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Geotechnical Feasibility Assessment
Proposed Infill #2 Lot Development
Guggieville Industrial Subdivision Area
Dawson City, Yukon – 2019

Prepared For: **Yukon Government**

Date : **November 29th, 2019**

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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 feasibility assessment at a proposed infill region (referred to as Infill #2) located in the Guggieville Industrial Subdivision Area in Dawson City, Yukon.

The town of Dawson City is located ~ 533 km north of Whitehorse along the North Klondike Highway #2. The study area, which measures ~ 11.2 ha in size, is located ~ 2.5 km east of the downtown proper as noted in Figure 1.

Authorization to proceed with the assessment was granted by *YG – Community Services* - Senior Program Manager, Mr.K.Fisher on September 12th, 2019. Our field work was subsequently conducted on September 20th, 2019 in accordance with our September 8th, 2019 proposal.

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

2.0 SCOPE-OF-WORK

The purpose of our assessment was to delineate regions within the study area which may be geotechnically suitable for potential subdivision/lot development and provide general recommendations regarding infrastructure development. It's understood that the envisioned infrastructure would involve road construction, building construction and septic field installations utilizing conventional construction methodologies following site pre-grading operations.

As our assessment is preliminary in nature, further evaluation will be required through subsurface investigation to verify site-specific geotechnical parameters if development is to be considered in greater detail.

3.0 METHODOLOGY

Our methodology was comprised of a literature review and site reconnaissance.

3.1 Literature Review

A literature review was conducted to evaluate technical reports, surficial geology maps, topographical data, satellite imagery, a selection of aerial photos and other similar types of resources pertaining to the study area. This information was utilized to evaluate the regional conditions and detail the field work program.

The following sources of information were reviewed;

Surficial Geology Map

A 1:25,000 surficial geology map (Open File 2014-12) entitled Surficial Geology, Dawson Region, Yukon – Parts of NTS 115O/14 & 15 and 116B/1, 2, 3 & 4 compiled by K.McKenna and P.Lipovsky - *Yukon Geological Survey* was reviewed to provide insight into the regional geomorphology.

A portion of this map and the corresponding limits of the study area has been provided in Section 4.4, below.

Bedrock Geology Map

A bedrock geology map, available through the *Yukon Geological Survey*, identified the regional bedrock types and characteristics within the study area. The map was entitled *Yukon Bedrock Geology Map* – *Yukon Geological Survey* – Open File 2016-1 - 1:1,000,000 scale compiled by M.Colpron, S.Israel, D.Murphy, L.Pigage, and D.Moynihan. A more detailed delineation of these contacts was subsequently found on the *Yukon Geological Survey* website as noted in Section 4.6, below.

Topographical Information

The regional topography was assessed by viewing a 1:50,000 scale topographical map (116 B03 Dawson) and the *YG- Water Placer Atlas* website.

These maps showed the study area is located near the base of the Klondike River valley.

Aerial Photographs

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

The following air photos were reviewed;

Flight Line	Photo No.	Date	Comments
A13139	1-22	1951	35,000' altitude
A17155	96-117	August 1960	15,000' altitude
A24708	22-45	1977	7,700' altitude
A24704	43-56	1977	7,500' altitude
NW9584	79-92	May 1984	11,200' altitude
WP8611	70-93	August 1986	1:20,000 scale
A27483	99-117	July 1989	24,500' altitude
A27664	123-156	July 1990	12,000' altitude
A27669	66-87	August 1990	1:10,000 scale
A28237	187-223	August 1995	1:20,000 scale
G03070868	17-32	July 2003	1:40,000 scale

Satellite Imagery

Satellite imagery, which was available from *Google Earth*, was reviewed to assess the site conditions relative to more recent imagery dated between September 2006 and June 2019.

Technical Reports

A report entitled Dawson Natural Landscape Hazards – Geoscience Mapping for Climate Change Adaptation Planning Report compiled by the *Northern Climate ExChange – Yukon Research Center – Yukon College* (B.Benkert, K.Kennedy, D.Fortier, A.Lewkowicz, L.Roy, K.Grandmont, I.de Grandpre, S.Laxton, L.McKenna and K.Moote), 2015 was reviewed to provide additional background regarding the natural hazard potential in the region of the study areas.

This report was compiled to serve as a baseline to allow for climate change adaptation planning as adverse effects of a warming environment have become a reality in northern Yukon. The intent was to generate a hazards map to help identify the potential for permafrost thaw, landslides and flooding. Their study

area paralleled the limits of a 1:25,000 surficial geology map (Open File 2014-12) which has been described below (in Section 4.7).

The hazards report indicated that an approach was generated to consider local community concerns and infrastructure, disturbance history, permafrost distribution and characteristics, surficial geology conditions, hydrology and projections of future climate. Following the retention of scientific information and case studies, data related to slope angle, slope aspect, surficial materials and permafrost probability were input into a raster comprised of pixels which each represented 30 m^2. The hazard potential relative to each of these criteria was assigned and a map based upon a cumulative weighted risk was generated.

The report was clear to indicate that while the hazard map can serve as an initial guide to local conditions, there are limitations due to site specific conditions and so detailed site studies (e.g., geotechnical or engineering studies) would still be required.

Other Resources

The *Yukon Government – Placer Watershed Atlas* website was reviewed as it provided the boundaries of various land dispositions, mining claims, drainage regimes and other similar types of information. The corresponding boundaries of the study area have been illustrated on the *Placer Watershed Atlas* map as noted in Section 4.8, below.

3.2 Field Work Program

Following collation of the above noted information our firm conducted a field work program which was comprised of a site reconnaissance. This work was conducted by the undersigned on September 20th, 2019 to note geological features and other points of interest.

During this time, the region was traversed on foot such that the local field conditions and geological features could be observed. As our field work coincided with what was considered to be extremely low levels of the Klondike River, the field conditions during our traverse were considered to be favorable.

Our observations were documented through a combination of field notes, GPS waypoints and photographs. These observations have been summarized in Section 4.0 – Site Conditions, below.

4.0 SITE CONDITIONS

4.1 Location of Study Area

The study area is located in the Klondike River valley approximately 2.5 km east of the downtown proper of Dawson City, Yukon as noted in Figure 1.

This region of the valley is predominately comprised of remnant mine tailings piles which were formed as a result of historical mining activities. These mining activities generally utilized dredges in order to process the fluvial valley deposits once they were thawed through steaming operations. The fluvial deposits are generally characterized by organics/peat which overlie fine-grained fluvial materials which are comprised of frozen ice-rich silts which contain varying amounts of sand and gravel. These materials overlay frozen coarse-grained granular materials which contained high percentages of cobble to boulder sized materials and gold.

4.2 Physiographic Region

The study area is part of the Boreal Cordillera Ecozone and lies within the Klondike Plateau immediately south-west of the Tintina Trench. The mountains in the region are of the Dawson Range, a sub-range of the Yukon (Mountain) Range which dominate much of central Yukon and eastern Alaska. These mountains rise to elevations in the order of 1500 meters. The terrain can be described as smooth, rolling, unglaciated terrain, which is incised by narrow, deep, V-shaped valleys.

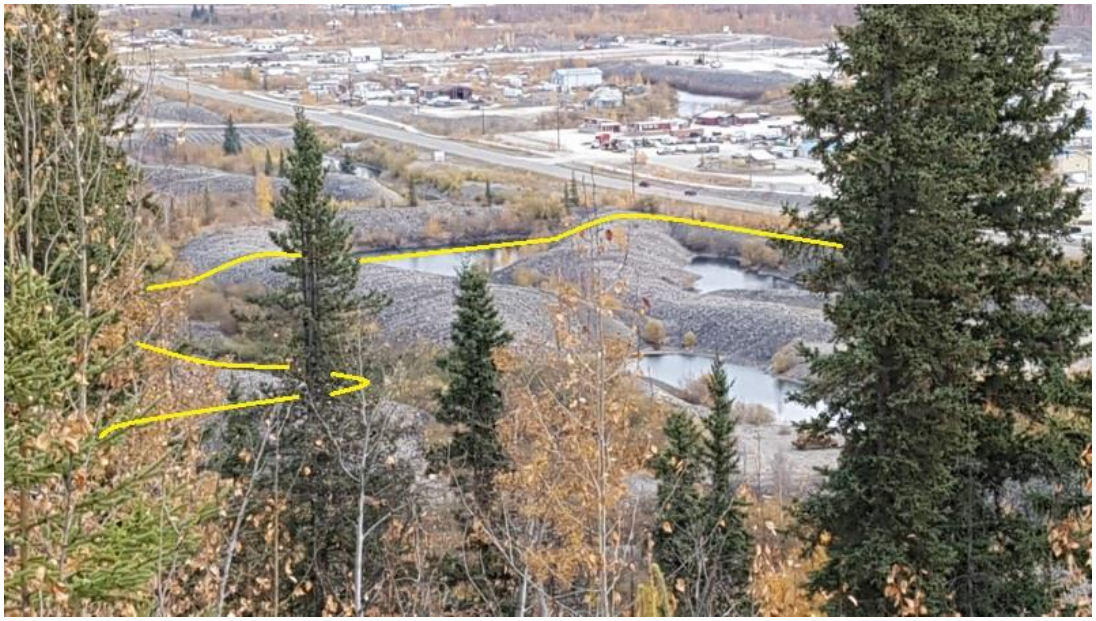
Located in the Klondike Valley, the prevailing elevation in the region of the study area is in the order of 330 meters. Higher mountainous terrain, with elevations up to 1000 meters, are located both north and south of the study area on the ridges which define the valley. Regionally, the vegetation is predominately comprised of sparse boreal forest. Black spruce and birch dominate regions which are underlain with permafrost. The understory in these regions consists of a variety of lichen, mosses, willow, alders and shrubs.

Permafrost is extensive, discontinuous and overlain with turbic cryosols in regions where undisturbed native soil deposits are present.

4.3 Site Description

The study area, which measures ~11.2 ha in size, is comprised of mine tailings piles, ponds and undisturbed areas which harbor fluvial deposits as noted in Figure 2.

The southern periphery of the study area lies adjacent to the North Klondike Highway.



Partial view of study area facing southeast taken from slope located above the western bank of the Klondike River.

Some of the tailings piles have been levelled or else partially levelled. A number of trails, foot paths, seasonal drainage courses/ponds, seeps, former dredge buckets and signs of shoreline erosion were also identified within the study area. The approximate locations of these features, as well as the locations of two 45-gallon barrels and a D-8 Caterpillar bulldozer, were noted in the figure.

View of central trail transecting remnant tailings pile.

Remnants of dredge buckets.

The topography is best described as flat, with only minor changes in elevation where former mine tailings are present.

View of southern tailings pond facing east.

View of central tailings pond facing west.

As the majority of the site has been disturbed through historical mining activities, vegetation is sparse. However, some stands of trees comprised of poplar, white birch, aspen and spruce are present, particularly in the northwestern region of the study area where fluvial deposits are present. Where present, the understory consists of a variety of grasses, willows and shrubs.

View of trail facing east in region of undisturbed fluvial deposits.

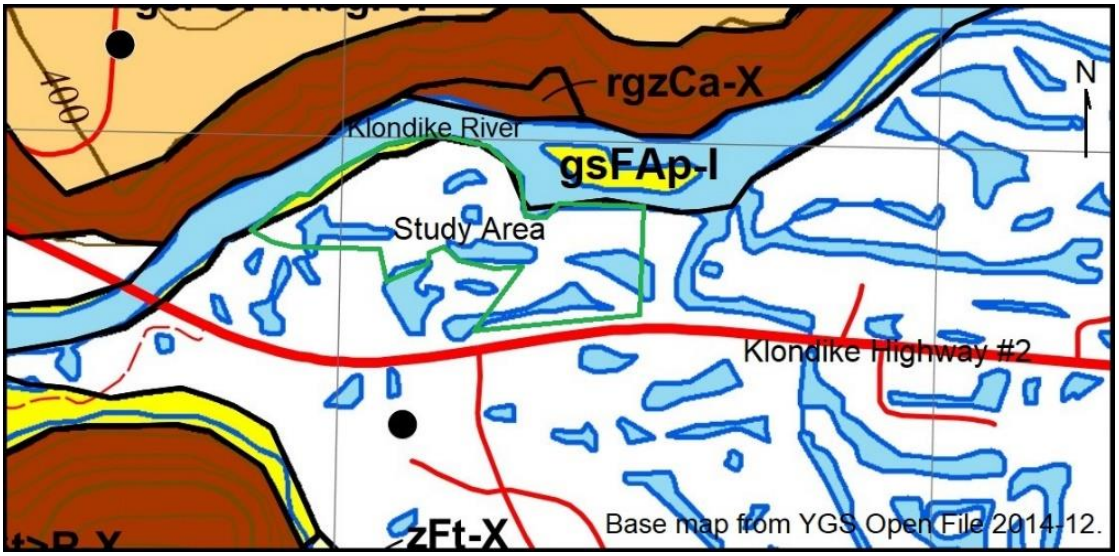
View of central trail facing north in region of undisturbed fluvial deposits.

Potential riparian areas were identified in the northern and northwestern realms of the study area.

Panoramic view of southwestern pond facing south.

4.4 Surficial Geology

The surficial deposits were described in the surficial geology map of Dawson (YGS Open File 2014-12) as being comprised of predominately anthropogenic materials. However, active fluvial deposits were also identified in the northwestern and northern realms of the study area. The approximate distribution of these deposits within the study area have been illustrated in a segment of the surficial geology map as noted below;



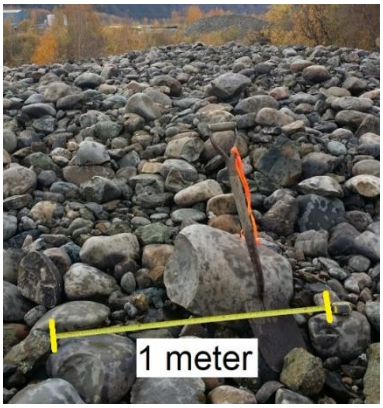
As the scale of mapping in the surficial geology map was limited, a more accurate delineation of these deposits can be found in Figure 2.

In brief, these deposits were described by the surficial geology map as follows;

Anthropogenic Deposits – (gAr)

These deposits are dominated by soils which have been significantly disturbed due to human activities. In this case, these deposits are predominately

comprised of mine tailings which were derived from fluvial deposits which are prevalent throughout the Klondike River valley. While these fluvial materials were generally comprised of gravels which contain cobble to boulder sized materials, deleterious fine-grained and organic soils may also be present within the tailings materials.



Fluvial Deposits - (gsFAp)

These active fluvial materials are known to be comprised of a sequence of fine-grained silts which overlie coarse-grained sands and gravels. These deposits are overlain with a veneer of organics and organic silt and are subject to frequent flooding. The granular components contain cobble to boulder sized materials. The fluvial deposits are known to be frozen where they lie beyond the thermal influence of the Klondike River.

4.5 Geomorphology

Deposition

The soils located within the study area are comprised of fluvial deposits which are associated with the Klondike River. Some of these soils have been disturbed through historical mining and more recent human activities.

Glaciation

Evidence shows that the Dawson area and Klondike Plateau have probably not been glaciated since Pre-Reid advances (2.65 Ma to > 200 Ka).

Permafrost

Dawson lies within the zone of extensive discontinuous permafrost (50-90%). The permafrost in this zone can vary from poorly bonded soils with non-visible ice to massive ice lenses ranging in size to tens of meters. Regionally the permafrost is probably more than 100 m thick with taliks (thawed subsurface) present beneath large rivers, lakes and south-facing slopes.

Although some of the soils which are located within the study area have been disturbed through historical mining operations, it's possible permafrost has formed within the tailings materials since the time these waste materials were generated.

The fluvial deposits which are located within the study area are likely thawed due to the thermal influence of the nearby Klondike River.

Watercourses

The study area is located adjacent to the Klondike River.

A series of tailings ponds and naturally occurring ponds are located within and immediately adjacent to the study area. One of the northernmost ponds (which contained a semi-buoyant 45-gallon barrel) was inundated with logs which had flowed into the pond during Klondike River flooding.

View of northern pond facing northeast.

View of seasonal tributary facing east.

Several seasonal tributaries, which appeared to direct surface waters from east to west, were noted in the northern half of the study area. These tributaries appear to assist in the regional drainage and flow regimes associated with the Klondike River.

Groundwater

Shallow groundwater would be expected in the form of seepage zones and sheet-wash flows given the nature of the terrain and anticipated soil types. Some of these seepage zones, which were noted on the western side of the study area, coincided with seasonal tributaries.

The groundwater elevation would closely parallel local pond elevations which are heavily influenced by the Klondike River. Some of these pond levels are influenced due by the presence of dams which have been constructed by the local beaver

population. Groundwater may be encountered at shallower elevations where perched conditions (or permafrost) are present.


View of seepage zone along western side of the study area.

The direction of groundwater flow would likely parallel the Klondike River.

Surface Drainage

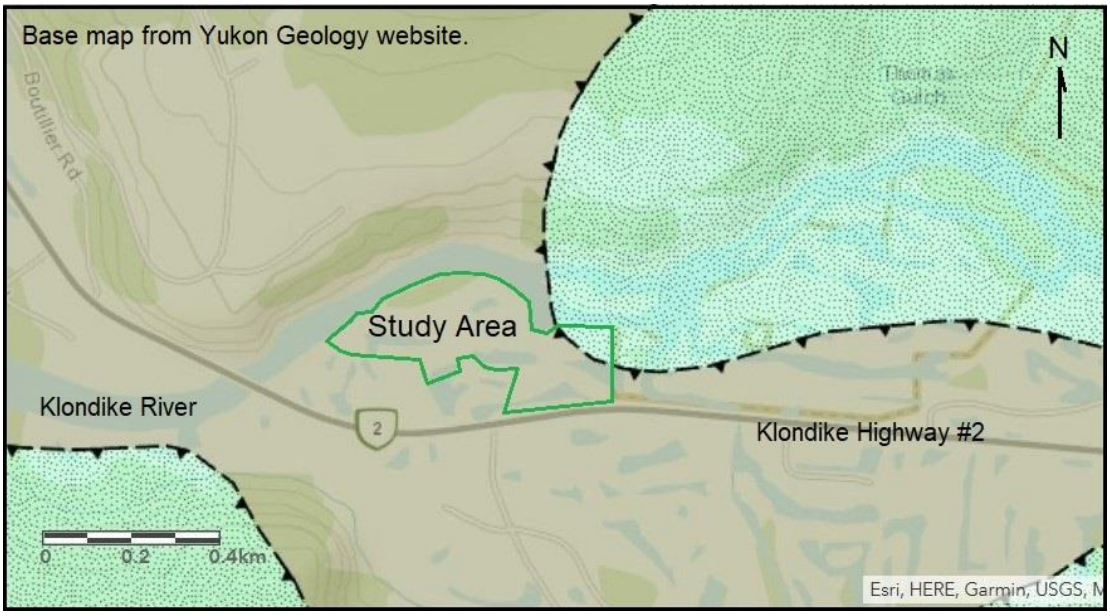
The mine tailings which were encountered within the study area are generally free draining. There were no signs of defined surface drainage in these areas.

While the surface drainage in the regions of the fluvial deposits was generally undefined and irregular, some drainage courses which directed surface waters from the east to west were noted in the regions where seasonal tributaries were identified.

4.6 Bedrock Geology

There was no indication of near surface bedrock within the study area.

The geology maps indicate the study area is located in Yukon-Tanana Terrane which is predominately comprised of green schist to lower amphibolite facis metamorphic

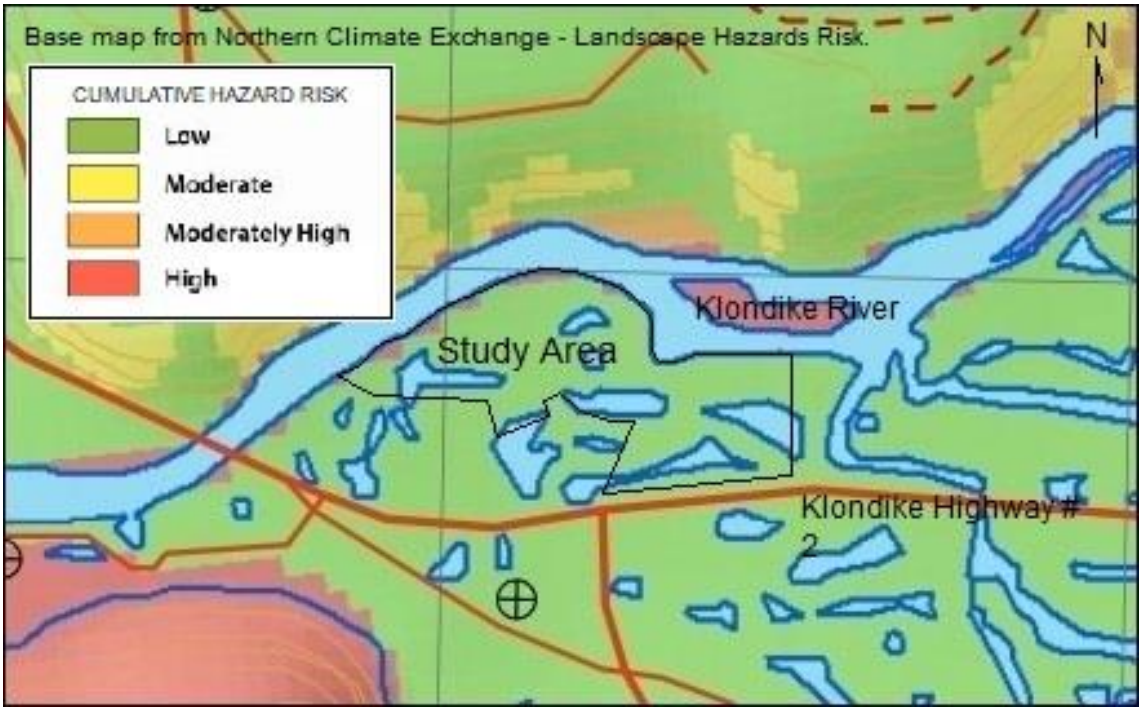


rocks. These rocks consist of locally pillowed dark green to black basalt and greenstone of the Slide Mountain suite. Dark grey to black carbonaceous metasedimentary rocks of the Finlayson Suite lie in the northeastern realms of the study area. These assemblages are thought to be separated by a thrust fault as illustrated in the *Yukon Geology* website as noted in the image above;

While the depth to bedrock will vary, it's understood that it generally lies at depths of 20 to 30 meters in this region of the Klondike Valley.

4.7 Natural Hazards Risks

The natural hazard potential in the Klondike Valley was assessed in the Dawson Natural Landscape Hazards – Geoscience Mapping for Climate Change Adaptation Planning Report compiled by the *Northern Climate ExChange*. The study classified the hazard potential in the region of the study area as follows;



In brief, the report classified the majority of the terrain within the study area as having a low hazard potential. However, the northern realms of the study area were classified as having a high hazard potential, likely due to the risks related to flooding. As the delineation of these areas was limited due to the scale of mapping and their scope-of-

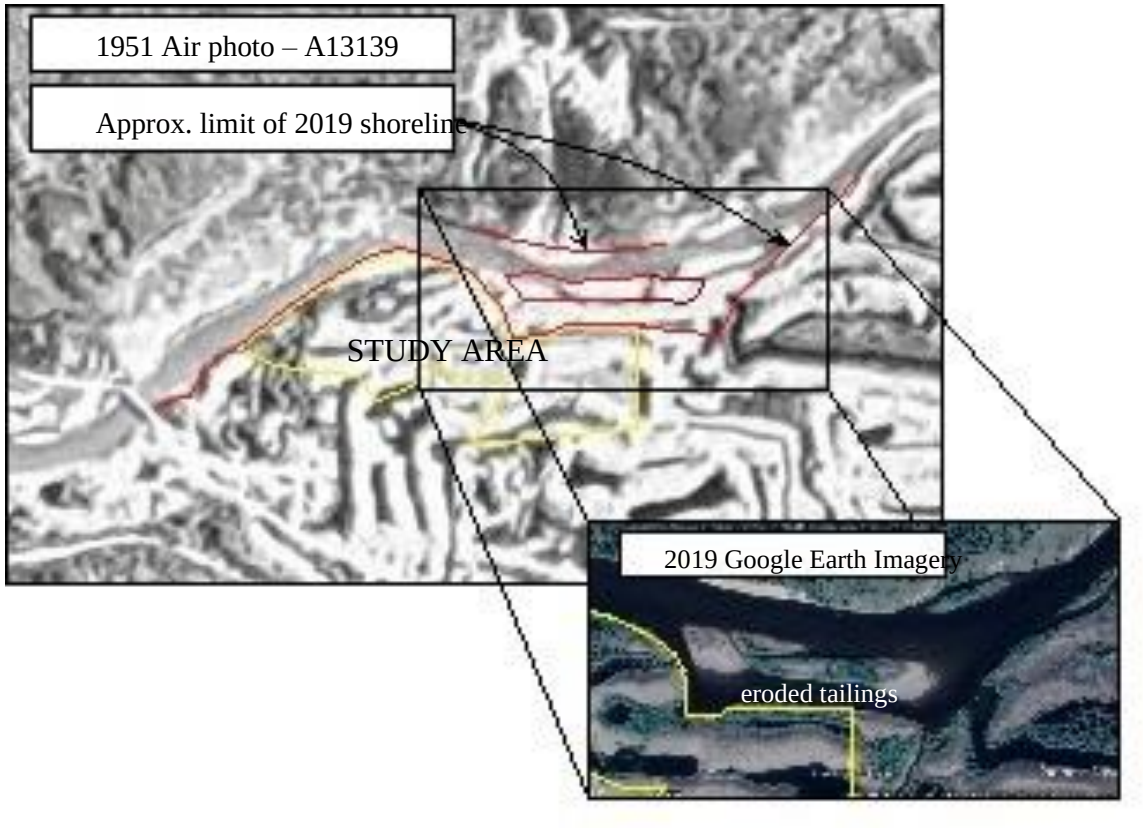
work, based upon our observations, the high hazard potential would likely extend to regions wherever fluvial deposits were identified as noted in Figure 2.

Additional consideration would be required to assess the hazard potential related to shoreline erosion which was identified along the banks of the Klondike River, particularly with respect to the tailings piles which were once located along the northeastern periphery of the study area.

View of northeastern region facing north.

View of northeastern region facing east.

Based upon a comparison of the earliest available air photo (which was taken in 1951) relative to recent (2019) satellite imagery, it appears the tailings piles have been progressively eroded by the Klondike River as noted in the images below;



4.8 Placer/Quartz Claims and Land Dispositions

The *YG - Placer Watershed Atlas* website was reviewed to identify the presence of (placer and quartz) mining claims and land dispositions which may be located within the study area. The locations of these claims and dispositions relative to the limits of the study area were illustrated as noted in the image attached below.

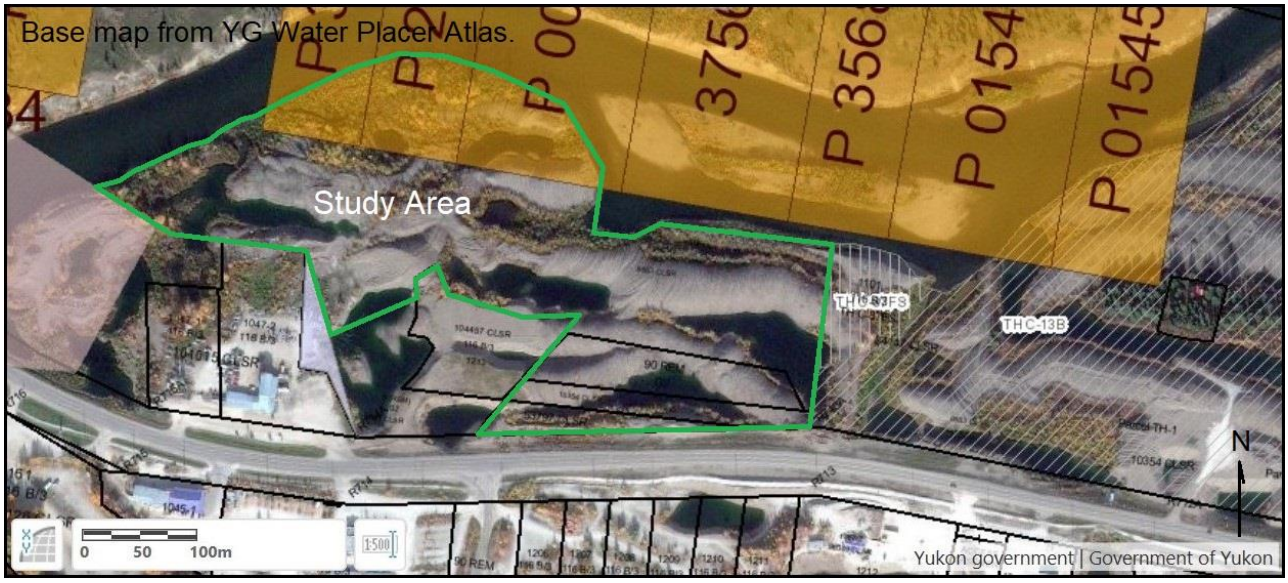
In brief, there were three (3) placer claims which extend into the northern realms of the study area. These claims were identified as P35187, P28927 and P00691. The tenure status of these mining claims was listed as being 'Active'.

In addition, two (2) placer claims (37566 & P35685) were located immediately north of the eastern realms of the study area.

While quartz claims were not located within the limits of the study area, a quartz claim (identified as grant number YC36344) borders the northern realms of the study area.

Three surveyed land parcels are located within the southeastern region of the study area as noted above. The parcels were identified as CLSR FB6410 (Lot 90, Group 2), CLSR 53797 & Hunker Road 10354 CLSR.

Two (2) land dispositions were identified immediately adjacent to the study area. Disposition #980081 located west of the study area was identified as a 'Bridgehead Reservation'. A commercial land application (#2018-3280) is located adjacent to the central regions of the study area.



5.0 DISCUSSIONS

5.1 Regional Development

Regionally, developed regions within the Guggieville Industrial Subdivision coincide with the locations of pre-existing mine tailings and/or regions where tailings ponds have been infilled with these materials through pre-grading operations.

In general, the undisturbed areas in the region have not undergone any significant development as these regions are generally more costly to develop due to the potential presence of permafrost and/or organics and fine-grained materials.

5.2 Development Potential Classification

As the overall development potential of the study area is generally dependent upon the availability of suitable mine tailings materials, we have classified the development potential of the various areas within the study area as being either 'Suitable' or 'Unsuitable' as described below;

Suitable

These regions, which are predominately comprised of mine tailings and tailings ponds, will generally allow for unfettered lot development utilizing conventional construction methodologies once the areas have been properly pre-graded.

Unsuitable

Regions which harbor naturally occurring ponds, active floodplains, fine-grained/organic deposits or which are in close proximity to the Klondike River would generally be considered unsuitable for lot development.

5.3 Development Potential

The development potential within the study area is primarily dependent upon the presence and availability of mine tailings and site-specific geotechnical conditions. As such, the development potential within the study area will vary as illustrated in Figure 3.

In general, the region located south of the 'demarcation line' should allow for lot development utilizing conventional cut/fill construction methodologies.

The 'demarcation line' was arbitrarily established as a setback relative to shoreline erosion and potential riparian areas, which were identified in the northeastern and northwestern realms of the study area, respectively.

As access to the region of the study area located north of the existing lots may be challenging (Figure 3 – *'Suitable (A)'*), additional consideration may be required if this region is to be developed.

Ideally, building construction should coincide with regions of cut within the mine tailings as these materials have generally undergone an adequate amount of consolidation since the time they were originally generated. Unless structural fills are established, buildings should not be constructed in regions of fill as the amount of differential and/or total settlement in these regions may otherwise exceed tolerable limits. Buildings should not be constructed in regions where ponds may have been infilled during pre-grading operations. Geotechnical/development setbacks will need to be observed relative to building construction in regions which are located near adjacent mine tailings slopes as described in Section 6.5, below.

As the extent of the mine tailings is limited, where possible, roadways, parking and yard areas should be situated in regions where ponds may have been infilled during lot development.

While septic fields would need to be constructed in regions of pre-existing mine tailings additional consideration would be required given the proximity to the groundwater table and the generally porous/coarse-grained nature of the mine tailings. If the site conditions are not favorable for septic field installations, then the use of insulated holding tanks would be required.

Development of the region located north of the 'demarcation line' is not recommended at this stage as this area would need to first be assessed from a hydrological perspective. Specifically, as our assessment determined that groundwater and seasonal tributaries flow through this region, additional consideration will be required as disruption to the flow regime may impact the Klondike River (particularly with respect to freeze/break-up and rate of shoreline erosion). This may be of concern as the Klondike River bridge is located approximately 200 meters down-stream of the study area.

While development of this 'Unsuitable' region would require further study, it's likely the tailings materials located within this region will be suitable for use as

general purpose fill to develop regions which were deemed to be suitable within the study area (and/or potentially other sites). Additional consideration will be required relative to utilizing the tailings materials which are located on the existing placer claims for this purpose.

6.0 RECOMMENDATIONS

The following recommendations have been provided assuming the site conditions are deemed to be suitable following completion of a subsurface geotechnical evaluation. Development should be restricted to regions of the study area where the development potential has been identified as being 'Suitable' as noted in Figure 3.

6.1 Site Development

In general, regions which have been deemed to be 'Suitable' for development should be pre-graded through conventional cut/fill construction methodologies in order to establish the required design elevations. These design elevations should parallel those which have been established in other nearby developed areas located in the Guggieville Industrial Subdivision Area.

Initially, clearing, grubbing and stripping operations should be conducted to prepare the region for site grading as determined through future geotechnical evaluation. Caution should be exercised during site preparation if permafrost is encountered as their disturbance may result in thaw-degradation of the underlying soils. Once the site has been adequately prepared, low-lying regions should be backfilled through systematic placement and compaction of approved tailings materials.

If the quantities of onsite mine tailings are insufficient to establish the required design elevations, then approved granular fills would need to be imported.

All backfilled materials should be placed and compacted in uniform, level lifts. If the mine tailings are to be utilized as structural fill, then materials larger than 150 mm in diameter would need to be removed from the tailings prior to use. Caution will need to be exercised during backfill operations as the mine tailings may also harbor deleterious materials such as organics, fine-grained materials, frozen soils and/or ice. These deleterious materials will not be suitable for backfill use and would need to be wasted in designated areas or else hauled offsite.

As water within the ponded regions will be displaced during backfill, excess water (above the groundwater elevation) should be removed during backfill operations such that subsequent backfill is placed in a drained state. Additional consideration may be required relative to infilling ponds due to the turbidity that would be created during the backfill operations.

6.2 Surface Utilities

The mine tailings will generally be suitable for use as road and yard area subgrade materials. These regions should be properly shaped in order to establish positive drainage which incorporates the use of ditches and culverts.

Granular subbase and base course materials will need to be imported to establish the roadways. These materials should be placed in uniform, level lifts upon approved subgrade materials while being compacted to the required specified densities. While the thickness of the road structure would depend upon the envisioned traffic frequencies and loads, at this stage, we anticipate the road thickness should measure in the order of 0.5 meters.

As the tailings materials contain large cobbles and boulders, granular fills may need to be imported to properly prepare driveways, parking and yard areas.

Roadways which are constructed over potentially disturbed disturbed/undisturbed areas and/or ponds will generally require additional time to stabilize relative to potential long-term settlement and so an increased level of maintenance may initially be required in these regions.

6.3 Subsurface Utilities

Septic fields should be situated in regions of pre-existing mine tailings. They should not be established in regions of fill or former pond areas. The presence of permafrost will preclude the installation of septic fields where encountered within the study area.

Additional consideration will be required relative to the installation of septic fields given the proximity to the groundwater table and generally porous/coarse-grained nature of the mine tailings. If required, filter sand may need to be imported during septic field construction in order to reduce the rate of percolation and allow for their installation.

If septic field installation is not feasible, then insulated holding tanks would need to be utilized to handle sewage effluent.

The tailings materials will generally allow for installation of subsurface utility lines. However, as tailings materials contain large cobbles and boulders, excavation difficulties may be encountered. Caution will need to be exercised to ensure these

materials are not placed within 300 mm of utility pipes. The utility pipes should be encased in bedding sand as per standard installation practices.

If the installation of water wells is not feasible, water tanks would need to be incorporated into heated buildings.

6.4 Building Foundations

Following pre-grading operations, buildings can be founded upon conventional footing or monolithic-slab concrete foundation systems which are constructed upon engineered granular fills. These buildings should be situated in cut areas (in regions of pre-existing mine tailings) provided the tailings exposed at the subgrade elevation(s) are undisturbed and considered suitable for development.

Unless structural fills are established, buildings should not be constructed in regions of fill (or disturbed regions) as the amount of differential and/or total settlement in these areas may otherwise exceed tolerable limits. Buildings should not be constructed in regions where ponds or undisturbed regions may have been infilled during pre-grading operations.

Buildings should be closed to the weather and heated prior to the onset of winter conditions and throughout their lifespan whenever freezing temperatures prevail.

6.5 Geotechnical/Development Setbacks

Development setbacks should be considered relative to the active mining claims which were identified in Section 4.8, above.

Geotechnical/building setbacks (in the order of 15 meters in width) should be observed relative to the crests of adjacent slopes to allow for a factor of safety relative to potential slope movements. These slopes would generally be comprised of either pre-existing mine tailings materials or else mine tailings which have been placed during more recent pre-grading operations.

While buildings and septic fields should not be constructed in these setback regions, some of these areas could be incorporated into individual lots for use as laydown areas as assessed on a case-by-case basis.

6.6 Additional Assessments and Evaluations

As our findings are preliminary in nature, additional assessments and evaluation(s) will be required to verify site-specific design parameters, as described below.

Site Survey

Detailed site surveys (which compile bathymetric charts and extend beyond the limits of the study area) should be conducted to better assess development options where cut/fill operations are to be considered. Specifically, the intent would be to determine the volume of mine tailings which may be available to fill the tailings ponds and potentially other areas which are to be developed.

These survey results should be assessed during the geotechnical evaluation phase to assist in soil and terrain classification within the study area.

Geotechnical Evaluation

A geotechnical evaluation should be conducted by qualified personnel prior to lot development to assess the sub-surface conditions and identify site-specific geotechnical parameters.

Environmental Site Assessment

A Phase I Environmental Site Assessment (ESA) should be conducted to identify potential environmental liabilities which may be associated with the study area and nearby properties if lot development is to be considered.

Hydrogeological Assessment

A hydrogeological study would be required to assess the feasibility of installing water wells within the study area. During this time, the aquifer capacity should be assessed relative to supporting the envisioned water wells.

Hydrological Study

A hydrogeological study should be conducted if the region located north of the demarcation line is to be developed to determine the potential impact lot development may have upon the flow regime of the Klondike River. Specifically, the study should determine whether or not any proposed lot development may have an impact upon seasonal freeze/break-up of the Klondike River and/or rate of shoreline erosion, particularly considering that the Klondike River bridge is located ~ 200 meters downstream of the study area.

Habitat Assessment

As riparian areas were identified within the study area in regions located near the Klondike River, habitat assessments should be conducted by qualified personnel to identify potential setbacks and/or measures which may need to be employed to mitigate the impacts of potential lot development.

Heritage Assessment

A heritage assessment should be conducted to determine whether or not the study area harbors any heritage items of value.

Other Plans, Studies and Assessments

Additional plans should be compiled to identify site grading, surface drainage, erosion control, potential insect control requirements.

Other similar types of studies/assessments may be required as deemed necessary during the development of conceptual plans and the design processes.

Construction Monitoring, Testing and Inspection Services

As the suitability of the mine tailings and site conditions would need to be assessed on a case-by-case, qualified geotechnical personnel should provide construction monitoring, testing and inspection services at the time of lot development.

Shoreline Monitoring Program

Following lot development, the Klondike River shoreline should be monitored on an intermittent long-term basis for signs of erosion. If required, protective measures such as rip-rap placement and/or sheet-pile wall installations may be required to mitigate potential impacts of shoreline erosion.

7.0 CONCLUSIONS

7.1 Development Potential

The development potential within the study area is primarily dependent upon the presence and availability of mine tailings materials and site-specific geotechnical conditions. As such, the development potential of the study area will vary as illustrated in Figure 3.

In general, the region located south of the 'demarcation line' should allow for lot development utilizing conventional cut/fill construction methodologies.

While the mine tailings should generally be suitable for use as fill to develop other regions within the study area (and/or potentially other sites), additional consideration may be required on a case-by-case basis during lot development as the tailings may contain deleterious materials.

If the quantities of onsite mine tailings are insufficient to establish the required design elevations, then approved granular fills would need to be imported.

As access to the central region of the study area located north of the existing lots (Figure 3 – *'Suitable (A)'*) will be challenging, additional consideration may be required if this region is to be developed.

Development of the region located north of the 'demarcation line' is not recommended at this stage as this area would need to first be assessed from a hydrological perspective particularly as development of this region may disrupt the flow regime of the Klondike River and potentially impact the nearby Klondike River bridge during seasonal freeze/break-up.

7.2 Road Construction

The mine tailings materials will generally be suitable for use as road, parking and yard area subgrade materials once the site has been pre-graded. Granular fills would need to be imported to establish finished design elevations. Where possible, this infrastructure should be situated in regions where ponds may have been infilled during lot development such that the tailings areas are available to allow for building construction.

If access the study area is to be established from the North Klondike Highway, additional consideration will be required relative to establishing potential highway acceleration/deceleration lanes.

7.3 Building Construction

Following pre-grading operations, buildings can be founded upon conventional footing or monolithic-slab concrete foundation systems which are constructed upon engineered granular fills. These buildings should be situated in cut areas (in regions of pre-existing mine tailings) provided the tailings exposed at the subgrade elevation(s) are considered suitable for development.

Unless structural fills are established, buildings should not be constructed in regions of fill (or disturbed regions) as the amount of differential and/or total settlement in these areas may otherwise exceed tolerable limits. Buildings should not be constructed in regions where ponds or undisturbed regions may have been infilled during pre-grading operations.

Buildings should be closed to the weather and heated prior to the onset of winter conditions and throughout their lifespan whenever freezing temperatures prevail.

7.4 Septic Field Suitability

Additional consideration would be required to assess the feasibility of installing septic fields in regions of pre-existing mine tailings given the proximity to the groundwater table and the generally porous/coarse-grained nature of the mine tailings. If deemed feasible, filter sands may need to be imported during septic field construction to slow the rate of percolation. Otherwise the use of insulated holding tanks would be required if site-specific conditions are not suitable for septic field installation.

Septic fields should not be developed in regions of permafrost, fill or former pond areas.

7.5 Additional Assessments and Evaluations

As our findings are preliminary in nature, additional assessments and evaluation(s) should be conducted to verify site-specific design parameters, as described in Section 6.6, above.

8.0 LIMITATIONS

This report is intended for the sole use of *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 comments contained herein reflect our best judgment in light of the information available to our firm at the time of our assessment. They are based upon our collation of available literature, observations made during our site reconnaissance, recognition of geomorphic features and generally accepted engineering practices.

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

Due to the geomorphological nature of the deposits encountered, interpolations of subsurface conditions have not been made or implied other than for discussion purposes. The anticipated construction conditions have also been discussed, but only to the extent that they may influence design decisions. Suggestions of construction methods contained herein express our opinion and are not intended to direct contractors on how to carry out construction. Any reference to structures, roads or overall use of the study area have been for discussion purposes only. The actual use of the study area will need to be determined during future geotechnical evaluations and the design process.

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

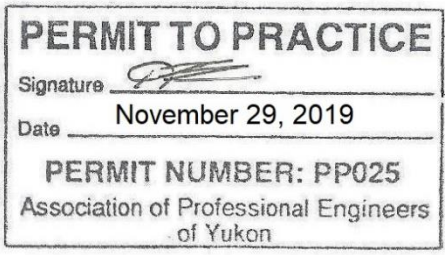
9.0 CLOSURE

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

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,

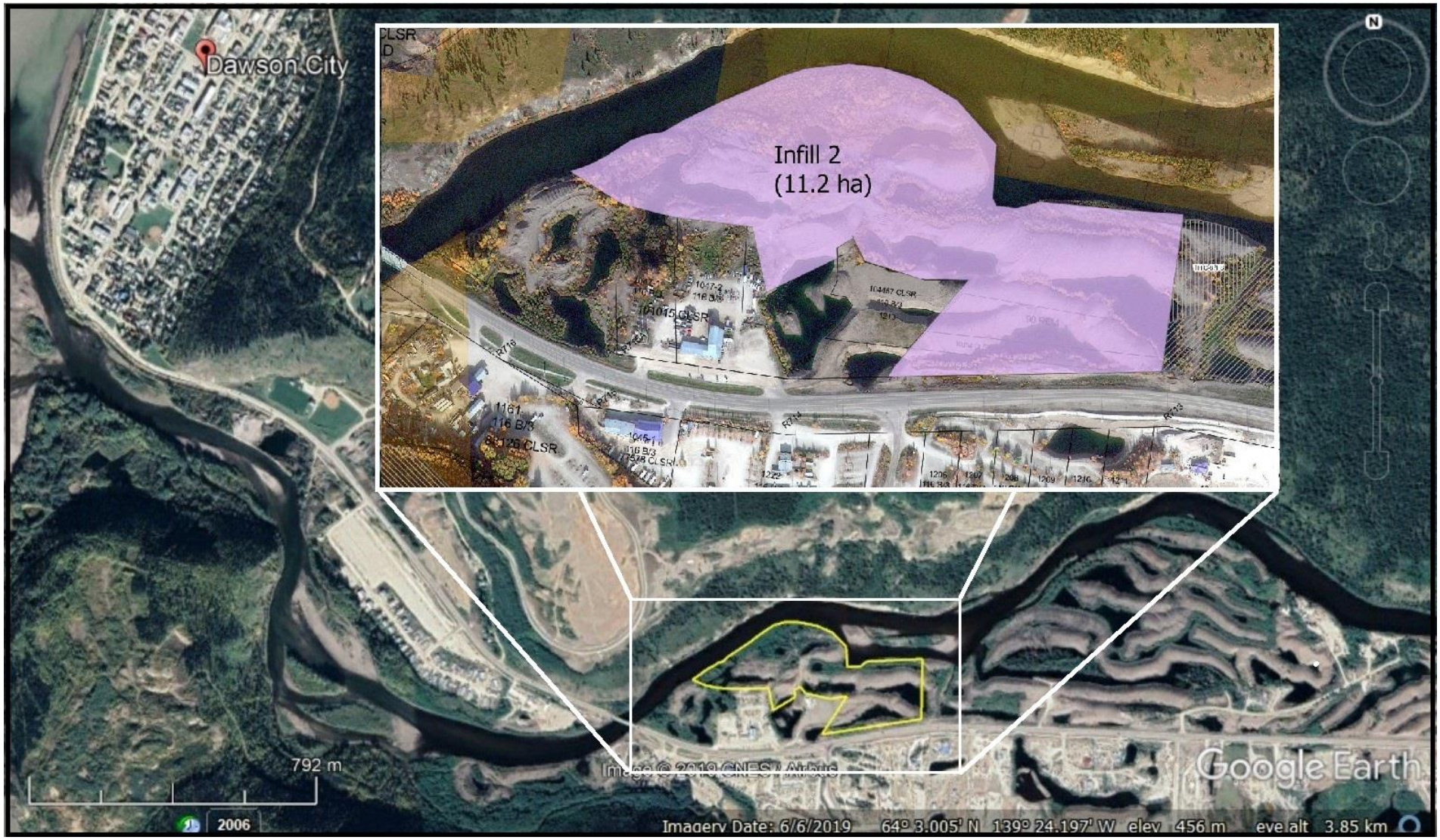
CHILKOOT GEOLOGICAL ENGINEERS LTD.



Tares Dhara, P.Eng.
Senior Geotechnical Engineer

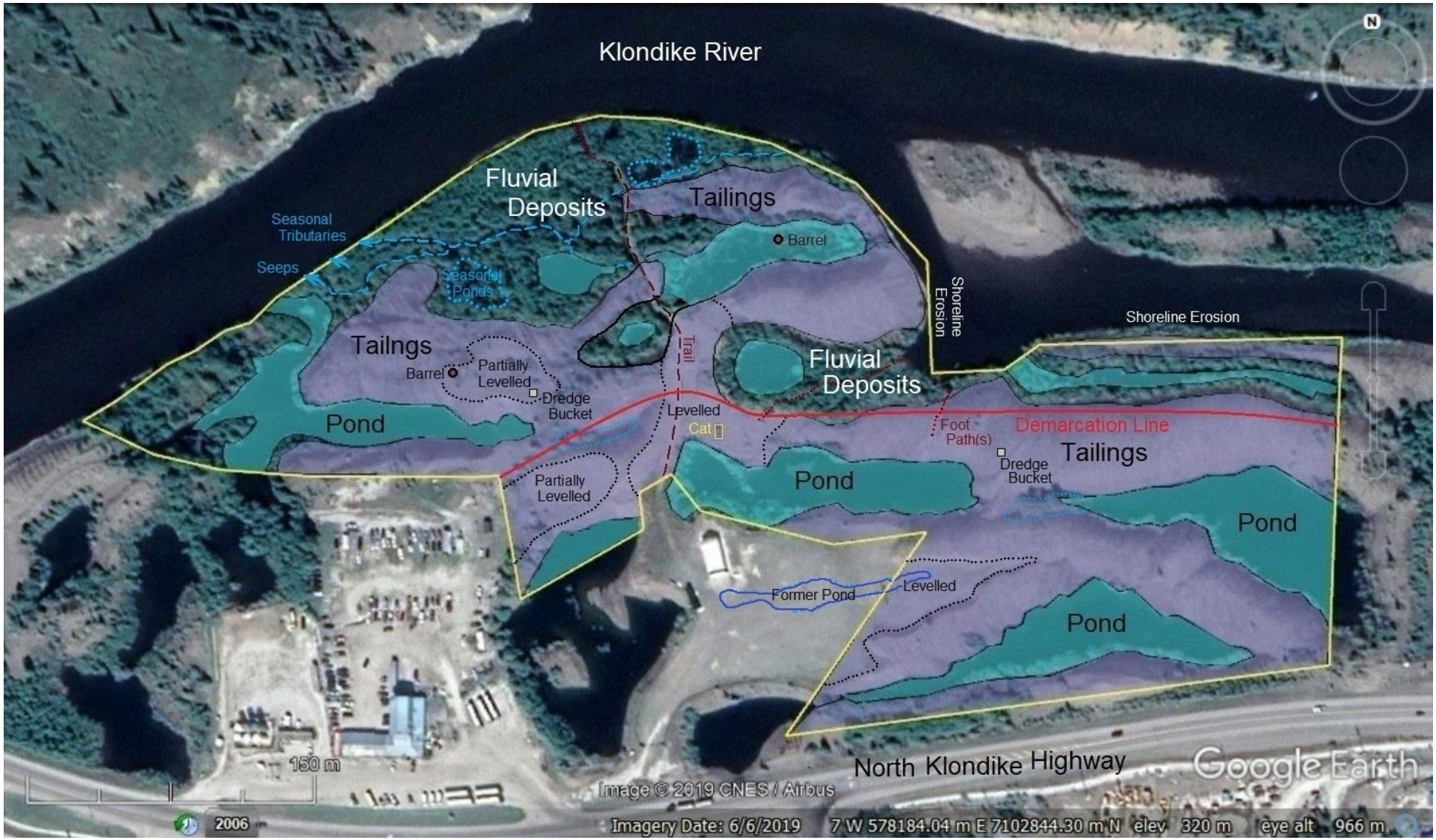
TD/td

Geotechnical Feasibility Assessment
Proposed Lot Infill Development
Guggieville Industrial Subdivision Area - Dawson City, Yukon - 2019
Figure 1 – Site Location – Infill #2



Based map from Google Earth and YG supplied Site Plan – Not to Scale – Locations are approximate. Compiled November 2nd, 2019 by T.Dhara

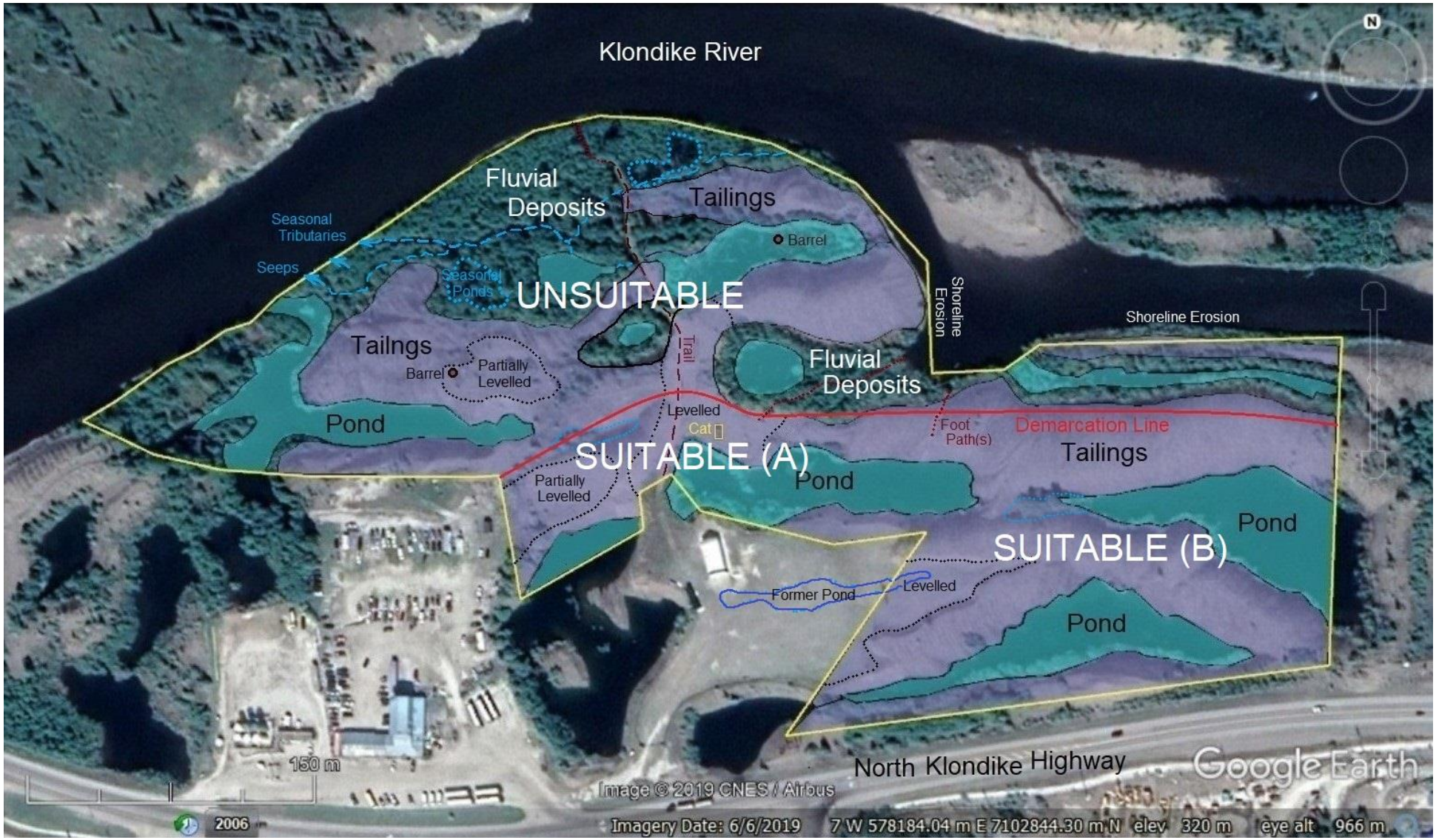
Geotechnical Feasibility Assessment
Proposed Lot Development - Guggieville Industrial Subdivision Area
Dawson City, Yukon - 2019
Figure 2 – Site Conditions - Infill #2



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

Compiled November 4th, 2019 by T.Dhara, P.Eng.

Geotechnical Feasibility Assessment
Proposed Lot Development - Guggieville Industrial Subdivision Area
Dawson City, Yukon - 2019
Figure 3 – Development Potential - Infill #2



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

Compiled November 4th, 2019 by T.Dhara, P.Eng.