Geotechnical Evaluation
Freegold Road and Lot 193 Residential Development
Carmacks, Yukon

PRESENTED TO
Government of Yukon

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Tetra Tech Canada Inc.
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
Tel 867.668.3068 Fax 867.668.4349

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LIMITATIONS OF REPORT

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1.0 INTRODUCTION

1.1 General

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Government of Yukon, Department Community Services – Land Development Branch (CS-LDB) to complete a geotechnical evaluation for two proposed lot developments, one located along the west side of the Freegold Road, where five lots are planned, and the second at Lot 193 along Prospector Road in Carmacks, Yukon. CS-LDB has indicated that the proposed lots are residential to address the current lot shortage in Carmacks. The purpose of this study is to provide general geotechnical recommendations for the development of the proposed areas. This report presents a summary of our field geotechnical evaluation, site conditions, and general recommendations for lot development, foundations, and septic disposal systems.

Authorization to proceed with this work was given by way of a signed Yukon Government contract (Contract #: C00060878 as a call up to our standing offer agreement with Community Services (SOA #2021/22-260).

2.0 SCOPE OF WORK

Tetra Tech's scope of work for this project was completed in accordance with the scope of work described in our proposal submitted to CS-LDB on June 14, 2021, that comprised the following:

- Desktop review of historical files;
- Geotechnical site exploration program including initial field investigations, testpitting, and percolation testing;
- Laboratory geotechnical index testing consisting natural moisture content and particle size distribution by sieve analysis; and
- Reporting which includes the results of the desktop study; description of surficial features, potential hazard areas, surface and subsurface site conditions; drafted borehole logs; laboratory test results; percolation testing results; general discussion on the suitability of the site for development including a summary of any geotechnical challenges; preliminary recommendations for site preparation; and general guidance and recommendations for building foundations, septic field design, excavations, and backfill.

3.0 FIELD GEOTECHNICAL INVESTIGATION

3.1 Site Reconnaissance

Tetra Tech completed a site reconnaissance on July 29, 2021 to assess the terrain at each of the subject sites and determine locations for testpitting and proposed routes for clearing to gain access to the testpits. Tetra Tech determined that one testpit for Lot 193 and five testpits for the Freegold Road site would provide sufficient geotechnical information to inform recommendations. Access to the testpit locations were kept to current trails to minimize clearing unless no trails existed to gain access to a location.

3.2 Bird Survey and Clearing for Site Access

As the site investigation fell within the migratory birds nesting season, Tetra Tech retained EDI Dynamics Ltd. (EDI) to conduct a bird survey in advance of clearing. On August 5, 2021, Tetra Tech accompanied EDI to conduct the bird survey. EDI provided two experienced biologists that swept an area 10 m wide on either side of access routes or testpit locations to look for bird nests or evidence of nesting. EDI did not find evidence of nesting migratory birds along any access routes or surrounding testpit locations and provided clearance to Tetra Tech to conduct clearing operations.

Tetra Tech retained Highwind Industries Ltd. (Highwind) to hand clear larger trees. Hand clearing using a chainsaw was chosen to minimize the impact to the forest floor as uprooting trees with an excavator would cause significant damage. Highwind began clearing on August 5 and completed the clearing on August 6.

3.3 Testpitting

The testpitting program was completed on August 7 and 8, 2021. Six testpits were excavated to a termination depth of approximately 4.0 m, or refusal, using a John Deere 135 tracked excavator sub-contracted from Northern Construction of Whitehorse, Yukon. One testpit was excavated within Lot 193 and five testpits were excavated throughout the Freegold Road area. Testpit locations are shown on the attached site plans (Figures 1 and 2).

Representative disturbed samples were collected at nominal intervals or upon a change in soil type in each of the testpits. The geotechnical conditions were recorded, and the soils were classified as per the Unified Soil Classification System (USCS). Percolation testing was performed in Testpits TP21-02, TP21-04, TP21-05, and TP21-06.

Drafted testpit logs detailing the geotechnical conditions encountered along with accompanying laboratory test results are presented in Appendix B.

3.4 Laboratory Testing

Laboratory testing on retained disturbed samples was carried out in Tetra Tech's Whitehorse laboratory and included determination of natural moisture content, particle size distribution by sieve analysis, and Atterberg limits.

Laboratory test results are included after the borehole logs in Appendix B and are also shown on the logs where applicable.

4.0 SITE DESCRIPTION

4.1 Site Location

The study area is comprised of two development lots, Lot 193 and proposed development near the Freegold Road located in Carmacks, Yukon. The area of Lot 193 is accessed from the Klondike Highway via Prospector Road. The other proposed development area lies at the junction of Mt. Nansen and Freegold Road, herein referred to as the Freegold Road area. Access to the testpits in this area was via an existing trail network from the Mt. Nansen Road, and the north side of the site can also be accessed along the Freegold Road.

4.2 Geological Setting

4.2.1 Lot 193

The underlying bedrock geology of Lot 193 is characterized by the sedimentary rocks of the Tantalus Formation of the middle Jurassic Whitehorse trough. The Whitehorse trough lies within the Intermontane belt of the Canadian Cordillera. The Tantalus Formation is characterized by extensive chert pebble and other conglomerates that are interpreted as shallow braided gravel riverbed deposits. Local sandstone and mudstone are also present within the formation. The conglomerate units are well to moderately sorted, medium and large pebbled with well-rounded sub-equant clasts and clast supported matrix. Clasts dominantly consists of chert, and minor sandstone, igneous, and metamorphic clasts.

4.2.2 Freegold Road Area

The Freegold Road area is underlain by the volcanic rocks of the Upper Cretaceous Casino Formation of the Carmacks Group. Volcanic rocks of the Carmacks Group are interpreted to form post-accretion of the Canadian Cordillera and are likely to represent erosional remnants of what once formed an extensive volcanic cover in the area. The Carmacks Group largely comprises dacite and rhyodacite with minor black to brown basalt and basaltic andesite. The basalt and andesite are commonly porphyritic with flow banding and flattened vesicles. These rocks generally occur as scattered rubble throughout the proposed lot. They generally form topographic features with positive relief.

A major fault is exposed at the south boundary of the Freegold Road area. This fault is interpreted as the northwest-southeast striking, strike-slip Braeburn fault. There was no surficial expression of bedrock or fault rock during site visit.

4.3 Climate

Carmacks is located in the Central Yukon Plateau. It is a relatively dry region that receives only 250 to 300 mm of precipitation annually, with two-thirds occurring during the summer months (Yukon Ecoregions Working Group, 2004). The mean annual temperature is – 4 °C, with mean January temperatures as low as – 30 °C and mean July temperatures up to 15 °C. The area is within the extensive discontinuous permafrost zone of Canada meaning 40 to 90% of the ground may be underlain by permafrost (Bonnaventure et al., 2012).

4.4 Surface Conditions

The Carmacks area has been glaciated multiple times with the most recent being the Reid and McConnell glaciations. As ice receded, meltwater cut through valley walls and ridges along the ice margins. In front of the ice sheet, large glaciofluvial outwash plains formed which were subsequently incised as the water withdrew leaving behind terraces. Stagnant ice filled the Yukon and Nordenskiold River valleys forming terraces, kettle depressions, and hummocky topography. During the deglaciation, large volumes of sediments were mobilized by strong winds across the area in narrow veneers covering some areas of glaciofluvial sediments.

4.4.1 Lot 193

The proposed site on Lot 193 lies on the gravel terrace of the Yukon River. The terrane is generally flat lying. The most southwest corner of the lot is situated at higher elevations due to the constructed embankment of the Alaska Highway.

The predominant vegetation present in this lot is moderately spaced spruce with a few poplar trees with grass and shrub ground cover. Local open lenses of grass and shrubs were observed at previously cleared areas. No overland drainage was observed in the area; however, the moss cover was moist.

4.4.2 Freegold Road Area

The terrane at Freegold Road area can be divided into two general regions, based on the topographic nature and geological history. The boundaries were roughly determined by both LiDAR Digital Elevation Model (DEM) and air photos, and then confirmed by the site visit.

The largest region (Region 1) occupies most of the proposed development and is located on the central and eastern side of Freegold Road area. This region is gently sloped to the east and characterized typical knoll and kettle topography created by the retreating glacier. The area is underlain by gravel, sand, and silt of glaciofluvial origin within terraces deposited during the McConnell glaciation.

Region 1 is characterized by thickly wooded poplar trees growing through grass and willow shrubs with local open grassy areas. Towards the west, the area transitions to a moderately spaced poplar, pine, and spruce tree vegetation growing through mossy floor and willow shrubs. Notably, as the ground floor becomes increasingly moister towards the west and shaded by the relatively north facing slope, the moss cover also increases.

The second region (Region 2) occupies the most western side of the proposed lot. This area has steep topography, sloped to the east. The most northern part of this area has grassy slopes with no vegetation, whereas the south side is thickly vegetated by black spruce and pine trees.

Recently published Landscape Hazard Susceptibility Analyses (Cronmiller et al., 2020) including hillslope, permafrost, and fluvial hazard measures show that the area particularly by Region 2 is ranked high for hazard susceptibility mainly due to its steep sloped nature and permafrost susceptibility. During the site visits no landslide movement, erosion, or loose colluvium were noted on the hillslope.

4.5 Subsurface Conditions

Test pit logs of the encountered subsurface materials are presented in Appendix B. A general description of the soil profiles is described and summarized in Table 1 below. Please note that the testpit logs and laboratory results contain detailed information describing the geotechnical conditions at the site and should be read in preference to the generalized description provided below:

4.5.1 Lot 193

Lot 193 is characterized by typical fluvial clastic sediments of the Yukon River consisting of dominantly gravel, sand, and trace silt. These sediments are classified as inactive fluvial (e.g., not subjected to ongoing erosion or deposition) deposits.

- Testpit TP21-01 was excavated in Lot 193. Below the moss ground cover and organics, silty and sandy gravel was encountered and extended to the depth of 1.2 m. Some cobbles were also noted. Immediately below, fluvial sand and gravel were found with some cobbles and trace silt to the depth of 2 m, overlying a 1 m thick sandy, cobbly gravel layer with trace of boulders.

4.5.2 Freegold Road Area

This area consists mainly of gravel, sand, and silt of glaciofluvial origin. On the steep slopes, these observed sediments are likely modified by ice contact and rapid mass movement of debris slides due to the steep terrain in this region.

- Testpit TP21-02 was excavated in Region 2. At this location, heavy moss cover and organic root mat was noted over a thin veneer of ash layer. At 0.2 m, silty sand was encountered to the depth of 2.4 m. At 2.4 m glaciofluvial sand and gravel with some cobbles and some boulders were encountered and extended to the 4.0 m testpit termination depth.
- Testpit TP21-03 was also excavated in Region 2, close to the hillside. Below the moss ground cover and organic rootles mixed with ash, silty sand was encountered to the depth of 2.4 m. From 2.4 m onwards, silt with trace sand was dominant. This fine-grained, frost susceptible, moist soil unit extended to the termination depth of 4.3 m.
- Testpit TP21-04 was excavated within the central part of Region 1. Below the organic layer of moss and rootlets a distinctive, 5 mm thick ash layer was noted. Between 0.2 m to 2.9 m, glaciofluvial sand with trace silt was present overlying an interbedded sand and silt unit, which extended to the termination depth of 4.1 m.
- Testpit TP21-05 was excavated in the northwest side of Region 1. At this location moss cover and organic root mat was noted above a 15 mm thick coarse ash layer. Between 0.2 m to 4.1 m silty sand was observed throughout the testpit.
- Testpit TP21-06 was excavated in the northeast side of Region 1. Similarly, to the previous testpit (TP21-05), below the surficial organics and thin ash layer, silty sand was encountered and extended to the 4.4 m testpit excavation depth.

Table 1 – Summary of Subsurface Conditions

Soil Type	Depth (m)					
	Lot 193	Freegold Road Area				
	TP21-01	TP21-02	TP21-03	TP21-04	TP21-05	TP21-06
Surficial Organics & Ash	0.0 – 0.1	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.1
Gravel	0.1 – 1.2	-	-	-	-	-
Sand	-	-	0.2 – 2.4	0.2 – 2.9	0.2 – 4.1	0.1 – 4.4
Silt	-	0.2 – 2.4	2.4 – 4.3	-	-	-
Sand and Silt	-	-	-	2.9 – 4.1	-	
Sand and Gravel	1.2 – 2.0	2.4 – 4.0	-	-	-	-
Gravel	2.0 – 3.0	-	-	-	-	
End of Testpit	3.0	4.0	4.3	4.1	4.1	4.4

Refer to the testpit logs in Appendix B for a detailed description of subsurface conditions.

4.6 Permafrost

The Carmacks area lies in the widespread discontinuous permafrost region. Region 2 in the Freegold Road area was closely evaluated for its high hazard ranking by the Yukon Geological Survey likely due to suspected permafrost and its steep slopes. During the initial assessment of the site, thick moss cover at the toe of the NE facing slope was observed, inferring that permafrost might be present. To evaluate this possibility Testpits TP21-02 and TP21-03 were excavated in the suspected permafrost area. There was no visible ground ice noted in either testpit,

but poorly bonded frozen soil was observed in Testpit TP21-02 and very cold soil temperatures were noted near the base of TP21-03 which may indicate that permafrost is present beyond the reach of the excavator.

There was no permafrost encountered in any of the other testpits excavated on the site.

The inferred area of permafrost is shown on Figure 3.

4.7 Bedrock

Tetra Tech did not encounter bedrock in any of the testpits.

4.8 Groundwater and Site Drainage

Groundwater was not observed in any of the testpits, and overland drainage was not noted on the hillslope in Region 2 within the Freegold Road area.

5.0 RECOMMENDATIONS AND CONSIDERATIONS

5.1 General

The subsurface conditions at each site are considered acceptable for residential lot development, subject to the recommendations and considerations outlined below. Each site has specific recommendations and limitations for construction and should be adhered to but are generalized based on the field geotechnical investigation. Variations in site conditions may be encountered, and lot owners should contact a qualified professional geotechnical engineer for further recommendations if ground conditions are not consistent with those in this report.

5.2 Foundation Types

Both development locations are suitable for typical shallow foundations used in residential home construction if the recommendations in this report are adhered to.

5.3 General Site Preparation Recommendations

The following site preparation recommendations apply to Lot 193 and the Freegold Road area and should be read in conjunction with the site-specific preparation recommendations in sections below. Site preparation should be completed in accordance with the following recommendations:

- Surficial organics and ash should be removed to expose the mineral soils beneath.
- Excavations must be protected from the inflow of surface water at all times.
- Excavations should conform to the most recent Yukon Occupational Health and Safety Regulations for excavation sidewalls and sloping.
- Concrete should not be cast directly onto or above seasonally frozen ground.
- Final site grading must direct all water away from the foundation elements of the structure. It is recommended to raise the ground level of the building at least 200 mm above surrounding grades to ensure positive drainage

of at least 2% away from the structure. Ponding adjacent to the structure must be prevented, as water infiltration adjacent to the foundation could have detrimental effects on the performance of the building foundations. This is particularly important during late fall, just prior to freeze-up.

5.4 Site Specific Recommendations

5.4.1 Lot 193

In conjunction with the general site preparation recommendations in Section 5.3, site preparation for Lot 193 should be undertaken in accordance with the following recommendations:

- Within the building footprint, and outward at least 1.5 m on all sides, the frost-susceptible soils should be excavated to expose the alluvial river gravels. Care should be taken not to disturb the subgrade. If the subgrade is disturbed, the subgrade should be moisture conditioned and recompacted to 98% standard Proctor maximum dry density (SPMDD, as per ASTM D698).
- Backfill should consist of 80 mm pit run gravel, conforming to the specifications in Section 5.4.3, placed in maximum 250 mm thick lifts, moisture conditioned, and compacted to at least 98% SPMDD.
- A 150 mm thick lift of 20 mm crushed basecourse gravel, conforming to the specifications in Section 5.4.3, should be placed beneath concrete elements to provide a smooth, level bearing surface for concrete placement. The basecourse gravel should be moisture conditioned and compacted to at least 98% SPMDD.

If the owner does not wish to excavate and replace the frost-susceptible soils, then the recommendations in Section 5.4.3 should be followed based on the foundation chosen.

5.4.2 Freegold Road Area

Three site preparation options are presented below as frost-susceptible soils within the expected frost penetration depth were encountered throughout the subject site. If perimeter insulation is required, recommendations for perimeter insulation are presented in Section 5.5.

Residential foundations must not be constructed within the “Potential Permafrost Area” shown on the Site Plan (Figure 3) unless the site is cleared several years in advance of construction, and additional site investigations are conducted to verify that the permafrost has thawed.

5.4.2.1 Full Subexcavation

The full subexcavation option assumes a full basement or if the owner wishes to not use perimeter insulation for a slab-on-grade or footings at ground surface foundation. Site preparation for a full subexcavation should be undertaken in accordance with the following recommendations:

- Within the building footprint and outward at least 2.4 m on all sides, the frost-susceptible soils should be subexcavated to at least 2.4 m below final grade. Care should be taken not to disturb the subgrade soils. If the subgrade is disturbed, the subgrade should be moisture conditioned and recompacted to 98% SPMDD.
- Backfill should consist of 80 mm pit run gravel, conforming to the specifications in Section 5.4.3, placed in maximum 250 mm thick lifts, moisture conditioned, and compacted to at least 98% SPMDD.

- A 150 mm thick lift of 20 mm crushed basecourse gravel, conforming to the specifications in Section 5.4.3, should be placed beneath concrete elements to provide a smooth, level bearing surface for concrete placement. The basecourse gravel should be moisture conditioned and compacted to at least 98% SPMDD.

5.4.2.2 Crawlspace Foundation

The crawlspace foundation recommendations assume a 1.2 m deep crawlspace and will require perimeter insulation unless the owner excavates the frost-susceptible soils to 2.4 m below ground surface and replaces them with non-frost susceptible (NFS) soils. If the frost-susceptible soils are not removed, and the crawlspace foundation will not be at 1.2 m below ground surface, see the perimeter insulation recommendations section for modifications to insulation thickness and width. Site preparation for a crawlspace foundation should be undertaken in accordance with the following recommendations:

- Within the building footprint and outward at least 2.0 m on all sides, the frost-susceptible soils should be subexcavated to at least 0.3 m below the base of the footings or floor slab. Care should be taken not to disturb the subgrade. If the subgrade is disturbed, the subgrade should be moisture conditioned and recompacted to 98% SPMDD.
- Backfill should consist of 20 mm crushed basecourse gravel, conforming to the specifications in Section 5.4.3, in 150 mm thick lifts, moisture conditioned, and compacted to 98% SPMDD.
- Perimeter insulation should be installed around the building in accordance with the recommendations in Section 5.5.

5.4.2.3 No Subexcavation

The following recommendations are for a slab-on-grade or footings placed on ground surface with minimal subexcavation of the underlying frost-susceptible soils. Site preparation should be undertaken in accordance with the following recommendations:

- After removal of the surficial organics and ash layer, a subexcavation to allow at least 0.3 m of structural backfill below the underside of concrete elements should be undertaken within the building footprint and outward at least 0.5 m on all sides. Care should be taken not to disturb the subgrade. If the subgrade is disturbed, the subgrade should be moisture conditioned and recompacted to 98% SPMDD.
- Backfill should consist of 20 mm crushed basecourse gravel, conforming to the specifications in Section 5.4.3, in 150 mm thick lifts, moisture conditioned, and compacted to 98% SPMDD.
- Perimeter insulation should be installed around the building in accordance with the recommendations in Section 5.5.

5.4.3 Granular Material Specifications

Granular backfill used for site preparation should be composed of NFS soils. The recommended granular material gradation for NFS soils is shown below in Table 3.

Table 3 – Recommend Gradation for Granular Infill

150 mm Pit Run Gravel		20 mm Crushed Basecourse Gravel	
Particle Size (mm)	**% Passing by Mass**	**Particle Size (mm)**	**% Passing by Mass**
80	75 – 100	-	-
25	55 – 100	20	100
12.5	42 – 84	12.5	64 – 100
5.0	26 – 65	5.0	36 – 72
1.25	11 – 47	1.25	12 – 42
0.315	3 – 30	0.315	4 – 22
0.080	0 – 8	0.080	3 – 6

5.5 Perimeter Insulation

5.5.1 General

The expected frost penetration depth in Carmacks under snow-free areas is 2.4 m below ground surface. Perimeter insulation is required when frost-susceptible soils are found within the frost penetration depth beneath foundation elements of a structure. The following subsections provide perimeter insulation recommendations for development where frost-susceptible soils are present.

5.5.2 Conditions for Frost-Related Ground Movement

Seasonal frost-related movement is common in cold climates and occurs when three conditions have been satisfied:

- The ground temperature is below freezing;
- Frost susceptible soils are present; and
- Excess water is available during the freezing process.

5.5.3 Perimeter Insulation Recommendations

The thickness and width of perimeter insulation are dependent on the ground conditions, foundation configuration, and extent of subexcavation. The following recommendations are minimum requirements for the various site preparation recommendations:

- Full Subexcavation:
  - No perimeter insulation is required if all the frost-susceptible soils are removed to at least 2.4 m below the final grade surrounding the building.
- Crawlspace Foundation:
  - Assuming a 1.2 m subexcavation, perimeter insulation should be installed 100 mm thick and outward from the building 1.5 m on all sides.
  - If the crawlspace foundation requires less than a 1.2 m subexcavation, the perimeter insulation thickness should be increased by 25 mm and extended outward from the building by an additional 0.3 m for every 0.3 m of reduced subexcavation up to 200 mm and 2.4 m, respectively.

- No Subexcavation:
  - Perimeter insulation should be installed 200 mm thick and outward from the building 2.4 m on all sides.
- Perimeter insulation should be moisture-resistant, rigid board insulation suitable for burial.

Perimeter insulation should be installed as per the attached figures.

5.6 Bearing Resistance

Bearing resistances have been established based on the soils encountered during the field geotechnical investigation. If increased bearing resistances are required, a site-specific geotechnical evaluation should be considered.

5.6.1 Limit States Design

The 2015 edition of the National Building Code of Canada (NBCC 2015) stipulates that foundation design must be carried out using Limit State Design (LSD) methods. Under LSD, a minimum of two loading cases must be considered by geotechnical and structural designers: the Ultimate Limit State (ULS) and the Serviceability Limit State (SLS). The ULS and SLS bearing resistances are calculated differently. The ULS bearing resistance is the maximum pressure that can be applied to the soil without causing bearing failure. The SLS bearing resistance is the bearing pressure that corresponds to a specified tolerable amount of settlement (typically 25 mm). Both the ULS and SLS bearing resistances are highly dependent on soil properties and foundation geometry, including the size, shape and burial depth.

Resistance factors are applied to the calculated (unfactored) resistances to determine the factored resistance used for design.

5.6.2 Foundation Design

The following bearing resistances are based on an at grade foundation system and are the minimum bearing resistances that should be used for design. Tetra Tech recommends designing foundations in accordance with the following recommendations:

- Design bearing resistances have been developed in accordance with LSD methods described in NBCC 2015:
  - The ULS bearing resistances presented below are unfactored. Resistance factors are typically applied, per Table K-1 in the NBCC 2015 Structural Commentaries (User's Guide – NBCC 2015: Part 4 Division B).
  - The SLS bearing resistances presented below are unfactored and based on an allowable elastic settlement of 25 mm. Post-construction consolidation settlement is not expected to affect the design SLS bearing resistances.
  - Bearing resistances have been calculated assuming that the footings have been provided with at least 0.3 m of soil cover.
  - The bearing resistances provided are for minimum allowable footing sizes as per NBCC 2015.
  - Bearing resistance is highly sensitive to soil properties and foundation geometry (e.g. burial depth, footing size, shape, etc.). A qualified geotechnical engineer should be contacted to provide revised bearing resistances if geometries or burial depth change.

  - Foundation elements should not be cast directly on or over seasonally frozen soils, and the underlying soils must not be allowed to freeze during construction.

- Lot 193:
  - For a 0.9 m wide spread footing, an unfactored ULS bearing resistance of 300 kPa, and a SLS bearing resistance of 300 kPa is appropriate for design.
  - For a 0.3 m wide strip footing, an unfactored ULS bearing resistance of 200 kPa, and a SLS bearing resistance of 300 kPa are appropriate for design.
- Freegold Road:
  - Residential foundations must not be constructed within the “Potential Permafrost Area” shown on the Site Plan (Figure 3) unless the site is cleared several years in advance of construction, and additional site investigations are conducted to verify that the permafrost has thawed.
  - For non-permafrost areas using a minimum 0.9 m wide spread footing, an unfactored ULS bearing resistance of 240 kPa, and a SLS bearing resistance of 300 kPa is appropriate for design.
  - For non-permafrost areas using a minimum 0.3 m wide strip footing, an unfactored ULS bearing resistance of 150 kPa, and a SLS bearing resistance of 300 kPa is appropriate for design.

5.7 On Site Sewage Disposal Systems

The field geotechnical investigation established fair to good potential for the design and construction of approved on-site sewage disposal systems for the Freegold Road area.

Percolation rates in both regions were measured as less than 5 minutes/25 mm in TP21-02 and TP21-03, and TP21-04 to TP21-06 (sand soils). As long as the absorption systems are constructed above 1.5 m depth on this site, identifying an accepting soil zone should not be an issue.

The one area of concern will be for systems in Region 2, Freegold Road area as potential permafrost was encountered in TP21-02 and inferred in TP-03. A septic field is possible within this area where gravels are present, but the owner would have to confirm that suitable soils exist at the proposed septic field location, and they must clear the area to allow the permafrost to thaw before constructing a septic field. It is not recommended to construct septic fields in the permafrost zone, if possible.

Although this site evaluation has established potential for on-site sewage disposal system construction throughout this study area, each lot will require a site specific testpitting and percolation test program at the chosen field location to be included in the Environmental Health Application. Measured percolation rates from the site investigation program are presented in Table 4, below.

Table 4 – Percolation Rates and Recommended Absorption Bed Area

Testpit	Soil Type	Depth	Percolation Rate Minutes/25 mm	Expected Field Area m^2/bedroom
TP21-02	Sand	1.3 m	< 5 min /25 mm	17.4
TP21-04	Sand	1.3 m	< 5 min/25 mm	17.4
TP21-05	Sand	1.3 m	< 5 min/25mm	17.4
TP21-06	Sand	1.3 m	< 5 min /25mm	17.4

5.8 Lot Size Recommendations

5.8.1 Freegold Road

Based on the findings of this geotechnical study, Tetra Tech recommends a minimum lot size of 0.5 ha for this site. As noted in Section 5.7 above, care must be taken during final lot configuration to ensure that there is sufficient area so that the proposed septic field is not underlain by permafrost (see Figure 3).

6.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

Prepared by:
Nikolett Kovacs, MSc., P.Geo. (BC)
Professional Geoscientist
Engineering Practice
Direct Line: 867.668.9209
Nikolett.Kovacs@tetratech.com

Prepared by:
Adam Mickey, M.Eng., EIT
Geotechnical Engineer, Arctic Group
Engineering Practice
Direct Line: 867.668.9214
Adam.Mickey@tetratech.com

Reviewed by:
J. Richard Trimble, FEC, P.Eng.
Principal Consultant, Arctic Group
Engineering Practice
Direct Line: 867.668.9216
Richard.Trimble@tetratech.com

/cr

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FIGURES

0 1,000m

Scale: 1:20,000 @ 8.5"x11"

CLIENT

GOVERNMENT OF YUKON - LAND DEVELOPMENT BRANCH

FREEGOLD ROAD & LOT 193 DEVELOPMENT GEOTECHNICAL EVALUATION - CARMACKS, YUKON

SITE LOCATION

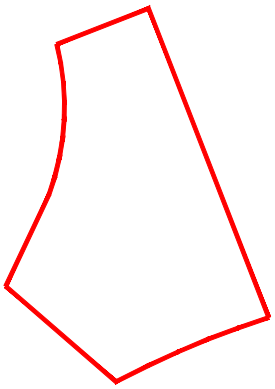
TETRA TECH

PROJECT NO.	DWN	CKD	REV
ENG.WARC03839-08	CB	NK	0

OFFICE	DATE
EBA-WHSE	August 18, 2021

Figure 1

Q:\Whitehorse\Data\0201drawings\Carmacks\ENGWARC03839-08 Freegold Road & Lot 193 Development Geotech Evaluation\ENG.WARC03839-08 Fig.1-R0.dwg [FIGURE 1] August 25, 2021 - 4:12:51 pm (BY: BUCHAN, CAMERON)



LEGEND

- TESTPIT LOCATION

0 200m

Scale: 1:4,000 @ 8.5"x11"

CLIENT

GOVERNMENT OF YUKON - LAND DEVELOPMENT BRANCH

TETRA TECH

FREEGOLD ROAD & LOT 193 DEVELOPMENT GEOTECHNICAL EVALUATION - CARMACKS, YUKON

LOT 193 SITE PLAN

PROJECT NO.	DWN	CKD	REV
ENG.WARC03839-08	CB	NK	0

OFFICE	DATE
EBA-WHSE	August 18, 2021

Figure 2

LEGEND

- TESTPIT LOCATION

0 200m

Scale: 1:4,000 @ 8.5"x11"

CLIENT

GOVERNMENT OF YUKON - LAND DEVELOPMENT BRANCH

TETRA TECH

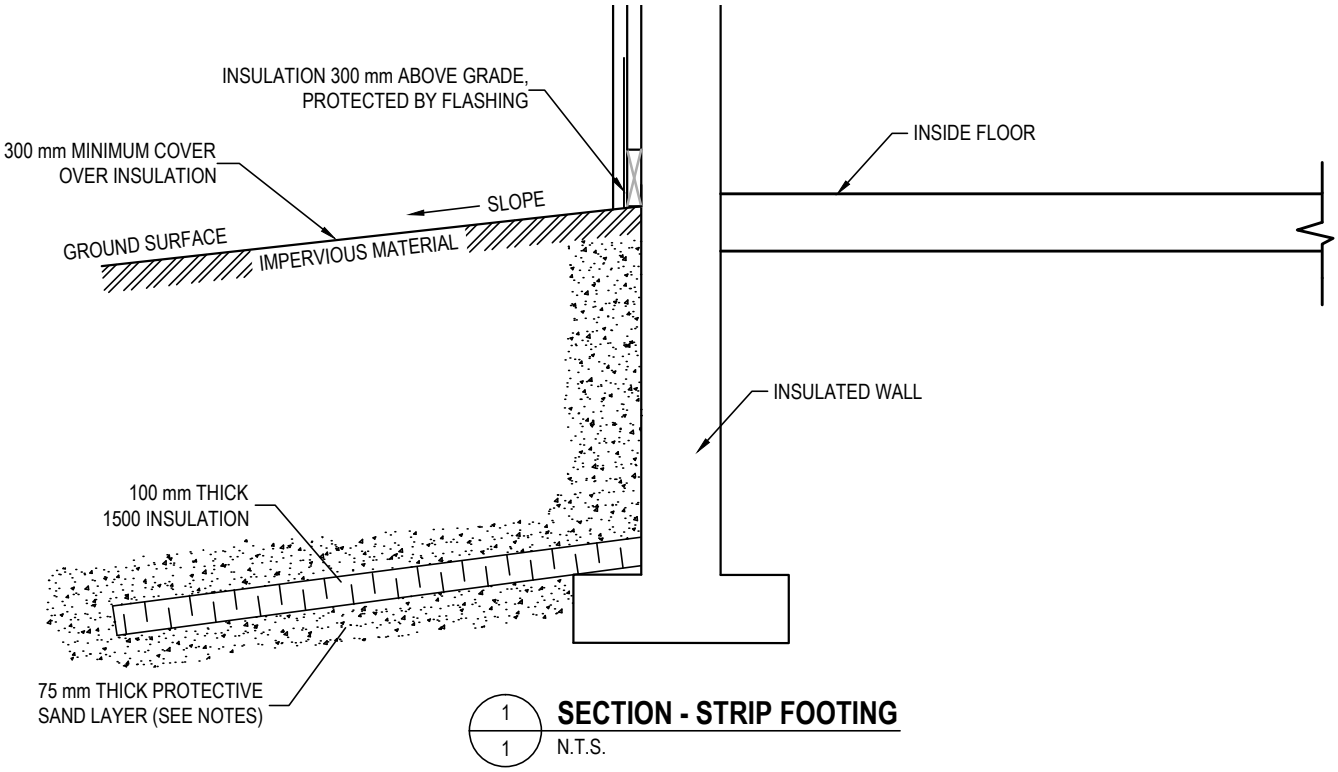
FREEGOLD ROAD & LOT 193 DEVELOPMENT GEOTECHNICAL EVALUATION - CARMACKS, YUKON

FREEGOLD ROAD SITE PLAN

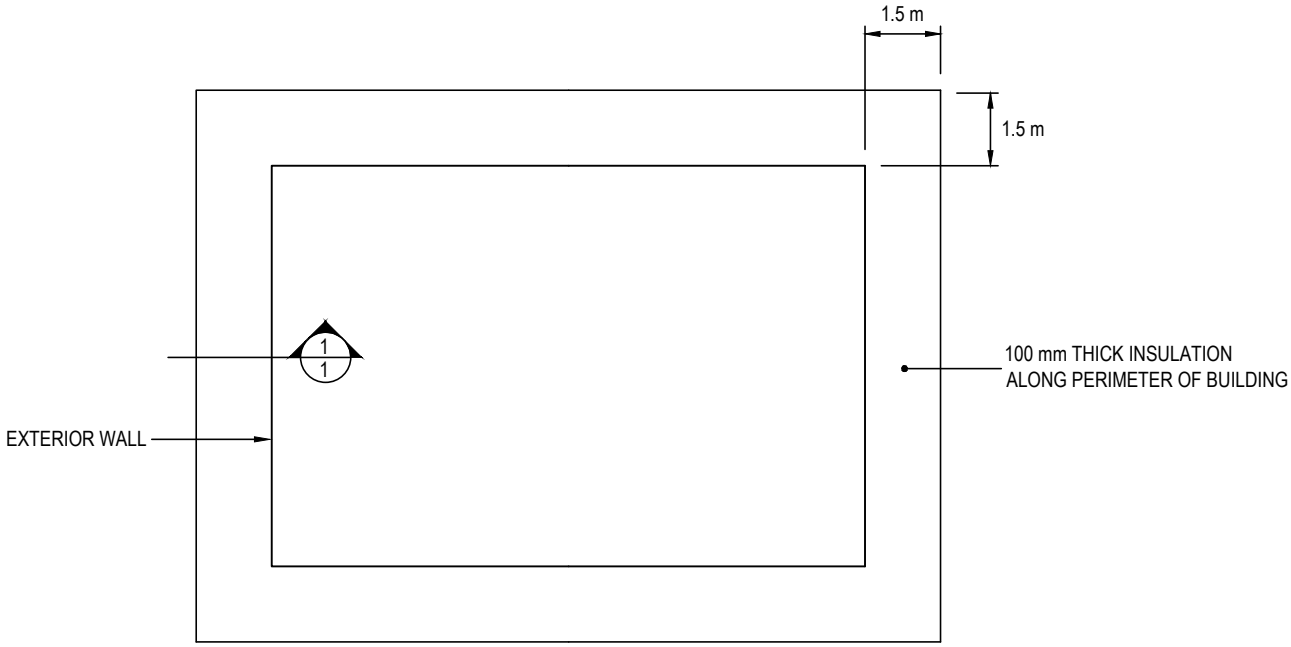
PROJECT NO.	DWN	CKD	REV
ENG.WARC03839-08	CB	NK	0

OFFICE	DATE
EBA-WHSE	August 18, 2021

Figure 3



1
1 **SECTION - STRIP FOOTING**
N.T.S.



PLAN
N.T.S.

NOTES :

- THE INSULATION (DOW CHEMICAL HI SERIES STYROFOAM OR POLYURETHANE OR APPROVED EQUIVALENT) SHOULD BE MOISTURE RESISTANT AND SUITABLE FOR BURIAL UNDER VEHICULAR TRAFFIC AREAS.
- A MINIMUM BEDDING THICKNESS OF 75 mm OF FINE TO MEDIUM GRAINED SAND SHOULD BE PLACED ABOVE AND BELOW THE INSULATION FOR PROTECTION.
- THIS PLAN IS NOT TO SCALE

CLIENT
GOVERNMENT OF YUKON - LAND DEVELOPMENT BRANCH

FREEGOLD ROAD & LOT 193 DEVELOPMENT
GEOTECHNICAL EVALUATION - CARMACKS, YUKON

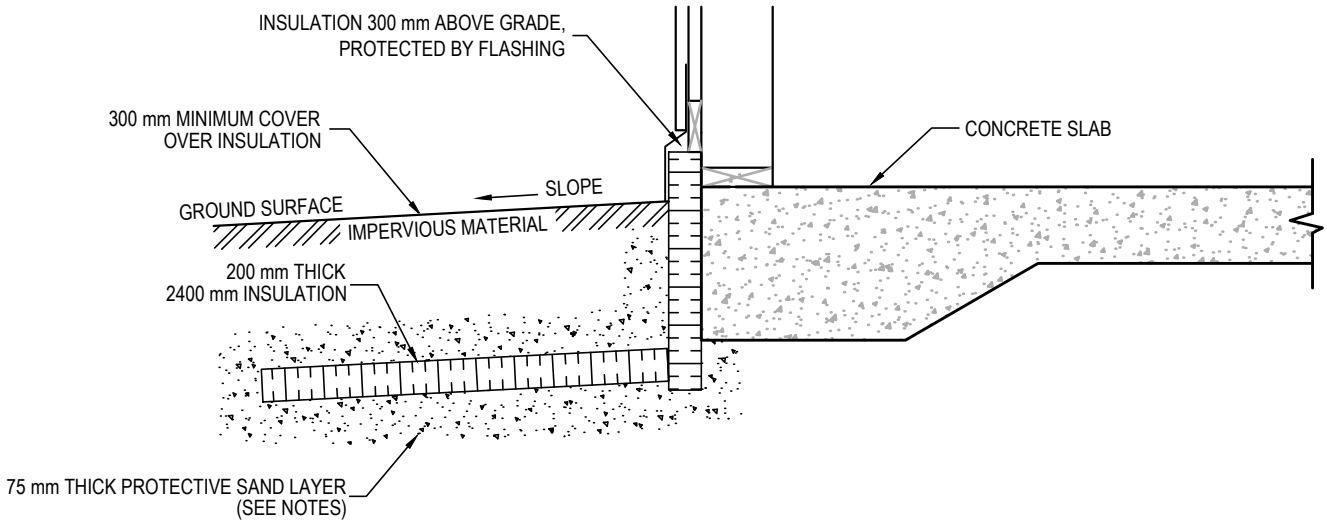
TYPICAL CRAWLSPACE
FOUNDATION INSULATION DETAIL

TETRA TECH

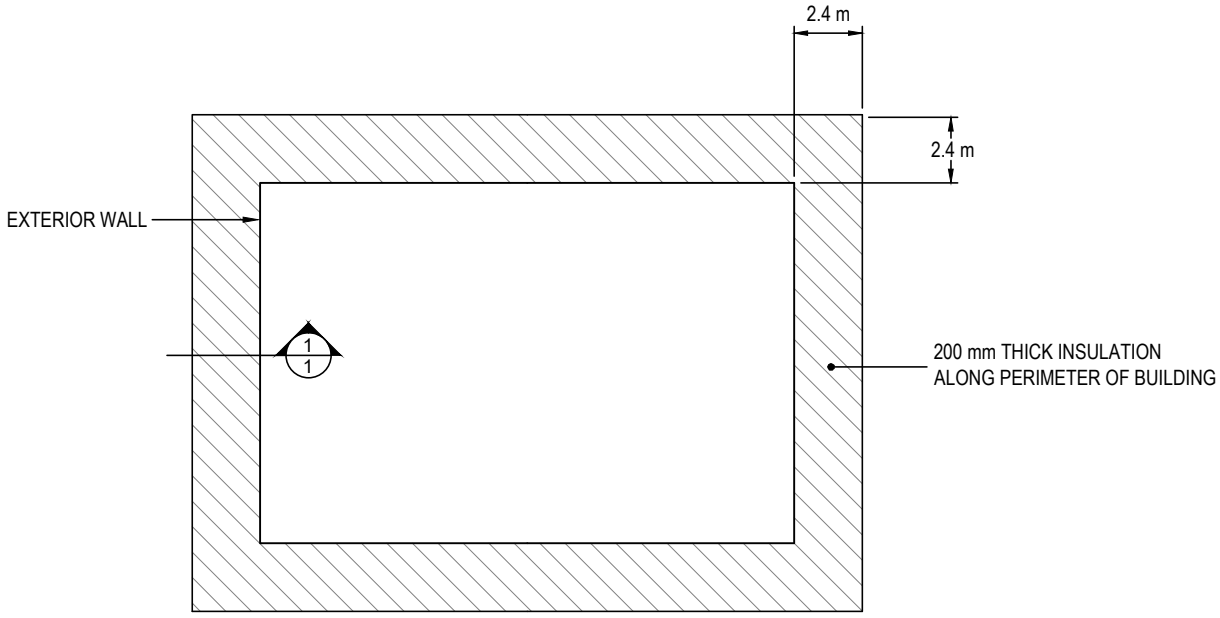
PROJECT NO.	DWN	CKD	REV
ENG.WARC03839-08	CB	AM	0

OFFICE	DATE
EBA-WHSE	August 18, 2021

Figure 4



1/1 **SECTION - MONOLITHIC SLAB**
N.T.S.



PLAN
N.T.S.

NOTES :

- THE INSULATION (DOW CHEMICAL HI SERIES STYROFOAM OR POLYURETHANE OR APPROVED EQUIVALENT) SHOULD BE MOISTURE RESISTANT AND SUITABLE FOR BURIAL UNDER VEHICULAR TRAFFIC AREAS.
- A MINIMUM BEDDING THICKNESS OF 75 mm OF FINE TO MEDIUM GRAINED SAND SHOULD BE PLACED ABOVE AND BELOW THE INSULATION FOR PROTECTION.
- THIS PLAN IS NOT TO SCALE

CLIENT
GOVERNMENT OF YUKON - LAND DEVELOPMENT BRANCH

FREEGOLD ROAD & LOT 193 DEVELOPMENT
GEOTECHNICAL EVALUATION - CARMACKS, YUKON

TYPICAL SLAB-ON-GRADE PERIMETER FOUNDATION INSULATION DETAIL

TETRA TECH

PROJECT NO.	DWN	CKD	REV
ENG.WARC03839-08	CB	AM	0

OFFICE	DATE
EBA-WHSE	AAugust 18, 2021

Figure 5

PHOTOGRAPHS

Photo 1: Freegold Road Area – Testpit 2 (TP21-02).

Photo 2: Freegold Road Area – Testpit 3 (TP21-03).

Photo 3: Freegold Road Area – Testpit 4 (TP21-04) percolation rates testing.

Photo 4: Freegold Road Area – Testpit 5 (TP21-05).

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL – YUKON GOVERNMENT

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the use of TETRA TECH's Client, its officers, employees, agents, representatives, successors and assigns (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH. Any changes to the conclusions, opinions, and recommendations presented in TETRA TECH's Professional Document must be authorized by TETRA TECH.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems, as per agreed project deliverable formats. TETRA TECH makes no representation about the compatibility of these files with the Client's future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be brought to the attention of TETRA TECH within a reasonable time.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, and subject to the standard of care herein, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage, except where TETRA TECH has subcontracted for such information.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to make, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the Client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.8 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.9 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.10 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.11 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.12 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.13 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.14 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.15 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.16 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.17 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.18 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.19 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX B

TESTPIT LOGS AND LABORATORY TEST RESULTS

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on 0.075mm sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as inferred from laboratory or in situ tests.

DESCRIPTIVE TERM	RELATIVE DENSITY	N (blows per 0.3m)
Very Loose	0 TO 20%	0 to 4
Loose	20 TO 40%	4 to 10
Compact	40 TO 75%	10 to 30
Dense	75 TO 90%	30 to 50
Very Dense	90 TO 100%	greater than 50

The number of blows, N, on a 51mm O.D. split spoon sampler of a 63.5kg weight falling 0.76m, required to drive the sampler a distance of 0.3m from 0.15m to 0.45m.

FINE GRAINED SOILS (major portion passing 0.075mm sieve): Includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as estimated from laboratory or in situ tests.

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH (KPA)
Very Soft	Less than 25
Soft	25 to 50
Firm	50 to 100
Stiff	100 to 200
Very Stiff	200 to 400
Hard	Greater than 400

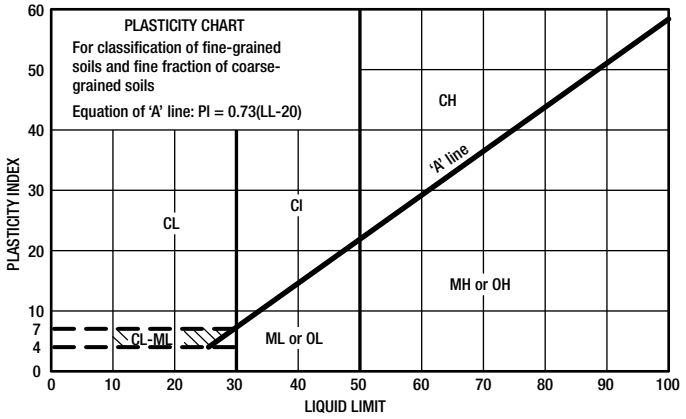
NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil.

GENERAL DESCRIPTIVE TERMS

Slickensided - having inclined planes of weakness that are slick and glossy in appearance.
Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated - composed of thin layers of varying colour and texture.
Interbedded - composed of alternate layers of different soil types.
Calcareous - containing appreciable quantities of calcium carbonate.;
Well graded - having wide range in grain sizes and substantial amounts of intermediate particle sizes.
Poorly graded - predominantly of one grain size, or having a range of sizes with some intermediate size missing.

MODIFIED UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE - GRAINED SOILS More than 50% retained on No. 75 µm 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 75 µm sieve More than 12% pass 75 µm sieve 5% to 12% pass 75 µm sieve GW, GP, SW, SP GM, GC, SM, SC Borderline classification requiring use of dual symbols	$C_U = D_{60} / D_{10}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ 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 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ 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 above 'A' line and 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 (by behavior) 50% or more passes 75 µm sieve*	SILTS Liquid limit <50		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands of slight plasticity		
	SILTS Liquid limit >50		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts		
	CLAYS Above "A" line on plasticity chart negligible organic content Liquid limit <30		CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays		
	CLAYS Above "A" line on plasticity chart negligible organic content Liquid limit 30-50		CI	Inorganic clay of medium plasticity, silty clays		
	CLAYS Above "A" line on plasticity chart negligible organic content Liquid limit >50		CH	Inorganic clay of high plasticity, fat clays		
	ORGANIC SILTS AND CLAYS Liquid limit <50		OL	Organic silts and organic silty clays of low plasticity		
	ORGANIC SILTS AND CLAYS Liquid limit >50		OH	Organic clays of medium to high plasticity		
HIGHLY ORGANIC SOILS			PT	Peat, muck and other highly organic soils		



* Based on the material passing the 75 mm sieve

† ASTM Designation D 2487, for identification procedure see D 2488 USC as modified by PFRA

GROUND ICE DESCRIPTION

ICE NOT VISIBLE

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION	
N	Nf	Poorly-bonded or friable	
	Nbn	No excess ice, well-bonded	
	Nbe	Excess ice, well-bonded	

VISIBLE ICE LESS THAN 50% BY VOLUME

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION	
V	Vx	Individual ice crystals or inclusions	
	Vc	Ice coatings on particles	
	Vr	Random or irregularly oriented ice formations	
	Vs	Stratified or distinctly oriented ice formations	

VISIBLE ICE GREATER THAN 50% BY VOLUME

ICE	ICE + Soil Type	Ice with soil inclusions	
	ICE	Ice without soil inclusions (greater than 25 mm thick	

NOTES:

1. Dual symbols are used to indicate borderline or mixed ice classifications.
2. Visual estimates of ice contents indicated on borehole logs ± 5%
3. This system of ground ice description has been modified from NRC Technical Memo 79, Guide to the Field Description of Permafrost for Engineering Purposes.

LEGEND: Soil ☐ Ice ■

TETRA TECH

BOREHOLE KEYSHEET

Water Level Measurement

 Measured in standpipe, piezometer or well

 Inferred

Sample Types

 A-Casing

 Core

 Disturbed, Bag, Grab

 HQ Core

 Jar

 Jar and Bag

 75 mm SPT

 No Recovery

 Split Spoon/SPT

 Tube

 CRREL Core

Backfill Materials

 Asphalt

 Bentonite

 Cement/ Grout

 Drill Cuttings

 Grout

 Gravel

 Sand

 Slough

 Topsoil Backfill

Lithology - Graphical Legend[1]

 Asphalt

 Bedrock

 Cobbles/Boulders

 Clay

 Coal

 Concrete

 Fill

 Gravel

 Limestone

 Mudstone

 Organics

 Peat

 Sand

 Sandstone

 Shale

 Silt

 Siltstone

 Conglomerate

 Topsoil

 Till

1. The graphical legend is an approximation and for visual representation only. Soil strata may comprise a combination of the basic symbols shown above. Particle sizes are not drawn to scale

TETRA TECH

Testpit No: **TP21-01**

Project: Freegold Rd. & Lot 193 Developments	Project No: ENG.WARC03938-08
Location: Residential Development Lot 193	Ground Elev: 528 m
Carmacks, Yukon	UTM: 432551 E; 6884684 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		SURFICIAL ORGANICS - ash layer, (50 mm thick)	Unfrozen					528
	Excavated	GRAVEL - silty, sandy, some subrounded to subangular cobbles to 100 mm diameter, fine to coarse grained sand and gravel, damp, brown - 100 mm thick ash layer - grey			SA01	4.5	●	
1								527
		SAND AND GRAVEL - some cobbles, trace silt, trace subangular to subrounded boulders, fine to coarse grained sand, damp, brown			SA02	2.3	●	
2								526
		GRAVEL - sandy, cobbly, trace subangular to subrounded boulders, fine to coarse grained sand, moist, brown			SA03	2.6	●	
3		END OF TESTPIT (3.0 metres)						525
4								524
5								523

Contractor: Northern Construction	Completion Depth: 3 m
Excavator: John Deere 135	Start Date: 2021 August 7
Logged By: NK	Completion Date: 2021 August 7
Reviewed By: JRT	Page 1 of 1

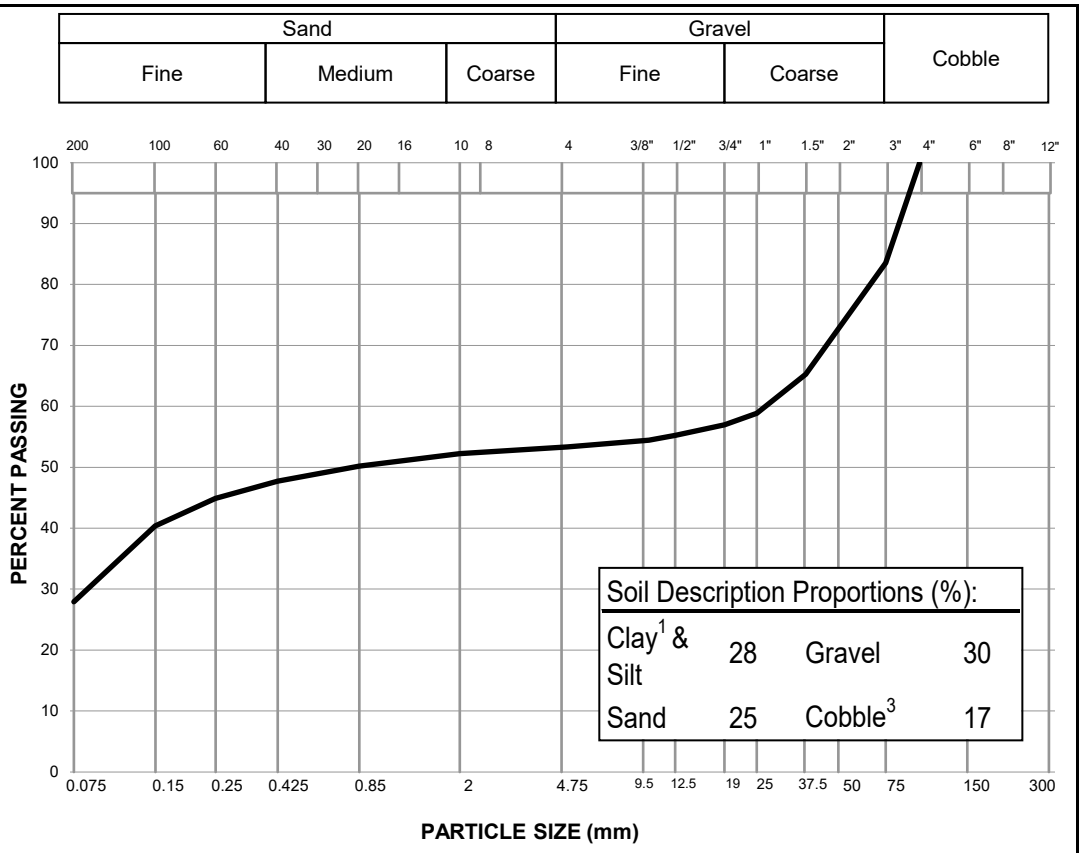
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Freegold Road & Lot 193 Development	Sample No.:	SA01
Project No.:	ENG.WARC03938-08	Material Type:	-
Site:	Freegold Road	Sample Loc.:	TP21-01
Client:	Government of Yukon	Sample Depth:	0.2 m
Client Rep.:	Eamonn Pinto	Sampling Method:	Grab
Date Tested:	August 11, 2021 By: FC	Date Sampled:	August 9, 2021
Soil Description[2]:	GRAVEL - silty, sandy, some cobble	Sampled By:	AMM
		USC Classification:	GM-ML Cu: #N/A
Moisture Content:	4.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
300	
200	
150	
100	100
75	84
50	
38	65
25	59
19	57
12.5	55
10	54
5	53
2	52
0.85	50
0.425	48
0.25	45
0.15	40
0.075	28.0



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tt WM4400 description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

Reviewed By: _____ E.I.T.

TETRA TECH

Testpit No: **TP21-02**

Project: Freegold Rd. & Lot 193 Developments	Project No: ENG.WARC03938-08
Location: Freegold Road Lot	Ground Elev: 543 m
Carmacks, Yukon	UTM: 431008 E; 6886028 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		SURFICIAL ORGANICS - moss, rootlets, roots, (150 mm thick)	Unfrozen					543
		ASH - (50 mm thick)						
	Excavated	SILT - some sand, fine grained sand, damp, brown			SA04	8.2		
		- grey						
1					SA05	12.6		542
2								541
		SAND AND GRAVEL - some cobbles, some subrounded to subangular boulders, trace silt, fine to coarse grained sand, damp, brown	Permafrost					
3					SA06	1.8		540
4		END OF TESTPIT (4.0 metres)						539
5								538

TETRA TECH

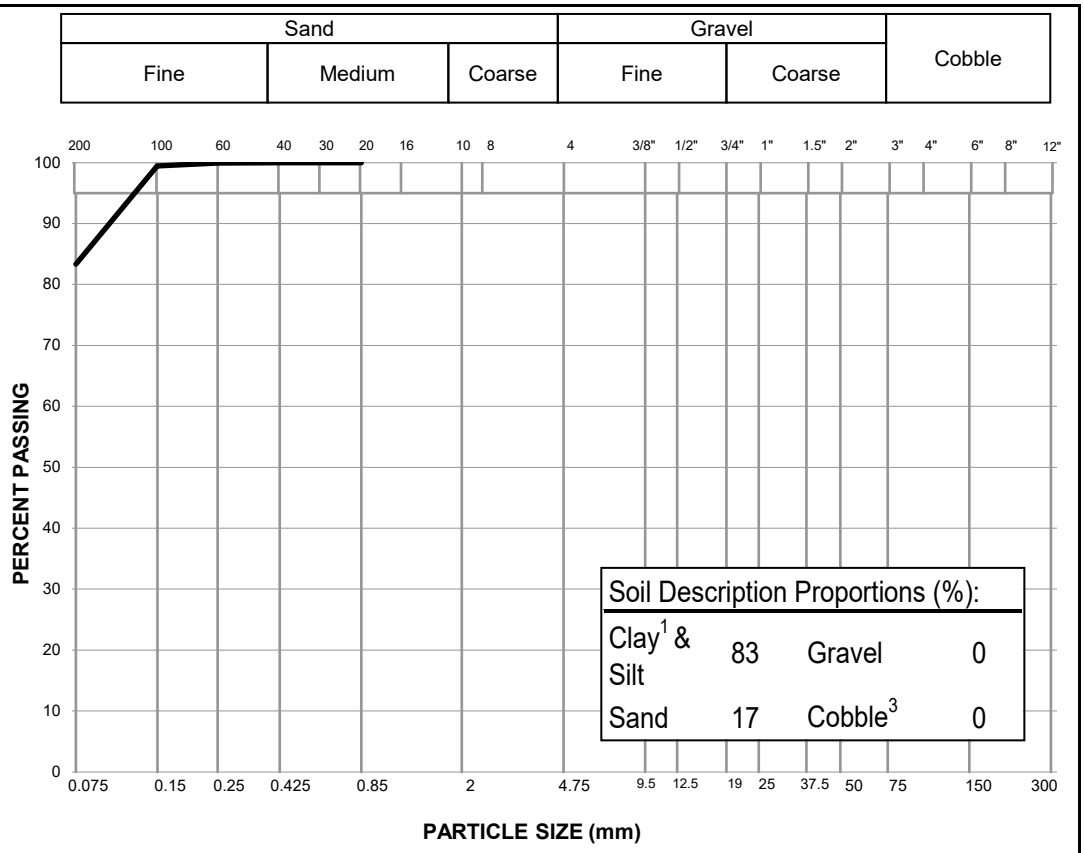
Contractor: Northern Construction	Completion Depth: 4 m
Excavator: John Deere 135	Start Date: 2021 August 8
Logged By: NK	Completion Date: 2021 August 8
Reviewed By: JRT	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Freegold Road & Lot 193 Development	Sample No.:	SA05
Project No.:	ENG.WARC03938-08	Material Type:	-
Site:	Freegold Road	Sample Loc.:	TP21-02
Client:	Government of Yukon	Sample Depth:	1.1 m
Client Rep.:	Eamonn Pinto	Sampling Method:	Grab
Date Tested:	August 11, 2021 By: FC	Date Sampled:	August 9, 2021
Soil Description[2]:	SILT - some sand	Sampled By:	AMM
		USC Classification:	ML Cu: #N/A
Moisture Content:	12.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	
19	
12.5	
10	
5	
2	
0.85	100
0.425	100
0.25	100
0.15	99
0.075	83.3



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tt WM4400 description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

Reviewed By: _____ E.I.T.

TETRA TECH

Testpit No: **TP21-03**

Project: Freegold Rd. & Lot 193 Developments	Project No: ENG.WARC03938-08
Location: Freegold Road Lot	Ground Elev: 552 m
Carmacks, Yukon	UTM: 430904 E; 6886228 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		ORGANICS - moss, roots, rootlets, mixed with ash, (150 mm thick)	Unfrozen					552
	Excavated	SAND - silty, fine grained sand, damp, brown			SA07	4		
1		- grey			SA08	5.1		551
2					SA09	9.3		550
		SILT - trace fine grained sand, moist, low plastic, grey						
3								549
4		- cold soil temperature noted, possible permafrost			SA10	29.2		548
		END OF TESTPIT (4.3 metres)						
5								547

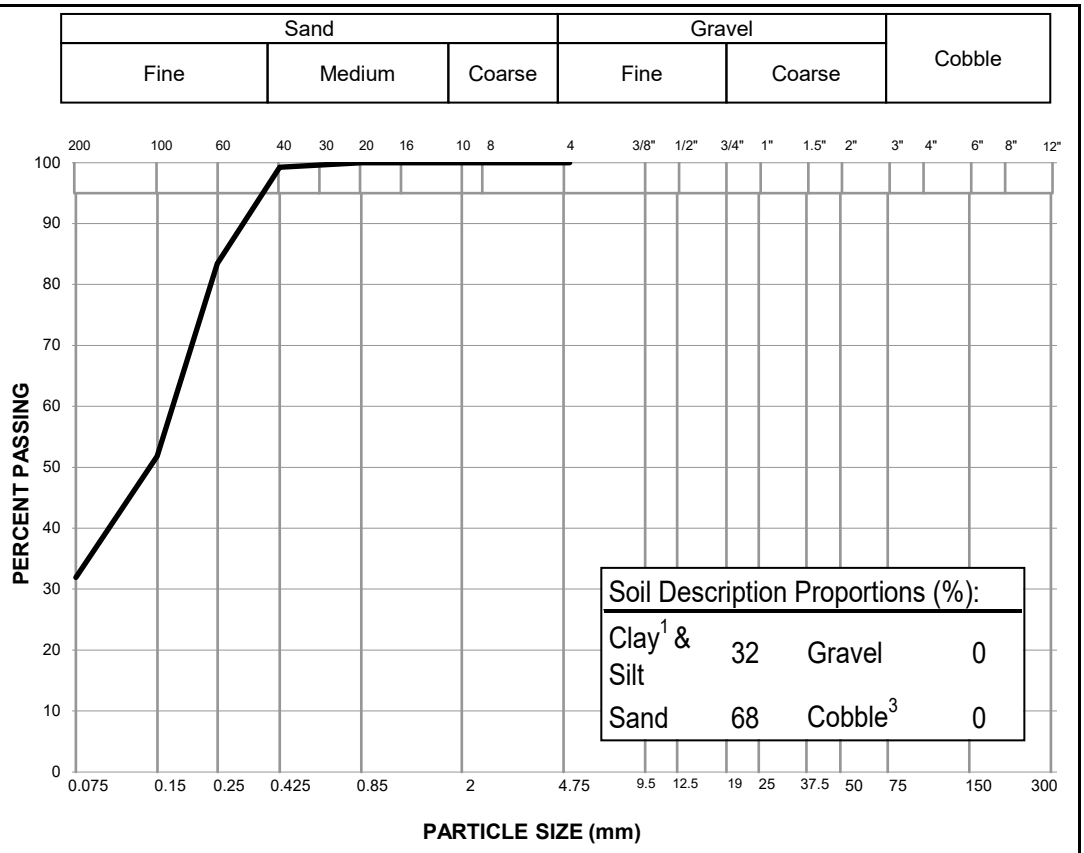
Contractor: Northern Construction	Completion Depth: 4.3 m
Excavator: John Deere 135	Start Date: 2021 August 8
Logged By: NK	Completion Date: 2021 August 8
Reviewed By: JRT	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Freegold Road & Lot 193 Development	Sample No.:	SA08
Project No.:	ENG.WARC03938-08	Material Type:	-
Site:	Freegold Road	Sample Loc.:	TP21-03
Client:	Government of Yukon	Sample Depth:	1.2 m
Client Rep.:	Eamonn Pinto	Sampling Method:	Grab
Date Tested:	August 11, 2021 By: FC	Date Sampled:	August 9, 2021
Soil Description[2]:	SAND - silty	Sampled By:	AMM
		USC Classification:	SM Cu: #N/A
Moisture Content:	5.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	
19	
12.5	
10	
5	100
2	100
0.85	100
0.425	99
0.25	83
0.15	52
0.075	31.9



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tt WM4400 description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

Reviewed By: _____ E.I.T.

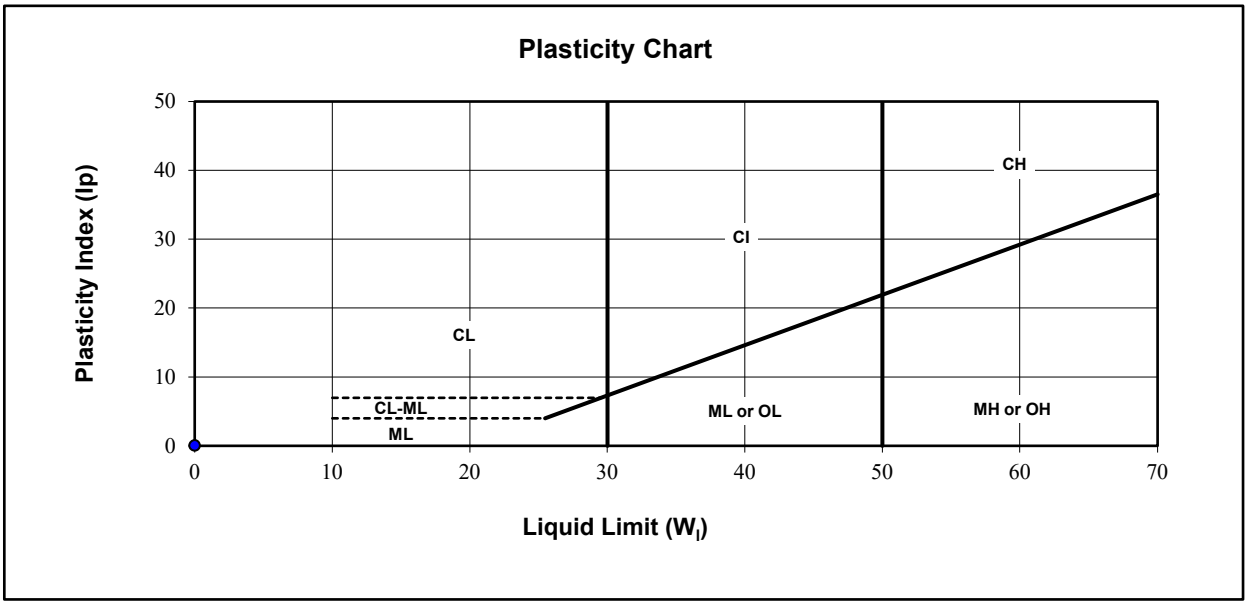
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Freegold & Lot 193 Development	Sample Number:	SA10
		Borehole Number:	TP21-03
Project No:	ENG.WARC03938-08	Source:	-
Client:	Government of Yukon	Sampled By:	AMM Tested By: BW
Attention:	Eamonn Pinto	Date Sampled:	August 9, 2021
Email:	Eamonn.Pinto@yukon.ca	Date Tested:	August 18, 2021

Sample Description: SILT - sandy



Liquid Limit ($W_{1)}$:	0	Natural Moisture (%)	29.2
Plastic Limit :	0	Soil Plasticity:	Low
Plasticity Index (Ip) :	**0**	Mod.USCS Symbol:	NP

Remarks:

Reviewed By: _____ E.I.T.

TETRA TECH

Testpit No: **TP21-04**

Project: Freegold Rd. & Lot 193 Developments	Project No: ENG.WARC03938-08
Location: Freegold Road Lot	Ground Elev: 543 m
Carmacks, Yukon	UTM: 431013 E; 6886199 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		ORGANICS - roots, mosses, rootlets, (100 mm thick)	Unfrozen					543
		ASH - (70 mm thick)						
		SAND - trace silt, few organic rootlets, fine to medium grained sand, amp, brown						
					SA11	7.5	●	
1					SA12	3.5	●	542
		- medium to coarse grained sand, damp to moist, grey						
	Excavated							
2								541
		SAND AND SILT - interbedded, fine to medium grained sand, damp, grey						
3								540
					SA13	6.5	●	
4								539
		END OF TESTPIT (4.1 metres)						
5								538

TETRA TECH

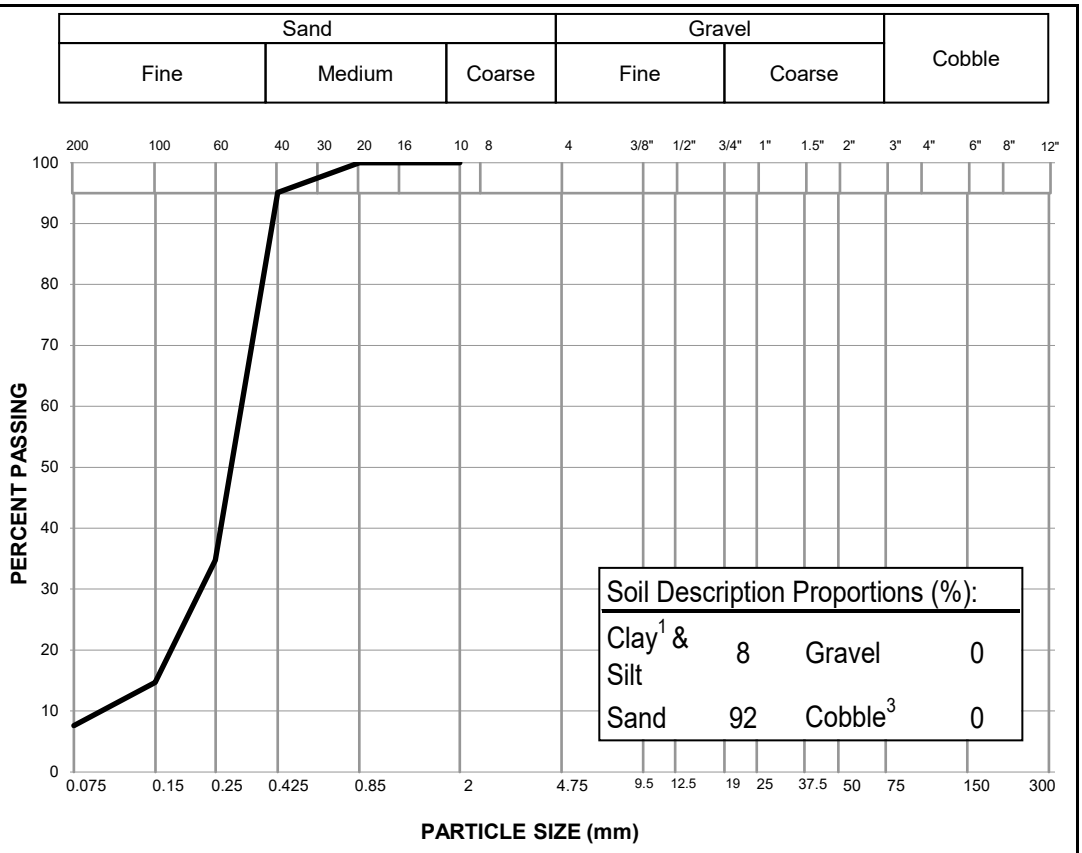
Contractor: Northern Construction	Completion Depth: 4.1 m
Excavator: John Deere 135	Start Date: 2021 August 8
Logged By: NK	Completion Date: 2021 August 8
Reviewed By: JRT	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Freegold Road & Lot 193 Development	Sample No.:	SA12
Project No.:	ENG.WARC03938-08	Material Type:	-
Site:	Freegold Road	Sample Loc.:	TP21-04
Client:	Government of Yukon	Sample Depth:	1.1 m
Client Rep.:	Eamonn Pinto	Sampling Method:	Grab
Date Tested:	August 11, 2021 By: FC	Date Sampled:	August 9, 2021
Soil Description[2]:	SAND - trace silt	Sampled By:	AMM
		USC Classification:	SW Cu: 3.2
Moisture Content:	3.5%		Cc: 1.6

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	
19	
12.5	
10	
5	
2	100
0.85	100
0.425	95
0.25	35
0.15	15
0.075	7.6



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tt WM4400 description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

Reviewed By: _____ E.I.T.

TETRA TECH

Testpit No: **TP21-05**

Project: Freegold Rd. & Lot 193 Developments	Project No: ENG.WARC03938-08
Location: Freegold Road Lot	Ground Elev: 533 m
Carmacks, Yukon	UTM: 430957 E; 6886311 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		ORGANICS - roots, rootlets, moss, (50 mm thick)	Unfrozen					533
		ASH - coarse, (150 mm thick)						
		SAND - silty, fine to coarse grained sand, damp, brown			SA14	5.3		
1		SILT AND SAND - medium grained sand, damp, grey						532
	Excavated				SA15	15.7		
2								531
					SA16	3.5		
		SAND - trace silt, medium to coarse grained sand, damp, grey						
3								530
4								529
		END OF TESTPIT (4.1 metres)						
5								528

TETRA TECH

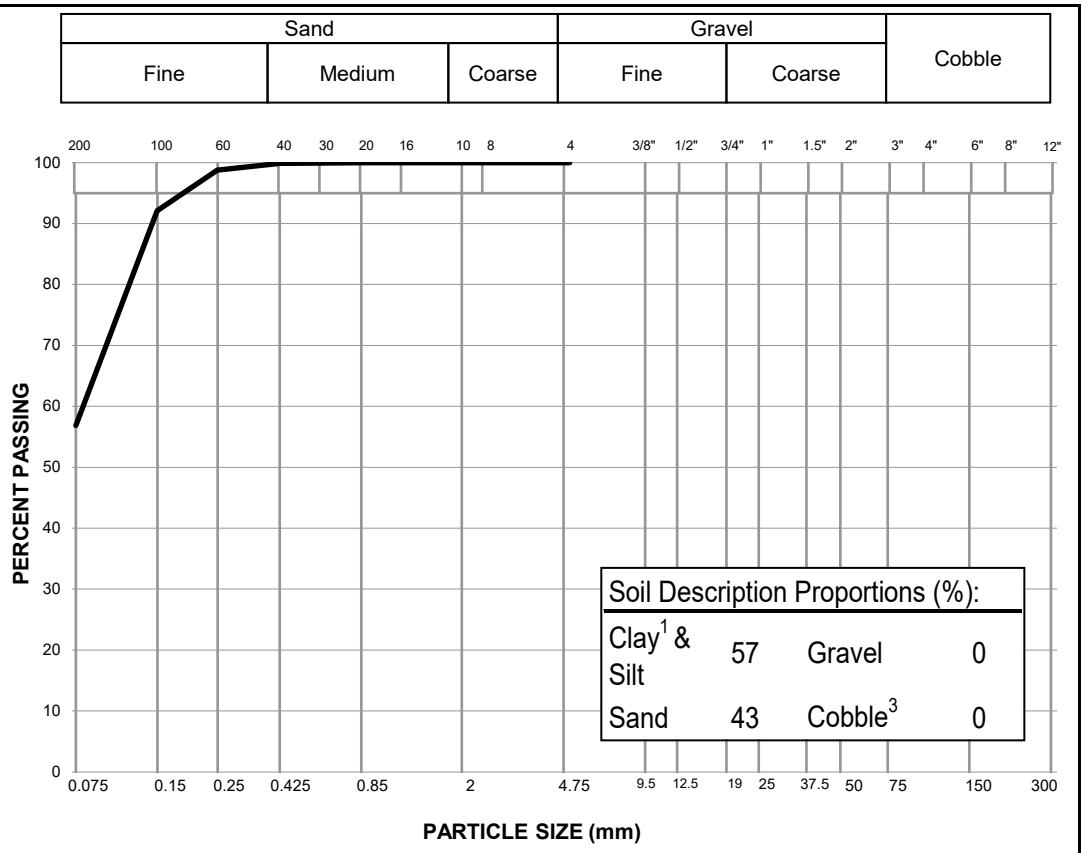
Contractor: Northern Construction	Completion Depth: 4.1 m
Excavator: John Deere 135	Start Date: 2021 August 8
Logged By: NK	Completion Date: 2021 August 8
Reviewed By: JRT	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Freegold Road & Lot 193 Development	Sample No.:	SA15
Project No.:	ENG.WARC03938-08	Material Type:	-
Site:	Freegold Road	Sample Loc.:	TP21-05
Client:	Government of Yukon	Sample Depth:	1.4 m
Client Rep.:	Eamonn Pinto	Sampling Method:	Grab
Date Tested:	August 11, 2021 By: FC	Date Sampled:	August 9, 2021
Soil Description[2]:	SILT and SAND	Sampled By:	AMM
		USC Classification:	ML Cu: #N/A
Moisture Content:	15.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	
19	
12.5	
10	
5	100
2	100
0.85	100
0.425	100
0.25	99
0.15	92
0.075	56.9



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tt WM4400 description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

_____

Reviewed By: _____ E.I.T.

TETRA TECH

Testpit No: **TP21-06**

Project: Freegold Rd. & Lot 193 Developments	Project No: ENG.WARC03938-08
Location: Freegold Road Lot	Ground Elev: 535 m
Carmacks, Yukon	UTM: 431048 E; 6886189 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		ORGANICS - moss, roots, rootlets, (10 mm thick) ASH - coarse, (70 mm thick) SAND - silty, fine to medium grained sand, damp, brown	Unfrozen					535
					SA17	5.5		
1								534
	Excavated	- moist, grey						
2								533
					SA18	8.7		
3								532
4								531
					SA19	11.3		
		END OF TESTPIT (4.4 metres)						
5								530

TETRA TECH

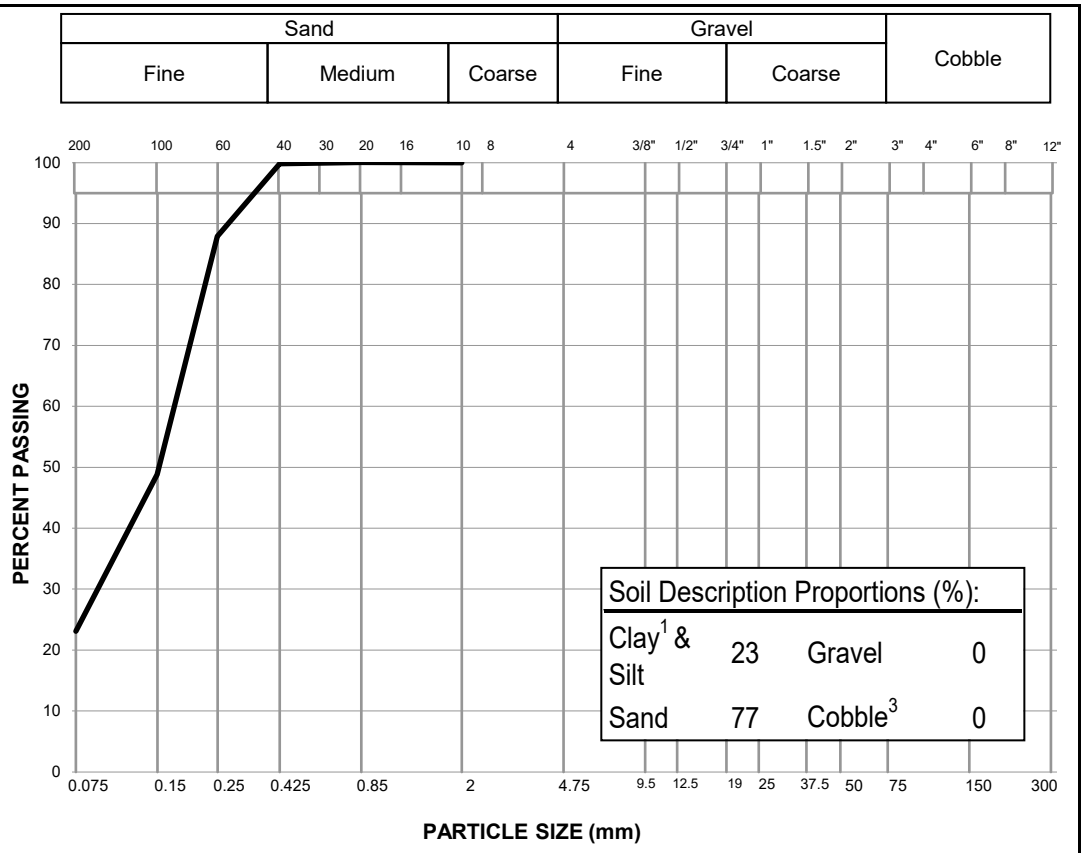
Contractor: Northern Construction	Completion Depth: 4.4 m
Excavator: John Deere 135	Start Date: 2021 August 8
Logged By: NK	Completion Date: 2021 August 8
Reviewed By: JRT	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Freegold Road & Lot 193 Development	Sample No.:	SA18
Project No.:	ENG.WARC03938-08	Material Type:	-
Site:	Freegold Road	Sample Loc.:	TP21-06
Client:	Government of Yukon	Sample Depth:	2.3 m
Client Rep.:	Eamonn Pinto	Sampling Method:	Grab
Date Tested:	August 11, 2021 By: FC	Date Sampled:	August 9, 2021
Soil Description[2]:	SAND - silty	Sampled By:	AMM
		USC Classification:	SM Cu: #N/A
Moisture Content:	8.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	
19	
12.5	
10	
5	
2	100
0.85	100
0.425	100
0.25	88
0.15	49
0.075	23.1



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tt WM4400 description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

Reviewed By: _____ E.I.T.

TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Freegold Road & Lot 193 Development	Sample No.:	Various
Project Number:	ENG.WARC03938-08	Date Tested:	August 10, 2021
Client:	Government of Yukon	Tested By:	FC
Address:	Freegold Road	Page:	1 of 1

T.P. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
TP21-01	SA01	4.5	GRAVEL - silty, sandy, some cobble
	SA02	2.3	
	SA03	2.6	
TP21-02	SA04	8.2	
	SA05	12.6	SILT - some sand
	SA06	1.8	
TP21-03	SA07	4.0	
	SA08	5.1	SAND - silty
	SA09	9.3	
	SA10	29.2	
TP21-04	SA11	7.5	
	SA12	3.5	SAND - trace silt
	SA13	6.5	
TP21-05	SA14	5.3	
	SA15	15.7	SILT and SAND
	SA16	3.5	
TP21-06	SA17	5.5	
	SA18	8.7	SAND - silty
	SA19	11.3	

Reviewed By: _____ E.I.T.

TETRA TECH