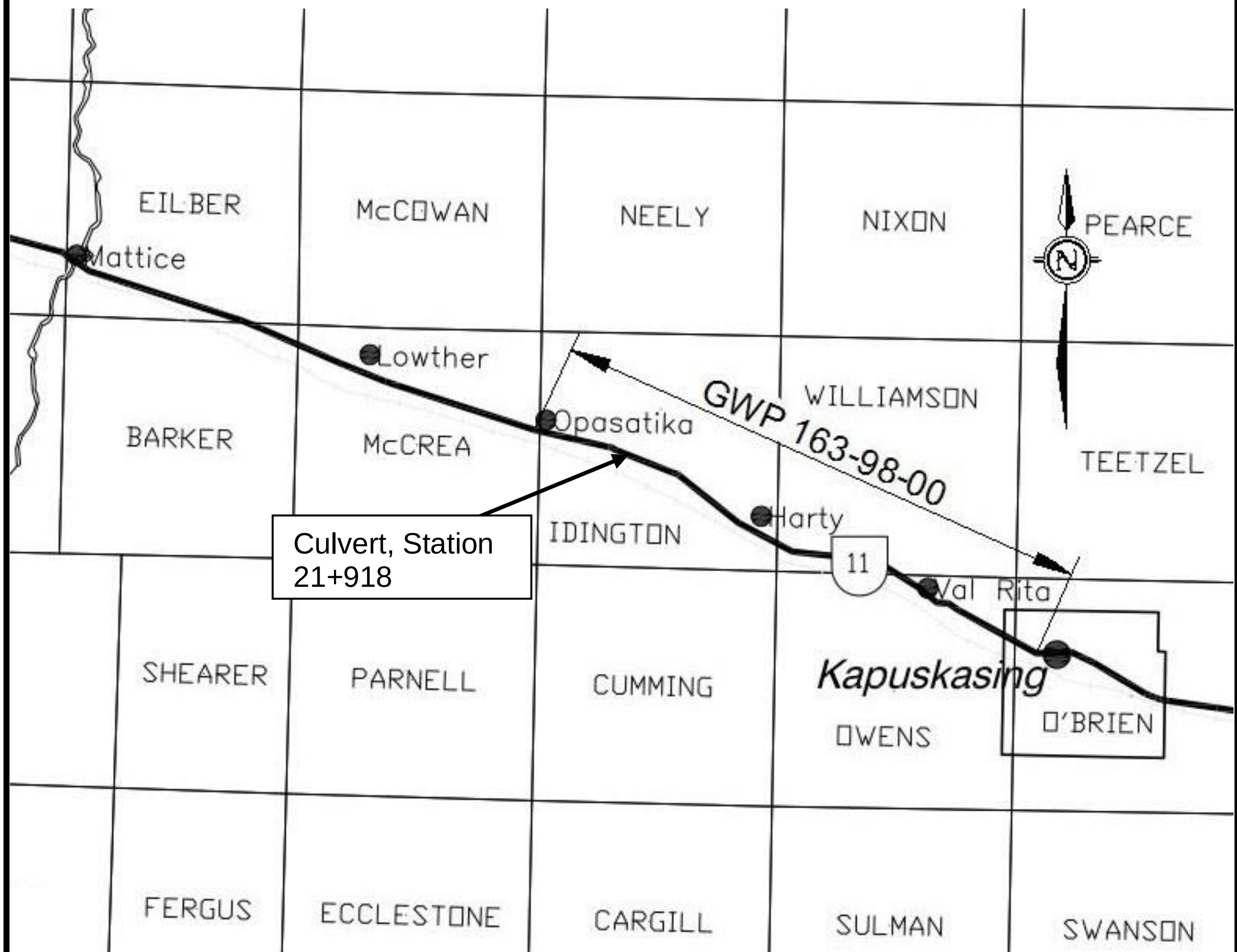
Appendix 1 Key Plan

Drawing No. 1	Key Plan

MACRO KEY PLAN

Drawing No.1

NOT TO SCALE



FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 163-98-00

Highway 11

Station 21+918 Culvert

Township of Idington

Reference No: 15/05/15059-F6 February 2016

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Appendix 2 Subsurface Data

Enclosure No. 1	List of Abbreviations and Symbols
Enclosure Nos. 2 to 5	Record of Borehole Sheet

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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.

ENCLOSURE NO.:2 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 1

Englobe

REFERENCE 15/05/15059-F6	DATUM Geodetic	LOCATION N 5484681.8 E 397125.7 - Idington Twp., Station 21+919.5	ORIGINATED BY JL
PROJECT GWP 163-98-00, Highway 11		BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers	COMPILED BY SH
CLIENT AECOM		DATE (Started) 23 July 2015 / DATE (Completed) 23 July 2015 / TIME (Completed) 9:50:00 AM	CHECKED BY MAM

ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT (water content %)	GR SA (SI CL)
231.7	Ground Surface						
0.0	305 mm Crushed Gravel GRANULAR FILL- sand, some gravel, trace silt brown, moist (compact)	1	SS	25		○	17 73 (10)
230.8 / 0.9	SILTY CLAY FILL - silty clay, trace gravel, trace to with sand brown Moist (very stiff/stiff)	2	SS	17	231	○	
		3	SS	7	230	○	
		4	SS	7		○	3 23 47 27
		5	SS	7	229	○	
227.6	grey, trace black decayed wood	6	SS	9	228	○	
227.4 / 4.1 / 4.3	ORGANIC SOIL - silty organics, trace decayed wood black						
	CLAY TILL - silty clay, trace to some gravel, with sand Brown to grey (stiff/very stiff)	7	SS	10	227	○	13 33 46 18
		8	SS	39	226	○	
		9	SS	31	225	○	2 22 48 28
		10	SS	26	224	○	
		11	SS	29	223 / 222	○	
221.9 / 9.8	End of Sampling End of Borehole						

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_P, Natural Moisture Content W, Liquid Limit W_L; Water Content (%) 20 40 60

Unit Weight γ kN/m³

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.

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 23/7/15 9:50:00 AM	DRY	-
2) 27/7/15 10:30:00 AM	2.3	-
3) 28/7/15 6:45:00 AM	2.3	-

MEL-GEO 15059 - F6 BOREHOL LOGS - 15-10-27.GPJ MEL-GEO.GDT 23/2/16

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

ENCLOSURE NO.:3 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 2

Englobe

REFERENCE 15/05/15059-F6 DATUM Geodetic LOCATION N 5484688.7 E 397127.2 - Idington Twp., Station 21+916.7 ORIGINATED BY JL

PROJECT GWP 163-98-00, Highway 11 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY SH

CLIENT AECOM DATE (Started) 23 July 2015 DATE (Completed) 23 July 2015 TIME (Completed) 12:15:00 PM CHECKED BY MAM

ELEV / DEPTH	DESCRIPTION (see Enclosure No. 1)	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
231.7	Ground Surface				
0.0	203 mm Crushed Gravel GRANULAR FILL- sand, trace to some gravel, some silt brown, moist (compact)	1	SS	29	
		2	SS	18	1 86 (13)
230.3 / 1.4	SILTY CLAY FILL - brown silty clay, trace gravel, trace to with sand, trace organics Moist (very stiff/stiff)	3	SS	8	5 23 42 30
		4	SS	8	
		5	SS	6	
227.7 / 4.0	ORGANIC SOIL - fibrous peat Moist Black	6	SS	5	
227.0 / 4.7	CLAY TILL - silty clay, trace gravel, some to with sand Brown to grey (very stiff/hard)	7	SS	12	
		8	SS	35	3 20 50 27
		9	SS	17	
224.6 / 7.1	SILT TILL - with sand, with gravel, trace clay Grey (very dense)	10	SS	72	26 29 42 3 NP
223.1 / 8.6	CLAY TILL - silty clay, trace to some gravel, some sand Grey (very stiff)	11	SS	28	
221.9 / 9.8	End of Sampling End of Borehole				

Chart columns: GROUND WATER CONDITIONS; ELEVATION SCALE (231–222); 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_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Vane couldn't be advanced

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) 23/7/15 12:15:00 PM	6.2	6.7
2) 28/7/15	-	-
3)	-	-

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

MEL-GEO 15059 - F6 BOREHOL LOGS - 15-10-27.GPJ MEL-GEO.GDT 23/2/16

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ENCLOSURE NO.:4 (Pg. 1 of 1)

RECORD OF BOREHOLE NO. 3

METRIC

Englobe

REFERENCE 15/05/15059-F6	DATUM Geodetic	LOCATION N 5484705.2 E 397143.3 - Idington Twp., Station 21+920	ORIGINATED BY JL
PROJECT GWP 163-98-00, Highway 11		BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers	COMPILED BY SH
CLIENT AECOM		DATE (Started) 27 July 2015 / DATE (Completed) 27 July 2015 / TIME (Completed) 9:40:00 AM	CHECKED BY MAM

ELEV / DEPTH	DESCRIPTION (see Enclosure No. 1)	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	Water content (%) / Plastic limit	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
227.2	Ground Surface						
0.0 / 226.9	ORGANIC SOIL - fibrous peat and organics, black	1	SS	4			
0.3	CLAY TILL - silty clay, trace gravel, some sand; Grey; (very stiff)	2	SS	18		plastic range plotted	2 20 46 32
		3	SS	17			
224.3		4	SS	22			
2.9	SILT TILL - sandy silt, trace gravel, trace clay; compact	5	SS	25			3 31 63 3 NP
223.5 / 3.7	CLAY TILL - silty clay, trace gravel, some sand; (compact)	6	SS	50/76mm			
221.6		7	SS	21			
5.6	SILT TILL - trace gravel, some sand; Grey; (compact)	8	SS	20		plastic range plotted	6 16 65 13
220.1 / 7.1	CLAY TILL - silty clay, trace gravel, trace to some sand; Grey; (very stiff)	9	SS	30	Water level and cave-in marked		
217.4		10	SS	23			
9.8	End of Sampling; End of Borehole						

ELEVATION SCALE: 227, 226, 225, 224, 223, 222, 221, 220, 219, 218

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_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

COMMENTS

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

WATER LEVEL RECORDS

	Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1)	27/7/15 9:40:00 AM	7.5	8
2)		-	-
3)		-	-

MEL-GEO 15059 - F6 BOREHOL LOGS - 15-10-27.GPJ MEL-GEO.GDT 23/2/16

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ENCLOSURE NO.:5 (Pg. 1 of 1)

METRIC

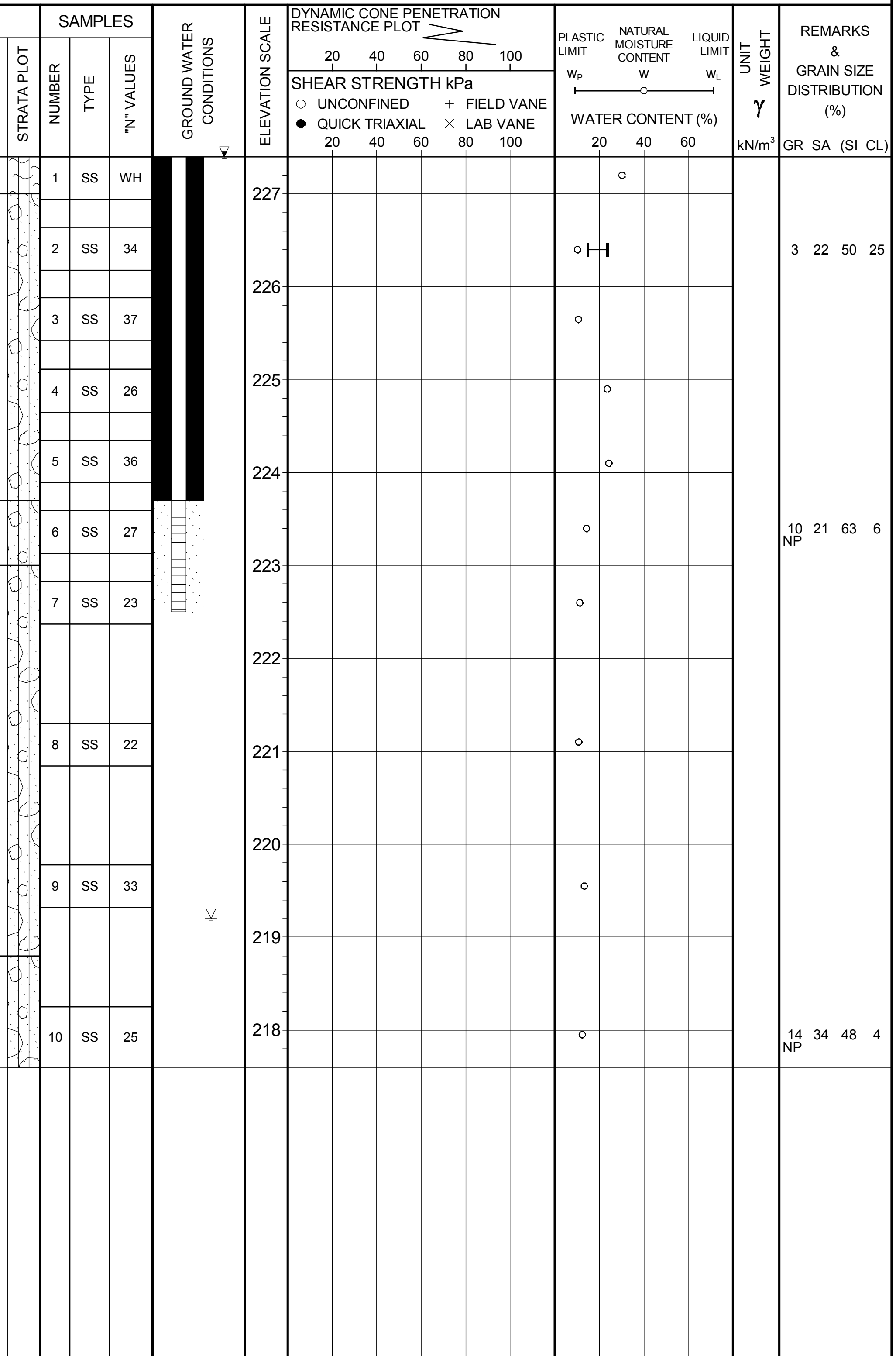
RECORD OF BOREHOLE NO. 4

REFERENCE 15/05/15059-F6 DATUM Geodetic LOCATION N 5484673.4 E 397114.0 - Idington Twp., Station 21+915 ORIGINATED BY JL

PROJECT GWP 163-98-00, Highway 11 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY SH

CLIENT AECOM DATE (Started) 27 July 2015 DATE (Completed) 27 July 2015 TIME (Completed) 1:10:00 PM CHECKED BY MAM

ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
227.4	Ground Surface				
0.0 / 227.0	ORGANIC SOIL - silty organics, Dark brown	1	SS	WH	
0.4	CLAY TILL- silty clay, trace gravel, some sand. Grey (very stiff)	2	SS	34	3 22 50 25
		3	SS	37	
		4	SS	26	
223.7		5	SS	36	
3.7	SILT TILL - trace gravel, with sand, trace clay. Grey (compact)	6	SS	27	10 21 63 6 NP
223.0 / 4.4	CLAY TILL - silty clay, some gravel, some sand. Grey (very stiff/hard)	7	SS	23	
		8	SS	22	
218.8		9	SS	33	
8.6	SILT TILL - sandy, some gravel, trace clay. Grey (compact)	10	SS	25	14 34 48 4 NP
217.6 / 9.8	End of Sampling. End of Borehole				



COMMENTS

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

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 27/7/15 1:15:00 PM	8.2	-
2) 28/7/15 6:50:00 AM	0	-
3)	-	-

MEL-GEO 15059 - F6 BOREHOL LOGS - 15-10-27.GPJ MEL-GEO.GDT 23/2/16

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

Appendix 3 Borehole Plan and Laboratory Data

Drawing No. 2:	Borehole Location and Soil Strata
Figure Nos. L-1 to L-4:	Grain Size Distribution Curves
Figure No. L-5:	Atterberg Limits
Table No. L-6:	Laboratory Test Summary Sheet

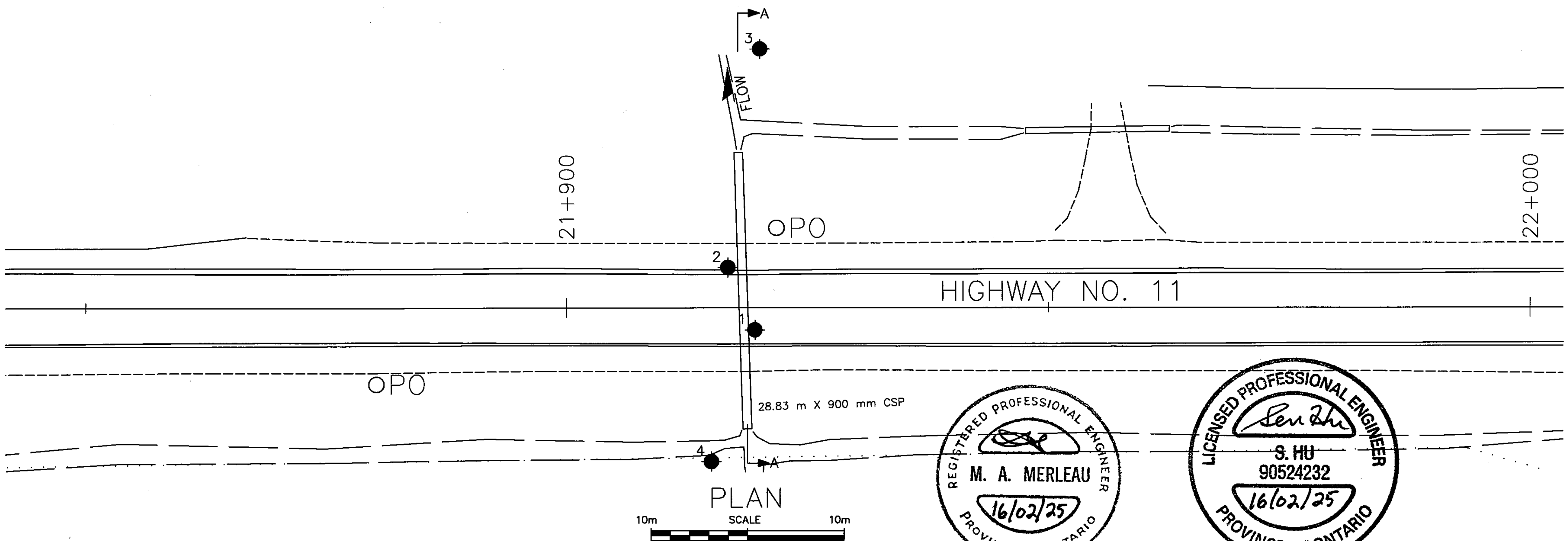
DISTRICT
CONT. No.
GWP No. 163-98-00

HWY 11 CULVERT
STA. 21+918

BOREHOLE LOCATIONS AND SOIL STRATIGRAPHY

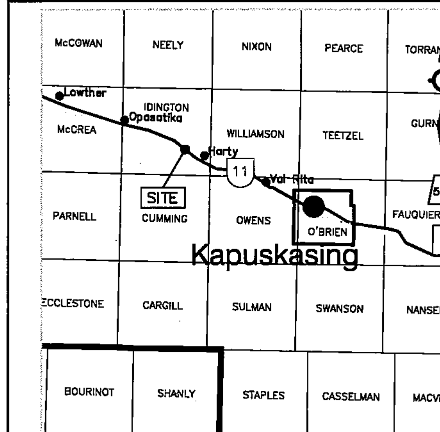
DRAWING 2

Englobe



REGISTERED PROFESSIONAL ENGINEER
M. A. MERLEAU
16/02/25
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S. HU
90524232
16/02/25
PROVINCE OF ONTARIO



KEY PLAN
N.T.S.

LEGEND

- Borehole w/ DCPT
- Borehole
- N — Blows/0.3 m (Std Pen Test, 475 J/blow)
- DCPT — Blows/0.3 m (60° Cone, 475 J/blow)
- Water Level at Time of Investigation
- A/R — Auger Refusal at Elevation
- E/S — End of Sampling
- Piezometer

BOREHOLE No.	ELEVATION	O/S	NORTHING	EASTING
1	231.7	2.3m Rt	5484681.8	397125.7
2	231.7	4.2m Lt	5484688.7	397127.2
3	227.2	27.0m Lt	5484705.2	397143.3
4	227.4	16.0m Rt	5484673.4	397114.0

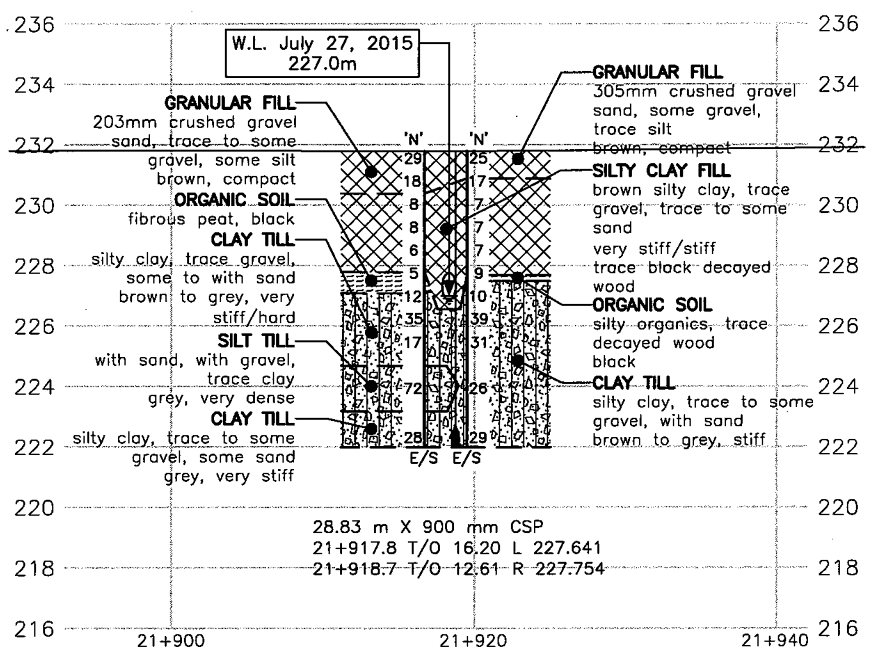
NOTES:

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 August 4, 2015

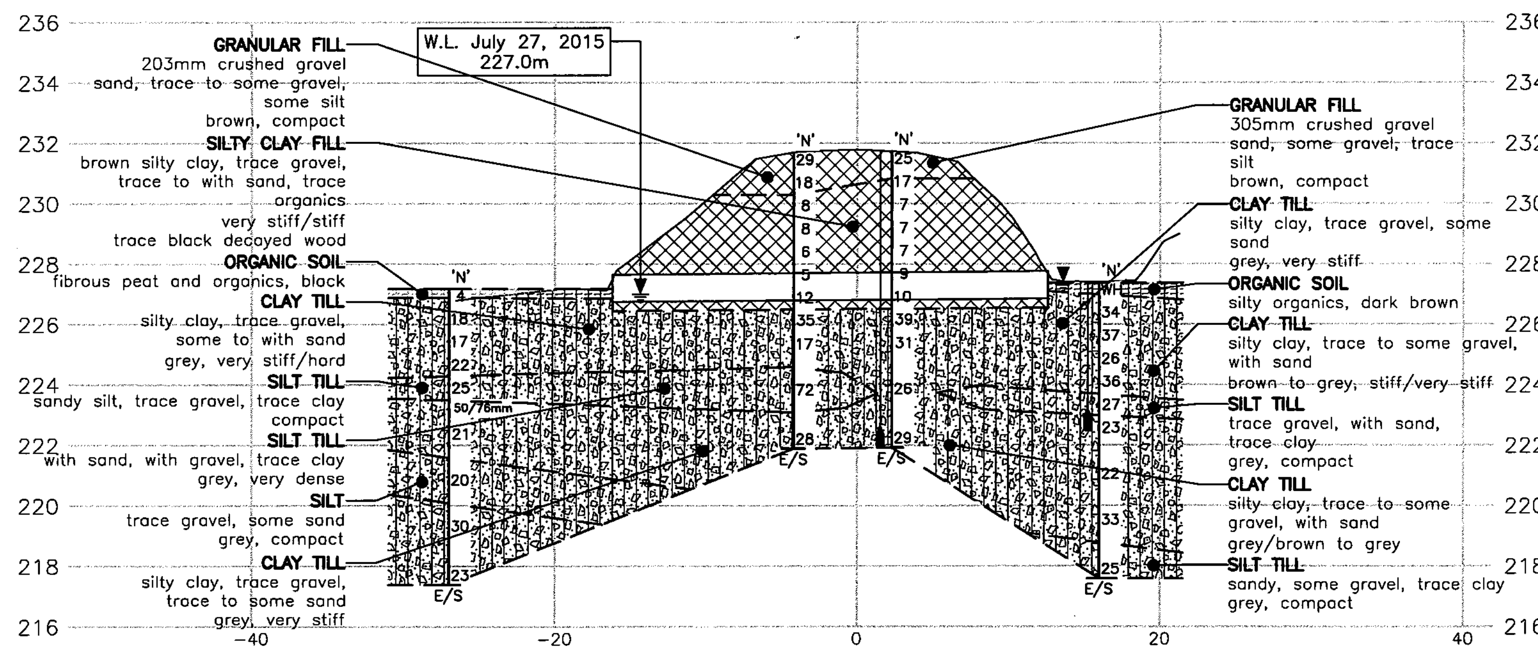
Coordinates based on MTM Zone 13 NAD83 CSRS

GEOCRES No. 42G-59



C/L PROFILE of HWY 11

SCALE HOR 10 5 0 10 20m; VERT 5 2.5 0 5 10m



CROSS SECTION A-A

SCALE HOR 10 5 0 10 20m; VERT 5 2.5 0 5 10m

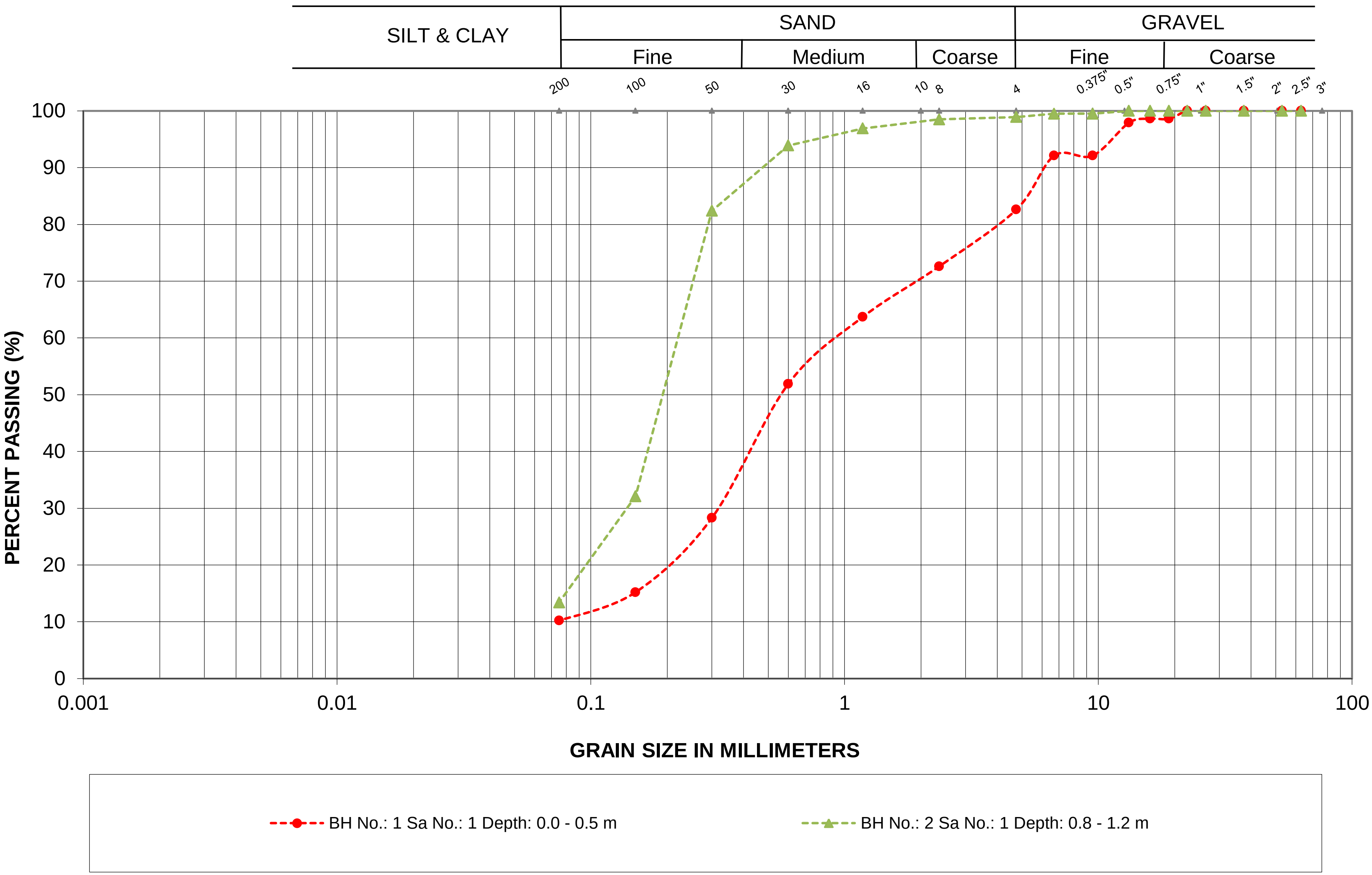
This drawing is for subsurface information only. Surface details and features are for conceptual illustration. The proposed structure location is shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contract Documents.

REVISIONS			
NOV/15	DM	DRAFT	
FEB/16	DM	FINAL	
		DESCRIPTION	

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

Reference No.: 15/05/15059-F6
Date: September, 2015

GRAIN SIZE ANALYSIS



GRANULAR FILL

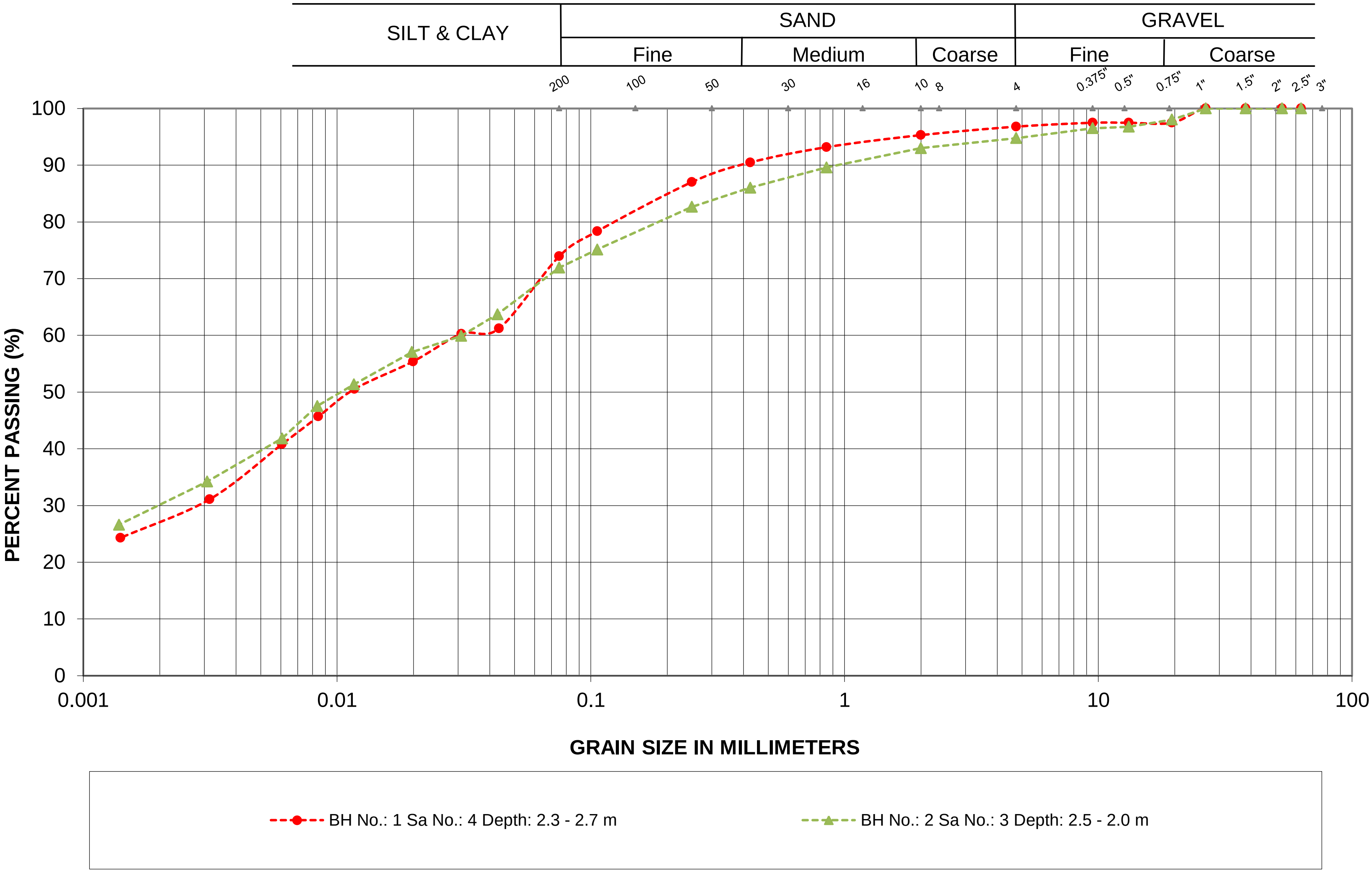
LOCATION: Hwy 11, Culvert Station 21+910
TWP of Idington

Englobe Corp.

FIGURE L-1

Reference No.: 15/05/15059-F6
Date: September, 2015

GRAIN SIZE ANALYSIS



SILTY CLAY FILL

LOCATION: Hwy 11, Culvert Station 21+910
TWP of Idington

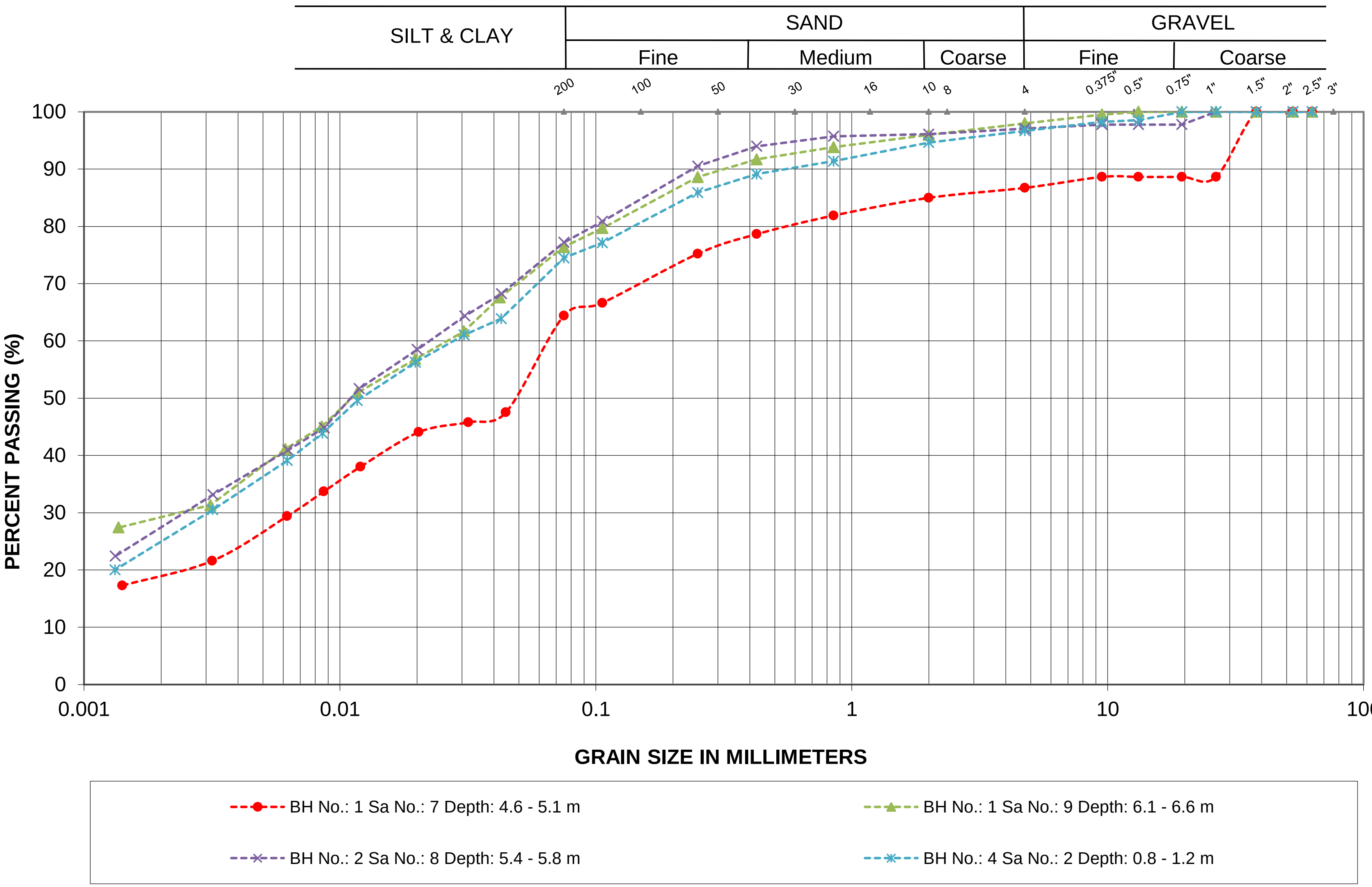
Englobe Corp.

FIGURE L-2

Reference No.: 15/05/15059-F6
Date: September, 2015

Englobe

GRAIN SIZE ANALYSIS



SILTY CLAY TILL

LOCATION: Hwy 11, Culvert Station 21+910
TWP of Idington

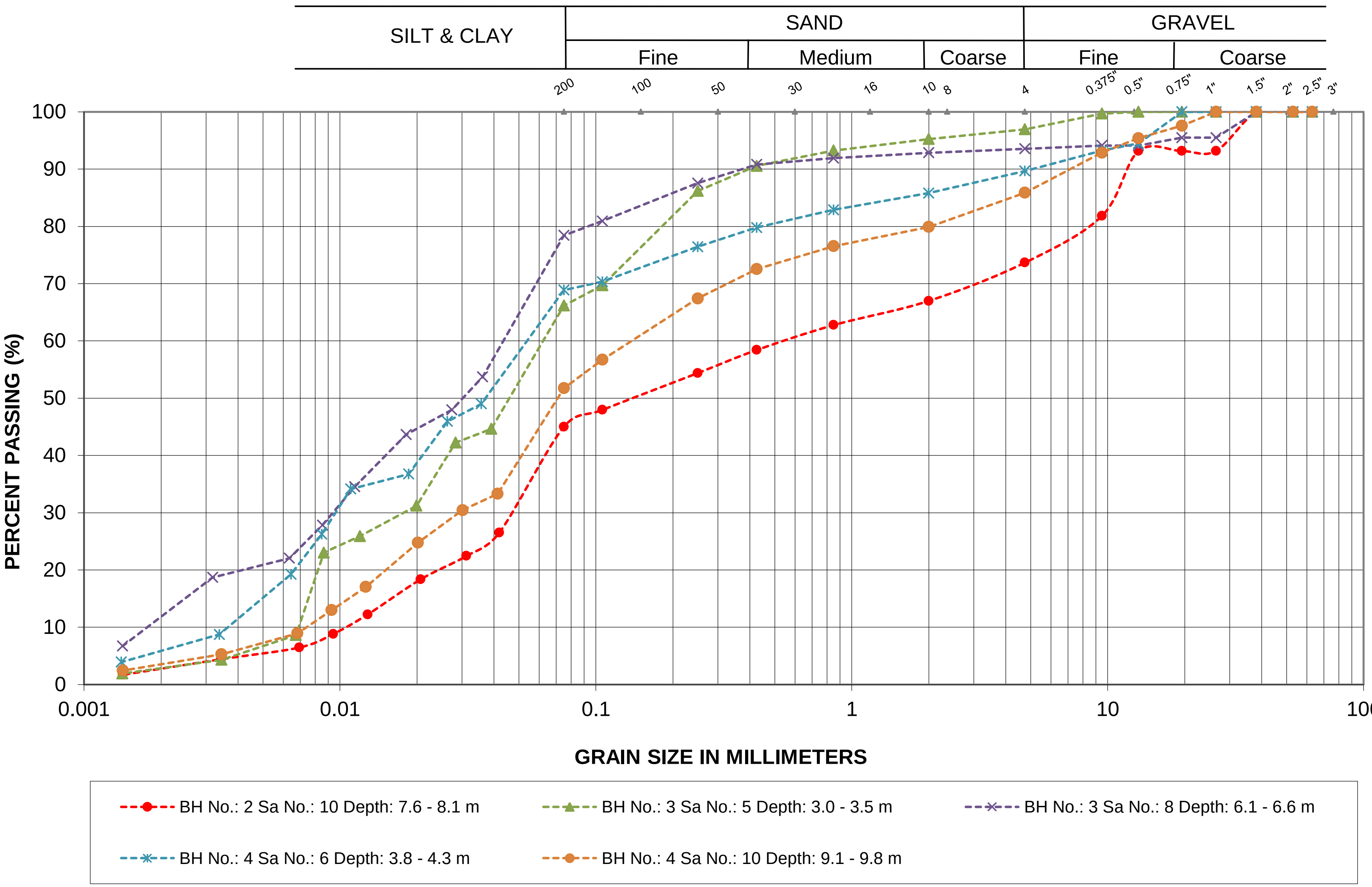
Englobe Corp.

FIGURE L-3

Reference No.: 15/05/15059-F6
Date: September, 2015

Englobe

GRAIN SIZE ANALYSIS



SILT TILL

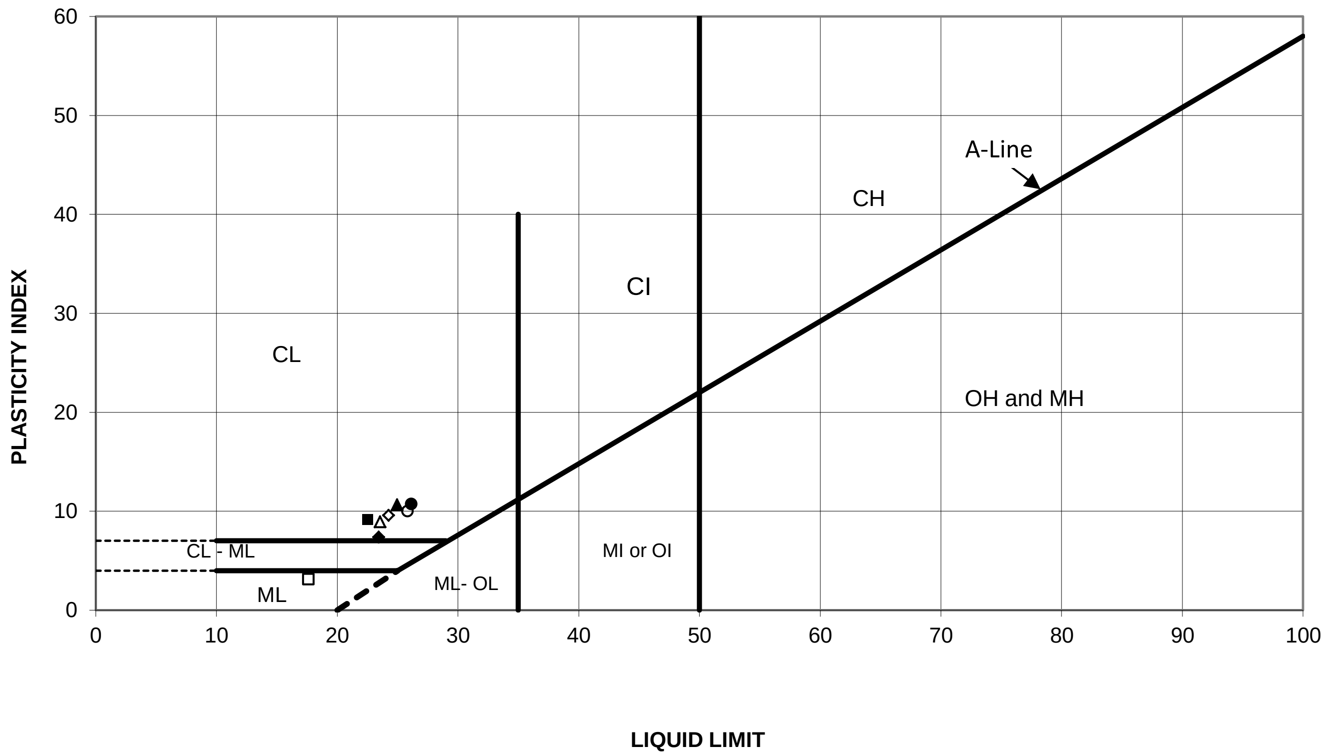
LOCATION: Hwy 11, Culvert Station 21+910
TWP of Idington

Englobe Corp.

FIGURE L-4

ATTERBERG LIMITS TEST RESULTS	FIGURE L-5

ATTERBERG INDICES



SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plastic Limit	Plasticity Index	NMC %
●	1	4*	2.5	229.2	26.1	15.4	10.7	13.0
◆	1	7	4.8	226.9	23.4	16.1	7.4	13.0
■	1	9	6.3	225.4	22.5	13.4	9.1	10.7
▲	2	3*	1.8	229.9	25.0	14.3	10.6	12.0
○	2	8	5.6	226.1	25.8	15.9	10.0	10.0
◇	3	2	1.0	226.2	24.3	14.7	9.6	10.2
□	3	8	6.3	220.9	17.6	14.5	3.1	13.4
Δ	4	2	1.0	226.4	23.6	14.6	8.9	10.1

*note test on silty clay fill

Date: Sep-15
Project: Hwy 11, T
Location: Sta. 21+910, TWP. of Idington

Prep'd: AT
Chkd: MAM
Ref. No.: 15/05/15059-F6

Englobe Corp.

Laboratory Tests - Summary Sheet

Englobe

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	17	73	10		3.3				25			
	2	0.8					11.1				17			
	3	1.5					14.0				7			
	4	2.3	3	23	47	27	13.0	24.1	15.4	8.7	7			
	5	3.1					17.9				7			
	6	3.8					15.2				9			
	7	4.6	13	23	46	18	13.0	23.4	16.1	7.4	10			
	8	5.3					10.7				39			
	9	6.1	2	22	48	28	10.7	22.5	13.4	9.1	31			
	10	7.6					10.7				26			
	11	9.2					9.5				29			
2	1	0.0					4.9				29			
	2	0.8	1	86	13		3.6				18			
	3	1.5	5	23	42	30	12.0	25.0	14.3	10.6	8			
	4	2.3					14.6				8			
	5	3.1					16.1				6			
	6	3.8					21.1				5			
	7	4.6					11.3				12			
	8	5.3	3	20	50	27	10.0	25.8	15.9	10.0	35			
	9	6.1					23.9				17			
	10	7.6	26	29	42	3	11.7				72			Non-Plastic (NP)
	11	9.2					11.2				28			

Laboratory Tests - Summary Sheet

Englobe

Borehole No.	Sample No.	Depth	Grain Size Analysis: Gravel Size (%)	Grain Size Analysis: Sand Size (%)	Grain Size Analysis: Silt Size (%)	Grain Size Analysis: Clay Size (%)	NMC	Atterberg Limits: LL (%)	Atterberg Limits: PL (%)	Atterberg Limits: IP (%)	SPT 'N'	USCS	Unit Weight (kN/m3)	Remarks
3	1	0.0					13.4				4			
	2	0.8	2	20	46	32	10.2	24.3	14.7	9.6	18			
	3	1.5					11.1				17			
	4	2.3					30.6				22			
	5	3.1	3	31	63	3	17.9				25			Non-Plastic (NP)
	6	3.8					10.2				50/76mm			
	7	4.6					10.8				21			
	8	6.1	6	16	65	13	13.4	17.6	14.5	3.1	20			
	9	7.6					17.8				30			
	10	9.2					14.5				23			
4	1	0.0					30.2				WH			
	2	0.8	3	22	50	25	10.1	23.6	14.6	8.9	34			
	3	1.5					10.6				37			
	4	2.3					23.5				26			
	5	3.1					24.2				36			
	6	3.8	10	21	63	6	14.2				27			Non-Plastic (NP)
	7	4.6					11.2				23			
	8	6.1					10.7				22			
	9	7.6					13.2				33			
	10	9.2	14	34	48	4	12.3				25			Non-Plastic (NP)

Appendix 4 Photo Essay

Enclosure No. 6: Photo Essay

Existing Embankment – Looking East along south ditch, Note ONR embankment	Photo: 1

Looking North, towards culvert outlet	Photo: 2

Project: Hwy 11 – Culvert, Station 21+918, Township of Idington	Photos Provided By:Englobe Date: July 2015

Looking South, towards culvert inlet. Note culvert shown is in the ONR embankment.	Photo: 3

Culvert Inlet – Looking North	Photo: 4

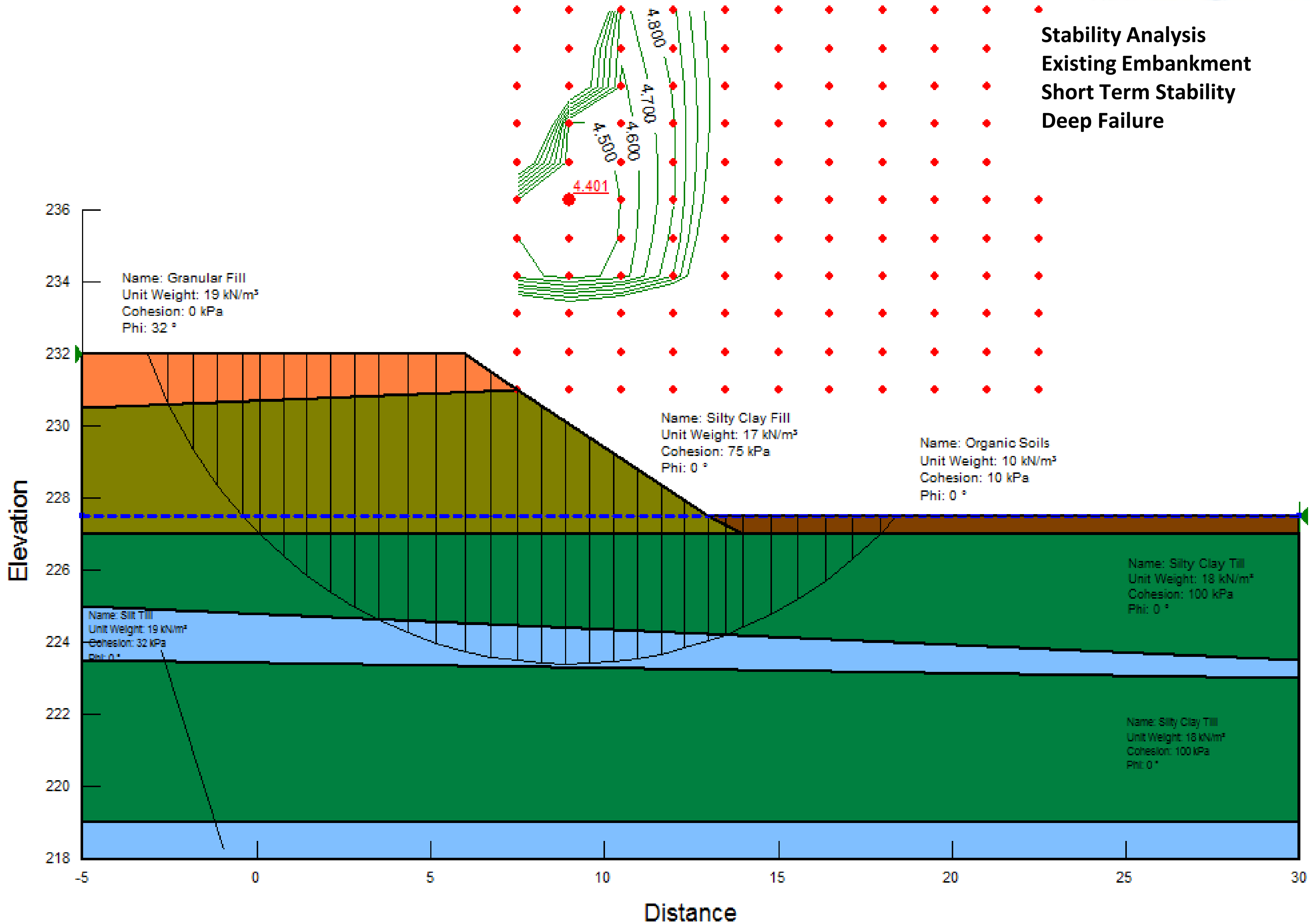
Project: Hwy 11 – Culvert, Station 21+918, Township of Idington	Photos Provided By:Englobe Date: July 2015

Appendix 5 Design Data

Figure Nos. S-1 to S-3:	Slope Stability Analyses
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

Englobe

Reference No.: 15/05/15059-F6
Date: February 2016



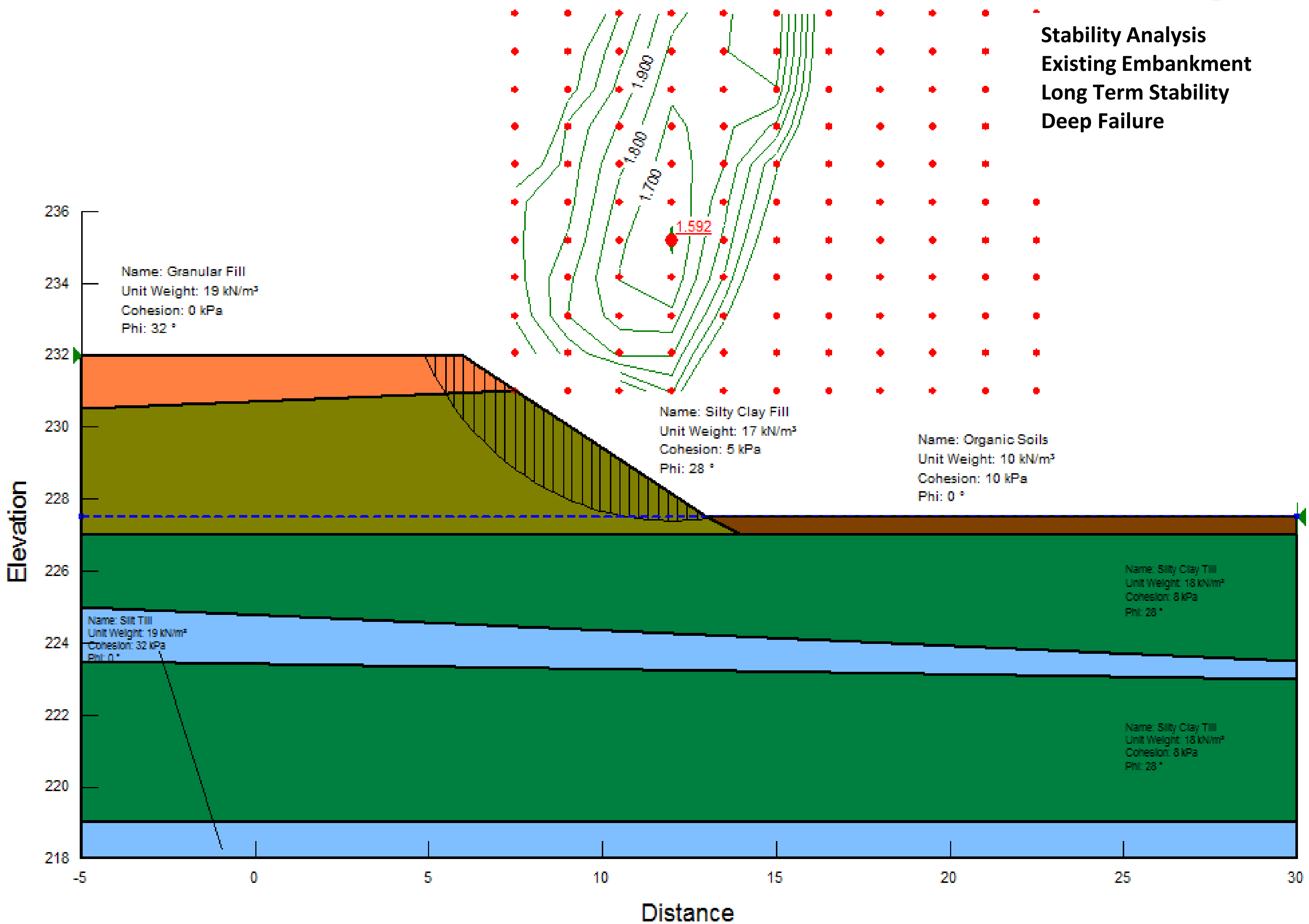
South Slope
Culvert Station 21+910

Project: G.W.P 163-98-00
Location: Hwy 11, Township of Idington

Figure No. S-1

Reference No.: 15/05/15059-F6
Date: February 2016

Englobe



South Slope
Culvert Station 21+910

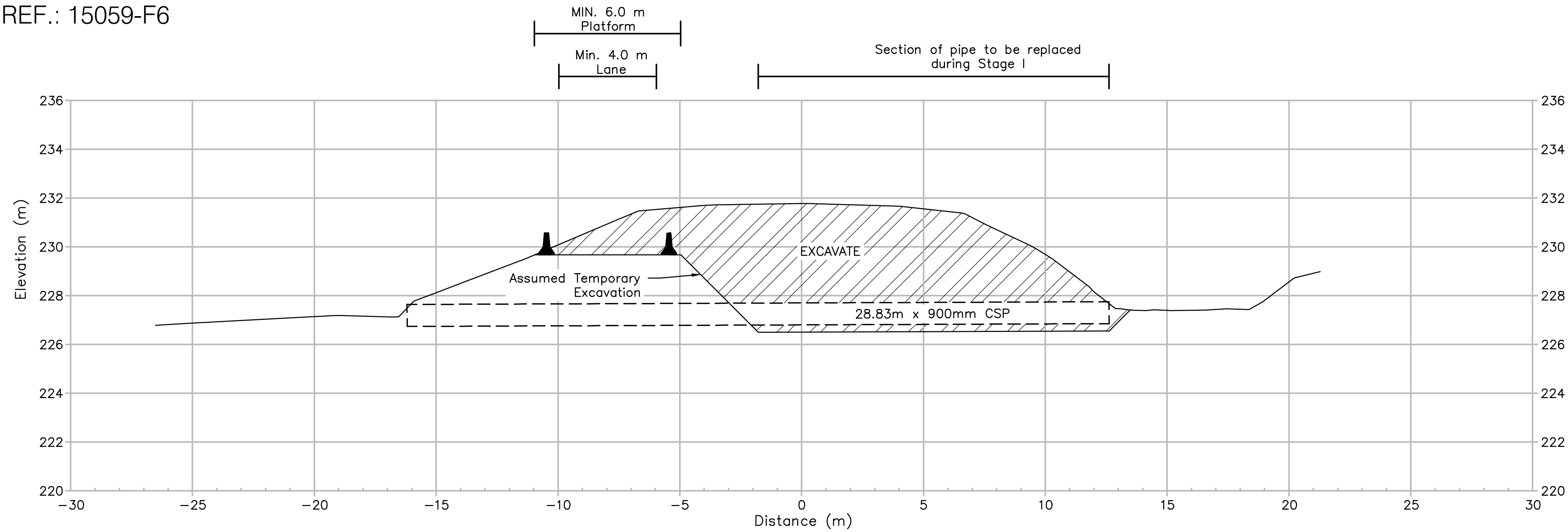
Project: G.W.P 163-98-00
Location: Hwy 11, Township of Idington

Figure No. S-2

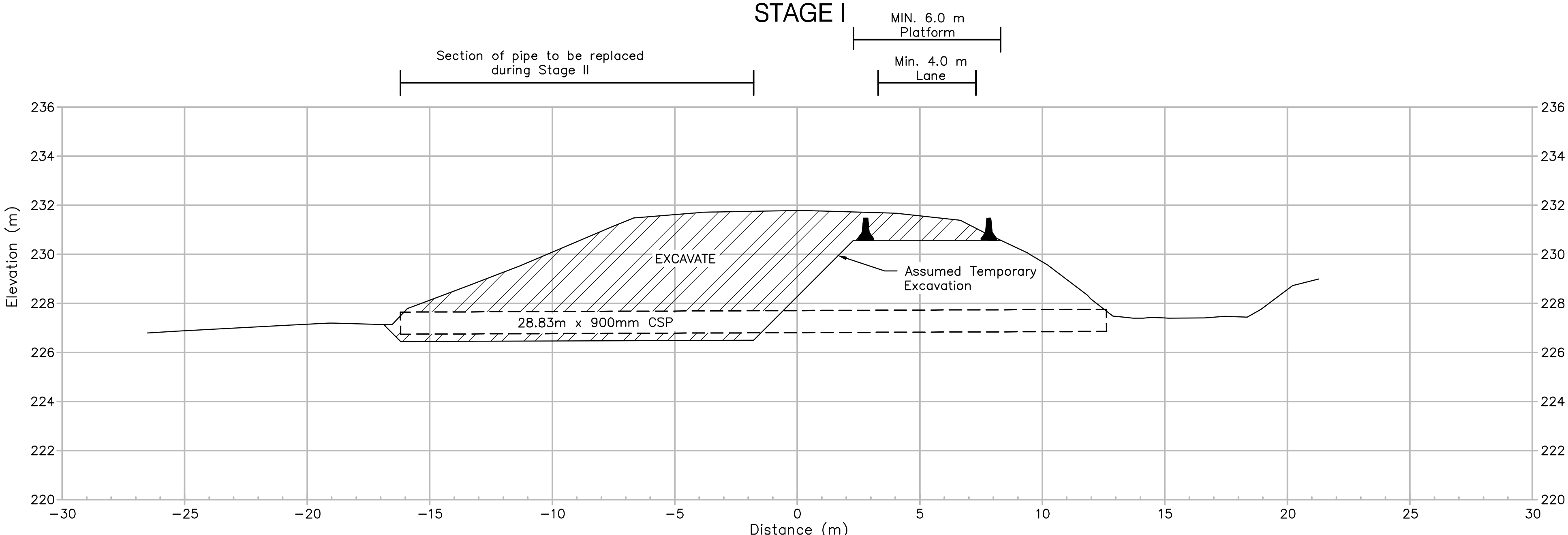
Table A – Comparison of Shoring Alternatives

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	Considered for protection system. Not recommended due to very stiff/ dense till deposits.	\$ 650/m^2
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Recommended for temporary protection.	\$ 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	Not considered due to higher cost	\$ 725/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 Considered due to higher costs	
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 Considered due to higher costs	\$ 900/m^2

REF.: 15059-F6



STAGE I



STAGE II

METRIC

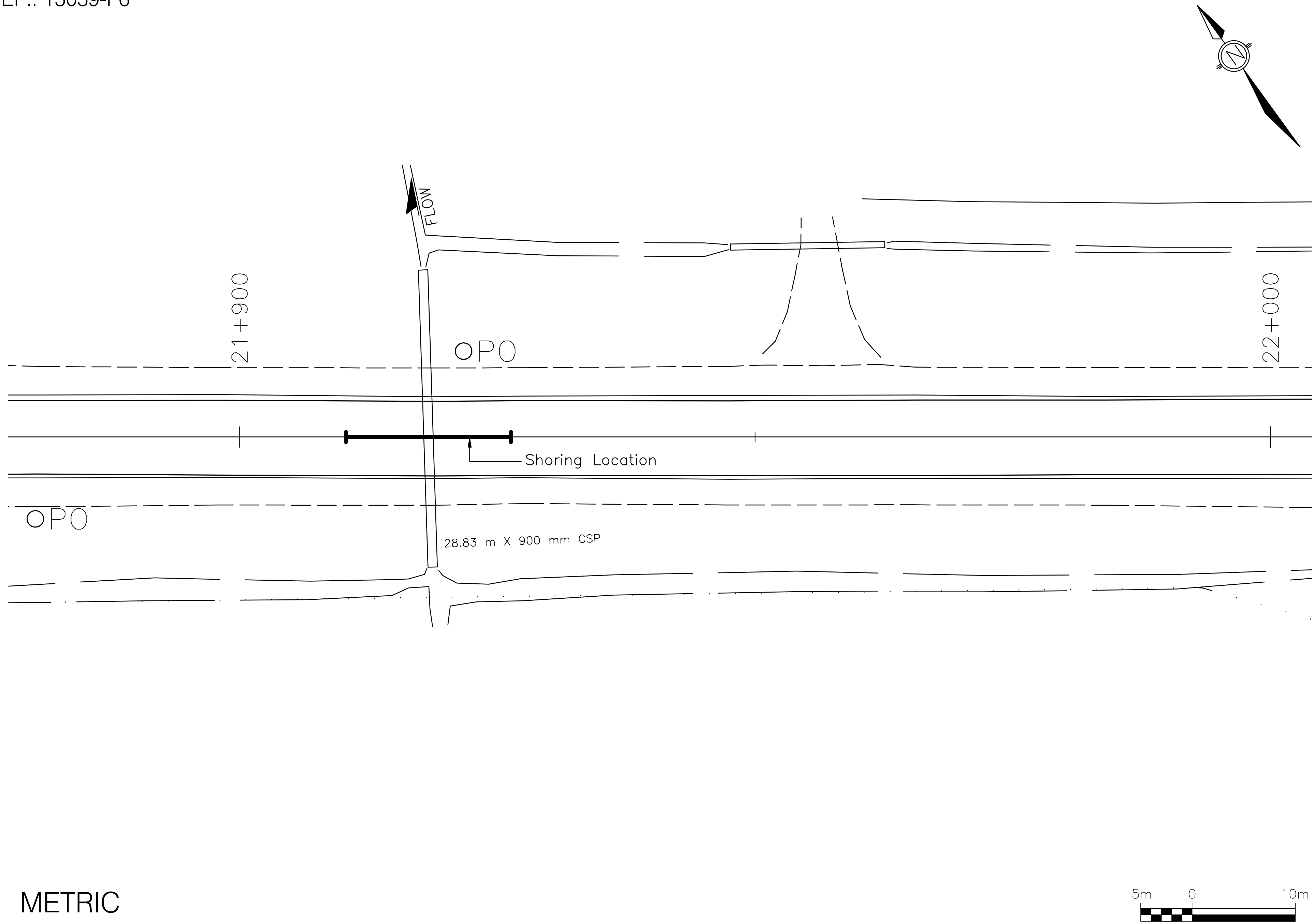
Dimensions are in meters and/or millimeters unless otherwise shown. Stations are in kilometers + meters.

2.5m 0 5m

Highway 11, Township of Idington - Culvert at Station 21+918
Conceptual Staging Cross-Section

FIGURE SK-3

REF.: 15059-F6



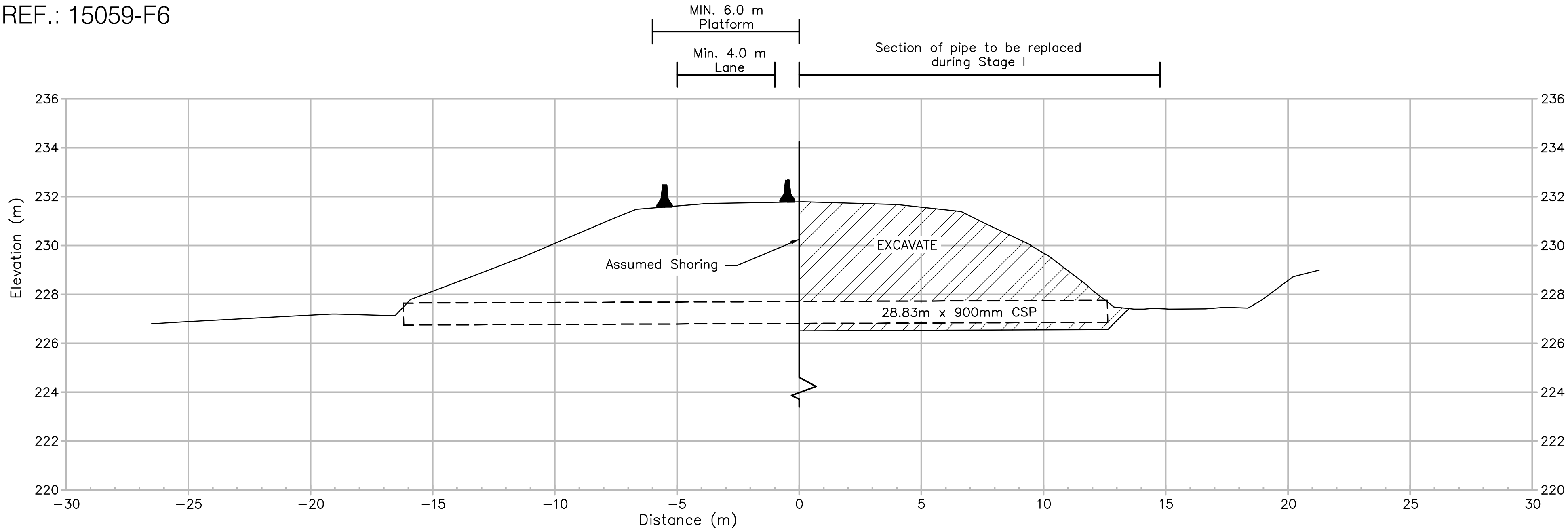
METRIC

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

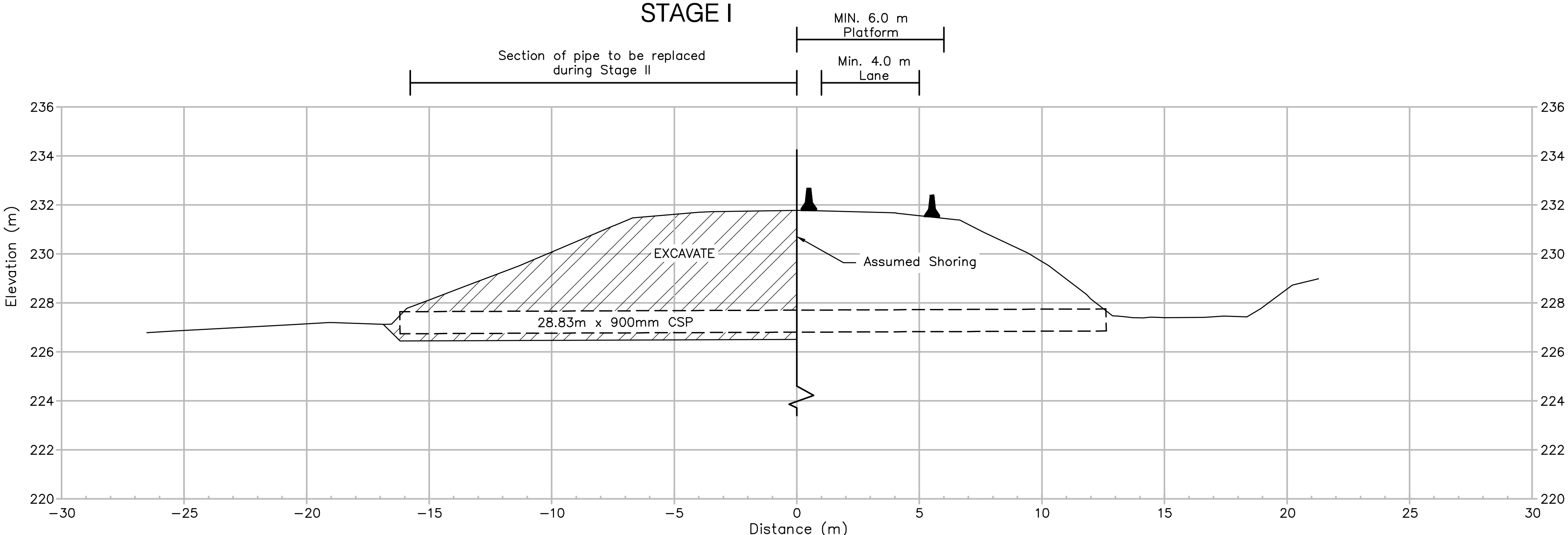
Highway 11, Township of Idington - Culvert at Station 21+918
Conceptual Shoring Location Plan

FIGURE SK-4

REF.: 15059-F6



STAGE I



STAGE II

METRIC

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

2.5m 0 5m

Highway 11, Township of Idington - Culvert at Station 21+918
Conceptual Shoring Cross-Section

FIGURE SK-5