GEOTECHNICAL INVESTIGATION & HYDROGEOLOGICAL ASSESSMENT

PROPOSED INDUSTRIAL SUBDIVISION
10919 LONGWOODS ROAD
MUNICIPALITY OF MIDDLESEX CENTRE, ONTARIO

LDS PROJECT NO. GE-01104

NOVEMBER 24, 2023

Submitted to:

10919 LONGWOODS ROAD INC.

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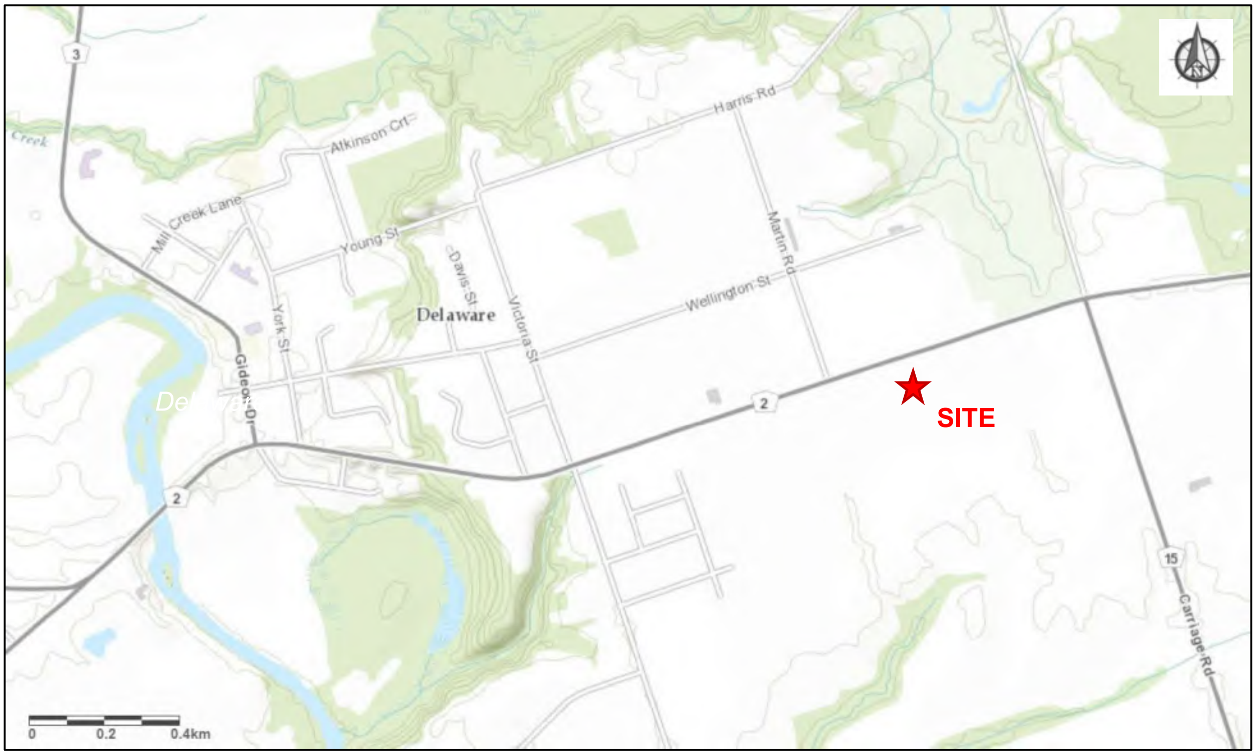
1. INTRODUCTION

LDS Consultants Inc. (LDS) has been retained by 10919 Longwoods Road Inc. to conduct a Geotechnical Assessment for a proposed industrial development. The subject site is located west of the intersection of Carriage Road and Longwoods Road, just east of the Village of Delaware, Municipal Number (MN) 10919 Longwoods Road. A Key Plan showing the general site location is provided on Figure 1, below.



It is understood that the proposed development will include the construction of approximately 18 industrial lots. The proposed development will be accessed with an internal roadway, and will be serviced with temporary septic beds and municipal water service. A stormwater management block is proposed within the southeast limits of the site. A preliminary concept plan is provided on Drawing 1, in Appendix A.

1.1 Terms of Reference

This report has been prepared for the purposes of providing geotechnical comments and recommendations for the design and construction of a proposed industrial development located at MN 10919 Longwoods Road, in the Municipality of Middlesex Centre.

As an overview, this report provides geotechnical comments and recommendations for the proposed development, including: site preparation (including the re-use of excavated materials as engineered fill, structural fill, and guidance for engineered fill placement), temporary excavations, excavation support and lateral earth pressures, groundwater control measures for construction dewatering, foundation design (including soil bearing capacity, subgrade preparation, and potential settlements), concrete slab construction and foundation backfilling, seismic design considerations, concrete (in accordance with CSA classifications) requirements, site servicing (including the re-use of onsite soils in service trenches, pipe bedding, and trench backfill), pavement design (including recommendations for concrete curbs and sidewalks within the site), and excess soils management discussion.

The report also provides preliminary information about the characterization of the hydrogeological setting for the site, including: characterization of the hydrologic and hydrogeological setting, a summary of MECP well records within 500 m of the site, construction dewatering discussion and stormwater management considerations (including factored soil infiltration rates for at-source infiltration features, including a discussion of limitations which result from soil and/or shallow groundwater conditions.

This report is provided on the basis of the terms noted above, and on the assumption that the design will follow applicable codes and standards. The site investigation and recommendations provided in this report follow generally accepted practice for geotechnical consultants in Ontario. The format and content of this report has been guided to address specific client needs. LDS has provided engineering guidelines for the geotechnical design and construction at the site. Laboratory testing, where applicable, follows ASTM or CSA Standards.

1.2 Background Studies

In preparing the scope of work for the client, LDS reviewed the Geotechnical Investigation Report and Supplemental Geotechnical Letter Reports for the site, prepared by MTE (File Number 45013-300) A summary of each is provided below, for reference:

- Geotechnical Investigation Report (dated March 27, 2019): A series of nine (9) boreholes were advanced at the site, with depths ranging between 6.6 and 6.7 m below existing grade. Soils were generally described as surficial topsoil, underlain by natural sand and silt soils. Saturated conditions were noted within the natural soils in each borehole at depths of 0.3 to 1.2 m (Elevation 233.4 to 235.2m) during the geotechnical program, and monitoring wells were installed in six of the boreholes. Geotechnical lab testing on collected soil samples includes seven (7) gradation analysis.

- In-situ Infiltration Testing (dated July 3, 2020): Two (2) infiltration tests were conducted at three (3) locations across the site to support the design of at-source stormwater infiltration facilities. Based on the results of the infiltration, Design Infiltration Rates ranging between 6 and 29 mm/hr are proposed.

- Groundwater Level Monitoring Program (dated October 24, 2023): Stabilized groundwater measurements were recorded in the monitoring wells installed across the site from 2019 to 2023. Shallow groundwater is present within the near surface sandy soils, approximately 0.2 to 3.8 m below existing ground surface (corresponding to Elevations 232.2 to 235.5 m asl.)

1.3 Qualifications of Assessor

This assessment was reviewed by Rebecca Walker, P. Eng., QP, who has been thoroughly trained in conducting geotechnical and hydrogeological assessments. Mrs. Walker is a licensed professional engineer in the Province of Ontario. She obtained a Bachelor of Applied Science in Geological Engineering from Queen’s University in 1998 and is a Qualified Person (QP_{ESA}) registered with MECP. She has been practicing geoscience services under the Guideline of Professional Engineers Providing Geotechnical Engineering Services under the Professional Engineers Act in Ontario.

Mrs. Walker has 25 years of experience in the geotechnical and hydrogeological consulting industry. Over 4,800 projects have been completed under her supervision. Mrs. Walker is also a recognized expert in the industry and has testified as an expert witness in Local Planning Appeal Tribunal (formerly Ontario Municipal Board) hearings and Municipal Councils related to groundwater hydrogeology and geotechnical matters for land development and construction. She has been retained for many projects, both directly and indirectly (as a subconsultant) by local municipalities as a hydrogeological and geotechnical consultant.

2. SITE CHARACTERIZATION

2.1 Site Description, Topography and Surface Drainage

A review of aerial photographs from 2006 to present day indicates that the site previously contained three buildings (two residences and a metal shed), which all fronted on Longwoods Road, with the remaining lands being cultivated. Some time between 2018 and 2023, the three buildings were demolished.

The site is rectangular in shape, and comprises an area of approximately 6.7 hectares. From a topographical perspective, the site is described as gently rolling, and exhibits am overall relief of 1.5 meters across the site. Any minor surface flows which occur at the site under existing conditions, are generally expected to follow the topography of the site. The grade along Longwoods Road is set slightly above the ground surface at the site, and it appears that stormwater run-off from the boulevard area sheet flows towards the drainage ditch, which is present along the northern limits of the site.

There are no significant natural heritage features (woodlots or wetlands) or surface water features within the site limits. The site is bordered by agricultural lands to the west and south, agricultural lands and residential dwellings to the west, and Longwoods Road to the north.

Site features are identified on the aerial photograph provided on Drawing 2, in Appendix A.

2.2 Source Water Protection Mapping

Where construction projects are being planned, it is important to determine the presence of Significant Groundwater Recharge Areas and High Vulnerability Aquifers in the area. These areas are protected under the Clean Water Act (2006). In general, Significant Groundwater Recharge Areas are defined as areas where water seeps into an aquifer from rain and melting snow, supplying water to the underlying aquifer. A highly vulnerable aquifer occurs where the subsurface material offers limited protection from contamination resulting from surface activities.

LDS has reviewed the MECP Source Water Protection Information to determine whether the site is located in any identified areas of source water concern, as they relate to local groundwater quality (current to August 9, 2023). The following observations are noted for the site:

- The majority of the subject property is located within the Upper Thames River Source Protection Area, with a small section within the southeastern limits of the property being located within the Lower Thames Valley Source Protection Area.

- The Property is not located in any of the following designated areas listed in the MECP Source Protection mapping:
  - Wellhead Protection Area E (GUDI);
  - Wellhead Protection Area Q1 or Wellhead Protection Area Q2;
  - Intake Protection Zone or Intake Protection Zone Q;
  - Issue Contributing Area;
  - Event Based Area;

- The Subject Property is located within a Significant Groundwater Recharge Area; and

- The Subject Property is located within a Highly Vulnerable Aquifer with a rating/score of 6, indicative of a high vulnerability rating.

The above comments are demonstrated on Drawing 2, in Appendix A.

2.3 Conservation Authorities - Generic Regulation

As noted above, the majority of the subject property is located within the Upper Thames River Source Protection Area, with a small section within the southeastern limits of the property being located within the Lower Thames Valley Source Protection Area.

In May 2006, a series of Ontario Regulations were introduced throughout the province which locally implemented the Generic Regulation (Development, Interference with Wetlands and Alterations to Shoreline and Watercourses). The regulations replaced the former Fill, Construction and Alteration to Waterways regulations, and is intended to ensure public safety, prevent property damage and social disruption, due to natural hazards such as flooding and erosion. The regulations are identified (as follows) and are implemented by the local Conservation Authority, by means of permit issuance for works in or near watercourses, valleys, wetlands, or shorelines, when required:

- Lower Thames Valley Conservation Authority Regulation 152/06 (2006); and,
- Upper Thames River Conservation Authority Regulation 157/06 (2006).

The existing woodlot located north of Longwoods Road is identified as being within the Upper Thames River Source Protection Area. However, the proposed development does not fall within the Regulated Lands; Therefore, the proposed development is not expected to be subject to Section 28 permits from the Upper Thames River Conservation Authority.

The proposed development also does not fall within the Regulated Lands of the Lower Thames Valley Source Protection Area; Therefore, the proposed development is not expected to be subject to Section 28 permits from the Lower Thames Valley Conservation Authority.

2.4 Review of Geological Mapping

Select geological mapping and publications were reviewed for the purposes of reviewing regional characteristics for soil conditions in the area of Delaware, Ontario. Findings are summarized below, for reference.

Site Physiography - Physiographic mapping for Southwestern Ontario *(Chapman, L.J. and Putnam, D.F. 2007. Physiography of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 228)*, identifies that the site is located within the central area of the Physiographic Region known as the Caradoc Sand Plains and London Annex, and is set within a sand plain. Natural subgrade soil conditions are expected to be predominantly comprised of sand and silty sand soils

Quaternary Geology - Quaternary geology mapping for the Delaware area *(Quaternary Geology, Ontario Geological Survey Map 1964, St. Thomas Area (west half), Scale 1:50,000)* indicates that the study area consists of Aeolian deposits, comprised of fine sand. An excerpt from the aforementioned mapping is provided on Drawing 4, in Appendix A.

Bedrock Geology - Bedrock geology mapping for Southwestern Ontario *(Ontario Geological Survey. 1:250 000 scale, Bedrock Geology of Ontario. Ontario Geological Survey, Miscellaneous Release Data 126, Revised 2006)* indicates that bedrock in the general area consists of limestone, dolostone and shale from the Hamilton Group, from the Middle Devonian Period.

Geological publications and well records in the area indicate that the bedrock surface is below 52-54 m of overburden soils in the vicinity of the site. Bedrock was not encountered during the fieldwork for this investigation.

2.5 MECP Well Record Review

A review of local well records available through the Ministry of Environment, Conservation, and Parks (MECP) for this area was carried out to review the water levels recorded in the nearby wells. Drawing 5 in Appendix A shows the location of the wells (with corresponding Well Registration No.) which are in close proximity (within 500 m) of the site. The well records are summarized in the Table below, for reference.

Water supply wells are generally set into the shallow (<15 m depth) or intermediate (15-30 m depth) overburden aquifers, with reported static water levels ranging between 1.2 and 5.5 m, and 3.7 and 5.5 m, respectively. One water supply well (located ~400 m northwest of the site) is set in the deep (>30m depth) limestone bedrock aquifer, with a reported static water level of 30.2 m. Several water supply wells in the area have likely been abandoned, following access to municipal water supply serving which is now available in the area.

Table 1 - MECP Well Record Summary

MECP Well ID	Registration Year	Well Type	Depth of Well (m)	Depth Water Found (m)	Static Water Level (m)	Pump Rate (L/min)
Water Supply Wells						
4100483	1964-09-22	Domestic	7.9	5.5	5.5	7.6
4100485	1965-08-31	Domestic	7.9	3.7	3.7	3.8
4100486	1963-10-23	Domestic	7.6	5.5	5.5	7.6
4105016	1970-06-15	Domestic	6.4	5.2	3.0	11.4
4105180	1970-09-02	Domestic	10.1	5.2	5.2	11.4
4105666	1971-10-21	Domestic	8.2	5.2	5.2	11.4
4106083	1972-10-11	Domestic	8.5	2.4	2.4	*NR*
4106534	1973-10-22	Domestic	8.2	2.4	2.4	15.1
4106886	1974-08-21	Domestic	8.5	2.1	2.1	18.9
4107459	1975-08-28	Domestic	4.9	2.1	1.2	11.4
4108176	1977-08-18	Domestic	7.6	4.6	4.6	11.4
4109036	1979-09-18	Domestic	9.8	4.0	4.0	18.9
4110193	1984-07-07	Domestic	9.1	3.7	2.7	18.9
4110371	1985-10-08	Domestic	11.6	11.3	3.7	18.9
4110900	1987-06-16	Domestic	13.7	1.8	1.8	18.9
4110987	1987-11-03	Commercial	9.1	4.6	4.6	18.9
4111377	1988-07-12	Domestic	10.7	3.4	3.4	18.9
4111752	1989-07-22	Domestic	10.7	2.4	2.4	18.9
4112051	1990-05-05	Domestic	8.2	1.5	1.5	18.9
4114391	1999-07-28	Domestic	15.2	5.2	5.2	15.1
4115205	2003-03-17	Industrial	78.3	69.5	30.2	11.4
7193887	2012-09-21	Livestock	15.2	7.3	5.5	11.4
7234325	2014-10-31	Domestic	18.0	10.7	3.7	22.7
Well Abandonment Records						
7331895	2019-03-21	Not Recorded	*NR*	*NR*	*NR*	*NR*
4104941	1969-10-27	Abandoned-Supply	36.6	*NR*	*NR*	*NR*
4104942	1969-10-20	Abandoned-Supply	53.3	*NR*	*NR*	*NR*

3. FIELD PROGRAM AND LABORATORY TESTING

LDS has reviewed the Geotechnical Investigation Report for the site, prepared by MTE (File Number 45013-300, dated March 27, 2019.) A series of nine (9) boreholes were advanced at the site by a local drilling-contractor, using a track-mounted drill-rig, with depths ranging between 6.6 and 6.7 m below existing grades. Subgrade soils were generally described as surficial topsoil, underlain by natural sand and silt soils. Monitoring wells were installed in six of the boreholes.

A summary of the field program and laboratory analyses conducted by MTE is provided in the following sections.

3.1 Soil Conditions

A series of nine boreholes were advanced at the site to examine soil and shallow groundwater conditions. The borehole location plan prepared by MTE is provided in Appendix B, for reference. In general, soils observed in the boreholes consisted of topsoil overlying natural sand and silt soils. General descriptions of subsurface conditions are summarized in the following sections. A copy of the Borehole logs are also provided in Appendix B.

It should be noted that boundaries of soil indicated in the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries reflect transition zones for the purposes of geotechnical design and should not be interpreted as exact planes of geological change.

Topsoil - Each borehole was surfaced with a layer of topsoil. The topsoil consisted of dark brown/black sandy silt with some organics, and the thickness generally ranging from 205 to 355 mm across the site. The topsoil was in a very moist to saturated state at the time of the fieldwork, based on visual and tactile examination. Plastic and glass fragments were observed within the topsoil layer encountered in Borehole BH107-19. *It should be noted that topsoil quantities noted above are based on information provided at the borehole locations only, and may vary in areas with existing vegetation and tree cover, and where tilling has occurred and mixed the topsoil with the underlying soil strata. If required, a more detailed analysis (involving additional shallow test pits) is recommended to accurately quantify the amount of topsoil to be removed for construction purposes.*

Sand and Silt - The predominant subgrade soil encountered during the field program was a layer of sand and silt, and each borehole terminated within this layer. The sand and silt was generally described as brown to grey in colour. The distribution of sand and silt contents varied across the site. Seven samples of the sand and silt were submitted for gradation analysis, and the following table shows the grain size distribution.

Table 2 – Gradation Summary, Sand and Silt

Borehole Number	Sample Depth (m)	Unified Soil Classification		
		% Clay	% Silt	% Sand
MW101-19	0.76 – 1.37	2	30	68
MW102-19	0.76 – 1.37	2	67	31
MW102-19	4.57 – 5.18	2	79	19
MW103-19	4.57 – 5.18	3	74	23
MW104-19	0.76 – 1.37	9	10	81
MW105-19	4.57 – 5.03	4	80	16
BH108-19	0.76 – 1.37	6	69	25

The sand and silt is generally in a compact to dense state, based on Standard Penetration Test (SPT) N-values in the range of 10 to 46 blows per 0.3 m of split-spoon sampler penetration. Loose (SPT N-value < 10 blows) soil conditions were encountered within the upper 1.5 m of the sand and silt layer in each layer. Moisture content determinations conducted on recovered samples of the sand and silt generally range between 16 to 27 percent, generally indicative of very moist to saturated soil conditions.

3.2 Soil Permeability

The hydraulic conductivity of a soil depends on a number of factors, including particle size distribution, degree of saturation, compactness, adsorbed water (which depends on clay content). The heterogeneous nature of glacial deposits can also contribute to variations in soil permeability where the soil composition may include localized areas with increased fine material or sandy material which can influence soil permeability at different points within the soil strata.

The soil permeability of select sand and silt samples was assessed by two methods. The first method is correlation of hydraulic conductivity and factored infiltration rates based on the results of gradation analyses on collected samples. The second method is with field measurements during insitu infiltration testing.

Grain Size Analyses - Based on the gradation results presented in Section 3.1, the following values for saturated hydraulic conductivity are presented in Table 5 of the Geotechnical Investigation Report prepared my MTE.

Table 3 - Hydraulic Conductivity and Factored Infiltration Rates From Grain Size Analyses

Sample ID	Sample Depth (m bgs)	Borehole Elevation (m asl)	Soil Type	Sat. Hydraulic Conductivity (m/sec)	Factored Infiltration Rate (mm/hr)
MW101-19	0.76 – 1.37	235.0	Silty Sand	1.3×10^{-6}	20
MW102-19	0.76 – 1.37	235.6	Sandy Silt	1.3×10^{-6}	20
MW102-19	4.57 – 5.18	235.6	Silt	7.8×10^{-10}	3
MW103-19	4.57 – 5.18	235.3	Sandy Silt	1.0×10^{-9}	3
MW104-19	0.76 – 1.37	236.4	Sand	3.3×10^{-6}	25
MW105-19	4.57 – 5.03	234.2	Silt	2.9×10^{-10}	2
BH108-19	0.76 – 1.37	235.1	Sandy Silt	8.9×10^{-10}	3

Insitu Infiltration Testing - Insitu infiltration testing was carried out at three test pit locations on April 15&16, 2020 within the proposed footprint of the at-source stormwater infiltration facilities. Table 4 (below) summarises the measured and factored infiltration rates, as determined during the testing described above, as presented in Tables 1 and 2 of the In-situ Infiltration Testing Letter prepared by MTE (File Number 45013-300, dated July 3, 2020.)

Table 4 - Hydraulic Conductivity and Factored Infiltration Rates from In-situ Percolation Testing

Test ID	Borehole Elevation (m asl)	Test Elevation (m asl)	Soil Description	Sat. Hydraulic Conductivity (m/sec)	Design Infiltration Rate (mm/hr)
IT-1	235.65	235.15	Sand, some silt to sandy silt with trace clay	1.0×10^{-5}	29
IT-2	235.37	234.87	Sand, some silt to sandy silt	1.7×10^{-6}	18
IT-3	236.29	235.79	Sandy Silt	2.9×10^{-8}	6

The water-bearing sand and silt are expected to have a saturated hydraulic conductivity in the range of 10^{-5} to 10^{-10} m/s, based on the above results. The infiltration rates have been calculated using correlation from TRCA/CVC Low Impact Development Stormwater Management Planning and Design Guide protocol which references Ministry of Municipal Affairs and Housing (MMAH) Supplementary Guidelines to the Ontario Building Code 1997, SG-6 Percolation Time and Soil Descriptions. A Factor of Safety of 2.5 has been applied to the results provided in Table 3, in accordance with TRCA/CVC Low Impact Development Stormwater Management Planning and Design Guide protocol. A Factor of Safety of 3.0 has been applied to the results provided in Table 4.

Onsite Verification During Construction - A number of factors can influence the actual soil permeability and infiltration rate onsite during the site grading activities, including cut-fill activities, and the use of onsite or imported materials to achieve design grades. It is recommended that geotechnical inspection of materials which are used onsite and field testing during the construction phase of the project be carried out to confirm that infiltration rates which have been used for design purposes are appropriate to the actual site conditions.

3.3 Shallow Groundwater Conditions

LDS has reviewed the Results of the Limited Groundwater Level Monitoring Program prepared by MTE (File Number 45013-300, dated October 24, 2023.) Stabilized water level measurements were recorded in the monitoring wells installed across the site from 2019 to 2023. In general, seasonal highs in the groundwater levels were observed during Spring months, with lows occurring during the late summer/fall period. The following table provides a summary of groundwater variations for each of the monitoring wells installed across the site.

Table 5 – Stabilized Groundwater Summary

Monitoring Well	Ground Surface Elev. (m, asl)	Depth to Groundwater (m, bgs) *Groundwater Elevation (m, asl)*	
		GW High (Spring 22/23')	GW Low (Fall 22')
MW101-19	235.03	0.24 *234.79*	1.68 *233.35*
MW102-19	235.58	0.62 *234.96*	2.53 *233.05*
MW103-19	235.34	0.88 *234.46*	2.22 *233.12*
MW104-19	236.43	0.96 *235.47*	3.35 *233.08*
MW105-19	234.24	0.33 233.91	2.02 232.22
MW106-19	235.49	1.06 234.43	2.86 232.63

Shallow groundwater is present within the near-surface sand and silt soils, below Elevation 235.5 m asl. Shallow groundwater will vary in response to climatic or seasonal conditions, and, as such, may differ at the time of construction, with higher levels possible during mild weather conditions which create melting conditions, and during wet periods. The manual groundwater measurements recorded in the monitoring wells indicate a local groundwater flow direction in a east/south-easterly direction.

4. GEOTECHNICAL COMMENTS AND DISCUSSION

It is understood that the proposed development will include the construction of approximately 18 industrial lots. The proposed development will be accessed with an internal roadway, and will be serviced with temporary septic beds and municipal water service. A stormwater management block is proposed within the southeast limits of the site. A preliminary concept plan is provided on Drawing 1, in Appendix A.

The boreholes drilled at the site generally revealed a layer of surficial topsoil which is underlain by natural sand and silt soils. Shallow groundwater is present below Elevation 235.5 m asl.

The following sections of this report provide geotechnical comments and recommendations to assist with design and construction of the proposed development, including: site preparation (including the re-use of excavated materials as engineered fill, structural fill, and guidance for engineered fill placement), temporary excavations (including maximum slope inclinations to provide stable excavation side slopes in accordance with OHSA requirements), excavation support and lateral earth pressures, groundwater control measures for construction dewatering, foundation design (including soil bearing capacity, subgrade preparation, and potential settlements), concrete slab construction and foundation backfilling, seismic design considerations, concrete (in accordance with CSA classifications) requirements, site servicing (including the re-use of onsite soils in service trenches, pipe bedding, and trench backfill), pavement design (including recommendations for concrete curbs and sidewalks within the site), and excess soils management discussion.

4.1 Site Preparation

4.1.1 Site Grading Activities & Engineered Fill Placement

Based on existing site conditions, it is expected that some site grading activities will be required. Vegetation removal and topsoil stripping is anticipated throughout the area to be developed. In general, this is expected to require the removal of about 205 to 355 mm of surficial topsoil. Thicker topsoil areas may be present between the borehole locations, and where local depressions are present at the site. Surficial topsoil may be stockpiled on site for possible re-use as landscaping fill. In the event that material is disposed of offsite, testing of the material for transport should conform to MECP Guidelines and requirements.

Prior to placement of engineered fill or new building foundations, existing fill and topsoil, vegetation and otherwise deleterious materials should be removed. Once complete, the exposed subgrade should be thoroughly proof-rolled and inspected by geotechnical field staff from LDS. Any loose or soft zones noted during the inspection should be over excavated and replaced with approved fill.

In areas which engineered fill is to be placed to raise grades, the exposed subgrade soils should be approved by the geotechnical consultant following topsoil stripping. In accordance with the Ontario Building Code (Section 4.2.4.15), foundations may be set on fill material provided that it can be demonstrated that the fill is capable of safely supporting the building and that detrimental movement of the building will not occur. In this regard, it is recommended that any fill material placed in future building footprints be engineered and verified through an inspection and testing program. Engineered fill should consist of suitable, compactable, inorganic soils, which are free of topsoil, organics, and miscellaneous debris. For best compaction results, the fill material should have a moisture content within about 3 percent of optimum, as determined by Standard Proctor testing.

The placement of the engineered fill should be monitored by the geotechnical consultant to verify that suitable materials are used, and to confirm that suitable levels of compaction are achieved. The engineered fill material should be placed in maximum 300 mm (12 inch) thick lifts and uniformly compacted to 100 percent Standard

Proctor Maximum Dry Density (SPMDD). Additional notes regarding engineered fill placement are provided on Drawing 6, in Appendix A.

The existing natural subgrade soils, that are not mixed with obviously unsuitable material may be suitable for re-use as engineered fill. The possible re-use of onsite soils should be subject to review and approval by the geotechnical consultants.

Fill material containing building debris and / or topsoil and organic inclusions is generally not expected to be suitable for re-use onsite, except where landscaping (non-structural) fill may be needed. Offsite disposal of these soils will require analytical testing, in accordance with MECP Guidelines and classification requirements for transport and disposal. The testing requirements for disposal will depend on the requirements outlined by the receiver.

In the event that any abandoned water supply wells are encountered, they should be decommissioned in accordance with the Regulations outlined in O.Reg. 903.

4.1.2 Excess Soils Management Considerations

In December of 2019, the Ministry of Environment, Conservation, and Parks (MECP) released a regulation under the Environmental Protection Act, titled *On-Site and Excess Soil Management* to support improved management of excess construction soil. The current version of Regulation 406/19 includes recent amendments from December 2022. It is noted that further amendments to the Regulation have been proposed, and are currently posted on the ERO for comments.

Excess soil is defined as material that was generated during construction activities at a site but will not be needed for grading, fill, or other purposes and therefore needs to be transported off-site. The regulation requires a project leader to comply with specific requirements before removing excess soil from a project area.

Generally, these requirements include:

- Preparation of an Assessment of Past Uses Report which is similar to a Phase One Environmental Site Assessment for the source site, to evaluate the presence of potentially contaminating activities which may have resulted in the potential for impacted soil or groundwater conditions to be present at the source site;
- Preparation and implementation of a Sampling and Analysis Plan which outlines the suggested sample locations and sampling intervals, analytical sample testing parameters, and sampling frequency;
- Preparation of a Soil Characterization Report, following the soil sampling and analytical testing;
- Preparation of an Excess Soil Destination Assessment Report which identifies where excess soils can be disposed offsite, including a review of Beneficial Reuse Sites, if the developer and/or their contractor have a potential re-use site being considered; and,
- Development and implementation of a tracking system.

The site is within a predominantly residential/agricultural area. LDS is not currently aware of the site being considered as an “enhanced investigation project area” as defined in O.Reg. 406/19 and O.Reg. 153/04, as amended. Provided that no significant environmental concerns were identified with respect to current and/or former activities at the subject properties, the proposed development qualifies for an exemption from the regulatory requirements (preparation of planning documents, soil characterization, and tracking requirements), as noted in Section 8 of the Regulation.

In the event that the site requires imported fill material to achieve design grades, the site would be characterized as a Beneficial Re-Use Site. As such, a Qualified Person (QP) will need to be retained to prepare an Excess Soil Destination Assessment Report (ESDAR), which outlines the geotechnical requirements for beneficial reuse of imported materials onsite along with the environmental soil quality criteria (including the applicable O.Reg. 153/04 Site Condition Standards) for material which is appropriate to be accepted at the Site. In this case, material meeting the O.Reg. 406/19 Table 2.1 Site Condition Standards, Residential/Parkland/Institutional Land Use (or better) is generally considered appropriate for this site.

4.2 Excavations and Groundwater Control

Excavations for the proposed buildings and site services are generally expected to extend into the natural soils, or possible engineered fill material, depending on final site grades. Site servicing depths are generally expected to be in the range of 4 m maximum depth.

All work associated with design and construction relative to excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). The following soil classifications are provided in accordance with Section 226 of Ontario Regulation 213/91:

- The natural sand and silt soils encountered within the boreholes are generally classified as Type 3 soil. For excavations which extend through or terminate in Type 3 soil, temporary excavation side slopes must be cut back at a maximum inclination of 1H:1V from the base of the excavation.

Where perched groundwater is present within the near-surface sandy soils, excavations may exhibit Type 4 Soil characteristics, with significant sloughing below the groundwater level. For excavations which extend through or terminate in the wet silt/sand, temporary excavation side slopes should be cut back at a maximum inclination of 3H:1V from the base of the excavation.

In the event that construction occurs in seasonally wet conditions or when frozen soil conditions are present, care will be required to maintain safe excavation side slopes, and suitable excavation bases. The contractor should use a reasonable effort to direct surface run-off away from open excavations.

4.2.1 Excavation Support

If space restrictions at the site do not allow for conventional open cut without risk of undermining, or where excavation sizes are to be limited, the use of adequate bracing or shoring may be required. In the natural subgrade soils, bracing will not normally be required if the structures are behind a 45-degree line drawn up from the near edge of the excavation.

If the construction excavation side slopes recommended above cannot be maintained due to lack of space or close proximity of other structures, an engineered excavation support system must be used. Minimum support system requirements for steeper excavations are stipulated in Sections 234 through 242 of the Act and Regulations. The shoring system must be designed to be internally (overturning, and sliding) and externally stable (slope stability/base heave).

A prefabricated trench box may be used for service trench excavations, provided that it is designed (by a professional engineer) to withstand the soil and hydrostatic loading (if applicable).

Based on the field and laboratory testing during the present geotechnical investigation and our experience with similar soils, the following soil parameters are recommended for the design of the engineered shoring system.

Table 6- Soil Parameters for Excavation Support

Soil	φ	γ (kN/m^3)	K_a	K_o	K_p
Compact Sand and Silty Sand	30	19.5	0.33	0.50	3.15
Compact Granular 'B' (OPSS 1010)	32	22.0	0.31	0.47	3.25

Notes:
Φ denotes internal friction angle (degrees)
γ denotes soil bulk unit weight
K_a denotes active earth pressure coefficient (Rankine, dimensionless)
K_o denotes at-rest earth pressure coefficient (Rankine, dimensionless)
K_p denotes passive earth pressure coefficient (Rankine, dimensionless)

In the event that imported fill material is present near the excavation which vary materially from the above soils, the geotechnical consultant should review the soil conditions to confirm the design parameters.

4.2.2 Groundwater Control

Groundwater is present within the near-surface sandy soils, below Elevation 235.5 m. Based on the results of the Limited Groundwater Monitoring Program provided by MTE, shallow groundwater is expected to be encountered within typical servicing depths, from water-bearing soils located approximately 0.2 to 3.8 m below existing ground surface.

Conventional groundwater control methods are expected to be suitable for shallow excavations which remain above the groundwater table at the site, to address surface water infiltration and minor shallow groundwater seepage for excavations which do not extend below the stabilized groundwater table.

In the event that servicing excavations extend into areas where shallow groundwater is present, positive groundwater control methods may need to be utilized for construction dewatering. Soil permeability values in the natural subgrade soils are expected to be in the range of 10^{-5} to 10^{-10} m/s, based on laboratory testing (presented in Section 3.1.2). This information is provided to assist with determining appropriate construction dewatering methods. The use of sump pits and pumps and/or interceptor trenches to reroute groundwater seepage which can accumulate in open excavations is expected to be sufficient for groundwater control of typical excavations.

Groundwater control measures at the site should be sufficient to maintain stable excavated slopes; and provide a dry and stable base for excavations and construction operations. The contractor should use a reasonable effort to direct surface run-off away from open excavations.

At this time, the need for a Permit to Take Water (required for water takings in excess of 400,000 L/day) is not anticipated for construction dewatering associated with typical site servicing and foundation depths. It is recommended that consideration be given to obtaining an Environmental Activity and Sector Registry (EASR) for construction dewatering. The EASR allows for daily pumping in the range of 50,000 to 400,000 L/day and can also be used for the management of stormwater run-off, if needed.

A Construction Dewatering and Discharge Plan will be required for the EASR submission. LDS can assist with the preparation of these documents. Preparation of the Construction Dewatering and Discharge Plan requires information from the contractor carrying out the excavation work, and the contractor responsible for providing groundwater control. The construction methodology, including details for the typical length and depth of service trenches, information about excavation support or cut-off systems (such as trench liner boxes) which may be utilized, and the method of groundwater control which will be utilized. This information is included, to inform the discussion which is provided in the Dewatering Plan, which is expected to include discussion on potential impacts to soil settlement, impact to existing groundwater users and surface water features, along with consideration for extreme weather events. The Plan will also identify the discharge location for pumped water, including sediment and erosion control measures which will be utilized where water is contained onsite in surface water features, or where filtering of discharge water is planned, for water being outletted to municipal infrastructure. Some preliminary dewatering calculations are provided in Section 5 of this report.

4.3 Building Design and Construction

4.3.1 Foundation Design

For design of conventional strip and pad footings on the natural compact sand and silt soils, or supported on engineered fill, the following allowable bearing pressures (net stress increase) can be used for design of conventional strip and pad footings.

- Serviceability Limit States (SLS) 145 kPa (~3000 psf)
- Ultimate Limit States (ULS) 215 kPa (~4500 psf)

It should be noted that loose soil conditions may be anticipated within the upper 1.5 m of the subgrade soils. Re-compaction and a thorough proof-roll of the subgrade soils is recommended where loose soils are encountered. Site review to confirm the condition of the subgrade soils at the proposed footing base level is recommended and should be undertaken by the geotechnical engineer at the time of excavation.

All footings exposed to seasonal freezing conditions should be protected from frost action by at least 1.2 m (4 ft.) of soil cover or equivalent insulation. The natural subgrade soils may be susceptible to disturbance by construction activities, especially during adverse weather conditions or when water seepage from excavation sidewalls are present. Consequently, after the founding surfaces have been exposed, the soils should be thoroughly recompacted to provide a uniform base, suitable to provide the bearing capacity noted above. Consideration should be given to placing concrete foundations as soon as possible following excavation and subgrade inspection.

Excessive differential settlements can occur where the subgrade support material types differ below the underside of continuous strip footings, (i.e., natural sand soils to engineered fill). As such, where strip footings transition from one material to another the transition between the materials should be suitably sloped or benched to mitigate differential settlements. It is recommended that the following transition precautions to mitigate/accommodate potential differential settlements be considered, and incorporated into the design, subject to review by the structural engineer:

- For strip footings, the transition zones should be adequately reinforced with additional reinforced steel lap lengths or widened footings;
- Steel reinforced poured concrete foundation walls; and
- Control joints throughout the transition zone(s).

Individual spread footings should generally be spaced a minimum distance of 1.5 times the largest footing width apart from each other to avoid stress bulb interaction between footings. This assumes the footings are at the same elevation.

Footings at different elevations should be located such that the higher footings are set below a line drawn up at 10 horizontal to 7 vertical from the closest edge of the lower footing. It is important that servicing excavations which encroach on the building foundations are checked to ensure that they do not undermine the building foundations.

Verification of the footing base conditions should be undertaken by the geotechnical engineer at the time of excavation. Provided that the stability of the soils exposed at the founding level is not compromised as a result of construction activity, precipitation, cold weather conditions, etc., and the design bearing pressures are not exceeded, the total and differential settlements of footings are expected to be less than 25 mm and 19 mm, respectively.

It should be noted that the recommended bearing capacities have been calculated by based on the observations of the soil and groundwater conditions within the borehole program at the site. Where variations occur between the borehole locations, and during construction of the new buildings, site verification by the LDS' geotechnical engineer is recommended to confirm soil conditions and verify soil bearing capacity.

4.3.2 Slab on Grade Construction

Concrete floors for the new building may be constructed using conventional concrete poured slab techniques, following the review and approval of the subgrade soils. In preparation for the construction of the floor slab, any unstable (loose) fill material should be removed and recompacted (as noted previously) where founding soils will support the floor slab. In the event that the exposed subgrade soils are wet they will exhibit a greater sensitivity to disturbance. Structural fill placed below the concrete floor slab should be comprised of inorganic soils, placed and compacted in uniform lifts, to a minimum of 98 percent SPMDD.

Care should be taken to protect the subgrade below the floor slab during construction, by limiting construction traffic on the prepared subgrade soils. In addition, if the exposed subgrade soils are exposed to inclement weather conditions (i.e. rain, snow, freezing conditions), some remedial works may be required to remove wet, soft, or disturbed soils prior to stone and concrete placement.

A moisture barrier, consisting of a minimum 200 mm thick of uniformly compacted 19 mm clear stone should be placed over the approved subgrade. For design purposes, the modulus of subgrade reaction (k) can be taken as 45 MPa/m, for the compacted stone over approved subgrade soils. An alternate configuration of compacted granular material such as OPSS 1010 Granular A may also be considered for the moisture barrier. If alternative materials are proposed for use onsite, the minimum level of compaction and overall design thickness of the moisture barrier layer should be reviewed by the geotechnical consultant.

The water-to-cement ratio of the concrete utilized in the floor slab should be strictly controlled to minimize shrinkage of the slab. Adequate joints and / or the use of fibre reinforcement may be considered by the designer to help control cracking. The sawcut depth for control joints should be ¼ of the slab thickness. The use of super plasticizers should be considered to reduce shrinkage and increase workability of the concrete.

During construction, concrete sampling and testing is recommended to ensure that concrete mix design requirements are satisfied.

4.3.3 Foundation Backfilling and Drainage

In general, the existing soils excavated from the building footprints (from above the stabilized water level) are generally expected to be suitable for re-use as foundation wall backfill. The materials to be re-used as foundation wall backfill should be within three percent of optimum moisture content for best compaction results. If the weather conditions are very wet during construction, site review by the geotechnical consultant may be advised to confirm the suitability of onsite soils for reuse.

In the event that excavated materials contain topsoil, organics or otherwise unsuitable material, such materials should be stockpiled separately, and limited to re-use where settlements can be tolerated.

It is recommended that heavy compaction equipment be restricted within 0.5 m of the foundation walls. Backfill should be brought up evenly on both sides of the foundation walls which have not been designed to resist lateral earth pressures. During construction, the fill surface around the perimeter of buildings should be sloped in such a way that the surface runoff water does not accumulate around the structure.

The near-surface soils may be susceptible to frost effects, which can impact hard landscaping adjacent to the building. At locations where the proposed building is expected to have exterior entrances, care should be taken in detailing the exterior slabs and/or sidewalks providing insulation, drainage, and non-frost susceptible backfill to maintain flush transitions in cold weather conditions.

Exterior perimeter foundation drains are not required where the finished floor elevation is set at least 150 mm above the exterior grade, or where the exterior grade is positively sloped away from the building to promote surface water run-off and reduce groundwater infiltration adjacent to foundation walls.

4.3.4 Exterior Concrete Slabs

In the event that exterior concrete slabs are planned for the site, the following recommendations are provided.

The concrete apron may be constructed using conventional slab-on-grade techniques. Subgrade preparation for the subgrade soils below the slab will be a key aspect of the construction. The exposed subgrade should be thoroughly proof-rolled and inspected by the geotechnical consultant to verify the suitability of the subgrade soils to support the slab. Additional compaction effort, or subgrade restoration work may be required in the event that soft or loose soils are encountered within the area of exterior concrete slabs.

It is recommended that a granular layer consisting of a minimum of 300 mm of Granular ‘A’ be provided directly below the slab. The Granular ‘A’ should be compacted to 100 percent SPMDD, and verified through in-situ density testing.

For external concrete slabs, or where slab-on-grade concrete is placed in unheated areas, consideration may be given to provide insulation below the slabs to minimize the potential for movements as a result of frost action. In general, the use of high-density rigid board extruded polystyrene, such as DOWTM HI-40 or equivalent is considered appropriate. LDS can provide additional recommendations regarding design thickness, depending on specific structural requirements. In general, the insulation should extend a minimum of 1.2 m beyond the edges of the slab. The portion of the rigid board insulation which extends beyond the edges of the slab should be sloped in a manner that promotes drainage of surface water away from the slab area.

In the event that exterior concrete slabs abut the building, it is recommended that a suitable expansion joint be used between the exterior slab and the building foundations.

4.3.5 Concrete Recommendations

CSA A.23-1.04 provides minimum requirements for concrete, including Exposure Class, maximum water to cement ratios, allowable air entrainment, slump, temperature requirements, etc. The design of the building foundations should have regard to the above referenced standard, and should be reviewed by the designer for conformance to CSA standards.

It is recommended that the water-cement ratio and slump of concrete used for floor slabs be controlled to minimize shrinkage of the slabs. Adequate joints and/or the use of fibre reinforcement may be considered by the designer to help control cracking. During construction, concrete sampling and testing is recommended to ensure that concrete mix design requirements are satisfied.

Concrete sampling and testing for foundations and concrete slabs (in accordance with CSA A23.1-04) is recommended. During cold weather, freshly placed concrete should be covered with insulating blankets to protect against freezing.

4.3.6 Seismic Design Considerations

Subsoil and groundwater information at the Site have been examined in relation to Section 4.1.8.4 of the Ontario Building Code (OBC) 2012. The subsoils expected below the buildings will generally consist of sand and silt soils.

Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2012 indicated that to determine the site classification, the average properties in the top 30 m are to be used. The boreholes at the site were advanced to a maximum depth of 6.6 m below existing ground surface. The Site Classification recommendation is based on the available information as well as our interpretation of conditions at and below the test holes, and based on a review of geological mapping and MECP well records, and our knowledge of the soil conditions in the area.

Based on the above assumptions, interpretations in combination with the known local geological conditions, the Site Class for the proposed development is classified as “C” as per Table 4.1.8.4.A, Site Classification for Seismic Site Response, OBC 2012. In the event that a higher Site Classification is being sought by the structural design engineer, additional deep boreholes and / or multichannel analysis of surface waves (MASW) testing would be required to determine if the soil conditions below the current depth of exploration can support a higher Site Classification.

44 Site Services

Subgrade soils beneath new services are generally expected to consist of sand and silt soils. Although no bearing problems are anticipated for flexible or rigid pipes founded on natural deposits, localized base improvement along the trench bottom may be required for excavations which terminate in wet subgrade soils. The extent of base improvement or stabilization is best determined in the field during construction, with consultation from LDS’ geotechnical engineer. The bedding material should be compacted to a minimum 95 percent SPMDD. Water lines installed outside of heated areas should be provided with a minimum 1.2 m of soil cover for frost protection.

Based on the results of this investigation, excavated material for trenches will generally consist of sand and silt. Select portions of this inorganic material may be used for construction backfill provided that reasonable care is exercised in handling the material. In this regard, material should be within 3 percent of the optimum moisture as determined by the Standard Proctor density test. Stockpiling of material for prolonged periods of time should be avoided. This is particularly important if construction is carried out in wet, adverse weather. Backfilling operations during cold weather should avoid inclusions of frozen lumps of material, snow and ice. A program of in situ density testing should be set up to ensure that satisfactory levels of compaction are achieved. It is recommended that trench backfill be compacted to a minimum 98% SPMDD in areas where settlements above the service trenches cannot be tolerated.

Soils excavated from below the stabilized groundwater table may be too wet for re-use as backfill, unless adequate time is allowed for drying, or if material is blended with approved dry fill; otherwise, it may be stockpiled onsite for re-use as landscape fill, or disposed of off-site, testing of the material for transport should conform to MECP Guidelines and requirements. Backfill above bedding aggregate can consist of excavated (inorganic) soils, compacted in maximum 300 mm thick lifts to a minimum of 95 percent SPMDD. A program of in situ density testing should be set up to ensure that satisfactory levels of compaction are achieved.

Normal post-construction settlement of the compacted trench backfill should be anticipated, with the majority of such settlement taking place within about 6 months following the completion of trench backfilling operations. This settlement may be compensated for, where necessary, by placing additional granular material prior to asphalt paving. Alternatively, if the asphalt binder course is placed shortly following the completion of trench backfilling operations in these areas, any settlement that may be reflected by subsidence of the binder asphalt should be compensated for by placing an additional thickness of binder asphalt or by padding.

4.5 Pavement Design

The development will be accessed with an internal road network, accessing Longwoods Road on the north end of the site. The exposed subgrade soils within the roadways are expected to be comprised of re-compacted soils comprised of sand and silt. The road subgrade should be thoroughly proof-rolled and reviewed by the geotechnical consultant. In the event that loose or soft areas are noted, additional work may be required to sub excavate and replace unstable soils with suitable compactable material. In general terms, subgrade soils supporting site pavements should be compacted to a minimum level of 98 percent SPMDD.

The recommended pavement structure provided in this report is based on the natural subgrade soils encountered in the boreholes or suitably re-compacted soils, as described previously. Provided that the preceding recommendations are followed, the pavement thickness design requirements given in the following table are recommended for the anticipated subgrade conditions and traffic loading on the internal network of local roads.

Table 7 – Pavement Design Recommendations

Pavement Component for Local Roads	Pavement Component Thicknesses		Compaction Requirements
	Internal Roadways	Restoration of Longwoods Road (if required)	
Asphaltic Concrete	40 mm HL 3 45 mm HL 8	Match existing asphalt thicknesses (est. 2 lifts)	97% Bulk Relative Density (BRD)
Granular A Base	150 mm	150 mm	100% SPMDD
Granular B Subbase	300 mm	450 mm	100% SPMDD

Other granular configurations may be possible provided the granular base equivalency (GBE) thickness is maintained. These recommendations on thickness design are not intended to support heavy and concentrated construction traffic, particularly where only a portion of the pavement section is installed. If frequent construction traffic is anticipated while only a portion of the site pavements are in place, or if construction is undertaken in poor weather conditions, thickening of the granular subbase may be appropriate and can be reviewed during construction, by the geotechnical consultant.

Where local roads connect to existing pavements, subgrade levels and pavement components should be tapered to match / tie-into existing pavement structures to minimize differential settlements at the transition from existing to new pavement.

It is recommended that a program of inspection and materials testing (including laboratory analyses and compaction testing) be carried out during construction to confirm that geotechnical requirements are satisfied.

- Samples of both the Granular 'A' and Granular 'B' aggregates should be checked for conformance to OPSS 1010 prior to use on site, and during construction.
- The asphaltic concrete paving materials should conform to the requirements of OPSS 1150. The asphalt should be placed in accordance with OPSS 310.

- Specified compaction levels are identified in Table 7, above. Alternatively, to the specified compaction range noted in the above table for asphalt compaction, a compaction level of 92.0 to 96.5 percent of the Marshall relative density (MRD) is also an appropriate measure for asphalt compaction

Good drainage provisions will optimize long term pavement performance. The finished pavement surface should be free of depressions and should be sloped (preferably at a minimum grade of two percent) to provide effective surface drainage. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. The sandy subgrade soils have good natural drainage and therefore pavement subdrains are not anticipated.

4.6 Curbs and Sidewalks

The concrete for any new exterior curbs and sidewalks should be proportioned, mixed placed and cured in accordance with the requirements of OPSS 353, OPSS 1350.

During cold weather (when the air temperature is at or is likely to fall below 5°C within 96 hours of concrete placement) the freshly placed concrete must be covered with insulating blankets to protect against freezing, as per OPSS 904. Ice and snow must be removed from the area where concrete is to be placed and the concrete must not be placed against frozen ground. All cold weather protection material shall be on site prior to each concrete placement.

Subgrade for sidewalks should consist of undisturbed natural soil or well compacted fill. A minimum 100 mm thick layer of compacted (minimum 100 percent SPMDD) Granular 'A' should be placed below sidewalk slabs. It is recommended that Granular 'A' material extend at least 150 mm beyond the edges of the proposed sidewalk. The subgrade and granular base should be prepared in accordance with the requirements of OPSS 315. Field sampling and testing of concrete should be in accordance with OPSS 904.

4.7 Erosion and Sediment Control Considerations

Sediment and erosion control measures will be required during construction, particularly around the zone of construction, to contain and filter sediment-laden stormwater run-off, before reaching existing stormwater infrastructure. The design of the Sediment and Erosion Control Plan for the site should incorporate suitable erosion control practices and strategies which are suitable to site conditions, and have regard for contingency measures planned in the event that the integrity of the system is compromised. The following general mitigation measures are suggested as best management practices:

- Delineate work areas to limit construction activities.
- Monitoring of discharge water (for water quality – turbidity) from stormwater run-off and construction dewatering activities.
- Maintain perimeter silt fence (and other perimeter ESC measures) in place until disturbed areas are stabilized.
- Build-up boulevard areas to help limit sediment-laden stormwater run-off from discharging into catchbasins and stormwater infrastructure, and regular inspection and maintenance of silt bags / geotextile filters installed in catchbasins.

An inspection and reporting schedule should be incorporated into the Sediment and Erosion Control Plan. Contractors working at the site will be required to adhere to the approved Plan. Adjustments to the plan may be required to adapt to site conditions and seasonal conditions to ensure that the system and erosion control strategy remains effective through the various stages of construction. The frequency of inspections will depend on weather conditions.

4.8 Geotechnical Inspection and Testing

An effective inspection and testing program is an essential part of construction monitoring. The Inspection and Testing Program may include the following items:

- Subgrade examination prior to engineered fill placement;
- Inspection and materials testing during engineered fill placement (full-time monitoring is recommended) and site servicing works, including soil sampling, laboratory testing, and compaction testing;
- Footing base confirmations for any foundations constructed on engineered fill;
- Concrete sampling and testing for building footings, foundations and floor slabs;
- Inspection and testing for site pavements including compaction testing and laboratory testing;
- Concrete sampling and testing for curbs and sidewalks; and,
- Inspection and materials testing for base and surface asphalt.

Sufficient geotechnical inspections and materials testing is recommended for this project, to verify that project specifications have been satisfied during construction.

5. HYDROGEOLOGICAL DISCUSSION

5.1 Hydrogeologic Setting

As discussed in Section 3.3, stabilized water levels were recorded by MTE within the monitoring wells across the site from 2019 to 2023. The results indicate that shallow groundwater is present in the near-surface sand and silt soils, with stabilized water levels measured between 0.2 to 3.4 m below existing ground surface (corresponding to Elevations ranging from 232.2 to 235.5 m asl).

The shallow groundwater encountered in the monitoring wells installed at the site contact the shallow (< 15 m depth) and intermediate (15 - 30 m depth) unconfined overburden aquifers. This type of aquifer can be interconnected with surface water features, and is generally fed by infiltrated surface water. Shallow overburden aquifers tend to be heavily influenced by site topography. The water level measurements taken at the site are indicative of a southerly/southeasterly groundwater flow direction. It is important to note that shallow groundwater will vary in response to climatic or seasonal conditions, and, as such, may differ depending on the seasonal conditions. Shallow groundwater in unconfined aquifers can be significantly influenced by exceptional and/or sustained rainfall events.

As shown on Drawing 4 in Appendix A, bedrock is estimated at more than 52 to 54 m below ground surface in the vicinity of the site. As such, the potential impact to the bedrock aquifer from the proposed residential development at the site is not anticipated to be significant, and no further discussion is provided regarding the bedrock aquifer.

5.2 Water Quality Considerations

Baseline groundwater conditions (including general chemistry parameters) have not been established under the current scope of work for this investigation. Prior to construction, consideration may be given to carrying out baseline water quality sampling to establish the general chemistry and characteristics of the shallow groundwater, if encountered. LDS is not aware of any contaminant plumes or existing environmental contamination in the vicinity of the site.

Construction activities at the site are generally not expected to impact the chemistry or bacteriological properties of the intermediate depth aquifer. However, the possibility exists that a spill or uncontrolled release of fuel or associated material could occur during construction, which could have a direct impact to the unconfined shallow to intermediate groundwater aquifer, or that sediment discharge could impact the effectiveness of stormwater infrastructure in the area. Additional comments are provided below, in this regard.

Given the naturally low permeability of the silt/clay soils which underlie the site (as described in the MECP well records), the deep overburden aquifers are not considered to be vulnerable to contamination from surface sources. However, shallow groundwater contained within sandy soils (such as those noted within the well records) may be more susceptible to water quality impacts as a result of surface activities during construction, since it does not have the benefit of a low-permeability protective soil layer above it.

5.2.1 Potential Impact from Construction Equipment

The possibility exists that a spill or uncontrolled release of fuel or associated material could occur during construction, which could have a direct impact to surface water and shallow groundwater conditions.

A Best Management Practice (BMP) and spill contingency plan (including a spill action response plan) should be in place for fuel handling, storage and onsite equipment maintenance activities. It is recommended that there be a designated equipment fuelling areas, and implementing a spill contingency plan (including a spill action response plan) for fuel handling, storage and onsite equipment maintenance activities to minimize the risk of contaminant releases as a result of the proposed construction activities.

It is important to note that if a spill (possible incident) is related to the contractor's activities, the contractor is responsible to report the incident to the Spills Action Centre, and/or notify the local MECP office. Depending on the type of incident, water sampling and quality testing may be warranted to document the extent of the impact. Scoping for the required testing will depend on the incident report.

5.2.2 Potential Impact from Uncontrolled Erosion / Sediment Discharge

Surface water quality can be detrimentally impacted by uncontrolled erosion and sediment discharge from the site. As such, it is imperative that an adequate Sediment and Erosion Control Strategy be established for the site. In addition to implementing sediment and erosion controls during construction, regular inspection and maintenance will also be necessary to ensure that sensitive receptors are not negatively impacted during construction.

Sediment and erosion control measures will be required to limit sediment discharge towards the natural features. It is important to ensure that the sediment control measures are installed properly, and in accordance with the design drawings. If deficiencies are identified in its performance through regular inspection, enhancements beyond the recommended design may be required. Refer to additional discussion in Section 4.8.

5.3 Impact Assessment

5.3.1 Construction Dewatering

Conventional groundwater control methods are generally expected to be suitable for shallow excavations at the site, to address surface water infiltration and minor shallow groundwater seepage for excavations which do not extend below the stabilized groundwater table.

Where excavations extend below the stabilized groundwater table, or where groundwater levels are elevated, positive groundwater control methods may need to be utilized for construction dewatering. Groundwater control measures at the site should be sufficient to maintain stable excavated slopes; and provide a dry and stable base for excavations and construction operations. The contractor should use a reasonable effort to direct surface run-off away from open excavations.

As noted in Section 4.3.2, it is recommended that the contractor obtain an EASR to allow for dewatering efforts to pump in excess of 50,000 litres per day (and less than 400,000 litres per day. Preliminary dewatering estimates for water-taking volumes and zone of influence calculations are provided below; However, a more detailed analysis can be carried out when servicing depths and design grades are available. Under the EASR approval process, a dewatering and discharge plan would need to be prepared.

Assessment of Water Taking Volume - The water-bearing subgrade soils were generally comprised of silt and sand. A saturated hydraulic conductivity with a geometric mean value of 7.90×10^{-5} cm/sec has been identified for these natural subgrade soils, based on correlations with grain size analyses and in-situ percolation tests conducted at the site.

In establishing the preliminary estimate for the dewatering volumes which may be anticipated at the site, LDS has relied upon the soil permeabilities determined from the in-situ percolation tests conducted at the site under three separate scenarios. It is assumed that the excavation limits are expected to be approximately 100 m in length, an average aquifer thickness of 13.7 m (based on the average elevation to the top of the clay aquitard contacted within the MECP well records) and a spring high water level in the range of 233.9 to 235.5 m across the site. Site servicing depths are generally expected to be in the range of 4 m maximum depth.

In this regard, total factored (FOS =3) dewatering volumes of 331,000 to 355,000 L/day are anticipated to control seepage from the excavation sidewalls. In addition, provision for an additional 50% is recommended to allow for variations in the soil conditions, and for handling stormwater run-off during/following typical (2-year) rain events, resulting in a net factored volume estimated in the range of 496,500 to 532,500 L/day.

Zone of Influence - To estimate the potential zone of influence for construction dewatering activities, a range of effective dewatering depths has been calculated, based on the Sischart and Kryieleis calculation method (Powers, Eq. 6.12), which uses the following equation:

$$R_o = 3000\,(H\text{-}h_w)\,k^{1/2}$$

Based on the geometric mean for the water-bearing soils in the range of 7.90×10^{-5} m/sec, the following zone of influence distances have been determined:

- Effective dewatering depth of 3 m, unfactored zone of influence – 7.7 m
- Effective dewatering depth of 5 m, unfactored zone of influence – 13.1 m

These values are relatively low, based on the soil permeability of the natural subgrade soils which are noted above and observed in the boreholes.

Turbidity Monitoring - While active construction dewatering occurs at the site, a program which includes turbidity monitoring is recommended, to confirm that the quality of discharge water will not have adverse impacts to sensitive receptors. In the event that water discharged from the site is considered to have an elevated turbidity level, associated construction activities should be halted until remedial measures can be implemented. Such measures may include enhanced or more robust sediment and erosion control measures, incorporating pooling areas and measures that will reduce suspended solids, temporary storage measures to prevent off-site discharge.

Some dewatering contractors have the capability to employ live-time monitoring of water quality, using Environmental Monitoring and Compliance (EMAC) monitoring equipment, which can be incorporated into the dewatering system, and accessed remotely to review flow, velocity and water quality parameters (including temperature, total suspended solids and turbidity, as well as other parameters).

5.3.2 Local Water Supply Wells

Typical site servicing depths and excavations for building foundations are expected to be well above the intermediate and deep overburden aquifers. From a quantitative standpoint, temporary construction dewatering will not result in the alterations in the water level within those aquifers.

As noted in the MECP well records, several water supply wells In the general vicinity of the site set within the shallow overburden aquifer. However, these wells are located some 90 to 400 m away from the site, or are located upgradient of the inferred groundwater flow direction (east/southeast) and therefore should not be affected by temporary construction dewatering activities at the site. In the event that additional information becomes available which indicates the presence of shallow wells in closer proximity to the site, it is recommended that a contingency plan be prepared with the provision of providing a temporary water supply via temporary piped water supply, or trucking municipal water into the property to meet the daily needs for the residence. The contingency plan must provide a sufficient potable water volume to accommodate regular single-family residential use. A well survey of the nearby and neighbouring properties is recommended to confirm the presence of any additional shallow wells which may be present in the area.

In the unlikely event that long-term or permanent water supply interference occurs to a shallow well located in the area, which can be attributed to the development activities at the site, the developer should have a contingency plan which includes providing an alternate water source, which may include a suitable replacement well, either by deepening the existing well, or installation of a new well.

5.3.3 Well Decommissioning

Monitoring wells have been installed at the site by MTE to document stabilized groundwater conditions. When the monitoring wells are determined to be no longer required, the wells should be properly decommissioned in accordance with Ontario Regulation 903. This regulation identifies that only certified and qualified well drilling technicians are permitted to direct the decommissioning work for existing wells.

Decommissioning a well which is no longer in use helps to ensure the safety of those in the vicinity of the well, prevents surface water infiltration into an aquifer via the well, prevents the vertical movement of water within a well, conserves aquifer yield and hydraulic head and can potentially remove a physical hazard.

5.4 Low Impact Development Considerations

Consideration has been given to identify stormwater management options which allow secondary infiltration or reduced run-off under post-development conditions, to be incorporated into the stormwater management design. LID (Low Impact Development) strategies help to mitigate the impacts of increased runoff and stormwater pollution by managing runoff as close to its source as possible, by incorporating site features which enhance post-development infiltration, evapotranspiration, filtration and detention of stormwater. These practices can help to reduce contaminants in runoff, and can reduce the volume and intensity of stormwater flows.

The infiltration capacity of a soil depends on a number of factors, including particle size distribution, degree of saturation, compactness, adsorbed water (which depends on clay content). The heterogeneous nature of glacial deposits can also contribute to variations in soil permeability where the soil composition may include localized areas with increased fine material or sandy material which can influence soil permeability at different points within the soil strata.

Based on the permeability results presented in Section 3.1, the natural water-bearing subgrade soils have a saturated hydraulic conductivity in the range of 10^{-5} to 10^{-10} m/s, corresponding to factored infiltration rates in the range of 2 to 29 mm/hr. In addition, consideration must be given to the depth of shallow groundwater, and the potential drawdown effects of site servicing on perched groundwater levels.

It is also important to note that the presence and effective depth of sandy soils may be altered by site grading activities at the site. The stormwater management strategy at the site will need to consider site grading activities at the site, which may alter the near-surface soil conditions, as a result of cut-fill activities to accommodate design grades.

Where low permeability soils are present (such as the glacial till deposits), the use of infiltration-based features may not be effective. Alternative measures such as grassed swales, thickened topsoil, reduced lot grading and discharging water collected from roof leaders into landscaped areas are generally considered better suited to the soil conditions at the site. These alternative measures extend the retention time for surface water run-off, to help moderate and potentially reduce run-off volumes, and provide opportunities for evapotranspiration and limited infiltration.

The placement of fill soils throughout the site to raise grades, or to balance the cut-fill requirements across the site, may alter soil conditions and the effective depth to groundwater. Field confirmation of soil permeability and effective infiltration rates in the natural or reconstructed subgrade soils will need to be undertaken to confirm soil suitability for any infiltration-based LID measures which are considered at the site.

7. CLOSING

The geotechnical recommendations provided in this report are applicable to the project described in the text. LDS would be pleased to provide a review of design drawings and specifications to ensure that the geotechnical comments and recommendations provided in this report have been accurately and appropriately interpreted.

It is important to note that the geotechnical investigation involves a limited sampling of the subsurface conditions at specific borehole locations. The conclusions and recommendations presented in this report reflect site conditions existing at the time of the investigation and a review of available information which has been presented in the report. Should subsurface conditions be encountered which vary materially from those observed in the boreholes, we recommend that LDS be consulted to review the additional information and verify if there are any changes to the geotechnical recommendations.

The comments given in this report are intended to provide guidance for design engineers. Contractors making use of this report are responsible for their construction methods and practices, and should seek confirmation or additional information if required, to ensure that they understand how subsurface soil and groundwater conditions may affect their work.

No portion of this report may be used as a separate entity. It is intended to be read in its entirety.

We trust this satisfies your present requirements. If you have any questions or require anything further, please feel free to contact our office.

Respectfully Submitted,

LDS CONSULTANTS INC.

LICENSED PROFESSIONAL ENGINEER
Nov 24, 2023
S. M. HADDEN
100231255
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
Nov 24, 2023
R.A. WALKER
PROVINCE OF ONTARIO

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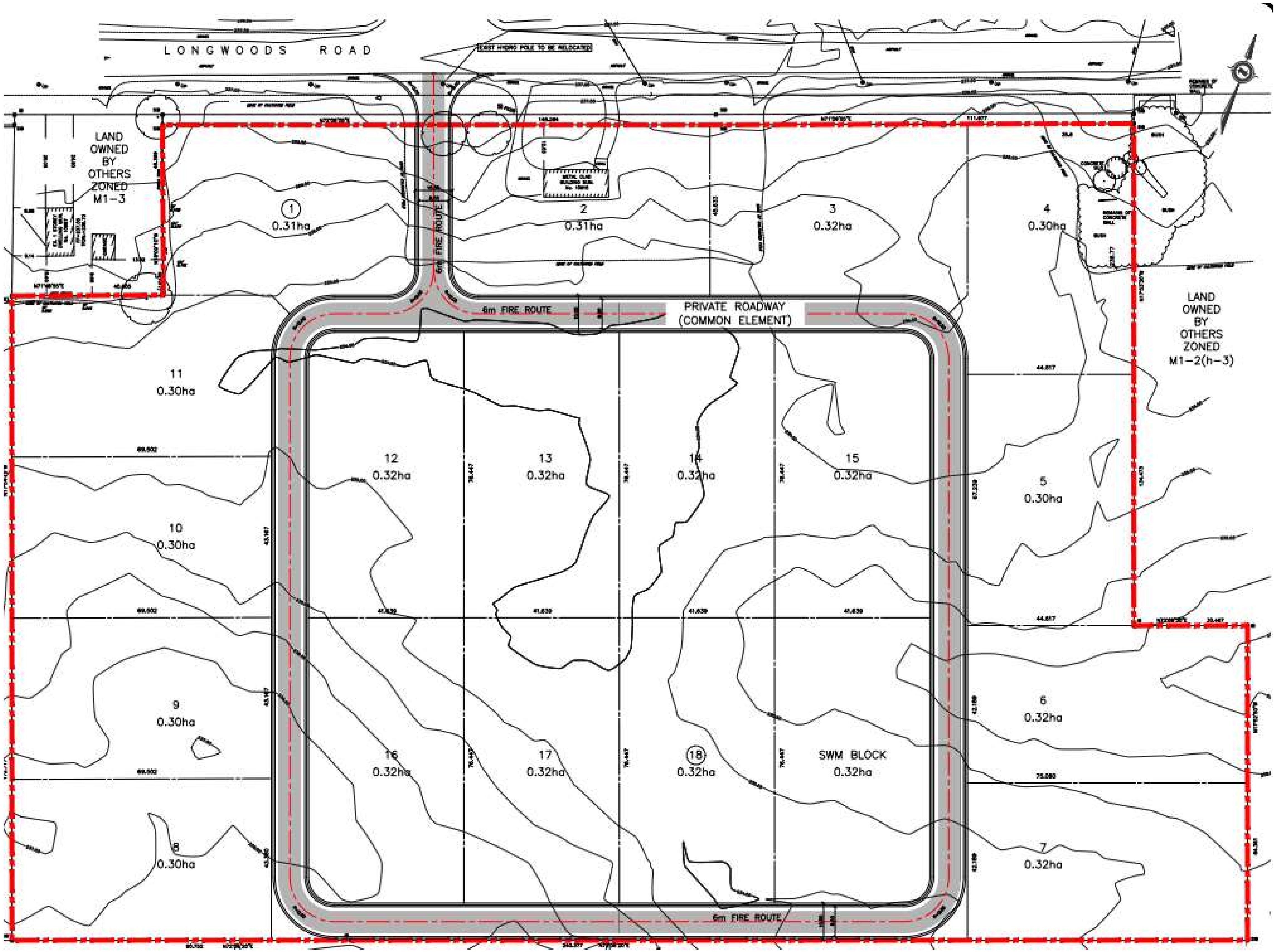
APPENDIX A

DRAWINGS AND NOTES



SOURCE:
Produced from "Draft Plan of Vacant Land Condominium", sheet A100, prepared by LDS Consultants Inc., July 20, 2023

PROJECT NAME
Proposed Industrial Subdivision

PROJECT LOCATION
10919 Longwoods Road
Municipality of Middlesex Centre, ON

DRAWING NAME
Concept Plan

SCALE	PROJECT NO.
NTS	GE-01104
DATE	**DRAWING NO.**
November 2023	1

SOURCE:
Google Earth Pro, Version 7.3.6.9345,
Coordinates 17T, 467501 m E, 4750791 m N,
Imagery date 7/2/2018

PROJECT NAME

Proposed Industrial Subdivision

PROJECT LOCATION

10919 Longwoods Road
Municipality of Middlesex Centre, ON

DRAWING NAME

Site Features

SCALE	PROJECT NO.
As Shown	GE-01104
DATE	**DRAWING NO.**
November 2023	2

SOURCE

Source Protection Information Atlas, Ministry of Environment, Conservation and Parks www.gisapplication.lrc.gov.on.ca/SourceWaterProtection/ Current to August 9, 2023.

PROJECT NAME

Proposed Industrial Subdivision

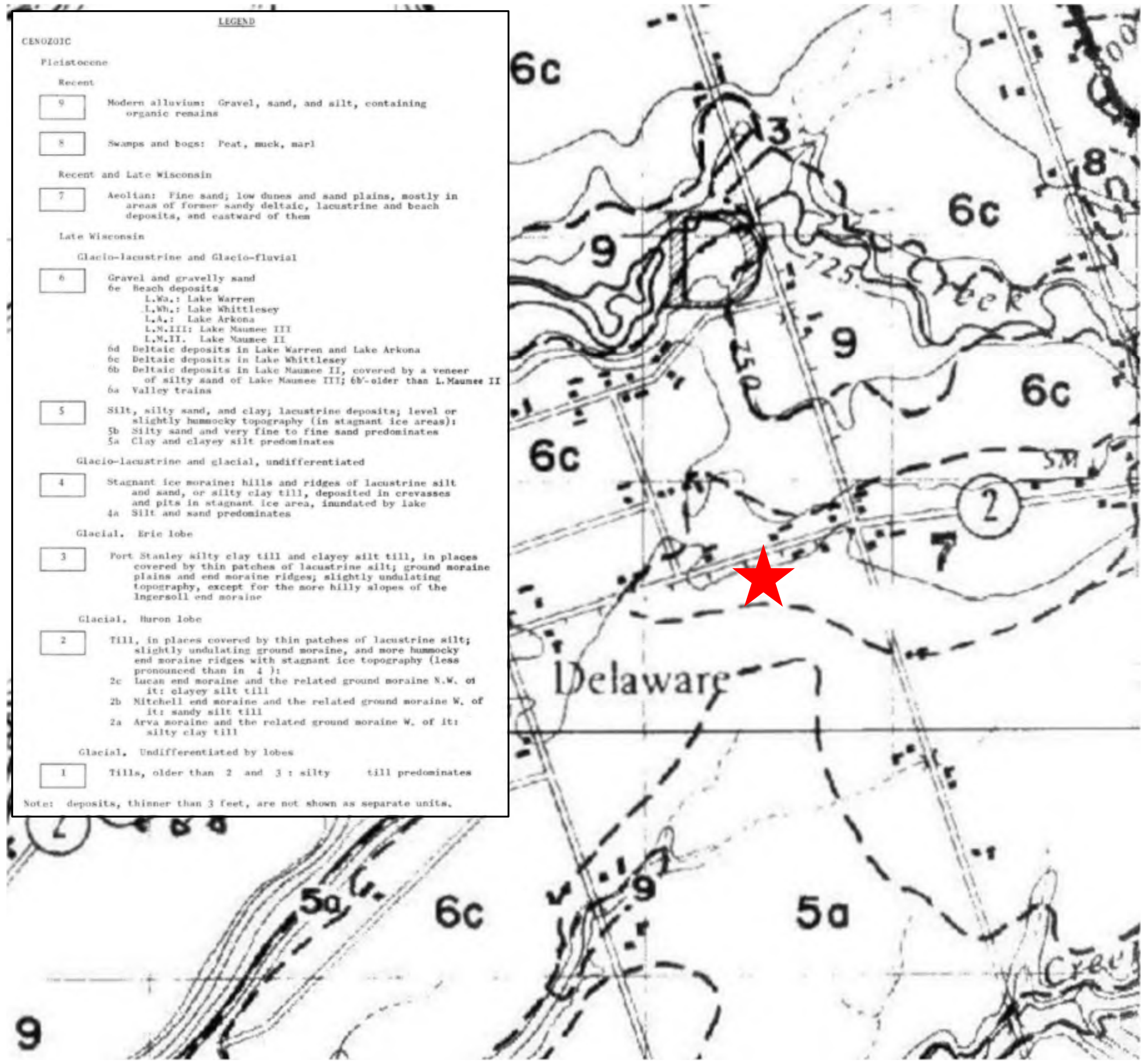
PROJECT LOCATION

10919 Longwoods Road
Municipality of Middlesex Centre, ON

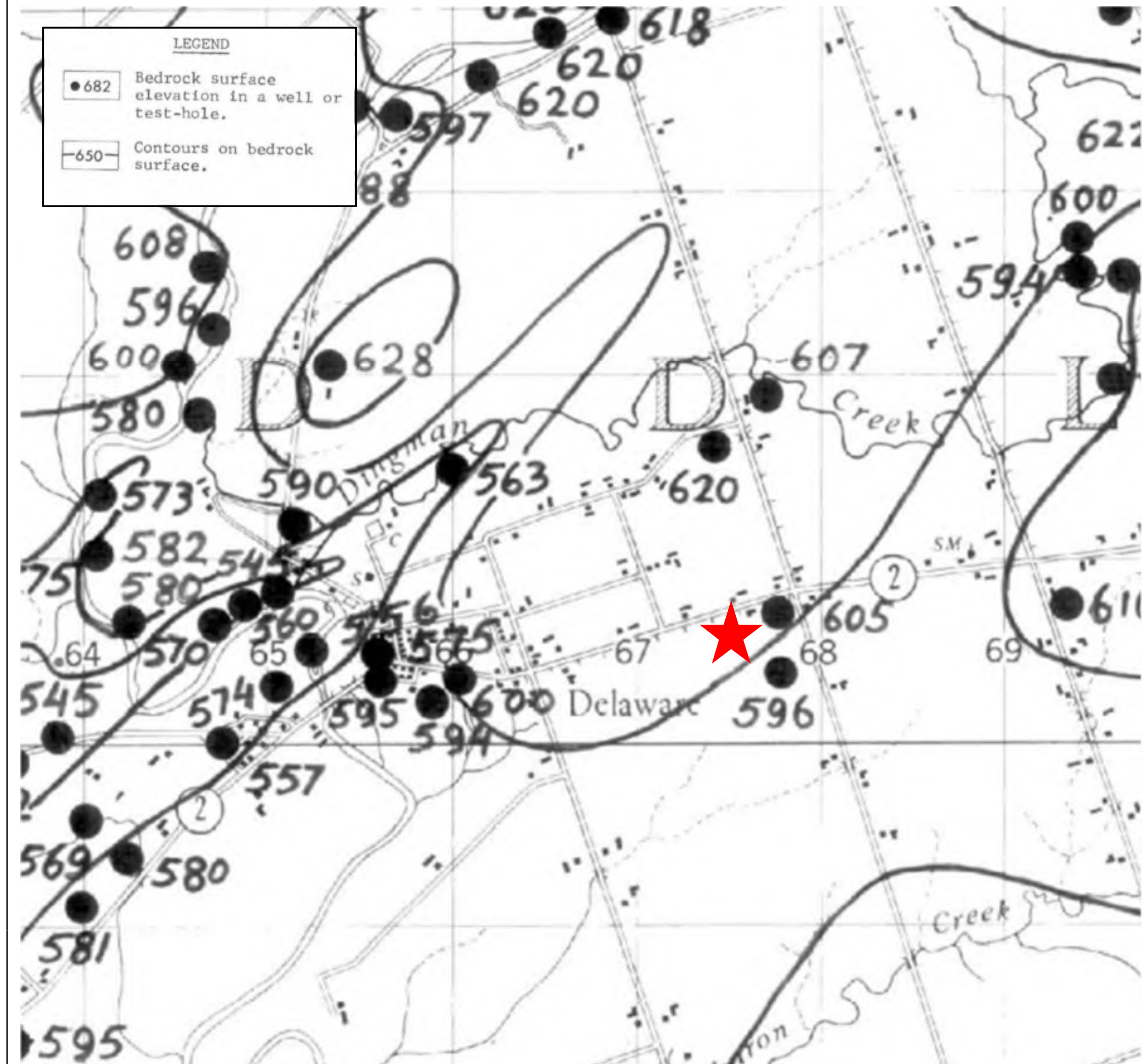
DRAWING NAME

Source Water Protection Mapping

SCALE	PROJECT NO.
As Shown	GE-01104
DATE	**DRAWING NO.**
November 2023	3



SOURCE
Quaternary Geology, St. Thomas Area (west half), Ontario Geological Survey Map P0238,
Scale 1:50,00, © 1964



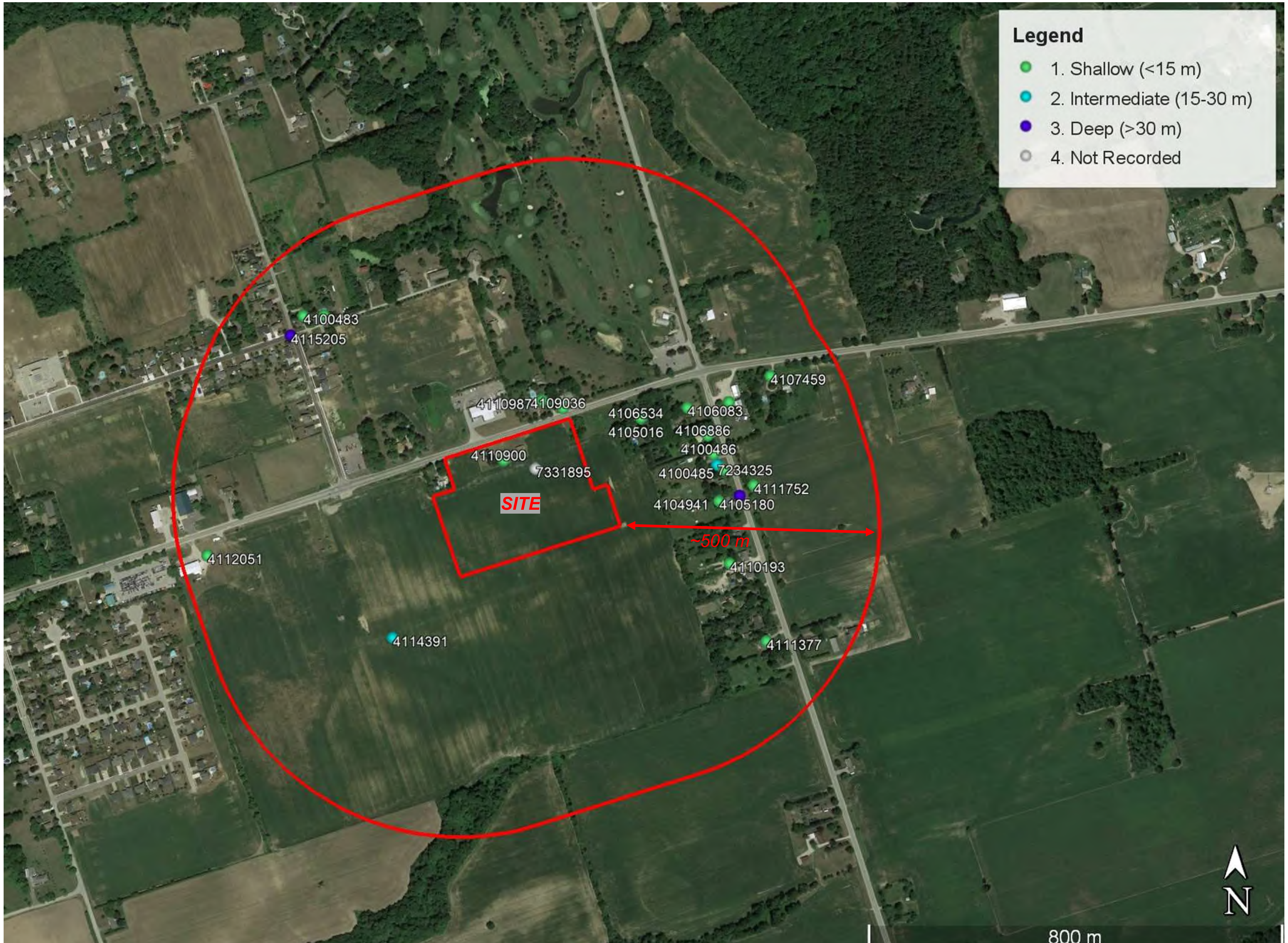
SOURCE
Bedrock Topography, St Thomas Sheet, Ontario Geological Survey Map P0482
Scale 1:50,000, © 1968

PROJECT NAME
Proposed Industrial Subdivision

PROJECT LOCATION
10919 Longwoods Road
Municipality of Middlesex Centre, ON

DRAWING NAME
Geological Mapping

SCALE	PROJECT NO.
1:50,000	GE-01104
DATE	**DRAWING NO.**
November 2023	4



Source
Base drawing from Google Maps, Imagery © 2018. Well locations based on MECP Water Well database, available online at www.ontario.ca/environment-and-energy/map-well-records

LDS

PROJECT NAME
Proposed Industrial Subdivision

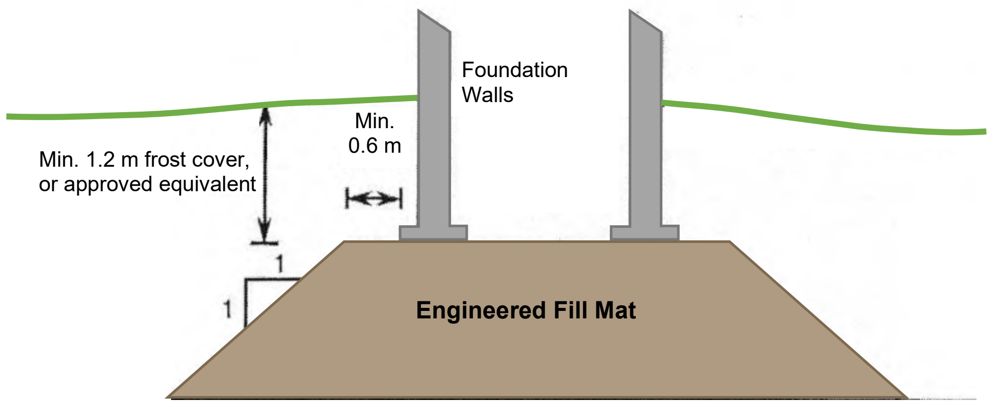
PROJECT LOCATION
10919 Longwoods Road
Municipality of Middlesex Centre, ON

DRAWING NAME
MECP Well Location Plan – All Wells

SCALE	PROJECT NO.
As Shown	GE-01104
DATE	**DRAWING NO.**
November 2023	5

ENGINEERED FILL PLACEMENT

SCHEMATIC DIAGRAM



NOTES:

1. The area must be stripped of all topsoil contaminated fill material, and other unsuitable soils, and proof rolled. Soft spots must be dug out. The stripped natural subgrade must be examined and approved by the geotechnical consultant.
2. In areas where engineered fill is placed on a slope, the fill should be benched into the approved subgrade soils.
3. Material used for engineered fill must be free of topsoil, organics, frost and frozen material, and otherwise unsuitable or compressible soils, as determined by a Geotechnical Engineer. Any material proposed for use as engineered fill must be examined and approved prior to use onsite.
4. Engineered fill should be placed in maximum 300 mm thick lifts, and uniformly compacted to 100% Standard Proctor dry density. For best compaction results, engineered fill should be within 3 percent of its optimum moisture content, as determined by the Standard Proctor density test.
5. Full time geotechnical monitoring, inspection and in-situ density (compaction) is required during placement of the engineered fill.
6. Site grades should be maintained during area grading activities to promote drainage, and to minimize ponding of surface water on the engineered fill mat. Rutting by construction equipment should be kept to a minimum, where possible. Additional work to ensure suitability of engineered fill may be required if fill is placed in inclement weather conditions.
7. The fill must be placed such that the specified geometry is achieved. Refer to schematic diagram for minimum requirements. Environmental protection may be required, such as frost protection during construction, and after the completion of the engineered fill mat.
8. An allowable bearing pressure of 145 kPa (3000 psf) may be used provided that all conditions outlined above, and in the Geotechnical Report are adhered to.
9. These guidelines are to be read in conjunction with the Geotechnical Report prepared by LDS.
10. For foundations set on engineered fill, footing enhancement and/or concrete reinforcing steel placement may be recommended. The footing geometry and extent of concrete reinforcing steel will depend on site specific conditions. In general, consideration may be given to having a minimum strip footing width of 500 mm (20 inches), containing nominal steel reinforcement.

LDS	**PROJECT NAME** Proposed Industrial Subdivision	**PROJECT NO.** GE-01104
	PROJECT LOCATION 10919 Longwoods Road, Municipality of Middlesex Centre, ON	**DRAWING NO.** 6

APPENDIX B

BOREHOLE LOGS ,
LABORATORY TEST RESULTS
& MANUAL GROUNDWATER MEASUREMENTS

(PREPARED BY OTHERS)

LEGEND

BH107–19 MTE BOREHOLE

MW101–19 MTE MONITORING WELL

REFERENCES:

- AERIAL IMAGE FROM GOOGLE EARTH PRO.
- BOREHOLE ELEVATIONS SURVEYED BY MTE.

MTE
Engineers | Scientists | Surveyors

SITE PLAN

Project Name
10919 LONGWOODS ROAD PROPOSED INDUSTRIAL SUBDIVISION

Site	Client
10919 LONGWOODS ROAD, MUNICIPALITY OF MIDDLESEX, ON	10919 LONGWOODS ROAD INC.

Scale (11x17)	MTE Project No.	Date	Figure No.
1:2000	45013-300	MARCH 27, 2019	**2**

Project: 45013–300 CAD: P:\P\45013\300\BH FIGURES\45013–300 BH FIGURES.DWG
FIGURE 2 – SITE PLAN
March 27, 2019 – 11:39 a.m. – Plotted By: awilliams

ID Number: MW101-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

SUBSURFACE PROFILE

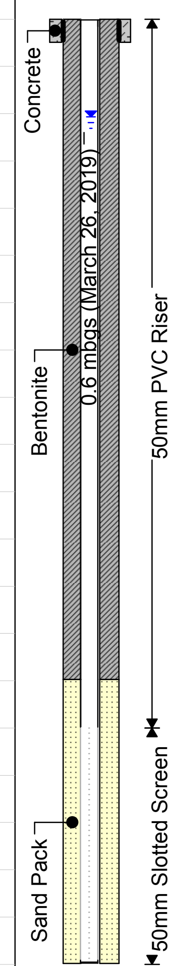
Depth (ft / m)	Soil Description	Elevation (masl) / Depth (m)
0 / 0	Ground Surface	235.0
	TOPSOIL dark brown/black sandy silt, some organics, wet	0.0
	SAND AND SILT loose light brown sandy silt, saturated	234.7 / 0.3
	compact light brown silty sand, saturated	234.2 / 0.8
	grey	231.8 / 3.2
	dense	230.4 / 4.6
	Drilling Terminated	228.4 / 6.6

SAMPLE

Number	Type	Standard Penetration (N)	Water Content (%)
1	SS	4	24
2	SS	15	21
3	SS	12	21
4	SS	11	21
5	SS	18	19
6	SS	32	18
7	SS	38	22

Dynamic Cone ×
Standard Penetration ● 20 40 60 80
Shear Strength (PP) ▲ kPa
Shear Strength (FV) ■ kPa 50 100 150 200
Water Content ● % 10 20 30

Groundwater Observations and Standpipe Details



Initial water level at 0.3mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

MTE

Sheet: 1 of 1

ID Number: MW102-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

SUBSURFACE PROFILE

Depth (m)	Soil Description	Elevation (masl) / Depth (m)
0	Ground Surface	235.6 / 0.0
0.0–0.3	**TOPSOIL** dark brown/black sandy silt, some organics, wet	235.3 / 0.3
0.3–0.8	**SAND AND SILT** loose dark brown sandy silt, wet	234.8 / 0.8
0.8–1.5	light brown, trace clay, saturated	234.1 / 1.5
1.5–2.3	compact	233.3 / 2.3
2.3–4.6	grey	231.0 / 4.6
4.6–6.1	compact grey silt, some sand, trace clay, saturated	229.5 / 6.1
6.1–6.7	compact grey sandy silt, saturated	228.9 / 6.7
6.7	Drilling Terminated	

SAMPLE

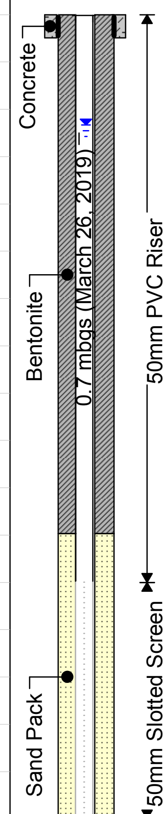
Number	Type	Standard Penetration (N)	Water Content (%)
1	SS	4	24
2	SS	8	23
3	SS	10	22
4	SS	10	25
5	SS	10	23
6	SS	10	21
7	SS	11	21

Dynamic Cone ×; Standard Penetration ● 20 40 60 80

Shear Strength (PP) kPa ▲; Shear Strength (FV) kPa ■ 50 100 150 200

Water Content % ● 10 20 30

Groundwater Observations and Standpipe Details



Initial water level at 0.8mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

MTE

Sheet: 1 of 1

ID Number: MW103-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

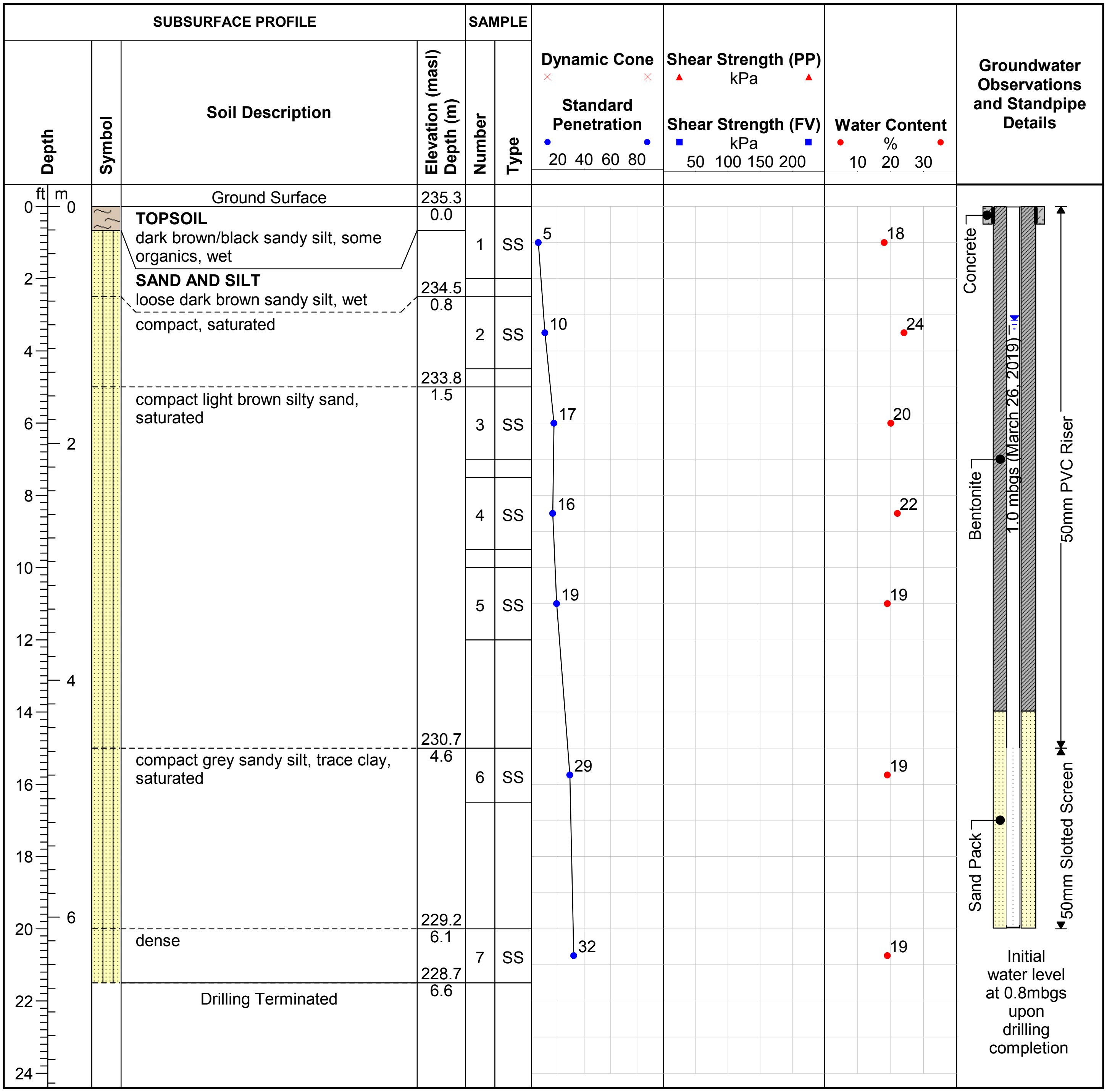
Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

SUBSURFACE PROFILE

Soil Description	Elevation (masl) / Depth (m)	Sample Number	Type	SPT N	Water Content (%)
Ground Surface	235.3				
TOPSOIL dark brown/black sandy silt, some organics, wet	0.0	1	SS	5	18
SAND AND SILT loose dark brown sandy silt, wet	234.5 / 0.8				
compact, saturated		2	SS	10	24
compact light brown silty sand, saturated	233.8 / 1.5	3	SS	17	20
		4	SS	16	22
		5	SS	19	19
compact grey sandy silt, trace clay, saturated	230.7 / 4.6	6	SS	29	19
dense	229.2 / 6.1	7	SS	32	19
Drilling Terminated	228.7 / 6.6				



Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

MTE

Sheet: 1 of 1

ID Number: MW104-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

SUBSURFACE PROFILE

Soil Description	Elevation (masl) / Depth (m)
Ground Surface	236.4 / 0.0
TOPSOIL dark brown/black sandy silt, some organics, saturated/frozen	
SAND AND SILT very loose dark brown silty sand, wet	235.6 / 0.8
loose dark brown sand, some silt, trace clay, wet	235.2 / 1.2
saturated	234.9 / 1.5
compact	234.6 / 1.8
light brown	
dense, brown	231.8 / 4.6
grey	231.4 / 5.0
dense grey sandy silt, saturated	230.3 / 6.1
Drilling Terminated	229.8 / 6.6

SAMPLE

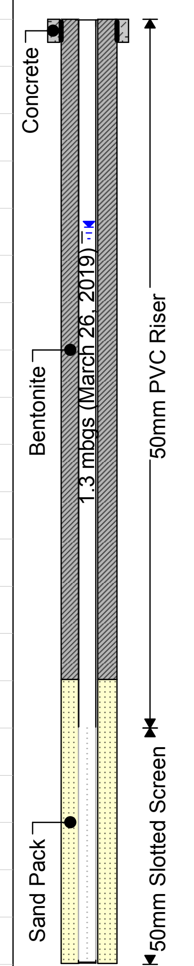
Number	Type	Standard Penetration (N)	Water Content (%)
1	SS	3	16
2	SS	4	24
3	SS	14	25
4	SS	17	21
5	SS	15	22
6	SS	35	21
7	SS	31	22

Dynamic Cone / Standard Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200

Water Content %: 10 20 30

Groundwater Observations and Standpipe Details



Initial water level at 0.8mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

MTE

Sheet: 1 of 1

ID Number: MW105-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

SUBSURFACE PROFILE

Soil Description	Elevation (masl)	Depth (m)
Ground Surface	234.2	0.0
TOPSOIL dark brown/black sandy silt, some organics, saturated	233.8	0.4
SAND AND SILT loose dark brown sandy silt, wet	233.4	0.8
compact, saturated; light brown	232.7	1.5
grey	229.6	4.6
compact grey silt, some sand, trace clay, saturated	228.1	6.1
dense grey silty sand, saturated	227.6	6.6
Drilling Terminated		

SAMPLE

Number	Type	Standard Penetration	Water Content (%)
1	SS	4	22
2	SS	14	23
3	SS	18	21
4	SS	12	22
5	SS	11	20
6	SS	21	17
7	SS	36	18

Depth: ft 0–24; m 0–6

Dynamic Cone; Standard Penetration: 20 40 60 80

Shear Strength (PP) kPa; Shear Strength (FV) kPa: 50 100 150 200

Water Content %: 10 20 30

Groundwater Observations and Standpipe Details

Concrete

Bentonite

Sand Pack

0.6 mbgs (March 26, 2019)

50mm PVC Riser

50mm Slotted Screen

Initial water level at 0.8mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

ID Number: MW106-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

SUBSURFACE PROFILE

Depth (m)	Soil Description	Elevation (masl) / Depth (m)
0	Ground Surface	235.5 / 0.0
0.0–0.3	**TOPSOIL** dark brown/black sandy silt, some organics, wet	235.2 / 0.3
0.3–0.8	**SAND AND SILT** loose dark brown sandy silt, wet	234.7 / 0.8
0.8–1.5	saturated	234.0 / 1.5
1.5–3.0	compact, light brown	232.5 / 3.0
3.0–6.6	grey	228.9 / 6.6
6.6	Drilling Terminated	

SAMPLE

Number	Type	Standard Penetration (N)	Water Content (%)
1	SS	4	18
2	SS	9	24
3	SS	10	21
4	SS	24	21
5	SS	13	20
6	SS	17	22
7	SS	24	21

Dynamic Cone ×; Standard Penetration ● (20 40 60 80)

Shear Strength (PP) kPa ▲; Shear Strength (FV) kPa ■ (50 100 150 200)

Water Content % ● (10 20 30)

Groundwater Observations and Standpipe Details

Concrete

Bentonite

Sand Pack

1.2 mbgs (March 26, 2019)

50mm PVC Riser

50mm Slotted Screen

Initial water level at 0.8mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

MTE

Sheet: 1 of 1

ID Number: BH107-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/21/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

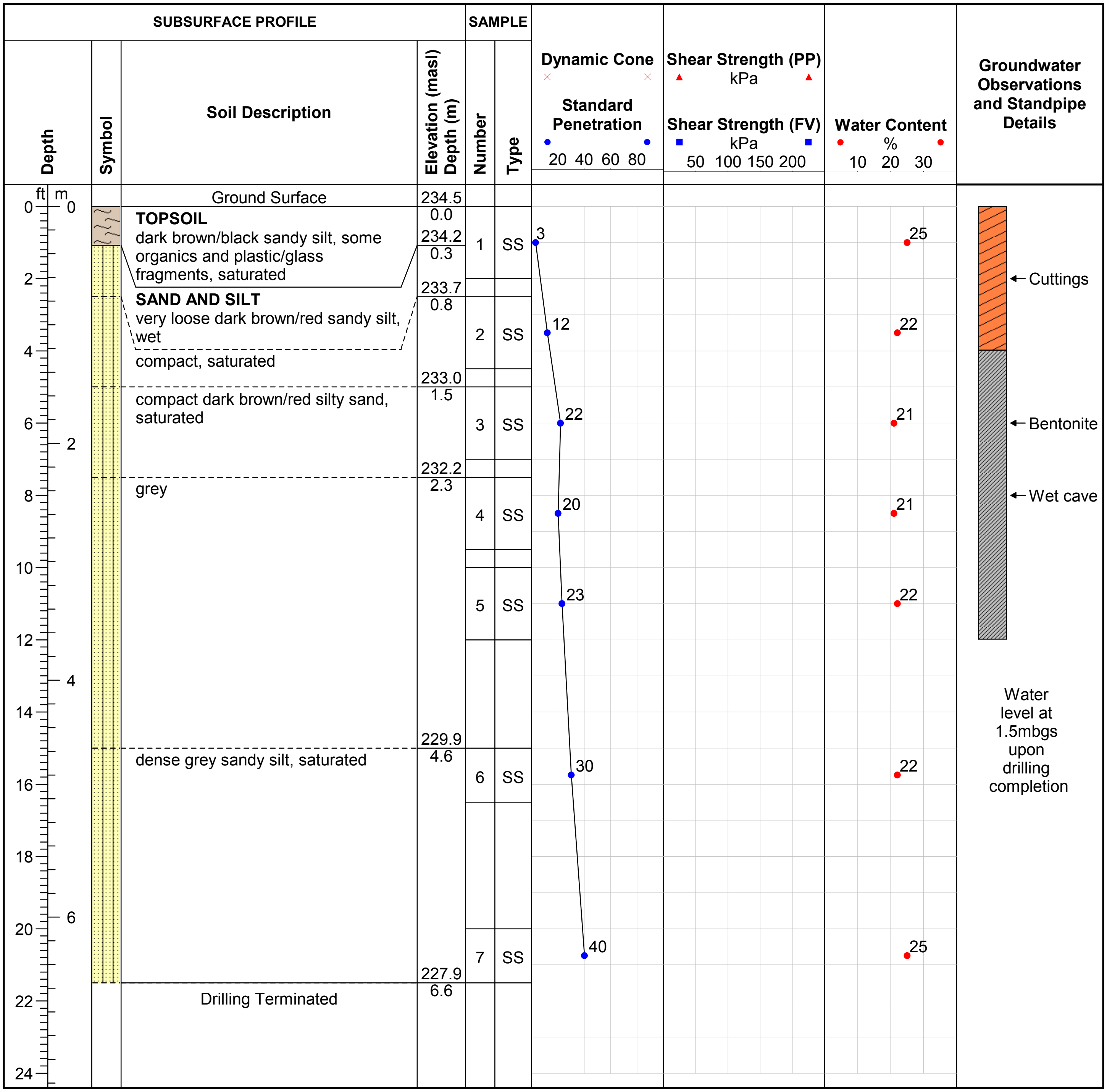
Protective Cover: Monument Casing

SUBSURFACE PROFILE

Soil Description	Elevation (masl) / Depth (m)
Ground Surface	234.5 / 0.0
TOPSOIL dark brown/black sandy silt, some organics and plastic/glass fragments, saturated	234.2 / 0.3
SAND AND SILT very loose dark brown/red sandy silt, wet	233.7 / 0.8
compact, saturated	233.0 / 1.5
compact dark brown/red silty sand, saturated	232.2 / 2.3
grey	229.9 / 4.6
dense grey sandy silt, saturated	227.9 / 6.6
Drilling Terminated	

SAMPLE

Number	Type	Standard Penetration	Water Content (%)
1	SS	3	25
2	SS	12	22
3	SS	22	21
4	SS	20	21
5	SS	23	22
6	SS	30	22
7	SS	40	25



Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

Notes:
Bentonite forced into wet cave at 2.4mbgs

ID Number: BH108-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/21/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

SUBSURFACE PROFILE			SAMPLE						
Depth (ft / m)	Soil Description	Elevation (masl) / Depth (m)	Number	Type	Dynamic Cone / Standard Penetration (20 40 60 80)	Shear Strength (PP) kPa / Shear Strength (FV) kPa (50 100 150 200)	Water Content % (10 20 30)	Groundwater Observations and Standpipe Details
0	Ground Surface	235.1						
	TOPSOIL dark brown/black sandy silt, some organics, saturated	0.0	1	SS	4		23	Cuttings
	SAND AND SILT loose dark brown sandy silt, wet	234.7 / 0.4						
	trace clay, saturated	234.3 / 0.8	2	SS	5		20	
	compact, light brown	233.6 / 1.5	3	SS	12		20	Bentonite
	compact grey silty sand, saturated	232.8 / 2.3	4	SS	16		19	
			5	SS	19		18	Wet cave
	compact grey sandy silt, saturated	230.5 / 4.6	6	SS	19		20	
	dense	229.0 / 6.1	7	SS	35		19	
	Drilling Terminated	228.5 / 6.6						

Water level at 1.5mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

Notes:
Bentonite forced into wet cave at 3.1mbgs

ID Number: BH109-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/21/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

SUBSURFACE PROFILE

Soil Description	Elevation (masl)	Depth (m)
Ground Surface	235.4	
TOPSOIL dark brown/black sandy silt, some organics, saturated		0.0
SAND AND SILT loose dark brown sandy silt, wet	235.0	0.4
compact, saturated	234.6	0.8
grey	233.1	2.3
dense grey silty sand, saturated	229.3	6.1
Drilling Terminated	228.8	6.6

SAMPLE

Number	Type	Standard Penetration	Water Content (%)
1	SS	5	27
2	SS	10	22
3	SS	15	21
4	SS	19	20
5	SS	17	20
6	SS	26	18
7	SS	46	20

Dynamic Cone; Standard Penetration (20 40 60 80); Shear Strength (PP) kPa; Shear Strength (FV) kPa (50 100 150 200); Water Content % (10 20 30)

Groundwater Observations and Standpipe Details

Cuttings

Bentonite

Wet cave

Water level at 1.5mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

MTE

Sheet: 1 of 1

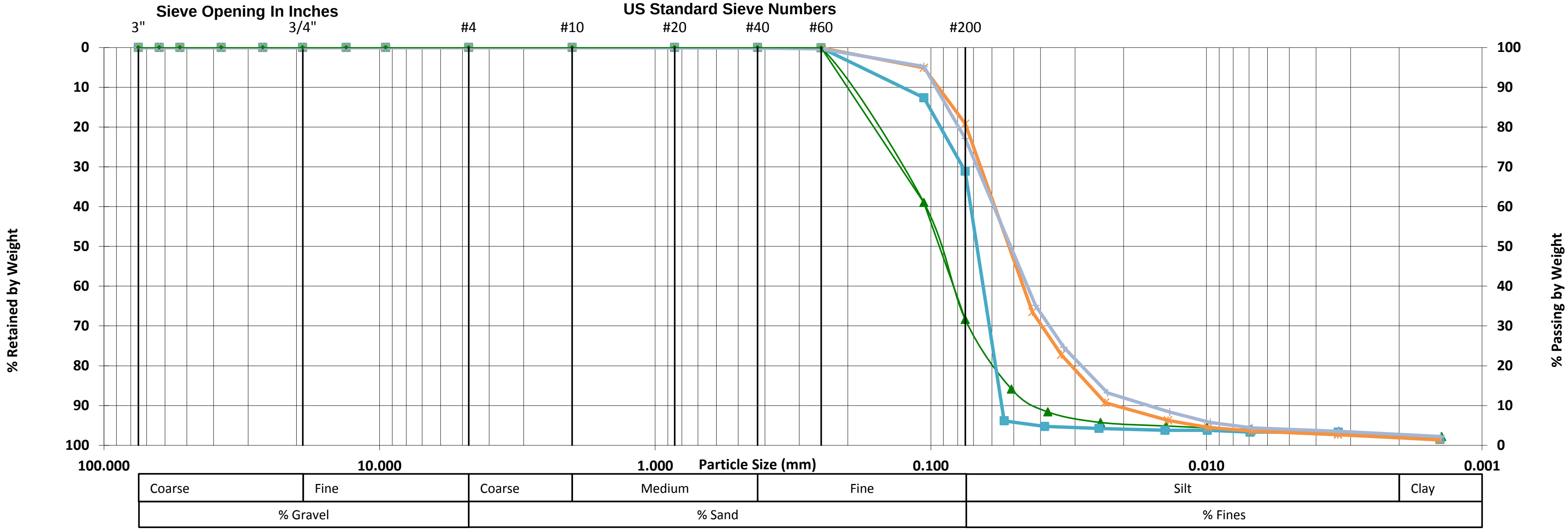
Particle Size Distribution Analysis Test Results

PROJECT NAME: Proposed Industrial Subdivision
CLIENT: 10919 Longwoods Road Inc.
LOCATION: 10919 Longwoods Road, Municipality of Middlesex Centre, ON

DATE SAMPLED: Mar. 20, 2019
DATE TESTED: Mar. 22-26, 2019

FILE No.: 45013-300
TABLE #: 1

Unified Soil Classification



Symbol	Borehole ID	Sample #	*Sample Depth*	Description
▲ (green)	MW101-19	SS-2	0.76-1.37 mbgs	Silty SAND, trace Clay
■ (blue)	MW102-19	SS-2	0.76-1.37 mbgs	Sandy SILT, trace Clay
✳ (orange)	MW102-19	SS-6	4.57-5.18 mbgs	SILT, some Sand, trace Clay
+ (grey)	MW103-19	SS-6	4.57-5.03 mbgs	Sandy SILT, trace Clay

CERTIFIED BY CCIL
Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

NOTES:

MTE Consultants Inc.
365 Home Street
Stratford, Ontario N5A 2A5
Phone: 519-271-7952
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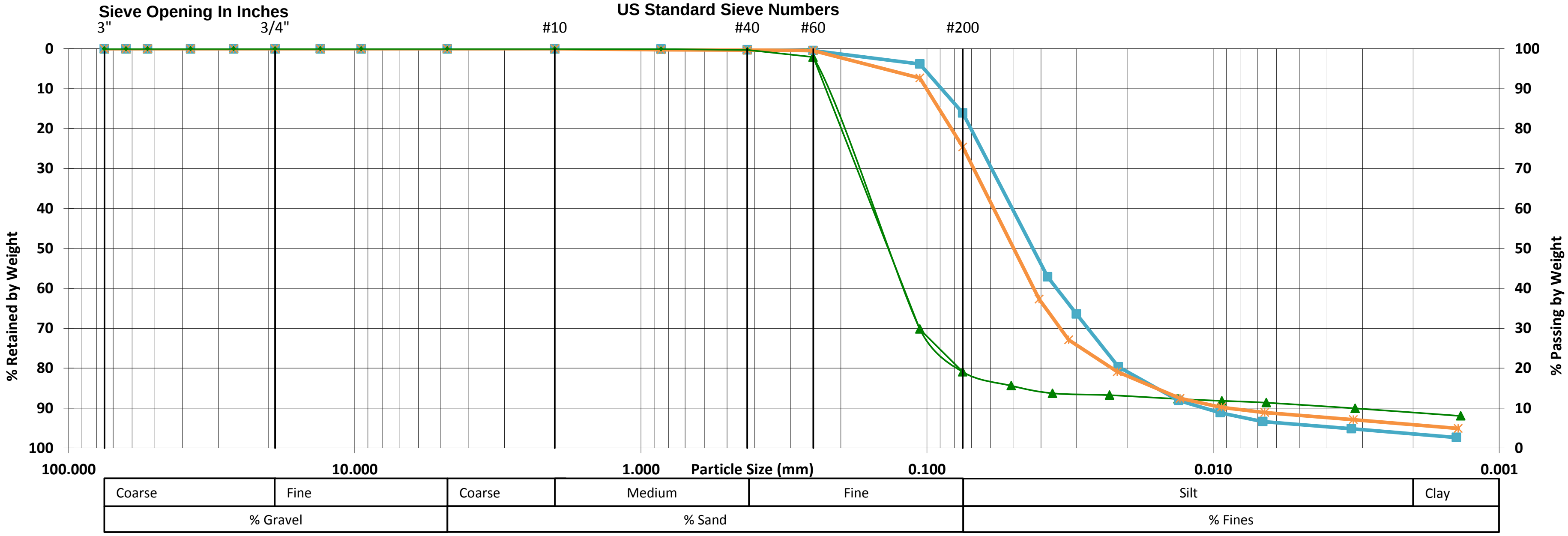
Particle Size Distribution Analysis Test Results

PROJECT NAME:	Proposed Industrial Subdivision	DATE SAMPLED:	Mar. 20, 2019	FILE No.:	45013-300
CLIENT:	10919 Longwoods Road Inc.	DATE TESTED:	Mar. 22-26, 2019	TABLE #:	2
LOCATION:	10919 Longwoods Road, Municipality of Middlesex Centre, ON				

Unified Soil Classification



Symbol	Borehole ID	Sample #	*Sample Depth*	Description
▲	MW104-19	SS-2	0.76-1.37 mbgs	SAND, some Silt, trace Clay
■	MW105-19	SS-6	4.57-5.03 mbgs	SILT, some Sand, trace Clay
✳	BH108-19	SS-2	0.76-1.37 mbgs	Sandy SILT, trace Clay

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Phone: 519-271-7952
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Table 1: Summary of Manually Measured Groundwater Levels

Monitoring Well	Ground Elevation (m AMSL)	Top of Pipe Elevation (m MASL)	Groundwater Elevation (m AMSL)						
			2019-03-26	2019-07-22	2019-09-13	2019-10-04	2020-12-10	2021-01-12	2021-02-16
MW101-19	235.03	235.90	234.40	234.14	234.09	234.32	234.42	234.43	234.25
MW102-19	235.58	236.49	234.87	234.13	234.16	234.62	234.69	234.59	234.33
MW103-19	235.34	236.21	234.38	234.11	233.90	234.17	234.33	234.33	234.13
MW104-19	236.43	237.14	235.09	234.48	234.10	233.97	234.63	234.93	234.50
MW105-19	234.24	235.09	233.62	233.46	233.36	232.81	233.67	233.63	233.47
MW106-19	235.49	236.38	234.29	233.73	233.80	233.25	234.23	234.23	233.96

NOTES:

1. Refer to Borehole Logs in Geotechnical Report (MTE, 2019) for well construction details.
2. Dates are provided in Standard International (SI) format (i.e., yyyy-mm-dd).
3. Elevations are provided in metres (m) above mean sea level (AMSL).
4. "-" Indicates no measurement or not applicable.
5. MW102-19 was noted to have been damaged and was inaccessible during and following the August 2023 monitoring event.

Table 1: Summary of Manually Measured Groundwater Levels

Monitoring Well	Ground Elevation (m AMSL)	Top of Pipe Elevation (m MASL)	Groundwater Elevation (m AMSL)						
			2021-03-18	2021-04-13	2021-05-10	2021-06-08	2021-07-15	2021-08-13	2021-09-14
MW101-19	235.03	235.90	234.45	234.56	234.27	233.88	234.20	234.31	234.16
MW102-19	235.58	236.49	234.55	234.62	234.39	233.76	234.39	234.39	234.00
MW103-19	235.34	236.21	234.33	234.39	234.20	233.96	234.17	234.18	233.93
MW104-19	236.43	237.14	234.91	234.82	234.57	234.24	234.52	234.23	233.93
MW105-19	234.24	235.09	233.63	233.60	233.52	233.29	233.63	233.48	233.21
MW106-19	235.49	236.38	234.20	234.13	234.00	233.64	234.01	233.89	233.54

NOTES:

1. Refer to Borehole Logs in Geotechnical Report (MTE, 2019) for well construction details.
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Table 1: Summary of Manually Measured Groundwater Levels

Monitoring Well	Ground Elevation (m AMSL)	Top of Pipe Elevation (m MASL)	Groundwater Elevation (m AMSL)						
			2021-10-15	2021-11-22	2021-12-22	2022-01-25	2022-02-24	2022-03-23	2022-05-02
MW101-19	235.03	235.90	234.47	234.59	234.47	234.31	234.72	234.79	234.73
MW102-19	235.58	236.49	234.53	234.75	234.76	234.33	235.00	234.84	234.78
MW103-19	235.34	236.21	234.32	234.39	234.34	234.14	234.40	234.46	234.42
MW104-19	236.43	237.14	234.77	234.97	235.04	234.65	234.72	234.87	235.02
MW105-19	234.24	235.09	233.63	233.67	233.64	233.47	233.91	233.72	233.67
MW106-19	235.49	236.38	234.18	234.29	234.29	233.99	234.43	234.28	234.28

NOTES:

1. Refer to Borehole Logs in Geotechnical Report (MTE, 2019) for well construction details.
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Table 1: Summary of Manually Measured Groundwater Levels

Monitoring Well	Ground Elevation (m AMSL)	Top of Pipe Elevation (m MASL)	Groundwater Elevation (m AMSL)						
			2022-05-31	2022-06-27	2022-07-27	2022-08-24	2022-09-26	2022-10-31	2022-11-22
MW101-19	235.03	235.90	234.05	233.77	233.56	233.53	233.35	233.36	233.53
MW102-19	235.58	236.49	234.59	233.72	233.34	233.28	233.05	233.09	233.13
MW103-19	235.34	236.21	234.03	233.75	233.38	233.29	233.12	233.25	233.31
MW104-19	236.43	237.14	234.56	234.17	233.65	233.48	233.28	233.08	-
MW105-19	234.24	235.09	233.37	-	232.66	232.44	232.22	232.27	232.30
MW106-19	235.49	236.38	233.85	233.46	232.90	232.86	232.63	232.68	232.77

NOTES:

1. Refer to Borehole Logs in Geotechnical Report (MTE, 2019) for well construction details.
2. Dates are provided in Standard International (SI) format (i.e., yyyy-mm-dd).
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Table 1: Summary of Manually Measured Groundwater Levels

Monitoring Well	Ground Elevation (m AMSL)	Top of Pipe Elevation (m MASL)	Groundwater Elevation (m AMSL)						
			2022-12-12	2023-01-20	2023-02-16	2023-03-08	2023-04-18	2023-05-18	2023-06-16
MW101-19	235.03	235.90	233.89	233.83	233.89	234.47	234.33	233.54	233.64
MW102-19	235.58	236.49	233.25	234.07	234.12	234.91	234.65	234.96	234.51
MW103-19	235.34	236.21	233.67	233.96	234.04	234.43	234.40	233.78	233.76
MW104-19	236.43	237.14	234.96	233.62	233.63	234.44	234.44	235.47	235.25
MW105-19	234.24	235.09	232.65	233.15	233.13	233.66	233.65	232.79	232.72
MW106-19	235.49	236.38	233.29	233.60	233.80	234.32	234.22	234.29	234.15

NOTES:

1. Refer to Borehole Logs in Geotechnical Report (MTE, 2019) for well construction details.
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Table 1: Summary of Manually Measured Groundwater Levels

Monitoring Well	Ground Elevation (m AMSL)	Top of Pipe Elevation (m MASL)	Groundwater Elevation (m AMSL)		
			2023-07-12	2023-08-17	2023-09-27
MW101-19	235.03	235.90	234.07	234.73	233.79
MW102-19	235.58	236.49	234.40	-[5]	-
MW103-19	235.34	236.21	234.07	234.64	233.85
MW104-19	236.43	237.14	235.16	234.82	234.93
MW105-19	234.24	235.09	232.86	233.38	233.19
MW106-19	235.49	236.38	234.51	235.19	234.40

NOTES:

1. Refer to Borehole Logs in Geotechnical Report (MTE, 2019) for well construction details.
2. Dates are provided in Standard International (SI) format (i.e., yyyy-mm-dd).
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