

GEOTECHNICAL INVESTIGATION

153 UNION STREET EAST, WATERLOO

PROJECT No. SC-02525

MARCH 30, 2026

Submitted to:

**SOUTHSIDE CONSTRUCTION
75 BLACKFRIARS STREET
LONDON, ON, N6H 1K8**

Distribution (via email):

Michael Frijia, Vice President



TABLE OF CONTENTS

1. INTRODUCTION	1
1.1 Terms of Reference.....	1
1.2 Background Studies.....	2
2. SITE CHARACTERIZATION	3
2.1 Site Description.....	3
2.2 Review of Geological Mapping	3
2.3 Review of MECP WELL RECORDS.....	4
2.4 Review of Source Water Protection Mapping.....	5
3. SUMMARIZED CONDITIONS.....	5
3.1 Field Program and Laboratory Testing.....	5
3.2 Borehole and Test Pit Findings.....	7
3.3 Soil Permeability	9
3.4 Shallow Groundwater Conditions.....	10
4. GEOTECHNICAL RECOMMENDATIONS.....	12
4.1 Site Preparation	12
4.1.1 Engineered Fill Placement	13
4.1.2 Excess Soil Management Considerations	13
4.2 Excavations and Groundwater Control.....	15
4.2.1 Excavation Support.....	15
4.2.2 Construction Dewatering	16
4.3 Foundation DESIGN.....	17
4.3.1 Soil Bearing Capacity.....	17
4.3.2 Foundations and Shallow Groundwater	19
4.4 Building Construction	19
4.4.1 Concrete Slabs.....	19
4.4.2 Elevator Shafts	20
4.4.3 Lateral Earth Pressures.....	20
4.4.4 Backfill and Perimeter Drainage.....	21
4.4.5 Underground Parking	21
4.4.6 Concrete Recommendations.....	22
4.5 Seismic Design Considerations	23
4.6 Crane Pad Support.....	23
4.7 Site Services.....	23
4.8 Pavement Design	24
4.9 CURBS & SIDEWALKS.....	25
4.10 Geotechnical Inspection and Testing	25
5. STORMWATER DESIGN CONSIDERATIONS	26
6. CLOSING	27



APPENDICES

Appendix A – Drawings

Drawing 1 – Site Features, Aerial Photograph

Drawing 2 – Proposed Development Plans

Drawing 3 – Local Geology – Physiography of Southern Ontario

Drawing 4 – MECP Well Record Location Plan

Drawing 5 – Source Water Protection Mapping

Drawing 6 – Borehole Location Plan

Drawing 7 – Engineered Fill Schematic

Appendix B – Borehole Logs and Lab Results



1. INTRODUCTION

Stonecain Consulting Inc. [Stonecain] has been retained by Southside Group to conduct a Geotechnical Investigation for two multi-storey apartment buildings at 153 Union Street East, in Waterloo. The subject site is located west of the intersection of Webster Street and Union Street, as shown on the aerial plan provided on Drawing 1, in Appendix A. A Key Plan which also shows the site location is provided on Figure 1, below.



It is understood that the development at the site involves the demolition of the existing slab-on-grade building (already completed), and the construction of two multi-Storey apartment buildings. The northerly building (denoted as Building A) is expected to be about 11 storeys in height, and the south building (denoted as Building B) is expected to be 12 storeys. Site parking will be accessed from Union Street East (along the north) and from Roger Street (to the south), with surface parking around the buildings, and a level of underground parking. A concept plan is provided on Drawing 2, in Appendix A.

1.1 TERMS OF REFERENCE

This document has been prepared for the purposes of providing geotechnical comments and recommendations for the design and construction of a proposed apartment building, located at MN 153 Union Street East, in the City of Waterloo.

It is noted that this report relies on soil and shallow groundwater information collected by LDS Consultants Inc. (LDS). LDS ceased operations in September 2024, and the geotechnical project files were transferred to Stonecairn to maintain them with the same supervising engineer, and author of this current report.

This report provides a summary of the borehole findings (documenting soil and groundwater conditions at the site). The report provides geotechnical comments and recommendations for the proposed development, including:

- Site Preparation, including discussion on excess soils which may be generated from onsite excavations, and which may require disposal offsite, in addition to discussing possible regulatory exemptions, under O.Reg. 406/19.
- Temporary excavations, including maximum slope inclinations to provide stable excavation side slopes in accordance with OHSA requirements, excavation support (shoring methods, if required);
- Groundwater Control for construction dewatering, if required;
- Foundation design, including soil bearing capacity, subgrade preparation and allowable settlements, foundation drainage and backfilling, and lateral earth pressures;
- In the event that deep foundation alternatives are recommended, additional discussion can be provided in this regard;
- Concrete slab and basement / in-ground construction;
- Seismic design considerations based on borehole data and published information for soil conditions below the depth of exploration;
- Pavement design, including pavement component thicknesses and recommendations for concrete curbs and sidewalks within the site.

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.

Laboratory testing, where applicable, follows ASTM or CSA Standards.

1.2 BACKGROUND STUDIES

LDS previously completed Phase One and Phase Two Environmental Site Assessment (ESA) Reports for this site, in support of obtaining a Record of Site Condition for the property, as noted below:

- Phase One ESA, 153 Union Street East, Waterloo, prepared by LDS Consultants Inc., project reference GE-00867, dated May 22, 2024.
- Phase Two ESA, 153 Union Street East, Waterloo, prepared by LDS Consultants Inc., project reference GE-00867, dated May 22, 2024.

A preliminary geotechnical report was also prepared by LDS, as noted below:



- Geotechnical Report, 153 Union Street East, Waterloo, prepared by LDS Consultants Inc., project reference GE-00867, dated February 15, 2024.

Pertinent information from these documents has been incorporated into this report, where appropriate.

2. SITE CHARACTERIZATION

2.1 SITE DESCRIPTION

Based on a review of aerial photographs dating from 2005 to current, the north half of the site previously contained a commercial building, which fronted on Union Street East, with associated paved parking areas to the north, east and south of the building, while the south half of the site has generally remained vacant, with a mixture of small to medium sized trees.

The commercial building has been demolished. Remnants of a former asphalt driveway extends from the building area towards the southeast limits of the site, towards Roger Street. Site topography was observed to gently slope towards the south-southwest, towards the Canadian National Railway Corridor railway and Roger Street.

There are no significant natural heritage features (woodlots or wetlands) or surface water features within the site limits. The site is bordered by Roger Street and a railway corridor to the south, commercial developments to the west and east, and Union Street to the north.

2.2 REVIEW OF GEOLOGICAL MAPPING

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

Physiography & Quaternary Geology

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 northeasterly limits of the Physiographic Region known as the Waterloo Hills, and is characterized by glacial kame moraines. As such, the subgrade soils are generally expected to be predominantly comprised of sand and gravel, with minor silt, clay and till soils.

Quaternary geology mapping for the Waterloo area (Quaternary Geology, Ontario Geological Survey Map, 1993, Stratford Area, Scale 1:50,000) indicates that the study area predominantly consists of ice-contact deposits, comprised of fine to coarse grained sand, and/or gravel, from the Late Wisconsin glaciation period. An excerpt from the aforementioned mapping is provided on Drawing 3, 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 sandstone, shale, dolostone, and/or siltstone of the Guelph Formation, from the Silurian Period. Geological publications and well records in the area indicate that the bedrock surface is below 251-253 m of overburden soils in the vicinity of the site. Bedrock was not encountered during the fieldwork for this investigation.

2.3 REVIEW OF MECP WELL RECORDS

One water supply well is located west of Second Street, west of the site. The well dates from 1948. It is unclear if that well still exists; however, no well abandonment record is available to confirm if it has been decommissioned. It is anticipated that the well has been decommissioned, since this part of the city is serviced with municipal water. The remaining well records in proximity to the site are recorded as observation wells or test holes, as summarized in the following table.

Table 1 – MECP Well Record Summary

MECP Well ID	Registration Date	Depth, m	Usage	Depth Water Found, m	Static Water Level, m
<i>Observation/Monitoring/Test Wells</i>					
6510730	2006-05-23	24.00	Observation Well	22.00	NR
7156380	2010-11-10	7.80	Test Hole	NR	5.30
7159032	2011-01-17	12.20	Test Hole	NR	NR
7215790	2013-09-18	6.10	Observation Well	NR	NR
7311085	2018-04-11	4.57	Observation Well	NR	NR
7311098	2018-04-11	4.88	Observation Well	NR	NR
7341056	2019-07-12	5.49	Observation Well	2.74	NR
7358193	2020-03-20	19.81	Monitoring and Test Hole	NR	NR
7358194	2020-03-20	21.34	Monitoring and Test Hole	NR	NR
<i>Abandonment Records</i>					
7047455	2007-05-28	24	Abandoned-Other	NR	NR
<i>Type of Well Record not reported</i>					
7267052	NR	NR	Not Recorded	NR	NR
7299470	2017-10-31	NR	Not Recorded	22.20	NR
7310183	2017-03-06	NR	Not Recorded	28.90	19.80

The majority of the observation wells and test holes noted in the well records were advanced to shallow to intermediate depths, with subgrade soils generally described as fill materials overlying natural sandy silt or silty sand soils. Reported shallow groundwater depths in the area, where listed, ranged between 5.3 and 22.0 m below existing grades.

Excerpts of the local well record mapping available through the MECP online interactive mapping portal are provided on Drawing 4, in Appendix A.



2.4 REVIEW OF SOURCE WATER PROTECTION MAPPING

Where proposed developments 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.

MECP Source Water Protection Information has been reviewed to determine whether the site is located in any identified areas of source water concern, as they relate to local groundwater quality (current to January 2026). The property is located within the Grand River Source Protection Area, and the following observations are noted for the site:

- The Property is located in the following designated areas listed in the MECP Source Protection mapping:
 - Wellhead Protection Area C (Score of 6)
 - Wellhead Protection Areas Q1 and Q2 (Stress level - low)
 - Issue Contributing Area for the following contaminants: sodium, chloride and trichloroethylene

The Property is not located within a Significant Groundwater Recharge Area (SGRA) or Highly Vulnerable Aquifer (HVA). Excerpts of the Source Water Protection Mapping for the study area are provided on Drawing 5, in Appendix A

3. SUMMARIZED CONDITIONS

3.1 FIELD PROGRAM AND LABORATORY TESTING

A field program consisting of a total of nine boreholes advanced to depths ranging between 1.4 m (4.5 feet) and 14.2 m (46.5 feet) below existing grades, and three test pits was carried out by LDS in 2023. The boreholes were advanced at the site by a local drilling-contractor and supervised by Stonecain technical staff, using a truck-mounted drill-rig. The boreholes were advanced to a depth of 12.6 m below existing grade (m bgs).

Within the boreholes, Standard Penetration Tests (SPTs) were performed to assess the compactness of the underlying soils and to obtain representative samples. The SPT testing was carried out using a 63.5 kg drop hammer, falling from a height of 0.76 m. During the drilling, the stratigraphy in the boreholes was examined and logged in the field by geotechnical personnel. During collection, all samples were assessed from a visual and olfactory perspective to determine if there were any obvious signs of contamination or environmental impact. No discernible impacts were identified in the collected samples. Natural moisture contents of recovered soil samples were recorded on the borehole logs.



Ground surface elevations at the borehole locations were surveyed using a Trimble R12 GPS rover. The location of the boreholes is summarized below, and illustrated on Drawing 6, in Appendix A. It should be noted that the elevations at the as-drilled borehole locations were not provided by a professional surveyor and should be considered to be approximate. Contractors performing any work referenced to the borehole elevations should confirm the borehole elevations for their work.

Table 2 – Borehole Coordinates (UTM 17T)

Location	Northing, m N	Easting, m E	Ground Surface Elevation, m asl
BH1A/MW	4812344.29	539870.44	333.04
BH1/MW	4812351.63	539864.32	332.88
BH2	4812366.58	539851.32	332.79
BH2A	4812327.34	539816.70	332.00
BH3	4812349.03	539827.84	332.32
BH4/MW	4812380.32	539787.25	332.51
BH5/MW	4812410.26	539814.62	332.72
BH6/MW	4812423.96	539765.87	332.70
BH7	4812457.83	539765.17	332.81
TP1	4812333.24	539818.72	331.98
TP2	4812340.15	539844.61	332.45
TP3	4812376.97	539812.82	332.47

Monitoring wells were installed in five of the boreholes to allow for monitoring the stabilized groundwater level at the site. Wells are comprised of a 50 mm diameter CPVC pipe, with a slotted and filtered screen. Details of monitoring well construction are provided on the attached borehole logs. The screens on each well are mill-slotted, with a slot spacing of 0.5 mm, and were backfilled with Type 2 Silica Sand. Above the screened depth, the annular space was backfilled with a bentonite slurry, up to ground surface. The wells have been equipped with lockable caps. The monitoring wells have been registered with the Ministry of Environment, Conservation, and Parks (MECP), in accordance with Ontario Regulation (O.Reg.) 903.

The following table summarizes the well construction details.

Table 3: Monitoring Well Summary

Borehole	Ground Surface Elevation, m asl	Well Installation Depth, m bgs	Screened Length, m	Screened Strata
BH1A/MW	333.03	13.72	3.05	Silty Sand
BH1/MW	332.88	4.57	1.52	Silty Sand and Sandy Silt
BH4/MW	332.51	4.57	3.05	Fine to Medium Sand, and Silty Sand
BH5/MW	332.72	3.05	1.52	Silty Sand
BH6/MW	332.70	4.57	3.05	Fine to Medium Sand, and Silty Sand



The depth to groundwater seepage and short-term water level measurements were obtained prior to backfilling the test pits and boreholes. The test pits were backfilled with the excavated material, and recompacted with the bucket of the excavator. Boreholes were backfilled with a mixture of bentonite chips and cuttings, to restore holes back to level conditions with the ground surface. A photographic log of the open test pit conditions is appended, for reference.

Three (3) grain size analyses were carried out on select soil samples, where perched groundwater conditions were identified. Routine moisture content determinations were carried out on select samples and results are presented on the borehole logs and test pit summary provided in Appendix B.

3.2 BOREHOLE AND TEST PIT FINDINGS

A series of nine boreholes and three test pits were advanced at the site to examine soil and shallow groundwater conditions. The borehole locations are shown on Drawing 6, appended. In general, the soils encountered throughout this investigation consisted of fill overlying interlayered deposits of natural sand and silt. Descriptions of subsurface conditions are summarized in the following sections. A detailed test pit summary and borehole logs are provided in Appendix B, for reference.

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.

Existing Pavement Structure

Each borehole, with the exception of Borehole BH1A, BH2A, BH3, and Test Pit TP3 was surfaced with a layer of asphaltic concrete ranging in thickness from 25 mm to 60 mm. The asphalt is underlain by granular base material ranging in thicknesses from 50 mm and 120 mm respectively. The pavement component thicknesses are summarized in Table 3, below:

Table 4 – Existing Pavement Structure

Borehole	Asphalt Thickness (mm)	Granular Base Thickness (mm)
BH1/MW	25	100
BH2	50	50
BH4/MW	50	50
BH5/MW	60	100
BH6/MW	50	80
BH7	50	120
TP3	50	100

Topsoil

Borehole BH3 and Test Pits TP1 and TP2 were surfaced with a layer of topsoil. The topsoil consisted of dark brown silty loam, with a reported thickness ranging between 50 to 100 mm. The topsoil was in a damp to moist state at the time of the fieldwork, based on visual and tactile examination.



Fill

A layer of fill was encountered below the pavement structure in each borehole, with the exception of Borehole BH7, and extended to depths ranging between 0.3 and 1.7m. The predominant fill material generally consisted of recompacted brown silty sand with trace to some topsoil inclusions. Furthermore, a buried topsoil layer was encountered at the base of the silty sand fill in Boreholes BH1 and BH2, and Test Pits TP1 and TP2, and ranged in thickness between 0.2 and 0.5m. A second layer of fill was encountered in Borehole BH1, and consisted of dark brown clayey silt, with trace gravel. The fill is in a loose to compact state, based on Standard Penetration Test (SPT) N-values which are typically in the range of 4 to 17 blows per 0.3 m of split-spoon sampler penetration. Moisture content determinations conducted on recovered samples of the fill generally range between 3.0 to 12.0 percent, generally indicative of damp to moist soil conditions.

It should be noted that topsoil/fill quantities noted above are based on information provided at the borehole locations only, and may vary in areas with existing vegetation and tree cover. If required, a more detailed analysis (involving additional shallow test pits) is recommended to accurately quantify the amount of topsoil/fill to be removed for construction purposes.

Sand/Silty Sand

A layer of natural sand was encountered underlying the fill material in each borehole and test pit. Each borehole and test pit, with the exception of Boreholes BH1 and BH6, terminated within this layer. The sand was generally described as being brown in colour and stratified, with a fine- to medium-grained texture, with a noted variation in silt content across the site. A sample of the sand layer was submitted for gradation analysis, and the following table shows the grain size distribution. The results are also shown graphically in Appendix B.

Table 5 – Gradation Summary, Silty Sand

Sample ID	Unified Soil Classification			
	% Silt	% Sand	% Gravel	% Cobbles
BH4, Sample 5 – 3.0 m depth	32.9	67.1	0.0	0.0

Note: Particle size determination in accordance with the Unified Soil Classification System

The sand is in a variable loose to compact state, based on SPT N-values in the range of 4 to 30 blows per 0.3 m of split-spoon sampler penetration. Dense (SPT N-value > 30 blows) soil conditions were encountered within the sand layer in boreholes BH2A and BH7 at depths ranging between 1.1 and 4.0 m below ground surface. Very dense (SPT N-value > 50 blows) soil conditions were encountered within the sand layer in borehole BH1 at a depth of 6.0 m below ground surface. Moisture content determinations conducted on recovered samples of the sand range between 6.6 and 16.7 percent above the stabilized groundwater elevation, and on the order of 17.0 to 22.0 percent below the stabilized groundwater level.

Sandy Silt/Clayey Silt



A layer of sandy silt was encountered within the sand layer in Boreholes BH1, BH2 BH5 and BH6, and Borehole BH1 terminated within this layer. The silt was generally described as brown to grey in colour. Several moist to very moist sand seams (~50 to 150 mm thickness) were encountered at variable depths within the sand layer across the entire site. A layer of clayey silt was encountered at the base of the sandy silt in Boreholes BH5 and BH6, and Borehole BH6 terminated within this layer. Two samples of the sandy silt were submitted for gradation analysis, and the following table shows the grain size distribution. The results are also shown graphically in Appendix B.

Table 6 – Gradation Summary, Sandy Silt

Sample ID	Unified Soil Classification			
	% Silt	% Sand	% Gravel	% Cobbles
BH5, Sample 4 – 2.2 m depth	61.9	38.1	0.0	0.0
BH6, Sample 5 – 3.0 m depth	69.5	30.4	0.1	0.0

Note: Particle size determination in accordance with the Unified Soil Classification System

The sandy silt is in a compact state, based on SPT N-values in the range of 15 to 25 blows per 0.3 m of split-spoon sampler penetration. Moisture content determinations conducted on recovered samples of the silt range between 10.3 and 14.3 percent above the stabilized groundwater elevation, and on the order of 15.6 to 21.0 percent below the stabilized groundwater level.

3.3 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.

Based on the gradation results presented in Section 3.2, the following value for saturated hydraulic conductivity have been determined for the predominantly sandy soils encountered across the site. Hazen's method was used to correlate the grain size analysis to the hydraulic conductivity of the silty sand and sandy silt soils. This correlation is based on the following relationship:

$$k \text{ (cm/s)} = C(d_{10})^2$$

where, d_{10} is the diameter (size measured in mm) at which 10% of the sample passes; and,
C is an empirical coefficient (average value of 1.0).



Table 7 – Hydraulic Conductivity and Factored Infiltration Rates from Grain Size Analyses

Sample ID	Sample Composition			Parameter		
	% Fines	% Sand	% Gravel	D ₁₀ (mm)	Saturated Hydraulic Conductivity (m/sec)	Factored Infiltration Rate (mm/hr)
Silty Sand						
BH4, Sample 5 – 3.0 m depth	32.9	67.1	0.0	0.05 5	3.03 x10 ⁻⁵	46
Sandy Silt						
BH5, Sample 4 – 2.2 m depth	61.9	38.1	0.0	0.013	1.69 x10 ⁻⁶	21
BH6, Sample 5 – 3.0 m depth	69.5	30.4	0.1	0.018	3.24 x10 ⁻⁶	25

The natural water-bearing silty sand and sandy silt soils have a saturated hydraulic conductivity in the range of 10⁻⁵ to 10⁻⁶ m/s, based on the results presented above.

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, in accordance with TRCA/CVC Low Impact Development Stormwater Management Planning and Design Guide protocol.

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.

3.4 SHALLOW GROUNDWATER CONDITIONS

Shallow groundwater was not encountered within the open test pits.

Stabilized water level measurements were recorded in the monitoring wells installed across the site from April 2023 through to June 2024, and are summarized in the following table.



Table 8 – Stabilized Groundwater Observations

Location	Ground Surface Elev. (m)	Depth to Groundwater (m, bgs) Groundwater Elevation (m, asl)									
		24-Apr-23	12-May-23	29-Jun-23	14-Jul-23	17-Aug-23	20-Sep-23	16-Feb-24	27-Mar-24	22-Apr-24	18-Jun-24
BH1A/MW	330.03	13.50 316.53	13.51 316.52	13.21 316.82	13.21 316.82	13.35 316.68	12.88 317.15	12.31 317.72	12.15 317.88	11.99 318.04	12.65 317.38
BH4/MW	332.91	3.12 329.39	3.08 329.43	3.24 329.27	2.69 329.82	3.33 329.18	3.26 329.25	Snow covered	3.70 329.21	4.64 328.27	Dry
BH5/MW	332.72	1.89 330.83	1.86 330.86	2.16 330.56	1.24 331.49	3.02 329.70	2.38 330.34	Snow covered	3.20 329.31	3.14 329.37	4.27 328.24
BH6/MW	332.70	2.65 330.05	2.53 330.17	2.36 330.34	2.50 330.21	2.88 329.82	2.59 330.11	Snow covered	2.00 330.72	1.83 330.89	3.00 329.72

Shallow groundwater is present within the near-surface sandy soils. 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.

Wells have been registered with MECP and may be used for further stabilized water level measurements and/or water quality sampling, as needed.



4. GEOTECHNICAL RECOMMENDATIONS

The following geotechnical comments and recommendations are provided to assist in the design of the new multi-storey apartment buildings. The following sections of this report provide geotechnical comments and recommendations for the proposed developments, including: site preparation (including the re-use of excavated materials as engineered fill, structural fill, and guidance for engineered fill placement), excavations and excavation support (including maximum slope inclinations to provide stable excavation side slopes in accordance with OHSA requirements, shoring methods, if required, and lateral earth pressures), groundwater control, foundation design (including soil bearing capacity, subgrade preparation, and potential settlements) and additional site characterization work, concrete slab and basement/underground construction (including modulus of subgrade reaction), seismic design considerations, site servicing (including the re-use of onsite soils in service trenches, pipe bedding, and trench backfill), pavement design (including pavement component thicknesses for parking lot and access roads), and excess soil management discussion.

4.1 SITE PREPARATION

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 south half of the area to be developed. Some localized restoration and subgrade improvement is also anticipated in the former building area, where demolition has already occurred. Private water supply and septic systems are not expected to be encountered at the site.

It should be noted that the boreholes were located away from the demolished building and site services. If existing services are encountered during the site preparation work, they may need to be removed or rerouted, as appropriate, particularly if they are located within future building footprint areas. Fill material associated with trench backfill may require site review by the geotechnical consultant to determine its suitability to remain in place, depending on the final site design.

Exposed subgrade soils which have been disturbed during the building demolition should be inspected by a geotechnical engineer, and thoroughly recompact to ensure that uniform subgrade conditions are available to support future building foundations and structures.

Where existing site pavements are also removed, consideration may be given to pulverizing and stockpiling this material for re-use in the new site pavements which are planned within the development limits. Temporary offsite storage may be required, based on limited space available for staging and stockpiling materials. Coordination with a Qualified Person (QP) is recommended to ensure that regulatory Excess Soil Requirements are satisfied.

Foundations for the new buildings should be set on competent subgrade soils. In the event that unstable or otherwise unsuitable subgrade soils are encountered in the future building footprints, they should be removed, and the area restored with engineered fill.



4.1.1 Engineered Fill Placement

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. A typical engineered fill detail is provided on Drawing 7, appended.

The existing fill material encountered in the boreholes and test pits is not considered suitable for re-use as engineered fill, due to the presence of mixed topsoil and organics. This is also applicable to fill material which may be encountered elsewhere onsite, where mixed topsoil and organic material is present, and is not deemed practical to separate during construction.

The existing natural subgrade soils, comprised of sand and silt, 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.

The exposed subgrade should be thoroughly proof-rolled and inspected by geotechnical field staff from Stonecairn. Any loose or soft zones noted during the inspection should be sub excavated and replaced with approved fill.

In the event that construction is required during freezing temperatures, the subgrade should be protected immediately from freezing using straw, propane heaters and insulated tarpaulins, or other suitable means.

4.1.2 Excess Soil 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 (December 2022), and the regulation is now fully implemented. 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.

Since a Record of Site Condition has been filed for the property, the site is considered to be exempt from the full regulatory requirements for planning documents noted above. In addition, the environmental sampling and testing (and associated reporting) may also replace some of the aforementioned planning documents. Stonecairn can provide further guidance with regards to current Excess Soil requirements which are applicable for the site when construction activities commence.

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 property use (or better) is generally considered appropriate for this site.



4.2 EXCAVATIONS AND GROUNDWATER CONTROL

All work associated with design and construction relative to excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). Based on the results of the geotechnical investigation and in accordance with Section 226 of Ontario Regulation 213/91, the following soil classifications are identified for the site:

- The compact silt encountered in the boreholes is generally classified as Type 2 soil. For excavations which extend through or terminate in Type 2 soil, temporary excavation side slopes must be cut near vertical in the bottom 1.2 m, and sloped back at an inclination of 1H:1V above that level.
- The natural sand and silty sand soils are generally classified as Type 3 soil above the stabilized water table, or where soils have been suitably dewatered. 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 cut into the wet sandy soils may exhibit Type 4 Soil characteristics, with significant sloughing below the groundwater level. For excavations which extend through or terminate in the wet sand, temporary excavation side slopes should be cut back at a maximum inclination of 3H:1V from the base of the excavation.

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 site servicing 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 9 – Soil Parameters for Excavation Support

Soil	ϕ	γ (kN/m ³)	K_a	K_o	K_p
Compact Sandy Silt and Silty Sand	30	19.5	0.33	0.50	3.15
Compact Silt Till & Clayey Silt	28	18.5	0.36	0.53	2.78
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 Construction Dewatering

Prior to commencing excavations, it is recommended that potential surface water is controlled and diverted away from the work area. Conventional groundwater control methods are expected to be suitable for excavations at the site, to address surface water infiltration and minor shallow perched groundwater seepage. Based on the results of the investigation, perched shallow groundwater (where present) is located approximately 1.9 to 3.3 m below existing ground surface.

Where excavations extend into the perched groundwater table, or where groundwater levels are elevated, positive groundwater control methods may need to be utilized for construction dewatering. Soil permeability values in the natural sandy subgrade soils are expected to be in the range of 10^{-5} to 10^{-6} m/s, based on laboratory and field testing (presented in Section 3.3). This information is provided to assist with determining appropriate construction dewatering methods.

Groundwater control measures at the site should help to maintain stable excavated slopes; reduce saturated soil conditions to allow for possible reuse of excavated material; and provide a dry and stable base for excavations and construction operations. Consideration may be given to staging excavations and limited excavation sizes which are open to full design depth to help reduce the amount of groundwater control and active pumping which may be required.

Pumped groundwater will need to be directed to an appropriate outlet. If municipal stormwater infrastructure is planned as a receiver for construction dewatering effluent, the contractor will need to have regard for local Sewer Use By-Laws, to ensure that suitable testing is carried out to verify that water quality meets the municipal standards, and may need to consider additional filtration measures (such as a siltation tank or other treatment measures) to achieve a suitable water quality, prior to discharging to local storm or sanitary sewers. Municipal approvals may be required in this regard.

Due to the anticipated presence of shallow perched groundwater conditions which may be encountered on a seasonal basis, consideration should be given to having an Environmental Activity



and Sector Registry (EASR) submission in support of the construction dewatering activities during construction. This allows for water taking volumes in excess of 50,000 L/day.

Some of the factors which directly contribute to the volume of construction dewatering expected at the site includes the following:

- Localized variations in soil conditions;
- Seasonal influences on stabilized water table;
- Design depth for excavations;
- Length and staging to advance continuous open-cut excavations (i.e.: excavations for site servicing); and,
- Methodology and experience of the contractor.

For construction dewatering requiring an EASR, a construction dewatering plan and discharge plan will be required to estimate the quantity of water to be removed. The dewatering plan should also include calculations for the zone of influence, identify potential impacts to existing structures, and identify potential qualitative and quantitative impacts to nearby properties which rely on the shallow groundwater table as a potable water source. Details regarding volume monitoring, water quality analyses and method / location of discharge water will also be required.

4.3 FOUNDATION DESIGN

4.3.1 Soil Bearing Capacity

Soil bearing values for foundations set on the compact to dense natural subgrade or approved engineered fill at conventional depths is noted below:

- SLS Soil Bearing - 175 kPa
- ULS Soil Bearing – 250 kPa

The buried topsoil layer encountered within the near surface fill soils is not considered suitable to support the proposed site structures without the risk of settlement. If organic material is encountered within the building footprint, it must be removed entirely and excavations should be restored in accordance with the engineered fill recommendations identified in Section 4.1.1.

It should be noted that loose soil conditions may be anticipated within the weathered zone and near surface silty sand. Re-compaction and a thorough proof-roll of the subgrade soils will be required to ensure that loose soils are recompacted, and to ensure that uniform soil bearing is available in the exposed subgrade soils. Site review to confirm the condition of the subgrade soils at the proposed footing base level is required by the geotechnical consultant at the time of excavation.

Below 4.0 m depth, higher soil bearing capacities are available on the dense subgrade soils. If higher soil bearing is desired, additional boreholes are recommended within the proposed building footprint to confirm depth to higher bearing zones, or to provide additional recommendations for deeper foundation alternatives.



Site review to confirm the condition of the subgrade soils at the footing base level should be undertaken by the geotechnical engineer at the time of excavation.

In the event that construction is undertaken during winter months, exposed subgrade soils should be protected from freezing. If the subgrade was impacted by frost, subgrade soils should be completely thawed, and inspected prior to placing concrete.

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 geotechnical consultant is recommended to confirm soil conditions and verify soil bearing capacity.



4.3.2 Foundations and Shallow Groundwater

A review of the Site grading should be conducted to confirm that building foundations will be set above the stabilized groundwater level. If this can be confirmed, no special water-proofing measures are required. Foundations should be provided with damp-proofing and foundation drainage tiles, in accordance with standard Ontario Building Code (OBC) requirements.

Shallow groundwater may be present at/near the design underside of footing elevation, where wet soils are present. The addition of subfloor drains, connected to the sump pump may be advised. Site review by the geotechnical consultant can assist in this regard. Consideration may be given to enhanced damp-proofing measures (such as subfloor drains), where there is reasonable concern that in-ground levels may conflict with the high groundwater level on an intermittent basis.

Where in-ground levels are expected to extend below the stabilized groundwater level, waterproofing will be required, and the effects of buoyancy will need to be considered within the design. When buildings are designed with water-tight foundations, care should be taken in the design and installation of the water-proofing measures to avoid moisture problems, or actual water seepage through any normal shrinkage cracks which may develop in the concrete walls, floor slabs, foundations and/or construction joints.

Care will be required during the installation of the water-proofing membrane to ensure that it is not cut or otherwise damaged during installation, during the construction of the raft slab foundation, or during the construction of the building foundations and backfilling activities.

Where penetrations through the water-proofing membranes do occur to accommodate pipes or pits, the penetration areas will need to be properly sealed, to provide a continuous extension of the water-tight measures through the base of the excavation, and adjacent to the foundation sidewalls.

Inspection of the water-proofing installation is recommended.

4.4 BUILDING CONSTRUCTION

4.4.1 Concrete Slabs

In preparation for the construction of the floor slab, all unstable 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.

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 subgrades below the floor slabs 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 $\frac{1}{4}$ of the slab thickness. The use of super plasticizers should be considered to reduce shrinkage and increase workability of the concrete.

4.4.2 Elevator Shafts

Based on the available soil conditions, the following general comments are provided regarding the excavation of elevator shafts:

- Shaft design may consider the use of drilled shafts to limit the extent of open cut excavation below the lowest floor slab level.
- If drilled shafts are utilized, sufficient liners should be provided by the contractor to prevent loss of ground. The liners should be advanced before the auger and removal of any materials.
- If open cut excavations are utilized, excavation support may be required to limit excavation size and amount of disturbed soil around the pit location.

Elevator pits are expected to extend below the lowest parking level. Water proofing may be required depending on the design depth. At a minimum, it is anticipated that elevator pits or shafts will be designed as water-tight structures. Once elevator shaft locations and details are known, additional comments and recommendations may be provided to supplement the information available in this report.

4.4.3 Lateral Earth Pressures

The portion of exterior basement walls below finished groundwater level should be damp-proofed and designed to resist a horizontal earth pressure 'P' at any depth 'h' below the surface as given by the following expression:

$$P = K [\gamma h + q]$$

where, P = lateral earth pressure in kPa acting at depth h;

γ = natural unit weight of soil, a value of 20.0 kN/m³ may be assumed;

h = depth of point of interest in m;



q = equivalent value of any surcharge on the ground surface in kPa; and,
 K = earth pressure coefficient, assumed to be 0.4

The above expression assumes that the perimeter drainage system prevents build-up of any hydrostatic pressure behind the wall. Below the groundwater table the buoyant unit weight of soil should be used and full hydrostatic water pressure should be added.

The Canadian Foundation manual indicates that assuming good construction practice, lateral wall movements and adjacent vertical settlements are usually about 0.2 percent of the adjacent excavation depth where design is based on an active earth pressure ($k=k_a$) and about 0.1 percent of the adjacent excavation depth where earth pressure.

For water-tight foundations, the earth pressures against the exterior walls will need to account for the buildup of porewater pressures in the adjacent soils. Stabilized seasonal high groundwater levels should be used in the design, to account for permanent conditions at the site at rest ($k=k_o$) is used in design.

4.4.4 Backfill and Perimeter Drainage

In general, the excavated natural soils from the foundation areas should be suitable for re-use as backfill around the building foundations. The materials to be re-used as backfill should be within three percent of optimum moisture content for best compaction results. If inclement weather conditions persist during construction, site review by the geotechnical consultant may be advised to confirm the suitability of onsite soils for reuse.

It is recommended that heavy compaction equipment be restricted within 0.5 m from foundations. Backfill should be brought up evenly on both sides of foundation walls which have not been designed to resist lateral earth pressures. In the event that excavated materials contain topsoil, organics or otherwise unsuitable material, such materials are limited to re-use where settlements can be tolerated. The specified level of compaction for foundation wall backfill will depend on hard or soft landscaping which is planned around the perimeter of the building. Where concrete pads or sidewalks are planned, a minimum 98% SPMDD is recommended for the uppermost 1 m of backfill.

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.

4.4.5 Underground Parking

In the event that underground parking is being considered for one or both of the proposed apartment buildings, the following comments are provided.

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 unheated concrete slabs near the parking lot entrance.

It is recommended that a minimum 200 mm (8 inch) thick compacted layer of 19 mm ($\frac{3}{4}$ inch) clear stone be placed between the prepared subgrade and the floor slab to serve as a moisture barrier.

For concrete slabs, or where slab-on-grade concrete is placed in unheated areas or near the entrances of the garage (if heated), 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. Stonecairn 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.

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

Foundation walls may be subject to groundwater seepage, and as such, it is recommended that suitable damp-proofing and foundation wall drainage be considered in the design of any underground parking structures. It may be prudent to incorporate an exterior vertical drainage system connected to the perimeter drains to reduce the risk of water penetration into the underground portion of the building.

Perimeter weeping tiles should be wrapped with filter fabric, and set in stone to limit the movement of fines into the drain tiles. The drains should be provided with a frost-free outlet from which the water can be removed. It is anticipated that water could be collected in a sump pit located in the lowest level of the building.

4.4.6 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 and equipment foundations should have regard to the above referenced standard, and should be reviewed by the structural engineer for conformance to the 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 (in accordance with CSA A23.1 and project specifications) is recommended. During cold weather, freshly placed concrete should be covered with insulating blankets to protect against freezing.



4.5 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, 2024). The subsoils expected below the buildings will generally consist of sand and silt subgrade soils.

Table 4.1.8.4 -B, Site Classes, S for Site Designation Xs, OBC 2024 indicated that to determine the site classification, the average properties in the top 30 m are to be used. The Site Classification recommendation is based on the available information as well as our interpretation of conditions at and below the boreholes, and based on a review of geological mapping, 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 “D” as per Table 4.1.8.4 -B. 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.

4.6 CRANE PAD SUPPORT

It is anticipated that one or more crane pads will be required to accommodate the construction of the two multi-storey apartment buildings. In this regard, areas which are designated to support the cranes should be identified early in the construction process, to ensure that suitable measures are carried out to prepare and protect the subgrade soils which will support the cranes.

Where the crane supplier does not have a prescribed design for the crane pad design, the following recommendations are provided for general guidance.

- A granular pad is recommended over the approved subgrade soils, to provide adequate support which is less susceptible to disturbance by construction activities onsite.
- The crane pad should be comprised of a minimum 600 mm thick layer of compacted OPSS 1010 Granular B is recommended, surfaced with a 150 mm thick layer of Granular A or recycled asphalt.
- The granular mat should be compacted to a minimum 100 % SPMDD, verified with insitu density testing by the geotechnical consultant.

4.7 SITE SERVICES

Subgrade soils beneath new services are generally expected to consist of silt till. Servicing depths are generally expected to be above the stabilized groundwater level, although minor seepage from stormwater runoff may be anticipated. No bearing problems are anticipated for flexible or rigid pipes founded on natural deposits.



Bedding aggregate should be compacted to a minimum 95 percent SPMDD. Water and sewer 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 silt and silt till. Excavated soils may be used for service trench 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.

A program of in situ density testing should be set up to ensure that satisfactory levels of compaction are achieved.

4.8 PAVEMENT DESIGN

The exposed subgrade soils within the driveway and parking areas are expected to be comprised of silt or silt till. Exposed subgrade soils should be thoroughly proof-rolled and reviewed by the geotechnical consultant. In the event that loose or soft areas are noted, remedial work to remove unstable soils and restore with suitable compactable material may be required. In general terms, subgrade soils supporting site pavements should be compacted to a minimum level of 98 percent SPMDD.

The following pavement design thicknesses are suggested for the site pavements, based on anticipated subgrade conditions and traffic loading.

Table 10: Pavement Design Recommendations

Pavement Component	Pavement Component Thicknesses		Specified Compaction Levels
	Internal Roadway / Surface Parking	Main Access / Trucks	
Asphaltic Concrete	40 mm HL 3 50 mm HL 8	50 mm HL 3 80 mm HL 8	97% BRD
Granular A Base	150 mm	150 mm	100% SPMDD
Granular B Subbase	300 mm	450 mm	100% SPMDD

Where asphalt car parking is located over the underground parking roof deck, a reduced pavement structure is considered appropriate for paving over the structurally designed concrete deck. In this case, the Granular B subbase layer may be removed from the pavement structure, and the Granular A base may be substituted with a nominal layer of sand (75 mm) to allow for fine grading and protection of any water-proofing or damp-proofing measures on the concrete deck, to help minimize damage. Through drains may be required to accommodate stormwater runoff, and may require coordination with the civil consultant and mechanical consultant.

Quality control during construction should include material sampling and laboratory testing. In this regard, samples of both Granular 'A' and Granular 'B' aggregates should be checked for conformance



to OPSS 1010 prior to use on site, as well as achieved compaction levels during placement. Asphalt should be placed in accordance with OPSS 310.

Where the site pavements tie into the streets which border the site, the subgrade beneath new pavement should be tapered to match existing road subgrade to minimize differential frost heaving for the pavement structure

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.

Good drainage provisions will optimize 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. Where sandy subgrade soils are present, there may be opportunity to take advantage of the improved subsurface drainage available in those soils, and the need for pavement subdrains may be waived in those locations.

4.9 CURBS & 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, and 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. Sampling and testing of concrete should be in accordance with OPSS 904.

4.10 GEOTECHNICAL INSPECTION AND TESTING

An effective inspection and testing program is an essential part of construction monitoring. The Inspection and Testing Program may include 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; and, inspection and testing during construction of site pavements. The Municipality may require inspection and testing records for servicing tie-ins to verify that project specifications have been satisfied for site servicing connections and road repairs, if required.



5. STORMWATER DESIGN CONSIDERATIONS

Low Impact Development (LID) 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 following comments are provided for the potential use of source control and conveyance control LID measures, where appropriate.

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 fines 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 analyses conducted on collected samples from the site, the water-bearing soils encountered in the boreholes have a saturated hydraulic conductivity in the range of 10^{-5} to 10^{-6} m/s, with factored infiltration rates ($FS = 2.5$) in the range of 25 to 45 mm/hr.

It is 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.

Field confirmation of soil permeability with percolation testing and confirmation of the effective infiltration rates in the natural or reconstructed subgrade soils will need to be undertaken to confirm soil suitability for the enhanced infiltration-based LID strategies which are considered at the site.



6. CLOSING

The geotechnical recommendations provided in this report are applicable to the project described in the text. The comments given in this report are intended to provide guidance for design engineers. Supplemental boreholes and additional geotechnical and hydrogeological consultation should be anticipated during the detailed design stage, to ensure that suitable information is available to support the detailed design and preparation of engineering drawings.

It is important to note that this 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 Stonecairn be consulted to review the additional information and verify if there are any changes to the geotechnical recommendations.

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

Stonecairn 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.

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.

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,

STONECAIRN CONSULTING INC.



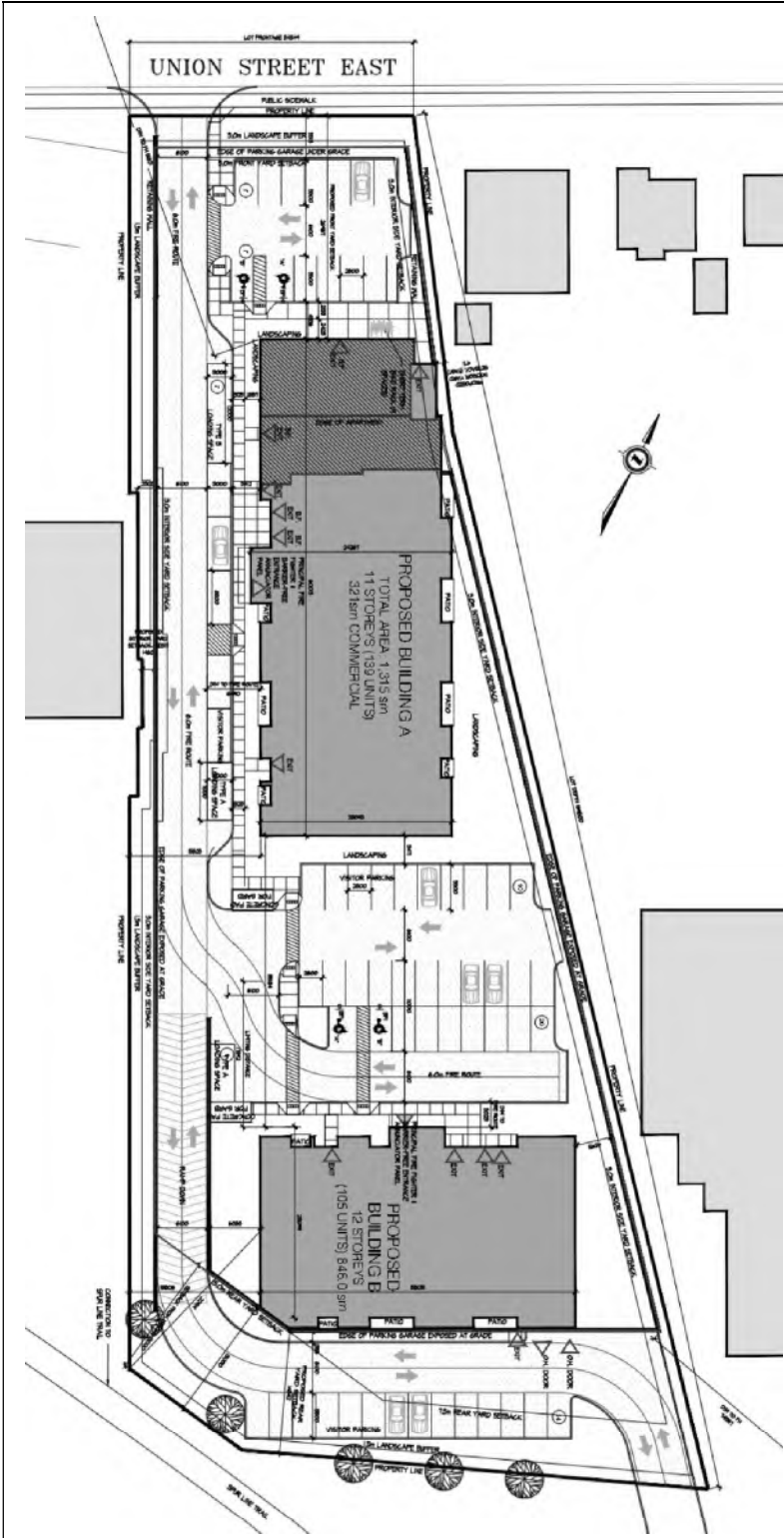
Rebecca Walker, P.Eng.
President, Geotechnical Director
rebecca.walker@stonecairn.ca



APPENDIX A – DRAWINGS



STONECAIRN CONSULTING	DRAWING NAME	DATE	PROJ No.
	Site Features - Aerial Photo, 2024	Mar 2026	GE-02525
	LOCATION	SCALE	DWG No.
	153 Union Street East, Waterloo	NTS	1

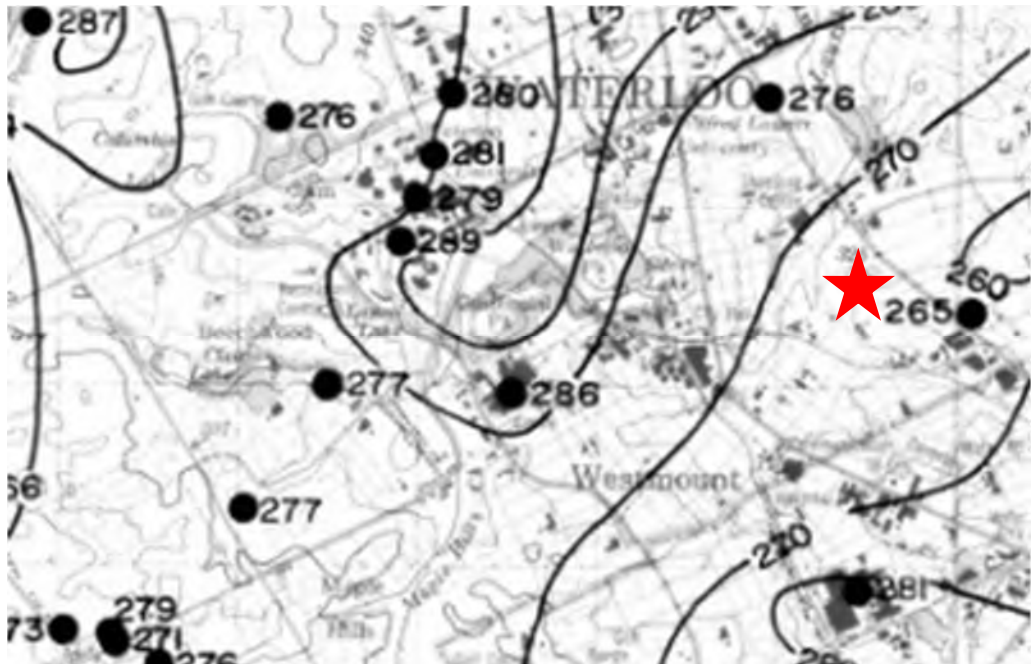


Source: Proposed Site Plan, prepared by Phillip Agar Architect Inc., Sheet A101, Sep 2025

	DRAWING NAME	DATE	PROJ No.
	Proposed Development	Mar 2026	GE-02525
	LOCATION	SCALE	DWG No.
	153 Union Street East, Waterloo	NTS	2



SOURCE: Quaternary Geology, Stratford Area, Ontario Geological Survey Map M2559, Scale 1:50,000, © 1993



SOURCE: Bedrock Topography, Stratford Area, Ontario Geological Survey Map P3211, Scale 1:50,000, © 1993

STONECAIRN
CONSULTING

DRAWING NAME

Local Geology - Physiography of
 Southern Ontario

LOCATION

153 Union Street East, Waterloo

DATE

Mar 2026

SCALE

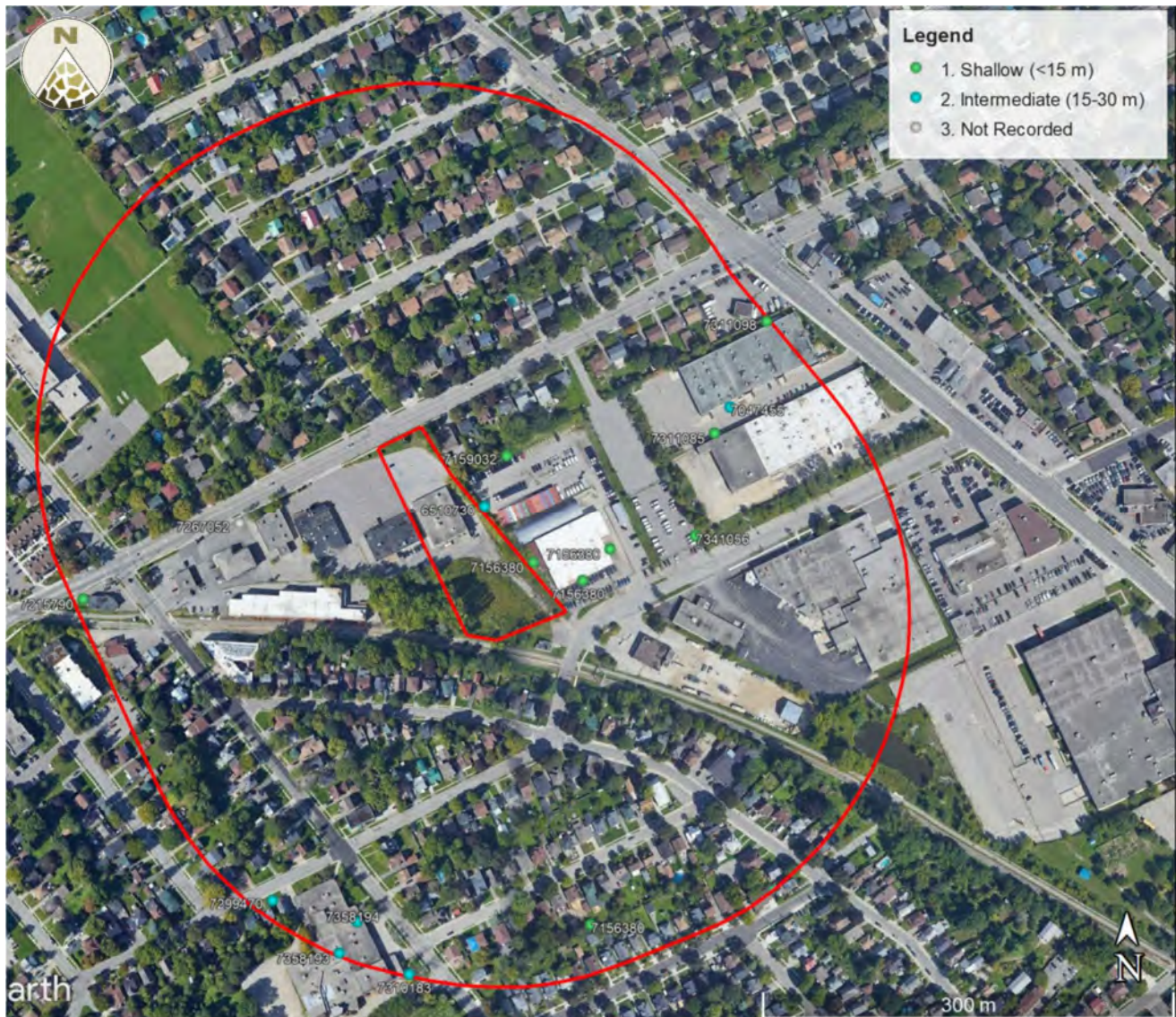
NTS

PROJ No.

GE-02525

DWG No.

3



SOURCE: MECP Well Record Interactive Database, updated January 2024

STONECAIRN
CONSULTING

DRAWING NAME

MECP Well Record Location Plan

DATE

Mar 2026

PROJ No.

GE-02525

LOCATION

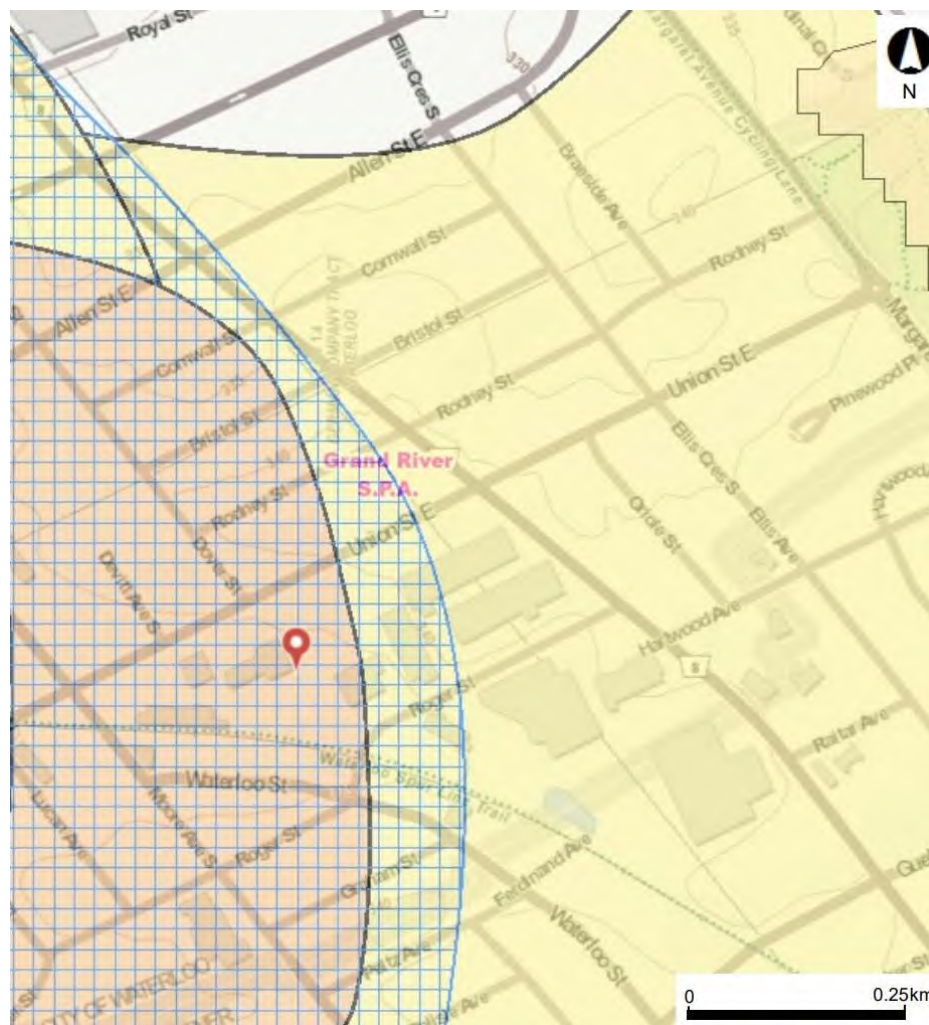
153 Union Street East, Waterloo

SCALE

NTS

DWG No.

4



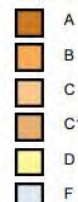
Legend

Significant Groundwater Recharge Area



- Issue Contributing Areas
- Highly Vulnerable Aquifers

Wellhead Protection Area



- Intake Protection Zone 1
- Intake Protection Zone 2
- Source Protection Areas

Latitude: 43.46337 Longitude: -80.50790
 UTM Zone: 17
 Easting: 539807.76 Northing: 4812391.1
 Upper Tier Municipality: **REGIONAL MUNICIPALITY OF WATERLOO**
 Lower Tier Municipality: **CITY OF WATERLOO**
 Township Concession and Lot: **WATERLOO LOT 15 GERMAN COMPANY TRACT**
 Assessment Parcel Address: **153 Union Street East**
 Assessment Roll #: **30160214501010000000**
 MECP District: **Guelph**
 MECP Region: **West Central Region**

Source Protection Details for Location

Source Protection Area: **Grand River**
[View Source Protection Plan](#)
 Wellhead Protection Area: **C**; score is **6**
 Wellhead Protection Area (WHPA-E): **No**
 Issue Contributing Area: **Yes** Contaminant: **Sodium, Chloride, Trichloroethylene**
 Significant Groundwater Recharge Area: **No**
 Highly Vulnerable Aquifer: **No**
 Event Based Area: **No**
 Wellhead Protection Area Q1: **Yes** Stress: **Low**
 Wellhead Protection Area Q2: **Yes** Stress: **Low**
 Intake Protection Zone Q: **No**
 Information is current as of: **January 30, 2026**

Source: MECP Source Water Protection Interactive Mapping, updated January 2026

**STONECAIRN
CONSULTING**

DRAWING NAME

Source Water Protection Mapping

DATE

Mar 2026

PROJ No.

GE-02525

LOCATION

153 Union Street East, Waterloo

SCALE

NTS

DWG No.

5



Source:

Google Earth Pro, Version 7.3.2.5776,
Coordinates 17T, 539844 m E, 4812369 m N,
Imagery date 8/9/2018

**STONECAIRN
CONSULTING**

DRAWING NAME

Borehole Location Plan

DATE

Mar 2026

PROJ No.

GE-02525

LOCATION

153 Union Street East, Waterloo

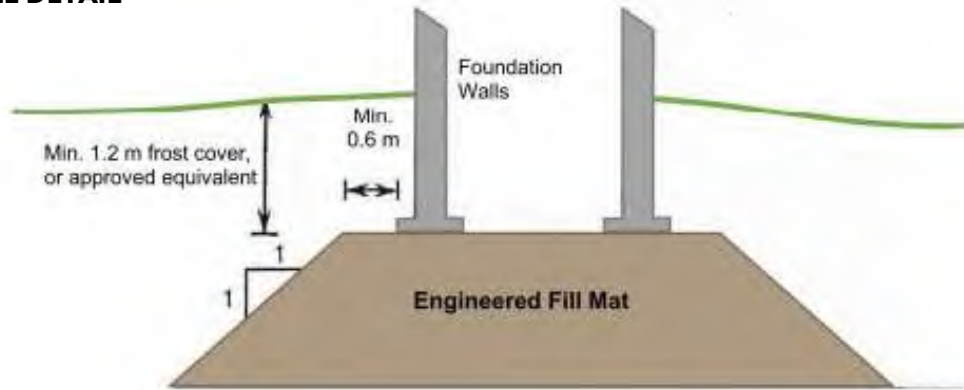
SCALE

NTS

DWG No.

6

ENGINEERED FILL DETAIL



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 175 kPa 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 Stonecain.
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.

STONECAIRN
CONSULTING

DRAWING NAME

Engineered Fill Details

LOCATION

153 Union Street East, Waterloo

DATE

Mar 2026

SCALE

NTS

PROJ No.

GE-02525

DWG No.

7

APPENDIX B – BOREHOLE LOGS & LAB RESULTS

NOTES ON SAMPLE DESCRIPTIONS

- All descriptions included in this report follow the Canadian Foundation Engineering Manual soil classification system, based on visual and tactile examination which are consistent with the field identification procedures. Soil descriptions and classifications are based on the Unified Soil Classification System (USCS), based on visual and tactile observations. Where grain size analyses have been specified, mechanical grain size distribution has been used to confirm the soil classification.

Soil Classification (based on particle diameter)
Clay: < 0.002 mm
Silt: 0.002 – 0.075 mm
Sand: 0.075 – 4.75 mm
Gravel: 4.75 mm – 75 mm
Cobbles: 75 – 200 mm
Boulders: > 200 mm

Terminology & Proportion
Trace: < 10%
Some: 10-20%
Adjective, sandy, gravelly, etc.: 20-35%
And, and gravel, and silt, etc.: > 35%
Noun, Sand, Gravel, Silt, etc.: > 35% and main fraction

- The compactness condition of cohesionless soils is based on excavator / drilling resistance, and Standard Penetration Test (SPT) N-values where available. The Canadian Foundation Engineering Manual provides the following summary for reference.

Compactness of Cohesionless Soils	SPT N-Value (# blows per 0.3 m penetration of split-spoon sampler)
Very Loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	50+

- Topsoil Thickness - It should be noted that topsoil quantities should not be established from information provided at the test hole locations only. If required, a more detailed analysis with additional test holes may be recommended to accurately quantify the amount of topsoil to be removed for construction purposes.
- Fill material is heterogeneous in nature, and may vary significantly in composition, density and overall condition. Where uncontrolled fill is contacted, it is possible that large obstructions or pockets of otherwise unsuitable or unstable soils may be present beyond the test hole locations.
- Where glacial till is referenced, this is indicative of material which originates from a geological process associated with glaciation. Because of this geological process, till must be considered heterogeneous in composition and as such, may contain pockets and / or seams of material such as sand, gravel, silt or clay. Till often contains cobbles or boulders and therefore, contractors may encounter them during excavation, even if they are not indicated on the test hole logs. Where soil samples have been collected using borehole sampling equipment, it should be understood that normal sampling equipment can not differentiate the size or type of obstruction. Because of horizontal and vertical variability of till, the sample description may be applicable to a very limited area; therefore, caution is essential when dealing with excavations in till material.
- Consistency of cohesive soils is based on tactile examination and undrained shear strength where available. The Canadian Foundation Engineering Manual provides the following summary for field identification methods and classification by corresponding undrained shear strength.

Consistency of Cohesive Soils	Field Identification	Undrained Shear Strength (kPa)
Very Soft	Easily penetrated several cm by the fist	0 – 12
Soft	Easily penetrated several cm by the thumb	12 – 25
Firm	Can be penetrated several cm by the thumb with moderate effort	25 – 50
Stiff	Readily indented by the thumb, but penetrated only with great effort	50 – 100
Very Stiff	Readily indented by the thumb nail	100 – 200
Hard	Indented with difficulty by the thumbnail	200+

	Project	Proposed Apartment Building	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	1/MW
	Project Number	GE-00867	Sheet 1 of 1

Date Drilled	Friday, June 23, 2023	Ground Surface Elevation	332.88 m asl
Drill Rig	D50 Turbo	Groundwater Level at Completion	
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	S Hadden, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests
					HEX (ppm)	IBL (ppm)			
0.5		1	90	9	30	0	 0.69m	ASPHALT ~ 25 mm thick GRANULAR FILL ~100 mm thick FILL - brown, silty sand, fine grained, moist, loose	MC - 6.8%
1.0		2	80	6	20	0	 1.07m	TOPSOIL - brown/black, moist, loose	MC - 14.3%
1.5							 1.21m	FILL - dark brown, clayey silt, trace gravel, moist, loose	
2.0		3	90	8	20	0		SILTY SAND - fine grained, brown, moist, no odour, no staining - occasional damp fine sand layers (~150 mm thick) between 1.5 and 3.0 m depth	MC - 13.0%
2.5		4	95	9	20	1			MC - 12.8%
3.0								- becoming compact and saturated below 3.0 m depth	
3.5		5	95	11	25	1	 3.75m		MC - 22.0%
4.0		6	90	25	30	1		SILT - brown, moist, firm - occasional damp sand seams encountered below 4.0 m depth	MC - 13.8%
4.5								- becoming fine to medium grained sandy silt below 4.6 m depth	
5.0		7	95	22	20	1	 5.18m		MC - 14.3%
5.5								Borehole terminated at 5.18 m MW Installed at 4.57 m - refer to details below	

Legend	Well Construction Details	Additional Notes
 Split Spoon Sample	Pipe Diameter 50 mm CPVC pipe	MC - denotes moisture content
 Auger Sample	Installation Depth 4.57 m	Water Levels:
 Shelby Tube	Screen Length 1.52 m	June 29, 2023 - dry
 Stabilized Groundwater	Depth of Bentonite Seal 2.41 m	July 14, 2023 - dry
 Inferred Groundwater	Well finished with flush-mount cover	September 20, 2023 - dry

	Project	Geotechnical Investigation	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	1A/MW
	Project Number	GE-00867	Sheet 1 of 3

Date Drilled	Thursday, April 13, 2023	Ground Surface Elevation	330.03 m
Drill Rig	D50 Turbo	Groundwater Level at Completion	N/R
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests	
					HEX (ppm)	IBL (ppm)				
0.5		1	50	12	50	0	 <i>1.98 m</i>	ASPHALT ~ 50 mm thick (fragments) FILL - brown, silty sand, fine to medium grained, moist, compact		
1.0		2	70	6	30	0				
1.5		3	70	3	25	0				
2.0		4	90	7	25	0	 <i>3.81 m</i>	SAND - brown, fine to medium grained, trace to some silt, stratified, moist, loose		
2.5								- very moist below 3.05 m depth		
3.0										
3.5		5	80	10	55	0				
4.0		6	100	13	55	0		SILTY SAND - brown, fine to medium grained, moist, compact		
4.5		7	90	43	55	0		- intermittent thin wet sand seams noted between 3.8 and 4.6 m depth		
5.0										
5.5		8	80	39	30	0				
continued on next page										

Legend  Split Spoon Sample  Auger Sample  Shelby Tube  Stabilized Groundwater  Inferred Groundwater		Well Construction Details Pipe Diameter 50 mm dia. CPVC pipe Installation Depth 13.72 m Screen Length 3.05 m Depth of Bentonite Seal 10.36 m Well finished with flush-mount cover	Additional Notes MC - denotes moisture content Water Levels: April 17, 2023 - 13.48 m bgs April 24, 2023 - 13.51 m bgs July 14, 2023 - 13.21 m bgs
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Date Drilled	Thursday, April 13, 2023	Ground Surface Elevation	330.03 m
Drill Rig	D50 Turbo	Groundwater Level at Completion	N/R
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

[illegible]

<u>Legend</u>	<u>Well Construction Details</u>	<u>Additional Notes</u>
 Split Spoon Sample	Pipe Diameter 50 mm dia. CPVC pipe	MC - denotes moisture content
 Auger Sample	Installation Depth 13.72 m	Water Levels:
 Shelby Tube	Screen Length 3.05 m	April 17, 2023 - 13.48 m bgs
 Stabilized Groundwater	Depth of Bentonite Seal 10.36 m	April 24, 2023 - 13.51 m bgs
 Inferred Groundwater	Well finished with flush-mount cover	July 14, 2023 - 13.21 m bgs

	Project	Geotechnical Investigation	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	1A/MW
	Project Number	GE-00867	Sheet 3 of 3

Date Drilled	Thursday, April 13, 2023	Ground Surface Elevation	330.03 m
Drill Rig	D50 Turbo	Groundwater Level at Completion	N/R
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests
					HEX (ppm)	IBL (ppm)			
11.5								<i>continued from Page 2</i>	
12.0								SILTY SAND - grey, fine grained, damp, very dense	
12.5		16	70	82	60	0		- wet seam between 12.2 and 12.5 m	
13.0									
13.5								April 24, 2023 WL - 13.5 m bgs - saturated below 13.5 m	
14.0		17	100	66	65	0			
14.5							14.17 m	Borehole terminated at 14.17 m. MW installed to 13.72 m - refer to details below	
15.0									

Legend	Well Construction Details	Additional Notes
 Split Spoon Sample	Pipe Diameter 50 mm dia. CPVC pipe	MC - denotes moisture content
 Auger Sample	Installation Depth 13.72 m	Water Levels:
 Shelby Tube	Screen Length 3.05 m	April 17, 2023 - 13.48 m bgs
 Stabilized Groundwater	Depth of Bentonite Seal 10.36 m	April 24, 2023 - 13.51 m bgs
 Inferred Groundwater	Well finished with flush-mount cover	July 14, 2023 - 13.21 m bgs

	Project	Geotechnical Investigation	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	2
	Project Number	GE-00867	Sheet 1 of 1

Date Drilled	Friday, June 23, 2023	Ground Surface Elevation	332.79 m asl
Drill Rig	D50 Turbo	Groundwater Level at Completion	Dry
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests
					HEX (ppm)	IBL (ppm)			
0.5		1	90	9	25	0	0.20m	ASPHALT ~ 50 mm thick GRANULAR FILL ~50 mm thick	MC - 11.3%
							0.69m	FILL - brown sandy silt, moist, loose	
								TOPSOIL - brown/black, moist, loose	
1.0		2	90	4	20	0		SILTY SAND - fine grained, brown, some oxidation, moist, loose	MC - 10.6%
1.5							1.46m		
2.0		3	85	10	25	1		SAND - fine grained, brown, compact - occasional sandy silt seams encountered throughout	MC - 16.7%
							2.29m		
2.5		4	90	15	30	1		SANDY SILT - brown, moist, compact - occasional wet sand seams encountered between 2.3 and 2.4 m depth	MC - 12.0%
3.0									
3.5		5	95	20	30	1		- becoming grey below 3.2 m depth	MC - 10.3%
							3.96m		
4.0		6	90	41	30	1		SILTY SAND - fine grained, brown, moist, dense	MC - 12.3%
4.5									
5.0		7	80	49	20	1			MC - 12.3%
							5.03m		
5.5								Borehole terminated at 5.03 m Borehole observed open at time of completion Borehole observed dry at time of completion	

Legend  Split Spoon Sample  Auger Sample  Shelby Tube  Stabilized Groundwater  Inferred Groundwater		Well Construction Details Pipe Diameter No well installed Installation Depth Screen Length Depth of Bentonite Seal	Additional Notes MC - denotes moisture content
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	Project	Geotechnical Investigation	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	2A
	Project Number	GE-00867	Sheet 1 of 1

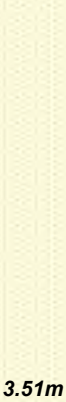
Date Drilled	Thursday, April 13, 2023	Ground Surface Elevation	332.01 m
Drill Rig	D50 Turbo	Groundwater Level at Completion	Dry
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests
					HEX (ppm)	IBL (ppm)			
0.5		1	30	5	85	0		FILL - topsoil (~ 150 mm thick)	
1.0		2	50	12	40	2		FILL - brown, silty sand, fine to medium - some topsoil intermixed between 0.76 and - becoming compact below 1.0 m depth	
1.5							1.37 m		
2.0		3	90	10	30	1		SILTY SAND - brown, fine to medium grained, moist, loose	
2.5		4	100	18	45	1		- becoming compact below 2.5 m depth	
3.0									
3.5		5	100	15	55	0		- very moist and more silt content near 3.4 m depth	
4.0		6	100	23	60	0	4.11 m		
4.5							4.50 m	SAND - brown, fine grained, damp, compact	
5.0		7	100	18	35	0	5.03 m	SILTY SAND - brown, fine to medium grained, very moist, compact - becoming wet below 4.72 m	
5.5								Borehole terminated at 5.03 m Borehole observed open at time of completion Borehole observed dry at time of completion	

Legend  Split Spoon Sample  Auger Sample  Shelby Tube  Stabilized Groundwater  Inferred Groundwater		Well Construction Details Pipe Diameter No well installed Installation Depth Screen Length Depth of Bentonite Seal	Additional Notes MC - denotes moisture content
--	--	--	--

	Project	Geotechnical Investigation	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	3
	Project Number	GE-00867	Sheet 1 of 1

Date Drilled	Thursday, April 13, 2023	Ground Surface Elevation	332.32 m asl
Drill Rig	D50 Turbo	Groundwater Level at Completion	Dry
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests
					HEX (ppm)	IBL (ppm)			
0.5		1	90	6	80	0		TOPSOIL - dark brown, moist, 100 mm	
1.0		2	90	5	70	0		FILL - silty sand, fine to medium grained, brown, moist, loose - becoming brown/black topsoil mixed with silty sand below 0.8 m depth	
1.5		3	80	11	65	0		SAND - brown, fine to medium grained, trace silt, stratified, moist, compact	
2.0		4	60	12	55	0			
2.5		5	70	16	50	0			
3.0									
3.5									
4.0								Borehole terminated at 3.51 m Borehole observed open at time of completion Borehole observed dry at time of completion	
4.5									
5.0									
5.5									

Legend  Split Spoon Sample  Auger Sample  Shelby Tube  Stabilized Groundwater  Inferred Groundwater	Well Construction Details Pipe Diameter No well installed Installation Depth Screen Length Depth of Bentonite Seal	Additional Notes
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	Project	Geotechnical Investigation	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	4/MW
	Project Number	GE-00867	Sheet 1 of 1

Date Drilled	Friday, April 14, 2023	Ground Surface Elevation	332.51 m asl
Drill Rig	D50 Turbo	Groundwater Level at Completion	
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests
					HEX (ppm)	IBL (ppm)			
0.5		1	90	13	0	1		ASPHALT ~ 50 mm thick (fragments) GRANULAR FILL ~ 50 mm thick	MC - 7.9%
1.0		2	70	4	0	0		FILL - brown, silty sand, fine to medium grained, moist, loose	MC - 12.0%
1.5		3	90	17	5	1	1.68m		
2.0								SAND - brown, fine to medium grained, trace silt, stratified, moist, compact	MC - 15.8%
2.5		4	90	29	10	0			MC - 10.3%
3.0							2.90m		
3.5		5	90	30	15	1		SILTY SAND - brown, fine grained, saturated, compact Gradation: 0% Gravel, 67% Sand, 33% Silt/Clay April 24, 2023 WL - 3.12 m bgs	MC - 19.0%
4.0		6	90	26	20	0			MC - 19.0%
4.5		7	80	21	20	0			MC - 22.0%
5.0							5.03m		
5.5								Borehole terminated at 5.03 m MW Installed at 4.57 m - refer to details below	

Legend	Well Construction Details	Additional Notes
 Split Spoon Sample  Auger Sample  Shelby Tube  Stabilized Groundwater  Inferred Groundwater	Pipe Diameter 50 mm CPVC pipe Installation Depth 4.57 m Screen Length 3.05 m Depth of Bentonite Seal 1.21 m Well finished with flush-mount cover	MC - denotes moisture content Water Levels: April 24, 2023 - 3.12 m bgs July 14, 2023 - 2.69 m bgs September 20, 2023 - 3.26 m bgs

	Project	Geotechnical Investigation	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	5/MW
	Project Number	GE-00867	Sheet 1 of 1

Date Drilled	Friday, April 14, 2023	Ground Surface Elevation	332.72 m asl
Drill Rig	D50 Turbo	Groundwater Level at Completion	
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests
					HEX (ppm)	IBL (ppm)			
0.5		1	80	17	13	0	0.32m	ASPHALT ~ 60 mm thick GRANULAR FILL ~ 100 mm thick	MC - 3.0%
								FILL - brown silty sand, fine to medium grained, moist, compact	
1.0		2	90	11	80	0	0.91m	SAND - brown, fine to medium grained, trace silt, moist, compact	MC - 10.3%
1.5								SILTY SAND - brown, fine grained, very moist, compact	MC - 20.0%
2.0		3	80	12	10	0	2.13m	- saturated below 1.07 m depth April 24, 2023 WL - 1.89 m bgs	
2.5		4	60	14	11	0		SANDY SILT - brown, very moist, compact Gradation: 0% Gravel, 38% Sand, 62% Silt/Clay	MC - 17.7%
3.0									MC - 16.7%
3.5		5	80	19	12	0			
4.0		6	80	15	10	0	3.96m	CLAYEY SILT - brown, moist, compact	MC - 11.9%
4.5							4.42m		
5.0		7	80	19	11	0	5.03m	SAND - brown, fine grained, trace silt, moist, compact	MC - 11.3%
								Borehole terminated at 5.03 m MW Installed at 3.05 m - refer to details below	
5.5									

Legend	Well Construction Details	Additional Notes
 Split Spoon Sample  Auger Sample  Shelby Tube  Stabilized Groundwater  Inferred Groundwater	Pipe Diameter 50 mm CPVC pipe Installation Depth 3.05 m Screen Length 1.52 m Depth of Bentonite Seal 1.21 m Well finished with flush-mount cover	MC - denotes moisture content Water Levels: April 24, 2023 - 1.89 m bgs July 14, 2023 - 1.24 m bgs September 20, 2023 - 2.38 m bgs

	Project	Geotechnical Investigation	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	6/MW
	Project Number	GE-00867	Sheet 1 of 1

Date Drilled	Friday, April 14, 2023	Ground Surface Elevation	332.65 m asl
Drill Rig	D50 Turbo	Groundwater Level at Completion	
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests
					HEX (ppm)	IBL (ppm)			
0.5		1	80	17	13	0		ASPHALT ~ 50 mm thick GRANULAR FILL ~80 mm thick FILL - brown, silty sand, fine to medium grained, moist, compact	MC - 10.2%
1.0		2	90	11	80	0		SAND - brown, fine to medium grained, trace silt, damp, compact - becoming very moist below 1.4 m depth	MC - 6.6%
1.5		3	80	12	10	0			MC - 16.4%
2.0								SANDY SILT - brown, fine grained, saturated, compact April 24, 2023 WL - 2.65 m bgs Gradation: 0% Gravel, 30% Sand, 70% Silt/Clay	MC - 18.2%
2.5		4	60	14	11	0			
3.0									
3.5		5	80	19	12	0			MC - 21.0%
4.0		6	80	15	10	0		- some clayey silt lenses (~ 5 to 10 cm thick) embedded below 3.81 m depth	MC - 15.6%
4.5								CLAYEY SILT - brown, moist, compact	MC - 13.9%
5.0		7	80	19	11	0			
5.5								Borehole terminated at 5.03 m MW Installed at 4.57 m - refer to details below	

Legend	Well Construction Details	Additional Notes
 Split Spoon Sample	Pipe Diameter 50 mm CPVC pipe	MC - denotes moisture content
 Auger Sample	Installation Depth 4.57 m	Water Levels:
 Shelby Tube	Screen Length 3.05 m	April 24, 2023 - 2.65 m bgs
 Stabilized Groundwater	Depth of Bentonite Seal 1.21 m	July 14, 2023 - 2.50 m bgs
 Inferred Groundwater	Well finished with flush-mount cover	September 20, 2023 - 2.59 m bgs

	Project	Geotechnical Investigation	Borehole
	Project Location	153 Union Street East, Waterloo, Ontario	7
	Project Number	GE-00867	Sheet 1 of 1

Date Drilled	Thursday, April 13, 2023	Ground Surface Elevation	332.81 m asl
Drill Rig	D50 Turbo	Groundwater Level at Completion	Dry
Drilling Method	Hollow Stem Auger	Technician	N Ungerer
Drilling Contractor	London Soil Test	Checked By	R Walker, P.Eng.

Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT N-value (blows/0.3 m)	Soil Vapour Field Screening		Graphic Log	Material Description	Remarks and Other Tests
					HEX (ppm)	IBL (ppm)			
0.5		1	80	16	13	0		ASPHALT ~ 50 mm thick GRANULAR FILL ~120 mm thick	MC - 7.6%
1.0		2	80	32	125	0		SILTY SAND - brown, fine to medium grained, moist, compact - becoming dense below 0.8 m depth	MC - 13.9%
1.5							1.42m		
2.0		3	70	36	14	0		SAND - brown, fine to medium grained, trace silt, saturated, dense	MC - 17.0%
2.5		4	80	44	12	0			MC - 21.1%
3.0							2.85m		
3.5		5	80	46	11	0		SILTY SAND - brown, fine to medium grained, saturated, dense	MC - 18.4%
3.51m							3.51m		
4.0								Borehole terminated at 3.05 m Borehole observed open at time of completion Borehole observed dry at time of completion	
4.5									
5.0									
5.5									

Legend  Split Spoon Sample  Auger Sample  Shelby Tube  Stabilized Groundwater  Inferred Groundwater		Well Construction Details Pipe Diameter No well installed Installation Depth Screen Length Depth of Bentonite Seal	Additional Notes MC - denotes moisture content
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Particle Size Distribution Results of Sieve Analysis

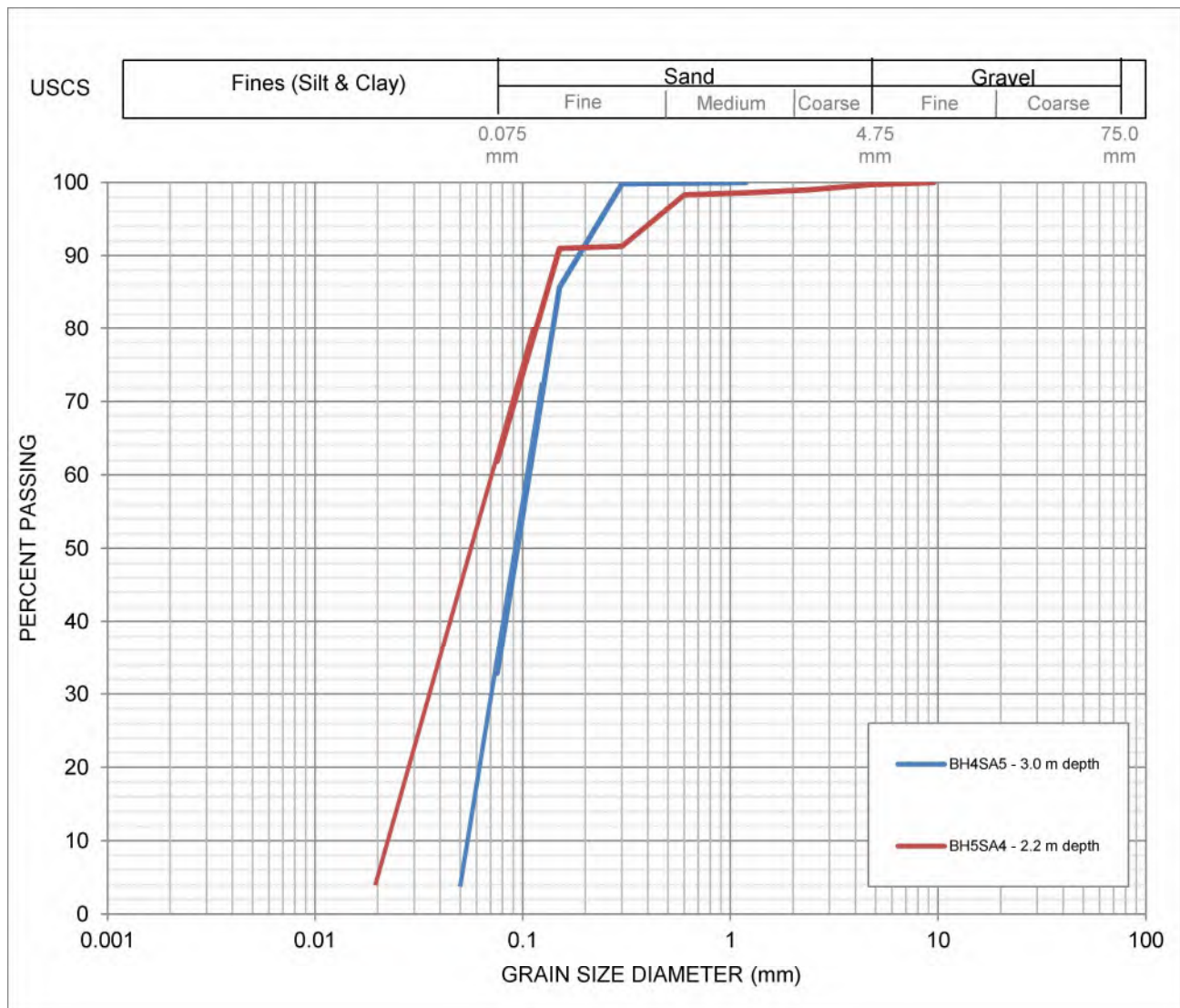
Project Name: Proposed Apartment Building

Date: 16-Oct-23

Project Location: 153 Union Street East, Waterloo

Project No.: GE-00867

Sample ID	Unified Soil Classification				Moisture Content (%)
	Fines (Silt & Clay)	% Sand	% Gravel	% Cobbles	
BH4SA5 - 3.0 m depth	32.9%	67.1%	0.0%	0.0%	19.0
BH5SA4 - 2.2 m depth	61.9%	38.1%	0.0%	0.0%	17.7





Particle Size Distribution Results of Sieve Analysis

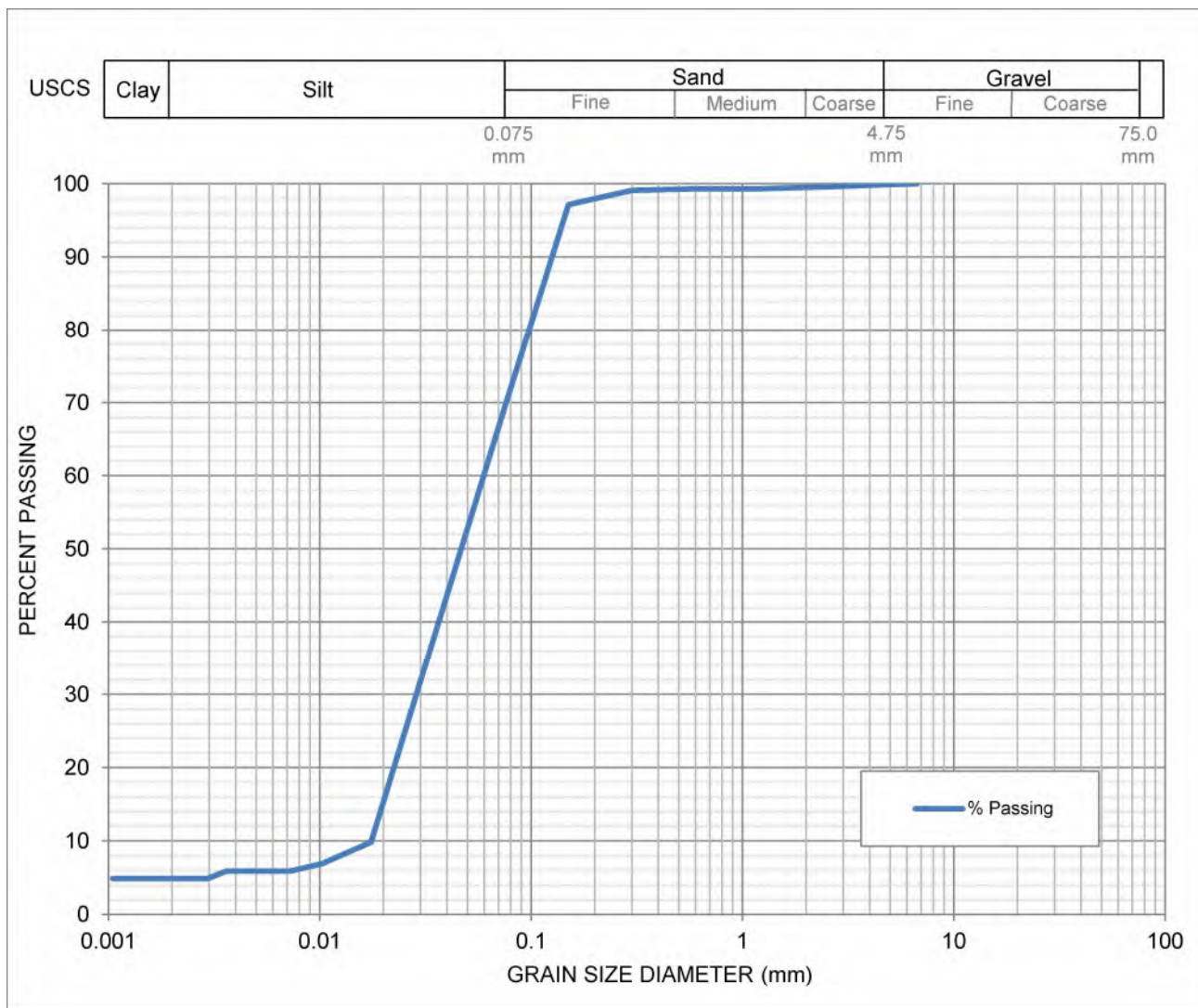
Project Name: Proposed Apartment Building

Date: 16-Oct-23

Project Location: 153 Union Street East, Waterloo

Project No.: GE-00867

Sample ID	Unified Soil Classification				Moisture Content (%)
	% Clay	% Silt	% Sand	% Gravel	
BH6SA5 - 3.0 m depth	6.9	62.5	30.4	0.1	21.0



TEST PIT SUMMARY

Test Pit TP1					<i>Surface elevation: 331.98 m asl</i>
0 - 0.05	-	-	-	-	FILL: topsoil, brown, very moist, loose
0.05 - 0.61	SA1 (0.2 m)	0	0	Metals, PAH, EC, SAR, pH	FILL: silty sand, brown, moist, no petroleum odour or staining
	SA2 (0.6 m)	0	0	-	
0.61 - 0.91	-	-	-	-	BURIED TOPSOIL: silty loam, dark brown/black, moist, no petroleum odour or staining
0.91 - 1.37	SA3 (1.2 m)	0	0	-	SILTY SAND: fine to medium grained, brown, moist, no petroleum odour or staining
					<i>Test pit terminated at 1.37 m depth. Test pit remained open with no water seeping into test pit at time of termination.</i>
Test Pit TP2					<i>Surface elevation: 332.45 m asl</i>
0 - 0.05	-	-	-	-	FILL: topsoil, brown, very moist, loose
0.05 - 0.31	SA1 (0.2 m)	0	1	-	GRANULAR FILL: sand and gravel, brown, moist, no petroleum odour or staining
0.31 - 0.91	SA2 (0.6 m) DUP1	0	1	Metals, PAH, EC, SAR, pH	FILL: silty sand, brown, moist, no petroleum odour or staining
0.91 - 1.07	-	-	-	-	BURIED TOPSOIL: silty loam, dark brown/black, moist, no petroleum odour or staining
1.07 - 1.50	SA3 (1.4 m)	0	2	-	SILTY SAND: fine to medium grained, brown, moist, no petroleum odour or staining
					<i>Test pit terminated at 1.50 m depth. Test pit remained open with no water seeping into test pit at time of termination.</i>

TEST PIT SUMMARY

Test Pit TP3					<i>Surface elevation: 332.47 m asl</i>
0 - 0.15	-	-	-	-	FILL: recycled asphalt intermixed with sand and gravel, dark brown/black, moist
0.15 - 0.31	SA1 (0.2 m)	0	1	Metals, PAH, EC, SAR, pH	FILL: silty sand, brown, moist, no petroleum odour or staining
0.31 - 4.57	SA2 (0.5 m)	0	0	-	SILTY SAND: layered with sandy silt, brown, moist, no petroleum odour or staining
	SA3 (1.5 m)	0	0	-	
	SA4 (3.7 m)	0	1	VOC, PHC, PCB	
					<i>Test pit terminated at 4.57 m depth. Test pit remained open with no water seeping into test pit at time of termination.</i>

TEST PIT PHOTOGRAPHS
September 20, 2023



Test Pit TP1

Test Pit 1 at time of termination. Test pit remained open and dry. Buried topsoil (dark layer indicated by arrow) was encountered.

TEST PIT PHOTOGRAPHS
September 20, 2023



Test Pit TP2

Test Pit 2 at time of termination. Test pit remained open and dry. Buried topsoil (dark layer indicated by arrow) was encountered.

TEST PIT PHOTOGRAPHS
September 20, 2023



Test Pit TP3

Test pit remained open and dry at time of completion. No buried topsoil was encountered at this location.

Notes:

Test Pits TP1 to TP3 were advanced at the Site on September 20, 2023.

Test pits were excavated by a rubber-tired excavator arranged by the Client.

LDS field staff: N. Ungerer

Field screening was completed using a calibrated RKI Eagle II gas detector.



85 Midpark Road – Unit 3
London, Ontario, N6N 1B2

www.stonecairn.ca

