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

Highway 124 Rehabilitation
Culvert Replacement
Station 25+160 - Twp. of Croft
GWP 5467-09-00

Highway 124
From 1.0 km West of West Junction Hwy 520, Easterly 20.7 km to 2.4 km East of Hwy 510

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

Date: May 30, 2013
Ref. Nº: 12/08/12141-F2

Geocres No. 31E-322B

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Final Foundation Investigation and Design Report

Prepared by:

Alexander Tepylo, B.Sc, E.I.T.
LVM | Merlex – Geotechnical Assessor

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

Reviewed by:

Jake Berghamer, P. Eng.
LVM | Merlex – Regional Manager

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LVM | MERLEX

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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	2013-02-20	DRAFT Report Issued
01	2013-05-30	Final FIDR Report Issued

REPORT DISTRIBUTION	
2 hard copy	AECOM
5 hard copy, 1 electronic copy	MTO Project Manager
1 hard copy, 1 electronic copy	MTO Pavements and Foundations Sections
1 hard copy	File

1 INTRODUCTION

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 for the proposed replacement of an existing culvert and a possible detour or protection system to be used during the culvert replacement. This culvert replacement is located on Highway 124, some 350 m West of the East Junction with Hwy 520, in the Township of Croft.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5011-E-0021. The terms of reference for the scope of work are outlined in LVM | MERLEX's Proposal P-11-151, dated March, 2012. The purpose of this investigation was to determine the subsurface conditions in the area of the culvert, proposed detour and possible protection system in order to provide geotechnical design recommendations. 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 existing 800 mm diameter Corrugated Steel Pipe (CSP) culvert, to be replaced, is located at Station 25+160, Township of Croft. The topography at the site is low, and the culvert allows flow from a ditch, on the south side of the embankment, to Whalley Lake to the north. The existing highway embankment currently supports two undivided lanes of highway, running in an east-west direction. The existing highway, at the culvert location, is constructed on a rock fill embankment some 4.3 m in height, with centerline elevation of 294.0 m at the culvert location. The culvert at this location is an 800 mm diameter CSP culvert, some 28.67 m in length. Flow was not observed in the culvert at the time of this investigation (see Photo Essay, Appendix 4). In general, the flow at this culvert location is from south to north based on culvert inverts and topography.

Infrastructure at the culvert location consists of overhead wires on the south (right) side of the highway.

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 124 is generally slightly rolling. There are exposed bedrock ridges. At many locations, significant layers of earth overlay the bedrock. Organic terrain was also observed. Within the specific culvert area overburden consists primarily of silts and sands.

3 INVESTIGATION PROCEDURES

The field work for this investigation was carried out during the period of August 29th to September 20th, 2012 during which time ten (10) sampled boreholes and DCPTs, were advanced. For the purposes of foundation design for the culvert replacement and for the detour or possible protection system, two boreholes were advanced at the culvert outlet, three boreholes were advanced through the embankment and five boreholes were advanced along the south toe of the embankment, two of which were advanced at the culvert inlet.

The field investigation was carried out using a Bombardier and a truck mounted CME drilling rig equipped with hollow stem augers, standard augers, 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 mounted in a trip (automatic) hammer. The number of blows per 300 mm penetration was recorded as the "N" value. At the boreholes, a Dynamic Cone Penetration Test (DCPT) was carried out to give a continuous plot of the soil resistance with depth. 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. 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. 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 field work for this investigation was under the full time direction of a senior member of our 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, Atterberg Limits testing, as well as specific gravity testing. 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 C (Figures Nos. L-1 to L-7).

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.

4 SUBSURFACE CONDITIONS

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Appendix 2) and on Figure 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 and Dynamic Cone Penetration Tests (DCPT), plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of a 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 25+160, TWP OF CROFT

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Figure No. 2, Appendix 3. During the course of the exploration program, ten (10) sampled boreholes were put down at this site, with Borehole Nos. 3, 9, and 10 advanced through the embankment, and Borehole Nos. 1 and 4, and 2 and 8, advanced at the culvert inlet and outlet, respectively. Boreholes No. 5 to 7 inclusive were advanced at the toe of the embankment to the south (right) of the existing embankment. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 10 were recorded at 290.6, 290.2, 294.0, 290.7, 293.1, 291.9, 292.6, 290.5, 294.0, and 294.0 m, respectively.

4.1.1 Pavement Structure

At surface at Borehole Nos. 3, 9, and 10, a pavement structure consisting of 65 to 75 mm of asphalt and 425 to 550 mm crushed gravel was penetrated.

4.1.2 Fill

Underlying the crushed gravel at Borehole Nos. 3, 9, and 10, a deposit of fill consisting of brown sand trace to with silt trace to some gravel was penetrated. A distinction between the subbase and embankment fill was not observed. The natural moisture content measured on samples of this deposit was in the order of 2 to 22%. Gradation analyses were carried out on five (5) samples of this deposit, the results of which indicated 1 to 20% gravel size particles, 63 to 81% sand size particles, and 6 to 23% silt and clay size particles (Figure No. L-1, Appendix 3). Based on SPT ‘N’ values of 15 to 76 blows per 300 mm penetration, the compactness of this deposit was described as compact to very dense, generally compact. This deposit was encountered to a depth of 4.3 m below grade at Borehole Nos. 3 and 9 (elevation 289.7 m). Auger refusal, probably on a boulder/rock fill, was encountered in this deposit at a depth of 2.3 m at Borehole No. 10 (elevation 291.7 m).

4.1.3 Surficial Organics

At surface at BH Nos. 2, 6, 7, and 8, a layer of surficial organics, some 50 to 100 mm thick, was penetrated.

4.1.4 Peat

Underlying the surficial organics at Borehole No. 8, a deposit of black fibrous peat was encountered. The natural moisture content measured on samples of this deposit was in the order of 56%. This deposit was encountered to a depth of 0.8 m below grade (elevation 289.7 m).

4.1.5 Silty Sand

At surface at Borehole Nos. 1, 4, and 5, underlying the surficial organics at Borehole Nos. 2, 6, and 7, underlying the peat at Borehole No. 8, and underlying the fill at Borehole Nos. 3 and 9, a deposit of grey silty sand described as a sand with silt to a silt and sand, trace to with gravel was penetrated. Trace organics were encountered in this deposit. The natural moisture content measured on samples of this deposit was in the order of 15 to 39%. Gradation analyses were carried out on five (5) samples of this deposit, the results of which indicated 0 to 25% gravel size particles, 35 to 78% sand size particles, and 22 to 65% silt and clay size particles (Figure No. L-2, Appendix 3). Based on SPT ‘N’ values of 0 (static weight of hammer) to 4 blows per 300 mm penetration, the compactness of this deposit was described as very loose. This deposit was encountered to depths of 1.5, 1.5, 5.7, 0.9, 0.7, 0.8, 1.4, and 5.2 m below grade at Borehole Nos. 1, 2, 3, 4, 5, 7, 8, and 9, respectively (elevations 289.1, 288.7, 288.3, 289.8, 292.4, 291.8, 289.1, and 288.8 m, respectively).

4.1.6 Silty Clay

Underlying the silty sand at Boreholes Nos. 2, 3, 7, and 8, and at surface at Borehole No. 6, a deposit of grey silty clay was penetrated. The natural moisture content measured on samples of this deposit was in the order of 25 to 54%. Hydrometer analyses were carried out on six (6) samples of this deposit, the results of which indicated 0% gravel size particles, 1 to 14% sand size particles, 56 to 83% silt size particles, and 16 to 40% clay size particles (Figure No. L-3, Appendix 3). Atterberg Limits testing was carried out on six (6) samples of this deposit, the results of which indicated a Plastic Limit in the order of 19 to 23% and a Liquid Limit in the order of 32 to 46% (Figure No. L-6, Appendix 4). Based on results of Atterberg Limits testing, this deposit was described as a silty clay of low to medium plasticity (CL to CI). Based on in-situ shear strengths of 16 to 94 kPa, this deposit was described as soft to stiff. This deposit was encountered to depths of 3.8, 6.7, 0.8, 3.8, and 3.7 m below grade at Borehole Nos. 2, 3, 6, 7, and 8, respectively (elevations 286.4, 287.3, 291.1, 288.8, and 286.8 m, respectively).

4.1.7 Silt

Underlying the silty clay at Borehole Nos. 2, 3, 6, 7, and 8 and underlying the silty sand at Borehole No. 9, a deposit of grey silt, trace to with sand, trace clay gravel was penetrated. The natural moisture content measured on samples of this deposit was in the order of 18 to 26%. Hydrometer analyses were carried out on three (3) samples of this deposit, the results of which indicated 0% gravel size particles, 7 to 31% sand size particles, 69 to 88% silt size particles, and 2 to 5% clay size particles (Figure No. L-4, Appendix 3). This deposit was encountered to depths of 5.8 and 1.5 m below grade at Borehole Nos. 2 and 6, respectively (elevations 284.4 and 290.4 m, respectively). Auger refusal was encountered in the deposit at depths of 8.7, 6.2, 6.1, and 9.0 m, at Borehole Nos. 3, 7, 8 and 9, respectively (elevations 285.3, 286.4, 284.4, and 285.0 m, respectively).

4.1.8 Sand

Underlying the silty sand deposit at Borehole Nos. 1, 4, and 5, and underlying the silt deposit at Borehole Nos. 2 and 6, a deposit of grey sand trace to with silt, some to with gravel was penetrated. Occasional cobbles and boulders were encountered in this deposit. The natural moisture content measured on samples of this deposit was in the order of 10 to 23%. Gradation analyses were carried out on two (2) samples of this deposit, the results of which indicated 18 to 27% gravel size particles, 49 to 77% sand size particles, and 5 to 24% silt and clay size particles (Figure No. L-5, Appendix 3). Auger refusal was encountered in this deposit at depths of 2.9, 6.9, 1.9, 1.5, and 3.8 m at Borehole Nos. 1, 2, 4, 5, and 6, respectively (elevations 287.7, 283.3, 288.8, 291.6, and 288.1 m, respectively).

4.1.9 DCPT

Dynamic Cone Penetration Tests (DCPT) were advanced from grade at BH Nos. 1 to 10. DCPT refusal was encountered at depths of 3.1, 6.2, 8.1, 2.2, 1.5, 3.9, 6.2, 6.5, 8.8, and 4.8 m below grade at Borehole Nos. 1 to 10, respectively (elevations 287.5, 284.0, 285.9, 288.5, 291.6, 288.0, 286.4, 284.0, 285.2, and 289.2 m, respectively).

4.2 GROUNDWATER DATA

The water level in Whalley Lake was measured at elevation 290.0 m at the time of this investigation.

Measurements of the groundwater and cave-in levels were undertaken, where possible, in the open boreholes during the advance of the individual borings and upon completion. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix B). The water levels were measured between elevations 289.0 and 291.3 m upon completion at Borehole Nos. 1 to 4, and 6 to 8. Borehole Nos. 5, 9, and 10 were dry upon completion.

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 culvert replacement and design of a detour as identified in the RFP.

The existing culvert, located at Station 25+160 in the Township of Croft, is an 800 mm diameter CSP culvert some 28.67 m long. The existing highway embankment currently supports two undivided lanes of highway, running in an east-west direction. Flow through the culvert is from right to left (i.e. south to north). Based on data from this foundation investigation, the embankment at this site has been constructed using a granular pavement structure overlying earth fill. The native material, underlying the earth fill, generally consisted of silty sands underlain by silty clays underlain by silts and sands, with refusal at the borehole locations ranging between elevations 283.3 to 291.6 m.

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

5.2 FOUNDATION CONSIDERATIONS

The founding native compact silts, sandy silts, and soft to stiff silty clays 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 during construction, as discussed in Section 5.6.

Based on the characteristics of the native sandy silt and underlying silty clay subgrade present below the culvert, the response of the existing embankment, and a founding elevation similar to that of the existing culvert, a factored bearing resistance at ULS of 150 kPa can be used for a closed culvert (i.e. precast concrete frame box culvert or CSP culvert). In consideration of the width of the culvert and the depth of overburden, a geotechnical resistance at SLS of 75 kPa can be used for design, in consideration of 25 mm settlement.

If an open culvert (i.e. concrete frame open culvert, with wall footings, or a pipe arch culvert on footings) is considered, then a factored bearing resistance at ULS of 100 kPa, and a geotechnical resistance at SLS of 50 kPa would apply for design, taking into consideration the limited depth of overburden along the interior and smaller footing width. Considering the relatively small culvert size we do not consider an open culvert practical for this site, in consideration of the footing depth required for frost cover and scour protection.

5.2.1 Slope Stability

The maximum height of fill above surrounding grade of the embankment at this location is some 4.2 m at the culvert location. The existing embankment slopes are at an angle of some 2.8H:1V

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 embankment slopes of 2H:1.0V in earth fill. The embankment material was modeled as earth fill, using a unit weight of 18 kN/m^3 and a friction angle of 30°. The native silty sands were modeled using a unit weight of 18 kN/m^3 and a friction angle of 28°. The silty clays were modeled using representative values of unit weight of 16.5 kN/m^3 and a shear strength of 20 kPa. The native silts were modeled using a unit weight of 17.5 kN/m^3 and a friction angle of 27°. The native sands were modeled using a unit weight of 19 kN/m^3 and a friction angle of 30°. The unit weights and friction angles for the slope calculations are based on general representative values for soil types, obtained through laboratory testing. The results of the analysis indicated a factor of safety in the order of 1.48 against failure through the underlying native silty sand subgrade (see Figure Nos. S-1, Appendix 5). The stability of the finished embankment slope will not be an issue provided it is constructed to match the existing embankment.

5.3 CULVERT DESIGN, BEDDING, AND EMBEDMENT

The embankment consists of granular fills overlying rock fill. The results of this investigation indicate that, below the culvert invert, the native soils at Borehole No. 3 consist of a sandy silt underlain by a thin layer soft to stiff silty clay. A review of the condition of the pavement surface, at the culvert location, revealed minor asphalt cracking, however, in general, the embankment appears to have performed well. The existing embankment has preloaded the soils at the culvert locations and since there will be no change in the height of the embankment, and therefore no increase in embankment load, no appreciable settlement of the embankment is anticipated. As such, installing the culvert on a camber will not be required at this site.

Due to the height and composition of the embankment at the culvert location, longitudinal frost tapers shall not be required, as per the geotechnical report also by LVM | MERLEX, Ref No. 12/08/12141.

5.3.1 Rigid Concrete Culvert

A concrete pipe can be considered for culvert replacement at this site. Due to the culvert size a concrete box culvert is not warranted at this site. A Class B Bedding for the concrete pipe shall consist of Granular A with a thickness of 200 mm. Alternatively, specifically if construction is carried out under wet conditions, a 19 mm clear stone bedding should be used, which would aid in dewatering operations. During backfilling, the embedment fill should be placed in a balanced manner on each side of the pipe. The elevation difference of the backfill on either side of the pipe during backfilling must be limited to a maximum 200 mm. Cover material for concrete pipe can consist of Granular A and placed to the dimensions as shown on OPSD 802.031.

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 3 m in width, 500 mm thick and extend across the stream bed. Clay seals are generally used where significant head differences exist between the inlet and outlet of a culvert to prevent flow through the embankment. Clay seals are not considered necessary considering the anticipated water levels and flow at this culvert location.

5.3.2 Flexible Culvert

A flexible culvert (i.e. CSP/SPCSP/HDPE) can also be considered for culvert replacement at this site. If a flexible pipe is 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 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 a balanced manner on the outer sides of the culvert unit. The elevation difference of the backfill on either side of the culvert during backfilling must be limited to a maximum 200 mm.

Considering the nature of the embankment fill and shallow culvert slope, 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 3 m in width, 500 mm thick and extend across the width of the stream bed at the inlet and outlet.

5.4 CULVERT INSTALLATION AND CONSTRUCTION STAGING CONSIDERATIONS

The invert elevation of the existing culvert is at 289.8 m, with the top of the embankment at elevation 294.0 m at centerline. As such, the embankment at this location is some 4.2 m in height above the culvert invert at the centerline. Therefore, a minimum 4.5 m deep excavation (i.e. to elevation 289.5 m) will be required in consideration of some 300 mm thick layer of bedding/embedment material. The present platform width at this location is some 10 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 in width to carry out an open excavation using staged construction. Consideration could be given to constructing a vertical wall for use as a protection system. It is understood that the preferred method of replacing the culvert is to construct a detour to the south (right) of the existing embankment to allow an open cut excavation for culvert replacement.

5.4.1 Detour

As noted, it is understood that a detour may be used to allow culvert replacement using open cut excavation. The detour will consist of a temporary road constructed to the south (right), to accommodate traffic while an open cut excavation is carried out to allow replacement of the culvert. It is anticipated that the detour will be temporary and greater than 1.2 m in height, as such, it will not be necessary to strip the topsoil/surficial organics however the tree cover should be cut. Based on the results of this investigation, the existing soils are considered acceptable to support the proposed detour embankment, which may consist of up to some 5 m of fill, depending upon design speed.

The proposed detour can be constructed using rock fill, granular fill, or earth fill (provided that it is at a moisture content that will allow compaction). Embankment fill should be placed in regular lifts in accordance with OPSS 206.07.07 and compacted to 95% Standard Proctor Dry Density (SPDD). The pavement structure on the detour should consist of a 300 mm subbase with a 100 mm base. The final lifts of Granular A and Granular B Type I should be compacted to 100% SPDD.

5.4.1.1 *Detour Slope Stability*

A stability analysis, using the GEO-SLOPE computer program, Slope/W was carried out at this location for a detour to the south of the existing embankment. The detour was modelled as an earth fill embankment with standard stable embankment slopes of 2.0H:1.0V. The earth fill material was modeled using a unit weight of 18 kN/m^3 and a friction angle of 30°. The results of the analysis indicated a factor of safety in the order of 3.1 against failure through the underlying native silt and sand subgrade (see Figure Nos. S-2, Appendix 5). The stability of the temporary detour will not be an issue provided it is constructed, with a 2H:1V slope.

5.4.2 Protection System

As noted above, consideration could also be given to constructing a vertical wall, along centerline, for use as a temporary protection system. The installation of a protection system for use in the culvert replacement operation will require penetration through some 4.3 m of earth fill. The embankment fill is generally underlain by very loose silty sands, underlain by silty clays, silts and sands. The embankment generally consists of earth fill, however layers/pockets of rock fill were encountered in the boreholes, and refusal was encountered at Borehole No. 10 at elevation 289.5 m. Considering the potential for the presence of rock fill in the embankment fill, advancing a temporary retaining system (i.e. driven sheet piles) through the embankment may be problematic. However, in general, the augers and DCPT were able to penetrate the embankment. Therefore, one possible 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. If a cobble/small boulder size rock is encountered during driving of a sheet section, the individual section could be left high and the cobble/boulder removed during excavation to allow continued driving. Conceptual shoring locations are illustrated on Figure No. SK-4, Appendix E.

Considering the cohesionless nature of the embankment fills (granular pavement structure over earth 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 $0.65*Ka*\gamma*H$, where:

Ka = active earth pressure,

γ = unit weight, and

H = height of wall above the base of excavation.

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, Appendix E. Conceptual shoring location is illustrated on Figure No. SK-4, Appendix E.

The protection system can be designed using the lateral earth pressure parameters as outlines in Section 5.5.

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	SSM/ EARTH FILL	NATIVE SILTY SAND	NATIVE SILTY CLAY	NATIVE SILT	NATIVE SAND
Unit Weight (kN/m^3)	22.8	21.0	18.0	18.0	16.5	17.5	19.0
Angle of Internal Friction	34°	31°	30°	28	-	27	30
Shear Strength (kPa)	-	-	-	-	40	-	-
Coefficient of Active Earth Pressure (Ka)	0.28	0.32	0.33	0.36	-	0.38	0.33
Coefficient of Passive Earth Pressure (Kp)	3.54	3.12	3.00	2.77	-	2.66	3.00
Coefficient of Earth Pressure at Rest (Ko)	0.44	0.48	0.50	0.53	-	0.55	0.50

For rigid structures, such as a precast concrete culvert, deflection cannot occur, as such the "at-rest" condition (Ko) applies. For flexible structures, such as CSP/HDPE culverts, deflection can occur, as such the "active" condition (Ka) 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 the open face of the excavation is 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.

The excavation backfill should be constructed to match the existing embankment. As such, an earth fill can be used as backfill. Permanent embankment slopes in earth or granulars should be established at the standard angle of 2H:1V. Granular sheeting, some 300 mm thick, should be used on earth slopes for erosion protection.

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

Excavations must be maintained in a dewatered condition during excavation and foundation construction and every reasonable effort must be made to prevent disturbing (piping/boiling) at the founding subgrade. Groundwater control, in accordance with OPSS 517 and 518, will be required to maintain a stable subgrade during culvert installation.

While water was not observed in the culvert, the water level in the lake was recorded at elevations 290.0 m at the outlet at the time of this investigation. Excavations to an approximate elevation 289.5 m would be required to install the culvert and bedding. As such dewatering will be required during excavation and culvert installation.

Considering the low flow, based on visual assessment at the time of investigation (see Photos Appendix 4) it is likely that constructing a cofferdam, with bypass pumping, will be adequate to control the anticipated stream flow during construction. A sheet pile type cofferdam could be considered to control groundwater at the culvert outlet. It should be noted that refusal was encountered at a shallow depth (2.0 m below grade) at the culvert inlet. As such, there may be insufficient depth for a sheet pile type cofferdam. A sand bag cofferdam can be considered at the culvert inlet. Considering the limited head of water (i.e. some 0.5 m) a sand bag cofferdam with sumps and pumps will probably be considered by the contractor.

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 foundation construction cannot be overstressed.

5.7 CONSTRUCTION CONCERNS

Constructing a new embankment for a temporary one lane (with lights) or two lane detour is feasible from a foundation point of view but would require additional property and environmental clearance. We do not anticipate any major construction difficulties during construction of the detour and culvert replacement if proper dewatering is carried out.

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

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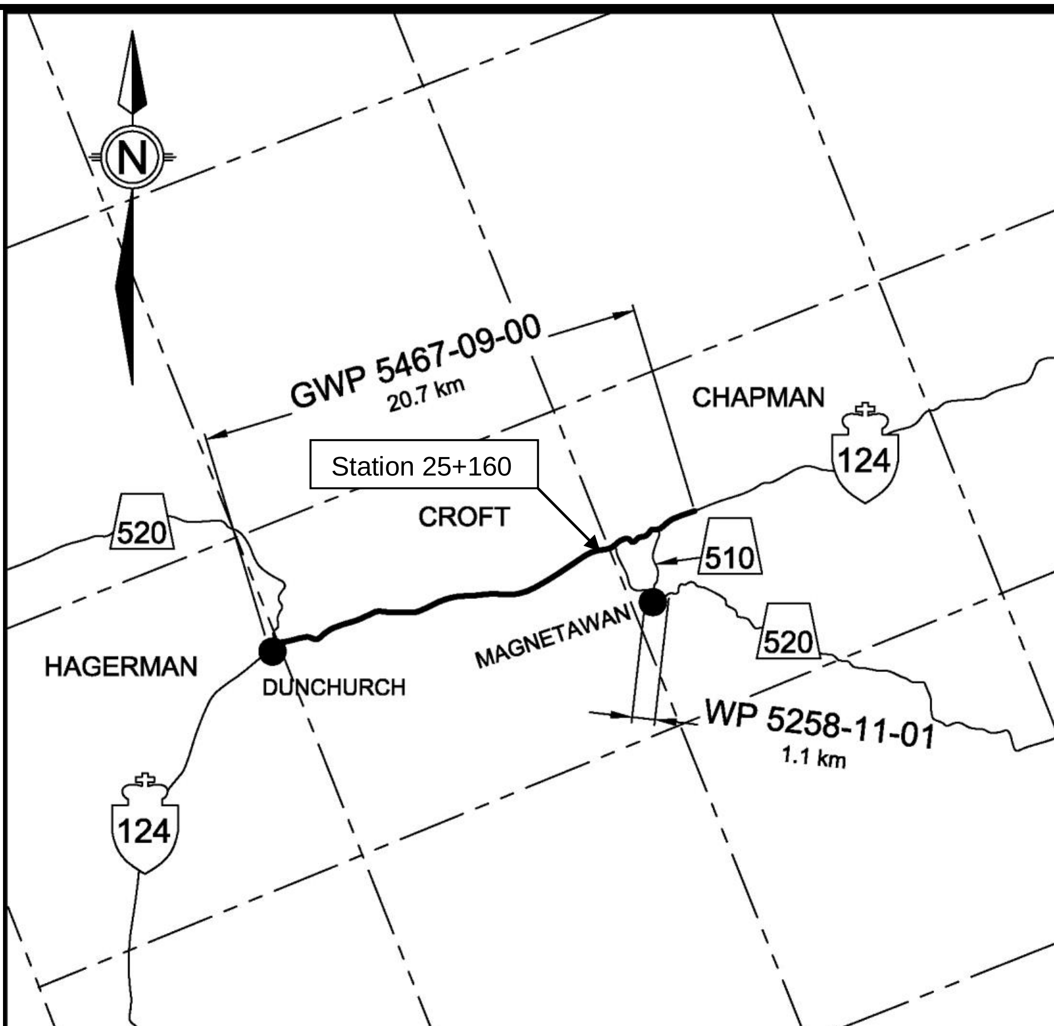
KEY PLAN

Drawing No. 1

NOT TO SCALE



FINAL
FOUNDATION INVESTIGATION
AND DESIGN REPORT
GWP 5467-09-00
Highway 124

From 1.0 km West of West Junction Hwy 520, Easterly 20.7 km to 2.4 km East of Hwy 510

Reference No: 12/08/12141-F2 May 2013

LVM | MERLEX

Appendix 2 Subsurface Data

Enclosure No. 1	List of Abbreviations and Symbols
Enclosure Nos. 2 to 11	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

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) *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.

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/or boulders frequency is an estimate based on drill response and field observations:

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

5. LABORATORY TESTS

P Standard Proctor Test
A Atterberg Limit Test
GS Grain Size Analysis
H Hydrometer Analysis
C Consolidation

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. 01

L|V|M

REFERENCE 12/08/12141-F2	DATUM Geodetic	LOCATION N 5060 625.3 E 291 724.5 - Township of Croft	ORIGINATED BY JL
PROJECT GWP 5467-09-00, Highway 124		BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers	COMPILED BY AT
CLIENT AECOM Inc.		DATE (Started) 30 August 2012 DATE (Completed) 30 August 2012 TIME (Completed) 11:10:00 AM	CHECKED BY MAM

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	NATURAL MOISTURE CONTENT w (%)	UNIT WEIGHT γ (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
290.6	Ground Surface								
0.0	SAND - grey sand with silt trace orgranics (very loose)	1	AS		▽ (0.4)		~38		
		2	SS	3	▽ (0.8)	290	~24		0 78 (22)
289.1 1.5	SAND - brown sand trace silt some gravel occasional cobbles and boulders (dense/very dense)	3	SS	56	Cave in (1.8)	289	~18		
		4	SS	41		288	~13		18 77 (5)
287.7 2.9	Auger Refusal								
287.5 3.1	DCPT Refusal 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

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) 30/8/12 11:00:00 AM	0.8	1.8
2) 31/8/12 10:00:00 AM	0.4	-
3)	-	-

MEL-GEO 12141 - AREA 2 - BOREHOL LOGS.GPJ MEL-GEO.GDT 5/6/13

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

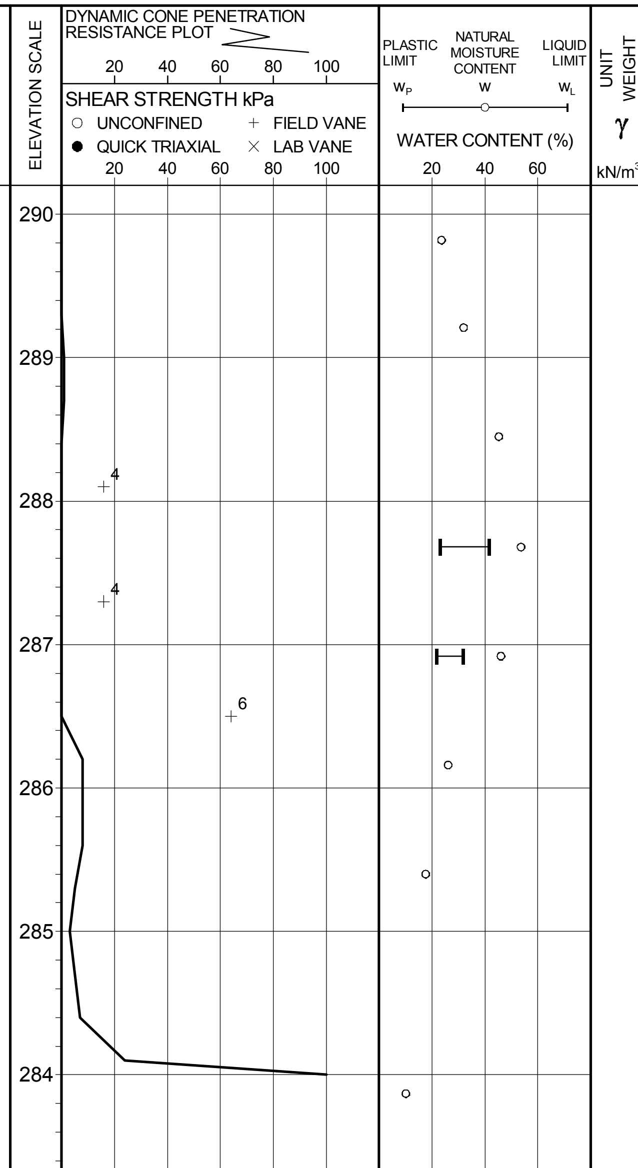
RECORD OF BOREHOLE NO. 02

METRIC

L|V|M

REFERENCE	12/08/12141-F2	DATUM	Geodetic	LOCATION	N 5060 658.2 E 291 725.3 - Township of Croft
PROJECT	GWP 5467-09-00, Highway 124	BOREHOLE TYPE	Track Mounted CME 45B - Hollow Stem Augers	ORIGINATED BY	JL
CLIENT	AECOM Inc.	DATE (Started)	31 August 2012	COMPILED BY	AT
		DATE (Completed)	31 August 2012	TIME (Completed)	10:10:00 AM
				CHECKED BY	MAM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
290.2	Ground Surface					
0.0	100 mm organics SILT AND SAND - grey sand and silt trace gravel (very loose)	1	AS			
		2	SS	WH	▽	1 46 (53)
288.7 1.5	SILTY CLAY - grey silty clay (soft/stiff)	3	SS	PM		
		4	SS	PM		0 0 60 40
		5	SS	PM		0 1 74 25
286.4 3.8	SILT - grey silt with sand trace clay (very loose)	6	SS	2	Cave	
		7	SS	WH		0 26 72 2
284.4 5.8	SAND - grey sand some silt some gravel (dense)					
284.0 6.2	DCPT Refusal	8	SS	57		
283.3 6.9	Auger Refusal 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)	31/8/12 10:00:00 AM	1.2	4
2)		-	-
3)		-	-

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

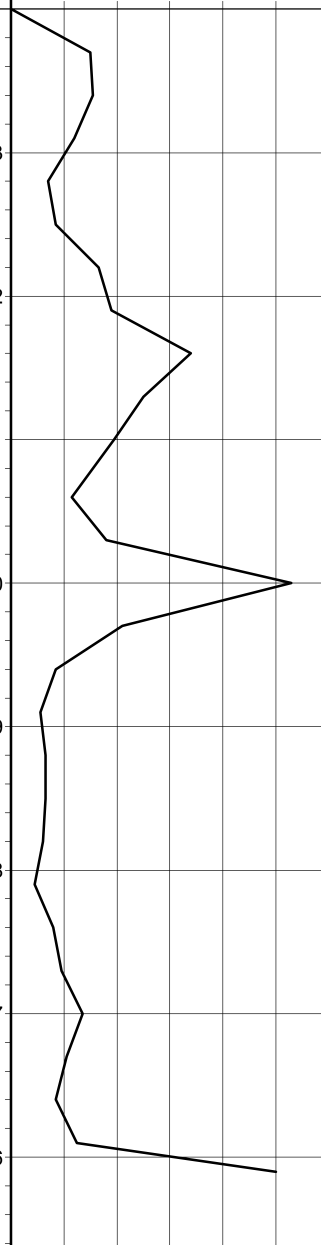
METRIC

RECORD OF BOREHOLE NO. 03

LVM

REFERENCE	12/08/12141-F2	DATUM	Geodetic	LOCATION	N 5060 642.2 E 291 722.0 - Township of Croft
PROJECT	GWP 5467-09-00, Highway 124	BOREHOLE TYPE	Truck Mounted CME 45B - Hollow Stem Augers and NQ casing		
CLIENT	AECOM Inc.	DATE (Started)	13 September 2012	DATE (Completed)	13 September 2012
TIME (Completed)	12:00:00 PM				
ORIGINATED BY	JL	COMPILED BY	AT	CHECKED BY	MAM

ELEV / DEPTH (m)	DESCRIPTION	STRATA PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
294.0	Ground Surface									
0.0	65 mm Asphalt 425 mm Crushed Gravel FILL - brown sand some to with silt trace to some gravel (compact/dense)		1	AS				o		
			2	SS	15		293	o		1 76 (23)
	trace asphalt		3	SS	48		292	o		
			4	SS	26		291	o		
			5	SS	16			o		19 63 (18)
			6	SS	25		290	o		
289.7 / 4.3	SANDY SILT - brown sandy silt trace clay trace organics (loose)		7	SS	4	▽	289	o		1 35 54 10
288.3 / 5.7	SILTY CLAY - grey silty clay (stiff)		8	SS	3		288	├o┤		0 1 83 16
287.3 / 6.7	SILT - grey silt some sand trace clay (very loose)		9	SS	2	Cave	287 286	o		
285.9 / 8.1	DCPT Refusal									
285.3 / 8.7	Auger Refusal End of Borehole									



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

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) 13/9/12 12:00:00 PM	4.7	7.1
2)	-	-
3)	-	-

MEL-GEO 12141 - AREA 2 - BOREHOL LOGS.GPJ MEL-GEO.GDT 5/6/13

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

METRIC

RECORD OF BOREHOLE NO. 04

LVM

REFERENCE 12/08/12141-F2 DATUM Geodetic LOCATION N 5060 626.9 E 291 728.8 - Township of Croft ORIGINATED BY JL

PROJECT GWP 5467-09-00, Highway 124 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 30 August 2012 DATE (Completed) 30 August 2012 TIME (Completed) 9:10:00 AM CHECKED BY MAM

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	NATURAL MOISTURE CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
290.7	Ground Surface							
0.0	SILTY SAND - brown silty sand with gravel occasional cobbles/boulders (loose)	1	AS		▽	290	○	25 43 (32)
289.8 / 0.9	SAND - grey sand trace silt with gravel occasional cobbles/boulders (compact/dense)	2	SS	10	⊠		○	
		3	SS	36		289	○	
288.8 / 1.9	Auger Refusal							
288.5 / 2.2	DCPT Refusal 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

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) 30/8/12 9:05:00 AM	0.5 ▽	1.2 ⊠
2)	-	-
3)	-	-

MEL-GEO 12141 - AREA 2 - BOREHOL LOGS.GPJ MEL-GEO.GDT 5/6/13

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

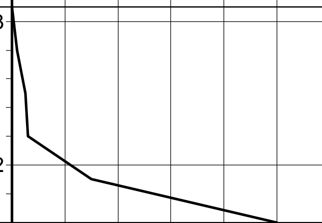
RECORD OF BOREHOLE NO. 05

METRIC

L|V|M

REFERENCE	12/08/12141-F2	DATUM	Geodetic	LOCATION	N 5060 625.5 E 291 694.6 - Township of Croft
PROJECT	GWP 5467-09-00, Highway 124	BOREHOLE TYPE	Track Mounted CME 45B - Hollow Stem Augers	ORIGINATED BY	JL
CLIENT	AECOM Inc.	DATE (Started)	30 August 2012	COMPILED BY	AT
		DATE (Completed)	30 August 2012	TIME (Completed)	12:05:00 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)
293.1	Ground Surface										
0.0	SILTY SAND - brown silty sand trace gravel		1	AS			293		○		
292.4 / 0.7	SAND - brown sand with silt with gravel occasional cobbles/boulders (dense)		2	SS	35/200 mm		292		○		
291.6 / 1.5	Auger Refusal DCPT Refusal 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) 30/8/12 12:00:00 PM	DRY	1.4
2)	-	-
3)	-	-

ENCLOSURE NO.: 7 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 06

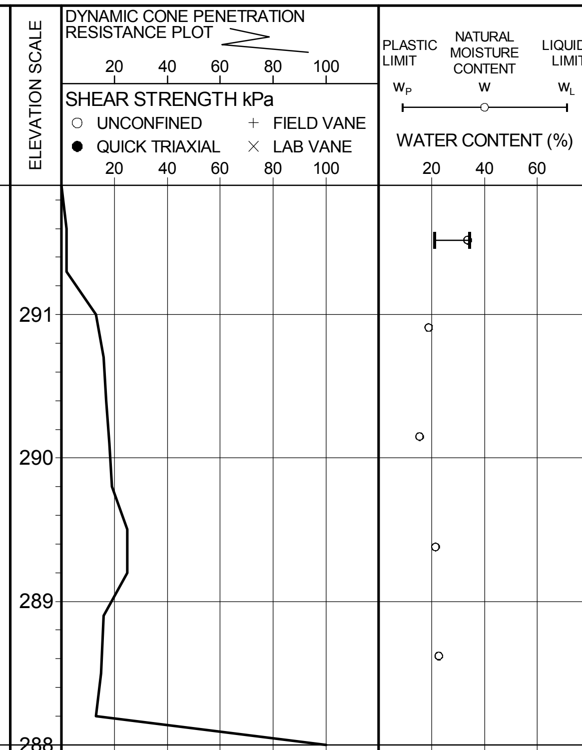
LVM

REFERENCE 12/08/12141-F2 DATUM Geodetic LOCATION N 5060 631.6 E 291 757.3 - Township of Croft ORIGINATED BY JL

PROJECT GWP 5467-09-00, Highway 124 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 29 August 2012 DATE (Completed) 29 August 2012 TIME (Completed) 5:22:00 PM CHECKED BY MAM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	(SI	CL)
291.9	Ground Surface								
0.0	50 mm organics SILTY CLAY - brown to grey silty clay some sand	1	AS			0	14	70	16
291.1 / 0.8	SILT - brown sandy silt (compact)	2	SS	22		0	31	(69)	
290.4 / 1.5	SAND - grey sand with silt with gravel occasional cobbles/boulders (loose/compact)	3	SS	17	▽ (1.7 m)	27	49	(24)	
		4	SS	7					
		5	SS	7					
288.1 / 288.0 / 3.8	Auger Refusal								
3.9	DCPT Refusal End of Borehole								



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) 29/8/12 5:15:00 PM	1.7	1.8
2)	-	-
3)	-	-

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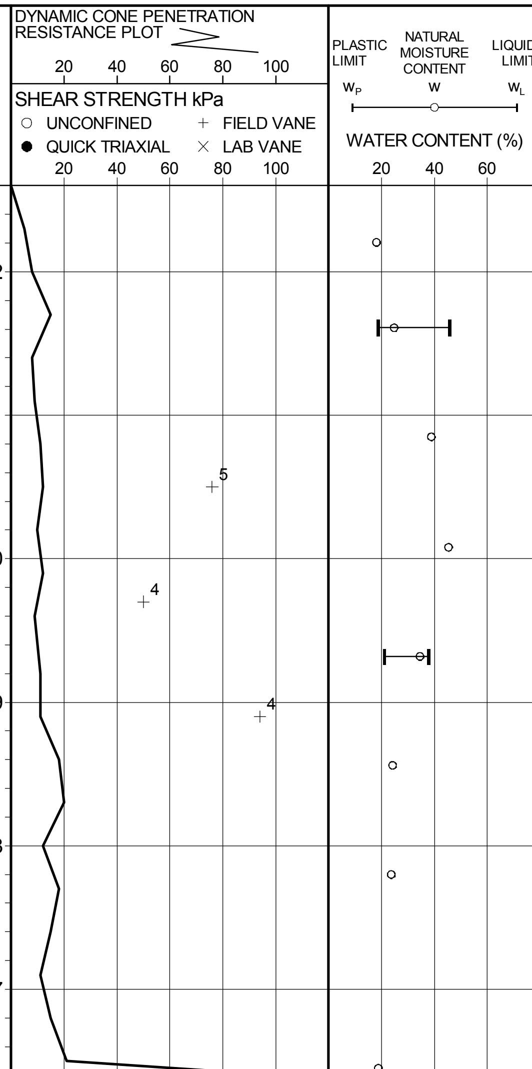
ENCLOSURE NO.: 8 (Pg. 1 of 1)

RECORD OF BOREHOLE NO. 07

METRIC

REFERENCE	12/08/12141-F2	DATUM	Geodetic
LOCATION	N 5060 638.5 E 291 797.7 - Township of Croft	ORIGINATED BY	JL
PROJECT	GWP 5467-09-00, Highway 124	BOREHOLE TYPE	Track Mounted CME 45B - Hollow Stem Augers
COMPILED BY	AT	CLIENT	AECOM Inc.
DATE (Started)	29 August 2012	DATE (Completed)	29 August 2012
TIME (Completed)	2:30:00 PM	CHECKED BY	MAM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
292.6	Ground Surface					
0.0	50 mm organics SILTY SAND - brown silty sand trace organics (loose)	1	AS			
291.8 / 0.8	SILTY CLAY - brown to grey silty clay trace sand (stiff)	2	SS	13		0 5 56 39
		3	SS	5		
		4	SS	2		
		5	SS	WH		0 0 77 23
288.8 / 3.8	SILT - grey silt sand trace clay (loose)	6	SS	10		0 7 88 5
		7	SS	4		
286.4		8	SS	25/50 mm		
6.2	Auger Refusal DCPT Refusal End of Borehole					



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) 29/8/12 2:25:00 PM	2.3	4.2
2) 29/8/12 5:10:00 PM	1.8	-
3) 31/8/12 10:10:00 AM	1.3	-

MEL-GEO 12141 - AREA 2 - BOREHOL LOGS.GPJ MEL-GEO.GDT 5/6/13

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ENCLOSURE NO.: 9 (Pg. 1 of 1)

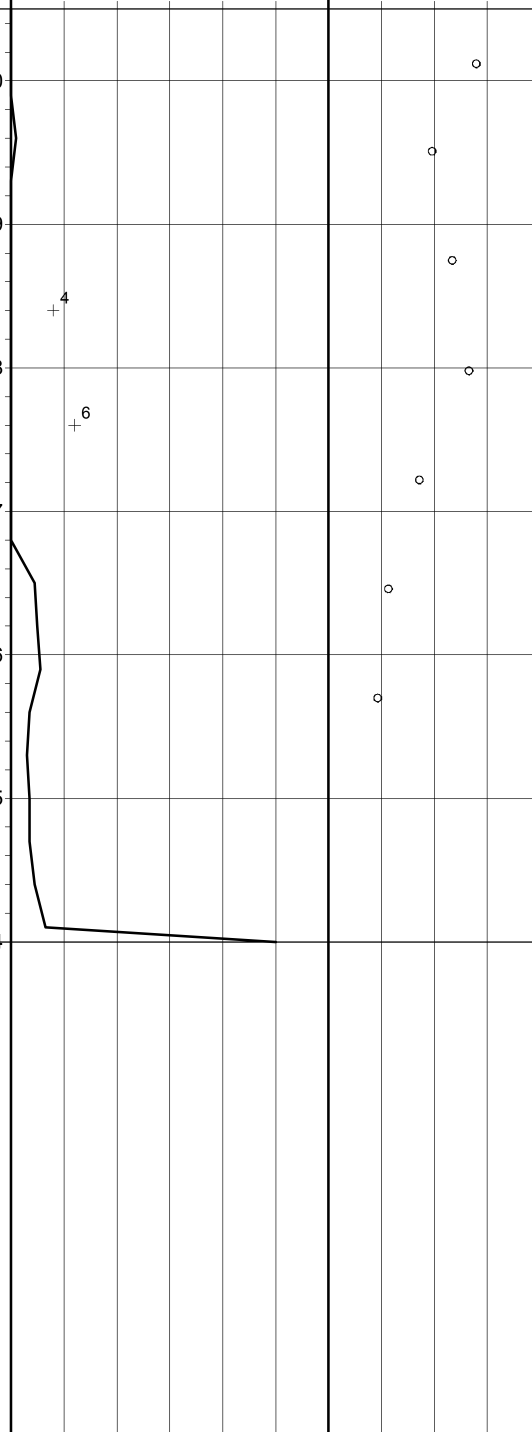
METRIC

RECORD OF BOREHOLE NO. 08

LVM

REFERENCE 12/08/12141-F2	DATUM Geodetic	LOCATION N 5060 655.8 E 291 718.5 - Township of Croft	ORIGINATED BY JL
PROJECT GWP 5467-09-00, Highway 124		BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers	COMPILED BY AT
CLIENT AECOM Inc.		DATE (Started) 30 August 2012; DATE (Completed) 30 August 2012; TIME (Completed) 4:40:00 PM	CHECKED BY MAM

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT / SHEAR
290.5	Ground Surface					
0.0	100 mm organics PEAT - black fibrous peat with sand	1	AS		▽ (0.1)	
289.7 0.8	SILTY SAND - grey silty sand trace gravel (very loose)	2	SS	WH	▽ (1.1)	
289.1 1.4	SILTY CLAY - grey silty clay (soft)	3	SS	WH		Field vane, sensitivity 4
		4	SS	PM		Field vane, sensitivity 6
		5	SS	PM		
286.8 3.7	SILT - grey silt with sand (very loose/loose)	6	SS	6		
		7	SS	WH	Cave in (4.8)	
284.4 6.1	Auger Refusal					
284.0 6.5	DCPT Refusal End of Borehole					



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) 30/8/12 4:35:00 PM	1.1	4.8
2) 31/8/12 8:00:00 AM	0.1	-
3)	-	-

L|V|M
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ENCLOSURE NO.: 10 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 09

LVM

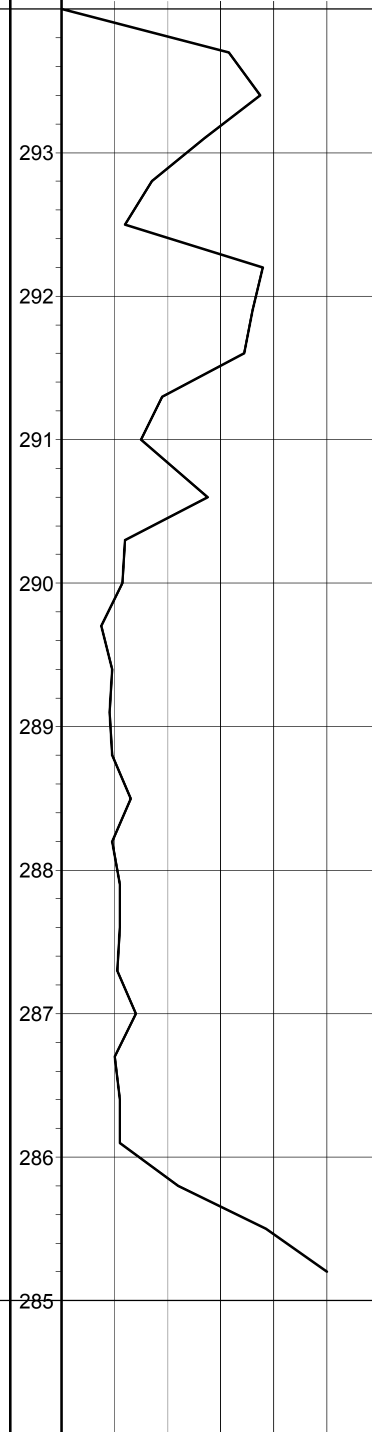
REFERENCE 12/08/12141-F2 DATUM Geodetic LOCATION N 5060 643.5 E 291 732.4 - Township of Croft ORIGINATED BY JL

PROJECT GWP 5467-09-00, Highway 124 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 17 September 2012 DATE (Completed) 17 September 2012 TIME (Completed) 2:00:00 PM CHECKED BY MAM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
294.0	Ground Surface					
0.0	75 mm Asphalt 550 mm Crushed Gravel	1	AS		o	
293.4 / 0.6	FILL - brown sand trace to some silt trace to some gravel	2	SS	29	o	4 81 (15)
	(compact/very dense)					
	layer of asphalt	3	SS	70	o	
		4	SS	18	o	20 74 (6)
	layer of rock fill	5	SS	46	o	
	layer of asphalt	6	SS	48	o	
289.7 / 4.3	SANDY SILT - grey sandy silt trace some clay trace organics (loose)	7	SS	4	wP–w–wL	0 35 54 11
288.8 / 5.2	SILT - grey silt with sand trace gravel (compact)	8	SS	24	o	
		9	SS	18	o	
285.2 / 8.8	DCPT Refusal					
285.0 / 9.0	Auger Refusal End of Borehole					

Column headings: SOIL PROFILE (ELEV DEPTH, 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)



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) 17/9/12 6:08:00 AM	-	-
2)	-	-
3)	-	-

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ENCLOSURE NO.: 11 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 10

L|V|M

REFERENCE	12/08/12141-F2	DATUM	Geodetic	ORIGINATED BY	JL
PROJECT	GWP 5467-09-00, Highway 124	LOCATION	N 5060 635.4 E 291 709.4 - Township of Croft	COMPILED BY	AT
CLIENT	AECOM Inc.	BOREHOLE TYPE	Truck Mounted CME 45B - Hollow Stem Augers	CHECKED BY	MAM
		DATE (Started)	20 September 2012		
		DATE (Completed)	20 September 2012	TIME (Completed)	10:30:00 AM

ELEV / DEPTH (m)	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
294.0	Ground Surface						
0.0	65 mm Asphalt 450 mm Crushed Gravel FILL - brown sand some silt with gravel (dense/very dense)	1	AS				
		2	SS	24			
	asphalt layer	3	SS	76	Cave in (2.1 m)		20 66 (14)
291.7 / 2.3	Auger Refusal on Rock Fill						
289.2 / 4.8	DCPT Refusal 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

ELEVATION SCALE: 293, 292, 291, 290

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) 20/9/12 10:25:00 AM	DRY	2.1
2)	-	-
3)	-	-

MEL-GEO 12141 - AREA 2 - BOREHOL LOGS.GPJ MEL-GEO.GDT 5/6/13

L|V|M
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

Drawing No. 2:	Borehole Location and Soil Strata
Figure Nos. L-1 to L-5:	Grain Size Distribution Curves
Figure No. L-6:	Atterberg Limits Sheet
Figure No. L-7:	Shear Strength Chart
Figure No. L-8:	Lab Test Summary Sheet

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Cont No	
GWP No 5467–09–00	

HWY NO. 124
Township of Croft
Culvert at Station 25+160
BOREHOLE LOCATIONS & SOIL STRATA

Drawing 2

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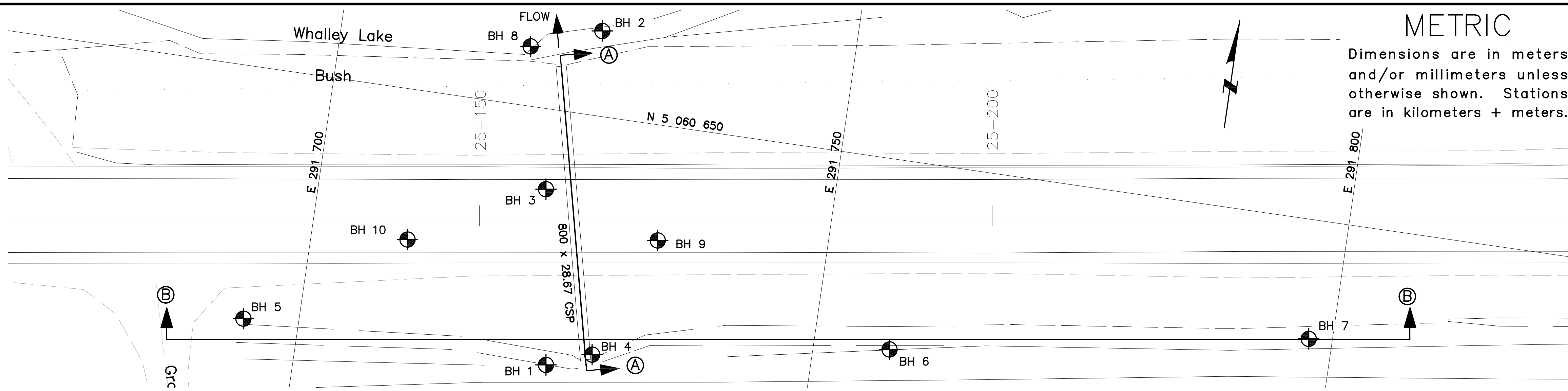
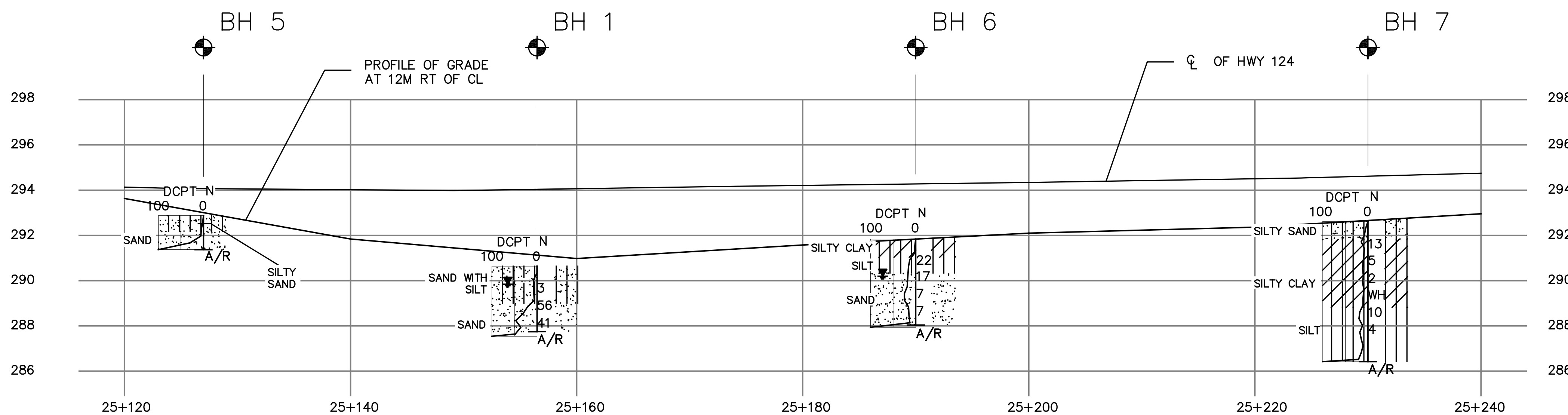
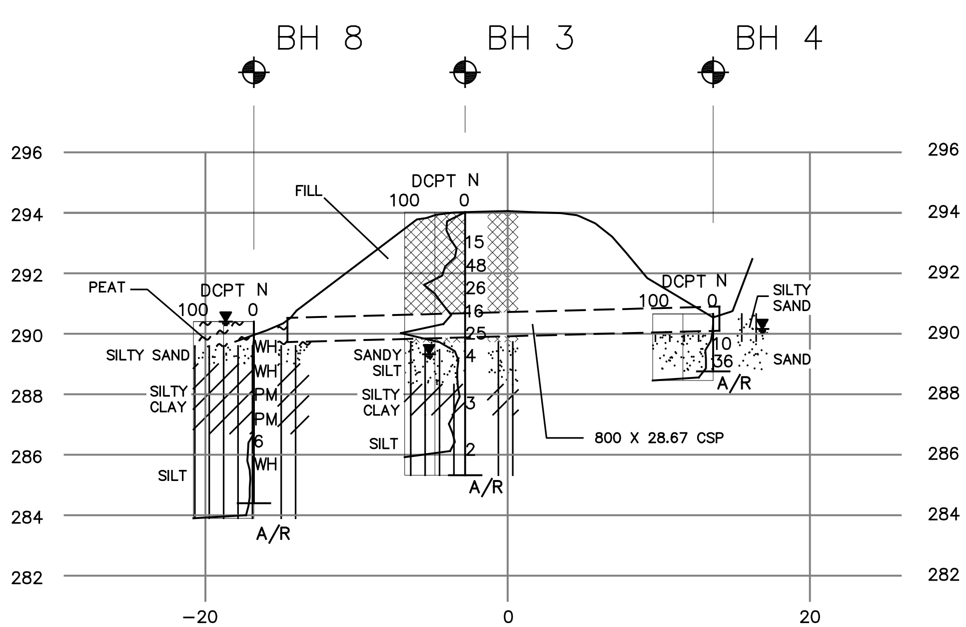
METRIC
Dimensions are in meters and/or millimeters unless otherwise shown. Stations are in kilometers + meters.



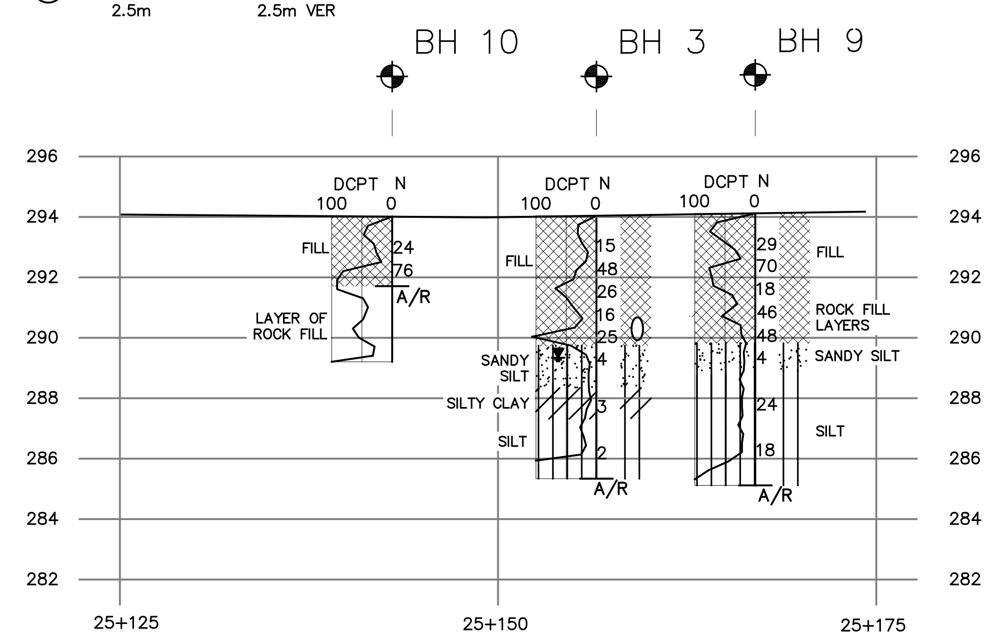
PLAN 5m SCALE 5m



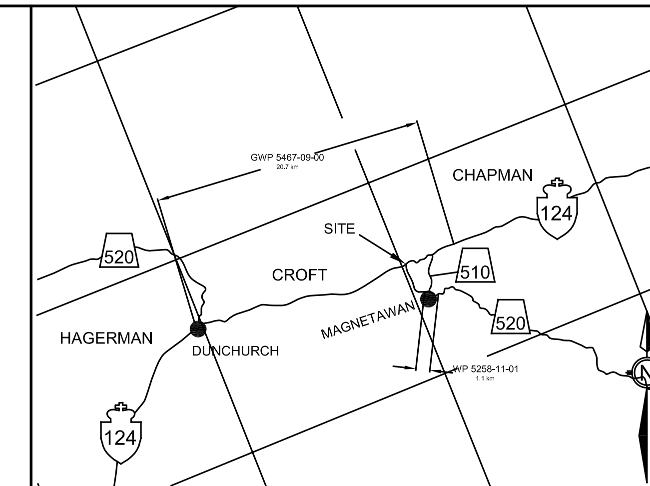
DETOUR PROFILE AT Ⓑ – Ⓑ 5m SCALE 5m HOR 2.5m 2.5m VER



SECTION AT CULVERT Ⓐ – Ⓐ 5m SCALE 5m HOR 2.5m 2.5m VER



℄ PROFILE 5m SCALE 5m HOR 2.5m 2.5m VER



KEY PLAN – NOT TO SCALE

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole and DCPT
- 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

Borehole No.	Elev.	O/S	Co–ordinates Northerly	Co–ordinates Easterly
Borehole No. 1	290.6	14.5m Rt	5060625.3	291724.5
Borehole No. 2	290.2	18.0m Lt	5060658.2	291725.3
Borehole No. 3	294.0	2.6m Lt	5060642.2	291722.0
Borehole No. 4	290.7	13.5m Rt	5060626.9	291728.8
Borehole No. 5	293.1	10.0m Rt	5060625.5	291694.6
Borehole No. 6	291.9	13.0m Rt	5060631.6	291757.3
Borehole No. 7	292.6	12.0m Rt	5060638.5	291797.7
Borehole No. 8	290.5	16.5m Lt	5060655.8	291718.5
Borehole No. 9	294.0	2.4m Rt	5060638.8	291733.5
Borehole No. 10	294.0	2.3m Rt	5060635.4	291709.4

NOTE 1: 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.

NOTE 2: 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.

REVISIONS DATE	BY	DESCRIPTION
Jan 2013	IK	DRAFT
May 2013	MCM	FINAL

HWY No. 124 – Croft Twp – Culvert at Station 25+159.20			REF 12141–F2
SUBM'D		GEOCRES 31E–322B	SITE
DRAWN IK	CHK MAM	DATE January 2013	FIG 2

Reference No.: 12/08/12141-F2
Date: May 2013

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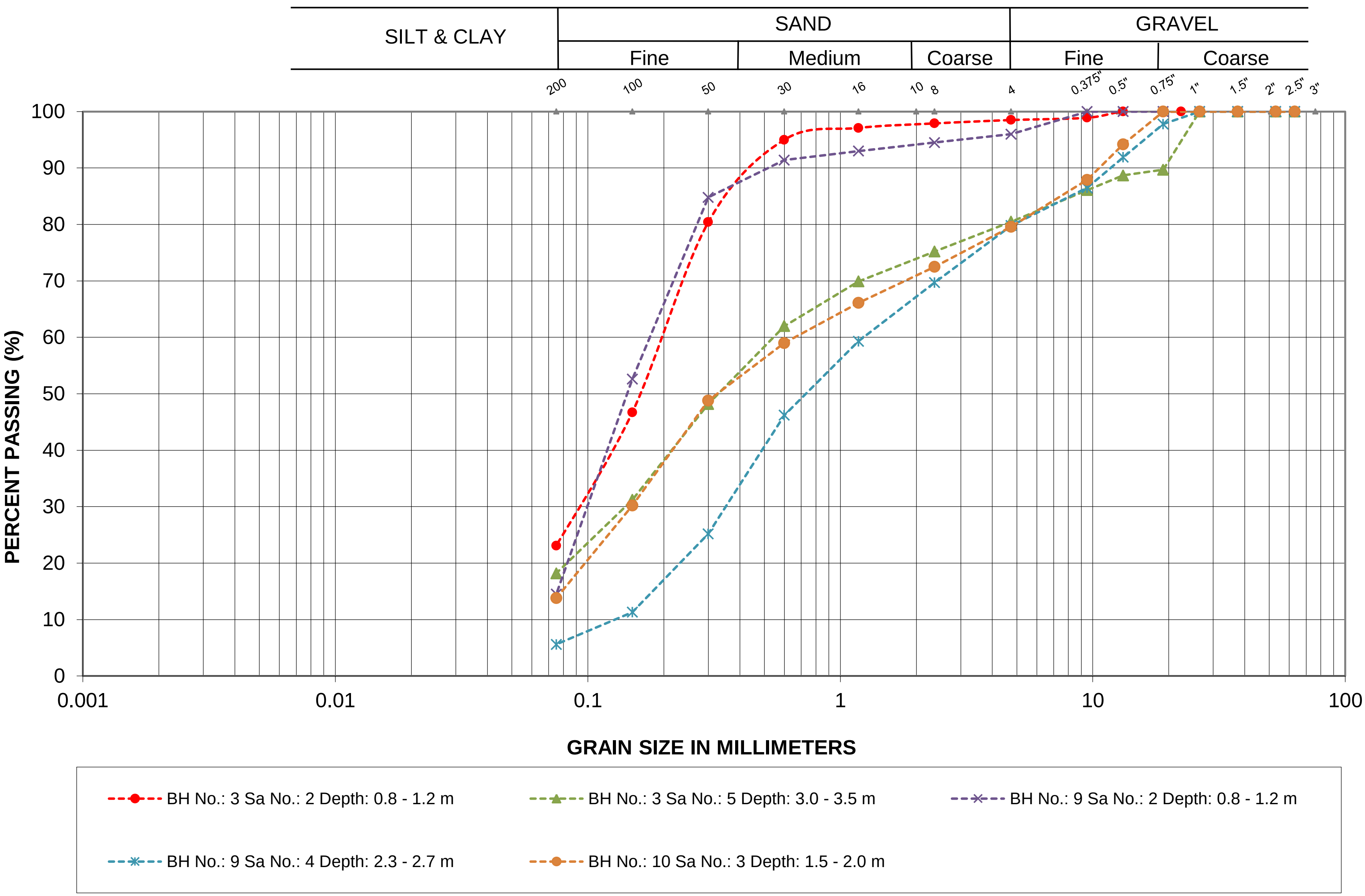
GRAIN SIZE ANALYSIS



G.W.P.: 5467-09-00
LOCATION: Hwy 124

EMBANKMENT FILL

Reference No.: 12/08/12141-F2
Date: May 2013

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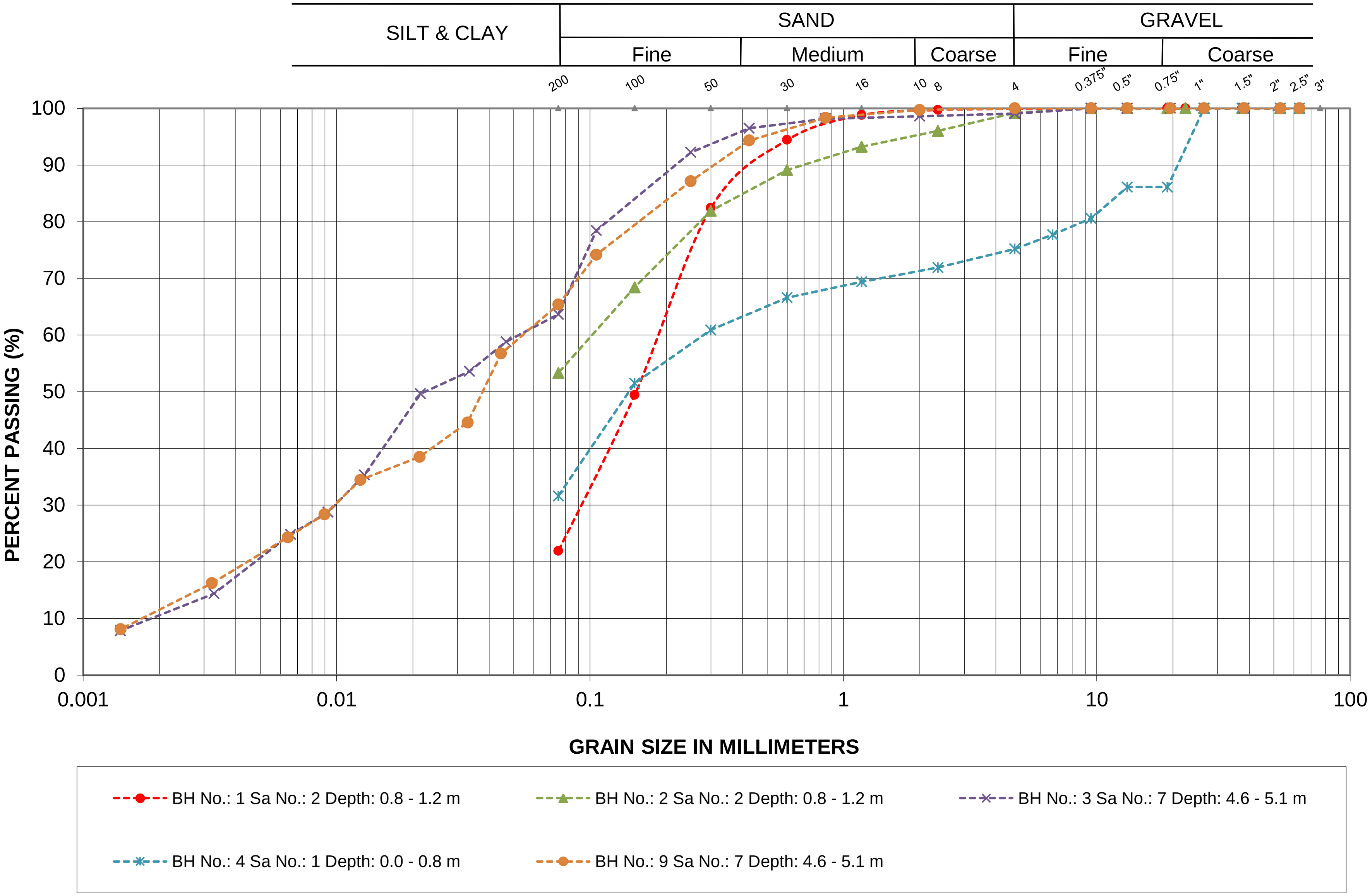
GRAIN SIZE ANALYSIS



G.W.P.: 5467-09-00
LOCATION: Hwy 124

SILTY SAND/SANDY SILT

Reference No.: 12/08/12141-F2
Date: May 2013

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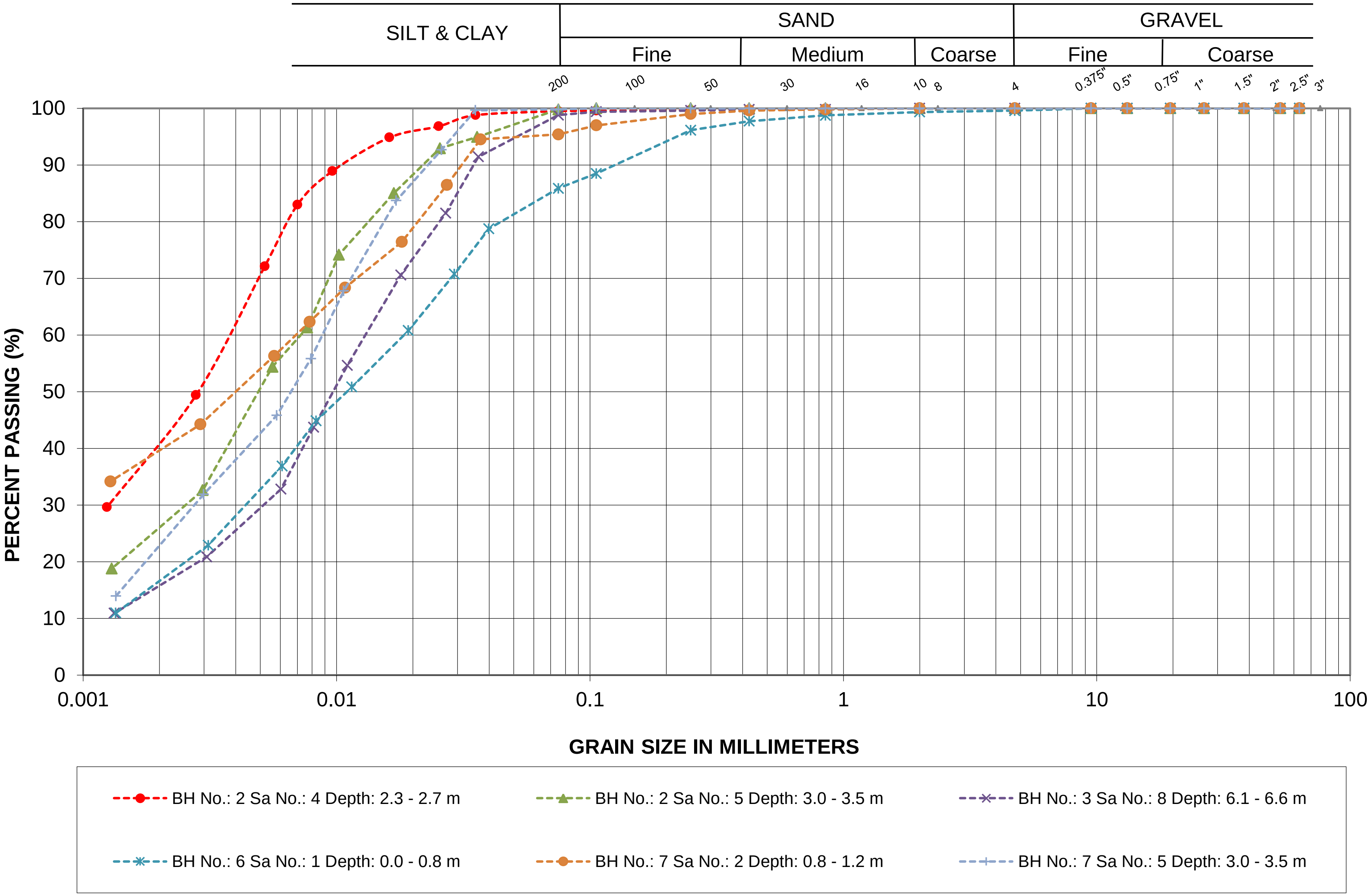
GRAIN SIZE ANALYSIS

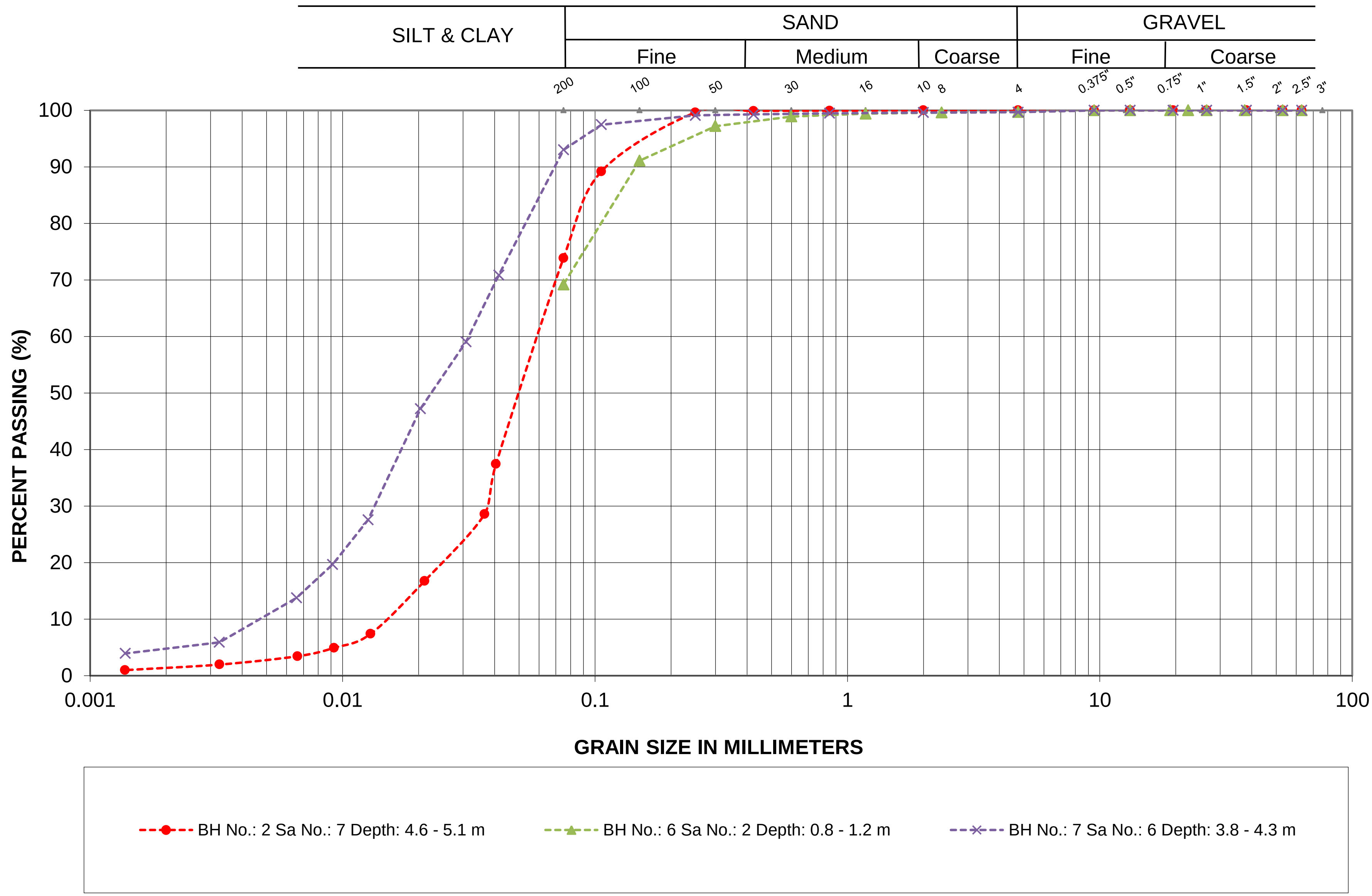


G.W.P.: 5467-09-00
LOCATION: Hwy 124

SILTY CLAY

Reference No.: 12/08/12141-F2
Date: May 2013

GRAIN SIZE ANALYSIS



G.W.P.: 5467-09-00
LOCATION: Hwy 124

SILT

Reference No.: 12/08/12141-F2
Date: May 2013

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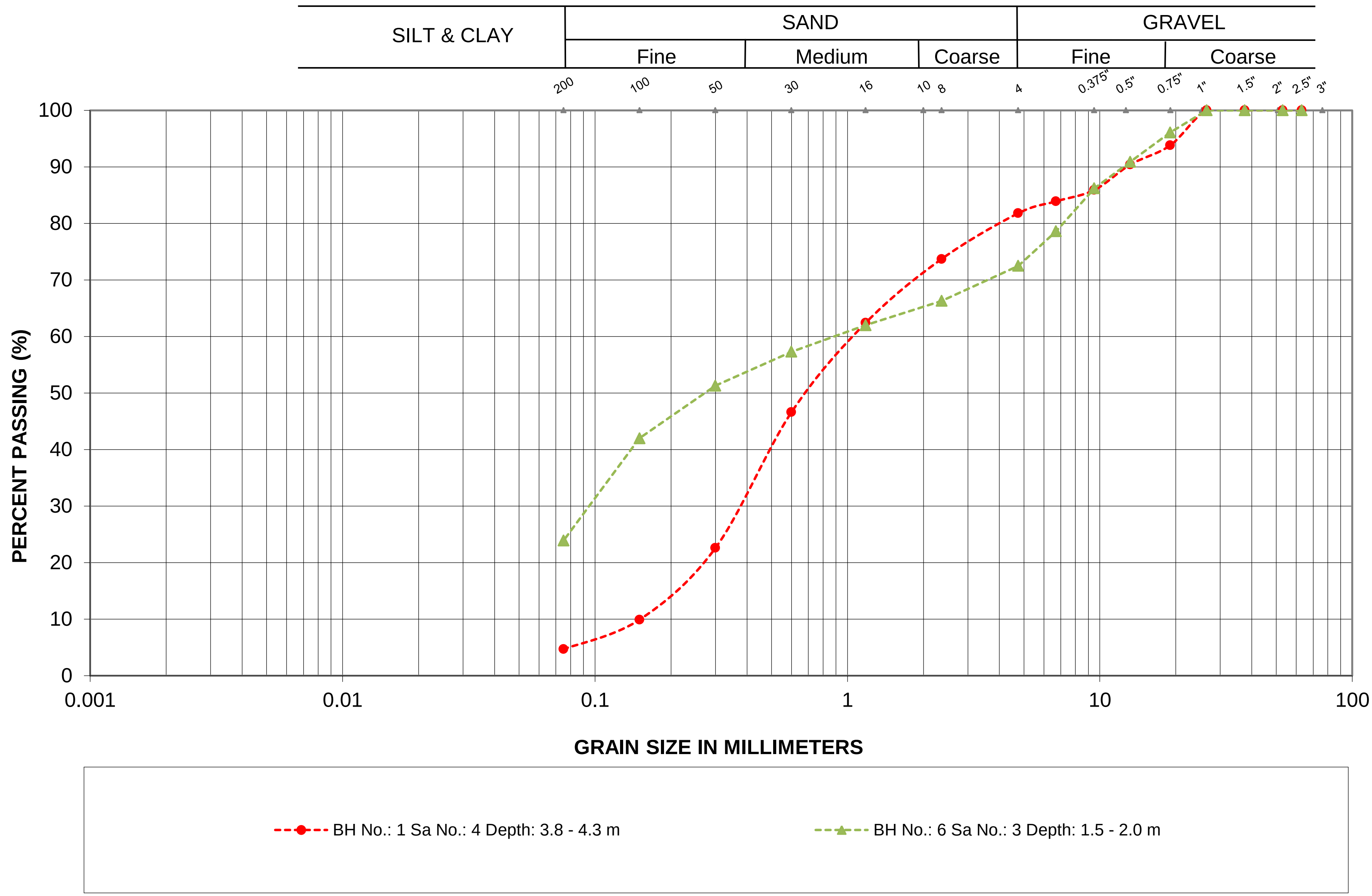
GRAIN SIZE ANALYSIS

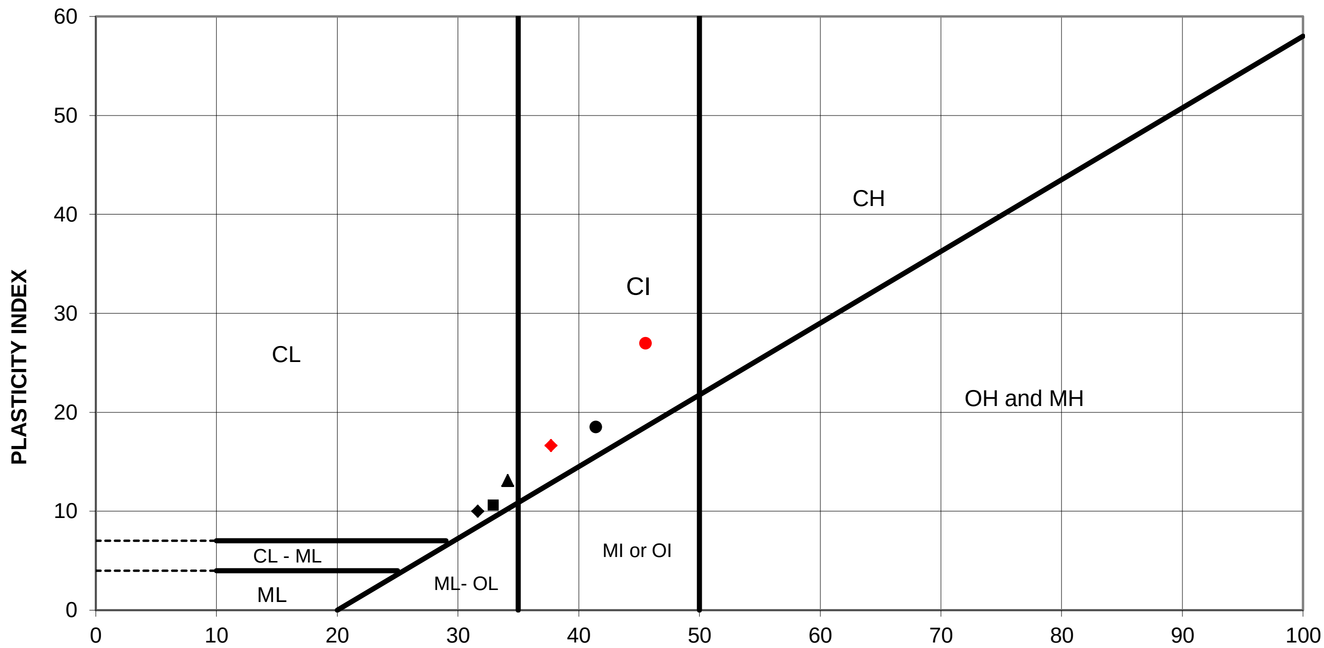


G.W.P.: 5467-09-00
LOCATION: Hwy 124

SAND

ATTERBERG LIMITS TEST RESULTS	FIGURE L-6

ATTERBERG INDICES



SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plastic Limit	Plasticity Index	NMC %
●	2	4	2.3	287.9	41.4	23.0	18.5	53.6
◆	2	5	3.0	287.2	31.7	21.7	10.0	46.0
■	3	8	6.1	287.9	32.9	22.3	10.6	30.1
▲	6	1	0.0	291.9	34.1	21.1	13.1	33.5
● (red)	7	2	0.8	291.8	45.6	18.6	27.0	24.8
◆ (red)	7	5	3.0	289.6	37.7	21.1	16.6	34.5

Date: May-13
Project: Hwy 124
G.W.P: 5467-09-00

Prep'd: AT
Chkd: MAM
Ref. No.: 12/08/12141-F2

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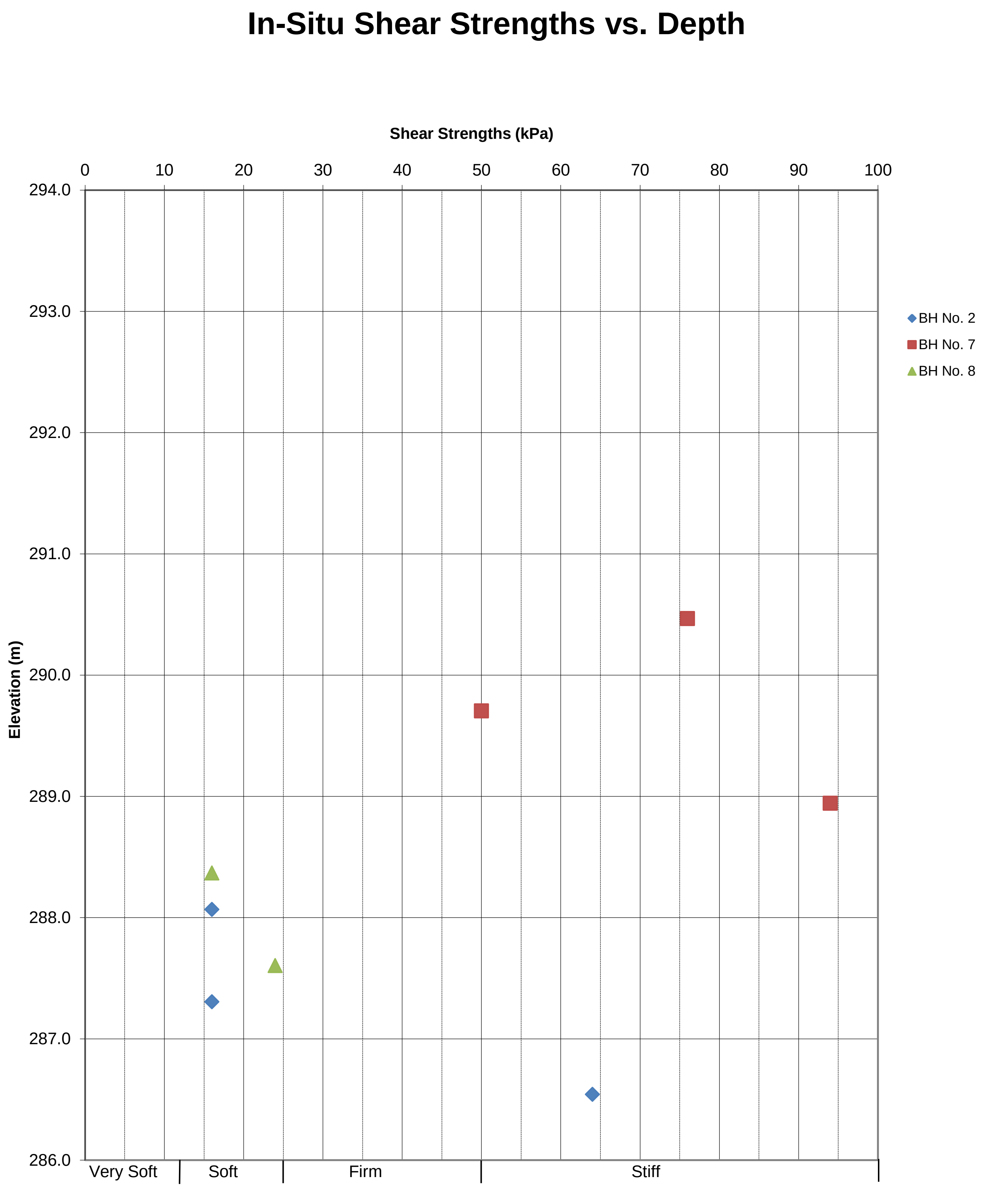
IN-SITU SHEAR STRENGTHS	Figure No. L-7



Project: 12/08/12141-F2
G**WP:** 5467-00-00

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Date: May 2013
Checked:MAM

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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					37.5				N/A			
	2	0.8	0	78	22		23.3				3			
	3	1.5					17.5				56			
	4	2.3	18	77	5		13.0				41			
2	1	0.0					23.5				N/A			
	2	0.8	1	46	53		31.9				WH			
	3	1.5					45.2				PM			
	4	2.3	0	0	60	40	53.6	41.4	23.0		PM			
	5	3.1	0	1	74	25	46.0	31.7	21.7		PM			
	6	3.8					26.1				2			
	7	4.6	0	26	72	2	17.6				WH			
	8	6.1					10.1				57			
3	1	0.0					5.3				N/A			
	2	0.8	1	76	23		10.1				15			
	3	1.5					9.2				48			
	4	2.3					6.7				26			
	5	3.1	19	63	18		14.0				16			
	6	3.8					15.4				25			
	7	4.6	1	35	54	10	31.0				4			
	8	6.1	0	1	83	16	30.1	32.9	22.3		3			
	9	7.6					25.5				2			
4	1	0.0	25	43	32		18.5				N/A			
	2	0.76					14.0				10			
	3	1.52					21.0				36			
5	1	0.0					14.6				N/A			
	2	0.8					12.9				35/200 mm			
6	1	0.0	0	14	70	16	33.5	34.1	21.1		N/A			

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 (%)				
6	2	0.8	0	31	69		18.9				22			
	3	1.5	27	49	24		15.4				17			
	4	2.3					21.4				7			
	5	3.1					22.7				7			
7	1	0.0					18.1				N/A			
	2	0.8	0	5	56	39	24.8	45.6	18.6		13			
	3	1.5					38.8				5			
	4	2.3					45.3				2			
	5	3.1	0	0	77	23	34.5	37.7	21.1		WH			
	6	3.8	0	7	88	5	24.2				10			
	7	4.6					23.7				4			
	8	6.1					18.8				25/50 mm			
8	1	0.0					55.7				N/A			
	2	0.8					39.1				WH			
	3	1.52					46.7				WH			
	4	2.29					53.01				PM			
	5	3.05					34.3				PM			
	6	3.81					22.57				6			
	7	4.57					18.49				WH			
9	1	0					2.95				N/A			
	2	0.76	4	8	15		6.31				29			
	3	1.52					6.22				70			
	4	2.29	20	74	6		3.32				18			
	5	3.05					13.14				46			
	6	3.81					21.5				48			
	7	4.57	0	35	54	11	31.37				4			
	8	6.1					23.19				24			

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 (%)				
9	9	7.6					21.7				18			
10	1	0.0					2.3				N/A			
	2	0.8					8.8				24			
	3	1.5					7.4				76			

Appendix 4 Photo Essay

Enclosure No. 12: Photo Essay

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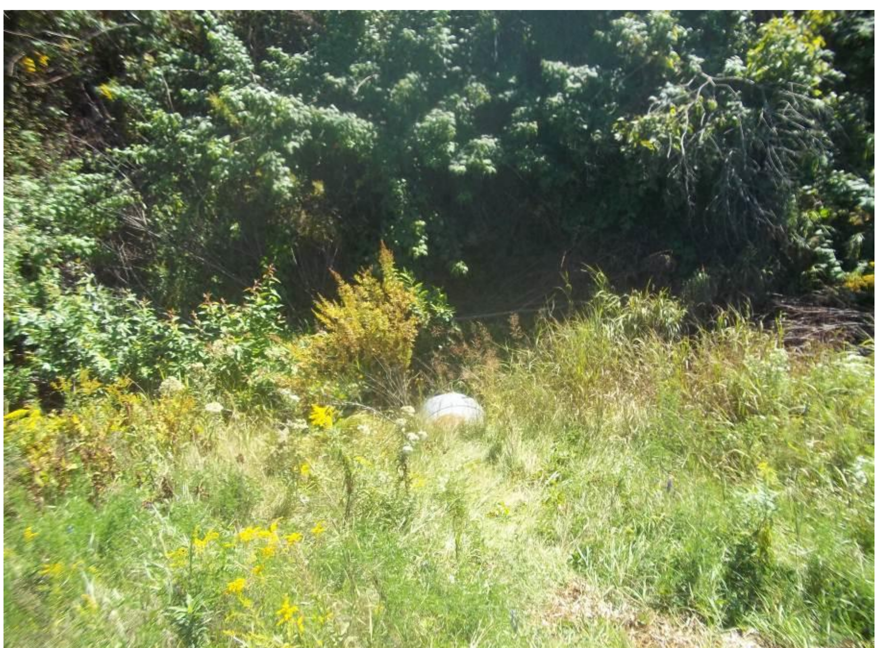
Existing Embankment – Looking East	Photo: 1

South Embankment Slope – Looking West	Photo: 2

Project: Hwy 124 – Station 25+160, Twp of Croft	Photos Provided By: LVM Date: September 2012

South Embankment Slope – Looking East	Photo: 3

Culvert Invert – Looking South	Photo: 4



Project: Hwy 124 – Station 25+160, Twp of Croft	Photos Provided By: LVM Date: September 2012

Location of Culvert Outlet – Looking North	Photo: 5

Culvert Outlet	Photo: 6

Project: Hwy 124 – Station 25+160, Twp of Croft	Photos Provided By: LVM Date: September 2012

Appendix 5 Design Data

Figure Nos. S-1 and S-2:	Slope Stability
Table A:	Comparison of Shoring Alternatives
Figure No. SK-4:	Conceptual Shoring Locations

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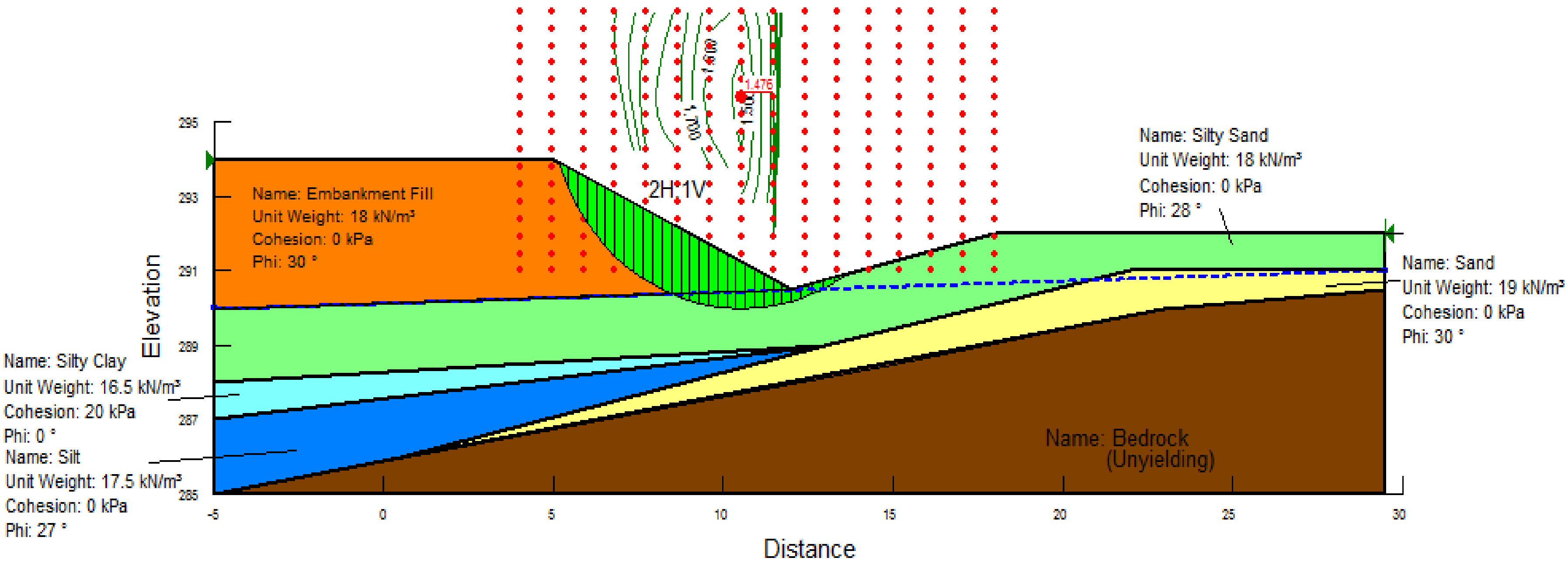
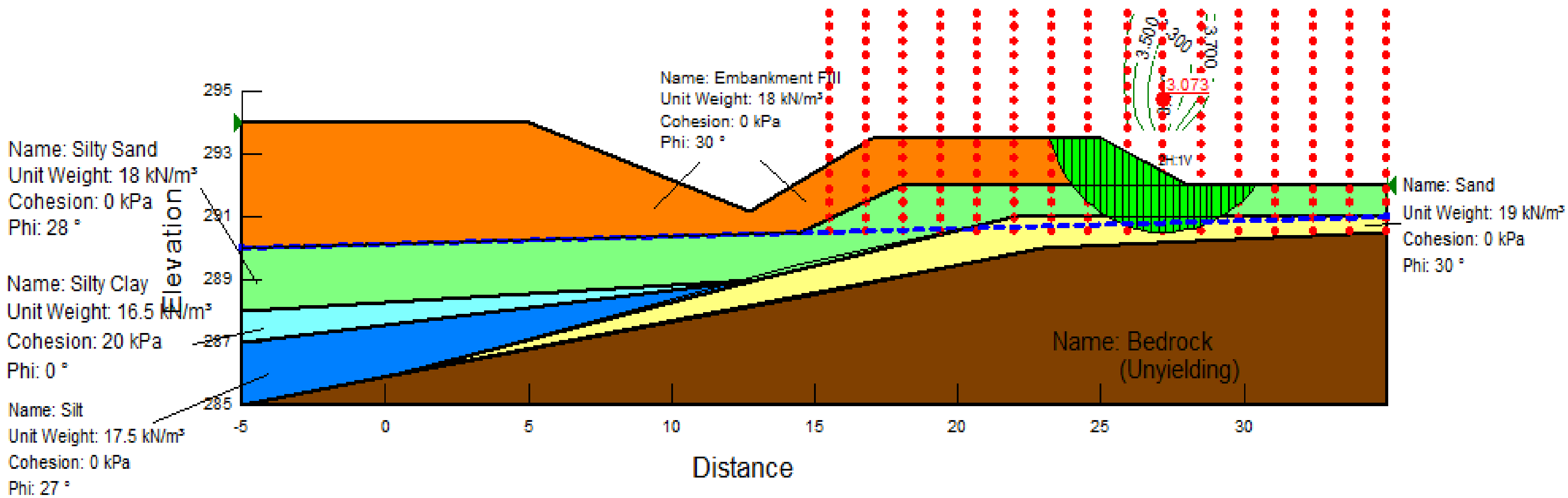
Stability Analysis
Embankment Stability
Long Term Stability
Failure of Native Material
2H:1V Slopes



Stability Analysis
Station 25+160
TWP of Croft

Stability Analysis
Embankment Stability
Temporary Detour
Failure of Native Material
2H:1V Slopes



Stability Analysis
Station 25+160
TWP of Croft

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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.	$ 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	
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	

REF.: 12141-F2

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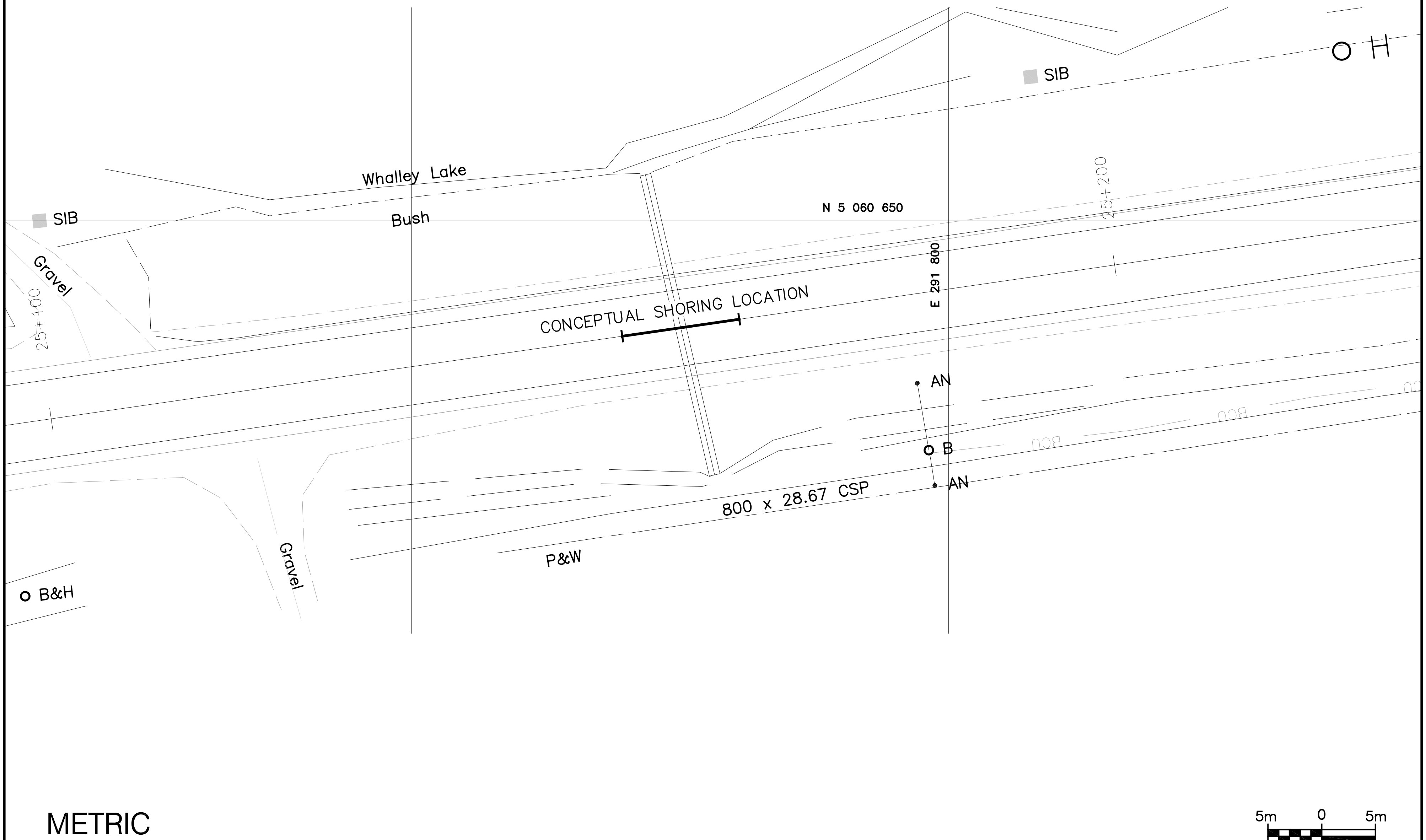

METRIC

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

HWY 124 - Township of Dunchurch - Culvert at 25+160
Conceptual Shoring Location

FIGURE SK-4