• City of Stratford

Geotechnical Investigation

Type of Document
FINAL

Project Name
Shakespeare Street Skate Park
Stratford, ON

Project Number
KCH-00236500-GE

Prepared By:

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Canada

Date Submitted
January, 2017

City of Stratford

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Date Submitted:
January, 2017

Legal Notification

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Table of Contents

1 Introduction and Background

Exp Services Inc. (**exp**) was retained by The City of Stratford to conduct a Geotechnical Investigation for a proposed new skate park at Shakespeare Street in Stratford, Ontario, hereinafter referred to as the 'Site'. Authorization for **exp** to proceed with the Geotechnical Investigation was given by Mr. Orion Raes, C.E.T. of the City of Stratford.

Based on an interpretation of the factual test hole data and a review of soil and groundwater information from test holes advanced at the site, **exp** has provided geotechnical engineering guidelines to support the proposed site improvements.

1.1 Terms of Reference

The geotechnical investigation was generally done in accordance with terms and conditions in **exp**'s current contract and with e-mailed instructions dated November 2, 2016.

The purpose of the investigation was to determine subsurface conditions to assist in the design and construction of the proposed new skate park. Based on a review of soil and groundwater information from test holes advanced at the site, **exp** has provided engineering guidelines for the geotechnical design and construction of the proposed skate park foundations, site preparation, dewatering and excavation requirements, slab-on-grade construction recommendations for trenching and backfilling.

This report is provided on the basis of the terms of reference presented above and on the assumption that the design will be in accordance with applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning geotechnical aspects of the codes and standards, this office should be contacted to review the design.

The investigation included limited environmental soil testing. The information in this report in no way reflects on the entire environmental aspects of the soil. Should specific information in this regard be needed, additional testing may be required.

2 Methodology

The fieldwork for this investigation was carried out on December 5, 2016 and consisted of three (3) sampled boreholes, advanced at the approximate locations shown on the attached Borehole Location Plan (Drawing 1).

The boreholes were advanced to depths of about 3.5 m below existing grade using a locally sub-contracted track-mounted CME-55 rig equipped with hollow stem augers, soil sampling and soil testing equipment.

Within the boreholes, Standard Penetration Tests (SPTs) were performed to assess the compactness of the underlying soils and to obtain representative samples. In cohesive soils, pocket penetrometer readings were taken to assess the undrained shear strength. During the drilling, the stratigraphy in the boreholes was examined and logged in the field by **exp** geotechnical personnel. Short-term groundwater level observations within the open boreholes and the natural moisture contents of recovered soil samples were recorded on the borehole logs.

Following the drilling the boreholes were backfilled with bentonite hole plug and/or auger cuttings in order to satisfy the requirements of O. Reg. 903.

The fieldwork was supervised by a member of the **exp** technical staff who directed the drilling and sampling operation, and logged the samples. All samples recovered were transported to **exp**'s Cambridge laboratory for detailed examination and selective testing. Laboratory testing for this investigation consisted of routine moisture content determinations.

Samples remaining after the classification testing will be stored for a period of three months following the date of sampling (i.e., until February, 2017). After this time, they will be discarded unless prior arrangements have been made for longer storage.

The ground surface elevations of the boreholes were referenced to the top of a fire hydrant situated at the junction of Downie and Guelph Street (assumed Elevation: 100.00 m). The approximate ground surface elevations at the boreholes are provided on the Borehole Logs.

3 Site and Subsurface Conditions

3.1 Site Description

The subject site is part of an existing park that has tennis courts and playground equipment. the southwest soccer fields at the Stratford. The site is flat, grassed, and at the grade of adjacent properties. The site is in a residential setting and the south, the site is bound by railway tracks.

The Pleistocene Geology of the Stratford Area, published by the Ministry of Northern Development and Mines, Map 2559, indicates that the native deposits in the vicinity of the Site consist of a sandy silt till.

3.2 Soil Stratigraphy

The stratigraphy encountered in the boreholes is detailed in the borehole logs found in Appendix B, and summarized in the following paragraphs. It must be noted that boundaries of soil indicated in the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect transition zones for the purposes of geotechnical design and should not be interpreted as exact planes of geological change.

3.2.1 Topsoil

Topsoil was encountered at surface at all borehole locations. The thickness of the existing surficial topsoil was noted to be approximately 125 mm.

It should be noted that topsoil quantities should not be established from the information provided at the borehole locations. If required, a more detailed analysis is recommended to accurately quantify the amount of topsoil to be removed for construction purposes.

3.2.2 Fill

Fill was encountered beneath the topsoil at all borehole locations, to a depth of about 1.9 m below existing grade, relative Elevation 97.1 to 98.0 m. The fill generally consists of dark brown/black silty sand having some gravel with organics/brick fragments. The compactness condition of the fill is loose to compact, based on Standard Penetration Test (SPT) N-values ranging from 4 to 13 blows per 300 mm penetration of the split spoon. Based on laboratory testing, the *in situ* moisture content of the fill ranges from 11 to 22 percent, indicating moist to very moist conditions.

3.2.3 Clayey Silt/Silty Sand or Sandy Silt

At Borehole 1, a layer of clayey silt was encountered beneath the fill to depths from about 1.9 to 2.6 m below existing grade, relative Elevation 96.6 to 97.4 m. In general, the clayey silt was noted to be brown with some sand and trace to some gravel. The compactness condition of the clayey silt is stiff to very stiff. Based on laboratory testing, the *in situ* moisture content of the clayey silt is about 18 percent.

At Borehole 2 and 3, a layer of sandy silt or silty sand was encountered beneath the fill, to depths from about 2.0 to 2.7 m below existing grade, relative Elevation 96.3 to 97.1 m. In general, the sandy silt or silty sand was noted to be brown having trace to some clay and trace gravel. The compactness condition of this layer is compact, based on SPT N-values ranging from 10 to 16 per 300 mm of the split spoon. Based on laboratory testing, the *in situ* moisture content of the sandy silt or silty sand ranges from about 10 to 16 percent, indicating moist conditions.

3.2.4 Sandy Silt Till

All boreholes were terminated with a sandy silt till deposit. In general, the sandy silt till was noted to be brown to grey with trace to some clay. The compactness condition of the sandy silt till is compact to dense, based on SPT N-values of 24 to 30 blows per 300 mm of penetration. The *in situ* moisture content of the sandy silt till is 15 to 16 percent, indicating moist conditions.

3.3 Groundwater Conditions

Details of the groundwater conditions observed within the boreholes are provided on the attached Borehole Logs. Measurement of the short-term water level measurements and moisture contents of selected samples are also recorded on the attached Borehole Logs.

Upon completion of drilling, free water was noted in Boreholes 1 and 2. These water levels ranged from about 1.8 to 3.0 m below existing grade. It is noted that insufficient time was allowed for the measurement of the depth to the stabilized groundwater table prior to backfilling the boreholes.

The wet conditions noted within the boreholes suggest that the shallow groundwater is likely present within the silty sand or sandy silty layer, or within the lower zone of the fill. It is noted that the observed water levels are expected to be intermittent and discontinuous, and dependant on wet periods and precipitation events. It is noted that the depth to the groundwater table may vary in response to climatic or seasonal conditions, and, as such, may differ at the time of construction. Capillary rise effects should also be anticipated within fine-grained soil deposits.

4 Discussion and Recommendations

4.1 General

Based on a review of the available sketch, the proposed skate park development is expected to include the construction of above ground concrete ramps and slab. Other details of the new development were not available.

Based on the above, and the results of the current investigation, the following sections of this report provide geotechnical comments and recommendations to assist with the design and construction of the proposed site improvements.

4.2 Site Preparation

Based on the existing site grades, only minor re-grading is expected to be required during construction. Because of the presence of fill material and topsoil, preparation of the subgrade soils for the proposed structures will be important. This site preparation will require some moderate excavation to reach competent subgrade soils.

Following the removal of the topsoil, the exposed subgrade surfaces should be examined by a geotechnical engineer. The subgrade beneath the topsoil has been identified as very loose to compact silty sand fill. Because of its variable nature and compactness condition, the fill in its existing condition is not considered suitable subgrade where settlement is of concern. Where this is a concern, full removal of the fill material down to native soil is recommended and where settlement is not of concern, partial removal to design subgrade level can be considered. In either option, the exposed subgrade, consisting of fill or native soil should be proof-rolled with a heavy roller. Where settlement is of concern, any soft or loose areas detected should be sub-excavated and replaced with approved material.

Where the exposed subgrade requires reconstruction to achieve the design elevations, structural fill should be used. The fill should be placed in maximum 300 mm thick lifts and compacted to a minimum of 98 percent Standard Proctor Maximum Dry Density (SPMDD). For best compaction results, the in situ moisture content of the fill should be within about three percent of optimum, as determined by a standard Proctor test.

The existing fill or native inorganic soils at the site that are not mixed with organic soils or other obviously unsuitable material may be re-used as bulk fill, if required. Some moisture content adjustment may be required for efficient compaction depending upon weather conditions at the time of construction. Any organic or excessively wet or otherwise deleterious material should not be used for backfilling purposes. These soils may be stockpiled for possible re-use onsite as non-structural (i.e., landscaping) fill, in areas where some settlements can be tolerated. Any shortfall of suitable on-site excavated material can be made up with suitable earth fill or imported granular material, OPSS Granular 'B' or equivalent.

Excess materials should be removed from the site and disposed of in accordance with MOE guidelines and requirements. Analytical sampling and testing may be required in accordance with O. Reg. 153 for transportation and off-site disposal of excavated material.

If imported fill material is used at the site, verification of the suitability of the fill may be required from an environmental standpoint. Conventional geotechnical testing will not determine the suitability of the material in this regard. Analytical testing and environmental site assessment may be required at the source. This will best be assessed prior to the selection of the material source. A quality assurance program should be implemented to ensure that the fill material will comply with the current Ministry of Environment (MOE) standards for placement and transportation.

As indicated previously, the disposal of excavated materials must also conform to the MOE Guidelines and requirements. **Exp** can be of assistance if an assessment of the materials is required.

4.3 Excavation and Groundwater Control

4.3.1 Excavations

Based on relative grades, excavations for the proposed structures and possible services are expected to penetrate the fill and extend into the native clayey silt and silty sand or sandy silt till. Excavation of the overburden should be undertaken with hydraulic equipment that is capable of removing possible cobbles within the native soil or debris within the fill.

All work associated with design and construction relative to excavations must be carried out in accordance with Part III of Ontario Regulation 213/91 under the Occupational Health and Safety Act. Based on the results of the geotechnical investigation and in accordance with Section 226 of Ontario Regulation 213/91, the loose fill and the compact and stiff native soils encountered at the site are classified as <u>Type 3</u> soil above the groundwater and <u>Type 4</u> below the water table. For excavations which extend through and terminate in <u>Type 3</u> soil <u>only</u>, temporary excavation side slopes must be cut back at a maximum inclination of 1H:1V from the base of the excavation. In the event groundwater egress loosens the sidewalls, flatter slopes will be required. For excavations which extend through or terminate within <u>Type 4</u> soils, temporary excavation side slopes must be cut back at a maximum inclination of 3H:1V from the base of the excavation.

Additionally, when excavating, care should be taken to not undermine or damage any existing buried utilities or structures. In the event that soils below existing foundations are disturbed, some method of temporary support or underpinning may be required. **Exp** can provide additional assistance in this regard, if necessary.

Where space limitations (from existing underground services, above ground structures, etc.) do not permit overburden cut slopes at inclinations specified above, a steeper cut slope can be employed if braced excavations or a trench liner box is used to protect workers. The excavation support should be designed by a professional engineer to withstand the soil and hydrostatic loading. Where trench boxes are used, the trench box should extend to base of the trench excavation. Some ground movement adjacent to the trench is to be expected if this option is used. Additional information is provided in Section 4.3.2 in this regard.

It should be noted that the presence of cobbles and boulders in glacial till deposits and construction debris within the existing fill may influence the progress of excavation and construction.

4.3.2 Groundwater Control

Based on the results of the investigation, shallow groundwater within the native sandy silt till or within the fill is anticipated as shallow as 1.8 m below existing grade. However, following the area grading, the depth to groundwater may change. Groundwater inflow through the excavation sidewalls is expected where the excavations extend through the wet zones and the stabilized groundwater table.

It is anticipated that minor groundwater infiltration into open excavations can be managed with positive drainage and localized sumps. Moderate groundwater inflow through the excavation sidewalls and base is expected where the excavations extend through the fill and below the observed groundwater table. Where more significant groundwater infiltration occurs, additional groundwater control measures will be required to maintain safe excavation side slopes, and suitable excavation bases.

If practical, additional test pits should be dug to obtain a full appreciation of the behaviour of excavations and to confirm the dewatering requirements. Contractors (including specialist dewatering contractors) who might be involved in the job should witness this series of pre-tender test pits.

Collected water from temporary excavations should be discharged a sufficient distance away from the excavated area to prevent the discharge water from returning to the excavation. Sediment control measures should be provided at the discharge point of the dewatering system. Caution should also be taken to avoid any adverse impacts to the environment.

4.4 Foundations

It is expected that the proposed structures will impose relatively light loads and typically would be designed for shallow foundations on competent native soil. The existing fill at the site, is not considered suitable for the support of proposed structures.

4.4.1 Conventional Shallow Footings

The new structures can be supported on conventional spread shallow foundations set on the natural, undisturbed clayey silt, sandy silt/silty sand, or the sandy silt till. For design of footings on these natural subgrade soils below depths of about 1.9 m below existing grade, the following allowable bearing pressures (net stress increase) can be used for design of footings:

Serviceability Limit States (SLS)	150 kPa (3,100 psf)
Ultimate Limit States (ULS)	225 kPa (4,700 psf)

Verification of the footing base conditions should be undertaken by the geotechnical engineer at the time of excavation. Locations and elevations of any existing structures and services in the vicinity should be reviewed as part of the final foundation design.

4.4.2 **Helical Piers**

Alternatively, the structures can be supported on helical piers. This type of foundation support works well where removal of fill and/or dewatering is to be avoided.

The helical pier consists of one or multi helices on the end of a small diameter solid steel shaft. The steel helices are screwed into the ground to the level of competent bearing soil. Based on the soil and groundwater conditions observed in the boreholes at the site, the helical pier systems should be installed in the native, compact silty sand, sand or dense to very dense sandy silt till.

The support capacity and installation procedures should conform to the manufacturer's specifications. For a preliminary reference, the following equation may be applied for determining the vertical capacity of a single helical pier:

$$Q_u = (N_q \gamma' H) \frac{\pi(D^2 - d^2)}{4}$$

Where:

Q_u = ultimate compressive load capacity (kN)

N_q = bearing capacity coefficient

H = height of soils above the helix plate (measured from the surface in the case of the upper-most helix and from the bottom of upper helix to the top of the lower helix in the case of multiple helix piles)

D = diameter of the helix

d = diameter of the shaft

γ' = effective soil unit weight

Where multiple helixes are used on a helical pier, the bearing capacity can be increased accordingly, and additional calculations are required. To determine the allowable capacities, a suitable factor of safety (at least 2.5) should be applied to the ultimate values. The design and installation of the helical piers should be done by specialist contractors and in accordance with the Canadian Foundation Engineering Manual.

Proof test should be conducted at each pier according to the manufacturer's requirements. It cannot be overemphasized that competent pier installation inspection involving a site inspector in conjunction with and under the direction of a qualified pier engineer is required to ensure their proper placement and penetration to firm bearing, to minimize danger of under driving and to maintain adequate records of the installations. For each pier, a complete record should be obtained by the inspector and reviewed during pier installation by the designer.

4.5 Site Servicing

Depending on grades and location, the subgrade soils beneath the new services are generally expected to consist of silty sand or sandy silt till at a depth of about 1.9 m below existing grade. Although no bearing problems are anticipated for flexible or rigid pipes founded on the natural deposits, localized base improvement along the trench bottom may be required for excavations which terminate in wet soils or within zones having wet seams, especially in wet weather seasons. The extent of base improvement or stabilization is best determined in the field during construction, with consultation from a geotechnical engineer.

For services supported on the native deposits, the bedding should conform to OPS Standards. The bedding course may be thickened if portions of the subgrade become wet during excavation. The bedding aggregate should be placed around the pipe to at least 300 mm above the pipe. The 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.

Clear stone or crushed stone bedding may be used in the service trenches as bedding below the spring line of the pipe if necessary to facilitate dewatering and provide stabilization to the excavation base in wet silty soils. A well-graded stone such as HL4 stone may be considered for this application. Geotextile should be wrapped around the stone bedding to minimize migration of fines. The potential locations for use of stone bedding should be identified during construction, and are expected to vary across the site due to seasonal conditions and variations in perched groundwater conditions.

Requirements for backfill in service trenches, etc. should also conform to Municipal and OPS Standards. A program of in situ density testing should be set up to ensure that satisfactory levels of compaction are achieved.

Based on the results of this investigation, the excavated material for the trenches will generally consist of silty sand. Select portions of the inorganic material may be used for construction backfill provided that it is separated and reasonable care is exercised in handling the material. In this regard the 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.

Soils excavated from below the stabilized groundwater table may be too wet for re-use as backfill, unless adequate time is allowed for drying, or if the material is blended with approved dry fill; otherwise, it may be stockpiled onsite for re-use as landscape fill, or disposed of.

Backfill above the bedding aggregate can consist of the excavated (inorganic) soils, compacted in maximum 300 mm thick lifts to a minimum of 95% SPMDD. A program of in situ density testing should be set up to ensure that satisfactory levels of compaction are achieved.

Disposal of any excess excavated materials off site should conform to current Ministry of Environment guidelines.

4.6 Slab-On-Grade Construction

The areas for any exterior slabs-on-grade should be stripped of all topsoil, organics and other obviously unsuitable material. As noted in Section 4.2 there are generally two options for the existing fill subgrade depending on concerns for long-term settlements. In either option, the exposed subgrade must be thoroughly proof-rolled. In settlement sensitive condition, any soft areas should be over-excavated and replaced with suitable compactable native soil, OPSS Select Subgrade Material (SSM), or Granular ‘B’, compacted to 98% SPMDD. The material should be placed within 3% of the optimum moisture as determined by the Standard Proctor Test.

If construction is undertaken under adverse weather conditions (i.e., wet or freezing conditions) subgrade preparation and granular base requirements should be reviewed by the geotechnical engineer. The use of geotextile (such as Terrafix 270R or approved equivalent), or the addition of a nominal sub-base layer to enhance drainage properties of the granular structure may be warranted in poor weather conditions, or where the subgrade soils are disturbed from the construction traffic. The extent of possible subgrade improvements can be confirmed at the time of construction, subject to site review by the geotechnical consultant.

The subgrade for exterior concrete slabs should consist of undisturbed natural soil or well-compacted fill. A minimum 150 mm thick layer of compacted (minimum 98 percent SPMDD) Granular 'A' should be placed below the slabs. For heavy-duty loading slabs that may be required, the thickness of the base should be increased to 300 mm and the thickness of the concrete increased to a minimum of 200 mm.

Samples of both the Granular 'A' and ‘B’ aggregate should be checked for conformance to OPSS 1010 prior to use on site, and during construction.

4.7 Concrete

The concrete for the skate structures and any other exterior slabs should be proportioned, mixed placed and cured in accordance with the requirements of OPSS 353, OPSS 1350 and Municipal requirements.

During cold weather, the freshly placed concrete should be covered with insulating blankets to protect against freezing.

4.8 Environmental Testing

Representative soil samples of the fill from Boreholes 1 and 3 were obtained for environmental testing during the drilling program. The soil samples was submitted to Maxxam Analytics Inc. for analysis of Petroleum Hydrocarbons and Toxicity Classification Leachate Procedure (TCLP).

The results indicate that petroleum hydrocarbons concentrations are below detectable limits. The results of the TCLP testing on two representative samples of the subgrade fill indicated that the soil would be classified as a non-hazardous solid waste.

The Certificates of Analysis are included in Appendix C.

5 General Limitations

The information presented in this report is based on a limited investigation designed to provide information to support an assessment of the current environmental conditions within the subject property. The conclusions and recommendations presented in this report reflect site conditions existing at the time of the investigation. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent. Should this occur, exp Services Inc. should be contacted to assess the situation, and the need for additional testing and reporting. **Exp** has qualified personnel to provide assistance in regards to any future geotechnical and environmental issues related to this property.

Our undertaking at exp, therefore, is to perform our work within limits prescribed by our clients, with the usual thoroughness and competence of the engineering profession. It is intended that the outcome of this investigation assist in reducing the client's risk associated with environmental impairment. Our work should not be considered 'risk mitigation'. No other warranty or representation, either expressed or implied, is included or intended in this report.

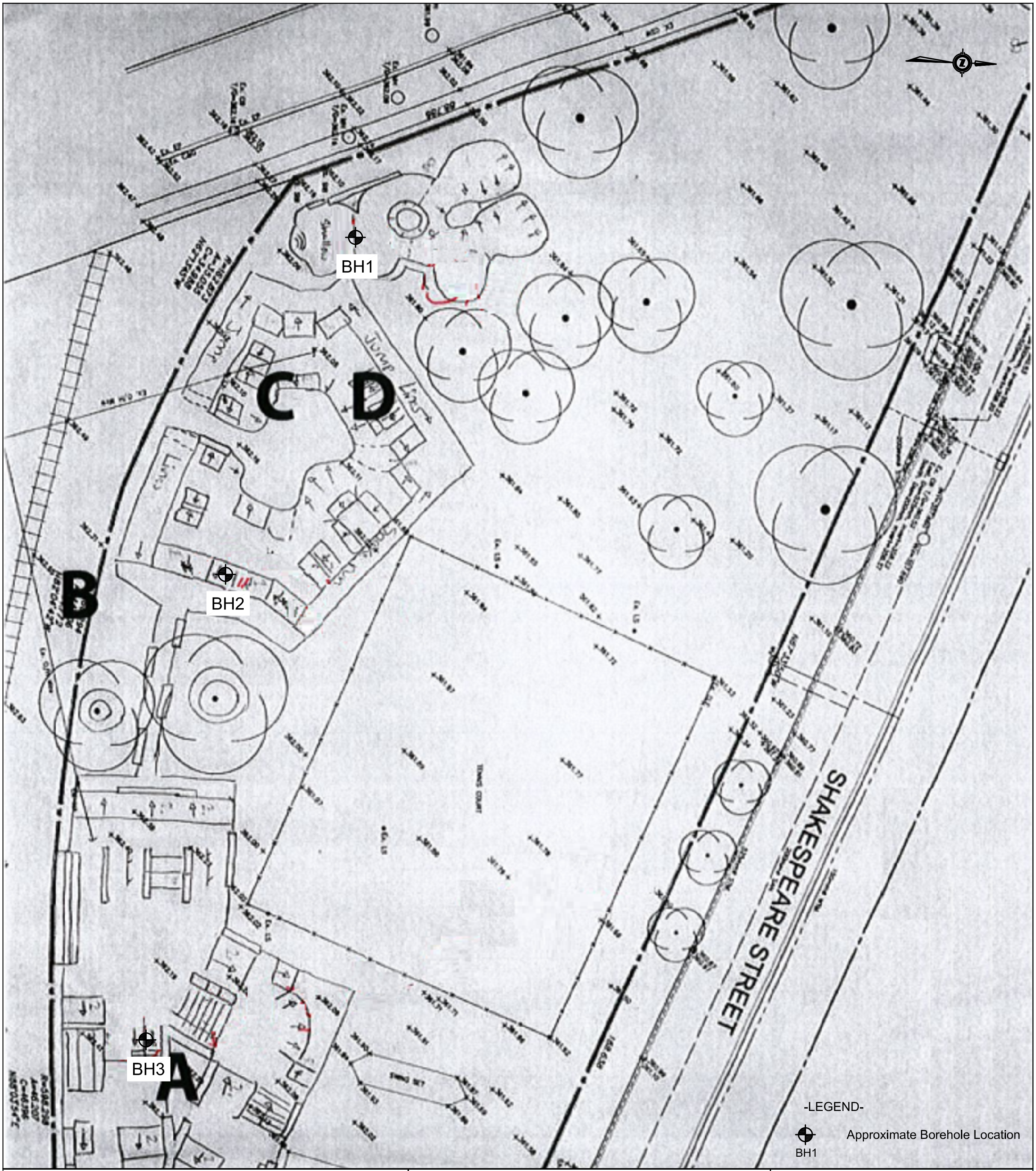
The comments given in this report are intended only for the guidance of design engineers. The number of test holes required to determine the localized underground conditions between test holes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

Exp Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not afforded the privilege of making this review, **exp** Services Inc. will assume no responsibility for interpretation of the recommendations in this report

This report was prepared for the exclusive use of The City of Stratford and may not be reproduced in whole or in part, without the prior written consent of exp, or used or relied upon in whole or in part by other parties for any purposes whatsoever. Any use which a third party makes of this report, or any part thereof, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. **Exp** Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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

Appendix A – Drawings



-NOTES-

1. The boundaries and soil types have been established only at test hole locations. Between test holes they are assumed and may be subject to considerable error.
2. Soil samples will be retained in storage for 3 months and then destroyed unless client advises that an extended time period is required.
3. Topsoil quantities should not be established from the information provided at the test hole locations.
4. The site plan has been reproduced from drawing provided by the client and should be read in conjunction with exp Geotechnical Report KCH-00236500-GE.

Geotechnical Investigation

Shakespeare Street Skate Park

Stratford, Ontario

CLIENT The Corporation of the City of Stratford

TITLE Borehole Location Plan

DRAWN BY:	REVIEWED BY:	SCALE
E.B.	G.F.	NTS

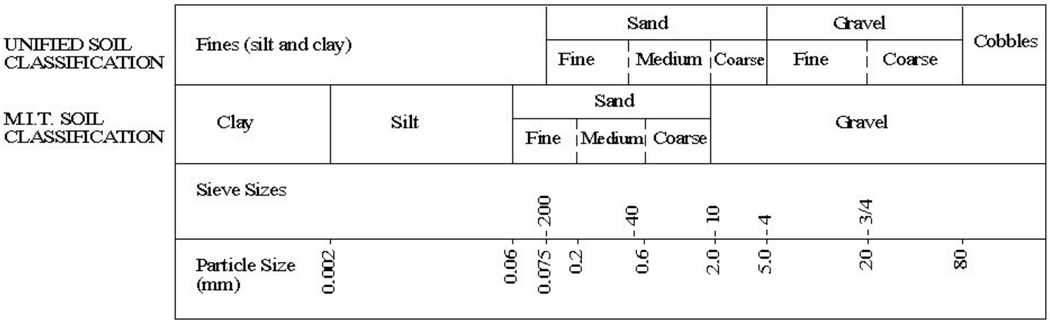
exp Services Inc.
15701 Robin's Hill Road
London, ON, N5V 0A5

DATE	PROJECT NO.	DWG.
JANUARY 2017	KCH-00236500-GE	1

Appendix B – Borehole Logs

NOTES ON SAMPLE DESCRIPTIONS

1. All descriptions included in this report follow the 'modified' Massachusetts Institute of Technology (M.I.T.) soil classification system. The laboratory grain-size analysis also follows this classification system. Others may designate the Unified Classification System as their source; a comparison of the two is shown for your information. Please note that, with the exception of those samples where the grain size analysis has been carried out, all samples are classified visually and the accuracy of the visual examination is not sufficient to differentiate between the classification systems or exact grain sizing. The M.I.T. system has been modified and the **exp** classification includes a designation for cobbles above the 75 mm size and boulders above the 200 mm size.



2. **Fill**: Where fill is designated on the borehole log, it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description therefore, may not be applicable as a general description of the site fill material. All fills should be expected to contain obstructions such as large concrete pieces or subsurface basements, floors, tanks, even though none of these obstructions may have been encountered in the borehole. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact and correct composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. The fill at this site has been monitored for the presence of methane gas and the results are recorded on the borehole logs. The monitoring process neither indicates the volume of gas that can be potentially generated or pinpoints the source of the gas. These readings are to advise of a potential or existing problem (if they exist) and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic waste that renders the material unacceptable for deposition in any but designated land fill sites; unless specifically stated, the fill on the site has not been tested for contaminants that may be considered hazardous. This testing and a potential hazard study can be carried out if you so request. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common, but not detectable using conventional geotechnical procedures.

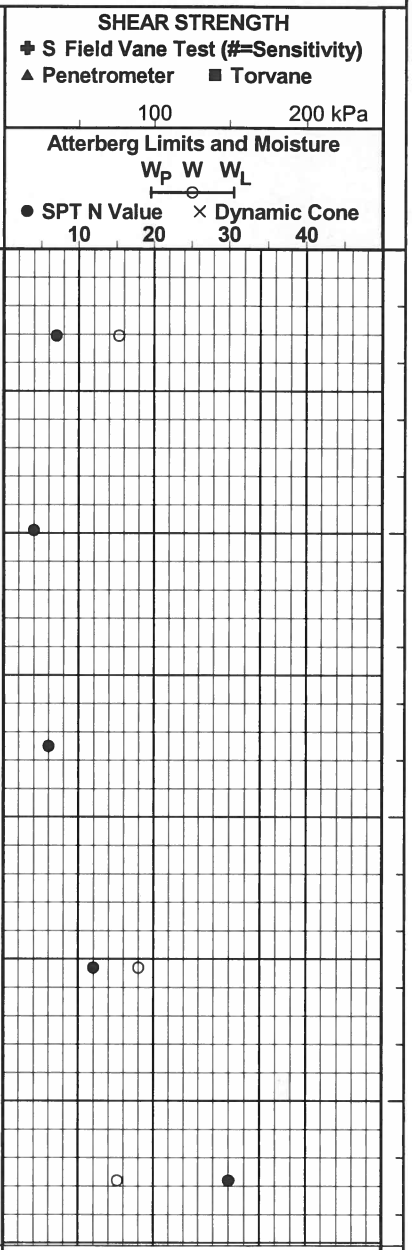
3. **Glacial Till**: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process, the till must be considered heterogeneous in composition and as such, may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (75 to 200 mm in diameter) or boulders (greater than 200 mm diameter) and therefore, contractors may encounter them during excavation, even if they are not indicated on the borehole logs. It should be appreciated that normal sampling equipment can not differentiate the size or type of obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited area; therefore, caution is essential when dealing with sensitive excavations or dewatering programs in till material.

BOREHOLE LOG

BH1
Sheet 1 of 1

PROJECT **Skate Park, Shakespeare St, Stratford, ON** PROJECT NO. **KCH-00236500-GE**
CLIENT **The Corporation of the City of Stratford** DATUM **Local**
DRILL TYPE/METHOD **Solid Stem Augers** DATES: Boring **Dec 5, 2016** Water Level

DEPTH (m)	ELEVATION (m) 99.3	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	NUMBER	RECOVERY (mm) or (%)	N VALUE (blows) or RQD (%)	PENETROMETER (kPa)
0	99.2	**TOPSOIL**: ~ 125 mm thick							
		FILL: Dark brown/black, silty sand, some gravel with organics, loose, moist			▨	S1	150	7	
1					▨	S2	150	4	
	97.4			∇	▨	S3	150	6	
2		**CLAYEY SILT**: Brown, some sand, trace to some gravel, compact, wet			▨	S4	250	12	
	96.6								
3	95.8	**SANDY SILT TILL**: Brown, some clay, dense, moist			▨	S5	350	30	
4		**End of Borehole at 3.51 m depth**							



NOTES

1) Borehole interpretation requires assistance by exp before use by others. Borehole Logs must be read in conjunction with exp Report KCH-00236500-GE. For definition of terms used on logs, see sheets prior to logs.
2) Borehole open and water observed at 1.85 m upon completion.

SAMPLE LEGEND
☒ AS Auger Sample ▨ SS Split Spoon ■ ST Shelby Tube
▥ Rock Core (eg. BQ, NQ, etc.) ▥ VN Vane Sample

OTHER TESTS
G Specific Gravity C Consolidation
H Hydrometer CD Consolidated Drained Triaxial
S Sieve Analysis CU Consolidated Undrained Triaxial
γ Unit Weight UU Unconsolidated Undrained Triaxial
P Field Permeability UC Unconfined Compression
K Lab Permeability DS Direct Shear

WATER LEVELS
∇ Apparent ▼ Measured ▲ Artesian (see Notes)

BOREHOLE LOG

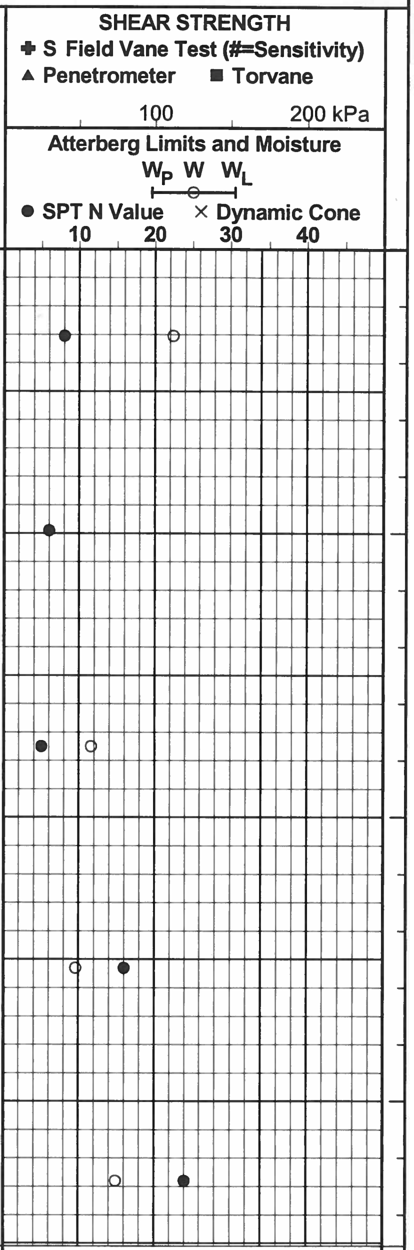
exp.

BH2
Sheet 1 of 1

PROJECT **Skate Park, Shakespeare St, Stratford, ON**
PROJECT NO. **KCH-00236500-GE**
CLIENT **The Corporation of the City of Stratford**
DATUM **Local**
DRILL TYPE/METHOD **Solid Stem Augers**
DATES: Boring **Dec 5, 2016**
Water Level

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	SAMPLES TYPE	SAMPLES NUMBER	RECOVERY (mm) or (%)	N VALUE (blows) or RQD (%)	PENETROMETER (kPa)
0	99.0						
	98.9	**TOPSOIL**: ~ 125 mm thick					
		FILL: Dark brown/black, silty sand, some gravel with organics and brick fragments, loose, moist	▨	S1	150	8	
1			▨	S2	150	6	
	97.1		▨	S3	150	5	
2		**SILTY SAND**: Brown, trace clay and gravel, compact, very moist	▨	S4	250	16	
	96.3						
3		**SANDY SILT TILL**: Brown, trace clay, compact, moist	▨	S5	350	24	
	95.5	**End of Borehole at 3.51 m depth**					
4							

WELL LOG: ⊻ at approximately 3.0 m



SAMPLE LEGEND
☒ AS Auger Sample ▨ SS Split Spoon ■ ST Shelby Tube
◫ Rock Core (eg. BQ, NQ, etc.) ▣ VN Vane Sample

OTHER TESTS

G Specific Gravity	C Consolidation
H Hydrometer	CD Consolidated Drained Triaxial
S Sieve Analysis	CU Consolidated Undrained Triaxial
γ Unit Weight	UU Unconsolidated Undrained Triaxial
P Field Permeability	UC Unconfined Compression
K Lab Permeability	DS Direct Shear

WATER LEVELS
⊻ Apparent ▼ Measured ⊼ Artesian (see Notes)

NOTES

1) Borehole interpretation requires assistance by exp before use by others. Borehole Logs must be read in conjunction with exp Report KCH-00236500-GE. For definition of terms used on logs, see sheets prior to logs.
2) Borehole open and water observed at 3.0 m upon completion.

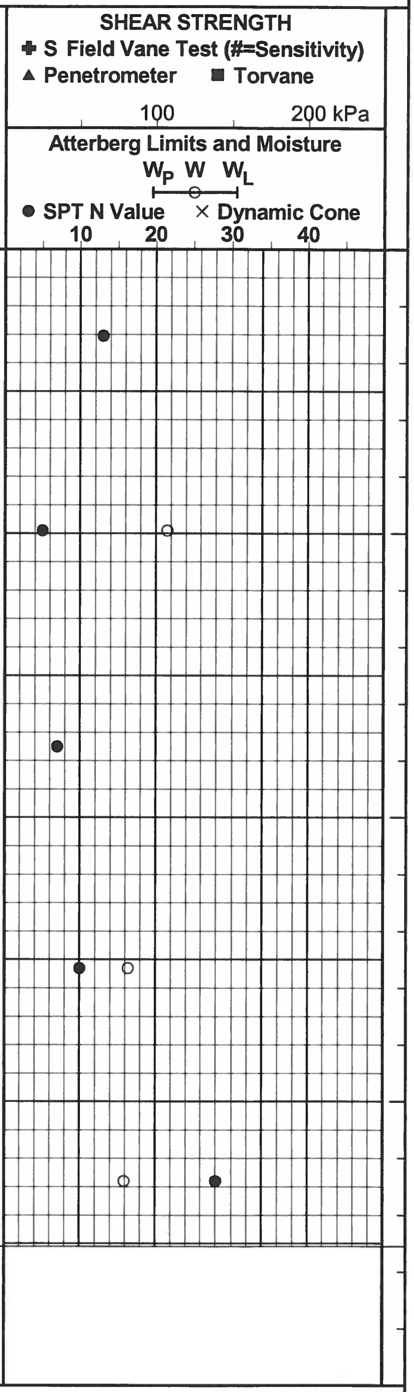
BOREHOLE LOG

BH 3
Sheet 1 of 1

PROJECT **Skate Park, Shakespeare St, Stratford, ON** PROJECT NO. **KCH-00236500-GE**
CLIENT **The Corporation of the City of Stratford** DATUM **Local**
DRILL TYPE/METHOD **Solid Stem Augers** DATES: Boring **Dec 5, 2016** Water Level

DEPTH (m)	ELEVATION (m) 100.0	STRATA DESCRIPTION
0	99.9	**TOPSOIL**: ~ 125 mm thick
		FILL: Dark brown/black, silty sand, some gravel with organics, compact to loose, moist
	98.0	
2		**SANDY SILT**: Brown, trace to some clay, trace gravel, compact, moist
	97.2	
		SANDY SILT TILL: Brown, trace clay, compact, moist
	96.5	
		End of Borehole at 3.51 m depth

SAMPLES TYPE	NUMBER	RECOVERY (mm) or (%)	N VALUE (blows) or RQD (%)
▨	S1	300	13
▨	S2	100	5
▨	S3	300	7
▨	S4	500	10
▨	S5	500	28



NOTES

1) Borehole interpretation requires assistance by exp before use by others. Borehole Logs must be read in conjunction with exp Report KCH-00236500-GE. For definition of terms used on logs, see sheets prior to logs.
2) Borehole open and dry upon completion.

SAMPLE LEGEND
☒ AS Auger Sample ▨ SS Split Spoon ■ ST Shelby Tube
▥ Rock Core (eg. BQ, NQ, etc.) ⊡ VN Vane Sample

OTHER TESTS

G Specific Gravity	C Consolidation
H Hydrometer	CD Consolidated Drained Triaxial
S Sieve Analysis	CU Consolidated Undrained Triaxial
γ Unit Weight	UU Unconsolidated Undrained Triaxial
P Field Permeability	UC Unconfined Compression
K Lab Permeability	DS Direct Shear

WATER LEVELS
▽ Apparent ▼ Measured ▲ Artesian (see Notes)

Appendix C – Certificates of Analysis

Your Project #: KCH-00236500-GE
Site Location: STRATFORD
Your C.O.C. #: na

Attention:Geordy Fournier
exp Services Inc
405 Maple Grove Rd
Unit 6
Cambridge, ON
N2E 1B6

Report Date: 2016/12/22
Report #: R4299093
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B6R3594
Received: 2016/12/15, 12:30

Sample Matrix: Soil
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Petroleum Hydrocarbons F2-F4 in Soil (1)	2	2016/12/17	2016/12/19	CAM SOP-00316	CCME CWS m
Mercury (TCLP Leachable) (mg/L)	2	N/A	2016/12/21	CAM SOP-00453	EPA 7470A m
Total Metals in TCLP Leachate by ICPMS	2	2016/12/20	2016/12/20	CAM SOP-00447	EPA 6020B m
Moisture	2	N/A	2016/12/19	CAM SOP-00445	Carter 2nd ed 51.2 m
TCLP - % Solids	2	2016/12/19	2016/12/20	CAM SOP-00401	EPA 1311 Update I m
TCLP - Extraction Fluid	2	N/A	2016/12/20	CAM SOP-00401	EPA 1311 Update I m
TCLP - Initial and final pH	2	N/A	2016/12/20	CAM SOP-00401	EPA 1311 Update I m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods. Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) All CCME PHC results met required criteria unless otherwise stated in the report. The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following "Alberta Environment's Interpretation of the Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil Validation of Performance-Based Alternative Methods September 2003". Documentation is available upon request. Modifications from Reference Method for the Canada-wide Standard for Petroleum Hydrocarbons in Soil-Tier 1 Method: F2/F3/F4 data reported using validated cold solvent extraction instead of Soxhlet extraction.

Maxxam
A Bureau Veritas Group Company

Your Project #: KCH-00236500-GE
Site Location: STRATFORD
Your C.O.C. #: na

Attention:Geordy Fournier

exp Services Inc
405 Maple Grove Rd
Unit 6
Cambridge, ON
N2E 1B6

Report Date: 2016/12/22
Report #: R4299093
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B6R3594
Received: 2016/12/15, 12:30

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total Cover Pages : 2

O.REG 558 TCLP LEACHATE PREPARATION (SOIL)

Maxxam ID		DQF923	DQF924		
Sampling Date		2016/12/05	2016/12/05		
COC Number		na	na		
	UNITS	**BH1 S1/S2**	**BH3 S2**	**RDL**	**QC Batch**
Inorganics					
Final pH	pH	5.24	6.15		4799306
Initial pH	pH	8.83	8.69		4799306
TCLP - % Solids	%	100	100	0.2	4799301
TCLP Extraction Fluid	N/A	FLUID 1	FLUID 1		4799303

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

O.REG 558 TCLP METALS (SOIL)

Maxxam ID			DQF923	DQF924		
Sampling Date			2016/12/05	2016/12/05		
COC Number			na	na		
	UNITS	**558**	**BH1 S1/S2**	**BH3 S2**	**RDL**	**QC Batch**
Metals						
Leachable Mercury (Hg)	mg/L	**0.1**	<0.0010	<0.0010	0.0010	4801293
Leachable Arsenic (As)	mg/L	**2.5**	<0.2	<0.2	0.2	4800326
Leachable Barium (Ba)	mg/L	**100**	0.3	0.5	0.2	4800326
Leachable Boron (B)	mg/L	**500**	0.2	0.1	0.1	4800326
Leachable Cadmium (Cd)	mg/L	**0.5**	<0.05	<0.05	0.05	4800326
Leachable Chromium (Cr)	mg/L	**5**	<0.1	<0.1	0.1	4800326
Leachable Lead (Pb)	mg/L	**5**	<0.1	<0.1	0.1	4800326
Leachable Selenium (Se)	mg/L	**1**	<0.1	<0.1	0.1	4800326
Leachable Silver (Ag)	mg/L	**5**	<0.01	<0.01	0.01	4800326
Leachable Uranium (U)	mg/L	**10**	<0.01	<0.01	0.01	4800326

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

558: Ontario Reg. 347/90 Schedule 4 Leachate Quality Criteria (as amended by Reg 558/00)

RESULTS OF ANALYSES OF SOIL

Maxxam ID		DQF925		DQF926		
Sampling Date		2016/12/05		2016/12/05		
COC Number		na		na		
	UNITS	**BH1 S3**	**QC Batch**	**BH3 S3**	**RDL**	**QC Batch**
Inorganics						
Moisture	%	18	4798245	34	1.0	4798092

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

PETROLEUM HYDROCARBONS (CCME)

Maxxam ID		DQF925	DQF926		
Sampling Date		2016/12/05	2016/12/05		
COC Number		na	na		
	UNITS	**BH1 S3**	**BH3 S3**	**RDL**	**QC Batch**
F2-F4 Hydrocarbons					
F2 (C10-C16 Hydrocarbons)	ug/g	<10	<10	10	4797374
F3 (C16-C34 Hydrocarbons)	ug/g	<50	<50	50	4797374
F4 (C34-C50 Hydrocarbons)	ug/g	<50	<50	50	4797374
Reached Baseline at C50	ug/g	Yes	Yes		4797374
Surrogate Recovery (%)					
o-Terphenyl	%	89	91		4797374

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

TEST SUMMARY

Maxxam ID: DQF923
Sample ID: BH1 S1/S2
Matrix: Soil

Collected: 2016/12/05
Shipped:
Received: 2016/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Mercury (TCLP Leachable) (mg/L)	CV/AA	4801293	N/A	2016/12/21	Magdalena Carlos
Total Metals in TCLP Leachate by ICPMS	ICP1/MS	4800326	2016/12/20	2016/12/20	Kevin Comerford
TCLP - % Solids	BAL	4799301	2016/12/19	2016/12/20	Jingwei (Alvin) Shi
TCLP - Extraction Fluid		4799303	N/A	2016/12/20	Jingwei (Alvin) Shi
TCLP - Initial and final pH	PH	4799306	N/A	2016/12/20	Jingwei (Alvin) Shi

Maxxam ID: DQF924
Sample ID: BH3 S2
Matrix: Soil

Collected: 2016/12/05
Shipped:
Received: 2016/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Mercury (TCLP Leachable) (mg/L)	CV/AA	4801293	N/A	2016/12/21	Magdalena Carlos
Total Metals in TCLP Leachate by ICPMS	ICP1/MS	4800326	2016/12/20	2016/12/20	Kevin Comerford
TCLP - % Solids	BAL	4799301	2016/12/19	2016/12/20	Jingwei (Alvin) Shi
TCLP - Extraction Fluid		4799303	N/A	2016/12/20	Jingwei (Alvin) Shi
TCLP - Initial and final pH	PH	4799306	N/A	2016/12/20	Jingwei (Alvin) Shi

Maxxam ID: DQF925
Sample ID: BH1 S3
Matrix: Soil

Collected: 2016/12/05
Shipped:
Received: 2016/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydrocarbons F2-F4 in Soil	GC/FID	4797374	2016/12/17	2016/12/19	Dorina Popa
Moisture	BAL	4798245	N/A	2016/12/19	Prgya Panchal

Maxxam ID: DQF926
Sample ID: BH3 S3
Matrix: Soil

Collected: 2016/12/05
Shipped:
Received: 2016/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydrocarbons F2-F4 in Soil	GC/FID	4797374	2016/12/17	2016/12/19	Dorina Popa
Moisture	BAL	4798092	N/A	2016/12/19	Min Yang

GENERAL COMMENTS

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD		Leachate Blank	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	Value	UNITS
4797374	o-Terphenyl	2016/12/19	87	60 - 130	84	60 - 130	92	%				
4797374	F2 (C10-C16 Hydrocarbons)	2016/12/19	81	50 - 130	82	80 - 120	<10	ug/g	NC	30		
4797374	F3 (C16-C34 Hydrocarbons)	2016/12/19	82	50 - 130	81	80 - 120	<50	ug/g	NC	30		
4797374	F4 (C34-C50 Hydrocarbons)	2016/12/19	83	50 - 130	82	80 - 120	<50	ug/g	NC	30		
4798092	Moisture	2016/12/19							2.6	20		
4798245	Moisture	2016/12/19							1.8	20		
4800326	Leachable Arsenic (As)	2016/12/20	NC	80 - 120	99	80 - 120			NC	35	<0.2	mg/L
4800326	Leachable Barium (Ba)	2016/12/20	NC	80 - 120	100	80 - 120			NC	35	<0.2	mg/L
4800326	Leachable Boron (B)	2016/12/20	NC	80 - 120	101	80 - 120			NC	35	<0.1	mg/L
4800326	Leachable Cadmium (Cd)	2016/12/20	103	80 - 120	100	80 - 120			NC	35	<0.05	mg/L
4800326	Leachable Chromium (Cr)	2016/12/20	93	80 - 120	95	80 - 120			NC	35	<0.1	mg/L
4800326	Leachable Lead (Pb)	2016/12/20	95	80 - 120	97	80 - 120			NC	35	<0.1	mg/L
4800326	Leachable Selenium (Se)	2016/12/20	96	80 - 120	100	80 - 120			NC	35	<0.1	mg/L
4800326	Leachable Silver (Ag)	2016/12/20	97	80 - 120	96	80 - 120			NC	35	<0.01	mg/L
4800326	Leachable Uranium (U)	2016/12/20	93	80 - 120	96	80 - 120			NC	35	<0.01	mg/L
4801293	Leachable Mercury (Hg)	2016/12/21	112	75 - 125	108	80 - 120	<0.0010	mg/L	NC	25	<0.0010	mg/L

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Leachate Blank: A blank matrix containing all reagents used in the leaching procedure. Used to determine any process contamination.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Eva Pranjic

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.