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FINAL REPORT

FOUNDATION INVESTIGATION
AND DESIGN

W.P. 5768-04-00

HIGHWAY 60 –

LONG LAKE CREEK

CULVERT REPLACEMENT

SITE NO. 40-121

Harmer Podolak Engineering

PROJECT NO. 1004574

GEOCRES NO. 31E-241

PROJECT NO. 1004574

FINAL REPORT – FOUNDATION INVESTIGATION AND DESIGN

TO

**Harmer Podolak Engineering
221 – 39 Robertson Road
Ottawa, ON K2H 8R2**

ON

W.P. 5768-04-00

**Highway 60 –
Long Lake Creek
Culvert Replacement
Site No. 40-121**

**Geographic Township of
McClintock**

District 52, Huntsville

**Ministry of Transportation
Ontario**

Geocres No. 31E-241

March 8, 2006

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FOUNDATION INVESTIGATION REPORT

for

W.P. 5768-04-00
Highway 60 – Long Lake Creek Culvert
Site No. 40-121
Geographic Township of McClintock
District 52, Huntsville

1.0 INTRODUCTION

This report was prepared in conjunction with the Detailed Design Study for Highway 60; Long Lake Culvert, W.P. 5768-04-00.

This report presents the results of a foundation investigation carried out for the proposed replacement of the existing Long Lake Creek Culvert on Highway 60, approximately 16 km east of the junction of Highways 60 and 35.

The foundation investigation was carried out in general accordance with our proposal number 1002289 dated July 12, 2005. Authorization to proceed was provided by the Ministry of Transportation of Ontario (MTO) under Agreement Number 5005-E-0007 with Harmer Podolak Engineering Consultants Inc. (Harmer Podolak), the Prime Consultant for this project.

This report has been prepared specifically and solely for the project described herein. It contains factual information pertaining to the subsurface conditions which was obtained as part of this investigation.

2.0 SITE DESCRIPTION AND GEOLOGY

The subject site is within the limits of MTO project W.P. 5768-04-00 (Highway 60). The site location is shown on the Key Plan inset to Drawing No. 1004574-1 provided in Appendix A. Photographs of the site are provided in Appendix C. It is noted that for project orientation purposes, Highway 60 will be assumed to run east-west with chainage increasing from west to east.

Physiographically, the site is located within the Algonquin Highlands. This region is characterized by rough rounded knobs and ridges with frequent outcrops of bare rock. The bedrock is generally shallow, however, the depth to bedrock varies greatly over short distances. Many of the valleys are floored with outwash sand and gravel. There are frequent swamps and bogs.

Long Lake Creek flows from south to north and is less than 5 m in width upstream of the highway. Water depths in the culvert vary significantly. Virtually no water was present during a site visit in September 2005. At the time of the drilling in November 2005 water levels had risen to higher than 700 mm. Water levels are influenced by a beaver dam upstream of the site. The surveyed water level at the inlet at the time of the investigation was 405.6 m Geodetic.

The existing roadway embankments are approximately 6 m high at the culvert. The highway embankment is approximately 20 m in total width and consists of the existing paved roadway on the north half and an abandoned alignment to the south. A shallow ditch separates the existing and abandoned alignments. Rockfill is exposed on the northern embankment slope which is sloped at approximately 1.25H:1V. Sand and gravel fill with frequent cobbles and boulders is present on the south embankment slope which is sloped at approximately 1.5H:1V. The ground surface off the embankment, within the highway right-of-way is vegetated with grass. Mature trees are present beyond the edges of the cleared right-of-way. Drainage in the area consisted of overland flow directed towards the creek. A low lying swampy area is present around the creek, north of the embankment.

Bedrock outcrops to the south and east of the culvert consist of massive to intact hornblende gneiss. Similar bedrock outcrops are present in roadway cuts to the east and west of the site.

The north half of the existing culvert consists of a concrete open box culvert (open footing), 4.88 m wide and 1.8 m high. It is understood that the elevation of the top of the existing footing is 404.8 m Geodetic. The south half of the existing culvert is a 3.6 m by 2.3 m structural plate pipe arch with a grouted corrugated steel pipe liner. It is understood that the elevation of the stream bed at the inlet is 405.1 m Geodetic.

A plan view and cross sections are shown on Drawing No. 1004574-1 provided in Appendix A.

3.0 PROCEDURE

3.1 Field Investigation

The site soil conditions were investigated with a borehole drilling investigation and laboratory testing program. The drilling was carried out using a combination of a truck-mounted CME-55 drill rig and a portable drill rig between November 5 and 18, 2005.

Drills were supplied and operated by Colbar Resources and OGS Drilling Limited under the supervision of E. Hamilton, B.Sc. of Jacques Whitford.

Dean Flanagan of Jacques Whitford carried out a quality control inspection of the site early in the drilling operations.

A total of ten (10) boreholes were put down during the field investigation. Boreholes 05-3, 05-4 and 05-7 were not drilled due to access restrictions.

All boreholes were advanced using casing. The subsurface conditions were identified in the field by Jacques Whitford Limited (JW) personnel from samples obtained while carrying out Standard Penetration Tests (SPT) (ASTM D1586) at regular intervals (760 mm at shallow depths to 3 m at depths greater than 15 m). Boreholes along the length of the culvert were advanced into bedrock using NQ sized coring equipment. Boreholes along the northern toe of the embankment terminated at SPT refusal. Standpipes were installed in Boreholes 05-10 and 05-12. The recovered soil samples were stored in moisture proof containers and returned to our laboratory. The subsurface conditions encountered are described in detail in the Borehole Records presented in Appendix B.

Prior to completing the investigation, the boreholes were backfilled with a bentonite mixture and auger cuttings.

3.2 Survey

Borehole locations were established in the field by Jacques Whitford personnel by measuring relative to existing site features such as the existing culvert. The ground surface elevations at the borehole locations were surveyed relative to a MTO benchmark identified as PBM 748393, located to the south of Highway 60. The location of the benchmark is indicated on Drawing 1004574-1 in Appendix A. It is understood that the Benchmark has an elevation of 411.523 m Geodetic.

3.3 Laboratory Testing

All samples returned to the laboratory were subjected to detailed visual classification by a geotechnical engineer. Routine testing, consisting of moisture content testing, and grain size distribution analysis was carried out on representative samples. Two representative soil samples were submitted for pH, sulphate and resistivity testing to assess the potential for corrosion of buried steel and the potential for sulphate attack on buried concrete.

Advanced geotechnical testing was deemed not to be necessary based on the soil conditions.

All soil samples will be stored for a period of one year after issuance of the final version of the preliminary foundation investigation report. Unless otherwise directed, the stored samples will be disposed of after this period.

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Profile

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided. In general, the subsurface profile consists of granular fill over rockfill over native glacial till over bedrock.

Borehole location plans and stratigraphic sections of the soils encountered within the boreholes are provided on Drawing 1004574-1 in Appendix A.

4.1.1 Fill: Gravel, with Sand

Granular fill was encountered at ground surface in both of the boreholes located on the existing Highway 60 embankment (05-1 and 05-2). The fill consisted of gravel with sand and is part of the roadway pavement structure. The thickness of the granular fill, where present, was 0.6 m. The underside of the granular fill was observed to range from elevation 410.0 m to 410.9 m.

4.1.2 Rock Fill

A rock fill was observed beneath the granular fill in Boreholes 05-1 and 05-2. The rock fill consisted of cobble and boulder sized material. The rock fill exposed on the north embankment side slope includes boulders as large as 2 m in size. The rock fill extended to depths of 7.6 m and 7.0 m in Boreholes 05-1 and 05-2 (elevations 403.9 m and 403.6 m) respectively. The boreholes could only be advanced by coring through the rock fill. No core was recovered in the rock fill however our interpretation is that the rock fill is probably well graded. The materials exposed on the slopes consists of gneiss similar to the bedrock which is described below.

4.1.3 Organic Material

An appreciable organic layer was observed at only two borehole locations. A peat material was encountered in Borehole 05-09 (0.3 m thick) and 05-12 (0.6 m thick).

4.1.4 Silty Sand to Gravelly Sand

A layer of silty sand to gravelly sand was observed in Boreholes 05-5, 05-6 and 05-8 through 05-13. This native material exhibited local lenses of coarser material (05-08 and 05-12) and finer material (05-09). The thickness of this deposit, where fully penetrated, ranged from 0.3 m to 3.7 m. Where full penetration was confirmed, the base of the unit varied from elevation 401.9 m to 403.9 m. Practical refusal to SPT driving was also encountered at significantly higher elevations ranging from 404.5 m to 412.0 m within or possibly at the base of this unit. SPT 'N' values ranged from 2 to 40 and average 17, suggesting a generally compact state. The moisture content of the 8 samples tested ranged from 7% to 33% with an average of 15%. Grain size analysis of seven samples (five full sieves and two wash tests) indicated that the samples contained 12% to 32% gravel, 56% to 77% sand and 8% to 21% silt and clay sized particles. The results of the grain size distribution tests are shown on Figure 1 in Appendix B. This material ranges from an SM to SP-SM to SW-SM soil using the MTO Soil Classification System.

4.1.5 Bedrock

Bedrock was proven by coring in Boreholes 05-1, 05-2, 05-5, 05-6 and 05-8. The bedrock was observed to consist of siliceous metasediment, generally hornblende gneiss. Banding is common with quartz rich and mica rich layers contrasting with the more massive gneissic matrix. A consistent joint set was observed at approximately 70° from the axis of the cores. This set was observed to be synchronous with mica or quartz banding. A second, less prevalent joint set was observed to have an orientation of approximately 10° from the axis of the core. This joint set was observed to have openings of as much as 3 mm filled with black shale particularly near the upper bedrock surface. Some rusting was also present. The joint surfaces were generally smooth with a sandy texture. Core recoveries ranged from 81% to 100% and averaged 93%.

RQD values on the recovered cores ranged from 0% to 83% and averaged 48%. This indicates a poor quality or severely fractured bedrock. Unconfined compressive strength testing was carried out on three samples with strength results ranging from 132 MPa to 149 MPa. The bedrock elevations encountered at the borehole locations are provided in the following table:

Table 4.1: Proven Bedrock Elevations

Borehole	Bedrock Elevation, Geodetic
05-1	403.9 m
05-2	403.6 m
05-5	401.9 m
05-6	403.8 m
05-8	403.9 m

4.2 Groundwater

Groundwater levels were measured in the standpipes on November 18, 2005. Away from the culvert, groundwater levels ranged from 0.5 m to 0.6 m below ground surface. The water level in Long Lake Creek on November 10, 2005, was surveyed to be at elevation 405.6 m and 404.9 m at the inlet and outlet of the culvert respectively. The groundwater level in the vicinity of the culvert is anticipated to be close to the creek water level.

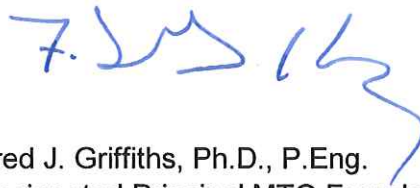
Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

5.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Yours very truly,

JACQUES WHITFORD LIMITED



Fred J. Griffiths, Ph.D., P.Eng.
Designated Principal MTO Foundation Contact



J.G.A. Raymond Haché, M.Sc., P.Eng., PMP
Designated Principal MTO Foundation Contact



FOUNDATION DESIGN REPORT

for

W.P. 5768-04-00
Highway 60 – Long Lake Creek Culvert
Site No. 40-121
Geographic Township of McClintock
District 52, Huntsville

6.0 DISCUSSION

6.1 Proposed Development

It is noted that, for project orientation purposes, Highway 60 will be assumed to run east-west at the site, with chainage increasing from west to east.

It is understood that the Ministry of Transportation of Ontario (MTO) plans to replace the southern half of the existing Long Lake Creek Culvert (Site No. 40-121). It is understood that the north half of the existing structure was constructed in the 1930's and consists of a 4.88 m by 1.8 m open footing box concrete culvert. The underside of the existing footings for the concrete culvert on the north side is understood to be at 404.2 m Geodetic. The original culvert was extended to the south in the 1950's by adding a 3.6 m by 2.3 m structural plate pipe arch. The embankment was widened and the profile raised at the time of the extension. The staging of the work resulted in the construction of an overbuilt embankment to the south of the existing paved surface. The structural plate pipe arch underwent a holding treatment in 2004 by placement of a grouted corrugated steel pipe liner. It is now proposed to replace the structural plate pipe arch. It is not proposed to alter either the existing horizontal or vertical alignments of the highway.

In order to maintain the existing culvert length and improve the slope geometry at the culvert inlet, it is proposed to construct a gabion wall 4 m in length and 4 m in height.

6.2 Soil Summary

Beneath a surficial layer of granular fill, the embankment material observed in Boreholes 05-1 and 05-2 consisted of rock fill. It is noted that the pavement investigation boreholes indicate that the depth from top of pavement to the top of rock fill varies somewhat. For design purposes the rock fill will be considered to have a unit weight of 19 kN/m^3 and an angle of internal friction of 47 degrees near surface and an angle of internal friction of 45 degrees at depths greater than 2 m.

The native soils at this site consist of a shallow deposit of non-cohesive materials ranging from gravelly sand to silty sand. For design purposes, the soils will be considered to be compact to dense, with a design N-value of 15 blows/100 mm. For preliminary design purposes, the native non-cohesive soils at this site have been considered to have a unit weight of 20 kN/m³ and an angle of internal friction of 30 degrees.

6.3 Foundation Issues

There are two foundation issues to be considered at this site: culvert type and staging.

6.3.1 Culvert Type

The following table compares the available culvert types complete with foundation options which have been considered for the replacement culvert.

Table 6.1: Culvert Type Option

Option	Advantages	Disadvantages	Relative Cost	Risk/Consequences
Structural Steel Plate Pipe	<ul style="list-style-type: none"> minimizes excavation depth minimizes excavation dewatering reduced consequences of scour 	<ul style="list-style-type: none"> connection to existing culvert corrosion potential leads to shorter life and earlier replacement 	Low	▪
Closed Concrete Box	<ul style="list-style-type: none"> could be pre-cast minimizes excavation depth minimizes excavation dewatering reduced consequences of scour 	<ul style="list-style-type: none"> connection to existing culvert 	Moderate	▪
Open Footing Box Culvert	<ul style="list-style-type: none"> could use precast to minimize traffic impact 	<ul style="list-style-type: none"> deeper excavations required for foundations scour protection most important 	Moderate	<ul style="list-style-type: none"> Dewatering – will need to control both surficial and groundwater flows

Given the scale of effort required for culvert replacement at this site, the structural steel plate is not recommended as it will have the shortest life.

It is recommended that an open footing box culvert be utilized at this site. It is also recommended that the foundations be placed on bedrock. Wherever there is a local area of deeper bedrock the foundations should be placed on mass concrete on bedrock.

6.3.2 Traffic Staging

The following table compares the traffic staging options considered for the culvert replacement as described in the Structural Memorandum of October 12, 2005:

Table 6.2: Foundation Comparison of Traffic Staging Options

Option #	Advantages	Disadvantages	Relative Cost	Risk/Consequences
1 Lower grade by 0.9 m on existing alignment	<ul style="list-style-type: none"> no impact outside existing footprint 	<ul style="list-style-type: none"> can achieve only single lane traffic during construction requires four stages 	Low	
2, a & b Widen embankment to the north	<ul style="list-style-type: none"> can maintain two lanes of traffic at normal design speed 	<ul style="list-style-type: none"> impact to adjacent marshy area requires three stages requires extending the culvert to the north benching of the existing embankment will be difficult due to the size of the rockfill 	High	
3, a & b Traffic to remain on one lane of existing roadway. Excavation supported by shoring	<ul style="list-style-type: none"> single stage minimum excavation no impact outside existing embankment footprint 	<ul style="list-style-type: none"> single lane of traffic rock fill presents significant challenges to shoring installation shallow bedrock therefore shoring would require anchors 	Low	<ul style="list-style-type: none"> rock fill prevents shoring installation

Table 6.2: Foundation Comparison of Traffic Staging Options

Option #	Advantages	Disadvantages	Relative Cost	Risk/Consequences
4, & 5 Lower grade by 2.1 m on existing alignment	<ul style="list-style-type: none"> no impact outside existing footprint can maintain two lanes of traffic during culvert construction 	<ul style="list-style-type: none"> requires four stages reduced design speed 	Low	

Given the presence of the rock fill and shallow rock, it is recommended that the shoring option not be considered further. From a foundation engineering perspective, the other options are viewed to be roughly equal. It is understood that Option 1 has been selected based on consideration of other criteria.

7.0 RECOMMENDATIONS

7.1 Structure Foundations

It is recommended that the culvert be supported on spread footings founded on sound bedrock at elevation 403.9 m. Where bedrock is encountered above elevation 403.9 m it should be removed within the foundation footprint. Where bedrock is not found to be at the planned footing elevation, it is recommended that the existing materials be removed to expose bedrock and that mass concrete be placed back up to the design footing elevation. Where bedrock is encountered at or above elevation 403.4 m, the mass concrete should extend at least 0.25 m beyond the edges of the footing. Where bedrock is encountered between elevation 403.4m and 402.9 m the mass concrete should extend to at least 0.375 m beyond the edges of the footing. Where bedrock is encountered between 402.9 m and 402.4 m the mass concrete should extend to at least 0.625 beyond the edges of the footing.

It is recommended that the underside of the gabion wall be set at Elevation 403.9 m. The Gabion wall should be founded directly on sound bedrock. Where bedrock is not encountered at the planned footing elevation, it is recommended that the gabions be constructed on a Structural Fill pad resting either on bedrock or glacial till. In the case where the pad rests on glacial till it should have a minimum thickness of 1.0 m. The Structural Fill pad should be constructed of compacted OPSS Granular A and should extend a minimum of 1000 mm laterally beyond the edges of the wall base. Alternatively the gabion wall could be founded on mass concrete placed on bedrock.

Spread Footings - Bearing Resistance

The following parameters may be used in the design:

Table 7.1: Recommended Spread Footing Design Parameters

Founding Layer	Footing Elev. (m)	Footing Width (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Resistance at SLS (kPa)
Bedrock or Mass Concrete on Bedrock	-	-	10,000	Note 1
1000 mm thick Structural Fill Pad over Native Soil	404.3	4 m square	300	200

Note 1: Practically, the rock mass will be unyielding in response to the anticipated foundation load and therefore an SLS resistance is considered non-applicable.

In accordance with Section 6.6 of the CHBDC, a resistance factor of 0.5 has been applied to calculate the factored geotechnical resistance at ULS.

The geotechnical resistance at SLS corresponds to a maximum settlement of 25 mm. Note that portions of the gabion wall may be supported on bedrock or mass concrete on bedrock and will undergo minimal settlement. Differential settlement could be equal to total settlement and may occur over a limited length.

Note that a reduction factor to account for inclined loads will need to be applied in accordance with Section 6.7.4 of the CHBDC.

Spread Footing – Horizontal Resistance

The unfactored horizontal resistance of spread footings may be calculated using an unfactored coefficient of friction of 0.7 between the bedrock and cast-in-place concrete, 0.6 between the gabion baskets and OPSS Granular A, and 0.5 between the gabion baskets and bedrock or cast-in-place concrete.

7.2 Frost Protection

Spread footings founded on soil should be provided with the equivalent of 1.8 m of earth cover for frost protection. Footings founded directly on sound bedrock or on mass concrete on bedrock do not require any frost cover. The underside of the gabions not on bedrock should be adequately protected with 0.5 m of cover provided the wall is founded on at least 1.0 m of non-frost susceptible material such as OPSS Granular A.

7.3 Earth Pressure Design

The culvert should be backfilled in accordance with OPSD 803.010

Computation of earth pressures should be in accordance with Section 6.9 of the CHBDC. For retaining walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied and unyielding structures, the at-rest earth pressure should be used for design. The following unfactored soil parameters may be used for design. The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6.9.3 of the CHBDC.

The total active and passive thrusts can be calculated using the following equations:

$$P_A = \frac{1}{2} K_a \gamma H^2$$

$$P_P = \frac{1}{2} K_p \gamma H^2$$

Where H is the height of the wall. Values for K_a , K_p and γ are provided below. The thrust acts at a point one third up the height of the wall.

Table 7.2: Recommended Lateral Earth Pressure Parameters

Parameter	Backslope	OPSS Granular B, Type I and II	OPSS Granular A and Granular B Type II
Total Unit Weight, γ (kN/m ³)		21	22
Effective Friction Angle		32 degrees	35 degrees
Coefficient of Active Earth Pressure (K_a)	Horizontal	0.31	0.27
Coefficient of Earth Pressure at Rest (K_o)	Horizontal	0.47	0.43
Coefficient of Passive Earth Pressure (K_p)	Horizontal	3.2	3.7
Coefficient of Active Earth Pressure (K_a)	2H:1V	0.47	0.39
Coefficient of Passive Earth Pressure (K_p)	2H:1V	8.6	10.8

The gabion wall will be backfilled with rock fill and will have a backslope of 1.25 H:1V. The back of the wall will be at 21 degrees from vertical after applying a 6 degree batter. The following earth pressure parameters are recommended for the design of the gabion wall.

Table 7.3: Recommended Lateral Earth Pressure Parameters for Gabion Wall

Parameter	Backslope	Rockfill
Total Unit Weight (kN/m ³)	-	19
Effective Friction Angle		45°
Coefficient of Active Earth Pressure (K _a)	1.25H:1V	0.29

The K_a value provided above should be applied to the vertical plane located at the back of the lowest gabion unit. The height of the wall used in the calculations of force must be based on top of fill to underside of gabion at the same vertical plane.

Compaction of the granular backfill near walls should be carried out using hand-operated equipment to prevent over-stressing the walls.

Granular backfill should be designed as per OPSD 3501 using a depth of frost penetration, *f*, of 1.8 m.

7.4 Seismic Design Considerations

7.4.1 Zonal Acceleration Ratio

Table A3.1.7 of the CHBDC indicates that the Zonal Acceleration Ratio for Huntsville, which is approximately 50 km west of the site, is 0.05. Reference is made to Section C4.6.4 of the CHBDC for the calculation of seismic forces on retaining walls.

7.4.2 Soil Profile Type

It is recommended that Soil Profile I as defined in CHBDC Section 4.4.6 be used in the seismic design of this site.

7.4.3 Liquefaction of Foundation Soils

An assessment of the potential for liquefaction of the foundation soils was carried out using the Seed and Idriss (1971) simplified procedure outlined in the CHBDC, Section C4.6.2 Liquefaction of Foundation Soils. The results of this assessment revealed that generally this site would not be classified as liquefiable under a 0.08 g earthquake.

7.4.4 Seismic Forces on Retaining Walls

Retaining walls should be designed to resist the earth pressures produced under earthquake conditions. CHBDC Clause 4.6.4 recommends the use of the combined coefficients of static and seismic earth pressure, referred to as K_{AE} for active conditions and K_{PE} for passive conditions, for routine design purposes.

The total active and passive thrusts under earthquake conditions can be calculated using the following equations:

$$P_{AE} = \frac{1}{2} K_{AE} \gamma H^2 (1 - k_v)$$

$$P_{PE} = \frac{1}{2} K_{PE} \gamma H^2 (1 - k_v)$$

where;

K_{AE} = active earth pressure coefficient (combined static and seismic)

K_{PE} = passive earth pressure coefficient (combined static and seismic)

H = height of wall

k_h = horizontal acceleration coefficient

k_v = vertical acceleration coefficient

γ = total unit weight

For this site, the following preliminary design parameters were used to develop the recommended K_{AE} and K_{PE} values.

- Zonal Acceleration Ratio, A 0.05
- Horizontal Acceleration Coefficient, k_h 0.025
- Vertical Acceleration Coefficient, k_v 0.017
- Vertical back of wall
- For yielding walls

The above k_h value corresponds to $\frac{1}{2}$ of the A value, and the k_v value corresponds to 0.67 of the k_h value. The angle of friction between the soil and the wall has been set at 0° to provide a conservative estimate.

Table 7.4: Combined Coefficients of Static and Seismic Earth Pressure

Parameter	OPSS Granular B Type I and II		OPSS Granular A & Granular B Type II	
	Horizontal Backslope	2H:1V Backslope	Horizontal Backslope	2H:1V Backslope
Total Unit Weight, γ (kN/m ³)	21	21	22.0	22.0
Effective Friction Angle	32 degrees	32 degrees	35 degrees	35 degrees
Active Earth Pressure (K_{AE})	0.32	0.51	0.28	0.43
Height of application of P_{AE} from base as ratio of wall height (H)	0.341	0.352	0.342	0.349
Passive Earth Pressure (K_{PE})	3.21	-	3.64	-
Height of application of P_{PE} from base as ratio of wall height (H)	0.325	-	0.325	-

7.5 Embankment Design

The existing embankments are constructed as steeply as 1.25H:1V and exhibit no signs of instability. Where embankments are constructed of rockfill they should be sloped no steeper than 1.25H:1V.

The available earth borrow in the area of the site will be similar to the native materials observed in the boreholes.

Where embankments are constructed of earth fill they should be sloped no steeper than 2H:1V.

The native soils are anticipated to settle less than 25 mm under a widened embankment. Soils beneath the existing embankment are not expected to have an appreciable amount of settlement. Embankment rock fill material may undergo as much as 2% self settlement.

The majority of this settlement will occur during construction provided the work is not carried out in winter conditions.

7.6 Unwatering

It is anticipated that the foundations of the culvert will extend to below elevation 403.9 m. The water level in the creek at the time of the investigation was 405.9 m. Control of the water flow in the creek will require a coffer dam (sand bags) and piping system for excavations adjacent to the creek.

It is noted that the water levels at the site are partially controlled by an upstream beaver dam. It is recommended that the unwatering plan for this site include removal of the beaver dam or alternatively the temporary construction coffer dam should be designed to allow complete failure of the upstream beaver dam.

The native materials were observed to be reasonably well graded and contained as much as 21% fines. It is anticipated, therefore that unwatering for foundation construction can be achieved using conventional sump and pump techniques.

7.7 Erosion and Scour Protection

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. The embankment slopes within 3 m of the structures should be surfaced with rock protection at least 300 mm thick placed on a Class II non-woven filter fabric. Earthfill embankments constructed at 2H:1V should be protected with an erosion control blanket.

Scour protection should be provided within the culvert and at the toe of the gabion wall. It is recommended that "rock protection" 100 mm to 400 mm in size be placed on a Class II non-woven filter fabric.

The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediments from running off the site.

The existing roadway embankment is constructed of rock fill. A compacted clay seal or equivalent at the inlet is not considered necessary at this site as the preferential flow path will not be within the backfill immediately around the culvert.

7.8 Other Construction Considerations

Site Grading and Preparation

All organic soils and other deleterious materials must be removed from beneath the proposed foundation units and fill. Where deleterious materials are encountered, the material should be excavated, wasted and replaced. The lateral extent of such excavation should include all deleterious material within the embankment footprint.

Stripping of deleterious materials should be inspected by geotechnical personnel to ensure that all unsuitable materials are removed prior to placement of embankment fill. The exposed subgrade surface should be surface-compacted using suitable compaction equipment to 95% of Standard Proctor maximum dry density where applicable.

Site preparation should be carried out in accordance with the requirements of SP 902S01 Excavation and Backfilling - Structures.

Excavation

Earth excavation should be carried out in accordance with OPSS-206.07.03. Side slopes for open cut excavations should conform to Occupational Health and Safety Act regulations. The soils to be excavated for the proposed foundations should be considered as a Type 3 soil. Temporary cut slopes should be no steeper than 1 horizontal to 1 vertical from the base of the excavation. Roadway protection will be required should steeper slopes be necessary.

Bedrock excavation to achieve the design footing elevation should be carried out using mechanical rock breakers/hoe rams.

Cement Type and Corrosion Protection

A representative soil sample was submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, resistivity, chloride and water soluble sulphate, in order to determine cement type and reinforcing steel protection requirements. The results are provided in the following table:

Table 7.5: Chemical Analysis Results

Borehole	Sample	pH	Resistivity	Soluble Sulphate	Chloride
BH05-6	SS-2	6.10	24000 ohm·cm	10 µg/g	<5 µg/g

The soluble sulphate result indicates that a Type 10 Portland cement would be suitable for use in concrete mixtures at this site. The chloride, pH and resistivity results should be considered by the structural engineer when designing against corrosion.

8.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above recommendations.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Yours very truly,

JACQUES WHITFORD LIMITED

Fred J. Griffiths, Ph.D., P.Eng.
Designated Principal MTO Foundation Contact

J.G.A. Raymond Haché, M.Sc., P.Eng., PMP
Designated Principal MTO Foundation Contact

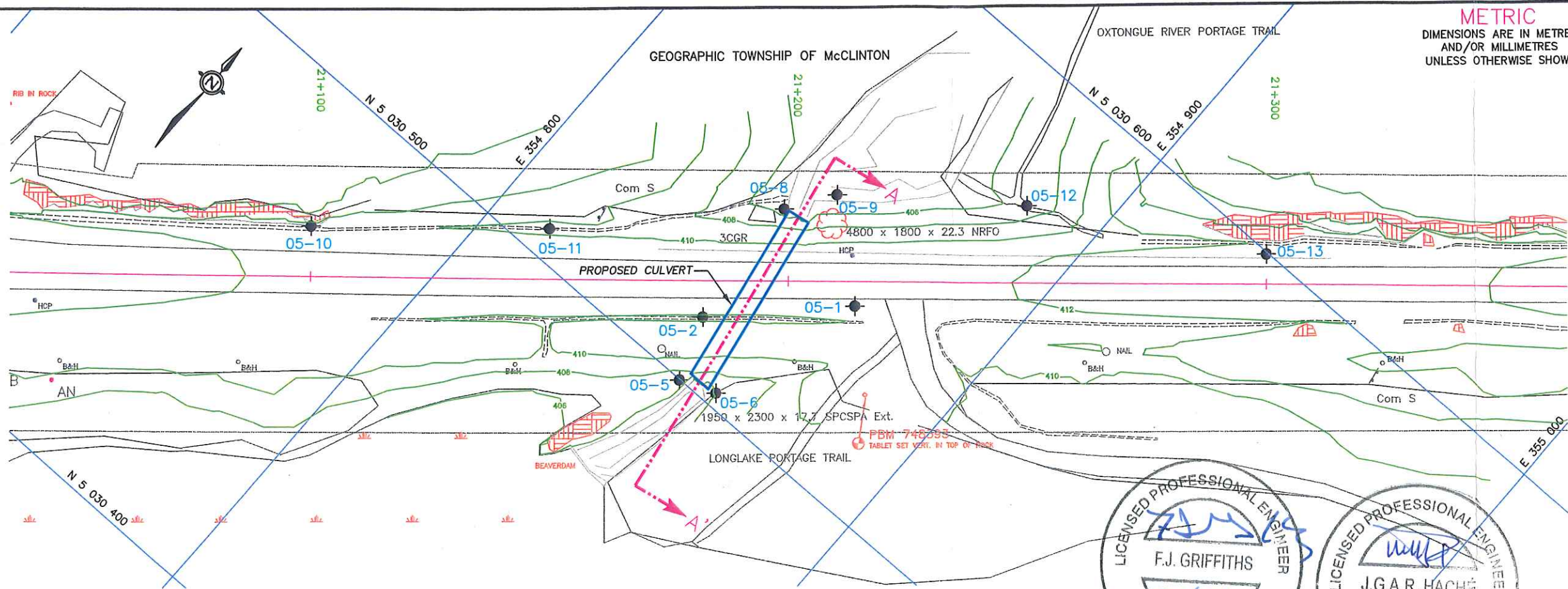


P:\GeoTech\1004574 - Long Lake Culvert\Foundations\FINAL Fdtns Report March 8, 2006.doc

APPENDIX A

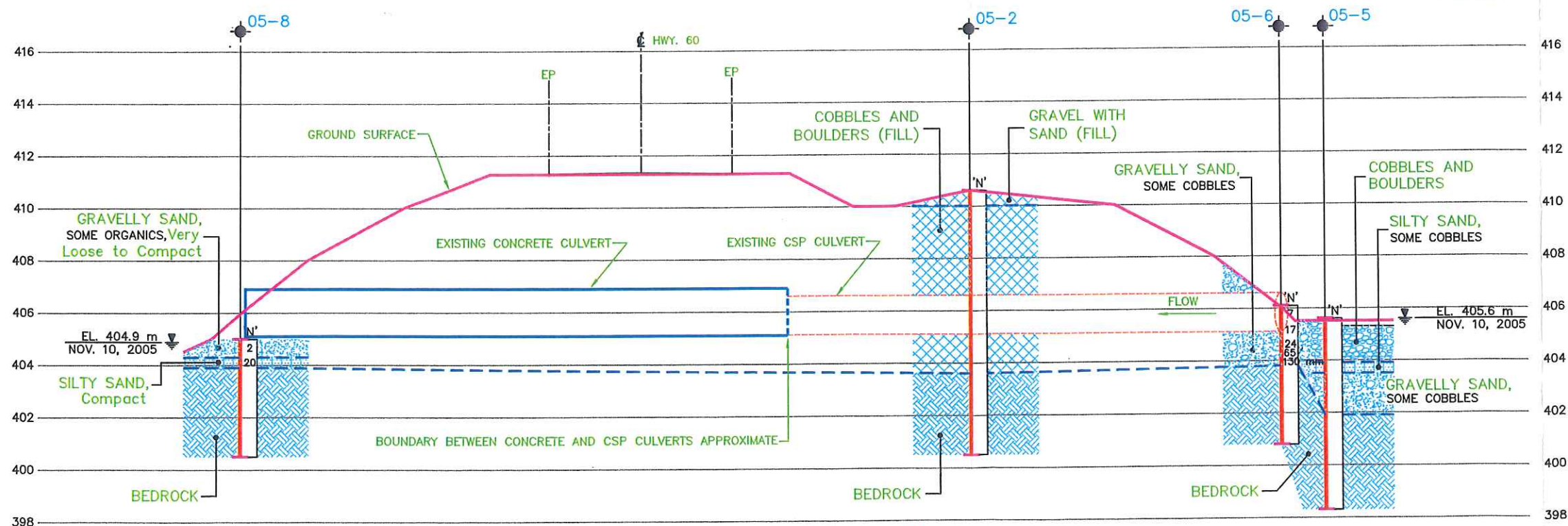
Borehole Location Plan and Profile Plot





NOTE: THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION ONLY. THE PROPOSED STRUCTURE LOCATION AND FEATURES ARE SHOWN FOR ILLUSTRATION PURPOSES ONLY AND MAY NOT BE CONSISTENT WITH THE FINAL DESIGN CONFIGURATION AS SHOWN ELSEWHERE IN THE CONTRACT DOCUMENTS.

PLAN
SCALE
10m 0 10 20m



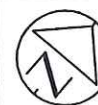
CROSS SECTION A-A'

SCALE
2m 0 2 4m

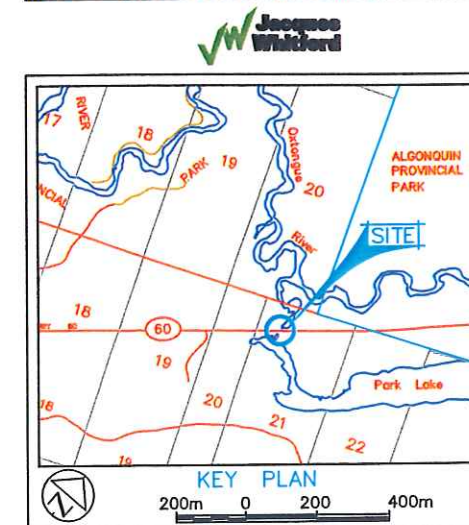
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 5768-04-00

LONG LAKE
CULVERT REPLACEMENT
STA 21+177.25 TO STA 21+300
BORE HOLE LOCATIONS & SOIL STRATA



SHEET
1



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- ↓ WL at time of investigation
- ↕ WL in Piezometer
- ⊥ Piezometer
- ▤ BEDROCK OUTCROP

No	ELEVATION	COORDINATES	
		NORTH	EAST
05-1	411.5	5 030 535.5	354 871.0
05-2	410.6	5 030 512.9	354 848.2
05-5	405.6	5 030 499.9	354 853.0
05-6	406.1	5 030 502.8	354 860.6
05-8	405.0	5 030 541.1	354 846.6
05-9	404.6	5 030 550.5	354 853.1
05-10	411.0	5 030 473.7	354 773.9
05-11	409.8	5 303 506.0	354 812.1
05-12	407.0	5 030 574.8	354 884.9
05-13	412.2	5 030 599.6	354 929.4

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS	DATE	BY	DESCRIPTION
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

GEORES No 31E-241

HWY No 60	CHECKED	DATE 2006/12/16	DIST 52
SUBM'D FJG	CHECKED	DATE 2006/12/16	SITE 40-121
DRAWN GBB	CHECKED	DATE 2006/12/16	DWG 1004574-1

APPENDIX B

Symbols and Terms Used on Borehole Records
Borehole Records
Grain Size Distribution Test Results



SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Topsoil</i>	-	mixture of soil and humus capable of supporting good vegetative growth
<i>Peat</i>	-	fibrous aggregate of visible and invisible fragments of decayed organic matter
<i>Till</i>	-	unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	-	any materials below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	-	having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	-	having cracks, and hence a blocky structure
<i>Varved</i>	-	composed of regular alternating layers of silt and clay
<i>Stratified</i>	-	composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	-	>75 mm
<i>Seam</i>	-	2 mm to 75 mm
<i>Parting</i>	-	< 2 mm
<i>Well Graded</i>	-	having wide range in grain sizes and substantial amounts of all intermediate particle sizes
<i>Uniformly Graded</i>	-	predominantly of one grain size

Terminology describing soils on the basis of grain size and plasticity is based on the Unified Soil Classification System (USCS) (ASTM D-2488). The classification excludes particles larger than 76 mm (3 inches). This system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%

The standard terminology to describe cohesionless soils includes the compactness (formerly "relative density"), as determined by laboratory test or by the Standard Penetration Test 'N' - value.

Relative Density	'N' Value	Compactness %
<i>Very Loose</i>	<4	<15
<i>Loose</i>	4-10	15-35
<i>Compact</i>	10-30	35-65
<i>Dense</i>	30-50	65-85
<i>Very Dense</i>	>50	>85

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests, or occasionally by standard penetration tests.

Consistency	Undrained Shear Strength		'N' Value
	kips/sq.ft.	kPa	
<i>Very Soft</i>	<0.25	<12.5	<2
<i>Soft</i>	0.25-0.5	12.5-25	2-4
<i>Firm</i>	0.5-1.0	25-50	4-8
<i>Stiff</i>	1.0-2.0	50-100	8-15
<i>Very Stiff</i>	2.0-4.0	100-200	15-30
<i>Hard</i>	>4.0	>200	>30

ROCK DESCRIPTION

Rock Quality Designation (RQD)

The classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from in situ fractures.

RQD

ROCK QUALITY


90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

Terminology describing rock mass:

Spacing (mm)	Bedding, Laminations, Bands	Discontinuities
2000-6000	<i>Very Thick</i>	<i>Very Wide</i>
600-2000	<i>Thick</i>	<i>Wide</i>
200-600	<i>Medium</i>	<i>Moderate</i>
60-200	<i>Thin</i>	<i>Close</i>
20-60	<i>Very Thin</i>	<i>Very Close</i>
<20	<i>Laminated</i>	<i>Extremely Close</i>
<6	<i>Thinly Laminated</i>	

Strength Classification	Uniaxial Compressive Strength (MPa)
<i>Very Low</i>	1-25
<i>Low</i>	25-50
<i>Medium</i>	50-100
<i>High</i>	100-200
<i>Very High</i>	>200

Terminology describing weathering:

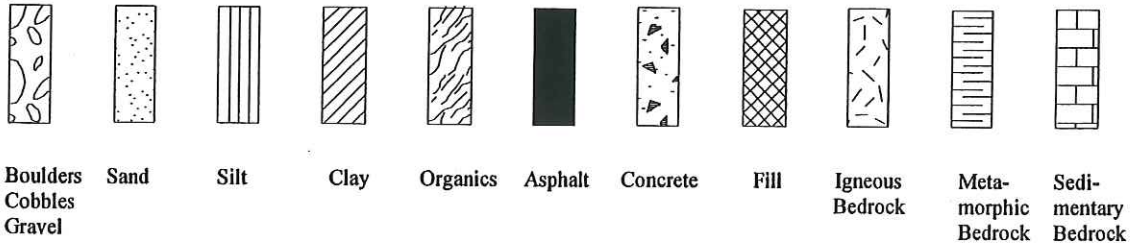
 <i>Slight</i>	-	Weathering limited to the surface of major discontinuities. Typically iron stained.
<i>Moderate</i>	-	Weathering extends throughout rock mass. Rock is not friable.

High

Weathering extends throughout rock mass. Rock is friable.

STRATA PLOT

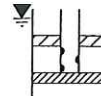
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT



Borehole or
Standpipe



Piezometer

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)	BS	Bulk sample
ST	Shelby tube or thin wall tube	WS	Wash sample
PS	Piston sample	HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits.

N - VALUE

Numbers in this column are the results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and 'N' values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75).

OTHER TESTS

S	Sieve analysis	H	Hydrometer analysis
G _s	Specific gravity of soil particles	γ	Unit weight
k	Permeability (cm/sec)	C	Consolidation
	Single packer permeability test; test interval from depth shown to bottom of borehole	CD	Consolidated drained triaxial
	Double packer permeability test; test interval as indicated	CU	Consolidated undrained triaxial with pore pressure measurements
	Falling head permeability test using casing	UU	Unconsolidated undrained triaxial
	Falling head permeability test using well point or piezometer	DS	Direct shear
		Q _u	Unconfined compression
		I _p	Point Load Index (I _p on Borehole Record equals I _p (50); the index corrected to a reference diameter of 50 mm)

RECORD OF BOREHOLE No BH05-01

1 OF 2

METRIC

W.P. 5768-04-00 LOCATION Long Lake Culvert, Station 21+214 Offset 5.0 m Rt ORIGINATED BY EH
DIST 52 HWY 60 BOREHOLE TYPE Cased SplitSpoons COMPILED BY EH
DATUM Geodetic DATE 14.11.05 - 14.11.05 CHECKED BY Fa

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED × FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
411.5 0.0	Gravel, with sand, brown (FILL)																
410.9 0.6	Cobbles and Boulders (ROCK FILL)																
			1	NQ													REC = 0
			2	NQ													REC = 0
			3	NQ													REC = 0
403.9 7.6	Homeblende Gneiss BEDROCK		4	NQ													REC = 92 RQD = 63
			5	NQ													REC = 91 RQD = 45

Continued Next Page

+ 3, × 3: Numbers refer to
Sensitivity

3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH05-01

2 OF 2

METRIC

W.P. 5768-04-00 LOCATION Long Lake Culvert, Station 21+214 Offset 5.0 m Rt ORIGINATED BY EH
DIST 52 HWY 60 BOREHOLE TYPE Cased Split Spoons COMPILED BY EIT
DATUM Geodetic DATE 14.11.05 - 14.11.05 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
							20 40 60 80 100	20 40 60 80 100	10 20 30					
	Homeblende Gneiss BEDROCK		6	NQ		400								REC = 88 RQD = 83
399.3 12.2	End of Borehole													

+ 3, × 3: Numbers refer to
Sensitivity

3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH05-02

1 OF 1

METRIC

W.P. 5768-04-00 LOCATION Long Lake Culvert, Station 21+182 Offset 7.5 m Rt ORIGINATED BY EH
 DIST 52 HWY 60 BOREHOLE TYPE Cased Split Spoons COMPILED BY EH
 DATUM Geodetic DATE 18.11.05 - 18.11.05 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
								UNCONFINED							FIELD VANE					
								QUICK TRIAXIAL							LAB VANE					
410.6	Old highway							20	40	60	80	100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	WATER CONTENT (%)	GR	SA	SI	CL
0.0	Gravel, with sand, brown (FILL)																			
410.0							410													
0.6	Cobbles and Boulders (ROCK FILL)		1	NQ			409													REC = 0
							408													REC = 0
			2	NQ			407													REC = 0
							406													REC = 0
			3	NQ			405													REC = 0
							404													REC = 0
			4	NQ			403													REC = 93 RQD = 71
403.6							402													REC = 93 RQD = 71
7.0	Sound Hornblende Gneiss BEDROCK		5	NQ			401													
			6	NQ																
400.6																				
10.1	End of Borehole																			





MTD 1004574MTO.GPJ ON_MOT.GDT 27/02/06

RECORD OF BOREHOLE No BH05-05

1 OF 1

METRIC

W.P. 5768-04-00 LOCATION Long Lake Culvert, Station 21+177 Offset 20.6 m Rt ORIGINATED BY EH
DIST 52 HWY 60 BOREHOLE TYPE Cased Split Spoons COMPILED BY EH
DATUM Geodetic DATE 08.11.05 - 09.11.05 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED × FIELD VANE										
								● QUICK TRIAXIAL × LAB VANE										
								WATER CONTENT (%)										
								20	40	60	80	100	10	20	30			
405.6	Water																	
0.0	WATER																	
405.3																		
0.3	COBBLES and BOULDERS		1	GS			405											
404.0							404											
1.7	SILTY SAND, some cobbles, dark grey (SM)																	
403.5																		
2.1	GRAVELLY SAND, some cobbles, greyish brown (SP - SM)						403											
401.9							402											
3.7	Hornblende Gneiss BEDROCK		2	NQ			401										REC = 81 RQD = 45	
							400											
			3	NQ													REC = 100 RQD = 50	
							399											
398.3																		
7.3	End of Borehole																	


MT0 1004574MTO.GPJ ON MOT.GDT 27/02/06

RECORD OF BOREHOLE No BH05-06

1 OF 1

METRIC

W.P. 5768-04-00 LOCATION Long Lake Culvert, Station 21+185 Offset 23.3 m Rt ORIGINATED BY EH
DIST 52 HWY 60 BOREHOLE TYPE Cased Split Spoons COMPILED BY EH
DATUM Geodetic DATE 07.11.05 - 08.11.05 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100						PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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406.1	Cobbles, blast rock		1	SS	7		406																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

RECORD OF BOREHOLE No BH05-08

1 OF 1

METRIC

W.P. 5768-04-00 LOCATION Long Lake Culvert, Station 21+199 Offset 15.0 m Lt ORIGINATED BY EH
DIST 52 HWY 60 BOREHOLE TYPE Cased SplitSpoons COMPILED BY EH
DATUM Geodetic DATE 10.11.05 - 10.11.05 CHECKED BY FH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100						
								SHEAR STRENGTH kPa						
								○ UNCONFINED × FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
							WATER CONTENT (%)							
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L							
405.0	Long grass, small trees, boulders													
0.0	GRAVELLY SAND, some organics, very loose, dark brown (SP - SM)		1	SS	2									27 65 (8)
404.4														
404.8	Gravel													
0.7	SILTY SAND, compact, dark brown to grey (SM)		2	SS	20									22 64 (14)
403.9							404							
1.1	Homeblende Gneiss BEDROCK		3	NQ										REC = 100 RQD = 0
														REC = 96 RQD = 51
			4	NQ			403							
			5	NQ			402							REC = 89 RQD = 43
			6	NQ										REC = 100 RQD = 24
			7	NQ			401							REC = 96 RQD = 45
400.5														
4.5	End of Borehole													

RECORD OF BOREHOLE No BH05-09

1 OF 1

METRIC

W.P. 5768-04-00

LOCATION

Long Lake Culvert, Station 21+210 Offset 18.0 m Lt

ORIGINATED BY EH

DIST 52 HWY 60

BOREHOLE TYPE

Cased Split Spoons

COMPILED BY EH

DATUM Geodetic

DATE

10.11.05 - 10.11.05

CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED × FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	10	20	30				
404.6	Marsh																
0.0	PEAT																
404.3																	
0.3	GRAVELLY SAND, compact, brown (SW - SM)		1	GS													
403.4			2	GS													
1.2	SILT, dense, grey (ML)		3	SS	100/150 mm												
403.0																	
1.7	End of borehole																
	Spoon Refusal on Inferred Bedrock																

1 OF 1

METRIC

W.P. 5768-04-00 LOCATION Long Lake Culvert, Station 21+100 Offset 10.5 m Lt ORIGINATED BY EH
DIST 52 HWY 60 BOREHOLE TYPE Cased Split Spoons COMPILED BY EH
DATUM Geodetic DATE 07.11.05 - 07.11.05 CHECKED BY FG

[illegible]

RECORD OF BOREHOLE No BH05-11

1 OF 1

METRIC

W.P. 5768-04-00

LOCATION Long Lake Culvert, Station 21+150 Offset 10.5 m Lt

ORIGINATED BY EH

DIST 52 HWY 60

BOREHOLE TYPE Cased Split Spoons

COMPILED BY EH

DATUM Geodetic

DATE 07.11.05 - 07.11.05

CHECKED BY FG


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
409.8	Grass, bush																
0.0	GRAVELLY SAND, compact, brown to grey (SW - SM)		1	SS	26												
409.1			2	SS	33/												
0.7	End of Borehole				100 mm		409										
	Spoon Refusal on Inferred Bedrock																

RECORD OF BOREHOLE No BH05-12

1 OF 1

METRIC

W.P. 5768-04-00 LOCATION Long Lake Culvert, Station 21+250 Offset 16.1 m Lt
DIST 52 HWY 60 BOREHOLE TYPE Cased Split Spoons ORIGINATED BY EH
DATUM Geodetic DATE 08.11.05 - 10.11.05 COMPILED BY EH
CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)	
								○ UNCONFINED × FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
407.0 0.0	Grass, boulders PEAT		1	SS	3	▽	406										GR SA SI CL		
406.4 0.6	SILTY SAND, some cobbles, loose to dense, yellowish brown to grey (SM)		2	SS	6														
			3	SS	40														
			4	SS	26														
404.5 2.4	GRAVELLY SAND, dense, grey (SW - SM)			5	SS	33/ 80 mm		405										12 67 (21)	
404.1 2.8	End of Borehole Spoon Refusal on Inferred Bedrock Standpipe Installed																17 67 (16)		

RECORD OF BOREHOLE No BH05-13

1 OF 1

METRIC

W.P. 5768-04-00 LOCATION Long Lake Culvert, Station 21+300 Offset 6.3 m LI
 DIST 52 HWY 60 BOREHOLE TYPE Cased Split Spoons
 DATUM Geodetic DATE 09.11.05 - 09.11.05
 ORIGINATED BY EH
 COMPILED BY EH
 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
412.2	Short grass																
0.0	GRAVELLY SAND, dense, brown		1	SS	33/		412										
412.0	(SW - SM)				100												
0.3	End of Borehole				mm												
	Spoon Refusal on Inferred Bedrock																

UNIFIED SOIL CLASSIFICATION SYSTEM

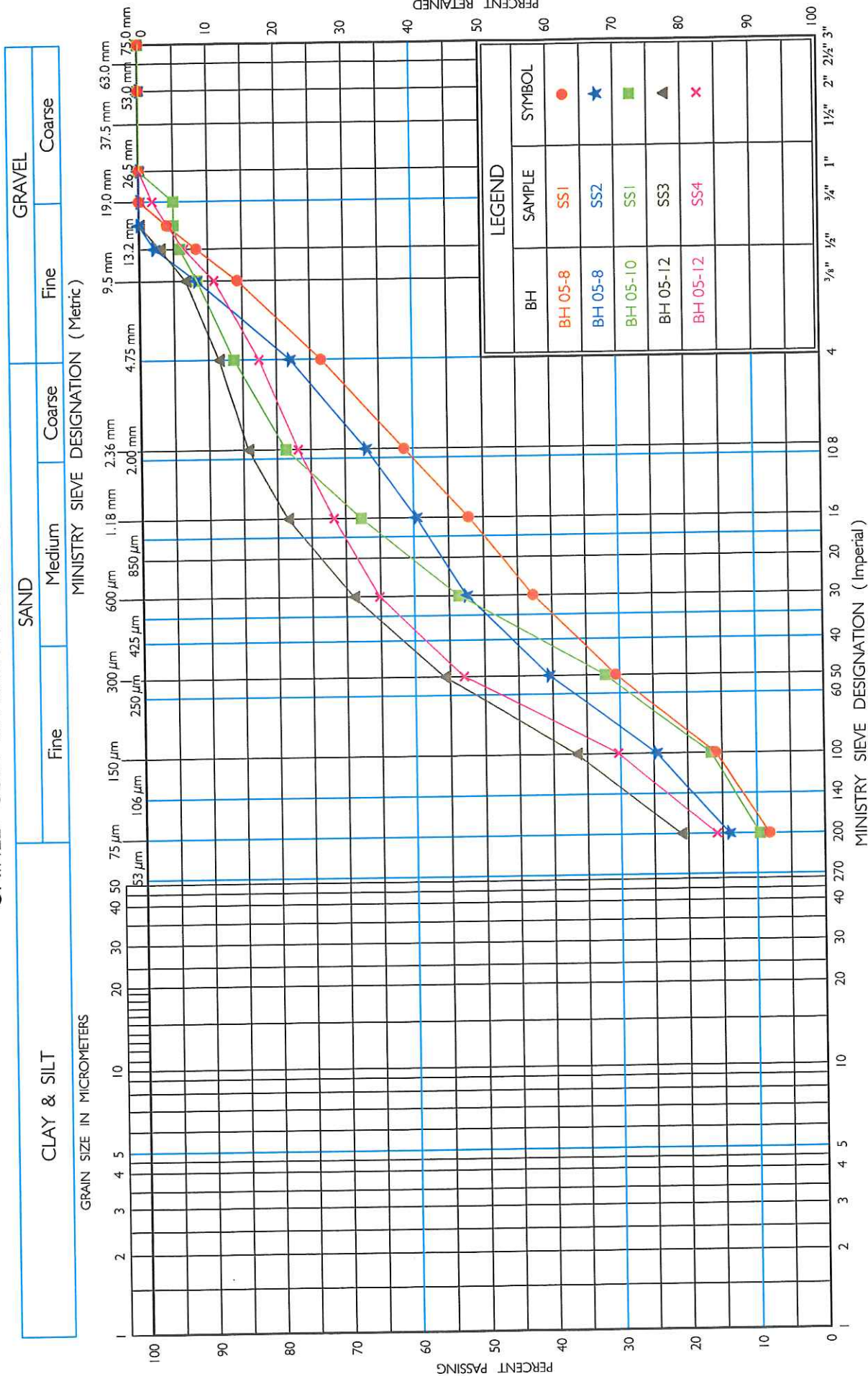


FIG No 1

W P 5768-04-00

GRAIN SIZE DISTRIBUTION

GRAVELLY SAND TO SILTY SAND

APPENDIX C

Site Photos





Photo 1: Culvert Inlet



Photo 2: Culvert Outlet



Photo 3: Site Looking West



Photo 4: Site Looking East

