LVM Merlex

Geotechnical, Materials and Environmental Engineering

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 60
Station 10+080 - Twp. of Chaffey
GWP 5005-05-00

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

Date: July 23, 2015
Ref. №: 14/07/14083-F1

Geocres No. 31E-351

LVM Merlex

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 60
Station 10+080 - Twp. of Chaffey
GWP 5005-05-00

Final Foundation Investigation and Design Report

Prepared by:

Alexander Tepylo, P.Eng.
LVM-Merlex – Project Engineer

LICENSED PROFESSIONAL ENGINEER S. HU 90524232 15/07/23 PROVINCE OF ONTARIO

Sen Hu, P. Eng.
LVM-Merlex – Senior Geotechnical Engineer

Reviewed by:

REGISTERED PROFESSIONAL ENGINEER M. A. MERLEAU 15/07/23 PROVINCE OF ONTARIO

M.A. Merleau, P. Eng.
LVM-Merlex – Principal Engineer
MTO Designate

TABLE OF CONTENTS

Property and Confidentiality

"This engineering document is the property of LVM-Merlex, a Division of EnGlobe Corp. (LVM-Merlex) and, as such, is protected under Copyright Law. It can only be used for the purposes mentioned herein. Any reproduction or adaptation, whether partial or total, is strictly prohibited without having obtained LVM-Merlex's and its client's prior written authorization to do so.

Test results mentioned herein are only valid for the sample(s) stated in this report.

LVM-Merlex's subcontractors who may have accomplished work either on site or in laboratory are duly qualified as stated in our Quality Manual's procurement procedure. Should you require any further information, please contact your Project Manager."

Client:
AECOM Canada Ltd.
189 Wyld Street, Suite 103
North Bay, Ontario
P1B 1Z2
Attention: **Mr. Al Rose**

REVISION AND PUBLICATION REGISTER		
Revision N°	Date	Modification And/Or Publication Details
00	2015-03-25	DRAFT FIDR Issued
01	2015-07-22	FINAL FIDR Issued

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

1 INTRODUCTION

LVM-Melex, a Division of EnGlobe Corp. (LVM-Merlex) 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 centerline culvert site. The site is located at approximately Station 10+080 in the Township of Chaffey on Highway 60, some 80 m east of the centreline of Highway 11.

The foundation investigation location was specified by the MTO in the Terms of Reference for work under Agreement No. 5013-E-0032. The terms of reference for the scope of work are outlined in LVM-Merlex's Proposal P-13-051, dated May, 2014. The purpose of this investigation was to determine the subsurface conditions in the area of the existing culvert. LVM-Merlex 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 60 at Station 10+080 in the Township of Chaffey. 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 west-east direction. The existing highway, at the culvert location, is constructed on a fill embankment (bridge approach) some 8.1 m in height, with centerline elevation of 310.0 m at the culvert location. The existing embankment slopes in the area of the culvert have been established at angles of approximately 2.1H:1V. The culvert at this location is a 910 mm diameter Corrugated Steel Pipe (CSP) culvert, some 51 m in length. Flow through the culvert is from north to south (left to right).

2.1 SITE PHYSIOGRAPHY AND SURFICIAL GEOLOGY

This project is located in the Geomorphic Sub-province known as the Muskoka Ridges and Pockets. The topography on this section of Highway 60 is generally rolling. Significant layers of earth overlay the bedrock. Organic materials were also observed. Within the project area native overburden consists primarily of sands overlying bedrock.

Bedrock in the area consists of migmatitic rocks and gneisses of undetermined protolith.

3 INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out during the period of October 14th to December 18th, 2014 during which time five (5) sampled boreholes, were advanced. Three (3) boreholes were advanced through the embankment at the location of the culvert, and a single borehole was advanced at each of the inlet (north) and outlet (south) ends of the culvert.

The field investigation was carried out using both a truck and bombardier mounted CME drilling rig 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 further 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(s) 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 LVM-Merlex 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-4 and Table No. L-5).

The location of the individual boreholes were 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 10+080, TWP OF CHAFFEY

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, five (5) sampled boreholes were put down at this site, with Borehole No. 1, 2, and 3, advanced through the embankment, Borehole No. 4 advanced at the culvert invert, and Borehole No. 5 advanced at the culvert outlet. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 5 were recorded at elevations 309.6, 309.9, 310.0, 303.2, and 303.3 m, respectively.

4.1.1 Pavement Structure

A pavement layer consisting of 100 to 150 mm of asphalt was encountered at Borehole Nos. 1 and 2. At Borehole No. 3, advanced through the paved raised median, a layer of asphalt some 60 mm thick was penetrated. Underlying the asphalt at Borehole No. 1, a layer of crushed gravel, some 50 mm thick, was penetrated.

4.1.2 Granular Fill

Underlying the pavement layers at Borehole Nos. 1, 2, and 3, and at surface at Borehole No, 5, a layer of fill consisting of brown sand trace to some silt trace to some gravel, was penetrated. Cobbles size rock pieces were encountered in this fill layer. The natural moisture content measured on samples of this deposit was in the order of 2 to 11%. Gradation analyses were carried out on four (4) samples of this deposit, the results of which indicated 3 to 16% gravel size particles, 78 to 93% sand size particles, and 4 to 6% silt and clay size particles (Figure No. L-1, Appendix 3). Based on SPT 'N' values of 8 to 44 blows per 300 mm penetration, the compactness of this deposit was described as loose to dense (generally compact). This deposit was encountered to depths of 5.6, 5.6, 5.6, and 0.7 m below grade at Borehole Nos. 1, 2, 3, and 5, respectively (elevations 304.0, 304.3, 304.4, and 302.6 m).

4.1.3 Silt Fill

Underlying the granular fill deposit at BH Nos. 1, 2, and 3, a deposit of fill consisting silt trace sand trace clay was penetrated. A layer of asphalt and crushed gravel was encountered underlying the silt fill at a depth of 6.2 m below grade (elevation 303.4 m) at the location of Borehole No. 1. The natural moisture content measured on samples of this deposit was in the order of 19 to 22%. A hydrometer analyses was carried out on one (1) sample of this deposit, the results of which indicated 0% gravel size particles, 5% sand size particles, 89% silt size particles, and 6% clay size particles (Figure No. L-2, Appendix 3). Based on SPT 'N' values of 15 to 34 blows per 300 mm penetration, the compactness of this deposit was described as compact to dense. This deposit was encountered to a depth of 6.7, 7.2, and 7.2 m below grade at Borehole Nos. 1, 2, and 3, respectively (elevations 302.9, 302.7, and 302.8 m, respectively).

4.1.4 Silty Sand Fill

Underlying the granular fill at BH No. 5, a layer of fill consisting of silty sand trace gravel was encountered. The natural moisture content measured on samples of this deposit was in the order of 18%. A gradation analysis was carried out on one (1) sample of this deposit, the results of which indicated 1% gravel size particles, 60% sand size particles, and 39% silt and clay size particles (Figure No. L-3, Appendix 3). Based on SPT ‘N’ values of 32 blows per 300 mm penetration, the compactness of this deposit was described as dense. This deposit was encountered to a depth of 1.4 m below grade at Borehole No. 5 (elevation 301.9 m).

4.1.5 Sands

Underlying the silt fill at Borehole Nos. 1, 2, and 3, underlying the silty sand fill at Borehole No. 5, and at surface at Borehole No. 4, a deposit of grey sand some to with silt trace to with gravel was penetrated. Cobble size rock pieces were encountered in this deposit. The natural moisture content measured on samples of this deposit was in the order of 10 to 16%. Gradation analyses were carried out on two (2) samples of this deposit, the results of which indicated 0 to 29% gravel size particles, 58 to 88% sand size particles, and 12 to 13% silt and clay size particles (Figure No. L-4, Appendix 3). Based on SPT ‘N’ values of 51 to 80 blows per 300 mm penetration, this deposit was described as very dense. Auger refusal on bedrock was encountered at depths of 9.8, 9.7, 9.4, 0.2, and 3.4 m below grade at Borehole Nos. 1 to 5, respectively (elevations 299.8, 300.2, 300.6, 303.0, and 299.9 m, respectively).

4.1.6 Bedrock

Underlying the above described sands at Borehole Nos. 1 to 5, bedrock was proven by diamond core drilling. The bedrock was described as grey gneiss bedrock. Based on RQD values of 73 to 100% the bedrock was described as fair to excellent quality. Sampling in the bedrock was terminated at depths of 12.9, 12.7, 12.8, 3.2, and 6.4 m below grade at Borehole Nos. 1 to 5, respectively (elevations 296.7, 297.2, 297.2, 300.0, and 296.9 m, respectively). 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 (December 18, 2014), the creek water level at the culvert outlet was measured at elevation 302.2 m.

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 4 to obtain the water levels post borehole completion. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix 2). The water levels were measured at elevations 302.5, 302.4, 302.3, 302.5, and 302.1 m at Borehole Nos. 1 to 5 between November 24 and December 18, 2014, respectively.

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

5 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

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

The existing culvert, located at Station 10+080, in the Township of Chaffey, is a 910 mm diameter CSP culvert some 51 m long. The existing culvert invert at centerline of highway is at a depth of some 8.1 m (elevation 301.9 m). The existing highway embankment currently supports two lanes of highway, running in an east-west direction. This culvert is located at the east approach to the Highway 11 overpass and a centerline median separates the two lanes of traffic. Flow through the culvert is from left to right (north to south). 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 mixed. The native material, underlying the embankment fill, generally consisted of very dense sands underlain by bedrock, at a relatively shallow depth.

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

5.2 FOUNDATION CONSIDERATIONS

The founding native very dense sands present below the existing embankment are considered adequate for support of a culvert and for a conventional highway embankment of this height. 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.

Based on the characteristics of the native sand subgrade present below the culverts, the response of the existing embankment, and a founding elevation similar to that of the existing culverts, a factored bearing resistance at ULS of 600 kPa can be used for a closed culvert. In consideration of the width of the culvert, depth of overburden, and response of the existing embankment, a geotechnical reaction at SLS of 300 kPa can be used for design, in consideration of 25 mm settlement.

The shallow bedrock was encountered at depth of 0.2 m below ground surface at location of Borehole No. 2 adjacent to the existing inlet of the culvert. The bedrock encountered at the site is described as fair to excellent quality, based on RQD data. As such, a geotechnical resistance at ULS not less than 1,000 kPa on the bedrock is appropriate with a minimum footing width of 600 mm. Since the bedrock is essentially an unyielding subgrade, a geotechnical reaction at SLS does not apply.

5.2.1 Slope Stability

A stability analysis, using the GEO-SLOPE computer program, Slope/W (GeoStudio 2007, version 7.17, Geo-Slope International Ltd.), was carried out at this location with standard embankment slopes of 2.0H:1.0V in granular fill. For the purposes of these analyses, the materials were modeled using the following parameters;

PARAMETER	MATERIAL		
	GRANULAR FILL	SILT FILL/SILTY SAND FILL	SAND
Unit Weight (kN/m^3)	20.0	18.0	18.5
Effective Friction Angle (degrees)	32	30	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 results of the analyses indicated a factor of safety for the new embankment in the order of 1.4 (see Figure No. S-1, Appendix 5). Lower factors of safety will occur during excavation and backfilling as discussed in Section 5.6. Short term stability should not be an issue if construction is carried out as described herein. The long term stability of the new embankment will not be an issue provided it is properly constructed.

5.3 CULVERT DESIGN, BEDDING, AND EMBEDMENT

The embankment consists of granular and silt to silty sand fills. The results of this investigation indicate that, below the culvert invert, the native soils consisted of very dense sands overlying bedrock. A review of the condition of the pavement surface, at the culvert locations, revealed some minor asphalt cracking, however, in general, the embankment appears to have performed well. The existing embankment has preloaded the soils at the culvert locations and since there will be no change in the height of the embankment, and therefore no increases in embankment load, no appreciable 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 19 mm clear stone bedding may be used, which would aid in dewatering operations. During backfilling, the embedment loose fill should be placed in uniform lifts not greater than 200 mm in thickness per OPSS 422, and a balanced manner on each side of the pipe. The elevation difference of the backfill on either side of the pipe must be limited to a maximum height of 200 mm. 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 in accordance with OPSS 501.

Considering the porous nature of the embankment fill and shallow pipe grade, 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 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.

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 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 embedment 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 fill should be placed in uniform lifts not greater than 200 mm in thickness for the full width of the trench per OPSS 401, and in a balanced manner on the outer sides of the culvert units. The elevation difference of the embedment fill on either side of the culvert must be limited to a maximum 200 mm.

Considering the porous nature of the embankment fill and shallow pipe grade, 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 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.

5.4 CULVERT INSTALLATION AND CONSTRUCTION STAGING CONSIDERATIONS

The invert elevation of the existing culvert is at 301.9 m, with the top of the embankment at elevation 310.0 m at centerline. As such, the embankment at this location is some 8.1 m in height above the culvert invert at the centerline. Therefore, a minimum 8.4 m deep excavation (i.e. to elevation 301.6 m) will be required in consideration of a 300 mm thick layer of bedding/embedment material. It is understood that the preferred method of carrying out the culvert replacement is to temporarily close the interchange to allow culvert replacement with open cut excavation. However, staged excavation and roadway protection will be discussed.

The present platform width at this location is some 19 m as can be seen on the cross section 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. However, considering the culvert is located in the approach to the Highway 11 overpass, lowering the grade is not considered feasible. As such open excavation using staged construction will not be discussed further.

5.4.1 Protection System

As noted above, consideration could be given to constructing a vertical wall, along centerline, for use as a temporary protection system. However, it should be noted that a centerline median is present along the approach. This must be accounted for if a protection system is used to allow culvert replacement.

The installation of a protection system for use in the culvert replacement operation will require penetration through some 8.4 m of fills. The embankment fills are generally underlain by very dense sands with bedrock at a relatively shallow depths ranging from 1 m above to 1.7 m below the culvert invert (i.e. elevation 303 m at location adjacent to the inlet, elevation 300.6 m at the centreline location, and elevation 299.9 m at location adjacent to the outlet). Cobble size rock pieces were encountered in the embankment fills and the bedrock was encountered at relatively shallow depths below the embankment fills and native soils at this culvert location, which may result in difficulty to adequately fix the toe of the steel sheet piles into the bedrock to resist the active pressure of the backfill. As such, if a temporary flexible wall is required for protection it would be more appropriate to use a shoring wall which requires drilled support members to penetrate a sufficient depth into very dense native soils/bedrock at the base of excavation.

One method to construct a protection system would be to penetrate the embankment fill with H piles (soldier piles) extending into the underlying very dense sands and/or into bedrock and install lagging with the required dewatering system as discussed in Section 5.6. Pre-drilling may likely be required to advance the H piles through the embankment fills, if oversized obstacles are encountered, and into the underlying bedrock to allow sufficient toe resistance. The H piles would be installed at an interval of 2 to 3 m apart and the lagging would be installed as the excavation progresses. Alternatively, a caisson wall or a drilled micropile system with an intermediate support system of reinforced shotcrete, to act as lagging, could be considered for roadway protection at this site; however these shoring systems are generally more costly.

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

$$R = \sigma_z' A_s L_s \alpha_g$$

Where: σ_z' = effective vertical stress at the midpoint of the load carrying length

A_s = effective unit surface area of the anchor

L_s = effective embedment length of the anchor

α_g = anchorage coefficient use 1.0 for granular backfill

For tieback design, a triangular earth pressure distribution over the height of the cut would be appropriate for design.

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

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 and a schematic cross section are illustrated on Figures Nos. SK-4 and SK-5 in 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 granular 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 $0.65 * K_a * \gamma * H$, 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 geostructural 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 design parameters for the bedding/embedment and backfill materials are as follows:

PARAMETER	GRANULAR A	GRANULAR B TYPE I	GRANULAR FILL	SILT FILL/SILTY SAND FILL	SANDS
Unit Weight (kN/m^3)	22.8	21.2	20.0	18.0	18.5
Angle of Internal Friction	34°	31°	32°	30°	32°
Coefficient of Active Earth Pressure (Ka)	0.28	0.32	0.31	0.33	0.31
Coefficient of Passive Earth Pressure (Kp)	3.54	3.12	3.25	3.00	3.25
Coefficient of Earth Pressure at Rest (Ko)	0.44	0.48	0.47	0.50	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.

5.6 EXCAVATION, DEWATERING, AND EMBANKMENT RECONSTRUCTION

All 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 will have to be cut back to an angle of 2H:1V, possibly shallower, dependent upon the Contractors' chosen method of controlling the groundwater. Temporary open cuts with a slope of 1H:1V cannot be left unattended (i.e. overnight, during breakdowns, etc.). If work must stop for extended periods of time, the temporary slopes must be flattened to a minimum angle of 2H:1V.

The excavation backfill should consist of Select Subgrade Material (SSM) as per OPS.PROV 1010, at a minimum, up to the underside of the pavement structure. An SSM material must be used within the depth of frost penetration. 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 mulch and seed to prevent ravelling. The seeding operations should be carried out in accordance with OPSS 804 requirements.

Bedrock was not encountered at the borehole locations within the anticipated depth of excavation, except at the location of Borehole No. 4; therefore bedrock excavation and/or blasting operations may be required at the culvert invert. It should be noted that bedrock elevation in the area can vary significantly over short horizontal distances. If blasting is required reference shall be made to OPSS 120. A blast design is required to be provided by the blasting contractor before blasting operations are carried out. A pre-blast survey (OPSS 120.07.03) and/or blast monitoring is probably not required considering the minimal depth and quantity of rock removal required.

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 was recorded at elevation 302.2 m at the time of this investigation and excavations to an approximate elevation 301.6 m will be required to install the culvert and bedding. As such dewatering will 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. 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 effectively lower the groundwater to a greater depth, a more sophisticated groundwater control system, such as a well points or closed sheeting, would have to be considered. To provide a stable working surface the water level must be controlled to below the base of excavation. When wet, silty/sandy subgrades can become easily disturbed, and can lose a significant 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. Shoring piles may also be considered for controlling stream flow; however, the generally shallow bedrock at the inlet and outlet (i.e. at depths of 0.2 and 3.4 m below ground surface at Borehole Nos. 4 and 5, respectively), will limit the penetration of a steel sheet pile type cofferdam. For base design, shoring piles should extend a minimum depth below base of proposed excavation equal to the height of water above the base of excavation. By-pass pumping can be carried out to divert the stream flow at the time of construction. It is recommended that by-pass pumping, through a temporary culvert installed through the embankment, be carried out to divert the stream flow past the work area isolated with the cofferdam system. 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.

5.7 CONSTRUCTION CONCERNS

Considering the nature of the granular fill embankment, no major construction concerns are anticipated if construction is carried out in general conformance with the above discussion. However, the cobble size rock pieces encountered in the embankment fills and native soils at varying depths, and the bedrock, which was encountered at relatively shallow depths below the embankment fills and native soils, must be recognized by the contractor. The contractor should be prepared to deal with these materials for dewatering, temporary protection system and other construction activities.

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 LVM-Merlex 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 LVM-Merlex 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

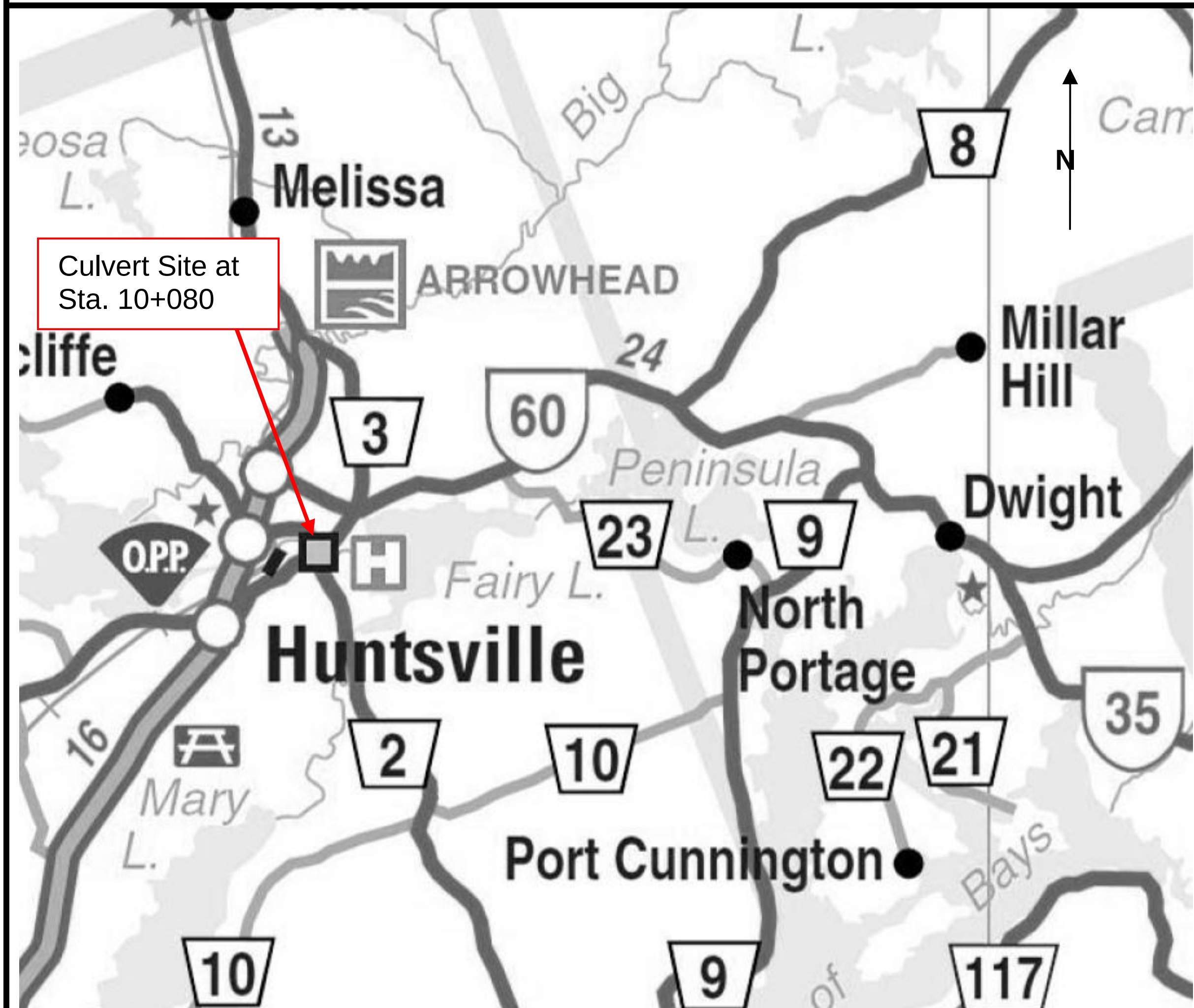
Drawing No. 1	Key Plan

LVM Merlex

KEY PLAN

Drawing No. 1

NOT TO SCALE



FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT
GWP 5005-00-00

Highway 60

Culvert 10+080, Township of Chaffey

Reference No: 14/07/13083-F1 July 2015

LVM Merlex

Appendix 2 Subsurface Data

Enclosure No. 1	List of Abbreviations and Symbols
Enclosure Nos. 2 to 6	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
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) *Cohesive Soils:*

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 2)

METRIC

RECORD OF BOREHOLE NO. 1

LVM Merlex

REFERENCE 14/07/14083-F1 DATUM Geodetic LOCATION N 5022967.1 E 325956.0 - Chaffey Twp., Station 10+089 ORIGINATED BY JL

PROJECT GWP 5005-05-00, Highway 60 BOREHOLE TYPE Truck Mounted CME 45 - Hollow Stem Augers and NQ Coring COMPILED BY AT

CLIENT AECOM DATE (Started) 14 October 2014 DATE (Completed) 17 October 2014 TIME (Completed) 11:30:00 AM CHECKED BY MAM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
309.6	Ground Surface					
0.0	100 mm Asphalt 50 mm Crushed Gravel FILL - sand trace silt trace gravel brown, dry (compact/dense)	1	SS	35	~0	
		2	SS	31	~1	16 78 (6)
		3	SS	44	~2	
		4	SS	40	~2	
		5	SS	30	~2	
		6	SS	31	~2	10 84 (6)
		7	SS	41	~3	
304.0 / 5.6	FILL - silt trace sand trace clay cobbles encountered (compact) Asphalt and crushed gravel encountered at 6.2 m depth	8	SS	27	~20	
302.9 / 6.7	SAND - some silt trace gravel cobbles encountered brown (very dense)	9	SS	81/175 mm	~7	
		10		25/0 mm		
299.8 / 9.8	Continued Next Page					

Ground water levels noted at approx. elev. 302.5 (7.1–7.2 m depth).

Legend: 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) 17/10/14 11:30:00 AM	DRY	-
2) 17/10/14 11:38:00 AM	7.2	-
3) 25/11/14 12:45:00 PM	7.1	-

MEL-GEO 14083 - BOREHOL LOGS - F1.GPJ MEL-GEO.GDT 23/3/15

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

METRIC

RECORD OF BOREHOLE NO. 1

LVM Merlex

REFERENCE 14/07/14083-F1	DATUM Geodetic	LOCATION N 5022967.1 E 325956.0 - Chaffey Twp., Station 10+089	ORIGINATED BY JL
PROJECT GWP 5005-05-00, Highway 60		BOREHOLE TYPE Truck Mounted CME 45 - Hollow Stem Augers and NQ Coring	COMPILED BY AT
CLIENT AECOM		DATE (Started) 14 October 2014 DATE (Completed) 17 October 2014 TIME (Completed) 11:30:00 AM	CHECKED BY MAM

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L – WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
	Continued from Previous Page										
	BEDROCK - grey gneiss										
	good to excellent quality		11	RC	Rec= 98% RQD= 88%		299				
			12	RC	Rec= 100% RQD= 100%		298				
							297				
296.7 12.9	End of Borehole										

MEL-GEO 14083 - BOREHOL LOGS - F1.GPJ MEL-GEO.GDT 23/3/15

LVM-Merlex, a Division of 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 2)

METRIC

RECORD OF BOREHOLE NO. 2

LVM Merlex

REFERENCE 14/07/14083-F1 DATUM Geodetic LOCATION N 5022959.6 E 325936.7 - Chaffey Twp., Station 10+072 ORIGINATED BY AT

PROJECT GWP 5005-05-00, Highway 60 BOREHOLE TYPE Truck Mounted CME 45 - Hollow Stem Augers and NQ Coring COMPILED BY AT

CLIENT AECOM DATE (Started) 24 November 2014 DATE (Completed) 24 November 2014 TIME (Completed) 2:15:00 PM CHECKED BY MAM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
309.9	Ground Surface					
0.0	150 mm Asphalt					
	FILL - sand some gravel trace silt brown, dry (compact/dense)	1	SS	19		
		2	SS	17		309
		3	SS	12		308
	cobble encountered below 2.3 m depth	4	SS	25		307
		5	SS	25		306
		6	SS	55/225 mm		
		7	SS	42		305
304.3 / 5.6	FILL - silt trace sand trace clay grey (compact)					304
		8	SS	15		303
302.7 / 7.2	SAND - some to with silt trace gravel cobbles encountered grey (very dense)				▽	
		9	SS	65/200 mm		302
						301
		10	SS	51		
300.2 / 9.7	BEDROCK - grey gneiss			Rec= 96%		300

Continued Next Page

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

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)

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) 24/11/14 2:15:00 PM	7.5	9.6
2)	-	-
3)	-	-

MEL-GEO 14083 - BOREHOL LOGS - F1.GPJ MEL-GEO.GDT 23/3/15

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

METRIC

RECORD OF BOREHOLE NO. 2

LVM Merlex

REFERENCE	14/07/14083-F1	DATUM	Geodetic	LOCATION	N 5022959.6 E 325936.7 - Chaffey Twp., Station 10+072
ORIGINATED BY	AT				
PROJECT	GWP 5005-05-00, Highway 60	BOREHOLE TYPE	Truck Mounted CME 45 - Hollow Stem Augers and NQ Coring	COMPILED BY	AT
CLIENT	AECOM	DATE (Started)	24 November 2014	DATE (Completed)	24 November 2014
TIME (Completed)	2:15:00 PM	CHECKED BY	MAM		

ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
	Continued from Previous Page										
	good to excellent quality		11	RC	RQD= 85%						
			12	RC	Rec= 93% RQD= 87%		299				
			13	RC	Rec= 100% RQD= 100%		298				
297.2 12.7	End of Borehole										

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

METRIC

RECORD OF BOREHOLE NO. 3

LVM Merlex

REFERENCE 14/07/14083-F1 DATUM Geodetic LOCATION N 5022962.3 E 325947.3 - Chaffey Twp., Station 10+082 ORIGINATED BY AT

PROJECT GWP 5005-05-00, Highway 60 BOREHOLE TYPE Truck Mounted CME 45 - Hollow Stem Augers and NQ Coring COMPILED BY AT

CLIENT AECOM DATE (Started) 25 November 2014 DATE (Completed) 25 November 2014 TIME (Completed) 9:48:00 AM CHECKED BY MAM

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
310.0	Ground Surface					
0.0	60 mm Asphalt FILL - sand trace silt trace gravel brown, dry (compact/dense) cobble encountered at 0.8 m depth	1	SS	16		
		2	SS	18		
		3	SS	18		3 93 (4)
		4	SS	38		
		5	SS	28		
	cobble encountered at 4.0 m depth	6	SS	33		
		7	SS	30		8 87 (5)
304.4 5.6	FILL - silt trace sand trace clay grey (dense)	8	SS	34		0 5 89 6 (NP)
302.8 7.2	SAND - some silt trace gravel cobble size rock pieces encountered grey (very dense)	9	SS	52	▽ (7.7)	0 88 (12)
300.6 9.4	BEDROCK - grey gneiss fair to excellent quality	10	RC	Rec= 100% RQD=	Cave (9.3)	

Elevation scale: 309, 308, 307, 306, 305, 304, 303, 302, 301

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

Continued Next Page

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) 25/11/14 9:48:00 AM	7.7	9.3
2)	-	-
3)	-	-

MEL-GEO 14083 - BOREHOL LOGS - F1.GPJ MEL-GEO.GDT 23/3/15

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

METRIC

RECORD OF BOREHOLE NO. 3

LVM Merlex

REFERENCE	14/07/14083-F1	DATUM	Geodetic	LOCATION	N 5022962.3 E 325947.3 - Chaffey Twp., Station 10+082
ORIGINATED BY	AT	PROJECT	GWP 5005-05-00, Highway 60	BOREHOLE TYPE	Truck Mounted CME 45 - Hollow Stem Augers and NQ Coring
COMPILED BY	AT	CLIENT	AECOM	DATE (Started)	25 November 2014
DATE (Completed)	25 November 2014	TIME (Completed)	9:48:00 AM	CHECKED BY	MAM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
	Continued from Previous Page				71%						
			11	RC	Rec= 100% RQD= 93%		299				
			12	RC	Rec= 88% RQD= 82%		298				
297.2 12.8	End of Borehole										

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

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

METRIC

RECORD OF BOREHOLE NO. 4

LVM Merlex

REFERENCE 14/07/14083-F1 DATUM Geodetic LOCATION N 5022986.4 E 325955.2 - Chaffey Twp., Station 10+083 ORIGINATED BY JL

PROJECT GWP 5005-05-00, Highway 60 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers and NQ Coring COMPILED BY AT

CLIENT AECOM DATE (Started) 17 December 2014 DATE (Completed) 18 December 2014 TIME (Completed) 2:55:00 PM CHECKED BY MAM

ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
303.2	Ground Surface										
303.0 / 0.0	SAND - sand some silt		1	SS	31/150 mm		303		○		
0.2	BEDROCK - grey gneiss fair to good quality		2	RC	Rec= 100% RQD= 73%		302				
			3	RC	Rec= 97% RQD= 89%		301				
300.0 / 3.2	End of Borehole						300				

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) 17/12/14 2:55:00 PM	0.8	-
2) 18/12/14 10:00:00 AM	0.7	-
3) 18/12/14 2:20:00 PM	0.7	-

MEL-GEO 14083 - BOREHOL LOGS - F1.GPJ MEL-GEO.GDT 23/3/15

ENCLOSURE NO.:6 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 5

LVM Merlex

REFERENCE 14/07/14083-F1 DATUM Geodetic LOCATION N 5022937.2 E 325935.0 - Chaffey Twp., Station 10+077 ORIGINATED BY JL

PROJECT GWP 5005-05-00, Highway 60 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers and NQ Coring COMPILED BY AT

CLIENT AECOM DATE (Started) 18 December 2014 DATE (Completed) 18 December 2014 TIME (Completed) 10:30:00 AM CHECKED BY MAM

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
303.3	Ground Surface					
0.0 / 302.6	FILL - sand trace to some silt trace gravel brown (loose)	1	SS	8		
0.7 / 301.9	FILL - silty sand trace gravel trace organics brown (dense)	2	SS	32	▽▼	1 60 (39)
1.4 / 299.9	SAND - trace to some silt with gravel; cobbles encountered below 1.8 m depth (very dense)	3	SS	80		
		4	SS	69	Cave in	29 58 (13)
		5	SS	100/50 mm		
3.4 / 296.9	BEDROCK - grey gneiss; good to excellent quality	6	RC	Rec= 100% RQD= 89%		
		7	RC	Rec= 100% RQD= 100%		
6.4						

Column headings: 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; ELEVATION SCALE 303–297; STRATA PLOT.

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)	18/12/14 10:30:00 AM	1.2 ▽	2.6
2)	18/12/14 2:05:00 PM	1.2 ▼	2.6
3)		- ▼	-

MEL-GEO 14083 - BOREHOL LOGS - F1.GPJ MEL-GEO.GDT 23/3/15

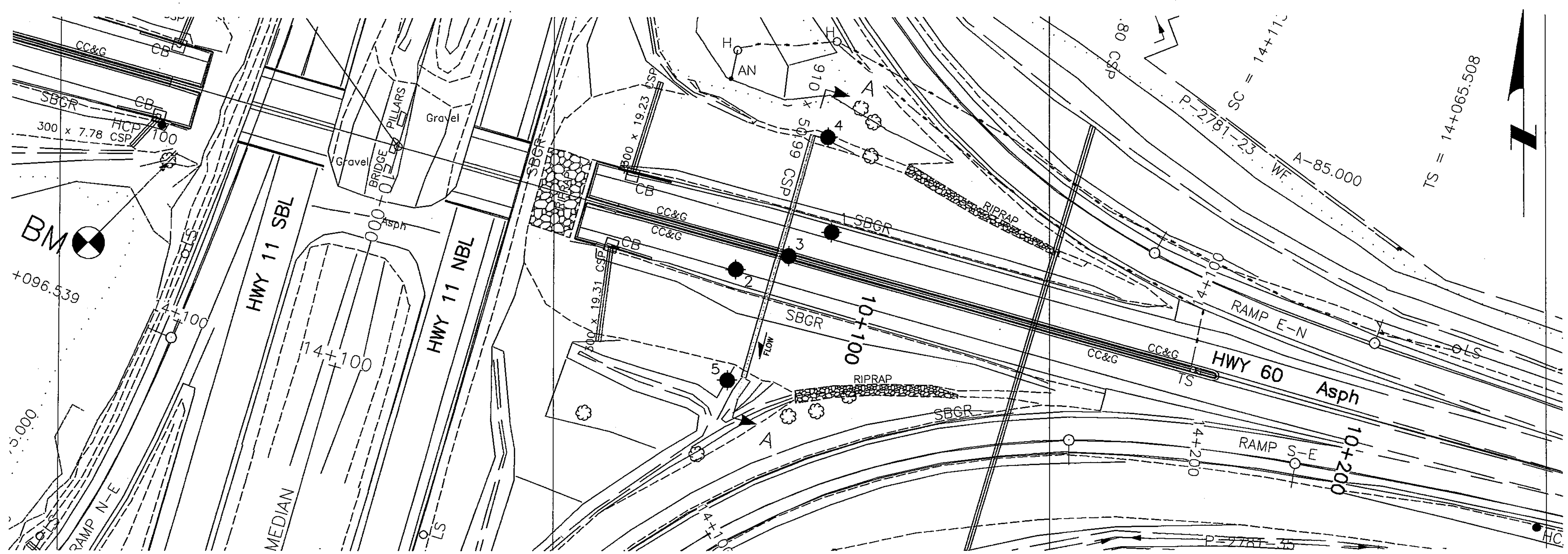
LVM-Merlex, a Division of EnGlobe Corp.

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 Lab Data

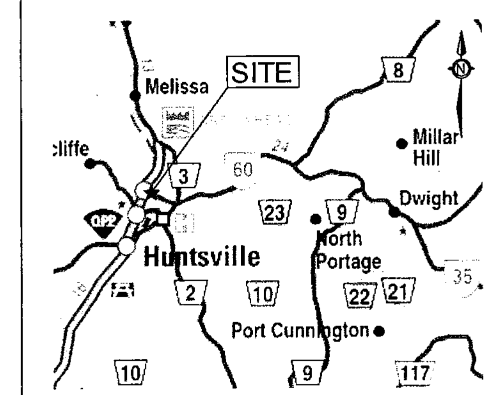
LVM Merlex

DISTRICT CONT. No. GWP No. 5005-05-00	
HWY 60 CULVERT AT STATION 10+080 CHAFFEY TOWNSHIP	DRAWING
BOREHOLE LOCATIONS AND SOIL STRATA	2
LVM Merlex	METRIC



PLAN

SCALE 10m 0m 10m



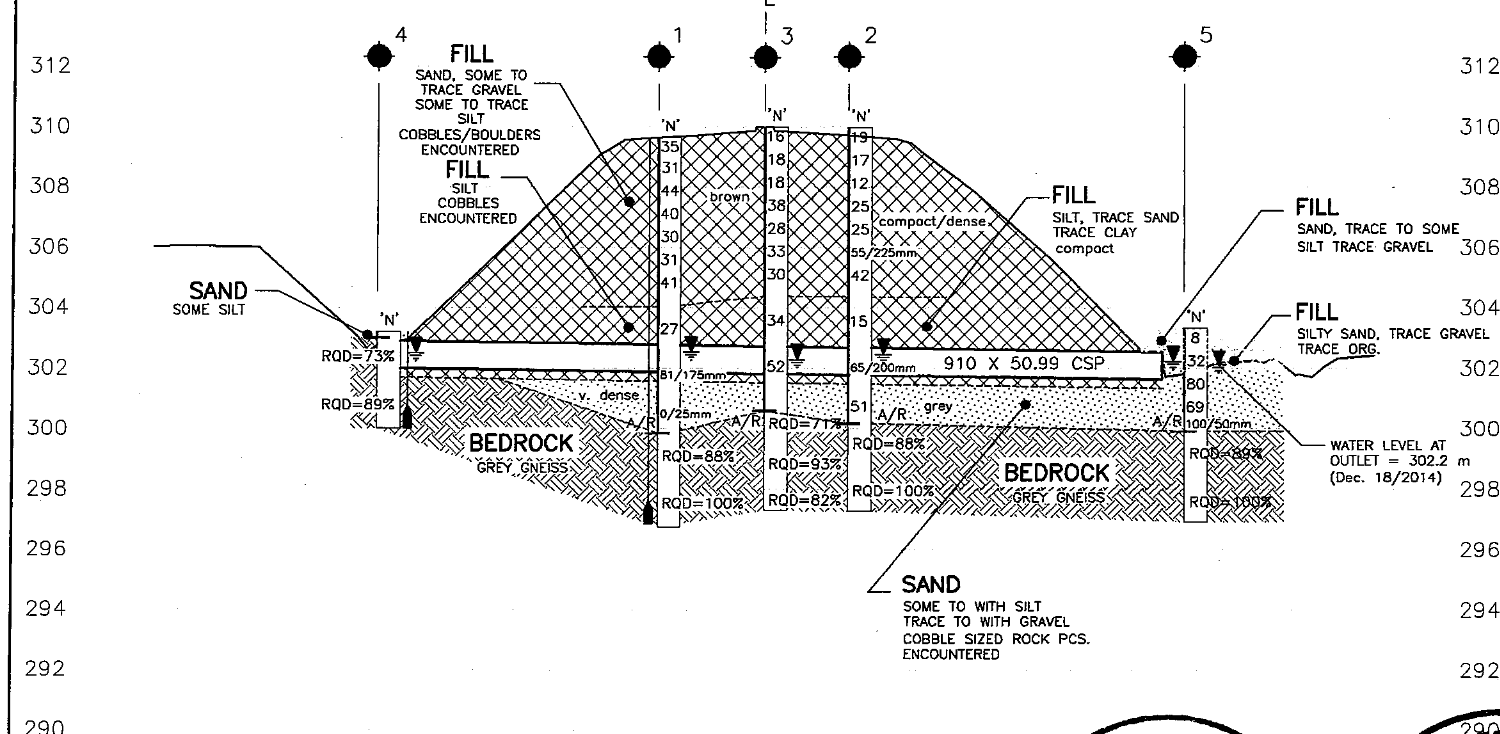
KEY PLAN

N.T.S.

LEGEND

Symbol	Description
●	Borehole
⊕	Borehole w/ Dynamic Cone Penetration Test
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	309.6	7.0m Lt	5022967.1	325956.0
2	309.9	5.5m Rt	5022959.6	325936.7
3	310.0	0m	5022962.3	325947.3
4	303.2	25.4m Lt	5022986.4	325955.2
5	303.3	27.5m Rt	5022937.2	325935.0

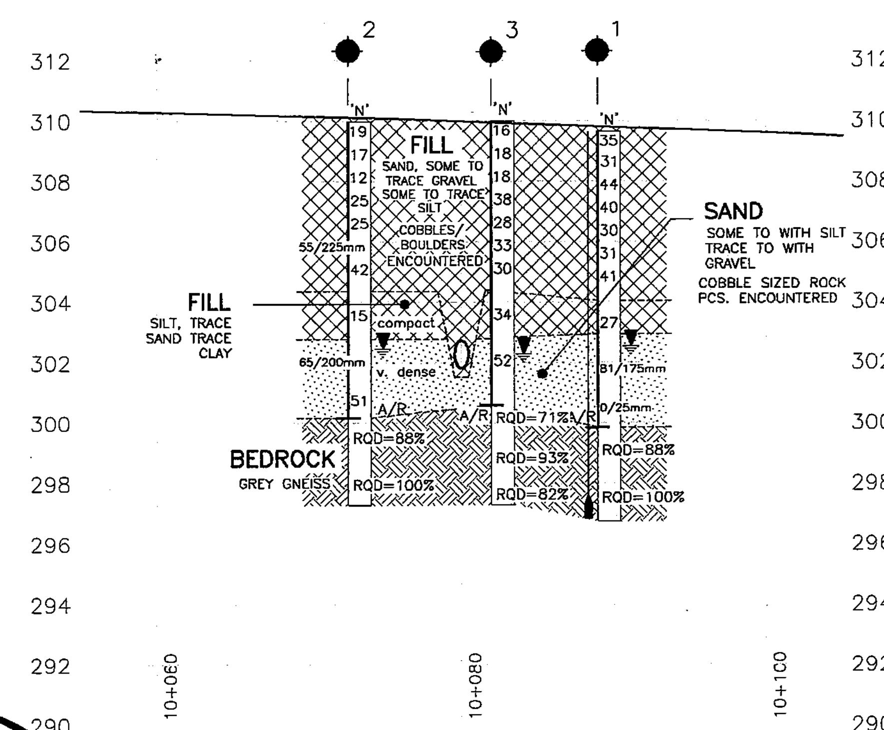


SECTION A-A

SCALE

HOR 10 5 0 10 20m

VERT 5 2.5 0 5 10m



C/L PROFILE of HWY 60

SCALE

HOR 10 5 0 10 20m

VERT 5 2.5 0 5 10m

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 exp. on February 6, 2015.

GEOCRES No. 31E-351

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.

REGISTERED PROFESSIONAL ENGINEER M. A. MERLEAU 15/07/23 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S. HU 90524232 13/07/23 PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED 50mm ON ORIGINAL DRAWING

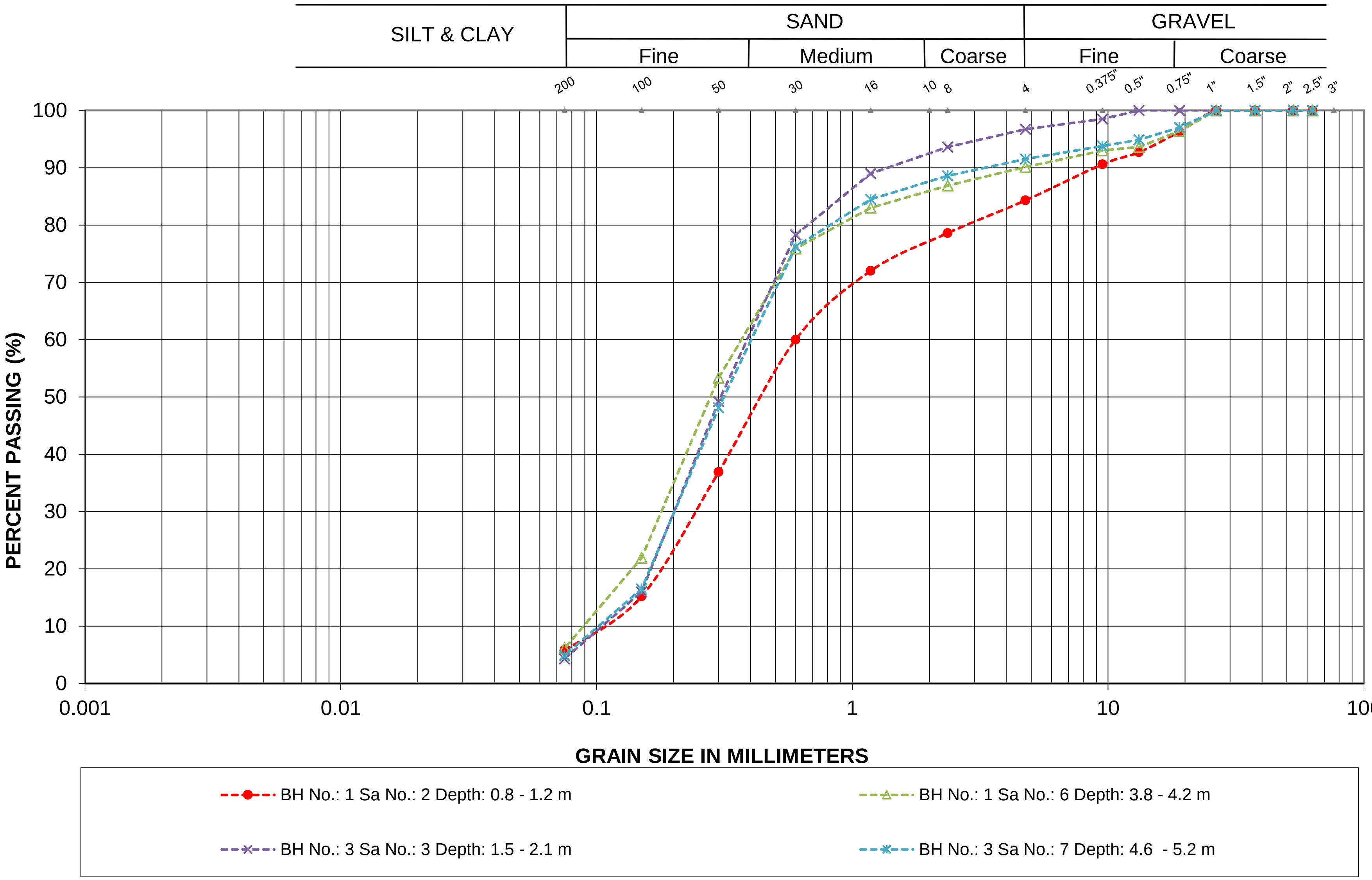
REVISIONS			
FEB/15	RG	DRAFT	
JUL/15	RG	FINAL	
		DESCRIPTION	

DESIGN	CHK	CODE	LOAD	DATE JUL/15
DRAWN RG	CHK AT	SITE	STRUCT	SCHEME	DWG 2

CAD FILE LOCATION AND NAME: \2014\14683 - PAV & FDN, Hwy 60, Huntsville (AECOM)\FOUNDATIONS\Drawings\F1\14683-F1 - BH Location Plan.dwg
MODIFIED: 7/22/2015 2:50:45 PM BY: GRASRY
DATE PLOTTED: 7/22/2015 2:53:21 PM BY: RYAN GRASSER

Reference No.: 14/07/14083-F1
Date: July 2015

GRAIN SIZE ANALYSIS



LOCATION: Hwy 60 CSP, Station 10+080
Chaffey TWP, Ontario

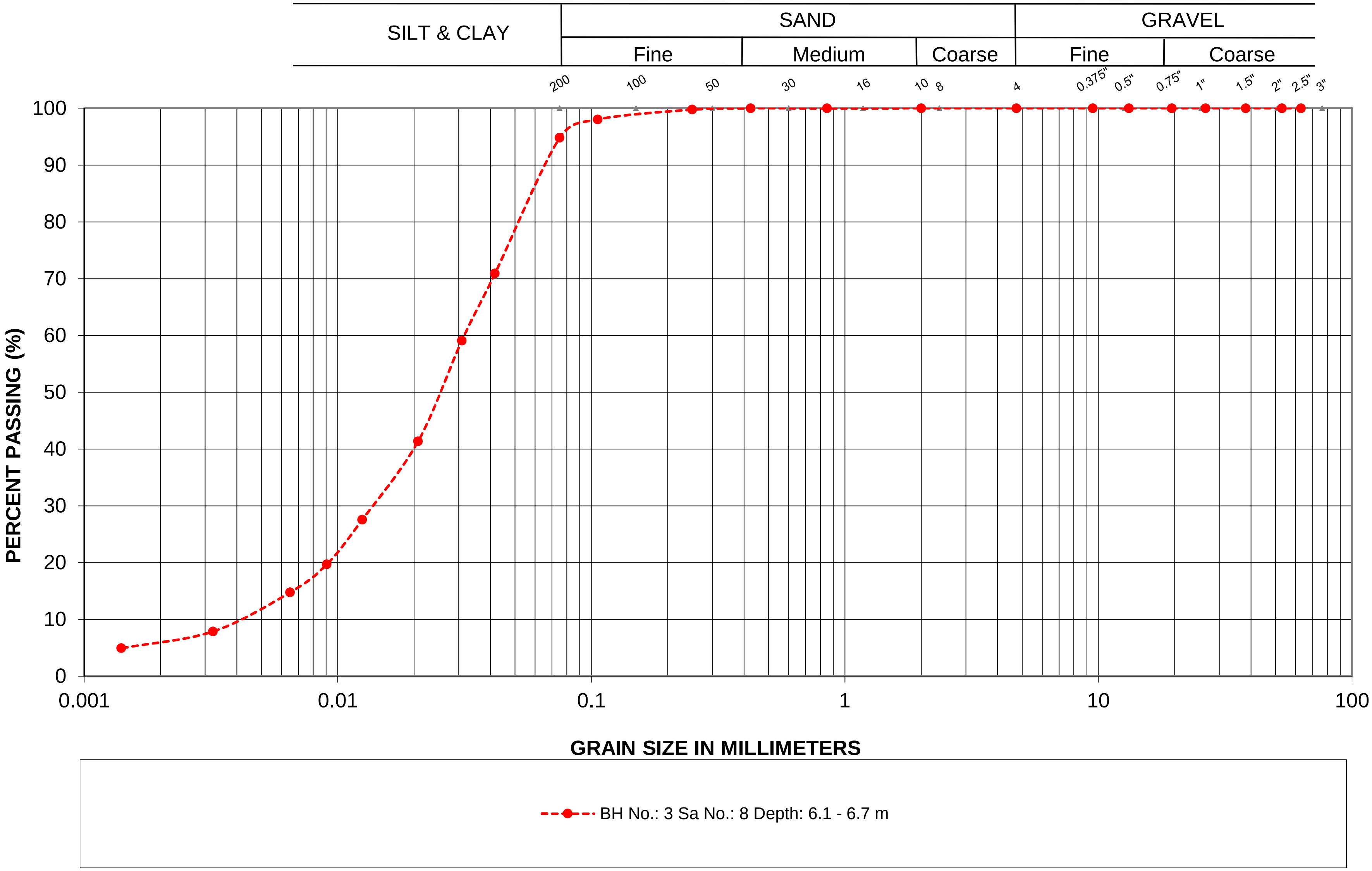
GRANULAR FILL

LVM-Merlex, a Division EnGlobe Corp.

FIGURE L-1

Reference No.: 14/07/14083-F1
Date: July 2015

GRAIN SIZE ANALYSIS



LOCATION: Hwy 60 CSP, Station 10+080
Chaffey TWP, Ontario

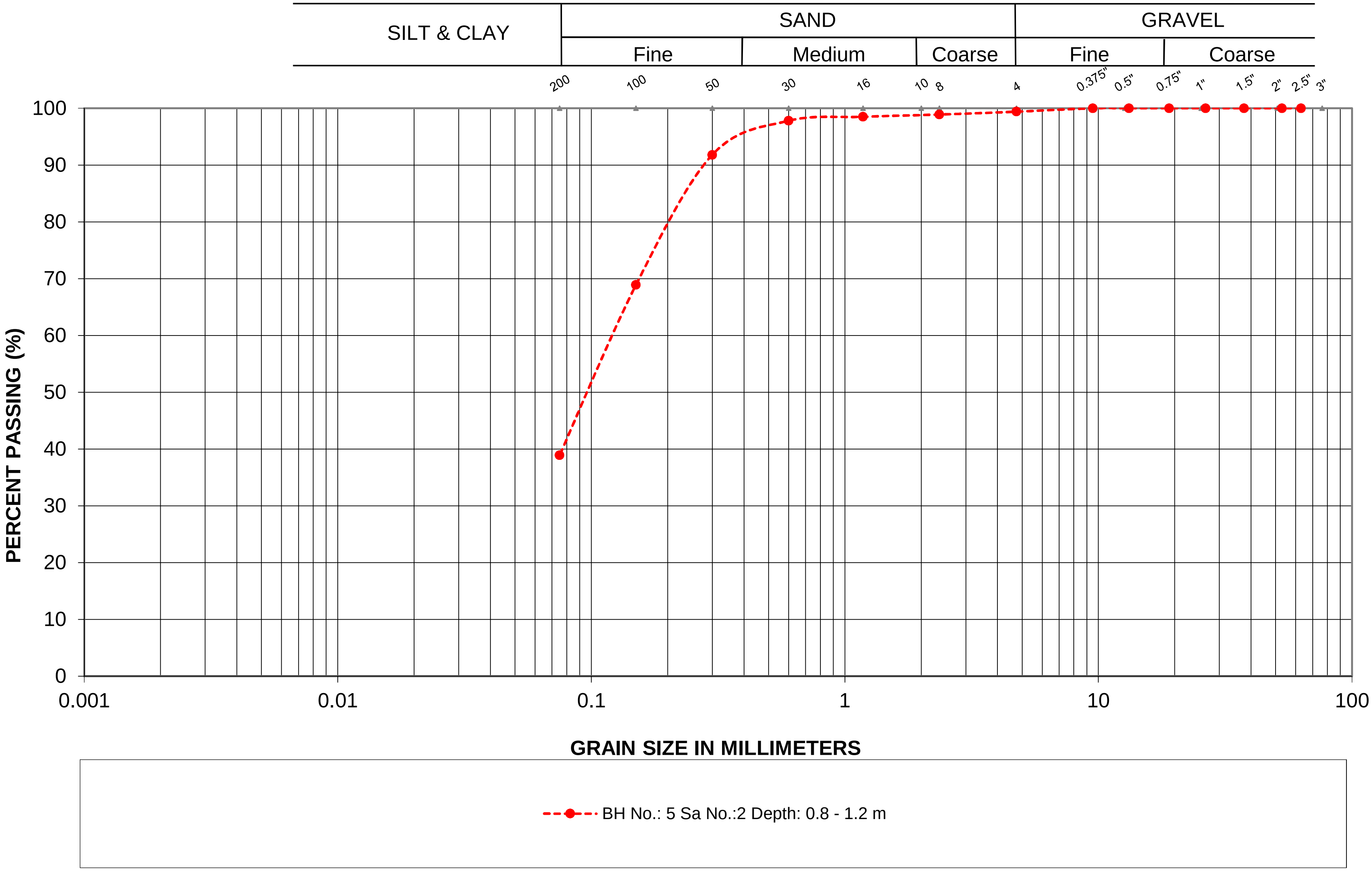
SILT FILL

LVM-Merlex, a Division EnGlobe Corp.

FIGURE L-2

Reference No.: 14/07/14083-F1
Date: July 2015

GRAIN SIZE ANALYSIS



LOCATION: Hwy 60 CSP, Station 10+080
Chaffey TWP, Ontario

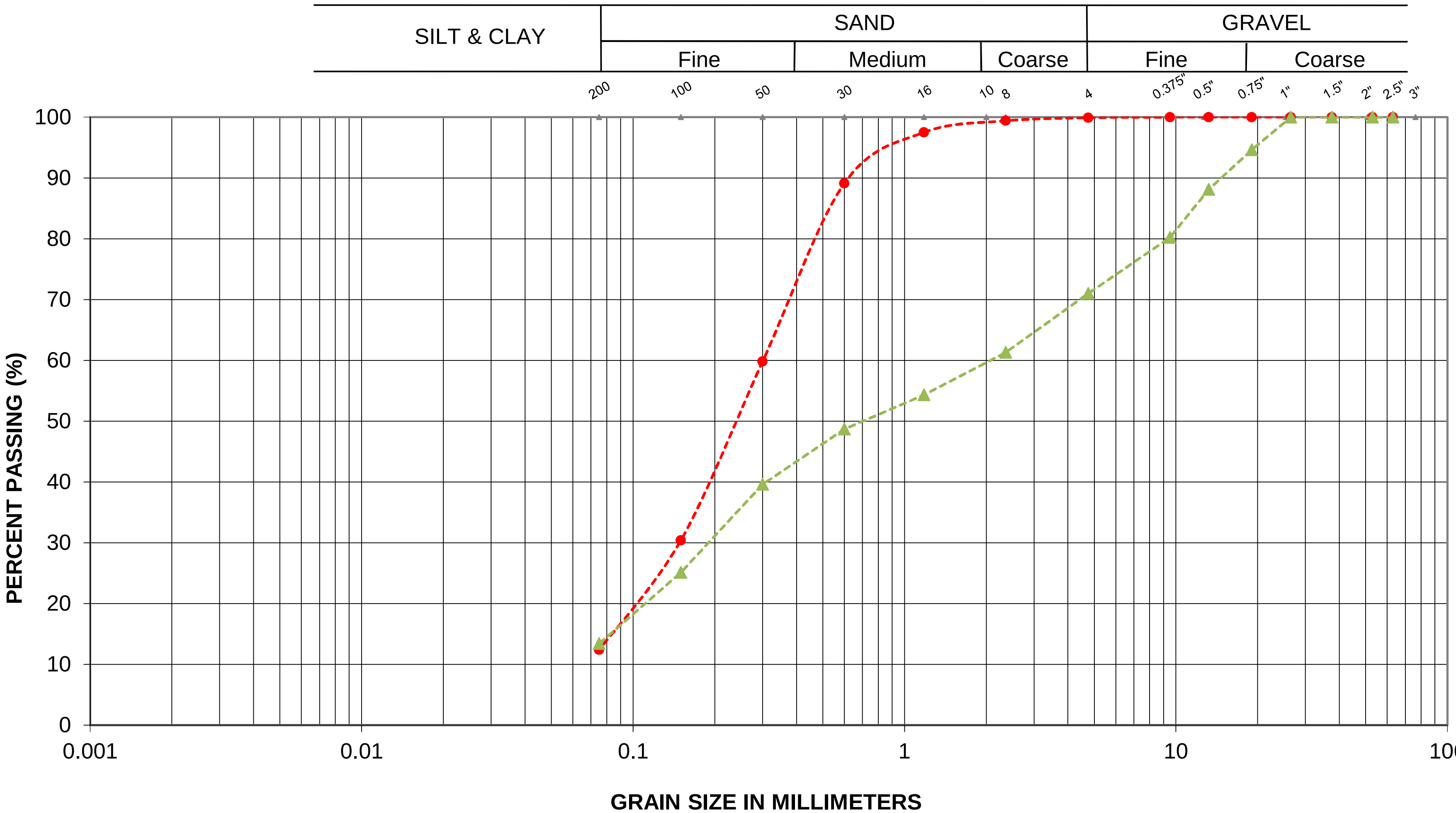
SILTY SAND FILL

LVM-Merlex, a Division EnGlobe Corp.

FIGURE L-3

Reference No.: 14/07/14083-F1
Date: July 2015

GRAIN SIZE ANALYSIS



LOCATION: Hwy 60 CSP, Station 10+080
Chaffey TWP, Ontario

SAND to SAND with GRAVEL

LVM-Merlex, a Division EnGlobe Corp.

FIGURE L-4

Reference No.: 14/07/14083-F1
Date: July 2015

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					2.4				35			
	2	0.8	16	78	6		3.0				31			
	3	1.5					4.0				44			
	4	2.3					3.9				40			
	5	3.1					3.7				30			
	6	3.8	10	84	6		3.7				31			
	7	4.6					4.9				41			
	8	6.1					20.7				27			
	9	7.6					10.6				81/175 mm			
	10	9.1									25/0 mm			
	11	9.9												Rec=98%, RQD=88%
	12	11.4												Rec=100%, RQD=100%
2	1	0.0					3.7				19			
	2	0.8					3.0				17			
	3	1.5					3.4				12			
	4	2.3					3.6				25			
	5	3.1					3.8				25			
	6	3.8					3.4				55/225 mm			
	7	4.6					4.1				42			
	8	6.1					21.8				15			
	9	7.6					15.6				65/200 mm			
	10	9.1					16.2				51			
	11	9.7												Rec=96%, RQD=85%
	12	10.3												Rec=93%, RQD=87%
	13	11.8												Rec=100%, RQD=100%

Laboratory Tests - Summary Sheet

LVM Merlex

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 (%)				
3	1	0.0					4.9				16			
	2	0.8					4.4				18			
	3	1.52	3	93	4		6.1				18			
	4	2.29					4.3				38			
	5	3.05					3.1				28			
	6	3.81					2.6				33			
	7	4.57	8	87	5		2.8				30			
	8	6.1	0	5	86	6	18.6				34			Non Plastic (NP)
	9	7.6	0	88	12		13.7				52			
	10	9.4												Rec=100%, RQD=71%
	11	10.4												Rec=100%, RQD=93%
	12	11.9												Rec=88%, RQD=82%
4	1	0					16.2				31/150 mm			
	2	0.2												Rec=100%, RQD=73%
	3	1.7												Rec=97%, RQD=89%
5	1	0					10.3				8			
	2	0.76	1	60	39		18.0				32			
	3	1.52					10.4				80			
	4	2.29	29	58	13		10.1				69			
	5	3.05					10.4				100/50 mm			
	6	3.4												Rec=100%, RQD=89%
	7	4.9												Rec=100%, RQD=100%

Appendix 4 Photo Essay

Enclosure No. 7: Photo Essay

Existing Embankment – Looking West	Photo: 1

Culvert Inlet – Looking North	Photo: 2

Project: Hwy 60 – Culvert at Station 10+080, Township of Chaffey	Photos Provided By: LVM Date: Oct, 2014/Dec, 2014

Culvert Outlet – Looking South	Photo: 3

Culvert Outlet - Looking East	Photo: 4

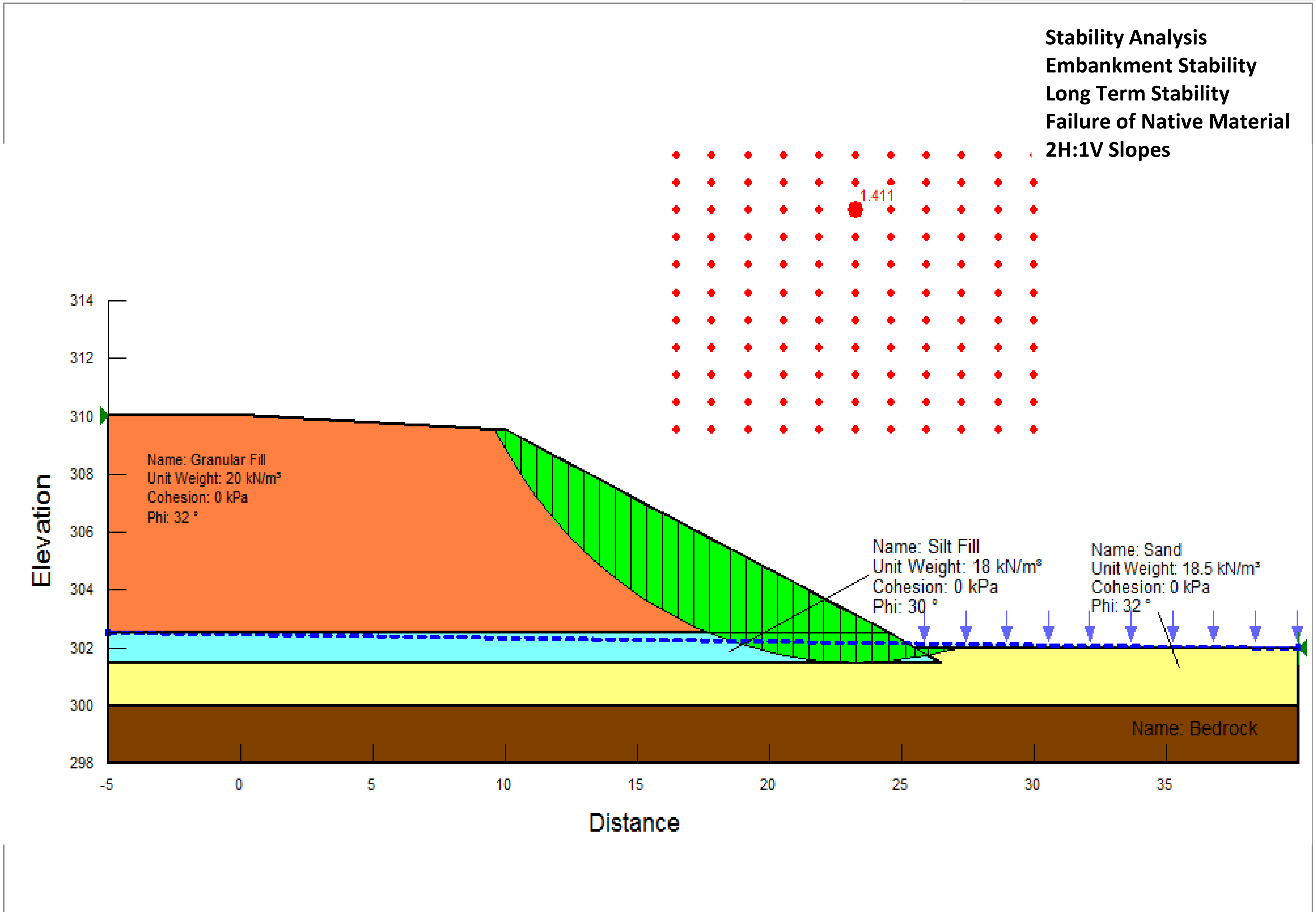
Project: Hwy 60 – Culvert at Station 10+080, Township of Chaffey	Photos Provided By: LVM Date: December 2014

Appendix 5 Design Data

Figure No. S-1:	Slope Stability
Table A:	Comparison of Shoring Alternatives
Figure No. SK-2:	Conceptual Shoring Location Plan
Figure No. SK-3:	Conceptual Shoring Cross-Section
	Notice to Contractor - Obstructions

LVM Merlex

Reference No.: 14/07/14083-F1
Date: July 2015



Stability Analysis
Culvert 10+080
TWP of Chaffey

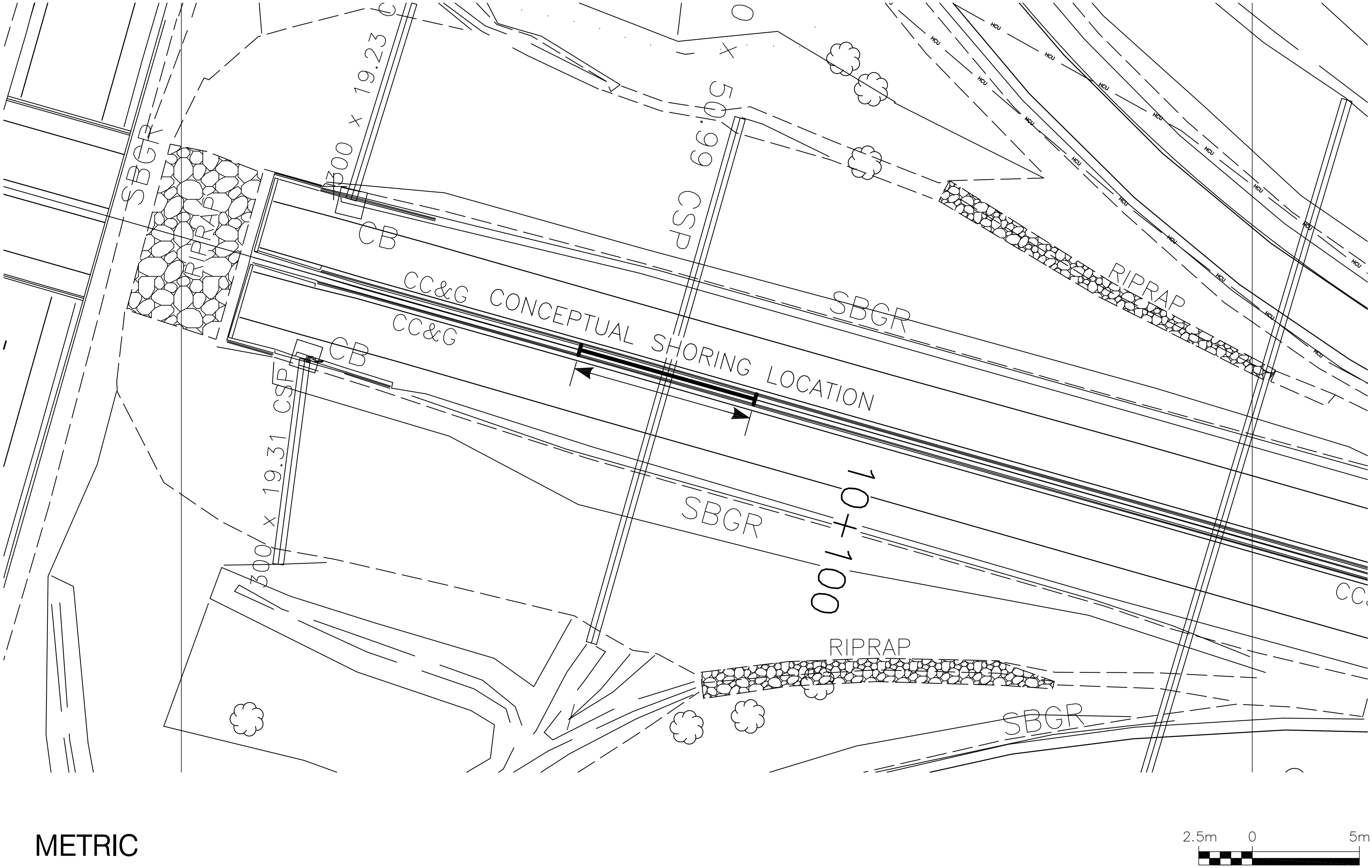
Project: G.W.P 5005-05-00
Location: Hwy 60

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 encountered cobble/boulders in embankment fill and native soils	$ 650/m^2
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Not recommended due to required embedment into bedrock	$ 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	Feasible provided sufficiently predrilled into shallow bedrock and dewatering during excavation	$ 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	Feasible using special equipment drilled into shallow bedrock	
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	Feasible	$ 1200 to 1500/m^2

REF.: 14083-F1



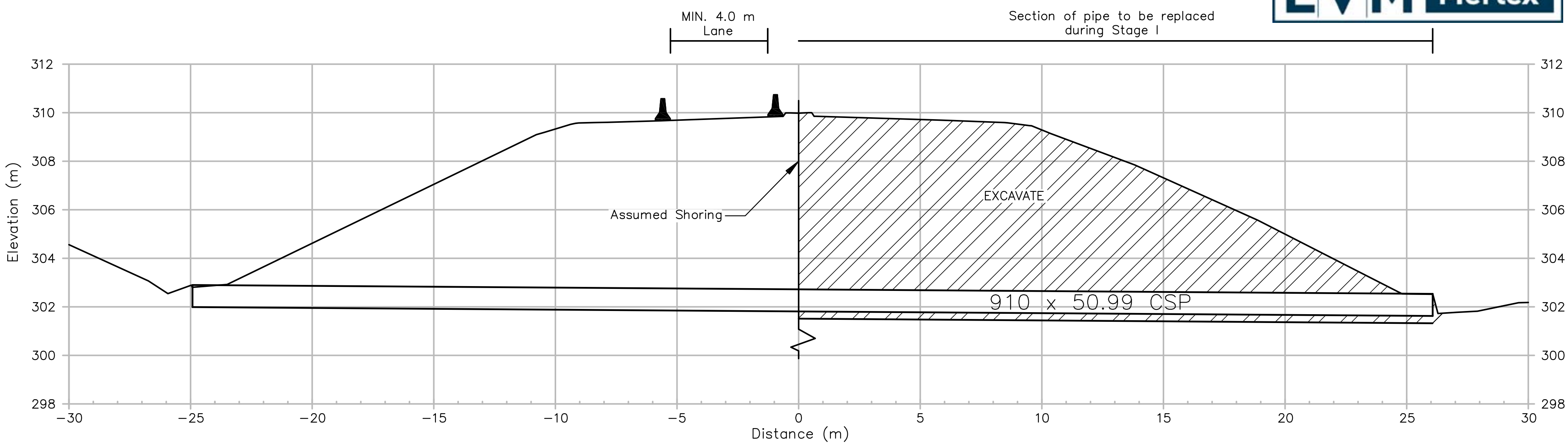
METRIC

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

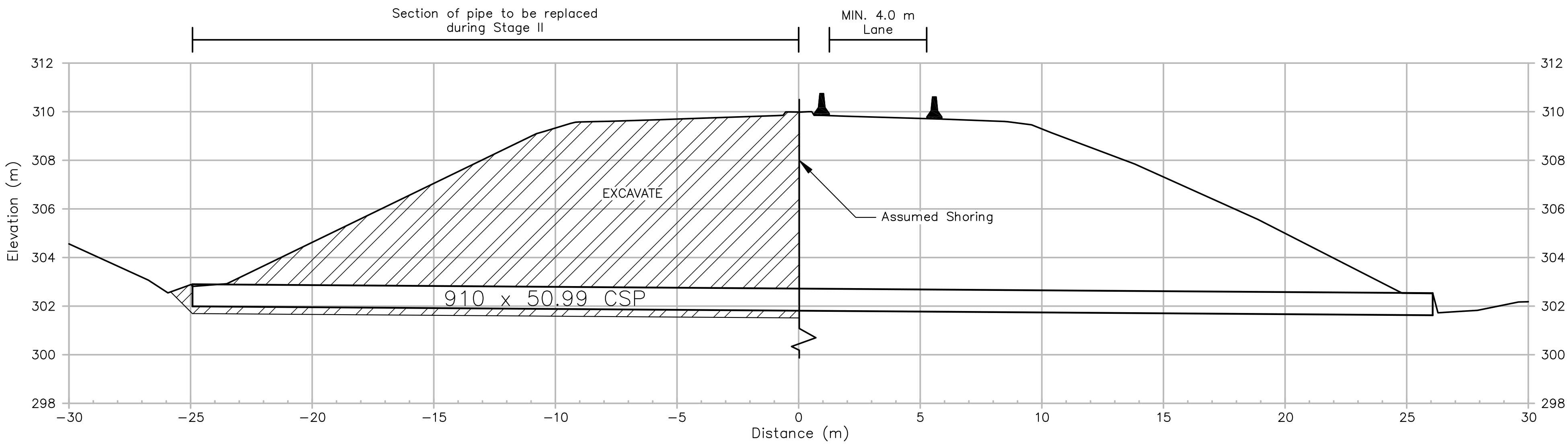
Highway 60, Township of Chaffey - Culvert at Station 10+080
Conceptual Shoring Location Plan

FIGURE SK-2

REF.: 14083-F1



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 60, Township of Chaffey - Culvert at Station 10+080
Conceptual Shoring Cross-Section

FIGURE SK-3

NOTICE TO CONTRACTOR – Obstructions in Fill and Native Soils

Special Provision

The Contractor is advised that, at the borehole locations, embankment fills and native soils includes sands, silts and gravels, and contains a mix of cobble/boulder sizes at varying depths. The bedrock was encountered at relatively shallow depths below the embankment fills and native soils. The contractor should be prepared to deal with these materials for dewatering, temporary protection system and other construction activities.

englobecorp.com