

# APPENDIX G

Geotechnical Site Investigation

---



# GEMTEC

[www.gemtec.ca](http://www.gemtec.ca)

**Geotechnical Site Investigation  
Highway 404 Ramp Extension at  
Major Mackenzie Drive (EA Amendment)  
Markham, Ontario**

GEMTEC Project: 101645.006

experience • knowledge • integrity



expérience • connaissance • intégrité



# GEMTEC

[www.gemtec.ca](http://www.gemtec.ca)

Submitted to:

Gannett Fleming Inc.  
Royal Bank Plaza, 200 Bay Street, Suite 1600  
Toronto, Ontario  
M5J 2J3

**Geotechnical Site Investigation  
Highway 404 Ramp Extension at  
Major Mackenzie Drive (EA Amendment)  
Markham, Ontario**

July 29, 2024  
GEMTEC Project: 101645.006

GEMTEC Consulting Engineers and Scientists Limited  
6695 Millcreek Drive, Unit 7,  
Mississauga, ON, Canada  
L5N 5M4

July 29, 2024

File: 101645.006 – Rev0

Gannett Fleming Inc.  
Royal Bank Plaza, 200 Bay Street, Suite 1600  
Toronto, Ontario  
M5J 2J3

Attention: Laura Chong, RPP, MCIP, Project Manager – Engineering  
City of Markham, Transportation Policy and Strategy

**Re: Geotechnical Site Investigation  
Highway 404 Ramp Extension at Major Mackenzie Drive (EA Amendment)  
Markham, Ontario**

---

Enclosed is our geotechnical site investigation for the proposed extension of the Highway 404 northbound off-ramp north from Major Mackenzie Drive to Markland Street, including a new bridge over the Highway 404 on-ramp. The report presented herein is based on the scope of work summarized in the proposal dated April 19, 2023. Authorization to proceed was provided by Gannett Fleming on November 1, 2023. This report was prepared by Connor McCormick, P.Eng., and reviewed by Matthew Kelly, P.Eng.



---

Connor McCormick, P.Eng.  
Geotechnical Engineer



---

Matthew Kelly, P.Eng.  
Senior Geotechnical Engineer

JCM/MWK/sv/af/mk

\\Lucid\Drawings and Files\Projects\101600\101645.006\03\_Submittals\Geotechnical Report\FINAL\101645.006\_RPT\_Geotechnical\_404 and Major Mackenzie Drive Bridge\_2024-07-29\_Rev0.docx

## TABLE OF CONTENTS

|         |                                                         |    |
|---------|---------------------------------------------------------|----|
| 1.0     | INTRODUCTION.....                                       | 1  |
| 2.0     | SITE AND PROJECT DESCRIPTION .....                      | 1  |
| 2.1     | Background.....                                         | 1  |
| 2.2     | Site Geology .....                                      | 2  |
| 3.0     | METHODOLOGY .....                                       | 2  |
| 3.1     | Geotechnical Site Investigation .....                   | 2  |
| 4.0     | SUBSURFACE AND GROUNDWATER CONDITIONS .....             | 3  |
| 4.1     | General.....                                            | 3  |
| 4.2     | Fill Material .....                                     | 4  |
| 4.3     | Silty Clay (CL/CL-ML) .....                             | 5  |
| 4.4     | Groundwater Levels.....                                 | 5  |
| 5.0     | GEOTECHNICAL RECOMMENDATIONS AND CONSIDERATIONS .....   | 6  |
| 5.1     | Design Considerations .....                             | 6  |
| 5.1.1   | Consequence and Site Understanding Classification ..... | 6  |
| 5.1.2   | Seismic Design .....                                    | 6  |
| 5.1.2.1 | Seismic Site Classification .....                       | 6  |
| 5.2     | Foundations Options.....                                | 7  |
| 5.2.1   | Shallow Foundations.....                                | 7  |
| 5.2.1.1 | Resistance to Lateral Forces/Sliding Resistance .....   | 8  |
| 5.2.2   | Driven Steel H-Piles.....                               | 8  |
| 5.3     | Resistance to Lateral Loads.....                        | 9  |
| 5.4     | Lateral Earth Pressure .....                            | 11 |
| 5.5     | Approach Embankments.....                               | 12 |
| 5.6     | Asphalt Pavement Recommendations .....                  | 13 |
| 6.0     | CLOSURE.....                                            | 14 |

NOTE: This document and any attachments are confidential and intended solely for the use of the individual or entity to whom they are addressed. If you have received this document in error, please notify the sender immediately and delete the document from your system. Any unauthorized disclosure, copying, distribution, or reliance on the contents of this document is prohibited. Thank you for your cooperation.

**LIST OF TABLES**

Table 4.1 – Summary of Grain Size Distribution Test (Earth Fill Materials) .....4

Table 4.2 – Summary of Atterberg Limits Test (Earth Fill Materials).....4

Table 4.3 – Summary of Grain Size Distribution Test (Silty Clay) .....5

Table 4.4 – Summary of Atterberg Limits Test (Silty Clay) .....5

Table 5.1 – Coefficient of Friction ( $\tan \phi'$ ) Values.....8

**LIST OF ATTACHMENTS**

Conditions and Limitations of This Report

**LIST OF APPENDICES**

|            |                                         |
|------------|-----------------------------------------|
| Appendix A | Borehole Location Plan                  |
| Appendix B | Record of Borehole Sheets               |
| Appendix C | Geotechnical Laboratory Testing Results |

## 1.0 INTRODUCTION

GEMTEC Consulting Engineers and Scientists Limited (GEMTEC) has been retained by Gannett Fleming Inc. (Gannett) to conduct a preliminary geotechnical site investigation in support of the proposed bridge and ramp realignment required to accommodate the proposed road extension north from Major Mackenzie to Markland Street in Markham, Ontario (herein referred to as the “site”).

The purpose of the preliminary geotechnical investigation was to identify the general subsurface soil and groundwater conditions at the site by means of a limited number of boreholes and monitoring wells. Based on the factual data obtained, preliminary geotechnical engineering design comments and recommendations for the project, including limited construction considerations that could influence design decisions are provided.

This geotechnical report is to inform the Addendum to a Municipal Class Environmental Assessment – Proposed Road Extension at Highway 404 Northbound Exit Ramp and Major Mackenzie Drive Intersection Environmental Study Report (2009 ESR).

It should be noted that this investigation is not sufficient to provide the minimum MTO pavement or foundations investigation in support of a Pavement Design Report or detailed Foundation Investigation and Design Report that will be required for detailed design. Reporting and consultation efforts in support of an MTO Pavement Investigation and Design Report or MTO Foundation Investigation and Design Report have not been included. Additional investigation will be required to meet MTO standards.

This report is subject to the *Conditions and Limitations of This Report*, which follow the text of this report and are considered an integral part of the report. The factual data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location, elevation, or if the project is not initiated within eighteen months of the date of the report, GEMTEC should be given an opportunity to confirm that the recommendations in this report are still valid.

## 2.0 SITE AND PROJECT DESCRIPTION

### 2.1 Background

It is proposed to construct a road extension from Major Mackenzie Drive north to Markland Street. In order to accommodate this road extension, the northbound on-ramp from Major Mackenzie drive will be realigned and a bridge would need to be constructed to carry the new roadway over the ramp.

It is understood the proposed bridge would be a single span with no centre pier. Based on site grading it is expected an embankment would be required on the north side to accommodate the

grade change for the proposed roadway. Only conceptual designs were available at the time this report was written, the recommendations provided in this report should be reviewed and revised as the design progresses.

## **2.2 Site Geology**

According to published physiographic mapping (*L.J. Chapman and Putnam, 1984; The Physiography of Southern Ontario, Third Edition*), the site is within a physiographic region known as the Peel Plain. The Peel Plain lies within the South Slope, and consists of a level to undulating tract of clay soils, underlain by a till containing large amounts of shale and limestone.

Although not shown on the geology maps, fill material associated with the development of the area and construction of existing roadways/highways/ramps is present at the site.

## **3.0 METHODOLOGY**

### **3.1 Geotechnical Site Investigation**

The fieldwork for this investigation was carried out on May 27 and 28, 2024, at which time two boreholes, designated as Boreholes BH24-01 and BH24-02, were advanced to an approximate depth of 9.6 m below ground surface (bgs). Borehole 24-01 was advanced within the shoulder of the existing E-N ramp and Borehole BH24-02 was advanced on a berm adjacent to the ditch north of the ramp at/near the southeast and northwest corners of the proposed bridge, respectively, (see Figure 1 in Appendix A).

The boreholes were advanced using truck/track-mounted drill rigs using 108 mm or 203 mm outer diameter hollow stem augers, supplied, and operated by 3D Drilling of Whitchurch-Stouffville, Ontario. Traffic protection was provided in accordance with MTO's Book 7 *Manual of Temporary Conditions* by Alliance Traffic Control of Etobicoke, Ontario.

Standard Penetration Tests (SPT) were carried out in the boreholes using conventional 38-millimeter (mm) internal diameter split spoon sampling equipment driven by an automatic hammer in accordance with the SPT procedures outlined in ASTM International Standard D1586: "Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils". The split-spoon samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 38 mm. Therefore, particles or objects that may exist within the soils that are larger than this dimension were not sampled or represented in the grain size distributions.

Both boreholes were suitably backfilled and the road surface was reinstated at Borehole BH24-01 upon completion of drilling. The groundwater levels presented on the Record of Borehole sheets have been interpreted from sample collection and water levels measured upon completion of drilling.

The fieldwork was supervised by a member of our engineering staff who directed the drilling operations, logged the boreholes, and collected soil samples. Following completion of the drilling, the soil samples were returned to our laboratory for further examination. Select representative samples were submitted for water content determination, grain size distribution testing and Atterberg Limits testing.

The borehole locations were selected by GEMTEC and positioned on-site relative to existing features, including considerations of underground and above ground utility locates, and drill rig access constraints. Upon completion of drilling, the ground surface elevation at each borehole location was extrapolated from a topographical survey drawing provided by Gannett Fleming, prepared by J.D. Barnes Limited.

The locations of the boreholes are shown on the Borehole Location Plan, Figure 1 (Appendix A). Descriptions of the subsurface conditions observed in the boreholes are provided on the Record of Borehole sheets in Appendix B. The results of the laboratory tests are provided on the Record of Boreholes sheets (Appendix B) and in Appendix C.

## **4.0 SUBSURFACE AND GROUNDWATER CONDITIONS**

### **4.1 General**

As previously indicated, the soil and groundwater conditions identified in the boreholes are given on the Record of Borehole sheets in Appendix B. The Record of Boreholes indicate the subsurface conditions at the specific test locations only. Boundaries between zones on the records are often not distinct, but rather are transitional and have been interpreted. The precision with which subsurface conditions are indicated depends on the method of drilling, the frequency and recovery of samples, the method of sampling, and the uniformity of the subsurface conditions. Subsurface conditions at locations other than the boreholes will vary from the conditions encountered in the boreholes both laterally and with depth. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties.

The groundwater conditions described in this report refer only to those observed at the place and time of observation noted in the report. These conditions may vary seasonally or because of construction activities in the area.

The soil descriptions in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves judgement and GEMTEC does not guarantee descriptions as exact but infers accuracy to the extent that is common in current geotechnical practice.

In general, the subsurface conditions underlying the pavement structure (i.e., asphalt surface and granular fill material) consist of fill materials, underlain by native interlayered sand and silty sand, and (predominantly) silty clay and organic silty clay deposits, all underlain by a silty sand till

deposit. The following presents an overview of the subsurface conditions encountered in the boreholes advanced during this investigation.

## 4.2 Fill Material

Fill materials were encountered in both boreholes at existing ground surface and generally consist of silty clay, some sand to sandy, and trace amounts of gravel, extending to depths ranging from approximately 5.0 m to 6.1 m below ground surface. The upper fill in Borehole BH24-01 was noted to be non-cohesive granular materials (sand and gravel, some silt) and is inferred to be a part of the pavement structure of the ramp shoulder.

A standard penetration test carried out in the non-cohesive fill material gave an SPT N-value of 22 blows per 0.3 m of penetration, which indicates a compact compactness condition. Standard penetration tests carried out in the cohesive fill materials gave SPT N-values ranging from 7 blows to greater than 50 blows per 0.3 m of penetration, suggesting a firm to hard consistency.

The water content measured on the sample of the non-cohesive fill material was about 6 percent, and the water content measured on samples of the cohesive fill materials ranged from about 8 percent to 24 percent.

Grain size distribution testing was undertaken on a sample of cohesive fill materials from each borehole. The results are provided in Appendix C and are summarized in Table 4.1.

**Table 4.1 – Summary of Grain Size Distribution Test (Earth Fill Materials)**

| Location | Sample Number | Sample Depth (metres) | Gravel (%) | Sand (%) | Silt / Clay (%) |
|----------|---------------|-----------------------|------------|----------|-----------------|
| BH24-01  | SS3           | 1.5 – 2.0             | 6.1        | 34.1     | 59.8            |
| BH24-02  | SS5           | 3.1 – 3.5             | 0.2        | 8.8      | 91.0            |

Atterberg limit testing was undertaken on a sample of the cohesive fill materials from each borehole. The results are shown on the Record of Boreholes, in Appendix C and are summarized in Table 4.2.

**Table 4.2 – Summary of Atterberg Limits Test (Earth Fill Materials)**

| Location | Sample Number | Sample Depth (metres) | Plastic Limit | Liquid Limit | Plasticity Index |
|----------|---------------|-----------------------|---------------|--------------|------------------|
| BH24-01  | SS3           | 1.5 – 2.0             | 14            | 24           | 10               |
| BH24-02  | SS5           | 3.1 – 3.5             | 22            | 48           | 26               |

### 4.3 Silty Clay (CL/CL-ML)

A deposit of silty clay with varying amounts of sand (some sand to sandy) and trace amounts of gravel was encountered in both boreholes and extended to the bottom of both boreholes.

Standard penetration tests carried out in the silty clay deposit gave SPT N-values ranging from 11 blows to 75 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.

Grain size distribution testing was undertaken on a sample of the silty clay deposit from each borehole. The results are provided in Appendix C and are summarized in Table 4.3.

**Table 4.3 – Summary of Grain Size Distribution Test (Silty Clay)**

| Location | Sample Number | Sample Depth (metres) | Gravel (%) | Sand (%) | Silt / Clay (%) |
|----------|---------------|-----------------------|------------|----------|-----------------|
| BH24-01  | SS7           | 6.0 – 6.6             | 2.0        | 12.5     | 85.4            |
| BH24-02  | SS9           | 9.1 – 9.6             | 7.0        | 31.4     | 61.6            |

Atterberg limit testing was undertaken on a sample of the silty clay deposit from each borehole. The results are shown on the Record of Boreholes, on a plasticity chart in Appendix C and are summarized in Table 4.4.

**Table 4.4 – Summary of Atterberg Limits Test (Silty Clay)**

| Location | Sample Number | Sample Depth (metres) | Plastic Limit | Liquid Limit | Plasticity Index |
|----------|---------------|-----------------------|---------------|--------------|------------------|
| BH24-01  | SS7           | 6.0 – 6.6             | 18            | 38           | 20               |
| BH24-02  | SS9           | 9.1 – 9.6             | 12            | 17           | 5                |

The results indicate the deposit can be classified as a silty clay of low to high plasticity.

The water content measured on samples of the silty clay deposit ranged from about 7 percent to 24 percent.

### 4.4 Groundwater Levels

Both boreholes were noted to be dry upon completion of drilling, however this condition is not considered to be a stabilized groundwater condition and the groundwater levels should be expected to fluctuate.

It should be noted that the groundwater levels may be higher during wet periods of the year such as the early spring or following periods of precipitation.

## 5.0 GEOTECHNICAL RECOMMENDATIONS AND CONSIDERATIONS

This section of the report provides engineering guidance on the geotechnical design aspects of the project based on our interpretation of the boreholes advanced as part of the site investigation. It is stressed that the information in the following sections is provided for the guidance of the designers and is intended for this project only. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety, and equipment capabilities.

The professional services retained for this aspect of the project and discussed herein include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible surface and / or subsurface contamination resulting from previous uses or activities of this site or adjacent properties, and / or resulting from the introduction onto the site from materials from off-site sources are outside the terms of reference for this report.

### 5.1 Design Considerations

#### 5.1.1 Consequence and Site Understanding Classification

It is expected that the proposed bridge would carry medium volumes of traffic that is assumed to not be essential to post-disaster recovery (e.g., lifeline) and/or having large societal or economic impacts. In accordance with Section 6.5 of the 2019 *Canadian Highway Bridge Design Code* CAN/CSA S6-19 and its Commentary (CHBDC 2019), the proposed bridge and its foundation system is considered to be classified as having a “typical consequence level” associated with exceeding limits states design. In addition, given the level of foundation investigation completed to date at this location in comparison to the degree of site understanding in Section 6.5 of the CHBDC (2019), the level of confidence for design is considered to be a “typical degree of site and prediction model understanding”. Accordingly, the appropriate corresponding Ultimate Limit State (ULS) and Serviceability Limit State (SLS) consequence factor,  $\psi$ , from Table 6.1 and geotechnical resistance factors,  $\phi_{gu}$  and  $\phi_{gs}$ , from Table 6.2 of the CHBDC have been used for design.

#### 5.1.2 Seismic Design

The new bridge is in Seismic Performance Category (SPC) 1 and therefore seismic analysis of bridges in SPC 1 is not a requirement of the CHBDC (Clause 4.4.5.1). However, design forces for restraining elements and bridge support lengths must meet the minimum requirements as outlined in CHBDC Clauses 4.4.10.2 and 4.4.10.5.

##### 5.1.2.1 Seismic Site Classification

The subsurface conditions for seismic site characterization were assessed based on the results of the field investigation and in situ testing. Based on the energy-corrected average penetration resistance,  $\bar{N}_{60}$  below the founding level, the site may be classified as Site Class D (Stiff Soil) if

founded in the overburden soils with more than 3 m of overburden between the foundations and bedrock, and in accordance with Table 4.1 of the 2019 CHBDC, in the absence of any geophysical testing. The seismic site class may be improved by additional borehole drilling, up to 100 ft below grade or to top of competent bedrock. Based on our previous experience in the general vicinity of the site, and in similar soil conditions, it is considered to be likely that the site soil classification would be improved if geophysical testing is carried out. This testing could be carried out either during, or prior to detailed design.

The 2019 CHBDC states that the seismic hazard values associated with the design earthquakes should be those established for the National Building Code of Canada (NBCC) by the Geological Survey of Canada (GSC). The current seismic hazard maps (referred to as the 5th generation seismic hazard maps) were developed by the GSC and were made available for public use in December 2015.

## **5.2 Foundations Options**

Both shallow and deep foundation options are considered feasible for support of the new bridge structure. Depending on the final geometry of the ramp and road extension, temporary protection systems will likely be required to facilitate construction of the new approach embankments and foundations for the new abutments in either case.

### **5.2.1 Shallow Foundations**

The abutments and any associated retaining walls for the new bridge may be founded on conventional spread/strip footings founded on the competent native soils at the depths given below.

At both abutments, existing fill materials with variable composition and density were encountered to a depth of about 5 to 6.5 m below grade. Due to the variability in the fill layers and the lack of records of the quality or construction / placement of the fill used to construct the berm north of the ramp embankment, these materials will require removal and replacement with engineered fill, unshrinkable fill, or mass concrete up to subgrade level. If records could be provided with regards to the source of the fill material and compaction testing results during placement, some of the fill material could potentially be left in place, in conjunction with additional inspection/verification during construction. The bearing resistance will depend on the material used to backfill the excavation to subgrade level. If properly placed and compacted OPSS1010 Select Subgrade Material is used for the engineered fill, or for footings founded directly on the properly prepared and inspected native subgrade, a factored ULS resistance of 300 kPa and a factored serviceability geotechnical reaction of 150 kPa may be used for design, based on an approximately 3-metre-wide footing. If properly placed and compacted OPSS1010 Granular A or unshrinkable fill is used for the engineered fill, a factored ULS resistance of 400 kPa and a factored serviceability geotechnical resistance of 500 kPa may be used for design, based on an approximately 3-metre-wide footing, and assuming a minimum thickness of about 1.5 m.

If an engineered fill or unshrinkable fill pad is used to replace the existing fill material, the fill pad should be constructed to 0.5 m beyond the footprint of the pier foundation and should extend outward and downward at a slope of 1 horizontal to 1 vertical to the bottom of the existing fill. The fill should be placed in loose lift thicknesses not exceeding 300 mm and compacted to a minimum of 100 percent of the materials Standard Proctor Maximum Dry Density (SPMDD).

The factored ultimate geotechnical resistances provided above are given based on a geotechnical ULS resistance factor of 0.5, and for loads that will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the footing, inclination of the load should be taken into account in accordance with Section 6.10.4 of the CHBDC (2014).

All footing subgrades should be inspected by a Foundation Engineer, in accordance with OPSS 902 (Excavating and Backfilling Structures), Special Provision SP109S12 and NSSP FOUN0003, to check that all existing fill(s), concrete, organics or otherwise deleterious materials have been removed.

The elevation of the underside of the footing should be maintained at a minimum depth below finished grade of approximately 1.4 m to provide adequate frost protection.

### 5.2.1.1 Resistance to Lateral Forces/Sliding Resistance

Resistance to lateral forces/sliding between the concrete spread/strip footings and the subgrade should be calculated in accordance with Section 6.10.4 of CHBDC 2019. Assuming that the founding soils are not loosened or disturbed during excavation and footing construction, the unfactored coefficient of friction ( $\tan \phi'$ ) values between the cast-in-place concrete footings and the inspected and approved subgrade may be taken as follows:

**Table 5.1 – Coefficient of Friction ( $\tan \phi'$ ) Values**

| Subgrade Material                                                      | Coefficient of Friction, $\tan \phi'$ |
|------------------------------------------------------------------------|---------------------------------------|
| Cast-in-place footing or working slab on compacted Granular ‘A’        | 0.6                                   |
| Cast-in-place footing or working slab on compacted SSM or native soils | 0.35                                  |

### 5.2.2 Driven Steel H-Piles

Based on the boreholes advanced at each foundation element, as well as publicly available historic data for the Highway 404 interchange construction, steel H-piles driven to found within the silty clay to clayey silt at about the depth that the boreholes were terminated, or piles driven to practical refusal are considered to be feasible to support the proposed bridge structure.

Refusal to further penetration for HP310x110 piles is expected to be achieved at a depth below the level at which the boreholes were terminated, and is anticipated to be at Elevation 190 m, although this should be confirmed through further investigation. For piles driven to practical refusal at about Elevation 187 m, a factored geotechnical axial resistance at ULS of 1400 kN may be used for design. For steel piles driven to practical refusal the Serviceability Limit State (SLS) reactions are anticipated to be higher and pile design will be governed by the ULS condition. The anticipated settlement of individual piles and of the pile group is anticipated to be 15 mm or less based on state-of-practice experience of steel piles driven to practical refusal.

For piles driven to about the depth of the borehole termination (about Elevation 201 m) a factored geotechnical axial resistance at ULS of 550 kN, and a geotechnical reaction of about 300 kN at SLS (for 25 mm of settlement) may be used for design.

The resistances given above have been estimated based on the current conventionally accepted engineering practice, as specified in the Canadian Foundation Engineering Manual (CFEM), by accounting for both the ultimate values of frictional resistance along the shaft and bearing resistance at the tip of the pile, and applying a resistance factor of 0.4. Dynamic testing (i.e., PDA testing) is recommended to be carried out at the foundation locations to aid in the evaluation of pile axial geotechnical resistances achieved in the field, hammer performance, installation criteria, and pile bearing certification. If suitable PDA testing is undertaken, the ULS geotechnical resistance factor can be increased from 0.4 to 0.5.

A minimum pile spacing of 2.5 times the pile diameter is recommended, otherwise vertical interaction effects would need to be considered.

If piles drive to refusal is adopted for design, the pile tips should be suitably reinforced with driving shoes to provide adequate seating and protection when penetrating into the anticipated very dense/hard till deposits, due to the potential for encountering cobbles and boulders.

### **5.3 Resistance to Lateral Loads**

Resistance to lateral loading may be derived using vertical piles, with enhanced support offered by inclined (battered) piles, if required. For vertical piles, the resistance to lateral loading will be derived solely from the soil in front of the piles, whereas inclined piles derive lateral resistance from the soil in front of the piles as well as the horizontal component of the axial load present in the inclined pile.

Where ground conditions are generally competent and the lateral loads on piles are relatively small such that the maximum lateral pile deflections will be relatively small, the resistance to lateral loading in front of a single pile can be estimated using subgrade reaction theory (as outlined below). However, the response of a pile to lateral loads is highly nonlinear and methods that assume linear behavior (such as subgrade reaction theory) are most appropriate where the maximum pile deflections are less than 1 percent of the pile width or diameter, where the loading

is static (no cycling) and where the pile material is linear as per the Canadian Foundation Engineering Manual (CFEM, 2006). Where these conditions are not met, and/or where required for the structural engineering model, the non-linear lateral behavior of the soil should be considered using P-y curves, which can be provided, if required.

The factored serviceability geotechnical response of the soil in front of the piles under lateral loading at this site may be calculated using subgrade reaction theory suggested in CHBDC (2014) Commentary (Section C6.11.2.2), where the coefficient of horizontal subgrade reaction,  $k_h$ , (kPa/m) is based on the equations given below, as described by Terzaghi (1955) and the Canadian Foundation Engineering Manual (CFEM 1992).

For non-cohesive soils:

$$k_h = \frac{n_h Z}{B}$$

Where:  $n_h$  is the constant of horizontal subgrade reaction (kPa/m), as given below;  
 $Z$  is the depth (m) of pile below ground surface; and,  
 $B$  is the pile diameter/width (m).

For cohesive soils:

$$k_h = \frac{67 s_u}{B}$$

Where:  $s_u$  is the undrained shear strength of the soil (kPa); and,  
 $B$  is the pile diameter/width (m).

The following values of  $n_h$  (Terzaghi, 1955) and  $s_u$  may be incorporated into the calculations of horizontal subgrade reaction ( $k_h$ ) for structural analyses for a single vertical pile. The ranges in values reflect the variability in the subsurface conditions, the soil properties, the approximate nature of the analysis and the non-linear nature of the soil behaviour (such that  $k_h$  is a function of deflection).

| Soil Unit                                   | Elevation Interval (m) | $n_h$ (kPa/m) | $s_u$ (kPa) |
|---------------------------------------------|------------------------|---------------|-------------|
| Existing Firm to Very Stiff Silty Clay Fill | 213.0 to 206.0         | --            | 75          |
| Stiff to Hard Silty Clay                    | Below 206.0            | --            | 100         |

Both the structural and geotechnical resistances of the piles should be evaluated to establish the governing case at ULS. At SLS, the horizontal reaction of the piles will be controlled by deflections and the horizontal resistance of the piles should be calculated based on the coefficient of horizontal subgrade reaction ( $k_h$ ) of the soil as discussed above. The SLS reaction should be taken as that corresponding to a horizontal deflection of 10 mm at the underside of the abutment wall for units supporting the abutments (CHBDC (2014) Commentary Section 6.11.2.2).

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 between rows of driven steel H-piles. Group action

can be evaluated by reducing the coefficient of horizontal subgrade reaction in the direction of loading by a reduction factor, R (NAVFAC, 1986) as follows:

| Pile Spacing in Direction of Loading<br>(D = Pile Diameter) | Subgrade Reaction<br>Reduction Factor, R |
|-------------------------------------------------------------|------------------------------------------|
| 8D                                                          | 1.00                                     |
| 6D                                                          | 0.70                                     |
| 4D                                                          | 0.40                                     |
| 3D                                                          | 0.25                                     |

The subgrade reaction reduction factor should be interpolated for pile spacings in between those provided in the above summary. Reduction for group effects is negligible when the centre-to-centre pile spacing exceeds three pile diameters measured in the direction perpendicular to loading.

## 5.4 Lateral Earth Pressure

The lateral earth pressures acting on the abutments will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the abutments.

The following recommendations are made concerning the design of the culvert walls:

- Free-draining granular fill meeting the specifications of OPSS.MUNI 1010 (Aggregates) Granular 'A' or Granular 'B' Type II should be used as backfill behind the walls. Longitudinal drains or weep holes should be installed to provide positive drainage of the granular backfill, as applicable.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls. Care must be taken during the compaction operation not to overstress the wall, with limitations on heavy construction equipment and requirements for the use of hand-operated compaction equipment per OPSS.MUNI 501 (Compacting). Other surcharge loadings should be accounted for in the design, as required.
- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.4 m behind the back of the wall. For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at flatter than 1 horizontal to 1 vertical extending up and back from the rear face of the wall or footing, as applicable.
- A unit weight of 21 kN/m<sup>3</sup>, a coefficient of lateral earth pressure at rest of 0.47, and a coefficient of active lateral earth pressure of 0.31 should be used for the granular fill.

If the wall does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), the at-rest earth pressures (plus any compaction surcharge) should be assumed for geotechnical design. In this case, a coefficient of lateral earth pressure at-rest of 0.5 should be used for the design.

## **5.5 Approach Embankments**

For an overpass configuration, approach embankment pavement elevations are anticipated to be as much as 8 m above the surrounding grades. Prior to construction of the new approach embankments any topsoil/organic soils and loosened/softened fill should be stripped from within the embankment footprint.

Fill for construction of the new embankments should consist of Select Subgrade Material meeting the specifications of OPSS.MUNI 1010 (Aggregates). The embankment fill should be placed and compacted in accordance with OPSS.MUNI 501 (Compacting) and OPSS.MUNI 206 (Grading). Embankment side slopes should be constructed no steeper than 2 horizontal to 1 vertical (2H:1V) in granular or earth fill.

To control erosion of the side slopes, a minimum 2 m wide bench is recommended where embankment slopes are greater than 8 m in height, such that the uninterrupted slope height does not exceed 8 m, consistent with OPSD 202.010 (Slope Flattening). To reduce surface water erosion on the granular embankment side slopes, topsoil and seeding as per OPSS 802 (Topsoil) and OPSS.MUNI 804 (Seed and Cover) should be carried out as soon as possible after construction of the embankments. If this slope protection is not in place before winter, then alternate protection measures, such as covering the slope with straw mats, or gravel sheeting as per OPSS.MUNI 511 (Rip Rap, Rock Protection and Granular Sheeting), and OPSS.MUNI 1004 (Aggregates – Miscellaneous) will be required to reduce the potential for erosion and to reduce the potential for the requirement of remedial works on the side slopes in the spring prior to topsoil dressing and seeding.

Limit equilibrium slope stability analyses were performed on the approach embankment side slopes using the commercially available program “Slide V.2018” published by Rocscience Inc., employing the Morgenstern-Price method of analysis. For all analyses, the Factor of Safety (FoS) of numerous potential failure surfaces was computed in order to establish the minimum FoS. The FoS is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum factored FoS of 1.5 is adopted for the design of embankment slopes under static conditions at the end of construction as per typical industry practice. This FoS is considered adequate for the embankments at this site considering the design requirements provided that a suitable number of boreholes are completed during the detailed design stage to confirm the anticipated subsurface conditions as described herein. The stability analyses were performed to assess if the target minimum FoS was achieved for the design embankment height and geometries.

For the new granular/earth fill and native soil deposits, effective stress parameters were employed in the analysis assuming drained conditions and the parameters were estimated from empirical correlations using the in situ SPT 'N'-values. The correlations proposed by Terzaghi and Peck (1967) were employed and the results were tempered by engineering judgment based on precedent experience in similar soils.

The analysis indicates that the approach embankments constructed of granular fill up to about 8 m in height will have a factored FoS greater than 1.5 against global instability.

Settlement of the founding soils under the north and south approach embankment areas can be expected as a result of the loading from the new fills on the existing fill and native soil deposits. Settlement of new granular fill that is properly placed and compacted for construction of the embankments would occur during construction.

To estimate the magnitude of the expected immediate settlements of the subgrade material, analyses were carried out using hand and spreadsheet calculations. The immediate compression of the existing fill and native cohesionless deposits was modelled by estimating an elastic modulus of deformation based on the SPT 'N'-values and using correlations proposed by Bowles (1984) and Kulhawy and Mayne (1990). Based on the analysis carried out, the settlement of the up to 8 m high approach embankment is expected to be about 50 mm, and this settlement is expected to occur within about 6 months following embankment construction.

## **5.6 Asphalt Pavement Recommendations**

The preliminary geotechnical investigation indicates that the standard City of Markham pavement design would likely be suitable. For more detailed pavement design recommendations, additional borehole drilling should be conducted along the proposed road alignment to confirm suitability of subgrade materials. As such, the following minimum pavement structure is suggested for the road reinstatement:

- 40 mm HL 3;
- 75 mm HL 8;
- 150 mm of Granular A;
- 300 mm of Granular B, Type II;
- prepared and approved subgrade.

Any organic soils within the proposed road alignment should be completely removed and replaced with engineered fill (if below the pavement structure) or granular fill material.

The pavement granular materials should be compacted in maximum 300 mm thick lifts to at least 100 percent SPMDD using suitable vibratory compaction equipment. The asphalt materials should be compacted to at least 92 percent of their Marshall Maximum Relative Density according to OPSS 310, as measured in the field using a nuclear density gauge.

Performance graded PG 58-34 asphaltic cement is recommended for the road. In areas where the new pavement structure will abut existing pavements, the depths of the granular materials should taper up or down at 5H:1V, or flatter, to match the depths of the granular material(s) exposed in the existing pavement. Any undermining or broken edges resulting from the construction activities should be removed by saw cut. All milled surfaces and butt joints should be properly tack coated prior to asphalt placement.

To provide drainage of the granular base and subbase, the granular material should extend to ditches. The bottom of the granular subbase layer should be at least 0.3 m above the bottom of the ditch.

## 6.0 CLOSURE

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report, please do not hesitate to contact our office.

Regards,

**GEMTEC Consulting Engineers and Scientists Limited**



Connor McCormick, P.Eng.  
Geotechnical Engineer



Matthew Kelly, P.Eng.  
Reviewer, Senior Geotechnical Engineer

## Conditions and Limitations of This Report

1. **Standard of Care:** GEMTEC has prepared this report in a manner consistent with generally accepted engineering or environmental consulting practice in the jurisdiction in which the services are provided at the time of the report. No other warranty, expressed or implied is made.
2. **Copyright:** The contents of this report are subject to copyright owned by GEMTEC, save to the extent that copyright has been legally assigned by us to another party or is used by GEMTEC under license. To the extent that GEMTEC owns the copyright in this report, it may not be copied without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to the Client in confidence and must not be disclosed or copied to third parties without the prior written agreement of GEMTEC. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests.
3. **Complete Report:** This report is of a summary nature and is not intended to stand alone without reference to the instructions given to GEMTEC by the Client, communications between GEMTEC and the Client and to any other reports prepared by GEMTEC for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. GEMTEC can not be responsible for use of portions of the report without reference to the entire report.
4. **Basis of Report:** This Report has been prepared for the specific site, development, design objectives and purposes that were described to GEMTEC by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document, subject to the limitations provided herein, are only valid to the extent that this report expressly addresses the proposed development, design objectives and purposes. Any change of site conditions, purpose or development plans may alter the validity of the report and GEMTEC cannot be responsible for use of this report, or portions thereof, unless GEMTEC is requested to review any changes and, if necessary, revise the report.
5. **Time Dependence:** If the proposed project is not undertaken by the Client within 18 months following the issuance of this report, or within the timeframe understood by GEMTEC to be contemplated by the Client, the guidance and recommendations within the report should not be considered valid unless reviewed and amended or validated by GEMTEC in writing.
6. **Use of This Report:** The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without GEMTEC's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, GEMTEC may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process.

Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.
7. **No Legal Representations:** GEMTEC makes no representations whatsoever concerning the legal significance of its findings, or as to other legal matters touched on in this report, including but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and change. Such interpretations and regulatory changes should be reviewed with legal counsel.

8. **Decrease in property value:** GEMTEC shall not be responsible for any decrease, real or perceived, of the property or site's value or failure to complete a transaction, as a consequence of the information contained in this report.
9. **Reliance on Provided Information:** The evaluation and conclusions contained in this report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in this report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by us. We are entitled to rely on such representations, information and instructions and are not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
10. **Investigation Limitations:** Site investigation programs are a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions but even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions.

The data derived from the site investigation program and subsequent laboratory testing are interpreted by trained personnel and extrapolated across the site to form an inferred geological representation and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Conditions between and beyond the borehole/test hole locations may differ from those encountered at the borehole/test hole locations and the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies. Accordingly, GEMTEC does not warrant or guarantee the exactness of the subsurface descriptions.

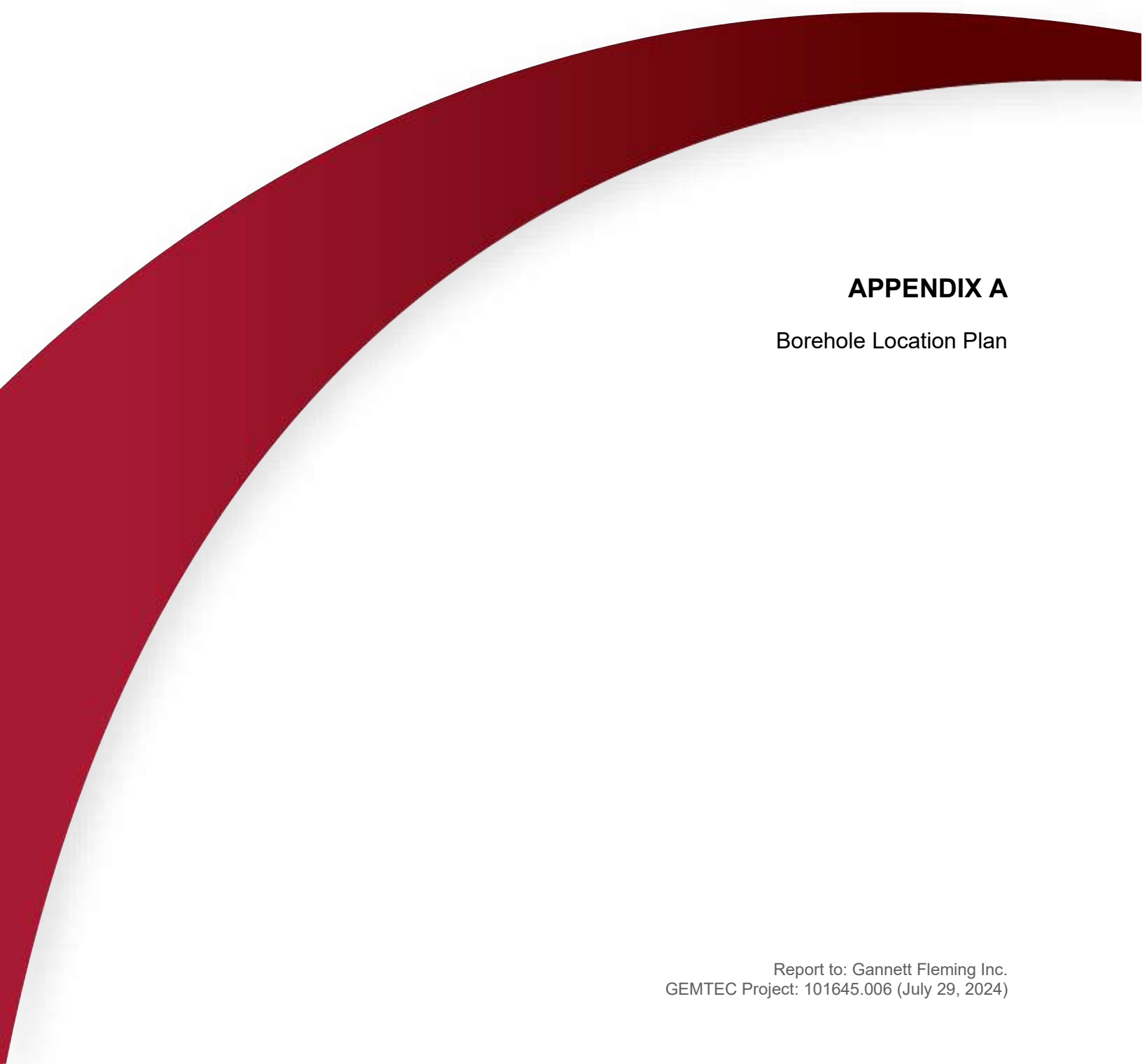
Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

In addition, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

11. **Sample Disposal:** GEMTEC will dispose of all uncontaminated soil and/or rock samples 60 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.
12. **Follow-Up and Construction Services:** All details of the design were not known at the time of submission of GEMTEC's report. GEMTEC should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of GEMTEC's report.  
  
During construction, GEMTEC should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not

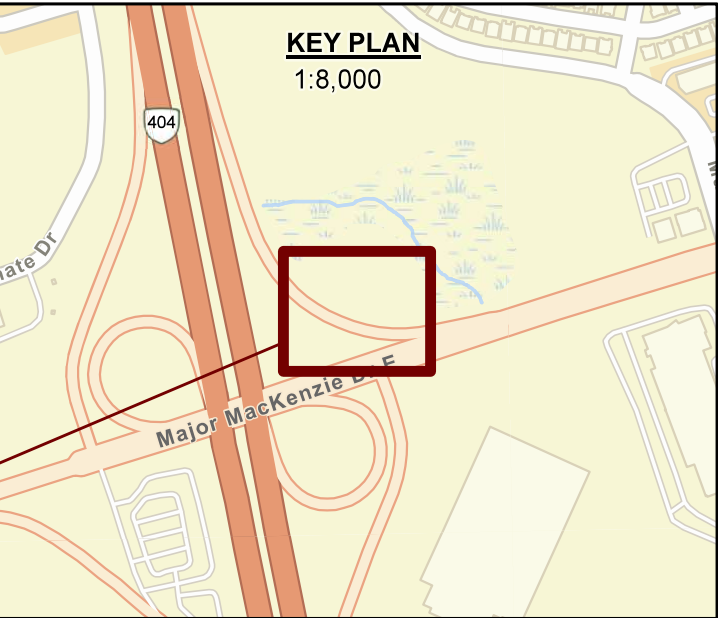
materially differ from those interpreted conditions considered in the preparation of GEMTEC's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in GEMTEC's report. Adequate field review, observation and testing during construction are necessary for GEMTEC to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, GEMTEC's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

13. **Changed Conditions:** Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that GEMTEC be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that GEMTEC be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.
14. **Drainage:** Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. GEMTEC takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.



## **APPENDIX A**

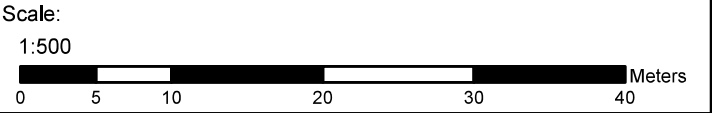
### Borehole Location Plan



**Legend**

- BH #    BOREHOLE ID
-  BOREHOLE LOCATION

- NOTES:
- 1. All locations approximate
  - 2. Coordinate system: NAD 1983 UTM Zone 17N
  - 3. Geographic dataset source: Ontario GeoHub.
  - 4. Contains information licensed under the Open Government Licence – Ontario.
  - 5. Service Layer Credits: World Imagery: Maxar, Microsoft World Street Map: Esri Community Maps Contributors, Province of Ontario, York Region, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada



Drawing

**BOREHOLE LOCATION PLAN**

Client:

**GANNETT FLEMING CANADA ULC**

Project

**HIGHWAY 404 RAMP EXTENSION,  
ADDENDUM TO CLASS EA STUDY,  
MAJOR MACKENZIE DRIVE,  
TORONTO, ONTARIO**

|          |      |          |        |
|----------|------|----------|--------|
| Drwn By: | S.J. | Chkd By: | M.W.K. |
|----------|------|----------|--------|

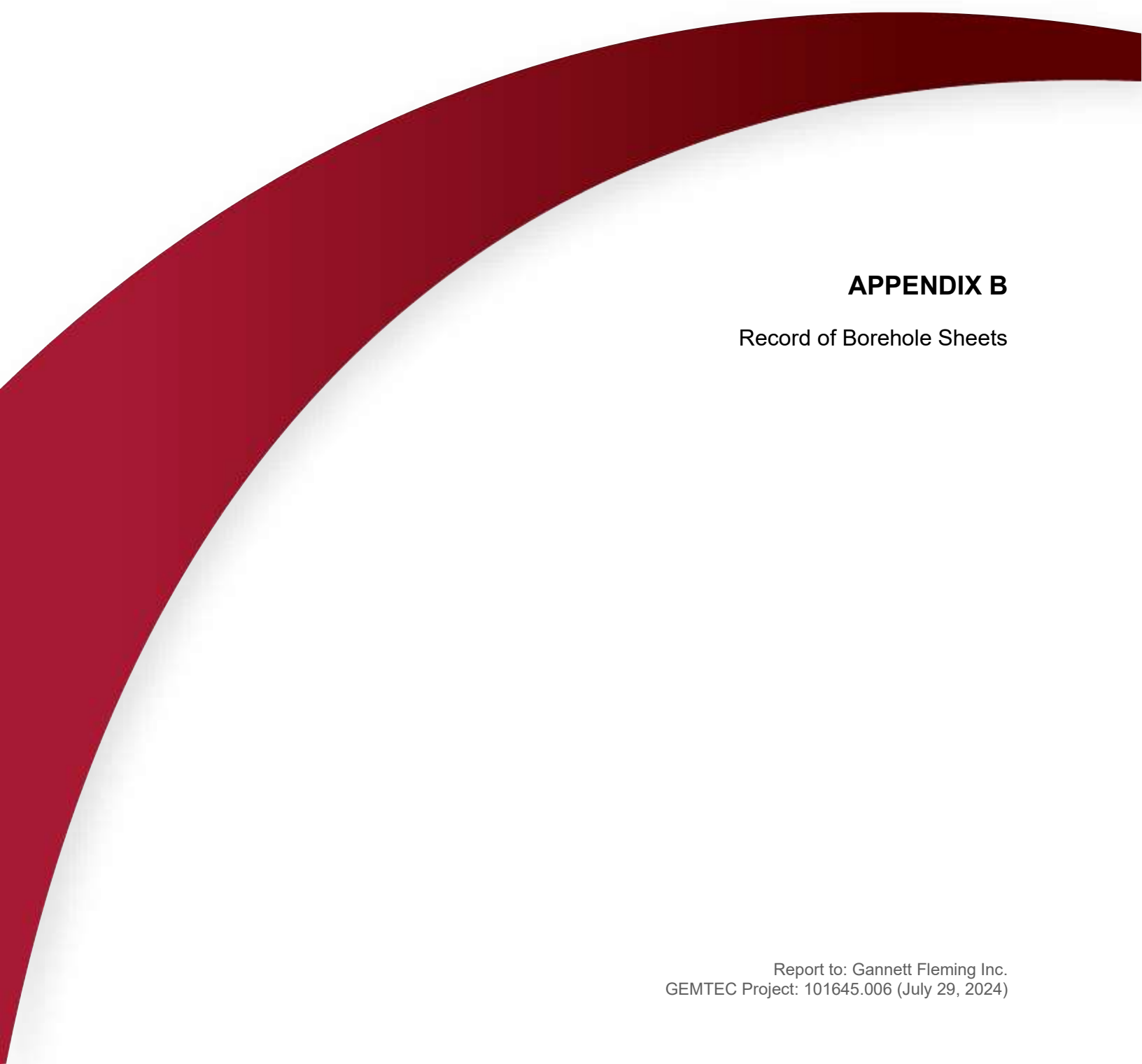
|             |            |              |   |
|-------------|------------|--------------|---|
| Project No. | 101645.006 | Revision No. | 0 |
|-------------|------------|--------------|---|

|      |           |                 |
|------|-----------|-----------------|
| Date | JUNE 2024 | <b>FIGURE 1</b> |
|------|-----------|-----------------|



**GEMTEC**  
CONSULTING ENGINEERS  
AND SCIENTISTS

6695 Millcreek DR #7,  
Mississauga, ON L5N 5M4  
T: (416) 347-7427  
www.gemtec.ca



## **APPENDIX B**

### Record of Borehole Sheets

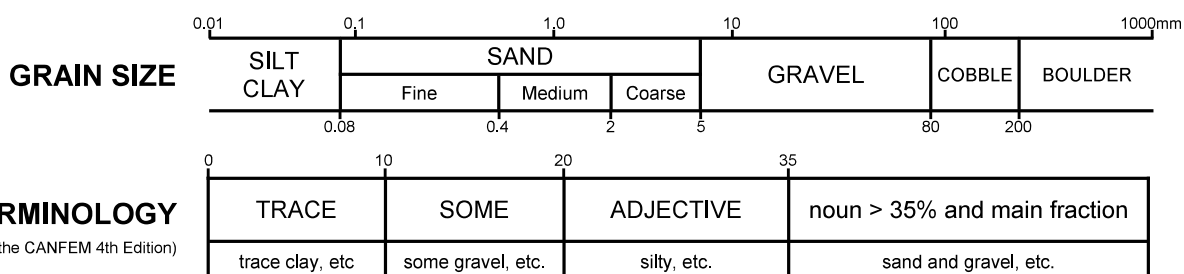
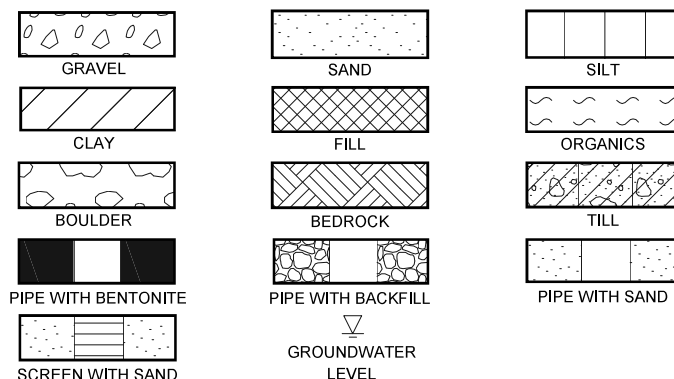
## ABBREVIATIONS AND TERMINOLOGY USED ON RECORDS OF BOREHOLES AND TEST PITS

| SAMPLE TYPES |                                |
|--------------|--------------------------------|
| AS           | Auger sample                   |
| CA           | Casing sample                  |
| CS           | Chunk sample                   |
| BS           | Borros piston sample           |
| GS           | Grab sample                    |
| MS           | Manual sample                  |
| RC           | Rock core                      |
| SS           | Split spoon sampler            |
| ST           | Slotted tube                   |
| TO           | Thin-walled open shelby tube   |
| TP           | Thin-walled piston shelby tube |
| WS           | Wash sample                    |

| SOIL TESTS |                                            |
|------------|--------------------------------------------|
| w          | Water content                              |
| PL, $w_p$  | Plastic limit                              |
| LL, $w_L$  | Liquid limit                               |
| C          | Consolidation (oedometer) test             |
| $D_R$      | Relative density                           |
| DS         | Direct shear test                          |
| $G_s$      | Specific gravity                           |
| 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                       |
| UC         | Unconfined compression test                |
| $\gamma$   | Unit weight                                |

| PENETRATION RESISTANCE                                                                                                                                                                                                                                                                                                                                          |                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| <b>Standard Penetration Resistance, N</b><br>The number of blows by a 63.5 kg (140 lb) hammer dropped 760 millimetres (30 in.) required to drive a 50 mm split spoon sampler for a distance of 300 mm (12 in.). For split spoon samples where less than 300 mm of penetration was achieved, the number of blows is reported over the sampler penetration in mm. |                                                            |
| <b>Dynamic Penetration Resistance</b><br>The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive a 50 mm (2 in.) diameter 60° cone attached to 'A' size drill rods for a distance of 300 mm (12 in.).                                                                                                                                 |                                                            |
| WH                                                                                                                                                                                                                                                                                                                                                              | Sampler advanced by static weight of hammer and drill rods |
| WR                                                                                                                                                                                                                                                                                                                                                              | Sampler advanced by static weight of drill rods            |
| PH                                                                                                                                                                                                                                                                                                                                                              | Sampler advanced by hydraulic pressure from drill rig      |
| PM                                                                                                                                                                                                                                                                                                                                                              | Sampler advanced by manual pressure                        |

| COHESIONLESS SOIL<br>Compactness |             | COHESIVE SOIL<br>Consistency |             |
|----------------------------------|-------------|------------------------------|-------------|
| SPT N-Values                     | Description | $C_u$ , kPa                  | Description |
| 0-4                              | Very Loose  | 0-12                         | Very Soft   |
| 4-10                             | Loose       | 12-25                        | Soft        |
| 10-30                            | Compact     | 25-50                        | Firm        |
| 30-50                            | Dense       | 50-100                       | Stiff       |
| >50                              | Very Dense  | 100-200                      | Very Stiff  |
|                                  |             | >200                         | Hard        |



### DESCRIPTIVE TERMINOLOGY

(Based on the CANFEM 4th Edition)

RECORD OF BOREHOLE BH24-01

CLIENT: Gannett Fleming  
PROJECT: Highway 404 Ramp Extension, Addendum to Class EA Study, Major Mackenzie Drive, Toronto, Ontario  
JOB#: 101645.006  
LOCATION: See Borehole Location Plan

SHEET: 1 OF 1  
DATUM: Unknown  
BORING DATE: May 27 2024

| DEPTH SCALE<br>METRES | BORING METHOD                                    | SOIL PROFILE                                                                                                                                                        |             |                       | SAMPLES |      |                 |            | PENETRATION<br>RESISTANCE (N), BLOWS/0.3m<br><br>▲ DYNAMIC PENETRATION<br>RESISTANCE, BLOWS/0.3m | SHEAR STRENGTH (Cu), kPA<br>+ NATURAL ⊕ REMOULDED |   | WATER CONTENT, %<br>Wp — W — Wl | ADDITIONAL<br>LAB. TESTING | PIEZOMETER<br>OR<br>STANDPIPE<br>INSTALLATION |
|-----------------------|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------------------|---------|------|-----------------|------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------|---|---------------------------------|----------------------------|-----------------------------------------------|
|                       |                                                  | DESCRIPTION                                                                                                                                                         | STRATA PLOT | ELEV.<br>DEPTH<br>(m) | NUMBER  | TYPE | RECOVERY,<br>mm | BLOWS/0.3m |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 0                     | Power Auger<br><br>Hollow Stem Auger (203 mm OD) | Ground Surface                                                                                                                                                      |             | 213.30                |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
|                       |                                                  | FILL - (SP/GP) SAND and GRAVEL, some silt; brown; non-cohesive, moist, compact                                                                                      |             | 0.00                  | 1       | SS   | 381             | 22         | ○ ●                                                                                              |                                                   |   |                                 | HEX: 0<br>IBL: 0           |                                               |
|                       |                                                  | FILL - (CL) SILTY CLAY, some sand, trace gravel; brown; cohesive, very stiff, w<PL                                                                                  |             | 212.84                |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
|                       |                                                  |                                                                                                                                                                     |             | 0.46                  |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 1                     |                                                  |                                                                                                                                                                     |             | 212.08                | 2       | SS   | 432             | 13         | ●                                                                                                |                                                   |   |                                 | HEX: 0<br>IBL: 0           |                                               |
|                       |                                                  | FILL - (CL) sandy SILTY CLAY, trace gravel; brown; cohesive, very stiff, w<PL                                                                                       |             | 1.22                  |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 2                     |                                                  |                                                                                                                                                                     |             |                       | 3       | SS   | 457             | 24         | ○ — ●                                                                                            |                                                   |   |                                 | MH<br>HEX: 0<br>IBL: 0     |                                               |
|                       |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
|                       |                                                  |                                                                                                                                                                     |             |                       | 4       | SS   | 381             | 18         | ●                                                                                                |                                                   |   |                                 | HEX: 0<br>IBL: 0           |                                               |
| 3                     |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
|                       |                                                  |                                                                                                                                                                     |             |                       | 5       | SS   | 457             | 15         | ○ ●                                                                                              |                                                   |   |                                 | HEX: 0<br>IBL: 0           |                                               |
|                       |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 4                     |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
|                       |                                                  |                                                                                                                                                                     |             |                       | 6       | SS   | 432             | 17         | ●                                                                                                |                                                   |   |                                 | HEX: 0<br>IBL: 0           |                                               |
| 5                     |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
|                       |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 6                     |                                                  | (CL-ML) SILTY CLAY, some sand to sandy, trace to some gravel; brown; cohesive, stiff to hard, w<PL                                                                  |             | 207.20                | 7       | SS   | 457             | 11         | ● — ○ — ]                                                                                        |                                                   |   |                                 | MH<br>HEX: 0<br>IBL: 0     |                                               |
|                       |                                                  |                                                                                                                                                                     |             | 6.10                  |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 7                     |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
|                       |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 8                     |                                                  |                                                                                                                                                                     |             |                       | 8       | SS   | 533             | 39         |                                                                                                  |                                                   | ● |                                 | HEX: 0<br>IBL: 0           |                                               |
|                       |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 9                     |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
|                       |                                                  |                                                                                                                                                                     |             |                       | 9       | SS   | 508             | 60         | ○                                                                                                |                                                   | ● |                                 | HEX: 0<br>IBL: 0           |                                               |
| 10                    |                                                  | End of Borehole                                                                                                                                                     |             | 203.70                |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
|                       |                                                  |                                                                                                                                                                     |             | 9.60                  |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 11                    |                                                  | Notes:<br><br>1. Borehole open and dry upon completion of drilling.<br><br>2. Borehole was backfilled with bentonite and soil cuttings upon completion of drilling. |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |
| 12                    |                                                  |                                                                                                                                                                     |             |                       |         |      |                 |            |                                                                                                  |                                                   |   |                                 |                            |                                               |

GEO - BOREHOLE LOG 101645.006, MAJORMACKENZIED, GINT, GEOTECH, R0\_2024\_05\_31.GPJ, GEMTEC 2018.GDT 6/25/24

RECORD OF BOREHOLE BH24-02

CLIENT: Gannett Fleming  
PROJECT: Highway 404 Ramp Extension, Addendum to Class EA Study, Major Mackenzie Drive, Toronto, Ontario  
JOB#: 101645.006  
LOCATION: See Borehole Location Plan

SHEET: 1 OF 1  
DATUM: Unknown  
BORING DATE: May 28 2024

| DEPTH SCALE<br>METRES | BORING METHOD                                   | SOIL PROFILE                                                                                                                                                        |                                                                                                         |              | SAMPLES |      |                 |            | PENETRATION RESISTANCE (N), BLOWS/0.3m |   | SHEAR STRENGTH (Cu), kPA |         | ADDITIONAL<br>LAB. TESTING | PIEZOMETER<br>OR<br>STANDPIPE<br>INSTALLATION |             |    |                        |                        |
|-----------------------|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|--------------|---------|------|-----------------|------------|----------------------------------------|---|--------------------------|---------|----------------------------|-----------------------------------------------|-------------|----|------------------------|------------------------|
|                       |                                                 | DESCRIPTION                                                                                                                                                         | STRATA PLOT                                                                                             | ELEV.        | NUMBER  | TYPE | RECOVERY,<br>mm | BLOWS/0.3m | ●                                      | ▲ | WATER CONTENT, %         |         |                            |                                               |             |    |                        |                        |
|                       |                                                 |                                                                                                                                                                     |                                                                                                         | DEPTH<br>(m) |         |      |                 |            |                                        |   | +                        | NATURAL |                            |                                               | ⊕ REMOULDED | Wp | W                      | WL                     |
| 0                     | Power Auger<br><br>Hollow Stem Auger (108mm OD) | Ground Surface                                                                                                                                                      |                                                                                                         | 210.70       |         |      |                 |            |                                        |   |                          |         | HEX: 0<br>IBL: 3           |                                               |             |    |                        |                        |
|                       |                                                 | FILL - (CL) SILTY CLAY, trace to some sand, trace to some gravel; brown to greyish brown; cohesive, moist, firm to hard, w<PL                                       |                                                                                                         | 0.00         | 1       | SS   | 254             | 7          | ●                                      | ○ |                          |         |                            |                                               |             |    | HEX: 0<br>IBL: 5       |                        |
| 1                     |                                                 |                                                                                                                                                                     |                                                                                                         | 2            | SS      | 305  | 7               | ●          |                                        |   |                          |         |                            |                                               |             |    | HEX: 0<br>IBL: 2       |                        |
| 2                     |                                                 |                                                                                                                                                                     |                                                                                                         | 3            | SS      | 381  | 11              | ●          | ○                                      |   |                          |         |                            |                                               |             |    | HEX: 0<br>IBL: 1       |                        |
| 3                     |                                                 |                                                                                                                                                                     |                                                                                                         | 4            | SS      | 457  | 15              | ●          |                                        |   |                          |         |                            |                                               |             |    | MH<br>HEX: 0<br>IBL: 1 |                        |
| 4                     |                                                 |                                                                                                                                                                     |                                                                                                         | 5            | SS      | 432  | 16              | ●          | ○                                      | — |                          |         |                            |                                               |             |    | HEX: 0<br>IBL: 1       |                        |
| 5                     |                                                 |                                                                                                                                                                     | (CL) SILTY CLAY, trace gravel, trace sand; grey; cohesive, dry, hard, w<PL                              |              | 205.67  | 6    | SS              | 533        | 83                                     |   |                          |         |                            |                                               |             |    |                        | HEX: 0<br>IBL: 1       |
| 6                     |                                                 |                                                                                                                                                                     | 7                                                                                                       |              | SS      | 508  | 61              | ○          |                                        |   | ●                        |         |                            |                                               |             |    | HEX: 0<br>IBL: 1       |                        |
| 7                     |                                                 |                                                                                                                                                                     | (CL-ML) SILTY CLAY, trace gravel, some sand to sandy; greyish brown, cohesive, dry to moist, hard, w<PL |              | 204.15  |      |                 |            |                                        |   |                          |         |                            |                                               |             |    |                        | HEX: 0<br>IBL: 1       |
| 8                     |                                                 |                                                                                                                                                                     | 8                                                                                                       |              | SS      | 457  | 36              |            |                                        | ● |                          |         |                            |                                               |             |    |                        | MH<br>HEX: 0<br>IBL: 1 |
| 9                     |                                                 | 9                                                                                                                                                                   | SS                                                                                                      |              | 457     | 75   | ○               | —          |                                        |   | ●                        |         |                            |                                               |             |    |                        |                        |
| 10                    |                                                 | End of Borehole                                                                                                                                                     |                                                                                                         | 201.10       |         |      |                 |            |                                        |   |                          |         |                            |                                               |             |    |                        |                        |
| 11                    |                                                 | Notes:<br><br>1. Borehole open and dry upon completion of drilling.<br><br>2. Borehole was backfilled with bentonite and soil cuttings upon completion of drilling. |                                                                                                         | 9.60         |         |      |                 |            |                                        |   |                          |         |                            |                                               |             |    |                        |                        |

GEO - BOREHOLE LOG 101645.006.MAJORMACKENZIEDR\_GINT\_GEO TECH\_R0\_2024\_05\_31.GPJ GEMTEC 2018.GDT 6/25/24

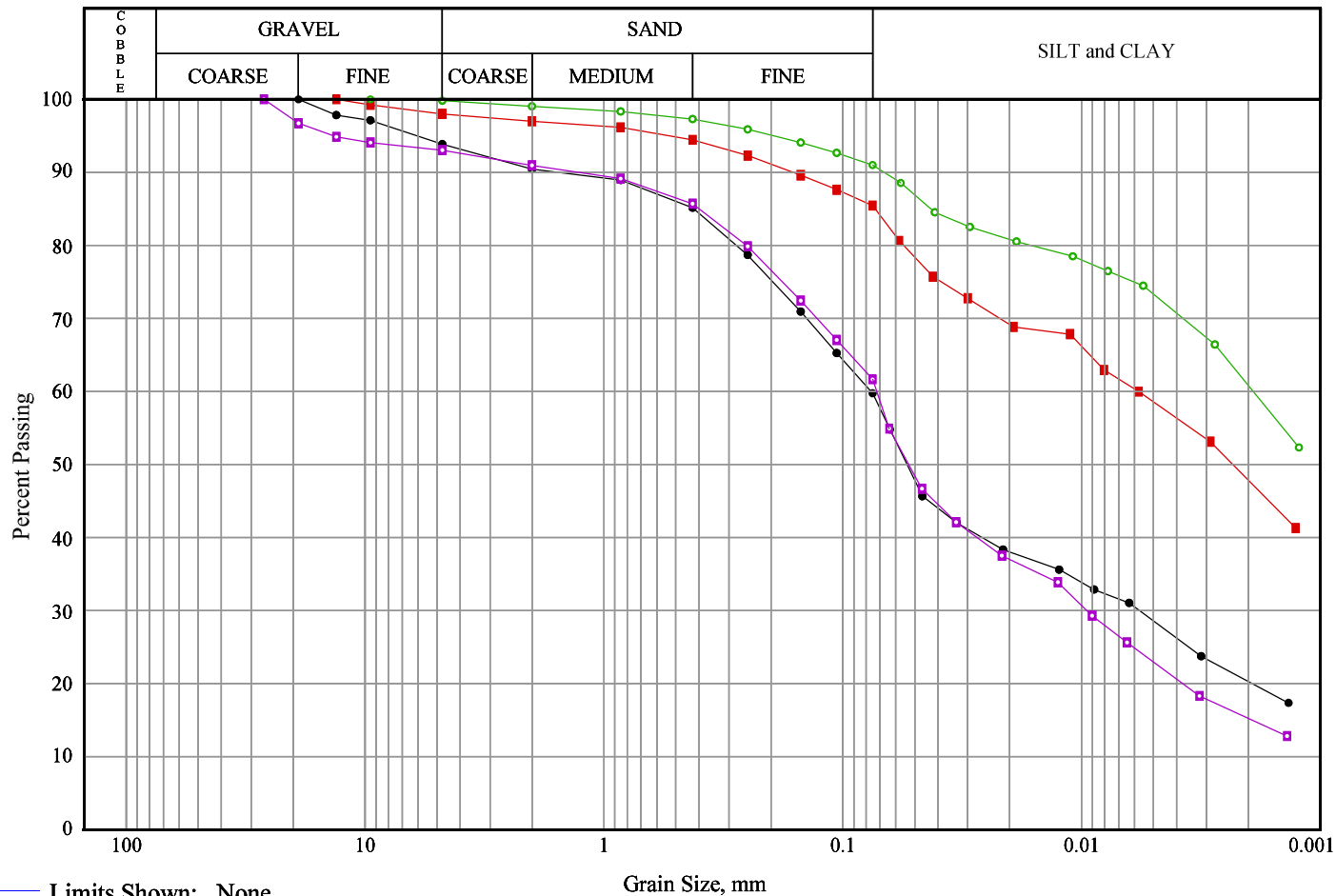


## **APPENDIX C**

### Geotechnical Laboratory Testing Results

|                                                                                                                                           |                                                                                                          |                                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
|  <b>GEMTEC</b><br>CONSULTING ENGINEERS<br>AND SCIENTISTS | Client: Gannett Fleming Canada ULC                                                                       | <b>Soils Grading</b><br><b>LS-702/ASTM</b><br><b>D-422</b> |
|                                                                                                                                           | Project: Highway 404 Ramp Extension, Addendum to Class EA Study,<br>Major Mackenzie Dr, Toronto, Ontario |                                                            |
|                                                                                                                                           | Project #: 101645006                                                                                     |                                                            |

Note: More information available upon request



| Line Symbol | Sample | Borehole/<br>Test Pit | Sample Number | Depth   | % Cob.+<br>Gravel | % Sand | % Silt and Clay |
|-------------|--------|-----------------------|---------------|---------|-------------------|--------|-----------------|
| —●—         |        | 24-1                  | SA-3          | 1.5-2.0 | 6.1               | 34.1   | 59.8            |
| —■—         |        | 24-1                  | SA-7          | 6.1-6.6 | 2.0               | 12.5   | 85.4            |
| —○—         |        | 24-2                  | SA-5          | 3.1-3.5 | 0.2               | 8.8    | 91.0            |
| —□—         |        | 24-2                  | SA-9          | 9.1-9.6 | 7.0               | 31.4   | 61.6            |

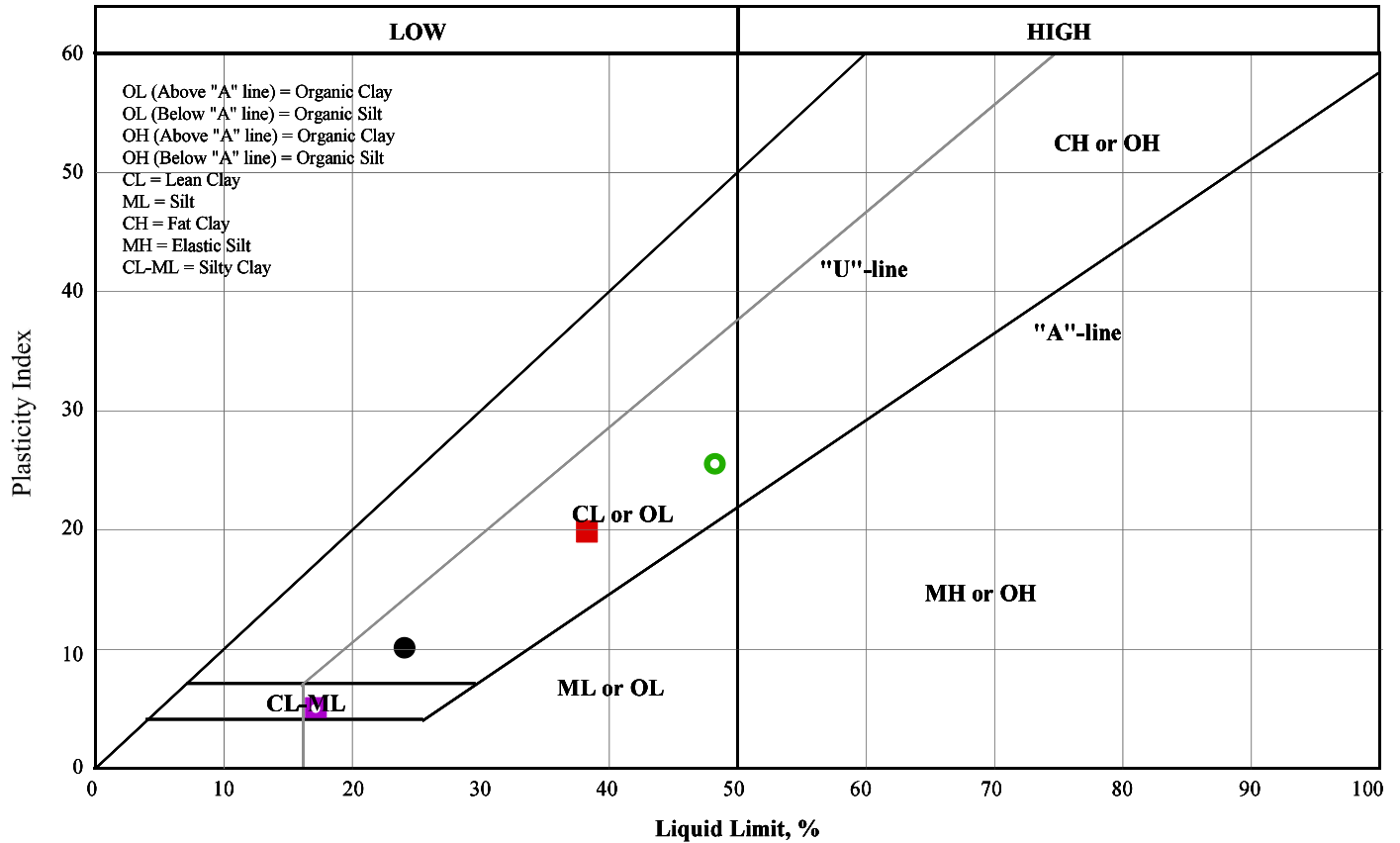
| Line Symbol | USCS Classification                      | USCS Symbol | D <sub>10</sub> | D <sub>15</sub> | D <sub>30</sub> | D <sub>50</sub> | D <sub>60</sub> | D <sub>85</sub> | % 5-75µm |
|-------------|------------------------------------------|-------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------|
| —●—         | Sandy clayey silt , trace gravel         | CL          | ---             | ---             | 0.01            | 0.05            | 0.08            | 0.42            | 39.5     |
| —■—         | Clay and silt , some sand , trace gravel | CL          | ---             | ---             | ---             | 0.00            | 0.01            | 0.07            | 37.6     |
| —○—         | Silty clay , trace gravel, trace sand    | CL          | ---             | ---             | ---             | ---             | 0.00            | 0.04            | 30.2     |
| —□—         | Sandy silt , some clay , trace gravel    | CL-ML       | ---             | 0.002           | 0.01            | 0.05            | 0.07            | 0.40            | 46.4     |

**GEMTEC**CONSULTING ENGINEERS  
AND SCIENTISTS  
Oshawa, ON

Client: Gannett Fleming Canada ULC

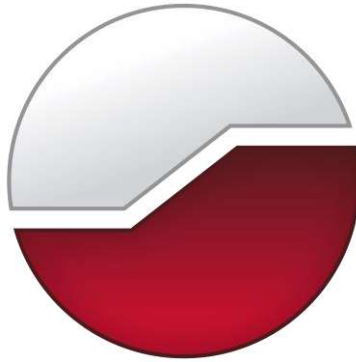
Project: Highway 404 Ramp Extension, Addendum to Class EA Study,  
Major Mackenzie Drive, Toronto, Ontario

Project #: 101645006

**Plasticity Chart**  
(LS-7034/ASTM D4318)

| Symbol | Borehole /Test Pit | Sample Number | Depth   | Liquid Limit | Plastic Limit | Plasticity Index | Non-Plastic | Moisture Content, % |
|--------|--------------------|---------------|---------|--------------|---------------|------------------|-------------|---------------------|
| ●      | 24-1               | SA-3          | 1.5-2.0 | 24.1         | 14.0          | 10               | N/A         | 8.4                 |
| ■      | 24-1               | SA-7          | 6.0-6.6 | 38.3         | 18.4          | 20               | N/A         | 23.1                |
| ○      | 24-2               | SA-5          | 3.1-3.5 | 48.2         | 22.7          | 26               | N/A         | 23.0                |
| ■      | 24-2               | SA-9          | 9.1-9.6 | 17.1         | 12.1          | 5                | N/A         | 6.5                 |

experience • knowledge • integrity



|                   |                                      |
|-------------------|--------------------------------------|
| civil             | civil                                |
| geotechnical      | géotechnique                         |
| environmental     | environnement                        |
| structural        | structures                           |
| field services    | surveillance de chantier             |
| materials testing | service de laboratoire des matériaux |

expérience • connaissance • intégrité

