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

Highway 535 Rehabilitation
Culvert Replacement – Site No. 46-198/C
Pine River Culvert
Station 13+753 - TWP of Cherriman
GWP 5563-04-00
WP 5534-05-01

Highway 535
From 8.1 km North of Highway 64 (Noelville) Northerly 12.1 km;
And, 0.6 km North of Highway 64 Northerly 1.4 km
District of Sudbury

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

Date: April 9, 2012
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Geocres No. 41I-282

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1.0 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 design of a protection system. This culvert replacement (GWP 5563-04-00, WP 5534-05-01) is located on Highway 535, some 27.7 km south of Hwy 17, in the Township of Cherriman.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5010-E-0015. The terms of reference for the scope of work are outlined in MEL's Proposal P-10-169, dated December, 2010. The purpose of this investigation was to determine the subsurface conditions in the area of the culvert in order to provide 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.

2.0 SITE DESCRIPTION

The foundation investigation for this SPCSP culvert is located at Station 13+753, Township of Cherriman (Site No. 46-198/C). The topography at the site is a low wet land area with flooded organic terrain to the left and right of the embankment. The existing highway embankment currently supports two undivided lanes of highway, running in a north-south direction. The existing highway, at the culvert location, is constructed on a fill embankment some 5.7 m in height, with centerline elevation of 200.9 m at the culvert location. The culvert at this location is a 4.6 m diameter SPCSP, with beveled ends some 24.6 m in length. Flow through the culvert is from left (west) to right (east) (see Photo Essay, Appendix D).

Infrastructure at the culvert location consists of overhead power and communication wires on the east (right) side of the highway.

2.1 Site Physiography and Surficial Geology

This project is located in the Geomorphic Sub-province known as the North Shore - Sudbury Ridges and Pockets. The topography on this section of Highway 535 is generally rolling. There are a few exposed bedrock ridges. At many locations, significant layers of earth overlay the bedrock. Organic terrain was also observed. Within the project area, overburden consists primarily of silty clay, overlying silts and sands.

Bedrock in the area, as indicated on OGS Map 2506, is of the Late to Middle Precambrian Era. At the location of this culvert foundation investigation, the bedrock comprises of Metasediments including: conglomerate, sandstone, siltstone, chert, and iron formations.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on May 27th, August 24th and 25th, and September 21st to September 23rd, 2011, during which eight (8) sampled boreholes, along with a series of unsampled auger probes and DCP Tests, were advanced. For the purposes of foundation design for the culvert replacement, two boreholes were advanced through the embankment slightly down chainage from the culvert, and one borehole was advanced at each the inlet and outlet ends of the culvert. Four boreholes were advanced through the embankment, two up and two down chainage from the culvert, to provide subsurface data to support the design of a protection system.

The field investigation, from the embankment, was carried out using a truck mounted CME drilling rig equipped with hollow stem augers, standard augers, N size casing and coring equipment and routine geotechnical sampling equipment. Unsampled borings and pre-drilling to allow advancement of borehole was undertaken with a Gardner Denver 300 hydraulic rock drill.

Initially Borehole Nos. 1, 2, and 3 were advanced, from the embankment, with conventional hollow stem auger however, shallow refusal was encountered on rock fill. A hydraulic rock drill was subsequently mobilized to the site and, unsampled probes were advanced at the location of Borehole No. 1, 2 and 3, to determine the thickness of the rockfill. At this time, the location of Borehole Nos. 1A, 2A, and 3A were pre-drilled, with the hydraulic rock drill , through the dense concentration of rock fill, to a depth of some 3 m. Borehole No. 1A, 2A, and 3A were all advanced on the right side at the locations as shown on Figure 2. This pre-drilling allowed the subsequent advance of N size casing through the dense concentration of large rock fill within the embankment. This pre-drilling allowed the advance of a DCPT at Borehole 1A, and sampled boreholes at Borehole Nos. 2A and 3A. In addition to the sampled boreholes a series of closely spaced auger probes were advanced along the left and right shoulder of the embankment, in the area of the culvert, to determine the depth to rock fill above the culvert. This data is shown on Figure No. SK-1, Appendix B.

The outlet and inlet to the culvert were flooded with 2 m plus depth of water at the time of investigation. A light-weight barrel type raft supporting a wash bore Mobile B-24 drill rig was mobilized to the site to undertake Borehole Nos. 4 and 5 (see Photos 3 and 4 Appendix D).

Where the borings were advanced beyond the rock fill with N casing, soil samples were obtained 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. Where possible 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, as well as Atterberg Limit testing and specific gravity. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix B), with a summary of results presented on the laboratory sheets in Appendix C (Figures Nos. L-1 to L-4).

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.

4.0 SUBSURFACE CONDITIONS

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs and Figure SK-1 (Appendix B) and on Figure No. 2 (Appendix C). 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 Test (DCPT) 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 Pine River Culvert, Station 13+753, TWP of Cherriman – Site No. 46-198/C

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Figure No. 2, Appendix C and Figure SK-1. During the course of the exploration program, eight (8) sampled boreholes were put down at this site, with Borehole Nos. 1 to 3 and Borehole Nos. 1A, 2A, and 3A advanced through the existing embankment, and Borehole Nos. 4 and 5 advanced at either end of the culvert. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 3 were recorded at 200.8, 200.8 and 200.9 m, respectively, with Borehole Nos. 1A, 2A, and 3A at elevations 200.8, 200.8 and 200.9 respectively. Borehole Nos. 4 and 5 were advanced at the culvert ends, from a raft in the river.

The water/river level at Borehole Nos. 4 and 5 was recorded at elevation 198.2 m, at the time of the investigation.

4.1.1 Surficial Layers

At surface, at Borehole Nos. 1 to 3, and 1A to 3A, a surficial layer of pavement structure consisting of 125 to 175 mm of asphalt and 125 mm of crushed gravel was encountered. At Borehole Nos. 4 and 5, free water was encountered from elevation 198.2 m to elevations 196.0 and 196.2 m, respectively.

4.1.2 Fill

Underlying the surficial pavement structure (asphalt and base granular layer) at Borehole Nos. 1 to 3, and 1A to 3A, a deposit of fill consisting of brown gravelly sand some silt was penetrated to depths varying between 0.6 to 1.1 m. The natural moisture content measured on samples of this deposit was in the order of 4 to 7%. A gradation analysis was carried out on one (1) sample of this deposit, the results of which indicated 34% gravel size particles, 50% sand size particles, and 16% silt and clay size particles (Figure No. L-1, Appendix C). Auger refusal was encountered on rock fill at depths of 0.6, 0.8, and 1.1 m below ground surface at Borehole Nos. 1 to 3, respectively (elevations 200.2, 200.0, and 199.8 m, respectively). Based on the response of the hydro track drill rig used to advance the probe holes through the rock fill, it appears the rock fill consisted of a high concentration of cobble/boulder size rock with granular to a depth of some 3 m below existing pavement surface. Below this depth, the concentration and size of rock pieces in the fill decreased. N size casing augers were advanced through this lower boundary of the fill deposit. Sampling of the lower embankment fill was started, through the casings, at Borehole Nos. 2A and 3A, at a depth of 3 m (elevation 197.8 and 197.9 respectively). Additionally, a DCPT was advanced through the lower fill deposit at BH No. 1A. The lower fill consisted of sands some gravel to gravelly trace silt, with occasional cobble size rock. The natural moisture content measured on samples of this deposit was in the order of 12 to 17%. Gradation analyses were carried out on three (3) samples of this deposit, the results of which indicated 23 to 38% gravel size particles, 56 to 72% sand size particles, and 5 to 6% silt and clay size particles (Figure No. L-1, Appendix C). Based on SPT 'N' values of 12 to 45 blows per 300 mm penetration, the compactness of this lower portion of the fill deposit was described as compact to dense, generally dense. This deposit was encountered to a depth of 6.4 m below grade at Borehole Nos. 2a and 3a (elevations 194.4 and 194.7 m, respectively).

A series of Auger Probes (AP Nos. 1 to 12) were advanced, with a Sterling auger and CME drill rig, from the embankment over the area of the culvert to determine if rock fill was present in the backfill, directly over the culvert. Auger refusal was encountered at each of the probes locations at depths ranging from 0.4 to 1.0 m (elevations 199.9 to 200.5 m), except at AP No. 9, were advance was terminated at a depth of 1.1 m (elevation 199.8 m), to prevent possible damage to the culvert, see Enclosure No. 7, Appendix B. Boreholes were also advanced for the geotechnical investigation carried out by LVM | MERLEX at this culvert location. Auger refusal was encountered at the geotechnical boreholes locations (GI Nos. 1 to 8) at depths of 0.6 to 0.8 m (elevations 200.1 to 200.3 m), see Enclosure No. 8, Appendix B. Refusal depths are illustrated on Figure SK-1, Appendix B.

4.1.3 Sand (Fill)

Below the river water level, at Borehole Nos. 4 and 5, a deposit of sand trace to some gravel trace to with silt was encountered. Refusal was encountered at depths of 2.9 and 2.4 m below top of water at Borehole Nos. 4 and 5, respectively (elevations 195.3 and 195.8 m, respectively). At Borehole No. 4, a series of DCPT probes were advanced, at distances varying from 14 to 21 m right of centerline. Refusal at DCPT 1 to 4 inclusive were encountered between elevations 195.4 to 195.5 m. Refusal at these locations was likely on cobbles/boulder size rock fill, possibly remaining after the original construction of the culvert and embankment.

4.1.4 Clay

Underlying the fill at Borehole Nos. 2A and 3A, a deposit of grey clay was penetrated. The natural moisture content measured on samples of this deposit was in the order of 74%. Atterberg Limits testing was carried out on one (1) sample of this deposit, the results of which indicated a Liquid Limit in the order of 88% and a Plastic Limit in the order of 28%. Based on the results of Atterberg Limits testing, this deposit was classified under USCS as a clay of high plasticity (CH) (Figure No. L-4, Appendix C). Based on in-situ shear strengths in this deposit of 42 kPa to greater than 100 kPa, this deposit was described as firm to very stiff (see Figure No. L-5, Appendix C). This deposit was encountered to depths of 8.8 and 7.6 m below grade at Borehole Nos. 2A and 3A, respectively (elevations 192.0 and 193.3 m, respectively).

4.1.5 Silty Clay

Below the clay a transition to silty clay occurred. The natural moisture content measured on samples of this deposit was in the order of 32 to 36%. Atterberg Limit testing was carried out on one (1) sample of this deposit, the results of which indicated a Liquid Limit in the order of 29% and a Plastic Limit in the order of 20%. Based on the results of Atterberg Limits testing, this deposit was classified under USCS as silty clay of low plasticity (CL) (Figure No. L-4, Appendix C). Based on in-situ shear strengths in this deposit of 43 kPa to 64 kPa, this deposit was described as firm to stiff (see Figure No. L-5, Appendix C). This deposit was encountered to depths of 10.4 and 8.5m below grade at Borehole Nos. 2A and 3A, respectively (elevations 190.4 and 192.4 m, respectively).

4.1.6 Silt

Underlying the silty clay at Borehole Nos. 2A and 3A, a deposit of grey silt trace gravel trace sand trace clay was penetrated. The natural moisture content measured on samples of this deposit was in the order of 21 to 25%. A gradation analysis was carried out on two (2) samples of this deposit, the results of which indicated 0 to 2% gravel size particles, 5 to 7% sand size particles, 83 to 86% silt size particles, and 8 to 9% clay size particles (Figure No. L-2, Appendix C). Based on SPT 'N' values of 6 to 7 blows per 300 mm penetration, the compactness of this deposit was described as loose. This deposit was encountered to depths of 11.6 and 10.2 m below grade at Borehole Nos. 2A and 3A, respectively (elevations 189.2 and 190.7 m, respectively).

4.1.7 Sand

Underlying the silt at Borehole Nos. 2A and 3A, a deposit of grey sand trace to some gravel trace silt was penetrated. The natural moisture content measured on samples of this deposit was in the order of 14 to 19%. Gradation analyses were carried out on two (2) samples of this deposit, the results of which indicated 3 to 12% gravel size particles, 80 to 94% sand size particles, and 3 to 8% silt and clay size particles (Figure No. L-3, Appendix C). Based on SPT 'N' values of 15 to 29 blows per 300 mm penetration, the compactness of this deposit was described as compact. Sampling was terminated in this deposit at depths of 12.8 and 18.9 m below grade at Borehole Nos. 2A and 3A, respectively (elevations 188.0 and 182.0 m, respectively).

DCPT were advanced to refusal at Borehole Nos. 1A and 2A DCPT refusal was encountered at depths of 28.7 and 29.2 m below grade, respectively (elevations 172.1 and 171.6 m, respectively).

4.1.8 Historical Information

Based on a previous foundation investigation, Geocres No. 41I-4, by GEOCON Ltd. carried out in 1964, the original alignment of the Pine River crossed the highway alignment at a distance of some 30 m south of the existing culvert. Originally the culvert area was a flooded muskeg swamp with some 2 m of muskeg (organic soil), at the culvert location, underlain by a deposit of stiff/firm clay underlain by loose silts, and sands and gravels similar to what was encountered during this investigation. The invert of the culvert, based on the original contract drawings, was set at an inlet and outlet elevation of 195.13 m and 195.01 m respectively, which was approximately at the interface between the muskeg and the underlying clay deposit. The inlet and outlet were established at a distance of 15.5 m left and right of centerline. The previous stratigraphy and borehole location plan, Drawing T7690-1, has been reproduced and included, for general information, as Enclosure No. 10 in Appendix E. The approximate location of the existing culvert has been shown on this enclosure for reference purposes.

It is understood that, based on the original contract drawings, during the construction of the culvert, the muskeg/organic soil was excavated from below the culvert and embankment as per Standard DD-406 using dragline equipment. Subsequently, a granular pad (of unknown thickness) was placed to support the culvert. This was shown on Sheet 6 from Contract No. 67-16 which has been included as Enclosure No. 11 in Appendix E.

Although not encountered during this current investigation, the historical 1964 geotechnical data indicates that artesian water pressure was encountered under the cohesive stratum at the location of the previous 1964 Borehole No. 1, which was located in the Pine River some 30 m south of the culvert. The artesian pressure elevated the confined water level 300 mm above the river ice level. The ice level was recorded at elevation 197.7 at that time. The previous data also indicates that the confining clay stratum is absent at the original 1964 Borehole No. 4, which was located some 21 m north of the existing culvert.

4.2 Groundwater Conditions

The water level in the culvert was measured at an elevation of 198.2 m, at the time of this investigation. The ice level, during the 1964 geotechnical investigation was at elevation 197.7 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. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix B). The water level in Borehole Nos. 2A and 3A were measured at elevation 199.5 and 198.5 upon completion, respectively. Borehole Nos. 4 and 5 were advanced at the culvert ends in the river, and as such the water level was that of the river at the time of this investigation (elevation 198.2 m). The groundwater and river water levels will fluctuate seasonally.

The water level/flow in the river is restricted by a beaver dam located some 41 m right of the centerline.

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5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

A foundation investigation was carried for the proposed replacement of an existing culvert and for a protection system, as identified in the RFP. The existing 4.6 m diameter SPCSP culvert is identified as Site No. 46-198/C and located at Station 13+753 in the Township of Cherriman.

The existing culvert is a 4.6 m diameter SPCSP with beveled ends some 24.6 m long. The drawings for Contract No. 67-16 indicate that the inverts ends were at an off-set of 15.5 m left and right of centerline and that the culvert was at a 70° skew to centerline. Flow through the culvert is from west to east with an average summer flow of 0.2 m^3/s and a one in ten year peak daily flow of 4.0 m^3/s.

The existing highway embankment currently supports two undivided lanes of traffic running in a north-south direction. Based on data from this foundation investigation, the embankment supporting the existing pavement structure, at the culvert site, has been constructed using rock fill, consisting of cobble/boulder size rock in a granular matrix. The embankment slopes at the culvert location were measured at approximately 1.9H:1.0V at the time of surveying. The native material underlying the embankment fill generally consisted of stiff to firm clays and silty clays underlain by silts underlain by sands with DCPT refusal encountered at depths of 28.7 to 29.2 m below existing grade (elevations 172.1 to 171.6 m).

It is understood that a 3.9 by 3.9 m precast concrete box culvert is proposed to replace the existing 4.6 m SPCSP culvert. The box culvert will likely be constructed at a similar vertical alignment and skew as the existing culvert. The vertical and horizontal alignment of the highway will remain as is.

5.2 Foundation Considerations

Based on the characteristics of the native stiff/firm clay subgrade present below the culvert, at approximately elevation 194.5 m, the response of the existing embankment, and a founding elevation similar to that of the existing culvert, a factored bearing resistance at ULS of 170 kPa can be used for a concrete frame **box** culvert. A geotechnical resistance at SLS of 80 kPa can be used for design, in consideration of less than 25 mm combined immediate and long term (consolidation) settlement. If a concrete frame **open** culvert is considered, then a factored bearing resistance at ULS of 125 kPa and a factored bearing resistance at SLS of 80 kPa should be used.

The existing embankment has preloaded the soils at the culvert location and since there will be no change in the height or width of the embankment, and therefore no increase in embankment load, no appreciable settlement of the embankment is anticipated. As such, it will not be necessary to install the culvert on a camber at this site.

5.3 Culvert Design, Bedding, and Embedment

The embankment consists of granular soils (pavement structure) overlying a stratum of rock fill (estimated at 2 m thick) underlain by granular fill with occasional cobble/boulder size rock. The results of this investigation indicate that, below the culvert invert, the native soils at Borehole Nos. 2A and 3A consist of a firm to very stiff clay overlying silts and sands. The original Contract Drawing, as shown on Enclosure No. 11, notes a granular pad was to be placed below the existing SPCSP however the depth is unknown as it is noted that the depth was to be as directed by the Engineer. A review of the condition of the pavement surface, at the culvert locations, revealed minor longitudinal and transverse asphalt cracking, however, in general, the embankment appears to have performed well (see Photo Essay, Appendix D).

It is understood that the preferred type of replacement culvert will be a precast rigid concrete box culvert. Bedding for a rigid concrete box culvert should consist of Granular A with a total thickness of 300 mm. The bedding under the middle third of the box unit base should be loosely placed and uncompacted, whereas the bedding on the outer one-thirds of the width shall be compacted in conformance with OPSS 501. The upper 75 mm portion of the Granular A bedding should be uncompacted throughout the width of the box and incorporated as the top levelling course in conformance with OPSS 422. During backfilling, the embankment fill should be placed in a balanced manner on the outer sides of the box unit. Cover material for concrete box culverts should consist of 300 mm of Granular A, placed in conformance with MTOD 803.021.

It is understood that frost tapers will not be required at this culvert, as per the geotechnical report also prepared by LVM | MERLEX, Ref No. 11/14/11046-P2, provided granular materials are used for backfill. To prevent loss of granular cover and backfill into the rock fill, if an open excavation is undertaken, a Non-Woven Class II Geotextile shall be placed as shown on SK-2 Appendix F. Backfill to the culvert may consist of Granular B Type I or better.

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

Apron (cut-off) walls, 1.2 m deep, must be added to the ends of the rigid box culverts in accordance with the MTO Concrete Culvert Design Manual. It is anticipated that wing walls will also be added at the concrete box culvert ends. An apron of rock protection will be required at the culvert ends if wing walls are not used. Clay seals are not considered necessary.

5.4 Culvert Installation and Construction Staging Considerations

The existing culvert is established in an embankment some 5.7 m in height and partially constructed of rock fill, between the depths of some 1 to 3 m. This rock fill is underlain by a fill consisting of granulars containing occasional cobble/boulder size rock fill. The embankment material is considered a Type 3 soil as defined in the Occupational Health and Safety Act and Regulations for Construction Projects. Short-term (i.e. day) open excavations will be stable above the groundwater table at a temporary angle of 1H:1V, however excavations established at this slope must not be left unattended at any time. Below the prevailing groundwater table, the slopes of open excavations will have to be flattened to 2H:1V or possibly shallower depending upon the method of dewatering employed.

The invert elevation of the existing culvert is at 195.1 m, with the top of the embankment at elevation 200.9 m at centerline. As such, the embankment at this location is some 5.7 m in height above the culvert invert at the centerline. Therefore, a 6.4 m deep excavation (i.e. to elevation 194.5 m) will be required, since the invert of the box will be placed a distance equal to 10% of the box height below the stream bed level and allowing for a minimum of 300 mm of bedding and leveling course below the culvert. The present platform width at this location is some 11 m, as can be seen on the cross section on Figure No. 2. This width, as is, will not be sufficient to carry out an open excavation using staged construction. As such, a temporary protection system will have to be used to carry out the excavation at this culvert location and maintain an active lane of traffic, since a detour is not considered appropriate at this site.

5.4.1 Protection System

The installation of a protection system (shoring) for use in the culvert replacement operation will require penetration through some 6.4 m of embankment fill and penetration into the native clay stratum. The field drilling program indicated that the pavement surface was supported on granular material to a depth varying between 0.6 to 1.1 m below grade. This granular layer was followed by a deposit of cobble/boulder size rock fill extending to a depth of some 3 m below grade at centreline. This stratum required pre-drilling with a hydro track rock drill, to allow advance of the augers and/or casing. Below a depth of some 3 m, conventional hollow stem augers and N size casing could be advanced without predrilling, however, occasional rock pieces requiring tri-cone drilling to penetrate the obstructions, were encountered in the lower region of the embankment fill. The embankment fill extended to approximately elevation 194.8 m, at the borehole locations.

This embankment fill is underlain by strata of clay and silty clay, followed at depth by silts underlain by sands and gravel over bedrock at depth. The deposit of cobble/boulder size rock fill in the embankment required pre-drilling to allow advance of conventional augering equipment and will therefore probably be difficult to penetrate with a conventional shoring/protection system. The high water level will also complicate this operation.

Based on the results of this drilling program, rock fill is present above and beyond the sides of the existing 4.6 m SPCSP culvert. However, the thickness of rock fill above the culvert is limited. Also, it is expected that the flexible culvert has a surround of granular embedment material, which should not contain rock fill, if installed as per standard specifications.

One method of constructing a protection system, that the contractor could consider, would be to install an interlocking sheet pile shoring/cofferdam systems, around each half of the culvert to maintain an active lane of traffic and aid in dewatering his excavation. The contractor would have to uses a sufficiently robust sheet pile section and plan on possibly having to advance a shallow excavation, over top of the width of the existing culvert, to remove rock fill should it prevent advance of a sheet pile down to the top of the culvert. The contractor would then install the steel sheets parallel to the culvert, driving the sheets through the granular embedment material that should be present along the sides of the culvert. Assuming a minimum of 300 mm of embedment material has been placed around the 4.6 m culvert span, this would result in a sheeted trench with outside dimension of some 5 m, which would allow placement of a 3.9 m wide box culvert. Continuing the sheet pile cofferdam wall to the end of the culvert and closing the ends off would allow the contractor to control the ground water and work within an enclosed coffer dam. This would result in two rectangular cofferdams, one enclosing the left half and the other enclosing the right half of the culvert. The sheets would have to penetrate the underlying clay stratum to cut off water flow.

The contractor may also consider a protection system consisting of a Secant Drilled Pile or other wall type, parallel to centreline, if he has down-the-hole hammer capabilities to penetrate the rock fill stratum. This type of protection system is more costly, however it may allow the contractor to reduce the length of shoring. However, dewatering would be difficult unless the river level was lowered by adjusting the downstream beaver dam.

Considering the cohesionless nature of the embankment fills (granular pavement structure over rock fill over granular fills) a rectangular 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 $K_a = 0.30$, and $\gamma = 20.0$ kN/m^3.

Sufficiently robust sheet piles can be considered for the protection system. If an obstruction is encountered during driving of a sheet, the individual sheet could be left high and the obstruction removed during excavation to allow continued driving. Since rock fill was encountered above the culvert, a shallow excavation to remove the upper layer of rock fill will be required prior to advancing the sheet pile wall. A whaler and strut may be used to span the trench width however, a tieback system may also be chosen by the contractor. The sheet pile design should be carried out by a structural engineer with experience designing sheet pile walls.

If tiebacks are used, the resistance (R) for grouted anchors, located outside the active failure wedge, in cohesionless soils, between a depth of some 3 and 6 m, can be estimated from the following equation as supplied in the Canadian Foundation Manual (4th Edition):

$\mathbf{R = \sigma_z' A_s L_s} \alpha_g$ 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

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

The temporary protection system should be designed and constructed to comply with OPSS 539. In consideration of the location of the protection 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/cover and backfill materials are as follows:

	Granular A	Granular B Type I	Rock Fill	Existing Embankment Fill
Angle of Internal Friction (degrees)	35	30	43	30
Unit weight (KN/m^3)	22	20	18.5	20
Active earth pressure (Ka)	0.27	0.33	0.19	0.33
At-rest earth pressure (Ko)	0.43	0.50	0.32	0.50

For rigid structures, such as precast concrete box, deflection cannot occur, as such the "at-rest" condition (Ko) applies. For flexible structures, such as CSP culverts, deflection can occur, as such the "active" condition (Ka) applies.

5.6 Excavation, Dewatering, and Embankment Reconstruction

If the contractor chooses to extend the protection system longitudinally up the central part of the embankment, to isolate the active traffic lane, an open excavation could be considered to allow installation of the culvert. All excavations greater than 1.2 m in depth must be sloped or shored in accordance with the Occupational Health and Safety Act Regulations for Construction Projects. The soil in the embankment can be considered a Type 3 soil above the prevailing water table. Temporary open excavations will be stable above the groundwater table at an angle of 1H:1V, however will have to be flattened to a 2:1 (H:V) or shallower below the water table depending upon the method of dewatering chosen by the contractor, or if large rock pieces are encountered in the fill.

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

Excavations must be maintained in an dewatered condition during excavation and foundation construction and every reasonable effort must be made to prevent disturbing the founding subgrade. This will require diverting the river flow around the culvert area and local dewatering operations during construction. The estimated average flow in the summer is 0.2 m^3/sec. The groundwater level was recorded in the culvert at elevation 198.2 m, at the time of this investigation. This water level is high due to the presence of a beaver dam a short distance downstream from the culvert. Lowering the water level by adjusting the beaver dam prior to or during construction would greatly reduce the difficulties and cost associated with dewatering. Groundwater control, in accordance with OPSS 517 and 518, will be required to maintain a stable subgrade during culvert installation.

If the contractor does not completely enclose the culvert excavation with a sheet pile cofferdam and instead chooses to use a linear centerline protection system for active lane protection and open cut methods for advancing the excavation, then an end dam will be required, along with temporary diversion of the stream flow. This decision will be dependent upon the depth of water at the time of construction. During construction, local temporary sandbagging, combined with installation of filtered sumps and pumping from the base of the excavation will, at a minimum, be required to maintain a non-cofferdam enclosed excavation in a dewatered condition during subgrade preparation.

By-pass pumping through a separate temporary culvert through the embankment should be considered for diverting stream flow. 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 an unwatered stable condition during excavation and foundation construction cannot be stressed enough.

5.7 Construction Concerns

The presence of rock fill in the embankment, including overlying the culvert, will result in difficulties during installation of the vertical members for the protection system. The contractor should be prepared to address the presence of rockfill and the impact of its presence on the protection system design. The rock fill was present in high concentrations in the embankment generally between depths from 1 to 3 m below grade.

6.0 CLOSURE

Information provided in this report is valid only at the locations described above. Any assumptions of continuity of soil stratigraphy between boreholes, as shown on the enclosed cross-sections, is intended as an aid for design purposes only and does not constitute a statement of existing conditions for contractual or construction purposes. Field investigation was carried out using a CME drill rig mounted on a Bombardier carrier owned by Chrisdamat Management Ltd. The report was prepared by Mr. J. R. Berghamer, P. Eng and reviewed by the firm's principal and MTO designate Mr. M. A. Merleau, P. Eng.

Details of the investigation, the material analysis and recommendation in this report are considered to be complete. However, should any questions arise, please do not hesitate to contact the undersigned.

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M. A. Merleau, P. Eng.
Principal Engineer
MTO Designate

J. R. Berghamer, P. Eng.
Regional Manager

Z:\PROJECT FILES\2011\11046 - PAVE & FDN, Hwy 535 Noelville to Hagar (AECOM)\`FOUNDATION\Reports\FINAL\Area 5 - GWP 5563-04-00 - Site 46-198C - Pine River Culvert\11046-F5 - FINAL FIDR, Hwy 535 GWP 5563-04-00 - Pine River.doc

Appendix A Key Plan

Figure No. 1: Key Plan

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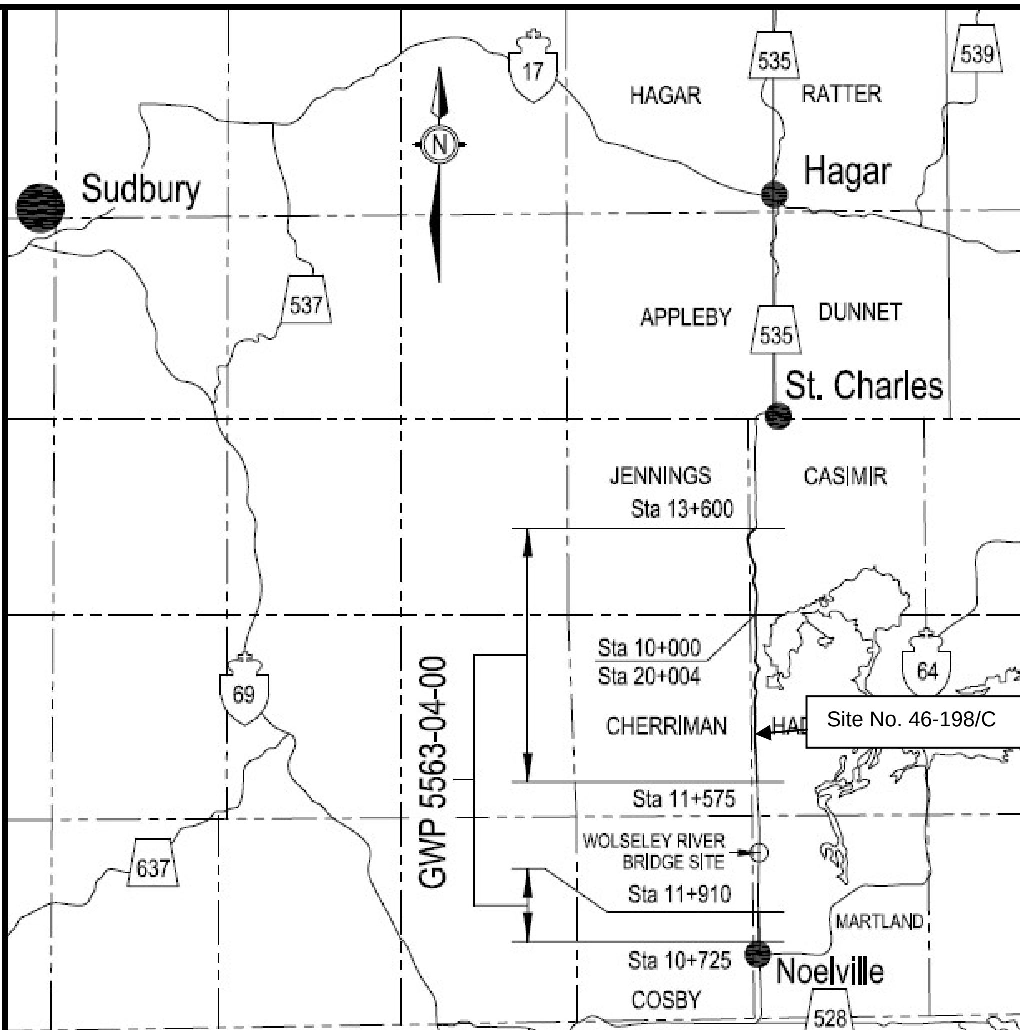
KEY PLAN

Figure No. 1

NOT TO SCALE



FINAL
FOUNDATON INVESTIGATION
AND DESIGN REPORT
GWP 5563-04-00
Highway 535
From 8.1 km North of Highway 64
(Noelville) Northerly 12.1 km;
And, 0.6 km North of Highway 64
Northerly 1.4 km
District of Sudbury

Ref. No.: 11/04/11046-F5 April, 2012

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Appendix B Abbreviations
Record of Borehole Sheets

Enclosure No. 1: List of Abbreviations and Symbols
Enclosure Nos. 2 to 9: Record of Borehole Sheets
Enclosure No. 10: Auger Probe Logs
Enclosure No. 11: Geotechnical Borehole Logs
Figure SK-1: Probe Cross Sections

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LIST OF ABBREVIATIONS AND 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
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

3. SOIL DESCRIPTION (Cont'd)

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

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%

5. LABORATORY TESTS

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

List of Abbreviations and Description of Terms

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.

List of Abbreviations and Description of Terms

Accep	Acceptable	**Hi**	Highly	**RSS**	Remoulded Shear Strength
Agg	Aggregate	**HP**	High Plasticity	**RF**	Rock Fill
Amor	Amorphous	**HM**	Hot Mix	**Sa**	Sand
Asph	Asphalt	**Ip**	Plasticity Index	**Sat**	Saturated
AP	Auger Probe	**L**	Loose	**SH**	Shale
BR	Bedrock	**Lt**	Light or Left	**Sh Rk**	Shot Rock
Blk	Black	**Liq**	Liquid	**Si (y)**	Silt (y)
Bl	Blue	**Lo**	Loam	**Sl (y)**	Slight (ly)
BH	Borehole	**Matl**	Material	**(L,M,H)SFH**	Susceptibility to Frost Heave (L – Low, M – Med, H – High)
Bld (y)	Boulder (y)	**Max**	Maximum		
Blds	Boulders	**Med**	Medium		
Br	Brown	**Mod**	Moderate	**SP**	Slight Plasticity
CF	Channel Face	**Mott**	Mottled	**SSM**	Select Subgrade Material
Cl	Clay	**Mrl**	Marl	**St**	Sensitivity
Co	Coarse	**Mul**	Mulch	**Stn (y)**	Stoney
Cob	Cobbles	**Num**	Numerous	**Stks**	Streaks
Comp	Compact	**MDD**	Maximum Dry Density	**Surf**	Surface
Conc	Concrete	**MWD**	Maximum Wet Density	**Temp**	Temperature
Contam	Contaminated	**MP**	Medium Plasticity	**TH**	Test Hole
Cr	Crushed	**NFP**	No Further Progress	**TP**	Test Pit
Dk	Dark	**NFP (Blds)**	No Further Progress (Boulders)	**Tps**	Topsoil
Decomp	Decomposed	**NMC**	Natural Moisture Content	**Tr**	Trace
D	Dense	**OCC**	Occasional	**USS**	Undisturbed Shear Strength
D_R	Relative Density	**Ora**	Orange	**Unreinf**	Unreinforced
E	Earth	**Org**	Organic	**Varv**	Varved
Fib	Fibrous	**Org M**	Organic Matter	**VF**	Very Fine
F	Fine	**Ob**	Overburden	**WT**	Water Table
Fr Wat	Free Water	**Pavt**	Pavement	**Weath**	Weathered
FB	Frost Boil	**Pedo**	Pedological	**W**	With
FH	Frost Heave	**Pen Mac**	Penetration Macadam	**w**	Field Moisture Content
Gran	Granular	**Psty**	Polystyrene	**Wd (y)**	Wood (y)
Gr	Gravel (ly)	**Poss**	Possible	**Wopt**	Optimum Moisture Content
Grn	Green	**PST**	Prime & Surface Treated	**Wp**	Plastic Limit
Gry	Grey	**Quant**	Quantity	**W_L**	Liquid Limit
H	Heavy	**Reinf**	Reinforced	**Yel**	Yellow

Example of an Abbreviated Borehole

10+000	On C/L	
0 - 300	Rooty Peat Fr Wat @ 200	
300 - 800	Br F Sa Tr Gr Tr Si NOT Accep Granular 'B' Type I 21% PASSING 75 µm Accep SSM	**20ELS107**
800 - 4.0	Gry Si F Sa Tr Gr w @ 3.6 = 20.0 % % Passing 2.00 mm = 91 425 µm = 80 75 µm = 34	**20ELS108** LSFH
4.0	NFP Bld or BR	

Station	Offset from Centerline (C/L) (Rt – Right; Lt – Left)
Depth below Grade*	Abbreviated Soil Description Groundwater Data (where encountered) Abbreviated Lab Data (where applicable) - Sample No., Type of Test(s) and Test Results - Relation to Ontario Provincial Standards and Specifications (OPSS) included (i.e. pass or fail; reason) where applicable

* Depths are measured in millimeters from 0 up to 1 meter and in meters for depths equal to greater than 1 meter

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

METRIC

RECORD OF BOREHOLE NO. 1

LVM | MERLEX

REFERENCE 11/04/11046-F5 DATUM Geodetic LOCATION N5120714.1 E348559.7 - Cherriman Township - Pine River ORIGINATED BY JL

PROJECT WP 5534-05-01, Highway 535 - Site No. 46-198/C BOREHOLE TYPE Truck Mounted CME 45B - H.S. Auger COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) May 27, 2011 DATE (Completed) May 27, 2011 TIME (Completed) 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)
200.8	Ground Surface										
0.0 / 200.2 / 0.6	FILL - 600 mm of pavement structure and granular fill over rock fill		1	AS	N/A				○		
	Auger Refusal End of Brehole										

COMMENTS
See Borehole No. 1A

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)	-	-
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS PINE RIVER.GPJ MEL-GEO.GDT 4/12/12

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ENCLOSURE NO.:3 (Pg. 1 of 2)

METRIC

RECORD OF BOREHOLE NO. 1A

LVM | MERLEX

REFERENCE 11/04/11046-F5 DATUM Geodetic LOCATION N5120715.1 E348560.7 - Cherriman Township - Pine River ORIGINATED BY JL

PROJECT WP 5534-05-01, Highway 535 - Site No. 46-198/C BOREHOLE TYPE Truck Mounted CME 45B - NW Casing COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) September 13, 2011 DATE (Completed) September 20, 2011 TIME (Completed) CHECKED BY MAM

ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
200.8	Ground Surface						
0.0	FILL - 600 mm of pavement structure and granular fill over rock fill coarse rock fill from 0.6 to 2.7 m depth (see comments below)						
198.1 2.7	Commenced DCPT Probably granular fill with occasional cobble/boulder size rock fill						
194.8 6.0	Native soils Probably Silty Clay below elevation 195 m based on DCPT Problably silts and sands below elevation 190 m based on DCPT Probably sands below elevation 182 m based on DCPT						

Continued Next Page

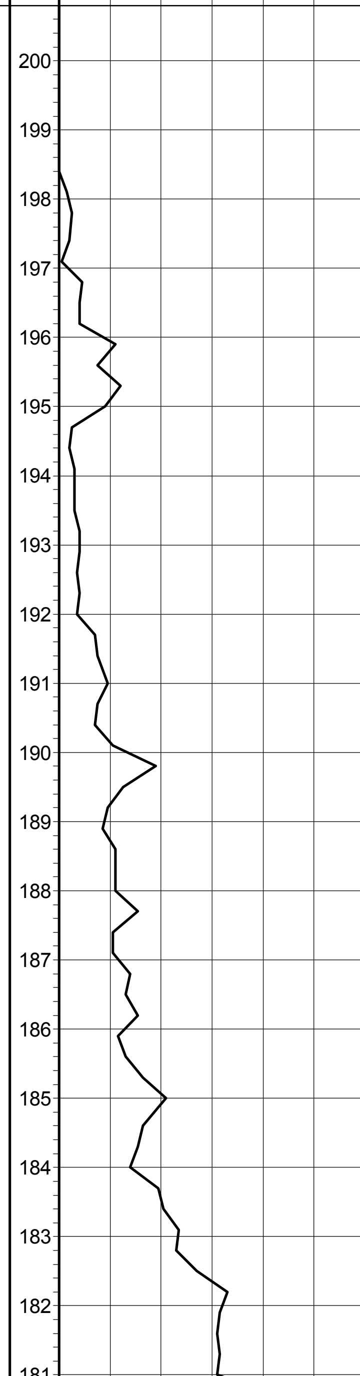
DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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



COMMENTS

Borehole No. 1 met auger refusal at 0.6 m depth. Borehole 1A advanced 3 m north of Borehole No. 1. Predrilled hole Sept 13 to 2.4 m with hydrotrack drill then ran NW casing to 2.4 m to allow driving of DCPT on Sept 20.

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)	-	-
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS PINE RIVER.GPJ MEL-GEO.GDT 4/12/12

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ENCLOSURE NO.:3 (Pg. 2 of 2)

METRIC

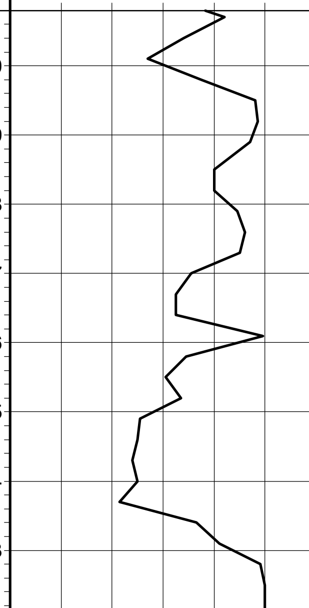
RECORD OF BOREHOLE NO. 1A

LVM | MERLEX

REFERENCE 11/04/11046-F5 DATUM Geodetic LOCATION N5120715.1 E348560.7 - Cherriman Township - Pine River ORIGINATED BY JL

PROJECT WP 5534-05-01, Highway 535 - Site No. 46-198/C BOREHOLE TYPE Truck Mounted CME 45B - NW Casing COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) September 13, 2011 DATE (Completed) September 20, 2011 TIME (Completed) CHECKED BY MAM

SOIL PROFILE			SAMPLES					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)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
	Continued from Previous Page						180, 179, 178, 177, 176, 175, 174, 173				
172.1 28.7	DCPT Refusal End of Borehole										

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

METRIC

RECORD OF BOREHOLE NO. 2

LVM | MERLEX

REFERENCE 11/04/11046-F5 DATUM Geodetic
LOCATION N5120705.5 E348555.8 - Cherriman Township - Pine River
ORIGINATED BY JL

PROJECT WP 5534-05-01, Highway 535 - Site No. 46-198/C
BOREHOLE TYPE Truck Mounted CME 45B - H.S. Auger
COMPILED BY AT

CLIENT AECOM Inc.
DATE (Started) May 27, 2011
DATE (Completed) May 27, 2011
TIME (Completed) 2:00:00 PM
CHECKED BY MAM

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)
200.8	Ground Surface										
0.0	FILL - Pavement structure and granular fill over rock fill		1	AS	N/A				○		
200.0 / 0.8	Auger Refusal End of Borehole						200				

COMMENTS
See Borehole No. 2A

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)	-	-
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS PINE RIVER.GPJ MEL-GEO.GDT 4/12/12

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ENCLOSURE NO.:5 (Pg. 1 of 2)

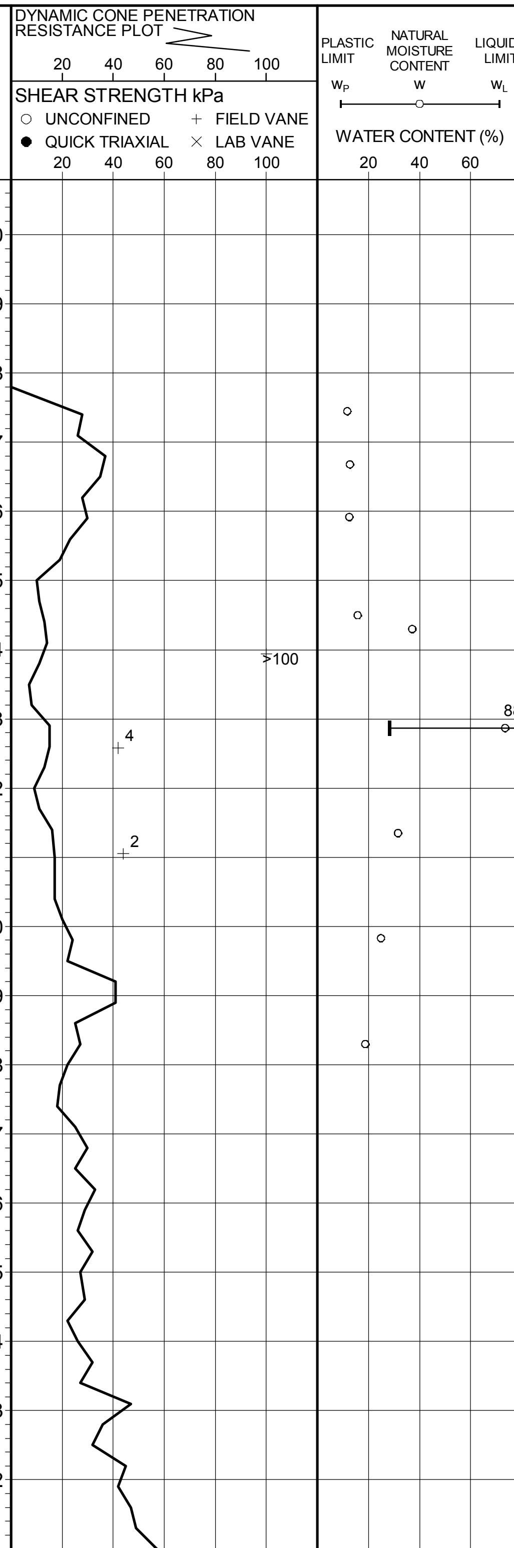
METRIC

RECORD OF BOREHOLE NO. 2A

LVM | MERLEX

REFERENCE: 11/04/11046-F5	DATUM: Geodetic	LOCATION: N5120706.3 E348562.1 - Cherriman Township - Pine River	ORIGINATED BY: JL
PROJECT: WP 5534-05-01, Highway 535 - Site No. 46-198/C		BOREHOLE TYPE: Truck Mounted CME 45B - NW Casing	COMPILED BY: AT
CLIENT: AECOM Inc.		DATE (Started): September 13, 2011; DATE (Completed): September 22, 2011; TIME (Completed): 2:00:00 PM	CHECKED BY: MAM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
200.8	Ground Surface				
0.0	FILL - 800 mm pavement structure and granular fill over rock fill coarse cobble/boulder size rock fill in granulars to 197.8 m (see comments below)				
197.8 3.0	FILL - grey gravelly sand fill trace silt occasional cobble size rock fill (compact)	1	SS	27	
		2	SS	28	
		3	SS	17	35 59 (6)
		4	SS	12	
		5	SS	8	
194.4 6.4	CLAY - grey clay (high plasticity) (very stiff/firm)	6	SS	WH	
192.0 8.8	SILTY CLAY - grey silty clay (low plasticity) (firm)	7	SS	2	
190.4 10.4	SILT - grey silt trace sand trace clay (loose)	8	SS	6	0 5 86 9
189.2 11.6	SAND - grey sand trace gravel trace silt (compact)	9	SS	15	3 94 (3)
188.0 12.8	End of Sampling Continuation of DCPT Probably sands and silts				



Continued Next Page

COMMENTS

Borehole No. 2 met refusal at 0.8 m depth. Predrilled Borehole No. 2A Sept 13 through rock fill to 3.0 m with hydrotrack drill. Advanced hole beyond with NW casing Sept 22.

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) 9/22/12 2:00:00 PM	1.3	1.4
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS PINE RIVER.GPJ MEL-GEO.GDT 4/12/12

ENCLOSURE NO.:5 (Pg. 2 of 2)

METRIC

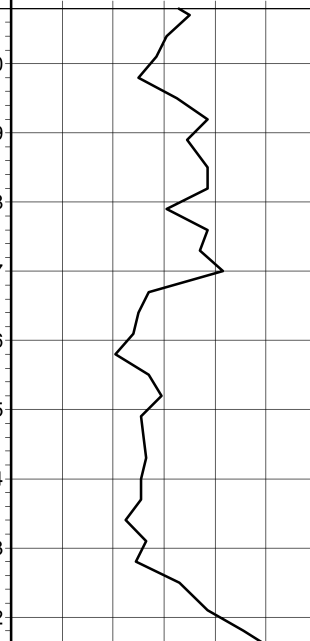
RECORD OF BOREHOLE NO. 2A

LVM | MERLEX

REFERENCE 11/04/11046-F5 DATUM Geodetic LOCATION N5120706.3 E348562.1 - Cherriman Township - Pine River ORIGINATED BY JL

PROJECT WP 5534-05-01, Highway 535 - Site No. 46-198/C BOREHOLE TYPE Truck Mounted CME 45B - NW Casing COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) September 13, 2011 DATE (Completed) September 22, 2011 TIME (Completed) 2:00:00 PM CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100)	PLASTIC LIMIT W_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)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
	Continued from Previous Page										
	Probably sands						180, 179, 178, 177, 176, 175, 174, 173, 172				
171.6 29.2	DCPT Refusal End of Borehole										

MEL-GEO 11046 - BH LOGS PINE RIVER.GPJ MEL-GEO.GDT 4/12/12

METRIC

RECORD OF BOREHOLE NO. 3

LVM | MERLEX

REFERENCE 11/04/11046-F5 DATUM Geodetic
LOCATION N5120727.2 E348552.5 - Cherriman Township - Pine River
ORIGINATED BY JL

PROJECT WP 5534-05-01, Highway 535 - Site No. 46-198/C
BOREHOLE TYPE Truck Mounted CME 45B - H.S. Auger
COMPILED BY AT

CLIENT AECOM Inc.
DATE (Started) May 27, 2011
DATE (Completed) May 27, 2011
TIME (Completed)
CHECKED BY MAM

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	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)
200.9	Ground Surface										
0.0	FILL - pavement stucture and granular fill over rock fill		1	AS	N/A				o		
			2	SS	55/175mm		200		o		34 50 (16)
199.8 1.1	Auger Refusal End of Borehole										

COMMENTS
See Borehole No. 3A

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)	-	-
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS PINE RIVER.GPJ MEL-GEO.GDT 4/12/12

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

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

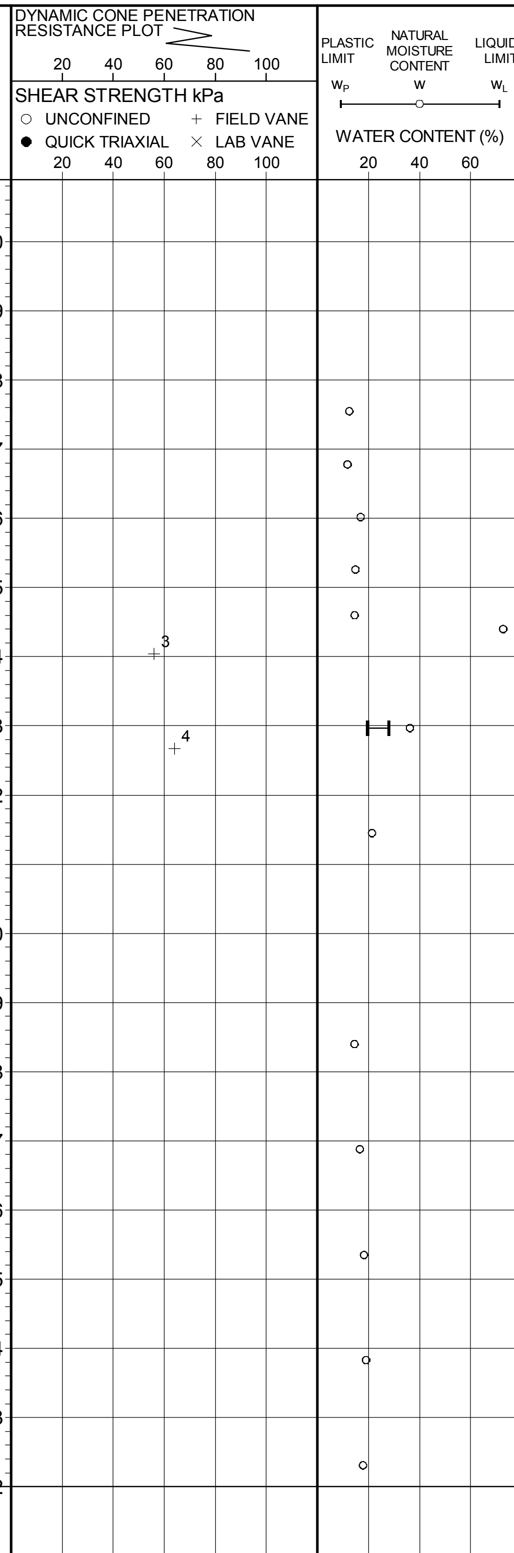
METRIC

RECORD OF BOREHOLE NO. 3A

LVM | MERLEX

REFERENCE	11/04/11046-F5
DATUM	Geodetic
LOCATION	N5120728.2 E348558.8 - Cherriman Township - Pine River
ORIGINATED BY	JL
PROJECT	WP 5534-05-01, Highway 535 - Site No. 46-198/C
BOREHOLE TYPE	Truck Mounted CME 45B - NW Casing
COMPILED BY	AT
CLIENT	AECOM Inc.
DATE (Started)	September 13, 2011
DATE (Completed)	September 21, 2011
TIME (Completed)	
CHECKED BY	MAM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
200.9	Ground Surface				
0.0	FILL - Pavement stucture and granular fill to 1 m depth over rock fill to 3.0 m depth (see comments below)				
197.9 3.0	FILL - grey sand fill some gravel to gravelly trace silt Occasional cobble size rock fill (compact/dense)	1	SS	45	38 56 (6)
		2	SS	21	
		3	SS	18	
		4	SS	25	23 72 (5)
194.5 6.4	CLAY - grey clay (high/low plasticity) (stiff)	5	SS	13	
193.3 7.6	SILTY CLAY - grey silty clay (low plasticity) (stiff)	6	SS	3	
192.4 8.5	SILT - grey silt trace gravel trace sand trace clay (loose)	7	SS	7	2 7 83 8
190.7 10.2	SAND - grey sand trace to some gravel trace silt (compact)	8	SS	15	
		9	SS	21	
		10	SS	21	
		11	SS	17	12 80 (8)
		12	SS	29	
		13	SS	15	
182.0 18.9	End of Sampling End of Borehole				



ELEVATION SCALE: 200, 199, 198, 197, 196, 195, 194, 193, 192, 191, 190, 189, 188, 187, 186, 185, 184, 183, 182

UNIT WEIGHT γ kN/m³

COMMENTS

Borehole No. 3 met auger refusal at 1.1 m depth. Predrilled holes for Borehole No. 3A Sept 13 with hydrotrack to 3.0 m depth. Advanced hole with NW casing Sept 21.

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)	9/21/12 4:10:00 PM	2.4	3.9
2)		-	-
3)		-	-

MEL-GEO 11046 - BH LOGS PINE RIVER.GPJ MEL-GEO.GDT 4/12/12

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

RECORD OF BOREHOLE NO. 4

METRIC

LVM | MERLEX

REFERENCE	11/04/11046-F5	DATUM	Geodetic	LOCATION	N5120724.7 E348569.4 - Cherriman Township - Pine River
PROJECT	WP 5534-05-01, Highway 535 - Site No. 46-198/C	BOREHOLE TYPE	Raft - B-24 Hydraulic Drill		
CLIENT	AECOM Inc.	DATE (Started)	August 24, 2011		
		DATE (Completed)	August 24, 2011	TIME (Completed)	2:10:00 PM

ORIGINATED BY: JL
COMPILED BY: AT
CHECKED BY: MAM

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	STRATA PLOT	SAMPLES – NUMBER	SAMPLES – 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)
198.2	Water Level										
0.0	Water						198				
							197				
196.0							196				
195.7 / 2.2	SAND - grey sand trace to with silt trace to some gravel		1	SS	44						
195.3 / 2.5	Refusal										
2.9	DCPT Refusal End of Borehole										

DCPT advanced 14 m Rt of CL
Refusal on DCPT 1 at 2.7 m

DCPT advanced 16.2 m Rt of CL
Refusal on DCPT 2 at 2.8 m

DCPT advanced 18.1 m Rt of CL
Refusal on DCPT 3 at 2.8 m

DCPT advanced 21.0 m Rt of CL
Refusal on DCPT 4 at 2.7 m

COMMENTS

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

$+^3$, $\times^3$: 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)	-	-
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS PINE RIVER.GPJ MEL-GEO.GDT 4/12/12

METRIC

RECORD OF BOREHOLE NO. 5

LVM | MERLEX

REFERENCE 11/04/11046-F5	DATUM Geodetic	LOCATION N5120710.9 E348545.0 - Cherriman Township - Pine River	ORIGINATED BY JL
PROJECT WP 5534-05-01, Highway 535 - Site No. 46-198/C		BOREHOLE TYPE Raft - B-24 Hydraulic Drill	COMPILED BY AT
CLIENT AECOM Inc.		DATE (Started) August 25, 2011 / DATE (Completed) August 25, 2011 / 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)
198.2	Water Level										
0.0	Water						198				
							197				
196.2 / 2.0	SAND - grey sand some gravel trace silt		1	SS	44/225 mm		196				
195.8 / 2.4	Refusal DCPT Refusal End of Borehole										

COMMENTS

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

$+^3, \times^3$: 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)	-	-
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS PINE RIVER.GPJ MEL-GEO.GDT 4/12/12

AP 1. 13+752.5 2 Rt C/L

0 - 850
850 NFP RF

AP 2. 13+754 2 Rt C/L

0 - 675
675 NFP RF

AP 3. 13+755 2 Rt C/L

0 - 475
475 NFP RF

AP 4. 13+756 2 Rt C/L

0 - 575
575 NFP RF

AP 5. 13+757 2 Rt C/L

0 - 850
850 NFP RF

AP 6. 13+757.5 2 Rt C/L

0 - 400
400 NFP RF

AP 7. 13+750 2 Lt C/L

0 - 675
675 NFP RF

AP 8. 13+750.5 2 Lt C/L

0 - 900
900 NFP RF

AP 9. 13+751.5 2 Lt C/L

0 - 1.05
1.05 End of Probe – stopped to prevent damge to culvert

AP 10. 13+752.5 2 Lt C/L

0 - 525
525 NFP RF

AP 11. 13+753.5 2 Lt C/L

0 - 950
950 NFP RF

AP 12. 13+755 2 Lt C/L

0 - 625
625 NFP RF

BH - GI 1 13+741 3.4 Rt C/L

0 - 70 Asph
70 - 280 Cr Gr/RAP
280 - 700 F-Med Sa W Gr
700 NFP RF

BH - GI 2 13+745 3.4 Rt C/L

0 - 80 Asph
80 - 260 Cr Gr/RAP
260 - 700 F-Med Sa W Gr & Sh Rk
700 NFP RF

BH - GI 3 13+749 3.4 Rt C/L

0 - 80 Asph
80 - 200 Cr Gr/RAP
200 - 700 F-Med Sa W Gr & Sh Rk
700 NFP RF

BH - GI 4 13+753 3.4 Rt C/L

0 - 80 Asph
80 - 240 Cr Gr/RAP
240 - 800 F-Med Sa w Gr & Sh Rk
800 NFP RF

BH - GI 5 13+758 3.4 Rt C/L

0 - 60 Asph
60 - 180 Cr Gr/RAP
180 - 700 F-Med Sa W Gr & Sh Rk
700 NFP RF

BH - GI 6 13+762 3.4 Rt C/L

0 - 60 Asph
60 - 230 Cr Gr/RAP
230 - 700 F-Med Sa W Gr & Sh Rk
700 NFP RF

BH - GI 7 13+766 3.4 Rt C/L

0 - 70 Asph
70 - 240 Cr Gr/RAP
240 - 600 F-Med Sa W Gr & Sh Rk
600 NFP RF

BH - GI 8 13+756 1.0 Lt C/L

0 - 110 Asph
110 - 300 Cr Gr
300 - 700 F-Med Sa W Gr
700 NFP RF

REF.: 11/04/11046–F5

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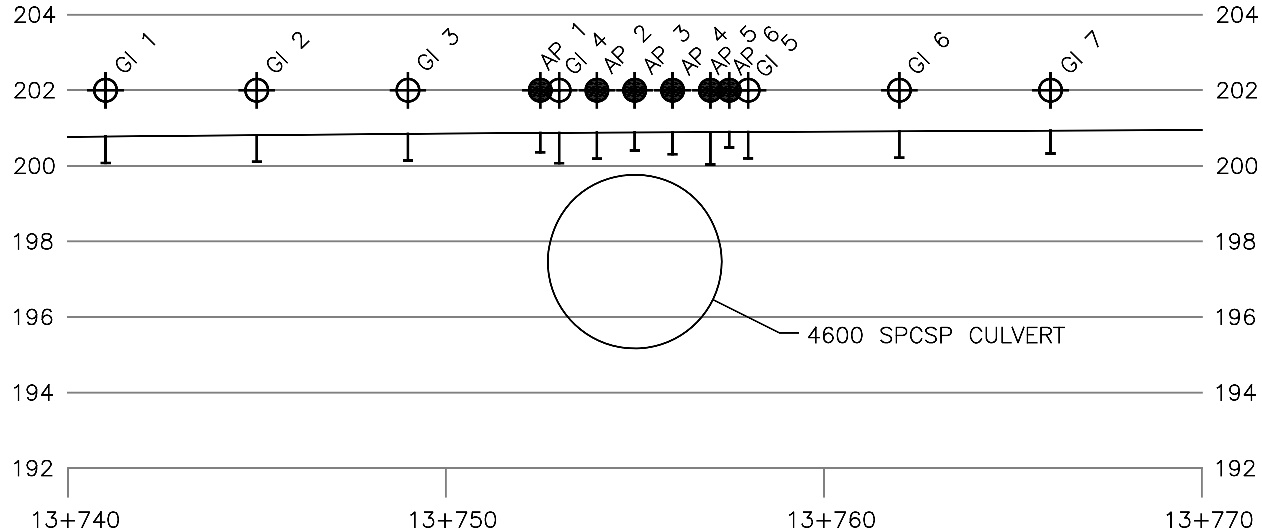
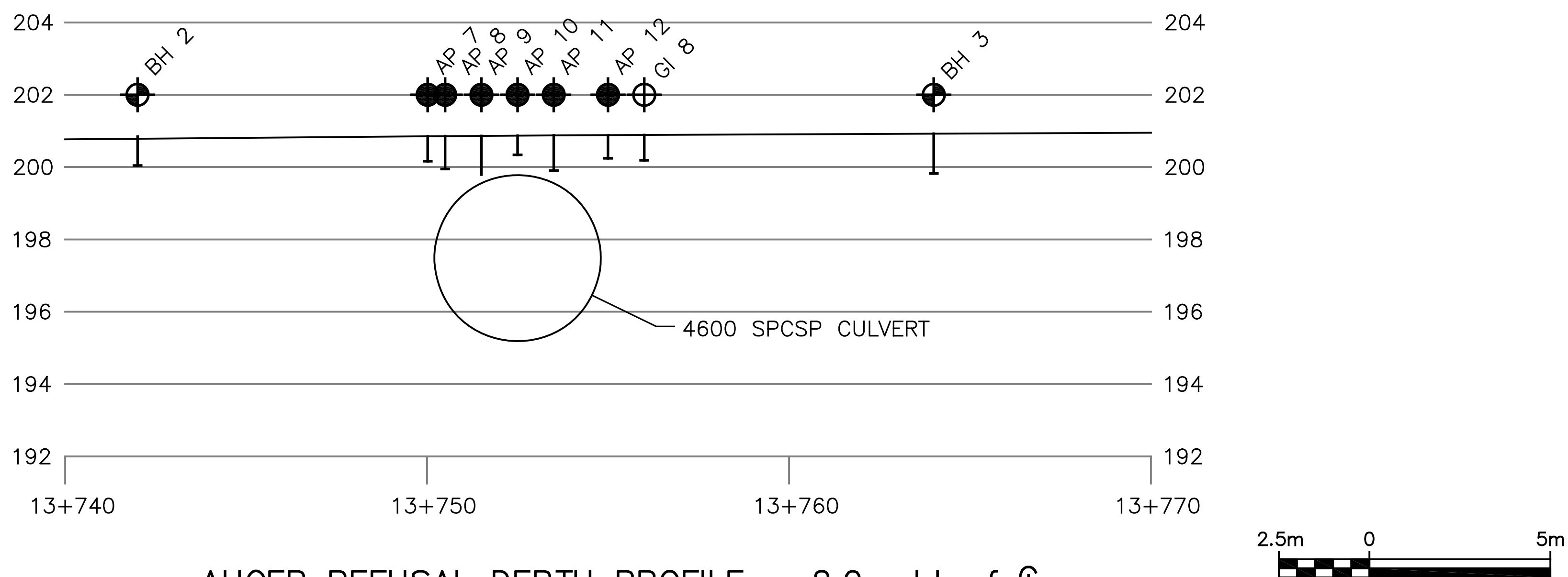


AUGER REFUSAL DEPTH PROFILE – 2.0m Rt of ℄



AUGER REFUSAL DEPTH PROFILE – 2.0m Lt of ℄

METRIC

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

HWY 535 – Township of Cherriman – Site No. 46–198/C
Auger Probe Profile

FIGURE SK–1

Appendix C Borehole Location Plan Labwork

Figure No. 2: Borehole Location and Soil Strata
Figure Nos. L-1 to L-3: Summary Grain Size Analysis Graph
Figure No. L-4: Plasticity Chart
Figure No. L-5: Shear Strength Chart

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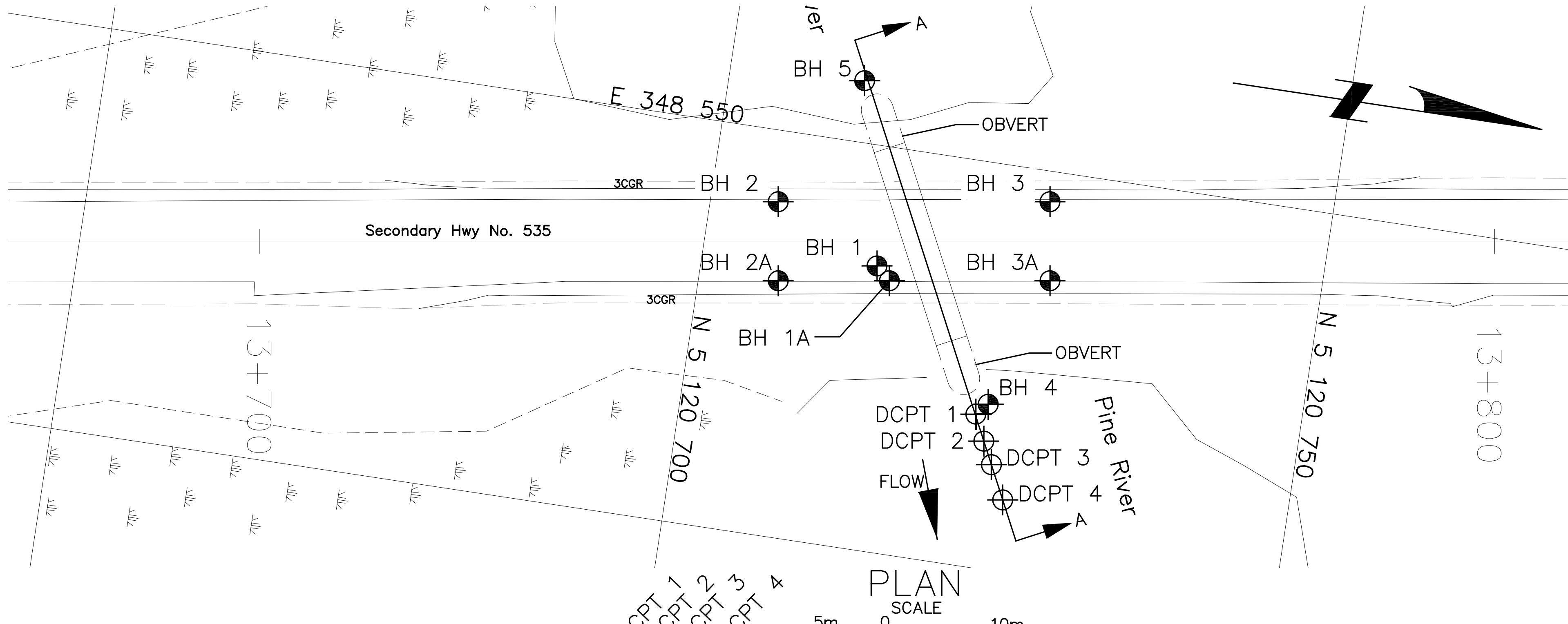
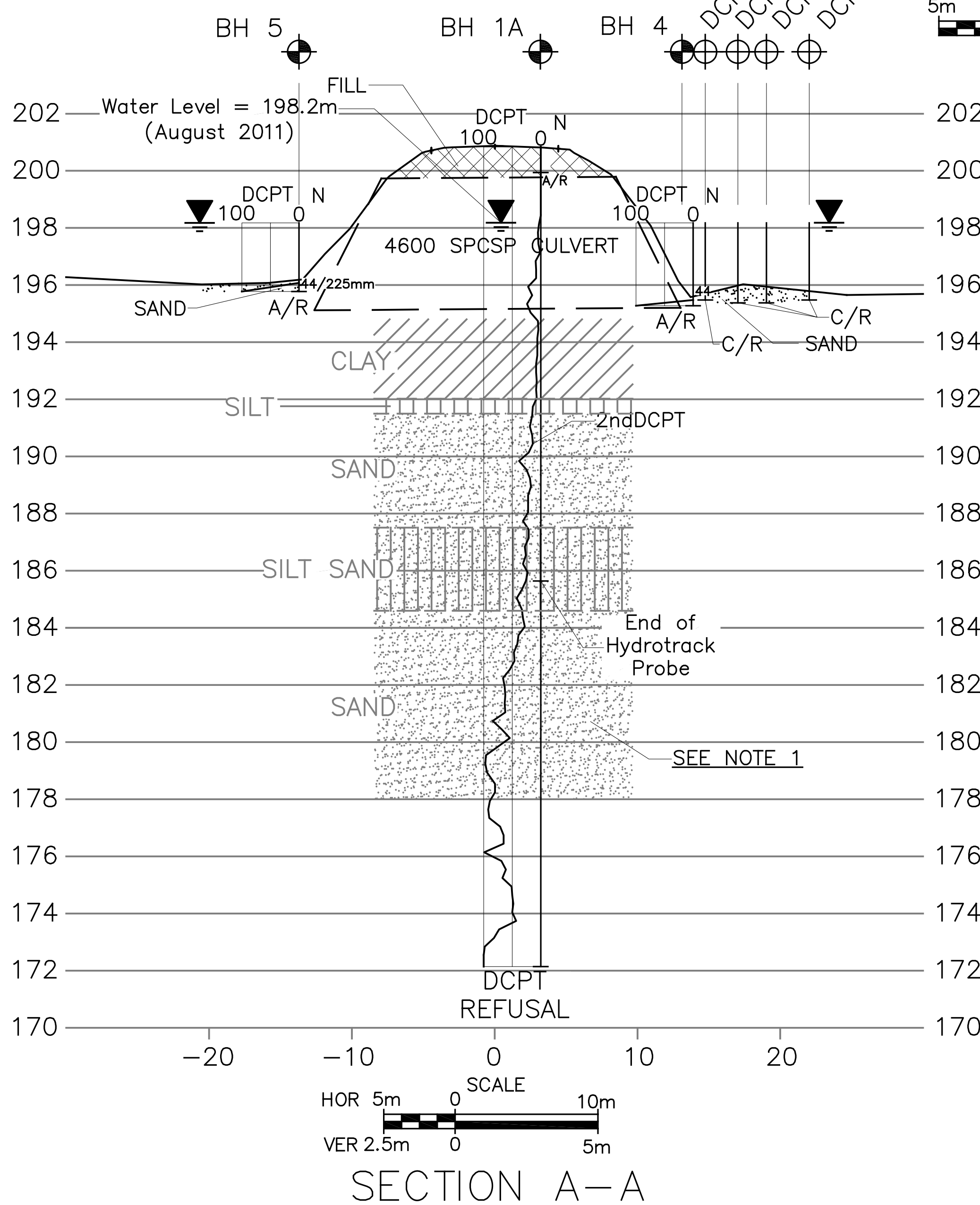
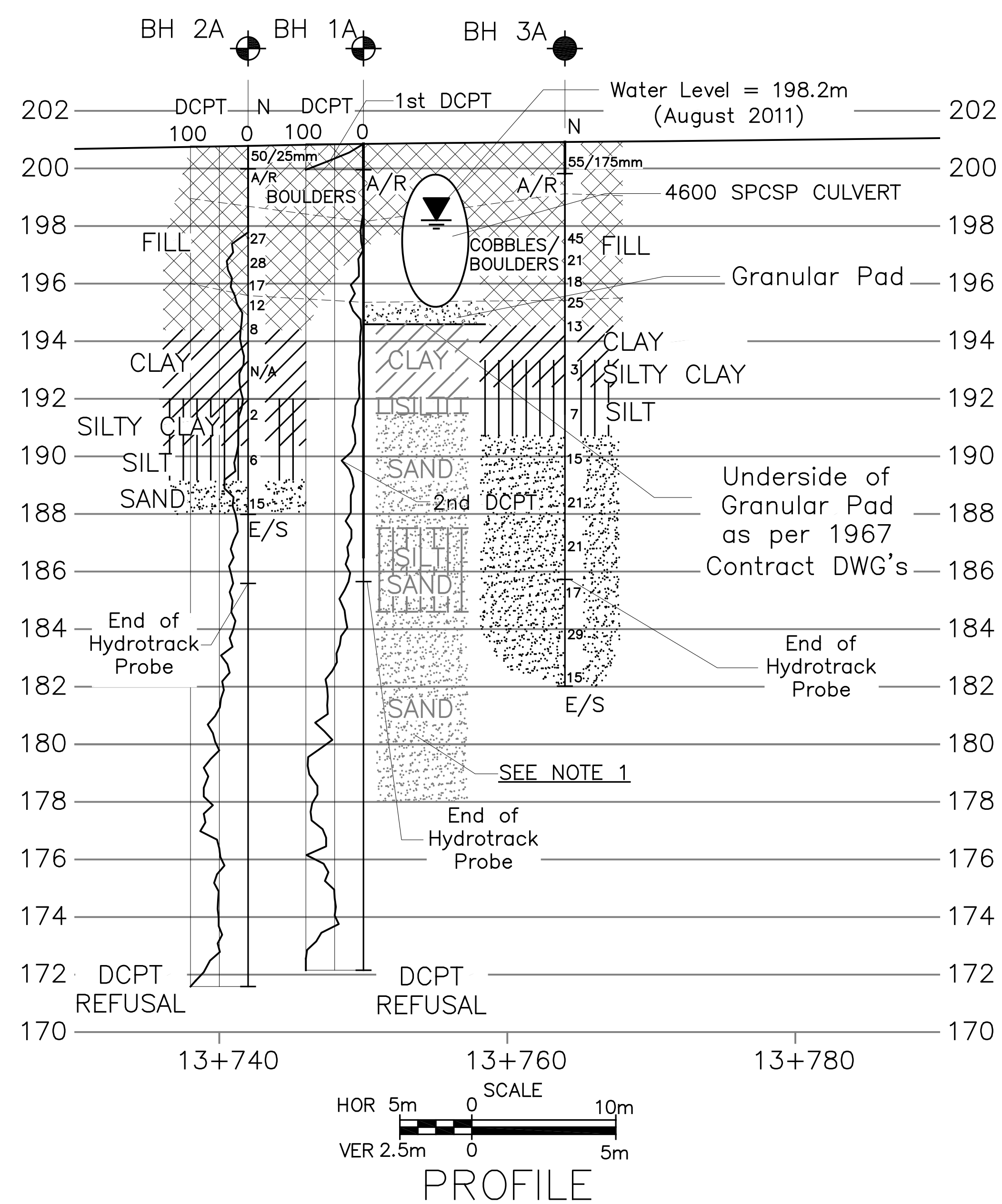


METRIC

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





SITE No 46–198/C
WP No 5534–05–01
GeoCres No 41I–282

N

HWY NO. 535 – Township of Cherriman

Pine River Culvert Replacement – Sta. 13+753

BOREHOLE LOCATIONS & SOIL STRATA

Figure 2

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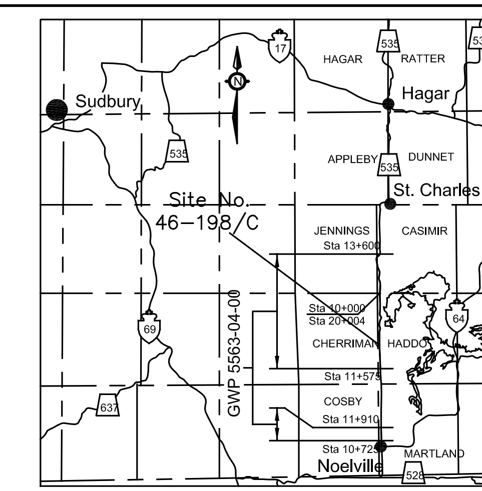

KEY PLAN – NOT TO SCALE

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & 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; C/R — Cone Refusal at Elevation
- E/S — End of Sampling

Borehole No.	Elev.	O/S	Co–ordinates	
			Northerly	Easterly
Borehole No. 1	200.8	2.0m Rt	5120714.1	348559.7
Borehole No. 1A	200.8	3.2m Rt	5120715.1	348560.7
Borehole No. 2	200.8	3.2m Lt	5120705.5	348555.8
Borehole No. 2A	200.8	3.2m Rt	5120706.3	348562.1
Borehole No. 3	200.9	3.2m Lt	5120727.2	348552.5
Borehole No. 3A	200.9	3.2m Rt	5120728.2	348558.8
Borehole No. 4	198.2	13.2m Rt	5120724.7	348569.4
Borehole No. 5	198.2	13.0m Lt	5120710.9	348545.0
DCPT No. 1	198.2	14.0m Rt	5120723.8	348520.4
DCPT No. 2	198.2	16.2m Rt	5120724.8	348522.4
DCPT No. 3	198.2	18.1m Rt	5120725.7	348524.2
DCPT No. 4	198.2	21.0m Rt	5120727.0	348526.9

NOTE 1: Stratigraphy in greyscale shows investigations by others. Reproduced for general information and completeness of stratigraphy. BH No. 1A was an unsampled DCPT.

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

HWY No. 535 – Cherriman – Pine River	REF: 11046
SUBM'D	SITE 46–198/C
DRAWN MCM · CHK MAM · DATE September 2011	FIG 2

Reference No.: 11/04/11046-F5
Date: April 2012

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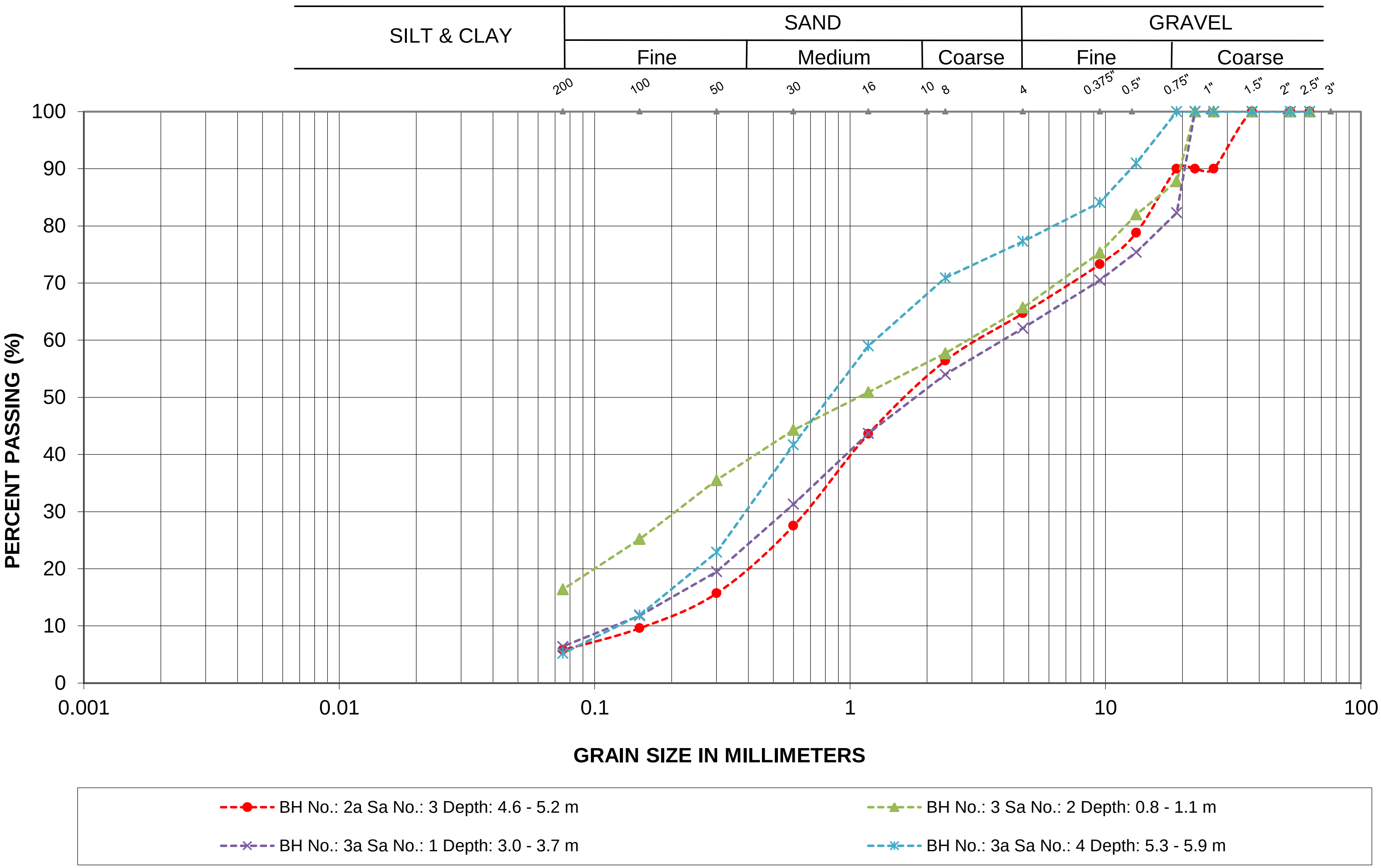
GRAIN SIZE ANALYSIS



G.W.P.: 5563-04-00
LOCATION: Hwy 535
SITE: 46-198/C

EMBANKMENT FILL

LVM | MERLEX

FIGURE L-1

Reference No.: 11/04/11046-F5
Date: April 2012

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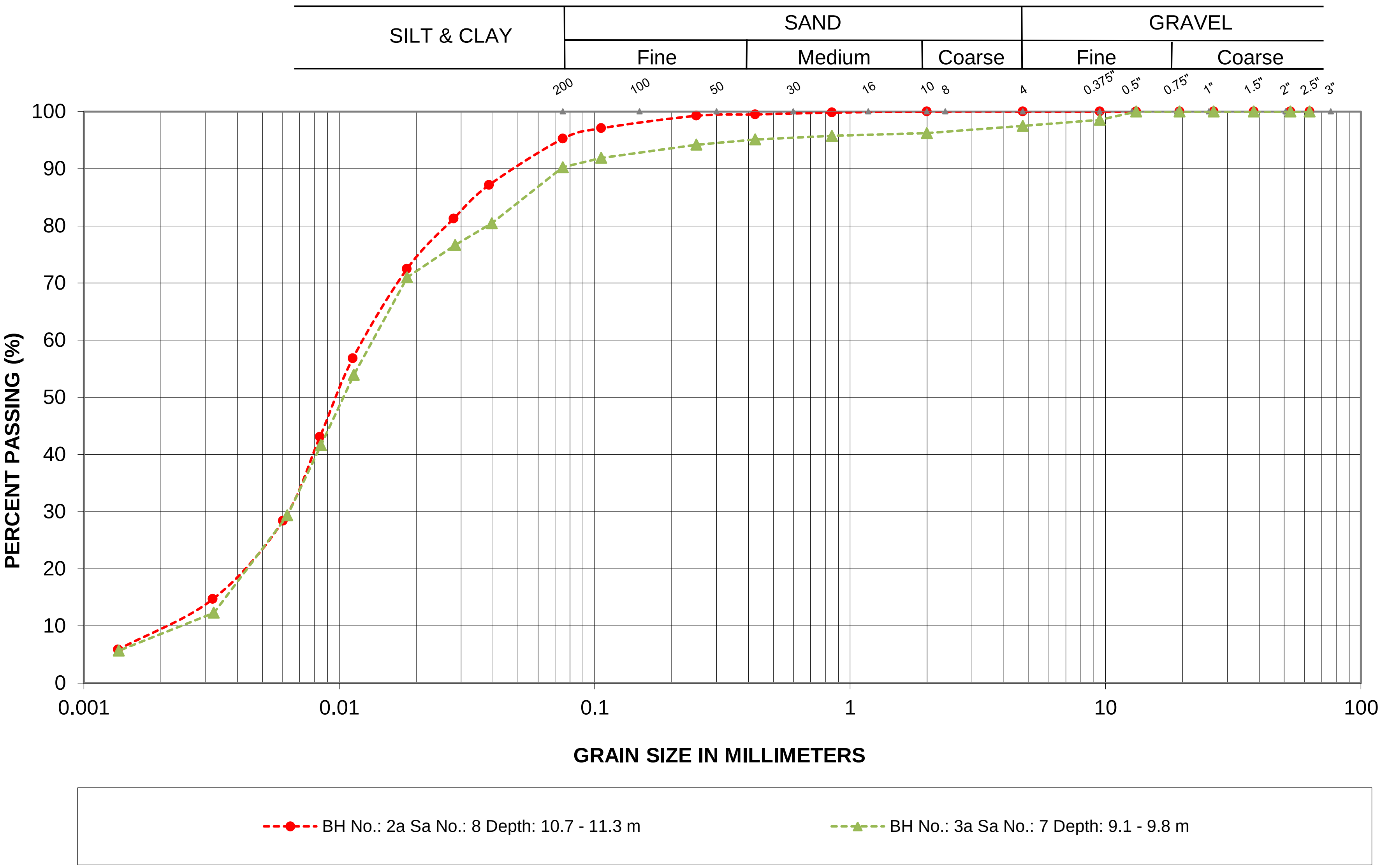
GRAIN SIZE ANALYSIS



G.W.P.: 5563-04-00
LOCATION: Hwy 535
SITE: 46-198/C

SILT

Reference No.: 11/04/11046-F5
Date: April 2012

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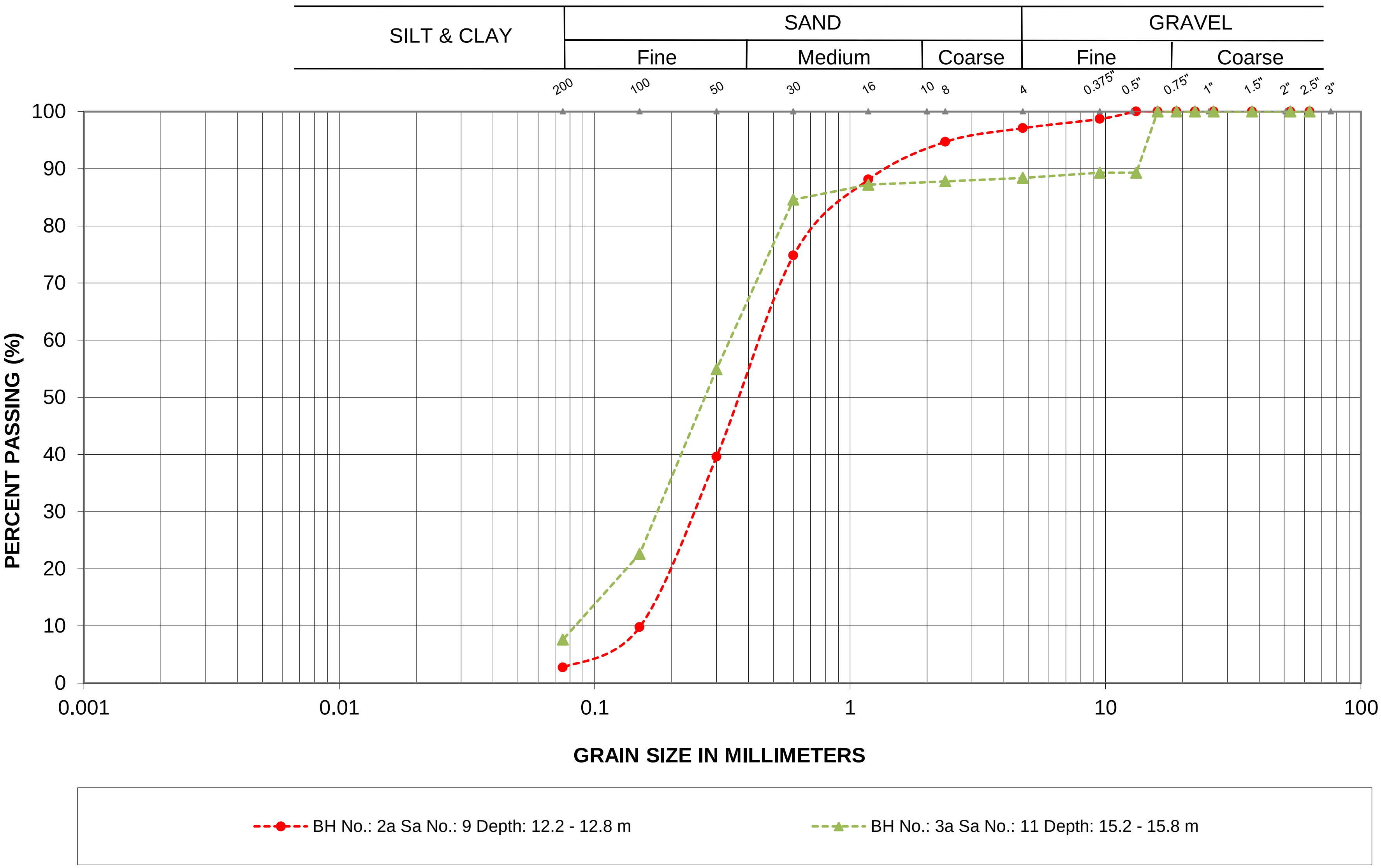
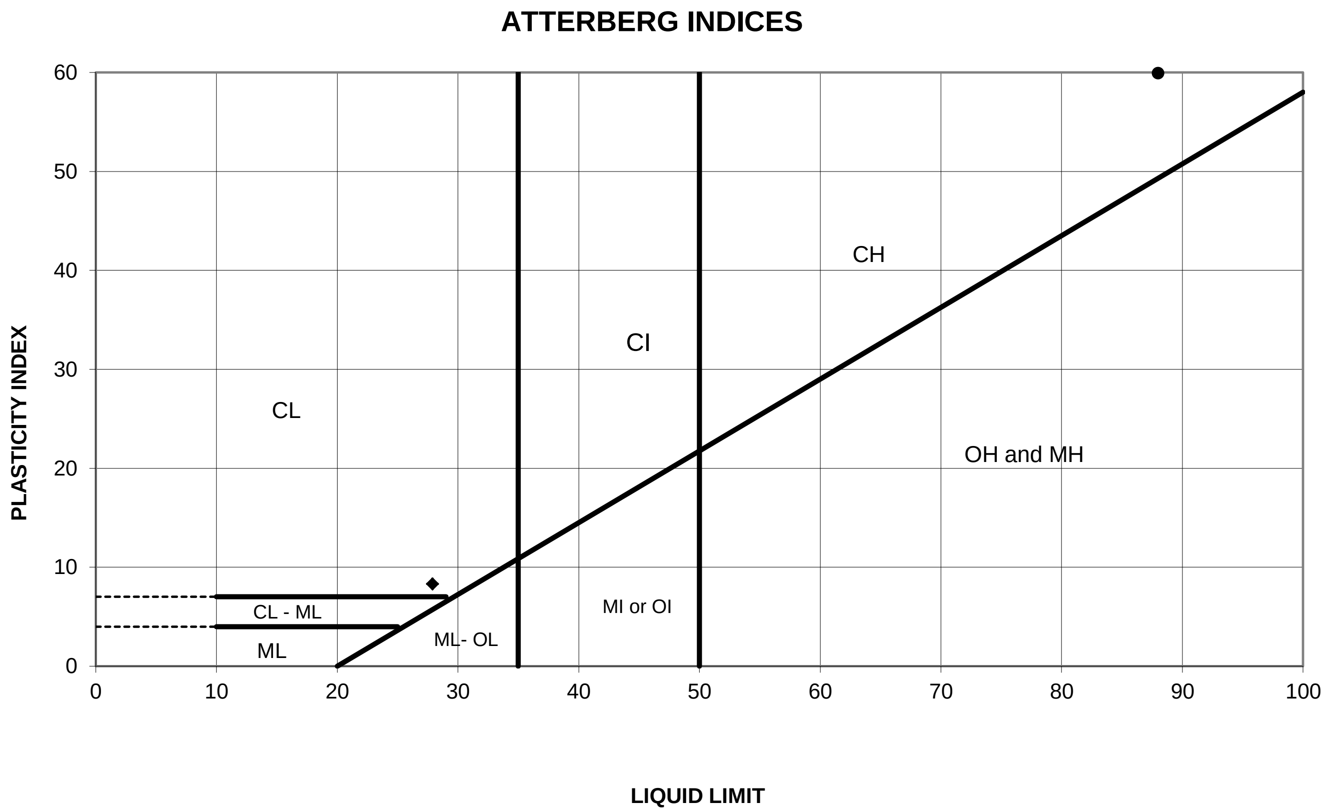
GRAIN SIZE ANALYSIS



G.W.P.: 5563-04-00
LOCATION: Hwy 535
SITE: 46-198/C

SAND

ATTERBERG LIMITS TEST RESULTS	FIGURE L-4



SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plastic Limit	Plasticity Index	NMC %
●	2A	6	7.6	193.2	88.0	28.1	59.9	73.5
◆	3A	6	7.6	193.5	27.9	19.6	8.3	36.2

Date: Apr-12
Project: Hwy 535 - Site 46-198/C
G.W.P: 5563-04-00

Prep'd: AT
Chkd: RG
Ref. No.: 11/04/11046-F5

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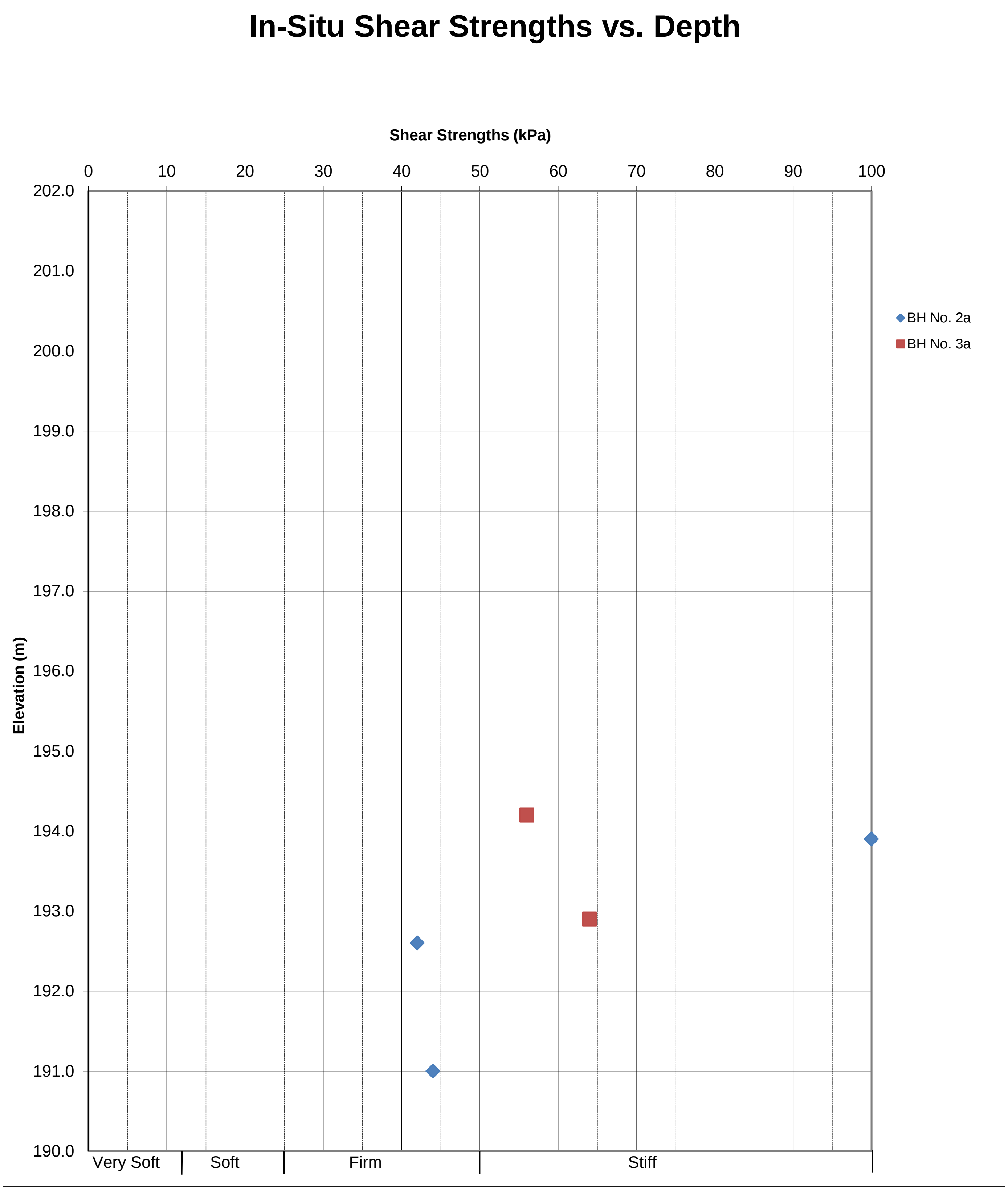
IN-SITU SHEAR STRENGTHS	Figure No. L-5



Project: 11/04/11046-F5
G**WP:** 5563-04-00

LVM | MERLEX

Date: April 2012
Checked:MAM

Appendix D Photo Essay

Enclosure No. 12: Photo Essay

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Top: Embankment at culvert outlet, looking north Bottom: Embankment at culvert inlet, looking north	Photo: 1 - 2

Reference Number: 11/04/11046-F5 Project: Hwy 535 – Pine River Culvert – Site No. 46-198/C	Provided By: LVM | MERLEX Date: May 2011

Top: Stream at culvert outlet, looking east Bottom: Stream at culvert inlet, looking west	Photo: 3 - 4

Reference Number: 11/04/11046-F5	Provided By: LVM | MERLEX
Project: Hwy 535 – Pine River Culvert – Site No. 46-198/C	Date: August 2011

Appendix E Historical Data

Enclosure No. 13:	Drawing T7690-1 (1964)
Enclosure No. 14:	Contract No. 67-16, Sheet 6

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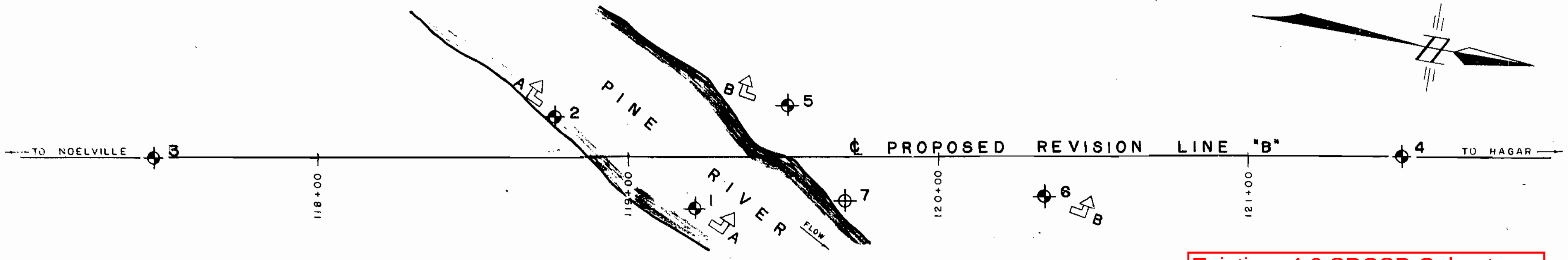
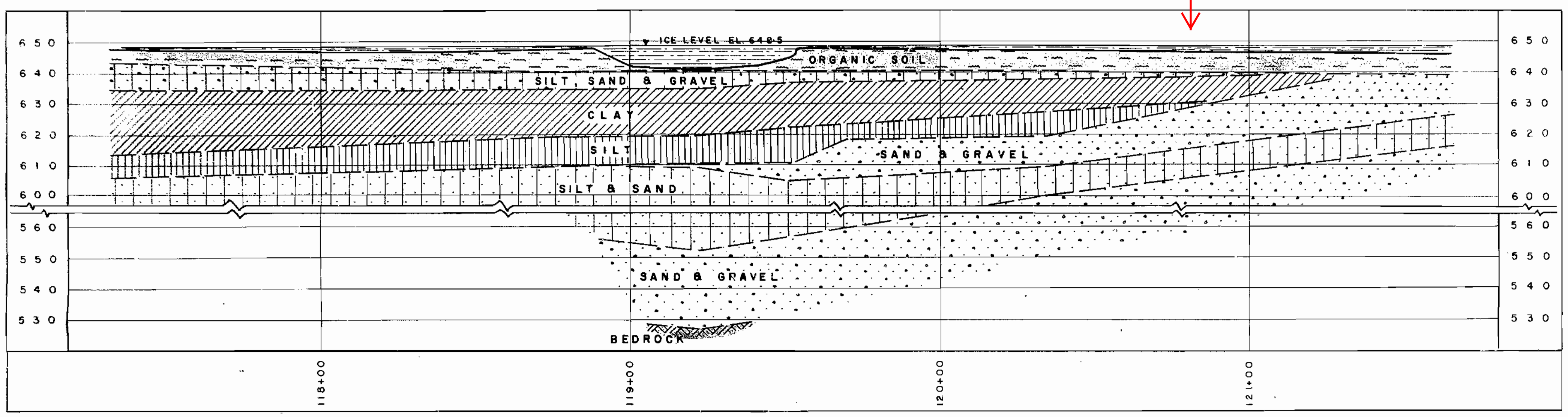
Enclosure No. 13

543800E
5119000 N
17
41I1W

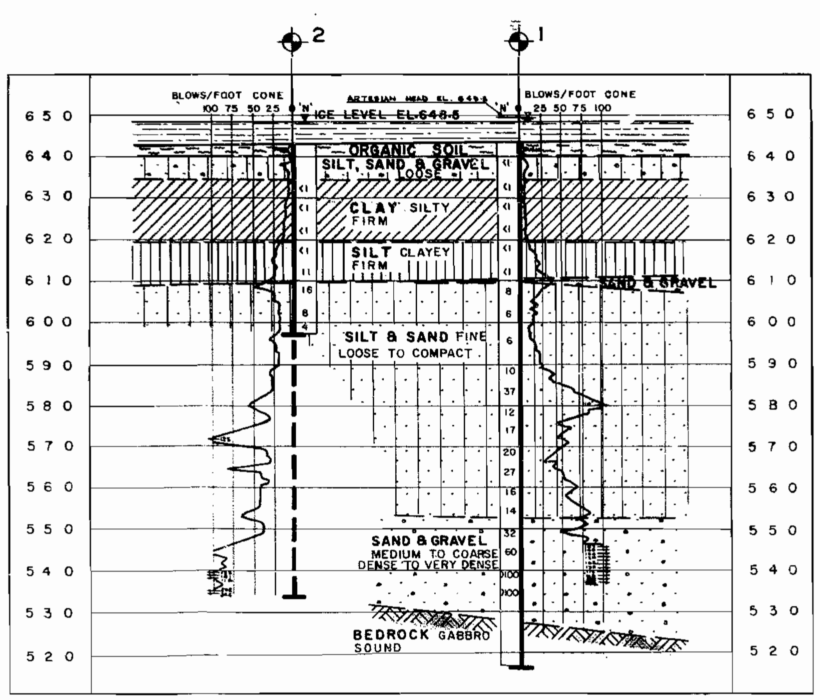


PLAN
SCALE IN FEET

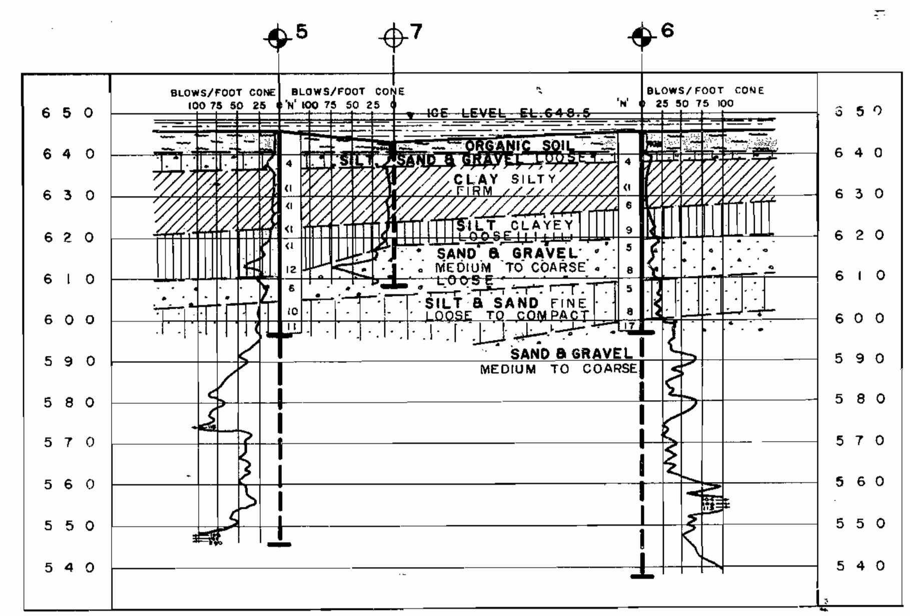
Existing 4.6 SPCSP Culvert
Station 120+80



PROFILE LINE 'B'
SCALE IN FEET

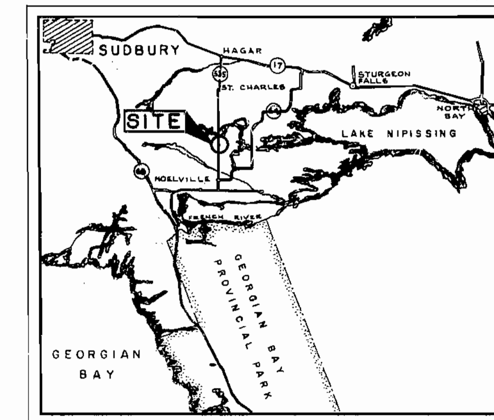


A – A



B – B

SECTIONS
SCALE IN FEET



KEY PLAN
SCALE IN MILES

LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation. NOV. 1964
- Artesian Head NOV. 1964

NO.	ELEVATION	STATION	OFFSET
1	643·5	119+22	17' RT.
2	642·9	118+77	13' RT.
3	645·5	117+47	—
4	648·0	121+50	—
5	646·0	119+52	16' LT.
6	645·5	120+35	13' RT.
7	642·5	119+70	15' RT.

– NOTE –

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & RESEARCH DIVISION – FOUNDATION SECTION

PINE RIVER BRIDGE

KING'S HIGHWAY NO. 535 DIST NO 13
CO. SUDBURY
TWP CHERRIMAN LOT I CON. III

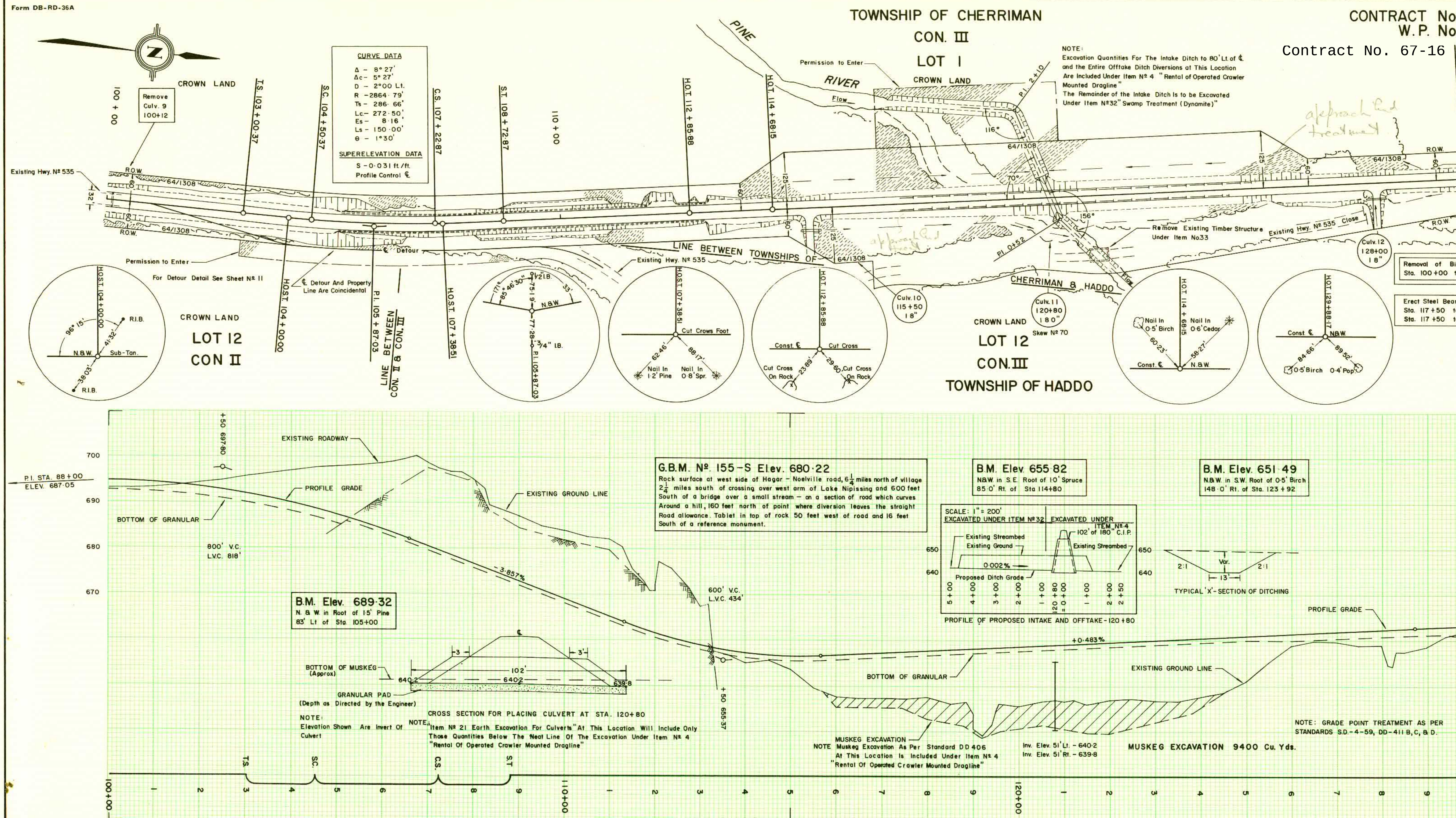
BOREHOLE LOCATIONS & SOIL STRATA

GEOCON LTD	SUBM'D B.T.D.	CHECKED D.B.Q.	W.P. NO. 271-63	M.&R. DRAWING NO
	DRAWN J.W.A.	CHECKED B.T.D.	JOB NO.	
DRAWING No. T 7690-1	DATE DEC. 30, 1964		SITE NO. E-4402-1	BRIDGE DRAWING NO
	APPROVED D.B. Oates		CONT. NO.	

PRINT RECORD
NO	FOR	DATE

Enclosure No. 14

Contract No. 67-16



Earth Cut	E.C. - 11,000 Cu. Yds.	E.C. - 2,300 Cu. Yds.	E.C. - 450 Cu. Yds.
Sub-Excavation			
Stripping	St. - 950 Cu. Yds.	St. - 50 Cu. Yds.	St. - 400 Cu. Yds.
Ditching		E.D. - 450 Cu. Yds.	E.D. - 550 Cu. Yds.
Muskeg Excavation			
Earth Fill	E.F. - 100 Cu. Yds.		E.F. - 6,500 Cu. Yds.
Rock Cut	R.C. - 13,000 Cu. Yds.	R.C. - 8,500 Cu. Yds.	
Shatter	Sh. - 850 Cu. Yds.	Sh. - 500 Cu. Yds.	
Rock Fill		R.F. - 11,000 Cu. Yds.	R.F. - 8,400 Cu. Yds.
Muskeg Backfill		M.B.R. - 3,900 Cu. Yds.	M.B.R. - 6,100 Cu. Yds.

GRANULAR 'A' & SAND CUSHION

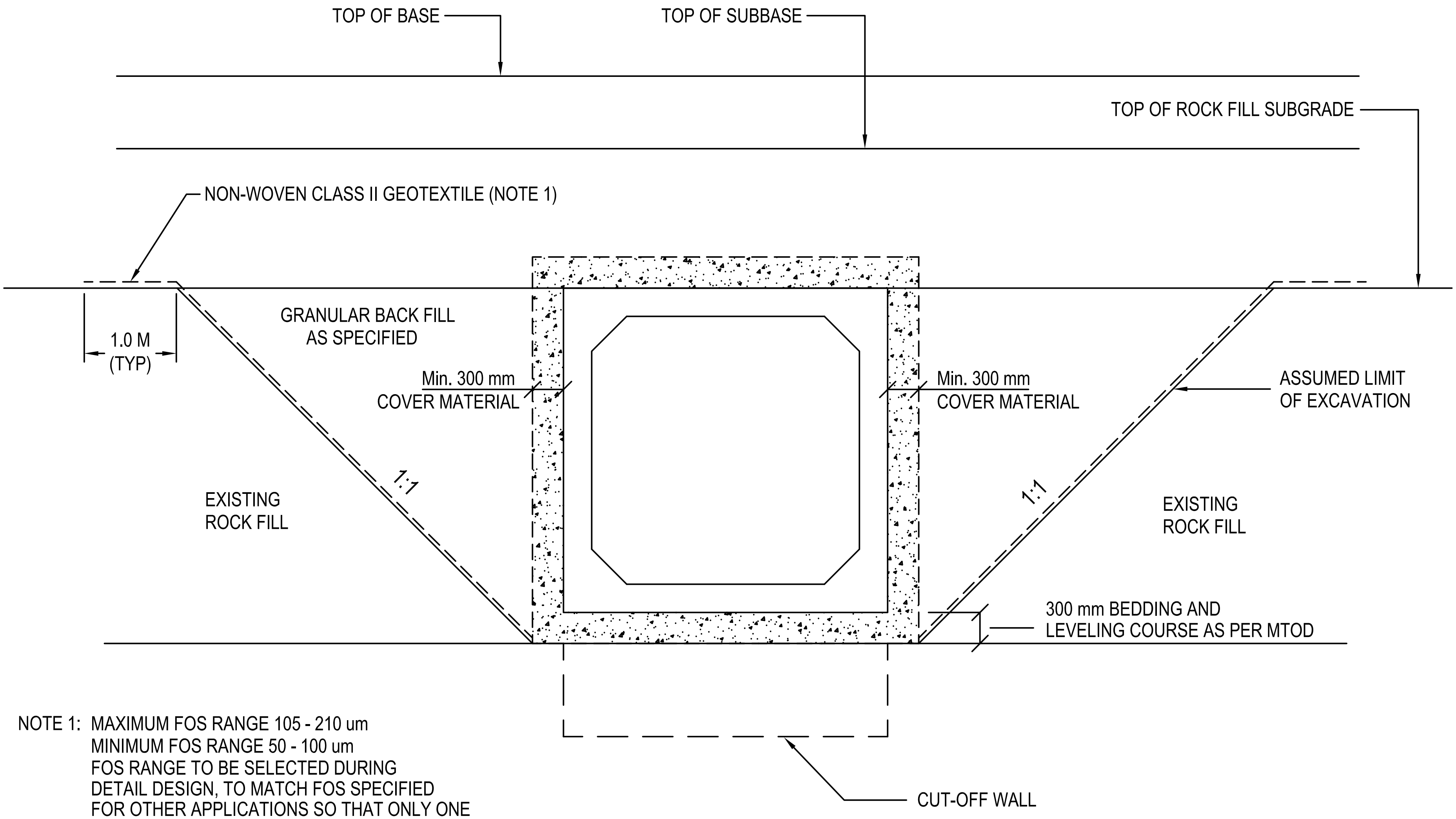
Appendix F Design Data

Sketch No. SK-2:	Box Culvert Replacement in Low Rock Fill
Sketch Nos. SK-3:	Conceptual Shoring Location
Table A:	Comparison of Shoring Alternatives

LVM | MERLEX

NOT TO SCALE

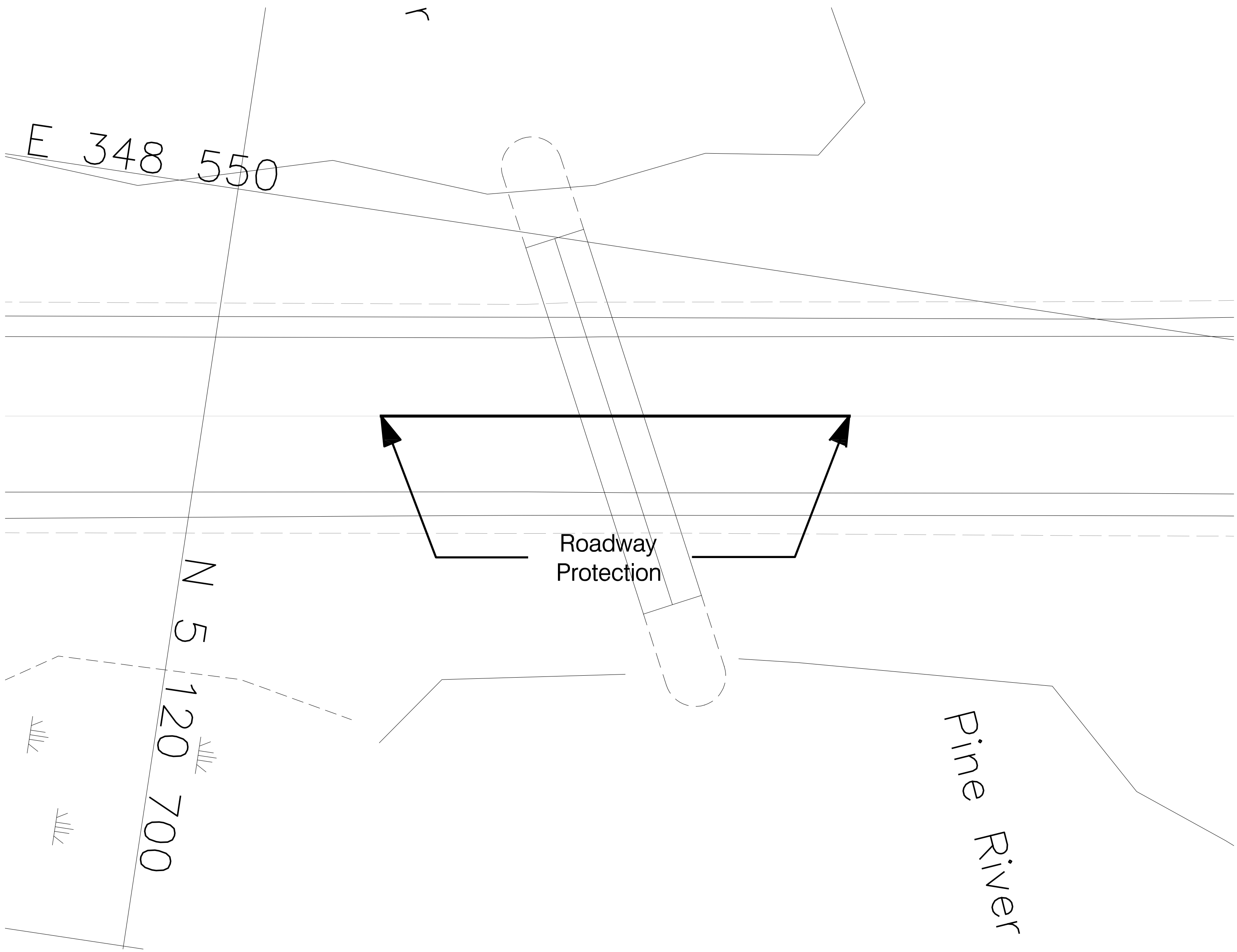
LVM | MERLEX



NOTE 1: MAXIMUM FOS RANGE 105 - 210 um
MINIMUM FOS RANGE 50 - 100 um
FOS RANGE TO BE SELECTED DURING DETAIL DESIGN, TO MATCH FOS SPECIFIED FOR OTHER APPLICATIONS SO THAT ONLY ONE FOS RANGE IS SPECIFIED IN THE CONTRACT

HWY 535 - Township of Cheriman - Site 46-198/C Box Culvert Replacement in Low Rock Fill	FIGURE SK - 2

LVM | MERLEX



NOT TO SCALE

HWY 535 - Township of Cherriman - Site 46-198/C Conceptual Shoring Locations- Pine River Culvert	FIGURE SK-3

Table A – Protection Systems

Retaining System	Depth Range (m)	Advantages	Disadvantages	Remarks	Estimated Costs
Wood Sheeting	1.5 – 5	-Low cost, -Easily installed in good ground conditions	-Limited by soil conditions, -Limited depth of installation, -Low strength, -discontinuous	Not considered due to site conditions, embankment and water level.	
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Considered for excavations at this site.	$ 650 to 950/m^2
Soldier piles	5 – 25	-Easy installation -Readily available -Adaptable to various ground conditions	-Pre-drilling may be required -Possible ground loss	Not considered for excavations at this site due to water level.	
Pre-cast concrete panels	3 – 10	-Durable -Assists in minimizing seepage	-Limited depths -Can be damaged by driving -Limited by soil conditions (i.e. obstructions)	Not considered due to site conditions and 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 for excavations at this site due to high water level.	
Tangent/ Secant/ Staggered Drilled Piles	10 – 18	-Readily available -Adaptable to various ground conditions	-Possible ground loss and/or seepage -Poor alignment tolerance	Considered for excavations at this site.	$ 900/m^2
Concrete Diaphragm	10 – 30	-High Strength -Durable -Can be permanent	-High cost -Requires specialized equipment/control	Not Considered due higher costs and water level.	