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REMARKS:

GEOCRES # 30M12-248

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FOUNDATION INVESTIGATION AND DESIGN REPORT
MULLET CREEK BRIDGE
HIGHWAY 403 WIDENING BETWEEN
HIGHWAYS 407 AND 401, MISSISSAUGA
G.W.P. 613-89-00, AGREEMENT NO. 2005-A-000201

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FOUNDATION INVESTIGATION REPORT
MULLET CREEK BRIDGE
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1.0 INTRODUCTION

Golder Associates Ltd. has been retained by The Greer Galloway Group Inc. (Greer Galloway) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation investigation and design services for the widening of Highway 403 between Highways 401 and 407 in Mississauga, Ontario. The foundations engineering component of the project includes widening of both the Mullet Creek bridge and the Matheson Boulevard overpass structures within the median area of Highway 403. This report addresses the Mullet Creek bridge widening.

The purpose of the foundation investigation is to determine the subsurface conditions at the site of the proposed structure by drilling boreholes, and carrying out in-situ tests and laboratory tests on selected samples. Existing subsurface data from a report prepared by the MTO ("Foundation Investigation Report for Proposed Structure over Relocated Mullet Creek and New Highway 403", GEOCRES No. 30M12-125, dated August 1977) was used to supplement the data obtained in the current investigation.

The terms of reference for the scope of work are outlined in Golder Associates Ltd. Proposal No. P01-1108, dated April 2000. The work was carried out in accordance with the Quality Control Plan for Foundation Design Services, submitted to MTO on June 26, 2000.

The General Arrangement plan showing the proposed abutment configuration for the widened Mullet Creek structure was provided by Greer Galloway in digital format on October 23, 2000.

2.0 SITE DESCRIPTION

The existing eastbound and westbound Highway 403 bridges over Mullet Creek are located approximately 500 m west of the Credit River, and about 300 m west of Mississauga Road, in the City of Mississauga, Regional Municipality of Peel.

The original Mullet Creek valley was about 80 m wide, with the valley floor at about Elevation 136 m to 137 m and the crest of the slopes at about Elevation 142 m. During the construction of the westbound and eastbound Highway 403 structures, the valley was partly infilled and Mullet Creek was rechannelled up to about 30 m west of its natural course. Within the Highway 403 median area, the original stream bed was located immediately east of the east abutments of the existing bridge structures.

Currently, the Highway 403 grade at Mullet Creek declines from about Elevation 145 m to 144 m between the west and east limits of the structures, and the stream bed is at about Elevation 135.2 m at the centreline of Highway 403. In the median within the approach embankment area, where fills were placed as part of the original construction, the present ground surface Elevation is about 143.5 m, approximately 0.5 m to 1.5 m lower than the adjacent Highway 403 grade. The existing median fill slopes down toward Mullet Creek in the vicinity of the west and east abutments, to about Elevation 136.5 m at the toe. Retaining walls are present adjacent to these slopes along the north and south sides of the eastbound and westbound structures, respectively.

The existing Highway 403 eastbound and westbound bridges over Mullet Creek are single-span structures supported on steel H-piles driven to bedrock, with the top of the pile caps at about Elevation 139.6 m. These foundation conditions were determined from the general layout drawings for the existing structures (Sheet 215 of Contract No. 80-71, and Sheet 157 of Contract No. 94-57). The structures were originally built under Contract No. 80-71, and widening of the outside lanes of both structures was carried out under Contract No. 94-57.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between October 19 and 26, 2000. At this time, four boreholes were advanced to obtain subsurface information in the vicinity of the west abutment and at the approach embankments. Also referenced in this report are boreholes advanced during the 1977 subsurface investigation carried out by the MTO (GEOCRES No. 30M12-125, referenced in Section 1.0) for the original construction of the Highway 403 structures over Mullet Creek.

The investigation was carried out using a bombardier-mounted CME-55 drill rig supplied and operated by Master Soil Investigations Ltd. of North York, Ontario. Boreholes 1 and 3 were extended to about 3.5 m depth at the approach embankments, and Boreholes 2 and 4 were advanced to between 5.9 m and 10.8 m depth at the west abutment. Samples of the overburden were obtained at 0.75 m to 1.5 m intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedure. The bedrock was cored using NQ-size coring equipment. The groundwater conditions in the open borehole were observed throughout the drilling operations.

The field work was supervised on a full-time basis by a member of our engineering staff who located the boreholes in the field, directed the drilling, sampling, coring and in-situ testing operations, and logged the boreholes. The soil and rock samples were identified in the field, placed in labelled containers and transported to our laboratory in Mississauga for further examination. Index and classification tests consisting of water content determinations and Atterberg Limits tests were carried out on selected soil samples.

The boreholes were located in the field relative to the existing structures, and the UTM northing and easting coordinates for these boreholes were determined from the digital files provided by Greer Galloway. The ground surface elevations at the borehole locations were surveyed relative to the existing bridge abutments, and were further compared to digital survey information provided by Greer Galloway; the borehole elevations are referenced to the geodetic datum. The borehole locations are shown on Drawing 1, and northing and easting coordinates are indicated on the Record of Borehole sheets.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

The site is located on the margin of the physiographic regions known as the Peel Plain and the Trafalgar Moraine portion of the South Slope. The surficial soils generally consist of clayey silt to silty clay till. In the area west of the Credit River, the till typically has a significant shale content, and overlies shale bedrock, with interbedded limestone layers, of the Georgian Bay Formation (Chapman and Putnam, "The Physiography of Southern Ontario", 3rd Edition, 1984).

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory testing carried out on selected soil samples, are given on the attached Record of Borehole sheets. The detailed subsurface conditions encountered in the 1977 boreholes are given on the Record of Borehole sheets in Appendix A. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

Boreholes 1 and 3 were advanced for the west and east approach embankments, respectively, while Boreholes 2 and 4 were advanced in the vicinity of the west abutment. The locations and elevations of the current and 1977 borings, together with the interpreted stratigraphic profile and sections at the bridge site, are shown on Drawing 1.

In summary, the subsoils encountered at the site consist of up to 9.5 m of fill overlying shale bedrock of the Georgian Bay Formation. A thin veneer of silty clay till was encountered overlying the bedrock in the 1977 investigation; this till is expected to be present below the fill, although it was not encountered in Boreholes 2 or 4 drilled through the full overburden depth during the current investigation. A detailed description of the subsurface conditions encountered in the boreholes for the current and 1977 investigations is provided in the following sections.

4.2.1 Topsoil

In the boreholes drilled as part of the current investigation, trace organics were encountered within the upper 100 mm to 300 mm of the silty clay fill. A surficial layer of topsoil, typically 300 mm in thickness, was encountered in the boreholes drilled during the 1977 investigation.

4.2.2 Fill

The fill material placed within the original Mullet Creek valley is up to 9.3 m thick as encountered in Borehole 2, drilled about 10 m west of the west abutments for the existing structures. In Borehole 2, the upper 1.4 m of this fill consists of compact to very dense silty sand containing some gravel. Below this depth, and from ground surface in the two boreholes (Boreholes 1 and 3) advanced for the approach embankments, the fill is comprised of brown to red-brown silty clay containing trace to some sand, gravel and shale fragments.

This silty clay fill is typically very stiff, although it varies from stiff to hard; the measured Standard Penetration Test (SPT) "N" values ranged from 9 to 32 blows per 0.3 m of penetration, but were typically between 15 and 25 blows per 0.3 m of penetration. The natural water contents measured on selected samples of the fill were typically between 5 and 17 per cent. Atterberg limits measured on a selected, representative sample of the fill indicated a plastic limit of about 18 per cent, a liquid limit of 29 per cent, and a plasticity index of about 12 per cent. These test results indicate that the silty clay fill is inorganic and of low plasticity.

4.2.3 Clayey Silt / Silty Clay Till

The boreholes drilled during the 1977 investigation encountered a thin veneer of clayey silt to silty clay till, about 0.5 m to 1.5 m in thickness, overlying the shale bedrock. Trace quantities of sand and gravel were reported. The till was typically described as stiff to hard, with measured SPT "N" values of 13 to 45 blows per 0.3 m of penetration. Atterberg limits measured on samples of the till indicated plastic and liquid limits of 16 to 20 per cent and 25 to 34 per cent, respectively, with plasticity indices of about 7 to 14 per cent. The measured water contents typically ranged from 7 to 21 per cent, near or below the plastic limit of the material.

4.2.4 Bedrock

Grey shale bedrock of the Georgian Bay Formation was encountered in all twelve of the 1977 boreholes, and was encountered in the two boreholes drilled in the vicinity of the west abutment during the current investigation. The surface of the bedrock in the areas investigated varies from about Elevation 134.7 m to 135.6 m; the bedrock surface elevation as encountered at the borehole locations is summarized in the following table:

Borehole Number	*Top of Bedrock Elevation*
2	135.7 m
4	135.5 m
77-1	134.8 m (442.1 ft.)
77-2	135.4 m (444.3 ft.)
77-3	134.8 m (442.4 ft.)
77-4	135.1 m (443.4 ft.)
77-5	135.2 m (443.7 ft.)
77-6	135.3 m (444.0 ft.)
77-7	135.1 m (443.4 ft.)
77-8	135.0 m (442.8 ft.)
77-9	134.7 m (442.0 ft.)
77-10	135.6 m (445.0 ft.)
77-11	135.2 m (443.6 ft.)
77-12	135.1 m (443.4 ft.)

Bedrock coring was carried out in the twelve 1977 boreholes, and in one of the two boreholes advanced near the west abutment as part of the current investigation. Typically, the upper 150 mm to 450 mm of the shale is weathered. Limestone and siltstone interbeds were evident throughout the recovered core, and were between 150 mm and 600 mm in thickness. Rock Quality Designation (RQD) values were measured between about 30 and 60 per cent in Borehole 4, and between 7 and 53 per cent in the 1977 investigation. The total core recovery (TCR) ranged from about 70 to 100 per cent in the boreholes advanced during both investigations.

4.3 Groundwater Conditions

The groundwater conditions were observed in the open boreholes following drilling operations in both the current and 1977 investigations. In the current investigation, Boreholes 1 to 3 were dry; the groundwater level in Borehole 4 was at about 1.7 m depth (Elevation 134.6 m). In the June 1977 investigation, the water level in the twelve boreholes varied between Elevations 135.5 m

and 136 m, approximately 1 m below the ground surface. The water levels observed in the boreholes during both investigations were similar to the water level in Mullet Creek.

It should be noted that groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods of the year.

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PART B

FOUNDATION DESIGN REPORT
MULLET CREEK BRIDGE
HIGHWAY 403 WIDENING BETWEEN
HIGHWAYS 407 AND 401, MISSISSAUGA
G.W.P. 613-89-00, AGREEMENT NO. 2005-A-000201

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides recommendations on the geotechnical aspects of design of the proposed widening of the Highway 403 structures over Mullet Creek, based on interpretation of the factual information obtained during the current and 1977 investigations. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

It is understood that widening of Highway 403 at Mullet Creek into the median area is proposed. The current ground surface is at about Elevation 143.5 m on the west and east sides of Mullet Creek, sloping down toward the floodplain grade of Elevation 136.5 m; it will be necessary to raise the median grade by about 0.5 m to 8 m to match the existing Highway 403 grade of approximately Elevation 144 m to 145 m.

Based on the general and foundation layout drawings for the existing structures, from Contracts No. 80-71 and 94-57, the single-span bridges (including widened portions) over Mullet Creek are supported on HP 310 x 110 steel piles driven to bedrock. At both structures, the top of the pile caps is at Elevation 139.6 m, and the pile cut-off Elevation is 139.0 m. It is understood that the piles are about 5 m in length; the front two rows of piles are battered at 1:3, while the back row is battered at 1:10.

5.2 Bridge Foundations

The subsoils encountered in the boreholes put down during the current and 1977 investigations consist of very stiff embankment fill and very stiff to hard clayey silt / silty clay till, overlying shale bedrock. The bedrock surface is about 9 m to 10 m below the proposed Highway 403 grade in the median area.

Given the site grades, the subsurface conditions (particularly the deep and variable fills) and the proximity of the proposed structure to the existing westbound and eastbound bridges, it is recommended that the proposed structure utilize the same type of foundation system as the existing structures. Shallow foundations are not recommended as the variable embankment fill placed in the median area during the original construction of the westbound and eastbound structures is not a suitable founding material.

5.2.1 Steel H-Pile Foundations

Steel HP 310 x 110 piles, driven to practical refusal on the shale bedrock below Elevation 135 m, are recommended for support of the abutments. The top of the pile cap would be at Elevation 139.6 m, and the pile cut-off Elevation would be 139.0 m to match the existing foundation systems.

It should be noted that the surface of the shale bedrock varies slightly across the site; in the boreholes drilled to date, it has been encountered between Elevation 134.7 m and 135.6 m. It is anticipated that the bedrock surface will be encountered at about Elevation 135 m at the proposed east abutment; at the proposed west abutment, it is anticipated that the bedrock surface will be encountered at about Elevation 135.5 m.

The silty clay fill and, where present, clayey silt / silty clay till through which the piles are to be driven may contain boulders or other obstructions, although none were encountered during the current borehole investigation and none were listed on the 1977 borehole records. Stiffening of the pile tip with flange plates, per OPSD 3301.00, will be required for protection during pile driving.

5.2.2 Factored Geotechnical Resistance

For design, the factored axial resistance at Ultimate Limit States (ULS) for HP 310 x 110 piles driven to practical refusal on the shale bedrock may be taken as 2,000 kN. Serviceability Limit States (SLS) conditions will not apply to piles driven to the bedrock at this site.

Pile termination or set criteria will be required to avoid overdriving and damage to the piles. The pile set criteria will be dependent on the pile driving hammer type and selected pile. The set criteria

can be determined through a variety of methods, including empirical correlations and wave equation analyses, at the time of construction once the hammer and pile types are known. The applicable note to be shown on the drawings is "Piles to be driven to bedrock."

Provision should be made to re-tap selected piles to confirm the set after adjacent piles have been driven, as per MTO's current Special Provision.

5.2.3 Resistance to Lateral Loads

The lateral loading could be resisted fully or partially by the use of battered piles. If vertical piles are used, the resistance to the lateral loading will have to be derived from the soil in front of the pile. If integral or semi-integral abutments are under consideration, there may also be a requirement for the piles to move sufficiently to accommodate the bridge deck deflections.

The resistance to lateral loading in front of the pile may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction, k_h, is based on the following equation:

$$k_h = \frac{k_{s1}}{5B}$$ where B is the pile diameter in m

For the typically very stiff silty clay fill at the site, the range in value of constant of horizontal subgrade reaction (k_{s1}) may be taken as 20 MPa to 45 MPa in the structural analysis.

Group action for lateral loading should be considered when the pile spacing in the direction of the loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of lateral subgrade reaction in the direction of loading by a reduction factor, R, as follows:

Pile Spacing in Direction of Loading	*Subgrade Reaction Reduction Factor, R*
8B	1.00
6B	0.70
4B	0.40
3B	0.25

5.2.4 Frost Protection

The pile caps should be provided with a minimum of 1.2 m of soil cover for frost protection.

5.3 Lateral Earth Pressures

The lateral pressures acting on the bridge abutments will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill and on the subsequent lateral movement of the structure. The following recommendations are made concerning the design of the abutments, in accordance with the Ontario Highway Bridge Design Code (OHBDC):

- Select free-draining granular fill meeting the specifications of OPSS Granular "A" or Granular "B" but with less than 5 per cent passing the 200 sieve should be used as backfill behind the abutments. This fill should be compacted in loose lifts not greater than 200 mm in thickness to 95 per cent of the material's Standard Proctor maximum dry density. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the abutment granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD 3501.00.

- A compaction surcharge equal to 16 kPa should be included in the lateral earth pressures for the structural design of the abutment wall, in accordance with OHBDC Figure 6-7.4.3. Compaction equipment should be used in accordance with OPSS 501.06.

- The granular fill may be placed either in a zone with width equal to at least 1.2 m behind the back of the stem (Case I) or within the wedge-shaped zone defined by a 60° line extending up and back from the bottom of the rear face of the footing (Case II).

- For Case I, the pressures are based on the existing and proposed embankment fill materials and the following parameters (unfactored) may be assumed:

Soil unit weight:	20 kN/m3
Coefficients of lateral earth pressure:	
Active, K_a	0.35
At rest, K_o	0.50

- For Case II, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	Granular "A"	**Granular "B" Type II**
Soil unit weight:	22 kN/m3	21 kN/m3
Coefficients of lateral earth pressure:		
Active, K_a	0.27	0.31
At rest, K_o	0.43	0.47

- If the wall support allows lateral yielding of the stem, active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design.

It should be noted that the above design recommendations and parameters assume level backfill and ground surface behind the abutment.

5.4 Excavations

5.4.1 Temporary Excavations for Pile Caps

Excavation for the pile caps will extend about 5 m to 6 m below the existing Highway 403 grade, through the stiff to very stiff silty clay fill. Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act for Construction Activities. The stiff to very stiff silty clay fill soils at this site would be classified as Type 2 soil. Temporary open-cut slopes should be maintained no steeper than 1 horizontal to 1 vertical (1H:1V). Where space restrictions dictate alongside Highway 403, roadway protection will be required; recommendations for such temporary protection are provided in Section 5.4.2.

The pile caps will be founded at about Elevation 139.0 m, on the generally very stiff silty clay fill. This soil will be sensitive to disturbance from ponded water, construction traffic and frost. It is recommended that a lean concrete mud coat be placed at the base of the pile cap excavation prior to

pile driving, to protect the subgrade from such softening and disturbance; the cleaned excavation base should be inspected by qualified geotechnical personnel prior to placement of the mud coat.

Groundwater seepage into the pile cap excavations could occur through the fill, although this is expected to be minor. Pumping from properly-filtered sumps or a filtered drain placed at the base of the excavation, but maintained outside of the pile cap area, should provide sufficient groundwater control during foundation works. In addition, surface water run-off should be directed away from the pile cap excavations.

5.4.2 Temporary Roadway Protection

Due to the limited space in the median area, temporary shoring will be required adjacent to the eastbound and westbound lanes of Highway 403 to facilitate excavation to the pile cap level, and driving from this level. The temporary support system could consist of soldier piles and lagging, with the piles socketted into pre-augered holes or driven below the excavation base into the very stiff silty clay fill and / or the shale and limestone bedrock. Lateral support to a soldier pile and lagging wall system would be in the form of struts and walers, rakers, or temporary soil anchors. If a soldier pile and lagging system is adopted, cobbles and boulders should be expected within the fill and till soils during soldier pile and soil anchor installation.

5.4.2.1 Earth Pressure Distribution for Temporary Shoring Design

The design of strutted soldier pile and lagging walls should be based on a rectangular earth pressure distribution, while the design of shoring walls supported by anchors or rakers should be based on a triangular earth pressure distribution; appropriate distributions and design parameters are provided below. Surcharge loadings, as for traffic on Highway 403, must be added to these distributions. The design groundwater level for both cases may be taken at Elevation 136 m.

The unfactored triangular earth pressure distribution can be calculated as follows:

$$p = K_a (\gamma H - p_w) + p_w$$

where

H = the height of the excavation at any point in metres
K_a = 0.3 for level ground behind excavation
γ = soil unit weight = 21 kN/m^3
p_w = porewater pressure, based on a design groundwater elevation of 136 m

The unfactored rectangular earth pressure distribution can be calculated as follows:

$$p = K \gamma H$$

where

H = the total height of the excavation
K = 0.3 for level ground behind excavation
γ = soil unit weight = 21 kN/m^3

The passive toe restraint to the soldier piles may be determined using a triangular earth pressure distribution acting over an equivalent width equal to three times the pile width or pile socket diameter. The coefficient of passive lateral earth pressure, K_p, may be taken as follows:

In very stiff silty clay till:	K_p	= 3.3
In shale / limestone bedrock:	K_p	= 7.5

5.4.2.2 Temporary Soil Anchor Design

The working load on temporary soil or rock anchors should not be greater than 60 per cent of the ultimate tensile strength of the anchor tendons or bars. The anchors may be sized based on the following ultimate bond stresses acting between the grout and the soil / rock; the ultimate anchor capacity calculated from these adhesion values should be reduced by a factor of safety of at least 1.5:

Very stiff silty clay fill above Elevation 135 m:	50 kPa
Shale / limestone bedrock below Elevation 135 m:	300 kPa

Because the ground-to-anchor bond is highly dependent upon the installation technique, the complete anchor design should be the responsibility of the Contractor, who should be held to an

anchor performance specification enforced by proof tests on all anchors. The Contract Documents should incorporate a Non-Standard Special Provision (NSSP) to this end. Temporary anchor installation and testing should be carried out under the full-time inspection of a geotechnical engineer. A performance test should be carried out, to 200 per cent of the design working load, on at least one anchor to confirm the design and the Contractor's installation method. In addition, each anchor should be proof-tested to 125 per cent of the working load. The tensile stress in the anchor bar or strands during test loading should not exceed 80 per cent of the guaranteed ultimate tensile strength of the bar or strands. Anchor installation and preloading should be complete before the excavation proceeds below the anchor elevation.

5.5 Embankment Construction

Placement of additional embankment fill material will be required in the median area of Highway 403; a grade raise of up to about 8 m will be required within the limits of the approach embankments. Provided that the approach embankment subgrade is properly prepared, as outlined below, settlement of the existing silty clay fill is expected to be negligible; any settlement is likely to occur within the new embankment fill itself.

In order to minimize differential settlement between the widened portion of Highway 403 and the existing westbound and eastbound Highway 403 embankments, the use of granular fill is recommended for the widening. The majority of settlement of granular fills will occur during construction whereas the majority of settlement of cohesive fills, if used, would occur post-construction. Fill placement should be controlled as outlined below.

In addition, keying of the new embankment fill into the existing side slopes along the eastbound and westbound lanes of Highway 403 would help to reduce the impact of differential settlement. Such benching should be carried out in accordance with OPSD 208.01. In general, differential settlement has the greatest impact on the travelled road surface and this should be addressed in the pavement design.

Topsoil and softened or disturbed fill soils should be stripped from below the approach embankment areas, and the subgrade proof-rolled to delineate any softened or disturbed areas; such

areas will require subexcavation and replacement with compacted granular soil prior to placement of the embankment fill. Construction of the embankment above the prepared subgrade may be carried out using clean earth fill meeting the specifications of OPSS 212, or Select Subgrade Material meeting the specifications of OPSS 1010, depending on material availability. All embankment fill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 per cent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course should be compacted to 100 per cent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

We trust that this report is sufficient for your current design requirements. If you have any questions or require further information, please contact the undersigned.

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LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π = 3.1416
ln x, natural logarithm of x
$\log_{10}$ x or log x, logarithm of x to base 10
g acceleration due to gravity
t time
F factor of safety
V volume
W weight

II. STRESS AND STRAIN

γ shear strain
Δ change in, e.g. in stress: $\Delta\sigma$
ε linear strain
ε_v volumetric strain
η coefficient of viscosity
ν Poisson's ratio
σ total stress
σ' effective stress ($\sigma' = \sigma - u$)
σ'_{vo} initial effective overburden stress
$\sigma_1,\sigma_2,\sigma_3$ principal stresses (major, intermediate, minor)
σ_{oct} mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ shear stress
u porewater pressure
E modulus of deformation
G shear modulus of deformation
K bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$ bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$ dry density (dry unit weight)
$\rho_w(\gamma_w)$ density (unit weight) of water
$\rho_s(\gamma_s)$ density (unit weight) of solid particles
γ' unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R relative density (specific gravity)of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e void ratio
n porosity
S degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (con't.)

w water content
w_l liquid limit
w_p plastic limit
I_P plasticity Index = $(w_l - w_p)$
w_S shrinkage limit
I_L liquidity index = $(w - w_p) / I_p$
I_C consistency index = $(w_l - w) / I_p$
e_{max} void ratio in loosest state
e_{min} void ratio in densest state
I_D density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h hydraulic head or potential
q rate of flow
v velocity of flow
i hydraulic gradient
k hydraulic conductivity (coefficient of permeability)
j seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c compression index (normally consolidated range)
C_r recompression index (overconsolidated range)
C_S swelling index
C_α coefficient of secondary consolidation
m_v coefficient of volume change
c_v coefficient of consolidation
T_v time factor (vertical direction)
U degree of consolidation
σ'_p pre-consolidation pressure
OCR Overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

(e) Shear Strength

τ_p, τ_r peak and residual shear strength
ϕ' effective angle of internal friction
δ angle of interface friction
μ coefficient of friction = tan δ
c' effective cohesion
c_u, s_u undrained shear strength ($\phi = 0$ analysis)
p mean total stress $(\sigma_1 + \sigma_3)/2$
p' mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q $(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u compressive strength $(\sigma_1 - \sigma_3)$
S_t sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$
2. Shear strength = (Compressive strength)/2

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering.

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 - 3 m
Moderately close	0.3 - 1 m
Close	50 - 300 mm
Very close	< 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

Note: * Grains >60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
ll - Parallel To	
⊾ - Perpendicular To	

RECORD OF BOREHOLE No 1

1 OF 1 **METRIC**

PROJECT 001-1131-A
W.P. 613-89-00
DIST _____ HWY 403
DATUM Geodetic

LOCATION N 4824353.7; E 289532.3
BOREHOLE TYPE 108mm Solid Stem Augers
DATE Oct.19/00

ORIGINATED BY GM
COMPILED BY LCC
CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
144.70	GROUND SURFACE										
0.00	Silty Clay, trace to some sand, gravel and shale fragments Very stiff to hard Red-brown Moist (Fill)		1	SS	16		144		○		
			2	SS	32						
			3	SS	16		143		○		
			4	SS	23		142				
141.19			5	SS	28				○		
3.51	END OF BOREHOLE Note: Borehole dry on completion of drilling.										

$+^{3}$, $\times^{3}$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

1 OF 1 **METRIC**

PROJECT 001-1131-A
W.P. 613-89-00
DIST _____ HWY 403
DATUM Geodetic

LOCATION N 4824365.2; E 289543.4
BOREHOLE TYPE 108mm Solid Stem Augers
DATE Oct.19/00

ORIGINATED BY GM
COMPILED BY LCC
CHECKED BY _____

ELEV / DEPTH	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 × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
145.00	GROUND SURFACE										
0.00	Silty Sand, some gravel Compact to very dense Brown Moist (Fill)		1	SS	52				○		
			2	SS	21		144				
143.63											
1.37	Silty Clay, trace to some sand, gravel and shale fragments, trace rootlets Stiff to very stiff Brown to red-brown Moist (Fill)		3	SS	32				○		
			4	SS	18		143				
			5	SS	9		142		○ —		
			6	SS	17		141				
			7	SS	16		140				
			8	SS	24		139		○		
							138				
135.68	Some organics in upper portion of Sample 9.		9	SS	50/.15		137			54.1 ○	
9.32	Shale with limestone interbeds (Georgian Bay Formation) Weathered to slightly weathered Grey						136				
134.20			10	SS	65/.08		135				
10.80	END OF BOREHOLE Note: Borehole dry on completion of drilling.										

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

RECORD OF BOREHOLE No 3

1 OF 1 **METRIC**

PROJECT 001-1131-A
W.P. 613-89-00
DIST _____ HWY 403
DATUM Geodetic

LOCATION N 4824400.7; E 289592.0
BOREHOLE TYPE 108mm Solid Stem Augers
DATE Oct.19/00

ORIGINATED BY GM
COMPILED BY LCC
CHECKED BY _____

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
143.70	GROUND SURFACE										
0.00	Silty Clay, trace sand and gravel, trace shale fragments Very stiff Red-brown Moist (Fill)		1	SS	18						
			2	SS	20		143				
			3	SS	17		142				
			4	SS	25		141				
140.19			5	SS	15						
3.51	END OF BOREHOLE Note: Borehole dry on completion of drilling.										

+ 3, × 3. Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 4

1 OF 1 **METRIC**

PROJECT 001-1131-A
W.P. 613-89-00
DIST _____ HWY 403
DATUM Geodetic

LOCATION N 4824377.0; E 289559.6
BOREHOLE TYPE 108mm Solid Stem Augers
DATE Oct.26/00

ORIGINATED BY GM
COMPILED BY LCC
CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
136.25	GROUND SURFACE										
0.00	Silty Clay, trace sand, gravel and organics (Fill) Stiff Brown Moist						136				
135.49											
0.76	Shale with limestone and siltstone interbeds (Georgian Bay Formation) Weathered to slightly weathered Grey		1	SS	80/.08	▽	135				
			2	SS	95/.08		134				
	Bedrock cored from 2.9m to 5.9m depth. For bedrock coring details, refer to Record of Drillhole 4.						133				
							132				
							131				
130.31											
5.94	END OF BOREHOLE Note: Water level on completion of drilling at 1.68m depth (Elev.134.6m).										

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

PROJECT: 001-1131-A

RECORD OF DRILLHOLE: 4

SHEET 2 OF 2

LOCATION: N 4824377.0; E 289559.6

DRILLING DATE: Oct.26/00

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-55

DRILLING CONTRACTOR: MASTER SOIL INVESTIGATIONS

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/m)	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		REFER TO RECORD OF BOREHOLE 4														
3		Shale with limestone and siltstone interbeds (Georgian Bay Formation) Weak to very weak Moderately to slightly weathered Grey Carbonaceous siltstone interbeds: 3.56m - 3.76m 4.40m - 4.50m 4.98m - 5.23m 5.38m - 5.79m Limestone layers: 5.23m - 5.38m		2.90	1											
4																
5					2											
6		END OF BOREHOLE		5.94												
7																
8																
9																
10																
11																
12																

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: GM
CHECKED: LCC

DRILLHOLE 1131AROC.GPJ GLDR_CAN.GDT 26/1/01 PS

OVERSIZE DRAWING

APPENDIX A

RECORD OF BOREHOLES
1997 MTO INVESTIGATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 1

WP 157-75-05 LOCATION Co-ords. N 15,827,211; E 950,002 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 22, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT / PLASTIC LIMIT / WATER CONTENT	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	W_P W W_L WATER CONTENT % 10 20 30	γ	% GR SA SI C
447.6	Ground Level									
0.0	Topsoil									
1.0	Heterogeneous mixture of clayey silt, sand & gravel (Glacial Till) Stiff		1	SS	28	▼				31 33 24 1
442.1										
5.5	Weathered					440				
437.1	Sound Shaly limestone Bedrock		2	BXL	Rec 70%					RQD 9%
10.5	End of Borehole									

Bedrock Description

From 5'5" to 5'11" Limestone, grey, medium textured, medium hard, fossiliferous with sandy sections.

From 5'11" to 10'5" Shale, grey, soft fissile with shaly sections.

...ICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 2

WP 157-75-05 LOCATION Co-ords. N 15,827,282; E 949,964 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 22, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	w_P w w_L WATER CONTENT % 10 20 30	γ	% GR SA SI CL
448.3	Ground Level									
0.0	Topsoil									
1.0 444.3	Heterogeneous mixture of clayey silt, sand, gravel (Glacial till) Stiff		1	SS	13	▼		o——		11 36 37 16
4.0 439.3	Shaly Limestone Bedrock Sound		2	BXL	Rec 100 %	440				RQD 40%
9.0	End of Borehole									

Bedrock Description

From 4'0" to 6'0" Limestone, grey, medium textured, medium hard to hard, fossiliferous.

From 6'0" to 10'5" Shale, grey, soft, fissile with shaly sections.

C CE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

HIGHWAY ENGINEERING DIVISION · ENGINEERING MATERIALS OFFICE · SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 3

WP 157-75-05 LOCATION Co-ords. N 15,827,355; E 949,932 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 21, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY RS

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w (w_P w w_L), WATER CONTENT % (10 20 30)	UNIT WEIGHT γ	REMARKS % GR SA SI C
448.4	Ground Level									
0.0	Topsoil									
1.0	Heterogeneous mixture of clayey silt, sand, & gravel. (Glacial Till), Hard		1	SS	45	▼				7 28 51 14
442.4			2	SS	100/5"					
6.0	— — — Weathered — — — Sound Shaly Limestone Bedrock		3	BXL	Rec 90%	440				RQD 7%
437.4										
11.0	End of Borehole									

Bedrock Description

From 6' to 7' Limestone, grey, medium textured, hard.

From 7' to 9'3" Shale, grey, soft, fissile with shaly sections.

From 9'3" to 9'9" Limestone, light grey, medium textured, hard, fossiliferous.

From 9'9" to 11' Shale, grey, soft, fissile with shaly sections.

C ..E REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 4

WP 157-75-05 LOCATION Co-ords. N 15,827,230; E 950,025 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 22, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT / PLASTIC LIMIT / WATER CONTENT	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	W_P W W_L WATER CONTENT % 10 20 30	γ	% GR SA SI C
446.9	Ground Level									
0.0	Topsoil									
1.0 / 443.4	Het.mix.of cl.si.sa.& gr.(Gl.Till) Hard		1	SS	38	▼		o		28 31 31 1
3.5 / 438.4	Shaly Limestone Sound Bedrock		2	BXL	Rec 100%	440				RQD 38%
8.5	End of Borehole									

Bedrock Description

From 3'5" to 5'5" Limestone, grey, medium textured, medium hard to hard, fossiliferous.

From 5'5" to 7'5" Shale, grey, soft, fissile with shaly sections.

From 7'5" to 8'5" Limestone, light grey, medium to coarse textured, medium hard, fossiliferous.

ICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 5

WP 157-75-05 LOCATION Co-ords. N 15,827,301; E 949,986 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 22, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	w_P w w_L WATER CONTENT % 10 20 30	γ	% GR SA SI CL
447.7	Ground Level									
0.0	Topsoil									
1.0	Heterogeneous mixture of clayey silt sa & gr									
443.7	Glacial Till, Hard		1	SS	45	▼		o——		13 15 55 17
4.0	Shaly Limestone Bedrock Sound		2	BXL	Rec 100%	440				RQD 45%
438.7										
9.0	End of Borehole									

Bedrock Description

From 4'0" to 6'4" Limestone, grey, medium textured, medium hard, fossiliferous.

From 6'4" to 8'5" Shale, grey, soft, fissile with shaly sections.

From 8'5" to 9' Limestone, grey, medium textured, medium hard, fossiliferous.

C ..E REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 6

WP 157-75-05 LOCATION Co-ords. N 15,827,376; E 949,961 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 21, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY RC

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 — SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	W_P W W_L — WATER CONTENT % 10 20 30	γ	% GR SA SI C
448.0	Ground Level									
0.0	Topsoil									
1.0 / 444.0	Het.mix.of cl.si.sa.& gr.(Gl.Till) V.Stiff		1	SS	16	▼				7 50 35 8
4.0 / 439.0	Shaly Limestone Bedrock Sound		2	BXL	Rec 100 %	440				RQD 28%
9.0	End of Borehole									

Bedrock Description

From 4' to 6'3" Limestone, grey, medium textured, hard, fossiliferous.

From 6'3" to 9' Shale, grey, soft, fissile, with shaly sections.

G ...E REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 7

WP 157-75-05 LOCATION Co-ords. N 15,827,333; E 950,024 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 22, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT w_L / PLASTIC LIMIT w_p / WATER CONTENT w (w_p — w — w_L) / WATER CONTENT % 10 20 30	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV			γ	% GR SA SI C
447.9 / 0.0	Ground Level Topsoil									
1.0 / 443.4	Heterogeneous mixture of clayey silt, sa. & gr. (Glacial till) V. Stiff		1	SS	22			○		45 31 16 8
4.5 / 438.4	Shaly Limestone Bedrock Sound		2	BXL	Rec 100 %	440				RQD 7%
9.5	End of Borehole									

Bedrock Description

From 4'5" to 6'6" Limestone, grey, medium textured, medium hard, fossiliferous.

From 6'6" to 8'7" Shale, grey, soft, fissile with shaly sections.

From 8'7" to 9'2" Limestone, grey, medium textured, medium hard, fossiliferous

From 9'2" to 9'5" Shale, grey, soft, fissile.

ICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 8

WP 157-75-05 LOCATION Co-ords. N 15,827,263; E 950,063 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 22, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	w_P — w — w_L WATER CONTENT %	γ	% GR SA SI C
444.8 Water Level										
442.8	Si,sa.&gr.(alluvial)					ELEV ▼				
2.0 / 437.8	Shaly Limestone Bedrock Sound		1	BXL	Rec 100 %	440				RQD 51%
7.0	End of Borehole									

Bedrock Description

From 2' to 3' Limestone, grey, medium to coarse textured, medium hard, fossiliferous.

From 3' to 5' Shale, grey, soft, fissile with shaly sections.

From 5' to 5'10" Limestone, grey, medium to coarse textured, medium hard, fossiliferous.

From 5'10" to 6'4" Shale, grey, soft, fissile.

From 6'4" to 6'7" Limestone, grey, medium to coarse textured, medium hard, fossiliferous.

From 6'7" to 7' Shale, grey, soft, fissile.

L ICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 9

WP 157-75-05 LOCATION Co-ords. N 15,827,404; E 949,986 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 21, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger – BXL Core CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P — w — w_L) WATER CONTENT %	UNIT WEIGHT γ	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES					% GR SA SI C
445.0	Water Level									
442.0	Silty sand & gravel (alluvial)									
3.0	Weathered									
	Sound Shaly Limestone Bedrock		1	BXL	Rec 96%	ELEV 440				RQD 53%
437.0										
8.0	End of Borehole									

Bedrock Description

From 3' to 3'6" Limestone, grey, fine to medium textured, hard.

From 3'6" to 6'2" Shale, grey, soft, fissile.

From 6'2" to 6'9" Limestone, grey, fine textured, hard, fossiliferous with thin seams of shale.

From 6'9" to 8' Shale, grey, soft, fissile, interbedded with shaly sections.

ICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 10

WP 157-75-05 LOCATION Co-ords. N 15,827,281; E 950,084 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 21, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	w_P — w — w_L WATER CONTENT % 10 20 30	γ	% GR SA SI C
448.5	Ground Level									
0.0	Topsoil									
445.0	Het.mix.of cl.si.sa. &gr.(Gl.Till)Hard		1	SS	55	▼		o		34 7 47 1
3.5	Shaly Limestone Bedrock Sound		2	BXL	Rec 100 %					RQD 40%
440.0										
8.5	End of Borehole									

Bedrock Description

From 3'5" to 5'1" Limestone, grey, medium textured, medium hard, fossiliferous.

From 5'1" to 7'3" Shale, grey, soft, fissile, with shaly sections.

From 7'3" to 8'5" Limestone, grey, medium textured, medium hard, inter-bedded with grey shale. Fossiliferous.

...CE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 11

WP 157-75-05 LOCATION Co-ords. N 15,827,353; E 950,047 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 21, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W / W_P — W — W_L / WATER CONTENT %	UNIT WEIGHT γ	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV				% GR SA SI C
445.1	Water Level									
443.6	Sl.Sa.&Gr.(Alluvial)		1	Wash						
1.5 / 438.6	Shaly Limestone Bedrock Sound		2	BXL	Rec 100 %	440				RQD 49%
6.5	End of Borehole									

Bedrock Description

From 1'5" to 2'11" Limestone, grey, medium textured, medium hard, fossiliferous.

From 2'11" to 5'0" Shale, grey, reddish, soft, fissile with shaly sections.

From 5'0" to 5'11" Limestone, light grey, medium textured, medium hard, fossiliferous.

From 5'11" to 6'5" Shale, grey, reddish, soft, fissile.

ICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 12

WP 157-75-05 LOCATION Co-ords. N 15,827,422; E 950,008 ORIGINATED BY VK

DIST 6 HWY 403 BORING DATE June 21, 1977 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Auger - BXL Core CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	W_P W W_L WATER CONTENT % 10 20 30	γ	% GR SA SI
447.4	Ground Level									
0.0	Topsoil									
1.0 443.4	Het.mix.of cl.si.sa.& gr.(Gl.Till) Hard		1	SS	118/9"			○		43 22 25
4.0 438.4	Shaly Limestone Bedrock Sound		2	BXL	Rec 100%	440				RQD 16%
9.0	End of Borehole									

Bedrock Description

From 4' to 6' Limestone, grey, med.textured,med.hard fossiliferous.

From 6' to 6'7" Shaly limestone.

From 6'7" to 7'3" Limestone, grey, medium textured, medium hard, fossiliferous.

From 7'3" to 7'10" Shale with thin seams of limestone.

From 7'10" to 9' Limestone, grey to pink, medium textured, medium hard, fossiliferous.

OFFICE REPORT ON SOIL EXPLORATION

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M12-248

DIST. CR REGION

W.P. No. 613-89-00

CONT. No.

W. O. No.

STR. SITE No. 24-0386

HWY. No. 403

LOCATION Mullet Cr Bridge
& Hwy 403

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

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

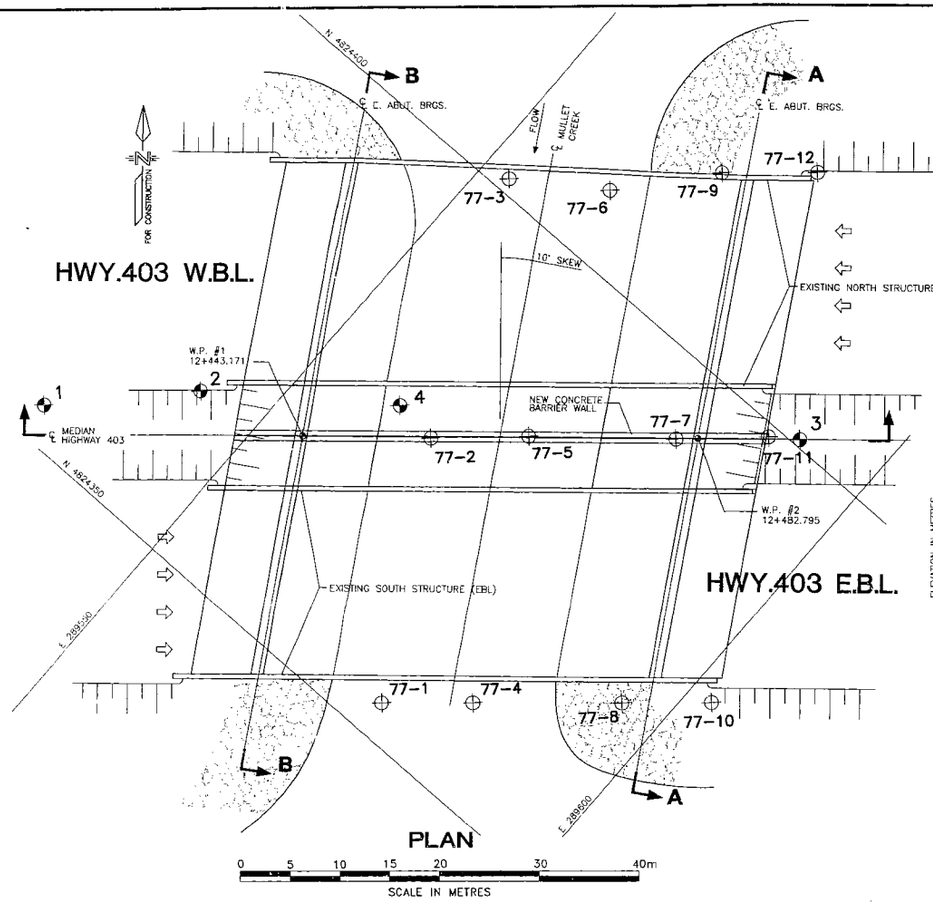
CONT. No.
WP No. 613-89-00

MULLET CREEK BRIDGE
HIGHWAY No. 403
BOREHOLE LOCATIONS & SOIL STRATA

SHEET

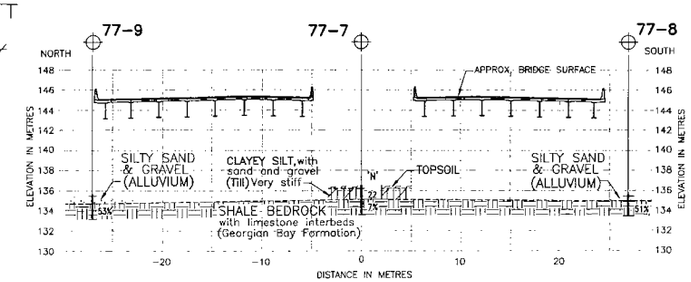
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

THE GREER GALLOWAY GROUP INC.
ENGINEERS + PLANNERS
PETERBOROUGH • OSHAWA • BANCROFT • BELLEVILLE • PEMBROKE

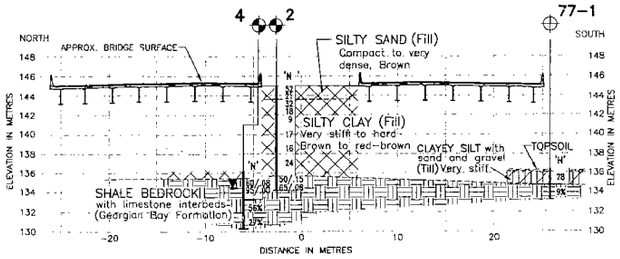


PLAN

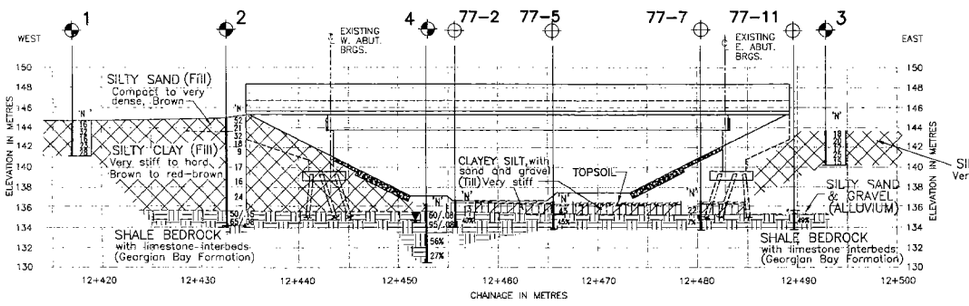
0 5 10 15 20 30 40m
SCALE IN METRES



SECTION A-A

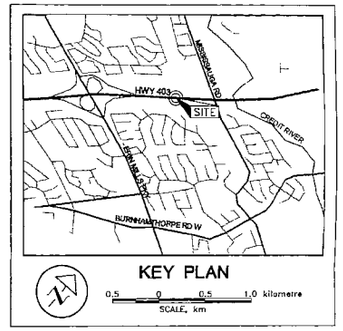


SECTION B-B



CENTRELINE PROFILE

0 5 10 15 20 30 40m
SCALE IN METRES



KEY PLAN
0.5 0 0.5 1.0 kilometre
SCALE, km

LEGEND

- Borehole Location, 2000 Investigation
- Borehole Location, 1977 MTO Investigation
- N — Blows/0.3m (Std. Pen. Test, 475 j/blow)
- RQD — Rock Quality Designation, %
- WL at time of investigation, October 2000

No.	ELEVATION	CO-ORDINATES NORTHING	CO-ORDINATES EASTING
1	144.7	4,824,353.71	289,532.25
2	145.0	4,824,365.20	289,543.41
3	143.7	4,824,400.70	289,591.98
4	136.3	4,824,377.03	289,559.60
77-1	136.4	4,824,353.59	289,577.51
77-2	136.6	4,824,376.70	289,564.00
77-3	136.7	4,824,401.43	289,552.89
77-4	136.2	4,824,359.53	289,584.37
77-5	136.5	4,824,383.20	289,571.22
77-6	136.6	4,824,407.08	289,561.27
77-7	136.5	4,824,392.72	289,582.52
77-8	135.6	4,824,369.37	289,595.68
77-9	135.6	4,824,415.93	289,568.48
77-10	136.7	4,824,375.16	289,602.42
77-11	135.7	4,824,398.96	289,589.48
77-12	136.4	4,824,422.03	289,575.88

NO.	DATE	BY	REVISION

Geocres No.

HWY. No. 403		PROJECT NO.: 001-1131A			
SUBM'D. LCC	CHK'D: ASP	DATE: 2001 01 12	SITE 24-386		
DRAWN: MHW	CHK'D. LCC	APP'D. ASP	DWG. 1		

ACAD FILE P1131A.DWG
plot scale 1:1mm(drawing scale 1:250)