GEOTECHNICAL INVESTIGATION

Proposed Gas Station

16621 Hwy 12, Midland, ON

Ref. No: DES21-03-13A

September 24, 2021

Prepared for: 2825951 Ontario Ltd.

Prepared by: Frontop Engineering Limited

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1.0 INTRODUCTION

Frontop Engineering Limited (Frontop) was retained by 2825951 Ontario Ltd. (the Client) to carry out a geotechnical Investigation for the proposed development, located at 16621 Hwy 12, Midland, Simcoe County, ON (the Site).

The purpose of this geotechnical investigation was to obtain required geotechnical information on the subsurface conditions with a limited number of boreholes, in-situ tests and laboratory program, and based on the assessment of the geotechnical information to provide geotechnical engineering comments and recommendations for the design of structures and related facilities.

The comments and recommendations are provided with conditions that the design will follow all applicable codes, standards, legislations and well accepted engineering practice, and are applicable only to the proposed development. On-going liaison and communication with Frontop during the design and construction phases of the project is highly recommended to confirm that the recommendations in this report are correctly interpreted and implemented. Also, any queries concerning the geotechnical aspects of the proposed project shall be directed to Frontop for further clarification and interpretation.

This report is based on the terms of reference presented in, or implied through, the approved proposal and our understanding of the development and site conditions. If there are any changes to the design relevant to the geotechnical analyses, or if any questions arise concerning the geotechnical aspects of the codes and standards, Frontop should be contacted to review the design, and it might be necessary to carry out further studies before the recommendations can be relied upon.

This report deals with geotechnical engineering only. Other related issues such as excess soil management and dewatering are beyond the scope of the investigation.

The site investigation and recommendations follow generally accepted practice for geotechnical engineering in Ontario, and laboratory program follows ASTM, CSA and MTO Standards or modifications of these standards that have become standard practice in Ontario, as well as generally accepted geological principles.

This report has been prepared for the Client only. Third party use of this report without consent from Frontop and the Client is prohibited

2.0 FIELDWORK

The fieldwork included a site visit, a site clearance, borehole drilling and monitoring well installation. The site visit involved visually observing the site conditions and marking potential borehole locations.

Following the site visit the site clearance for underground utilities was coordinated by Frontop to be completed by both public and private agencies to minimize the risk of encountering any utilities during the course drilling.

Borehole drilling was conducted on May 5 and May 12, 2021. Four boreholes (BH1 to BH4) were drilled at the approximate locations as shown in Drawing 1.

The boreholes were advanced with track mounted rig (GEO205 for BH1 and D9 for BH2 to BH4) owned and operated by specialized drilling contractors. Three boreholes (BH1 to BH3) were installed with monitoring wells, and all BH4 were backfilled. Monitoring well installation and backfill of borehole were carried out following the guidelines of Regulation 903 after taking soil samples. Soil samples were recovered using conventional split-spoon equipment in conjunction with standard penetration tests.

The boreholes were drilled from the existing ground surface to depths of 3.5 to 11 m below the existing grade. The locations and depth of boreholes were proposed by Frontop, and were reviewed by the Client. Both locations and depths of boreholes were adjusted according to the accessibility of the Site and the encountered soil conditions. Groundwater, moisture conditions and soil gas conditions were observed during the course of the drilling. Borehole logs were attached as Drawing 2 to 5.

The locations of boreholes were determined on Site with referencing to existing features such as driveway edge, building corners and trees.

Elevation data was read from the topographical survey drawing provided by the Client.

The fieldwork was conducted and supervised by a Frontop's field engineer, who monitored the drilling operations, logged the retrieved soil cores and recorded related information during drilling. All soil samples were transported to our laboratory for testing and detailed review by a senior geotechnical engineer of Frontop.

3.0 LABORATORY PROGRAM

The laboratory program was conducted to carry out required geotechnical testing, corroborate field findings, and refine identification and classification of soils. The following laboratory tasks were completed for this investigation.

- Moisture content determination for all recovered soil samples. The testing results are presented on the borehole logs in Drawings 2 to 5;
- Detailed examination, description and classification of soil samples and demarcation of stratigraphy boundaries according to ASTM standards and geological principles. The results are presented on the borehole logs in Drawings 2 to 5.

4.0 SUBSURFACE CONDITIONS

The detailed soil profile encountered in the boreholes, the relative soil density or consistency and its corresponding SPT 'N' Value, and the results of laboratory moisture content determinations are all presented on the attached borehole logs, Drawings 2 to 5. It should be noted that the soil boundaries indicated on the borehole log are inferred from non-continuous sampling and observations during drilling based on stratigraphic principles. These boundaries are intended to reflect approximate transition zones and should not be interpreted as exact planes of geological change. The "ABBREVIATIONS, TERMINOLOGY, GENERAL INFORMATION FOR BOREHOLE LOG" preceding the borehole logs form an integral part of this report and should be read in conjunction with this report.

4.1 Subsoil

The soil stratigraphy of the site, as revealed in the boreholes, comprises the following three units:

1. Clayey silt,
2. Gravelly sand;
3. Silty fine sand.

A brief description of the soil profiles, in order of depth from top down, is presented in the following.

1) Clayey Silt

This unit was encountered in all boreholes, and extended to a depth of 0.7 meters below ground surface (mbgs). This unit consists mostly of clayey silt, trace sand and rootlets, with brown to dark brown in color. This unit was in moist to wet in water condition, with moisture content ranging from 21% to 28%. The SPT ‘N’ values are 8 blows per 300 mm for all boreholes, indicating a soft consistency or loose relative density.

2) Gravelly Sand

Gravelly sand unit was encountered in all boreholes below the clayey silt unit and extended to a depth of 8.4 meters below ground surface (mbgs). BH, BH3 and BH4 were terminated in this unit. This unit consists of fine to medium sand matrix, some silt, and 20 to 30 % sound to weathered, angular to subangular Precambrian rock clasts and some limestone clasts (3 to 8 cm). The SPT ‘N’ values range from 26 blows to 100 blows per 300 mm, indicating compact to very dense relative density. This unit has a gray to brownish gray in color, and its water content condition ranges from moist to saturated from top to bottom with a moisture content values between 4% and 30%.

Facies change to fine to medium sand horizontally and vertically.

3) Silty Fine Sand

This unit was encountered in BH2 below the gravelly sand unit and extended beyond the depth of termination of BH12, which is 11.1 mbgs. This unit consists mostly of silty find sand and trace gravel, with brownish gray in color, and is locally laminated. This unit was in wet water condition, with moisture content of 12%. The SPT ‘N’ values ranged from 88 blows to 100 blows per 300 mm, indicating a very dense relative density.

Environmental observation was conducted during drilling in filed and soil classification in lab for all soil samples. No apparent stains and no odor were identified

4.2 Groundwater

Three monitoring wells were installed in the BH1 to BH3. Groundwater conditions in the open boreholes were observed during and upon completion of drilling. Moisture condition of soil was tracked in order to predict and delineate groundwater condition. One round of groundwater monitoring was conducted on May 19, 2021. The following table summarizes groundwater conditions.

Monitoring Well ID	Screen Interval (mbgs)	GW Level (mbgs)		
		First-Sight	Upon Completion of Drilling	May 19, 2021
BH1	5-6.5	Dry	1.83	4.63
BH2	9.6-11.1	2.43		9.27
BH3	3.5-5	Dry	3.05	3.29

Seasonal perched groundwater at the site should be anticipated considering generally high moisture content from all boreholes and the combination of soil layers of different hydraulic conductivity.

5.0 PROPOSED DEVELOPMENT

Based on the terms of reference and the site plan drawing provided by the Client, the proposed development includes the following features:

- Two underground gas storage tanks with diameter from 2.4 to 3.0 m and length from 12.0 to 15.3 m. The excavation may extend to 3.6 to 4.2 m in width, 14 to 15 m in length and 4.0 to 4.5 m in depth;
- A four post gas canopy with footprint of 200 m^2;
- A one story convenience store with a footprint of 218 m^2;
- A one story restaurant building with a footprint of 194 m2; and
- Associated asphalt pavement.

6.0 DISCUSSION AND RECOMMENDATIONS

The following recommendations and comments are based on factual information obtained from the investigation and the understanding of the proposed development, and are intended only for use by the design engineers. Subsurface conditions between and beyond the boreholes may differ from those encountered at the boreholes locations, and conditions that could not be detected or anticipated at the time of the site investigation may become apparent during construction. Therefore, Frontop should be retained during construction stage to conduct site inspection to confirm soil and groundwater conditions, based on which the design and construction procedure can be updated.

6.1 Demolition, Stripping and Regrading

Existing building and surficial features include a one story frame dwelling house, one wood frame garage, front gravel driveway and front parking area. Other areas of the property including backyard are grown out with grass and trees (Cover Page), and a soil ridge exists at backyard along east property boundary. Three boreholes (BH1 to BH3) were completed at backyard and one borehole (BH1) were drilled at front yard.

Based on visual observation and borehole information, the surficial soil should be able to support medium to heavy duty equipment for demolition, stripping and grading. However, during wet season or wet weather, the first unit of clayey silt may impose some challenge to wheel mounted equipment.

Depending on the age of these building features, a Designated Substance Survey (Regulation 490 of Ontario) may need to be completed in order to apply for a demolition permit.

Gravel materials from the gravel driveway should be reclaimed for future pavement and backfill uses at the Site or for other uses if the environmental quality of the materials meet requirement.

Ground surface at the Site has a relief between 0.5 to 1.0 m, and a small ridge was identified at the east border of the property. Small to medium sized dozer or medium size back hole should be enough to regrade the ground.

All organic materials should be stripped and shredded for composting and landscaping. All topsoil should be piled for later landscaping use. Surplus mineral soil should be stockpiled for later backfilling, or disposal if environmental quality of the materials meet requirement.

6.2 Foundation Considerations

6.2.1 Gas Tanks

Considering the diameter of the gas tanks, overexcavation, thickness of bedding and thickness of cover, the depth of subgrade (or founding level) may reach 4.0 to 5 .0 mbgs. Considering the subsoil conditions at the founding level, concrete pad footing is recommended to support the gas tank.

Assuming the gas tanks will sit on a concrete pad with a width of 5 m and a length of 14 m, the recommended Serviceability Limit State (SLS) bearing capacity is 300 kPa and the recommended Factored Ultimate Limit States (ULS) is 450 kPa. The settlements of the tanks are expected to be within the normally tolerated limits of 25 mm total and 19 mm differential movements.

Stabilized groundwater level is about 0.6 m above the subgrade. Plus the seasonal fluctuation of groundwater levels, the hydrostatic buoyance force corresponding to a water head of 1.6 m may exerts on the under side of the gas tank. An anchor or ballast system should be considered.

6.2.2 Gas Canopy

Based on the subsoil conditions, the proposed gas station canopy may be founded on the natural undisturbed second gravelly sand unit with depth between 1.5 to 3.0 mbgs. The recommended Serviceability Limit State

(SLS) bearing capacity is 200 kPa and the recommended Factored Ultimate Limit States (ULS) is 300 kPa. The settlements of the tanks are expected to be within the normally tolerated limits of 25 mm total and 19 mm differential movements. As the canopy will not be heated, snow should be removed from its vicinity in winter and a minimum of 1.8 m of earth cover or equivalent insulation should be provided to the footings to protect them from damage due to frost penetration.

6.2.3 Store and Restaurant Building

Based on the subsoil conditions, spread footing is recommended for the proposed store and restaurant building. The spread footing may be founded on the natural undisturbed second gravelly sand unit with depth between 1.5 to 2.0 mbgs. The recommended Serviceability Limit State (SLS) bearing capacity is 150 kPa and the recommended Factored Ultimate Limit States (ULS) is 225 kPa. The settlements of the tanks are expected to be within the normally tolerated limits of 25 mm total and 19 mm differential movements. A minimum of 1.4 m of earth cover or equivalent insulation should be provided to the footings to protect them from damage due to frost penetration

6.2.4 Floor Slab for Store and Restaurant Building

The floors for the proposed store and restaurant building are anticipated to sit on the clayey silt or gravelly sand unit. To prevent settlement, it is recommended that part of the clayey silt unit was replaced the granular material, following the following steps:

- Remove the topsoil, organics and soft materials;
- Carefully remove 0.5 meter of clayey silt;
- Compact the subgrade to 98 % of Standard Proctor Maximum Dry Density (SPMDD);
- Backfill with 0.5 m of Granular A material in lift under 15 cm thick and compact to 100 % of Standard Proctor Maximum Dry Density (SPMDD).

It should be noted that clayey silt may be difficult to compact if not in optimum moisture content. When removing the 0.5 meter of clayey silt the contractor must be very careful to minimize the disturbance to the unit.

For designing concrete slab, the Modulus of Subgrade Reaction (Ks) of 18000 (KN/m^3) can be considered for the subgrade prepared as above with Granular A materials and the underlying clayey silt, and Modulus of Subgrade Reaction (Ks) of 36000 (KN/m^3) can be considered for the subgrade prepared with gravelly sand unit.

Granular materials used to bring to final grade should consist of Granular A (OPSS 1010) with appropriate moisture content, placed not more than 150 mm per lift and compacted to 100 percent of its Standard Proctor Maximum Dry Density SPMDD.

6.2.5 Foundation and Subfloor Drainage for Store and Restaurant Building

Based on soil and groundwater condition at the Site, foundation perimeter drainage for the one story building without basement may not be needed. However, it is recommended to backfill the space surrounding the outside of the foundation wall with well drained material to prevent potential frost heave and adfreezing.

Based on soil and groundwater condition at the Site, subfloor drainage for the one story building without basement may not be needed. However, depending on the actual subgrade condition a moisture barrier might have to be considered. The moisture barrier should consist of a minimum 150 mm thick layer of well-compacted 19 mm clear crushed stone below the floor slab. If a moisture sensitive finish will be placed on the floor slab, a layer of polyethylene sheet or equivalent may be provided between the clear crushed stone layer and the floor slab as an additional moisture barrier.

Subfloor drain, if considered, may consist of drainage tiles consisting of 100 mm diameter perforated pipes wrapped with filter fabric and should discharge into a positive frost-free outlet. The requirement for underfloor drainage should be identified in the field by Frontop staff.

6.2.6 General Considerations

After excavating to desired depth for footing base, the soil should be inspected in detail for any soft spot and suspected nonnative materials. The soft spot and suspected nonnative materials should be subexcavated and backfilled with granular materials to final grade, followed by compaction to 100 percent of its Standard Proctor Maximum Dry Density SPMDD.

Footing base should be inspected by Frontop prior to pouring concrete to confirm the soil condition. The founding materials are susceptible to disturbance by construction activities especially during wet weather and care should be taken to preserve the integrity of the materials as bearing strata. The excavated footing bases should be covered with 75 mm thick mud slab (i.e. 10 MPa lean concrete) immediately after cleaning and the inspection by a geotechnical engineer if the soil is found loose or the soil has to be exposed for long period of time before concrete placement.

Where it is necessary to place footings at different depths, the lower footing must be installed first to help minimize the risk of undermining the upper footing and the upper footing must be founded below an imaginary 10 horizontal to 7 vertical line drawn up from the base of the lower footing.

In the vicinity of the existing buried utilities, all footings must be lowered to undisturbed native soils, or alternatively the services must be structurally bridged.

6.3 Excavation and Groundwater Control

6.3.1 Foundation Pits for Gas Tanks

As mentioned above, the excavation for the foundation pits of the gas tanks may extend to 4.0 to 4.5 mbgs. As shown with Drawing 2 to 5, the excavation will go through the first and second units. Based on density of soil and classification, medium to heavy duty backhoe excavator might be required for executing the excavation.

Excavation sequence, cutting slope forms and support system should be implemented in accordance with Regulation 213/91 under Occupational Health and Safety Act (OHSA) of Ontario and Ontario Building

Code. For the purpose of Regulation 213/91, the soil to be excavated at the Site can be classified as Type 2. The following lists the major criteria that a support is not required by the regulation for Type 2 soil:

- Excavation is less than 1.2 m below grade;
- No worker is required to enter;
- The excavation is not a trench and with respect to which no worker is required to be closer to a wall than the height of the wall;
- Excavation walls are sloped to 1.2 metres or less from its bottom with a slope having a minimum gradient of one vertical to one horizontal.

As presented above, the excavation will extend to deeper than 1.2 mbgs for gas tank, and there must be workers working in the trench to build foundation. Therefore, supporting system will have to be considered if the cutting slope is not to be flattened to one vertical to one horizontal from a height of less than 1.2 m from the bottom of the excavation pit.

Excavation should be closely inspected by geotechnical staff of Frontop. If soil condition exposed is different from findings from boreholes, excavation process and shoring system might have to be modified.

Excavated soil should be stockpiled at least 3 m away from the cutting wall crest if space is available to.

Unsupported excavation sequence should be arranged such as to minimize the time of the exposure of cutting slopes to elements and to execute the excavation in dry season as far as possible. Tarping may be needed during extended period of raining to prevent erosion and soaking of the slope. Care should be taken to direct surface water away from the open excavations.

Excess soil should be disposed of according to Ontario Regulation 406/19 under the Ontario Environmental Act and associated guidelines. TCLP (Toxicity Characteristic Leaching Procedure) assessment may be required if the excess soil is to be disposed of in landfill sites.

Considering the groundwater levels in Ontario usually are at the highest during spring and at the lowest in summer, the groundwater levels measured at the monitoring wells (BH1 to BH3) at the Site should be in the middle range, and groundwater levels in other seasons should be lower and higher than the measured levels.

Because the measured groundwater levels are higher than anticipated excavation base dewatering, groundwater control will have to be considered if the excavation is executed in wet seasons. A hydrogeological assessment is conducted in tandem with this geotechnical investigation. Detailed construction dewatering assessment can be found in the hydrogeological assessment.

Excavated clayey silt should be stockpiled separately from the excavated gravelly sand. The excavated clayey silt can be used for landscaping, or backfill after mixing with coarse material and adjusted to optimum water content. The excavated gravelly sand can be used for backfilling.

6.3.2 Spread Footings for Store and Restaurant Building and Gas Canopy

The excavation for the spread footings may extend to 1.2 to 1.5 mbgs. As shown with Drawing 2 to 5, the excavation will mostly go through the first and second unit. Based on density of soil and classification, medium to heavy duty backhoe excavator may be required for executing the excavation.

Excavation sequence, cutting slope forms and support system should be implemented in accordance with Regulation 213/91 under Occupational Health and Safety Act (OHSA) of Ontario and Ontario Building Code. For the purpose of Regulation 213/91, the soil to be excavated at the Site can be classified as Type 3. The following lists the major criteria that a support system should be in place as required by the regulation for Type 3 soil:

- Excavation is deeper than 1.2 m below grade;
- Cutting walls are not sloped from its bottom with a slope having a minimum gradient of one vertical to one horizontal;
- There will be workers working close to cutting walls for all excavation.

As presented above, the excavation will extend to, or, deeper than 1.2 mbgs, and there must be workers working in the trench to build foundation. Therefore, supporting system will have to be considered if the cutting slope is not flattened to one vertical to one horizontal.

Excavation should be closely inspected by geotechnical staff of Frontop. If soil condition exposed is different from findings from boreholes, excavation process and shoring system might have to be modified.

Excavated soil should be stockpiled at least 3 m away from the cutting wall crest if space is available.

Unsupported excavation sequence should be arranged such as to minimize the time of the exposure of cutting slopes to elements and to execute the excavation in dry season as far as possible. Tarping may be needed during extended period of raining to prevent erosion and soaking of the slope. Care should be taken to direct surface water away from the open excavations.

Excess soil should be disposed of according to Ontario Regulation 406/19 under the Ontario Environmental Act and associated guidelines. TCLP (Toxicity Characteristic Leaching Procedure) assessment may be required if the excess soil is to be disposed of in landfill sites.

Even considering one meter of fluctuation in groundwater levels, the groundwater level is still deeper than the expected excavation depth. Consideration for construction dewatering and groundwater control are not be needed. However, perched groundwater cannot be avoided considering the higher hydraulic conductivity of the fine sand unit, especially during wet season. Sump pump system should be in place during foundation construction.

Excavated clayey silt should be stockpiled separately from the excavated gravelly sand. The excavated clayey silt can be used for landscaping, or backfill after mixing with coarse material and adjusted to optimum water content. The excavated gravelly sand can be used for backfilling.

6.4 Backfilling

6.4.1 Gas Tanks

The excavated materials from gas tank foundation pit include the clayey silt unit and gravelly sand unit. Gravelly sand can be used for backfill for gas tanks. Backfill should be executed in a lift not more than 20 cm and compact to 95 percent of its Standard Proctor Maximum Dry Density SPMDD. Soil close to the tank should be compacted with less effort.

6.4.2 Spread Footings for Store and Restaurant Building and Gas Canopy

The excavated materials for spread footing for the store and restaurant building and the gas canopy should consist of mostly clayey silt and some gravelly sand. Both types of materials are considered suitable for use as trench backfill provided its water contents at the time of construction are at or near their optimum water content for compaction,

It is recommended that the two types of materials are mixed before placement.

The backfill should be placed in maximum 300 mm loose lift thickness and uniformly compacted to at least 95 percent of its SPMDD.

6.5 Seismic Considerations

The 2012 Ontario Building Code (OBC 2012) came into effect on January 1, 2014 and contains updated seismic analysis and design methodology. The seismic site classification methodology outlined in the code is based on subsurface conditions within the upper 30 m below grade.

As shown in Table 4.1.8.4A of the OBC, three methods of determining the site class are provided in the code: method 1 based on average shear wave velocity, method 2 based on average standard penetration resistance (N-value), and method 3 based on undrained shear strength.

Considering the availability of information, Frontop used the second method to determine the site class. The following table lists the averaged N-value for subsoil encountered in the four boreholes completed for the geotechnical investigation.

Borehole ID	BH1	BH2	BH3	BH4
Averaged N-value	51	55	28	19
Average	38			

Subsoil encountered through the four boreholes includes native clayey silt, gravelly sand and fine to medium sand materials. Overall the subsoil can be classified as stiff soil. Based on the above averaged N-value and the subsoil property Frontop recommends a site class of D for seismic load design.

Considering that the subsoil usually becomes more consolidated with depth because of the increased overburden pressure and longer history of deposition and consolidation, and that the borehole depth for the study are far less than 30 m, the above seismic site classification is conservative. Should optimization of the site class be recommended by the structural engineer, in-situ geophysical testing or additional geotechnical investigation including additional deeper boreholes may be considered. However, considering that the proposed building is one story and without basement, optimization of the site class might not be needed.

6.6 Lateral Earth Pressure

The lateral earth pressure acting at any depth on underground walls can be calculated with the following equation:

$$p = K_1 (\gamma_1 h_1 + q)$$

p = lateral earth pressure in kPa acting at depth h_1

K_1 = earth pressure coefficient (K_1=0.50)

$\gamma 1$ = unit weight of overburden soil (γ_1=22 kN/m^3)

h_1 = depth in overburden soil

q = value of surcharge in kPa

The above formula can be used to estimate earth pressure for both foundation wall design and excavation shoring design.

The above expression assumes that the perimeter drainage system prevents the build-up of any hydrostatic pressure behind the wall. The hydrostatic water pressure should be factored into the calculation if there is potential that the water pressure accumulates behind the walls.

6.7 Pavement

Based the site plan provided by the Client, the area that need to be paved with asphalt includes a parking area for the convenience store, parking area in front of the gas canopy and driveway. Small area of concrete pavement may also be needed. As revealed with borehole drilling (Drawing 2 to 5), the first native clayey silt unit and the second gravelly sand unit can serve as the subgrade subject to appropriate preparation.

Recommended procedure for demolition and grading has been presented above. The following will discuss subgrade preparation and pavement structure.

6.7.1 Preparation of Subgrade and Base

Both the first native clayey silt unit and the second gravelly sand unit can serve as subgrade. However, the first unit will need more preparation than the second. Preparation of the subgrade may involve the following tasks:

- Removing and reclaiming topsoil;
- Removing all organic materials and roots;
- Inspection of exposed native materials to confirm its mechanical property and continuity, and identify any soft spots and depressions;
- Subexcavate soft spots and backfill and bring to grade with granular material (Granular A) or excavated gravelly sand materials (second unit);

- Backfill depressions to bring to grade with granular material (Granular A) or excavated gravelly sand materials (second unit);
- While backfilling with granular material (Granular A) or excavated gravelly sand materials (second unit), Compacting to 95 percent of Standard Proctor Maximum Dry Density (SPMDD);
- Proof rolling with heavy loaded truck, subdigging soft spots and backfilling with similar granular material (Granular A or excavated gravelly sand materials) and compacting to 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

The prepared sandy subgrade can be easily disturbed by construction activates. Construction procedure should be executed such as to minimize disturbance to the completed subgrade.

If the subgrade is disturbed by construction traffic and other activities especially during wet weather, the subgrade should be replaced with similar materials and compacted as above.

The subgrade should be cambered or shaped properly to facilitate drainage and to prevent the ponding of water. Proper cambering will allow water to escape towards the sides, where it can be discharged through subdrains or storm sewers. Otherwise, water trapped in the subgrade materials may cause problems due to softening and frost heave.

6.7.2 Asphalt Pavement Structure

Pavement at the Site include parking area and driveway. Parking area will be used for cars and other light vehicles, and driveway may have to accommodate light to heavy duty vehicles. Based on provincial guidelines and underground condition, the pavement structure is recommended in following table.

Material		**Thickness of Pavement (mm)**	
		Parking Area	**Driveway**
Hot-Mix Asphalt (OPSS 1150)	HL3 Surface Course	50	40
	HL8 Binder Course/Superpave 19		50
Base (OPSS 1010)	Granular A	150	150
Subbase (OPSS 1010)	Granular B Type II	300	300
Prepared Subgrade			

The granular base and subbase should be placed in maximum 150 mm thick lifts and compacted to a minimum of 98% of the SPMDD using suitable vibratory equipment.

The recommended pavement structures should be considered as preliminary design with a functional design life of ten years. This represents the number of years to the first rehabilitation, assuming regular maintenance is carried out. If required, a more refined pavement structure design can be performed based on specific traffic data and design life requirements.

6.7.3 Concrete Pavement Structure

It is anticipated that concrete pavement may be considered for part of the driveway and the pumping area. Based on CSA standards, the provincial guidelines and local experience, the recommended concrete pavement structure is presented in the following table.

Material		**Thickness of Pavement (mm)**
Reinforced concrete (>32 MPa at 28 days)		150
Base (OPSS 1010)	Granular A	100
Subbase (OPSS 1010)	Granular B Type II	300
Prepared Subgrade		

It is recommended that the concrete slab be reinforced with 152 x 152 MW25.8/25.8 gauge welded wire mesh. The reinforcement would be adequately supported by 50 mm thick blockers with a wire mesh overlap of a minimum 150 mm.

It should be noted that the reinforced concrete will be susceptible to frost heave if frost protection is not provided. Therefore, control and isolation joints are required for the subject concrete slabs.

To minimize the potential differential frost heave at the interface between the concrete pavement and adjacent asphalt pavement, a frost taper should be overexcavated below the asphalt pavement structure. The frost taper should extend to a depth of minimum 50 cm, and consists of a Granular A material placed in maximum 300 mm thick lifts and compacted to a minimum of 100% of the SPMDD, and extend horizontally at least 1.5 m beyond the outside edge of the concrete pad.

Full depth construction and isolation joints consisting of approximately 12 mm thick compressible material are recommended adjacent to any existing rigid structure such as curbs, poles, sidewalks and buildings to allow minor movement to occur independently from each other. The saw cut control joints should be placed at a minimum 2.4 m grid with a depth of 50 mm and a maximum width of 5 mm.

7.0 DESIGN REVIEW, MONITORING AND INSPECTION

Designs of different stages and design changes during construction should be reviewed by the geotechnical engineer of Frontop to confirm that the geotechnical recommendations and comments have been properly interpreted and implemented, and that the intention of the report has been meet, and to provide geotechnical input as required.

During construction, full-time engineered fill monitoring, sufficient foundation inspections, slope inspection, subgrade inspections, groundwater inspection, in-situ density testing, and materials sampling and testing should be carried out by Frontop to confirm that the conditions exposed and encountered are consistent with those encountered in the boreholes and assumed in the report, and to monitor conformance to the pertinent project specifications.

8.0 LIMITATIONS

Frontop Engineering Limited should be retained for general review of designs and for required monitoring and inspection. If not accorded the privilege, Frontop will assume no responsibility for the interpretation of the recommendations in this geotechnical report.

The comments provided in this report are intended only for the guidance of design engineers.

It should be noted that the recommended foundation type, founding depths, bearing capacity, excavation procedure and subgrade preparation were based on the borehole information only. Since the boreholes only determine the localized underground conditions at the boreholes, the interpretation of borehole information must, therefore, be validated during excavation operations. Whenever excavation exposes conditions that have not been observed during this investigation, Frontop should be contacted to assess the situation and additional testing and study may be required.

This report was prepared by Frontop for the account of the Client. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Frontop accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

9. CLOSURE

We trust this report is satisfactory for your purposes. Should you have any questions or comments, please do not hesitate to contact our office.

Yours truly,

Frontop Engineering Limited

Tony Jin
Field Engineer, B.Eng

LICENSED PROFESSIONAL ENGINEER
F. C. LIU
100164358
PROVINCE OF ONTARIO

Frank C. Liu P.Eng & P.Geo
Geotechnical Engineer

Frank Feng P. Eng
Geotechnical Manager

ABBREVIATIONS, TERMINOLOGY, GENERAL INFORMATION FOR BOREHOLE LOGS

Sample method:

SS	**split spoon**
ST	**Shelby tube**
AS	**auger sample**
WS	**wash sample**
RC	**rock core**
WH	**weight of hammer**
PH	**pressure, hydraulic**

Penetration Resistance:

Standard Penetration Test (SPT) resistance ('N' values) is defined as the number of blows by a hammer weighing 63.6 kg (140 lb.) falling freely for a distance of 0.76 m (30 in.) required to advance a standard 50 mm (2 in.) diameter split spoon sampler for a distance of 0.3 m (12 in.)

Dynamic Cone Test (DCT) resistance is defined as the number of blows by a hammer weighing 63.6 kg (140 lb.) falling freely for a distance of 0.76 m (30 in) required to advance a conical steel point of 50 mm (2 in.) diameter and with 60° sides on 'A' size drill rods for a distance of 0.3 m (12 in.).

SOIL DESCRIPTION

COHESIONLESS SOILS:

Relative Density	*'N' value*
very loose	< 4
loose	4-10
compact	10-30
dense	30 - 50
very dense	> 50

COHESION SOILS:

Consistency	*Undrained Shear Strength, kPa*	*'N' value*
very soft	< 12	< 2
soft	12-25	2-4
firm	25-50	4-8
stiff	50-100	8-15
very stiff	100-200	16-32
hard	> 200	> 32

SOIL COMPOSITION:

	% by weight
'trace' (e.g. trace silt)	< 10
'some' (e.g. some gravel)	10 – 20
adjective (e.g. sandy)	20 – 35
'and' (e.g. sand and gravel)	35 - 50

TESTS, SYMBOLS:

MH	mechanical sieve and hydrometer analysis
W	water content
Wl	liquid limit
Wp	plastic limit
Ip	plasticity index
k	coefficient of permeability
γ	soil unit weight, bulk
Φ'	angle of internal friction
c'	cohesion shear strength
Cc	compression index

Drawing 1 – Borehole Location Plan

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ENGINEERING LTD

101 Amber Street, Units 1&2
Markham ON L3R 3B2
Tel: 905.947.0900; Fax: .905.305.9370
Email:info@frontop.ca;
Web: www.frontop.ca

LEGEND:

●	BH1	Borehole Number
●	BH3	Monitoring well number

NOTES:

1. The boundaries and soil types have been established only at borehole locations. Between boreholes, they are assumed and may be subject to considerable error.
2. Soil samples will be retained in storage for 3 months and then destroyed unless client advises that an extended time period is required.
3. This drawing forms part of the report, project number as referenced, and should be used only in conjunction with this report.

0	May 2021	
Rev.	Date	Mark
Scale		NTS

Geotechnical Investigation
16621 Hwy 12, Midland, ON

Ref. No. DES21-03-13A

Drawing 1 –
Borehole Location Plan

Drawing 2 to 5 – Borehole Logs

Log of Borehole 1

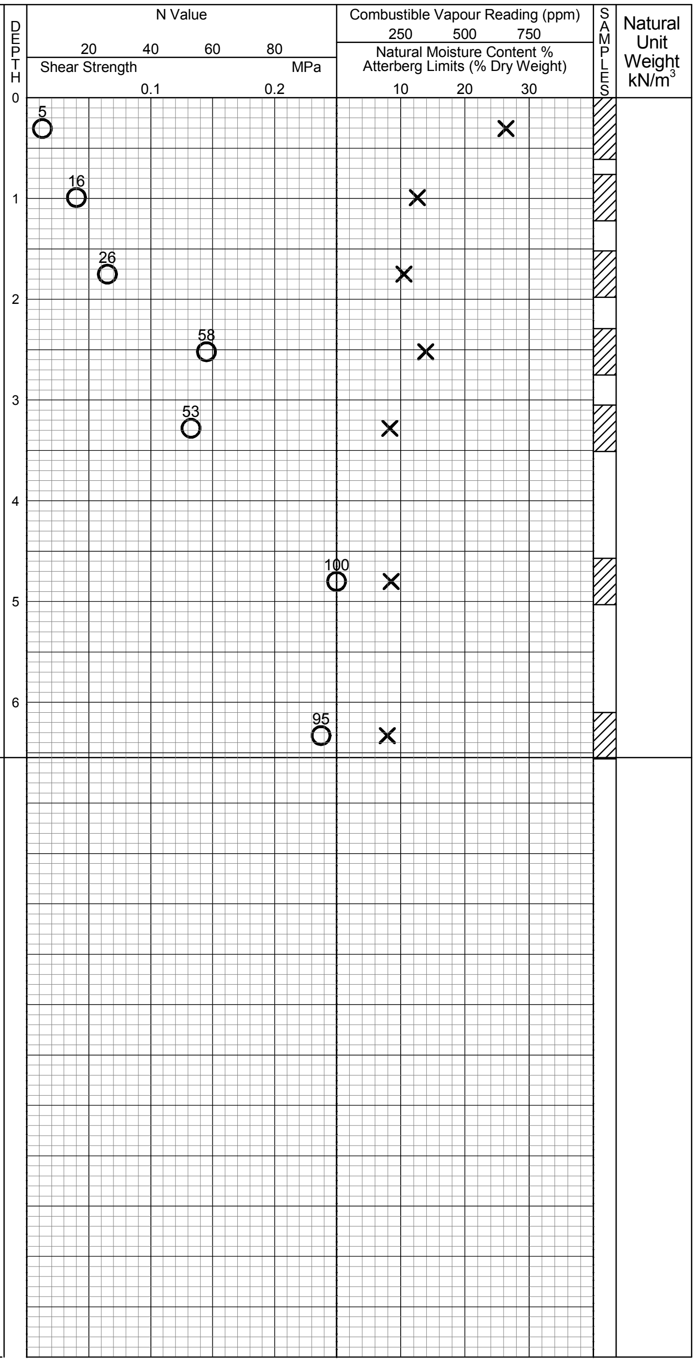
Project No. DES21-03-13A
Drawing No. 2
Project: Geotechnical Investigation
Sheet No. 1 of 1
Location: 16621 Hwy 12, Midland, ON

Date Drilled: May 5, 2021
Drill Type: GEO205
Datum: Geodetic

Auger Sample	☒
SPT (N) Value	○ ▨
Dynamic Cone Test	—
Shelby Tube	■
Field Vane Test	✚ S
Combustible Vapour Reading	☐
Natural Moisture	×
Plastic and Liquid Limit	├──○
Undrained Triaxial at % Strain at Failure	⊕
Penetrometer	▲

Soil Description	ELEV. m
	214.05
TOPSOIL	213.9
CLAYEY SILT trace sand, trace rootlets, soft, mottled brown and brown blalck, wet, no stain and no odor.	213.4
GRAVELLY SAND: fine to medium sand matrix; 20% to 30% sound to decomposed, angular to subangular precambrian rock clasts (<2-4cm), trace silt, silt pockets at top; locally stratified at top; dense, gray, saturated to wet, no stain, no odor. ---Saturated ---Wet ---Saturated ---Wet	210.0
	209.42
MEDIUM SAND: trace silt, trace sound to decomposed, angular to subangular precambrian rock clasts (<5cm), matrix supported, dense, gray, saturated, no stain and no odor	209.0
GRAVELLY SAND: fine to medium sand matrix; 20% to 30% sound to decomposed, angular to subangular precambrian rock clasts (<2-4cm), trace to some silt; dense, gray, saturated, no stain, no odor.	207.5
END OF BOREHOLE	

Notes:
1) Borehole was open and groundwater was found at 1.83 mbgs upon completion of drilling.



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Time	Water Level (m)	Depth to Cave (m)
On completion	1.83	
May 19, 21	4.63	

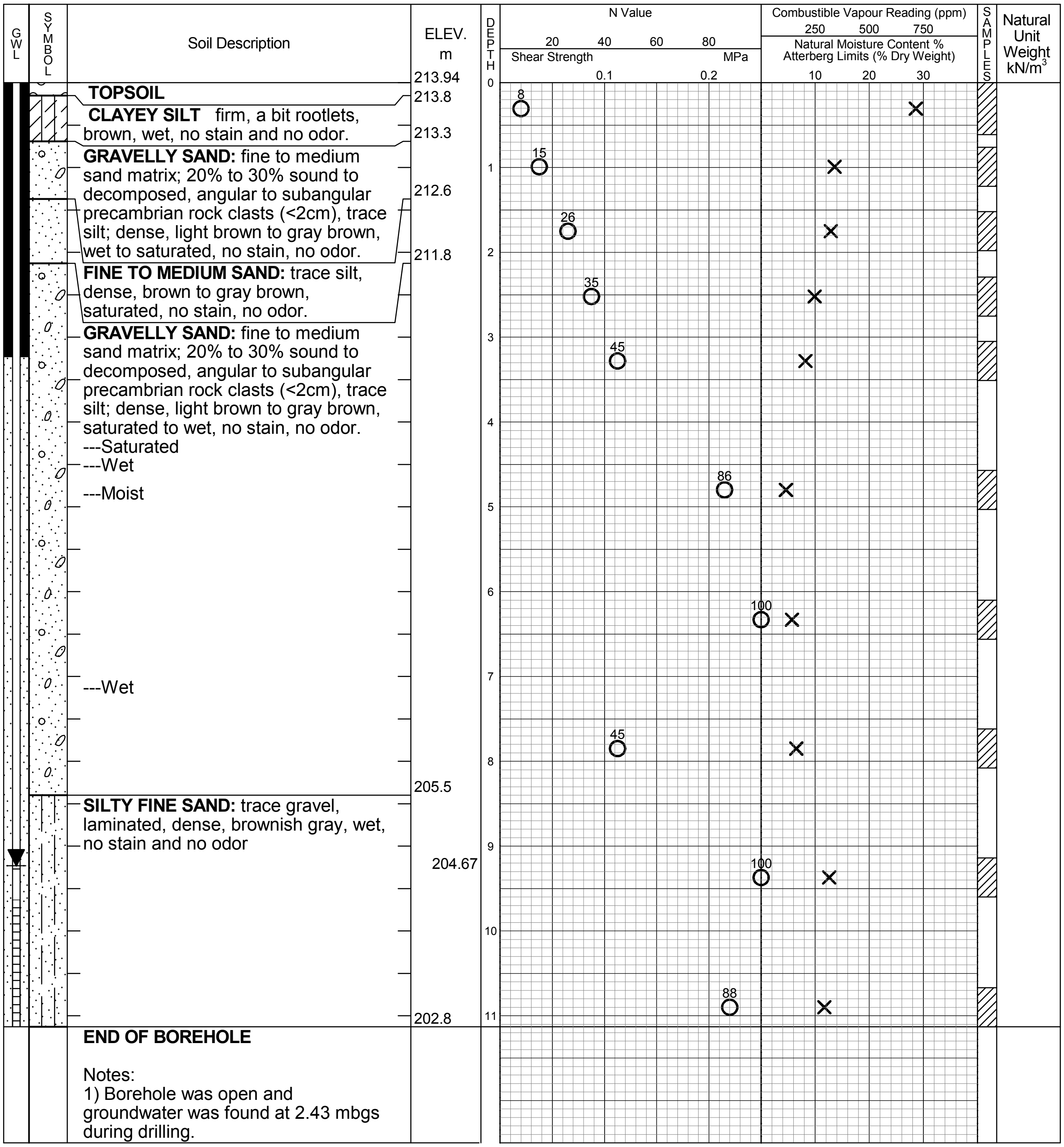
Log of Borehole 2

Project No. DES21-03-13A
Project: Geotechnical Investigation
Location: 16621 Hwy 12, Midland, ON

Drawing No. 3
Sheet No. 1 of 1

Date Drilled: May 12, 2021
Drill Type: D-9
Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├—○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲



213.94

TOPSOIL — 213.8

CLAYEY SILT firm, a bit rootlets, brown, wet, no stain and no odor. — 213.3

GRAVELLY SAND: fine to medium sand matrix; 20% to 30% sound to decomposed, angular to subangular precambrian rock clasts (<2cm), trace silt; dense, light brown to gray brown, wet to saturated, no stain, no odor. — 212.6, 211.8

FINE TO MEDIUM SAND: trace silt, dense, brown to gray brown, saturated, no stain, no odor.

GRAVELLY SAND: fine to medium sand matrix; 20% to 30% sound to decomposed, angular to subangular precambrian rock clasts (<2cm), trace silt; dense, light brown to gray brown, saturated to wet, no stain, no odor.
---Saturated
---Wet
---Moist

---Wet

205.5

SILTY FINE SAND: trace gravel, laminated, dense, brownish gray, wet, no stain and no odor

204.67

202.8

END OF BOREHOLE

Notes:
1) Borehole was open and groundwater was found at 2.43 mbgs during drilling.

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Time	Water Level (m)	Depth to Cave (m)
During drilling	2.43	
May 19, 21	9.27	

Log of Borehole 3

Project No. DES21-03-13A
Project: Geotechnical Investigation
Location: 16621 Hwy 12, Midland, ON

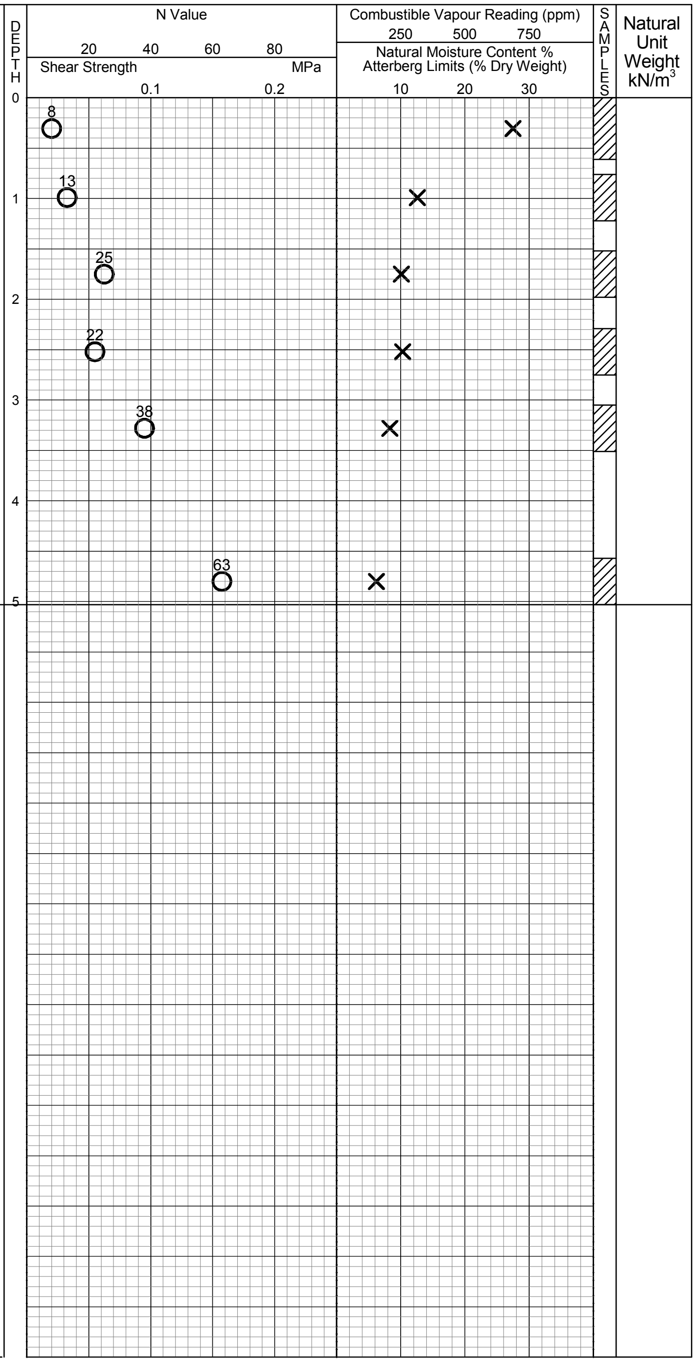
Drawing No. 4
Sheet No. 1 of 1

Date Drilled: May 12, 2021
Drill Type: D-9
Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	⊢—○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲

Soil Description	ELEV. m
	214.10
TOPSOIL	213.9
CLAYEY SILT trace rootlets, soft, dark brown, moist to wet, no stain and no odor.	213.4
GRAVELLY SAND: fine to medium sand matrix; 10% to 20% sound to decomposed, angular to subangular precambrian rock clasts (<3cm), trace silt; compact, light brown to gray brown, wet to saturated, no stain, no odor.	212.7 212.0
FINE TO MEDIUM SAND: trace gravel (<1cm), trace silt, dense, gray, saturated, no stain, no odor.	210.81
GRAVELLY SAND: fine to medium sand matrix; 20% to 25% sound to decomposed, angular to subangular precambrian rock clasts (<3cm), trace silt; dense, gray, saturated to wet, no stain, no odor. ---Saturated ---Moist ---Wet ---Moist	209.1
END OF BOREHOLE	

Notes:
1) Borehole was open and groundwater was found at 3.05 mbgs upon completion of drilling.



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Time	Water Level (m)	Depth to Cave (m)
On completion	3.05	
May 19, 21	3.29	

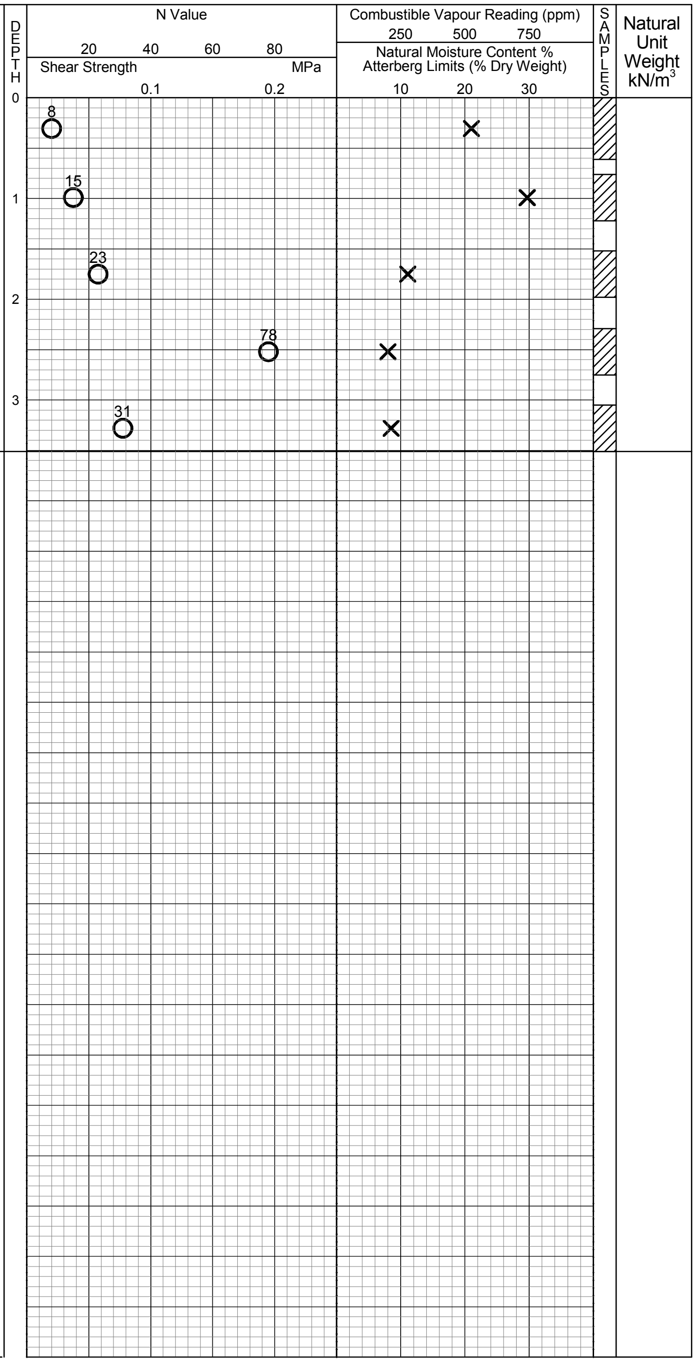
Log of Borehole 4

Project No. DES21-03-13A
Drawing No. 5
Project: Geotechnical Investigation
Sheet No. 1 of 1
Location: 16621 Hwy 12, Midland, ON

Date Drilled: May 12, 2021
Drill Type: D-9
Datum: Geodetic

Auger Sample	⊠	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	⊢—○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲

GWL	SYMBOL	Soil Description	ELEV. m
			213.98
		TOPSOIL	213.9
		CLAYEY SILT trace sand, firm, dark brown to brown black, moist to wet, no odor and slightly stain.	213.3
		GRAVELLY SAND: fine to medium sand matrix; 20% to 30% sound to decomposed, angular to subangular precambrian rock clasts (<3-8cm); soft to dense, light brown, saturated to wet, no stain, no odor. Upper part might have been disturbed.	210.5
		END OF BOREHOLE Notes: 1) Borehole was open and dry upon completion of drilling.	



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Time	Water Level (m)	Depth to Cave (m)