

**HARMER PODOLAK ENGINEERING CONSULTANTS INC.**

**FOUNDATION INVESTIGATION  
AND DESIGN REPORT**

**W.P. 5089-03-00**

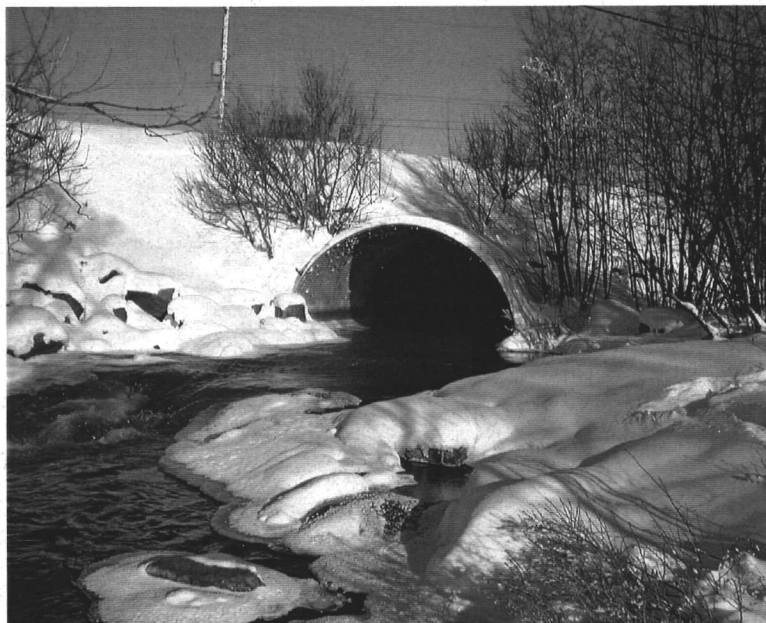
**HIGHWAY 124**

**MCKELLAR LAKE CULVERT REPLACEMENT**

**TOWNSHIP OF MCKELLAR, ONTARIO**

**GEOCRES NUMBER 31E-202**

**HUNTSVILLE AREA OFFICE  
MINISTRY OF TRANSPORTATION ONTARIO**



**PROJECT NO. ONO11711**

**FOUNDATION INVESTIGATION AND DESIGN REPORT**

**TO**

**HARMER PODOLAK ENGINEERING CONSULTANTS INC.**

**ON**

**W.P. 5089-03-00**

**GEOCRES NO. 31E-202**

**HIGHWAY 124**

**McKELLAR LAKE CULVERT REPLACEMENT  
TOWNSHIP OF McKELLAR, ONTARIO**

**HUNTSVILLE AREA OFFICE  
MINISTRY OF TRANSPORTATION ONTARIO**

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# FOUNDATION INVESTIGATION REPORT

For

**McKellar Lake Culvert Replacement**

**Township of McKellar, Ontario**

**W.P. 5089-03-00**

**Highway 124**

**Huntsville Area Office**

## 1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out for the proposed replacement of the McKellar Lake Culvert located on Highway 124 in the Town of McKellar, Ontario, approximately 20 km east of Parry Sound. The proposed culvert replacement will include replacement of both the concrete and stone masonry bridge structure at the inlet end (built circa 1921) and the 3.07 m x 4.72 m x 42 m long structural plate pipe arch (CSPA) culvert that was added as an extension to the outlet end of the bridge structure in 1970.

The work was carried out under Agreement No. 5005-A-00391 and in general accordance with our proposal dated December 18, 2003. Authorization to proceed was provided by Mr. David Harmer, P.Eng., of Harmer Podolak Engineering Consultants Inc. (Harmer Podolak).

This report contains the factual information obtained from the field and laboratory investigation.

## 2.0 SITE DESCRIPTION AND GEOLOGY

The project site is located on Highway 124 within the Town of McKellar. The centreline of the culvert is located at Station 13+673 McKellar Township. The water flow in the culvert is from north to south, from McKellar Lake into Manitouwabing Lake. The site location is shown on the Key Plan portion of Drawing No. 11711-1 in Appendix 2.

The project site is within an area identified by Chapman and Putnam as the Georgian Bay fringe. The region is characterized by very shallow soil and bare rock knobs and ridges.

The surrounding lands drain toward McKellar Lake and Manitouwabing Lake. The regional drainage is toward the south.

Highway 124 generally has a two lane rural cross-section within the study limits.

The concrete and stone masonry bridge structure at the inlet end was originally located beneath the former Highway 124 alignment and is now aligned at a 51 degree skew to the centreline of the current Highway 124 alignment. The CSPA which is connected to the outlet of the concrete and stone masonry structure is aligned at a 34 degree skew to the centreline of the current Highway 124 alignment. A rock ledge approximately 1.5 m in height was located downstream of the outlet of the old bridge and was incorporated into the CSPA design by including a 45 degree vertical elbow section.

The existing embankment is approximately 15 m wide at the top. The maximum height of the embankment is approximately 4.5 m on the right (outlet) side and 3.5 m on the left (inlet) side. The sideslopes on the right side consist of rock fill and are sloped at approximately 1.5H:1V. The sideslopes on the left side are vegetated over granular fill and are sloped at approximately 2H:1V. Stone masonry wing walls are present at both sides of the inlet to the old bridge structure.

### **3.0 INVESTIGATION PROCEDURES**

#### **3.1 Field Program**

The field work for this investigation was carried out in February 2004. The subsurface conditions were investigated through a borehole drilling program. A total of eleven (11) boreholes, numbered 04-1 through 04-9, 04-11 and 04-12, were advanced at select locations. All boreholes were advanced to a minimum of 1.5 m below the bedrock surface by coring. At location 04-10 bedrock was visible at surface below the water. No drilling or coring was carried out at the location of 04-10.

Boreholes 04-1 through 04-5 were drilled using a track-mounted CME 55 power auger drill suitably equipped for soil and bedrock sampling. Hollow stem auger equipment was used to advance the boreholes in the overburden. Soil samples were generally retrieved at 0.75 m intervals by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). The SPT carried out with the drilling equipment was performed using a standard 64 kg hammer with a 760 mm drop. Where boulders were encountered in the boreholes, N-size casing and NQ-size core barrels were used to advance the boreholes through the boulders. Boreholes 04-1 through 04-5 were advanced a minimum of 3 m into bedrock by coring (NQ-size).



Boreholes 04-7 and 04-8 were drilled using a truck-mounted CME 75 power auger drill suitably equipped for soil and bedrock sampling. Hollow stem auger equipment was used to advance the boreholes in the overburden. Soil samples were generally retrieved at 0.75 m intervals by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). The SPT carried out with the drilling equipment was performed using a standard 64 kg hammer with a 760 mm drop. Where boulders were encountered in the boreholes, N-size casing and NQ-size core barrels were used to advance the boreholes through the boulders. Boreholes 04-7 and 04-8 were advanced a minimum of 3 m into bedrock by coring (NQ-size).

Boreholes 04-6, 04-9, 04-11 and 04-12 were drilled using a portable electric core drill suitably equipped for soil and bedrock sampling. Casing was used to advance the boreholes in the overburden. Soil samples were generally retrieved at 0.75 m intervals by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). The SPT carried out with the drilling equipment was performed using a one-third weight (21.3 kg) hammer with a 760 mm drop. The SPT N-values shown on the borehole records have been corrected to account for the one-third weight hammer by dividing the number of blows by three. These boreholes were advanced through boulders and to a minimum of 1.5 m into bedrock by coring with N and/or E size casing and core barrels.

The subsurface conditions are described in detail in the Borehole Records presented in Appendix 1. All soil samples recovered were identified in the field, stored in moisture proof containers and were returned to our laboratory for detailed classification and testing.

Groundwater levels were recorded in the open boreholes throughout the duration of the investigation. Prior to completing the investigation, the boreholes were backfilled with a cement/bentonite mixture.

Borehole locations were established in the field by Jacques Whitford personnel relative to the ends of the existing culvert structures. Eastings and northings at the borehole locations were established relative to the MTM coordinate system, Zone 10, using a Trimble Pathfinder XRS Global Positioning System (GPS) Unit. The ground surface elevations at the borehole locations were referenced to a benchmark located to the right of Highway 124 at approximately Station 13+820. The benchmark was identified on the contract survey plans as a cut cross in the rock outcrop and having a geodetic elevation of 250.309 m. The base plan drawings showing the roadway in plan and profile with metric chainages were provided by Harmer Podolak.

### 3.2 Laboratory Testing

All samples returned to the laboratory underwent detailed visual classification by a geotechnical engineer. Selected samples were tested for moisture content and grain size distribution. Selected samples of the recovered rock core were tested for unconfined compressive strength. All soil and bedrock samples will be stored for a period of twelve months after issuance of the final report. Unless otherwise directed, the stored samples will be disposed of after this period.

## 4.0 SUBSURFACE CONDITIONS

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix 1. An explanation of the symbols and terms used to describe the Borehole Records is also provided. A borehole location plan is shown on Drawing 11711-1 along with a Stratigraphic Plot. The historical information for this site includes four boreholes drilled in 1969. This information is provided in Appendix 3. Three of the 1969 boreholes (1, 3 and 4) are relevant to the present investigation. A detailed description of the subsurface conditions encountered is given below.

### 4.1 Sand, trace Gravel, trace Silt with Boulders (Fill)

Fill deposits were observed at all of the borehole locations. The composition of the fill was variable. Sand and gravel, trace silt, was observed within the existing road base and subbase. Large diameter rock fill with a sand matrix was observed in boreholes drilled through the existing roadway embankment, and sand, trace gravel, trace silt, at some locations within the embankment including boreholes drilled immediately adjacent to the existing CSPA culvert.

The total thickness of the fill ranged from 0.4 m to 7.6 m.

Standard Penetration tests in the fill yielded N values ranging from 1 blow/0.3 m to 41 blows/0.3 m indicating that the fill ranges in density from very loose to dense. Split spoon refusal (50+ blows/0.15 m) was encountered at several locations within the fill. The occurrences of split spoon refusal have been attributed to the presence of coarse particles (e.g. cobbles and boulders) within the fill rather than to the density of the deposit. Poor sample recovery was achieved at some test locations. This may also have been due to the presence of coarse particles such as boulders, cobbles and gravel that could not enter the sampler.

The natural moisture content of nine samples tested ranged from 9% to 22% with an average of 16%. Three grain-size distribution analyses carried out on representative samples of the fill indicated that it contained 1% to 8% gravel, 87% to 96% sand, and 3% to 8% silt and clay sized particles, see Figure 1, Appendix 1. Cobbles and boulders were also present within the fill and were penetrated by coring.



## 4.2 Sand, trace Gravel, trace Silt

A deposit of sand trace gravel, trace silt was encountered below the fill layer in BH 04-2 and BH 04-3. This material was brown to grey and extended from as high as elevation 239.0 m to as low as 236.9 m.

Standard Penetration tests in the sand, trace gravel, trace silt yielded N values ranging from 6 blow/0.3 m to 19 blows/0.3 m indicating that the sand, trace gravel, trace silt ranges in density from loose to compact.

The natural moisture content of the four samples tested ranged from 15% to 21% with an average of 19%. The results of two grain-size distribution analyses carried out on representative samples of the sand, trace gravel, trace silt indicated that it contained 2% to 7% gravel, 89% to 92% sand, and 4% to 6% and clay sized particles, see Figure 2, Appendix 1.

Boulders were encountered beneath the sand, trace gravel, trace silt in Borehole 04-3.

It is noted that the sand, trace gravel, trace silt is very similar in composition to portions of the embankment fill and historical design documents suggest that all overburden soil was to have been removed from beneath the CSPA culvert and replaced with rock fill. It is therefore possible that the sand, trace gravel, trace silt and underlying boulders are fill.

## 4.3 Bedrock

Bedrock was proven by coring at all of the borehole locations except 04-10 where bedrock was visible adjacent to the footing of the existing old bridge structure. The bedrock surface elevations from the 1969 and 2004 investigations are presented in the table below.

| Location | Bedrock Surface Elevation (m) |
|----------|-------------------------------|
| 04-1     | 239.5                         |
| 04-2     | 236.9                         |
| 04-3     | 236.0                         |
| 04-4     | 238.3                         |
| 04-5     | 241.9                         |
| 04-6     | 240.0                         |
| 04-7     | 239.8                         |
| 04-8     | 242.5                         |
| 04-9     | 242.2                         |
| 04-10    | 241.9                         |

| Location | Bedrock Surface Elevation (m) |
|----------|-------------------------------|
| 04-11    | 239.9                         |
| 04-12    | 239.4                         |
| 1        | 237.8                         |
| 3        | 236.2                         |
| 4        | 237.5                         |

The bedrock consists of granite gneiss with close to moderately spaced fractures. The apertures of the fractures were typically less than 0.5 mm. Several fractures were observed to be filled with mica. The coloring is typically grey with some pink zones. With the exception of 04-8 where a severely weathered vertical fracture was encountered, core recoveries were typically between 95 % and 100 % and rock quality designations (RQD) generally ranged from 63 % to 100 % indicating fractured to very sound conditions. It is noted that the RQD values for the boreholes drilled with portable equipment are low, which may be a reflection of the small core barrel diameter rather than the true quality of the rock mass. Detailed rock core descriptions are provided in the Rock Core Summary Table in Appendix 1.

Unconfined compressive strength testing was carried out on eleven samples of the recovered rock core. The results ranged from 97 MPa to 138 MPa with an average of 116 MPa.

#### 4.4 Groundwater

The water level in the backfill surrounding the culvert is controlled by the water levels in McKellar Lake and Manitouwabing Lake. The water level at the outlet of the culvert was surveyed on February 5, 2004. At that time the water level was found to be at elevation 240.77 m

Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated. In addition, it is understood that the water level in McKellar Lake is dam controlled, and therefore the water levels may be affected by the dam operations.



## 5.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions provided herein are based on information gathered at specific borehole locations and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions as well as the history of the site reflecting natural, construction and other activities. 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 AND ASSOCIATES LIMITED



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# FOUNDATION DESIGN REPORT

For

**McKellar Lake Culvert Replacement**  
**Township of McKellar, Ontario**  
**W.P. 5089-03-00**  
**Highway 124**  
**Huntsville Area Office**

## 6.0 DISCUSSION

### 6.1 PROPOSED DEVELOPMENT

The Ministry of Transportation (MTO) has identified the need for the replacement of the existing McKellar Lake Culvert as a result of sudden and excessive deflection noted in the surface of the Highway 124 pavement structure above the south end of the culvert in November 2003. The MTO implemented a detour to remove traffic from above the south end of the culvert. Concrete barriers were erected, shifting both traffic lanes to the north. In addition, the fill material directly above the south end of the culvert was removed to reduce the load on the CSPA culvert.

The proposed reconstruction will include removal of both the existing CSPA culvert and the old concrete/stone masonry bridge structure at the north (inlet) end. The proposed alignment of the new culvert will follow the same alignment as the existing CSPA culvert. The existing change in the horizontal alignment at the junction between the CSPA culvert and the concrete/stone masonry structure is to be removed.

Minor modifications to the embankment geometry on the south side are planned in order to accommodate a new sidewalk along the south side of the highway and to move the toe of the embankment closer to the highway. No changes to the profile or alignment of Highway 124 are proposed.

The proposed culvert replacement is indicated on Drawing No. ONO11711-1 in Appendix 2.

## Design Objectives:

The preliminary structural design has identified a 45.7 m concrete box culvert as the most suitable alternative for the new culvert. The opening of the box culvert is to be 5.0 m wide by 3.0 m high. Retaining walls will be constructed on both sides of the culvert at both the inlet and outlet. The invert elevation at the inlet and outlet have been defined as 241.2 m and 239.9 m, respectively. The base of the culvert will have a slope of 0.1%, with the exception of a section just south of the centreline of Highway 124. At this location, the culvert will drop 1.25 m over a length of 3.65 m in order to follow the existing profile over a ledge in the underlying bedrock.

Due to the presence of a fish spawning bed, no in-water work can be carried out between April 1 and May 31. Other environmental restrictions may also apply to the proposed work.

The site is within an area with a Mean Freezing Index of 1000 Degree Days (°C)(Canadian Foundation Engineering Manual). Using Figure 3.4 of the MTO Pavement Design Rehabilitation Manual, the Frost Penetration depth for this area is 1.8 m.

## **6.2 FOUNDATION ASSESSMENT**

Soil conditions vary along the length of the proposed structure. The critical features of the soils profile include:

- Shallow bedrock along the northern most 18 m.
- A depression within the bedrock profile infilled with loose to compact granular soils to approximately 3 m below the culvert invert along most of the southern half of the culvert length.
- Shallow bedrock at the southwest end of the culvert and beneath the proposed retaining wall west of the outlet.
- Groundwater levels slightly higher than the invert level of the culvert.

Some of the critical design considerations for the proposed work include the following:

- Traffic Staging: requires two lanes of traffic throughout duration of work. The limited work area and soil conditions suggest that excavation sideslopes will need to be supported. Given the shallow depth to rock and the presence of boulders in the existing fill materials, the most feasible shoring system will consist of soldier piles and lagging. H-piles placed in pre-drilled sockets will provide the lateral resistance required. A churn drill will be required to penetrate through the boulder fill and to create the rock socket.



- Erosion and piping control: it is postulated that the failure that occurred at this site was at least partially attributable to piping within the culvert backfill. The design must include means to reduce flow of water through the embankment fill or to include suitable filtering. In addition, protection from scour will be required for foundations.
- Construction Dewatering: the site will need to be isolated from flow during construction by installing upstream and downstream coffer dams. Even with the installation of coffer dams, it is anticipated that it will be very difficult to dewater the granular soils under the southern portion of the culvert.

### 6.3 Foundation Options

Based on the initial assessment and discussion with the Structural Consultant, the following basic features will be incorporated into the design:

- The culvert will be constructed as several structures isolated with joints. This will allow for a reduction in the effects of potential differential settlement.
- The northern section of the culvert will be an open box culvert with spread footing foundations placed directly on bedrock.
- Both inlet retaining walls and the retaining wall on the west side of the outlet will be constructed as separate structures. The retaining wall on the east side of the outlet is of limited length and will likely be constructed as a wing wall extending from the culvert.

The following design options have been considered for the southern portion of the culvert:

1. Open box culvert supported on H-Piles placed in rock sockets.
2. Open box culvert supported on rock socketed caissons.
3. Open box supported on Pipe-piles placed in rock sockets.
4. Open box supported on spread footings. All loose soils in subgrade removed and replaced with clearstone fill.
5. Closed box culvert. All loose soils in subgrade removed and replaced with clearstone fill.
6. Closed box culvert. All loose soils in subgrade removed and replaced with compacted fill.
7. Closed box culvert. Portion of loose soils in subgrade removed and replaced with clearstone fill pad to target of 1.0 m below bottom of culvert.
8. Closed box culvert supported on soils improved by Dynamic Compaction or Vibroflotation.

The advantages, disadvantages and relative cost of these eight alternatives were previously presented in a foundation design summary table, a copy of which is included in Appendix 4. Based on this assessment and discussions with the MTO and structural engineer, Alternative 5 (Closed box culvert. All loose soils in subgrade removed and replaced with clearstone fill) is the recommended foundation design alternative and will be discussed in detail in Section 7 of this report. Although this alternative was identified as somewhat more costly than Alternative 4 (Open box supported on spread footings - all loose soils in subgrade removed and replaced with clearstone fill), the closed box configuration has the advantage of preventing scour of the footings. The closed box type culvert was selected for the southern end of the culvert alignment for this reason.

## 7.0 RECOMMENDATIONS

### 7.1 Structure Foundations

#### 7.1.1 Shallow Foundations on Bedrock

The north portion of the culvert, including the retaining walls at the north end and the southwest retaining wall, will be founded directly on bedrock. The following maximum Geotechnical Resistance values for Limit States design are provided for spread footings founded directly on clean, level, non-weathered granite gneiss at this site:

#### Footings on Rock

| Footing Width | Footing Embedment Depth | Factored Geotechnical Resistance at ULS | Geotechnical Resistance at SLS |
|---------------|-------------------------|---|--------------------------------|
| 0.3 m minimum | 0.0 m                   | 20,000 kPa                              | 15,000 kPa                     |

The Geotechnical Resistance at Serviceability Limit States (SLS) is based on limiting settlement to 12 mm. In the case of spread footings founded on bedrock, the SLS resistance is governed by the influence of fractures within the rock mass (i.e. compression of open fractures or soil filled fractures). The ULS Resistance provided above is based on an empirical relationship between the spacing of discontinuities and the average unconfined compressive strength of the bedrock (Canadian Foundation Engineering Manual, 3<sup>rd</sup> Edition, Section 9.2). The Factored Geotechnical Resistance at Ultimate Limit States (ULS) is conservative and includes a resistance factor of 0.5.



### 7.1.2 Shallow Foundations on Soil

At the south end of the culvert, the depth to bedrock is up to 4 m below the invert elevation of the outlet. The soil consists of boulders and loose to compact sand, trace gravel, trace silt. These deposits are not considered suitable for support of the structure foundations. Beneath this end of the culvert the following site preparation is recommended:

- Remove all loose soil and boulders down to the bedrock surface.
- South of the subgrade transition, where necessary, excavate bedrock to 1.0 m below proposed footing invert to provide for a relatively uniform support.
- Backfill to 200 mm above the water level with crushed quarry source clear stone meeting the following gradation requirements:

| MTO Sieve Designation | % Passing By Mass |
|-----------------------|-------------------|
| 106 mm                | 100%              |
| 37.5 mm               | 0 to 75%          |
| 26.5 mm               | 0 to 5%           |

- Backfill with a minimum of 300 mm of compacted OPSS Granular A to underside of footing. A filter fabric (Class II non-woven geotextile) should be used to separate the Granular A from the clear stone.

For spread footings founded on OPSS Granular A over clear stone as described above, recommended maximum Geotechnical Resistance values for Limit States design are provided in the table below. The Ultimate Limit State (ULS) value is based on an angle of internal friction of 35° for the OPSS Granular A and includes a resistance factor of 0.5. The Serviceability Limit State (SLS) value is based on total settlement of 19 mm. Differential settlement is expected to be equal to total settlement due to the variations in depth to bedrock.

#### Footings on Granular A/Clearstone over Rock

| Footing Width | Footing Embedment Depth | Factored Geotechnical Resistance at ULS | Geotechnical Resistance at SLS |
|---------------|-------------------------|---|--------------------------------|
| 5620 mm       | 0.0 m                   | 485 kPa                                 | 300 kPa                        |

### 7.1.3 Shallow Foundations - General

The Reduction Factor to account for inclined loads will need to be applied in accordance with Section 6.7.4 of the Canadian Highway Bridge Design Code.

Construction joints should be included in the culvert structure at all locations where the bearing material beneath spread footings changes from bedrock to granular Fill.

Sliding resistance can be calculated using the following unfactored friction coefficients:

| <u>Condition</u>                      | <u>Unfactored Friction Coefficient</u> |
|---------------------------------------|--|
| Between Concrete and Granular A       | 0.61                                   |
| Between Concrete and Clean Sound Rock | 0.70                                   |

All foundation subgrade surfaces should be inspected in accordance with SP902S01.

## 7.2 Earth Pressure Design

To prevent hydrostatic pressure buildup, backfill against retaining structures should consist of free draining granular materials. OPSS Granular A or OPSS Granular B, Type II are recommended. The zone of granular backfill must be at least 0.9 m wide and be connected to a drainage system at the base of the retaining walls or culvert walls.

Earth pressures are provided below for different backslope conditions. In order to use the coefficients of pressure for a particular granular material, the granular backfill must be provided within a wedge extending from the base of the wall at 45 degrees (or smaller) to the horizontal. If a smaller wedge is used, the coefficients of earth pressure of the materials outside the backfill wedge must be used for lateral pressure design calculations.

For retaining walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied structures (e.g. walls of box culvert), the at-rest pressure should be used for design, unless the wall can deflect enough (approximately 0.05% of the wall height) to establish the active pressure.



Lateral earth pressures may be calculated using the following parameters:

| Parameters                              | OPSS Granular A | OPSS Granular B, Type II | Existing Embankment Fill |
|---|-----------------|--------------------------|--------------------------|
| Unit Weight (kN/m <sup>3</sup> )        | 22.0            | 22.0                     | 19.0                     |
| Angle of Internal Friction, $\phi$      | 35°             | 35°                      | 32°                      |
| <b>Horizontal Backslope</b>             |                 |                          |                          |
| Coeff. of Active Earth Pressure, $K_a$  | 0.27            | 0.27                     | 0.31                     |
| Coeff. of Passive Earth Pressure, $K_p$ | 3.69            | 3.69                     | 3.25                     |
| Coeff. of Earth Pressure at Rest, $K_o$ | 0.43            | 0.43                     | 0.47                     |
| <b>2H:1V backslope</b>                  |                 |                          |                          |
| Coeff. of Active Earth Pressure, $K_a$  | 0.39            | 0.39                     | 0.47                     |
| Coeff. of Passive Earth Pressure, $K_p$ | 10.82           | 10.82                    | 8.61                     |

### 7.3 Embankment Design

The existing embankment side slopes are generally at 1.5H:1V to 2.0H:1V. No signs of instability in the slopes were observed at the time of the field investigation work. Shallow bedrock is present beneath the embankment and the north side is founded directly on the shallow bedrock. Deep-seated failure is therefore not a concern. In addition, the embankment consists of granular fill including sand and rock fill. Stability of the embankment side slopes is acceptable based on the slope geometry observed and the composition of the embankment fill.

No detailed slope stability analysis was carried out and none is deemed necessary provided the embankment sideslopes are maintained no steeper than 2H:1V for embankments constructed of clean granular fill and no steeper than 1.25H:1V for slopes constructed of rock fill.

Reinstatement of the embankment above the new culvert structure shall be constructed in accordance with OPSS 206 and 501.

Settlement of the embankment is not a significant design issue since the embankment will be founded on bedrock. It is noted that there will be a minor amount of internal settlement of the embankment material (less than 25 mm). This settlement will occur very quickly and will likely be complete within a week of completion of the embankment.

## **8.0 CONSTRUCTION RECOMMENDATIONS**

### **8.1 Open Cut Excavations**

Earth excavation should be carried out in accordance with OPSS-206. Side slopes for open cut excavations should conform to the requirements of the edition of the Occupational Health and Safety Act and Regulations for Construction Projects current at the time of construction. In accordance with the present act, the existing embankment fill would be considered a Type 3 soil and temporary excavations deeper than 1.2 m should be made with side slopes no steeper than one horizontal to one vertical from the base of the excavation. The construction should be subject to time constraints such that temporary excavations are open for no longer than 10 calendar days. Flatter side slopes will be required for open cut excavations in loose sand deposits below the water line unless appropriate dewatering methods are employed.

Excavation side slopes should be protected from erosion and should be inspected regularly for signs of instability. Slopes should be flattened as required to maintain safe working conditions.

### **8.2 Supported Excavations – Shoring**

Shoring will be required to support the traffic lanes during excavation and construction of the adjacent stage of the new culvert structure.

Due to the shallow depth to bedrock, uneven bedrock surface and presence of boulders within the existing embankment fill, steel sheet-piles are not recommended. It is recommended that shoring consist of soldier piles and lagging. The soldier piles will need to be installed within pre-drilled holes in the underlying bedrock.

The lateral earth pressures provided in Section 7.2 may be used for the design of the shoring system. The surcharge load imposed by traffic should also be considered in the design.

It is anticipated that the soldier piles placed in pre-drilled holes in the bedrock will act in a cantilevered manner to provide the lateral resistance required (i.e. no tie-back anchors). The proposed staging will require construction of the shoring wall a short distance north of the high side of the rock ledge. Locating the pre-drilled holes in close proximity to the rock ledge will decrease the lateral resistance available. Therefore, it is recommended that the uppermost 1000 mm of the rock socket not be included in estimating the lateral resistance of the piles.

For design purposes, the unfactored lateral resistance of a pile concreted or grouted into bedrock may be calculated as follows:



$$R_u = 4.5 U_c D_s L^1 \text{ (unfactored)}$$

Where  $R_u$  = unfactored geotechnical lateral resistant, kN

$U_c$  = unconfined compressive strength of bedrock within depth interval of rock socket  
( $U_c = 116$  MPa is recommended for bedrock at this site), see Note below

$D_s$  = diameter of socket, m

$L^1$  = effective length of socket, m, being equal to total length below top of rock minus 1.0 m

Note: Where the unconfined compressive strength of the concrete or grout used to fix the H-pile into the rock socket is less than the unconfined compressive strength of the intact bedrock, the pile width should be substituted for  $D_s$  and the unconfined compressive strength of the concrete or grout should be used to determine the unfactored geotechnical lateral resistance.

It is noted that the minimum value of  $L^1$  recommended for this project is 1.0 m and therefore the minimum total socket length recommended is 2.0 m.

Sockets should be spaced at least six socket diameters apart.

It is recommended that a geotechnical resistance factor of 0.5 be used to calculate the factored geotechnical resistance at ULS for the temporary shoring.

### 8.3 Site Preparation

All overburden soil, loose and heavily weathered bedrock should be removed from areas where foundations are proposed to bear on bedrock. Based on the recovered rock core at the borehole locations, the surface of the bedrock is typically fresh to slightly weathered. Therefore, rock excavation required for site preparation is expected to be minimal (0 to 100 mm) except where rock excavation is required to reach the design grades.

Rock excavation to a depth of up to 500 mm may be required at selected located to reach design grades. Due to the shallow depth of bedrock excavation, it is recommended that excavation be carried out by mechanical rock breaking techniques such as line-drilling and hoe-ramming. Blasting is not recommended due to concerns regarding possible over-break beneath future foundations and due to environmental constraints associated with nearby fish habitat.

All vegetation, organic soil and any loose soil and boulders should be removed from beneath structural fill that will be placed for the support of structure foundations. In addition, some bedrock excavation may be required near the south end of the culvert to ensure that the thickness of clearstone/Granular A fill is at least 1.0 m beneath the entire length of the footings.

Inspection and certification of founding conditions should be in accordance with SP90S501.

## **8.4 Dewatering**

Cofferdams and a diversion pipe will be required to divert the creek flow during construction of the new culvert.

Dewatering should be provided such that construction can be carried out in dry conditions for construction of the northern section of the new culvert. The foundation options presented in this report for the south end of the new culvert will require partial dewatering. The water will need to be lowered so that concrete placement for the footings, walls and apron walls can be carried out in dry conditions. In addition, dewatering will be required to lower the water to below the top of the clear stone fill so that the overlying layer of OPSS Granular A can be placed and compacted.

It is expected that dewatering can be achieved using sump pumps provided an adequate seal is achieved at the cofferdams.

## **8.5 Erosion and Piping Control**

Slope protection and drainage measures will be required to ensure the long-term stability of the embankment slopes. Normal slope vegetation should be established as soon as possible after completion of the embankment in order to control surface erosion. Alternatively, protection in the form of rip-rap or gabion baskets should be provided.

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

The presence of the inlet end retaining walls, which will be founded on bedrock will help to minimize the flow of water through the culvert backfill material. In addition, it is recommended that where existing rockfill is exposed by the excavation for the culvert replacement, the surface of the existing rockfill should be rechecked and a Class II non-woven filter fabric be placed between the backfill material and the existing fills.

The risk of piping within the existing embankment material can be reduced by removing the outermost 1.0 m of the existing fill on the downstream side within 20 m of the culvert and replacing it with 300 mm nominal size rockfill over a Class II non-woven filter fabric. A sketch of this proposed treatment is provided in Appendix 5.



## 8.6 Frost Protection

The foundations for the north end of the culvert and retaining walls at the inlet will be founded on bedrock that is considered non frost-susceptible. The footings for the south end of the culvert are also founded on non-frost susceptible material (bedrock or clear stone). In addition, these foundations will be within the water and water flow is maintained year-round in the culvert. Therefore frost protection is not required in these areas.

The retaining wall at the east side of the culvert outlet will be constructed as a wing wall founded on the Granular A and clear stone. Although the Granular A and clear stone fill is not highly frost susceptible, the underside of the wing wall may extend above the water level and frost protection in the form of 50 mm of expanded polystyrene insulation should be placed beneath the grade beam.

## 8.7 Cement Type and Corrosion Potential

Three soil samples collected during the investigation were submitted to Paracel Laboratories Limited in Ottawa, Ontario, for analysis of resistivity, pH, soluble sulphate and soluble chloride. The test results are summarized in the table below.

| Borehole | Sample | Depth | Soluble Sulphate ( $\mu\text{g/g}$ ) | Resistivity (Ohm-m) | pH   | Soluble Chloride ( $\mu\text{g/g}$ ) |
|----------|--------|-------|--------------------------------------|---------------------|------|--------------------------------------|
| 04-2     | SS4    | 3.4 m | 15                                   | 270                 | 8.44 | 10                                   |
| 04-4     | SS4    | 3.4 m | 25                                   | 12                  | 5.30 | 590                                  |
| 04-5     | SS4    | 3.3 m | <5                                   | 11                  | 5.32 | 560                                  |

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000  $\mu\text{g/g}$  generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type 10 Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results are provided in the above table for use in the selection of coatings. In general, the results from the samples from Boreholes 04-4 and 04-5 indicate a severe degree of corrosiveness.

## 9.0 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 foundation investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction, and other activities. 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.

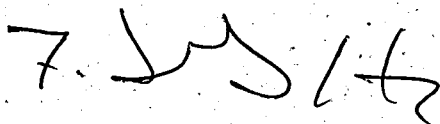
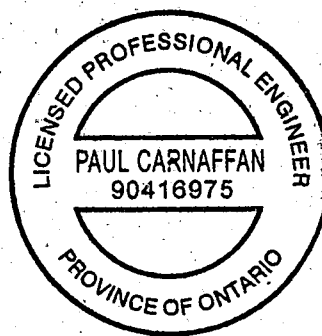
We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Yours very truly,

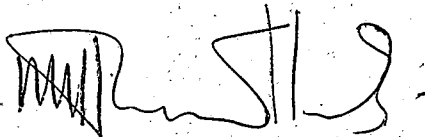
**JACQUES, WHITFORD AND ASSOCIATES LIMITED**



Paul Carnaffan, M.Eng., P.Eng.



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



J.G.A. Raymond Haché, M.Sc., P.Eng.  
Quality Control Auditor

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## 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.                       |

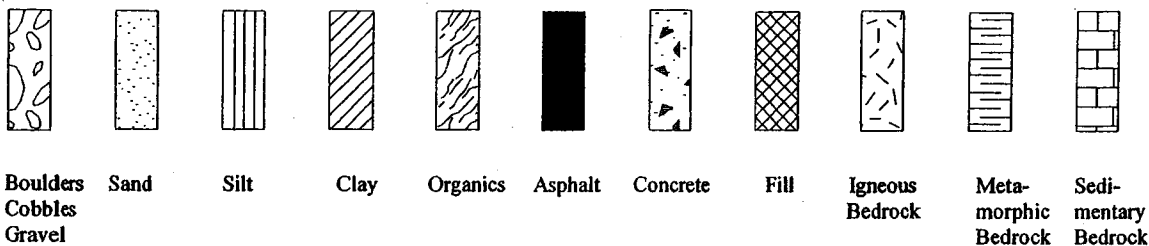


High

Weathering extends throughout rock mass. Rock is friable.

## STRATA PLOT

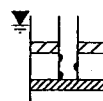
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



## 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 <sub>s</sub>  | Specific gravity of soil particles  | $\gamma$       | 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 <sub>u</sub> | Unconfined compression  |
|   |   | I <sub>p</sub> | Point Load Index (I <sub>p</sub> on Borehole Record equals I <sub>p</sub> (50); the index corrected to a reference diameter of 50 mm) |



RECORD OF BOREHOLE No BH 04-1

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040941.2 N 271947.7 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE HS Augers/Casing, Track-mounted CME 55 COMPILED BY PC  
DATUM Geodetic DATE 02.02.04 - 02.02.04 CHECKED BY FJG.

| SOIL PROFILE  |   |            | SAMPLES |      |             | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---|------------|---------|------|-------------|----------------------------|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES  |                            |                 | 20  | 40 | 60 | 80 | 100 |                                    |                                     |                                   |                     |   |
| 240.9         | Rock Fill   |            | 1       | NQ   | -           |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     | GR SA SI CL                                       |
| 240.7         | ROCK FILL   |            |         |      |             |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     | REC = 100%  |
| 0.3           | Sand, trace gravel, trace silt, loose, brown (FILL) |            |         |      |             |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 239.5         |   |            | 2       | SS   | 50/<br>30mm |                            | 240             |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 1.4           | BEDROCK   |            |         |      |             |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               | Granite Gneiss                                      |            |         |      |             |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               | Fractured to very sound                             |            | 3       | NQ   | -           |                            | 239             |   |    |    |    |     |                                    |                                     |                                   |                     | REC = 95%,<br>RQD = 67%                           |
|               |   |            |         |      |             |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |   |            | 4       | NQ   | -           |                            | 238             |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |   |            |         |      |             |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |   |            |         |      |             |                            | 237             |   |    |    |    |     |                                    |                                     |                                   |                     | REC = 99%,<br>RQD = 99%                           |
| 236.5         | End of Borehole                                     |            |         |      |             |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 4.4           |   |            |         |      |             |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |

RECORD OF BOREHOLE No BH 04-2

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040944.9 N 271948.5 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE HS Augers/Casing, Track-mounted CME 55 COMPILED BY PC  
DATUM Geodetic DATE 02.02.04 - 02.02.04 CHECKED BY FSG.

| SOIL PROFILE  |  | SAMPLES    |        |      | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br>γ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|--------|------|----------------------------|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER | TYPE | "N" VALUES                 |                 | 20  | 40 | 60 | 80 | 100 |                                    |                                     |                                   |                     |   |
| 241.0         | Grass  |            |        |      |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 0.0           | Sand, trace silt, loose, brown (FILL)                        |            |        |      |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 240.5         | Boulders and cobbles with sand (FILL)                        |            | 1      | NQ   | -                          | 240             |   |    |    |    |     |                                    |                                     |                                   |                     | REC = 74%   |
| 0.5           |  |            | 2      | NQ   | -                          |                 |   |    |    |    |     |                                    |                                     |                                   |                     | REC = 52%   |
| 239.0         | Sand, trace gravel, trace silt, loose to compact, brown, wet |            | 3      | SS   | 6                          | 239             |   |    |    |    |     |                                    |                                     |                                   |                     | 7 89 (4)  |
| 2.0           |  |            | 4      | SS   | 13                         | 238             |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 236.9         |  |            | 5      | SS   | 50/<br>100mm               | 237             |   |    |    |    |     |                                    |                                     |                                   |                     | REC = 94%,<br>RQD = 56%                           |
| 4.1           | BEDROCK  |            | 6      | NQ   | -                          |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               | Granite Gneiss   |            |        |      |                            | 236             |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               | Fractured to very sound                                      |            | 7      | NQ   | -                          | 235             |   |    |    |    |     |                                    |                                     |                                   |                     | REC = 97%,<br>RQD = 63%                           |
|               |  |            | 8      | NQ   | -                          | 234             |   |    |    |    |     |                                    |                                     |                                   |                     | REC = 100%,<br>RQD = 100%                         |
| 233.4         | End of Borehole  |            |        |      |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 7.6           |  |            |        |      |                            |                 |   |    |    |    |     |                                    |                                     |                                   |                     |   |

MTD 11711.GPJ ON MOT.GDT 12/05/04

RECORD OF BOREHOLE No BH 04-3

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040949.8 N 271937.7 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE HS Augers/Casing, Track-mounted CME 55 COMPILED BY PC  
DATUM Geodetic DATE 03.02.04 - 03.02.04 CHECKED BY FJG

| SOIL PROFILE  |   |            | SAMPLES |      |             | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |          | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|---|------------|---------|------|-------------|----------------------------|-----------------|---|--|--|--|----------|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES  |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |          |                                    |                                     |                                   |  |  |
|               |   |            |         |      |             |                            |                 | ○ UNCONFINED      × FIELD VANE              |  |  |  |          |                                    |                                     |                                   |  |  |
|               |   |            |         |      |             |                            |                 | ● QUICK TRIAXIAL      × LAB VANE            |  |  |  |          |                                    |                                     |                                   |  |  |
|               |   |            |         |      |             |                            | 20 40 60 80 100 |   |  |  |  | 10 20 30 |                                    |                                     |                                   |  |  |
|               |   |            |         |      |             |                            | 20 40 60 80 100 |   |  |  |  | 10 20 30 |                                    |                                     |                                   |  |  |
| 245.4         | Granular Shoulder   |            |         |      |             |                            | 245             |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 0.0           | Sand and gravel, trace silt, brown, frozen (FILL)           |            | 1       | SS   | 50/<br>50mm |                            |                 |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 244.2         |   |            | 2       | NQ   | -           |                            | 244             |   |  |  |  |          |                                    |                                     |                                   | REC = 100%                               |  |
| 1.1           | Boulders with sand (FILL)                                   |            | 3       | NQ   | -           |                            | 243             |   |  |  |  |          |                                    |                                     |                                   | REC = 87%                                |  |
| 242.8         |   |            | 4       | NQ   | -           |                            | 242             |   |  |  |  |          |                                    |                                     |                                   | REC = 63%                                |  |
| 242.6         | Sand, trace silt, brown (FILL)                              |            | 5       | SS   | 9           |                            | 241             |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 2.7           | Boulders with sand (FILL)                                   |            | 6       | SS   | 6           |                            | 240             |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 241.7         |   |            | 7       | SS   | 50/<br>80mm |                            |                 |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 3.7           | Sand, trace gravel, trace silt, loose, brown to grey (FILL) |            | 8       | NQ   | -           |                            | 239             |   |  |  |  |          |                                    |                                     |                                   | REC = 75%                                |  |
| 239.5         |   |            | 9       | NQ   | -           |                            | 238             |   |  |  |  |          |                                    |                                     |                                   | REC = 25%                                |  |
| 5.8           | Sand with cobbles, some boulders, grey (FILL)               |            | 10      | SS   | 19          |                            | 237             |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 237.7         |   |            | 11      | SS   | 50/<br>80mm |                            |                 |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 7.6           | Sand, trace gravel, trace silt, compact, grey, wet          |            | 12      | NQ   | -           |                            |                 |   |  |  |  |          |                                    |                                     |                                   | REC = 62%                                |  |
| 237.1         |   |            | 13      | NQ   | -           |                            |                 |   |  |  |  |          |                                    |                                     |                                   | REC = 88%                                |  |
| 8.2           | Boulders with sand  |            | 14      | NQ   | -           |                            | 236             |   |  |  |  |          |                                    |                                     |                                   | REC = 100%                               |  |
| 236.0         |   |            | 15      | NQ   | -           |                            | 235             |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 9.3           | BEDROCK   |            | 16      | NQ   | -           |                            | 234             |   |  |  |  |          |                                    |                                     |                                   |  |  |
|               | Granite Gneiss  |            |         |      |             |                            |                 |   |  |  |  |          |                                    |                                     |                                   | REC = 98%,<br>RQD = 75%                  |  |
|               | Fractured to sound  |            |         |      |             |                            |                 |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 233.1         |   |            |         |      |             |                            |                 |   |  |  |  |          |                                    |                                     |                                   |  |  |
| 12.2          | End of Borehole   |            |         |      |             |                            |                 |   |  |  |  |          |                                    |                                     |                                   | REC = 100%,<br>RQD = 90%                 |  |

MTD 11711.GPJ ON MOT.GDT 12/05/04

RECORD OF BOREHOLE No BH 04-4

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040959.9 N 271938.1 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE HS Augers/Casing, Track-mounted CME 55 COMPILED BY PC  
DATUM Geodetic DATE 04.02.04 - 04.02.04 CHECKED BY FSG

| SOIL PROFILE  |                                       |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION<br>SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                 |          | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br>γ    | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---------------------------------------|------------|---------|------|------------|----------------------------|--------------------|---|-----------------|----------|------------------------------------|-------------------------------------|-----------------------------------|------------------------|---|
| ELEV<br>DEPTH | DESCRIPTION                           | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                    | SHEAR STRENGTH kPa                          |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            |         |      |            |                            | 20 40 60 80 100    | 20 40 60 80 100                             | 20 40 60 80 100 | 10 20 30 |                                    |                                     | kN/m <sup>3</sup>                 | GR SA SI CL            |   |
| 245.4         | 80 mm ASPHALT                         |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
| 244.9         | 150 mm SAND and GRAVEL, trace silt    |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
| 244.2         | Sand, trace gravel, trace silt (FILL) |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               | - frozen to 1.2 m                     |            | 1       | SS   | 50/80mm    |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               | - very loose                          |            | 2       | SS   | 1          |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               | - becomes compact to dense            |            | 3       | SS   | 18         |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            | 4       | SS   | 21         |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            | 5       | SS   | 41         |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            | 6       | SS   | 25         |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            | 7       | SS   | 40         |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
| 239.5         |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
| 5.9           | Boulders and sand (FILL)              |            | 8       | SS   | 50/80mm    |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            | 9       | NQ   | -          |                            |                    |   |                 |          |                                    |                                     |                                   | REC = 100%             |   |
| 238.3         |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
| 7.1           | BEDROCK                               |            | 10      | NQ   | -          |                            |                    |   |                 |          |                                    |                                     |                                   | REC = 100%, RQD = 100% |   |
|               | Granite Gneiss                        |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               | Very Sound                            |            | 11      | NQ   | -          |                            |                    |   |                 |          |                                    |                                     |                                   | REC = 98%, RQD = 98%   |   |
|               |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
|               |                                       |            | 12      | NQ   | -          |                            |                    |   |                 |          |                                    |                                     |                                   | REC = 100%, RQD = 100% |   |
| 234.6         |                                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |
| 10.8          | End of Borehole                       |            |         |      |            |                            |                    |   |                 |          |                                    |                                     |                                   |                        |   |



MTD 11711.GPJ ON MOT.GDT 12/05/04

RECORD OF BOREHOLE No BH 04-5

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040972.2 N 271951.4 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE HS Augers/Casing, Track-mounted CME 55 COMPILED BY PC  
DATUM Geodetic DATE 05.02.04 - 05.02.04 CHECKED BY PJA.

| SOIL PROFILE  |  |  | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |  | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |
|---------------|--|--|---------|------|---------------|----------------------------|-----------------|---|--|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION                                  | STRAT PLOT   | NUMBER  | TYPE | "N" VALUES    |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |  |                                    |                                     |                                   |  |  |
| 245.6         | 80 mm ASPHALT                                |   |         |      |               |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 245.0         | Sand, trace gravel, trace silt, brown (FILL) |  | 1       | SS   | 50/<br>50mm   |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
|               | - frozen to 1.2 m                            |  | 2       | SS   | 34            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
|               |  |  | 3       | SS   | 15            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
|               |  |  | 4       | SS   | 20            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 241.9         | BEDROCK                                      |  | 5       | SS   | 100/<br>130mm |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 3.8           | Granite Gneiss                               |  | 6       | NQ   | -             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
|               | Sound to Very Sound                          |  | 7       | NQ   | -             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
|               |  |  | 8       | NQ   | -             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 238.0         | End of Borehole                              |  |         |      |               |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 7.6           |  |  |         |      |               |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |

RECORD OF BOREHOLE No BH 04-6

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040940.8 N 271939.6 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE Casing, portable electric core drill COMPILED BY IC  
DATUM Geodetic DATE 17.02.04 - 18.02.04 CHECKED BY FSG

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |  | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br>γ       | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |                                 |  |  |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|---------------------------|---|---------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |  |                                    |                                     |                                   |                           |   | WATER CONTENT (%)               |  |  |
|               |  |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |  |  |  |                                    |                                     |                                   |                           |   | w <sub>p</sub> w w <sub>L</sub> |  |  |
| 240.4         | Rock Fill  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                                 |  |  |
| 0.0           | Sand and gravel, trace silt,<br>occasional cobbles, wet (FILL) |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                                 |  |  |
| 240.0         |  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                                 |  |  |
| 0.4           | BEDROCK  |            | 1       | RC   | -          |                            | 240             |   |  |  |  |  |                                    |                                     |                                   | REC = 100%,<br>RQD = 0%   |   |                                 |  |  |
|               | Granite Gneiss   |            | 2       | RC   | -          |                            |                 |   |  |  |  |  |                                    |                                     |                                   | REC = 100%,<br>RQD = 100% |   |                                 |  |  |
|               | Sound  |            | 3       | RC   | -          |                            | 239             |   |  |  |  |  |                                    |                                     |                                   | REC = 100%,<br>RQD = 92%  |   |                                 |  |  |
|               |  |            | 4       | RC   | -          |                            |                 |   |  |  |  |  |                                    |                                     |                                   | REC = 92%,<br>RQD = 92%   |   |                                 |  |  |
| 238.5         |  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                                 |  |  |
| 2.0           | End of Borehole  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                                 |  |  |

RECORD OF BOREHOLE No BH 04-7

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040969.1 N 271940.7 E ORIGINATED BY TF  
 DIST 52 HWY 124 BOREHOLE TYPE HS Augers/Casing, Truck-mounted CME 75 COMPILED BY PC  
 DATUM Geodetic DATE 17.02.04 - 17.02.04 CHECKED BY FJG

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION<br>SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br>γ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|---------|------|------------|----------------------------|--------------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                    | 20  | 40 | 60 | 80 | 100 |                                    |                                     |                                   |                     |   |
| 245.5         |  |            |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 244.9<br>0.1  | 100 mm ASPHALT<br>Sand and gravel, trace silt, brown,<br>frozen (FILL) |            |         |      |            |                            | 245                |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 244.6<br>0.9  | Boulder  |            | 1       | NQ   | -          |                            | 244                |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 243.7<br>1.8  | Sand and gravel, trace silt,<br>occasional boulders (FILL)             |            |         |      |            |                            | 243                |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |  |            |         |      |            |                            | 242                |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |  |            |         |      |            |                            | 241                |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |  |            |         |      |            |                            | 240                |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 239.8<br>5.7  | BEDROCK<br>Granite Gneiss<br>Very Sound                                |            | 2       | SS   | 50/        |                            | 239                |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |  |            | 3       | NQ   | 30mm       |                            | 238                |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |  |            | 4       | NQ   | -          |                            | 237                |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |  |            | 5       | NQ   | -          |                            |                    |   |    |    |    |     |                                    |                                     |                                   |                     |   |
|               |  |            | 6       | NQ   | -          |                            |                    |   |    |    |    |     |                                    |                                     |                                   |                     |   |
| 236.1<br>9.3  | End of Borehole  |            |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |                     |   |

MTD 11711.GPJ ON MOT.GDT 12/05/04

RECORD OF BOREHOLE No BH 04-8

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040987.3 N 271954.5 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE HS Augers/Casing, Truck-mounted CME 75 COMPILED BY PC  
DATUM Geodetic DATE 17.02.04 - 30.12.99 CHECKED BY FSG.

| SOIL PROFILE  |   |            | SAMPLES |      |             | GROUND WATER<br>CONDITIONS | ELEVATION SCALE  | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |            |    |     |    | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br>γ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---|------------|---------|------|-------------|----------------------------|------------------|---|------------|----|-----|----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES  |                            |                  | SHEAR STRENGTH kPa                          |            |    |     |    |                                    |                                     |                                   |                     |   |
|               |   |            |         |      |             |                            | 20               | 40  | 60         | 80 | 100 |    |                                    |                                     |                                   |                     |   |
|               |   |            |         |      |             |                            | ○ UNCONFINED     | ×   | FIELD VANE |    |     |    |                                    |                                     |                                   |                     |   |
|               |   |            |         |      |             |                            | ● QUICK TRIAXIAL | ×   | LAB VANE   |    |     |    |                                    |                                     |                                   |                     |   |
|               |   |            |         |      |             |                            | 20               | 40  | 60         | 80 | 100 |    |                                    |                                     |                                   |                     |   |
|               |   |            |         |      |             |                            |                  |   |            |    |     | 10 | 20                                 | 30                                  |                                   |                     |   |
| 245.8         |   |            |         |      |             |                            |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 245.0         | 100 mm ASPHALT  |            |         |      |             |                            |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 245.0         | Sand and gravel (crushed), trace silt, grey (FILL)                            |            |         |      |             |                            |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 245.0         | Sand, some gravel, occasional boulders (FILL)                                 |            |         |      |             |                            |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 244.3         |   |            | 1       | SS   | 50/<br>30mm | 245                        |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 244.3         |   |            | 2       | SS   | 20          | 244                        |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 244.3         | Sand and gravel, some clay, occasional wood pieces, brown to dark grey (FILL) |            | 3       | SS   | 9           | 243                        |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 242.5         |   |            | 4       | SS   | 50/<br>30mm | 242                        |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 242.5         | BEDROCK   |            | 5       | NQ   | -           | 241                        |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 242.5         | Granite Gneiss  |            | 6       | NQ   | -           | 240                        |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 239.5         |   |            |         |      |             |                            |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |
| 239.5         | End of Borehole   |            |         |      |             |                            |                  |   |            |    |     |    |                                    |                                     |                                   |                     |   |



RECORD OF BOREHOLE No BH 04-10

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040991.2 N 271947.0 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE Elevation of exposed bedrock COMPILED BY JL  
DATUM Geodetic DATE 20.02.04 - 20.02.04 CHECKED BY FJG.

| SOIL PROFILE  |                            |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |     |       | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|----------------------------|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|---|-----|-------|---|--|
| ELEV<br>DEPTH | DESCRIPTION                | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20  | 40 | 60 | 80 | 100 | $w_p$   | $w$ | $w_L$ |   |  |
| 241.9<br>0.0  | Exposed Bedrock at Surface |            |         |      |            |                            |                 |   |    |    |    |     |   |     |       |   |  |
|               |                            |            |         |      |            |                            | 241             |   |    |    |    |     |   |     |       |   |  |

MT0 11711.GPJ ON MOT.GDT 12/05/04

RECORD OF BOREHOLE No BH 04-11

1 OF 1

METRIC

W.P. 5089-03-00 LOCATION 5040939.9 N 271935.3 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE Casing, portable electric core drill COMPILED BY PC  
DATUM Geodetic DATE 18.02.04 - 18.02.04 CHECKED BY FJG.

| SOIL PROFILE  |                                   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|-----------------------------------|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|--|---|
| ELEV<br>DEPTH | DESCRIPTION                       | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20  | 40 | 60 | 80 | 100 |                                    |                                     |                                   |  |   |
| 241.9         | Rock Fill                         |            |         |      |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  |   |
| 0.0           | Boulders (FILL)                   |            | 1       | RC   | -          |                            | 241             |   |    |    |    |     |                                    |                                     |                                   |  | REC = 56%   |
|               |                                   |            | 2       | RC   | -          |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  | REC = 78%   |
| 240.3         |                                   |            |         |      |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  |   |
| 1.6           | Sand and gravel, some silt (FILL) |            |         |      |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  |   |
| 239.9         |                                   |            |         |      |            |                            | 240             |   |    |    |    |     |                                    |                                     |                                   |  |   |
| 2.0           | BEDROCK                           |            |         |      |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  |   |
|               | Granite Gneiss                    |            | 3       | RC   | -          |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  | REC = 100%,<br>RQD = 100%                         |
|               | Very Sound                        |            | 4       | RC   | -          |                            | 239             |   |    |    |    |     |                                    |                                     |                                   |  | REC = 100%,<br>RQD = 100%                         |
| 238.4         |                                   |            |         |      |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  |   |
| 3.5           | End of Borehole                   |            |         |      |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  |   |

RECORD OF BOREHOLE No BH 04-12

1 OF 1

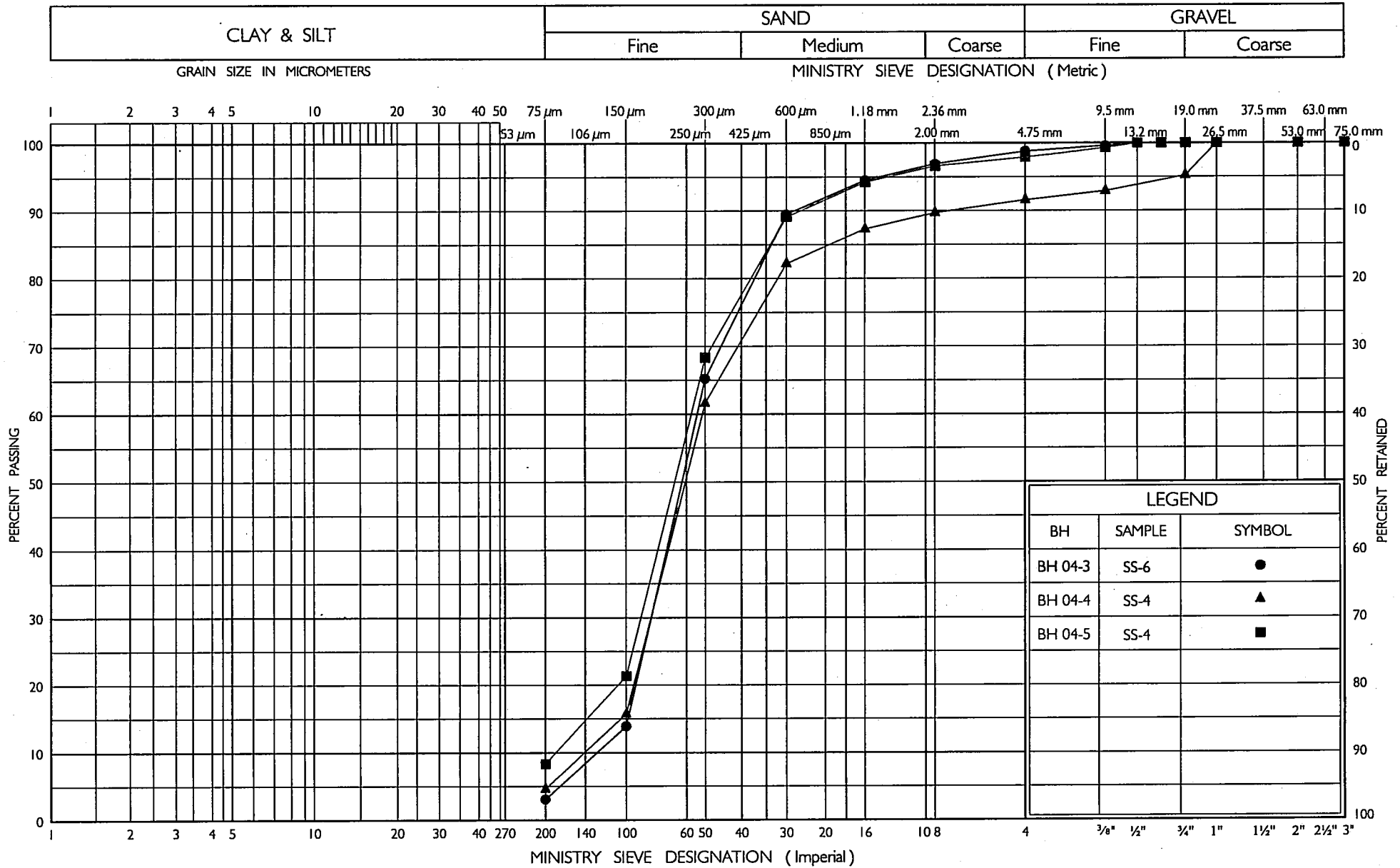
METRIC

W.P. 5089-03-00 LOCATION 5040941.3 N 271944.7 E ORIGINATED BY JF  
DIST 52 HWY 124 BOREHOLE TYPE Casing, portable electric core drill COMPILED BY PC  
DATUM Geodetic DATE 16.02.04 - 17.02.04 CHECKED BY FJG

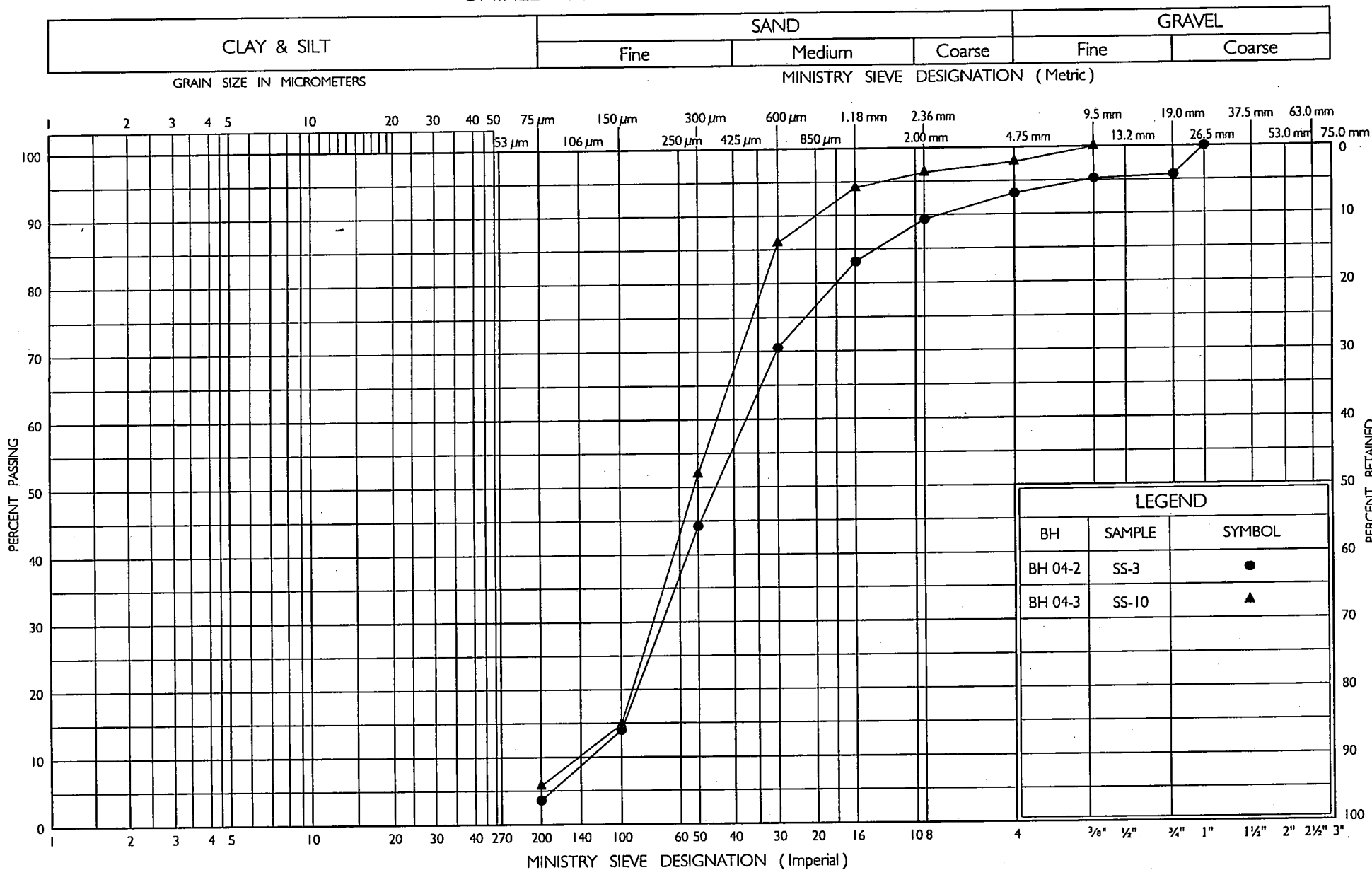
| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |  | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br>γ       | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |                   |  |  |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|---------------------------|---|-------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION                                | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |  |                                    |                                     |                                   |                           |   | WATER CONTENT (%) |  |  |
|               |  |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |  |  |  |                                    |                                     |                                   |                           |   | 10 20 30          |  |  |
|               |  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                   |  |  |
| 240.5         | Rock Fill                                  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                   |  |  |
| 0.0           | Boulders (FILL)                            |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                   |  |  |
| 240.3         |  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                   |  |  |
| 0.3           | Sand and gravel, occasional cobbles (FILL) |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                   |  |  |
| 239.4         |  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                   |  |  |
| 1.1           | BEDROCK                                    |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                   |  |  |
|               | Granite Gneiss                             |            | 1       | RC   | -          |                            |                 |   |  |  |  |  |                                    |                                     |                                   | REC = 86%,<br>RQD = 0%    |   |                   |  |  |
|               |  |            | 2       | RC   | -          |                            |                 |   |  |  |  |  |                                    |                                     |                                   | REC = 100%,<br>RQD = 77%  |   |                   |  |  |
|               |  |            | 3       | RC   | -          |                            |                 |   |  |  |  |  |                                    |                                     |                                   | REC = 94%,<br>RQD = 44%   |   |                   |  |  |
| 237.9         |  |            | 4       | RC   | -          |                            |                 |   |  |  |  |  |                                    |                                     |                                   | REC = 100%,<br>RQD = 100% |   |                   |  |  |
| 2.7           | End of Borehole                            |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |                           |   |                   |  |  |

MT0 11711.GPJ ON MOT.GDT 12/05/04

# UNIFIED SOIL CLASSIFICATION SYSTEM



# UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
SAND, TRACE GRAVEL, TRACE SILT

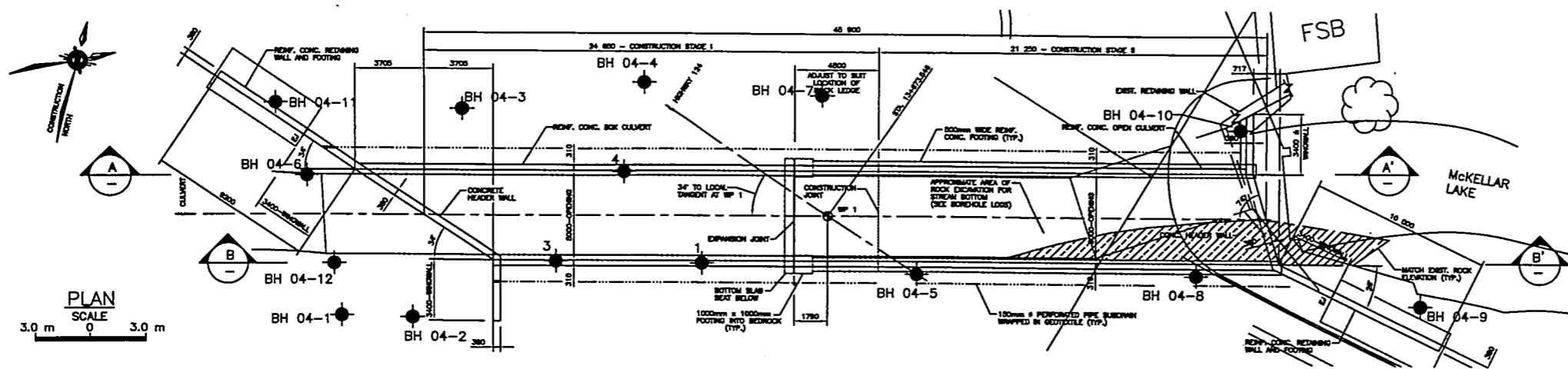
FIG No 2  
WP 5089-03-00

**Rock Core Description**  
**W.P. 5089-03-00**

| Borehole # | Rock Core # | Recovery (%) | R.Q.D. (%) | Description   |
|------------|-------------|--------------|------------|---|
| BH 04-1    | 3           | 95           | 67         | GRANITE GNEISS, grey, slightly weathered; close to moderately spaced fractures: planar, rough, clean                    |
|            | 4           | 99           | 99         |   |
| BH 04-2    | 6           | 94           | 56         | GRANITE GNEISS, grey to pink, slightly weathered; closely spaced fractures: planar to stepped, rough, very thin bedding |
|            | 7           | 97           | 63         |   |
|            | 8           | 100          | 100        | GRANITE GNEISS, grey to pink, fresh rock; moderately spaced fractures: horizontal, rough, clean                         |
| BH 04-3    | 15          | 98           | 75         | GRANITE GNEISS, grey, slightly weathered; closely spaced fractures: planar, rough, clean                                |
|            | 16          | 100          | 90         |   |
| BH 04-4    | 10          | 100          | 100        | GRANITE GNEISS, grey, fresh rock; close to moderately spaced fractures: horizontal, rough, clean                        |
|            | 11          | 98           | 98         |   |
|            | 12          | 100          | 100        |   |
| BH 04-5    | 6           | 100          | 81         | GRANITE GNEISS, grey, slightly weathered; close to moderately spaced fractures: planar, rough, very thin bedding        |
|            | 7           | 98           | 98         |   |
|            | 8           | 97           | 97         | GRANITE GNEISS, grey, fresh stained; moderately spaced fractures: planar, rough, clean                                  |
| BH 04-6    | 1           | 100          | 0*         | GRANITE GNEISS, grey, fresh rock; closely spaced fractures: horizontal to planar, rough, clean                          |
|            | 2           | 100          | 100        |   |
|            | 3           | 100          | 92         |   |
|            | 4           | 92           | 92         |   |
| BH 04-7    | 4           | 100          | 100        | GRANITE GNEISS, grey, fresh stained; moderately spaced fractures: horizontal, rough, clean                              |
|            | 5           | 100          | 100        |   |
|            | 6           | 100          | 100        |   |
| BH 04-8    | 5           | 93           | 0          | GRANITE GNEISS, grey to pink, highly weathered; closely spaced fractures: planar, rough, very thin bedding              |
|            | 6           | 100          | 30         |   |
| BH 04-9    | 4           | 100          | 90         | GRANITE GNEISS, grey, fresh rock; close to moderately spaced fractures: horizontal, rough, clean                        |
| BH 04-11   | 3           | 100          | 100        | GRANITE GNEISS, grey, fresh rock; close to moderately spaced fractures: planar, rough, clean                            |
|            | 4           | 100          | 100        |   |
| BH 04-12   | 1           | 86           | 0*         | GRANITE GNEISS, grey to pink, fresh rock; closely spaced fractures: horizontal, rough, clean                            |
|            | 2           | 100          | 77         |   |
|            | 3           | 94           | 44*        |   |
|            | 4           | 100          | 100        |   |

\*RQD values affected by portable drilling techniques and are not necessarily reflective of rock quality.





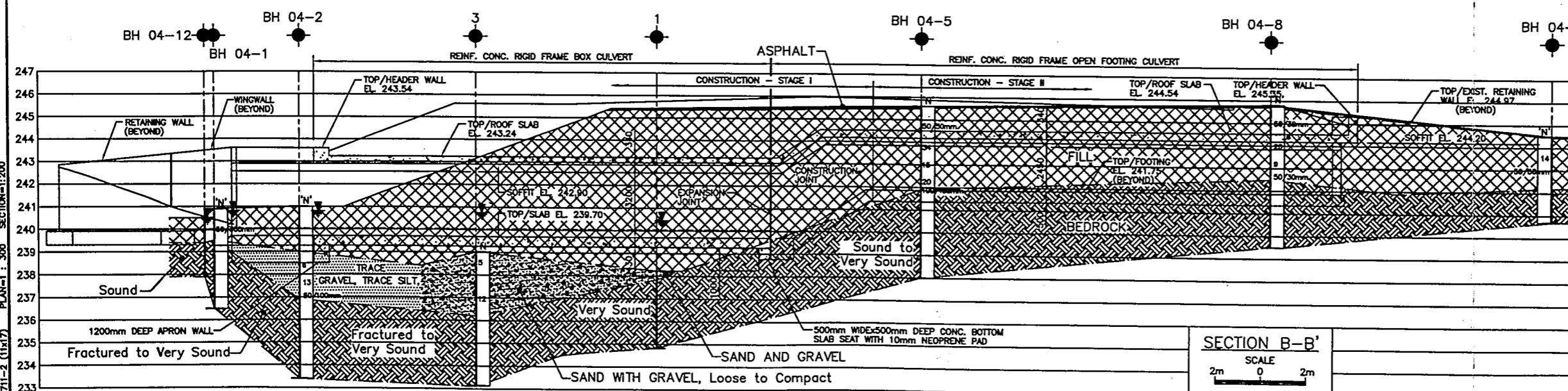
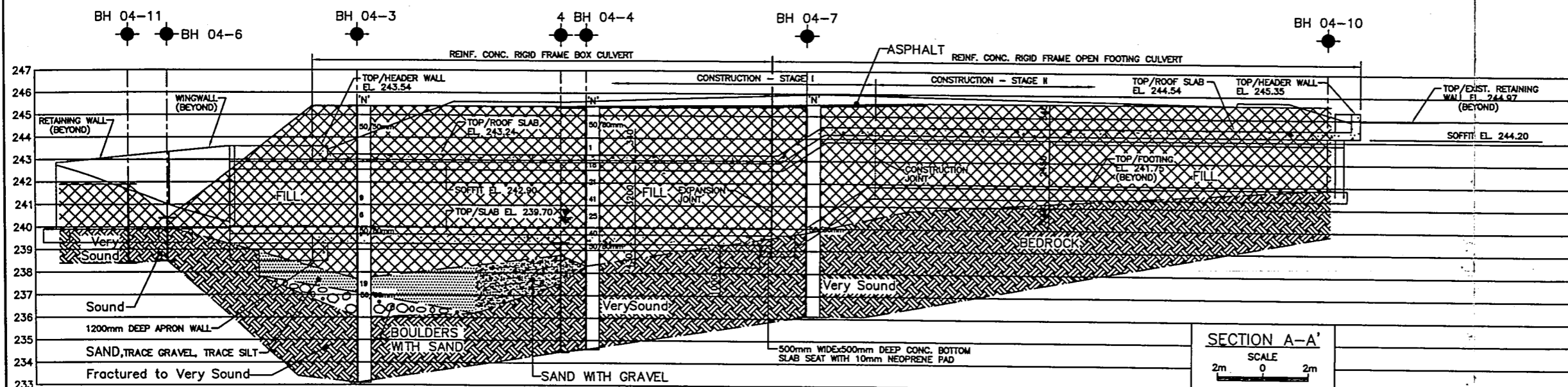
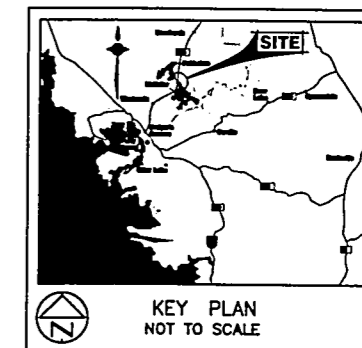
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

GEOCRE No 31E-202  
CONT No 2003-5654  
WP No 5089-03-00  
MCKELLAR LAKE CULVERT  
MCKELLAR TOWNSHIP  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

JACQUES, WHITFORD AND ASSOCIATES LIMITED



- LEGEND**
- Bore Hole
  - ⊕ Dynamic Cone Penetration Test (Cone)
  - ⊙ Bore Hole & Cone
  - ⊖ Probe Hole
  - 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
  - CONE Blows/0.3m (60' Cone, 475 J/blow)
  - W. at time of investigation

| BORE HOLES |           |                   |                  |  |
|------------|-----------|-------------------|------------------|--|
| No         | ELEVATION | COORDINATES NORTH | COORDINATES EAST |  |
| 04-1       | 240.9     | 5 040 941.2       | 271 947.7        |  |
| 04-2       | 241.0     | 5 040 944.9       | 271 948.5        |  |
| 04-3       | 245.4     | 5 040 949.8       | 271 937.7        |  |
| 04-4       | 245.4     | 5 040 959.9       | 271 938.1        |  |
| 04-5       | 245.6     | 5 040 972.2       | 271 951.4        |  |
| 04-6       | 240.4     | 5 040 940.8       | 271 939.6        |  |
| 04-7       | 245.5     | 5 040 969.1       | 271 940.7        |  |
| 04-8       | 245.8     | 5 040 987.3       | 271 954.5        |  |
| 04-9       | 244.5     | 5 040 999.0       | 271 958.4        |  |
| 04-10      | 241.9     | 5 040 991.2       | 271 947.0        |  |
| 04-11      | 241.9     | 5 040 939.9       | 271 935.3        |  |
| 04-12      | 240.5     | 5 040 941.3       | 271 944.7        |  |
|            | 238.2     | 5 040 961.0       | 271 948.6        |  |
|            | 240.2     | 5 040 953.1       | 271 946.9        |  |
|            | 239.0     | 5 040 957.8       | 271 942.8        |  |

**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.

| DATE              | BY              | DESCRIPTION |
|-------------------|-----------------|-------------|
|                   |                 |             |
| GEOCRE No         |                 |             |
| WP No 124         |                 | DIST        |
| SUBMIT PC CHECKED | DATE 2004-05-21 | SITE 44-374 |
| DRAWN GBB CHECKED | DATE            | DWG 2       |

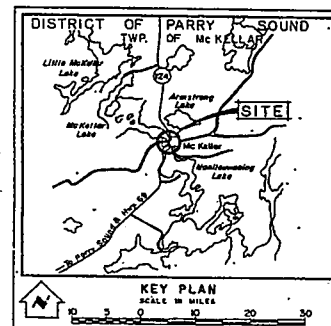
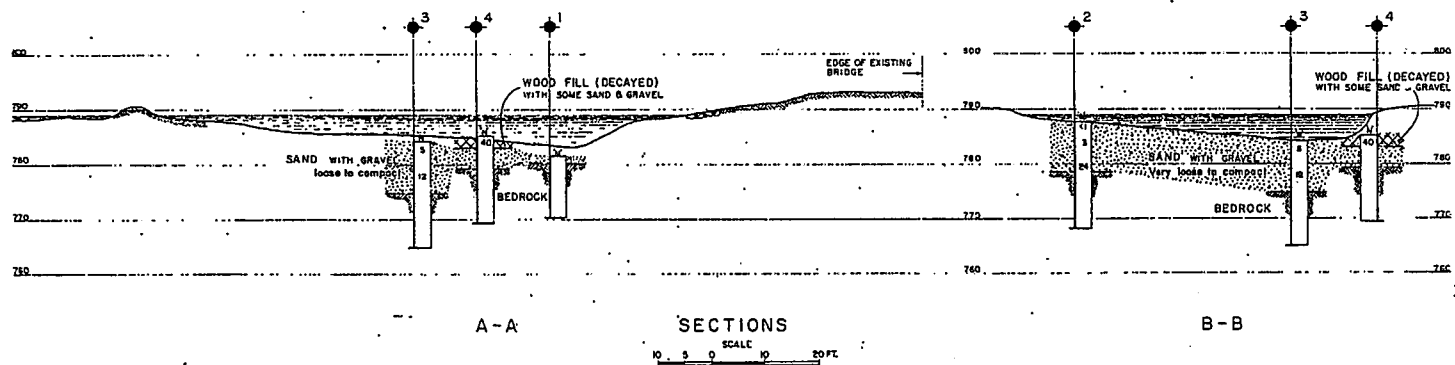
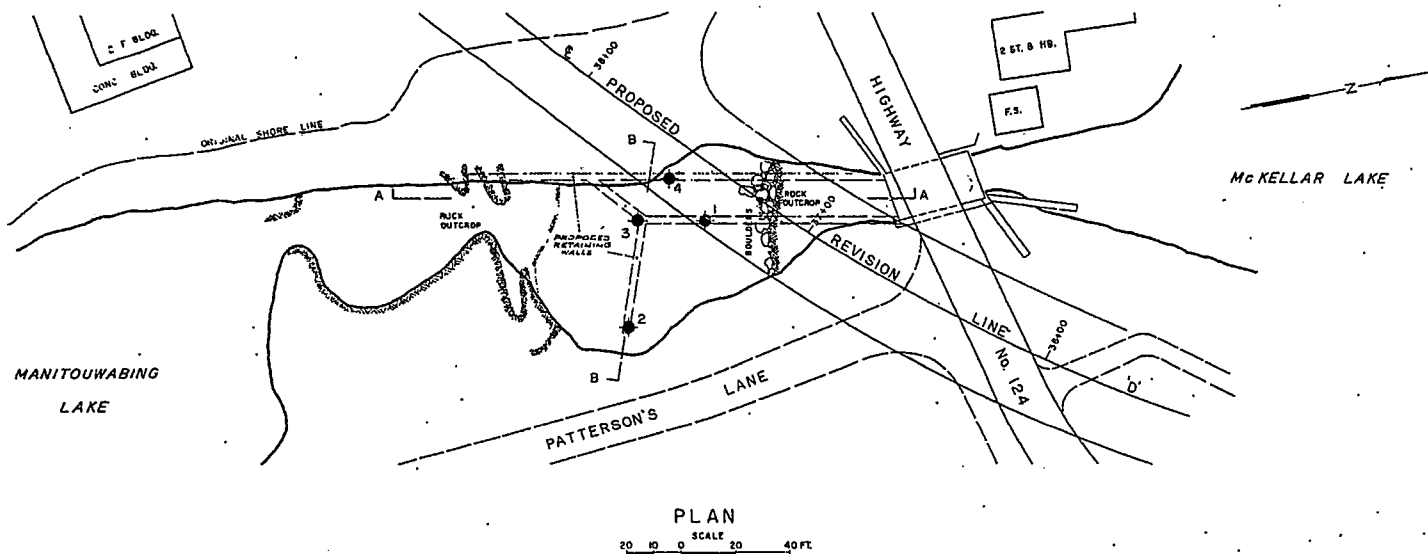
#69-F-204C





W.P. 203-65

HWY #24, LINE 'D'

REVISION

McKELLAR LAKE OUTLET



| LEGEND  |  |  |  |
|---|--|--|--|
|  | Bore Hole  |  |  |
|  | Cone Penetration Hole  |  |  |
|  | Bore & Cone Penetration Hole                                       |  |  |
|  | Water Levels established at time of field investigation, OCT. 1959 |  |  |

**- NOTE -**

The boundaries, as well as the bore holes 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 & TESTING OFFICE - FOUNDATION SECTION

Mc KELLAR LAKE OUTLET

KING'S HIGHWAY NO. 124 LINE D REV'N DIST. NO. 11  
DISTRICT OF PARRY SOUND  
TWP. Mc KELLAR LOT 20 CON. B

| BORE HOLE LOCATIONS & SOIL STRATA |  |  |  |  |  |
|-----------------------------------|--|--|--|--|--|
|                                   |  |  |  |  |  |

|                             |                |           |                    |                               |
|-----------------------------|----------------|-----------|--------------------|-------------------------------|
| DESIGNER'S P.O.M.           | CHECKED P.O.M. | SEA. NO.  | 203 - 63           | DRAWING NO.<br><b>T9261-1</b> |
| DRAWN A.E.L.                | CHECKED P.O.M. | JOB NO.   |                    |                               |
| DATE OCT. 24, 1969          |                | SITE NO.  |                    |                               |
| APPROVED <i>W. J. Jones</i> |                | CONT. NO. |                    |                               |
|                             |                |           | BRIDGE DRAWING NO. |                               |

MEMORANDUM

To: Mr. B. R. Davis,  
Bridge Engineer,  
Bridge Office,  
Admin. Bldg.

FROM: Foundation Section,  
Materials & Testing Office,  
Room 107, Lab. Bldg.

ATTENTION: Mr. S. McCombie

DATE: October 30, 1969

OUR FILE REF.

IN REPLY TO

OCT 30 1969

SUBJECT:

FOUNDATION INVESTIGATION REPORT -  
By Geocon Ltd., Consulting Engrs.  
McKellar Lake Outlet - Hwy. #124  
W.P. 20-55 - Dist. #11 (Huntsville)

Attached please find the above mentioned report prepared and submitted by the Consultant, Geocon Ltd.

We have reviewed the report and believe it contains sufficient information for further design work.

We agree with the Consultant's recommendations that the entire structure be founded on bedrock. However, because of the depth of bedrock below the water table (up to 14 ft. at the time of investigation), difficulties in unwatering must be expected. Bedrock is granite, and we have reservations as to whether penetration of sheeting into the rock, in order to assure watertightness, could be achieved.

If piles are used, we would suggest that H-piles with reinforced tips be chosen and that they be driven reasonably hard once they have reached bedrock.

As far as retaining walls are concerned, a coefficient of earth pressure of 0.3 rather than 0.5, should be used.

Should you have any questions regarding the report, please feel free to contact this Office.

AGE/adeF

Attach.

cc: Messrs. B. R. Davis (2)  
H. A. Tregaskes  
D. W. Farren  
H. McArthur  
W. S. Aitken  
J. C. McAllister  
E. R. Saint  
B. A. Singh  
Foundations Files  
Gen. Files

*A. G. Stermac*  
A. G. Stermac  
PRINCIPAL FOUNDATION ENGINEER

69-F-2042

# GEOCON LTD

## HEAD OFFICE

420 MICHEL JASMIN, DORVAL, QUEBEC  
TELEPHONE 631-9827

## DISTRICT OFFICES

14 HAAS ROAD  
REXDALE, TORONTO, ONT.  
TEL. 743-3031

295 EAST 11TH AVENUE  
VANCOUVER 10, B.C.  
TEL. 879-2620

P.O. BOX 351  
FREDERICTON, N.B.  
TEL. 475-8967

Rexdale, Ontario  
October 7th, 1969

Department of Highways, Ontario  
Materials and Research Division,  
Downsview, Ontario.

Attention: Mr. A. G. Stermac, P.Eng.  
Principal Foundation Engineer.

Re: Soil Conditions and Foundations,  
McKellar Lake Outlet,  
McKellar Lake, Ontario.

Dear Sirs:

This letter accompanies our report on the above investigation.

We found that the site is underlain by a variable thickness of very loose to compact sand with gravel, through which bedrock frequently outcrops.

Based on the findings of this investigation the culvert and wing wall foundations should be carried on bedrock either directly or by such means as piers or end bearing piles. The choice of foundation will largely be decided on the basis of economics. A number of recommendations are given in the report covering design and construction.

We believe that this report contains all of the information required from this investigation. Should you have any questions regarding any aspect of the report or if we can

Department of Highways, Ontario  
October 27th, 1969  
Page 2.

---

be of assistance otherwise, please do not hesitate to call us.

Yours very truly,

GEOCON LTD



D. B. Oates, P.Eng.  
District Engineer

T 9261  
sb

T 9261  
REPORT  
TO  
DEPARTMENT OF HIGHWAYS, ONTARIO  
ON  
SOIL CONDITIONS AND FOUNDATIONS,  
McKELLAR LAKE OUTLET,  
McKELLAR LAKE                      ONTARIO.

Distribution:    11 copies - Department of Highways, Ontario  
   Downsview, Ontario.

2 copies - Geocon Ltd

**GEOCON**

# I N D E X

Page

## PART I

|     |                                      |   |
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| 3.0 | DISCUSSION . . . . .                 | 1 |
| 4.0 | PERSONNEL . . . . .                  | 6 |

## APPENDIX I

|     |                            |   |
|-----|----------------------------|---|
| 1.0 | PROCEDURE . . . . .        | 1 |
| 2.0 | FIELD EQUIPMENT . . . . .  | 2 |
| 3.0 | SITE AND GEOLOGY . . . . . | 2 |
| 4.0 | SOIL CONDITIONS . . . . .  | 3 |
| 5.0 | WATER CONDITIONS . . . . . | 4 |
| 6.0 | BEDROCK . . . . .          | 5 |

OFFICE REPORTS ON SOIL EXPLORATION

## APPENDIX II

FIGURES - LABORATORY TESTING

## APPENDIX III

PHOTOGRAPHS

DRAWING AT REAR OF REPORT.

**GEOCON**

## 1.0 INTRODUCTION

1.

Geocon Ltd has been retained by the Department of Highways, Ontario by letter of October 2nd, 1969 to carry out a foundation investigation for a proposed culvert at McKellar where Highway 124 crosses the McKellar Lake Outlet. The proposed culvert will extend south from an existing concrete and steel beam bridge.

The purpose of the investigation was to determine the soil conditions at the culvert site as required for foundation design.

## 2.0 SUMMARIZED SOIL CONDITIONS

A deposit of very loose to compact sand with gravel of an encountered thickness of up to about 9 feet is underlain by bedrock. Extensive bedrock outcrops occur to the north and south of the site. To the west of the proposed culvert location an area of wood fill exists.

## 3.0 DISCUSSION

### 3.1 General

It is understood from information obtained from Department of Highways, Ontario Plan No. B 1083-4 that the proposed culvert will be constructed as part of the Highway 124 Revision project and will be required to carry the natural drainage from McKellar Lake to Manitouwabing Lake under the new highway.

It is understood that the width of the culvert

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### 3.0 DISCUSSION - Continued

2.

#### 3.1 General - Continued

bay will be approximately the same as the span of the existing bridge and will form an extension to the existing bridge to the south. The axis of the proposed culvert is understood to lie at a slight angle to the west of existing bridge axis, running approximately parallel to the present west shoreline.

Two wing walls will be provided at the south east corners of the culvert, one parallel to the culvert axis and the other at approximately right angles. In addition the existing wing wall at the north east corner of the existing bridge will be replaced by a wing wall parallel to the culvert axis.

#### 3.2 Foundations

Bedrock outcrops at the north section of the culvert. This outcrop extends to about 50 feet south of the existing bridge and its elevation varies from about 794 to 789. Bedrock also outcrops approximately 140 feet to the south at an elevation of about 789. Photographs of the site and outcropping are in Appendix III.

The investigation indicates that very loose to compact sand with gravel overburden of a maximum encountered thickness of about 9 feet occurs between the two outcrops .

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## 3.2 Foundations - Continued

As located on Department of Highways, Ontario Plan No. B 1083-4 the culvert would be constructed on exposed bedrock over the section about 50 feet south of the existing bridge. The south west wing wall will also be partly located on exposed bedrock. Over the remainder of the culvert and south east wing wall site the bedrock was found to slope to a maximum encountered depth at about elevation 775 beneath the overburden.

It is understood from an internal memorandum dated September 10th, 1969 from the Bridge Planning Northern Region Office that consideration is being given to founding the culvert in part on bedrock with certain sections of the culvert and the wing walls supported on piles. In view of the variable and loose relative density of the existing overburden, where it occurs, we concur that the foundations for the culvert and wing walls should be supported on bedrock either directly or by means of end bearing piles. The final choice of foundation treatment will largely be dependent on economic considerations of construction, which are beyond the terms of this report. For spread foundations carried directly on bedrock a bearing pressure of 20 tons per square foot may be used. Where piles are used to support sections of the

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## 3.2 Foundations - Continued

structure, it is recommended that suitable pile tips be provided to facilitate keying of the piles on sloping bedrock surfaces. Pile caps where subject to frost action should be provided with at least five feet of earth cover for frost protection purposes.

## 3.3 Approach Embankments - Continued

It is understood that the grade of the approach embankments will be about 805 . Assuming that clean granular fill is used for embankment construction and that normal side slopes of 1 vertical to 2 horizontal are adopted, it is considered that the stability of the approach embankments will be adequate.

It is recommended however that the sawdust and wood fill be removed from beneath locations of the embankment to the west of the site . It is understood that this filled area extends to about 50 feet west of the existing shoreline as far north as the edge of the present highway.

It is recommended that the backfill to the culvert and wing walls consist of well compacted free draining non-frost susceptible granular material and that adequate provision be made for drainage of the backfill. In this event the walls of the

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## 3.2 Approach Embankments - Continued

culvert and wing walls should be designed for a lateral earth pressure coefficient of 0.5 with due allowance for surcharge.

The wing walls should incorporate a factor of safety of at least 1.5 against lateral sliding. Where founded directly on bedrock a coefficient of friction of 0.35 between concrete and bedrock would apply. Resistance to lateral sliding could be increased by dowels into bedrock acting in tension or shear.

## 3.3 Construction

With the culvert founded directly on bedrock, construction would involve excavation into the sand and gravel for a distance of 14 feet below observed river level. Some means therefore would be required to control water inflow. For this purpose close sheeting extending to bedrock could be used with pumping from sumps.

Alternatively, the pool could be drained by pumping and the excavations could be dewatered using a well point system in conjunction with dykes to control the inflow of water from McKellar Lake and Manitouwabing Lake. The use of sheeting or wellpoints would have to contend with possible boulders in the overburden. Temporary slopes in the sand and gravel, after dewatering, could be cut

3.0 DISCUSSION - Continued

6.

3.3 Construction - Continued

to about 1 horizontal to 1 vertical.

4.0 PERSONNEL

The field work of this investigation was carried out under the supervision of Mr. P. G. Williams. This report was written by Mr. P. G. Williams and checked by Mr. D. B. Oates, P.Eng.

Respectfully submitted,

*P G Williams*

P. G. Williams

*D B Oates*

D. B. Oates, P. Eng.

T 9261

**GEOCON**

APPENDIX I

PROCEDURE

FIELD EQUIPMENT

SITE AND GEOLOGY

SOIL CONDITIONS

WATER CONDITIONS

BEDROCK

OFFICE REPORTS ON SOIL EXPLORATION

**GEOCON**

1.0 PROCEDURE

The field work for this project was carried out between October 2nd and 10th, 1969. A total of four boreholes were put down in BX casing size through the overburden and cored in AXT size into the underlying bedrock to depths ranging from 18.6 to 24.0 feet below the water surface. Standard penetration resistances were also obtained in conjunction with the samples.

The boreholes were located using as reference the abutments of the existing concrete and steel beam bridge and the centre line of the proposed revision of Highway 124 as indicated on Department of Highways, Ontario Plan B 1083-4. The locations of the boreholes together with the inferred soil stratigraphy are shown on Drawing T 9261-1 at the rear of this report.

The soil testing was carried out in our Soil Mechanics Laboratory. The soil samples remaining after testing will be stored until November 1st, 1970 at which time you will be contacted for instructions regarding their disposal.

All elevations mentioned in this report are referred to Geodetic datum. They were established using Bench Mark No. P 101 which is located on the top of a hill of rock on the south side of the road, west of Highway 124 and 370 feet west of the concrete bridge. The elevation of this bench mark was given as 825.54 by the Engineering Staff of Department of Highways, Ontario in Huntsville.

**GEOCON**

2.0 FIELD EQUIPMENT

The four boreholes were put down using a diamond drill mounted on a floating drill platform.

The granular overburden was sampled using a 2 inch O. D. split spoon sampler, adapted with a foot valve to aid in the recovery of the material, at minimum intervals of 5 feet.

3.0 SITE AND GEOLOGY

The site is located in the village of McKellar about thirteen miles north of Parry Sound. The proposed culvert location extends south of an existing concrete and steel beam bridge over which Highway 124 crosses an outlet of McKellar Lake flowing into Manitouwabing Lake. The actual drilling program was carried out in a pool, shown on the photographs - Appendix III, directly south of an outcrop of bedrock on which the concrete bridge is founded. It is understood from conversations with local inhabitants that the flow of water used to be farther to the west of its existing course in the region of the site and that this area was filled with stone slabs, sawdust and wood logs from a nearby sawmill. This area is understood to extend about fifty feet to the west of the existing shoreline.

It is known from available geological information<sup>1</sup> that the area was glaciated during Pleistocene times and

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<sup>1</sup> Geology and Mineral Deposits of the Parry Sound - Huntsville Area : Ontario Department of Mines. 1967.

3.0 SITE AND GEOLOGY - Continued

deposits of glacial till and sand and gravel are present in the area. The overburden is generally sparse, underlain by granite and metamorphic gneisses or sedimentary and derived metamorphic rock.

4.0 SOIL CONDITIONS

The following soil strata were encountered by the boreholes:

4.1 Decayed Wood Fill with Some Sand & Gravel

A layer of decayed sawdust and wood with some sand and gravel was encountered in Borehole 4 to a depth of about 2 feet. One Standard Penetration Resistance or 'N' value of 40 blows per foot was obtained in the fill stratum.

4.2 Very Loose to Compact Grey Brown to Grey Sand with Gravel

Underlying the surface fill stratum in Borehole 4 and through the full depth of overburden penetrated in Boreholes 1 to 3, very loose to compact sand with gravel was encountered. The thickness of this stratum was found to range from about 1 foot in Borehole 1 to about 9 feet in Borehole 3. Traces of decayed wood particles were encountered in samples recovered from the upper region of this stratum. Some silt was encountered in the sand with gravel at depth in Boreholes 2 and 3. The sand with gravel is generally grey brown in colour in the upper region changing to grey with depth. Although no boulders were encountered within this stratum it is possible that boulders do occur in-situ.

Grain size analyses were carried out on representative samples of this stratum and the results of these tests are presented as grain size distribution curves on Figure 1 in Appendix II. These curves show that the granular material as tested contained 18 to 40 percent gravel, 60 to 76 percent sand and from about 0 to 10 percent silt sized particles.

Standard Penetration Resistances or 'N' values obtained in the sand with gravel ranged from 1 blow per foot near

**GEOCON**

## 4.0 SOIL CONDITIONS - Continued

4.2 Very Loose to Compact Grey Brown to Grey Sand with Gravel  
Continued

the surface to 25 blows per foot at depth. The relative density is considered therefore to range from very loose to compact.

Two falling head permeability tests were carried in the lower region of the overburden in Boreholes 2 and 3. The computed<sup>(1)</sup> permeabilities were  $5.0 \times 10^{-3}$  and  $5.8 \times 10^{-4}$  centimeters per second.

## 5.0 WATER CONDITIONS

During the time of the investigation the river elevation in the pool where drilling took place remained at an approximately constant elevation of 788.9. It is understood the water level in the outlet is subject to considerable variations partly due to seasonal effects and also to control by dams in McKellar Lake and Manitouwabing Lake. At the time of the investigation it is understood from local inhabitants that the water flow through the outlet was less than normally anticipated for the time of the year.

## 6.0 BEDROCK

Bedrock was core drilled in AXT size in all the four boreholes for a depth of about 10 feet. The rock surface was encountered at depths of between 8.6 and 14.0 feet below the water surface. In all cases the rock core

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(1) M.J. Hvorslev. Time Lag and Soil Permeability in Ground Water Observations - Bulletin No. 36 Waterways Experiment Station - U.S. Corps of Engineers (1951)

6.0 BEDROCK - Continued

was 100 percent.

The rock was identified by our Geological Engineer as sedimentary granite with biotite and quartzite phases.

Bedrock outcrops were visible to the north of the borehole locations, on which the concrete bridge was founded; and also to the south, about 140 feet from the bridge. The approximate elevation and location of the bedrock encountered in the boreholes in relation to these outcrop is given on Drawing T 9261-1 at the rear of this report.

GEOCON

## EXPLANATION OF THE FORM "OFFICE REPORT ON SOIL EXPLORATION"

The object of this form is to enable a comprehensive study of the soil to be made by combining on one sheet all of the information obtained from the boring. An explanation of the various columns of the report follows.

### ELEVATION AND DEPTH

This column gives the elevation and depth of boundaries between the various soil strata. The elevation is referred to the datum shown in the general heading.

### WATER CONDITIONS

In this column the water level in the casing at the time of boring or the water table in the ground, determined by a series of observations in a piezometer or standpipe, is indicated to scale by a horizontal line with the symbol W.L. or W.T. above the line. A notation of any complicated groundwater conditions will be made in this column.

### DESCRIPTION

A description of the soil, using standard terminology, is contained in this column. The consistency of cohesive soils and the relative density of non-cohesive soils are described by the following terms:

| <u>Consistency</u> | <u>U-Strength<br/>Tons/sq. ft.</u> | <u>Relative Density</u> | <u>Standard Penetration<br/>Resistance. Blows/ft.</u> |
|--------------------|------------------------------------|-------------------------|---|
| Very soft          | 0.03 to 0.25                       | Very loose              | 0 to 4  |
| Soft               | 0.25 to 0.5                        | Loose                   | 4 to 10   |
| Firm               | 0.5 to 1.0                         | Compact                 | 10 to 30  |
| Stiff              | 1.0 to 2.0                         | Dense                   | 30 to 50  |
| Very stiff         | 2.0 to 4.0                         | Very dense              | over 50   |
| Hard               | over 4.0                           |                         |   |

### STRATIGRAPHIC PLOT

The stratigraphic plot follows the standard symbols of the National Research Council, Canada.

### ELEVATION SCALE

The information in all columns is plotted to a true elevation scale which is shown in this column.

### GRAPHS

The main body of the report forms a graph which is used to plot to correct elevation the important soil properties which are obtained through field and laboratory tests. The scales and symbols for the plotting are shown at the head of the column.

### OTHER TESTS

In this column are shown, by symbol, the other field or laboratory tests which have been performed on the soil and for which the results have not been plotted on the above graph.

### SAMPLES

The first three columns describe the condition, type and number of each sample obtained from the boring. The location and extent of each sample is plotted to scale.

In the last column is shown the penetration resistance in blows of 4200 inch-pounds required to drive one foot of the sampler into the ground. When a 2 inch Drive Sampler is used the result obtained is termed the "Standard Penetration Resistance".

**GEOCON**

## APPENDIX I

## GEOCON

## OFFICE REPORT ON SOIL EXPLORATION

CONTRACT 19261 BORING 1 and 2 DATUM GEODETIC CASING BX  
 BORING DATE Oct 8, 1969 REPORT DATE Oct 10, 1969 COMPILED BY AEL CHECKED BY PGW  
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN - LBS. ENERGY)

## SAMPLE CONDITION

☒ DISTURBED  
☐ FAIR  
☐ GOOD  
☐ LOST

## SAMPLE TYPES

A.S. - AUGER SAMPLE  
 S.T. - SLOTTED TUBE  
 W.S. - WASHED SAMPLE  
 D.O. - DRIVE-OPEN  
 D.F. - DRIVE-FOOT VALVE  
 C.S. - CHUNK SAMPLE

F.S. - FOIL SAMPLE  
 S.O. - SLEEVE-OPEN  
 S.F. - SLEEVE-FOOT VALVE  
 T.O. - THIN WALLED OPEN  
 R.C. - ROCK CORE

## ABBREVIATIONS

V - IN-SITU VANE TEST  
 M - MECHANICAL ANALYSIS  
 U - UNCONFINED COMPRESSION  
 OC - TRIAXIAL CONSOLIDATED UNDRAINED  
 Q - TRIAXIAL UNDRAINED  
 S - TRIAXIAL DRAINED  
 γ - WET UNIT WEIGHT  
 K - PERMEABILITY  
 C - CONSOLIDATION  
 WL - WATER LEVEL IN CASING  
 WT - WATER TABLE IN SOIL

| SOIL PROFILE                          |                  |   |                             | SAMPLES                                 |           |      |        | DEPTH - FEET                     |
|---------------------------------------|------------------|---|-----------------------------|---|-----------|------|--------|----------------------------------|
| ELEV. DEPTH                           | WATER CONDITIONS | DESCRIPTION   | STRAT. PLOT ELEVATION SCALE | OTHER TESTS                             | CONDITION | TYPE | NUMBER | PENETRATION RESISTANCE BLOWS/FT. |
| WATER CONTENT W% _____ G NAT ELW Δ PW |                  |   |                             | DYNAMIC PENETRATION TEST BLOWS PER FOOT |           |      |        |                                  |
| 788.9<br>30.0                         | ▼                | WATER LEVEL   | 790                         |   |           |      |        | 0                                |
| 781.6<br>7.3                          |                  | RIVER BOTTOM  | 785                         |   |           |      |        | 5                                |
| 86                                    |                  | VERY BROWN SAND AND GRAVEL                                | 780                         | M<br>RC<br>RECOV                        | 2' DO     | 1    | 1      | 10                               |
|                                       |                  |   | 775                         | 100%                                    | AXT. RC.  | 2    | 1      | 15                               |
|                                       |                  | BEDROCK   | 770                         | 100%                                    |           | 3    | 1      | 20                               |
| 770.4<br>18.5                         |                  | END OF HOLE   | 765                         |   |           |      |        |                                  |
| 788.9<br>30.0                         | ▼                | WATER LEVEL   | 790                         |   |           |      |        | 0                                |
| 781.6<br>7.3                          |                  | RIVER BOTTOM  | 785                         |   |           |      |        | 5                                |
|                                       |                  | VERY LOOSE TO COMPACT GREY BROWN TO GREY SAND WITH GRAVEL | 780                         | M                                       | 2' DO     | 1    | <1     | 10                               |
|                                       |                  | (Color change to grey silty with depth)                   | 775                         |   |           | 2    | 3      | 15                               |
| 778.7<br>10.2                         |                  |   | 770                         | M<br>RC<br>RECOV                        | 2' DO     | 3    | 24     | 20                               |
|                                       |                  |   | 765                         | 100%                                    | AXT. RC.  | 4    | 1      |                                  |
|                                       |                  | BEDROCK   | 760                         | 100%                                    |           | 5    | 1      |                                  |
| 768.1<br>20.8                         |                  | END OF HOLE   | 755                         |   |           |      |        |                                  |

## APPENDIX I

## GEOCON

## OFFICE REPORT ON SOIL EXPLORATION

CONTRACT T9261 BORING = 3 and 4 DATUM GEODETIC CASING BX  
 BORING DATE OCT 6-9/69 REPORT DATE OCT 10, 1969 COMPILED BY AEI CHECKED BY PGW  
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN - LBS. ENERGY)

## SAMPLE CONDITION



A.S. - AUGER SAMPLE  
 S.T. - SLOTTED TUBE  
 W.S. - WASHED SAMPLE  
 D.O. - DRIVE-OPEN  
 D.F. - DRIVE-FOOT VALVE  
 C.S. - CHUNK SAMPLE

## SAMPLE TYPES

F.S. - FOIL SAMPLE  
 S.O. - SLEEVE-OPEN  
 S.F. - SLEEVE-FOOT VALVE  
 T.O. - THIN WALLED OPEN  
 R.C. - ROCK CORE

## ABBREVIATIONS

V. - IN-SITU VANE TEST  
 M. - MECHANICAL ANALYSIS  
 U. - UNCONFINED COMPRESSION  
 CC. - TRIAXIAL CONSOLIDATED UNDRAINED  
 Q. - TRIAXIAL UNDRAINED  
 S. - TRIAXIAL DRAINED  
 W. - WET UNIT WEIGHT  
 K. - PERMEABILITY  
 C. - CONSOLIDATION  
 WL. - WATER LEVEL IN CASING  
 WT. - WATER TABLE IN SOIL

| SOIL PROFILE                          |                  |   |                             | SAMPLES                                 |           |      |        |
|---------------------------------------|------------------|---|-----------------------------|---|-----------|------|--------|
| ELEV. DEPTH                           | WATER CONDITIONS | DESCRIPTION   | STRAT. PLOT ELEVATION SCALE | OTHER TESTS                             | CONDITION | TYPE | NUMBER |
| WATER CONTENT W% _____ G NAT SLW Δ Pw |                  |   |                             | DYNAMIC PENETRATION TEST BLOWS PER FOOT |           |      |        |
| [3]                                   |                  |   |                             |   |           |      |        |
| 789.9<br>0.0                          | ▼                | WATER LEVEL   | 790                         |   |           |      |        |
| 784.1<br>1.7                          |                  | RIVER BOTTOM  | 785                         |   |           |      |        |
|                                       |                  | LOOSE TO COMPACT GREY BROWN TO GREY SAND WITH GRAVEL<br>(Color change to S' silty with depth) | 780                         |   |           |      |        |
| 774.3<br>14.0                         |                  | BEDROCK   | 775                         |   |           |      |        |
| 764.9<br>24.0                         |                  | END OF HOLE   | 765                         |   |           |      |        |
| [4]                                   |                  |   |                             |   |           |      |        |
| 785.9<br>3.5                          | ▼                | WATER LEVEL   | 790                         |   |           |      |        |
| 785.2<br>3.7                          |                  | RIVER BOTTOM  | 785                         |   |           |      |        |
| 783.3<br>5.7                          |                  | DECAYED WOOD FILL WITH SOME SAND AND GRAVEL   | 780                         |   |           |      |        |
| 779.3<br>9.6                          |                  | GREY SAND WITH GRAVEL   | 775                         |   |           |      |        |
| 769.3<br>19.6                         |                  | BEDROCK   | 770                         |   |           |      |        |
|                                       |                  | END OF HOLE   |                             |   |           |      |        |

APPENDIX II

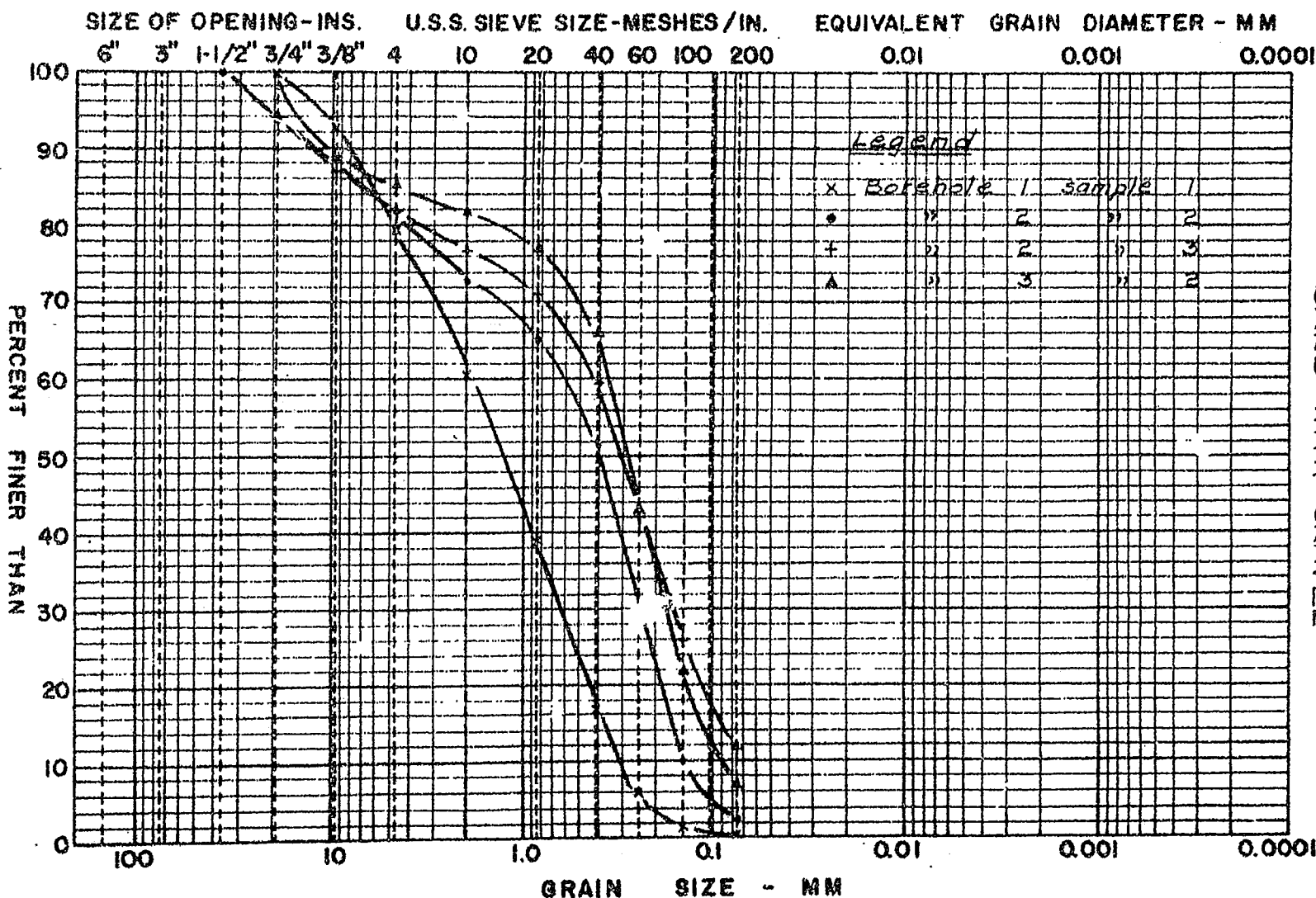
FIGURES -- LABORATORY TESTING

GEOCON

# GRAIN SIZE DISTRIBUTION

APPENDIX 11  
FIGURE 1  
PROJECT T9261

| COBBLE | GRAVEL SIZE |        |      | SAND SIZE |        |      | FINE GRAINED |             |
|--------|-------------|--------|------|-----------|--------|------|--------------|-------------|
| ← SIZE | COARSE      | MEDIUM | FINE | COARSE    | MEDIUM | FINE | SILT SIZE    | CLAY SIZE → |



GEOCON

M.I.T. GRAIN SIZE SCALE

APPENDIX III

PHOTOGRAPHS

GEOCON

APPENDIX III  
PLATE 1.

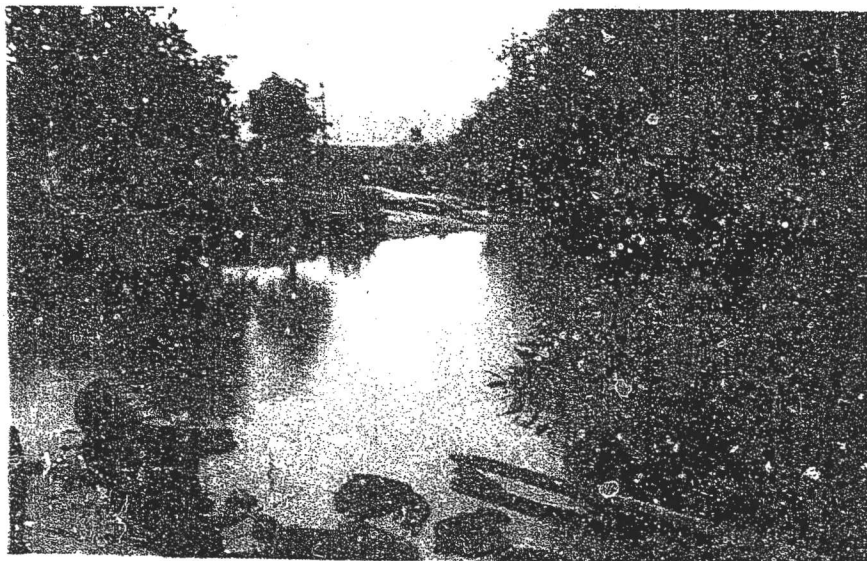


View of Bridge from South

GEOCON

SHUTTER SPEED 1/1000 SEC  
APPLAS AS MOUNTED ON FILM

APPENDIX III  
PLATE 2.



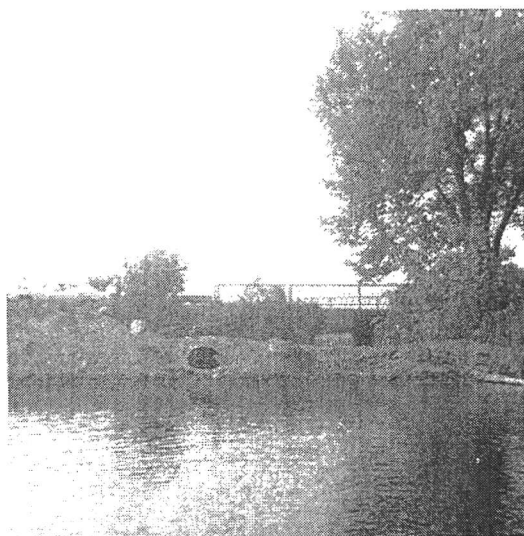
View from Bridge Looking South

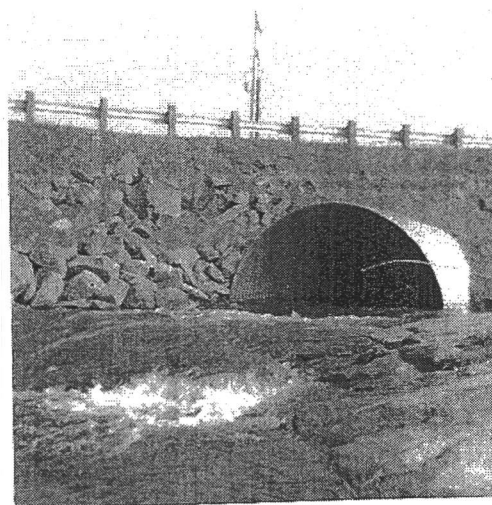
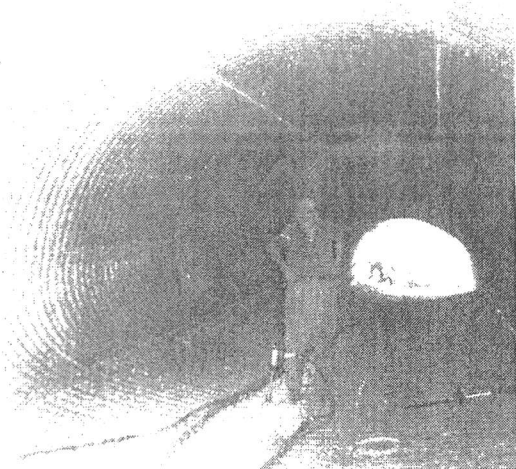
GEOCON

8-11-11 10:00 AM  
10-11-11 10:00 AM



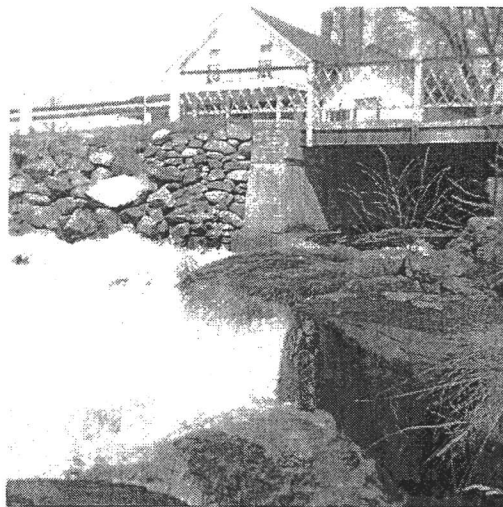
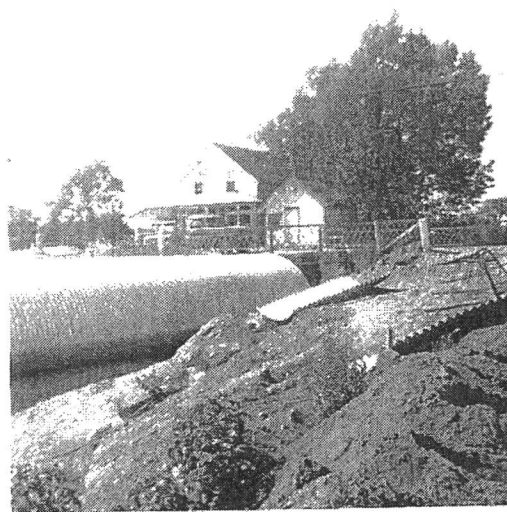
INSTALLATION OF McKELLAR CREEK CULVERT

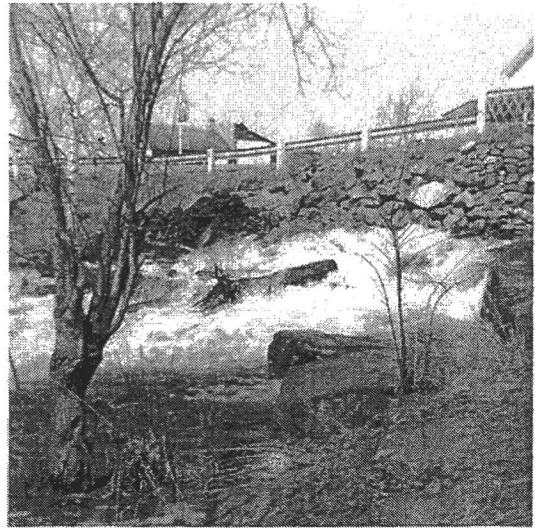
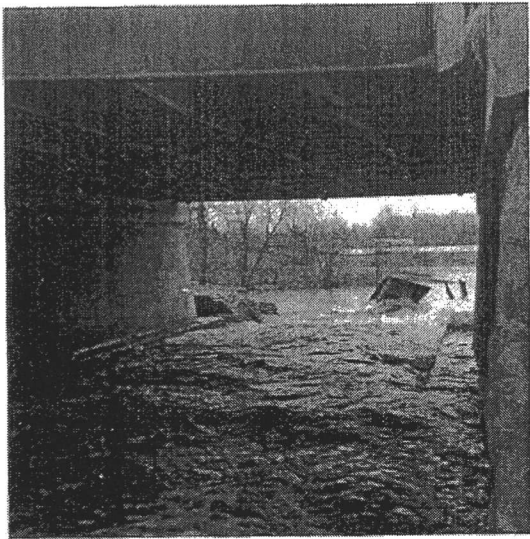


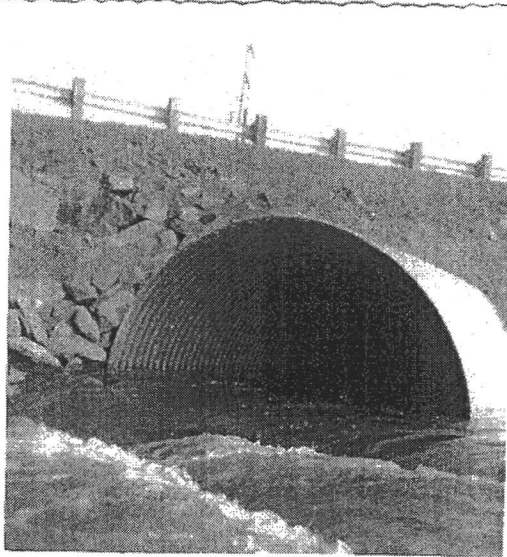
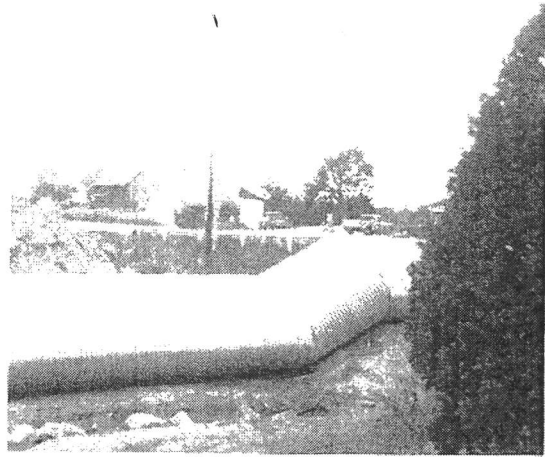


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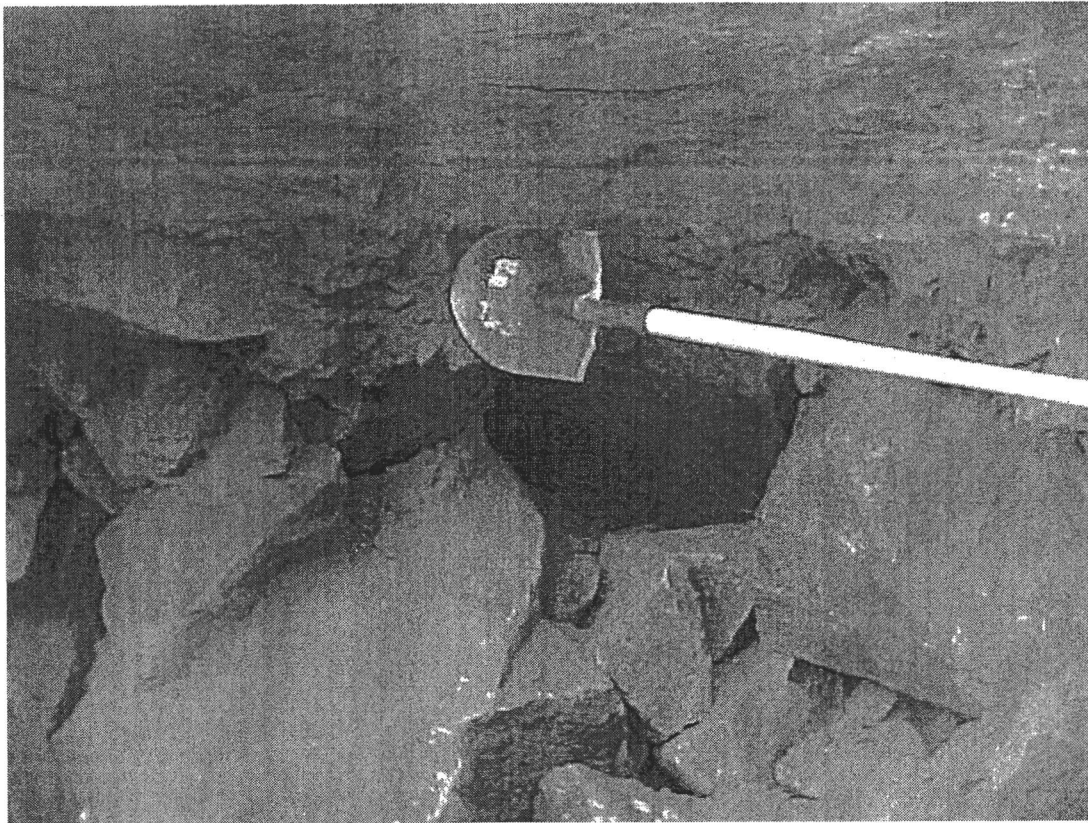




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FINDINGS SURING EXCAVATION (DEC 8/2003)





**Highway 124, McKellar Lake Culvert Replacement**  
**WP No. 5089-03-00**

May 13, 2004

ONO11711

**Foundation Design Summary Table**

| Alternative  | Advantages  | Disadvantages  | Relative Cost   | Risk/Consequence   | Comment  |
|--|---|--|-----------------|--|--|
| 1. Open box culvert supported on H-Piles placed in rock sockets  | H-piles on site as part of shoring for staging.<br>No deep excavations.<br>Groundwater control eased.   | Very short H-piles, difficult to maintain alignment and set pile shoes.<br>Must protect against scour.   | Moderate +      |  | Not recommended; less cost effective; no advantage over caissons (Alt 2) |
| 2. Open box culvert supported on rock socketed caissons  | Churn drill on site as part of shoring design.<br>No deep excavations.<br>Groundwater control eased.<br>Uniform foundation support for entire culvert length. | Must protect against scour.  | Moderate        |  | Best alternative for deep foundation on bedrock                          |
| 3. Open box supported on Pipe-piles placed in rock sockets.  | No deep excavations.<br>Groundwater control eased.  | Very short piles.<br>Must protect against scour.   | Moderate +      |  | Not recommended; less cost effective; no advantage over caissons (Alt 2) |
| 4. Open box supported on spread footings. All loose soils in subgrade removed and replaced with clearstone fill. | Simple construction.<br>Dewatering minimal as excavation and backfill carried out in the wet.   | Deep excavation, however traffic affect minor due to presence of bedrock.<br>Can not inspect base of excavation.<br>Must protect against scour.  | Low to Moderate | Settlement and differential settlement of culvert/ May need to include additional construction joints. | Most cost effective alternative  |
| 5. Closed box culvert. All loose soils in subgrade removed and replaced with clearstone fill.                    | Simple construction.<br>Dewatering minimal as excavation and backfill carried out in the wet.<br>Closed box prevents scour of footings.                       | Deep excavation, however traffic affect minor due to presence of bedrock and shoring requirement.<br>Can not inspect base of excavation.<br>Will need extra depth in culvert for rock fill for environmental reasons.<br>Difficult to accommodate dewatering by-pass pipe. | Moderate        | Settlement and differential settlement of culvert/ May need to include additional construction joints. | Less cost effective than Alternative 4.                                  |





| Alternative  | Advantages  | Disadvantages   | Relative Cost | Risk/Consequence   | Comment  |
|--|---|---|---------------|--|--|
| 6. Closed box culvert. All loose soils in subgrade removed and replaced with compacted fill.   | Simple construction.<br>Closed box prevents scour of footings.  | Dewatering difficult.<br>Deep excavation, however traffic affect minor due to presence of bedrock and shoring requirement.<br>Will need extra depth in culvert for rock fill for environmental reasons.<br>Difficult to accommodate dewatering by-pass pipe.  | Moderate      | Settlement and differential settlement of culvert/ May need to include additional construction joints.<br>Inability to dewater/ May need to switch to alternative 1 during construction. | Not recommended due to dewatering concerns   |
| 7. Closed box culvert. Portion of loose soils in subgrade removed and replaced with clearstone fill pad to target of 1.0 m below bottom of culvert | Simple construction.<br>Dewatering minimal as excavation and backfill carried out in the wet.<br>Closed box prevents scour of footings. | Will need to put a geotextile below the clearstone to achieve material separation.<br>Deep excavation, however traffic affect minor due to presence of bedrock and shoring requirement<br>Can not inspect base of excavation.<br>Will need extra depth in culvert for rock fill for environmental reasons.<br>Difficult to accommodate dewatering by-pass pipe. | Moderate      | Settlement and differential settlement of culvert/ May need to include additional construction joints.   | Not recommended, as superior settlement performance achieved with minimal additional effort using Alternative 5. |
| 8. Closed box culvert supported on soils improved by Dynamic Compaction or Vibroflotation.   | No deep excavations.<br>Groundwater control eased.<br>Closed box prevents scour of footings.  | Very small area for Dynamic Compaction (high mobilization costs).<br>Limited depth will reduce effectiveness of vibroflotation probe.<br>Overhead service lines.<br>Difficult to accommodate dewatering by-pass pipe.   | Moderate +    | Damage to surrounding facilities.<br>Risk to existing embankment due to vibrations.  | Not recommended.   |

CLASS II  
NON-WOVEN  
GEOTEXTILE

NEW EMBANKMENT FILL

1 m

EXISTING EMBANKMENT FILL

CULVERT

FLOW

RIP RAP

## CROSS-SECTIONAL VIEW

TOP OF EMBANKMENT

RIP RAP

1 m

WING WALL

CULVERT

WING WALL

20 m

20 m

TOE OF EMBANKMENT

## PROFILE VIEW

HARMER PODOLAK ENGINEERING CONSULTANTS INC.  
MCKELLAR LAKE CULVERT REPLACEMENT  
W.P. 5089-03-00, HIGHWAY 124  
PIPING PROTECTION DETAIL

Scale:  
N.T.S.

Dwg. No.:  
SKETCH No. 1

Date:  
04/05/17

Dwn. by:  
GBB

Appd.:  
*PC*



Jacques  
Whitford

MCKELLAR TWP.,

ONTARIO