

City of Iqaluit

Geotechnical Investigation

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Project Name

Geotechnical Investigation Proposed Waste Transfer Station Lots 3586 228/17/18/20 and 3480 220 1 Iqaluit, Nunavut

Project Number OTT-00248813-A0

Prepared By:

EXP Services Inc. 100-2650 Queensview Drive Ottawa, ON K2B 8H6 Canada

Date Submitted October 19, 2018

City of Iqaluit

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Geotechnical Investigation

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Project Name:

Geotechnical Investigation Proposed Waste Transfer Station Qaqqamuit Road, Iqaluit, Nunavut

Project Number:

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Executive Summary

A geotechnical investigation was undertaken at the site of the proposed Waste Transfer Station to be located on Qaqqamuit Road in the City of Iqaluit, Nunavut. This work was authorized by the City of Iqaluit via Service Contract SC000818 dated August 16, 2018.

Preliminary information indicates that the proposed structure will be an insulated metal-clad building set on a concrete pad at grade. It would be located on a 2.4-hectare site. The exact location of the structure on the site and the structural details of the proposed structures were not available at the time of the preparation of this report. It is understood that other buildings may also be located at the site.

The geotechnical investigation comprised of drilling six boreholes across the site to a depth of 10 m to 15 m. The fieldwork was undertaken with an air-track drill rented from a local drilling company. During drilling, bulk soil samples were obtained from the boreholes at selected depths. The investigation revealed that the surficial soil at the site is generally sand fill, which extends to 1.5 m to 2.5 m depth (Elev. 24.4 m to 26.4 m). The fill in the central part of the site (Borehole Nos. 1 and 3 to 5) is underlain by gravelly sand to sandy gravel to 3.1 m to 9.5 m depth (Elev. 18.4 m to 25.4 m). The predominant soil underlying this stratum in the north part of the site (Borehole Nos. 1 to 3) is well graded sand to gravelly sand, which extends to the entire depth investigated (i.e. 10 m to 15 m). In the south part of the site, the predominant soil underlying the gravelly sand to sandy gravel stratum is poorly graded sand, which extends to the entire depth investigated (i.e. 10 m to 15 m).

Free water was encountered in Borehole Nos. 2 to 5 and the groundwater table was established at a depth of 1.2 m to 3.0 m below the existing ground surface (Elev. 24.9 to 26 m.)

The investigation has revealed that the geotechnical conditions at the site are suitable for construction of the proposed building on a concrete pad at grade with provisions of extruded polystyrene (EPS) insulation and thermosyphons to maintain the soil below the founding level permanently frozen. Adfreeze piles are not suitable for slab on grade structures because of loss of heat from the building to the piles. End bearing piles are not feasible since bedrock was not encountered to the maximum depth investigated, i.e. 15 m. The concrete pad should be set on an engineered granular fill mat. The thickness of the granular mat would have to be established by undertaking a geothermal analysis of the site. The Serviceability Limit State (SLS) bearing pressure will be a function of the compressive strength of the insulation used as detailed in the report.

Any other structures proposed for the site may be founded on adfreeze piles so long as a minimum air gap of 600 mm is provided below the floor slab to prevent heat loss from the building to the piles. The criteria for design of the piles is presented in the report.

The site has been classified as Class C for seismic site classification in accordance with the requirements of the National Building Code, 2015. The on-site frozen soils are not susceptible to liquefaction during a seismic event.



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Limited chemical tests undertaken on selected soil samples indicate that General Use (GU) Portland cement may be used in the subsurface concrete at this site. The on-site soils are considered to be mildly corrosive to corrosive to buried steel. A corrosive specialist should be consulted if steel is to be buried at the site.

Excavation at the site for construction of the granular mat is expected to be relatively straight forward if undertaken during the cold months when the soil is frozen since only minimal free water would be encountered in the excavation. However, site dewatering would be required if construction is undertaken during the summer months to maintain the groundwater table below the excavation base level during construction and during the installation of the piles.

The exterior grade should be sloped away from the building to prevent water ponding adjacent to the structure.

The above and other related considerations have been discussed in greater detail in the report.



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1 Introduction

EXP Services Inc. (EXP) has carried out a geotechnical investigation at the site of the proposed Waste Transfer Station to be located on Qaqqamuit Road in the City of Iqaluit, Nunavut (Figure 1). This work was authorized by the City of Iqaluit via service contract SC000818 dated August 16, 2018.

The site under consideration is to be located on City Lots 3586 228/17/18/20 and 3480 220 1 located approximately 1 to 2 km north of the Iqaluit Airport. The site is approximately 2.4 hectares with one half currently occupied by site office trailers, shipping containers and a fire training centre used by the City fire department. The other half of the site is used for material storage by a local contractor.

Preliminary information indicates that the transfer station will be an insulated metal-clad building on a concrete pad. Its location on the site and structural loads were not known at the time of preparation of this report. Other structures may be also constructed at the site as part of the site development.

The geotechnical investigation was undertaken to:

- i) Establish the geotechnical and groundwater profile at the site;
- ii) Establish active layer thickness;
- iii) Determine the most suitable type of foundations, founding depth and Serviceability Limit State (SLS) and Ultimate Limit State (ULS) of the bearing stratum;
- iv) Assess the site for seismic site classification in accordance with the requirements of National Building Code of Canada, 2015 edition and comment on liquefaction potential of on-site soils;
- v) Provide recommendations for site dewatering during construction;
- vi) Discuss site drainage;
- vii) Comment on perimeter and underfloor drainage requirements;
- viii) Provide recommendations for backfill materials and compaction requirements for slab-on-grade construction;
- ix) Discuss suitability of on-site materials as backfill.

The comments and recommendations given in this report are based on the assumption that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations or it may require additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.



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2 Procedure

The fieldwork for this project was undertaken on September 14, 2018 using an air-track drill rented from a local drilling company. The fieldwork was supervised on a full-time basis by a senior geotechnician from EXP experienced with permafrost soils and northern construction techniques. The fieldwork consisted of drilling a total of six boreholes (Borehole Nos. 1 to 6) to 10 m to 15 m depth.

The locations of the boreholes were established in the field by EXP's representative and are shown on the appended Site Plan, Figure 2. Elevations of the boreholes were established by a survey crew from EXP and refer to a geodetic datum.

During drilling, bulk soil samples were obtained from different depths from each borehole. All the soil samples retrieved were visually examined and logged. Samples were preserved in watertight plastic bags. A portion of each sample was wrapped in tin foil, placed in a smaller plastic bag and weighed on-site to assure accurate moisture content determination. The soil samples were transported to the EXP laboratory in the City of Ottawa, Ontario where they were visually examined in the laboratory by a senior geotechnical engineer and borehole logs prepared. The engineer also assigned the laboratory testing which consisted of performing natural moisture content on all the samples and grain-size analyses, pH, sulphate, chloride, and electrical conductivity tests on selected soil samples.

In addition to the above fieldwork, nine (9) test pits were excavated at the site by EXP as part of the Phase II Environmental Site assessment (ESA) which was completed prior to the geotechnical investigation. Logs of the test pits excavated as part of the Phase II ESA are included in Appendix A.

Multi-bead thermistors were installed in Borehole Nos. 2 and 4, whereas a slotted standpipe was installed in Borehole Nos. 2 and 5. The installation configuration of the thermistors and piezometers are presented on the respective borehole logs.



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3 Site Description

The site is located on the south side of Qaqqamuit Road adjacent to an active aggregate pit in the City of Iqaluit, Nunavut. It comprises of Lots 3586 228/17/18/20 and 3480 220 1. It is located approximately 1 km to 2 km north of the Iqaluit Airport. It is approximately 2.4 hectares in size. One half of the site is currently occupied by office trailers, shipping containers and fire training centre used ty the City fire department. The other half of the site is occupied by a local contractor for storage of materials.

The site is mainly flat lying with a gentle slope to the south. The ground surface elevations at the site vary from Elev. 29.9 m approximately close to the north property boundary to Elev. 27.6 m close to the south property boundary.



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4 Site Geology

The site is located in the glacial marine delta comprising of sand, silt, boulders and gravel. The thickness of this deposit varies from 2 m to 30 m. The sediments are massive to cross-bedded moving upwards in ice-contact deposits, or at termination of outwash trains or melt-water channels.

The bedrock at the site is expected to be Monzogranite of the Paleoproterozoic Cumberland Batholith (batholith is a large body of igneous rock formed beneath the Earth's surface by the intrusion and solidification of magma. It is commonly comprised of coarse-grained rocks, e.g. granite or granodiorite with surface exposure of 100 sq. kms or larger). Cumberland Batholith is 2500 to 1600 million years old. (Paleoproterozoic Era).



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5 Soil Description

A detailed description of the subsurface soil and groundwater conditions determined form the boreholes are given on the attached Borehole Logs, Figures 3 to 8 inclusive. The borehole logs and related information depict subsurface conditions only at the specific locations and times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the locations where sampling was conducted. The passage of time also may result in changes in the conditions interpreted to exist at the locations where sampling was conducted. Boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of potential environmental conditions.

It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The "Note on Sample Descriptions" preceding the borehole logs form an integral part of this report and should be read in conjunction with this report.

A review of the borehole logs indicates the following soil stratigraphy in descending order:

5.1 Fill (GP)

The surficial soil at the site is fill, which extends to 1.5 m to 2.5 m depth (Elev. 24.4 m to 26.5 m). The fill consists of gravelly sand to sandy gravel. A grain-size analysis undertaken on the fill sample from Test Pit No. 5 excavated for the environmental work is given on Figure 9. It indicates a soil composition of 1 percent clay and silt, 17 percent sand, and 82 percent gravel.

5.2 Gravelly Sand to sandy Gravel (SW-GP)

The fill in Boreholes 1 and 3 to 5 is underlain by gravelly sand to sandy gravel, which extends to a depth of 3.1 m to 9.5 m (Elev. 18.4 m to 25.4 m). Two grain-size analyses performed on this stratum from Test Pits 1 and 12 excavated for the environmental investigation are given on Figures 10 and 11. A review of these figures indicates a soil composition of 0 to 12 percent silty and clay, 43 to 59 percent sand and 29 to 57 percent gravel. Th moisture content of this stratum varies from 4 to 16 percent. Ice lenses were encountered in this stratum in Borehole No. 3 from 5.5 m to 9.5 m depth. Free water was encountered below 1.2 m to 3 m depth when drilling through this stratum, i..e on Borehole Nos. 3 and 5.

5.3 Void

A 0.9 m void was encountered in Borehole No. 1 from 3.1 m to 4.0 m depth (Elev. 24.5 m to 25.4 m). This void is likely the result of melting of the ice lens during drilling.



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5.4 Well Graded Sand to Gravelly Sand (SW)

Beneath the void in Borehole No. 1, the fill in Borehole No 2, and the gravelly sand stratum in Borehole No. 3, well graded sand extends to the entire depth investigated in the boreholes, i.e. 10 m to 15 m depth (Elev. 12.9 m to 18.5 m). The stratum comprises of 4 to 8 percent clay and silt, 68 to 85 percent sand and 10 to 28 percent gravel (Figures 12 to 14). The natural moisture content of this stratum varies from 6 to 13 percent. Free water was encountered in this stratum at 1.5 m depth in Borehole Nos. 2, and 3 m depth in Borehole No. 3. In addition, ice lenses were observed in the soil samples for Borehole No. 3 between 9.5 m and 13 m depth.

5.5 Poorly Graded Sand (SP)

The gravelly sand to sandy gravel stratum in Borehole Nos. 4 and 5 and the fill in Borehole No. 6 are underlain by poorly graded sand (SP) to the entire depth investigated in all the boreholes, i.e. 10 m depth (Elev. 12.5 m to 17.3 m). This stratum comprises of 9 to 15 percent clay and silt, 85 to 91 percent sand and 0 percent gravel (Figures 15 to 17).

5.6 Groundwater

Groundwater observations were made in the boreholes during drilling and subsequent to drilling in piezometer installed in Borehole Nos. 2 and 5. The groundwater observations have been summarized on Table 1.

Та	ible 1: Summary of Gr	oundwater Observatior	ıs
Borehole No.	Time of Observation During Drilling	Depth to Groundwater	Groundwater Elevation (m)
1	During drilling	Free water not encountered	
2	During drilling	1.5 m	25.4
	2 days after drilling	6.8 m (P)	20.1
3	During drilling	3.0 m	24.9
4	During drilling	1.5 m	25.8
5	2 days after drilling	1.2 m (P)	26.0
6	During drilling		
Note: (P) indicates obser	vations made in piezomete	er.	

A review of the above table indicates that groundwater table at the site is at a depth of 1.2 m to 3 m below the ground surface (Elev. 24.9 m to 26.0 m). The groundwater table in the piezometer installed in Borehole No. 2 had not likely stabilized by the time the observations were made.



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6 Ground Temperature

Multi-bead thermistors were installed in Borehole Nos. 2 and 4 to monitor the ground temperature. The readings obtained are shown on Table 2 below.

	Table 2: Gr	ound Temperature	Measurements	
D I . I . N	Ti continue Bond (co)	G	Ground Temperature (°C	C)
Borehole No.	Thermistor Depth (m)	September 17, 2018	September 18, 2018	September 21, 2018
	Air	0.0	2.0	
	Surface	0.0	2.2	3.8
	Surface	0.2	1.3	2.8
	Surface	0.2	0.8	5.0
	Surface	0.0	0.7	6.0
	Surface	-0.2	0.0	5.8
	Surface	-0.3	0.0	8.1
2	0.5	-0.3	-0.4	6.0
	1.0	0.3	-0.1	0.5
	2.0	0.9	0.7	0.3
	3.0	0.8	0.7	0.3
	4.0	0.3	0.3	0.2
	5.0	-0.1	-0.1	-0.2
	6.0	-1.5	-1.9	-1.9
	7.0	-2.6	-2.7	-2.7
	Air 0.0 2.0			<u> </u>
Borehole No.	Thermistor Depth (m)	September 16, 2018	September 17, 2018	September 18, 2018
	Air	0.0	0	2.0
	0.5	7.2	9.3	8.7
	1.0	1.8	1.2	1.4
	1.5	1.5	0.8	0.8
	2.0	1.4	0.8	0.5
	2.5	0.9	0.5	0.3
				0.2
Borehole No.			0.3	0.2
				-0.9
				-1.5
				-2.0
				-2.4
				-3.1
				-3.7
	10.0	-4.1	-4.4	-4.5



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A review of Table 2 indicates that the soil in Borehole Nos. 2 and 4 is not frozen to a depth of 4 m to 5 m. However, it is considered that the heat generated during drilling likely melted the permafrost in the soil samples. This is corroborated by the fact that 15 test pits examined at the site for the environmental work all met refusal to excavation with a backhoe at a depth of 1.4 m to 2.8 m. Also, field observations revealed that although the soils retrieved from Borehole No. 4 between 2 m and 10 m depth were not frozen, the temperature of the soil samples was below -1°C. Since the test pits were excavated during the first week of September 2018, it is considered that the refusal depth most likely represents the active layer thickness.



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7 Soil Salinity

The salinity of the soil at the site was measured by conducting electrical conductivity tests on selected soil samples. The test results are given on Table 3.

Table	3: Results of Salinity Tests	on Soil Samples
Borehole No.	Sample Depth (m)	Salinity Parts Per Thousand (ppt)
1	2.0 – 2.8	0.040
4	2.5	0.157
5	2.0	0.080
6	5.0	0.755

The above results indicate that the salinity of the soil varies from 0.04 ppt to 0.76 ppt. On the basis of these results, the soil may be classified as low salinity.



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8 Foundation Considerations

The investigation has revealed that the geotechnical conditions at the site are suitable for construction of the proposed metal-clad building on a concrete pad at grade with provision of EPS insulation and thermosyphons to maintain the soil below the founding level permanently frozen. Since the proposed structure is to have an at-grade floor, adfreeze piles are not feasible because of the loss of heat from the building to the piles will result in degradation of the permafrost adjacent to the piles and resultant loss of pile capacity. End bearing piles are not feasible since bedrock was not encountered at the site to the depth investigated, i.e. to 15 m.

Other structures proposed for this site may be founded on adfreeze piles provided a minimum of 0.6 m of air space is provided between the floor slab of the structure and the ground surface.

8.1 Concrete Mat Foundation

It is recommended that the proposed structure should be founded on a concrete mat set on an engineered granular fill pad incorporating EPS insulation and thermosyphon system.

Thermosyphons are two-phase passive refrigeration devices containing a fluid that transmits heat from the ground to the air when appropriate temperature differential exists. Therefore, they help to stabilize permafrost dependent infrastructure.

Thermosyphons extract heat from the ground and discharge it into the atmosphere whenever the air temperature is colder than the ground temperature. A commonly used fluid medium is carbon-dioxide that is contained in a closed 'pipe' pressure vessel. The thermosyphons remove heat from below the building by liquid gas phase change. During the winter, the outside air is colder than the ground temperature causing the gas in the pipe above the ground to condense and flow as a liquid to the base of the pipe. The warmer ground contact with the evaporator drops the pressure in the gas, thereby causing the fluid in the subsurface pipe to evaporate. Heat is extracted from the ground supporting the building and dissipated to the atmosphere throughout the winter. During the summer, the soil is preserved in frozen condition by a layer of insulation located above the horizontal evaporator pipes. Although there are four types of thermosyphons available, the flat loop system is the most commonly used system these days.

A thermosyphon foundation system consists of the following components:

- a.) Evaporator pipes below grade;
- b.) Radiator section on top of vertical conductor pipe;
- c.) Rigid insulation; and
- d.) A layer of non-frost susceptible gravel in which evaporator pipes and insulation are buried.



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It is noted that a geothermal analysis would be required for design of the thermosyphon system to establish the thickness and extent of granular pad, the thickness and extent of rigid insulation and the thermosyphon spacing and area required under the building.

The design proposes to place the floor slab of the building at existing site grade. To achieve this, excavation of the native soils to a depth established by the geothermal analysis would be required (likely 2 m approximately). The excavation should extend at least 2 m beyond the perimeter of the structure, or the insulation, whichever is greater, with the sides of the excavation cut back to 2H:1V. The engineered fill pad may be constructed up from the base of the excavation.

From a geotechnical perspective, the requirements would be that the granular bed should comprise thaw stable sand and gravel, preferably conforming to the gradation given on Table 4. The fill should be placed in 200 mm thick lifts at above freezing temperatures and each lift compacted to at least 98 percent of Standard Proctor Maximum Dry Density (SPMDD) in accordance with ASTM D698-12e2.

The placement and compaction of the granular fill pad should be undertaken under the supervision of a geotechnician working under the direction of a geotechnical engineer. In place density tests should be performed on each lift to ensure that the specified degree of compaction is being achieved.

The proposed structure should be founded on a concrete mat underlain by EPS insulation set on the engineered fill pad.

The SLS bearing pressure of the engineered fill pad will be a function of the compressive strength of the insulation used. If EPS insulation having a compressive strength of at least 275 kPa is used, the SLS bearing pressure should be limited to 90 kPa. If EPS insulation having a compressive strength of at least 400 kPa is used, the SLS bearing pressure for design purposes may be assumed as 130 kPa. It is noted that these SLS bearing pressures will be valid only if ice wedges or other massive ice bodies are not present under the building. Ice lenses were encountered in the soil during drilling. Whether ice wedges are also present can be best determined by examining the excavation base during construction. The corresponding modulus of subgrade reaction of the engineered pad may be taken as 35 MPa/m and 50 MPa/m for EPS insulation with compressive strengths of 275 kPa and 400 kPa, respectively.



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Table 4: P	hysical Requireme	nts of Engineered Fill
Gradation	ASTM	Pents of Engineered Fill Requirements Percent Passing 100 50 – 100 20 – 55 10 – 40 5 – 22 0 – 10 60 % minimum 0 Max 15%
Sieve Size		Percent Passing
100 mm		100
25 mm		50 – 100
4.75 mm	ASTM C-136M	20 – 55
1.18 mm		10 – 40
300 μm		5 – 22
75 μm		0 – 10
Percent Crushed (two faces)		60 % minimum
Plasticity Index	ASTM D4318	0
Flat Elongated	ASTM D4791	Max 15%

8.2 Adfreeze Piles

Other structures proposed for the site may be founded on adfreeze piles provided that a minimum of 0.6 m of air gap is provided between the floor slab of the building and the ground surface to prevent the transference of heat from the building to the piles.

Based on results of the investigation and a review of the available information, the following parameters and scenarios were used in computing the load carrying capacity of the adfreeze piles.

- Design active layer thicknesses = 3.0 m
- Mean annual ground temperature = 6.5°C
- Allowance for global warming = + 2°C
- Pore water salinity = <2 ppt
- Design mean annual ground temperature = 2°C
- Assumed Pile diameter = 114 mm and 141 mm
- Allowable long-term settlement of the piles = 25 mm in 25 years.

The Serviceability Limit State (SLS) of the piles are given on Table 5.



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Table 5: Adfreeze Strength of Piles										
Pile Diameter (mm)	Depth of Pile below final grade (m)	SLS Ad-Freeze Strength (KPa)								
114	0 – 3.0 m	0								
114	below 3.0 m	45								
1.11	0 – 3.0 m	0								
141	Below 3.0 m	45								

In order to compute the minimum embedment for each pile type to resist anticipated frost jacking forces, a frost jacking force of 150 kPa through the design active layer thickness of 3.0 m should be used. Therefore, a minimum embedment length of 13 m should be used for design of the pile. In addition, it is recommended that the upper portion of each pile within the design 3.0 m active zone should be covered with heavy grease and wrapped with polyethylene sheets coated with heavy grease to minimize uplift forces. For lateral load design purposes, the upper 3.0 m of the piles should also be considered as unsupported.

Adfreeze piles carry the load in bond between the pile and the surrounding soil. Normal practice is to use sand slurry for this purpose. It is essential that a good bond is developed between the pile and the frozen sand slurry. Round hollow structural section (HSS) steel is recommended as the pile material. The steel piles below 3.0 m active zone must be properly cleaned. They must be free of paint, lacquer, oil, grease, dirt and excessive rust to ensure development of a good bond.

The piles should be installed open ended in pre-drilled oversized holes. In order to obtain proper backfill around a pile, the hole should be partially backfilled with saline free sand and fresh water slurry prior to installing the pile. The pile should then be placed in the hole and vibrated down to the bottom of the hole whilst adding more sand and fresh water around the pile diameter.

Piles installed according to the above procedure will require a hole which is 50 mm larger in diameter than the outside diameter of the pile. The interior of the piles should be filled with dry low saline sand to the final ground elevation to prevent air circulation inside the pile.

The investigation has revealed that free water is present on the site and that the groundwater table is very high. Installation of the piles is easier when the active layer is frozen. During summer or fall, accumulations of groundwater in the active layer will cause the holes to collapse and fill with water. It is therefore considered that the drilled holes for the piles must be cased. In addition, prior to installation of the piles, the site should be drained by installation of perimeter ditches, grading the site to the ditches and pumping from sumps.

Freeze back around the piles may take two to three months before full pile capacity can develop. It is recommended that a string of thermistors should be installed at various depths along the pile surface to monitor the freeze back. The piles should not be fully loaded until such time that the ground temperature readings indicate stabilized frozen conditions around the piles.



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The base of the heated structures should be at least 600 mm above the final grade to permit air circulation under the building. It is necessary to maintain this clear space to ensure that heat from the structure will not degrade the permafrost and reduce the pile capacity. The air space should not be hoarded and should not be used for storage.

It is possible that some piles may be installed in groups. The minimum centre to centre spacing of the piles installed in a group should be three times the pile diameter.

It is noted that the worse effects of climate warming on pile capacities may not be realized for 15 to 20 years in the future. The active layer is expected to deepen with time and may impact the capacity of the adfreeze piles. Rather than abandon the current pile design strategy, it is recommended that the pile design be adapted to address potential climate warming effects. It is recommended that thermistors should be installed at the site to monitor the ground temperature. In addition, thermistor beads should be installed on select piles to measure the ground temperature at the interface of soil and piles. If the ground temperatures are found to be warming and the active layer deepening, then remedial actions can be initiated before pile capacities are compromised and structural distress results. Potential mitigation strategies may include the placement of rigid insulation, the installation of thermosyphons, the installation of pile adjustment devices, etc.



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9 Seismic Site Classification

The investigation has revealed that the sites contain surficial fill consisting of gravelly sand, which extends to a depth of 1.5 m to 4.5 m. It is underlain by granular soils.

It has been recommended that the proposed structure should be founded on a concrete mat set on engineered fill pad containing thermosyphons to maintain the underlying soils in a frozen state. Therefore, the on-site soils below the foundations will be continuously maintained in a frozen state. Hence, the site has been classified as Class C in accordance with the requirements of the National Building Code, 2015.

The on-site frozen soils are not susceptible to liquefaction during a seismic event.



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10 Subsurface Concrete Requirements

Chemical tests limited to pH, sulphates and electrical conductivity were performed on eight soil samples. The results are given on Table 6.

	Tab	le 6: Resu	Its of Chemica	al Results on Soil S	Samples
Borehole No.	Depth	рН	Sulphates (%)	Chloride (%)	Electrical Resistivity (ohm – cm)
1	2.0 – 2.8	7.68	0.0005	0.005	15,873
4	2.5	8.70	0.0044	0.0051	4081
5	2.0	8.23	0.0018	0.0018	7937
6	5.0	8.07	0.0380	0.0450	847
Threshold Values		<5	<0.1	>0.04	<700 High Corrosion Potential

The results indicate that the subsurface soils contain a maximum of 0.038 percent water soluble sulphates. This concentration of sulphates would have negligible sulphate attacks on concrete. Therefore, General Use (GU) Portland cement may be used in the subsurface concrete at this site. The subsurface concrete should be dense, well compacted and cured. It should be designed to meet the National Standard of Canada (CDN/CSA A23.1) requirements.

The results of the resistivity tests of the soil samples collected from the site vary from 847 ohm-cm to 15,873 ohm-cm, which indicates non-corrosive to corrosive soils to buried steel. It is therefore recommended that a corrosion specialist should be consulted to provide recommendations regarding mitigating measures necessary if steel is to be buried on-site.



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11 Excavation

It is understood that the floor slab of the proposed structure is to be constructed as a slab on grade. It has been recommended that the proposed structure should be founded on a granular pad with thermosyphons to maintain the soil under the building in a frozen state. The thickness of the granular pad would have to be determined by a geothermal analysis of the site but is expected to be in the area of 2 m to 2.5 m. Therefore, excavation at the site will extend to this depth for installation of the granular pad. If the excavation is undertaken during the fall to spring period, when the soil at the site is frozen, the excavation is expected to be fairly straight forward. Some seepage of melt water into the excavation may take place. However, it should be possible to remove this water by collecting in sumps located at low points and pumping. However, if the excavation is undertaken during the summer months, the excavation will extend below the groundwater table and will also be prone to a 'base-heave' type of failure of the excavation. Therefore, it would be necessary to lower the groundwater table to below the final excavation depth before commencing the excavation work. This may be undertaken by installation of sumps and pumping. It is anticipated that in this case, continuous pumping of the water flow from the excavation will be required to maintain the groundwater below the excavation base until the granular fill has been placed and compacted to the ground surface level. Construction of temporary ditches may be required for disposal of the groundwater, depending on the layout of the land.



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12 Backfill Requirements

As indicated previously, the engineered fill to be placed under the concrete pad should conform to the gradation requirements of Table 4. It should be placed in lifts with their thickness compatible with the type of compaction equipment used and each lift should be compacted to 100 percent SPMDD. This work should be undertaken under the full-time supervision of a geotechnician. In-place density tests should be performed on each lift to ensure that the specified degree of compaction is being achieved.

The investigation has revealed that the on-site soils are predominantly granular. These soils may be used for backfilling purposes provided they are screened to remove cobbles and boulders. All backfill should be compacted to at least 95 percent of SPMDD.



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13 Site Grading and Drainage

Information regarding grading of the site was not available at the time of writing this report. However, it is recommended that the finished grade around the building should be sloped away from the structure at an inclination of at least 2 percent to prevent ponding of the water close to the foundations of the structure.



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14 Design Review and Foundation Monitoring

It is recommended that a geotechnical review of the foundation drawings and specifications should be undertaken by this office to ensure that recommendations made in the report have been properly interpreted.

It is recommended that installation of the foundations at the site should be monitored by qualified geotechnical personnel. The monitoring would ensure that the material used in construction of the granular pad meets the specification and its adequately compacted.



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15 General Closure

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions, between boreholes 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.

The information contained in this report in no way reflects on the environmental aspects of the soils. Should specific information be required, additional testing may be necessary.



EXP Services Inc.

Client: City of Iqaluit Project Name: Geotechnical Investigation. Proposed Waste Transfer Station Iqaluit, Nunavut

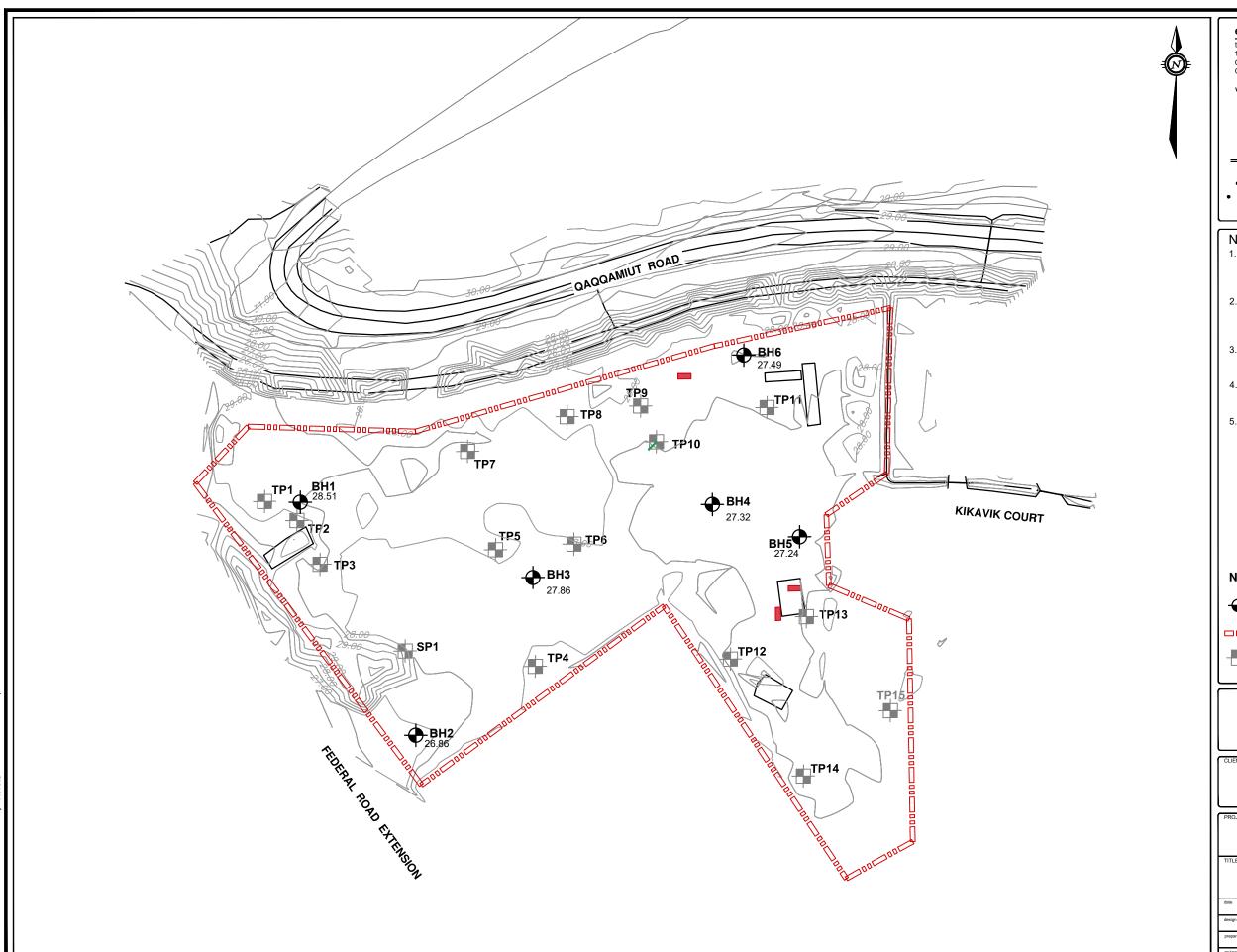
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Figures



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NOTES:

- 1. THE BOUNDARIES AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
- 2. SOIL SAMPLES WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
- 3. BOREHOLE ELEVATIONS SHOULD NOT BE USED TO DESIGN BUILDING(S) OR FLOOR SLABS OR PARKING LOT(S) GRADES.
- 4. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.
- 5. BASEPLAN FROM CITY OF IQALUIT BASE MAPPING, SHEET 03 & 09, BY JACK M. BYRNE CONSULTANTS LTD., PUBLISHED NOVEMBER 2000.TOPOGRAPHICAL CONTOURS FROM AERIAL LIDAR SURVEY BY EXP, SEPTEMBER 2018

NOTES:

BH3

BOREHOLES by **exp**, 2018

APPROXIMATE SITE OUTLINE



TEST PIT by exp, PHASE TWO ESA, 2018

HORIZONTAL 1:1250

CITY OF IQALUIT

GEOTECHNICAL INVESTIGATION WASTE TRANSFER STATION IQALUIT, NU

BOREHOLE LOCATION PLAN

date	OCTOBER 2018	OTT-00248813-A0
design by	S.A.	drawing no.
prepared by	J.R.	FIG 2

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Notes On Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Society for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by **exp** Services Inc. also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

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CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
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UNIFIED SOIL CLASSIFICATION

- 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 may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. 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 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. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.
- 3. 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 (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.



	OTT-00248813-A0 Geotechnical Investigation - Proposed	I Waste Transfer Station						F	igure I	_	3					
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.See Notes on San	nple Descriptions ead with exp. Services Inc. report															

	4. See Notes on Sample Descriptions
)	5. This Figure is to read with exp. Services Inc. repo

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ate Drilled: '	September 14, 2018				olit Spo			9	×	_		Combustible Vapour Reading							
ocation:	Geotechnical Investigation - Propo Qaqqamuit Road, City of Iqaluit, N						<u>-</u>					Pa	age.	_1	of	1			

Log of Borehole BH-5

roject No: OTT-00248813-A0	of Bo							iaure l	No.	7	•		^
oject: Geotechnical Investigation - Propo	sed Waste Ti	ransfe	Station	1				-	ge.		1		•
cation: Qaqqamuit Road, City of Iqaluit, N	unavut								90	<u>. </u>	<u> </u>		
te Drilled: 'September 14, 2018			Spoon Sa	mple	е				stible Vap		ng		
ll Type: <u>Air Track</u>			er Sample (N) Value			I			Moisture of g Limits	Content	F		× ⊕
tum: Geodetic		Dynamic Cone Test Shelby Tube				ed Triaxia n at Failur				\oplus			
gged by: B.V. Checked by: S.K	.A	Shear Strength by + Vane Test S				:		Strength by meter Tes				A	
S		D	Standard	Pen	etration •	Test N Va	lue		stible Vap			S	NI - 4
S Y Y SOIL DESCRIPTION O L	Geodetic Eleva m	atio e	20 ear Streng	4 th	0 (60	80 kPa		250 5 tural Moist berg Limit		nt % Veight)	»AMP-L	Natura Unit Wi kN/m ³
ĭ ⋙ FILL	27.24	0 0	50	10	00 1	50 2	200	1			60 	L E S	
Gravelly sand, some cobbles, grey, mois	t –												
	26.04	1 1						2/11/2					
GRAVELLY SAND TO SANDY GRAVEL	25.5	2											
(SW-GP) Occasional cobbles, grey, wet, (not froze	en) _							×				E	
ं ैं। 	-	3										-	
	-					1:2:::::::			1::::::::::::::::::::::::::::::::::::::				
	22.7	4											
POORLY GRADED SAND (SP)													
Fine, some silt, occasional gravel, brown dark grey, moist.		5											
<u>₩</u>		6											
경기 경기		133							×			S	
호텔 호텔	-	7										-	
84. 86.	-	33						3443			3 2 1 3	:	
	-	8	1.3						x			im	
(1) (4)	-												
		9						>	4			i en	
	17.2	10											
Borehole Terminated at 10.0 m Depth	n												
ES:			:::::	::1				1::::	1::::	1::::	1::::		
rehole/Test Pit data requires Interpretation by exp.	WATEI Elapsed	R LEVE Wa	L RECOF		Hole Op	en	Run	CC	oth	LLING R % Re			QD %
ezometer installed in Borehole upon completion	Time	Leve			To (m		No.	(m					

LOG OF BOREHOLE BH LOGS - 248813.GPJ TROW OTTAWA.GDT 10/10/18 3. Field work supervised by an EXP representative. 4. See Notes on Sample Descriptions 5. This Figure is to read with exp. Services Inc. report OTT-00248813-A0

WAI	EN LEVEL NECO	INDS
Elapsed	Water	Hole Open
Time	Level (m)	To (m)
2 days	1.2	
•		

	COILDI	ALLING INLOGI	\D
Run	Depth	% Rec.	RQD %
No.	(m)		
1		I	

Log of Borehole BH-6

ct: Geotechnical Investigation - Propose	ed Waste T	ran	sfer Sta	ation				Figure N		8			•
tion: Qaqqamuit Road, City of Iqaluit, Nur	navut						_	Pag	e	1_ of			
Drilled: 'September 14, 2018		_	Split Spoo	on Samp	le	\boxtimes		Combusti	ble Vapo	our Readi	ng		
ype: Air Track			Auger Sa					Natural M		Content			
n: Geodetic			SPT (N) \ Dynamic		st			Atterberg Undraine	d Triaxial				- О
ed by: B.V. Checked by: S.K.A		_	Shelby Tu Shear Str		,	■		% Strain : Shear Str	ength by	,			→
			Vane Tes			+ s		Penetrom	eter Tes	t			
	Geodetic Eleva	D				Test N Val		25	0 5		50	S A M P	Natura
SOIL DESCRIPTION	m	p t h	Shear S	Strength			kPa	1		ure Conte (% Dry V		D-L-HOS	Unit W
FILL	27.49	0	5	0 1	00 1	150 2	00	20) 4	l0 €	60 	S	
Gravelly sand, some cobbles, grey and brown, moist												1	
		1											
	25.5	2]	
POORLY GRADED SAND (SP) Fine, trace silt, grey, moist to wet.		-											
		3						×				(M)	
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	12.5	15	2012								3213		
Borehole Terminated at 15.0 m Depth													

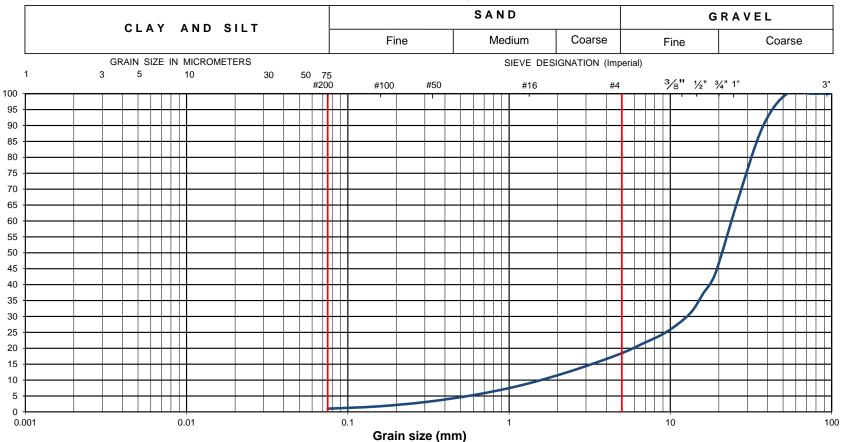
LOG OF BOREHOLE BH LOGS - 248813.GPJ TROW OTTAWA.GDT 10/10/18 2. Borehole backfilled upon completion 3. Field work supervised by an EXP representative. 4. See Notes on Sample Descriptions 5. This Figure is to read with exp. Services Inc. report OTT-00248813-A0

WAI	EN LEVEL NECO	INDO
Elapsed	Water	Hole Open
Time	Level (m)	To (m)
Completion	ND	
·		

	CORE DR	CILLING RECOR	KD
Run	Depth	% Rec.	RQD %
No.	(m)		
		l	



Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136



EXP Project No.:	OTT-00248813	Project Name :		Geotechnical Consulting Services Public Works Facility Expansion							
Client :	Colliers Project Leaders	Project Location	oject Location : City of Iqaluit, NU								
Date Sampled :	N/S	Borehole No:		TP5	Sample	:	32	Depth (m) :	0.8-1.5		
Sample Composition :		Gravel (%)	82	Sand (%)	17	Silt & Clay (%)	1	Figure :	0		
Sample Description :		Poorly Grade	d Sand	rigule .	3						



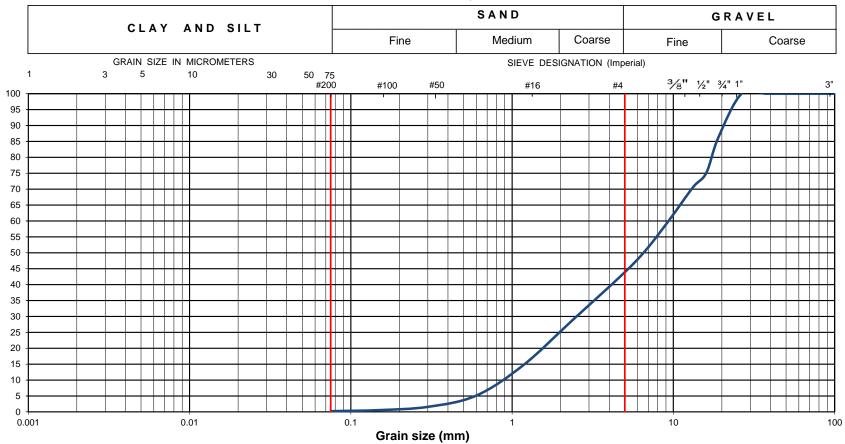
Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136



EXP Project No.:	OTT-00248813	Project Name :		Geotechnical Consulting Services Public Works Facility Expansion							
Client :	Colliers Project Leaders	Project Location	1 :	City of Iqaluit, NU							
Date Sampled :	N/S	Borehole No:	orehole No:		Sample:		S3	Depth (m):	1.0-1.5		
Sample Composition :		Gravel (%)	29	Sand (%)	59	Silt & Clay (%)	12	Figure :	10		
Sample Description :		Well-graded Gravelly Sand (SW)							10		

Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136

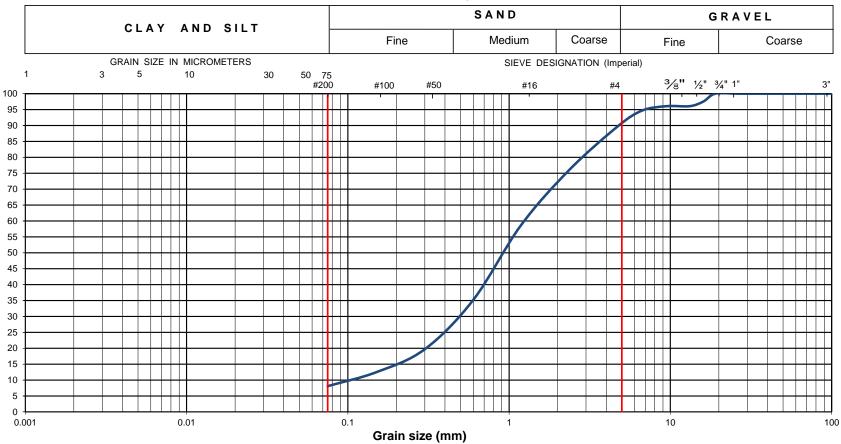
100-2650 Queensview Drive Ottawa, ON K2B 8H6



EXP Project No.:	OTT-00248813	Project Name :		Geotechnical Consulting Services Public Works Facility Expansion							
Client :	Colliers Project Leaders	Project Location	1 :	City of Iqaluit, NU							
Date Sampled :	N/S	Borehole No:		TP12	Sample	: ;	S3	Depth (m) :	1.5-2.1		
Sample Composition :		Gravel (%)	57	Sand (%)	43	Silt & Clay (%)	0	Figure :	44		
Sample Description :		Poorly Grade	d Sand	ly Gravel (GP)				rigure :	11		

Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136

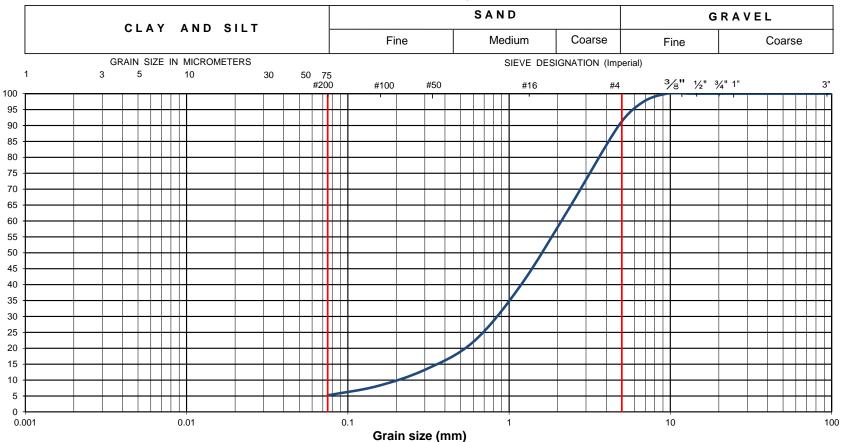
100-2650 Queensview Drive Ottawa, ON K2B 8H6



EXP Project No.:	OTT-00248813	Project Name :		Geotechnical Consulting Services Waste Transfer Station							
Client :	Colliers Project Leaders	Project Location	1 :	City of Iqaluit, NU							
Date Sampled :	September 14, 2018	Borehole No:		BH1	Sample:		S2	Depth (m) :	4.5		
Sample Composition :		Gravel (%)	10	Sand (%)	82	Silt & Clay (%)	8	Figure :	12		
Sample Description :		Well Gra	Well Graded Sand (SW)								

Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136

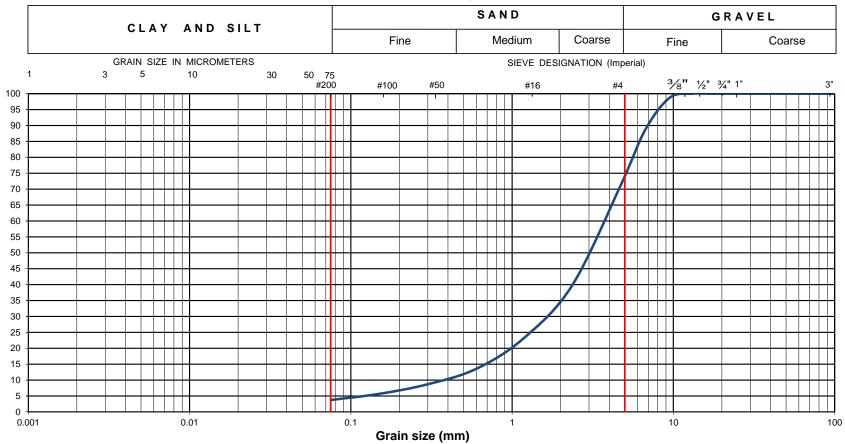
100-2650 Queensview Drive Ottawa, ON K2B 8H6



EXP Project No.:	OTT-00248813	Project Name :		Geotechnical Consulting Services Waste Transfer Station							
Client :	Colliers Project Leaders	Project Location	1 :	City of Iqaluit, N							
Date Sampled :	September 14, 2018	Borehole No:		BH2	Sample:		S 1	Depth (m):	2.7		
Sample Composition :		Gravel (%)	10	Sand (%)	85	Silt & Clay (%)	5	Figure :	13		
Sample Description :		Well Graded Sand (SW)							13		

Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136

100-2650 Queensview Drive Ottawa, ON K2B 8H6



EXP Project No.:	OTT-00248813	Project Name :		Geotechnical Consulting Services Waste Transfer Station							
Client :	Colliers Project Leaders	Project Location	1 :	City of Iqaluit, NU							
Date Sampled :	September 14, 2018	Borehole No:		ВН3	Sample	: 5	3 4	Depth (m) :	11.5		
Sample Composition :		Gravel (%)	28	Sand (%)	68	Silt & Clay (%)	4	Figure :	14		
Sample Description :		Grave	Gravelly Sand (SW)						14		

Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136

100-2650 Queensview Drive Ottawa, ON K2B 8H6



EXP Project No.:	OTT-00248813	Project Name :		Geotechnical C	onsultino	g Services Wast	e Transf	er Station	
Client :	Colliers Project Leaders	Project Location	ı :	City of Iqaluit, N	IU				
Date Sampled :	September 14, 2018	Borehole No:		BH4	Sample:	:	S2	Depth (m):	5.5
Sample Composition :		Gravel (%)	0	Sand (%)	86	Silt & Clay (%)	14	Figure :	15
Sample Description :	P	oorly Graded S	and (S	P) with litle fine	es	•		rigule .	15

Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136

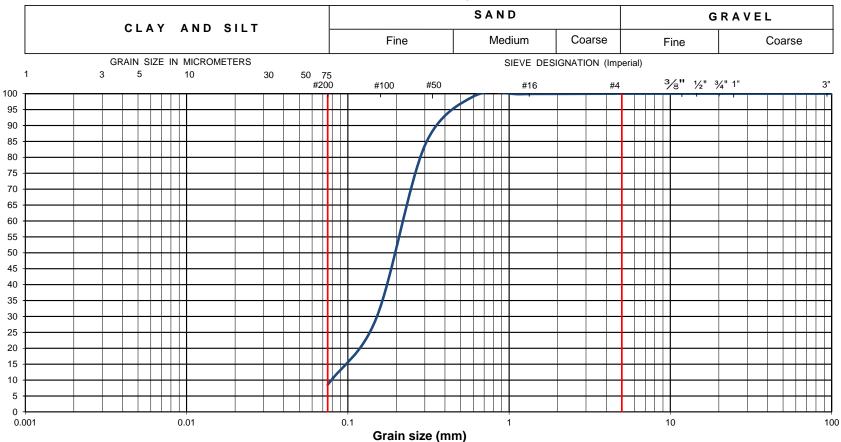
100-2650 Queensview Drive Ottawa, ON K2B 8H6



EXP Project No.:	OTT-00248813	Project Name :		Geotechnical C	onsultino	Services Wast	e Transf	er Station	
Client :	Colliers Project Leaders	Project Location	ı :	City of Iqaluit, N	IU				
Date Sampled :	September 14, 2018	Borehole No:		BH5	Sample:	:	S 3	Depth (m):	8.5
Sample Composition :		Gravel (%)	0	Sand (%)	85	Silt & Clay (%)	15	Figure :	16
Sample Description :	P	oorly Graded S	and (SI	P) with little find	es			rigule .	10

Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136

100-2650 Queensview Drive Ottawa, ON K2B 8H6



EXP Project No.:	OTT-00248813	Project Name :		Geotechnical C	onsultin	g Services Wast	e Transf	er Station	
Client :	Colliers Project Leaders	Project Location	ı :	City of Iqaluit, N	1U				
Date Sampled :	September 14, 2018	Borehole No:		ВН6	Sample	: ;	S1	Depth (m) :	2.5
Sample Composition :		Gravel (%)	0	Sand (%)	91	Silt & Clay (%)	9	Figure :	47
Sample Description :		Poorly G	raded S	Sand (SP)				rigure :	17

EXP Services Inc.

Client: City of Iqaluit

Project Name: Geotechnical Investigation. Proposed Waste Transfer Station

Iqaluit, Nunavut

EXP Project Number: OTT-00248813-A0

Date: October 19, 2018

Appendix A: Test Pit Logs from Phase II ESA



-	OTT-00248813-A0									ļ	Figur	e N	lo	1			
Project:	Phase II Environmental Site As									_	ı	Pag	ge.	1_ of	_1		•
_ocation:	City Lots 3586 228 18/18/19/20	0 and 3480	220 1	, Iqal	uit, N	IU				_			_				
Date Drilled:	September 6th, 2018					on Sam	ole							our Read	ing		
Orill Type:	Backhoe - 710J John Deere				ıger Sa PT (N) '				■				/loisture g Limits	Content	H		× →
Datum:	Assumed				namic nelby T	Cone Te	est	-	_				ed Triaxia at Failur				\oplus
ogged by:	MAD Checked by:	RR	_	Sł		rength by	y		+ s				rength b				A
						ndard Pe	enetra	tion Te		IIE .	Con	nhus	tible Var	our Read	ing (ppm)	Is	
SY M B B O L	SOIL DESCRIPTION	A	Assumed	D e p	2	20	40	60		30		25	50 5		'50	SAMPLES	Natura Unit W
_	0011 50		m 3.92	h s		Strength 50	100	150) 2	kPa	A.	tterb			Veight) 60	E S	kN/m ³
XXX \ Sanc	<u>SOIL</u> ~ 50 mm d with some gravel and fines, org roots, moist, no odour, (surficial	ganics /	3.8								ф					m	S1
	ing nearby).															-	
Fine	to medium grained sand with so	ome 27	7.7	1							е					m	S2
some	e boulders and cobbles, brown e orange near lower interface, m dour.							3 3 4 1	3 (0 () 3 3 (0 () 3 ()							-	
SAN	D AND GRAVEL AND BOULDER	<u>RS</u>		2							5 —					m	S3
	COBBLES vn, moist, no odour.	26	3.5	2							5 					584	(analy
Re	fusal on Permafrost at 2.38 m D Test Pit Terminated	Depth,														Ī	, ,
NOTES:	it data requires Interpretation by exp.		WATER	R LEV	ÆL RI	ECORF)S	-::1		1::::	1::	COF	RE DRI	LLING F	RECORF)	
before use by ot	hers	Elapsed Time		W	ater el (m)		Hole	Oper	1	Run No.		Dept (m)	th	% Re			QD %
B. Field work was s B. See Notes on Sa	backfilled upon completion. supervised by an exp representative. ample Descriptions read with exp. Services Inc. report	completio	on		<u>ei (m)</u> dry			0.0		INU.		<u>(111)</u>	,				

Project No: OTT-00248813-A0 Figure No. Project: Phase II Environmental Site Asessment 1 of 1 Page. Location: City Lots 3586 228 18/18/19/20 and 3480 220 1, Iqaluit, NU Date Drilled: September 6th, 2018 Split Spoon Sample \boxtimes Combustible Vapour Reading × Auger Sample Natural Moisture Content Drill Type: Backhoe - 710J John Deere SPT (N) Value 0 0 Atterberg Limits Dynamic Cone Test Datum: Undrained Triaxial at Assumed \oplus % Strain at Failure Shelby Tube Shear Strength by Logged by: MAD Checked by: RR Shear Strength by Penetrometer Test Vane Test Standard Penetration Test N Value Combustible Vapour Reading (ppm) SYMBO-Natural 250 500 750 G W L Assumed SOIL DESCRIPTION Natural Moisture Content % Atterberg Limits (% Dry Weight) Unit Wt. Shear Strength kPa kN/m³ 28.21 **FILL** Medium to coarse grained sand and gravel (analyzed) and boulders and cobbles, brown (surficial staining at surface), moist, no odour. S2 S3 S4 25.4 Refusal on Permafrost at 2.75 m Depth, **Test Pit Terminated** NOTES: 1. Borehole/Test Pit data requires Interpretation by exp. before use by others WATER LEVEL RECORDS CORE DRILLING RECORD RQD % Elapsed Water Hole Open Run Depth % Rec. 2. The test pit was backfilled upon completion. Time Level (m) To (m) No (m) completion dry 0.0 3. Field work was supervised by an exp representative. 4. See Notes on Sample Descriptions 5. This Figure is to read with exp. Services Inc. report OTT-00248813-A0

SEPTEMBER 11, 2018.GPJ TROW OTTAWA.GDT 9/28/18

PITS -

LOGS OF TEST

Е

TEST

LOG OF

Project No:	OTT-00248813-A0	est		Pi	t	-	<u> </u>	Р	<u>3</u>			Fi	gur	e N	0.		(3		\in	X	О.
Project: Location:	Phase II Environmental Site Assessmen		1 1/	aaluit	NII						_		F	⊃ag	e.	_1	_ 0	f_	1		-	
	City Lots 3586 228 18/18/19/20 and 34	+00 220	1, 10								_											
	September 6th, 2018		-	Split			mple	Э								•	ur Re Conter		g		□ X	
Drill Type:	Backhoe - 710J John Deere		-	SPT (N			Т		(Э				-	Limi					<u> </u>	\rightarrow	
Datum:	Assumed		_	Shelby			res	il					% St	rain	d Tria at Fa	ilure					\oplus	
Logged by:	MAD Checked by: RR			Shear Vane 1			by			 S					engt neter						•	
G W L BO L	SOIL DESCRIPTION	Assumed m	Dep th	Shea	20	reng	4		Test N V 60 50	/alu 80 20	0 kF	Pa		25	o ral M erg Li	50	00	75	g (ppr 60 nt % eight)	I A	Natura Unit W kN/m ³	t.
FILL Medi	um to coarse grained sand and gravel boulders and cobbles, brown turning		0									10):]: ::							m	· S1	
	moist, no odour.		1									0							-2-4-1	en v	S2	
	-			0.00						2 1		- 4				(·) ·) (·) ·)					32	
												4]]							m	S3	
		25.9	2	3.51						;		10								574	(analy	/zed)
	rusal on Permafrost at 2.38 m Depth, Test Pit Terminated																					
NOTES: 1.Borehole/Test Pi	t data requires Interpretation by exp.	WATE	RL	EVEL	RE	COF	RDS	3					-	COF	RE D	RIL	LING	RE	COF	RD		
before use by ot	ners Elar	osed me		Water Level (r			F	Hole Op To (m		f	Rur No.			Dept (m)			%	Rec) .	R	QD %	
3. Field work was s 4. See Notes on Sa	upervised by an exp representative.	pletion		2.3				-														

LOG OF TEST PIT LOGS OF TEST PITS - SEPTEMBER 11, 2018.GPJ TROW OTTAWA.GDT 9/28/18

Tost Pit. TPA

-	OTT-00248813-A0									F	igure I	No.	4		_	T
Project:	Phase II Environmental Site Asess										•	_	1 of	1		•
Location:	City Lots 3586 228 18/18/19/20 an	nd 3480 220	1, I	qaluit,	NU						. ~	90				
Date Drilled:	September 6th, 2018		_	Split Sp		nple		_	\boxtimes				oour Read	ing		
Orill Type:	Backhoe - 710J John Deere			Auger S SPT (N				_			Natural Atterber		Content	ŀ		× ⊕
Datum:	Assumed			Dynami	c Cone	Test			_		Undrain	ed Triaxi n at Failu		-		⊕
_ogged by:	MAD Checked by: RR			Shelby Shear S		by		-	+ s		Shear S		ру			•
				Vane To												
S Y M	SOIL DESCRIPTION	Assumed	1 6)	andard 20	Pene 40	etration T		/alue 80		2	250		750	S A M	Natura
G S Y M B O L	SOIL DESCRIPTION	m 27.06	1 E	וו	Strengt 50				200	kPa	l	tural Moi: berg Limi 20	sture Conte ts (% Dry \ 40	ent % Veight) 60	SAMPLES	Unit Wt kN/m ³
FILL Fine	to medium grained sand with some	27.96	()	Ĭ				200		15	Tilliani Tilliani	Ť.	Ĭ		
grave_	el boulders and cobbles, metal drum	n 🗕													S	(analy
some	s present (crushed drums), brown v e darker brown, moist, no odour.	27.1									15					•
FILL Medi	um to coarse grained sand and gra	vel		2 2 1							P					S2
and b	poulders and cobbles, brown, moisting wet, no odour.	-		-0.0-1-			0 1 - 2 - 0 - 1 0 1 - 2 - 0 - 1	-2-0-1			0	1-2-2-2-		1 - 2 - 3 - 3 - 3 - 3 - 3		
			2	2						1	D				m	S3
		25.6									io:				m	S4
Ref	iusal on Permafrost at 2.44 m Deptl Test Pit Terminated	h,														
NOTES:	.,, . ,,	\\/\	_ 	E//E/ T	PECOF	De l	. : : : :			:::	CC	DE DD		ECOR		
 Borehole/Test Pi before use by oth 	t data requires Interpretation by exp.	Elapsed		EVEL F Water			ole Ope			Run	Dep	oth	ILLING R			QD %
·	backfilled upon completion.	Time completion		<u>Level (m</u> 2.1	1)		To (m) -			No.	<u>(m</u>	1)				
4. See Notes on Sa	upervised by an exp representative. Imple Descriptions read with exp. Services Inc. report															

Project No:	OTT-00248813-A0_	Tes	t	Pi	t:	• • •	TF	25							_	•		е	xp
Project:	Phase II Environmental Site Asess	ment								ı	=igu		-		5				ı
Location:	City Lots 3586 228 18/18/19/20 and	d 3480 220 1	1, 10	qaluit, N	NU					-		Pag	ge	_1	_ of	_1	_		
Date Drilled:	September 6th, 2018			Split Spo	oon Sa	ample			\boxtimes		Cor	nbus	tible Va	apou	ur Rea	ding			
Drill Type:	Backhoe - 710J John Deere			Auger Sa SPT (N)	ample						Nat	ural N	Moistur g Limits	e Co		-			
Datum:	Assumed			Dynamic					0		Unc	draine	- ed Triax	xial a	at				→
_ogged by:	MAD Checked by: RR		_	Shelby T Shear St		h by			+		She	ar St	at Fail trength	by					A
				Vane Te					S				meter T						
G M B O	SOIL DESCRIPTION	Assumed	e	2	andaro 20	l Pene 40	etration 7	Fest N	Value 80	•		2	stible Va	50	0	750		SA M P.	Natural Unit Wt.
Ľ B C	COLE BECOME TION	28	t h	Shear				50	200	kPa	<i>f</i>		ural Mo erg Lin 20	nits (Weig 60	ht)	LES	kN/m ³
FILL Medi	um to coarse grained sand and grav		0								5							- kus	S1
and b	ooulders and cobbles, trace metal s in upper portion, brown, moist	-		100000			******** *****************************	1			Ψ.						2 · 1 · 2		31
turnir	ng wet, no odour.		1								0						: : : : : : : : : : : : : : : : : : :	. m	00
				3 3 1 3													(· ! ·)		S2
		7		10.01110				13.33			5								(l
—		-	2	2 -2 -2 -1 -2	1111		0.1.2.0. 0.1.2.0.	1000		(-) - (·) (-) - (·)	Ш : :	- 1 - 1 - 1	1.3.000		. (.) .)		0-1-0 0-1-0	ورو	(analy
		25.4		10 0 1 10				13.00			5 —						(. ; . ; (. ; . ;	m	S4
NOTES:	it data requires Interpretation bury	W∆T⊏	.B I	EVEL R	FCO	RD8] [CO	RE DE	3II I	IING	RFC	ORL)	
before use by oth		Elapsed		Water			lole Op			Run		Dep	th	VILI	% R		JAL		QD %
3. Field work was s 4. See Notes on Sa	upervised by an exp representative. Imple Descriptions read with exp. Services Inc. report	Time completion	<u> </u>	<u>Level (m)</u> 2.4	,		<u>To (m)</u> -)		No.		<u>(m</u>))						

roject No:	OTT-00248813-A0	Te	3	•	•		L.				_	_	iau	re N	lo.			6	***	•	9	X
roject:	Phase II Environmental Site Asessm	ent									_	Г	•			_	1		1	-		'
ocation:	City Lots 3586 228 18/18/19/20 and	3480 220 1	1, 10	qaluit	t, N	١U								Paţ	je.	_	<u> </u>	OI		-		
ate Drilled:	September 6th, 2018		_	Split	Spo	on Sa	ample	е					Cor	nbus	tible '	Vap	our F	Readi	ng			
rill Type:	Backhoe - 710J John Deere		_	-		ample Value								ural N			Cont	ent		<u></u>		X ⊕
atum:	Assumed		_	Dyna	mic	Cone		st	_	$\frac{\circ}{-}$			Unc	Iraine Strain	d Tri	axia						Φ
ogged by:	MAD Checked by: RR			Shelb Shea Vane	ır Stı	rength	n by			+ s			She	ar St etror	reng	th b	y					•
S Y M B O	SOIL DESCRIPTION	Assumed m	D e p t	She	2	andard 20 Streng	4	etration 0	Test N		80	Pa		2	50	5	00	7	ng (pr 50 nt % Veigh		SA M P L	Natural Unit Wt. kN/m³
FILL		28.38	0		5	50	10	00	150	2	00		0		0	:::	40		60 		Ē S	
and I with	im to coarse grained sand and gravel boulders and cobbles, surficial staining oily residue and odour at 0.00 to 0.75 epth, brown, moist turning wet.	9-											Ď								\$ 7	(analy:
			1	10.00								i i i				::: ::: :::			10.00		8	S2
													5								: :	S3
		1	2				: i :		133	;;;;) []			(·) (:)					M	S4
	fusal on Permafrost at 2.54 m Depth, Test Pit Terminated																					
pefore use by ot The test pit was	backfilled upon completion.	WATE apsed Time npletion		EVEL Wate evel 2.2	er (m)			S Hole Op To (m			Ru			COI Dep (m)	th	DRII		IIG R	ECC c.	PRD		QD %

roject:	OTT-00248813-A0Phase II Environmental Site Asea	ssment									_	Fig				7		-	ı
ocation:	City Lots 3586 228 18/18/19/20 a	and 3480 220	1, lo	qaluit	, N	U					_		Pa	ige.	_	1_ of	_1	-	
ate Drille	d: September 6th, 2018			Split S	Spoo	n Samp	le			\boxtimes		C	ombu	stible	Vapo	our Rea	ding		
rill Type:	Backhoe - 710J John Deere			Auger									atural terbe			Content		1	
atum:	Assumed			Dynar	mic (Cone Te	st		_	_		Uı	ndrair	ned T	riaxia			ı	— ⊕
ogged by:	: MAD Checked by: RF	R		Shelb Shear	-	be ength by	,			+ s		SI	Strai	Streng	gth by	y			•
				Vane									enetro					. [6	. 1
S Y M B O	SOIL DESCRIPTION	Assume	d e	'	Stan 20	idard Pe	netra 40		rest N 30	l Valu 81				250	5	our Rea 500 ture Con	750	16	Natura Unit W
L		28.4	h	She		trength	100		50	20	kPa		Atte	berg 20		ture Con s (% Dry 40	Weight 60) L	kN/m ³
FIL Me	edim to coarse grained sand and gra	vel										45						580	∮ (analy
wit	d boulders and cobbles, surficial starth oily residue and odour at 0.00 to 0																		, (ariar)
_m	depth, brown, moist.	_	1	3 3 3				:::::		::::		5_						₆ 00	} S2
		26.9		-2.0								T							32
FIL Sa	nd and gravel and boulders and cob								333			5	(:):						
_wit	th some silt, brown, moist, no odour.	26.1	2	10.01				· · · · · · · · · · · · · · · · · · ·	122	1:2:									S3
F	Refusal on Permafrost at 2.34 m Dep Test Pit Terminated						T	**						T					
	rost it rominated																		
								: :											
								: :											
														L					
OTES: Borehole/Tes before use by	t Pit data requires Interpretation by exp.		ER L			CORD][DRII	LLING			
•	as backfilled upon completion.	Elapsed Time	L	Wate evel ((m)			(m)		4	Run No.		De (n			% R	ec.	F	RQD %
	is supervised by an exp representative.	completion		dry			(0.0		\perp 1									

•	OTT-00248813-A0									Fi	gure 1	No	8			
Project:	Phase II Environmental Site Asessmen		,	.=1:::!:							Pa	ge	1_ of	_1_		-
ocation:	City Lots 3586 228 18/18/19/20 and 34	180 220 1	l, IC	aluit, I	NU											
	September 6th, 2018		-	Split Spo Auger S			Э						oour Read Content	ing		□ X
٠.	Backhoe - 710J John Deere		-	SPT (N)	Value	•		C		,	Atterber	g Limits				$\stackrel{\frown}{\rightarrow}$
atum:	Assumed		_	Dynamic Shelby		e Tes	t		- 			ed Triaxi nat Failu				\oplus
ogged by:	MAD Checked by: RR			Shear S Vane Te		h by		+	-			trength t meter Te				A
S Y M B O	COIL DESCRIPTION	Assumed	D e			d Pen	etration 1		alue 80		2	50	pour Read	750) S A M P	Natura
Y M B O L	SOIL DESCRIPTION	m _27.51	p t h	Shear	20 Streng 50				60 kF 200	Pa	Nat Atterb	tural Mois berg Limi 20	sture Conte ts (% Dry \	ent % Neight) 60	L	Unit Wi
Sand	SOIL ~ 150 mm with some gravel and fines and lers and cobbles, organics and roots,	27.3	0	-5.6.1.5						0					5 "	(analy
FILL Sand	with some gravel and boulders and		1							0					m	S2
cobbl	les, brown, moist, no odour.	-		-3 3 3 3 3							0 1 1 1 0 0 1 1 1 0 0 1 1 1 0					
	D AND GRAVEL AND BOULDERS	25.5 25.4	2	.3 (1:::	::::: :-:::				4			1 2 3 3 3 3		m	S3
before use by oth The test pit was be. Field work was so See Notes on Sa	t data requires Interpretation by exp. lers backfilled upon completion. upervised by an exp representative. mple Descriptions read with exp. Services Inc. report	ne		EVEL R Water evel (m 2.0			Hole Op To (m)		Rur No.		CO Dep (m	oth	ILLING F % Re			QD %

Project:	OTT-00248813-A0 Phase II Environmental Site Asessme	nt									_	F	•	re N Pag		_		9 of	1	-		ı
ocation:	City Lots 3586 228 18/18/19/20 and 3	480 220 1	, Ic	qaluit, N	IU						_									-		
ate Drilled:	September 7th, 2018		-	Split Spo			е									•	ur R		ng			
rill Type:	Backhoe - 710J John Deere		_	Auger Sa SPT (N) \						■					vioisti g Limi		Conte	ent		⊢		× ⊕
atum:	Assumed		_	Dynamic Shelby Tu		e Tes	st			_					ed Tri at Fa							\oplus
ogged by:	MAD Checked by: RR			Shear Str Vane Tes	reng	th by				+ s					rengt							A
S Y M B O	SOIL DESCRIPTION	Assumed m	D e p	Shear S	20	4	netrati 0	on T 6		Valu 80)	Pa		25	50	50	00	7	ng (pp 50 nt % /eight		SAMPLES	Natura Unit Wt kN/m³
× FILL	<u> </u>	27.6	h 0		50		00	15	0	20	0						0		0	:::	S	
Silty and	sand with some gravel and boulders cobbles, brown, moist, no odour.	27.0														::::: :::::					5 %	(analy
SAN	DY GRAVEL WITH BOUDLERS COBBLES										· • · • · • · · · · · · · · · · · · · ·			· • · · · · · · · · · · · · · · · · · ·		 					\exists	
	vn, moist turning wet, no odour.		1									.	,								m	S2
		-		.5.0.1.5.				; ;; ; ; ;; ;				 ,		. ; . ; .					13.33		\vdash	
		25.5	,									Ė	þ			:::: ::::		20			m2	S3
	fusal on Permafrost at 2.14 m Depth, Test Pit Terminated																					
before use by of The test pit was	backfilled upon completion.	WATE psed ime pletion		EVEL Rt Water .evel (m) 2.0			Hole	Ope (m)			Rui			COI Depi (m)	th	DRIL		G R	ECO.	RD	RO	QD %

•	OTT-00248813-A0	103		•		•	_	<u> </u>		<u>U</u>	•	F	igur	e N	lo.		10	•	ϵ	X
Project:	Phase II Environmental Site As										_		•		je.	1			-	
Location:	City Lots 3586 228 18/18/19/20	0 and 3480 22	0 1, I	qalu	it, N	IU					_		-				-		-	
Date Drilled:	September 7th, 2018					on Sa	mple								tible Va			ing		
Drill Type:	Backhoe - 710J John Deere			-	er Sa 「(N) \					$lue{lue}$					/loisture Limits	e Cor	ntent		<u> </u>	× —⊖
Datum:	Assumed			-	amic Iby Tu	Cone ube	Test		_	_					ed Triax at Failu		İ			\oplus
Logged by:	MAD Checked by:	RR		She		ength	by			+ s					rength l neter Te					A
SY MB BO	SOIL DESCRIPTION	Assur	med le	D e p	2	:0	Peneti 40		Test N		80			25	tible Va 50 ural Moi erg Lim	500	7	750	m)	Natural Unit Wt.
L		27.4		h °		Strengt 0	h 100	1	150	. 20	00 1 · · ·	(Pa	A	tterb		its (%		Weight 60	, ,	kN/m³
	sand with some gravel and boul											: : : C	j P::::) (analyz
SILT	cobbles, brown, moist, no odour	·/[]																		
SAN	organics, brown/grey, moist, no DY GRAVEL WITH BOUDLERS	odour.j		1					1.2.0			C	р <u></u> Р				· i · i · i		6	% S2
AND Brow	COBBLES /n, moist turning wet, no odour.	_		1.5				· · · · · · · · · · · · · · · · · · ·	1.2.2			i i					· · · · · · · · · · · · · · · · · · ·			
												:: :: (C	. D						6	% S3
	for all and Danier from the 4 0 00 and D	25.1		<u> </u>					1:3:3											
Rei	fusal on Permafrost at 2.29 m D Test Pit Terminated	eptn,																		
NOTES:		3010		 	1 0		DC		1::								NC 5	DECC!	 DD	
Borehole/Test Pi before use by other	it data requires Interpretation by exp. hers	Elapsed	ATER	Wa	ter	-COF	Но	le Op		+	Ru			Dept			NG F			RQD %
	backfilled upon completion.	Time completion		Leve 1.				<u>o (m</u> -)	$\dashv \dagger$	No	D.		(m))				-	
	supervised by an exp representative. ample Descriptions																			
5. This Figure is to OTT-00248813-	read with exp. Services Inc. report A0																			
										╛╽										

Project No:	OTT-00248813-A0	es	t	Pit	t:	-	<u>TP</u>	<u>1</u>	<u>1</u>	_							е	ΧĽ).
Project:	Phase II Environmental Site Asessmen	nt								F	Figu	ıre N		_	11			- 1	
Location:	City Lots 3586 228 18/18/19/20 and 34	480 220 1	l, lo	galuit, Nl	U					-		Pag	ge.	_1	_ of				
	September 7th, 2018					male			7	_	Co	mbuo	tible \/	onoi	ır Doodi	20			
Drill Type:	Backhoe - 710J John Deere		-	Split Spoor		трк	=		_						ur Readi ontent	ng		×	
Datum:	Assumed		-	SPT (N) Va Dynamic C		Tes	t		-				g Limit ed Tria		at	ŀ		→	
Logged by:	MAD Checked by: RR		-	Shelby Tub	be						%	Strain	at Fai	ilure				Φ .	
Logged by.	MAD Checked by. KR			Shear Stre Vane Test		ı by		 S	5				neter					•	
S Y M B C O	SOIL DESCRIPTION	Assumed m	p t	20 Shear St)	4	etration T		alue 80	kPa		2	50	50		ng (ppm) 50 nt % Veight)	SAMPLES	Natural Unit Wt. kN/m³	
ξ FILL		27.34	h 0	50		10	00 15	50	200)			0	40		60 	S	KI WIII	-
Silty	sand with some gravel and boulders cobbles, brown, moist, no odour.	27.0		0.000							10						5 %	(analyz	ed)
SILT	AND FINE SAND organics, brown/grey, moist, organic ir.	26.6	1								• •						m	S2	
	ium grained, brown, moist turning wet,	25.6		.5 3.1.5 1.			3.1.5		4		0						m	S3	
	fusal on Permafrost at 1.73 m Depth, Test Pit Terminated																		
NOTES: 1.Borehole/Test P	it data requires Interpretation by exp.	WATE	RL	EVEL RE	COF	RDS	3		Γ			CO	RE D	RILI	ING R	ECORI)		
before use by ot 2. The test pit was	□ □	osed me	I	Water _evel (m)		H	Hole Ope To (m)			Run No.		Dep			% Re	C.	R	QD %	1
3. Field work was s 4. See Notes on Sa	compared by an exp representative. ample Descriptions read with exp. Services Inc. report	oletion		1.6			_												

LOG OF TEST PIT LOGS OF TEST PITS - SEPTEMBER 11, 2018.GPJ TROW OTTAWA.GDT 9/28/18

-	OTT-00248813-A0									F	=igu	ıre l	No.			12		`	_	
Project:	Phase II Environmental Site As	sessment								-	9.			_	1 (1	_		'
ocation:	City Lots 3586 228 18/18/19/20	and 3480 220) 1, lo	qaluit,	NU					_			go.	_	<u> </u>	٠.		_		
Date Drilled:	September 7th, 2018		_	Split Sp	oon S	ample)		\boxtimes		Со	mbus	stible	Vapo	our R	eadir	ng			
Orill Type:	Backhoe - 710J John Deere		_	Auger S					Ⅲ				Moist g Lim		Conte	nt		⊢		X ⊕
Datum:	Assumed		_	Dynami		e Tes	t		_				ed Tr							\oplus
ogged by:	MAD Checked by: I	RR		Shelby Shear S	Strengt	h by			+ s		Sh	ear S	streng	gth by	/					A
			1	Vane Te		d Don	etration	Toet N							our R	padii	na (ni	nm)	Isl	
SY W B O L	SOIL DESCRIPTION	Assume m 28.52	p t h	Shear	20 Stren	4	0	60	80	kPa		Nat Atterl	250	5 Moist Limits	00 ure C s (% E	7: onte Ory W	50		SAZP-IES	Natural Unit Wt. kN/m ³
FILL Fine with	to medium grained sand and gra boulders and cobbles, brown, m	avel	0						200		0 								(3)	S1
no oc		,																		
		ا ا	1								5								8 2	(analy
	D AND GRAVEL AND BOULDER	_		.5 (.1.)		3.1.					0	(-) - (-		. (.) .		:: :: ::::::::::::::::::::::::::::::::	3.0	. ; . ;	: :82	S3
Brow	COBBLES /n, wet, no odour.	26.7	+	100000	1 : : :	:::::	11111			<u> </u>	<u> </u>		1::::		1 : :	·:· (· 	1 : :	::::	.07	- 33
Ref	fusal on Permafrost at 1.83 m D Test Pit Terminated	eptn,																		
											:									
											:									
											:									
											:									
											:									
											:									
											:									
	it data requires Interpretation by exp.	WAT	ΓER L	EVEL F	RECC	RDS	;					CO	REI	DRIL	LIN	G R	ECC	RD)	
before use by oth. The test pit was	hers backfilled upon completion.	Elapsed Time	L	Water _evel (m	1)	H	Hole Op To (m			Run No.		Dep (m			%	Re	C.		R	QD %
	supervised by an exp representative.	completion		1.3			-													
.See Notes on Sa	ample Descriptions																			
.This Figure is to	read with exp. Services Inc. report A0																			

Project N Project: Location:	Phase II Environmental Site Assessment			noluit N							_	Fig	gure N Pag		1	13 of	<u>1</u>	_	フ /	^
		80 220 1	, IC								_									
	ed: September 7th, 2018		-	Split Spoo			е			X I			Combust latural N		•		ding			□ ×
Orill Type			-	SPT (N) \			ıt.	_		0			tterberg Indraine	•		at		-		Э
Datum:	Assumed Charled by BB		-	Shelby Tu	ube							%	6 Strain 6 Strain 6 Shear St	at Fail	lure	at			(⊕
_ogged b	y: MAD Checked by: RR			Shear Str Vane Tes		h by			-	+ s			enetror						4	•
S Y W B L	COIL DESCRIPTION	Assumed	D e	'		d Per	etration					ľ	Combus	50	50	0	750	om)	S A M	Natural
G M W B O L	SOIL DESCRIPTION	m _27.5	t h	Shear S	20 Strenç 50	gth	0	150		20	kPa	1		ural Mo erg Lin :0	oistu nits 40		tent % Weigh 60	t)		Jnit Wt. kN/m³
XXX 5	FILL Sand and gravel with boulders and	27.5	0								· · · · · · · ·	10								analy
	cobbles, trace wood, plastic and metal – lebris, brown, moist, diesel odour, (surficial	-									1.7.0	T								ariary
	staining)	26.4	1			::::: ::::::::::::::::::::::::::::::::					1.3.0.0	_ 5 _							m	S2
	SAND AND GRAVEL AND BOULDERS AND COBBLES			-0.0-1-0-1		::::: ::::::::::::::::::::::::::::::::					1-3-0-1			12 12 1		(+1+2 (+1+3				
<i>62</i> 20 E	Brown, moist turning wet, no odour. Test Pit Terminated at 1.68 m Depth	25.8			. : . :	:- i - : : :		: -	: :: : : : : :	:: - : :	1-2-0-3	Ψ.			::-	111			m ₂	S3
NOTES: 1. Borehole/Tu	est Pit data requires Interpretation by exp.	WATER		EVEL RE	€CO	RDS	8						COI	RE DI	RIL	LING	RECC	PRD		
3. Field work v	by others was backfilled upon completion. was supervised by an exp representative. on Sample Descriptions is to read with exp. Services Inc. report 813-A0	ne	L	Water <u>∟evel (m)</u> 1.4		I	Hole O To (r -		1		Run No.		Dept (m)			% R	ec.		RQI	D %

	Test	Pit: TP1	4		eyn
Project No:	OTT-00248813-A0			E: 11 11	
Project:	Phase II Environmental Site Asessment			Figure No. 14	_
Location:	City Lots 3586 228 18/18/19/20 and 3480 220	1, Iqaluit, NU		Page. <u>1</u> of <u>1</u>	_
Date Drilled:	September 7th, 2018	Split Spoon Sample		Combustible Vapour Reading	
Drill Type:	Backhoe - 710J John Deere	Auger Sample — SPT (N) Value		Natural Moisture Content Atterberg Limits	×
Datum:	Assumed	Dynamic Cone Test Shelby Tube		Undrained Triaxial at % Strain at Failure	Φ
Logged by:	MAD Checked by: RR	Shear Strength by Vane Test	+ s	Shear Strength by Penetrometer Test	A

G W L	SYMBO	SOIL DESCRIPTION	Assume m	d e p	Shear	20		netrat	tion T	est N		0	Pa	Com	25	0	50		750	ppm) ht)	ΡI	Natural Jnit Wt. kN/m³
) L		27.3	h		50	-	00	1	50	2(00	_		20		4		60		E S	KIN/III
	\bigotimes	FILL Sand and gravel with boulders and cobbles, brown, moist, no odour, (sur												J: : : :							89	S1
	$\otimes\!\!\otimes$	staining).	26.4		10000						· • · · · · ·					• • • • •	::::					
		- SAND AND GRAVEL AND BOULDER	<u> </u>	1			: :: :	1	::::	17.7				7: ::				1 1 1 1	`` ``		s02	(analy
		AND COBBLES											:: }-	4: ::							84	(analy
	<i>92</i> 2	Brown, moist turning wet, no odour. Test Pit Terminated at 1.53 m De	25.8		2011		<u> </u>	1::	:::::	100	. : . : .	. ; . ;	: : ·		· :	. ; . ; .	(· ; ·	. (.)		(+1+2+	4	
	TEC:								::		<u> </u>	::	::			::	: : :					
.E	TES: Borehole	e/Test Pit data requires Interpretation by exp. lse by others	WAT	ER L	EVEL F	RECO	DRD	S						C	COF	RE D	RIL	LING	REC	ORD		
b	efore u	ise by others	Elapsed		Water			Hole			7	Ru			eptl	h	Т	% R	lec.		RC	D %
		pit was backfilled upon completion.	Time		_evel (n				(m)			No			(m)							

- 2. The test pit was backfilled upon completion.
- 3. Field work was supervised by an exp representative.
- 4. See Notes on Sample Descriptions
- LOG OF TEST PIT 5. This Figure is to read with exp. Services Inc. report OTT-00248813-A0

WAT	ER LEVEL RECO	RDS
Elapsed Time	Water Level (m)	Hole Open To (m)
completion	1.1	<u>-</u>

	CORE DR	RILLING RECOF	RD
Run No.	Depth (m)	% Rec.	RQD %

Project No: OTT-00248813-A0	est)	it		1	ſΡ	1	5) -									\in	<u>ز</u>	ΧĽ)
Project: Phase II Environmental Site Asessm	ent										F	igu	re N	١o.	_		15				-	
Location: City Lots 3586 228 18/18/19/20 and		I. Io	ıalu	it, N	١U								Pa	ge.	_	1_	of _	1				
Date Drilled: September 7th, 2018						ampl	ام		\boxtimes			Con	hue	tible '	\/anc	our P	aadir	na		ı		
Drill Type: Backhoe - 710J John Deere			Aug	er Sa	ampl	е	iC					Nati	ural I	Moist	ure (ig			×	
Datum: Assumed					Valu Con	e e Te	st	_	0					g Lim ed Tri		lat			-		Ð	
Logged by: MAD Checked by: RR		-		lby T		th by						% S	train	at Fa	ailure	Э				,	⊕	
enotice by. Mine				e Te		штыу			+ s			Pen	etror	neter	Tes	t				•	•	
G Y M B O L DESCRIPTION	Assumed m	D e p t h	Sh	near s	20 Stren	gth	netration 10	60		80	kPa		Nat tterb	50 ural N erg L	5 Noist imits	00 ure C s (% [75 Sonter Ory W	nt % /eight)	n) {	ËΙ	Natural Jnit Wt. kN/m³	
FILL Sand with gravel, brown, moist, no odour, (surficial staining nearby).	27.75 	0	-3.0		50	1	00	150	::;	200		D: (2	20		10	6	0			analyz	ed
SAND AND GRAVEL AND BOULDERS	26.9	1	13.3						::: ::::			Dia 1							7	nz.	S2	
AND COBBLES Brown, moist, no odour.	26.4			::::					::2 :::	#:	} ::: {: 				1:1: 1:1:		***		*	+		-
Test Pit Terminated at 1.37 m Depth																						
The test pit was backfilled upon completion. Field work was supervised by an exp representative. 4. See Notes on Sample Descriptions	WATE lapsed Time mpletion		Wa	ter I (m)			S Hole O _l To (n	n)		Ri	un o.		CO Dep (m	th	DRIL		G RI	ECOF		RQ	D %	
5. This Figure is to read with exp. Services Inc. report OTT-00248813-A0																						

LOG OF TEST PIT LOGS OF TEST PITS - SEPTEMBER 11, 2018.GPJ TROW OTTAWA.GDT 9/28/18

EXP Services Inc.

Client: City of Iqaluit

Project Name: Geotechnical Investigation. Proposed Waste Transfer Station

Iqaluit, Nunavut

EXP Project Number: OTT-00248813-A0

Date: October 19, 2018

Appendix B: Results of Chemical Tests on Soil Samples and AGAT Laboratories Certificate





5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

CLIENT NAME: EXP SERVICES INC

2650 QUEENSVIEW DRIVE, UNIT 100

OTTAWA, ON K2B8H6

(613) 688-1899

ATTENTION TO: SURINDER AGGARWAL

PROJECT: OTT-248813

AGAT WORK ORDER: 18Z389131

SOIL ANALYSIS REVIEWED BY: Yris Verastegui, Report Reviewer

DATE REPORTED: Oct 01, 2018

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories (V1)

*NOTE O

Page 1 of 5

Member of: Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Western Enviro-Agricultural Laboratory Association (WEALA) Environmental Services Association of Alberta (ESAA) AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation.



CLIENT NAME: EXP SERVICES INC

9575069

SAMPLING SITE:Iqaluit Waste Transfer Station

Certificate of Analysis

AGAT WORK ORDER: 18Z389131

PROJECT: OTT-248813

5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

ATTENTION TO: SURINDER AGGARWAL

SAMPLED BY:exp

Inorganic Chemistry (Soil)

					<u> </u>				
DATE RECEIVED: 2018-09-25								DA	TE REPORTED: 2018-10-01
		SAMPLE DES	CRIPTION:	BH1 S2 2.0m	BH4 S1 2.5m	BH5 S1 2.0m		BH6 S2 5.0m	
		SAM	PLE TYPE:	Soil	Soil	Soil		Soil	
		DATE	SAMPLED:	2018-09-14	2018-09-14	2018-09-14		2018-09-14	
Parameter	Unit	G/S	RDL	9575066	9575067	9575068	RDL	9575069	
pH (2:1)	pH Units		N/A	7.68	8.70	8.23	N/A	8.07	
Electrical Conductivity (2:1)	mS/cm		0.005	0.063	0.245	0.126	0.005	1.18	
Chloride (2:1)	μg/g		2	5	51	18	4	450	
Sulphate (2:1)	µg/g		2	5	44	18	4	380	

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Elevated RDLs indicate the degree of sample dilutions prior to the analysis to keep analytes within the calibration range, reduce matrix interference and/or to avoid contaminating the instrument.

Certified By:





5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

Quality Assurance

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 18Z389131

PROJECT: OTT-248813

ATTENTION TO: SURINDER AGGARWAL

SAMPLING SITE: Iqaluit Waste Transfer Station

SAMPLED BY:exp

						_								
			Soi	l Ana	alysis	3								
		D	UPLICAT	E		REFEREN	ICE MA	TERIAL	METHOD	BLANK	(SPIKE	MAT	RIX SPI	KE
Batch	Sample	Dup #1	Dup #2	RPD	Method Blank				Recovery	Lie		Recovery	Lin	ptable nits
	la					value	Lower	Upper	•	Lower	Upper	,	Lower	Upper
9575066	9575066	7.68	7.79	1.4%	N/A	100%	90%	110%	NA			NA		
9575066	9575066	0.063	0.065	3.1%	< 0.005	94%	90%	110%	NA			NA		
9575066	9575066	5	5	NA	< 2	97%	70%	130%	99%	70%	130%	95%	70%	130%
9575066	9575066	5	5	NA	< 2	95%	70%	130%	102%	70%	130%	105%	70%	130%
	9575066 957506 957506 957506 957506 957506 957506 957506 957506 957506 957506 957506 957506 957506 957506 957506 957506 9575066 9575000 95750000 9575000 9575000 9575000 9575000 9575000 9575000 9575000 95750000 9575000 9575000 9575000 9575000 9575000 9575000 9575000 95750000 9575000 9575000 9575000 9575000 9575000 9575000 95750000 9575000 95750000 95750000 95750000 95750000000000	Sampla	Batch Sample d Dup #1 9575066 9575066 7.68 9575066 9575066 0.063 9575066 9575066 5	Soi DUPLICAT Batch Sample Id Dup #1 Dup #2 9575066 9575066 7.68 7.79 9575066 9575066 0.063 0.065 9575066 9575066 5 5	Soil Ana DUPLICATE Batch Sample Id Dup #1 Dup #2 RPD 9575066 9575066 7.68 7.79 1.4% 9575066 9575066 0.063 0.065 3.1% 9575066 9575066 5 5 NA	DUPLICATE Method Blank Dup #1 Dup #2 RPD Method Blank Sample Id Dup #1 Dup #2 RPD Method Blank S75066 9575066 7.68 7.79 1.4% N/A 9575066 9575066 0.063 0.065 3.1% < 0.005 9575066 9575066 5 5 NA < 2	DUPLICATE Dup #1 Dup #2 RPD Method Blank Measured Value	Dup #1 Dup #2 RPD Method Blank Measured Value Lin Lower	Duplicate Dup #1 Dup #2 RPD Method Blank Measured Value Acceptable Limits Lower Upper	Soil Analysis DUPLICATE Method Blank Measured Value Limits Lower Upper Recovery	Soil Analysis DUPLICATE Method Blank Measured Value Dup #1 Dup #2 RPD Method Blank Measured Value Dup #2 RPD Method Blank Measured Value Dup #3 Dup #4 Dup #4 Dup #4 RPD Method Blank Measured Value Dup #4 Dup #6 Dup #6 Dup #7 Dup #7 Dup #7 Dup #7 Dup #8 Soil Analysis DUPLICATE Batch Sample Id Dup #1 Dup #2 RPD Method Blank Measured Value Limits Lower Upper Measured Limits Lower Upper Dup #3 Limits Lower Upper Dup #4 Du	Soil Analysis DUPLICATE Batch Sample Id Dup #1 Dup #2 RPD Method Blank Method Blank Method Blank Measured Value Limits Lower Upper Limits Recovery Lower Upper Limits Recovery Lower Upper Recovery NA NA 9575066 9575066 0.063 0.065 3.1% 0.005 94% 90% 110% NA NA NA 9575066 9575066 5 5 NA 0.005 94% 90% 110% NA NA NA 9575066 9575066 5 5 NA 0.005 94% 90% 130% 99% 70% 130% 95% 130% 95% 130% 95% 130% 95% 130	Soil Analysis DUPLICATE Batch Sample Id Dup #1 Dup #2 RPD Method Blank Measured Value Lower Upper Lower Upper Recovery Lower Upper Recovery Recovery Lower Upper Recovery Recovery Recovery Lower Upper Recovery Recovery Lower Upper Recovery Recovery Recovery Lower Upper Recovery Recovery Lower Upper Recovery Lower Upper Recovery Recovery Lower Upper Recovery Recovery Lower Upper Upper Upper Upper Recovery Lower Upper Recovery Lower Upper Recovery Lower Upper	
Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By:

Inis Verastegui



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Method Summary

CLIENT NAME: EXP SERVICES INC AGAT WORK ORDER: 18Z389131

PROJECT: OTT-248813 ATTENTION TO: SURINDER AGGARWAL

SAMPLING SITE: Iqaluit Waste Transfer Station SAMPLED BY:exp

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH



5835 Coopers Avenue Mississauga, Ontario L4Z 1Y2 Ph: 905.712.5100 Fax: 905.712.5122 webearth.agatlabs.com

Laboratory Use Only
Work Order #: 187389

Regular TAT

□ TH™

☐ BTEX

P ONH, OTKN

ustom Metals

Rush TAT (Rush Surcharges Apply)

Cooler Quantity:	one tooic

Turnaround Time (TAT) Required:

Arrival Temperatures:

5 to 7 Business Days

Chain of	Custody Record If this is	a Drinking Water sample, pleas	e use Drinking Water Chain of	Custody Form (potable wa	ter consumed by humans)
Report Info	ormation: Exp Sarvices		Regulatory Requ		Regulatory Requ
Contact:	Swinder Aggard	val.	Regulation 153/04	Sewer Use	Regulation 5

ducensuieur dirive

Phone: Surinder. Aggerwal @ exp. com Reports to be sent to: 1. Email:

Pre	niect	Infor	matic	n:	
2.	Email:		-		

Project: Site Location: Sampled By: AGAT Quote #: PO: Please note: If quotation number is not provided, client will be billed full price for analysis

Invoice Information:	Bill To Same: Yes 📈 No 🗆
Company:	
Contact:	
Address:	
Email:	

Regulatory Requ		No Regulatory Requirement
Regulation 153/04	Sewer Use	Regulation 558
Table ————————————————————————————————————	Sanitary	ССМЕ
☐ Res/Park ☐ Agriculture	□Storm	Prov. Water Quality Objectives (PWOO)
Soil Texture (Check One)	RegionIndicate One	Other
Fine	MISA	Indicate One
Is this submission		Report Guideline on

Filtered - Metals, Hg, CrVI

☐ Yes	□ No
Sample Mat	rix Legend

Biota

Soil

Sediment

SD

Ground Water

Report Guideline on
Certificate of Analysis

	-
Yes	No

WS CO CHE

O. Reg 153

153 Metals (excl. Hydri s ☐ 153 Metals (Incl. H Hydri

3 Business Days	2 Business Days	Next Busine
OR Date Requ	uired (Rush Surcharge	es May Apply):

For 'Same Day	' analysis,	, please	contact your	AGAT	CPN

□PCBs

□ B(a)P

ABNS

VOCs

			sw	Surface Water	Fiel	Field sand fretals and fretals and side Metals are also a		Field stand de Meta			etals S	is D	es:	F1 - F4		□ Tota	ochlor] M&I	Nse	9		e	
Sample Identification	Date Sampled		Comments/ Special Instructions	Y/N	Metals	☐ All Metals │ ☐ Hydride Me	ORPs: C	Full Metals So	Nutrients:	Volatiles:	PHCs	ABNs	PCBs:	Organochlorin	TCLP: \$\Big M&	Sewer	DAR O	2 3	Elect				
RH 1 S1 2.0m	Sof 14/18										1			2				✓ v	1 1	J			
BH 4 61 2.5m																	- ,	1	11	J			
3H 5 SI 2.0m					The said	441											١,	1	1	7			
3HG 52 5.0m	↓																	11	1	J			
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MANOJ J amples Received By (Print Name and Sign

Page .

Client: City of Iqaluit

Project Name: Geotechnical Investigation. Proposed Waste Transfer Station

Iqaluit, Nunavut

EXP Project Number: OTT-00248813-A0

Date: October 19, 2018

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