TETRA TECH

June 25, 2019

ISSUED FOR REVIEW
FILE: 704-ENG.WARC03386-38
Via Email: elise.bingeman@gov.yk.ca

Government of Yukon
Community Services – Infrastructure Development Branch
Box 2703
Whitehorse, Yukon
Y1A 2C6

Attention: Elise Bingeman, P.Eng
Senior Project Manager

Subject: Public Works Building and Fire Hall - Lot 1117 and Lot 181
Geotechnical Evaluation – Village of Carmacks, Yukon

This 'Issued for Review' document is provided solely for the purpose of client review and presents our interim findings and recommendations to date. Our usable findings and recommendations are provided only through an 'Issued for Use' document, which will be issued subsequent to this review. Final design should not be undertaken based on the interim recommendations made herein. Once our report is issued for use, the 'Issued for Review' document should be either returned to Tetra Tech Canada Inc. (Tetra Tech) or destroyed.

1.0 INTRODUCTION

1.1 General

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Government of Yukon Department of Community Services, Infrastructure Development Branch (YG) to complete a geotechnical evaluation and provide preliminary recommendations for the construction of a new public works building and a new fire hall located on Lot 1117 and Lot 181, respectively, in the Village of Carmacks, Yukon. The work was procured via Tetra Tech's Standing Offer Agreement No. 2017/18-2753-03 and authorized under YG contract No. C00049288.

1.2 Scope of Services

To provide geotechnical input for foundation design and construction of a new public works building and fire hall, a geotechnical drilling program was completed at each of the sites and a geotechnical report was prepared to address the following:

- Summary of the geotechnical and groundwater conditions observed at the site, including site plans showing borehole locations, borehole logs, and results of laboratory testing;
- Recommendations for site preparation for construction of the new buildings;
- Preliminary bearing resistance for shallow building foundations (spread/strip footings or thickened slabs-on-grade);
- Seismic site classification; and
- Recommended construction monitoring and materials testing requirements during construction.

2.0 GEOTECHNICAL SITE INVESTIGATION

Tetra Tech retained Donjeck Drilling of Whitehorse, Yukon, to carry out a geotechnical drilling program at the two sites using a truck-mounted CME75 drilling rig. The drilling program was completed between May 22 and May 24, 2019. Two boreholes were advanced at each site (i.e., four boreholes in total) to depths that ranged from 8.8 m to 9.3 m below ground surface using hollow and solid stem augers.

Before commencing the drilling program, underground utility locates were completed by ATCO Electric, Northwestel, and the Village of Carmacks Public Works.

During the drilling program, the soil profile encountered in each borehole was logged in the field by Tetra Tech's representative, Mr. Taylor Pasloski, P.Eng. Representative disturbed soil samples were collected and returned to Tetra Tech's Whitehorse laboratory for geotechnical index testing.

Standard Penetration Testing (SPT) was completed at approximately 1.5 m intervals in each borehole to estimate the subsurface soil consistency and to recover disturbed soil samples. Dynamic Cone Penetration Testing (DCPT) was completed below 4.9 m depth in boreholes BH19-01 and BH19-02, and below 2.9 m depth in borehole BH19-04, where heaving sand into the hollow stem augers made it impossible to carry out SPT. The DCPT involved using an SPT drop-hammer to advance a cone-shaped tip that is similar in size and shape to the SPT split spoon sampler. The number of blows required to advance the DCPT are recorded for each 300 mm penetration into the ground; DCPT blow counts are considered to be approximately equivalent to the SPT field N-value.

Site plans showing the locations of boreholes drilled at the proposed public works building (Lot 1117) and fire hall site (Lot 181) are presented in Figures 1 and 2, respectively. Boreholes logs and test results for the public works building site and fire hall site are attached in Appendix B and Appendix C, respectively.

3.0 SITE CONDITIONS

3.1 Public Works Building (Lot 1117)

3.1.1 Surface Features

The public works building is located on Lot 1117, which is in the south end of Carmacks along Garvice Road. The site is approximately 190 m east of the Nordenskiold River, which flows north into the Yukon River. The property has been cleared of vegetation and is currently used as a storage laydown for the Village of Carmacks Public Works Department. The proposed building location is in the north end of the lot in an area that is currently occupied by two existing structures.

3.1.2 Subsurface Conditions

The subsurface conditions encountered during the drilling program varied slightly between the two boreholes. In borehole BH19-01, the soil consisted sand fill overlaying a layer of organics and sand to a depth of 1.4 m, over gravel and gravelly sand which extended beyond the termination depth of the borehole. BH19-02 consisted of surficial organics overlaying poorly graded sand to a depth of 1.4 m, over gravel and sand, similar to the material encountered in BH19-01, that extended beyond the termination depth of the borehole.

3.1.3 Groundwater

Groundwater was encountered in both holes at approximately 3 m below ground surface. The groundwater depth at the site is expected to be sensitive to water levels in the Nordenskiold River and will fluctuate seasonally. In general, groundwater levels at the site are expected to be highest in late summer.

3.1.4 Permafrost and Seasonal Frost

Permafrost was not encountered during the field program.

3.1.5 Bedrock

Bedrock was not encountered in any of the boreholes and is not anticipated within the depth of the interest for the proposed building foundations.

3.2 New Fire Hall (Lot 181)

3.2.1 Surface Features

The site of the proposed new fire hall is located on Lot 181 along River Drive, near the site of the existing Waste Water Treatment Plant (WWTP). The site is near the Yukon River, on the south side of an outside bend in the river channel. Surficial soil at the site is expected to consist of alluvial (Yukon River) floodplain deposits.

The WWTP currently occupies the middle of the lot, and the proposed fire hall location is in the undeveloped portion of the lot on the west side of the access road between the WWTP and River Drive. The proposed fire hall location is currently vegetated with coniferous trees and low-lying shrubs.

3.2.2 Subsurface Conditions

The subsurface conditions encountered during the drilling program were generally consistent between the two boreholes. The site consisted of a layer of organics overlying seasonally frozen silt which varied in thickness from 0.6 m to 1 m. The silt was underlain by sand to approximately 2.2 m depth, where it transitioned to a dense gravelly sand that extended beyond the termination depth of the boreholes.

Between the WWTP access road and the existing cleared trees to the west where the proposed fire hall is located, a French drain has been installed to promote drainage across River Drive from the WWTP site to the Yukon River.

3.2.3 Groundwater

Groundwater was encountered in both holes at approximately 3.4 m below ground surface. The groundwater depth at the site is expected to be sensitive to water levels in the Yukon River, and will fluctuate seasonally. In general, groundwater levels at the site are expected to be highest in late summer.

3.2.4 Permafrost

Permafrost was not encountered in any of the boreholes.

3.2.5 Bedrock

Bedrock was not encountered in any of the boreholes and is not anticipated within the depth of the interest for the proposed building foundations.

4.0 RECOMMENDATIONS

4.1 Public Works Building (Lot 1117)

YG has indicated that the preferred foundation type is a slab-on-grade with thickened perimeter strip footings. Based on the results of the geotechnical evaluation, Tetra Tech considers the site to be suitable for the construction of a new public works building using the preferred foundation type. Recommendations for site preparation, design, and construction of shallow foundations are provided in the following sections.

4.1.1 Site Preparation

Site preparation should be undertaken in accordance with the following recommendations:

- The site should be excavated to remove the overlaying silty sand and expose the underlaying gravel;
- Sand removed from the excavation may be suitable for re-use as backfill. Material re-used as backfill should conform to the particle size distribution for engineered fill provided in Table 1. Material that does not meet the gradation specifications or is too silty for re-use as engineered fill may be suitable for use on site as general, non-structural fill for landscaping or similar purposes;
- The base of the excavation should extend horizontally at least 1.0 m out from the foundation perimeter in all directions;
- The exposed subgrade should be inspected by a qualified geotechnical engineer to confirm that suitable ground conditions have been encountered and to provide additional recommendations if necessary;
- Depending on the time of year the subcut is completed, the base of the excavation may be close to or below the local groundwater elevation. Seepage into the bottom of the excavation should be expected and dewatering may be required to prevent water accumulation. Potential for problems related to groundwater seepage can be reduced by scheduling excavation work to take place in late spring or early summer, when groundwater conditions are generally lower. Tetra Tech can be retained to provide recommendations for excavation dewatering during construction, if required;
- The approved subgrade should be moisture conditioned (if necessary) and compacted to at least 98% of the Standard Proctor Maximum Dry Density (SPMDD);
- The excavation should be backfilled using engineered fill conforming to the specification outlined in Table 1. The engineered fill should be placed in lifts no thicker than 300 mm, moisture conditioned, and compacted to at least 98% SPMDD;
- A 150 mm thick layer of 20 mm crushed basecourse conforming to the specifications in Table 1 should be placed immediately below the underside of the concrete foundations or slab-on-grade. The basecourse should be moisture conditioned and compacted to at least 98% SPMDD; and
- Because the excavation will be deeper than 1.2 m the side slopes must be shored or shaped in accordance with the most recent edition of the Yukon Occupational Health and Safety Regulations. Tetra Tech should be

contacted to provide recommendations if steeper sidewall slopes are designed or planned. Any overhanging cobbles or boulders should be removed from the sidewalls. Spoil piles should be kept a distance away from the excavation crest equal to or greater than the excavation depth.

Table 1 - Recommended Gradation for Granular Material

Engineered Fill		20 mm Crushed Basecourse Gravel	
Particle Size (mm)	**% Passing by Mass**	**Particle Size (mm)**	**% Passing by Mass**
80.0	100	-	-
25.0	55 – 100	20.0	100
12.5	42 – 84	12.5	64 – 100
5.00	26 – 65	5.00	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

4.1.2 Foundation Design

4.1.2.1 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 pressure is the maximum allowable pressure required to limit the settlement to a tolerable amount. Both the ULS and SLS bearing resistances are highly dependent on soil properties and footing geometry, including the footing size, shape, and burial depth.

Resistance factors are applied to the calculated (unfactored) resistances to determine the maximum allowable factored design load. Geotechnical resistance factors for design of shallow foundations against vertical bearing failure (ULS), horizontal displacement (sliding under lateral loading), and overturning, per the NBCC 2015, are provided in Table 2.

Table 2 - Geotechnical Resistance Factors - Shallow Foundations

Item	Resistance Factor
Vertical Bearing Resistance (ULS)	0.5
Sliding (ULS)	0.8
Overturning (ULS)	0.5

4.1.2.2 Foundation Recommendations

As noted above, a slab-on-grade with thickened perimeter strip footings is considered to be an acceptable foundation system for the public works building. As such, design and construction of the foundation should be undertaken in accordance with the following recommendations:

- Strip footings refer to thickened areas within the structural slab-on-grade that are designed to provide the required bearing resistance under building loads. For the purpose of design, Tetra Tech has assumed a strip

footing thickness of 0.3 m and a minimum depth of cover of 0.3 m from finished grade to the underside of footing;

- Unfactored bearing resistances are provided based on footing width of 0.4 m. Bearing resistance is highly sensitive to soil properties and footing geometry (i.e., burial depth, footing size, footing shape, etc.). Tetra Tech should be notified to review and adjust the provided bearing resistances if different footing sizes, shapes, burial depth, or higher bearing resistances are required;
- An unfactored ULS bearing resistance of 290 kPa should be used for the new public works foundation. An unfactored SLS bearing pressure of 600 kPa should be used for the new public works foundation, based on an allowable elastic settlement of 25 mm, which is generally sufficient to limit total and differential settlement to tolerable levels for typical building projects.
- Foundation elements should not be cast directly onto or over seasonally frozen soils, and the soils under the foundation must not be allowed to freeze during construction; and
- Finished grades should be sloped to promote positive drainage and direct surface runoff away from the building foundations.

4.1.3 Seismic

4.1.3.1 Site Classification

The 2015 National Building Code of Canada (2015 NBCC) requires that a site classification be established for seismic design of new structures, based on average soil properties of the top 30 m (i.e., “site stiffness”). Based on the SPT N-values and DCPT blow counts recorded during the geotechnical drilling program, Tetra Tech recommends that the site be considered Site Classification E, per Table 4.1.8.4.A (National Research Council of Canada, 2015).

4.1.3.2 Liquefaction

Seismic loading can result in a loss of strength in soils, which is known as seismic liquefaction for granular, non-plastic (“sand-like”) soils, and cyclic softening for fine-grained, plastic (“clay-like”) soils. Liquefaction of sand-like soils is characterized be a severe, sudden loss of soil strength; cyclic softening of clay-like soils is also characterized by a loss of strength but is generally less severe and occurs less suddenly than liquefaction of sand-like soil.

Potential for liquefaction triggering in the sand was checked using the Simplified Method described by Idriss and Boulanger (2008), using the SPT N-values and DCPT blow counts measured in boreholes BH19-01 and BH19-02, seismic hazard deaggregation for the site provided by the National Research Council of Canada, and assuming a worst-case scenario with the groundwater table located immediately below the foundation. At depths 7.7 to 8.7 in BH19-01, the factor of safety was slightly less than 1, indicating there is potential for zones or pockets of liquefiable soils that could cause settlement of approximately 40 mm during a 1 in 2,475 year seismic event.

4.1.4 Seasonal Frost Protection

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
- Soil pore space is near 100% saturation

Based on the results of particle size analysis completed on disturbed samples collected during the drilling program, the gravel is considered to be non-frost susceptible. Perimeter insulation should not be required if site preparation and foundation recommendations presented in Sections 4.1.1 and 4.1.2 are followed, respectively.

4.1.5 Concrete

Concrete should be cast onto a clean, level, compacted granular bearing surface. It is important that no loose and/or disturbed materials be allowed to remain on the bearing surface. As noted in Section 4.1.1, foundation bearing surface should consist of 20 mm crushed basecourse, moisture conditioned and compacted to at least 98% SPMDD.

Tetra Tech recommends that all concrete be designed, mixed, placed and tested in accordance with the most recent editions of the Canadian Standards Association (CSA) standard CAN/CSA-A23.1 and 23.2. according to these standards, concrete should be designed to at least satisfy minimum durability requirements as defined by exposure class.

The exposure class of the concrete is dependent upon the presence or lack of chloride, sulphates, freezing and thawing conditions and soil saturation. Based on the recommendations, the foundation will have concrete exposed to cycles of freezing in non-saturated conditions. The governing exposure class is “F-2” and type GU cement is acceptable. Exterior concrete exposed to chlorides, freezing and thawing conditions should be designed using exposure class ”C-1” (structurally reinforced) or “C-2” (non-structurally reinforced) concrete.

In addition to the above, CAN/CSA-A23.1 also provides recommendations for cold weather concrete placement. These include protecting freshly placed concrete from freezing conditions.

4.2 New Fire Hall (Lot 181)

YG has indicated that the preferred foundation type is a slab-on-grade with thickened perimeter strip footings. Based on the results of the geotechnical evaluation, Tetra Tech considers the site to be suitable for the construction of a new fire hall building using the preferred foundation type. Recommendations for site preparation, design, and construction of shallow foundations are provided in the following sections.

4.2.1 Site Preparation

Site preparation should be undertaken in accordance with the following recommendations:

- The existing ground surface should be cleared of vegetation and the site should be excavated to remove the overlaying silt and silty sand and expose the underlaying gravelly sand. An excavation depth of about 2 to 2.5 m is expected based on the soil profile encountered in the boreholes; however, due to alluvial depositional setting, the depth to the gravel and sand contact may vary throughout the site;
- Native sand and gravel removed from the excavation may be suitable for re-use as backfill. Material re-used as backfill should conform to the particle size distribution for engineered fill provided in Table 1. Material that does not meet the gradation specifications or is too silty for re-use as engineered fill may be suitable for use on site as general, non-structural fill for landscaping or similar purposes;
- The base of the excavation should extend horizontally at least 1.5 m out from the foundation perimeter in all directions;
- Based on drawings provided to Tetra Tech, the proposed fire hall will encroach on the existing French drain. If the drain is required to continue functioning after the building is constructed, the drain should be relocated;

- The exposed subgrade should be inspected by a qualified geotechnical engineer to confirm that suitable ground conditions have been encountered and to provide additional recommendations if necessary;
- The approved subgrade should be moisture conditioned (if necessary) and compacted to at least 98% of the SPMDD;
- Depending on the time of year the subcut is completed, the base of the excavation may be close to or below the local groundwater elevation. Seepage into the bottom of the excavation should be expected and dewatering may be required to prevent water accumulation. Potential for problems related to groundwater seepage can be reduced by scheduling excavation work to take place in late spring or early summer, when groundwater conditions are generally lower. Tetra Tech can be retained to provide recommendations for excavation dewatering during construction, if required;
- To reduce challenges associated with excavation below the water table, it may be reasonable to do a partial sub-excavation and leave some sand and silt in place. Performance of the building foundations and risk of frost heaving would have to be carefully considered to proceed with a partial sub-excavation, and Tetra Tech should be retained to provide additional recommendations if this option will be pursued;
- The excavation should be backfilled using engineered fill conforming to the recommended gradation provided in Table 1. The engineered fill should be placed in lifts no thicker than 300 mm, moisture conditioned, and compacted to at least 98% SPMDD;
- If the excavation extends below the groundwater table, a non-woven geotextile should be used to line the excavation and clean gravel or rock fill used to backfill up to the water elevation;
- A 150 mm thick layer of 20 mm crushed basecourse conforming to the specifications in Table 1 should be placed immediately below the underside of the concrete foundations and/or or slab-on-grade. The basecourse should be moisture conditioned and compacted to at least 98% SPMDD; and
- If the excavation is deeper than 1.2 m the side slopes must be shored or shaped in accordance with the most recent edition of the Yukon Occupational Health and Safety Regulations. Tetra Tech should be contacted to provide recommendations if steeper sidewall slopes are desired or planned. Any overhanging cobbles or boulders should be removed from the sidewalls. Spoil piles should be kept a distance away from the excavation crest equal to or greater than the excavation depth.

4.2.2 Foundation Design

As noted above, a slab-on-grade with thickened perimeter strip footings is considered to be an acceptable foundation system for the fire hall building. As such, design and construction of the foundation should be undertaken in accordance with the following recommendations:

- Strip footings refer to thickened areas within the structural slab-on-grade that are designed to provide the required bearing resistance under building loads. For the purpose of design, Tetra Tech has assumed a strip footing thickness of 0.3 m and a minimum depth of cover of 0.3 m from finished grade to the underside of footing;
- Unfactored bearing resistances are provided based on footing width of 0.4 m. Bearing resistance is highly sensitive to soil properties and footing geometry (i.e., burial depth, footing size, footing shape, etc.). Tetra Tech should be notified to review and adjust the provided bearing resistances if different footing sizes, shapes, burial depth, or higher bearing resistances are preferred;
- An unfactored ULS bearing resistance of 290 kPa should be used for the new fire hall foundation. An unfactored SLS bearing pressure of 600 kPa should be used for the new fire hall foundation, based on an allowable elastic

settlement of 25 mm, which is generally sufficient to limit total and differential settlement to tolerable levels for typical building projects.

- Foundation elements should not be cast directly onto or over seasonally frozen soils, and the soils under the foundation must not be allowed to freeze during construction; and
- Finished grades should be sloped to promote positive drainage and direct surface runoff away from the building foundations.

4.2.3 Seismic Site Classification

Based on the SPT N-values recorded during historical field programs and DCPT blow counts from BH19-04, Tetra Tech recommends that the site be considered Site Classification D, per Table 4.1.8.4.A (National Research Council of Canada, 2015).

The subgrade soils encountered in the historical and current drilling programs are not expected to be susceptible to seismic liquefaction.

4.2.4 Seasonal Frost Protection

Based on particle size analysis of disturbed samples collected during the field program, the soil is considered to be potentially frost susceptible. Tetra Tech recommends that 50 mm of perimeter insulation be incorporated into the final design. Typical foundation details are shown in Figure 3

If some thickness of frost susceptible soil is left in place beneath the building foundations for any reason (e.g., not possible to remove due to high groundwater), Tetra Tech should be retained to provide recommendations for additional frost protection.

4.2.5 Concrete

Concrete should be cast onto a clean, level, compacted granular bearing surface. It is important that no loose and/or disturbed materials be allowed to remain on the bearing surface. As noted in Section 4.2.1, foundation bearing surface should consist of 20 mm crushed basecourse, moisture conditioned and compacted to at least 98% SPMDD.

Tetra Tech recommends that all concrete be designed, mixed, placed and tested in accordance with the most recent editions of the Canadian Standards Association (CSA) standard CAN/CSA-A23.1 and 23.2. according to these standards, concrete should be designed to at least satisfy minimum durability requirements as defined by exposure class.

The exposure class of the concrete is dependent upon the presence or lack of chloride, sulphates, freezing and thawing conditions and soil saturation. Based on the recommendations, the foundation will have concrete exposed to cycles of freezing in non-saturated conditions. The governing exposure class is “F-2” and type GU cement is acceptable. Exterior concrete exposed to chlorides, freezing and thawing conditions should be designed using exposure class ”C-1” (structurally reinforced) or “C-2” (non-structurally reinforced) concrete.

In addition to the above, CAN/CSA-A23.1 also provides recommendations for cold weather concrete placement. These include protecting freshly placed concrete from freezing conditions.

5.0 CONSTRUCTION OBSERVATIONS AND TESTING SERVICES

All recommendations presented herein are site specific and based on the assumptions that an adequate level of monitoring during foundation excavation and construction will be provided, and that all construction activities will be carried out by a suitably qualified, experienced contractor. An adequate level of construction monitoring also provides opportunity to confirm that recommendations based on data obtained at discrete locations are relevant to other areas of the sites.

It is recommended that Tetra Tech be given the opportunity to review details related to the geotechnical aspects of the final design prior to construction. Experience has shown that this may prevent inconsistencies, deficient performance, and/or increased costs that may lead disputes.

For this project, the following construction monitoring and testing activities are recommended:

- Inspection and approval of prepared subgrade;
- Compaction testing during granular fill placement; and
- Concrete testing of foundation elements, slabs, and other concrete structures.

Tetra Tech would be pleased to prepare a proposal to provide these services during construction, if required.

6.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the Government of Yukon and their agents. Tetra Tech Canada Inc. (operating as Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the Government of Yukon, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

7.0 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.

FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
ISSUED FOR REVIEW
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38

Prepared by:
Taylor Pasloski, P.Eng.
Geotechnical Engineer, Arctic Region
Direct Line: 867.668.9213
Taylor.Pasloski@tetratech.com

FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
ISSUED FOR REVIEW FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38
FILE:704-ENG.WARC03386-38

Reviewed by:
Adam Wallace, M.Eng., P.Eng.
Geotechnical Engineer, Arctic Region
Direct Line: 867.668.9218
Adam.Wallace@tetratech.com

/cr

FIGURES

LEGEND

- BOREHOLE LOCATION

0 25m

Scale: 1:750 @ 8.5"x11"

CLIENT

Yukon Government

TETRA TECH

PUBLIC WORKS BUILDING GEOTECHNICAL EVALUATION
CARMACKS, YUKON

SITE PLAN SHOWING
PROPOSED PUBLIC WORKS BUILDING

PROJECT NO.	DWN	CKD	REV
ENG.WARC03386-38	CB	TP	0

OFFICE	DATE
EBA-WHSE	May 28, 2019

Figure 1

LEGEND

- BOREHOLE LOCATION

0 50m

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

CLIENT

Yukon Government

TETRA TECH

FIRE HALL GEOTECHNICAL EVALUATION
CARMACKS, YUKON

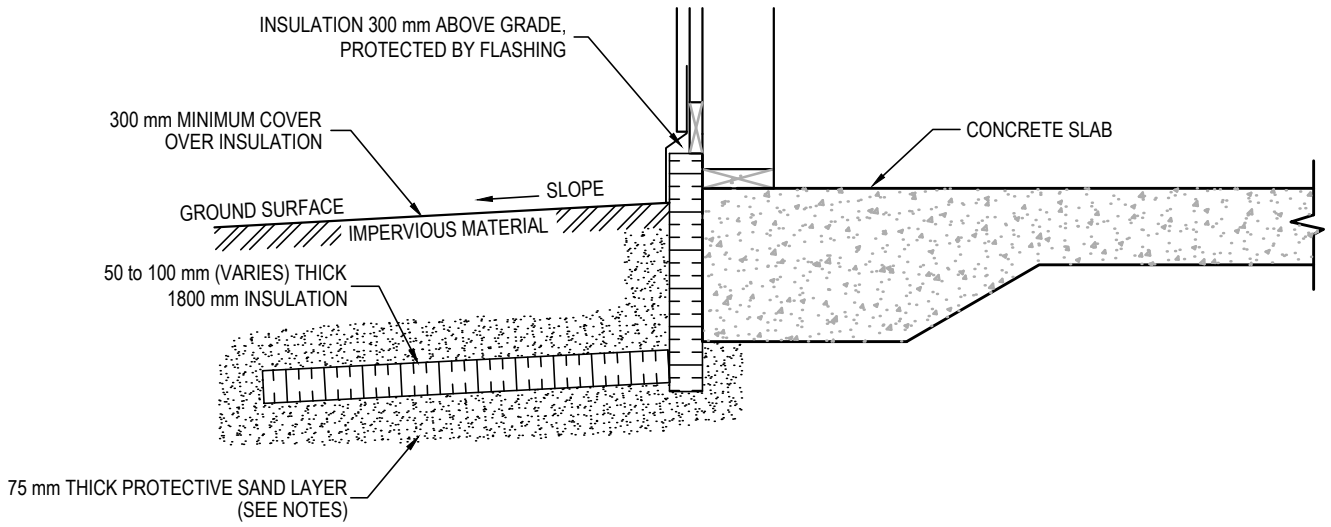
SITE PLAN SHOWING PROPOSED FIRE HALL

PROJECT NO.	DWN	CKD	REV
ENG.WARC03386-38	CB	TP	0

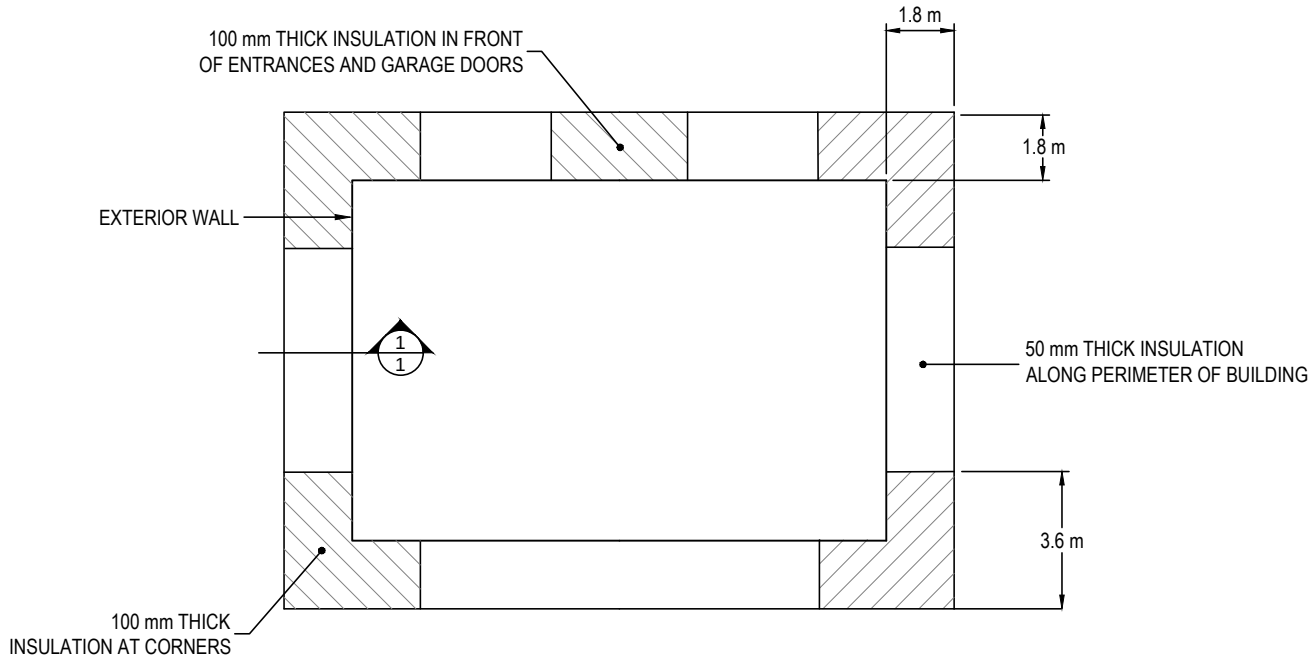
OFFICE	DATE
EBA-WHSE	May 28, 2019

Figure 2

Q:\Whitehorse\Data\0201drawings\Carmacks\ENGWARC03386-38 New Fire Hall & Public Works Building Geotech Evaluation\ENGWARC03386-38 Fig.2-R0.dwg [FIGURE 2] May 28, 2019 - 11:42:10 am (BY: BUCHAN, CAMERON)



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
Yukon Government

TETRA TECH

FIRE HALL GEOTECHNICAL EVALUATION
CARMACKS, YUKON

TYPICAL SLAB ON GRADE PERIMETER INSULATION DETAIL

PROJECT NO.	DWN	CKD	REV
ENG.WARC03386-38	CB	TP	0

OFFICE	DATE
EBA-WHSE	May 28, 2019

Figure 3

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 sole use of TETRA TECH's Client (**Yukon Government**) 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 unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of the Yukon Government or TETRA TECH. It is acknowledged that the Yukon Government, the Client, may reproduce the report freely for internal usage.

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.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or 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. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

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

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. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

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, 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.

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 document, 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, 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 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.

1.8 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.

1.9 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.

1.10 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.

1.11 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.

1.12 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.

1.13 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.

1.14 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.

1.15 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.

1.16 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.

1.17 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.

1.18 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

PUBLIC WORKS BUILDING (LOT 1117) – BOREHOLES 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 GW, GP, SW, SP GM, GC, SM, SC Borderline classification requiring use of dual symbols Less than 5% pass 75 µm sieve More than 12% pass 75 µm sieve 5% to 12% pass 75 µm sieve	$C_U = D_{60} / D_{10}$ 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 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			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 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			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	PLASTICITY CHART For classification of fine-grained soils and fine fraction of coarse-grained soils Equation of 'A' line: PI = 0.73(LL-20) PLASTICITY INDEX LIQUID LIMIT CH 'A' line CL CI MH or OH CL-ML ML or OL	
	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 Liquid limit 30-50		CI	Inorganic clay of medium plasticity, silty clays		
	CLAYS 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 ■

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

Goverment of Yukon

Borehole No: **BH19-01**

Project: Geotechnical Evaluation - New Public Works Building	Project No: 704-ENG.WARC03386-38
Location: Lot 1117	
Carmacks, Yukon	UTM: 432526 E; 6883280 N; Z 8 NAD83

Depth (m)	Method	Soil Description	Sample Type	Sample Number	DCPT (N)	SPT (N)	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	DCPT (N) 20 40 60 80 / SPT (N) 20 40 60 80	Depth (ft)
0										0
	Solid stem auger	ORGANICS								
		SAND (fill) - some silt, trace gravel, poorly graded, damp, brown		SA1			18.8			1
		ORGANICS - approximately 50 mm thick		SA2			39.1			2
		SILT - some sand, damp, slight plasticity, light brown to white								
1		SAND - some silt, medium grained, damp, brown		SA3			8.5			3
										4
	Hollow stem auger	GRAVEL - some sand, trace silt, platy, sub angular, damp, dense, grey		SA4		49	2			5
		- rock stuck in the end of split spoon sampler at SA4								6
2										7
										8
		SAND and GRAVEL - trace silt, coarse grained, wet, compact, brown								9
3				SA5		26	9.7			10
										11
										12
4										13
										14
		SAND - gravelly, trace silt, well graded, wet, compact, brown								15
		- rock stuck in the end of split spoon sampler at SA6		SA6		20	52.7			16
5		- sand heaving into hollow stem augers, switch to DCPT below 4.9 m			19					17
	Dynamic cone penetration				12					18
		- SA7 collected from additional solid stem auger hole drilled adjacent to BH19-01		SA7	19		11.6			19
6					19					20
		No samples recovered below 6.2 m, inferred compact, gravelly SAND.			15					21
					13					22
7					14					23
					14					24
					14					25
					11					26
8		- loose to compact below 8.0 m			9					27
					11					28
					12					29
9		End of Borehole at 8.8 m (Target Depth)								30
										31
10										32

TETRA TECH

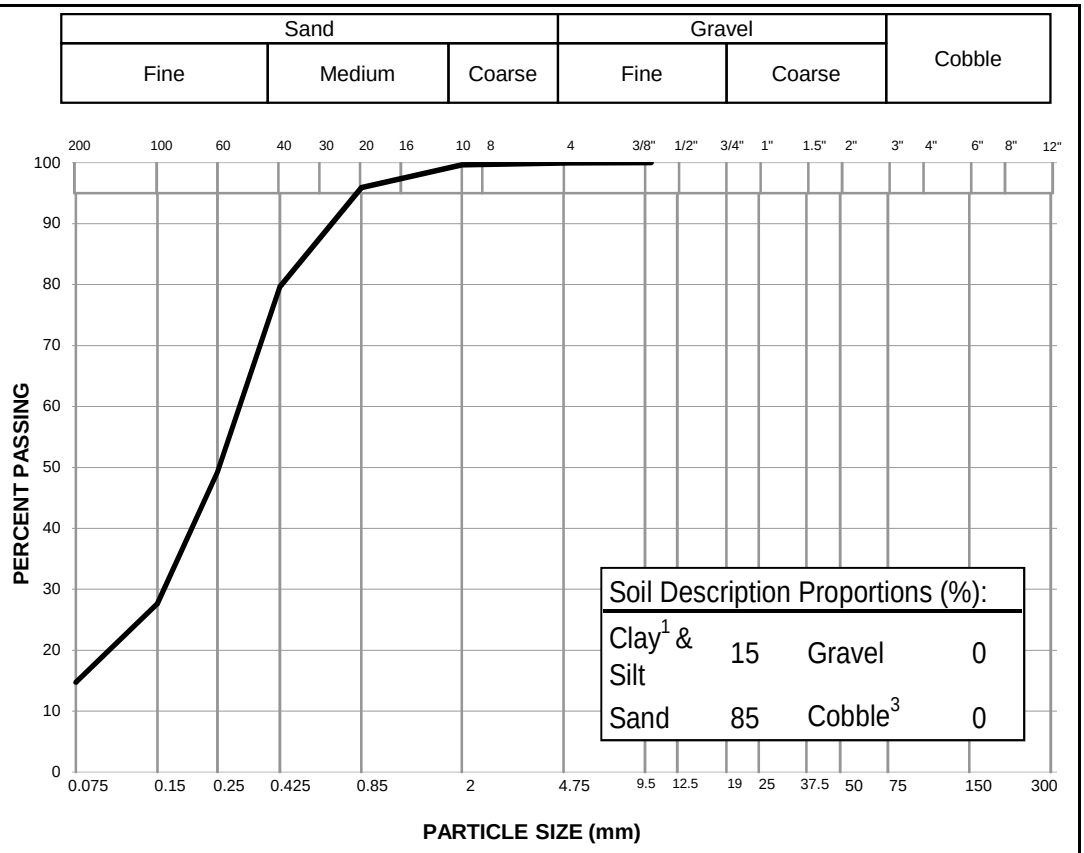
Contractor: Donjeck Drilling	Completion Depth: 8.8 m
Drilling Rig Type: CME75 Truck Mounted	Start Date: May 22, 2019
Logged By: TP	Completion Date: May 23, 2019
Reviewed By: AWW	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Carmacks Fire Hall and Public Works	Sample No.:	SA03
Project No.:	ENG.WARC03386-38	Material Type:	-
Site:	Carmacks, YT	Sample Loc.:	BH19-01
Client:	YG Community Services	Sample Depth:	0.9 - 1.1 m
Client Rep.:	Elise Bingman	Sampling Method:	Grab
Date Tested:	June 3, 2019 By: SY	Date Sampled:	May 22, 2019
Soil Description[2]:	SAND - some silt	Sampled By:	TP
		USC Classification:	SP Cu: #N/A
Moisture Content:	8.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	
19	
12.5	
10	100
5	100
2	100
0.85	96
0.425	80
0.25	49
0.15	28
0.075	14.8



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: _____ P.Eng.

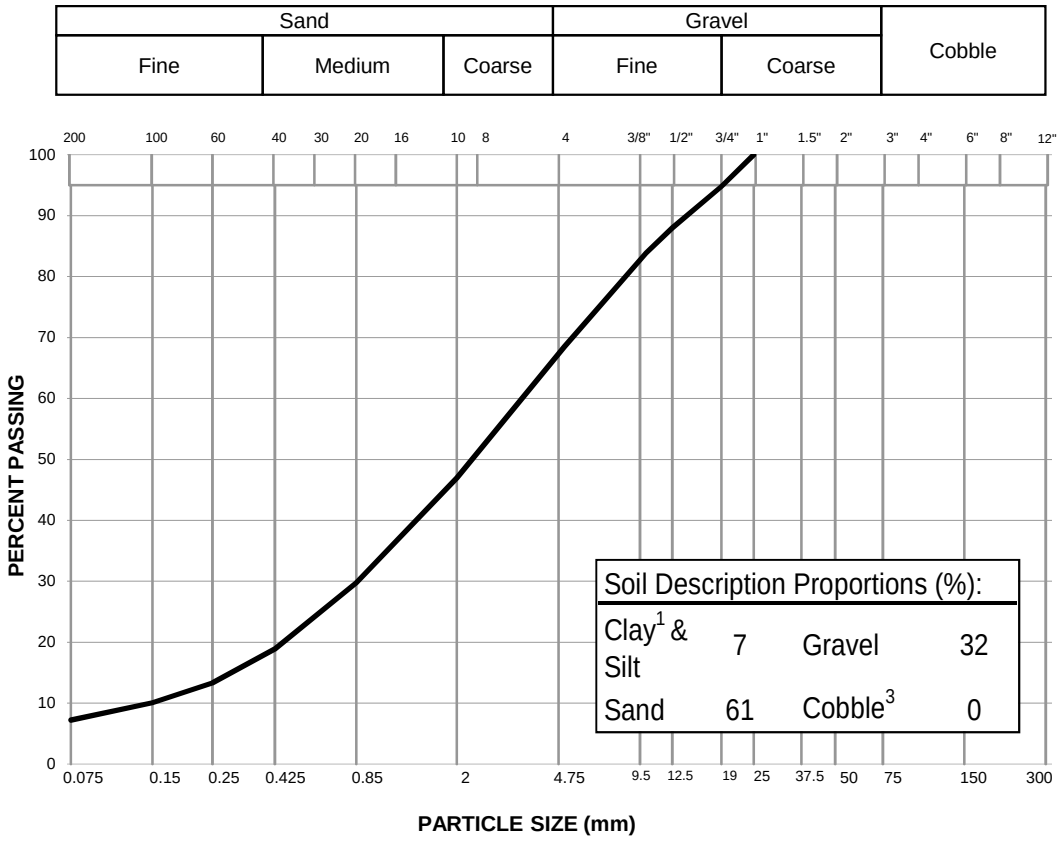
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Carmacks Fire Hall and Public Works	Sample No.:	SA07
Project No.:	ENG.WARC03386-38	Material Type:	-
Site:	Carmacks, YT	Sample Loc.:	BH19-01
Client:	YG Community Services	Sample Depth:	5.8 - 6.1 m
Client Rep.:	Elise Bingman	Sampling Method:	Grab
Date Tested:	June 6, 2019 By: SM	Date Sampled:	May 22, 2019
Soil Description[2]:	SAND - some gravel, trace silt	Sampled By:	TP
		USC Classification:	SW Cu: 25.8
Moisture Content:	11.6%		Cc: 1.3

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	100
19	95
12.5	88
10	84
5	69
2	47
0.85	30
0.425	19
0.25	13
0.15	10
0.075	7.2



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: _____ P.Eng.

TETRA TECH

Goverment of Yukon

Borehole No: **BH19-02**

Project: Geotechnical Evaluation - New Public Works Building	Project No: 704-ENG.WARC03386-38
Location: Lot 1117	
Carmacks, Yukon	UTM: 432498 E; 6883265 N; Z 8 NAD83

Depth (m)	Method	Soil Description	Sample Type	Sample Number	DCPT (N)	SPT (N)	Moisture Content (%)	Depth (ft)
0								0
1	Solid stem auger	ORGANICS SAND - some silt, trace gravel, poorly graded, damp, brown		SA1			11.5	1
2	Hollow stem auger	GRAVEL and SAND - trace silt, well graded, wet, very dense, brown - rock stuck in the end of split spoon sampler at SA2		SA2		60	2.1	5
3	Hollow stem auger	- dense below 2.9 m		SA3		39	11	10
4	Hollow stem auger	- compact below 4.4 m - sand heaving into hollow stem augers, switch to DCPT below 4.9 m		SA4		21	18	15
5	Dynamic cone penetration	No samples recovered below 4.9 m, inferred compact, gravelly SAND.			8			16
					9			18
					13			19
6					17			20
					15			21
					17			22
7					19			23
					31			24
					25			25
					23			26
8					22			27
					17			28
					26			29
9					25			30
		End of Borehole at 9.3 m (Target Depth)						31
10								32

Plastic Limit / Moisture Content / Liquid Limit: 20 40 60 80

◆ DCPT (N) ◆ 20 40 60 80

■ SPT (N) ■ 20 40 60 80

TETRA TECH

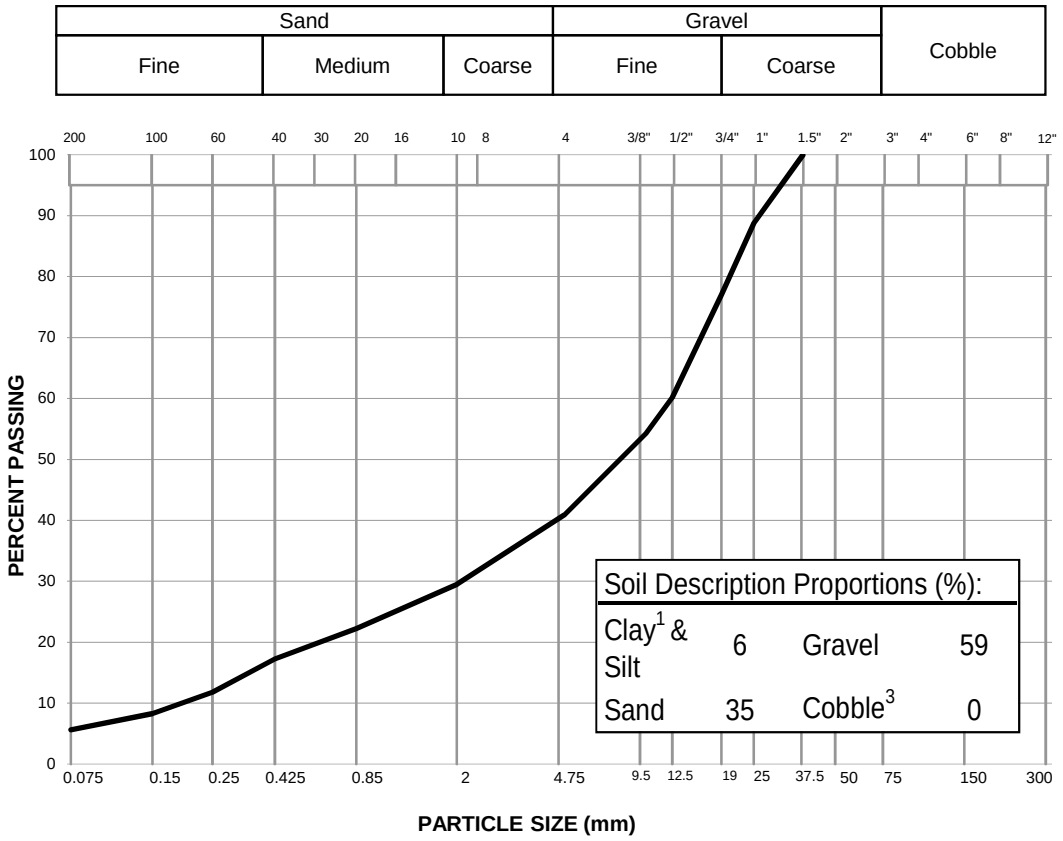
Contractor: Donjeck Drilling	Completion Depth: 9.3 m
Drilling Rig Type: CME75 Truck Mounted	Start Date: May 23, 2019
Logged By: TP	Completion Date: May 23, 2019
Reviewed By: AWW	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Carmacks Fire Hall and Public Works	Sample No.:	SA02
Project No.:	ENG.WARC03386-38	Material Type:	-
Site:	Carmacks, YT	Sample Loc.:	BH19-02
Client:	YG Community Services	Sample Depth:	1.4 - 1.8 m
Client Rep.:	Elise Bingman	Sampling Method:	Grab
Date Tested:	June 3, 2019 By: SY	Date Sampled:	May 23, 2019
Soil Description[2]:	GRAVEL and SAND - trace silt	Sampled By:	TP
		USC Classification:	GW Cu: 62.5
Moisture Content:	2.1%		Cc: 1.8

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	100
25	89
19	77
12.5	60
10	54
5	41
2	29
0.85	22
0.425	17
0.25	12
0.15	8
0.075	5.6



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: _____ P.Eng.

TETRA TECH

APPENDIX C

FIRE HALL (LOT 181) – BOREHOLES 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 GW, GP, SW, SP GM, GC, SM, SC Borderline classification requiring use of dual symbols Less than 5% pass 75 µm sieve More than 12% pass 75 µm sieve 5% to 12% pass 75 µm sieve	$C_U = D_{60} / D_{10}$ 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 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			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 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			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	PLASTICITY CHART For classification of fine-grained soils and fine fraction of coarse-grained soils Equation of 'A' line: PI = 0.73(LL-20) PLASTICITY INDEX LIQUID LIMIT CH 'A' line CL CI MH or OH CL-ML ML or OL	
	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 Liquid limit 30-50		CI	Inorganic clay of medium plasticity, silty clays		
	CLAYS 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 ■

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

Goverment of Yukon

Borehole No: **BH19-03**

Project: Geotechnical Evaluation - New Fire Hall	Project No: 704-ENG.WARC03386-38
Location: Lot 181	
Carmacks, Yukon	UTM: 432107 E; 6885154 N; Z 8 NAD83

Depth (m)	Method	Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	Depth (ft)
0						Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	SPT (N) (20 40 60 80)
0	Solid stem auger	ORGANICS					0
		SILT - some sand, seasonally frozen, brown, light brown					1
1				SA1		27.1	3
		SAND - some silt, poorly graded, damp, light brown		SA2		15.6	4
		SILT - sandy, some clay, fine sand, damp, slightly plastic, firm, grey and orange oxidization		SA3	5	23.8	5
2	Hollow stem auger	SAND - gravelly, some silt, well graded, sub rounded to sub angular, wet, dense, brown					7
		- poor recovery in split spoon at SA4, sample not representative		SA4	32	7.3	10
3							11
4		- SPT attempted at 4.1 m, refusal at zero penetration on rock/gravel		SA5		10	14
	Solid stem auger	- sand heaving into hollow stem augers, switch to solid stem below 4.5 m - poor recovery below 4.5 m					15
5		- silty, trace gravel, poorly graded, wet, grey-brown, easier drilling below 5.1 m		SA6		14	18
6							20
7				SA7		13.4	24
8							26
				SA8		19	28
9		End of Borehole at 9.0 m (Target Depth)					30
10							32

TETRA TECH

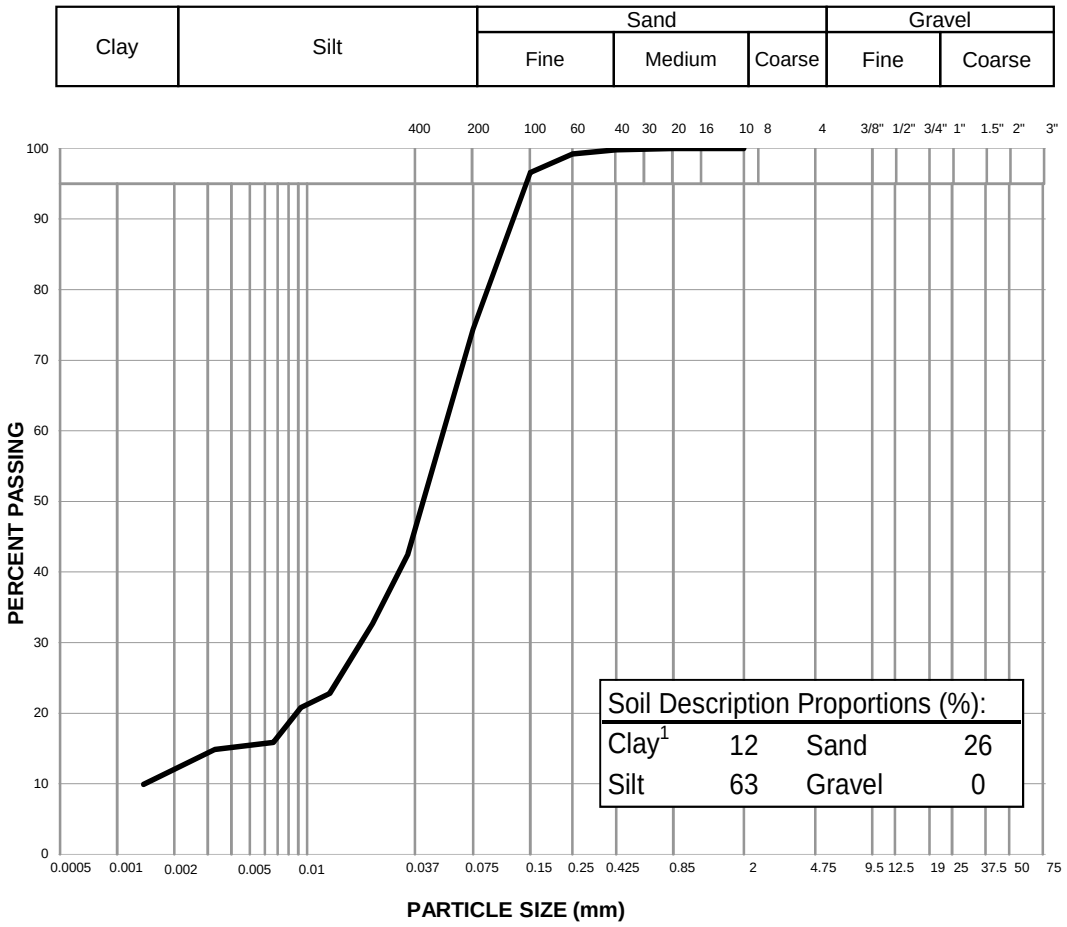
Contractor: Donjeck Drilling	Completion Depth: 9 m
Drilling Rig Type: CME75 Truck Mounted	Start Date: May 23, 2019
Logged By: TP	Completion Date: May 24, 2019
Reviewed By: AWW	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Carmacks Fire Hall and Public Works	Sample No.:	SA03
Project No.:	ENG.WARC03386-38	Material Type:	-
Site:	Carmacks, YT	Sample Loc.:	BH19-03
Client:	YG Community Services	Sample Depth:	1.4 - 1.8
Client Rep.:	Elise Bingman	Sampling Method:	Grab
Date Tested:	June 4, 2019 By: AT	Date Sampled:	May 23, 2019
Soil Description[2]:	SILT - sandy, some clay	Sampled By:	TP
		USC Classification:	ML Cu: 39.9
Moisture Content:	23.8%		Cc: 4.9

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	
5	
2	100
0.85	100
0.425	100
0.25	99
0.15	97
0.075	74.4
0.0340	42.6
0.0222	32.7
0.0132	22.8
0.0093	20.8
0.0066	15.8
0.0033	14.9
0.0014	9.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to Tetra Tech description protocols

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Eng.

TETRA TECH

Goverment of Yukon

Borehole No: **BH19-04**

Project: Geotechnical Evaluation - New Fire Hall	Project No: 704-ENG.WARC03386-38
Location: Lot 181	
Carmacks, Yukon	UTM: 432120 E; 6885171 N; Z 8 NAD83

Depth (m)	Method	Soil Description	Sample Type	Sample Number	DCPT (N)	Moisture Content (%)	Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	DCPT (N) (20 40 60 80)	Depth (ft)
0									0
	Solid stem auger	ORGANICS							
		SILT - some sand, seasonally frozen, light brown							
				SA1		52.2			
1		SAND and SILT - damp, light brown, light grey and orange oxidization throughout		SA2		11			
2		- gravelly, fine grained sand, poorly graded, damp, light brown below 2.3 m		SA3		12.5			
3	Dynamic cone penetration	Borehole collapsing, not possible to recover samples, switch to DCPT below 2.9 m, inferred dense, gravelly SAND			35				
					49				
					52				
4					41				
					86				
					75				
5					99				
					92				
					74				
6					51				
					53				
					43				
					50				
7					61				
					34				
					59				
8					53				
					42				
		- compact below 8.6 m			25				
9					21				
		End of Borehole at 9.1 m (Target Depth)							
10									32

TETRA TECH

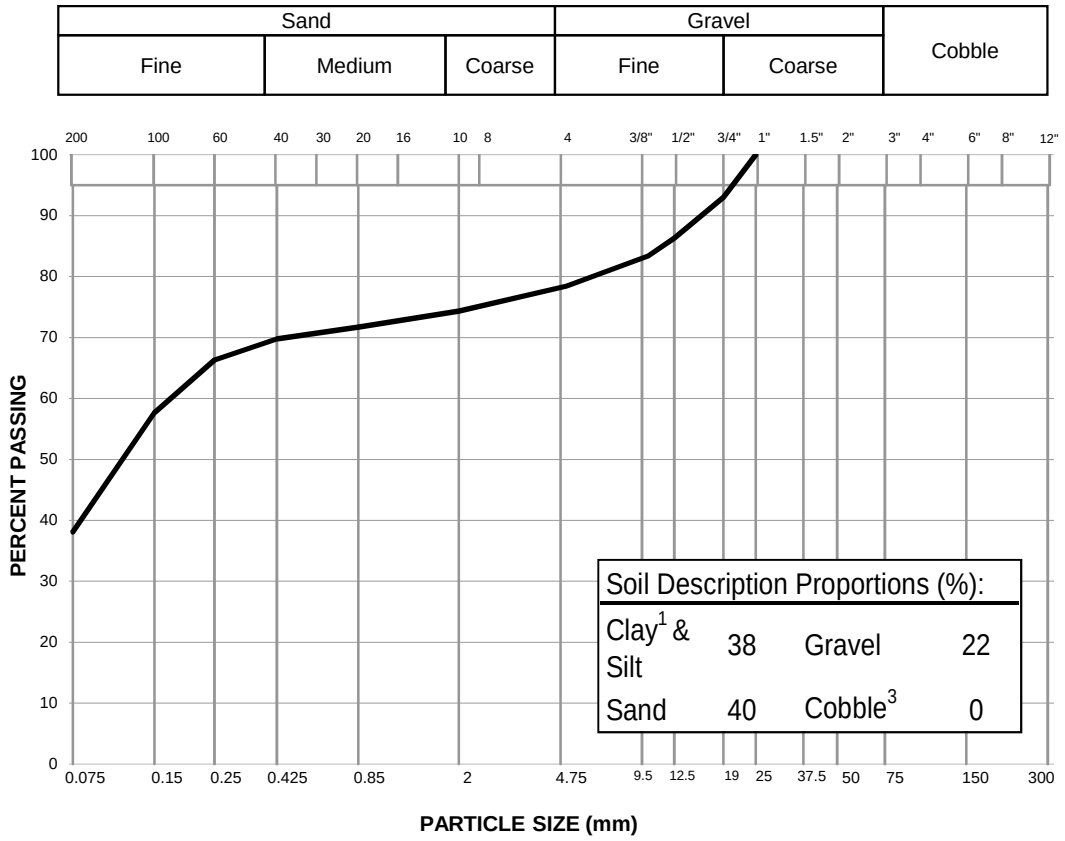
Contractor: Donjeck Drilling	Completion Depth: 9.1 m
Drilling Rig Type: CME75 Truck Mounted	Start Date: May 24, 2019
Logged By: TP	Completion Date: May 24, 2019
Reviewed By: AWW	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	Carmacks Fire Hall and Public Works	Sample No.:	SA03
Project No.:	ENG.WARC03386-38	Material Type:	-
Site:	Carmacks, YT	Sample Loc.:	BH19-04
Client:	YG Community Services	Sample Depth:	2.4 - 2.6 m
Client Rep.:	Elise Bingman	Sampling Method:	Grab
Date Tested:	June 3, 2019 By: SY	Date Sampled:	May 24, 2019
Soil Description[2]:	SAND and SILT - gravelly	Sampled By:	TP
		USC Classification:	- Cu: #N/A
Moisture Content:	12.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	100
19	93
12.5	86
10	83
5	78
2	74
0.85	72
0.425	70
0.25	66
0.15	58
0.075	38.1



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: _____ P.Eng.

TETRA TECH