GEOTECHNICAL ASSESSMENT

Lot 18 Block 34, Plan 74380 LTO
Haines Junction, YT

Prepared For:

Yukon Government Community Services
Land Development Branch

January 24, 2024

CAP File: WEC0012

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APPENDICES

1. INTRODUCTION

CAP Engineering (CAP) was retained by Yukon Government (YG), Department of Community Services - Land Development Branch under a standing offer agreement (SOA 2021/22-260-3), to conduct a desktop geotechnical assessment for Lot 18 Block 34, Plan 74380 LTO of Haines Junction, which is 158 km west of Whitehorse. The purpose of the assessment is to provide geotechnical analysis and familiarization on the ground to determine the lot's suitability for the construction of industrial development.

Authorization to proceed with the work was granted on July 17th, 2023, by Ibrahim Taleb, YG Project Manager.

2. METHODOLOGY

2.1 Literature Review

The following information was reviewed as part of the geotechnical evaluation:

- Gartner Lee Limited – Yukon Groundwater and Ground Source Heat Potential Inventory – 2003
- Tetra Tech – Geotechnical Evaluation – Sewage Lagoon and Infrastructure Upgrades, Haines Junction, YT – 2016
- Government of Yukon – Design Requirements and Technical Standards – 2017
- National Building Code of Canada – 2015
- 2020 National Building Code of Canada Seismic Hazard Tool (https://seismescanada.rncan.gc.ca/hazard-alea/interpolat/nbc2020-cnb2020-en.php)
- GeoYukon
  - **[uTrB1]** – Bear Creek Assemblage – intermediate to mafic metavolcanic rocks
  - Bedrock Geology: Major Rock Type – Greenstone
  - Water Wells: Several points on GeoYukon are located near the lot in Haines Junction where water well drilling or investigations took place (See Figure A).
  - Contaminated Sites:
    - In summer 2012 contaminated soil associated with a fuel tank was removed from a location approximately 230 m Southeast of the site. Confirmatory samples indicated that contamination remained. The remaining contamination was delineated, and it was estimated to be ~6 m^3. It is unknown if additional remedial efforts were conducted.
    - In September 2012, a fuel tank was removed, and contamination associated with the tank was discovered and ~138 m^3 of soil contaminated with PHCs was removed. The extent of contamination is not fully delineated and the base and western wall of excavation are above the applicable standards. (Approximately 405 m Southeast of the site)

3. SITE CONDITIONS

3.1 Site Description

Lot 18 Block 34 is situated in the vicinity of the Village of Haines Junction, which is currently covered by trees and surrounded by industrial infrastructure. Based on the projected elevations at the corners of the lots, it appears that this lot has a slope towards Quill Crescent from the back of the lot with an approximate grade of 2.2%. The total area of the lot is 432 m^2 (refer to Appendix A for more details).

The village of Haines Junction features diverse vegetation influenced by its northern climate and varied ecosystems. Notably, the Kluane National Park and Reserve encompassing the region showcases different vegetation zones: boreal forests with spruce, pine, and birch trees at lower elevations, transitioning into subalpine meadows with wildflowers, shrubs, and alpine tundra with low-growing plants at higher elevations. Riparian areas along water bodies display willows and alders, while wetlands exhibit sedges, grasses, and aquatic plants.

The forest within the Haines Junction community zone is a mixture of even-aged pure spruce patches through to pure trembling aspen patches, including mixes of the two primary types.

3.2 Subsurface Soil Conditions and Water Table Summary

According to the above-noted references, Haines Junction is situated on a softly rolling plateau overlooking the Dezadeash River. The southern edge of the village is bordered by the floodplain of the Dezadeash River. The original soil beneath most of the village is believed to be a thin or sporadically formed layer of sandy and silty glacial lake soil and glacial till. Given that the Takhini Valley was home to multiple glacial lakes before around 1800, the till underneath the village is probably mixed with deposits like silt from the glacial lake.

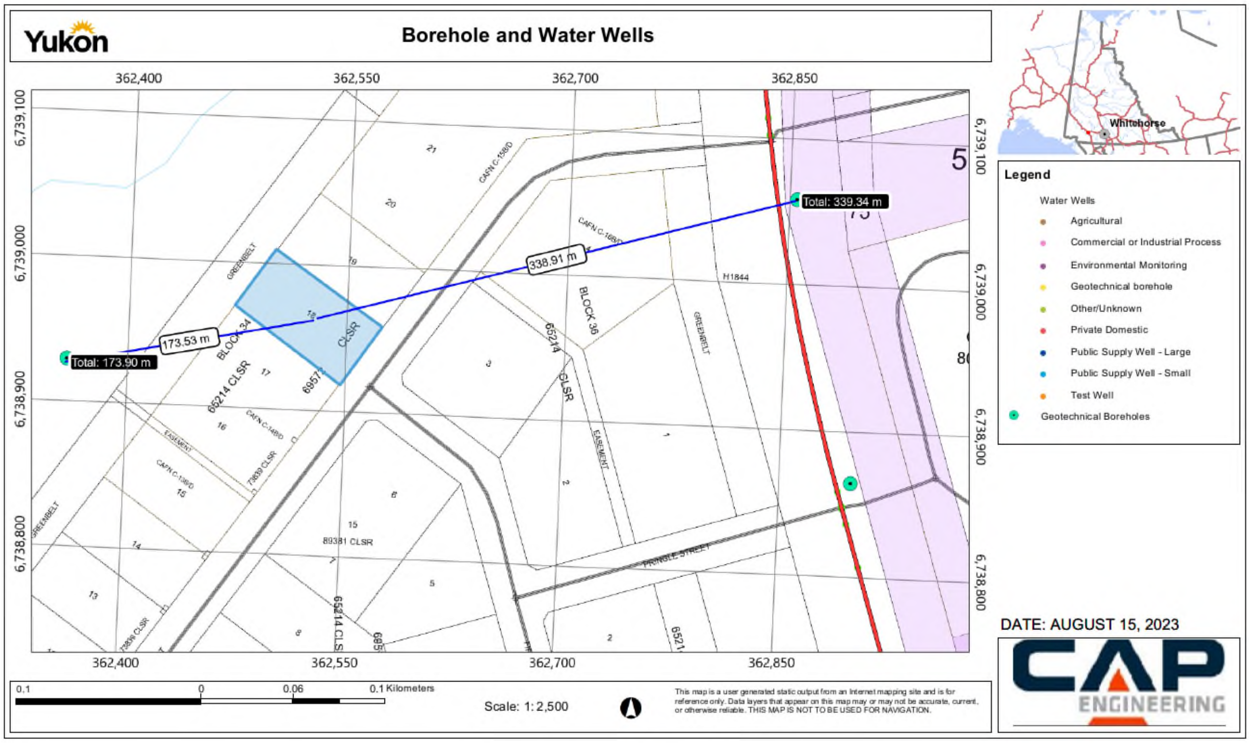
Data from water well records reveal the presence of slim layers of coarse-textured river sediment beneath the floodplain of the Dezadeash River. The majority of the nearby shallow water wells are constructed within these sediment layers. Loose materials, primarily comprising till continue down to depths exceeding 380 m below the village.

The subsurface characteristics of this lot were summarized using three nearby boreholes, two test pits, one geophysics log, and one water well. The topmost layer consists of lacustrine clay soils up to 4.8 m deep, which overlay a till deposit described primarily as a silt or clay with some gravel and sand. This till layer extended to the bottom of the holes in this area up to 6.1 m below ground surface (bgs). Seasonal frost was found at approximately 1.0 m bgs on two test pits. Permafrost was found between 1.0 m to 2.0 m bgs on one borehole near Fireweed Street drilled in 1983.

The location of the lot and boreholes/test pits/water well as well as the borehole/test pit/water well data used for this report is included in Appendix B. Borehole tests have been conducted extensively in the Haines Junction village, covering different plots. The borehole and water well data selected is relevant to the study, verifying that the information obtained was sufficiently close to the lot mentioned in this report.

For a visual representation of the locations of the boreholes and water wells, please refer to Figure A below.

Figure A: Plan Borehole and Water Well Locations



3.2.1 Bedrock

No bedrock was encountered in any of the test sites, but one water well indicates it is deeper than 95 m in this area.

3.2.2 Permafrost and Seasonal Frost

Based on the soil test sites around this lot, the seasonal frost penetrates the ground approximately 1.0 m below the surface in regions where the snow cover remains intact. Nevertheless, it is estimated the seasonal frost will likely reach even greater depths, surpassing 3.0 m in the Haines Junction area.

According to the borehole records, there was permafrost up to 2.0 m bgs on a lot near Fireweed Street. It was in the fine grained upper lacustrine layer. This borehole was drilled in September 1983 indicating this frost may be year-round (i.e. permafrost). There is no information if this lot was treed or cleared at the time of drilling. Nonetheless, areas with substantial organic ground cover and dense forests are more prone to having permafrost. This variability makes it challenging to anticipate where permafrost might or might not be present within Lot 18. To accurately determine the presence of permafrost in this area, it is recommended to perform a site-specific geotechnical site assessment, with boreholes, of this lot to confirm.

3.2.3 Potential for Frost Heave

The primary issue regarding underground utilities and shallow foundation buildings in the Haines Junction region is the susceptibility of the underlying soils to frost heave. The clay and silt soils near the surface are highly prone to frost, making the risk of frost heave considerable. This risk becomes even greater if there is unregulated infiltration of surface water around foundation components. Allowing surface water to penetrate the soil near foundations substantially elevates the likelihood of frost heave. Consequently, it is crucial to ensure proper site drainage away from all infrastructure foundations and that structures are properly insulated from the frost heave effects.

3.2.4 Climate

Located at an elevation of 611 m above sea level, Haines Junction has a Tundra climate (Classification: ET). The district's yearly average temperature is -3.15°C which is 5.24°C lower than the national average. Haines Junction typically receives about 15.24 mm of precipitation and has 27.83 rainy days annually (7.62% of the time).

3.2.5 Limitations of Data

None of the boreholes and test pits referenced in this report are situated within the boundaries of the specific lot being considered. The data acquired from the boreholes, test pits and water wells, as outlined in Appendix B, were utilized to formulate geotechnical recommendations in the report.

3.3 Seismic Consideration

It is best practice to perform a site-specific site investigation for an industrial-zoned lot, which would assist in determining the site classification for this lot. The type of structure will dictate the necessity for a site-specific investigation, which will be determined by the owners and professionals involved in developing the lot.

Based on National Building Code 2020 Table 4.1.8.4-B, which considers the density and wave speed of soils in the upper 30 m to determine site classification, one can determine the site classification for seismic design. There was no Standard Penetration Test (SPT) or Cone Penetration Data (CPT) data available for the industrial lot, so site classification is estimated based on soil stratigraphy. Due to the presence of dense till in all boreholes, it can be estimated that the soils in the industrial lot may be classified as Site Class D. To confirm this site classification, it would be necessary to perform a site-specific investigation using SPT, CPT, or other related testing.

The online Canada Seismic Hazard Tool designates the Sa (0.2) for Lot 18 Block 34 in Haines Junction as 1.28.

4. RECOMMENDATIONS

4.1 Site Suitability

Overall, the site is deemed suitable for future industrial development purposes, provided that certain construction methods and standards are adhered to. Lot 18 Block 34 was proposed by the Yukon Government to be an area for industrial infrastructure. Considering the intended use of this lot is for industrial development, conducting a site-specific geotechnical investigation and assessment is recommended. Such an assessment will provide essential insights into the soil and geological conditions of the site, enabling informed decision-making throughout the planning, design, and construction phases. This investigation would help determine in-situ soils, and bearing capacities for the intended structures and determine whether permafrost is present in these lots.

It is recommended to clear such forested lot with suspected permafrost and wait for approximately one year before proceeding with construction, aligning with common practice in mitigating potential permafrost-related issues.

Foundation recommendations based on a geotechnical investigation are recommended due to the higher stresses of larger industrial infrastructure compared to residential structures. Appropriate foundation options for this site will be dependent upon structure types and may include reinforced monolithic foundations with increased thickness, strip and pad foundations, and pile foundations.

Furthermore, the excavation depth below the building will depend on the encountered materials during the construction process. The till layer was encountered around the area of this lot in Haines Junction at a depth of approximately 2 m to 5 m bgs. It is expected the till layer would be an adequate founding soil for a foundation, but it will depend on how deep it is in the lot as it may not be economical to excavate to this depth. Careful examination of the subsurface conditions will aid in determining the appropriate depth for excavation, ensuring a solid foundation, and minimizing disturbances to the permafrost layer if it is present in this lot.

Due to the presence of fine-grained silt and clay soils in all the test sites around the lot, it will be necessary to ensure proper measures are taken to protect the foundation elements from frost heave effects using non-frost susceptible soils and/or insulation.

Soil corrosivity testing is a fundamental step in the construction process. It safeguards infrastructure, enhances safety, prolongs the lifespan of structures, saves costs, and ensures compliance with regulations. By identifying and addressing corrosive soil conditions beforehand, construction projects can be executed more efficiently and with greater confidence in their long-term viability.

By implementing these construction methods and adhering to relevant standards, the site can be developed effectively and sustainably, considering the challenges posed by the presence of potential permafrost around the area of the industrial lot.

For any parking areas, a gravel structure is assumed for this area. For a concrete or paved driveway, it is recommended that a geotechnical firm be consulted to ensure proper base preparation and pavement structure, as permafrost areas require special considerations.

It is recommended to consult a geotechnical engineer during the planning of the industrial lot to determine whether the intended structure requires a site-specific investigation.

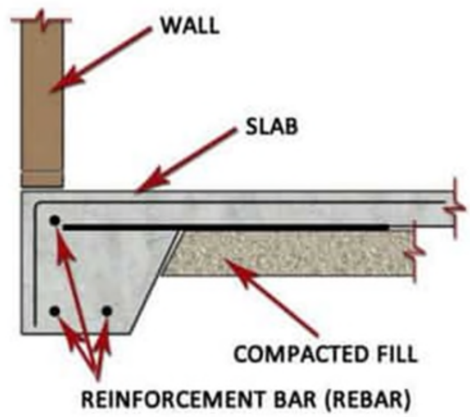
4.2 Foundation Recommendations

There are various foundation solutions that may be viable for development of this lot depending on the actual soil conditions encountered and the intended structure(s) to be constructed. In the case no permafrost is encountered, or the presence of permafrost is mitigated it would be possible to use monolithic slab, strip and pad or a pile foundation. In the case permafrost is encountered on the lot and the frost is not removed or melted then it is recommended to use an adjustable type of foundation such as space frame, screw jacks, or pad-wedge type foundations. Details about these foundation types can be found below.

<u>Monolithic Foundation</u>

A monolithic slab refers to a type of concrete slab that is cast as a single unit and usually maintains a consistent thickness throughout its entire depth. Nonetheless, variations can occur based on the locality, where the outer portion might be constructed with increased thickness to counter frost heaving and offer improved structural support for external walls. See Figure B.

Figure B: Monolithic Foundation



Strip and Pad/Spread Foundations

Strip foundations are versatile and can be used for various subsoils, but they are most effective for soils with decent bearing capacity. They work well for structures with relatively light loads, such as many residential buildings with a few stories. In these cases, mass concrete strip foundations can be used. However, if the situation is different and requires stronger support, reinforced concrete may be required.

Pad foundations are generally shallow, but their depth can be adjusted based on the ground conditions. These foundations are spread-out platforms made of concrete in shapes such as rectangles, squares, or circles. They are designed to carry specific point loads, like the weight of columns or groups of columns in a building's structure. The load is then spread out by the foundation to the soil or rock below. It is also worth noting that pad foundations can also be used to support ground beams in some cases. See Figures C and D.

Figure C: Pad/Spread Foundation

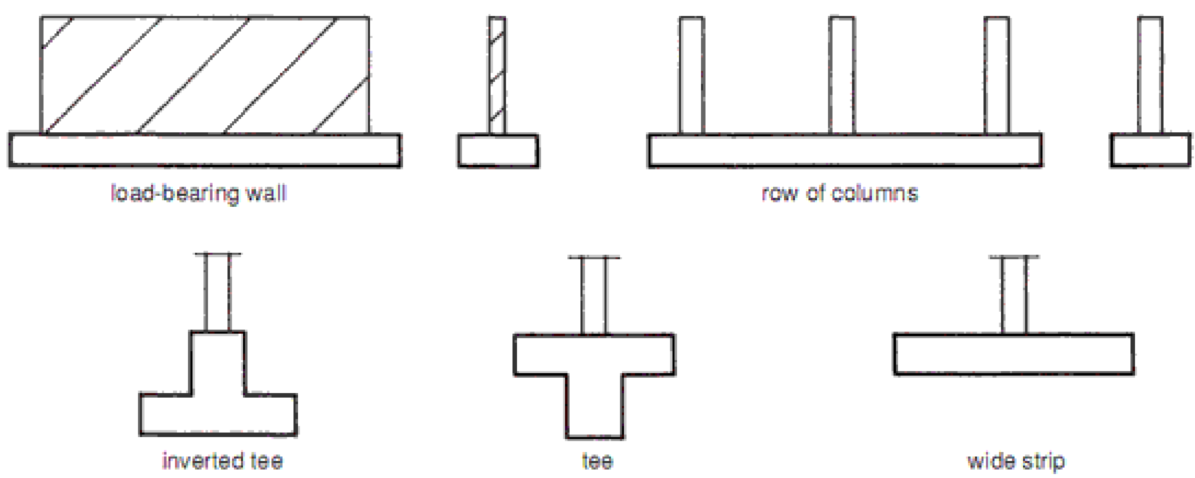
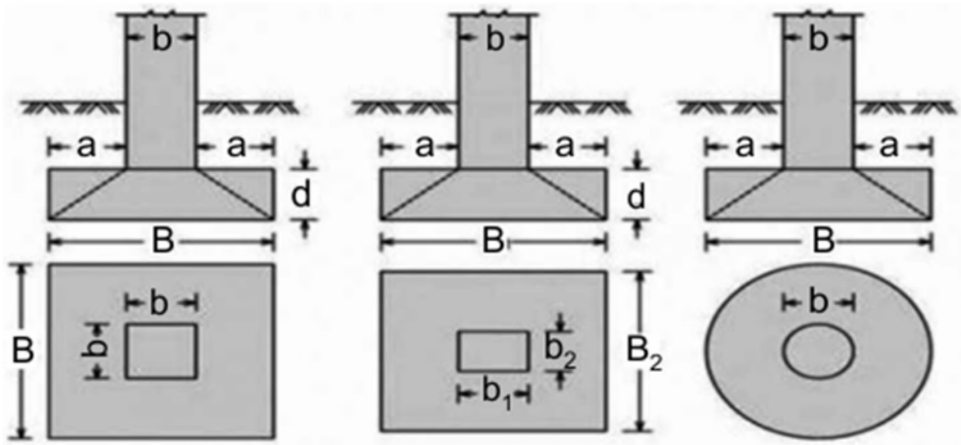


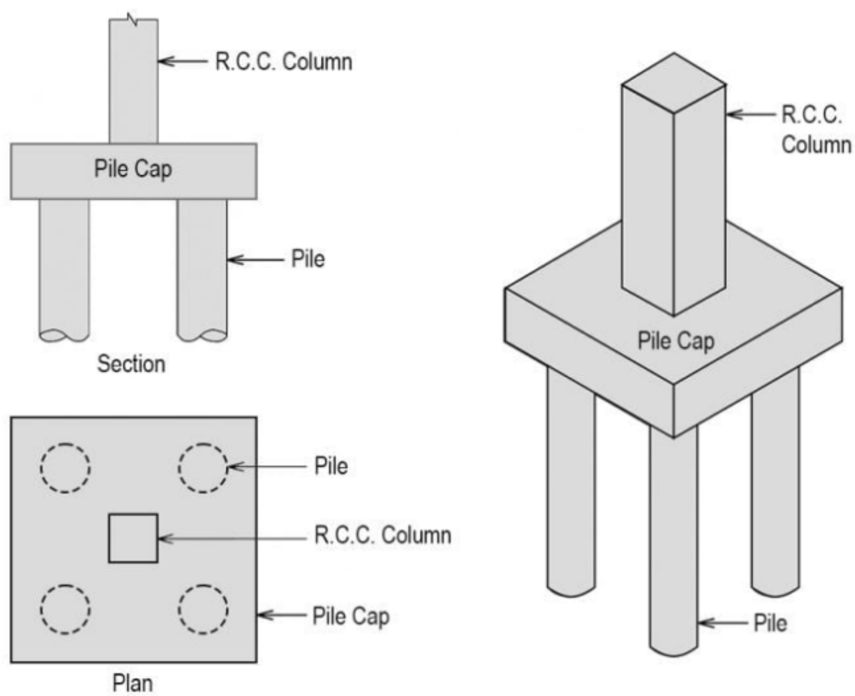
Figure D: Pad/Spread Foundation



<u>Pile Foundation</u>

Pile foundations belong to the category of deep foundations and involve one or multiple vertical structural elements inserted into the ground. Their purpose is to transfer the weight of structures through unsuitable layers of soil to more reliable foundation soil. These foundations derive their load-bearing capacity from either skin friction (the adhesive forces between the pile's sides and the nearby soil), end-bearing on stable soil or bedrock, or a combination of both factors. Moreover, pile foundations can also be engineered to counteract forces that attempt to lift or shift them horizontally, which is particularly relevant in areas with high water tables or artesian conditions. See Figure E.

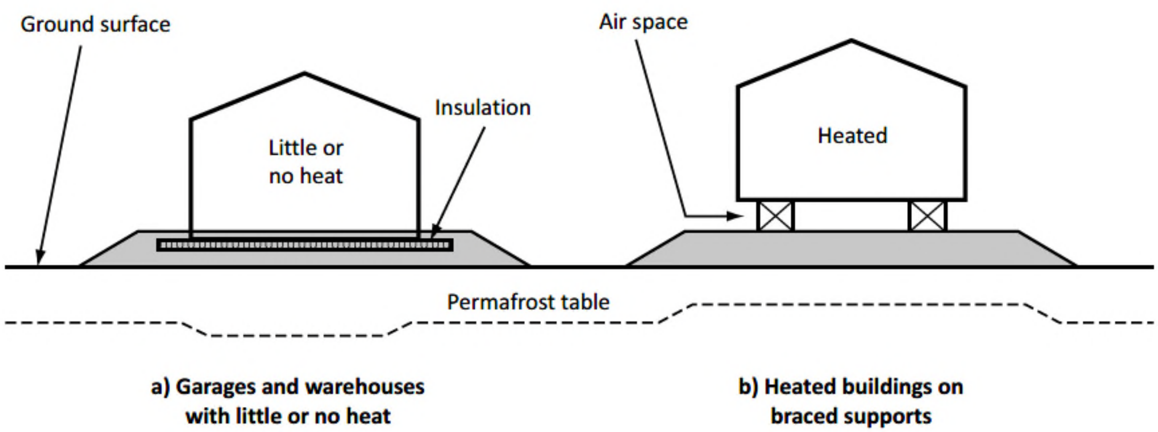
Figure E: Pile Foundation



Basic Pad Foundations and Spread Footings

A granular material pad is commonly used as a base for building on permafrost. It improves access to the site and protects the underlying permafrost. The pad is made of gravel or crushed rock, designed to stay stable during freezing and thawing cycles. It allows permafrost to grow into the base, joining the frozen ground. To prevent heat transfer, buildings are elevated at least 1 m above the pad, allowing air circulation underneath. If buildings are directly on the pad, alternative heat exchangers are used. This method helps to ensure stable construction and protects the permafrost. See Figure F.

Figure F: Two Basic Pad Foundation Design (CSA 2010)



Space Frame Foundations

Space frame foundations consist of pre-manufactured metal members flattened on each end and connected by welding or bolts. They are commercially available, and custom-made to the building size for which it is to be used. It is assembled directly on-site on a compacted granular foundation.

Screw Jacks and Pad-Wedge Foundation

Surface footing on a granular pad with open space below the building is a commonly used foundation type for construction above permafrost, especially for smaller structures like homes. This type of foundation is designed to move with the ground, allowing it to adjust to differential settlement or heave. To accommodate potential future settlement, especially in areas with known thaw-sensitive permafrost, the foundation is equipped with jacking and shimming mechanisms. In some cases, screw jacks may be permanently installed at each footing to facilitate re-leveling if necessary. This ensures stability and flexibility in the construction to adapt to the changing permafrost conditions.

4.3 Perimeter Insulation and Lot Grading

It is common practice in the Yukon to install frost protection to an equivalent of 2.5 m and 3.0 m depth for heated structures and unheated structures respectively that are in contact with the ground such as slab on grade, strip footings, or basements. If these types of foundations are desired, then a site-specific geotechnical evaluation is recommended. This means consideration for additional insulation should be considered when there is less than 3.0 m of foundation wall backfill or frost susceptible material within the upper 3.0 m below foundation elements. A general rule for insulation is that 25 mm of rigid (SM Styrofoam) insulation is equivalent to 300 mm of soil cover. When considering unheated structures built on shallow foundations it is common to see an equivalent of 3.0 m of frost protection depending on the type of structure in this region.

Soil in contact with shallow foundations can freeze to the foundation, developing a substantial ad freeze bond. Backfill soil that is frost susceptible can heave and transmit uplift forces to the foundation. It is best practice to backfill foundation walls with a non-frost-susceptible material and ensure this material is well drained to reduce or eliminate any uplift forces.

The rigid insulation sheets should be placed with a minimum soil cover of 300 mm on top and extend at least 1.2 m out from the structure. A sheet of vertical insulation should be fastened to the exterior wall above the horizontal insulation up to the insulated exterior wall.

Site grading is be carried out and maintained to ensure water is directed away from all building structures to prevent the accumulation of surface water at the building in accordance with the National Building Code of Canada. It is also a requirement that the surface water may not be directed onto neighbouring properties.

4.4 Sewage Disposal Systems

On-site sewage disposal systems are used to treat wastewater from a building not connected to a municipal sewer system. As per the Design Specifications for Sewage Disposal Systems (DSSDS) put forth by the Government of Yukon, “No person shall construct, install, enlarge, rebuild, substantially repair, or connect to an existing system, any sewage disposal system or any thereof, or cause the same to be done, without first obtaining a written permit from a health officer.”

The size of the required field will be dependent on the number of people working/living in the structures, the amount of water estimated to be used and the percolation rate of water into the soil. It is necessary to dig test hole(s) where the system is intended to be built. Within the test hole, a sample is collected, and a percolation test is conducted at the elevation where the water is expected to drain into the ground. The steps for installing an approved sewage disposal system in the Yukon are attached in Appendix C.

While the Village of Haines Junction has water and wastewater treatment infrastructure for many areas of town, this lot does not have water and sewer infrastructure nearby as per details provided by the YG Project Manager. An investigation (percolation test and soil test) should be conducted to determine what kind of septic system can be used to follow the DSSDS. Before installing a septic field, the soil type, depth of the water table, lot size, and bedrock depth are needed. A minimum depth of 1.2 m between the drain tile and any impermeable layer or groundwater is required.

YG Environmental Health Services recommends that septic fields should be the primary option. As it is a requirement to provide locations for two septic fields, it is more difficult to accomplish this for lots less than one hectare and in areas with shallow water tables. Unserviced smaller lots (less than one hectare) are better suited for engineered septic systems due to the space requirements for septic fields and the high pump-out cost for holding tanks. Holding tanks are advised to be used as a last resort after other options have been explored.

5. CONCLUSION AND LIMITATIONS

In general, Lot 18 Block 34 is deemed suitable for future industrial infrastructure and development purposes as per the industrial zoning outlined by YG.

It is recommended that a qualified geotechnical engineer be consulted during design and construction to confirm the ground conditions and to ensure the proposed design meets Yukon construction standards. This will ensure the foundation type(s) selected for industrial development on this lot are well suited to the insitu ground conditions for the proposed structures.

By implementing these recommendations and conducting further on-site investigations as needed, the Yukon Government can ensure that any future developments in Haines Junction are well-prepared to handle the challenges posed by permafrost and other challenging ground conditions. This proactive approach will result in resilient and sustainable infrastructure that can withstand the unique environmental conditions of the region.

This report and its contents are intended for the sole use of the Yukon Government and its agents. CAP Engineering does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained in the report when the report is used or relied upon by any other party or for projects outside the subject area. Any such unauthorized use of this report is at the sole risk of the user. CAP has exercised a fair level of care and skill consistent with that put into practice by members of the engineering and science professions currently practicing under similar conditions, subject to time limits and physical constraints applicable to this report.

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Signature
Date 2024-01-25
PERMIT NUMBER: PP189
Association of Professional Engineers of Yukon

APPENDIX A

SITE MAP

Yukon

Lot 18 Block 34

362,400 362,550 362,700 362,850

6,739,000 6,738,900 6,738,800 6,738,700

362,400 362,550 362,700 362,850

6,739,000 6,738,900 6,738,800 6,738,700

Legend

LOT BOUNDARY

ELEVATION

Elevations came from Airborne liDAR data from year 2014 in GeoYukon

DATE: AUGUST 15, 2023

CAP ENGINEERING

0.1 0 0.06 0.1 Kilometers

Scale: 1: 2,500

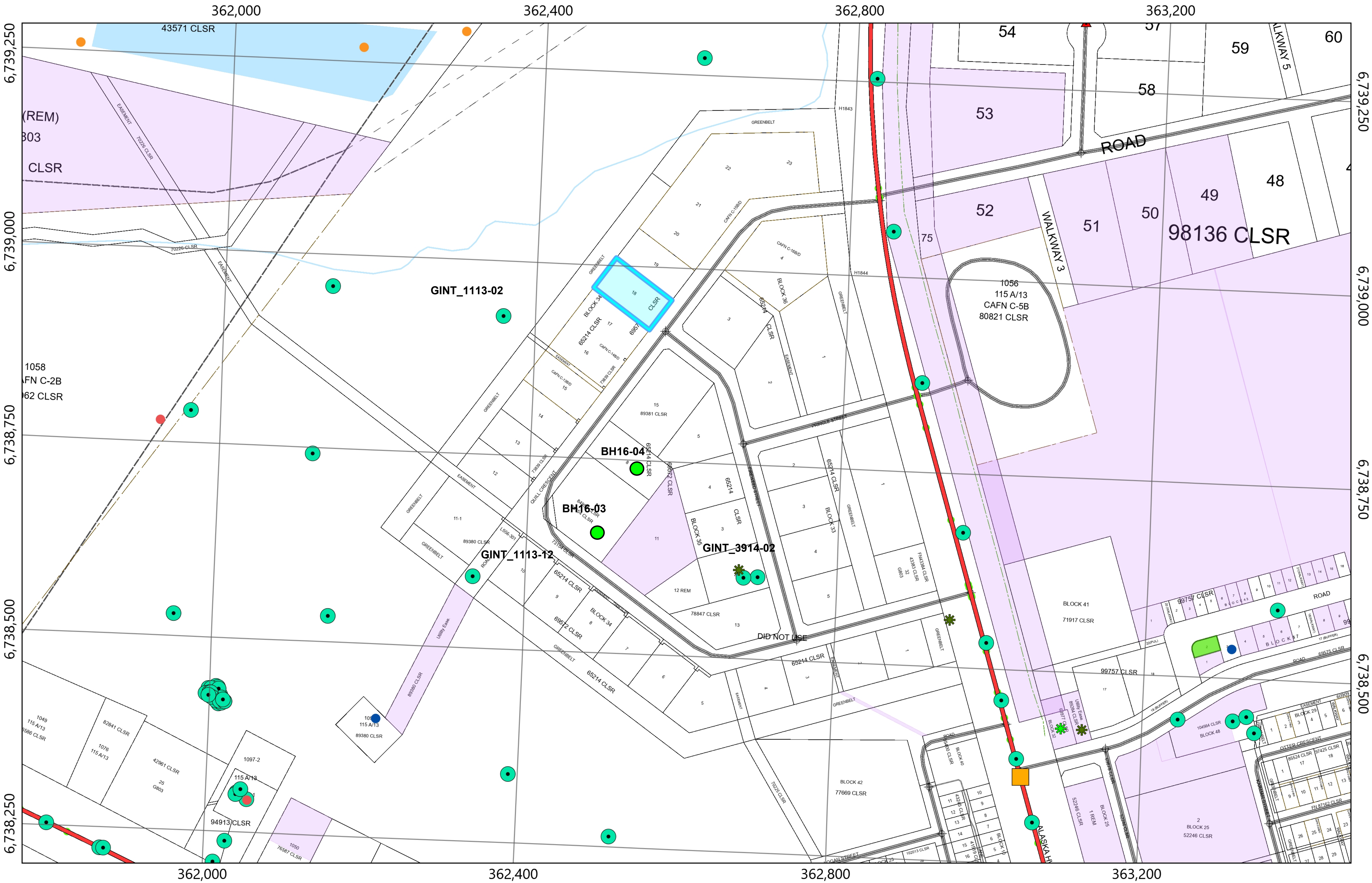
This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. THIS MAP IS NOT TO BE USED FOR NAVIGATION.

APPENDIX B

BOREHOLE, TEST PIT, AND WATER WELL DATA

Yukon

Lot 18 Block 34 - Borehole and Water Well



Legend

Water Wells

- Agricultural
- Commercial or Industrial Process
- Environmental Monitoring
- Geotechnical borehole
- Other/Unknown
- Private Domestic
- Public Supply Well - Large
- Public Supply Well - Small
- Test Well

Geotechnical Boreholes

Geotechnical Reports Point

Geotechnical Reports Line

Permafrost Reports Point

Notes

0.3 0 0.13 0.3 Kilometers

Projection: Yukon Albers Equal Area Conic

Produced from: GeoYukon application

Scale: 1: 5,000

This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. THIS MAP IS NOT TO BE USED FOR NAVIGATION.

Date Printed: 12-Jan-2024

GINT_11135-02

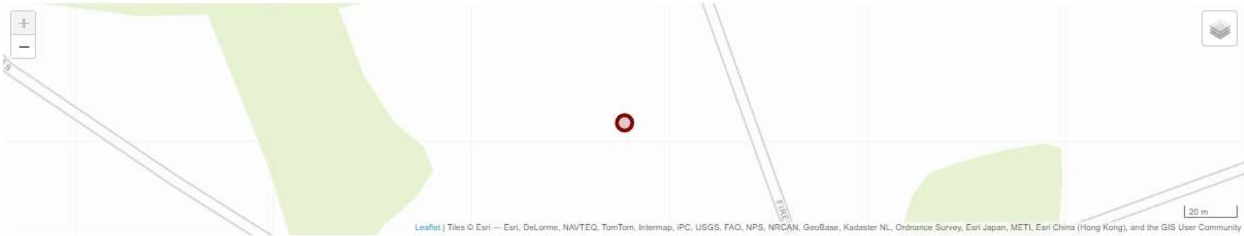
Top depth (m)	Bottom depth (m)	Boundary	Soil description
0.00	0.15	NA	ORGANIC ROOT MAT-frozen, black
0.15	2.00	0	CLAY AND SILT-trace of fine sand, rootlets to 0.3 m, seasonally frozen to 1.0 m, moist below frost, firm, dark olive
2.00	4.10	0	SILT AND CLAY-trace of fine sand, even, parallel horizontal laminae approximately 5 mm thick, moist, stiff, dark olive
4.10	5.00	0	SILT(TILL)-sandy, some fine gravel, some clay, wet, firm, dark olive
5.00	5.20	0	NA
5.20	5.40	NA	END OF TESTPIT 5.0 m
5.40	5.40	NA	NOTES: Ground Cover - grass and willows Predominant Vegetation - mature poplars with occasional spruce trees; lots of leaning poplars throughout area Snow Cover - 0.5 m

Sample

Sample number	Top depth (m)	Bottom depth (m)	Type
1	0.10	0.30	G
2	0.80	1.00	G
3	1.80	2.00	G
4	2.80	3.00	G
5	3.80	4.00	G
6	4.80	5.00	G

Site id	Project name	Location description	Elevation (m)	Hole depth (m)	Start date	End date	Client
GINT_11135-02	SITE SUITABILITY STUDY	GEOTECHNICAL INVESTIGATION, HAINES JUNCTION, YUKON	605.50	5.00	1993-01-19 00:00:00	1993-01-19 00:00:00	LORIMER & ASSOCIATES

GINT_3914-02



Top depth (m)	Bottom depth (m)	Boundary	Soil description
0.00	1.00	NA	SILT - clayey, some sand, trace of rootlets near surface, damp, dense, olive brown
1.00	1.30	NA	- Frozen from 1.0 m to 2.0 m, Nbn
1.30	1.70	NA	- trace of gravel sizes
1.70	2.40	NA	- occasional light brown sand lenses
2.40	4.80	0	SILT(TILL) - clayey, some sand and gravel, trace of cobbles, damp, dense, olive brown
4.80	4.80	0	END OF BOREHOLE AT 4.8 m

Sample

Sample number	Top depth (m)	Bottom depth (m)	Type
1	1.10	1.70	SPT
2	2.20	2.40	G
3	2.80	3.30	SPT
4	4.30	4.80	SPT

Site id	Project name	Location description	Hole depth (m)	Start date	End date
GINT_3914-02	HAINES JUNCTION MUNICIPAL SHOP	HAINES JUNCTION, YUKON,	4.80	1983-09-08 00:00:00	1983-09-08 00:00:00

GINT_11135-12

Top depth (m)	Bottom depth (m)	Boundary	Soil description
0.00	0.15	NA	ORGANIC ROOT MAT-seasonally frozen, black
0.15	1.00	0	CLAY AND SILT-trace of fine sand, rootlets to 0.3 m, seasonally frozen to 1.0 m, dark olive
1.00	4.80	0	SILT AND CLAY-trace of fine sand, even, parallel horizontal laminae, approximately 5 mm thick, moist, very stiff, dark olive to olive grey
4.80	5.00	NA	-trace of gravel in silt matrix, (likely TILL interface)
5.00	5.20	0	NA
5.20	5.40	NA	END OF TESTPIT 5.0 m
5.40	5.40	NA	NOTES: Poplar and spruce throughout area-Percolation test completed adjacent to testpit at a depth of 2.1 m-Percolation rate measured as 75 min/25 mm after a 4 hour presoak period

Show USC code descriptions

Sample

Sample number	Top depth (m)	Bottom depth (m)	Type	USC code
1	0.10	0.30	G	NA
2	0.80	1.00	G	NA
3	1.80	2.00	G	NA
4	2.80	3.00	G	NA
5	3.80	4.00	G	MH/CL
6	4.80	5.00	G	NA

Site id	Project name	Location description	Elevation (m)	Hole depth (m)	Start date	End date	Client
GINT_11135-12	SITE SUITABILITY STUDY	GEOTECHNICAL INVESTIGATION, HAINES JUNCTION, YUKON	609.50	5.00	1993-01-21 00:00:00	1993-01-21 00:00:00	LORIMER & ASSOCIATES

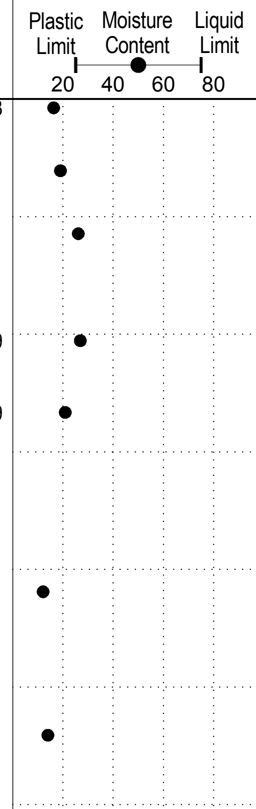
Borehole No: **BH16-03**

Project: Sewage Lagoon and Infrastructure Upgrades	Project No: ENG.WARC03134-01
Location: Septage Dumping Station (See Fig. 2)	Ground Elev: 616 m
Haines Junction, Yukon	UTM: 362519 E; 6738632 N; Z 8

Stantec

Method: Solid stem auger

Depth (m)	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Elevation (m)
0	TOPSOIL AND ROOT MAT - (50 mm thick)	Unfrozen		SA13	16.3	616
	SAND - clayey, silty, poorly graded, damp, compact, light brown, organic inclusions, fine sand, (250 mm thick)			SA14	19	
	CLAY - silty, sandy, stratified, damp, stiff to very stiff, non plastic, greyish brown					
1	- no visible sand, hard, dark grey			SA15	26.1	615
	- moist, stiff, low plastic, grey					
2	CLAY (TILL) - silty, trace sand, trace gravel, no visible clay, no visible structure, medium plastic, grey			SA16	26.9	614
				SA17	20.9	
3	- damp, low plastic					613
4	- some sand, trace cobbles and boulders, dry, non plastic, brownish grey			SA18	12.1	612
5				SA19	14	611
6	END OF BOREHOLE (6.10 metres) slough - none at 0 hrs. water - dry at 0 hrs.					610
7						609
8						608
9						607
10						606
11						605
12						604



DRAFT

TETRA TECH

Contractor: Donjeck Drilling	Completion Depth: 6.1 m
Drilling Rig Type: Truck Mounted CME75	Start Date: August 27, 2016
Logged By: TM	Completion Date: August 27, 2016
Reviewed By: CPC	Page 1 of 1

Borehole No: **BH16-04**

Stantec

Project: Sewage Lagoon and Infrastructure Upgrades	Project No: ENG.WARC03134-01
Location: Septage Dumping Station (See Fig. 2)	Ground Elev: 616 m
Haines Junction, Yukon	UTM: 362537 E; 6738648 N; Z 8

Depth (m)	Method	Soil Description	Ground Ice Description	Sample Type	Sample Number	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0	Solid stem auger	TOPSOIL AND ROOT MAT - (150 mm thick)	Unfrozen					616
		SAND - clayey, silty, poorly graded, dry, compact, greyish brown, fine sand		■	SA20	21.3	●	
1		CLAY - silty, trace sand, trace clay, stratified, damp, stiff, low plastic, grey - hard, dark grey - no visible sand		■	SA21	24.8	●	615
2		- moist, firm, high plastic, grey - 50 mm thick zones of hard, dark grey silt for 600 mm		■	SA22	29	●	614
3		CLAY (TILL) - silty, trace gravel, moist, firm, high plastic, grey						613
		- trace sand, no visible structure		■	SA23	16.6	●	
4		- some sand, dry, stiff, non plastic, brownish grey		■	SA24	13.1	●	612
		- very stiff						
5		- damp, stiff - 150 mm thick damp, hard, dark grey silt						611
				■	SA25	13.5	●	
6		END OF BOREHOLE (6.10 metres) slough - none at 0 hrs. water - dry at 0 hrs.						610
7								609
8								608
9								607
10								606
11								605
12								604

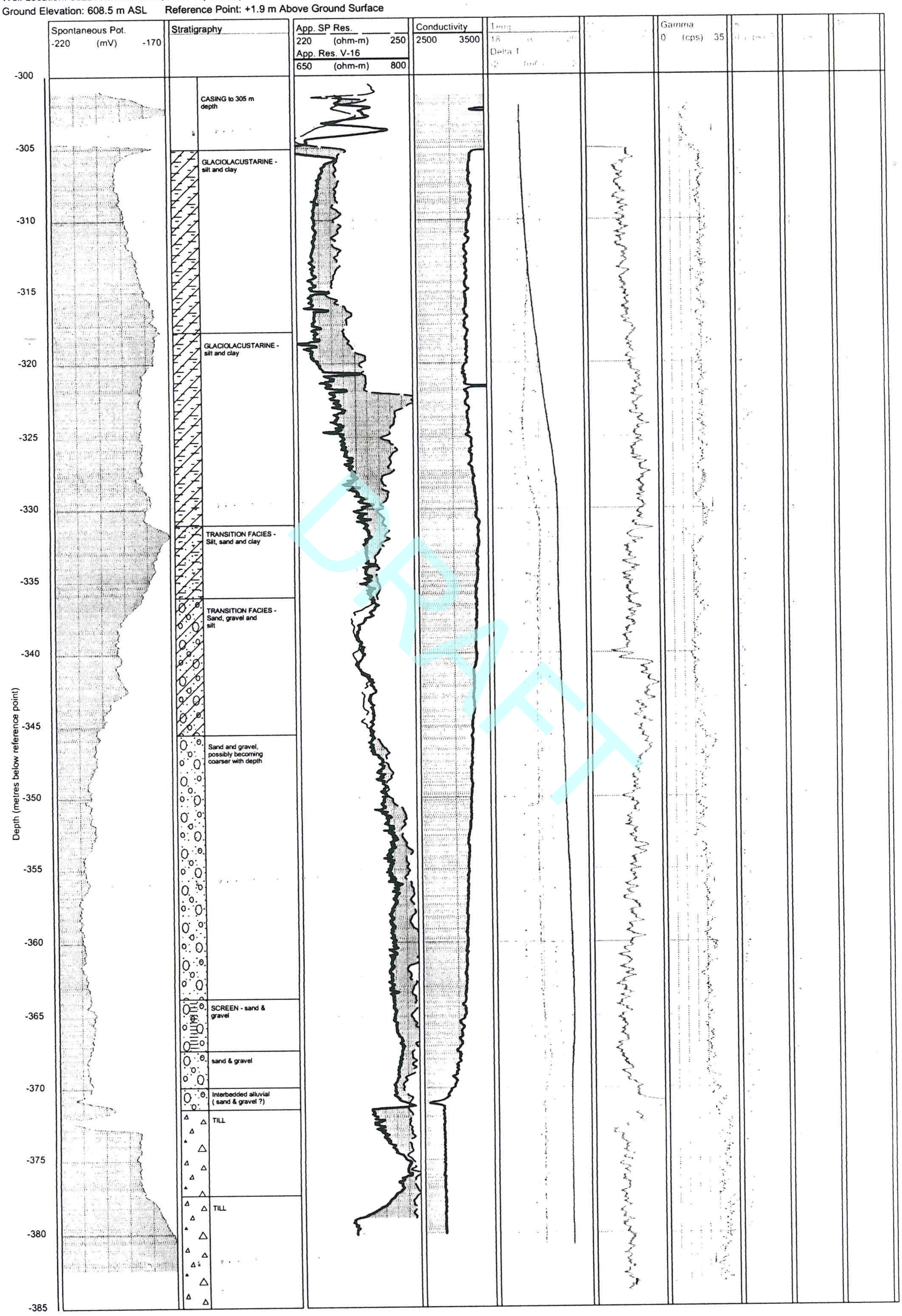
DRAFT

TETRA TECH

Contractor: Donjeck Drilling	Completion Depth: 6.1 m
Drilling Rig Type: Truck Mounted CME75	Start Date: August 27, 2016
Logged By: TM	Completion Date: August 27, 2016
Reviewed By: CPC	Page 1 of 1

Figure 3. Geophysical and Borehole Log of Well No. 5
Location: Haines Junction, Yukon

Hole Logged By: Aurora Geosciences Ltd., September 9, 2002. Log #3 & #4
Logging Tool: IFG Corp. BFG-06 Multiparameter Probe
Log Prepared By: Gartner Lee Limited, 22-345
Well Location: 362215E 6738404N, Zone 7 (NAD83)
Ground Elevation: 608.5 m ASL   Reference Point: +1.9 m Above Ground Surface



indicated significantly lower resistivity in sections where the SP and gamma logs indicated possible clean and permeable beds. This suggested that any mud invasion the occurred after pumping the pill was minimal.

6. Temperature log: The temperature log generally repeated between runs. The maximum bottom hole temperature recorded was over 20 ^{0}C during the open hole down run.

The following is an interpretation of the log results based on discussions with [redacted] Interpreted depths are taken from the resistivity log.

Interval	Interpreted section	
305.7 - 331 m	*Clay rich sand / silt*	This section of the log is characterized by higher SP response, relatively higher gamma, lower SPR and 16" resistivity, higher conductivity and an increasing temperature gradient.
331.0 - 332.3 m	*Permeable sand*	Positive SP deflection, gamma decrease (strongest in SP log). Also weak and non-repeated conductivity decrease for 0.5 m in this interval. Section below this has lower gamma response. May correspond to noticeable decrease in sampl clay content noted at sample logged at 329 m (GLL).
332.3 - 341.5 m	*Sand or gravel*	Lower gamma and conductivity response, increasing resistivity. SP response gradually declining. Slight increase in magnetic susceptibility at 340 m. Also note change in temperature gradient near 330 m which repeats in both logs. This appears to be a resistive sand lower in clay than overlying material (<330 m)
341.5 - 343.0 m	*Permeable sand*	Positive SP deflection, immediately above a small gamma increase (sand over clay seam). No appreciable change in resistivity.
343.0 - 345.0 m	*Sand or gravel*	Same response as 332.3 - 341.5
345.0 - 347.0 m	*Dirty sand*	Gamma response increases, suggesting possible minor increase in clay content.
347.0 - 370.0 m	*Gravel*	Gravel reported from drill samples in this interval. Subtle decrease in magnetic susceptibility towards base. Gamma response is flat to very slightly increasing. Temperature increasing with a gradient similar to overlying sand. SP is flat and relatively negative with respect to surrounding strata. Resistivity increases towards base. Conductivity decreases towards base suggesting that the unit may coarsen towards the bottom.

370. 0 - 373.0 m	*Permeable gravel*	Strong positive SP deflection. Positive magnetic susceptibility increase (?lag deposit of magnetic clasts?). Resistivity increases over this interval with a very weak 16" response and a repeated conductivity response which corroborates the resistivity. Gamma response begins to increase at the top of this unit and carries on into the overlying till layer. Temperature gradient changes from positive to negative over this interval suggesting possible inflow of cold water or change in thermal conductivity
373.0 - 384.6 m	*Glacial till*	Marked change in SP response. Increase in gamma response suggesting increase in clay content. 16" resistivity appears to decline over this interval; conductivity does not repeat in this interval. Clay rich glacial till with subangular clasts was recovered from a sample at 378.9 m and similar material was recovered from the temperature probe casing at the base of the logging tool.

It should be stressed that the geophysical log responses are not strong enough to independently estimate overburden composition.

e. Conclusions. The bore hole log results suggest the following conclusions:

1. The drill hole appears to have intersected a sequence of gravel and sand in the interval from 331 to 373 m.

2. There appears to be three zones which are more permeable than the remainder of the section. The lowest interval, from 370 - 373 m appears to be the thickest and displayed the strongest indication of permeability.

3. The warmest water in the drill hole appears to originate from 331 - 370 m.

Respectfully submitted,
AU[redacted]IENCES LTD.

GEOPHYSIC
9 OCT 02
[redacted]
N.W.T.

WELL FORM **Impact Drilling** 867-668-6943 H-5 sheet ____ of ____

6" - 12" • Water Wells • Pump Installation • Exploration • Dual Rotary Air Rig • Pilings

Owner name: [redacted]

Mailing address: ________ City / Town: ________ Prov. / Terr. ________ Postal Code ________

Well Location Address: Street No. Km 1580 Street name Alaska Hwy City / Town Haine Junction

OR Legal description: Lot ________ **Plan** ________ D.L. ________ Block ________

OR PID: ________ **AND Description of well location** (attach sketch if nec.): To Left of driveway Approx 100' from house

NAD 83: Zone: ________ **AND UTM Easting:** 08361923E m **UTM Northing:** 6738778N m **OR Latitude:** ________ **Longitude:** ________

Method of drilling: ☐ air rotary ☑ dual rotary ☐ cable tool ☐ mud rotary ☐ auger ☐ driving ☐ jetting ☐ other (specify) ________

Orientation of well: ☑ vertical ☐ horizontal Ground elevation ________ ft (asl) Method: ________

Class of well: ________

Water supply wells, indicate water use: ☑ private domestic ☐ water supply system ☐ irrigation ☐ commercial or industrial ☐ other (specify) ________

LITHOLOGIC DESCRIPTION

		Surficial Material							Bedrock Material								Color								Hardness				Water Content						
From ft (bgl)	To ft (bgl)	Clay	Silt	Till	Sand with clay/silt	Sand, fine-med	Sand, med-coarse	Sand with gravel	Siltstone/Shale	Sandstone	Granodiorite	Limestone	Basalt	Volcanic	Crystalline	Other Surficial Bedrock	Red	Orange	Brown	Black	Light Grey	Blue	Green	Dark Grey	Very Hard	Hard	Dense / Stiff	Loose	Dry	Moist	Wet	High Production	Lost circulation	Not available	Observations (e.g. other geological materials (e.g. boulders) est. water bearing flow (USgpm), or closure details)
0	16	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	●	○	○	○	○	
16	20	●	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	
20	55	○	○	○	●	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	
55	78	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	Won't clean up
78	207	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	
207	213	○	●	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	silty water
216	299	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	●	○	○	○	○	○	
299	307	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	
307	313	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	
		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	

CASING DETAILS

From ft (bgl)	To ft (bgl)	Dia in	Casing Material / Open Hole	Wall Thickness in	Drive Shoe
0	300	6 5/8	Steel	219	D.P

Surface seal: Type Bentonite Depth 15 ft

Method of installation ☑ Poured ☐ Pumped Thickness 10 in

Backfill: Type ________ Depth ________ ft

Liner: ☐ PVC ☐ Other (specify): ________

Diameter ________ in Thickness ________ in

From ________ ft (bgl) To ________ ft (bgl)

Perforated: From ________ ft (bgl) To ________ ft (bgl)

SCREEN DETAILS

From ft (bgl)	To ft (bgl)	Dia in	Type	Slot Size
299	304	6	SS	12
304	307	6	SS	15

Intake: ☑ Screen ☐ Open bottom ☐ Uncased hole

Screen type: ☑ Telescope ☐ Pipe size

Screen material: ☑ Stainless steel ☐ Plastic ☐ Other: ________

Screen opening: ☑ Continuous slot ☐ Slotted ☐ Perforated pipe

Screen bottom: ☐ Bail ☑ Plug ☐ Plate ☐ Other: ________

Filter pack: From ________ ft To: ________ ft Thickness: ________ in

Type and size of material: ________

DEVELOPED BY

☑ Air lifting ☐ Surging ☐ Jetting ☐ Pumping ☐ Bailing

Other (specify): ________ Total duration: ________ hrs

Notes: ________

WELL YIELD ESTIMATED BY

☐ Pumping ☑ Air lifting ☐ Bailing ☐ Other (specify): ________

Rate: ________ USgpm Durtation: ________ hrs

SWL before test: ________ ft (btoc) Pumping water level: ________ ft (btoc)

OBVIOUS WATER QUALITY CHARACTERISTICS

☐ Fresh ☐ Salty ☑ Clear ☐ Cloudy ☐ Sediment ☐ Gas

Colour / Odour: ________ Water sample collected: ☐

WELL DRILLER (print clearly)

Name (first, last): [redacted]

Consultant (if applicable; name & company) ________

Signature of Driller Responsible [redacted]

FINAL WELL COMPLETION DATA

Total depth drilled: 313 ft Finished well depth: 307 ft (bgl)

Final stick up: 18 in Depth to bedrock: ________ ft (bgl)

SWL: ________ ft (bgl) Estimated well yield 4 USgpm

Artesian flow: ________ USgpm, or Artesian pressure: ________ ft

Type of well cap: Locking Well disinfected: ☑ Yes ☐ No

Where well ID plate is attached: ________

WELL CLOSURE INFORMATION

Reason for closure: ________

Method of closure: ☐ Poured ☐ Pumped

Sealant Material: ________ Backfill material: ________

Details of closure: ________

DATE OF WORK (yyyy/mm/dd)

Started: Aug 2017 **Completed** Aug 2017

Comments: ________

PLEASE NOTE: The information recorded in this well report describes the works and hydrogeologic conditions at the time of construction, alteration or closure as the case may be. Well yield, well performance and water quality are not guaranteed as they are influenced by a number of factors, including natural variability, human activities and condition of the works, which may change over time.

WHITE: CUSTOMER COPY | YELLOW: YTG COPY | PINK: DRILLER COPY

APPENDIX C

STEPS FOR INSTALLING AN APPROVED SEWAGE DISPOSAL SYSTEM IN THE YUKON

Application Submission Requirements

Please be advised that applications must be received at least 48 hours in advance of planned receipt of the permit.

As a minimum, the following must be submitted to Environmental Health Services along with an *Application For A Permit To Install A Septic System*:

- A site plan drawing showing a profile of the system layout, including septic tank, absorption system, plus a the location and horizontal distances between all system components, water supply, structures and lot boundaries.
- An 8-cup soil sample from the percolation test hole from the depth at which the soil absorption system will be installed.
- Where applicable, the pump-up system design rationale and specifications for:

  - pump selection

  - controls (level switch settings)

  - force main (type, diameter, class, insulation)

  - height and distance for effluent transfer from tank to absorption system

Designs for septic systems can be completed by the homeowner, contractor or an engineering consultant.

A permit must be issued prior to installing any part of the system.

Permitting

If all necessary data is supplied and the proposed system is deemed suitable, a ***Permit to Install a Sewage Disposal System*** will be issued. Note that the permit is also subject to compliance with federal, territorial and municipal laws, including subdivision prospectus agreements.

After the sewage disposal permit has been issued, a building permit for new house construction may be issued by the municipal or territorial government. An occupancy permit will not be issued by the Building Department until final approval to use the septic system is obtained from Environmental Health Services.

> ***Once a permit has been issued there can be no alteration to the sewage disposal system or other work it refers to without the approval of a health officer.***
> *S.11 Sewage Disposal Systems Regulation*

Installation

It is very important that a septic system be installed carefully and in strict accordance with the approved design. Failure to do so may result in problems with the system. The septic tank must be installed and suitably bedded, design grades for building sewers must be adhered to, and care must be taken to ensure the absorption bed components are installed according to the approved design and design specifications.

Before backfilling a septic system, the owner or agent must contact Environmental Health Services at least 72 hours before a final inspection is required. An inspection may be scheduled by a health officer. The system may not be backfilled until permission is granted by Environmental Health Services.

Photographic Record of the Stages of Installation Required

The *Sewage Disposal Systems Regulation (s.13(1)(a)* requires a photographic record of the stages of installation to be provided to a Health Officer within 30 days of installation of the sewage disposal system.

The photographic submission requirements must be met, regardless of whether a health officer completes an inspection during the system installation.

All photographs must be marked with the permit number and the legal description of the property on which the sewage disposal system was installed. **Please refer to the list below** and **add the relevant number from the list to the photograph so as to confirm what is depicted in the photograph**. Several listed items may be shown in a single photograph; in such case please add all relevant numbers to that photograph.

Delays in issuing Approval to Use may occur if the photographs do not clearly depict all stages of installation of the sewage disposal system, or if the record is incomplete.

Septic Tanks and Sewage Holding Tanks

If a septic tank or sewage holding tank will be installed, submit photos depicting the:

1. Certification marking or label on septic tank or sewage holding tank (e.g., CAN/CSA-B66).
2. Volume marking(s) on the septic tank or sewage holding tank (e.g., stencil on the tank).
3. Excavation with bedding material at base (prior to placement of tank).
4. Excavation containing the septic tank or sewage holding tank.
5. Bedding material (e.g., pea gravel) surrounding tank.
6. Trench between septic tank or sewage holding tank and the building to which it will be/is connected – must show pipe in place with flex coupler.
7. The septic tank or sewage holding tank covered with soil to original ground level showing all clean-outs and observation pipes, and relationship to building that it services (if present) or other distinguishing permanent landmark(s).

If a septic tank will be installed, submit a photo depicting the:

8. Pipe with flex coupler in place in trench between septic tank and soil absorption system.

If a sewage holding tank will be installed, submit photos depicting the:

9. High level alarm and automatic water shut-off.
10. Floats attached to float tree within the tank. If the tank will be installed in a location with high ground water or an area prone to flooding, submit a picture depicting the:
11. Anchoring harnesses, turnbuckles, and cables in place and attached to tank as per manufacturer's requirements.
12. "Deadmen" or concrete pad used for anchoring purposes as per manufacturer's requirements.

Soil Absorption System

If a soil absorption system will be installed, submit a photo depicting the:

13. Excavation for the soil absorption system that shows the soil profile.

If installing a soil absorption system in **"fast soils"** (less than 5 minutes per inch percolation rate) submit photos depicting the:

14. Filter sand and its depth – a tape measure or similar device must appear in the picture.

If installing a soil absorption system using **drain rock**, submit a picture depicting the:

15. Drain rock and its depth – a tape measure or similar device should appear in the picture. For trenches, show width and depth.
16. Perforated pipe(s) laid out on the drain rock - the total length of the pipes and width between the pipes must be clear and easy to determine - a tape measure or similar device should appear in the picture. If soil absorption system is installed in sections, a picture of each stage of installation of the pipe must be provided.
17. Solid header and footer pipes. A level should appear in the picture to show that these have been installed level.
18. Cleanout and monitor standpipes in place.
19. Perforated pipe(s) covered with drain rock.
20. Drain rock covered with geotextile or rigid insulation.
21. Soil absorption system covered with soil to original ground level showing all clean-outs, observation pipes, and relationship to building that it services (if present) or other distinguishing permanent landmark(s).

If installing a soil absorption system using **chambers**, submit a picture depicting the:

22. Chambers (the area and width must be clear and easy to determine) – if installed in sections, a picture of each stage of installation of the chambers must be provided.
23. Layer of geotextile cloth laid beneath first section of chamber (unless product-specific splash plate, gravel, perforated piping or other method is used, if so provide photo showing that).
24. Monitor and clean-out pipes in place extending from chambers.
25. Header pipe feeding each chamber run.
26. Soil absorption system covered with soil to original ground level showing all clean-outs, observation pipes, and relationship to building that it services (if present) or other distinguishing permanent landmark(s).

Pump-Up and Raised Soil Absorption Systems

If the sewage disposal system is to contain a mechanical pump (inside your septic tank) that discharges sewage to a raised soil absorption system, submit photos depicting the:

27. Pump on mount or stand in septic tank.
28. Floats in place attached to float tree.
29. Force-main exiting man-way.
30. Force-main mounded or otherwise elevated (to ensure that the pipe drains completely back to pump chamber).
31. Insulation of the force-main (if/when burial depth is less than four feet).
32. Vacuum breaker (to prevent back-siphoning)
33. Frost lid or other suitable insulating method of man-way.
34. Warning indicator system and automatic water shut-off systems in place.

Note: Please include photographs that show any part of the installation of the sewage disposal system not described above.

Getting Your System Approved

Within 30 days of the installation of the system, the following information shall be provided to a Health Officer:

- *Septic Tank and Sewage Holding Tank Installation Declaration* form;
- *Notification of Installation and Undertaking to Maintain a Sewage Disposal System* form, or *Notification of Installation and Undertaking to Maintain a Sewage Holding Tank* form;
- *Electrical Assurance* forms completed by a certified electrician;
- Photographic Record of the stages of installation;
- Other documentation as requested by the Health Officer (e.g., septic or holding tank CSA approval, *Notification of Abandonment and Reclamation of a Sewage Disposal System* form, receipts for purchase).

> ***Provided that the Health Officer is satisfied that all requirements have been met, written approval to use the sewage disposal system shall be issued by the Health Officer.***
> *13(2) Sewage Disposal Systems Regulation*

Records of installation and a letter of approval will help in future sale of the property and in the processing of financing arrangements.