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Geotechnical Evaluation
Lot 27 – Dredge Pond Subdivision (99-0199 LTO)
Dawson City, Yukon – 2015

Prepared For: **Yukon Government – Energy, Mines & Resources**

Date : **September 8, 2015**

Project No: **200-006-15**

TABLE OF CONTENTS

Geotechnical Evaluation

Lot 27 – Dredge Pond Subdivision (99-0199 LTO)

Dawson City, Yukon – 2015

TABLE OF CONTENTS

Geotechnical Evaluation

Lot 27 – Dredge Pond Subdivision (99-0199 LTO)

Dawson City, Yukon – 2015

APPENDICES

1.0 INTRODUCTION

Chilkoot Geological Engineers Ltd. was retained by *Yukon Government (YG) - Energy Mines and Resources* to conduct a Geotechnical Evaluation at Lot 27 located in the Dredge Pond Subdivision in Dawson, Yukon.

The purpose of the evaluation was to determine the subsurface conditions at the proposed subject property and provide geotechnical recommendations regarding residential foundation construction for an envisioned cribbing and ventilated crawlspace foundation system and overall site development.

Authorization to proceed was granted on July 31st, 2015 by *YG - Energy, Mines and Resources - Lands Management Branch - Lands Availability Manager*, Mr.R.Gorczyca.

The field work was conducted on August 12th, 2015 in accordance with our July 16th, 2015 proposal.

A detailed description of our methodology and geotechnical recommendations which will allow for residential building construction have been provided below

2.0 METHODOLOGY

Our work methodology was comprised of a literature review as well as a field reconnaissance.

2.1 Literature Review

A literature review was conducted prior to the field work program to better evaluate the regional conditions. The following sources of information were reviewed;

Surficial Geology Map

A 1:250,000 surficial geology map (*YT, File 3288*) compiled by *A.Duk-Rodkin, 1996*, was reviewed to assess the regional soil conditions.

In brief, the map described the area as being comprised of fluvial deposits.

Bedrock Geology Map

The following bedrock geology maps were reviewed through the *Yukon Geological Survey* website;

Geology, Ogilvie, Map 711A, by H.Bostock, 1942	*Scale 1:253,440*
Bedrock Geology, YT, G.S.C. Open File 3754, 2001	*Scale 1:1,000,000*

The maps suggest that Dawson is underlain mainly by green schist to lower amphibolite facis metamorphic rocks of the Yukon-Tanana Terrane.

2.2 Field Work Program

The field work program was comprised of a site reconnaissance, utility locates and drilling program.

The field work program was comprised of a site reconnaissance.

Site Reconnaissance

A site reconnaissance was previously conducted to note the field conditions at the subject property on June 30th, 2015. Our observations have been presented in Section 3.3 – Site Description, below.

Utility Locates

Northwestel, *Yukon Energy Corporation* and the *City of Dawson* were contacted to verify the presence of local utilities. In brief, phone and power-lines were located overhead along Pay Dirt Way. There are no *City of Dawson* (sewer or water) utilities located near the lot.

Locally, the surrounding properties did not appear to have septic fields. Regionally, however, there were indeed a few properties along Eureka Drive where heaped septic fields were noted.

3.0 SITE CONDITIONS

3.1 General

The subject property is comprised of historically disturbed land which is currently vacant.

3.2 Legal Description and Site Location

The legal description of the subject property is;

Lot 27 Dredge Pond Subdivision (99-0199 LTO - 82936 CLSR)

The subject property is located in Dawson, Yukon, as noted in Figure 1.

The subject property (a.k.a. 'site') is approximately 0.838 ± ha in size and is irregular in shape.

Access to the site is via Pay Dirt Way which lies to the north.

3.3 Site Description

Regionally, the subject property is located in a region of historical mine tailings where relief in the order of 10 meters is common between the tops of tailings piles relative to ponded regions.

Local site development and residential construction is occurring on a number of nearby properties. The work appears to be comprised of placement of clean granular backfill upon which cribbing and residential houses are being constructed. One lot located in the Pay Dirt Way cul-de-sac however, is utilizing concrete footing/slab-on-grade components to construct what appears to be a garage.

At present, although essentially undeveloped, there is a region where a portion of the tailings have been levelled and where someone has been storing a variety of derelict pick-up trucks as well as other mechanical supplies such as boat motors, engines and other similar types of automotive/boating parts. A small wooden shed, which may have at one time been utilized to store hunting meat, is also located amongst the vehicles and debris. In addition, there are two cat trails which have been advanced into the property along the southern periphery and from the west side of the property.

A selection of photos taken during our site reconnaissance has been provided in Appendix B.

3.4 Geomorphology

Glaciation

Although the full extent of the earliest glaciation is unknown, evidence shows that the Dawson area and Klondike Plateau have probably never been glaciated.

Natural Hazards

The primary natural hazard in the region of the site would be the potential for flooding due to ice jamming of the Klondike River. The site however appears to be located at elevations high enough to avoid the potential increases in water elevations.

3.5 Surficial Geology

The deposits noted in the Dawson area are comprised of Klondike River Valley Deposits. These deposits are characterized by organics/peat which overlie fine grained fluvial materials ranging from sands to silts with minor amounts of gravel. These materials overlie predominately coarse grained materials (where the coarse fraction of the tailings are derived). Based upon the undersigned's past experience in the Dawson area, it is anticipated that these soils are clean and contain high percentages of cobble to boulder sized materials.

Due to the poor founding nature of the soils located in the Dawson area, considerable amounts of fill have been imported to facilitate both historical and more recent development. The historical fills overlie the above noted native deposits and are typically medium to coarse grained but contain an appreciable amount of fines and deleterious (organic) materials.

3.6 Bedrock Geology

In brief, the geology maps suggest that Dawson is underlain mainly by green schist to lower amphibolite facis metamorphic rocks of the Yukon-Tanana Terrane. While the depth to bedrock in the low lying valley regions will vary, it is understood that it is typically encountered at depths of 20 to 30 meters in the region of the townsite.

3.7 Subsurface Conditions

Soil Stratigraphy

The soils located within the limits of the lot are comprised of mine tailings. These tailings were derived from historical dredging operations which occurred in the valley.

In general, prior to disturbance, the original soil stratigraphy in the Klondike Valley would have been comprised of:

> **Unit # 1 – Peat/Organic Stratum;**
> which are wet and rich in organics, overlying;

Unit # 2 – Alluvial Channel Deposits;

which are predominately silty in nature, but may contain finer clay sized materials and/or coarser interbedded granular materials. These soils would have been permanently frozen and overlay;

Unit # 3 – Alluvial Valley Deposits;

which are predominately clean, coarse grained and contain cobble and boulder sized materials. The majority of these materials would also have been permanently frozen.

Given the nature of the dredging operations, these materials would have been heavily disturbed and intermixed.

Groundwater

The depth to groundwater which would coincide with the water elevations in the ponds, was estimated to be in the order of 10 meters below the prevailing ground surface of the tailings materials near Pay Dirt Way.

Groundwater flow would likely be to the south, towards Eureka Creek and the Klondike River.

Seasonally Frozen Soils

Typically, the upper 1.8 to 2.0 meters of the soil column would be susceptible to seasonal frost. The depth of seasonal frost would depend upon the soil cover and types as well as climatic conditions.

Permafrost

Dawson lies within the zone of widespread discontinuous permafrost. The presence of permanently frozen soils can be anticipated in the tailings materials.

In general, the permafrost in the region can vary from poorly bonded soils with non-visible ice to massive ice lenses ranging in size to tens of meters. Regionally, where soil conditions allow, the permafrost is probably more than 100 meters thick with taliks (thawed subsurface) present beneath large rivers (and lakes) and beneath south-facing slopes.

Bedrock

There was no indication of near surface bedrock within the limits of the lot.

4.0 DISCUSSIONS

The construction of a residence on the lot utilizing standard concrete footing and/or slab-on-grade foundation systems would not be recommended due to the heterogeneous nature of the tailings deposits and permafrost potential. If these types of foundations are desired, then a site specific geotechnical evaluation should be conducted to determine the feasibility and geotechnical design parameters. Otherwise residential buildings should be constructed upon a (PWF) cribbing and ventilated crawlspace foundation system which is placed upon a granular pad prepared with the recommendations contained herein.

Although the remnant tailings visually appear coarse grained, they may also contain pockets of fine grained and organic soils which may be frozen and so caution should be exercised during foundation preparation.

5.0 GEOTECHNICAL RECOMMENDATIONS

5.1 Foundations

Standard residential building structures may be supported by (PWF) cribbing and ventilated crawlspace foundation system founded upon an approved granular base constructed in accordance with recommendations provided herein.

The (PWF) cribbing should be configured in such a way that the building structure can be intermittently re-levelled on an as needed basis.

The ventilated crawlspace should incorporate a sub-wall which skirts the buildings perimeter. The sub-wall should be comprised of wire mesh or lattice work such that air flow below the structure is unrestricted during the winter months. These openings should be configured in such a manner that they can be closed in the summer months to prevent (exterior warmer) air from flowing beneath the structure and impacting nearby permafrost. Ultimately, degradation of local or regional permafrost is not desirable and as such, efforts should be undertaken to protect the natural thermal regime.

5.2 Allowable Bearing Pressure

The allowable bearing pressure should not be greater than 125 kilopascals for a cribbing and ventilated crawlspace foundation system constructed on the structural granular pad described herein.

This figure includes the total of all live and dead loads.

5.3 Differential Movements

Differential movements in the order of (+/-) 25 mm may occur with the proposed foundation system. Periodic adjustment to the cribbing system should be anticipated throughout the life of the structure in order to accommodate the movements when these limits are exceeded or if gross settlement/heave occurs.

5.4 Deleterious Materials

If near surface fine-grained or organic materials are encountered, they should be removed from within the limits of the building load envelope to prepare the sub-grade surface. Once a level surface is prepared exposed sub-grade surfaces should be inspected by qualified geotechnical personnel to assess the suitability of the prepared surface on a case-by-case basis.

Subsequent preparation of a granular building pad should be conducted in accordance with Section 5.7.

Excavated soils which are frozen, have high moisture and/or organic contents should be hauled to waste as their use in non-structural applications will be limited.

5.5 Excavations

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

While excavation difficulties are not expected, hard digging will be encountered if/where frozen soils are encountered. If permafrost is exposed during excavation, it should be protected from degradation by implementing an accelerated work program, utilizing insulated tarps and/or scheduling the project to such a time that thermal loss would be minimized.

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

The surrounding surfaces should be graded so as to direct water away from the excavation.

The sub-grade may be sensitive to disturbance and so caution should be exercised during excavation and backfill operations. Wheeled equipment should not be allowed on the sub-grade surface. The sub-grade should be covered once exposed to minimize degradation as the sub-grade is moisture sensitive.

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

5.6 Excavation Parameters

The excavation parameters will be governed by the underside of PWF cribbing pad elevation. The selected elevation should ensure that surface drainage is directed away from the prepared granular base and that positive drainage is attained.

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 (exterior edge of PWF pad) perimeter until the founding strata has been attained (plus 1 meter horizontally).

The base of the excavation should be prepared in such a manner that positive drainage (at 2%) is maintained from a centrally located high spot.

The excavation backslopes should be cut at 1:1 to assist in side slope stability.

The actual configuration of the excavation should be verified by the retained geotechnical consultant at the time of construction.

5.7 Granular Pad

Any residential building constructed on the lot should be founded upon constructed granular pad comprised of an approved, clean, inorganic, well graded sand and gravel mixture which conform to the attached recommended grain size distribution.

The granular pad should measure ~ 1.8 meters thick and should be comprised of the following;

Granular Pad

UNIT	THICKNESS	COMPACTION [C]	COMPOSITION [D]
Base	150 mm[A]	100 %	20 mm minus crushed granular aggregate, overlying
Sub-base	450 mm	98 %	80 mm minus sub-base course aggregate, overlying
Sub-base	1200 mm[B]	95 %	150 mm minus and/or Class I Rip-Rap sub-base course aggregate, overlying
Geotextile Fabric	NA	NA	Non-woven filter fabric
Sub-grade	NA	95 %	approved native sub-grade materials

Notes;

[A] – The prepared surface of the granular backfill should be level in the region where PWF pads are to be placed. The granular pad should extend a minimum of 1.0 meters beyond the edge of the pad at these locations.

[B] – The thickness of this unit should be uniform through-out the building load envelope.

If long-term movements are to be reduced and/or if an increased allowable bearing capacity is required, then the sub-base should extend to the underlying coarse grained fluvial deposits provided the site conditions on the adjacent lots allow for it. Additional assessment will be required if this option is to be considered as construction dewatering and thermal protection aspects will need to be carefully assessed, on a case-by-case basis.

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

Caution should be exercised during compaction as the underlying sub-grade materials may be subject to a loss of strength if disturbed. Non-vibratory (static) rolling may be required.

All materials should be placed in uniform, level lifts that do not exceed 150 mm thick, as measured following compaction. The exception to this would be if Class I Rip-Rap (or equivalent coarse) materials are utilized. Typically these materials are placed in 0.5 meter thick lifts prior to leveling and static rolling.

D - If groundwater infiltration is encountered at the sub-grade elevation, then the backfill should be comprised of Class I Rip-Rap or else some other approved coarse fill. The course Class I Rip Rap (or equivalent) should be fully encased in geotextile fabric.

E - If underlying organic soil units are disturbed, then consideration should be given to replacing the soil unit with an equivalent level of thermal protection through the use of SM Styrofoam.

A recommended grain size distribution for the specified imported fills has been attached as Appendix A.

Considering the local site elevations, the granular pad should be constructed such that its surface is in the order of 1 meter higher in elevation than the prevailing grade of the roadway.

5.8 Filter Fabric

Due to the potential degradation of the excavation base and other exposed materials over time, the use of a filter fabric will be required to facilitate backfill operations. The fabric should extend across the excavation base and excavation sidewalls. If successive pieces are required, they should be either sewn or overlapped by a minimum of 1.5 meters. The overlap should be in the same direction as that of advancing backfill operations.

5.9 Structural Breaks & Reinforcing

Structural breaks, reinforcement and other similar features should be integrated into the building design to allow for differential movements caused by soil volume changes of the underlying soils.

In addition, it should be noted that structures built upon cribbing foundations are inherently more susceptible to seismic action and so this should be considered during design and construction of any residence/structure.

5.10 Site Drainage

The **g**ranular pad construction and surrounding areas should be graded to direct surface water away from the building structure. Typically, a 2 percent slope will be suitable for this purpose.

Eaves troughs should be incorporated into the roof structure. The discharge/outflows should extend a minimum of 3 meters away from the building structure.

The crawlspace must be protected from rain, snow and the ingress of surface and groundwater at all times.

5.11 Inclement Weather

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

5.12 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*.

In general, side slopes cut at 1:1 (horizontal/vertical) should allow for adequate stability provided that the depth of the excavation does not exceed 2 meters. If these parameters are to be exceeded, then they should be verified and monitored by qualified geotechnical personnel during the time of construction. The excavation sidewall (slope) stability will be dependent upon the material characteristics, configuration of the excavation, length of exposure, presence of groundwater and other similar factors which should be re-evaluated at the time of construction.

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

5.13 Surface and Groundwater

As the depth to groundwater will vary with seasonal conditions, the Contractor should be prepared to conduct construction dewatering operations on an as needed basis.

Surface and groundwater should be intercepted and removed from excavations (and construction areas) at all times during granular pad construction to ensure a dry working area.

Caution should however be exercised as lowering of the local groundwater regime may affect nearby structures due to settlement of the underlying soils. More detailed analysis would be required to assess the effects of construction dewatering on neighboring structures (i.e., buildings, utility poles, etc.) if the depth of excavation exceeds 1 meter.

5.14 Temporary Stockpiles

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

5.15 Sewage Disposal

Site specific characterization would be required to determine the suitability of the site for septic field installation once a building site has been chosen. However, as the percolation rate of the underlying soils is expected to be high and given the relatively close proximity to the groundwater table, it's likely that a septic holding tank will be required to allow for sewage disposal.

5.16 Sub-surface Utilities

Sub-utilities should be embedded in a bedding sand conforming to the grain size specifications provided in the imported fill Appendix. The utility pipe should be established on a base of bedding sand which measures 300 mm thick. In addition, the bedding sand should extend a minimum of 300 mm on all sides of the pipe. The material should be compacted to a minimum of 95% of the materials corresponding Proctor density at (or near) the materials optimum moisture content. If utility trenches are located within the building load envelope, then the materials should be compacted to 98% of the materials corresponding Proctor density at (or near) the materials optimum moisture content. If poor founding soils are encountered at the sub-grade elevation, then the pipe should be embedded in 28 mm minus clear stone (conforming to the imported fill Appendix) encased in filter fabric.

In general, the excavation spoils should be suitable for use as backfill so long as they are not located within the building load envelope or else parking areas. Otherwise the remaining trench backfill should conform to the recommended grain size distributions for imported fills provided in the Appendix.

Pipes should be well insulated to prevent freezing by means of soil cover, physical coating, heat trace or combination thereof.

Where possible, underground utilities be situated outside of the building perimeter to allow for ease of future maintenance.

5.17 Driveways and Parking Areas

The structure for driveways and parking areas should be comprised of;

UNIT	THICKNESS	COMPACTION [B]	COMPOSITION
Base	150 mm	100 %	20 mm minus crushed granular aggregate, overlying
Sub-base	300 mm[A]	98 %	80 mm minus sub-base course aggregate, overlying
Geotextile [C]	NA	NA	approved filter fabric
Sub-grade	NA	95 %	approved native sub-grade materials

Notes; [A] – If additional fill is required to meet the anticipated design elevations, then a clean, well graded ‘pit run’ material with maximum particle size of 150 mm can be utilized below the sub-base materials.

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

[C] – The use of geotextile fabric should be considered if poor subgrade materials are encountered or if additional structural support is required.

A recommended grain size distribution for the specified imported fills has been provided in the Appendices.

5.18 Construction Monitoring and Testing

During construction, qualified geotechnical personnel should monitor the excavation and side slopes and inspect all sub-grade surfaces prior to backfill to verify that the prepared sub-grade surface is suitable for use.

Materials testing services should be conducted during granular pad construction to assess the suitability of the imported structural fills through laboratory testing and to verify that adequate compaction has been attained through in-situ field density (compaction) testing.

5.19 Foundation Monitoring

As generally all structures in permafrost regions undergo some amount of movement due to underlying changes in the soil volume, the foundation should be monitored and the structure re-leveled on an as needed basis depending upon the design.

6.0 CONCLUSIONS

While construction of a footing or slab-on-grade foundation system could be considered following a site specific geotechnical evaluation, the long-term performance may not be guaranteed given the heterogeneous nature of the tailings materials and permafrost potential. As such, residential structures should be founded upon a (PWF) cribbing and ventilated crawlspace foundation system placed upon a granular pad prepared in accordance with the recommendations provided herein.

Long-term maintenance through periodic re-levelling will be required throughout the life of the structure to accommodate movements caused by fluctuations in the underlying soil volumes as well as thermal and groundwater regimes.

Further site specific characterization would be required to determine the suitability of the site for septic field installation once a building site has been chosen. However, as the percolation rate of the underlying soils is expected to be high and given the relatively close proximity to the groundwater table, it’s likely that a septic holding tank will be required to allow for sewage disposal.

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 are based upon the subsurface conditions encountered at the time of our investigation, current construction techniques and environmental standards 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 data presented may not be sufficient to assess all factors that may have an effect upon construction. While references to underground utilities have been made, the locations of sub-surface utilities should be verified by prior to construction.

It is important to emphasize our evaluation is based, in fact, on a random sampling of the subject property site. Our comments are based upon the results obtained at the borehole and sample locations. Due to the geomorphological nature of the deposits encountered, interpolations of subsurface conditions between the borehole and other locations on the site have not been made or been implied. The soil and ground conditions at this site are dynamic and thus the subsurface conditions will vary over time.

The recommendations have been provided without consideration to the effects of deep and long-term thaw of local and/or regional permafrost which may stem from global warming, the proposed or nearby construction/structures or other causes. In addition, geotechnical consideration regarding seismic constraints have not been considered. Structures built upon cribbing foundations are inherently more susceptible to seismic action and so this should be considered during design and construction.

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 at such time.

9.0 CLOSURE

Thank you for allowing our firm to provide you with the above noted assessment. While we trust the information will suit your purposes, please feel free to contact the undersigned if you have any questions.

Respectfully Submitted,

CHILKOOT GEOLOGICAL ENGINEERS LTD.

PROFESSIONAL #1277 YUKON TARES DHARA TERRITORY ENGINEER

PERMIT TO PRACTICE
Signature
Date September 8, 2015
PERMIT NUMBER: PP025
Association of Professional Engineers of Yukon

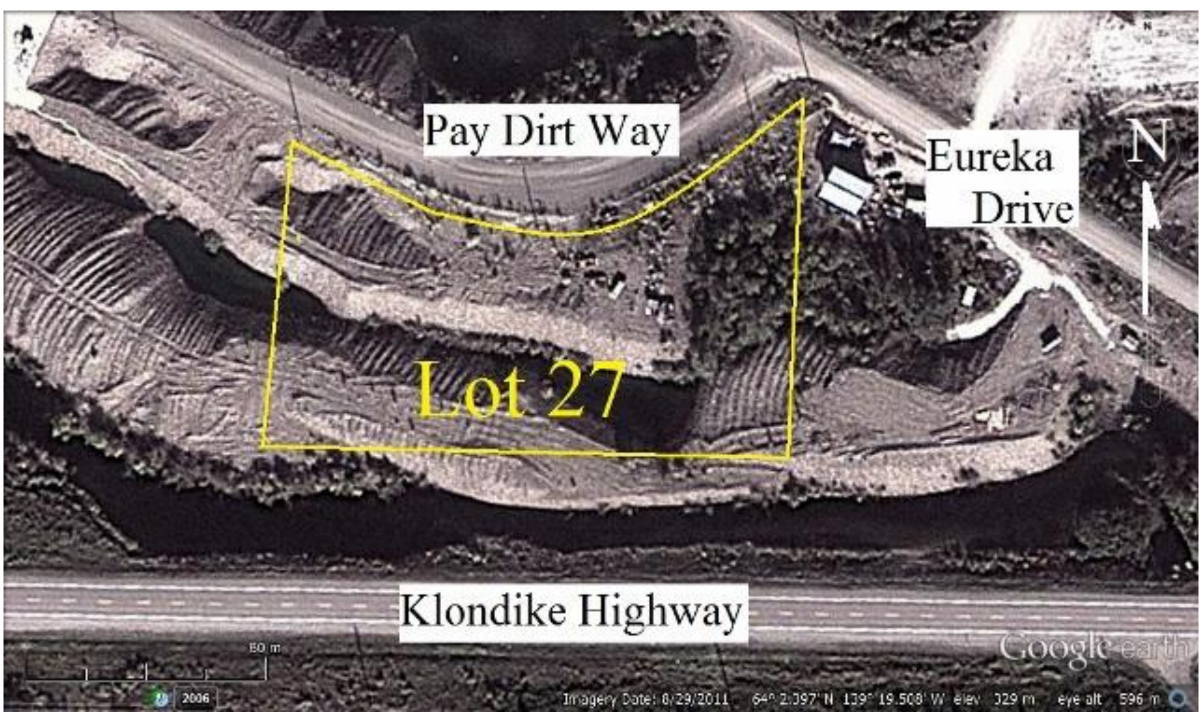
Tares Dhara, P.Eng.
Senior Geotechnical Engineer

TD/td

Geotechnical Evaluation

Lot 27, Dredge Pond Subdivision, 99-0199 LTO - Dawson, Yukon – 2015

FIGURE 1 – Site Location



Based map modified from Google Earth – Limits are approximate Compiled Aug.19, 2015 by T.Dhara

Geotechnical Evaluation

Lot 27, Dredge Pond Subdivision, 99-0199 LTO - Dawson, Yukon – 2015

FIGURE 2 – Local Setting

Based map modified from Google Earth – Limits are approximate

Compiled Aug. 26, 2015 by T.Dhara

CHILKOOT GEOLOGICAL ENGINEERS LTD.

APPENDIX A

Recommended Grain Size Distribution for Import Fills

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	2-15
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

APPENDIX B – SELECTION OF PHOTOS

Photo # 1 – Eastern pond conditions facing west

Photo # 2 – Site conditions facing north-west

Photo # 3 – Eastern pond facing east.

Photo # 4 - Conditions across Pay Dirt Way facing south-east

Photo # 5 - Conditions facing south-east towards Klondike Highway # 2