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**Geotechnical Evaluation
Proposed Urban Lot #15 (CLSR 55659)
Carmacks, Yukon – 2019**



Prepared For: Yukon Government

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1.0 INTRODUCTION

Our firm was retained by *Yukon Government - Department of Community Services, Rural Land Development - Land Development Branch (YG)* under a Standing Offer Agreement (No.2017/2018-2753) to conduct a geotechnical evaluation of a proposed residential lot which is located in Carmacks, Yukon.

The purpose of our evaluation was to assess the development potential of the study area through subsurface investigation and laboratory analysis in order to formulate geotechnical recommendations to assist in site development and preliminary foundation design where development was deemed feasible.

Our evaluation was meant to supplement our December 27th, 2018 Geotechnical Feasibility Assessment which identified the overall development potential of the proposed lot based upon a literature review and site reconnaissance.

The *Village of Carmacks*, located ~ 180 km north of Whitehorse along the North Klondike Highway, is one of number of Yukon communities where there is an increasing demand for overall lot development. The study area, which measures ~1.1 ha in size, is comprised of *Village of Carmacks Lot #15 (CLSR 55659)* as noted in Figure 1.

As our recent evaluation was more comprehensive in nature than our Geotechnical Feasibility Assessment, our findings and recommendations contained herein supersede those of our previous report where conflicts may exist.

Authorization to proceed with the evaluation was granted by *YG – Community Services - Senior Program Manager, Mr.K.Fisher* on August 2nd, 2019. Our field work was subsequently conducted between August 10th and 16th in accordance with our July 29th, 2019 proposal.

Our findings have been presented herein along with a description of our methodology.



2.0 METHODOLOGY

Our work methodology was comprised of the following components.

2.1 Literature Review

Our firm reviewed our December 27th, 2018 Geotechnical Feasibility Assessment report to re-familiarize ourselves with the regional conditions and detail the field work programs. During this time, we collated the information relative to a newly compiled topographical map (which was forwarded to us by *Inukshuk Planning & Development Ltd.*) in order to detail the field work program by identifying potential test-pit and borehole locations.

The new topographical survey, which was based upon third party data retained in 2014, has been attached as Figure 2. While the (0.2-meter) contours intervals denoted local fluctuations in the ground surface, considering the age of the survey, it may not necessarily reflect the existing site conditions. Specifically, we noted that fills, which were located on the northern periphery of the site, were not identified in the topographical data.

In addition to the topographical map, we reviewed a *YG* supplied geotechnical report prepared by *EBA Engineering Consultants Ltd.* The report, entitled Geotechnical Evaluation – Residential Expansion – Carmacks, Yukon (File No.0201-11730) was compiled February 23, 1995 and was prepared for *YG – Engineering and Development Branch* to assess a region in Carmacks to determine its suitability for residential expansion. A portion of their study area encompassed Lot #15. During their evaluation, a single test pit was excavated in the southeast corner of Lot #15 (at the approximate location noted in Figure 3) utilizing a *Caterpillar 335* tracked excavator.

In brief, *EBA* characterized the subsurface conditions as being comprised of “up to a meter of ice rich permafrost over unfrozen but wet silts. Granular soils (gravel and sand) was noted below the silt” along with a shallow groundwater table. At the time, *EBA* recommended excavation of the overlying permafrost soils to the depth of a thawed silt strata followed by granular backfill over geotextile to allow for development of an envisioned trailer park option. The trailer park option was preferred over the construction of residential structures as the trailers could be adjusted to “offset any movements caused by settlement of frost heave”. The *EBA* geotechnical evaluation report has been attached in Appendix A for reference purposes.



2.2 Field Work Program

The field work program was comprised of the following components;

Utility Locates

Northwestel, ATCO Electric Yukon and the *Village of Carmacks* were contacted prior to conducting the test pit and drilling programs to ensure the subsurface investigation would not impact local infrastructure.

In brief, the service providers indicated they did not have any utilities located within the limits of the study area. However, *Village of Carmacks* identified the presence of subsurface sanitary/sewer lines located along River Drive and Rowlinson Drive. Nearby water wells were identified on Lots 16 & 181, located north and west of the study area, respectively.

Site Reconnaissance

A site reconnaissance was conducted by the undersigned on August 10th, 2019 to mark anticipated test pit and borehole locations and delineate equipment access routes such that the potential for disturbance to vegetation and delays during the subsurface investigation was minimized. In addition, during this time we assessed the site conditions further to observations which were made during our geotechnical feasibility assessment.

Test Pit Program

A test pit program was conducted on August 11th, 2019 to assess the sub-surface conditions at select locations within the study area utilizing a *Bobcat E60* tracked excavator which was equipped with a digging bucket. The excavator was supplied and operated by *Yellow Truck Excavating Inc.* of Whitehorse, Yukon and was employed under the direction of our firm.

The work consisted of excavating three (3) test pits (TP 1-19 through TP 3-19) which were excavated at the approximate locations noted in Figure 3.

Test Pit Termination

The test pits were excavated to an average depth of 2.3 meters below the prevailing ground surface. The depth of excavation was limited in each of the test pits due to the presence of groundwater which caused immediate slough of granular alluvial floodplain deposits which were encountered beyond an average depth of 1.8 meters.

Refusal was not encountered.

The test pits were backfilled with the excavation spoils approximately fifteen (15) minutes following completion of excavation to allow for a period of time to assess sidewall stability and potential groundwater seepage/recharge rates. The surficial organic cover, which was stockpiled separately from the excavation spoils, was subsequently utilized to cap the backfill to reduce the potential for soil erosion and promote re-vegetation.



Backfilling test pit TP 3-19.

Drilling Program

A drilling program was conducted on August 16th, 2019 utilizing a CME-75 drill mounted on a 5500 Series GMC truck to obtain soil samples and characterize the subsurface conditions. The drill was owned and operated by *Donjek Drilling* of Whitehorse, Yukon and was employed under the direction of our firm.

The drilling program was comprised of advancing two (2) boreholes (BH 1-19 and BH 2-19) at the approximate locations noted in Figure 3. While borehole BH 1-19 was advanced to a depth of 9.14 meters utilizing 150 mm Ø continuous flight solid-stem augers, the second borehole, BH 2-19, was advanced to a depth of 7.62 meters utilizing 200 mm Ø continuous flight hollow-stem augers. As each of these boreholes were advanced through surficial fills, these depths equate to approximately 7.54 and 6.12 meters below the prevailing original ground surface.



Drilling borehole BH 1-19.

The use of the hollow-stem augers allowed for a monitoring well to be installed and bearing capacity assessments through standard penetration test (SPT) methodologies which were employed in accordance with *ASTM D1586-11*.

In brief, the SPT methodology allows for the relative density of the sub-surface soils to be assessed by measuring the number of blows (N-value) required to drive a 50 mm diameter uncased sampler tube a distance of 300 mm utilizing a 63.5 kg hammer dropped from a height of 760 mm. These ‘N’ values allow for correlation of the noted resistance relative to the materials density/consistency where thawed materials are encountered. The approximate correlation has been presented on the ‘Notes on Soil Logs’ enclosed in Appendix B.

Borehole Termination

The boreholes were terminated in granular alluvial deposits at an average depth of 6.83 meters below the prevailing elevation of the original ground surface.

While borehole BH 1-19 was backfilled utilizing a combination of auger cuttings and bentonite pellets, borehole BH 2-19 was backfilled with a combination of filter sand and bentonite as a monitoring well was installed in the borehole as described below.

Monitoring Well Installation

A 2” diameter ABS monitoring well was installed in borehole BH 2-19 to a depth of ~7.11 meters below the surface of the fill through which it was advanced to allow for monitoring of the local groundwater conditions. This equates to a depth of ~5.61 meters below the prevailing site elevations.



View of site from River Drive. Drilling borehole BH 2-19.

Monitoring Well Structure

The lower 5.33 meters of the well was screened and covered with a silt sock (to minimize the influx of fines and extend the life of the well). The annular space was backfilled with an imported filter sand (conforming to NSF/ANSI 61 standards). The exception to this was the region ~0.5 meters above the screened portion of the pipe where bentonite was used to seal the annular space to the ground surface in accordance with good well installation practices. Access to



Borehole BH 2-19 well.



the well was restricted through the installation of a high-visibility lockable steel casing which was concreted into the existing ground surface.

Survey Program

The locations of the test pits and boreholes were recorded in the field utilizing a hand-held GPS unit.

While local variations in the elevations of the original ground surface were noted, each of the test pits were arbitrarily given an elevation of 100.00 meters. The boreholes elevations were subsequently determined to be 101.6 and 101.5 meters, respectively as they were each advanced through fills which were placed in the northern realms of the lot.

Soil Logs

During the drilling and test pit excavation, field soil logs were maintained by the undersigned to record the stratigraphy of the soils that were encountered. This information was utilized along with visual observations and the results of the laboratory analysis in order to compile the Test Pit and Borehole Soil Logs which have been enclosed in Appendix B. This appendix also includes 'Notes on Soil Classification' and a description of the 'Unified Soil Classification System' and 'National Research Council' permafrost classification systems which were utilized to describe the soils.

Sampling Program

Soil samples were retained at regular intervals during the subsurface investigation to allow for additional observations to be made under field and laboratory settings.

In all, a total of twenty-nine (29) samples were obtained.

Fourteen (14) of these samples were obtained during the test pit program.

During this time, the near surface samples were retained by hand directly from the excavation sidewalls. The deeper samples were retained from the leading edge of the excavator bucket during the course of test pit excavation.

The remaining fifteen (15) samples were retained during the drilling program.

While two (2) of these drilling samples were retained through SPT methodologies, the remainder were retained directly off the auger flighting. It should be noted the retention of additional SPT samples was restricted beyond a depth of 5 meters due to the hydraulic influx of fine sands into the hollow-stem auger during centerline withdrawal.



An additional sample was retained from the *Yukon Government* gravel quarry located at km 354.3 RHS of the North Klondike Highway #2 (Disposition No.900101) to characterize potential fill materials which may be utilized during site development.

Once the soil samples were retained, they were described on the field soil logs and subsequently sealed in air-tight plastic bags. The samples were numbered sequentially in order to allow for laboratory analysis as described in Section 2.3, below.

2.3 Laboratory Work Program

The laboratory work program was comprised of both physical and analytical analysis.

Physical Laboratory Analysis

The physical laboratory work program was conducted at our Whitehorse laboratory facilities and those of our sub-consultant, *Golder Associates Ltd.* (located in Burnaby, British Columbia), in order to characterize the index properties and conditions of the retained soil samples.

The analysis was conducted between August 14th and September 6th, 2019 and was comprised of the following;

<i>Description of Analysis</i>	<i>ASTM Analysis</i>	<i>Quantity</i>	<i>Laboratory</i>
Moisture Content	D 2216-92	29	<i>Chilkoot</i>
Grain Size Distribution	D 422-633	16	<i>Chilkoot</i>
Hydrometer	D 422-633	1	<i>Golder Associates</i>
Atterberg Limit	D 4318-10	3	<i>Golder Associates</i>

In brief, each sample underwent moisture content analysis to determine the weight of the water within the sample relative to its dry weight. The results of the analysis have been denoted as ‘MC’ (⊙ - Symbol) on the Soil Logs enclosed in Appendix B.

The grain size distribution analysis was conducted on a selection of samples in order to assist in soil classification utilizing the *Unified Soil Classification System*. The results of the analysis have been noted on the Soil Logs with the percent composition of fines (silt & clay), sand and gravel denoted with the symbols - ▲, ● & ■, respectively.

The results of the Atterberg limit analysis have been attached in Appendix C.



The hydrometer analysis was conducted in order to determine the percentage of sand, silt and clay which was contained within the tested sample to provide a relative assessment of the soils engineering properties. The result of the hydrometer analysis has been attached in Appendix C.

Analytical Laboratory Analysis

The total sulphate ion content of a single soil sample was determined by our laboratory sub-consultant *Golder Associates Ltd.* in accordance with *CSA Standard A23.1 – 3C*. The purpose of the analysis was to assess the aggressiveness of soils which would potentially be imported to develop the site relative cast-in-place concrete.

The sample of material which would potentially be imported was retained from the *YG* gravel quarry (Disposition No.900101) located at km 354.3 RHS of North Klondike Highway #2.

The results of the sulphate ion content analysis have been attached in Appendix C.

3.0 SITE CONDITIONS

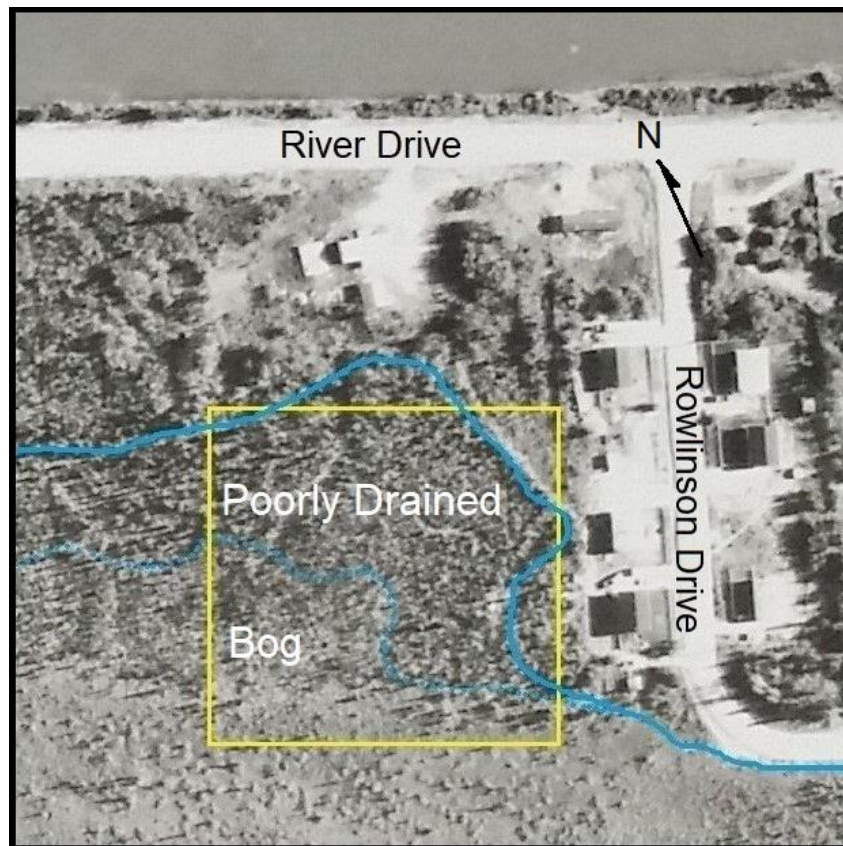
Details regarding the physiographic and geomorphic settings can be found in our December 27th, 2018 Geotechnical Feasibility Assessment report along with a description of the site.

The sub-surface conditions which were encountered during our evaluation have been summarized as follows;

3.1 Soil Stratigraphy

The soils located within the study area are comprised of alluvial floodplain deposits. In general, these deposits are comprised of gravels which are overlain with fine-grained soils which have been deposited as a result of meandering river/alluvial processes.

Based upon additional airphoto analysis and our field observations, it appears a bog is present within the southern realms of the lot. Poorly drained soils dominate the remainder of the lot. The approximate distribution of this terrain has been illustrated in the 1986 airphoto attached below.



There were two regions located in the eastern realms of the study area (Areas A – Figure 3) where it appears coarser grained surficial deposits overlies the gravels. These coarse-grained deposits are likely similar in composition to the fills which cover the northern periphery of the study area. The approximate distribution of the coarse-grained surficial deposits and fills have been illustrated in the figure, below;



Considering the boreholes were advanced in regions where the site elevations were approximately 1.5 meters higher than the prevailing grades (due to the presence of imported fills), any references to depths in the following discussions are relative to the prevailing grade of the original ground surface unless otherwise noted.

Fine-grained Alluvial Floodplain Deposits

The fine-grained alluvial floodplain deposits were generally classified as silts which contained varying amounts of clay, sand and gravel. While the majority of these fine-grained deposits were characterized as being non-plastic (as determined through Atterberg limit analysis), silty clay to clayey silt soils which exhibited slight plasticity was noted in test pit TP 2-19 (Sample No.8). This sample contained 13.4% clay as determined through hydrometer analysis.



On average, these fine-grained deposits extended to a depth of approximately 1.96 meters below the prevailing grades. However, as with all alluvial deposits, these soils (which may also consist of organic-rich materials) may extend to greater depths as a result of channel infilling.

The average moisture content of the fine-grained deposits was noted to be 22.9 % by weight (but varied between 19.3 and 29.3 %), indicating generally wet soil conditions.

Based upon the SPT N-value which was obtained from borehole BH 2-19, the relative density of these soils (above the groundwater table) was noted to be firm. These soils will likely be soft where encountered below the groundwater table.

Granular Alluvial Floodplain Deposits

The granular alluvial floodplain deposits were predominately comprised of sandy gravels which contained some silt. At times, the soils within this deposit were comprised of silty sandy gravels to gravelly sands with a trace of silt. While these granular deposits were comprised of silty sands (which contained up to some gravel) beyond a relative depth of ~ 5.25 meters in borehole BH 1-19, the sandy gravels were encountered to the (6.12 m) depth of borehole termination in borehole BH 2-19.

The deposits contained a 1.1 to 1.3 meter thick zone where cobble (to potentially boulder) sized materials were encountered. This zone was encountered at a depth of 3.5 and 4.6 meters (relative to the prevailing grades) in boreholes BH 1-19 and BH 2-19, respectively. As with all alluvial deposits, these cobble to boulder sized materials could be encountered any depth.

The average moisture content of the granular deposits was noted to be 9.6 % by weight (but varied between 4.2 and 14.5 %), indicating generally wet soil conditions.

Based upon the SPT N-value which was obtained from borehole BH 2-19 at a relative depth of ~2.7 meters, the relative density of these soils was noted to be compact.

Surficial Organics

The above noted deposits were overlain by wet organic silt and organic deposits which measured up to 300 mm thick. These organic deposits may be thicker in other regions of the site.



Fills/Coarse-Grained Surficial Alluvial Deposits

Approximately 1.5 to 1.8 meters of fill was encountered on the northern periphery of the site. These fills were classified as silty sandy gravels (which contained up to 34.3% fines by weight). As the majority of these fills extend onto Lot 16 located to the north, it's likely they're remnants of the excavation spoils which emanated from construction of the condominium building located on Lot 16.

As these coarse-grained soils were more resistant to erosion than the fine-grained alluvial deposits, it's likely that these materials would be similar in composition to those which would be found in the eastern realms of the site (Areas A – Figure 3).

3.2 Groundwater

Groundwater was encountered in each of the test pits and boreholes at depths which ranged between 1.2 (TP 1-19) to 1.5 (BH 1-19) meters. Considering the sites proximity to the Yukon River, it's anticipated that the groundwater levels at the site will be directly related to those of the river.

Measurements of a groundwater monitoring well which was installed in borehole BH 2-19 (to a depth of ~7.11 meters) revealed groundwater was located 3.02 meters below the adjacent ground surface. Considering the presence of approximate 1.5 meters of fill which overlay the site at this location, the depth of the groundwater relative to the prevailing original ground surface equates to approximately 1.5 meters.

The groundwater appeared to be encountered at progressively shallower depths towards the southern limits of the site where a poorly drained (bog) region is located.



Information retained from the *EBA* report suggests groundwater elevations will be lower during the winter months. Specifically, they indicated groundwater was encountered at a depth of ~3.2 meters during their February 6th, 1995 investigation.



3.3 Bedrock

There was no indication of bedrock in any of the test pits or boreholes which were excavated/drilled.

3.4 Permafrost

Carmacks is located in a zone where extensive discontinuous permafrost may be present (as identified in the Permafrost Map of Canada - Heginbottom et al, 1995).

While permafrost was not encountered during our subsurface investigation at our test pit or borehole locations, ice-rich permafrost was encountered in the south-eastern realms of the site in fine-grained silty sands during the 1995 test pit program which was conducted by *EBA Engineering Consultants Ltd.* (EBA - File No.0201-11730). This permafrost was classified by *EBA* as Vr & (30%) Vs relative to the *NRC* classification system for frozen soils. These classes are described by the *NRC* system as follows;

- Vr – Visibly segregated ice (less than 25 mm thick) with random or irregularly formed ice formations.
- Vs - Visibly segregated ice (less than 25 mm thick) with stratified or distinctly oriented ice formations.

It's possible permafrost may still be present in regions of the site which are heavily shaded and/or are well insulated by organic cover.

4.0 DISCUSSIONS

4.1 Development Potential

Relative to conventional construction methodologies, the lot will not be suitable for development due to the presence of surficial organics, volcanic ash, fine-grained soil deposits and potentially frozen soils. However, as these soils are underlain with a granular alluvial floodplain deposit (which was encountered ~ 2 meters below the prevailing site grades), the northern (approximately) two-thirds of the lot (Areas A & B – Figure 3) could be developed through progressive excavation/backfill (pre-grading) operations. The southern third of the lot (Area C – Figure 3) would not be suitable for development due to the presence of a bog which extends into this region.

Subdivision of the lot would not be feasible until completion of pre-grading operations, road construction and subsurface utility installations.

Excavation/backfill operations would need to be initiated from the northern side of the lot and systematically progress towards the south. During this time, the deleterious (organic, fine-grained and frozen) soils which overlie the granular alluvial deposits would need to be excavated and replaced with imported granular fill to allow for lot development. While the depth of excavation will be in the order of two (2) meters, the thickness of established backfill should measure in the order of three (3) meters.

Excavation/backfill operations will be challenging as shallow groundwater is anticipated. If groundwater is encountered at the base of the excavation(s), the initial lift(s) of backfill will need to be comprised of an approved drain/blast rock (similar in size to a Class I rip-rap) which is placed upon a geotextile fabric. This geotextile fabric should be overlapped as the backfill progresses towards the south.

If channel infilling is encountered, these regions will need to be sub-excavated if they contain organics, fine-grained soil deposits or as otherwise may be determined by the retained geotechnical consultant.

Additional efforts would be required in the northern realms of the site in order to remove overlying fills which were present in this region (as described in Section 3.1, above) such that the underlying deleterious materials can be removed.



As the soil conditions in Area A (Figure 3) are anticipated to be comprised of silty sandy gravels, these soils may also need to be removed as they may have poor engineering properties relative to lot development.

The establishment of approved granular fills should allow for subsequent lot development to construct residences, roadways and parking areas in Areas A & B. Lot development in Area C will not be feasible given the presence of shallow groundwater and poor subgrade conditions which would be encountered in this area. These poor soil conditions would likely preclude road construction and subsurface utility installations through (and immediately beyond) this area.

4.2 Building Foundations

As shallow groundwater was encountered at the site, the construction of basements will not be feasible. The incorporation of shallow crawlspaces would need to be carefully considered.

As it's anticipated that the deleterious soils which are located above the granular alluvial floodplain deposits will be replaced with engineered fills, buildings can be constructed utilizing conventional footing or monolithic-slab concrete foundation systems which are designed and constructed as described herein.

4.3 Sulphate Ion Analysis

The total sulphate ion content of a single soil sample was determined by our laboratory sub-consultant *Golder Associates Ltd.* in accordance with *CSA Standard A23.1 – 3C*. The purpose of the analysis was to assess the aggressiveness of soils, which would potentially be imported to develop the site, relative to cast-in-place concrete. The sample was comprised of sandy gravel which was retained from the *YG* gravel quarry (Disposition No.900101) located at km 354.3 RHS of North Klondike Highway #2. The sulphate ion content analysis of this sample revealed the total sulfate ion content was 0.06 %.

As this value is lower than 0.10 % threshold set forth by the *American Concrete Institute – Building Code Requirements for Structural Concrete* (ACI 318-05 – Table 4.3.1), the potential for sulphate exposure is expected to be negligible relative to these materials. As such, assuming this material is utilized as a backfill source during lot development, its anticipated that standard concrete which is designed as described herein can be utilized during the foundation work.

The results of the sulphate ion content analysis have been attached in Appendix C.

4.4 Subsurface Utility Installation

Subsurface utility installations would need to be conducted following completion of excavation/backfill operations which have been described in Section 5.1, above.

The granular alluvial floodplain deposits should allow for the installation of subsurface utilities. However, the presence of shallow groundwater will require the use of construction dewatering techniques along with drain rock and geotextile fabric in order to facilitate the utility installations. Additional consideration will be required if boulders are encountered as these materials may need to be removed during the work.

Subsurface utilities should be placed at depths >3 meters or else have equivalent insulation in order to protect them from frost. Additional thermal protection (in the form of insulated pipes, heat tape, re-circulation lines, overlying rigid insulation and other similar types of protective measures) should be considered in regions where critical infrastructure is installed.

Additional geotechnical consideration will be required relative to subsurface utility installation as the proposed route to access the lot is currently unknown.

4.5 Road Construction

The soils located within two (2) meters of the prevailing ground surface are susceptible to a loss of strength if disturbed due to their fine-grained composition and saturated conditions. As such, while a reinforced road structure which has a thickness of no less than 1.3 meters could be established upon these deposits, considering the presence of the anticipated nature of lot development (through excavation/backfill operations), the road structure should extend to the depth of the underlying granular alluvial deposits.

Additional geotechnical consideration will be required relative to road construction as the proposed route to access the lot is currently unknown.

4.6 Surface Drainage

As site development will involve excavation/backfill operations, the finished grades will need to be designed in order to ensure there is adequate surface drainage through the use of ditches/swales and site grading.

Surface waters and roof drainage should be carefully managed throughout the life of the building structures.

4.7 Potential Hazards

Given the sites proximity relative to the Yukon River, the finished site elevations should parallel those of existing lots which have been established along Rowlinson Drive and consider the 1:200-year flood event which is referenced in the *Village of Carmacks - Official Community Plan (OCP)*.

4.8 Seismic Site Response

The study area was classified for seismic site response in accordance with the *National Building Code of Canada*, based upon the information obtained during the field work program. In general, the classification is based upon the type of soils that are located below the intended structure(s) as follows:

CLASS	SOIL TYPE
A	hard rock
B	rock
C	dense soil or soft rock
D	stiff soil
E	>3 m of 'soft soil'
F	Others (liquefiable, peat, etc.)

Based upon the presence of the granular glaciofluvial plain deposits, the soils within the study area would be classified as a Class D site.

4.9 Geotechnical Evaluations

As it's anticipated that the site will be developed through excavation/backfill construction methodologies which will be overseen by qualified geotechnical personnel, there would not be a need for any additional geotechnical evaluations relative to building construction unless channel infilling is encountered during lot development.

As the lot will be connected to the municipal road and sanitary sewer systems, additional consideration may be required to verify the subsurface conditions in the



regions of the proposed routes once conceptual service designs have been formulated. The type(s) and conditions of the subsurface utilities should be verified at the locations of the proposed tie-ins through subsurface investigation to assess the in-situ conditions prior to design and construction.

Additional evaluation may be required relative to assessing building design parameters if channel infilling has occurred as should be identified during the excavation/backfill operations.

4.10 Hydrogeological Assessment

A hydrogeological study would be required to assess the suitability of the study area relative to water well installations.

4.11 Habitat Assessment

As a riparian area may be located near the southern realms of the site, a habitat assessment should be conducted by qualified personnel to identify any potential setbacks and measures to mitigate the impacts of lot development.

5.0 RECOMMENDATIONS

The following recommendations have been provided as a guideline for lot development assuming the northern two-thirds of the lot is developed through progressive excavation/backfill construction methodologies. Additional geotechnical consideration will be required as the proposed access road and subsurface utility routes are currently unknown. The soil conditions in the southern third of the lot (Figure 3 - Area C) will likely preclude road construction and subsurface utility installations through (and immediately beyond) this area.

As shallow groundwater was encountered at the site, the construction of basements will not be feasible. The incorporation of shallow crawlspaces would need to be carefully considered.

5.1 Site Development

Clearing and grubbing operations will be required to remove the existing trees/vegetation from regions where lot development is to occur. During this time, timber should be salvaged as outlined by the land use permit(s).

Clearing and grubbing operations utilizing heavy equipment will be restricted due to the presence of poor soil conditions and so hand clearing will be required. While the use of a low ground pressure tracked bulldozer could be considered during grubbing operations, as the subgrade conditions will be poor, we recommend this facet of work be conducted at the time the deleterious materials are removed from the site during the excavation/backfill operations.

Lot development will require removal of deleterious materials (which are comprised of surficial organics, fine-grained soil deposits and potential permafrost) to the (~2 meter) depth of the underlying granular alluvial floodplain deposits. Once removed, the excavation should be backfilled utilizing approved coarse grained granular backfill which is placed upon a geotextile fabric. This excavation/backfill sequence should progressively advance from the northern realms of the site (in east-west strips) towards the southern realms of Area B (Figure 3).

If channel infilling is encountered during excavation, these regions may need to be sub-excavated as directed by qualified geotechnical personnel. Specifically, sub-excavation will be required if the soils in these regions are comprised of organics or fine-grained soil deposits.



Excavation/backfill operations will be challenging as shallow groundwater is anticipated. As groundwater will likely be encountered at the base of the excavation, the initial lift(s) of backfill will need to be comprised of an approved drain/blast rock (similar in size to a Class I rip-rap) which is placed upon a geotextile fabric. This initial lift should be placed in an approximately 500 mm thick lift as approved by the retained geotechnical consultant. A second layer of geotextile fabric may need to be placed upon this initial lift depending upon its gradation.

Subsequent lifts of backfill should be comprised of 150 mm minus pit run which is placed and compacted to a minimum of 95% of the materials corresponding maximum Proctor dry density at (or within $\pm 2\%$ of) the materials optimum moisture content. This material should be placed in uniform, level lifts that do not measure greater than 150 mm thick, as measured following compaction.

5.2 Deleterious Materials

The surficial organics, volcanic ash and fine-grained soil deposits and potential permafrost which overlie the granular alluvial floodplain deposits are deleterious and so should be replaced with imported granular fills as described herein. As these deleterious soils are wet to saturated, they will need to be removed from the site and wasted. As the hydrometer analysis indicated that some of these soils are comprised of 13.4% clay, their overall engineering properties will be poor and so they may be difficult to handle during removal operations.

As the fills which are located in the northern realms of the lot are comprised of silty sandy gravels, these materials would also be considered deleterious. However, they could be utilized as general purpose (non-structural) fill as approved by the retained geotechnical consultant. If the soils encountered in Area A (Figure 3) are similar in composition to the fills, while deleterious, they could also be utilized as non-structural fill as approved by the retained geotechnical consultant at the time of excavation.

Saturated fills and deleterious soil deposits will need to be wasted.

5.3 Footings

Residential buildings may be supported by continuous and spread footings with slab-on-grade concrete foundation systems constructed in accordance with the recommendations contained herein.

Founding Strata

Deleterious materials should be sub-excavated to expose a uniform level sub-grade surface comprised of approved granular alluvial floodplain deposits or engineered fills.

Allowable Bearing Pressure

The net allowable bearing pressure should not be greater than 110 kilopascals for conventional strip footings or 130 kilopascals for spread footing types of foundation systems. These figures include the total of all live and dead loads.

Structural Fill

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

All deleterious materials below the slab-on-grade components should be sub-excavated to the depth of the approved founding strata and replaced with structural fill as recommended herein.

Interior backfill (below the slab components) should be comprised of the following;

THICKNESS ^A	COMPACTION ^B	COMPOSITION
100 mm	100 %	20 mm minus crushed granular aggregate, Overlying
200 mm	100 %	80 mm minus sub-base course aggregate, Overlying
As required	100 %	200 mm minus pit run, Overlying
NA	95 % (or as directed)	approved subgrade

Notes;

^A – The thickness of the granular pad should be uniform throughout its entirety. All materials should be placed in uniform, level lifts that do not exceed 150 mm in thickness, as measured following compaction. The exception to this would be the 200 mm thick layer of 80 mm minus

granular aggregate which can be placed in a single lift so long as adequate compaction is attained.

^B – Indicates percent compaction relative to the materials Proctor maximum dry density at (or near, $\pm 2\%$) its optimum moisture content.

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

Slab Components

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

Differential Movements

Foundations constructed in accordance with the recommendations contained herein may experience differential movements in the order of (+/-) 25 mm.

Lateral Earth Pressures

The foundation walls (and potentially other retaining walls) should be designed to resist lateral earth pressures.

Walls will be subjected to lateral earth pressures in an ‘at-rest’ condition and thus should be designed to withstand these pressures. The lateral earth pressure is linear and can be calculated at a given depth ‘H’ below the ground surface as;

$$P_0 = k_0(\gamma_s H + Q)$$

where: P_0 = Lateral Earth Pressure ‘at-rest’ condition

with no movement at given depth H (in kPa)

k_0 = coefficient of earth pressure ‘at-rest’ condition
(utilize 0.45 for granular backfill)

γ_s = unit weight of soil

(utilize 22.5 kN/m³ for granular backfill)

H = depth below finished grade (m)

Q = other surcharge pressures at finished grade (in kPa)

The above noted calculation assumes static conditions and that the backfill remains in a drained (unsaturated) condition.

The height of the backfill between the interior and exterior sides of wall components should not measure greater than 300 mm during construction such that undesirable lateral forces are not induced.

Weeping Tile System

A weeping tile system should be incorporated into the foundation design given the presence of shallow groundwater.

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

Residential buildings may be supported by monolithic slab foundation systems which are founded on an approved subgrade which is prepared in accordance with the recommendations provided herein.

Founding Strata

Deleterious materials should be sub-excavated to expose a uniform level sub-grade surface comprised of approved granular alluvial floodplain deposits.

Allowable Bearing Pressure

The net allowable bearing pressure should not be greater than 140 kilopascals for a monolithic slab type of foundation system. This figure includes the total of all live and dead loads.

Structural Fill

Monolithic slabs should be founded upon a structural granular pad comprised of the following;

THICKNESS ^A	COMPACTION ^B	COMPOSITION
200 mm ^C	100 %	20 mm minus crushed granular aggregate, Overlying
400 mm	100 %	80 mm minus sub-base course aggregate, Overlying
As required ^D	100 %	200 mm minus pit run, Overlying
NA	95 % (or as directed)	approved subgrade

Notes;

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

^B – Indicates percent compaction relative to the materials Proctor maximum dry density at (or near, $\pm 2\%$) its optimum moisture content.

^C – This thickness should be maintained below both the central slab and peripheral thickened slab components.

^D – Should extend to the depth of approved sub-grade material such that the thickness of the granular pad and insulation is equivalent to 3 meters.

The above noted structure assumes the presence of a 200 mm thick reinforced concrete slab which incorporates a thickened edge of slab component.

Differential Movements

Foundations constructed in accordance with the recommendations contained herein may experience differential movements in the order of (+/-) 25 mm.

5.5 Excavations

Excavations should be conducted utilizing a heavy tracked excavator equipped with a smooth lipped (clean-up) bucket in order to minimize disturbance of the sub-grade materials.

The sub-grade materials are subject to a loss of strength if they are disturbed (or become wet/saturated or desiccated). As such, equipment should not be allowed to operate directly on the sub-grade surfaces.

Loose, disturbed, remolded or slough materials should not be allowed to remain in prepared excavation(s). Disturbed materials should be sub-excavated to expose a suitable founding surface approved by the retained geotechnical consultant. If a suitable founding surface cannot be prepared through mechanical means, then hand cleaning may be necessary.

Excavation difficulties are not generally anticipated so long as seasonal frost is not encountered. However, large boulders may be encountered within the granular alluvial deposits depending upon the depth of subsurface utility installation. As shallow groundwater will likely be encountered during excavation operations, the Contractor should be prepared for excavation sidewall slough. The Contractor should be prepared to adjust their construction methodology and excavation profiles as soil and site conditions dictate.

The excavation limits will be governed by the proposed building elevation and that of the founding strata. The excavation limits should be defined by the theoretical loading footprint which can be described as a 1:1 slope which extends outwards from the building perimeter until the founding strata has been attained (plus 1 meter horizontally). This angle of repose should be reduced to 2:1 (horizontal to 1 vertical), or less, in regions where weak, fine-grained (or saturated) soil deposits are encountered.

The base of the excavation(s) should be prepared in such a manner that the sub-grade elevation does not vary. Specifically, the entire excavation should be excavated to the lowest elevation at which approved sub-grade deposits are encountered. This will allow for the establishment of structural backfill which is of uniform thickness.

The locations of sub-surface utilities should be confirmed by the retained contractor prior to excavation.

5.6 Temporary Excavations & Worker Safety

Worker safety is paramount.

Temporary excavations to conventional depths at this site should comply with current regulations under the *Yukon Workers Compensation Board - Occupational Health & Safety Act*.

The excavation sidewall (slope) stability will be dependent upon the material characteristics, configuration of the excavation and length of exposure. In general, side slopes cut at 1:1 should allow for adequate stability provided the depth of excavation does not exceed one (1) meter. Otherwise side slopes should be cut at 2:1 (horizontal/vertical). If these parameters are to be exceeded, then they should be verified and monitored by qualified geotechnical personnel throughout construction.

Slope stability will be poor if wet/saturated materials, fills or clean granular materials are encountered. As such, more gradual cut slopes may be required in these areas to minimize the potential for slope failure(s).

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

5.7 Backfill Requirements

The structural and imported fills should consist of approved, clean, inorganic, well graded sand and gravel mixtures which conform to the recommended grain size distribution noted in Appendix D.

All materials should be placed in uniform, level lifts that do not exceed 150 mm thick, as measured following compaction.

Exterior backfill should be evenly placed around the sides of the building such that the difference in backfill height between any of the sides is no more than 300 mm such that undesirable lateral forces are not induced. If interior backfill is required, the difference in backfill height on either side of the foundation wall(s) should not measure greater than 300 mm during construction unless authorized by the structural consultant.

Considering backfill will be placed adjacent to foundation walls, the compaction effort should be applied with equipment that will not compromise the foundations integrity. This may require utilizing light hand-operated compaction equipment and reducing the lift thicknesses. Exterior backfill work in these regions should not be conducted until approval is obtained from the structural consultant.

Typically backfill adjacent to wall components should not be conducted until seven (7) days have elapsed from the time of concrete placement such that adequate concrete strengths are attained.

5.8 Insulation

Care will be required to minimize the degree of potential foundation movement due to frost penetration, which is in the order of 3 meters in the Carmacks region.

Footings

Typically, frost protection is achieved through a combined use of rigid (SM Styrofoam) insulation and depth of soil cover to attain an equivalent of three



(3) meters of soil cover. As such, the thickness of rigid insulation will be dependent upon the depth of the footing.

For design purposes, two (2) inches of rigid (SM Styrofoam) insulation should be provided for every one (1) foot of soil cover which is not provided.

The rigid insulation should extend laterally no less than 1.2 m from the exterior edge of the concrete foundation walls. The thickness of insulation should be increased in regions where additional heat loss is expected, such as the corners of the building(s).

Monolithic Slab

Typically frost protection for monolithic slabs is afforded through the use of the underlying non-frost susceptible structural fills upon which the concrete slab is placed. However, as per good construction practice, some amount of rigid insulation should be placed directly below the concrete and extend laterally no less than 1.2 m from the slab edge.

As the rigid insulation is impervious, it should be placed in such a manner that a positive (2%) gradient (away from the building) is maintained to allow for proper sub-drainage. Seams of successive layers of insulation should be staggered or otherwise taped where weak zones are created.

In addition to frost protective measures, provisions should be included to protect the subsoils from excessive desiccation in regions where there is an intense degree of concentrated heat (such as potential boiler/furnace areas) to limit soil volume changes to tolerable amounts.

Subsurface utilities should be placed at depths >3 meters or else have equivalent insulation in order to protect them from frost. Additional thermal protection (in the form of insulated pipes, heat tape, re-circulation lines, overlying rigid insulation and other similar types of protective measures) should be considered in regions where critical infrastructure is installed.

All building structures should be closed to the weather and heated prior to the onset of freezing temperatures. These buildings should subsequently be heated during the winter months (and when freezing temperatures prevail) for the remainder of the building's lifespan.

5.9 Concrete

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

Based upon the results of sulphate ion content analysis, the potential for sulphate exposure is expected to be negligible. As such, it's anticipated that standard concrete which is designed as described herein can be utilized during foundation work.

While the sulphate ion content results of the sample retained from the YG granular quarry (Disposition No.900101) also indicated that the potential for sulphate exposure is expected to be negligible, the sulphate ion content of any imported fill which will be utilized during foundation construction/backfill should be assessed to verify their suitability once a source has been determined.

Normal Portland cement (C.S.A. Type 10), should be used in all concrete which is in direct contact with the soil.

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

The concrete should have a minimum 28-day compressive strength of 25 megapascals and be air entrained (~ 4 to 6 percent). This assumes a maximum aggregate size of 20 mm.

Higher strength (32 Mpa) concrete should be utilized where concrete may be subject to freeze/thaw cycles.

5.10 Structural Breaks & Reinforcing

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

Additional measures should be incorporated into the design if dynamic and/or point loads are expected. This should include thickening and reinforcing the areas of the slab

that may be subjected to these additional forces. Monolithic slabs should incorporate a thickened edge of slab component.

The slab component(s) of footing types of foundations should be structurally separated from other foundation components.

5.11 Vapor Barrier

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

5.12 Inclement Weather

The sub-grade, excavations and construction materials should be protected from drying, freezing, rain, snow, surface waters and groundwater at all times.

The sub-grade materials are subject to a loss of strength if they become wet/saturated and so caution will need to be exercised during construction. Once exposed, the sub-grade surface should immediately be covered with a structural granular course to protect it from precipitation, desiccation and/or disturbances.

5.13 Surface and Groundwater

Surface and groundwater should be removed from excavations at all times during foundation construction, subsurface utility installation and access road preparation. However, consideration could be given during the lot development component (where mass excavation/backfill operations occur) to conducting these operations ‘in the wet’ if a consistent construction methodology is employed as approved by the retained geotechnical consultant. In general, this would involve the systematic removal of deleterious materials followed by progressive placement of geotextile fabric and coarse drain rock backfill. In general, these operations should be initiated in the northern realms of the lot and progress towards the south (where shallower groundwater conditions are anticipated).

As groundwater will likely be encountered during construction, the Contractor should be prepared to undertake construction dewatering measures to ensure a dry working area is maintained. Specifically, this would include utilizing dewatering pumps, sump areas and drain rock backfill. While the use of sheet-pile wall and well-point

dewatering systems could be considered, the costs for these methodologies would likely prohibit their use.

The Contractor should be prepared to deal with ongoing excavation sidewall slough where excavations extend beyond the water table. The use of drain rock and geotextile fabric should be anticipated during subsurface utility installations and lot development.

As seasonal fluctuations will affect the groundwater regime, the Contractor should be prepared to adjust their construction methodology and excavation profiles.

Ditches and Swales

Ditches and swales should be incorporated into the design and construction phases to control perimeter, site and lot drainage.

Site Grading

The drainage in the region of building sites and roadways should be carefully controlled.

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

Surficial Cover

Exterior foundation backfill should be capped with a (200 mm thick layer of) low permeability soil or surface cover which is placed around the perimeter of building foundations following concrete placement in non-structural regions. The low permeability soil/surface cover will assist in directing surface waters away from the foundation and limits of the former excavation. The backfill should be placed to protect the sides of concrete slabs and prevent undermining of the slab during periods of heavy precipitation/run-off.

Eaves troughs

Eaves troughs should be incorporated into the building roof structures. The outlets from the roof drains should extend a minimum of 3.0 meters away from the building structures such that the discharged water is directed away from the structures.



5.14 Culvert Installations

Corrugated steel pipe (CSP) culverts should be incorporated where lot accesses and drainage is required in order to maintain positive drainage.

Culverts should be placed upon a 300 mm thick layer of clean bedding sand. This bedding sand should encompass the culvert such that a protective annulus which is no less than 300 mm thick is established around the culvert. The bedding sand should conform to the grain size specifications provided in Appendix D.

Culvert bedding and backfill should be placed in 150 mm thick lifts compacted to 95% of the materials maximum proctor dry density at (or near $\pm 2\%$) of the material's optimum moisture content.

Culverts should have a minimum soil cover of 500 mm.

The culvert inlet and outlet areas should be covered with protective rip-rap in accordance with good design and construction practices.

5.15 Roads & Parking Areas

The following road structure has been recommended assuming the lot will have been developed through excavation/backfill operations utilizing approved granular fills which were placed and compacted as described herein. As such, the structures for road and parking areas should be comprised of the following granular courses;

UNIT	THICKNESS	COMPACTION ^C	COMPOSITION
Base	200 mm ^A	100 %	20 mm minus crushed granular aggregate, overlying
Sub-base	300 mm	98 %	80 mm minus sub-base course aggregate, overlying
Sub-base	As required ^B	95%	150 mm minus pit run, overlying
Sub-grade	NA	95 %	approved sub-grade materials

Notes;

^A – This thickness can be reduced to 150 mm in driveways and parking areas.

^B – This sub-base layer should extend to the underlying approved engineered fills. Its thickness will depend upon the finished design elevations.

^C – Indicates percent compaction relative to the materials Proctor maximum dry density at (or near, $\pm 2\%$) its moisture content. All materials should be placed in uniform, level lifts that do not exceed 150 mm thick, as measured following compaction.

Roadways, driveways and parking areas should be designed to incorporate a minimum of 2% crowns such that positive drainage is provided.

If native fine-grained soils are encountered in regions beyond the limits of the lot, the ditch backslope should be constructed at 3 to 1 (horizontal to vertical) slope to minimize the potential for slough. This angle of repose may need to be reduced as dictated by the soil conditions which are encountered at the time of construction.

If bituminous surface treatment (BST) of the roadway(s) is to be considered, we recommend that it is applied no earlier than one year following road construction to allow time for consolidation/settlement.

5.16 Temporary Stockpiles

Stockpiled materials that may be utilized during construction should be protected from segregation and the ingress of snow, frost, rain and surface waters.

5.17 Subsurface Utility Installations

As the soil condition within the study area are poor, subsurface utility installations would need to be conducted following completion of excavation/backfill operations which have been described in Section 5.1, above.

New subsurface utility lines should be installed at a depth equivalent to 3 meters of soil cover and protected from frost. Where critical infrastructure is required, these lines should be well protected from frost through the use of insulated pipes, heat tape, re-circulation lines, overlying rigid insulation and other similar types of protective measures as determined by a qualified municipal engineer.



As groundwater will likely be encountered during subsurface utility installation, the use of (clear stone) drain rock encased in geotextile filter fabric should be utilized to bed the utility pipes. If groundwater is absent at the depth of installation, then the utility pipes can be placed upon a base of bedding sand which measures 300 mm thick. The bedding sand should extend a minimum of 300 mm around the pipe (to form a protective annulus). The drain rock and bedding sand should conform to the grain size specifications provided in Appendix D.

Any organics or fine-grained soils which are encountered during subsurface utility installations will not be suitable for use as trench backfill and so should be wasted.

The trench backfill should be comprised of an approved pit run in regions where trenches intersect building (or road) load envelope(s). Cobbles larger than 150 mm in size should not be placed within 1 meter of the utility pipes.

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

5.18 Construction Schedule

As lot development will require excavation/backfill operations to replace the deleterious materials which overlie the granular alluvial floodplain deposits, these activities should be scheduled for the early spring to minimize the potential that groundwater will be encountered. However, additional consideration will be required at this time as seasonal frost and freezing temperatures will likely be present.

As the soil conditions within (and potentially beyond) the lot are poor, subsurface utility installations would need to be conducted following completion of excavation/backfill operations which have been described in Section 5.1, above.

Building projects which are undertaken should be closed to the weather and heated prior to the onset of freezing temperatures (and whenever freezing temperatures) prevail throughout the remainder of the building's lifespan.

5.19 Geotechnical Evaluations

Geotechnical evaluations should be conducted at any location where roads and subsurface infrastructure is proposed (where this infrastructure extends beyond the limits of the lot) to verify site-specific geotechnical parameters.

Additional evaluation may be required relative to assessing building design parameters if channel infilling has occurred as identified by the retained geotechnical consultant during the excavation/backfill operations.

The type(s) and conditions of the subsurface utilities at the locations of the proposed tie-ins should be verified through subsurface investigation to assess the in-situ conditions prior to design and construction.

5.20 Construction Monitoring, Testing and Inspection Services

Qualified geotechnical personnel should provide construction monitoring, testing and inspection services during access road construction and other earthworks which may be required during the course of lot development. Following pre-grading operations, future lot owners should retain geotechnical personnel to monitor, test and inspect building foundations and subsurface infrastructure during individual lot development to identify potential site-specific liabilities and verify good construction practices are undertaken.

5.21 Site Survey

Although topographical survey data of the site is available from 2014, a more recent survey should be conducted by qualified personnel to assist the design team in establishing site grading profiles relative to the current site conditions.

5.22 Groundwater Monitoring Program

The groundwater elevation in the (BH 2-19) monitoring well should be measured and recorded on a regular (approximately quarterly) basis and prior to construction to better characterize the groundwater regime.



5.23 Monitoring Well Decommissioning

The groundwater monitoring well should be properly decommissioned following preparation of the subdivision.

5.24 Hydrogeological Assessment

A hydrogeological study would be required to assess the suitability of the study area relative to water well installations.

5.25 Habitat Assessment

As a riparian area may be located near the southern realms of the site, a habitat assessment should be conducted by qualified personnel to identify any potential setbacks and measures to mitigate the impacts of lot development.

6.0 CONCLUSIONS

6.1 Site Suitability

Relative to conventional construction methodologies, lot development will not be feasible due to the poor conditions of deleterious soils which are present throughout the site. However, as these soils are underlain with a granular alluvial floodplain deposit (which was encountered ~2 meters below the prevailing site grades), the northern (approximately) two-thirds of the lot (Figure 3 - Areas A & B) could be developed through progressive excavation/backfill operations. The southern third of the lot (Figure 3 - Area C) would not be suitable for development due to the presence of a bog which extends into this region. These conditions would likely preclude road construction and subsurface utility installation through (and immediately beyond) this area.

During excavation/backfill operations, the deleterious (organics, volcanic ash, fine-grained and frozen) soils which overlie the granular alluvial deposits would need to be systematically replaced with imported granular fills which are placed upon a geotextile fabric to allow for lot development. These operations will be challenging as shallow groundwater is anticipated.

Subsurface utility installations would need to be conducted following completion of excavation/backfill operations as the existing site conditions will otherwise be too poor to allow for installation.

If subdivision of the lot is to occur (to allow for subsequent building construction), it should occur after the completion of pre-grading operations, road construction and subsurface utility installations.

6.2 Deleterious Materials

The surficial organics, volcanic ash, fine-grained soil deposits and potential permafrost which overlies the granular alluvial floodplain deposits are deleterious and so should be replaced with imported granular fills as described herein. These materials and saturated fills/soils will need to be removed from the site and wasted.

6.3 Surface Utilities

As it's anticipated that the lot will be developed through excavation/backfill operations, the road structure should simply extend to the depth of the underlying approved engineered fills.

Additional geotechnical consideration will be required relative to road construction beyond the limits of the lot as the proposed route is currently unknown.

The drainage in the region of building sites and roadways should be carefully controlled to direct surface water away from infrastructure.

6.4 Building Construction

As it's anticipated that the deleterious soils which are located above the granular alluvial floodplain deposits will be replaced with engineered fills, buildings can be constructed utilizing conventional footing or monolithic-slab concrete foundation systems which are designed and constructed as described herein.

As shallow groundwater was encountered at the site, the construction of basements will not be feasible. The incorporation of shallow crawlspaces would need to be carefully considered.

6.5 Sulphate Attack Potential

The sulphate ion content of proposed imported fill(s) which will be utilized during foundation construction/backfill should be assessed to verify their suitability once a source has been determined.

The sulphate ion content analysis of a sample retained from the YG granular quarry (Disposition No.900101) revealed the potential for sulphate exposure is expected to be negligible. As such, if these materials are utilized during backfill, it's anticipated that standard concrete which is designed as described herein can be utilized during the foundation work.

6.6 Subsurface Utilities

The granular alluvial floodplain deposits should allow for the installation of subsurface utilities. However, the presence of shallow groundwater will require the use of construction dewatering techniques along with drain rock and geotextile fabric in order to facilitate the utility installations. Additional consideration will be required if boulders are encountered as these materials may need to be removed during the work.

Subsurface utilities should be placed at depths >3 meters or else have equivalent insulation in order to protect them from frost. Additional thermal protection (in the form of insulated pipes, heat tape, re-circulation lines, overlying rigid insulation and other similar types of protective measures) should be considered in regions where critical infrastructure is installed.

Additional geotechnical consideration will be required relative to subsurface utility installation as the proposed route to access the lot is currently unknown.

6.7 Potential Hazards

Given the sites proximity relative to the Yukon River, the finished site elevations should parallel those of existing lots which have been established along Rowlinson Drive and consider the 1:200-year flood event which is referenced in the *Village of Carmacks - Official Community Plan (OCP)*.

6.8 Seismic Site Classification

Based upon the information obtained during the field work program the study area was classified as a Class D site for seismic site response in accordance with the *National Building Code of Canada*.

6.9 Geotechnical Evaluations

Geotechnical evaluations should be conducted at any location where roads and subsurface infrastructure is proposed (where this infrastructure extends beyond the limits of the lot) to verify site-specific geotechnical parameters.

Additional evaluation may be required relative to assessing building design parameters if channel infilling has occurred as should be identified during the excavation/backfill operations.

The type(s) and conditions of the subsurface utilities at the locations of the proposed tie-ins should be verified through subsurface investigation to assess the in-situ conditions prior to design and construction.

6.10 Hydrogeological Assessment

A hydrogeological study would be required to assess the suitability of the study area relative to water well installations.

6.11 Habitat Assessment

As a riparian area may be located near the southern realms of the site, a habitat assessment should be conducted by qualified personnel to identify any potential setbacks and measures to mitigate the impacts of lot development.

7.0 LIMITATIONS

This report is intended for the sole use of the *Yukon Government*.

No portion of this report may be used as a separate entity; it is intended to be read in its entirety.

Any use of this report by a third party is the responsibility of such third party.

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

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

It is important to emphasize that the geotechnical investigation component of any evaluation is, in fact, a random sampling of the site and that subsequent discussions and assessments of the retained information are based upon the results obtained at the sample locations. Due to the geomorphological nature of the deposits which were encountered, interpolations of the subsurface conditions between the test locations have not been made or been implied.

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

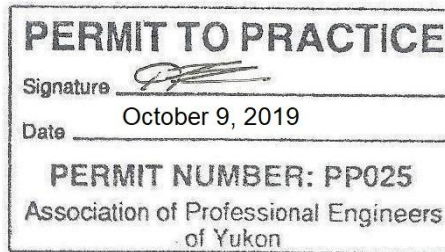
8.0 CLOSURE

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

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

Respectfully Submitted,

CHILKOOT GEOLOGICAL ENGINEERS LTD.



Tares Dhara, P.Eng.
Senior Geotechnical Engineer

TD/td

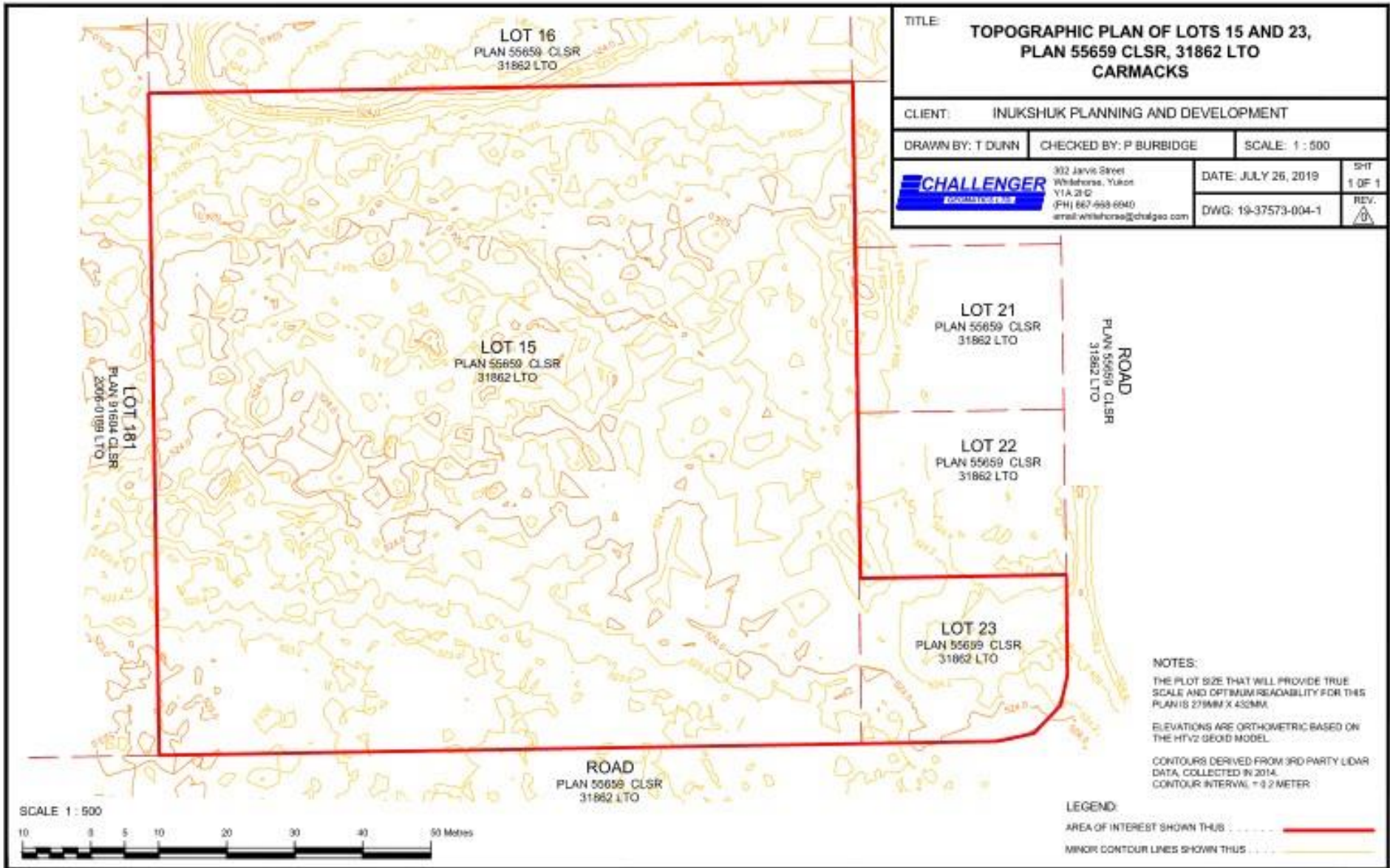


Geotechnical Evaluation
Proposed Urban Residential Lot#15 – Carmacks, Yukon – 2019
Figure 1 – Location of Study Area





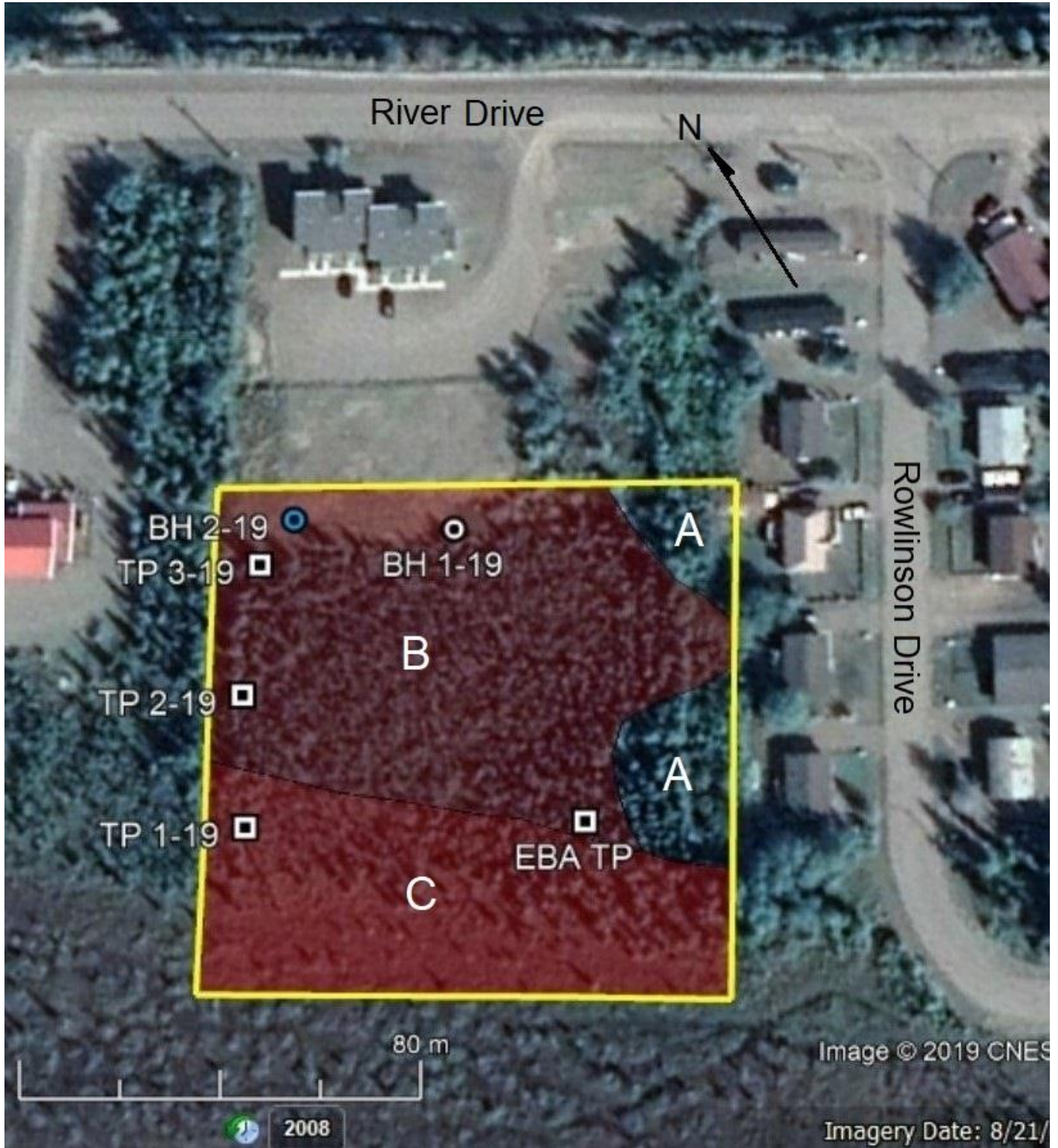
Geotechnical Evaluation
 Proposed Urban Residential Lot#15 – Carmacks, Yukon – 2019
 Figure 2 – Site Topography





Geotechnical Evaluation
Proposed Urban Lot #15
Carmacks, Yukon - 2019

Figure 3 – Site Conditions, Test Pit & Borehole Locations



Base map from *Google Earth*- Not to Scale – Locations are approximate
Compiled by T.Dhara, P.Eng. - Sept.10th, 2019



APPENDIX A

EBA Engineering Consultants Ltd. Report

Geotechnical Evaluation – Residential Expansion – Carmacks, Yukon

(EBA File No.0201-11730)

EBA Engineering Consultants Ltd.

February 23, 1994

Government of Yukon
Box 2703
Whitehorse, Yukon
Y1A 2C6

EBA File: 0201-11730

Attention: Mr. Rob Conrad, Manager, Land Development
Engineering And Development Branch

Dear Sir:

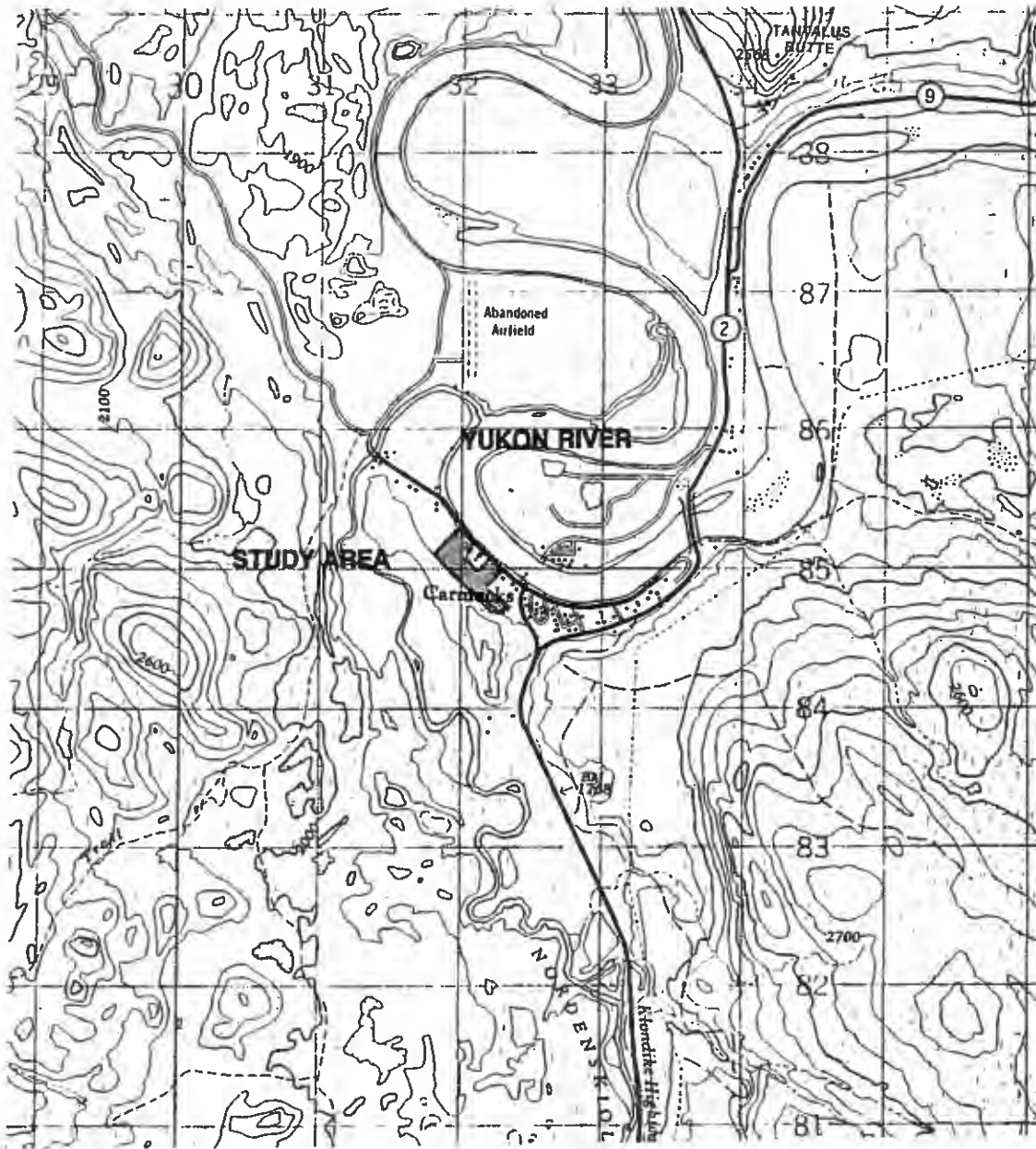
Subject: Geotechnical Evaluation
Residential Expansion-Carmacks, Yukon

1.0 INTRODUCTION

In a December 9, 1994 memorandum to YTG, Engineering and Development Branch, Mr. Ian Robertson of Inukshuk Planning & Development conveyed the wishes of the Carmacks town council to have a geotechnical investigation of the area west of Rawlinson Road along River Road completed to confirm the suitability of the area for residential expansion. The study area is presented on Figure 1, following.

EBA Engineering Consultants Ltd. (EBA) was retained to complete the geotechnical evaluation of the subject site under the authorization of Mr. Rob Conrad, Manager, Land Development, Engineering and Development Branch, YTG.

This letter report summarizes the results of this investigation, discusses the residential expansion potential of the area and presents development recommendations.



EBA Engineering Consultants Ltd.			PROJECT	RESIDENTIAL EXPANSION CARMACKS, YUKON
CLIENT			TITLE	GENERAL LOCATION MAP
GOVERNMENT OF YUKON ENGINEERING AND DEVELOPMENT			DATE	95-02-23
DWN	MCP	CHKD	DWG NO.	FIGURE 1
				0201-11730

2.0 SITE INVESTIGATION

On February 6, 1995, six testpits were excavated throughout the subject site. The testpits were excavated to depths ranging from 3.2 m to 4.2 m. A CAT 225 tracked excavator was contracted from Kando Enterprises of Carmacks to advance the testpits. Mr. M.C. Plaunt, C.E.T. was EBA's site representative. Testpits were located within each of the various terrain features encountered within the study area to provide an overview of surface and subsurface conditions.

Figure 2, following, presents the various terrain features noted during air photo interpretation and the site investigation.

3.0 EXISTING GEOTECHNICAL CONDITIONS

Detailed soils information is presented on the testpit logs and the location of each of the six testpits is presented on Drawing 11730-A-01, attached to this letter.

Generally, the subject site runs in a northwesterly direction. The physical boundaries of the site are River Road and the Yukon River at the front of the study area and the north facing toe of the ridge separating the Yukon and Nordenskiold Rivers at the back of the study area. The back half of the study area is quite typical of permafrost areas in the Yukon (characterized by the presence of thick moss ground cover and sparse, dwarf black spruce tree cover). Soil conditions in this portion of the subject site consist of up to a metre of ice rich permafrost over unfrozen but wet silts. Granular soils (gravel and sand) were noted below the silt. Groundwater was noted in each of the three testpits (TP's 1, 2 & 3) excavated in this portion of the study area. At the time of the investigation, significant glaciation of the ground surface was also noted. As well, on the airphotos utilized for this study, surface water was noted within the bermed area at the back of the developed portion of lot owned by Carl Scanlon.



<p>EBA Engineering Consultants Ltd.</p>	<p>PROJECT</p> <p>RESIDENTIAL EXPANSION - CARMACKS, YUKON</p>
<p>CLIENT</p> <p>GOVERNMENT OF YUKON ENGINEERING AND DEVELOPMENT</p>	<p>TITLE</p> <p>SITE PLAN SHOWING TERRAIN FEATURES</p>
<p>DATE 95-02-23</p>	<p>DWG NO. 0201-11730</p>
<p>DWN MCP</p>	<p>FIGURE 2</p>

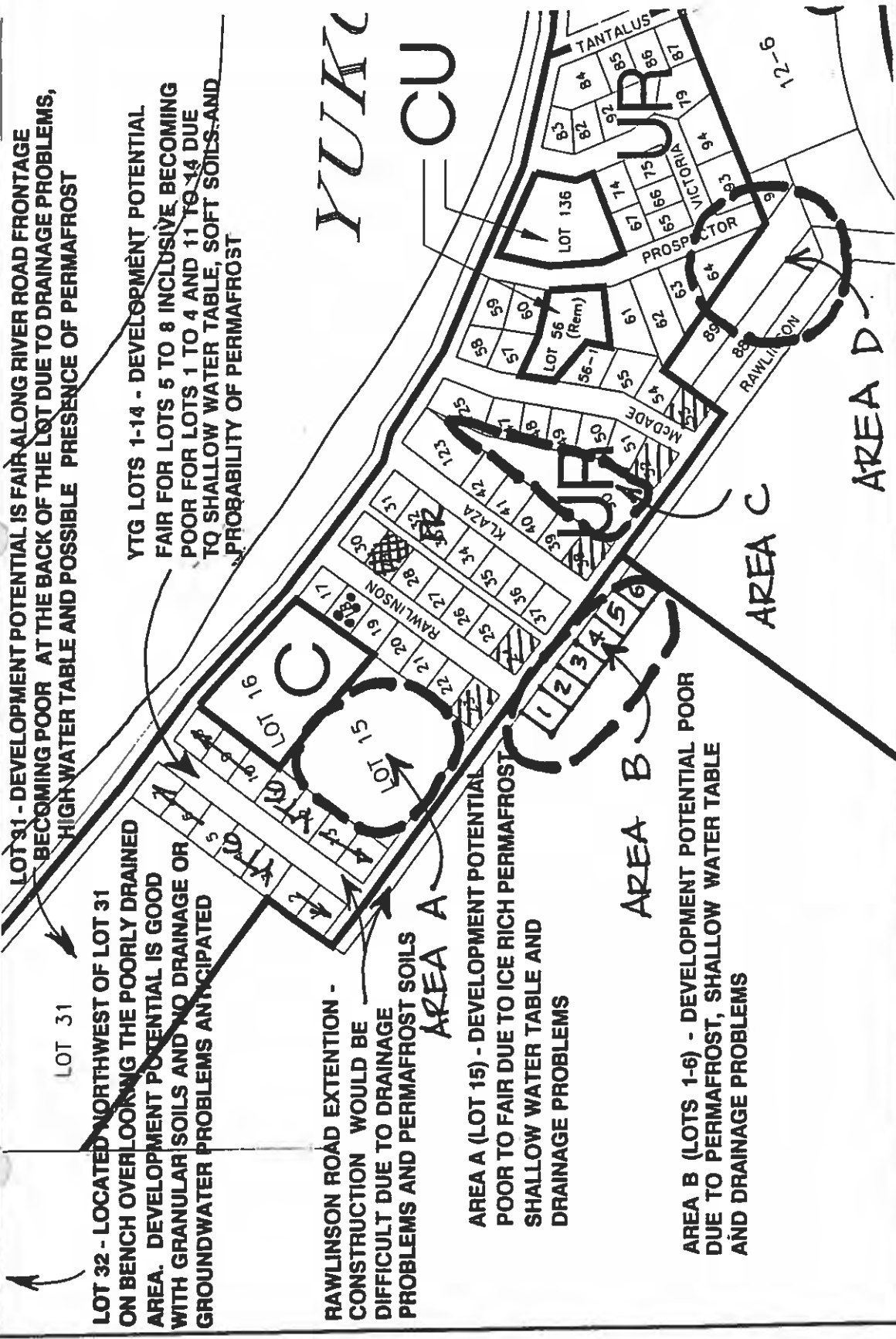
The northwest end of the study area (numbered as Lot 32 on the Zoning Map included in the Inukshuk planning report) is an elevated bench. Soil conditions in this area are comprised of up to 1.0 m of silt over granular soils. This area is covered with mature spruce and poplars and appears to be well drained.

4.0 DISCUSSION AND RECOMMENDATIONS

The Inukshuk Development Infill Needs Assessment report provided planning options for three sites within the study area contingent upon additional geotechnical information. The three areas are noted as Area A, Area B, and the YTG lots 1 to 14 as presented on Figure 3, following. The portions of these areas which are located in the wet, permafrost areas along the back of the study area will be difficult and expensive (but not impossible) to develop while available land along River Road and the upper bench located at the northwest end of the study area (Lots 31 & 32) are considered to be more conducive to development through conventional means. Recommendations for specific aspects of site development are presented below.

4.1 Area A (Lot 15)

Development of Lot 15 will require the subcut and removal of all ice rich permafrost soils and the subsequent backfill to design grade with granular materials. The silts found below the ice rich permafrost are fairly wet and soft so construction of the gravelled portions of the site will have to be completed with a minimum of disturbance to the subgrade. Utilization of a geotextile may be warranted. It is the opinion of the undersigned that the suggested trailer park option would be easier to construct but with considerable cost. The geotextile placement and gravel pad construction could be limited to the access road and trailer areas to minimize development costs. Another advantage to trailers as opposed to residential structures is that adjustments can be made to offset any movement caused by settlement or frost heave.



LOT 31 - DEVELOPMENT POTENTIAL IS FAIR ALONG RIVER ROAD FRONTAGE BECOMING POOR AT THE BACK OF THE LOT DUE TO DRAINAGE PROBLEMS, HIGH WATER TABLE AND POSSIBLE PRESENCE OF PERMAFROST

LOT 32 - LOCATED NORTHWEST OF LOT 31 ON BENCH OVERLOOKING THE POORLY DRAINED AREA. DEVELOPMENT POTENTIAL IS GOOD WITH GRANULAR SOILS AND NO DRAINAGE OR GROUNDWATER PROBLEMS ANTICIPATED

YTG LOTS 1-14 - DEVELOPMENT POTENTIAL FAIR FOR LOTS 5 TO 8 INCLUSIVE BECOMING POOR FOR LOTS 1 TO 4 AND 11 TO 14 DUE TO SHALLOW WATER TABLE, SOFT SOILS AND PROBABILITY OF PERMAFROST

RAWLINSON ROAD EXTENSION - CONSTRUCTION WOULD BE DIFFICULT DUE TO DRAINAGE PROBLEMS AND PERMAFROST SOILS

AREA A (LOT 15) - DEVELOPMENT POTENTIAL POOR TO FAIR DUE TO ICE RICH PERMAFROST, SHALLOW WATER TABLE AND DRAINAGE PROBLEMS

AREA B (LOTS 1-6) - DEVELOPMENT POTENTIAL POOR DUE TO PERMAFROST, SHALLOW WATER TABLE AND DRAINAGE PROBLEMS

CLIENT	EBA Engineering Consultants Ltd.		
PROJECT	RESIDENTIAL EXPANSION - CARMACKS, YUKON		
TITLE	SITE PLAN DELINEATING DEVELOPMENT POTENTIAL		
DATE	95-02-23	DWN	MCP
DWG NO.	FIGURE 3		0201-11730

4.2 Area B (Lots 1 to 6)

Of the six lots making up Area B on Figure 1 of the Inukshuk report, residential construction will probably be feasible for Lots 5 & 6 which are located on higher ground but permafrost, soft underlying soils and shallow groundwater make development of Lots 1 to 4 very difficult. Anecdotal information has indicated that shallow and fluctuating groundwater elevations have been a problem in the basements of a number of houses along Rawlinson and Klaza Roads.

4.3 YTG Lots 1 To 14

As stated in the Inukshuk report, the six lots closest to River Road (Lots 5 to 10) are founded on higher ground and vegetation patterns indicate that the area has some drainage. Along with the soil conditions noted for Testpit 11730-03, two boreholes drilled for YTG, Transportation Engineering Branch indicate that soil conditions along the front of the area are comprised of silts over sands or gravels below 2.0 m. An option which may be considered is the construction of a cul de sac from River Road into the site. The lots would have to be resurveyed but this would decrease the length of road required and minimize the amount of permafrost encountered during construction. The houses constructed along the bulb of the cul de sac would have to be placed on a foundation system which is comprised of the excavation of all permafrost soils and the construction of an engineered gravel pad.

4.4 Lot 31

The majority of lot 31 is being utilized as an equipment storage compound by Mr. Carl Scanlon of Carmacks. However, a small section located between Mr. Scanlon's lot and the creek located at the west edge of lot 31 could possibly be considered for infill along River Road if future truck traffic can be routed away from the area.

At the back of Mr. Scanlon's property is a berm which ties into a finger of higher land. This has created a bit of a barrier which may be one of the reasons that the south edge of the study area becomes glaciated in the winter.

4.5 Lot 32

This area has acceptable soil conditions and is definitely conducive to residential expansion. Further input should be sought from Mr. Ian Robertson of Inukshuk Planning And Development regarding design concepts and safety implications of accessing the area off of River Road.

Roadway construction in the area would require the stripping of at least 0.6 m of surficial soils which are very silty and may contain organics or volcanic ash and the subsequent construction of a 500 mm sub-base and 150 mm basecourse embankment.

4.6 Site Drainage

The problem of site drainage will have to be addressed if the study area is to be developed. The source and direction of groundwater flow in the area has not been determined as part of this investigation but it appears that steps will have to be taken to provide a channel for additional surface water to leave the area. A properly constructed ditch (with shallow sideslopes due to soil conditions and proper armouring to provide erosion protection) will have to be constructed along the base of the slope which defines the south boundary of the study site. As well, it will have to run unimpeded to the creek located adjacent to Carl Scanlon's property and subsequently into the Yukon River.

4.7 Construction Of New Road West Of Rawlinson

To be as cost effective as possible, it may be best to minimize the length of the new road to access Lot 15 only. Construction will require the subcut of all ice rich permafrost, the

placement of geotextile over the wet subgrade silts and the construction of a 500 mm sub-base and 150 mm basecourse embankment. Backslopes along the ditches should be constructed at a maximum of 3:1 (horizontal:vertical) to ensure slope stability.

4.8 **Underground Utilities Installation**

It is understood that the main reason for considering this area for development is its proximity to the sewage treatment facility. All sewer and service lines being installed will likely be founded below the groundwater table. Prospective contractors should be prepared to pump water, utilize drain rock for pipe bedding and deal with sloughing trench walls during construction. It may also be a good idea to perform a thermal analysis for the proposed system to determine adequate depth of burial and/or insulation requirements.

5.0 **CLOSURE**

It is hoped that this report satisfies your present requirements. If this area does undergo residential development in the future, EBA would be pleased to assist in the geotechnical implications of the detailed design. Terms and conditions for the use of this report are attached and if you have questions regarding the information presented here-in, please contact the undersigned.

Yours truly,
EBA Engineering Consultants Ltd.



M.C. Plaunt, C.E.T.
Engineering Technologist

MCP/mcp

**EBA ENGINEERING CONSULTANTS LTD.
GEOTECHNICAL REPORT
GENERAL CONDITIONS**

A.1 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site and development. It is not applicable to adjacent sites nor is it valid for types of development other than that to which it refers. Any variation from the site, or development, necessitates a geotechnical review in order to determine the validity of the design concepts evolved herein.

This report is not to be reproduced in part or in whole without consent in writing from EBA Engineering Consultants Ltd. (EBA). Additional copies of the report, if required, may be obtained upon request. Isolated information, logs of borings, or profiles are not to be reproduced, copied or transferred.

A.2 NATURE AND EXACTNESS OF SOIL DESCRIPTION

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

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

A.3 LOGS OF BORINGS

The boring logs are a compilation of conditions and classification of soils as obtained from field observations and laboratory testing of selected samples. Soil zones have been interpreted. Change from one geologic zone to the other, indicated on the logs as a distinct line, is in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil zone transition elevations may require special evaluation.

A.4 STRATIGRAPHIC AND GEOLOGIC SECTIONS

The stratigraphic and geologic sections indicated on drawings contained in this report are evolved from logs of borings. Stratigraphy is known precisely only at the locations of the borings. Actual geology and stratigraphy between borings may vary from that shown on these drawings. Natural variations in geologic conditions are inherent and a function of historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of exact locations of geologic units is necessary, it is cautioned that such determination requires special attention.

A.5 GROUNDWATER CONDITIONS

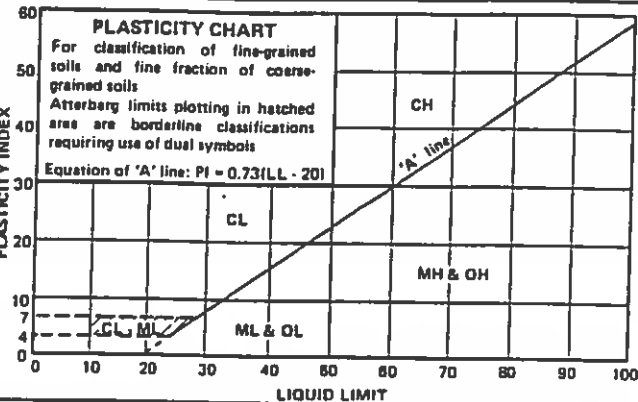
Groundwater conditions represented in this report refer only to those observed at the times recorded on logs of borings, and/or within the text of this report. These conditions vary with geologic detail between borings; annual, seasonal and special meteorologic conditions; and with construction activity. Where instruments have been established to record groundwater variations on an ongoing basis, the records will be specifically referred to. Interpretation of groundwater conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and construction activity. Deviations from these observations, may occur. No other warranty, express, or implied, is made by EBA.

A.6 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geologic materials to meteorological elements. Many geologic materials deteriorate rapidly upon exposure to climatic elements. Severe deterioration of materials may be caused by precipitation and/or the action of frost on exposures. Unless otherwise specifically indicated in this report, walls and floors of excavations must be protected from elements, particularly all forms of moisture, desiccation from arid conditions and frost action.

UNIFIED SOIL CLASSIFICATION †

MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES	CLASSIFICATION CRITERIA		
COARSE-GRAINED SOILS	More than 50% retained on No. 200 sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines GW, GP, SW, SP More than 12% pass No. 200 sieve 5% to 12% pass No. 200 sieve Borderline classification requiring use of dual symbols
			GRAVELS WITH FINES	GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines	
			SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS	SW	
		SANDS WITH FINES		SP	Poorly-graded sands and gravelly sands, little or no fines	
				SM	Silty sands, sand-silt mixtures	
		FINE-GRAINED SOILS	50% or more passes No. 200 sieve*	SILTS AND CLAYS Liquid limit 50% or less	ML	
	CL				Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
	OL				Organic silts and organic silty clays of low plasticity	
	SILTS AND CLAYS Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts		
		CH	Inorganic clay of high plasticity, fat clays			
OH		Organic clays of medium to high plasticity				
PT		Peat, muck and other highly organic soils				



GROUND ICE DESCRIPTION

ICE NOT VISIBLE

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

VISIBLE ICE LESS THAN 50% BY VOLUME

GROUP SYMBOLS	SYMBOLS	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 (1 in.) thick)	

- NOTE**
- Dual symbols are used to indicate borderline or mixed ice classifications
 - Visual estimates of ice contents indicated on borehole logs \pm 5%
 - 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



EBA Engineering Consultants Ltd.

**GOVERNMENT OF YUKON
ENGINEERING AND DEVELOPMENT**

PROJECT

RESIDENTIAL EXPANSION - CARMACKS, YUKON

TITLE

SITE PLAN SHOWING TESTPIT LOCATIONS

CHKD

MCP

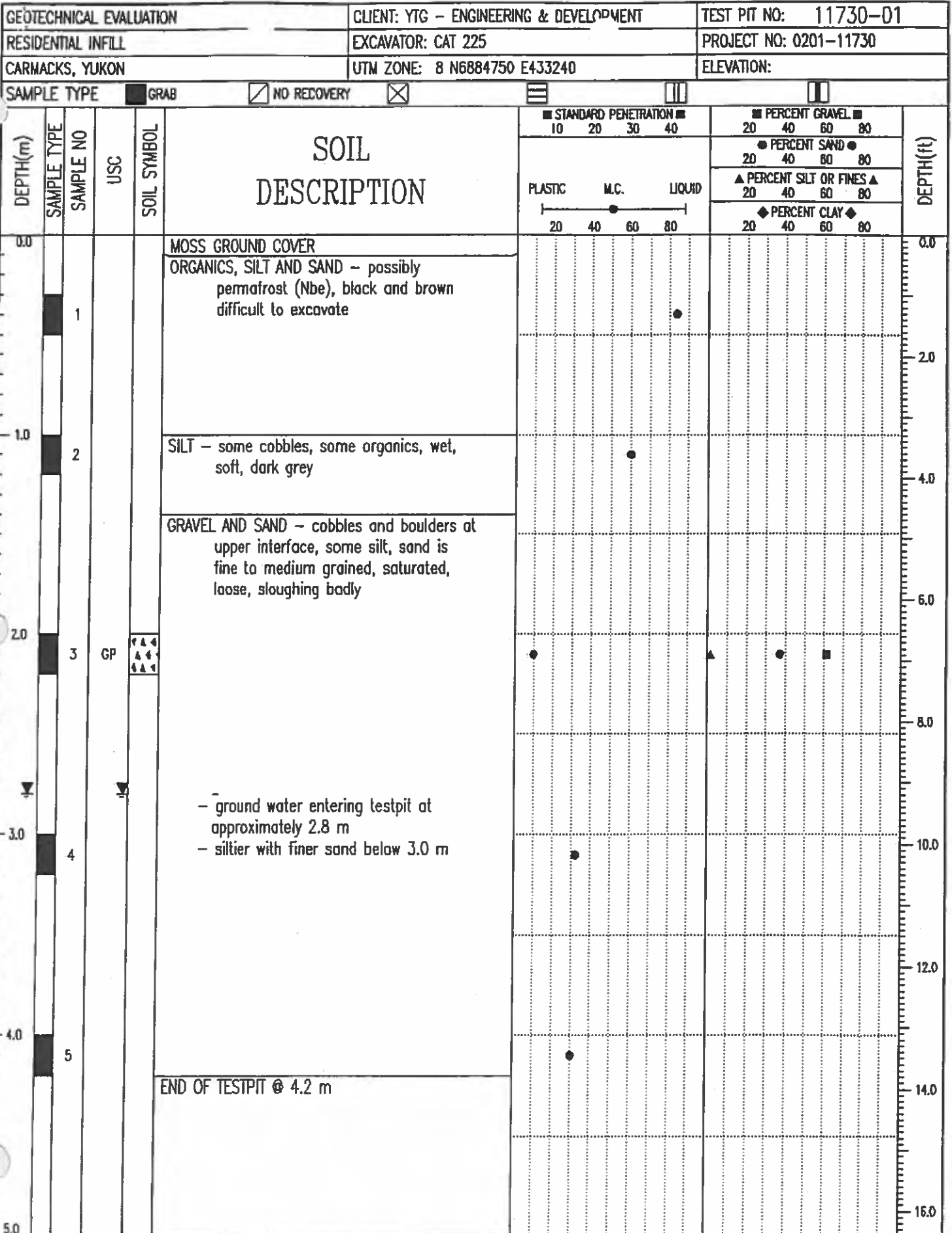
DWN

DATE 95-02-23

DWG NO.

11730-A-01

0201-11730



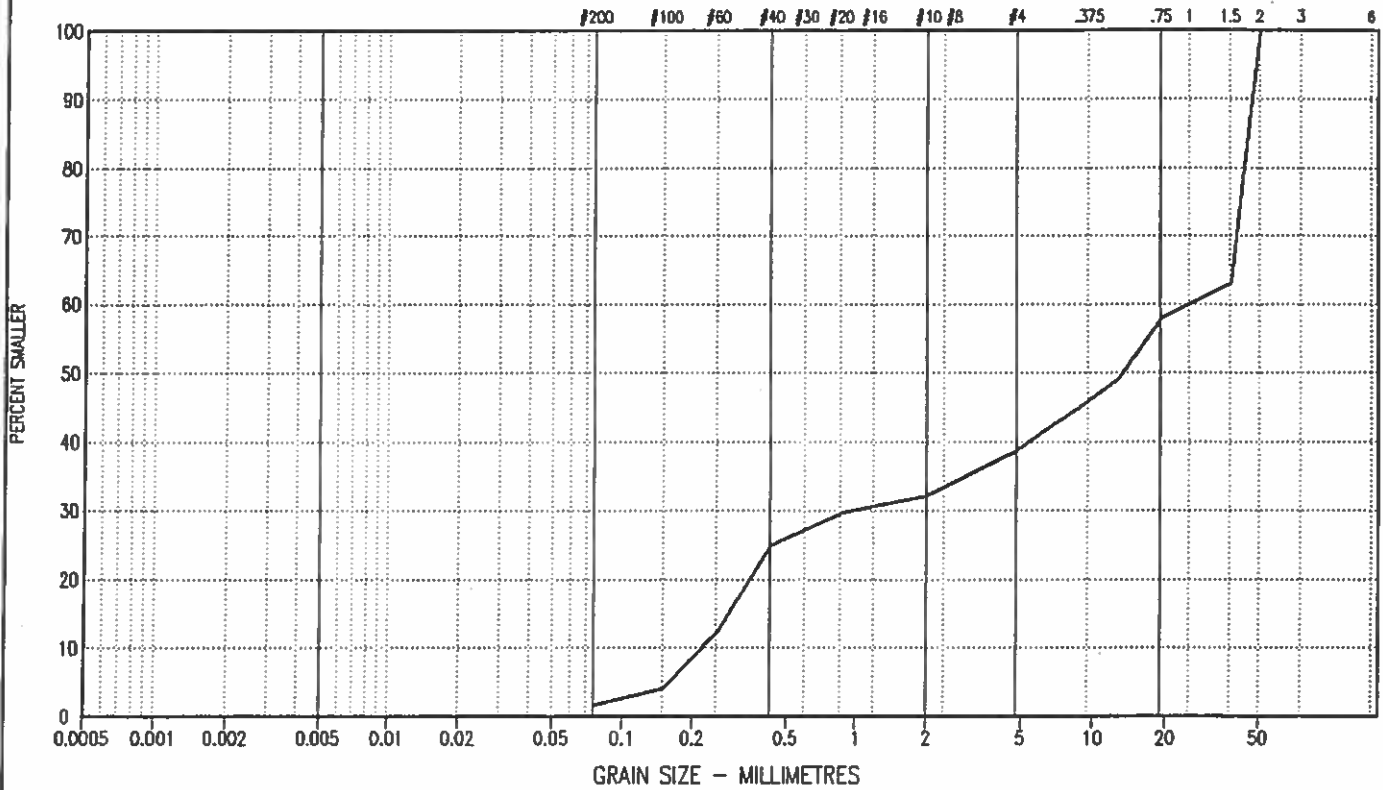
EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP	COMPLETION DEPTH: 4.2 m
REVIEWED BY: MCP	COMPLETE: 06/02/95
Fig. No:	Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—	11730-01	2.00 - 2.20	1.5	37.1	61.4	121.8	0.2	GP

Project: 0201-11730

Date Tested: 95/02/08

BY: MCP

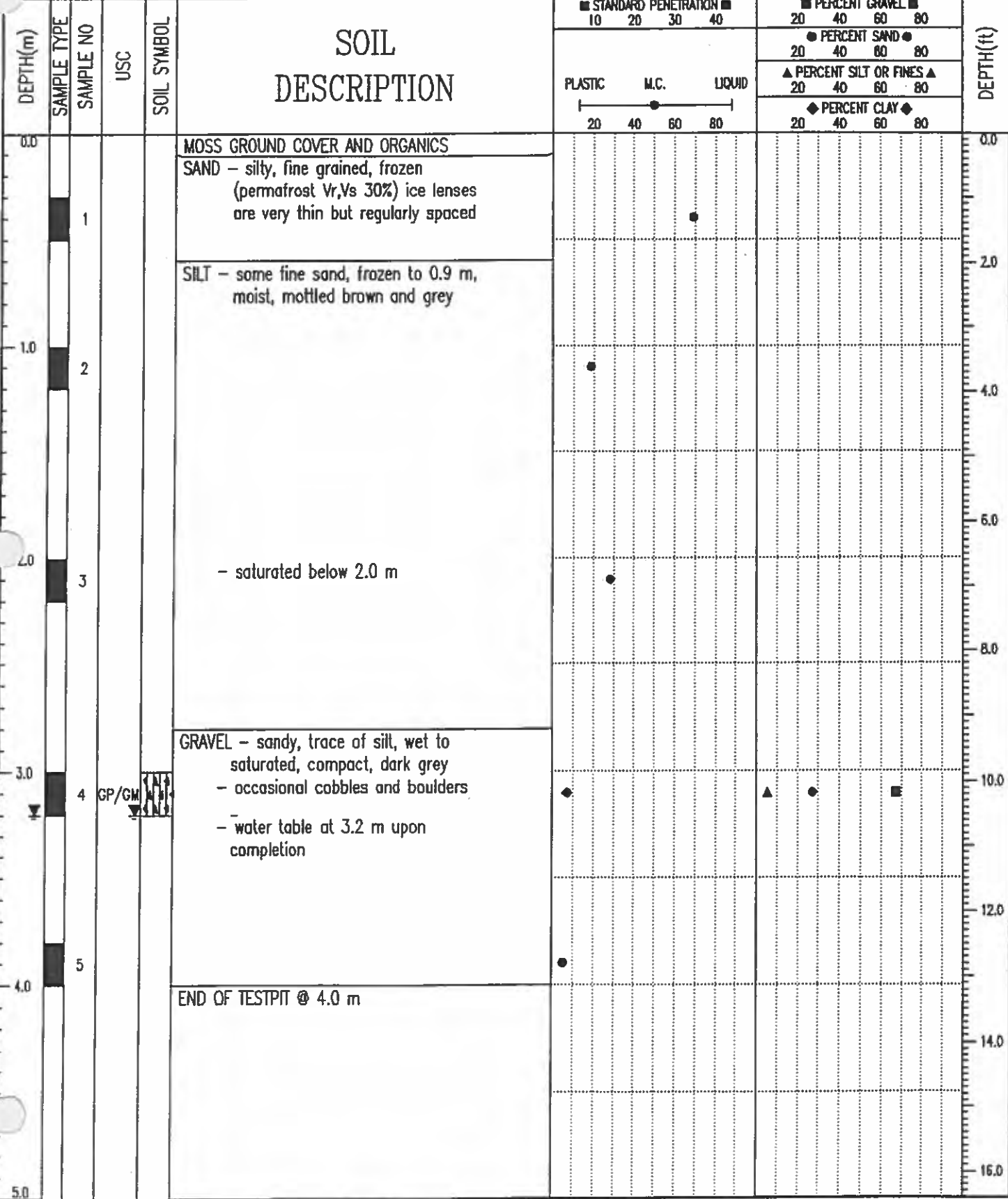
Tested in accordance with ASTM D422 unless otherwise noted.

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SAMPLE TYPE: GRAB NO RECOVERY [Symbol] [Symbol] [Symbol]



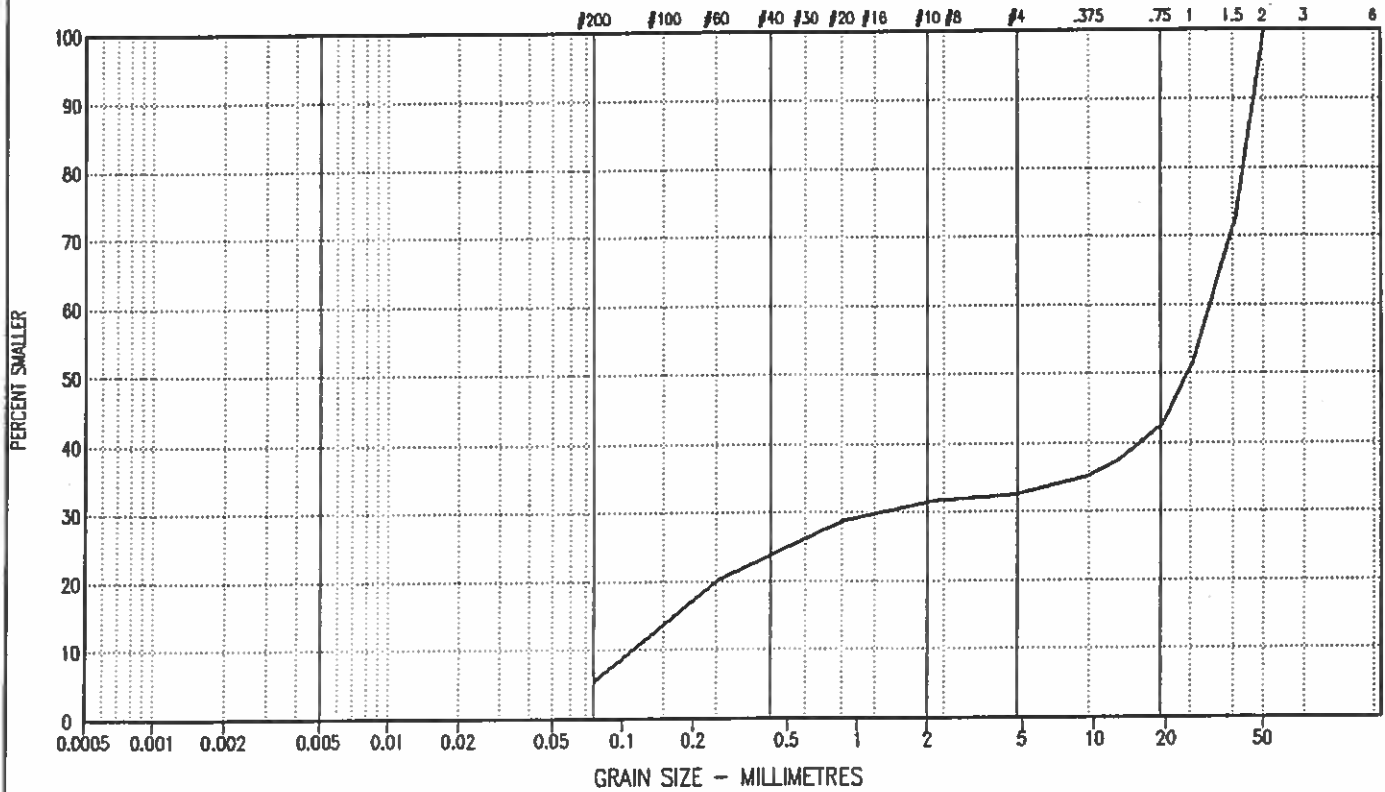
EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP	COMPLETION DEPTH: 4.0 m
REVIEWED BY: MCP	COMPLETE: 06/02/95
Fig. No:	Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—	11730-02	3.00 - 3.20	5.3	27.2	67.5	260.2	0.6	GP-GM

Project: 0201-11730

Date Tested: 95/02/08

BY: MCP

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GEO TECHNICAL EVALUATION		CLIENT: YTG - ENGINEERING & DEVELOPMENT		TEST PIT NO: 11730-03	
RESIDENTIAL INFILL		EXCAVATOR: CAT 225		PROJECT NO: 0201-11730	
CARMACKS, YUKON		UTM ZONE: 8 N6884960 E433150		ELEVATION:	
SAMPLE TYPE		<input checked="" type="checkbox"/> GRAB		<input checked="" type="checkbox"/> NO RECOVERY	
DEPTH(m)		SOIL DESCRIPTION		STANDARD PENETRATION	
SAMPLE TYPE				10 20 30 40	
SAMPLE NO				PERCENT GRAVEL	
USC				20 40 60 80	
SOIL SYMBOL				PERCENT SAND	
				20 40 60 80	
				PERCENT SILT OR FINES	
				20 40 60 80	
				PERCENT CLAY	
				20 40 60 80	
				PLASTIC M.C. LIQUID	
				20 40 60 80	
0.0		MOSS GROUND COVER AND ORGANICS - frozen, black			0.0
1		SAND AND SILT - fine grained, uniform, frozen with thin ice lenses (30% ice), may be seasonal, medium brown			2.0
2		SILT - some fine sand, frozen to 0.9 m, wet and stiff below frost, medium brown mottled with grey			4.0
3	GP/GM	GRAVEL AND SAND - some silt, occasional cobble, wet, compact, medium brown			6.0
4		GRAVEL - sandy, some silt, occasional cobble, wet to saturated with water table at 2.8 m, greyish brown			8.0
3.2		END OF TESTPIT @ 3.2 m			10.0
5.0					12.0
					14.0
					16.0

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

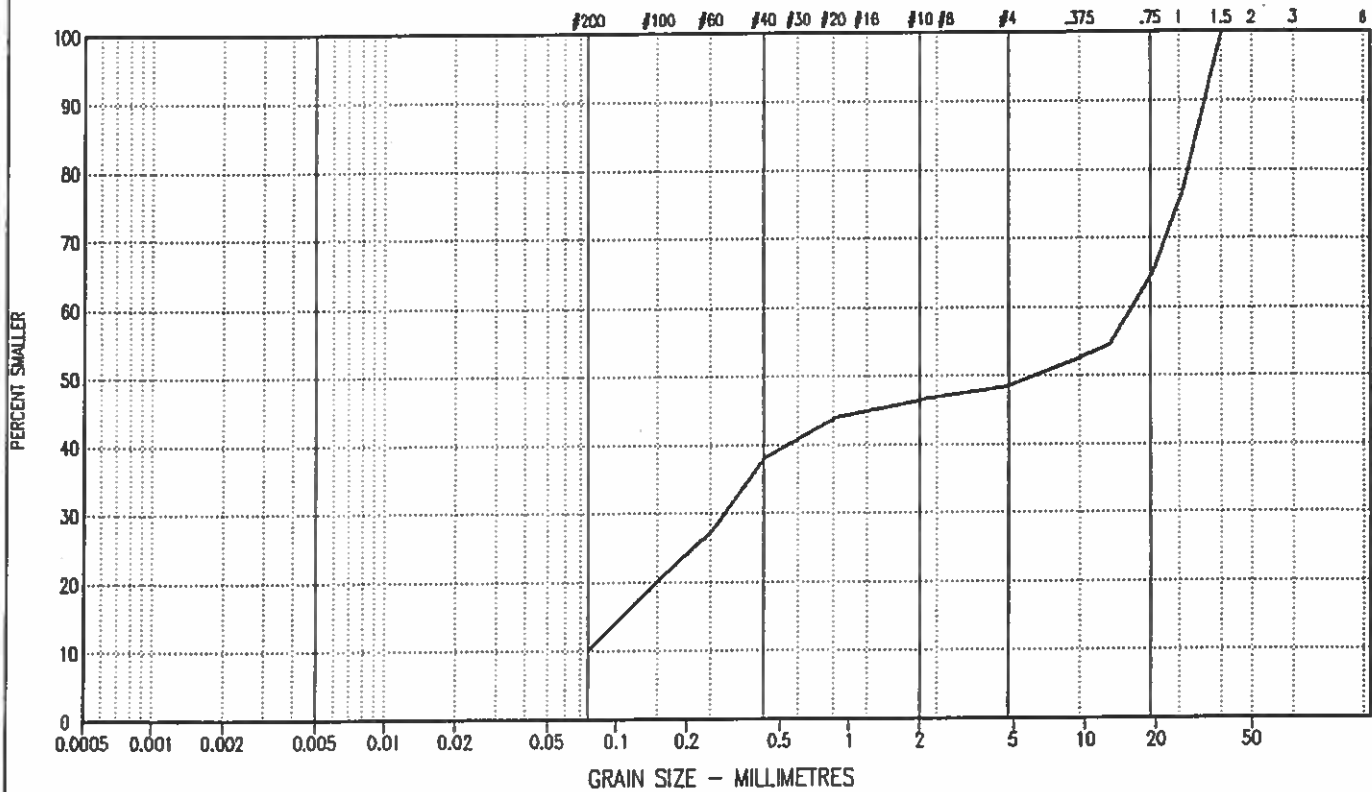
LOGGED BY: MCP
REVIEWED BY: MCP
Fig. No:

COMPLETION DEPTH: 3.2 m
COMPLETE: 06/02/95

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—	11730-03	2.00 - 2.20	10.0	38.3	51.7	216.1	0.1	GP-GM

Project: 0201-11730

Date Tested: 95/02/08

BY: MCP

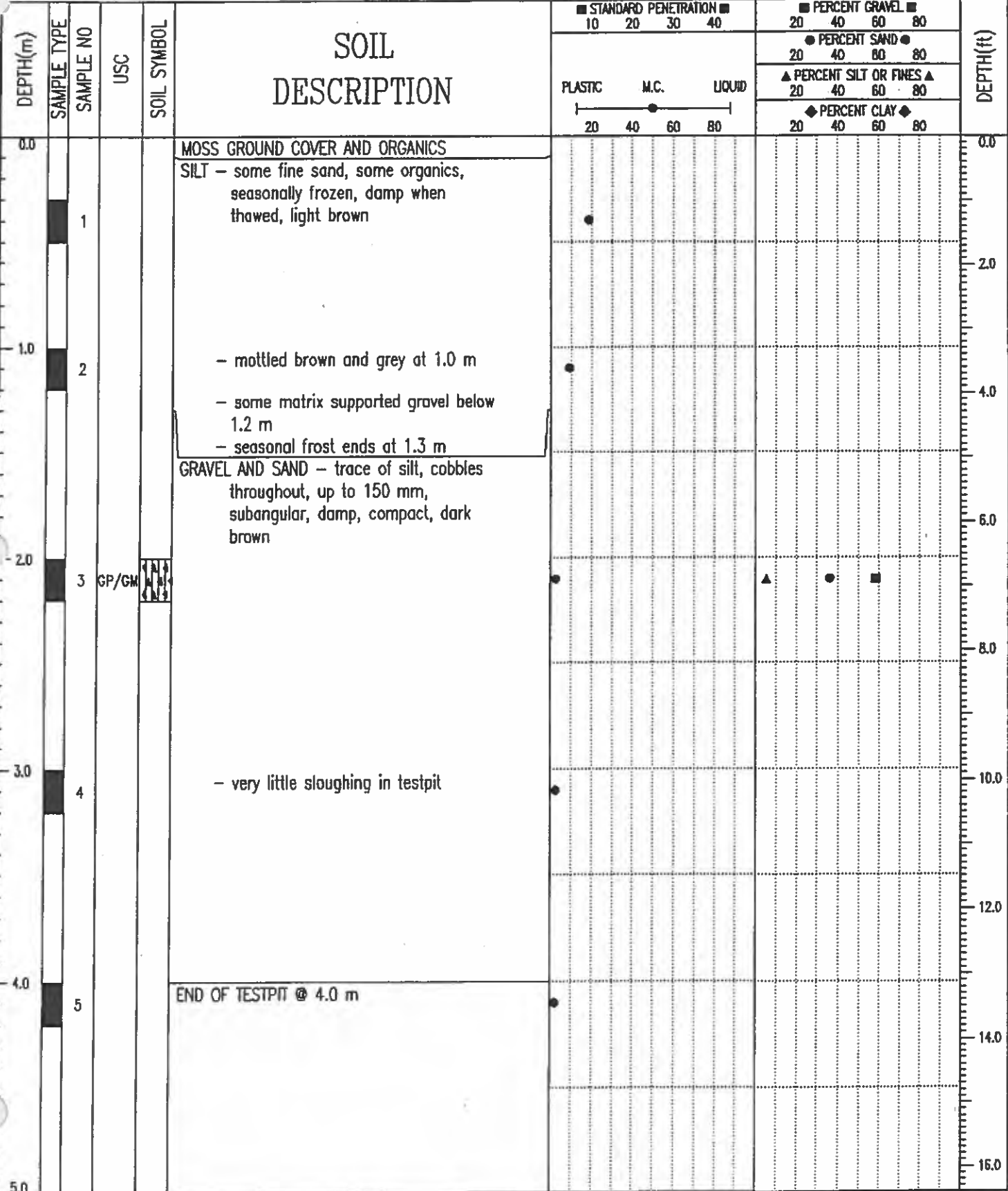
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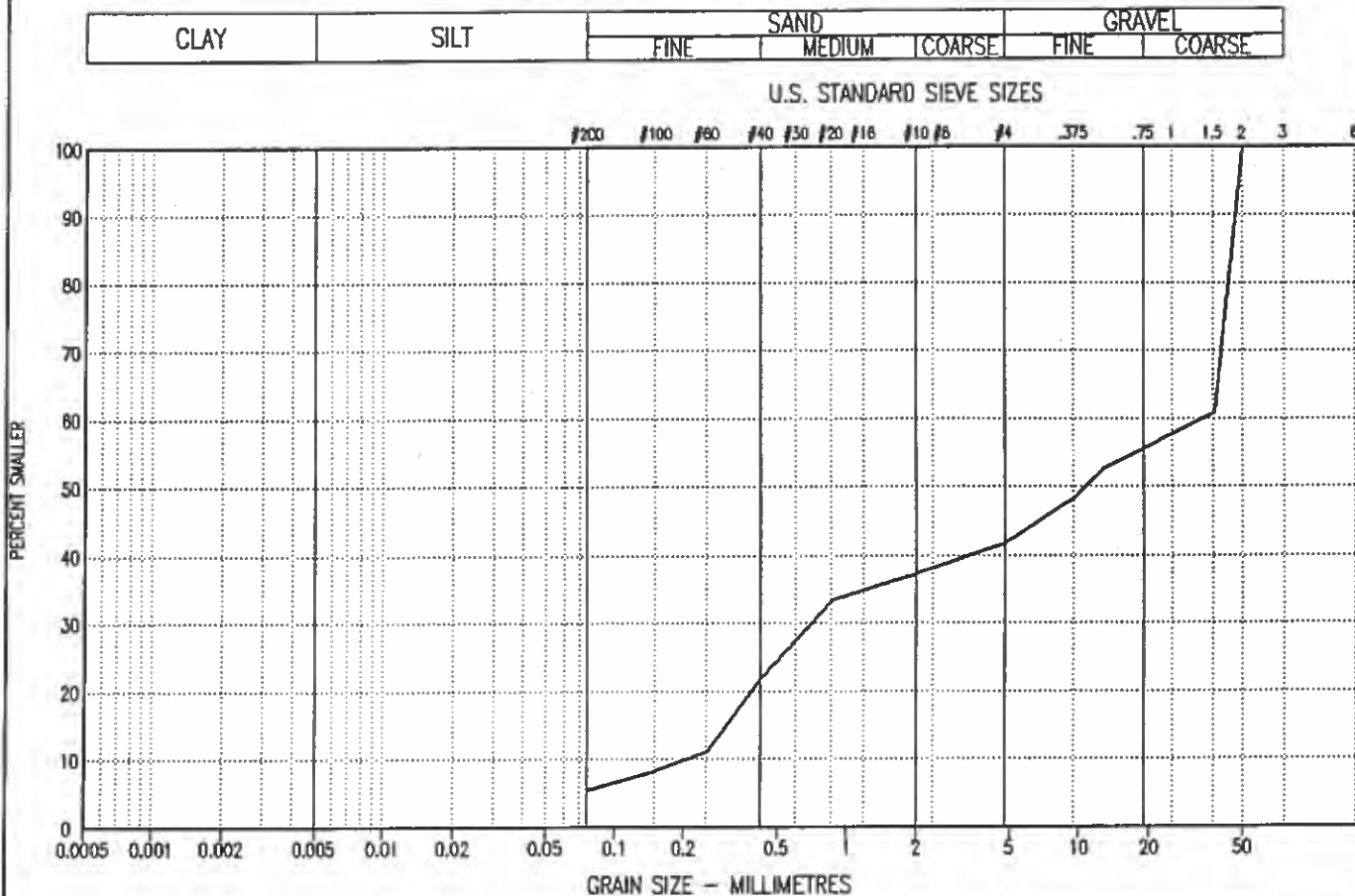
SAMPLE TYPE GRAB NO RECOVERY



EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP	COMPLETION DEPTH: 4.0 m
REVIEWED BY: MCP	COMPLETE: 06/02/95
Fig. No:	Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—	11730-04	2.00 - 2.20	5.4	36.1	58.5	165.1	0.1	GP-GM

Project: 0201-11730

Date Tested: 95/02/08

BY: MCP

Tested in accordance with ASTM D422 unless otherwise noted.

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GEOTECHNICAL EVALUATION		CLIENT: YTG - ENGINEERING & DEVELOPMENT		TEST PIT NO: 11730-05											
RESIDENTIAL INFILL		EXCAVATOR: CAT 225		PROJECT NO: 0201-11730											
CARMACKS, YUKON		UTM ZONE: 8 N6885140 E432850		ELEVATION:											
SAMPLE TYPE		<input checked="" type="checkbox"/> GRAB		<input type="checkbox"/> NO RECOVERY											
DEPTH(m)		SAMPLE TYPE		SAMPLE NO		USC		SOIL SYMBOL		SOIL DESCRIPTION				DEPTH(ft)	
										■ STANDARD PENETRATION ■ 10 20 30 40 PLASTIC M.C. LIQUID 20 40 60 80				■ PERCENT GRAVEL ■ 20 40 60 80 ● PERCENT SAND ● 20 40 60 80 ▲ PERCENT SILT OR FINES ▲ 20 40 60 80 ◆ PERCENT CLAY ◆ 20 40 60 80	
0.0		1						MOSS AND ORGANICS						0.0	
								SILT - some fine sand, some rootlets throughout, seasonally frozen, light brown							
1.0		2		GM		GM		GRAVEL AND SAND - silty, occasional cobbles and boulders to 300 mm, frozen (may be permafrost Nbn), olive brown, difficult to excavate						4.0	
2.0		3												8.0	
3.0		4						GRAVEL - sandy, trace of silt, gravel up to 200 mm, sand is medium to fine grained, damp, compact, medium brown						12.0	
4.0		5						END OF TESTPIT @ 4.2 m						14.0	
5.0														16.0	

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP

REVIEWED BY: MCP

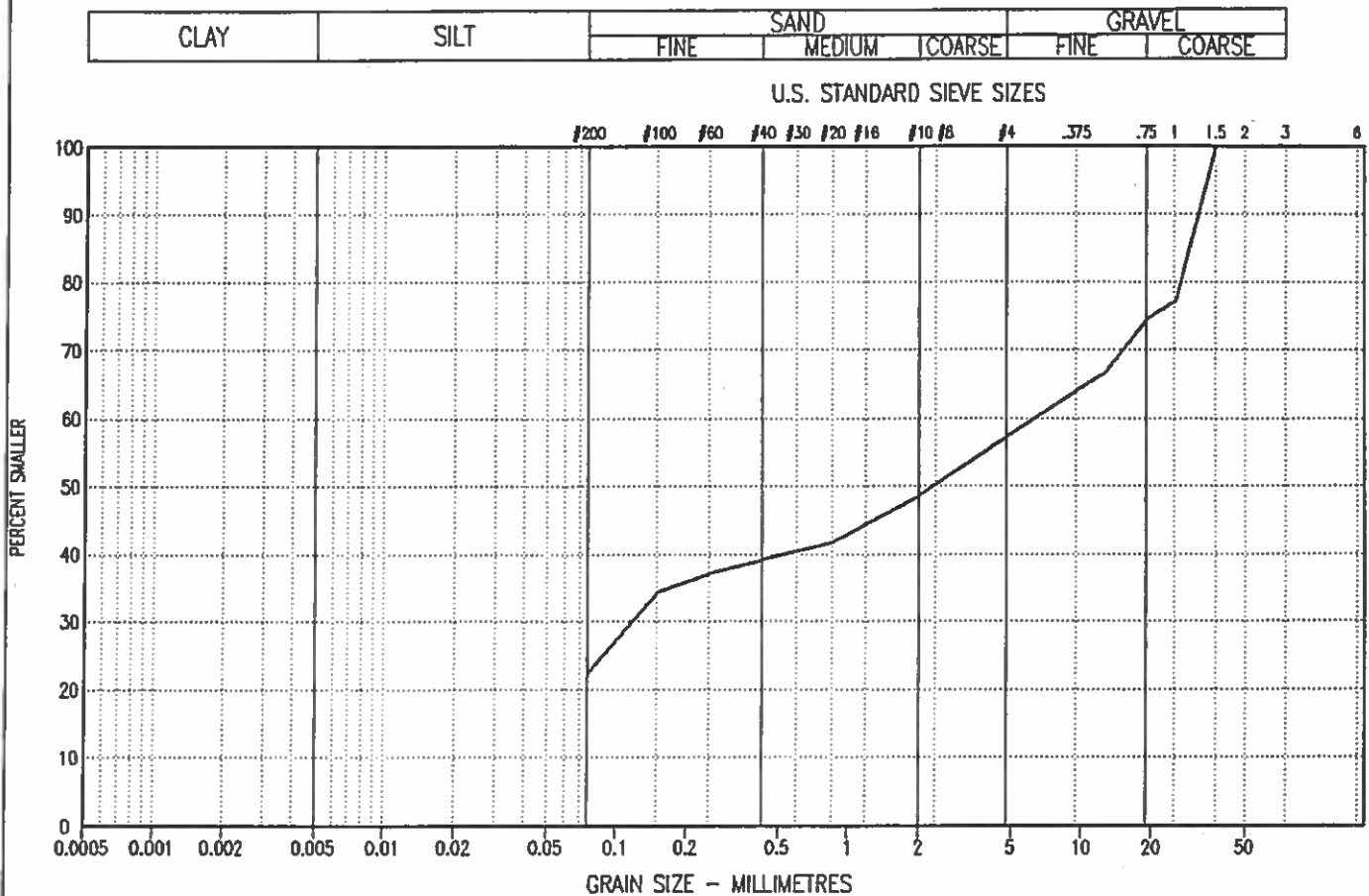
Fig. No:

COMPLETION DEPTH: 4.2 m

COMPLETE: 06/02/95

Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
	11730-05	1.00 - 1.20	22.3	34.7	43.0	202.4	0.1	GM

Project: 0201-11730

Date Tested: 95/02/08

BY: MCP

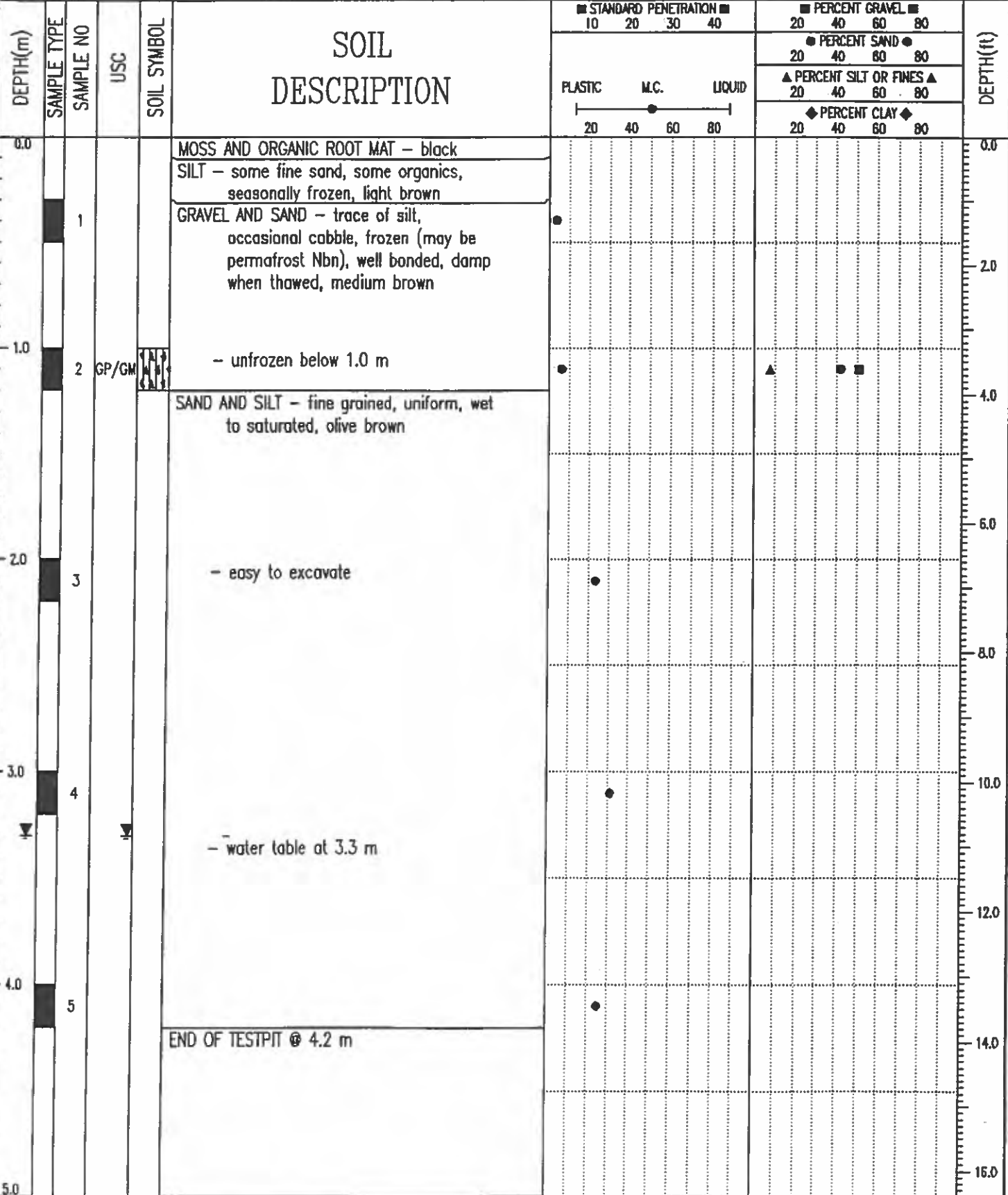
Tested in accordance with ASTM D422 unless otherwise noted.

Data presented hereon is for the sole use of the stipulated client. EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of EBA

The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.

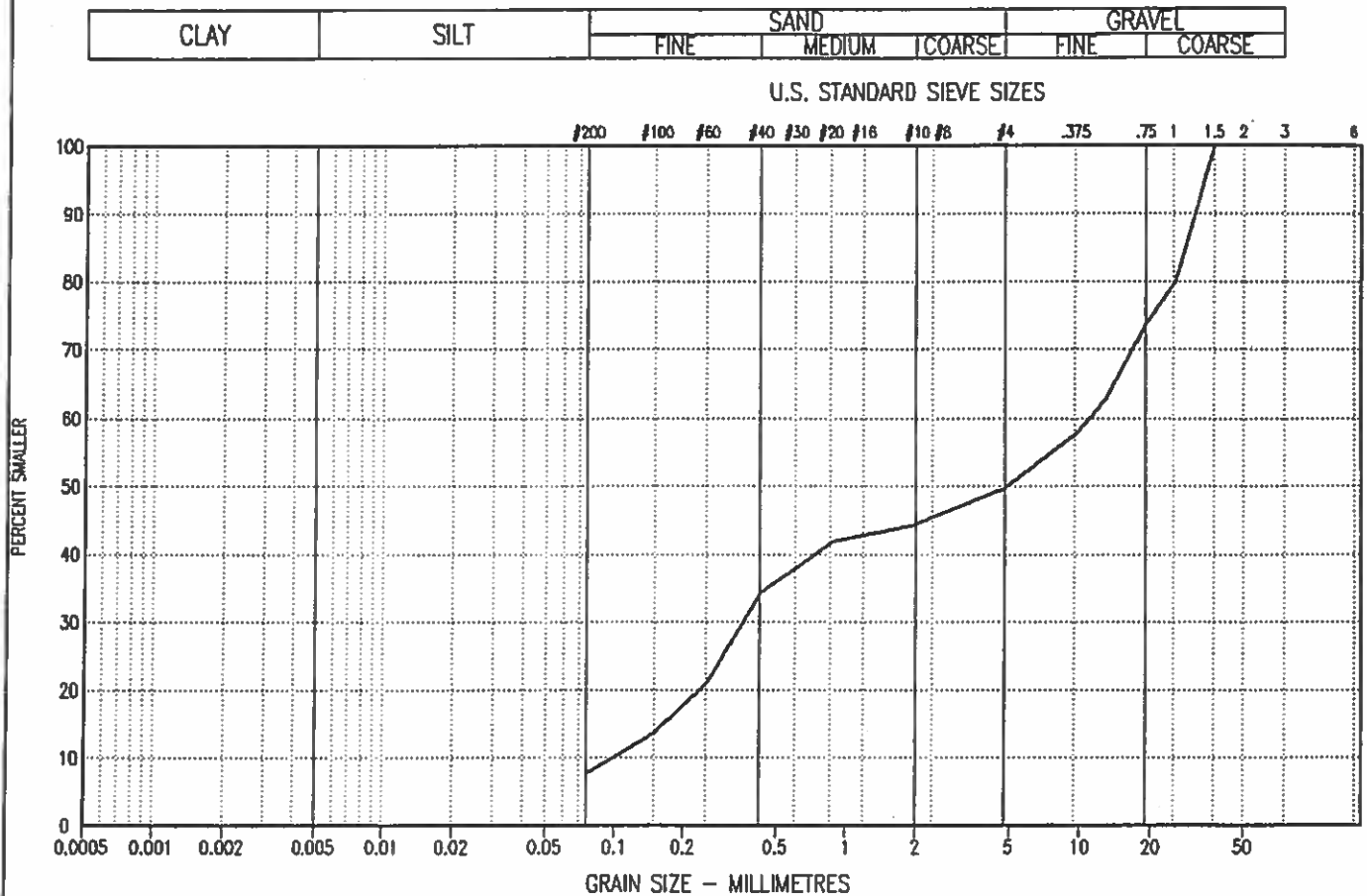


GEO TECHNICAL EVALUATION		CLIENT: YTG - ENGINEERING & DEVELOPMENT	TEST PIT NO: 11730-06
RESIDENTIAL INFILL		EXCAVATOR: CAT 225	PROJECT NO: 0201-11730
CARMACKS, YUKON		UTM ZONE: 8 N6885040 E432850	ELEVATION:
SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB	<input checked="" type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/>



EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 4.2 m
	REVIEWED BY: MCP	COMPLETE: 06/02/95
	Fig. No:	Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
---	11730-06	1.00 - 1.20	7.7	41.8	50.5	106.6	0.1	GP-GM

Project: 0201-11730

Date Tested: 95/02/08

BY: MCP

Tested in accordance with ASTM D422 unless otherwise noted.

Data presented hereon is for the sole use of the stipulated client. EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of EBA

The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.





APPENDIX B

Soil Logs

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon



TEST PIT LOG

Client: Yukon Government - Community Services
 Location: Carmacks, Yukon - Urban Lot #15
 Project: Geotechnical Evaluation - Proposed Lot Development
 Date Excavated: August 11, 2019

Elevation: 100.00 meters
 TP Termination Depth: 2.10 meters
 Instrumentation: NA
 Weather: Scattered Cloud 22°

TEST PIT

1-19

Sheet 1 of 1

Elev. (m)	Depth		Stratigraphic Description	Field Sample					Laboratory Results (%)				USCS/NRC	Symbol	Depth (m)	
	ft	m		Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	▲ - FINES	● - SAND MC	■ - GRAVEL				LL
			soft SURFICIAL ORGANICS & MOSS (300 mm)													
1			firm SANDY SILT - non-plastic, fine grained, rootlets to 0.6 m, brown some oxidation, orange-brown													
2	0.5															0.5
3		1.0														1.0
4			soft SILT trace SAND - non-plastic, fine grained, heavy oxidation, grey													
5	1.5															1.5
6			compact SANDY SILTY GRAVEL - fine to medium grained, poorly graded, cobbles in size to 150 mm, grey													
7	2.0		compact SANDY GRAVEL trace SILT - fine to medium grained, poorly graded, odd cobble in size to 150 mm, grey													
8		2.5														2.5
9																
10	3.0															3.0
11		3.5														3.5
12		4.0														4.0
13		4.5														4.5
14		5.0														5.0
15		5.5														5.5
16		6.0														6.0
17		6.5														6.5
18																
19																
20																
21																
22																



Test Pit terminated @ 2.10 m below the ground surface.
 Groundwater encountered @ 1.2 m

Groundwater Levels
 ▽ Inferred ▾ Observed

Excavated By: Yellow Truck Exc.
 Excavator Type: Bobcat E63
 Bucket Type: Digging

Logged By: T.Dhara, P.Eng. Aug.11, 2019
 Data Entry By: T.Dhara, P.Eng. Sept.7-20, 2019
 Reviewed By: Sept.23, 2019

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon



TEST PIT LOG




Client: Yukon Government - Community Services
 Location: Carmacks, Yukon - Urban Lot #15
 Project: Geotechnical Evaluation - Proposed Lot Development
 Date Excavated: August 11, 2019

Elevation: 100.00 meters
 TP Termination Depth: 2.40 meters
 Instrumentation: NA
 Weather: Scattered Cloud 22°

TEST PIT

2-19

Sheet 1 of 1

Elev. (m)	Depth		Stratigraphic Description	Field Sample					Laboratory Results (%)				USCS/NRC	Symbol	Depth (m)		
	ft	m		Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N	▲ - FINES	● - SAND MC LL	■ - GRAVEL				PL	LL
			soft SURFICIAL ORGANICS & MOSS (200 mm)											ORG			
			firm SANDY SILT - non-plastic, fine grained, rootlets to 0.6 m, some oxidation, mottled orange-brown/grey	⊗	6	NA	NA	0.75	NA	21.4				ML	0.5		
			soft SILT trace SAND - non-plastic, fine grained, some oxidation, orange-brown	■	7	NA	NA	0.5	NA	22.8				ML	1.0		
			soft SILTY-CLAY to CLAYEY-SILT - slight plasticity, varved, heavy oxidation, grey	■	8	NA	NA	NA	NA	19.2, 29.7, 29.3, 22.2	61.1, 64.5	80.8		CL-ML	1.5		
			compact SANDY GRAVEL trace SILT - fine to medium grained, poorly graded, cobbles in size to 150 mm, grey	■	9	NA	NA	NA	NA	8.2, 13.3, 7.4				GP-GM	2.0		
			compact - as above but some SILT	■	10	NA	NA	NA	NA					GM	2.5		
			Test Pit terminated @ 2.40 m below the ground surface. Groundwater encountered @ 1.4 m														
																	
																	
			Groundwater Levels ▽ Inferred ▼ Observed														
			Excavated By: Yellow Truck Exc. Excavator Type: Bobcat E63 Bucket Type: Digging										Logged By: T.Dhara, P.Eng. Aug.11, 2019 Data Entry By: T.Dhara, P.Eng. Sept.7-20, 2019 Reviewed By:  Sept.23, 2019				

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon



TEST PIT LOG

Client: Yukon Government - Community Services
 Location: Carmacks, Yukon - Urban Lot #15
 Project: Geotechnical Evaluation - Proposed Lot Development
 Date Excavated: August 11, 2019

Elevation: 100.00 meters
 TP Termination Depth: 2.40 meters
 Instrumentation: NA
 Weather: Scattered Cloud 22°

TEST PIT

3-19

Sheet 1 of 1

Elev. (m)	Depth		Stratigraphic Description	Field Sample					Laboratory Results (%)				USCS/NRC	Symbol	Depth (m)			
	ft	m		Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N'	▲ - FINES	● - SAND	■ - GRAVEL				PL	MC	LL
			soft SURFICIAL ORGANICS (150 mm) moist									20	40	60	80	ORG		
			loose VOLCANIC ASH (100 mm) damp													ASH		
1			firm	⊗	11	NA	NA	1.0	NA			22.3						
		0.5	SANDY SILT - non-plastic, fine grained, rootlets to 0.6 m, brown - as above															
2			firm	⊗	12	NA	NA	0.75	NA			19.3					ML	0.5
		1.0	but some oxidation, mottled orange-brown/grey															
3			soft															
		1.5	SILT - non-plastic, fine grained, heavy oxidation, grey															
4																		
5																		
6				■	13	NA	NA	0.5	NA			22.7						
		2.0	SANDY GRAVEL - fine to medium grained, poorly graded, cobbles in size to 150 mm, grey															
7																		
8				■	14	NA	NA	NA	NA	1.0		9.5	32.2		66.9			
		2.5	Test Pit terminated @ 2.40 m below the ground surface. Groundwater encountered @ 1.5 m															
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		
21																		
22																		



Groundwater Levels
 ▽ Inferred ▾ Observed

Excavated By: Yellow Truck Exc.
 Excavator Type: Bobcat E63
 Bucket Type: Digging

Logged By: T.Dhara, P.Eng. Aug.11, 2019
 Data Entry By: T.Dhara, P.Eng. Sept.7-20, 2019
 Reviewed By: Sept.23, 2019

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon



BOREHOLE LOG

Client: Yukon Government - Community Services
 Location: Carmacks, Yukon - Urban Lot #15
 Project: Geotechnical Evaluation - Proposed Lot Development
 Date Drilled: August 16, 2019

Elevation: 101.60 meters
 BH Termination Depth: 9.14 meters
 Instrumentation: NA
 Weather: Rain 17°

BOREHOLE

1-19

Sheet 1 of 2

Elev. (m)	Depth		Stratigraphic Description	Field Sample					Laboratory Results (%)				USCS/NRC	Symbol	Depth (m)
	ft	m		Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N	▲ - FINES	● - SAND	■ - GRAVEL			
									20	40	60	80			
1		0.5	FILL SILTY SANDY GRAVEL - fine to medium grained, poorly graded, odd cobble, odd rootlet brown	⊗	1	NA	NA	NA	NA	⊙	6.6				
2		1.0	- as above	⊗	2	NA	NA	NA	NA	⊙	6.0	28.8	34.3	36.9	
3		1.5													
4		2.0	SURFICIAL ORGANICS (150 mm)												
5		2.5	firm SANDY SILT moist - non-plastic, fine grained, rootlets from 1.75 to 2.3 m, some oxidation, orange-brown	⊗	3	NA	NA	NA	NA	⊙	22.5				
6		3.0	firm SILT trace SAND moist - non-plastic, fine grained, some oxidation, orange-brown	⊗	4	NA	NA	NA	NA	⊙	21.9				
7		3.5	soft SILTY CLAY to CLAYEY SILT wet - slight plasticity, varved, some oxidation, orange-brown	⊗	5	NA	NA	NA	NA	⊙	24.6				
8		4.0	compact GRAVELLY SAND wet trace SILT - medium to coarse grained, poorly graded, grey	⊗	6	NA	NA	NA	NA	▲	6.6	25.7	14.5	67.7	
9		4.5	compact SANDY GRAVEL trace SILT wet - medium to coarse grained, poorly graded, grey												
10		5.0	Hard Grindy Drilling @ 5.1 m												
11		5.5	dense - as above wet possible cobble to boulder sized materials	⊗	7	NA	NA	NA	NA	▲	5.4	44.4	50.2		
12		6.0	SEE PAGE 2												
13		6.5													
14		7.0													
15		7.5													
16		8.0													
17		8.5													
18		9.0													
19		9.14													



Caved To 3.20 m

Groundwater Levels
 ▽ During Drilling ▾ After Drilling

Logged By: T.Dhara, P.Eng. Aug.16, 2019
 Data Entry By: T.Dhara, P.Eng. Sept.7-20, 2019
 Reviewed By: Sept.23, 2019

Drilled By: Donjek Drilling
 Drill Type: CME-75
 Auger Size: 150 mm Solid-Stem
 Bit Type: Fish Tail

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon



BOREHOLE LOG

Client: Yukon Government - Community Services
 Location: Carmacks, Yukon - Urban Lot #15
 Project: Geotechnical Evaluation - Proposed Lot Development
 Date Drilled: August 16, 2019

Elevation: 101.60 meters
 BH Termination Depth: 9.14 meters
 Instrumentation: NA
 Weather: Rain 17°

BOREHOLE

1-19

Sheet 2 of 2

Elev. (m)	Depth		Stratigraphic Description	Field Sample						Laboratory Results (%)				USCS/NRC	Symbol	Depth (m)				
	ft	m		Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N	▲ - FINES	● - SAND	■ - GRAVEL	PL				MC	LL		
20			compact - as above - hard grindy drilling to 6.4 m possible cobble to boulder sized materials																	
21	6.5		compact SANDY GRAVEL some SILT - medium to coarse grained, poorly graded, grey	⊗	8	NA	NA	NA	NA	▲ 10.6	● 39.0	■ 50.4								
22										▲ 11.9										
23	7.0		compact SILTY SAND some GRAVEL - fine grained, poorly graded, grey	⊗	9	NA	NA	NA	NA	▲ 13.8	● 39.0									
24			- easy drilling							▲ 15.9										
25	7.5		compact SILTY SAND - fine to medium grained, poorly graded, grey	⊗	10	NA	NA	NA	NA											
26	8.0									● 20.9										
27			- easy drilling																	
28	8.5																			
29	9.0		- as above	⊗	11	NA	NA	NA	NA	▲ 21.1										
30										▲ 17.7										
31	9.5		Borehole terminated 7.64 m below the original ground surface. Groundwater encountered at 1.48 m below the original ground surface.																	
32			<p>#10</p>																	
33	10.0																			
34																				
35	10.5																			
36	11.0																			
37																				
38	11.5																			
39																				
40	12.0																			
41	12.5																			

Drilled By: Donjek Drilling
 Drill Type: CME-75
 Auger Size: 150 mm Solid-Stem
 Bit Type: Fish Tail

Groundwater Levels
 ▽ During Drilling ▼ After Drilling
 Logged By: T.Dhara, P.Eng. Aug. 16, 2019
 Data Entry By: T.Dhara, P.Eng. Sept. 7-20, 2019
 Reviewed By: Sept. 23, 2019

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon



BOREHOLE LOG

Client: Yukon Government - Community Services
 Location: Carmacks, Yukon - Urban Lot #15
 Project: Geotechnical Evaluation - Proposed Lot Development
 Date Drilled: August 16, 2019

Elevation: 101.50 meters
 BH Termination Depth: 7.62 meters
 Instrumentation: 2" Monitoring Well
 Weather: Rain 17° Combo #4762

BOREHOLE

2-19

Sheet 1 of 2

Elev. (m)	Depth		Stratigraphic Description	Field Sample					Laboratory Results (%)				USCS/NRC	Symbol	Depth (m)				
	ft	m		Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N	▲ - FINES	● - SAND	■ - GRAVEL				PL	MC	LL	
			FILL									20	40	60	80				
1		0.5																	0.5
2		1.0																	1.0
3		1.5																	1.5
4		2.0																	2.0
5		2.5	ORIGINAL GROUND SURFACE																2.5
6		3.0																	3.0
7		3.5																	3.5
8		4.0																	4.0
9		4.5	firm SANDY SILT (40 mm) moist - non-plastic, fine grained, brown ORGANIC SILT (40 mm) trace organics, mottled grey-black SANDY SILT (370 mm) - non-plastic, trace oxidation, orange-brown/grey	12	3.4	100	0.75	12	8.5	18.3	22.8								4.5
10		5.0																	5.0
11		5.5																	5.5
12		6.0																	6.0
13		6.5	- grindy drilling																6.5
14		7.0	compact SILTY SANDY GRAVEL wet - fine to medium grained, poorly graded, grey	13	NA	56	NA	23	8.5	15.9	19.0								7.0
15		7.5																	7.5
16		8.0																	8.0
17		8.5																	8.5
18		9.0																	9.0
19		9.5																	9.5
20		10.0																	10.0
21		10.5																	10.5
22		11.0																	11.0
			SEE PAGE 2																



Groundwater Levels
 ▽ During Drilling ▾ After Drilling

Drilled By: Donjek Drilling
 Drill Type: CME-75
 Auger Size: 200 mm Hollow-Stem
 Bit Type: Carbide Cutter

Logged By: T.Dhara, P.Eng. Aug.16, 2019
 Data Entry By: T.Dhara, P.Eng. Sept.7-20, 2019
 Reviewed By: Sept.23, 2019

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon



BOREHOLE LOG

Client: Yukon Government - Community Services
 Location: Carmacks, Yukon - Urban Lot #15
 Project: Geotechnical Evaluation - Proposed Lot Development
 Date Drilled: August 16, 2019

Elevation: 101.50 meters
 BH Termination Depth: 7.62 meters
 Instrumentation: 2" Monitoring Well
 Weather: Rain 17°

BOREHOLE

2-19

Sheet 2 of 2

Elev. (m)	Depth		Stratigraphic Description	Field Sample					Laboratory Results (%)				USCS/NRC	Symbol	Depth (m)		
	ft	m		Type	Number	Temperature (degrees C)	Recovery %	Penetrometer (kg/cm2)	SPT 'N	▲ - FINES	● - SAND	■ - GRAVEL				PL	MC
20			compact GRAVELLY SILTY SAND - fine to medium grained, poorly graded, grey	Wet	X	14	NA	NA	NA	NA	9.8	20.8	33.7	45.5		SM	6.5
21	6.5		- hard grindy drilling from 6.1 to 7.2 m - possible cobble to boulder sized materials														
22																	
23		7.0															
24			compact SANDY GRAVEL - medium to coarse grained, poorly graded, grey	Wet	X	15	NA	NA	NA	NA	4.9	8.6	34.2	60.8		GP	7.5
25	7.5																
26			Borehole terminated 6.12 m below the original ground surface. Groundwater encountered at 1.48 m below the original ground surface.														
27		8.0															
28			Samples No.14 & 15 retained as auger samples as the influx of fine sands into the hollow-stem auger during centerline withdrawal prevented SPT sampling beyond a depth of 5 meters.														
29		8.5															
30		9.0															
31		9.5															
32		10.0															
33		10.5															
34		11.0															
35		11.5															
36		12.0															
37		12.5															
38																	
39																	
40																	
41																	

Drilled By: Donjek Drilling
 Drill Type: CME-75
 Auger Size: 200 mm Hollow-Stem
 Bit Type: Carbide Cutter

Groundwater Levels
 ▽ During Drilling ▽ After Drilling
 Logged By: T.Dhara, P.Eng. Aug.16, 2019
 Data Entry By: T.Dhara, P.Eng. Sept.7-20, 2019
 Reviewed By: Sept.23, 2019



APPENDIX C

Golder Associates Laboratory Results

Atterberg Limit Analysis

Hydrometer Analysis

Sulphate Ion Content Analysis

Client: Chilkoot Geological Engineers Ltd.
Project: Carmacks, Yukon
Location: Whitehorse, YT
Project No.: 1780303 **Phase:** 6000

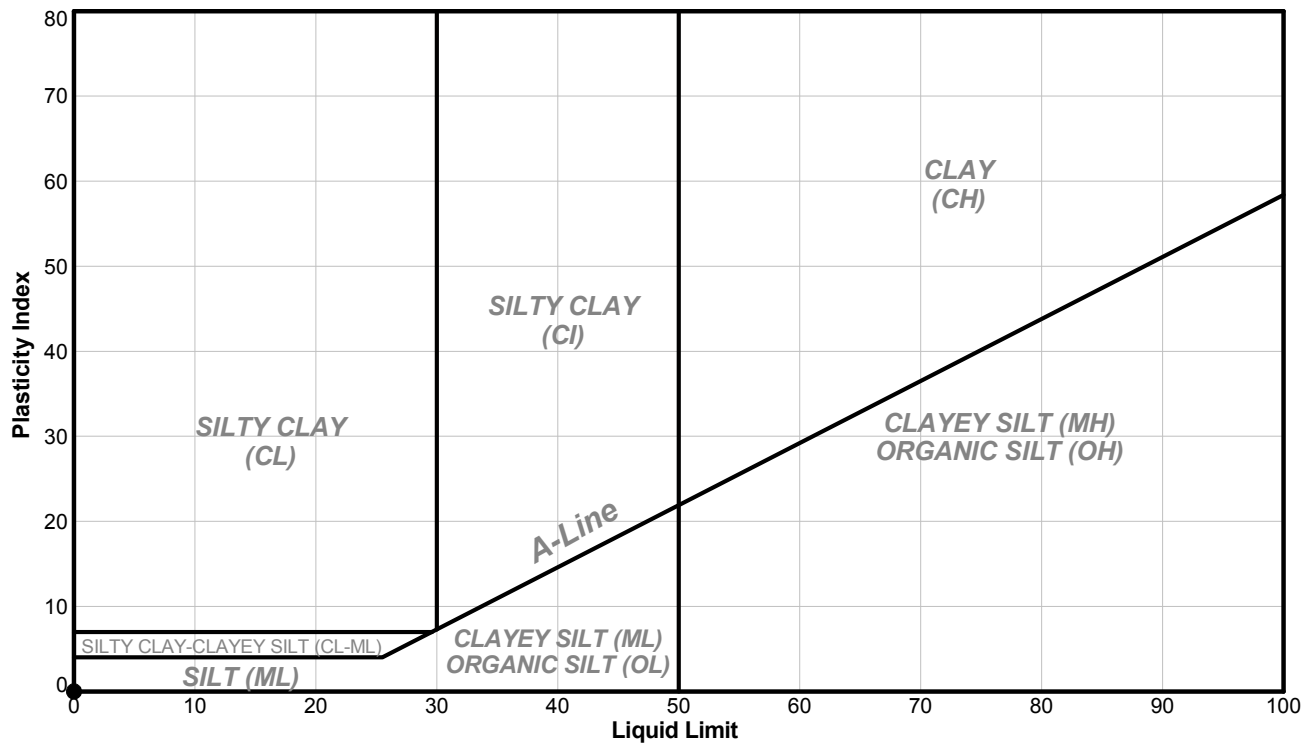
ID: Urban Lot #15
Sample No.: TP1-19 - SA3
Depth (m): 1.2
Lab Schedule No.: B19-275

Other Remarks: N/A

Test Method: A-Multi Point

Preparation Method: Air Dried

PLASTICITY CHART



National IM Server:GINT_GAL_NATIONAL\IM Unique Project ID: Output Form: LAB ATTERRBERG CASAGRANDE (SINGLE) 2018 SJ.dgn 6/9/19

Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	Urban Lot #15	TP1-19 - SA3	0.00	0.00	ND	NP	NP	NP	14.8	NP

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

FF	9/3/2019	SJ	9/4/2019
Tech	Date	Checked	Date

Client: Chilkoot Geological Engineers Ltd.
Project: Carmacks, Yukon
Location: Whitehorse, YT
Project No.: 1780303 **Phase:** 6000

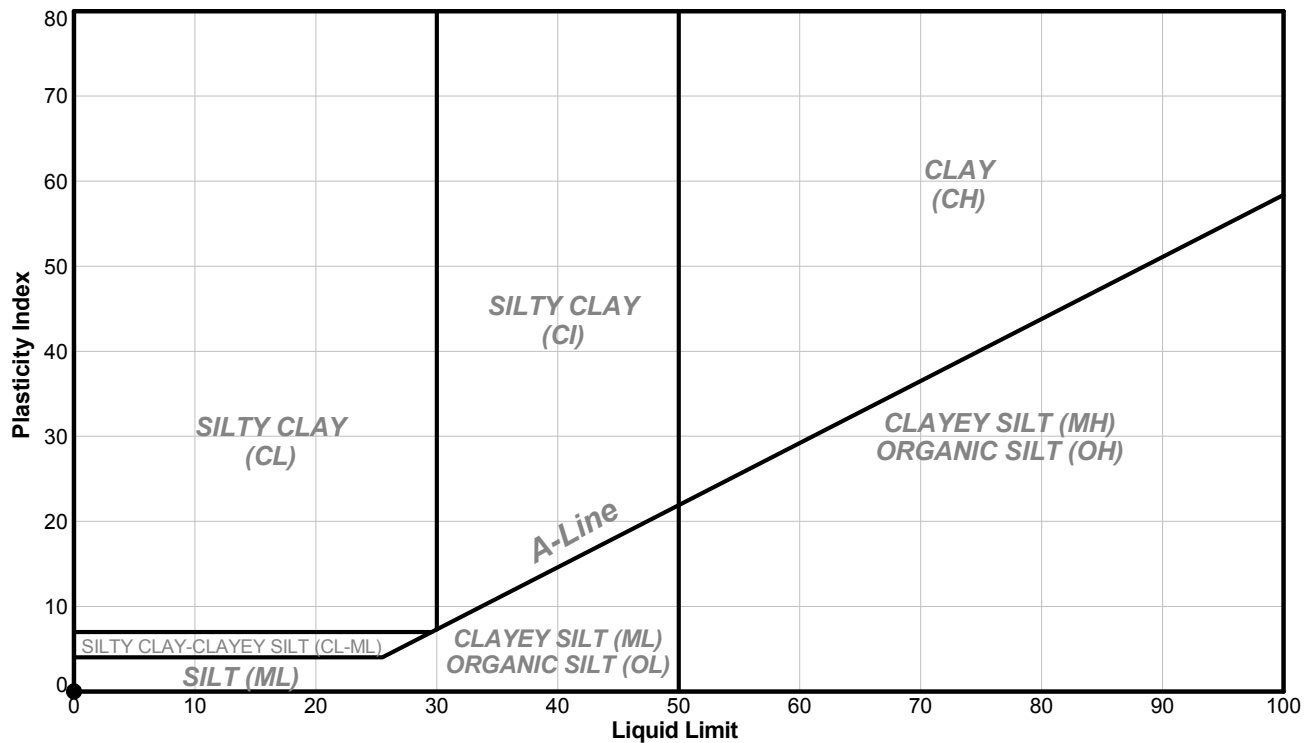
ID: Urban Lot #15
Sample No.: TP2-19 - SA7
Depth (m): 0.9
Lab Schedule No.: B19-275

Other Remarks: N/A

Test Method: A-Multi Point

Preparation Method: Air Dried

PLASTICITY CHART



National IM Server:GINT_GAL_NATIONAL\IM Unique Project ID: Output Form: LAB ATTERRBERG CASAGRANDE (SINGLE) 2018 SJ.01m 6/9/19

Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	Urban Lot #15	TP2-19 - SA7	0.00	0.00	ND	NP	NP	NP	18.1	NP

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

FF	9/3/2019	SJ	9/4/2019
Tech	Date	Checked	Date

Client: Chilkoot Geological Engineers Ltd.
Project: Carmacks, Yukon
Location: Whitehorse, YT
Project No.: 1780303 **Phase:** 6000

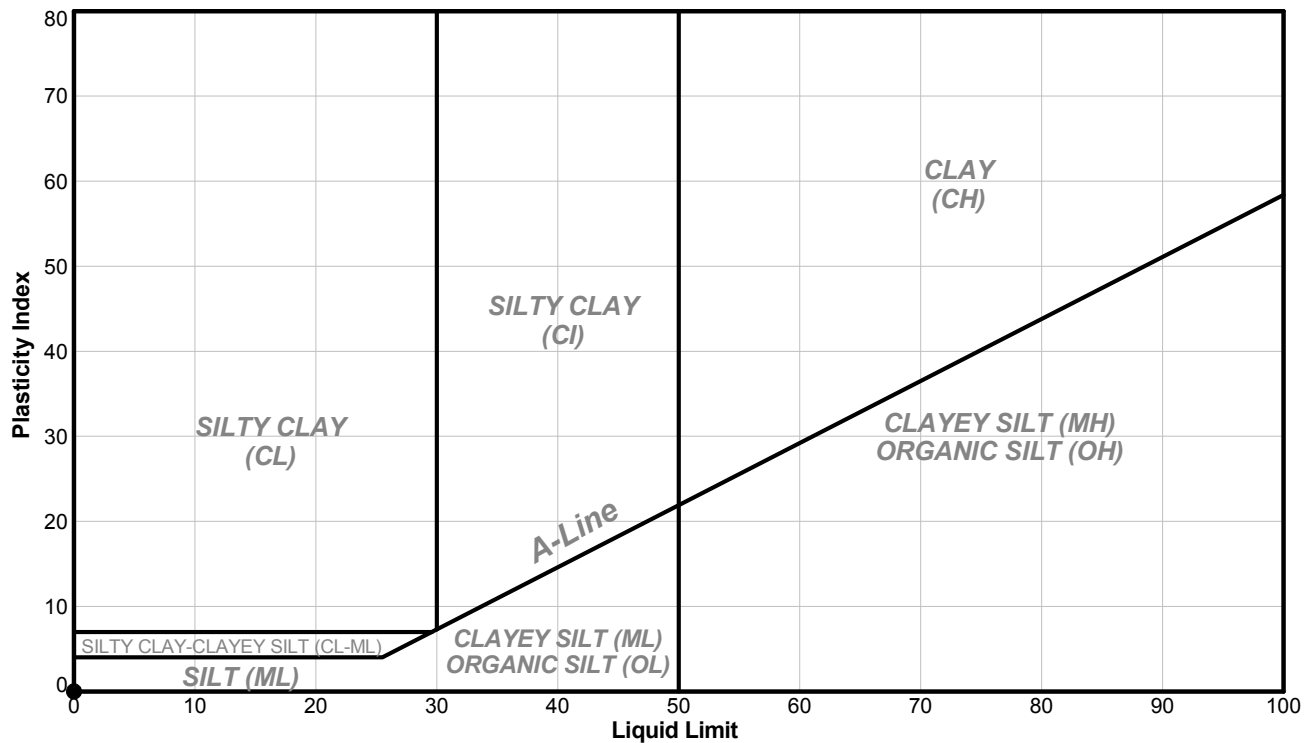
ID: Urban Lot #15
Sample No.: TP3-19 - SA13
Depth (m): 1.6
Lab Schedule No.: B19-275

Other Remarks: N/A

Test Method: A-Multi Point

Preparation Method: Air Dried

PLASTICITY CHART



National IM Server:GINT_GAL_NATIONAL\IM Unique Project ID: Output Form: LAB ATTERRBERG CASAGRANDE (SINGLE) 2018 SJ.dgn 6/9/19

Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	Urban Lot #15	TP3-19 - SA13	0.00	0.00	ND	NP	NP	NP	14.6	NP

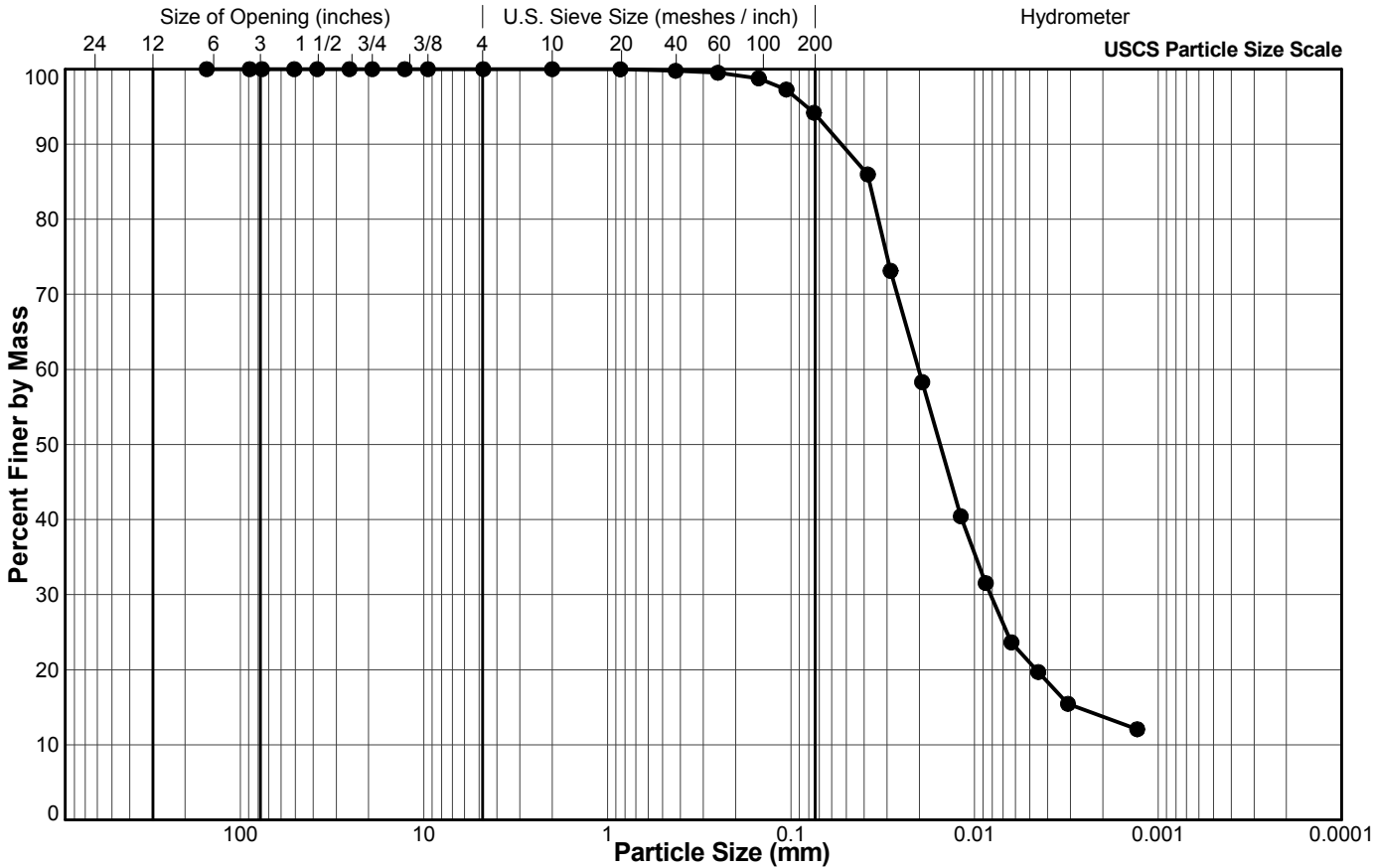
NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

JH	8/30/2019	SJ	9/4/2019
Tech	Date	Checked	Date

Client: Chilkoote Geological Engineers Ltd.
Project: Carmacks, Yukon
Location: Whitehorse, YT
Project No.: 1780303 **Phase:** 6000

Sample Location: Urban Lot #15
Sample No.: TP2-19 - SA8
Depth (m): 1.6
Lab Schedule No.: B19-275



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	100.0
3/4"	19.1	100.0
1/2"	12.7	100.0
3/8"	9.5	100.0
#4 US MESH	4.75	100.0
#10 US MESH	2	100.0
#20 US MESH	0.85	100.0
#40 US MESH	0.425	99.8
#60 US MESH	0.25	99.5
#100 US MESH	0.15	98.8
#140 US MESH	0.106	97.3
#200 US MESH	0.075	94.2
	0.0382	86.0
	0.0287	73.1
	0.0193	58.3
	0.0119	40.4
	0.0087	31.5
	0.0063	23.6
	0.0045	19.7
	0.0031	15.5
	0.0013	12.1

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

DC/VN

8/29/2019

SJ

9/4/2019

Tech

Date

Checked

Date



DETERMINATION OF TOTAL OR WATER-SOLUBLE SULPHATE ION CONTENT OF SOIL CSA A23.2-3B

September 6, 2019

Project Number: 1780303-6000

CHILKOOT GEOLOGICAL ENGINEERS LTD.
5B Bennett Road
Whitehorse, YT
Y1A 5P7

Attention: Mr. Tares Dhara, P.Eng.

PROJECT: Carmacks, Yukon

Date sampled: August 11, 2019

Date tested: August 30, 2019

Sampled by: Client - TD

Tested by: RZ

Site Location	Sample ID	Total Sulphate Ion Content %	Water-Soluble Sulphate Ion Content %
YG Pit - Disposition #900101	Sample #1	0.06	Not Applicable *

Notes:

- * Per Clause 9.1.4, the water-soluble sulphate ion content need not be tested when the total sulphate ion content is less than 0.20%
- Detection limit for the test is 0.005%

Reported by: R. Zhu

Reviewed by: _____

S. John, AScT



Notice: The test data given herein pertain to the samples provided. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.



APPENDIX D

Recommended Grain Size Distribution for Imported Fills



Appendix D

Recommended Grain Size Distribution for Imported Fill

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

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

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

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

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

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

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

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