**FOUNDATION INVESTIGATION AND DESIGN REPORT**
**W.P. 225-99-00**
**HWY 655, STA. 12+388, CARNEGIE TOWNSHIP**
**JOCKO CREEK CULVERT EXTENSION**

**MINISTRY OF TRANSPORTATION ONTARIO**

**GEOCRES NO. 42A-54**

PROJECT NO. ONO11385

# FOUNDATION INVESTIGATION AND DESIGN REPORT TO

MINISTRY OF TRANSPORTATION ONTARIO

ON

W.P. 225-99-00
HWY 655, STA. 12+388, CARNEGIE TOWNSHIP
JOCKO CREEK CULVERT EXTENSION

DISTRICT 53, NEW LISKEARD
MINISTRY OF TRANSPORTATION ONTARIO

GEOCRES NO. 42A-54


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**FOUNDATION INVESTIGATION REPORT**

**for**

**W.P. 225-99-00**
**Jocko Creek Culvert Extension**
**Hwy 655, STA. 12+388, Carnegie Township**

**District 53, New Liskeard**

# 1.0 INTRODUCTION

This report presents the results of a Geotechnical Foundation Investigation carried out for the proposed extension of the culvert at Station 12+388, Carnegie Township. The work was carried out in general accordance with our proposal of October 2000 and our quality control plan dated December 22, 2000.

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

# 2.0 SITE DESCRIPTION AND GEOLOGY

The subject site is within the limits of MTO Project W.P. 225-99-00, located on Highway 655 from 21.4 km north of Highway 101 northerly for 13.6 km. The site location is shown on the Key Plan provided in Appendix 1 (Drawing 11385-1).

The existing culvert is a multiplate design with a diameter of 3.7 m and a length of 55 m. Drawing 81 of Contract 77-93 indicates that the existing culvert was constructed with a concrete baffle wall at the upstream end. A 600 mm clay seal was also placed at the upstream end of the culvert and surfaced with 300 mm thick gravel sheeting and 600 mm of rip rap. The downstream embankment at the culvert was surfaced with 300 mm of gravel sheeting and 600 mm of rip rap. The rip rap extended 6.1 m beyond the end of the culvert.

The culvert is located within a roadway fill section. The fill height is approximately 11.9 m at the culvert. The side slopes are approximately 2H:1V and covered with grass. A plan view and a cross section of the culvert location are shown on Drawing No. 11385-1, provided in Appendix 1.
Drainage in the immediate area is provided by highway ditches.

The subject site is within the Geomorphic Sub-Province known as the Cochrane Clay Plain. Glacial and post-glacial drift features dominate the physiography. The overburden soils are generally deeper than 3 m and consist typically of silt and/or clay, with some organic deposits. The overburden soils are typically quite variable. Bedrock in the area is of Archean age and is composed largely of foliated to gneissic tonalite to granodiorite.

# 3.0 PROCEDURE

## 3.1 Field Investigation

The site soil conditions were investigated through a borehole drilling investigation and laboratory testing. The drilling was carried out using a truck-mounted CME-55 drill rig and portable wash boring equipment. The field work for this investigation was carried out between April 9 and May 12, 2001.

A total of five (5) boreholes, designated as 01-1 through 01-5, were put down during the field investigation. Boreholes 01-1 and 01-3 were put down at the proposed culvert extension locations on the upstream and downstream sides of the culvert, respectively. Boreholes 01-2 and 01-4 were located at the toe of the fill slopes. Borehole 01-5 was put down through the roadway embankment adjacent to the culvert.

The boreholes were advanced to a minimum depth of 5.9 m using hollow-stem augers and wash boring equipment. The subsurface conditions were identified in the field by JWA personnel while carrying out Standard Penetration Tests (SPT) (ASTM D1586). The SPT was carried out at regular intervals (maximum of 760 mm) and the recovered soil samples were returned to our laboratory. The subsurface conditions are described in detail in the Borehole Records presented in Appendix 2.

Standpipes were installed in Boreholes 01-2 and 01-4. These boreholes were backfilled with auger cuttings tamped into place. The remaining boreholes were backfilled with a cement-bentonite mixture.

All soil samples recovered were stored in moisture proof containers and were returned to our laboratory for classification and testing.

## 3.2 Survey

Borehole locations were established in the field by Jacques Whitford personnel relative to the existing culvert. The ground surface elevations at the borehole locations were surveyed relative to the top of the culvert on the downstream side, which is understood to have a geodetic elevation of 276.11 m.

## 3.3 Laboratory Testing

All samples returned to the laboratory were subjected to detailed visual classification by a geotechnical engineer. Selected samples were tested for moisture content, Atterberg limits, and grain size distribution. One representative water sample was submitted for pH, sulphate and chloride testing to assess the potential for corrosion of buried steel and the potential for sulphate attack on buried concrete. All soil samples will be stored for a period of one year after issuance of the final report. Unless otherwise directed, the stored samples will then be disposed of.

# 4.0 SUBSURFACE CONDITIONS

## 4.1 Subsurface Profile

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix 2. An explanation of the symbols and terms used to describe the Borehole Records is also provided. The general subsurface conditions include roadway fill over native silty sand, silty clay, silt and silty sand. A description of each soil deposit encountered is provided in the following sections. A borehole location plan and a cross-section of the soils encountered within the boreholes is shown on Drawing No. 11385-1.

### 4.1.1 Embankment Fill (Sand Fill over Silt Fill)

The full height of the existing roadway embankment was penetrated by Borehole 01-5. The materials encountered in that borehole include a pavement structure consisting of 60 mm of asphalt over 120 mm of gravelly sand, trace silt over 300 mm of sand some gravel trace silt. The embankment fill beneath the pavement structure was observed to be 5.0 m of dense to very dense sand with trace gravel and trace silt over 6.7 m of compact silt some gravel, some sand, trace clay. The SPT-N values were between 67 and 89 in the upper sand portion of the embankment fill and between 11 and 25 in the lower silt fill.

A thin layer of fill, ranging from 0.6 m to 3.1 m, was also observed within the boreholes at the toe of the embankment slopes. The fill consisted of a range of materials from silty sand and cobbles to clayey silt some sand. Organic material and pieces of wood were observed within this layer.

### 4.1.2 Silty Sand

A native deposit of silty sand was observed beneath the embankment fills in Borehole 01-1, 01-2 and 01-5. This layer ranged from 0.5 m to 1.8 m in thickness and was generally loose to compact. The moisture content of one representative sample was found to be 35%.

### 4.1.3 Silty Clay

A silty clay deposit was encountered in all boreholes. Frequent silt seams were observed within this unit. The undrained shear strength was measured using an MTO vane with the results ranging from 33 kPa to 78 kPa and averaging 49 kPa for 14 tests. The moisture content of the ten samples tested ranged from 26% to 46% with an average of 38%. Grain size analyses carried out on one sample of the silty clay indicated that it contained 0% gravel, 5% sand, 54% silt and 41% clay particles. Atterberg Limit testing was carried out on two samples. The liquid limit was determined to be 47% and 36% and the plastic limit 22% and 19%. Boreholes 01-2, 01-4 and 01-5 were terminated within the silty clay unit. Within Boreholes 01-1 and 01-3, the silty clay unit was observed to extend to a depth of 6.1 m and 6.9 m below ground surface respectively.

### 4.1.4 Silt

A silt deposit with some clay, trace sand was observed beneath the silty clay layer in Boreholes 01-1 and 01-3. Frequent clay seams were observed within this unit. SPT N-values ranged from 9 to 24, indicating a generally compact deposit. The moisture content of the ten samples tested ranged from 16% to 24% with an average of 21%. Grain size analyses carried out on one sample of the silt indicated that it contained 0% gravel, 3% sand, 75% silt and 22% clay particles. The silt layer was observed to extend to a depth of 10.1 m and 10.4 m below ground surface in Boreholes 01-1 and 01-3 respectively.

### 4.1.5 Silty Sand

A silty sand to sandy silt deposit was observed beneath the silt layer in Boreholes 01-1 and 01-3. SPT N-values ranged from 15 to 27, indicating a compact deposit. The moisture content of the five samples tested ranged from 16% to 18% with an average of 16%. The silty sand layer was observed to extend to the termination depth of the boreholes at 12.0 m and 12.4 m below ground surface in Boreholes 01-1 and 01-3, respectively.

## 4.2 Groundwater

Groundwater levels at the time of drilling were observed to be at ground surface, i.e. at Elevation 274.7 m and 274.1 m in Boreholes 01-2 and 01-4 respectively. The creek water was observed to be 1.2 m deep within the culvert at the downstream end, ie at elevation 273.3 m. Fluctuations in the creek and groundwater levels due to seasonal variations or in response to a particular precipitation event should be anticipated.

## 4.3 Chemical Testing

A visual inspection of the existing culvert indicated moderate rusting and scaling at the bottom and waterline. The culvert is in very good condition above the waterline.

The thickness of the culvert steel was measured using a digital micrometer at six locations after buffing the test locations clean of loose materials using steel wool. The results ranged from 2.861 mm to 3.260 mm with an average of 3.098 mm.

A representative water sample from Jocko Creek was submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, water soluble sulphate and chloride, in order to determine cement type and reinforcing steel protection requirements. The results are summarized in the table below.

| Location | pH | Soluble Chloride | Soluble Sulphate | Resistivity |
|---|---|---|---|---|
| Jocko Creek | 6.2 | 3.0 mg/L | 2.0 mg/L | 26,000 ohm.cm |

## 5.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations 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 truly,

**JACQUES, WHITFORD AND ASSOCIATES LIMITED**

LICENSED PROFESSIONAL ENGINEER F.J. GRIFFITHS PROVINCE OF ONTARIO

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# 6.0 DISCUSSION AND RECOMMENDATIONS

## 6.1 Proposed Development

Based on drawings of the culvert location, the embankment geometry is as follows:

| Culvert Location | Height of Fill Over Culvert | Height of Fill Over Culvert Invert | Sideslopes |
|---|---|---|---|
| 12+388 | 8.2 m | 11.9 m | approx: 2H:1V |

The existing culvert is a multiplate design with a diameter of 3.7 m and a length of 55 m. The culvert allows Jocko Creek to flow from the east to the west side of Highway 655.

Chemical test results were provided to Armtec Limited for review. Their assessment (copy provided in Appendix 3) is that the existing culvert has an expected service life remaining of 63 years. Based on this assessment it can be concluded that the culvert does not require replacement or remedial treatment at this time.

It is understood that the Ministry of Transportation of Ontario (MTO) plans to rehabilitate and widen Highway 655 through the subject site. The present cross-section is 9.7 m wide from rounding to rounding. The proposed cross-section will be 14.5 m wide. It is understood that the proposed roadway rehabilitation for this section of Highway 655 includes removal of existing materials to a depth of 640 mm and placement of 500 mm of OPSS Granular A, and 140 mm of hot mix asphalt. This represents no increase in the existing grades. The embankment must also satisfy Northern Region Engineering Directive 98-200 to overbuild embankments in preparation for future pavement rehabilitation. This will result in the creation of a 1 m wide bench at the pavement subgrade line on both sides of the highway.

It is anticipated that culvert extensions of as much as 4.7 m beyond the beveled ends of the existing culvert will be constructed to nearly match the existing culvert structure (i.e. same type of culvert and same founding elevation). This will require removal of existing fill and /or any loose material. The proposed embankment widening will result in increased stresses in the soil beneath the existing embankment and culvert. It is anticipated that concrete cut off walls will be constructed at the ends of the culvert.

It is understood that no retaining walls are proposed for this site.

## 6.2 Embankment Considerations

It is not proposed to raise the vertical alignment of the highway at the culvert location, however, the increase in roadway width will increase the load on the soils underlying the embankment by as much as 50 kPa.

Based on the anticipated loads, the observed soil conditions and the geometry of the embankment, settlement is estimated as follows:

- at the highway centreline — minimal (less than 5 mm)
- at the edge of the existing shoulder — 5 mm to 10 mm
- near the toe of existing embankment — 15 mm to 25 mm
- at the toe of the proposed embankment — 15 mm to 25 mm.

It is anticipated that 90% of the settlement will occur within one month due to the presence of numerous silt layers within the silty clay unit. It is recommended that the final lift of asphalt be placed no sooner than one month after completion of the embankment.

The stability of the embankment has been examined using a SLOPE/W with the Bishop (with ordinary and Janbu) analysis method. The following parameters were utilized in the analysis:

| Soil Type | Unit Weight (kN/m 3) | Angle of Internal Friction (degrees) | Cohesion (kPa) |
|---|---|---|---|
| Sand Fill | 20 | 32 | - |
| Silt Fill | 18 | 29 | - |
| Silty Sand | 18 | 29 | - |
| Silty Clay | 17.5 | 25 | 10 |
| Silt | 18 | 27 | - |
| Silty Sand | 19 | 29 | - |

An acceptable factor of safety (>1.3) is available against deep seated failures for the embankment, however, shallow raveling type failures associated with surface erosion may occur within 2 horizontal to 1 vertical embankment slopes constructed of sand. A 2 m wide mid-height berm could be constructed to improve surficial stability, however, this would increase the culvert extension by 2 m on each side. Given that the existing embankment does not have berms it is recommended that berms not be included in the widened embankment provided the slopes are protected against erosion. It is recommended that the outermost 1.0 m of the embankment widening be constructed with OPSS Granular B Type II or rockfill to minimize shallow raveling failures caused by erosion.

Initial examination of stability for the case where a retaining wall is constructed to minimize culvert extension lengths suggests that slope stability will be a concern. Further analysis will be required should this option be considered.

## 6.3 Lateral Earth Pressures

The following paragraphs provide recommendations that are applicable to retaining wall design, should they become necessary.

The highway sideslopes are understood to be no steeper than 2H:1V. A backfill slope of 2H:1V behind the retaining wall should be assumed for design purposes, should retaining walls be considered. Computation of earth pressures should be in accordance with Section 6-7 of the OHBDC 3rd Edition.

The following unfactored soil parameters may be used for the design of retaining walls with granular backfill inclined at 2H:1V:

| Parameter | OPSS Granular A | OPSS Granular B | Existing Sand Fill | Existing Silt Fill |
|---|---|---|---|---|
| Bulk Unit Weight, $\gamma$ (kN/m$^3$) | 22.5 | 21 | 20 | 18 |
| Effective Friction Angle, $\phi$ | 35° | 32° | 32° | 29° |
| Coulomb Active Earth Pressure Coefficient, $K_a$ | 0.4 | 0.47 | 0.47 | 0.57 |

The resultant force calculated from the Coulomb active earth pressure coefficient provided in the table above acts horizontally and intersects the wall at a point equal to one third of the height of the wall from the base of the wall. The earth pressure should have a triangular distribution with the apex at the ground surface.

The properties of the native soil/earth fill should be used to determine the lateral earth pressure unless the interface between the granular backfill and the native soil/earth fill is flatter than 45 degrees, in which case the properties of the granular backfill may be used.

The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6-7.4.3 of the OHBDC 3rd Edition.

Drainage should be provided behind retaining walls to prevent hydrostatic pressure build-up. Drainage should be provided by installing a 100 mm diameter subdrain wrapped in geotextile. The subdrain should be installed as per OPSD 3504.00 and should provide positive drainage to a frost-free outlet. In addition, weep holes through the wall should be provided at regularly spaced intervals.

## 6.4 Foundation Recommendations

Preliminary plans for this project do not include any concrete retaining walls (culvert headwalls or wing walls). Should retaining walls be considered, they would likely be too limited in length for retained soil systems to be economical.

The existing culvert invert is at elevation 272.1 m at the downstream end. It is anticipated that retaining walls, if required, will be founded at elevation 269.7 m in order to provide protection against frost action. A firm to stiff silty clay was encountered at the assumed foundation elevation in all boreholes.

Excavations for construction of retaining walls are expected to extend to a depth of approximately 2.4 m below the invert elevation of the existing culvert. The culvert has less than 1 m of soil cover above it at this location and therefore produces negligible loads on the underling soils. Temporary loss of soil from beneath the ends of the existing culvert will not result in a loss of stability of the culvert structure. Any soil lost from beneath the culvert structure should be reinstated with unshrinkable backfill (OPSS 1359).

The following geotechnical resistance values may be used for the design of a 1.5 m wide strip footing founded on the native silty clay or on structural fill overlying the native silty clay:

| | **Retaining Wall** |
|---|---|
| Founding Elevation (m) | 269.7 m |
| Factored Geotechnical Resistance at ULS | 115 kPa |
| Geotechnical Resistance at SLS | 70 kPa |

These values have been calculated based on an undrained shear strength of 45 kPa for the silty clay. A factor of 0.5 has been applied to arrive at the factored geotechnical resistance at ULS. The Geotechnical Resistance at SLS corresponds to a settlement of less than 25 mm due to the foundation loads. The settlement anticipated due to embankment widening must also be considered.

The effects of inclined loads should be accounted for in accordance with Section 6-8.4.2 of the OHBDC.

Sliding resistance should be calculated in accordance with Section 6-8.4.3 of the OHBDC using an unfactored friction coefficient of 0.30 for cast in place concrete in contact with native silty clay. If additional resistance to sliding is required to achieve an economical foundation design, a shear key may be constructed at the base of the foundation. The horizontal resistance provided by the shear key may be calculated from a triangular earth pressure distribution with its apex at ground surface. The passive pressure against the shear key may be calculated using a submerged unit weight of 7.7 $kN/m^3$ and passive earth pressure coefficient of 2.5.

The spread footings for retaining walls should be protected from frost action by a minimum soil cover of 2.4 m or equivalent insulation.

## 6.5 General Construction Recommendations

***Site Grading and Preparation***

All organic soils, and other deleterious materials including any existing rip rap must be removed from beneath the proposed culvert extensions and any retaining wall foundations. Where deleterious materials are encountered, the material should be excavated, wasted and replaced with structural fill. The lateral extent of such excavation should include all deleterious material within an imaginary line drawn at an angle of 1 horizontal to 1 vertical, downward and away from the edges of the culvert (or footing), to the competent native soil.

The existing concrete cut off wall, clay seal, gravel sheeting, and rip rap should be removed. Embankment widening should be constructed in accordance with OPSD-208.010.

Stripping of deleterious materials should be inspected by geotechnical personnel to ensure that all unsuitable materials are removed prior to placement of structural fill. Structural fill should consist of OPSS Granular A or Granular B, Type I or II, placed in lifts no greater than 300 mm thick and compacted to at least 98 % standard Proctor maximum dry density.

Embankment fill should consist of OPSS Granular B Type I, placed in lifts no greater than 300 mm and compacted to at least 95 % Standard Proctor Maximum Dry Density (SPMDD). The outermost 1.0 m shell of the embankment should be constructed with OPSS Granular B Type II or rockfill.

*Excavation and Backfill*

Excavation and backfill for the culverts should conform to OPSD-802.014. Rockfill can be used as backfill provided that within a lateral distance of 600 mm on each side and over the culvert, granular backfill such as OPSS Granular B or Granular A material is used to avoid high stress points on the culvert. This material should be placed in lifts no greater than 300 mm thick and compacted to at least 95 % SPMDD. During construction, the compacted grade on one side of the culvert should not exceed that on the opposite side by more than 0.6 m, to avoid distorting or moving the culvert during backfill placement and compaction.

Frost tapers for the embankment widening are not required as the depth of cover for this culvert is well over the frost penetration depth.

Excavation and backfill behind concrete retaining walls, if required, should conform to OPSD 3504.00

Side slopes for open cut excavations should conform to the Occupational Health and Safety Act and Regulations for Construction Projects.

The native soils below the water table should be considered as a Type 3 soil. In general, temporary excavations within a Type 3 soil should be made with slopes no steeper than one horizontal to one vertical from the base of the excavation.

It is expected that the site preparation work may encroach within the existing shoulder. This is acceptable, with the appropriate traffic protection, since the shoulder materials can be reinstated, however, excavation slopes immediately adjacent to the edge of pavement should be set back at least 1 m from the edge of pavement to prevent loss of support to the pavement structure. There is sufficient room to meet these geometric requirements without the need for temporary shoring, however, excavations for retaining wall foundations, if required, should be backfilled quickly (within one week) to minimize risk.

A depth of frost treatment, *f*, of 2.4 m should be used at this site.

*Dewatering and Protection of Founding Level*

The proposed founding elevations for the culverts and the cut off wall were below the water table at the time of the investigation. Dewatering will likely be required during construction. The use of sump pumps and coffer dams may be used during construction of the culvert extensions.

A 500 mm thick layer of free draining granular material such as clean crushed stone should be placed immediately beneath the culvert for levelling and support purposes. This will also serve to protect the base from disturbance and softening prior to culvert construction.

### *Erosion Protection & Sediment Control*

Erosion protection should be provided at the inlet and outlet ends of the proposed culvert extensions. Erosion protection can be achieved by placing a Class 2 non-woven geotextile on the graded ground surface and covering with at least 300 mm thick layer of rock protection. The protected area should extend laterally to at least 6 m beyond the cut off wall/wing walls/head wall, and should extend vertically to 0.5 m above the normal spring flow level. An upstream clay seal 600 mm thickness should be constructed prior to placement of the geotextile and rock protection.

It is understood that non-structural cut-off walls may be constructed at both the upstream and downstream ends. They should meet the requirements of OPSD 812.01. A 300 mm wide zone of Granular B or Granular A material should be used as backfill behind the Cut Off Walls.

The final erosion protection design should be reviewed by the geotechnical engineer.

The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent shoreline erosion and to prevent silt/sediments run-off from entering into the creek.

### *Cement Type and Corrosion Protection*

The sulphate result was below 150 mg/L, indicating that a negligible degree of sulphate attack is expected for concrete at this site. Therefore, a normal Type 10 Portland cement should be suitable for use in concrete.

The pH level and concentration of chloride give an indication to the level of potential attack on steel objects. The pH levels are within the normally acceptable range of 5.8 to 9, indicating no special corrosion potential problems. The chloride concentration result from the sample tested is greater than 0.25 mg/L, indicating an environment that may be favorable for corrosion of steel, however, high levels of chloride may be present in the ditches and creek water at certain times of the year due to roadway deicing.

The resistivity results are indicative of a low to very low degree of corrosiveness.

## 7.0 CLOSURE

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

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations 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 conclusions.

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 truly,

**JACQUES, WHITFORD AND ASSOCIATES LIMITED**

Fred J. Griffiths, Ph.D., P.Eng.

J.G.A. Raymond Haché, M.Sc., P.Eng.
Manager, Geotechnical Engineering Services

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## SOIL DESCRIPTION

Terminology describing common soil genesis:

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

Terminology describing soil structure:

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

| | |
|---|---|
| *Trace, or occasional* | Less than 10% |
| *Some* | 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 % |
|---|---|---|
| *Very Loose* | <4 | <15 |
| *Loose* | 4-10 | 15-35 |
| *Compact* | 10-30 | 35-65 |
| *Dense* | 30-50 | 65-85 |
| *Very Dense* | >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, unconfirined compression tests, or occasionally by standard penetration tests.

| Consistency | Undrained Shear Strength | | 'N' Value |
|---|---|---|---|
| | kips/sq.ft. | kPa | |
| *Very Soft* | <0.25 | <12.5 | <2 |
| *Soft* | 0.25-0.5 | 12.5-25 | 2-4 |
| *Firm* | 0.5-1.0 | 25-50 | 4-8 |
| *Stiff* | 1.0-2.0 | 50-100 | 8-15 |
| *Very Stiff* | 2.0-4.0 | 100-200 | 15-30 |
| *Hard* | >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 | *Very Thick* | *Very Wide* |
| 600-2000 | *Thick* | *Wide* |
| 200-600 | *Medium* | *Moderate* |
| 60-200 | *Thin* | *Close* |
| 20-60 | *Very Thin* | *Very Close* |
| <20 | *Laminated* | *Extremely Close* |
| <6 | *Thinly Laminated* | |

| Strength Classification | Uniaxial Compressive Strength (MPa) |
|---|---|
| *Very Low* | 1-25 |
| *Low* | 25-50 |
| *Medium* | 50-100 |
| *High* | 100-200 |
| *Very High* | >200 |

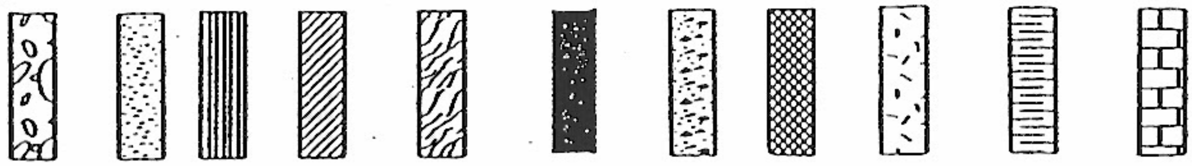
Terminology describing weathering:

*Slight* - Weathering limited to the surface of major discontinuities. Typically iron stained.

| | | |
|---|---|---|
| *Moderate* | - | Weathering extends throughout rock mass. Rock is not friable. |
| *High* | - | Weathering extends throughout rock mass. Rock is friable. |

## STRATA PLOT

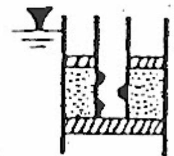
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



Boulders Cobbles Gravel — Sand — Silt — Clay — Organics — Asphalt — Concrete — Fill — Igneous Bedrock — Metamorphic Bedrock — Sedimentary Bedrock

## WATER LEVEL MEASUREMENT

Borehole or Standpipe



Piezometer

## SAMPLE TYPE

| | |
|---|---|
| SS | Split spoon sample (obtained by performing the Standard Penetration Test) |
| ST | Shelby tube or thin wall tube |
| PS | Piston sample |
| BS | Bulk sample |
| WS | Wash 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 |
| $G_s$ | Specific gravity of soil particles |
| k | Permeability (cm/sec) |
| ⊥ (arrow) | Single packer permeability test; test interval from depth shown to bottom of borehole |
| I | Double packer permeability test; test interval as indicated |
| ♀ (arrow) | Falling head permeability test using casing |
| ▽ (arrow) | Falling head permeability test using well point or piezometer |
| H | Hydrometer analysis |
| $\gamma$ | Unit weight |
| C | Consolidation |
| CD | Consolidated drained triaxial |
| CU | Consolidated undrained triaxial with pore pressure measurements |
| UU | Unconsolidated undrained triaxial |
| DS | Direct shear |
| $Q_u$ | Unconfined compression |
| $I_p$ | Point Load Index ($I_p$ on Borehole Record equals $I_p(50)$; the index corrected to a reference diameter of 50 mm) |

# RECORD OF BOREHOLE No BH01-1



**METRIC**

| | | | |
|---|---|---|---|
| W.P. 225-99-00 | LOCATION Hwy 655 Station 12+382, 29 Rt C/L, N 5399219 E 278873 | | ORIGINATED BY BK |
| DIST 53 | HWY 655 | BOREHOLE TYPE HS Augers, Split Spoons | COMPILED BY SS |
| DATUM Geodetic | | DATE 04.09.01 - 04.09.01 | CHECKED BY FG |

## SOIL PROFILE / SAMPLES

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|
| 274.0 | Ground Surface | | | | |
| 273.9 / 0.1 | 100 mm of ORGANICS, dark brown | | | | |
| 0.1 | Clayey silt, with woody organics, loose, brown (FILL) | | | | |
| 273.7 / 0.3 | Silt, with organics, some sand, some clay, loose, dark brown | 1 | SS | 1 | |
| | | 2 | SS | 5 | |
| | | 3 | SS | 8 | |
| 272.2 / 1.8 | SILTY SAND, some gravel, trace organics, loose, brown | 4 | SS | 9 | |
| 271.7 / 2.3 | SILTY CLAY, with silt seams, firm, grey | 5 | SS | 4 | |
| | | 6 | SS | 4 | |
| | | 7 | SS | 1/600 | |
| 269.4 / 4.6 | SILTY CLAY, with silt seams, stiff, grey | 8 | SS | 1 | |
| | | 9 | SS | 13 | |
| 267.9 / 6.1 | SILT, with clay, trace sand, compact, grey, with clay seams | 10 | SS | 13 | |
| | | 11 | SS | 15 | 0 3 75 22 |
| | | 12 | SS | 16 | |

GROUND WATER CONDITIONS | ELEVATION SCALE: 273, 272, 271, 270, 269, 268, 267

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED, ● QUICK TRIAXIAL, × FIELD VANE, × LAB VANE: 20 40 60 80 100

Field vane results (sensitivity): ×6 (at approx. 270.5), ×3 (at approx. 269.4), ×6 (at approx. 269.0)

PLASTIC LIMIT $W_P$ — NATURAL MOISTURE CONTENT W — LIQUID LIMIT $W_L$; WATER CONTENT (%): 15 30 45

UNIT WEIGHT γ kN/m³

Continued Next Page

$^3$, ×$^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH01-1



**METRIC**

W.P. 225-99-00 LOCATION Hwy 655 Station 12+382, 29 Rt C/L, N 5399219 E 278873 ORIGINATED BY BK

DIST 53 HWY 655 BOREHOLE TYPE HS Augers, Split Spoons COMPILED BY SS

DATUM Geodetic DATE 04.09.01 - 04.09.01 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE |
|---|---|---|---|---|---|
| | | 13 | SS | 18 | |
| | | 14 | SS | 9 | 265 |
| | | 15 | SS | 17 | 264 |
| 263.9 / 10.1 | SANDY SILT, compact, grey | 16 | SS | 21 | 263 |
| | | 17 | SS | 17 | |
| 262.0 / 12.0 | End of Borehole | | | | |

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, × FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT W, LIQUID LIMIT $W_L$; WATER CONTENT (%) 15 30 45; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH01-2

1 OF 1 **METRIC**

W.P. 225-99-00 LOCATION Hwy 655 Station 12+377, 29 Rt C/L, N 5399214 E 278876 ORIGINATED BY BK

DIST 53 HWY 655 BOREHOLE TYPE HS Augers, Split Spoons COMPILED BY SS

DATUM Geodetic DATE 04.10.01 - 04.10.01 CHECKED BY FG

| ELEV DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | SHEAR STRENGTH (FIELD VANE, kPa, sensitivity) |
|---|---|---|---|---|---|
| 274.7 | Ground Surface | | | | |
| 274.7 / 0.0 | Silty sand and cobbles, some organics, loose, dark brown (FILL) | | | | |
| 274.0 / 0.6 | CLAYEY SILT, trace sand, stiff, brown | 1 | SS | 7 | |
| 273.4 / 1.2 | SILT, some sand, some clay, compact, brown | 2 | SS | 11 | |
| 273.0 / 1.6 | SILT, some sand, some clay, compact to loose, grey, with clay seams | 3 | SS | 8 | |
| 272.2 / 2.4 | SILTY CLAY, with silt seams, firm, grey | 4 | SS | 4 | |
| | | 5 | SS | 1/600 | ×[5] |
| | | 6 | SS | 4 | ×[6] |
| | | 7 | SS | 4 | ×[6] |
| | | 8 | SS | 8 | |
| 268.7 / 5.9 | End of Borehole<br>Installed Standpipe<br>Note: Water was at surface upon completion. | | | | |

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (274, 273, 272, 271, 270, 269); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, × FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT $W$, LIQUID LIMIT $W_L$; WATER CONTENT (%) 15, 30, 45; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL



3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH01-3



**METRIC**

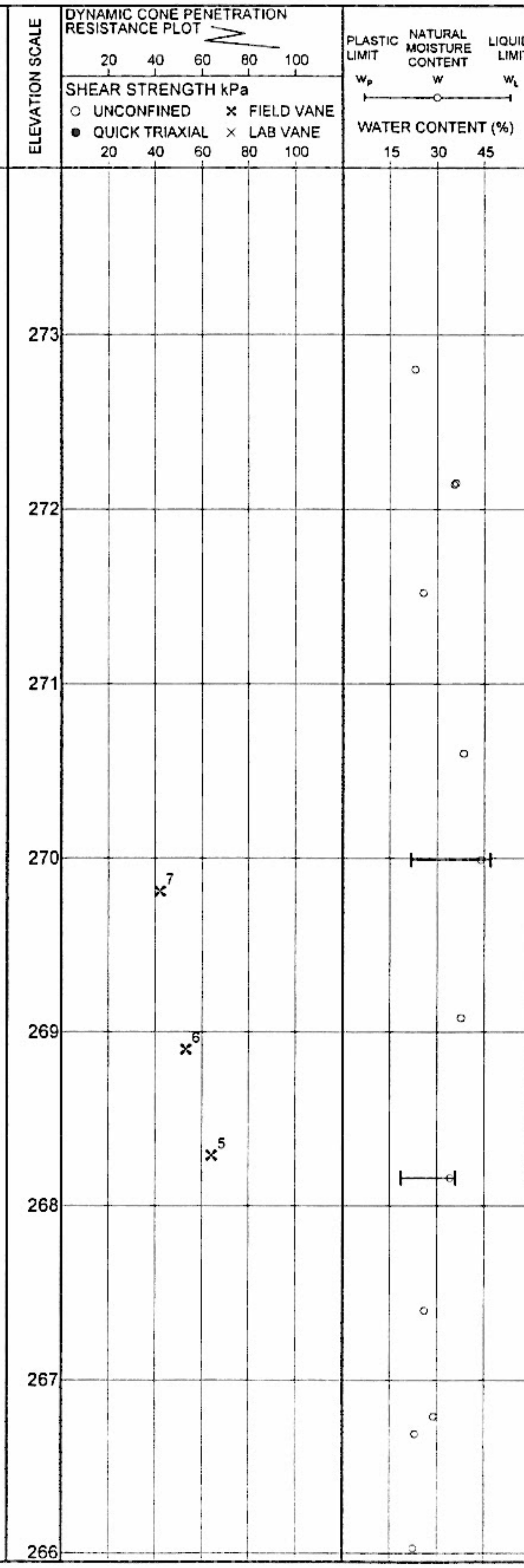
| | | | |
|---|---|---|---|
| W.P. 225-99-00 | LOCATION Hwy 655 Station 12+399, 27 Lt C/L, N 5399207 E 278816 | | ORIGINATED BY BK |
| DIST 53 | HWY 655 | BOREHOLE TYPE HS Augers, Split Spoons | COMPILED BY SS |
| DATUM Geodetic | DATE 04.10.01 - 04.10.01 | | CHECKED BY FG |

## SOIL PROFILE

| ELEV / DEPTH | DESCRIPTION |
|---|---|
| 274.0 | Ground Surface |
| 0.0 | Sand, trace silt, frequent cobbles, loose, brown (FILL) |
| 273.2 / 0.8 | Clayey silt, some sand, some organics, firm, brown (FILL) |
| 272.0 / 2.0 | Silty clay, trace sand, firm, grey (FILL) |
| 271.8 / 2.2 | Sand, some silt, some wood fragments, trace gravel, loose, brown (FILL) |
| 270.9 / 3.1 | SILTY CLAY, with silt seams, firm, grey |
| 269.4 / 4.6 | SILTY CLAY, with silt seams, stiff, grey |
| 267.1 / 6.9 | SILT, some clay, compact, grey, with clay seams |

## SAMPLES

| NUMBER | TYPE | "N" VALUES | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|
| 1 | SS | 4 | |
| 2 | SS | 5 | |
| 3 | SS | 8 | |
| 4 | SS | 2 | |
| 5 | SS | 1 | |
| 6 | SS | 1 | 0 5 54 41 |
| 7 | SS | 18 | |
| 8 | SS | 12 | |
| 9 | SS | 24 | |
| 10 | SS | 19 | |




Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH01-3



**METRIC**

| | | | |
|---|---|---|---|
| W.P. 225-99-00 | LOCATION Hwy 655 Station 12+399, 27 Lt C/L, N 5399207 E 278816 | | ORIGINATED BY BK |
| DIST 53 | HWY 655 | BOREHOLE TYPE HS Augers, Split Spoons | COMPILED BY SS |
| DATUM Geodetic | | DATE 04.10.01 - 04.10.01 | CHECKED BY FG |

| ELEV / DEPTH | SOIL PROFILE – DESCRIPTION | STRAT PLOT | SAMPLES – NUMBER | SAMPLES – TYPE | SAMPLES – "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, × FIELD VANE, × LAB VANE; 20 40 60 80 100) | PLASTIC LIMIT $w_P$ – NATURAL MOISTURE CONTENT $w$ – LIQUID LIMIT $w_L$ / WATER CONTENT (%) (15 30 45) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 11 | SS | 21 | | | | | | |
| | | | | | | | 265 | | | | |
| | | | 12 | SS | 14 | | | | | | |
| | | | 13 | SS | 22 | | 264 | | | | |
| 263.6 / 10.4 | SILTY SAND, compact, grey | | | | | | | | | | |
| | | | 14 | SS | 15 | | 263 | | | | |
| | | | 15 | SS | 20 | | | | | | |
| | | | 16 | SS | 27 | | 262 | | | | |
| 261.5 / 12.4 | End of Borehole | | | | | | | | | | |

${}^{3}$, $\times^{3}$: Numbers refer to Sensitivity    ○ 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

# RECORD OF BOREHOLE No BH01-4



**METRIC**

W.P. 225-99-00 LOCATION Hwy 655 Station 12+404, 26 Lt C/L, N 5399212 E 278814 ORIGINATED BY BK

DIST 53 HWY 655 BOREHOLE TYPE HS Augers, Split Spoons COMPILED BY SS

DATUM Geodetic DATE 04.11.01 - 04.11.01 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | FIELD VANE (sensitivity) |
|---|---|---|---|---|---|
| 274.1 | Ground Surface | | | | |
| 0.0 | Sand, some silt, frequent cobbles, compact, brown (FILL) | 1 | SS | 14 | |
| 273.4 / 0.7 | Clayey silt, some organics, firm, dark brown (FILL) | | | | |
| 273.1 / 1.0 | SILTY CLAY, with silt seams, firm, grey | 2 | SS | 8 | |
| | | 3 | SS | 2 | |
| | | 4 | SS | 2 | |
| | | 5 | SS | 1 | × 6 |
| | | 6 | SS | 1/600 | × 6 |
| 269.6 / 4.5 | SILTY CLAY, with silt seams, stiff, grey | 7 | SS | 1 | × 7 |
| | | 8 | SS | 12 | × 4 |
| 268.2 / 5.9 | End of Borehole | | | | |
| | Installed Standpipe | | | | |
| | Note: Water was at surface upon completion. | | | | |

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (274, 273, 272, 271, 270, 269); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, × FIELD VANE, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT $W_P$, NATURAL MOISTURE CONTENT $W$, LIQUID LIMIT $W_L$; WATER CONTENT (%) 15 30 45; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

MTO 11365A.GPJ ON_MOT.GDT 09/01/02

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH01-5



**METRIC**

| | | | |
|---|---|---|---|
| W.P. 225-99-00 | LOCATION Hwy 655 Station 12+386, 2 Rt C/L, N 5399209 E 278848 | | ORIGINATED BY BK |
| DIST 53 | HWY 655 | BOREHOLE TYPE HS Augers, Split Spoons | COMPILED BY SS |
| DATUM Geodetic | DATE 05.12.01 - 05.12.01 | | CHECKED BY FG |

| ELEV / DEPTH | SOIL PROFILE – DESCRIPTION | STRAT PLOT | SAMPLES – NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, ✕ FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100 | PLASTIC LIMIT $W_P$ / NATURAL MOISTURE CONTENT W / LIQUID LIMIT $W_L$; WATER CONTENT (%) 15 30 45 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 284.3 | Highway Surface | | | | | | | | | | |
| 284.2 / 0.1 | 60 mm of ASPHALT | | | | | | | | | | |
| 284.2 / 0.1 | Sand, trace silt, loose, grey (FILL) | | | | | | | | | | |
| 284.0 / 0.3 | Sand, trace silt, trace gravel, dense, brown (FILL) | | | | | | | | | | |
| | Sand, trace silt, trace gravel, occassional cobbles, dense to very dense, brown (FILL) | | | | | | 284 | | | | |
| | | | | | | | 283 | | | | |
| | | | 1 | SS | 67 | | | | | | |
| | | | | | | | 282 | | | | |
| | | | 2 | SS | 75 | | 281 | | | | |
| | | | | | | | 280 | | | | |
| | | | 3 | SS | 89 | | | | | | |
| 278.9 / 5.5 | Silt, some gravel, some sand, trace clay, compact, grey (FILL) | | | | | | 279 | | | | |
| | | | 4 | SS | 19 | | 278 | | | | |
| | | | | | | | 277 | | | | |
| | | | 5 | SS | 25 | | | | | | |

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Ministry of Transportation Ontario



# RECORD OF BOREHOLE No BH01-5



**METRIC**

W.P. 225-99-00 LOCATION Hwy 655 Station 12+386, 2 Rt C/L, N 5399209 E 278848 ORIGINATED BY BK

DIST 53 HWY 655 BOREHOLE TYPE HS Augers, Split Spoons COMPILED BY SS

DATUM Geodetic DATE 05.12.01 - 05.12.01 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | REMARKS |
|---|---|---|---|---|---|---|
| | | | | | 276 | |
| | | 6 | SS | 11 | 275 | |
| | | | | | 274 | |
| | | 7 | SS | 10 | 273 | |
| 272.2 / 12.2 | SANDY SILT, some organics, compact, grey black | 8 | SS | 13 | 272 | |
| 270.9 / 13.5 | SILTY CLAY, stiff, grey | 9 | SS | 4 | 271, 270 | |
| 269.7 / 14.6 | End of Borehole | | | | | |

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, ✕ FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) 15 30 45; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

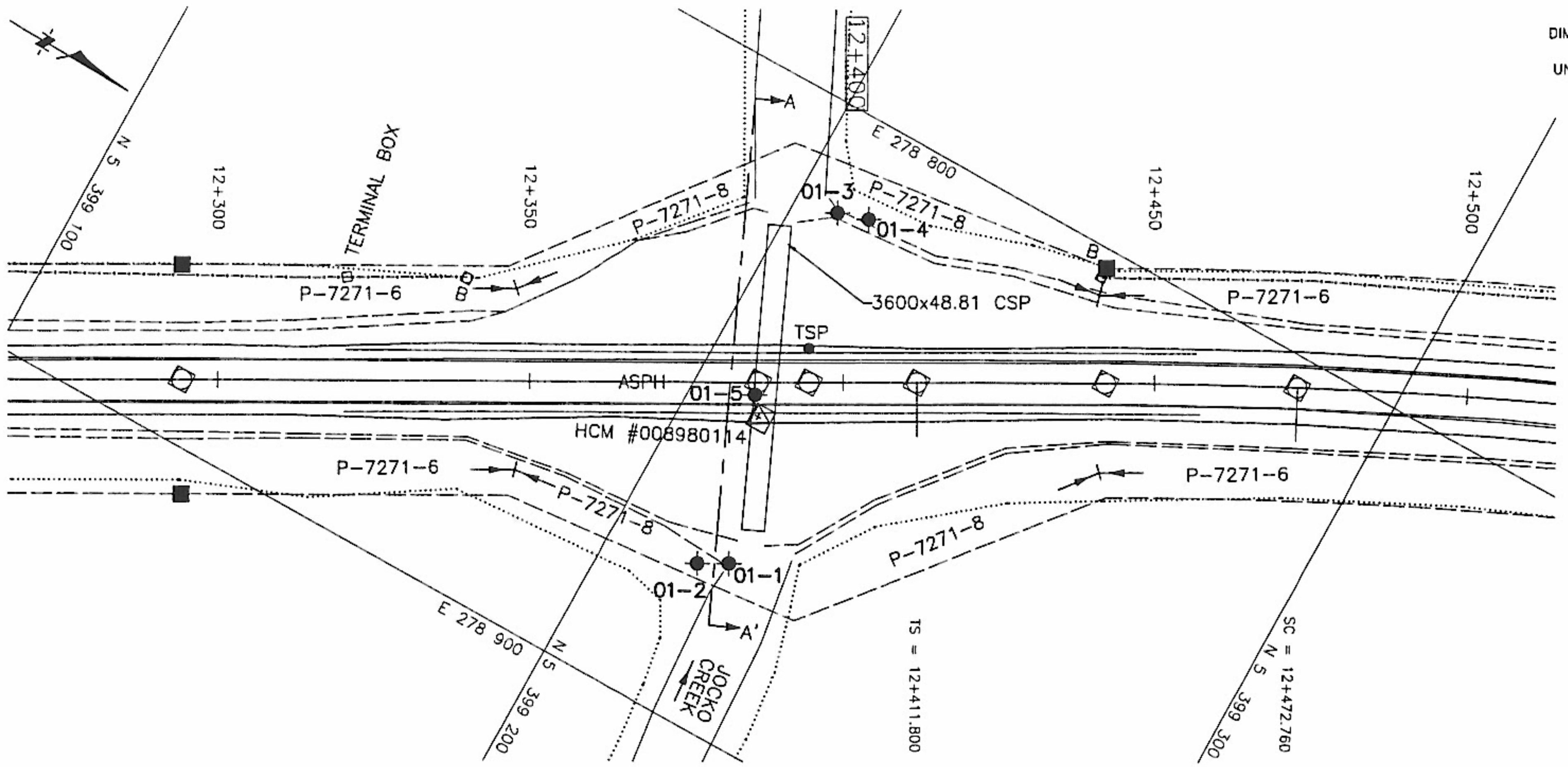
Field vane at approx. elev. 269.7: ✕ (sensitivity 2), shear strength approx. 45 kPa.

$^3 \times ^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

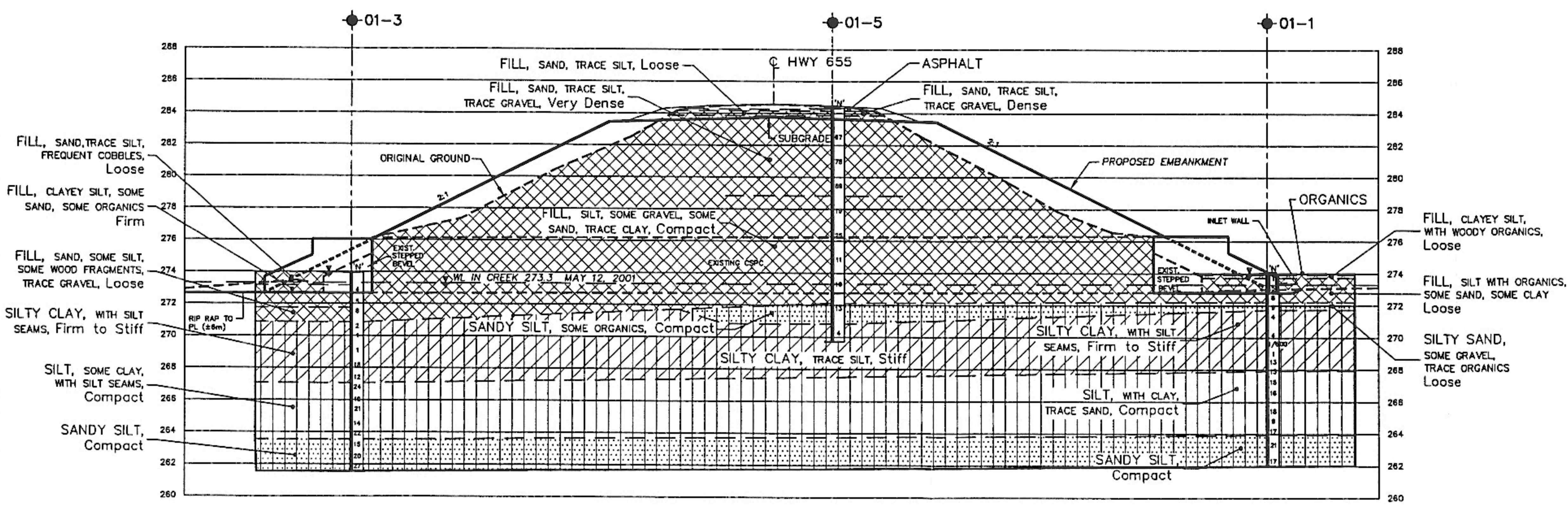
**METRIC**
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

| | |
|---|---|
| CONT No — | |
| WP No 225-99-00 | |
| CULVERT MODIFICATION<br>JOCKO CREEK<br>STA 12+350 TO STA 12+450<br>BORE HOLE LOCATIONS & SOIL STRATA | SHEET<br>1 |

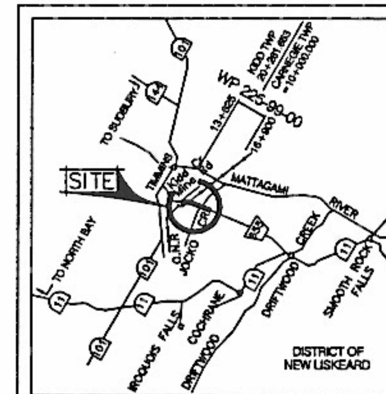
JACQUES, WHITFORD AND ASSOCIATES LIMITED




PLAN
SCALE 10m 0 10m




CROSS SECTION A–A
SCALE 3m 0 3m




KEY PLAN
NOT TO SCALE

**LEGEND**

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation
- WL in Piezometer
- Piezometer

| No | ELEVATION | NORTHINGS | EASTINGS |
|---|---|---|---|
| 01-1 | 274.0 | 5 399 219 | 278 873 |
| 01-2 | 274.7 | 5 399 214 | 278 876 |
| 01-3 | 274.0 | 5 399 207 | 278 816 |
| 01-4 | 274.1 | 5 399 212 | 278 814 |
| 01-5 | 284.3 | 5 399 209 | 278 848 |

**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.

| Rev. | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | - | | - |

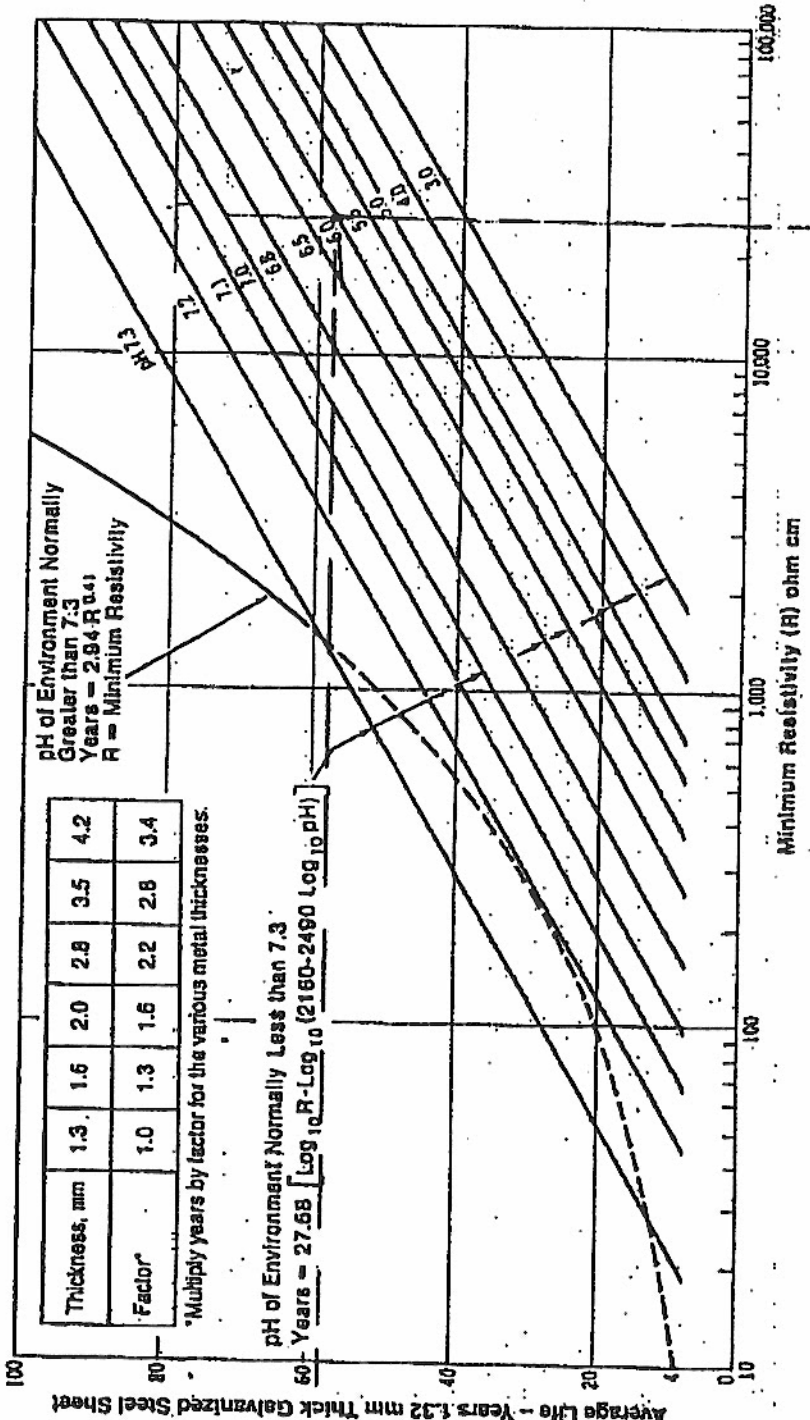
GEOCRES No 42A-54

| | | | |
|---|---|---|---|
| HWY No 655 | | | DIST 53 |
| SUBM'D FJG | CHECKED | DATE 2002-01-09 | SITE |
| DRAWN GBB | CHECKED | APPROVED | DWG 11385-1 |

11385-1

TO: Fred J. Griffiths
From: Les Renta Page 2 of 2






| Thickness, mm | 1.3 | 1.6 | 2.0 | 2.8 | 3.5 | 4.2 |
|---|---|---|---|---|---|---|
| Factor* | 1.0 | 1.3 | 1.6 | 2.2 | 2.8 | 3.4 |

Figure 5-4 Chart for estimating average life of plain galvanized culverts

armtec LIMITED

# FAX MESSAGE

| | | | |
|---|---|---|---|
| To | Fred J. Griffiths, Ph.D,P.Eng.<br>Jacques Whitford Consulting Engineers<br><br>Fax 613-738-0721<br>Tel 613-738-0708 | From | Les Ranta<br>Sudbury Sales Office<br><br>Phone 705-692-7007<br><br>Fax 705-692-7227<br><br>Toll Free 1-800-315-2720 |
| Date | Oct. 10, 2001 | | |
| Page | 1 OF 2 | | |

**SUBJECT: W.P. 225-99-00, HIGHWAY 655, DISTRICT NO. 53, NEW LISKEARD**
**JOCKO CREEK CULVERT**

Dear Sir:

Thank you for the opportunity to assist you with this project.

This opinion of life expectancy is based on the information contained in "Chapter 5: DURABILITY" of the "Handbook of Steel Drainage and Highway Construction Products – Canadian Edition (1984)".

Using Figure 5-4, "Chart for estimating average life of plain galvanized culverts" as a guide, one may expect the culvert in your description to have an 63 year "expected service life remaining". Here's the rational that I used:

- PH = 6.2
- Resistivity = 26,000 ohm*cm
- Average thickness 2.8mm

**Calculation 1:** From Figure 5-4, 1.3mm thick galvanized pipe would have an "Estimated Average Life" Of 58 years.

**Calculation 2:** For 2.8mm thick galvanized pipe material, "Estimated Average Life" would be 2.2 x 58 years = 127 years.

**Calculation 3:** Consideration should be given to the fact that the areas of minimum steel thickness are without zinc coating (bare steel) on at least one side. Some may conservatively use a 50% reduction to the "Estimated Average Life" from Figure 5-4. This would result in an "expect service life remaining" of 63 years.

I trust that this estimation meets your satisfaction at this time, and I welcome your call should you have any additional questions, comments or concerns.

Yours truly,

Les Ranta, P.Eng.
Armtec Limited