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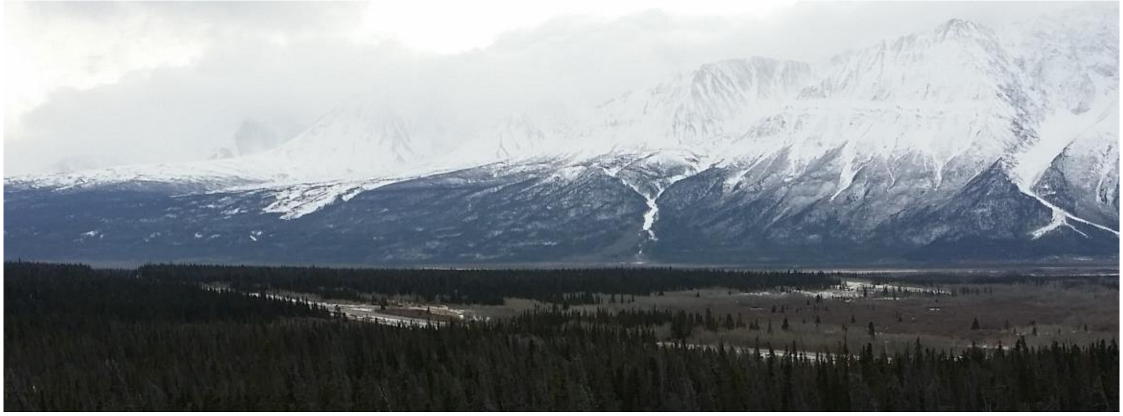
Geotechnical Evaluation
Proposed Bear Creek Country Residential Subdivision
Haines Junction, Yukon – 2017



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1.0 INTRODUCTION

Our firm was retained by *Yukon Government* (*YG*), *Energy, Mines and Resources – Lands Management Branch* to conduct a geotechnical evaluation of a region located near Haines Junction, Yukon to determine the feasibility of developing the area into a country residential subdivision.

The study area, which measures ~81 ha in size, is comprised of *Kluane First Nation* (*KFN*) Land Selection S-39B1 and adjacent *YG* commissioner lands which are located ~ 8 km west of Haines Junction along Highway # 1 as noted in Figure 1.

Authorization to proceed with the geotechnical evaluation was granted by *YG – EMR* - Project Manager, Mr.M.Barrault on October 18th, 2017. The field work was subsequently conducted between October 25th and November 2nd, 2017 in accordance with our October 3rd, 2017 proposal.

The findings of our evaluation have been presented herein along with a description of our methodology which was utilized to conduct the work.

2.0 SCOPE-OF-WORK

Our scope-of-work involved conducting a literature review as well as field and laboratory work programs to characterize the study area from a geotechnical perspective. The intent of our evaluation was to delineate regions within the study area which may be suitable for country residential development and provide preliminary geotechnical recommendations for construction of standard residential structures as well as surface and subsurface utilities.

3.0 METHODOLOGY

Our methodology was comprised of a literature review as well as field and laboratory work programs as described below.

3.1 Literature Review

A literature review was conducted to evaluate satellite imagery, a selection of aerial photos, topographical data and other technical resources which were readily available for the study area. This information was utilized to evaluate the regional conditions and detail the field work program.

The following sources of information were reviewed;

Surficial Geology Map

A 1:100,000 surficial geology map (Map 16-1981) entitled Surficial Geology, and Geomorphology, Pine Lake, Yukon Territory compiled by V.N.Rampton and S.Paradis - *Geological Survey of Canada*.

A portion of this map and the corresponding limits of the study area has been provided in Section 4.5, below.

Bedrock Geology Map

A bedrock geology map, available through the *Yukon Geological Survey,* identified the regional bedrock types and characteristics within the study area. The map was entitled *Yukon Bedrock Geology Map – Yukon Geological Survey* – Open File 2016-1 - 1:1,000,000 scale compiled by M.Colpron, S.Israel, D.Murphy, L.Pigage, and D.Moynihan.

A more detailed delineation of these contacts was found on the *Yukon Geological Survey* website as noted in Section 4.6, below.

Topographical Information

The regional topography was assessed by viewing a 1:50,000 scale topographical map (NTS - 115A13 Kloo Lake) and the *YG- Water Placer Atlas* website.

Aerial Photographs

A selection of aerial photographs were obtained from *YG – Energy, Mines and Resources* to allow for a more detailed assessment through airphoto terrain analysis.

The following airphotos were available for viewing;

Flight Line	Photo No.	Date	Comments
A18400	223-226	Pre-1975	NA
A24052	145-147	June 12, 1975	6,400' altitude
A37361	156-158	1976	10,500' altitude
A31727	94-96	Oct.16, 1995	1:20,000 scale
A28276	22-24	June 7, 1996	1:20,000 scale

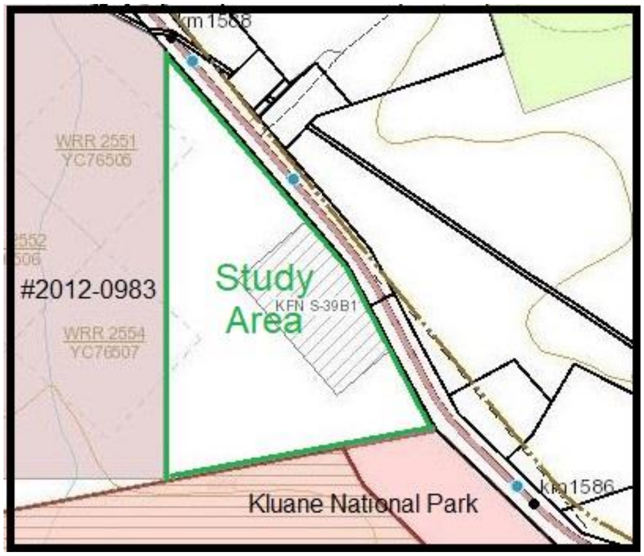
A selection of these aerial photographs has been attached as Appendix A.

Satellite Imagery

A review of satellite imagery from *Google Earth* allowed for an assessment of the site conditions relative to the more recent imagery. The imagery which was available dated between June 5th, 2005 and August 6th, 2013.

Other Resources

The *Yukon Government – Water Placer Atlas* website was reviewed as it provided the boundaries of various land dispositions, drainage regimes and other similar types of information. The corresponding boundaries of the study area have been illustrated on the *Water Placer Atlas* map as noted below.



In brief, the map noted that the western periphery of the study area intersects two (2) expired quartz mining claims (Grant Number YC76507 & YC76505). Otherwise the parcel to the west is comprised of (an Environmental Reservation) Land Disposition (#2012-0983). Kluane National Park borders the study areas southern boundary. The eastern periphery of the study area is defined by the western edge of the Alaska Highway right-of-way.

3.2 Field Work Program

The field work program was comprised of utility locates, a site reconnaissance and a test pit excavation program.

Utility Locates

Utility locates were conducted prior to test pit excavation in order to confirm that the proposed test pit locations were clear of potential underground hazards. This involved contacting *Northwestel* and *ATCO Electric Yukon*.

In brief, with the exception of a fiber optic cable which was located along the Alaska Highway right-of-way, there were no utilities located within the study area.

Site Reconnaissance

A site reconnaissance was conducted by the undersigned and our Sr.Soils Technician, Mr.G.Keitel, on October 25th, 2017 to note the field conditions and geological features within (and just beyond) the study area.

During this time, the region was traversed on foot such that both local and regional field conditions and geological features could be observed. While a 10-15 cm blanket of snow covered much of the site, the amount of exposed ground cover was sufficient to allow for site characterization.

Our observations were documented through a combination of field notes, GPS waypoints and photographs. These observations have been summarized in Section 3.0 – Site Conditions, below.

Test Pit Program

A test pit program was conducted on November 1st and 2nd, 2017 to assess the sub-surface conditions at select locations within the study area. This component of work was conducted by our Sr.Soils Technician Mr.G.Keitel.

Excavation of TP 1-17

The work consisted of excavating twelve (12) test pits utilizing a *Kubota kx-121* tracked excavator equipped with a digging bucket. The test pits were excavated to an average depth of 2.2 meters (but varied between 1.2 and 2.7 meters) below the existing ground surface at the approximate locations noted in Figure 2.

The excavator was supplied and operated by *Truckways Transport Ltd.* of Whitehorse, Yukon.

Survey

The test pit locations were surveyed during the work utilizing a hand-held GPS unit. Although there were minor variations in elevation, the test pit soil logs were each given arbitrary elevations of 100.0 meters due to the nature of the study.

Test Pit Soil Logs

During the test pit excavations, field soil logs were maintained by our Sr.Soils Technician to record the stratigraphy of the soils that were encountered.

In brief, the following information was recorded;

Soil description
  (depths, color, relative moisture content and density, gradation/plasticity, inclusions, oxidation, transition zones)
Sample depths and types
Comments regarding excavation effort
Other local observations

This information was utilized along with visual observations and results of the laboratory analysis in order to compile the Test Pit Soil Logs which have been enclosed in Appendix A. This appendix also includes '*Notes on Soil Classification'* and a description of the *'Unified Soil Classification System'* and '*NRC'* permafrost classification systems which were utilized in creating the soil logs.

Sampling Program

A total of forty-two (42) soil samples were retained at regular intervals during the test pit excavations to allow for laboratory analysis (as described in Section 3.3, below).

Typically, samples located within the upper meter of each test pit were retained by hand from the excavation sidewalls. The remainder of the samples were retained from the leading edge of the excavator bucket.

Once the soil samples were retained, they were described on the field soil logs, sealed in air-tight plastic bags and numbered consecutively to allow for subsequent laboratory analysis.

Test Pit Termination

The test pits were terminated at an average depth of 2.2 meters, but varied between 1.2 meters (TP 5-17) and 2.7 meters (TP 1-17 &TP 2-17). Nine of the twelve test pits were terminated within the glacial till deposits. The remaining three test pits (TP 1-17, TP 10-17, TP 11-17), were terminated within granular glaciofluvial deposits.

Refusal was encountered in TP 5-17 at a depth of 1.2 meters below the ground surface, due to the presence of frozen glacial till deposits.

The test pit excavations were each left open for approximately 10 minutes following excavation in order to assess the excavation sidewall stability over the course of time. In addition, this time allowed for observations of groundwater seepage to be made.

In brief, with the exception of the loose surficial aggregates, there was no sign of sidewall slough.

A possible seepage zone was encountered in TP 7-17 between a depth of 1.6 and 1.8 meters below the ground surface as evidenced by wet soil conditions. Oxidized soils were noted at some locations within the glacial till indicating the presence of seasonally/intermittent groundwater flow. Otherwise there was no indication of free-flowing groundwater.

Following our observations, all test pit excavations were backfilled with the excavation spoils. The test pits locations were subsequently marked utilizing survey lathe to allow for subsequent field location if required.

Photographic Documentation

Photos were taken during the course of the evaluation to document the field work, soil samples and site conditions.

3.3 Laboratory Work Program

A physical laboratory analysis was conducted between November 3rd and 8th, 2017 at our Whitehorse laboratory facilities in order to characterize the index properties and conditions of the retained soil samples.

The analysis was comprised of the following analysis;

Description of Analysis	*ASTM Analysis*	*Quantity*
Moisture Content	D 2216-92	42
Grain Size Distribution	D 422-633	24

The results of the moisture analysis have been denoted as ‘MC’ (⦿ - Symbol) on the Test Pit Soil Logs enclosed in Appendix A.

The grain size distribution analysis was conducted in order to assist in soil classification utilizing the *Unified Soils Classification System*.

The results of the analysis have been noted on the Soil Logs with the percent composition of fines (silt & clay), sand and gravel denoted with the symbols - ▲, ● & ■ , respectively. In addition, we have summarized the results of the laboratory analysis relative to the two primary soil deposits which were encountered during the evaluation as follows;

Summary of Laboratory Results – Glaciofluvial Deposits

Test Pit	Sample Number	USCS	Soil Description	Moisture Content (%)
1	3	SM	Gravelly Silty Sand	4.3
1	4	ML	Sandy Silt	11.9
2	5	SM	Silty Sand some Gravel	9.7
9	31	SM	Silty Sand	7.9
10	35	SM	Silty Sand	6.0
11	36	SM	Silty Sand some Gravel	8.3
11	38	SM	Sand some Silt	3.3

Summary of Laboratory Results – Glacial Till Deposits

Test Pit	Sample Number	USCS	Soil Description	Moisture Content (%)
2	8	SM	Silty Gravelly Sand	8.5
3	10	SM	Silty Gravelly Sand	8.4
3	12	SM	Silty Gravelly Sand	8.0
4	13	SM	Gravelly Silty Sand	6.8
4	16	SM	Silty Gravelly Sand	6.2
5	17	SM	Silty Sand	15.0
5	18	ML	Sandy Silt	26.3
6	21	SM	Silty Sand	27.1
6	23	SM	Silty Gravelly Sand	6.9
7	24	SM	Silty Sand some Gravel	12.2
7	26	SM	Silty Gravelly Sand	9.2
8	27	GM	Sandy Silty Gravel	5.6
8	29	SM	Gravelly Silty Sand	7.0
9	32	ML	Sandy Silt trace Gravel	10.6
12	41	ML	Sandy Silt trace Gravel	15.6

4.0 SITE CONDITIONS

4.1 Study Area

The study area, which measures ~81 ha in size, is comprised of *Kluane First Nation* (*KFN*) Land Selection S-39B1 and adjacent *YG* commissioner lands. The *KFN* land selection, located entirely within the study area is approximately 15 ha in size. The study area is located ~ 8 km west of Haines Junction along Highway # 1 as noted in Figure 1.

4.2 Physiographic Region

The study area is part of the St.Elias Mountain ecozone and lies within the Shakwak Valley. Located at the foothills of the Kluane Ranges, the prevailing elevation in the region of the study area lies in the order of 625 meters. The peaks of the Kluane Ranges located ~12 kilometers west of the study area, rise to elevations in the order of 2800 meters.

The terrain can be described as smooth, rolling, glaciated terrain, which is incised by broad, U-shaped valleys.

4.3 Site Description

The study area is comprised of two distinct areas.

The northern region is predominately comprised of a gentle exposed slope which is covered by willows, poplar trees and shrub brush. The terrain in this region gradually descends towards Bear Creek located to the west. A series of building structures and a previous alignment of the Alaska Highway were once located within this region as noted in the (1975 & 1976) airphotos enclosed in Appendix B.

The southern region is dominated by a well treed (spruce) terrace which is partially bisected by an old trail which trends approximately northwest-southeast. The understory consists of a variety of moss, willow, shrubs and grass.

The topography is best described as being flat to gently sloping, with only minor changes in elevation (less than 1 meter). Larger variations in elevation are encountered in the northwestern and southern peripheries of the study area where lower elevations are present.

A series of trails (which generally trend northwest to southeast), provides (predominately foot) access to the site. One of the trails however, was wide enough to be traversed with a small tracked excavator which allowed for the test pit program to be facilitated. This trail was clearly visible on the earliest (pre-1975) airphotos which were available for viewing and has been illustrated on the site plan attached as Figure 3.

A series of survey stakes were encountered along the primary trail which bisected the eastern portion of the study area (on both *KFN* and *YG* lands). These survey stakes were consecutively numbered (B3, B4….B47, etc) and were placed at approximately 15 meter intervals along lines which trended approximately northwest to southeast. Nearby trees were numbered with metal tags (#0814, etc) and corresponded to the stake locations. While the purpose of the stakes and tags could not be determined, they're likely associated with local forestry studies.

An overhead powerline parallels the study area on the north side of the Alaska Highway where slightly higher elevations prevail. The drainage from this region crosses the highway through a series of three CSP culverts which vary between 800 mm to 1000 mm in diameter as noted in Figure 3. The northern-most 800 mm Ø CSP discharges through a drainage course located in Area 1 of the study area. The central 1000 mm Ø CSP culvert coincides with the location of a former drainage course.

Conditions at outlet to northern 800 mm CSP culvert

4.4 Geomorphology

The terrain in this region of the Yukon has been heavily glaciated. As such, the deposits within the study area are comprised of glaciofluvial and glacial till deposits.

The glaciofluvial deposits, which are comprised of predominately granular (silty sand) materials, were deposited by glacial meltwaters. These deposits prevailed in Area 1 and Area 1A. Located at relatively lower elevations, the thickness of the overlying organics in Area 1A may be considerable given the areas proximity to Bear Creek. While glacial tills prevailed in Areas 2 and 2A, the tills in Area 2A were overlain with glaciofluvial deposits which measured greater than 1 meter thick (as noted in TP 9-17).

While the overlying glaciofluvial deposits were generally absent in Area 2, its western realms may be covered with less than 1 meter of glaciofluvial materials as was encountered in TP 2-17. The forest in Area 2 was generally more dense than the forest in Area 2A.

General site conditions in Area 2A

The till deposits are characterized by unsorted mixtures of clay, silt, sand and gravels which were deposited during melting of glacial ice.

The above noted glacially derived deposits are covered with a veneer of surficial organics and at some locations, fill. The granular fills are located in the northern region of the study area and would have been associated with the original highway alignment and dwellings which were once located along the nearby trail.

Soil Stratigraphy

In general, the subsurface soil units which were encountered in the study area can be classified as;

Organic Stratum;

This stratum is generally comprised of moist soft organics and organic silts which on average measured 150 mm thick (but varied between 50 mm and 300 mm). Thicker deposits would be expected in Area 1A. This stratum overlay the following fills and glacial deposits;

Fills;

As the northern regions of the site (in Area 1 and Area 2A) were historically developed through construction of the Alaska Highway and nearby structures (which may have been residences), fills were encountered in TP 10-17 & TP 12-17). While the grain size distribution analysis classified two of the fill samples as gravelly silty sand (SM), the fills may also contain deleterious materials such as organics and fine-grained soils.

The fills extended to depths of 0.6 meters and 1.0 meters below the adjacent ground surface where it was encountered in TP 10-17 and TP 12-17, respectively.

Glaciofluvial Deposits;

Based upon the laboratory analysis, these deposits are predominately comprised of moist compact silty sands (SM) which contained up to 15% gravel but may also be comprised of finer silt/clay sized materials as sandy silts (ML) were also encountered. On average, the moisture content of these deposits measured 7.1% but varied between 3.3 to 18.2%.

While these glaciofluvial deposits extended to the maximum depth of test pit excavation in TP 1-17, TP 10-17 & TP 11-17, they also overlay glacial till deposits in TP 2-17 and TP 9-17. These glacial tills were encountered at depths of 0.8 meters and 1.8 meters below the adjacent ground surface, respectively.

Test Pit TP 1-17 – Glaciofluvial Deposits

Glacial Deposits;

These deposits are predominately comprised of unsorted silt, sand and gravel mixtures which were deposited during glacial melting. While the laboratory analysis generally classified the materials as silty sands (SM) which contained varying amounts of gravel, sandy silt (ML) which contained up to a trace of gravel was also encountered. These deposits contain cobble to boulder sized materials. On average, the moisture content of these deposits measured 10.9% but varied between 5.5 to 27.1%.

Test Pit TP 3-17 Glacial Till Deposits

The nature of the material varied with depth. In general, compact grey-brown tills were encountered below the organic deposits and extended to an average depth of 1.4 meters below the adjacent ground surface. While this zone contained cobble to boulder sized materials at some locations, the frequency of cobbles and boulders increased beyond a depth of 1.4 meters where dense dark-grey-brown tills were generally encountered.

Although the subsurface boulders which were encountered measured less than 400 mm in size, as with generally all till deposits, larger boulders can be expected. Surficial boulders in size to 2.2 meters and larger were noted sporadically throughout the study area.

Boulder erratic located in Area 1

Glaciation

Evidence shows that the glacial features are likely associated with the late Wisconsinan age.

Permafrost

Although the study area lies just south of the southern edge of the zone of continuous permafrost, permafrost was not generally encountered.

The exception to this was in TP 5-17 excavated in Area 2, where permafrost was encountered at a depth of 0.9 meters below the ground surface. These frozen soils were classified in accordance with the *National Research Council* (Linnell & Kaplar, 1966) classification system as 'Nbn' – frozen soil with segregated ice not visible by eye, well-bonded with no excess ice. A grain size distribution analysis conducted on Sample # 18 which was retained from the test pit, classified the material as a sandy silt which had a moisture content of 26.3%. The very dense nature of the permafrost resulted in refusal at a depth of 1.2 meters below the adjacent ground surface.

TP 5-17 Excavation conditions

TP 5-17 - Sample # 19

As such, although sparse, the permafrost within the study area would be considered sporadic and discontinuous. As is typical in the north, the permafrost potential would increase in regions which are heavily shaded, located on north slopes and/or where the ground surface is well insulated. The permafrost may vary from poorly bonded soils with no-visible ice to large ice lenses.

Watercourses

There were no regions of flowing surface waters or ponds located within the study area. However, a drainage course, which discharged to the west across the northern realms of the site, was noted in Area 1A. This drainage course coincided with an 800 mm Ø CSP culvert located on the Alaska Highway.

A former drainage course was also identified at the boundary between the northern and southern regions. This former drainage course coincided with the location of a 1000 mm Ø CSP culvert.

Bear Creek flows to the south just beyond the western periphery of the study area and discharges into the Dezadeash River. The Dezadeash River flows to the west approximately 1.7 kilometers south of the study area.

Groundwater

While there was no indication of near surface groundwater during our field work program, groundwater may be present in the form of seepage zones and sheet-wash flows given the nature of the terrain and soil types. The groundwater may be encountered at shallow elevations where potentially perched conditions (and permafrost) exist.

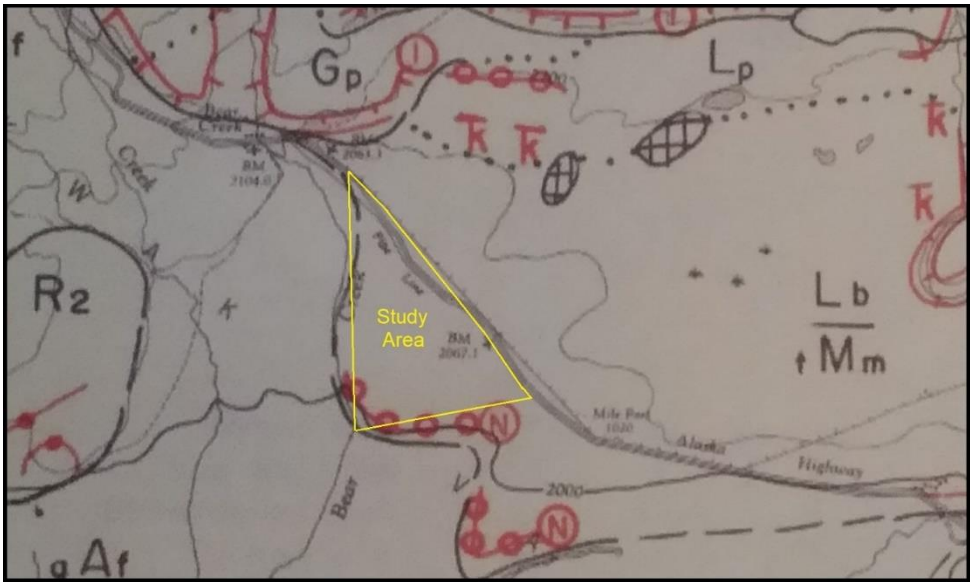
The direction of groundwater flow would generally be towards lower elevations (Bear Creek) which prevail west of the study area.

Bedrock

Bedrock was not encountered in any of the test pits.

4.5 Surficial Geology

The distribution of the surficial deposits within the study area has been illustrated in the surficial geology map of Pine Lake (Map 16-1981) as noted below.



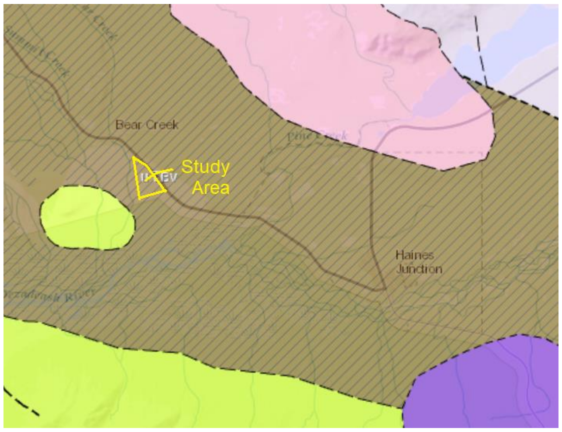
While the map describes the region as being comprised of morainal (till) deposits which are overlain with a lacustrine blanket, the lacustrine silts and clays were not present within the study area. The error in terrain identification was likely due to the scale of mapping. Likewise, while the surficial geology map identified the presence of a drumlin located on the southern periphery of the study area, no such feature was identified during our site reconnaissance.

> Drumlins are glacial till landforms that are characterized by the presence of elongated streamlined hills that formed during glacial retreat.

4.6 Bedrock Geology

There was no indication of any near surface bedrock during our field work program.

The geology maps indicate that the site is underlain by predominately metamorphic (greenstone) rocks of the Precambrian Age which have been intruded by granitic rocks of the Mesozoic Age.



5.0 DISCUSSIONS

Based upon the information retained during our literature review, field and laboratory work programs, the anticipated soil types and conditions will generally be favorable to allow for country residential subdivision development. However, there are geotechnical constraints which would need to be considered during the formulation of conceptual designs. Specifically, these constraints are related to terrain and subsurface considerations as follows;

Terrain Considerations

While the topography is predominately favorable for residential development, Areas 1A and 2B would not be suitable given the presence of low-lying and steeply sloped regions, respectively.

Geotechnical setbacks (in the order of 30 meters) should be observed for buildings relative to Area 1A, Area 2B and the crests of other steep slopes.

Additional consideration may be required in the area of both the existing and former drainage courses to ensure that regional drainage is well controlled and does not otherwise present a liability.

Subsurface Considerations

While the anticipated glaciofluvial and glacial till deposits will allow for residential construction utilizing conventional (footing and monolithic-slab types of) foundation systems, adjustments to the individual designs will be required to accommodate site-specific conditions as the soil types and conditions will vary across the study area.

In general, the use of the glacial tills for founding soils will allow for a greater allowable bearing capacity relative to the glaciofluvial deposits. The bearing capacity of the glacial till materials will generally increase with depth. Ideally, in Area 2 & 2A, footings and granular pads (prepared for monolithic-slabs) should extend to the dense dark-grey-brown glacial till deposits which are located at an average depth of 1.4 meters below the ground surface.

As the density and composition of the glacial till and glaciofluvial soils varies across the study area, site-specific assessments would be required prior to individual lot development to verify the suitability of the soils relative to *Yukon Health and Social Services – Design Specifications for Sewage Disposal Systems*. While the glaciofluvial soils would generally allow for septic field installation, the increasingly dense nature of the glacial till deposits with depth may not allow for a high enough rate of percolation relative to the design requirements. As such, insulated holding tanks may be required in regions where the soil types are deemed unsuitable for use as accepting soils.

Additional consideration would be required where permafrost is encountered as the construction of conventional building foundations in these areas should not be allowed. Residences in these areas would need to be constructed upon cribbing and ventilated crawlspaces if the permafrost conditions are deemed suitable following geotechnical evaluation. The presence of permafrost would preclude the installation of septic fields and so insulated holdings tanks would be required in these areas if residential development is deemed feasible.

6.0 RECOMMENDATIONS

6.1 General

While the following recommendations have been provided to outline the envisioned geotechnical requirements for country residential subdivision development, as our recommendations are preliminary in nature, additional evaluations will need to be conducted to verify the geotechnical parameters once conceptual designs have been completed and once building/septic field sites have been determined.

In general, construction of residential building foundations and surface utilities will be unfettered in Areas 1, 2 & 2A. However, additional consideration will be required relative to the installation of septic fields and the allowable bearing capacities associated with the residential building foundations as the soil types and conditions will vary across the study area. Specifically, the soils located at the envisioned septic fields should be assessed to verify whether or not they will be suitable for use as accepting soils. In addition, standard penetration tests (SPT's) should be conducted through drilling methodologies at the locations of proposed buildings to assist in determining the maximum net allowable bearing pressure of the founding soils.

Additional recommendations would need to be provided in the event that permafrost is encountered. While the presence of permafrost will restrict development of conventional building foundations and septic field installations, in general, the use of cribbing types of foundations and insulated (septic) holding tanks should still allow for site development.

Development in Areas 1A and 2B would not be recommended given the presence of low-lying and steeply sloped regions, respectively.

6.2 Footings

Proposed residential structures may be supported by continuous or spread footings and slab-on-grade foundation systems constructed in accordance with the recommendations contained herein.

Allowable Bearing Pressure

The net allowable bearing pressure would need to be determined prior to building construction. In general, the allowable bearing pressure may range between 85-115 kilopascals for conventional strip footings and 105-135 kilopascals for spread footing types of foundation systems founded upon the compact (silty sand) glaciofluvial deposits. While (the) higher values may be possible where the founding soils are comprised of dense glacial tills, the true values may vary outside of this anticipated range.

These figures include the total of all live and dead loads.

Differential Movements

Foundations installed in accordance with the recommendations contained herein can expect to experience differential movements in the order of (+/-) 20 mm.

Frost Protection

As a minimum, the underside of the footings should be placed at a depth of no less than 1.8 meters below the top of the prevailing adjacent exterior grade to allow for adequate frost protection.

If isolated spread footings are required, the footings should have a frost protection equivalent to 2.2 meters of earthen cover as measured from the underside of the footing.

The amount of earthen cover can be reduced if protective insulation is incorporated into the design.

Slab Components

The slab components should be structural separated from other components of the structure.

Structural Fill

The footing components should be founded upon a 150 mm thick layer of approved 20 mm minus crushed granular aggregate compacted to a minimum of 100 % of the materials corresponding maximum Proctor dry density at (or within ± 2% of) the materials optimum moisture content.

Interior backfill (below slab components) should be comprised of approved non-frost susceptible granular aggregate compacted to a minimum of 100 % of the materials corresponding maximum Proctor dry density at (within ± 2% of) the materials optimum moisture content. The backfill should be comprised of a minimum of 200 mm of 80 mm minus granular aggregate which is overlain with a 100 mm thick layer of 20 mm minus crushed granular aggregate. The interior backfill should be placed upon an approved subgrade surface.

Exterior backfill around footing columns (and wall components) should be comprised of non-frost susceptible granular aggregates with particle sizes less than 80 mm. This material should be compacted to a minimum of 95 % of the materials corresponding maximum Proctor dry density at (within ± 2% of) the materials optimum moisture content, unless otherwise over-ridden by recommendations provided herein.

The height of the backfill between the interior and exterior sides of wall components should not measure greater than 150 mm during construction so as not to induce undesirable lateral forces.

All backfill materials should be placed in uniform, level lifts which are 150 mm thick (as measured following compaction).

Backfill around newly placed concrete should not be conducted until a minimum of seven days has elapsed such that the concrete attains adequate strength.

Weeping Tile Systems

A weeping tile system should be incorporated into the design in regions where tills (or else fine grained soils) are encountered as these soils are not generally free draining.

6.3 Monolithic Footing/Slab-On-Grade (Monolithic Slab)

Residential building structures could also be supported by a monolithic slab foundation system founded upon an approved granular base constructed in accordance with recommendations provided below.

Founding Strata

The founding soils should be comprised of either compact glaciofluvial or else dense glacial till (silty sand) deposits.

Allowable Bearing Pressure

The net allowable bearing pressure would need to be determined prior to building construction. In general, while the allowable bearing pressure may range between 140-165 kilopascals for monolithic slabs constructed on a granular base founded upon approved glaciofluvial or glacial till deposits as described herein, the true allowable values could vary outside these parameters.

These figures include the total of all live and dead loads.

Differential Movements

Foundations installed in accordance with the recommendations contained herein can expect to experience differential movements in the order of (+/-) 25 mm.

Structural Fill

The monolithic slab should be founded upon a structural granular pad comprised of an approved, clean, inorganic, well graded sand and gravel mixture.

The structural granular pads should be comprised of the following;

THICKNESS [A]	**COMPACTION** [B]	**COMPOSITION** [C]
200 mm [D]	100 %	20 mm minus crushed granular aggregate, Overlying
400 mm	100 %	80 mm minus sub-base course aggregate, Overlying
1200 mm	98 %	200 mm minus pit run, Overlying
NA	NA	[E] filter fabric, overlying
NA	95 % (or as directed)	approved native sub-grade materials

Notes;

[A] – The thickness of the granular pad should be uniform throughout its entirety. All materials should be placed in uniform, level lifts that do not exceed 150 mm in thickness, as measured following compaction. The exception to this would be the 200 mm thick layer of 20 mm minus granular aggregate which can be placed in a single lift so long as adequate compaction is attained.

[B] – Indicates percent compaction relative to the materials Proctor maximum dry density at (or near, ± 2%) its optimum moisture content.

[C] –The imported fills should be comprised of a well graded sand and gravel mixture and should conform to the grain size distributions specified in Appendix C – Imported Fill Specifications

[D] – This thickness should be maintained below both the central slab and peripheral slab thickening components.

[E] – A geotextile filter fabric may be required at the sub-grade elevation to allow for additional structural support in regions where the composition and conditions of the founding soils are considered to be marginal as determined by qualified geotechnical personnel.

6.4 Concrete

All concrete work should conform to *Canadian Standards Association* (*CSA*) standard CAN/CSA – A23.1 and A23.2. According to the standard, the concrete should be designed to satisfy the minimum environmental durability requirements as defined by its exposure class. The exposure class is dependent upon the presence of chlorides and sulphates, freezing/thawing conditions and degree of soil saturation.

The potential for sulphate attack from soils placed in direct contact with the concrete should be assessed prior to use.

Concrete subject to frequent freeze-thaw cycles and/or deicing chemicals and should be designed in accordance with C.S.A. A23.1-94, Section 15.

Normal Portland cement (C.S.A. Type 10), should be used in all concrete work.

Residential concrete should have a minimum 28-day compressive strength of 25 MPa and be air entrained (5 to 7 percent). This assumes a maximum aggregate size of 20 mm.

6.5 Structural Breaks & Reinforcing

Structural breaks and reinforcing (rebar) should be integrated into concrete foundations to control cracking and allow for differential movements caused by soil volume changes of the underlying soil.

If heavy loads are anticipated, the monolithic slab foundation system(s) should be designed as structural slabs with thickened peripheries. Additional measures should be incorporated into the design if dynamic and/or point loads are expected. This should include thickening the areas of the slab that would be subjected to these additional forces and increasing the compressive strength of the concrete to a minimum of 32 MPa.

6.6 Vapor Barrier

A non-deteriorating vapor barrier should be placed beneath the concrete to prevent desiccation of the sub-base materials and promote concrete hydration.

6.7 Insulation

The glacial deposits are frost susceptible and so frost protection in the form of perimeter insulation or thickness of soil cover is required to reduce the risk of undesirable movements due to frost action as these soils are anticipated at the sub-grade elevation. The thickness of the insulation should be increased in regions where there may be a higher loss of heat such as the corners of the structure.

The minimum frost protection requirements have been outlined in Section 6.2 & 6.3, above.

Provisions should be included to protect the subsoils from excessive desiccation in regions where there is an intense degree of concentrated heat (such as potential boiler areas). Insulation should be incorporated in these areas so as to limit soil volume changes to tolerable amounts.

6.8 Deleterious Materials

The organics and fills that were encountered above the anticipated founding strata are not suitable to support structural loads. As such, these materials should be removed from within the structural load envelope.

If large cobbles and/or boulders are encountered at the founding (sub-grade) elevations in regions where footings are to be placed, then these materials should also be sub-excavated and replaced within clean structural fill as outlined herein.

If seasonal frost is encountered at the sub-grade elevations, the frozen soils should be sub-excavated until thawed soils are encountered. If permanently frozen soils are encountered, then additional consideration will be required as the use of conventional concrete foundations should not be allowed. These building sites may require the use of cribbing and ventilated crawlspace types of foundations as deemed feasible by qualified geotechnical personnel. Caution should be exercised where clearing is to be undertaken in regions where permafrost is encountered as the removal of the tree cover and/or thaw surficial organic mat will result in undesirable thaw-degradation of the underlying soils.

As the test pit locations are potential geotechnical liabilities due to the unconsolidated nature of backfill, building foundations should avoid these locations.

The resulting excavations should be backfilled utilizing non-frost-susceptible materials which are placed and compacted in accordance with Sections 6.2/6.3 – Structural Backfill.

In general, the deleterious materials should be suitable for use as general purpose fill so long as they are frost free and are placed and compacted in accordance with the recommendations provided herein. Organic soils should be utilized as soil cover in non-structural areas. Frozen soils will not be suitable for use and so should be wasted in designated areas.

Where excavation common materials are to be utilized for fill in non-structural applications, they should be placed in 300 mm thick lifts which are compacted to 95% of the materials Proctor maximum dry density at (or near, ± 2%) its optimum moisture content. These regions should be graded so as to maintain positive drainage. Otherwise the granular glaciofluvial and glacial till deposits will be suitable for use as embankment fills so long as they are placed and compacted as outlined herein.

6.9 Excavations

Excavation should be conducted utilizing a heavy tracked excavator equipped with a smooth lip (clean-up) bucket, to minimize disturbance of the native sub-grade materials. While excavation difficulties are not expected under thawed conditions, large boulders may be encountered and so this should be considered as additional measures may be required to facilitate their removal.

Loose, disturbed, remolded or slough materials should not be allowed to remain in prepared excavation(s). If a suitable founding surface cannot be prepared through mechanical means, then hand cleaning may be necessary.

The sub-grade materials are subject to a loss of strength if they are disturbed and as such, equipment should not be allowed to operate directly on the sub-grade surfaces.

The base of the footing and slab excavation(s) should be prepared in such a manner that the sub-grade elevation does not vary.

6.10 Excavation Limits

The excavation limits will be governed by the proposed design elevations and that of the founding strata.

The excavation limits should be defined by the theoretical loading footprint which can be described as a 1:1 slope which extends outwards from the perimeter of the structure (plus one meter) until suitable frost protection and founding strata has been attained. A 1:1 back-slope should be incorporated in order to provide for worker safety and maintain slope stability. This angle of repose should be reduced to 2 horizontal to 1 vertical (or less) in regions where fine grained (or saturated) deposits are encountered.

The recommended cut slopes should be verified by qualified personnel at the time of construction and (if required) modified by the construction contractor to accommodate the actual soil conditions which are encountered.

6.11 Road Construction

The road structure should be comprised of the following;

THICKNESS [A]	**COMPACTION** [B]	**COMPOSITION** [C]
200 mm	100 %	20 mm minus crushed granular aggregate, overlying
200 mm	98 %	80 mm minus sub-base course aggregate, overlying
300-600 mm [F]	95 %	200 mm minus pit run sub-base, overlying
NA	NA	[D] filter fabric, overlying
NA	95 %	[E] approved native sub-grade materials

Notes; [A] – All materials should be placed in uniform, level lifts that do not exceed 200 mm in thickness, as measured following compaction.

[B] – Indicates percent compaction relative to the materials Proctor maximum dry density at (or near, ± 2%) its optimum moisture content.

[C] –The imported fills should be comprised of a well graded sand and gravel mixture and should conform to the grain size distributions specified in Appendix C – Imported Fill Specifications

[D] – Geotextile fabric should be utilized if poor soil conditions/types are encountered at the sub-grade elevation.

[E] - The sub-grade surface should be proof-rolled. If excessive deflections are noted, then these regions should be sub-excavated to allow for construction as directed by qualified geotechnical personnel. This surface (and subsequent lifts of backfill) should be shaped with a 2% road crown to promote drainage.

[F] – The thickness of the pit run will vary. This granular course can measure 300 mm thick in regions where dense glacial tills are encountered. Otherwise the thickness should be increased to 600 mm in regions where glaciofluvial deposits are encountered or where embankments are to be constructed. If heavy traffic loads are anticipated (eg septic/water trucks, etc.), then consideration should be given to increasing the thickness of this granular course to 900 mm.

6.12 Subsurface Utility Installations

Site-specific assessments would be required prior to individual lot development to verify the suitability of the soils relative to *Yukon Health and Social Services – Design Specifications for Sewage Disposal Systems*.

Any sub-surface (water/sewer) pipes or tanks should be embedded in bedding sand which conforms to the grain size specifications provided in Appendix C.

Utility pipes and subsurface tanks should be established on a base of bedding sand which measures 300 mm thick. The bedding sand should extend a minimum of 300 mm on all sides of the pipe/tank. The material should be compacted to a minimum of

95% of the materials corresponding Proctor density at (or near) the materials optimum moisture content.

If sub-grade conditions are poor, then the use of (clear stone) drain rock encased in geotextile filter fabric can be utilized in lieu of the bedding sand.

The excavation spoils will generally be suitable for use as trench backfill in non-structural areas so long as the materials are inorganic and not frozen, however, cobbles/rocks larger than 150 mm in size should not be placed within 1 meter of the pipe. The trench backfill should be comprised of an approved pit run in regions where trenches intersect the building load envelope.

Trench (and tank) backfill materials should be placed in lifts which do not exceed 200 mm as measured following compaction. The material should be compacted to a minimum of 95% of the materials corresponding maximum Proctor dry density at (or near) the materials optimum moisture content. The compaction effort should be increased to a minimum of 98 % of the materials corresponding maximum Proctor dry density in regions where the sub-surface utilities cross roadways/parking areas or other regions where loading envelopes may be affected.

The installed utilities should be placed at depths >1.8 meters or else have equivalent insulation in order to allow for a sufficient degree of frost protection.

6.13 Inclement Weather

The sub-grade, excavations and construction materials should be protected from drying, freezing, rain, snow, surface waters and groundwater at all times. Protective tarps should be utilized to protect the sub-grade and construction materials from desiccation, freezing and precipitation.

The till deposits are moisture sensitive and so construction operations may need to cease or be altered at times of precipitation until drier weather conditions prevail.

The glacial deposits are frost susceptible and so it is critical that construction work is conducted during the summer months. If construction work is scheduled in the spring or early summer months, additional consideration may be required as seasonally frozen soils may be present. Caution should be exercised to ensure frozen soils are not present within the foundation load envelope at the time of construction or are utilized during granular pad construction.

Once foundations are constructed, the corresponding buildings should be closed to the weather and heated prior to the onset of any freezing temperatures for the remainder of the buildings life-span.

6.14 Temporary Stockpiles

Stockpiled materials should be protected from segregation and the ingress of snow, frost, rain and surface waters at all times.

6.15 Surface and Groundwater

Construction Operations
The subgrade materials may be subject to a loss of strength if they become wet or saturated. As such, the surfaces surrounding excavations should be graded so as to direct water away from the excavation. Surface and groundwater should be removed from excavations at all times during construction.

While groundwater was not encountered during our investigation, seasonal fluctuations may occur and thus the contractor should be prepared to undertake conventional construction dewatering to ensure a dry working area.

Ditches
Ditches should be incorporated into the design and construction phases to control perimeter drainage.

Site Grading
The drainage in the region of the site should be carefully controlled.

The surrounding areas should be graded to direct surface water away from the building structure and foundation/excavations. Typically, a 2 percent slope which extends a minimum of 5 meters away from the building perimeter will be sufficient for this purpose.

Exterior backfill should be capped with a low permeability soil or surface cover which is placed around the perimeter of building foundations following concrete placement. The low permeability soil/surface cover will assist in directing surface waters away from the foundation and limits of the former excavation. The backfill should be placed to protect the sides of concrete slabs and prevent undermining of the slab during periods of heavy precipitation/run-off.

Eaves troughs
Eaves troughs should be incorporated into roof structures. The outlets from the roof drains should extend a minimum of 4.0 meters away from the building structure such that the discharge is directed away from the structure(s).

6.16 Geotechnical Setbacks

Standard (30 m) geotechnical setbacks should be observed from low-lying regions located near Bear Creek (Area 1A) and from the crests of slopes (located in Area 2B).

6.17 Temporary Excavations & Worker Safety

Worker safety is paramount.

Temporary excavations to conventional depths at this site should comply with current *Occupational Health & Safety Regulations.*

While the excavation sidewall (slope) stability will be dependent upon the material characteristics, configuration of the excavation and length of exposure, in general, one to one cut slopes should provide adequate slope stability during excavation of the anticipated excavation common materials. Slope stability will however be poor where wet/saturated, loose or fine-grained materials are encountered and so more gradual cut slopes will be required in these areas to minimize the potential for slope failure.

The contractor should be prepared to adjust their construction methodology and excavation profiles as soil conditions dictate.

6.18 Construction Monitoring & Testing

During construction, qualified geotechnical personnel should inspect all subgrade surfaces prior to backfill to verify that the materials noted at the subgrade elevation are consistent with those identified in the applicable geotechnical report. Side slope parameters should be verified in the field by qualified personnel during the time of construction.

Materials testing services should be provided during foundation construction to assess the suitability of the structural fills and conduct in-situ field density (compaction) and concrete testing.

6.19 Additional Assessments

Additional assessments should be conducted to verify site specific design parameters as follows;

Geotechnical Evaluations
Geotechnical evaluations utilizing drilling methodologies should be conducted to verify the sub-surface conditions once a conceptual design is completed and once the locations of proposed buildings and septic fields have been determined.

Site Survey
A detailed site survey should be conducted to allow for additional evaluation from a geotechnical and civil design perspective as the scale of mapping provided in the 1:50,000 scale topographical map was too large to note site specific variations in local elevations.

Environmental Site Assessment(s)
A Phase I Environmental Site Assessment (ESA) should be conducted to identify potential environmental liabilities which may be associated with the former dwellings the former Alaska Highway alignment and the study area.

Other Studies and Plans
A hydrogeological study should be conducted if water wells are to be installed within the study area. The intent of the study should be to assess the impacts of well use upon the underlying aquifer and delineate any liabilities or constraints.

The organization conducting the forestry studies should be notified of the intent to develop the region into a subdivision and interviewed as they may have information pertaining to the study area.

Development plans should be compiled to identify site grading, surface drainage and erosion control requirements.

7.0 CONCLUSIONS

Based upon the retained information, the anticipated soil types and conditions which were encountered in the study area will generally be favorable to allow for country residential subdivision development as noted in Figure 4 and as described below.

Subsurface Conditions & Terrain

While the topography is predominately favorable for residential development, Areas 1A and 2B would not be suitable given the presence of low-lying and steeply sloped regions, respectively.

The development potential of the small region located at the northern tip of the study area was classified as being 'marginal' as the soil types in this area would need to be classified in greater detail. Its proximity relative to the low-lying region of Area 1 may create additional development challenges if standard (30 m) development setbacks are to be observed.

Additional consideration may be required in the area of the existing and former drainage courses (noted in Figure 3) to ensure that regional drainage is well controlled and does not otherwise present a liability.

Residential/Building Construction

While the anticipated glaciofluvial and glacial till deposits will generally allow for residential/building construction utilizing conventional (footing and monolithic-slab types of) foundation systems, adjustments to the individual designs will be required to accommodate site-specific conditions.

In general, the use of the glacial tills for founding soils will allow for greater allowable bearing capacities relative to the (generally unconsolidated) glaciofluvial deposits. Ideally, footings and granular pads (prepared for monolithic-slabs) in Area 2 & 2A, should extend to the dense glacial till deposits which were encountered at an average depth of 1.4 meters.

Surface Utilities

Construction of roads and ditches utilizing conventional cut/fill construction methodologies will be feasible. The thickness of the road structure may vary between 0.7 to 1.0 meters depending upon the composition of the subgrade and anticipated traffic loads.

Sub-surface Utilities (Septic Fields)

While the glaciofluvial soils would generally allow for septic field installation, the increasingly dense nature of the glacial till deposits with depth may not allow for a high enough rate of percolation relative to septic field design requirements. As such, insulated holding tanks may be required in regions where the soil types are deemed unsuitable for use as accepting soils.

Permafrost

As the site harbors sporadic discontinuous permafrost as it was encountered in one of the twelve test pits. As such, additional consideration would be required where permafrost is encountered as conventional subdivision development in these areas should not be allowed.

Residences in these areas would need to be constructed upon cribbing and ventilated crawlspaces if the permafrost conditions are deemed suitable following geotechnical evaluation.

The presence of permafrost would preclude the installation of septic fields and so insulated holdings tanks would be required in these areas if residential development is deemed feasible.

Additional consideration would be required to allow for road construction in these areas as the organic mat should be left intact (for use as insulation) prior to road construction.

Geotechnical Setbacks

At this scale, engineering considerations (which take into account the soil, drainage and topographical limitations) suggest that residential development within designated setback limits (from steep slopes, gullies, etc.) should be restricted until otherwise determined through future geotechnical evaluation. As such, standard (30 m) geotechnical setbacks should be observed for building construction relative to Area 1A, Area 2B and the crests of potentially other steep slopes.

Future Assessments

A geotechnical evaluation should be conducted once a conceptual design for the subdivision has been determined to verify the site specific geotechnical parameters for proposed roadways and other conceptual design features.

Additional site-specific geotechnical evaluation would be required at the time of individual lot development to;

- verify the suitability of the envisioned accepting soils relative to *Yukon Health and Social Services – Design Specifications for Sewage Disposal Systems*, and
- determine the soil types and conditions through drilling methodologies to assess the soil suitability and bearing capacity of the founding strata and identify potentially other geotechnical liabilities.

The organization conducting the forestry studies should be notified of the intent to develop the region into a subdivision and should be interviewed as they may have additional information pertaining to the study area.

Site surveys and environmental assessments should also be conducted to better characterize the site and identify potential liabilities.

8.0 LIMITATIONS

This report is intended for the sole use of the *Yukon Government.* No portion of this report may be used as a separate entity; it is intended to be read in its entirety. Any use of this report by a third party is the responsibility of such third party.

The content within this report reflects our best judgment in light of the information available to our firm at the time of report preparation. Our recommendations are based upon the subsurface conditions encountered at the time of our evaluation, current construction techniques and generally accepted engineering practices.

The anticipated construction conditions have been discussed, but only to the extent that they may influence design decisions. Prospective contractors should be aware that the data presented may not be sufficient to assess all factors that may have an effect upon construction. Any references to construction methods contained herein, express our opinion and are not intended to direct contractors on how to carry out construction.

It is important to emphasize that a geotechnical evaluation is, in fact, based upon random sampling and that our comments are based upon the results obtained at the test pit and sample locations. Due to the geomorphological nature of the deposits encountered, interpolations of subsurface conditions between the test locations have not been made or been implied. Our evaluation is limited as undisturbed samples were not retained and that a limited amount of sampling and testing was conducted.

Given the nature of our assessment and scale of mapping, the information contained herein may not be sufficient to assess all factors that may have an effect upon design and construction and so this should be considered. As such our findings should be supplemented through subsequent geotechnical evaluations and other technical studies as may be required.

Should unexpected subsurface conditions be encountered during future evaluations of the study area or during construction, our firm should be notified immediately in order to confirm the suitability of our recommendations and conclusions. If required, our firm may alter or modify our recommendations and conclusions at such time.

9.0 CLOSURE

Thank you for providing our firm with the opportunity to conduct the above noted evaluation.

We trust that the information we have provided will be suitable for your purposes, however, if you should have any questions or concerns, please feel free to contact the undersigned at your convenience.

Respectfully Submitted,
CHILKOOT GEOLOGICAL ENGINEERS LTD.

#1277
TARES DHARA

PERMIT TO PRACTICE
Signature
Date December 17, 2017
PERMIT NUMBER: PP025
Association of Professional Engineers of Yukon

Tares Dhara, P.Eng.
Senior Geotechnical Engineer

TD/td

CHILKOOT GEOLOGICAL ENGINEERS LTD.

Geotechnical Evaluation
Proposed Bear Creek Country Residential Subdivision – Haines Junction, Yukon - 2017

Figure 1 – Location of Study Area

Based map modified from Google Earth – Not to Scale – Locations are approximate

Compiled Dec.1st, 2017 by T.Dhara

Geotechnical Evaluation
Proposed Bear Creek Country Residential Subdivision
Haines Junction, Yukon - 2017
Figure 2 - Test Pit Locations

Base map from Google Earth

Compiled by T.Dhara, Dec.1st, 2017

Geotechnical Evaluation
Proposed Bear Creek Country Residential Subdivision
Haines Junction, Yukon - 2017
Figure 3 – Site Plan

Base map from Google Earth

Compiled by T.Dhara, Dec.1st, 2017

Geotechnical Evaluation
Proposed Bear Creek Country Residential Subdivision
Haines Junction, Yukon - 2017
Figure 4 – Development Potential

Base map from Google Earth

Compiled by T.Dhara, Dec.1st, 2017

APPENDIX A

Test Pit Soil Logs

NOTES ON SOIL LOGS

Soil Description

The soil is named after its principal component and modified by other components as follows;

Percent of Component	Modifier
> 15 %	XXX - ey
11% to 15%	some XXX
5% to 10%	trace XXX

Examples;

SILT	SAND	GRAVEL	Description
6	32	62	Sandy Gravel trace Silt
55	6	39	Gravelly Silt trace Sand
43	36	21	Silty Gravelly Sand

Note: In the cases where the coarse fraction (sand & gravel) comprise > 50% of the sample, then the larger component of the coarse fraction becomes the principal component.

Undrained Shear Strength of Cohesive Soils

Consistency	Undrained Shear Strength	
	p.s.f	kN/m^2
Very Soft	< 375	<20
Soft	375-750	20-40
Firm	750-1500	40-75
Stiff	1500-3000	75-150
Very Stiff	3000-6000	150-300
Hard	>6000	<300

Relative Density (Qualitative Classification)

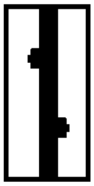
Cohesive Soils

Very Soft	- Exudes between fingers when squeezed by hand
Soft	- Moulded by light finger pressure
Firm	- Moulded by strong finger pressure
Stiff	- Cannot be moulded by fingers – Can be indented by thumb
Very Stiff	- Can only be indented by thumbnail
Hard	- Cannot be indented by thumbnail

Granular Soils

Very Loose	- Considerable sidewall sloughage noted
Loose	- Some sidewall sloughage noted – Easy digging
Compact/ Medium-Dense	- Unimpeded excavation – little to no sidewall sloughage
Dense	- Considerable effort required during excavation – Stable vertical sidewalls
Very Dense	- Extreme difficulty in excavation

Soil Log - Sample Type

Symbol	Test Pitting	Drilling
	**Grab Sample** Retained from excavation sidewall or base	**Auger Sample** Retained from Auger flighting
	**Bucket Sample** Retained from leading edge of excavator bucket	**Split-Spoon Sample** Retained from Split-Spoon Sampler tube

Relative Moisture

Described as - *dry*, *damp*, *moist*, *wet* or *saturated* - relative to the principal soil matrix.

> For example, a moisture content of 10 percent may be classified as '*moist*' for a coarse grained soil (sand or gravel) but '*damp*' for a fine grained (silt) soil.

The moisture content is recorded as a percentage (%) of the weight of water within the soil sample relative to the dry weight of the sample.

Recovery

Refers to the (linear) amount of sample retained after driving the Split Spoon (SPT) sampler tube 18 inches.

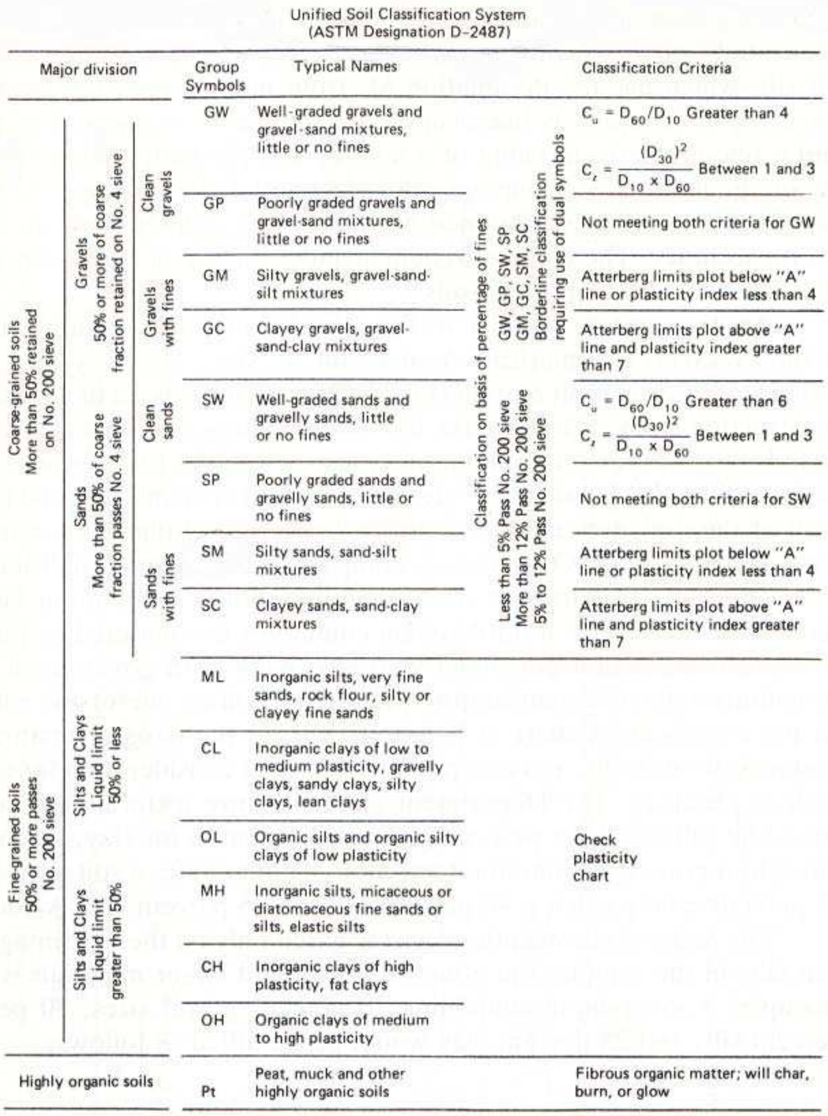
Recorded as a percentage (i.e. 12 inch sample/18 drive = 66 %)

N-Value

Refers to the total number of blows required to drive the Split Spoon sampler tube the final 12 inches of the 18 inch drive.

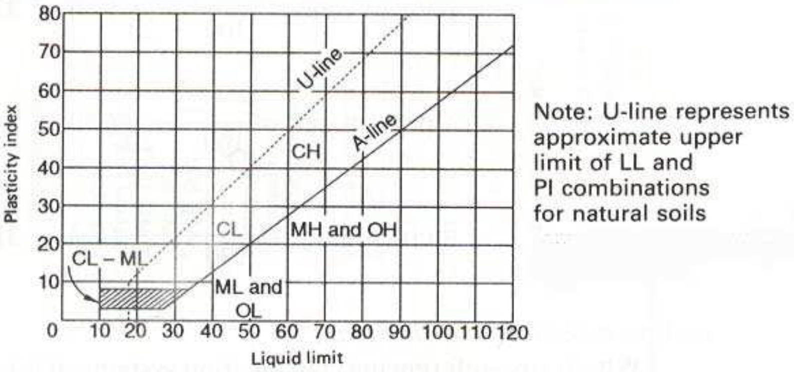
Relative Density based upon SPT 'N' Value

Non-cohesive (Granular) Soil		Cohesive (Clayey) Soils	
Relative Density	**Blows per Foot (N-value)**	**Consistency**	**Blows per Foot (N-value)**
Very Loose	< 5	*Very Soft*	0 to 2
Loose	5 to 9	*Soft*	3 to 4
Compact	10 to 29	*Firm*	5 to 8
Dense	30 to 50	*Stiff*	9 to 15
Very Dense	> 50	*Very Stiff*	16 to 30
		Hard	> 30



Unified Soil Classification System
(ASTM Designation D-2487)

Major division			Group Symbols	Typical Names		Classification Criteria
Coarse-grained soils More than 50% retained on No. 200 sieve	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% Pass No. 200 sieve GW, GP, SW, SP More than 12% Pass No. 200 sieve GM, GC, SM, SC 5% to 12% Pass No. 200 sieve Borderline classification requiring use of dual symbols	$C_u = D_{60}/D_{10}$ Greater than 4 $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits plot above "A" line and plasticity index greater than 7
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean sands	SW	Well-graded sands and gravelly sands, little or no fines		$C_u = D_{60}/D_{10}$ Greater than 6 $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW
		Sands with fines	SM	Silty sands, sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above "A" line and plasticity index greater than 7
Fine-grained soils 50% or more passes No. 200 sieve	Silts and Clays Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands		Check plasticity chart
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	Silts and Clays Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity		
Highly organic soils			Pt	Peat, muck and other highly organic soils		Fibrous organic matter; will char, burn, or glow



Plasticity chart for the classification of fine-grained soils.
Tests made on fraction finer than No. 40 sieve.

Unified Soil Classification System

Figure 18. UNIFIED SOIL CLASSIFICATION SYSTEM

Table 1.2 Description and classification of frozen soils (adapted from Linnell and Kaplar, 1966)

I: Description of soil phase (independent of frozen state)	Classify soil phase by the unified soil classification system						Classify soil phase by the unified soil classification system		
	Major group		Subgroup					Pertinent properties of frozen materials which can be measured by physical tests to supplement field identification	Thaw characteristics
	Description	Designation	Description		Designation		Field identification		
II: Description of frozen soil	Segregated ice not visible by eye	N	Poorly bonded or friable		Nf		Identify by visual examination; to determine presence of excess ice, use procedure under note (3) and hand magnifying lens as necessary; for soils not fully saturated estimate degree of ice saturation (medium, low); note presence of crystals or of ice coatings around larger particles	In-place temperature Density and void ratio a. In frozen state b. After thawing in place Water content (total H_2O, including ice) a. Average b. Distribution Strength a. Compressive b. Tensile c. Shear d. Adfreeze Elastic properties Plastic properties Thermal properties Ice crystal structure (using optical instruments) a. Orientation of axes b. Crystal size c. Crystal shape d. Pattern of arrangement	Usually thaw-stable
			Well bonded	No excess ice	Nb	n			
				Excess ice		e			Usually thaw-unstable
	Segregated ice visible by eye (ice 25 mm or less thick)	V	Individual ice crystals or inclusions		Vx		For ice phase, record the following as applicable		
			Ice coatings on particles		Vc		Location Orientation Thickness Length Spacing Hardness Structure } per part III below Color Size Shape Pattern of arrangement		
			Random or irregularly oriented ice formations		Vr				
			Stratified or distinctly oriented ice formations		Vs		Estimate volume of visible segregated ice present as percent of total sample volume		
III: Description of substantial ice strata	Ice greater than 25 mm thick	ICE	Ice with soil inclusions		ICE + soil type		Designate material as ice and use descriptive terms as follows, usually one item from each group, as applicable: Hardness: hard, soft (of mass, not of individual crystals) Structure: clear, cloudy, porous, candled, granular, stratified Color: colorless, gray, blue Admixtures: contains few thin silt inclusions	Same as part II above, as applicable, with special emphasis on ice crystal structure	
			Ice without soil inclusions		ICE				

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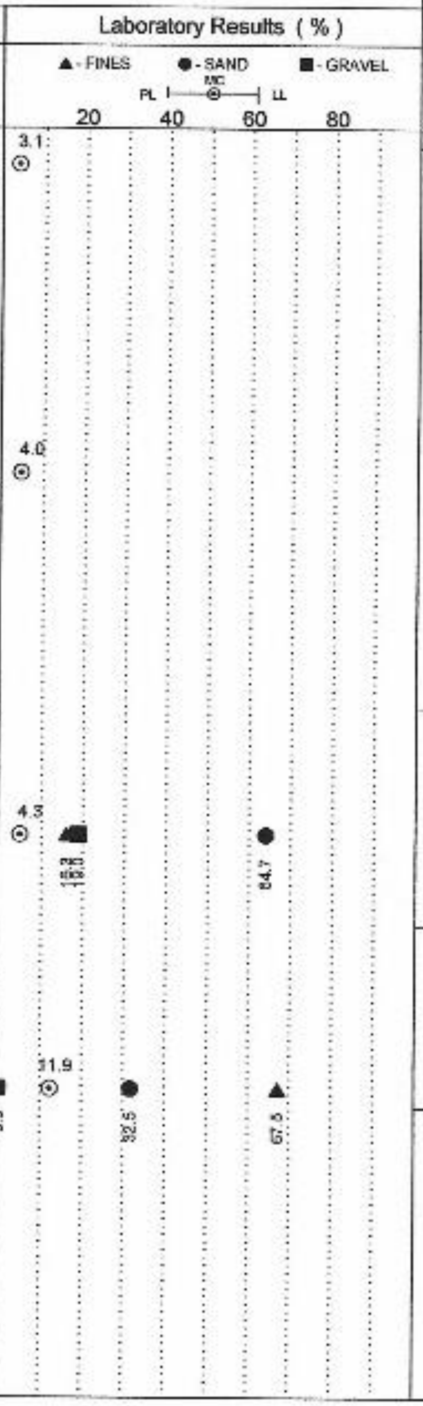
TEST PIT SOIL LOG

Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.1, 2017

Elevation : 100.0 meters
TP Termination Depth: 2.7 meters
Instrumentation: NA
Weather: Odd Flurry +3 to -4

TEST PIT
1-17
Sheet 1 of 1

Depth m	Relative Density	Stratigraphic Description	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	USCS/NRC Depth (m)	Elev. (m)
0.05	soft compact	ORGANICS & ORGANIC SILT (50 mm) w/ rootlets, black	moist dry-damp	☒	1	NA	NA	NA	NA	ORG	100 99.95
		SAND odd GRAVEL - poorly graded, fine to medium grained, light-brown - some rootlets to 0.55 m								SP	
	compact	- as above but brown	damp								99.5 99.45
		- as above		☒	2	NA	NA	NA	NA	1.0	99.1 99.0
1.60	compact	GRAVELLY SILTY SAND - poorly graded, fine to medium grained, brown	damp	■	3	NA	NA	NA	NA	SM 2.0	98.5 98.4 98.0
2.20	stiff	SANDY SILT - fine grained, non-plastic, grey - as above but increasingly consistency	damp	■	4	NA	NA	NA	NA	ML	97.8 97.5
2.70		End of TP @ 2.7 m - No groundwater or seepage zones - No sloughage - Surficial boulder in size to 2.2 m									97.3



Excavated By : Truckways Transport Ltd.
Excavator Type : Kubota kx121
Bucket Type : Digging

Water Level(s)
▽ During Excavation ▼ After Excavation
▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.1, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

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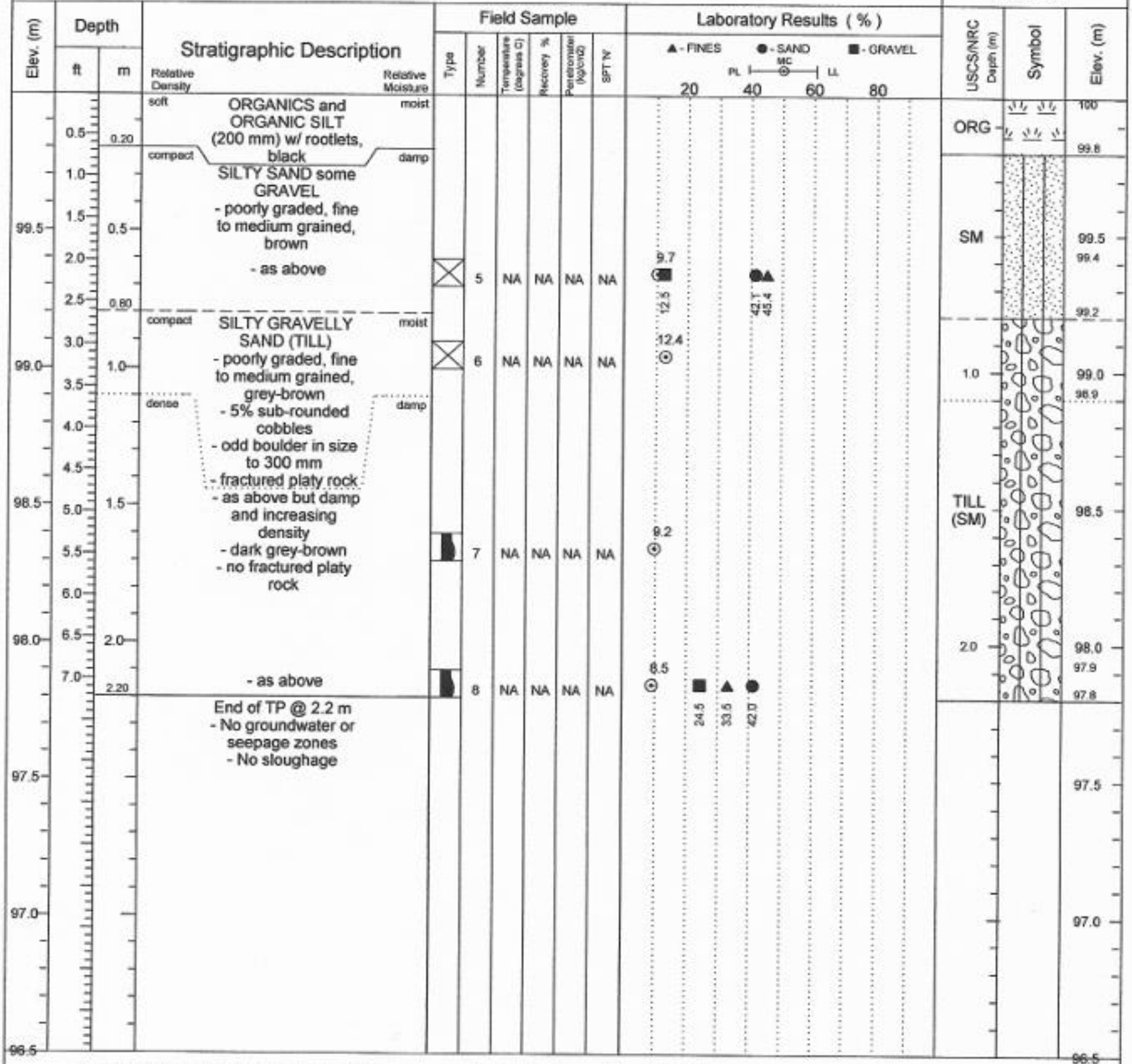
TEST PIT SOIL LOG

Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.1, 2017

Elevation : 100.0 meters
TP Termination Depth: 2.2 meters
Instrumentation: NA
Weather: Odd Flurry +3 to -4

TEST PIT
2-17
Sheet 1 of 1



Depth (m)	Relative Density	Stratigraphic Description	Relative Moisture
0 – 0.20	soft	ORGANICS and ORGANIC SILT (200 mm) w/ rootlets, black	moist
0.20 – 0.80	compact	SILTY SAND some GRAVEL - poorly graded, fine to medium grained, brown - as above	damp
0.80 – 2.20	compact	SILTY GRAVELLY SAND (TILL) - poorly graded, fine to medium grained, grey-brown	moist
	dense	- 5% sub-rounded cobbles - odd boulder in size to 300 mm - fractured platy rock - as above but damp and increasing density - dark grey-brown - no fractured platy rock - as above	damp

End of TP @ 2.2 m
- No groundwater or seepage zones
- No sloughage

Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT N'
5	NA	NA	NA	NA
6	NA	NA	NA	NA
7	NA	NA	NA	NA
8	NA	NA	NA	NA

Excavated By : Truckways Transport Ltd.
Excavator Type : Kubota kx121
Bucket Type : Digging

Water Level(s)
During Excavation
After Excavation
At End of Excavation

Logged By : G.Keitel
Date : Nov.1, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

TEST PIT SOIL LOG

Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.1, 2017

Elevation : 100.0 meters
TP Termination Depth: 2.3 meters
Instrumentation: NA
Weather: Odd Flurry +3 to -4

TEST PIT

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Sheet 1 of 1

▲ - FINES ● - SAND ■ - GRAVEL PL MC LL

Depth m	Relative Density	Stratigraphic Description	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT N'	Laboratory Results (%) MC	■ - GRAVEL	▲ - FINES	● - SAND	USCS/NRC	Elev. (m)
	soft	ORGANICS and ORGANIC SILT (150 mm) w/ rootlets, black	moist											ORG	100
0.15	compact	SILTY GRAVELLY SAND (TILL) - poorly graded, fine to medium grained, odd cobble in size to 150 mm - grey-brown	damp	☒	9	NA	NA	NA	NA	6.9					99.85
	dense	- as above but dark grey-brown	damp	■	10	NA	NA	NA	NA	8.4	20.1	37.0	42.9	TILL (SM)	98.8
1.70	v.dense	- 5% sub-rounded cobbles - odd boulder in size to 400 mm - dark grey-brown	damp	■	11	NA	NA	NA	NA	7.8					98.3
		- as above		■	12	NA	NA	NA	NA	8.0	25.1	34.7	40.2		97.8
2.30		End of TP @ 2.3 m - No groundwater or seepage zones - No sloughage													97.7

Excavated By : Truckways Transport Ltd.
Excavator Type : Kubota kx121
Bucket Type : Digging

Water Level(s)
▽ During Excavation ▼ After Excavation ▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.1, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

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TEST PIT SOIL LOG

Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.1, 2017

Elevation : 100.0 meters
TP Termination Depth: 2.4 meters
Instrumentation: NA
Weather: Odd Flurry +3 to -4

TEST PIT

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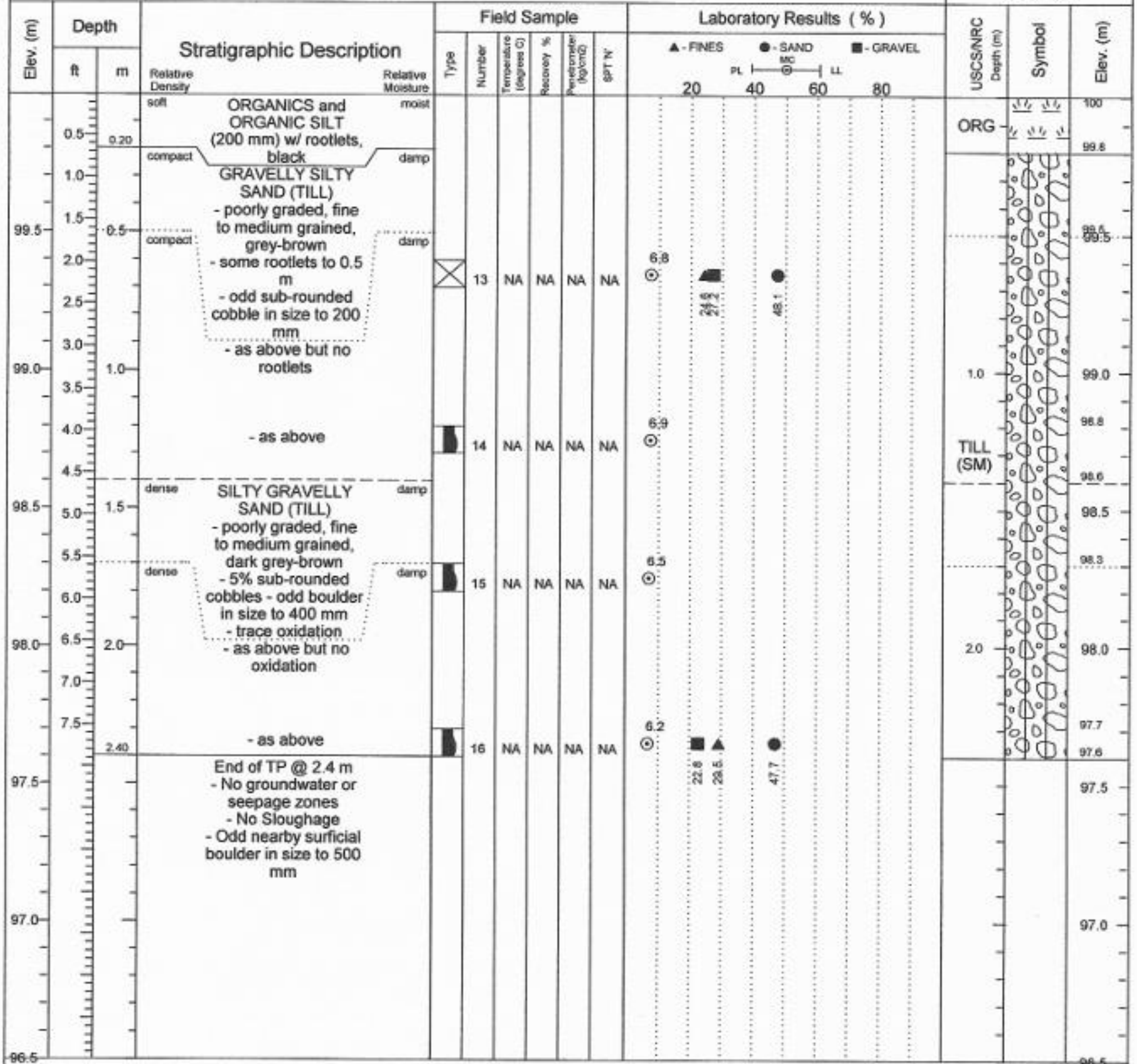
Sheet 1 of 1



Depth (m)	Relative Density	Stratigraphic Description	Relative Moisture
0 – 0.20	soft	ORGANICS and ORGANIC SILT (200 mm) w/ rootlets, black	moist
0.20	compact	GRAVELLY SILTY SAND (TILL) - poorly graded, fine to medium grained, grey-brown	damp
0.5	compact	- some rootlets to 0.5 m - odd sub-rounded cobble in size to 200 mm - as above but no rootlets - as above	damp
1.4	dense	SILTY GRAVELLY SAND (TILL) - poorly graded, fine to medium grained, dark grey-brown	damp
1.7	dense	- 5% sub-rounded cobbles - odd boulder in size to 400 mm - trace oxidation - as above but no oxidation - as above	damp
2.40		End of TP @ 2.4 m - No groundwater or seepage zones - No Sloughage - Odd nearby surficial boulder in size to 500 mm	

Field Sample Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	MC	■ Gravel	▲ Fines	● Sand
13	NA	NA	NA	NA	6.8	24.9	27.2	48.1
14	NA	NA	NA	NA	6.9			
15	NA	NA	NA	NA	6.5			
16	NA	NA	NA	NA	6.2	22.8	28.5	47.7

Excavated By : Truckways Transport Ltd. Excavator Type : Kubota kx121 Bucket Type : Digging

Water Level(s)
∇ During Excavation ▼ After Excavation
▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.1, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

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Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.1, 2017

Elevation : 100.0 meters
TP Termination Depth: 1.2 meters
Instrumentation: NA
Weather: Odd Flurry +3 to -4

TEST PIT

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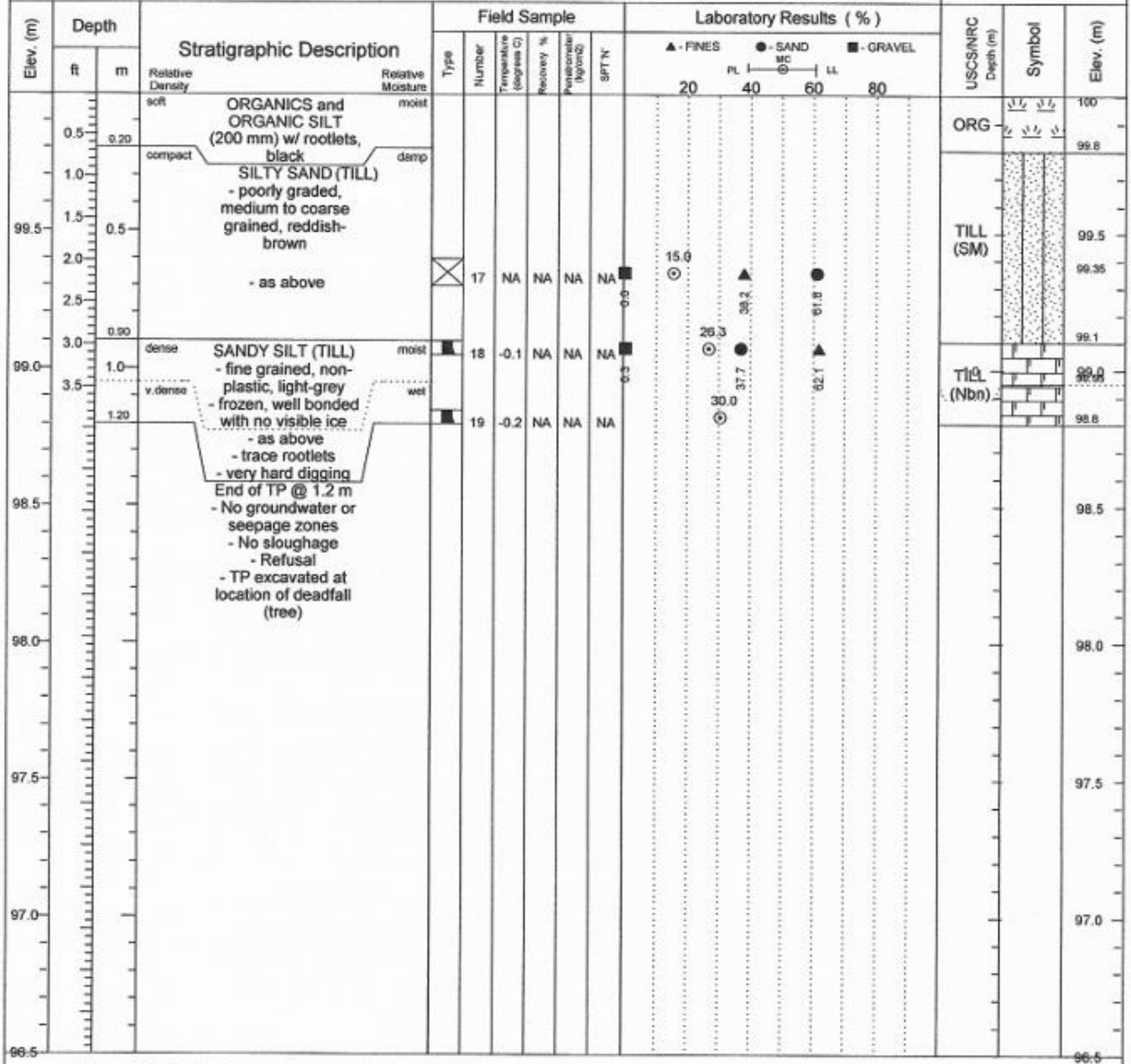
Sheet 1 of 1



Relative Density	Stratigraphic Description	Relative Moisture
soft	ORGANICS and ORGANIC SILT (200 mm) w/ rootlets, black	moist
compact	SILTY SAND (TILL) - poorly graded, medium to coarse grained, reddish-brown - as above	damp
dense	SANDY SILT (TILL) - fine grained, non-plastic, light-grey	moist
v.dense	- frozen, well bonded with no visible ice - as above - trace rootlets - very hard digging	wet

End of TP @ 1.2 m
- No groundwater or seepage zones
- No sloughage
- Refusal
- TP excavated at location of deadfall (tree)

Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT'N'
☒	17	NA	NA	NA	NA
■	18	-0.1	NA	NA	NA
■	19	-0.2	NA	NA	NA

Excavated By : Truckways Transport Ltd.

Excavator Type : Kubota kx121

Bucket Type : Digging

Water Level(s)
▽ During Excavation ▼ After Excavation
▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.1, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

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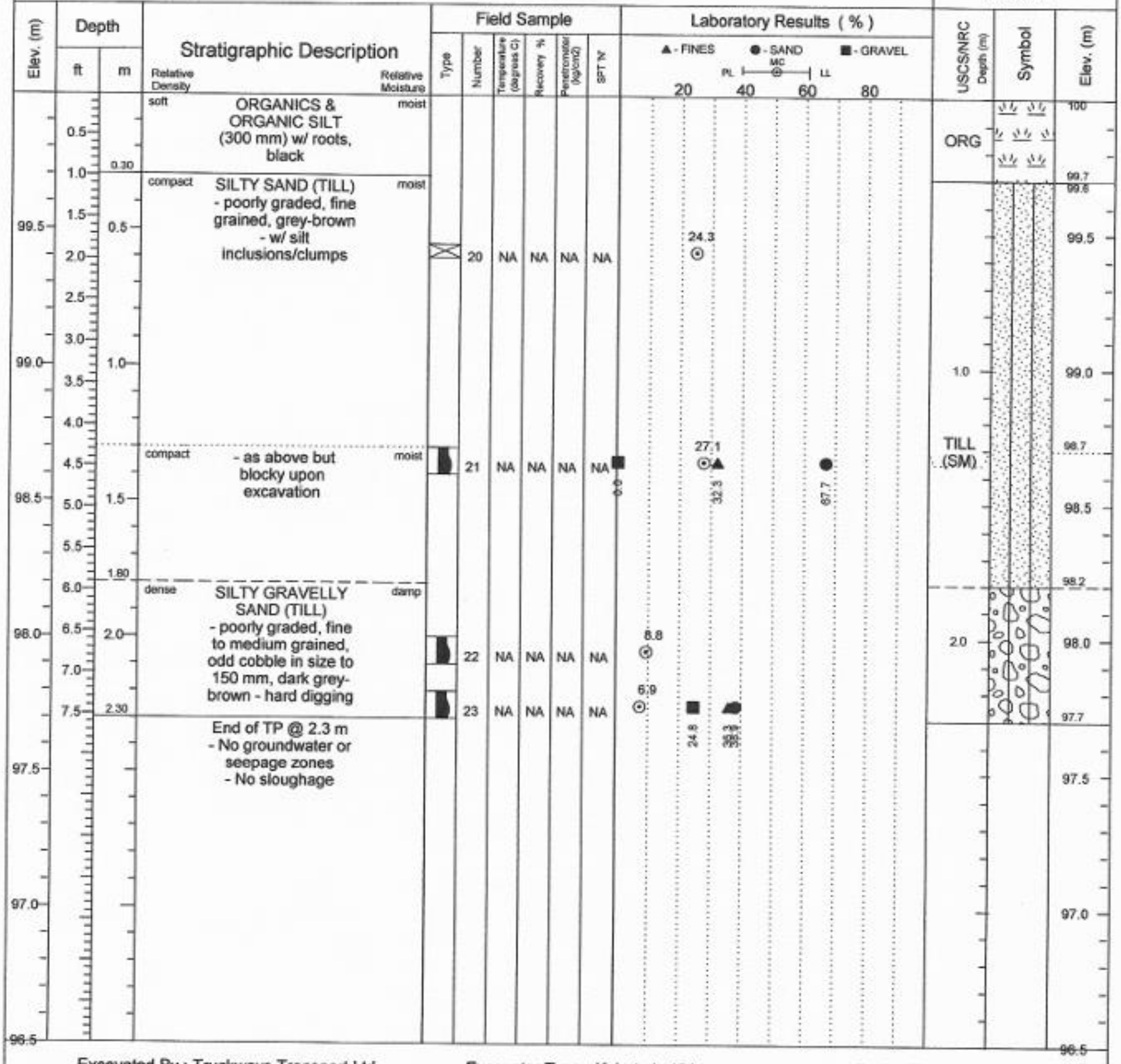
Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.1, 2017

Elevation : 100.0 meters
TP Termination Depth: 2.3 meters
Instrumentation: NA
Weather: Odd Flurry +3 to -4

TEST PIT
6-17
Sheet 1 of 1



Depth (m)	Relative Density	Stratigraphic Description	Relative Moisture	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT N	Laboratory Results (%)	USCS/NRC
0.30	soft	ORGANICS & ORGANIC SILT (300 mm) w/ roots, black	moist							ORG
	compact	SILTY SAND (TILL) - poorly graded, fine grained, grey-brown - w/ silt inclusions/clumps	moist	20	NA	NA	NA	NA	MC 24.3	
1.80	compact	- as above but blocky upon excavation	moist	21	NA	NA	NA	NA	MC 27.1 ■ 0.0 ▲ 32.3 ● 67.7	TILL (SM)
2.30	dense	SILTY GRAVELLY SAND (TILL) - poorly graded, fine to medium grained, odd cobble in size to 150 mm, dark grey-brown - hard digging	damp	22	NA	NA	NA	NA	MC 8.8	
				23	NA	NA	NA	NA	MC 6.9 ■ 24.8 ▲ 38.3 ● 36.9	

End of TP @ 2.3 m
- No groundwater or seepage zones
- No sloughage

Excavated By : Truckways Transport Ltd.
Excavator Type : Kubota kx121
Bucket Type : Digging

Water Level(s)
▽ During Excavation ▼ After Excavation
▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.1, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

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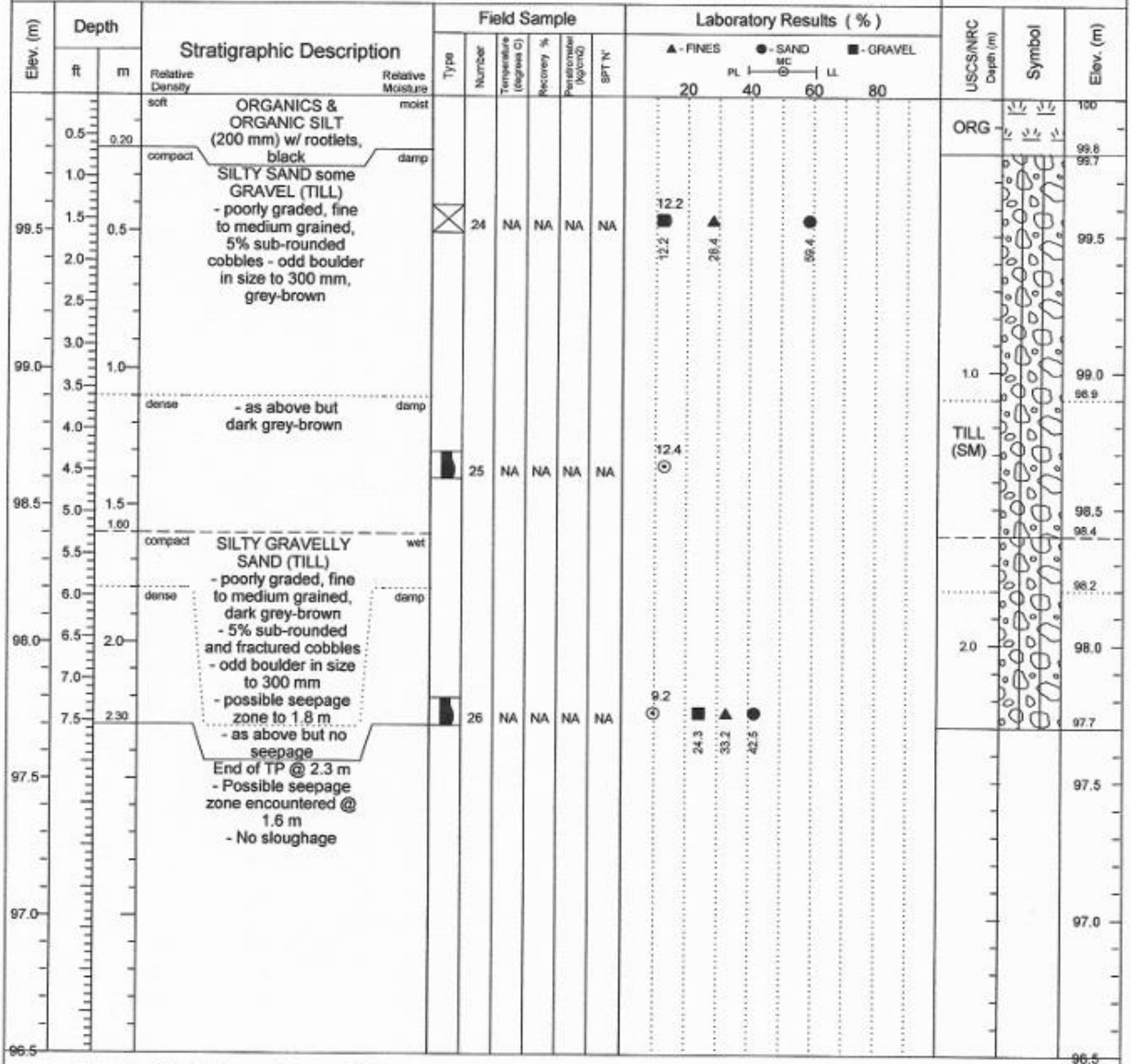
TEST PIT SOIL LOG

Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.1, 2017

Elevation : 100.0 meters
TP Termination Depth: 2.3 meters
Instrumentation: NA
Weather: Odd Flurry +3 to -4

TEST PIT
7-17
Sheet 1 of 1



Stratigraphic Description

soft — ORGANICS & ORGANIC SILT (200 mm) w/ rootlets, black — moist

compact — SILTY SAND some GRAVEL (TILL) - poorly graded, fine to medium grained, 5% sub-rounded cobbles - odd boulder in size to 300 mm, grey-brown — damp

dense — - as above but dark grey-brown — damp

compact — SILTY GRAVELLY SAND (TILL) - poorly graded, fine to medium grained, dark grey-brown - 5% sub-rounded and fractured cobbles - odd boulder in size to 300 mm - possible seepage zone to 1.8 m — wet

dense — - as above but no seepage — damp

End of TP @ 2.3 m
- Possible seepage zone encountered @ 1.6 m
- No sloughage

Field Sample

Type	Number	Temperature (Degrees C)	Recovery %	Penetrometer (Kg/cm2)	SPT 'N'
☒	24	NA	NA	NA	NA
▮	25	NA	NA	NA	NA
▮	26	NA	NA	NA	NA

Excavated By : Truckways Transport Ltd.
Excavator Type : Kubota kx121
Bucket Type : Digging

Water Level(s)
▽ During Excavation ▼ After Excavation
▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.1, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

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TEST PIT SOIL LOG

Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.2, 2017

Elevation : 100.0 meters
TP Termination Depth: 2 meters
Instrumentation: NA
Weather: Clear -2 to -11

TEST PIT

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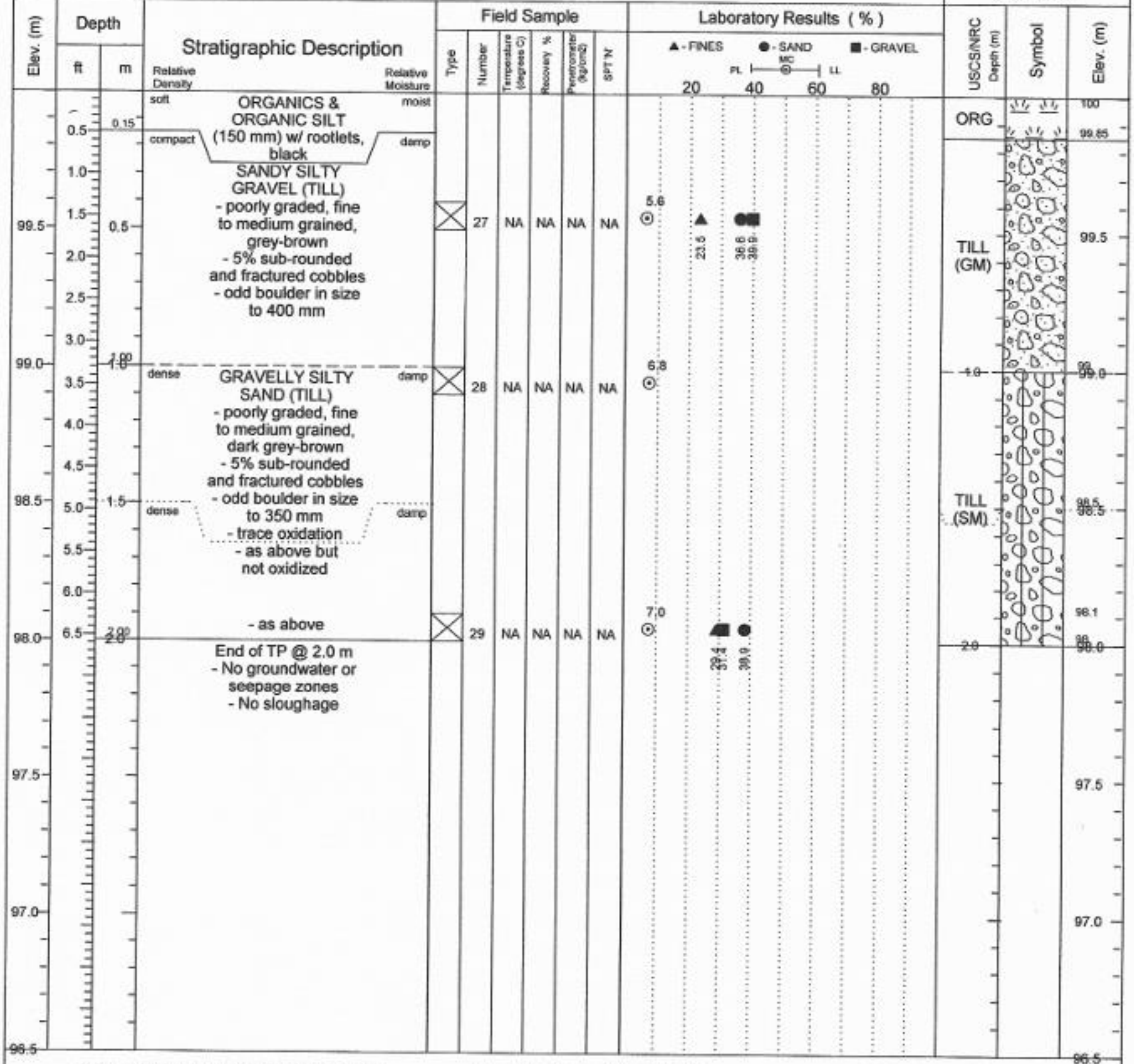
Sheet 1 of 1



Relative Density	Stratigraphic Description	Relative Moisture
soft	ORGANICS & ORGANIC SILT (150 mm) w/ rootlets, black	moist
compact	SANDY SILTY GRAVEL (TILL) - poorly graded, fine to medium grained, grey-brown - 5% sub-rounded and fractured cobbles - odd boulder in size to 400 mm	damp
dense	GRAVELLY SILTY SAND (TILL) - poorly graded, fine to medium grained, dark grey-brown - 5% sub-rounded and fractured cobbles - odd boulder in size to 350 mm - trace oxidation	damp
dense	- as above but not oxidized - as above	damp

Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'
☒	27	NA	NA	NA	NA
☒	28	NA	NA	NA	NA
☒	29	NA	NA	NA	NA

End of TP @ 2.0 m
- No groundwater or seepage zones
- No sloughage

Excavated By : Truckways Transport Ltd.   Excavator Type : Kubota kx121   Bucket Type : Digging

Water Level(s)
▽ During Excavation   ▼ After Excavation
▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.2, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

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TEST PIT SOIL LOG

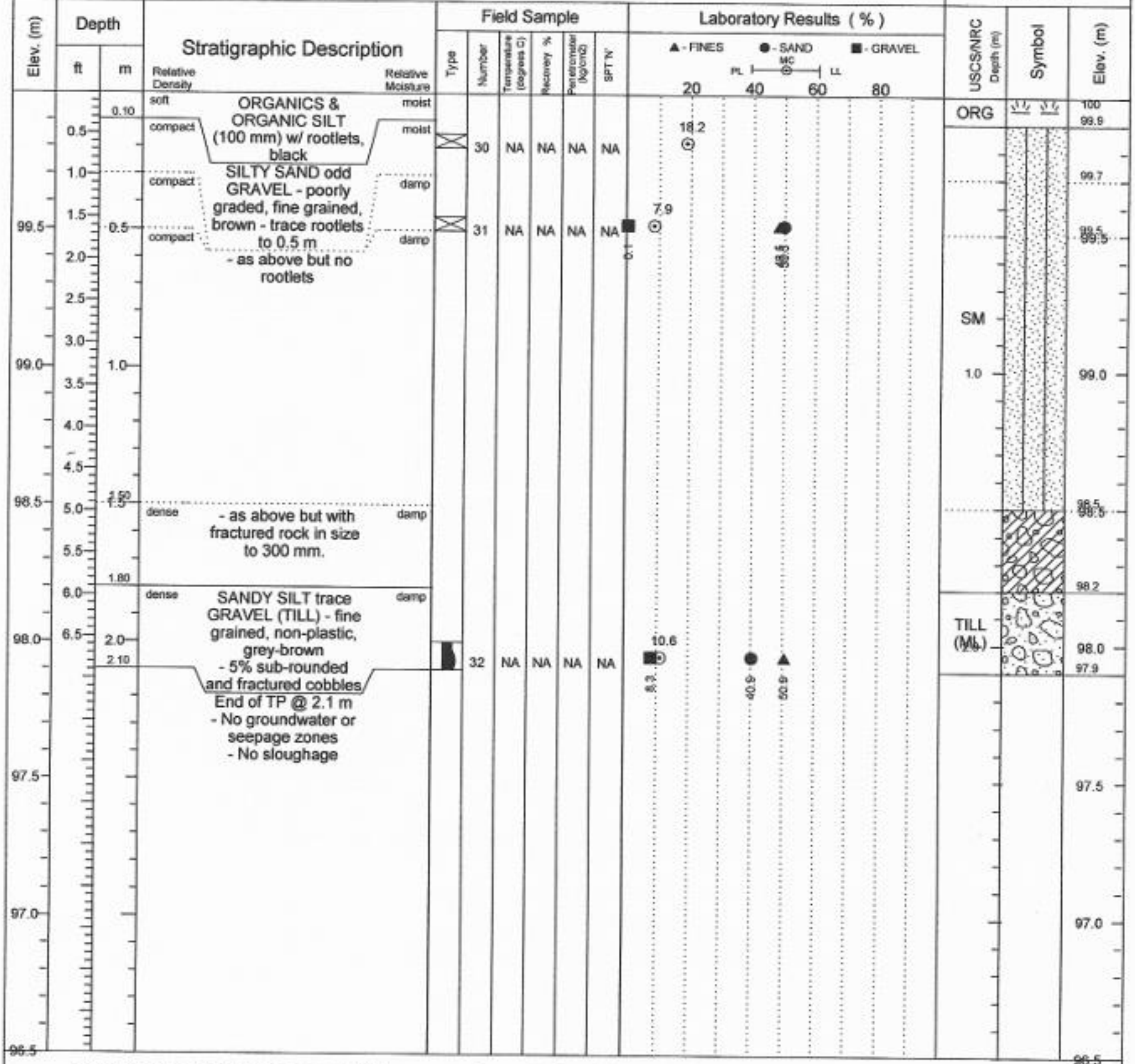
Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.2, 2017

Elevation : 100.0 meters
TP Termination Depth: 2.1 meters
Instrumentation: NA
Weather: Clear -2 to -11

TEST PIT

9-17

Sheet 1 of 1



Depth (m)	Relative Density	Stratigraphic Description	Relative Moisture
0 – 0.10	soft	ORGANICS & ORGANIC SILT (100 mm) w/ rootlets, black	moist
0.10	compact	SILTY SAND odd GRAVEL - poorly graded, fine grained, brown - trace rootlets to 0.5 m	moist
	compact		damp
0.5	compact	- as above but no rootlets	damp
1.50	dense	- as above but with fractured rock in size to 300 mm.	damp
1.80 – 2.10	dense	SANDY SILT trace GRAVEL (TILL) - fine grained, non-plastic, grey-brown - 5% sub-rounded and fractured cobbles	damp

End of TP @ 2.1 m
- No groundwater or seepage zones
- No sloughage

Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT N'
30	NA	NA	NA	NA
31	NA	NA	NA	NA
32	NA	NA	NA	NA

Excavated By : Truckways Transport Ltd. Excavator Type : Kubota kx121 Bucket Type : Digging

Water Level(s)
▽ During Excavation ▼ After Excavation
▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.2, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

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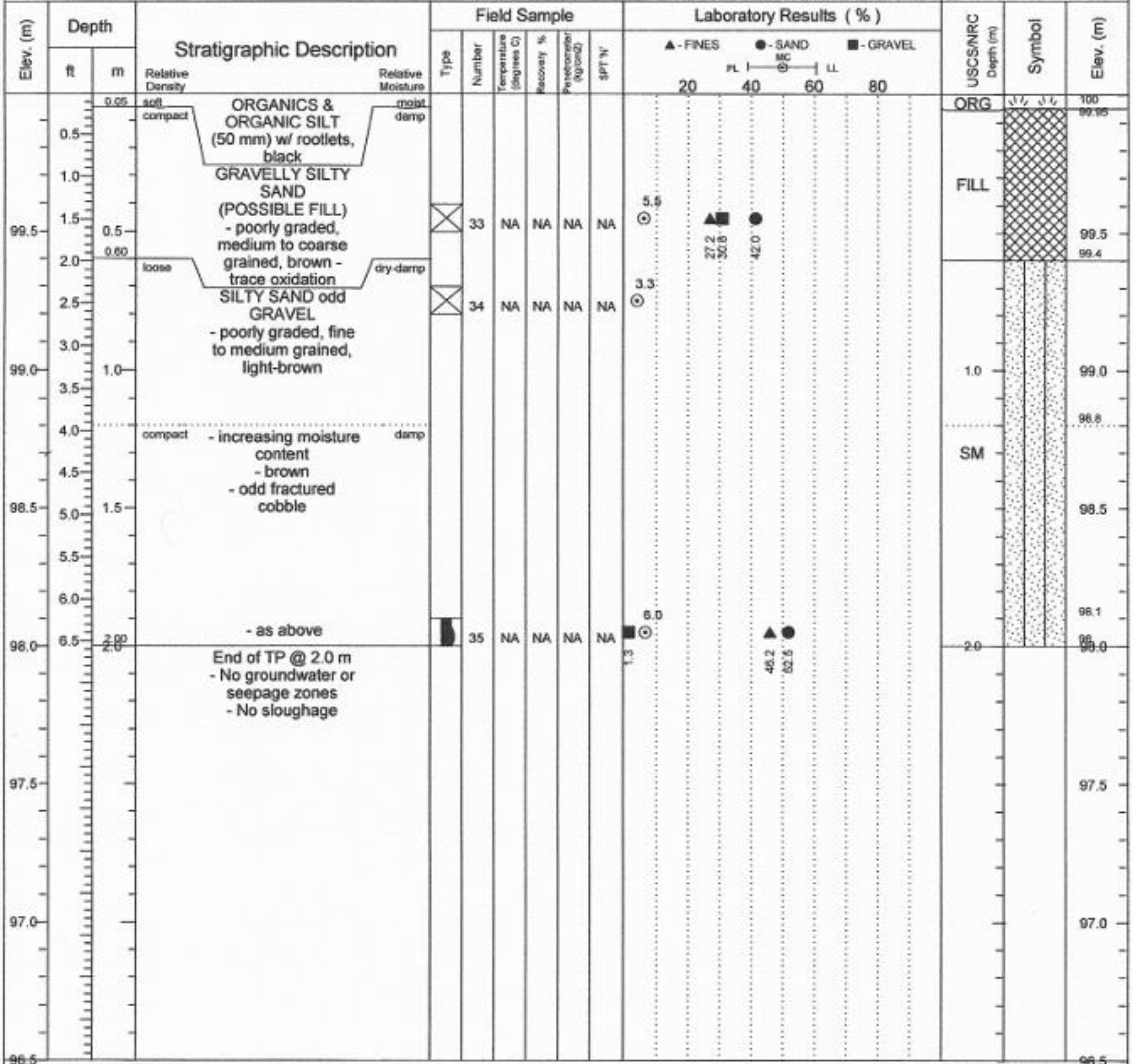
TEST PIT SOIL LOG

Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.2, 2017

Elevation : 100.0 meters
TP Termination Depth: 2 meters
Instrumentation: NA
Weather: Clear -2 to -11

TEST PIT
10-17
Sheet 1 of 1



Stratigraphic Description

soft / compact — ORGANICS & ORGANIC SILT (50 mm) w/ rootlets, black — moist / damp

GRAVELLY SILTY SAND (POSSIBLE FILL)
- poorly graded, medium to coarse grained, brown -
trace oxidation

loose — SILTY SAND odd GRAVEL — dry-damp
- poorly graded, fine to medium grained, light-brown

compact — damp
- increasing moisture content
- brown
- odd fractured cobble

- as above

End of TP @ 2.0 m
- No groundwater or seepage zones
- No sloughage

Field Sample

Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'
☒	33	NA	NA	NA	NA
☒	34	NA	NA	NA	NA
	35	NA	NA	NA	NA

Excavated By : Truckways Transport Ltd. Excavator Type : Kubota kx121 Bucket Type : Digging

Water Level(s)
During Excavation After Excavation
At End of Excavation

Logged By : G.Keitel
Date : Nov.2, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

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TEST PIT SOIL LOG

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Sheet 1 of 1

Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.2, 2017

Elevation : 100.0 meters
TP Termination Depth: 2.2 meters
Instrumentation: NA
Weather: Clear -2 to -11

Laboratory Results (%): ▲ - FINES ● - SAND ■ - GRAVEL PL ⊢ MC ⊙ ⊣ LL (20 40 60 80)

Depth (m)	Relative Density	Stratigraphic Description	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC	Depth (m)	Elev. (m)
0.10	soft	ORGANICS & ORGANIC SILT (100 mm) w/ rootlets, black	moist								ORG		100 99.9
	compact	SILTY SAND some GRAVEL - poorly graded, medium to coarse grained, light-brown	moist	☒	36	NA	NA	NA	NA	MC 8.3 ■ 11.4 ▲ 29.4 ● 59.3			99.8
1.00	compact	SAND some SILT (inclusions) odd GRAVEL - poorly graded, fine grained, brown - odd sub-rounded cobble	damp		37	NA	NA	NA	NA	MC 5.1	SM	1.0	99.0
1.50	loose	- as above but no silt inclusions - decreasing moisture content	dry-damp										98.5
2.20		- as above			38	NA	NA	NA	NA	MC 3.3 ■ 3.1 ▲ 12.6 ● 84.3 Caved To 2.0		2.0	98.0 97.9 97.8

End of TP @ 2.2 m
- No groundwater or seepage zones
- TP sloughed to 2.0 m
- Odd surficial boulder in size to 400 mm

Excavated By : Truckways Transport Ltd. Excavator Type : Kubota kx121 Bucket Type : Digging

Water Level(s)
▽ During Excavation ▼ After Excavation
▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.2, 2017

Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

TEST PIT SOIL LOG

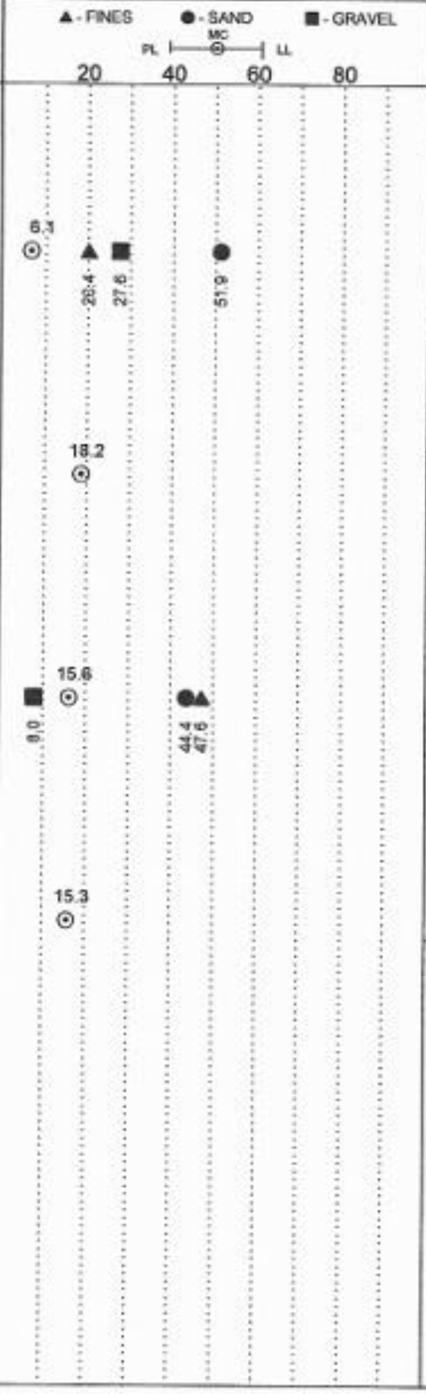
Client : Yukon Government - Energy Mines & Resources
Location : Haines Junction, Yukon
Project : Geotechnical Evaluation - Bear Creek Subdivision
Date Excavated: Nov.2, 2017

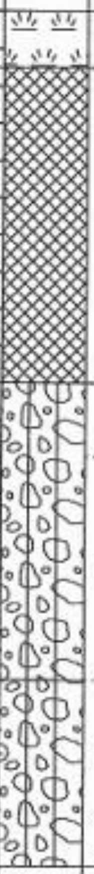
Elevation : 100.0 meters
TP Termination Depth: 2.3 meters
Instrumentation: NA
Weather: Clear -2 to -11

TEST PIT
12-17
Sheet 1 of 1

Depth (m)	Relative Density	Stratigraphic Description	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (Kg/cm2)	SPT 'N'	USCS/NRC	Elev. (m)
0	soft	ORGANICS & ORGANIC SILT (100 mm) w/ rootlets, black	moist							ORG	100
0.15	compact	GRAVELLY SILTY SAND (FILL) - poorly graded, medium to coarse grained, brown - 5% sub-rounded and fractured cobbles - odd boulder in size to 300 mm - trace oxidation	damp	☒	39	NA	NA	NA	NA	FILL	99.85
1.00	dense	SILTY SAND trace GRAVEL (TILL) - poorly graded, fine to medium grained, grey-brown	damp	▮	40	NA	NA	NA	NA	TILL (SM)	99.0
	dense	- trace rootlets to 1.2 meters - odd sub-rounded cobble - trace oxidation - as above but no rootlets	damp	▮	41	NA	NA	NA	NA		98.8
	dense	- as above but dark grey-brown - sub-round boulder in size to 600 mm - as above	damp	▮	42	NA	NA	NA	NA	2.0	98.2
2.30		End of TP @ 2.3 m - No groundwater or seepage zones - No sloughage									97.7

Laboratory Results (%)





Excavated By : Truckways Transport Ltd.
Excavator Type : Kubota kx121
Bucket Type : Digging

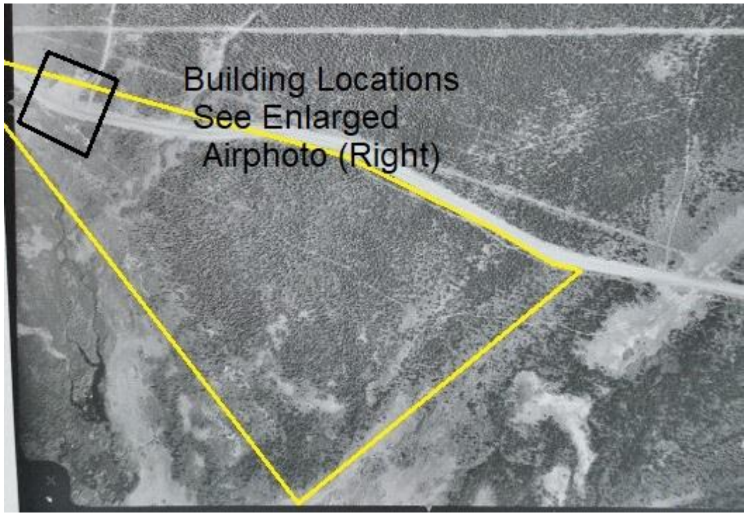
Water Level(s)
▽ During Excavation ▽ After Excavation
▼ At End of Excavation

Logged By : G.Keitel
Date : Nov.2, 2017

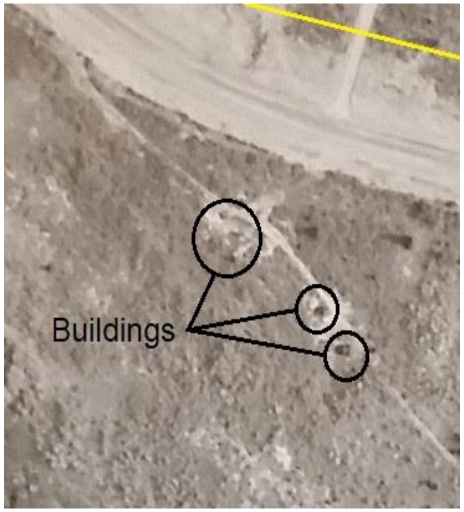
Data Entry By : T.Dhara, P.Eng.
Date : Nov.25-30, 2017

Reviewed By:
Date : Nov.30, 2017

Geotechnical Evaluation
Proposed Bear Creek Country Residential Subdivision – Haines Junction, Yukon - 2017
Appendix B – Selection of Airphotos



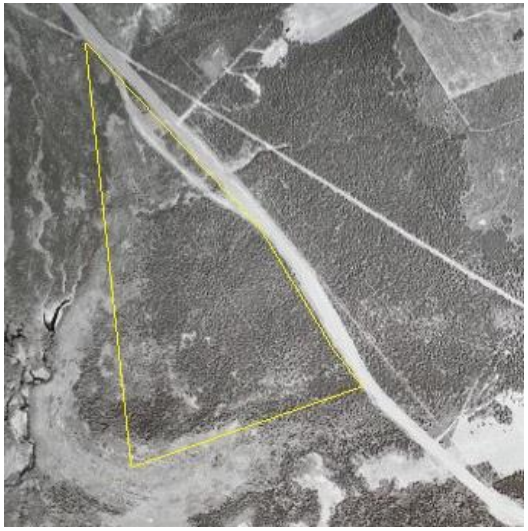
1975



1975 Buildings

1976

1995



1996

Limits are approximate.

Compiled December 1st, 2017 by T.Dhara

CHILKOOT GEOLOGICAL ENGINEERS LTD.

Appendix C

Recommended Grain Size Distribution for Imported Fill

Gran E Pit Run	
Sieve Size (mm)	% Passing By Wt
200	100
80	75-100
25	55-100
12.5	42-84
5	26-65
1.25	11-47
0.315	3-30
0.08	2-13
LA Abrasion 35 % Max Loss	

80 mm minus Sub-base	
Sieve Size (mm)	% Passing By Wt
80	100
25	60-100
12.5	40-90
5	20-65
1.25	9-35
0.315	3-15
0.08	0-8
LA Abrasion 35 % Max Loss	

Clear Stone	
Sieve Size (mm)	% Passing By Wt
28	100
20	70-100
12.5	55-100
10	30-80
5	0-40
2	0-10
NA	NA
LA Abrasion 35 % Max Loss	

Bedding Sand	
Sieve Size (mm)	% Passing By Wt
10	100
5	80-100
2	55-100
0.63	25-65
0.25	10-40
0.08	2-10

20 mm minus Base Course	
Sieve Size (mm)	% Passing By Wt
20	100
12.5	64-100
5	36-72
1.25	12-42
0.315	4-22
0.08	3-6

Class I Rip-Rap	
Sieve Size (mm)	% Passing By Wt
450	100
350	80
300	50
200	20

Class II Rip-Rap	
Sieve Size (mm)	% Passing By Wt
800	100
600	80
500	50
300	20

Class III Rip-Rap	
Sieve Size (mm)	% Passing By Wt
1200	100
900	80
800	50
500	20